Nuclear Safety

Dispersion Prognoses and Consequences in the Environment

- a Nordic development and harmonization effort

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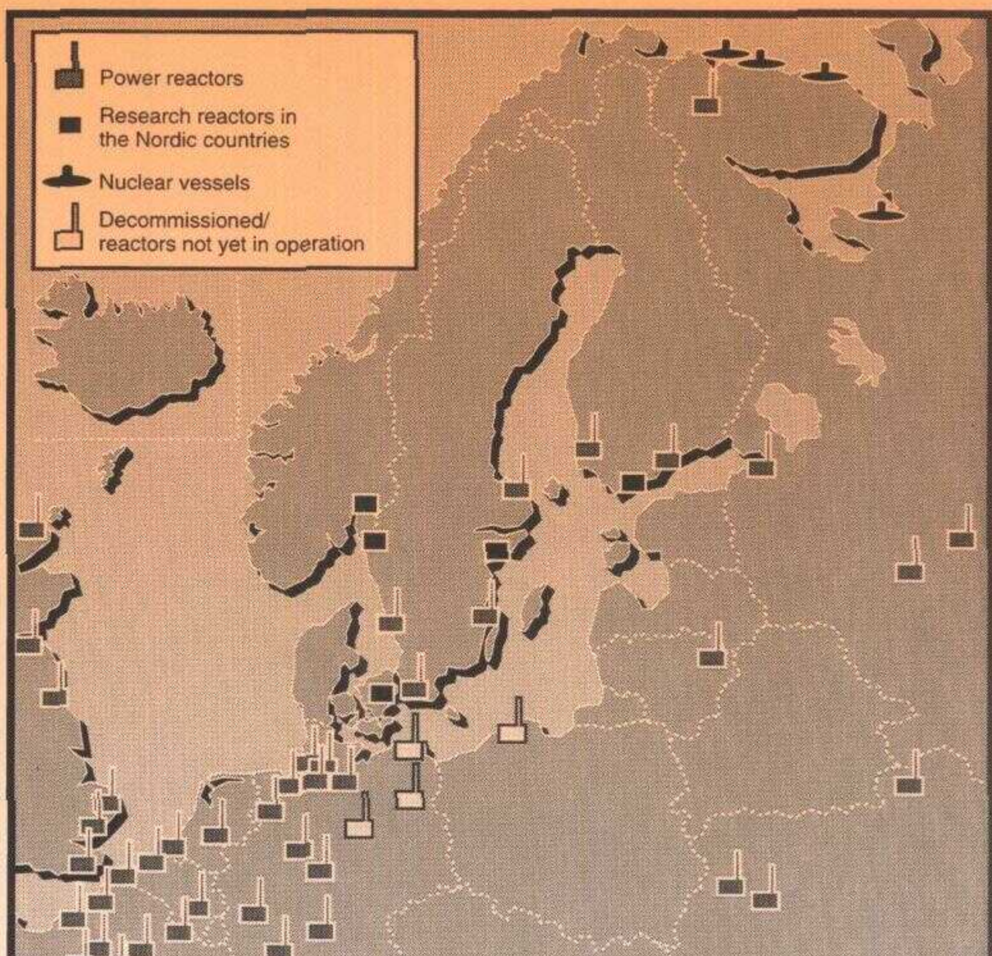

Dispersion Prognoses and Consequences in the Environment

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- a Nordic development and harmonization effort

Final report from the Nordic Nuclear Safety Research, Project BER-1.

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The Nordic Council of Ministers
was established in 1971. It submits proposals on co-operation between the governments of the five Nordic countries to the Nordic Council, implements the Council's recommendations and reports on results, while directing the work carried out in the targeted areas. The Prime Ministers of the five Nordic countries assume overall responsibility for the co-operation measures, which are co-ordinated by the ministers for co-operation and the Nordic Co-operation Committee. The composition of the Council of Ministers varies, depending on the nature of the issue to be treated.

The Nordic Council
was formed in 1952 to promote co-operation between the parliaments and governments of Denmark, Iceland, Norway and Sweden. Finland joined in 1955. At the sessions held by the Council, representatives from the Faroe Islands and Greenland form part of the Danish delegation, while Åland is represented on the Finnish delegation. The Council consists of 87 elected members - all of whom are members of parliament. The Nordic Council takes initiatives, acts in a consultative capacity and monitors co-operation measures. The Council operates via its institutions: the Plenary Assembly, the Presidium, and standing committees.

ABSTRACT

The project "BER-1, Dispersion prognoses and environmental consequences" is described. The report describes the work performed and the results obtained. The bulk of the report is concerned with the first subject area, atmospheric dispersion models. The world-wide status of long-range atmospheric dispersion models at the start of the project period is described, descriptions are given of the models in use at the Nordic meteorological institutes, and validation/verification and intercomparison efforts that have been performed within the project are described. The second subject area, covering environmental impact, is described much more briefly. The main results of this work have been published separately. All aspects of environmental impact of releases to the atmosphere have been treated, and the end product of this part of the project is a computerized "handbook" giving easy access to data on e.g. deposition, shielding, filtering, weathering, radionuclide transfer via all possible exposure pathways.

Key words: Chernobylsk-4 reactor; computer codes; contamination; coordinated research programmes; Denmark; deposition; earth atmosphere; environmental impacts; Finland; fission product release; Iceland; information systems; meteorology; Norway; radionuclide migration; reactor accidents; Sweden; trajectories; verification; weather.

SUMMARY

Experience shows that releases of radioactive materials resulting from accidents at nuclear power plants may cause contamination at great distances. The national authorities responsible for handling emergency situations involving radioactive materials need tools to predict the potential consequences of such releases. Different models for predicting the transportation in the atmosphere are available, and they are continuously developed. One class of atmospheric transportation models describes the movement of an air parcel under changing meteorological conditions, the so-called trajectory models. Such models are not capable of calculating the concentrations of radioactive material in the cloud. Other models are more advanced and can handle this problem, and in addition they can calculate the amounts of radioactive materials deposited at different locations.

Individual countries have often chosen different models. This may result in differences in the predictions, which in turn can lead the authorities to take different countermeasures. With the uncertainties inherent in such predictions, this is understandable, but it may lead to confusion when the same situation is evaluated by neighboring countries.

In a worldwide survey, carried out in early 1992, it was found that a large number of models of different types existed, which were meant for use in long-range calculations. It was also found that none of the Nordic countries used the same. The only model at the time in the Nordic countries capable of calculating concentrations was the Swedish MATCH model.

On the basis of the survey, each of the meteorological institutes of Denmark, Finland and Norway chose a system upon which future development would be based, and started implementation of the models needed. In Sweden a model developed at the Swedish Meteorological and Hydrological Institute had already been chosen. In Finland an existing Finnish model was redesigned, while in Denmark and Norway calculation systems based upon a British model were developed. In Iceland one has chosen, at least for the time being, to commission predictions, when needed, from the Meteorological Institute of Denmark or the Meteorological Office at Bracknell in the United Kingdom.

Before such models can be used by the authorities, their trustworthiness should be investigated. Therefore one of the models was used to calculate the passage of the plume from Chernobyl over the Nordic countries, and these results were compared to the observations actually made in 1986. There was fairly good agreement. This type of validation is useful in order to identify features of a model that require further improvement.

Another manner in which the dependability can be investigated is by comparing the results calculated by different models. Such intercomparisons were achieved, with participation from all five Nordic countries, by carrying out so-called functional exercises. Directed by a central Exercise Secretariat, the Nordic meteorological institutes were given the same problem to solve and requested to submit their results to the secretariat. A radioactive release was defined at a certain location, and calculations were to be carried out using the actual weather and weather predictions, closely imitating an emergency situation. Two such exercises have been carried out. Both exercises were follo-

wed by meetings at which the results were discussed, and subsequently improvements to the models were implemented.

The exercises revealed that the graphical presentations of the results, which are today in routine use at the meteorological institutes, may be difficult to understand properly and are difficult to transmit by telefax. In addition, it was found that the results transmitted often lacked important additional information needed to make it possible to understand fully what the results actually showed. A common scheme for result presentation has therefore been proposed.

The authorities responsible for emergency preparedness use the predictions from the atmospheric dispersion models to evaluate possible radiation doses to the population. Population can be exposed to radiation in different ways: by direct exposure from the atmosphere and soil, by inhalation, and by intake of contaminated food. All these pathways have to be taken into account when an emergency situation shall be evaluated. Much information on the different exposure pathways has been collected in the Nordic countries since the early 1950's. This information is published in a large number of reports, but is not easily accessible.

In an attempt to provide decision makers with more readily accessible information, a computerized "handbook" containing all pertinent information has therefore been developed. In addition to data and various information on different levels of detail, this handbook contains simple formulas for calculating doses and information on actions that may reduce doses for each of the exposure pathways in different types of areas (urban, agricultural, mountains etc.). The handbook is hierarchical in layout. Via highlighted keywords in the text, access is obtained to information of gradually higher detail. The terminology used in the handbook is kept as simple and straightforward as possible, so that no expert knowledge is needed to use it. It also contains a number of different search functions. It is accordingly well suited to be part of the information system built up by the emergency authorities.

SAMMENFATNING

Erfaring har vist at utslipp av radioaktive stoffer etter en reaktorulykke kan føre til forurensning langt fra utslipps-stedet. De nasjonale myndigheter som er ansvarlige for beredskapssituasjoner som involverer radioaktivitet, må ha tilgang til verktøy som kan hjelpe til å forutsi de potensielle konsekvenser av slike utslipp. Det finnes forskjellige modeller som anvendes for å forutsi transportveier i atmosfæren, og de er også under kontinuerlig videreutvikling. Én type slike modeller omtales som trajektoriemodeller. De beskriver bevegelsene til en "luftpakke" under skiftende meteorologiske forhold, men de kan ikke beregne luftkonsentrasjoner. Det finnes imidlertid andre, mer avanserte, typer modeller som kan gjøre dette, og som i tillegg beregner konsentrasjonen av materiale deponert på marken i forskjellige lokasjoner.

De forskjellige land har ofte valgt a basere seg på forskjellige modeller. Dette kan føre til at prediksjonene, for samme type situasjon, kan bli forskjellige, og dette igjen kan føre til at myndighetene i de forskjellige land velger å ta i bruk forskjellige typer og/eller grader av mottiltak. Med de usikkerheter som ligger inne i denne type beregninger er dette forståelig, men det kan allikevel være uheldig, og forvirre befolkningen, at samme situasjon vurderes forskjellige av forskjellige land.

I 1992 ble en verdensomspennende oversikt utarbeidet, og man fant at det eksisterer en lang rekke modeller av forskjellige type, utviklet for beregning av spredning i luft over lange avstander. Man fant også at ingen av de nordiske land brukte de samme modeller, og at den eneste operasjonelle modellen i de nordiske land på det tidspunktet, som kunne beregne konsentrasjoner var den svenske MATCH-modellen.

Basert på denne oversikten valgte hvert av de meteorologiske instituttene i Danmark, Finland og Norge hvilken type systemer de ønsket å basere fremtidig utvikling på, og begynte implementering av de nødvendige modeller. I Sverige hadde man allerede, som nevnt, valgt en modell utviklet ved Sverige's Meteorologiska och Hydrologiska Institut. I Finland valgte man å om-strukturere en allerede eksisterende modell, mens det i Danmark og Norge ble utviklet systemer basert på en britisk modell. I Island har man valgt, ihvertfall nå, å basere seg på å kjøpe beregninger ved behov fra Danmark's Meteorologiske Institut eller fra Meteorological Office ved Bracknell i Storbritannia.

Før slike modeller kan tas i bruk av myndighetene, må det undersøkes hvor pålitelige resultatene er. I denne hensikt har to modeller i bruk i Norden blitt brukt til å beregne passasjen av skyen fra Chernobyl over de nordiske land, og resultatene har blitt sammenlignet med målingene fra 1986. Det var rimelig god overenstemmelse. Denne type validering er også nyttig for å finne deler av en modell som kan trenge forbedring.

Pålitelighet kan også undersøkes ved å sammenligne resultater beregnet med forskjellige modeller, men for samme situasjon. Slike sammenligningsberegninger ble utført ved å gjennomføre to såkalte funksjonsøvelser, der all fem nordiske land deltok (Island bare i den siste). Under ledelse av et øvelses-sekretariat ble samme problem gitt til alle de nordiske meteorologiske instituttene, og resultatene av beregningene ble sendt til sekretariatet. Det ble postulert at et radioaktivt utslipp hadde funnet sted i en bestemt posisjon, og beregninger ble utført basert på det virkelige været den dagen øvelsen ble utført, kombinert med prediktert vær for timene og dagene fremover. På den måten søkte man å gjøre øvelsen så lik en virkelig ulykkes-situasjon som mulig.

Noen uker etter hver øvelse ble det arrangert oppfølgingsmøter, der resultatene ble diskutert inngående. Eventuelle forbedringer av modellene eller rutinene ble deretter innarbeidet.

Øvelsene viste blant annet at den måten resultatene vanligvis presenteres på i grafisk form lett kan føre til misforståelser, og at figurene egner seg dårlig til overføring via telefax. Det viste seg også at resultat-arkene mange ganger manglet viktig informasjon, nødvendig for å vite med sikkerhet akkurat hva slags resultater man har foran seg. På basis av disse erfaringene ble det utarbeidet et forslag til et felles format for resultatet-presentasjon.

Beredskaps-myndighetene anvender prediksjonene fra de atmosfæriske spredningsmodellene til å anslå stråledoser til befolkningen. Mennesker kan stråleeksponeres på mange forskjellige måter: Ved direkte (ekstern) eksponering fra luft eller mark, ved inhalasjon, og ved inntak av forurensete mat- eller drikkevarer. Alle disse eksponeringsmåter må tas i betraktning når en beredskapssituasjon skal vurderes. Store mengder informasjon om de forskjellige eksponeringsmåtene har blitt samlet i de nordiske land siden tidlig i 1950-årene. Informasjonen finnes publisert i en lang rekke rapporter og bøker, men den er ikke så lett tilgjengelig.

For å gi beslutningstagere lettere tilgang til dette informasjonsmaterialet, har det blitt utviklet en datorisert "håndbok". Den inneholder data, forskjellige typer viktig informasjon på varierende detalj-nivå, i tillegg til enkle matematiske formler som kan brukes for å beregne doser, og informasjon om de forskjellige typer mottiltak. Alt dette finnes for forskjellige typer områder (storby-områder, jordbruksområder, fjellområder osv.). Håndboken er hierarkisk oppbygget. Ved hjelp av tydelig markerte nøkkelord i teksten får man tilgang til stadig mer detaljert informasjon. Ordbruken i håndboken er forsøkt lagt på et så enkelt nivå som mulig, slik at det ikke skal være nødvendig med spesialkunnskap for å bruke den. Den omfatter også forskjellige søkefunksjoner. Den bør kunne bli et meget nyttig hjelpemiddel for de nordiske nasjonale beredskapsmyndighetene.

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1. INTRODUCTION

This report deals with a project within the part of the Nordic Nuclear Safety Research program referred to as "BER. Emergency in Abnormal Radiation Situations". The name of this particular project is "BER-1. Dispersion prognoses and consequences in the environment". The project, as apparent from the name, covers two distinct and quite different subject areas. In this report, as in the actual project work, the two subject areas were regarded more or less as two separate projects, "BER-1.1. Dispersion prognoses" and "BER-1.2. Consequences in the environment".

Most of this report is devoted to BER-1.1. The main product of the work in project BER-1.2 is a computerized "handbook" for use in emergency situations, which is available on diskette. In addition, three reports on respectively "removal of deposited cesium", "radioactive plume pathways" and "the aquatic environment" (BE93, HE92 and VE94) were published by participants in project BER-1.2. The project work for BER-1.2 is briefly described in chapters 11 and 12, as well as Appendix G of the present report. For more detailed information, the reader is referred to the two reports and the handbook.

2. HOW THE BER-1.1 PROJECT HAS EVOLVED THROUGHOUT THE PROJECT PERIOD

The project builds on previous projects within the Nordic Nuclear Safety Research program, where there has been cooperation on development and testing of dispersion models since the early 1980's. The primary aim of the present project, however, was different, as the main emphasis is laid on aspects that may make it easier for the authorities to handle a nuclear emergency situation.

It was found quite early in the project that the most valuable contributions from the project would probably be to contribute to harmonization of the approaches to dispersion prognoses applied in the different countries and in assuring easy access to the results of the prognoses by all potential users.

The obvious initial step in the project was to survey the status in the Nordic countries concerning the calculation tools available for performing dispersion prognoses on medium to long range. As a "by-product" a world-wide status report emerged from the work in the project group. The Nordic country-to-country status differed considerably at the start of the project period, and it became clear that it was unrealistic to expect all countries to adopt the same calculational tools. After all, however, the methods have converged considerably during the project period, primarily as a result of the many discussions in the project group.

Another important task that has been undertaken within the project concerns validation and intercomparison between the methods adopted in the countries. There has been cooperation between Denmark and Sweden within the project on a validation effort based on Chernobyl observations. And all four countries (Denmark, Finland, Norway and Sweden) have participated in two functional exercises where the same postulated accident scenario has been calculated by all four, and the resulting predictions compared. In the second of these exercises Iceland also joined, assisted on the computational side by Great Britain.

The third major effort within the project has been development of a harmonized manner in which to present results of dispersion calculations to the user (authority, decision maker). A Nordic standard, called NORVIEW, has been proposed and discussed, and the needed software is now under development at the Finnish Meteorological Institute. This standard has also been presented for an international forum; a joint meeting of the World Meteorological Organization and Environment Canada in Montreal in September 1993.

3. STATUS IN THE NORDIC COUNTRIES AND ELSEWHERE (BER-1.1)

In 1987 OECD's Group of Experts on Accident Consequences (GRECA) prepared an overview of available models for calculating atmospheric dispersion in real time (OE87). At the same time a description of desired features of such models from the point of view of an emergency organization was prepared. The desired system was referred to as an Emergency Response Assisting System (ERAS). Such a system should not only consist of an atmospheric dispersion model, but should also be able to base the prognoses on the current weather conditions via direct links to weather data, to iteratively improve the prognoses as environmental monitoring data become available (also referred to as "data assimilation"), to present the results in a manner well suited to assist in decision making, and to incorporate data storage features that will make it possible at any later time to retrieve any data pertinent to the situation, e.g. for evaluation of the manner in which the situation was handled.

A number of models (about twenty) were included in the survey. Some of these, however, were limited for use in the "near field" only, most incorporated very simple dispersion models and could not make proper use of available weather forecasting data in the prognoses, and none of the models could be described as comprehensive Emergency Response Assisting Systems.

A project group was formed within BER-1.1 to prepare an updated survey. It was felt that the collective information possessed within the group, together with information contained in proceedings from several recent international meetings in the field, would make it possible to prepare a close to complete review, with no need to mail out questionnaires etc., which may otherwise be extremely time-consuming and rather frustrating, since the degree of response may be quite low. The survey prepared by the group mainly served the purpose of assisting the Nordic authorities responsible for nuclear emergency preparedness together with the meteorological institutes in choosing a strategy for developing the atmospheric dispersion predictive tools required, and although the world-wide situation was assessed, main focus was on the situation in the Nordic countries. The survey was published as (TV92). This report is included in full as **Appendix A** of the present report. A few corrections have been included relative to the earlier version, but no attempt has been made to update it to the present date.

Model development is a continous process, and some important more recent efforts ought to be mentioned here:

The Commission of the European Union is developing an emergency handling system called RODOS (Real-time On-line DecisiOn Support system). A number of European countries are involved in this development effort. The project coordinator is Joachim Ehrhardt, Kernforschungszentrum Karlsruhe, Germany.

In Denmark one has developed the decision support system ARGOS-NT. Information on this system can be obtained from Torben Mikkelsen, Risø National Laboratory, Denmark.

4. CALCULATION MODELS WHEN THE PROJECT WAS INITIATED AND WHEN IT WAS COMPLETED (BER-1.1)

When the project was initiated, there was a fully operational long-range prediction model capable of calculating concentrations in Sweden (the MATCH model at the Swedish Meteorological and Hydrological Institute), which had been designed for use in nuclear emergency situations. The TRADOS model, developed by the Finnish Technical Research Centre (VTT) and the Finnish Meteorological Institute (FMI), was also capable of performing this type of calculations, but was at this time not specifically designed for use in emergency situations. All four countries (Iceland did not take actively part in the project at that time) had models for predicting trajectories at long range.

It became clear quite early in the project that it was unrealistic to expect the same model (e.g. MATCH) to be adopted in all four countries. Finland had already invested considerably in the development of the TRADOS model. This model was originally developed for reactor accident risk calculations by the Finnish Meteorological Institute and the Technical Research Centre of Finland in cooperation. Development of a real-time version was already at the planning stage at the time when this project was initiated. The Norwegian Meteorological Institute had become interested in the British NAME model, an interest which was enhanced when it was concluded in the status report from the project that this was one of the few models in existence that was really interesting, at least from the point of view of the project group. The Danish Meteorological Institute had no definite plans at the time.

Late 1993/early 1994, when the bulk of the present report was written, the situation was as follows:

The Danish Meteorological Institute have plans both for implementing NAME and MATCH. Implementation of the first of these two is probably underway when this report is published. The Technical Research Centre of Finland (VTT) and the Finnish Meteorological Institute (FMI) developed in co-operation an interactive real-time version of the earlier developed long-range model TRADOS (NO85); originally intended to be a research model for risk analyses concerning reactor accidents possibly taking place at distant locations. The new version of TRADOS can be operated solely by FMI and it is immediately available in preparedness situations and is capable of making predictions of trajectories and air and ground concentrations, and of performing simple radiation dose calculations. The model has also been used in emergency exercises. At the Norwegian Meteorological Institute a model called SNAP (Severe Nuclear Accident Program) is operational, though under continued development. It is based upon the NAME program. At the Swedish Meteorological and Hydrological Institute the MATCH model is fully operational at a range of different scales, and this program has also been adopted for use in the real-time decision support system called RODOS, which is under development under the Commission of the European Union. At Risø National Laboratory in Denmark a real-time, medium-range version of the model RIMPUFF has also been developed during this time period. This development has mostly been carried out independently of the BER-1.1 project, though the project has supported some specific parts of this development effort. Iceland has also chosen the NAME model for real-time predictions, although the model is actually run by the British Meteorological Office on request from Iceland when need arises.

MATCH is a Eulerian model and exists in version both for short, intermediate and long range. It was developed at the Swedish Meteorological and Hydrological Institute.

NAME is a Lagrangian Monte Carlo model with plume or puff dispersion. It was developed at the United Kingdom Meteorological Office, Bracknell. The model SNAP which is developed at the Norwegian Meteorological Institute is based upon NAME.

RIMPUFF is a multiple Gaussian puff model and was developed at Risø National Laboratory in Denmark.

TRADOS is a trajectory model. Dispersion is calculated assuming a Gaussian horizontal concentration distribution, while a Kz profile is assumed in the vertical direction, and this model is also capable of making predictions of external and internal radiation doses via different exposure pathways. The model was developed in cooperation between the Finnish Meteorological Institute and the Technical Research Centre of Finland.

Technical descriptions of the models above, except RIMPUFF, are included as **Appendix B** of the present report.

The programs above are used for calculating the transport and dispersion of a release. These predictions are based upon weather predictions performed by other programs. In Denmark, Finland and Sweden these weather predictions are performed by using the HIRLAM program, in Norway by using the program LAM50.

5. COMPARISON OF MODELS (BER-1.1)

As part of the BER-1.1 project two so-called functional emergency exercises have been carried out. The main purpose of these exercises was to test the models used in real-time mode in the Nordic countries to predict the movement of radioactivity released to the atmosphere and the resulting concentrations of radioactivity in the air masses near ground and concentrations of radioactivity deposited upon the ground.

The predictions were carried out by the meteorological institutes in the Nordic countries, each using their preferred prediction tools. These predictions will not come out as identical because of the differences inherent in the models, and such an exercise gives a unique opportunity for comparing the models under conditions very similar to the ones under which they are meant to be used.

The two exercises are described in detail in **Appendix E**. In this appendix are also included discussions of how the results from the different models compare. This aspect has, however, been treated in much more detail by the Swedish Meteorological and Hydrological Institute based upon the results from the second emergency exercise, included in the present report as **Appendix C**.

6. VALIDATION EXERCISE. CASE STUDIES CONCERNING DISPERSION OF ^{137}CS AFTER THE CHERNOBYL ACCIDENT

Two studies have been performed; at Risø National Laboratory in Denmark using the RIMPUFF model (see **Appendix DD**), and at the Swedish Meteorological and Hydrological Institute (SMHI) in which the MATCH model (Mesoscale Atmospheric Transport and CHemistry model) developed at SMHI has been used (see **Appendix D**), to simulate the dispersion and deposition of ^{137}Cs from the Chernobyl accident (April-May 1986). The RIMPUFF analysis was received very late, so the remainder of the present chapter contains only discussions of the MATCH case.

A similar validation of the TRADOS model, also using Chernobyl data, has been performed in Finland (KA87). However, as this effort was not performed as part of the BER-1.1 project, it is not included in the present report.

Meteorological data from the numerical weather prediction system HIRLAM (High Resolution Limited Area Model) were used to drive the MATCH model. The simulations were compared with available data on concentration and deposition of ^{137}Cs in Scandinavia. The HIRLAM data were supplied by the Meteorological Institute of Denmark.

The results indicate the ability of the MATCH model to capture major features of the observed concentration and deposition fields of ^{137}Cs over Scandinavia. The study was focused on the initial dispersion from Chernobyl when the radioactive cloud affected Scandinavia. Several alternative simulations were performed to study the sensitivity of the modeling system to different model assumptions and input data. A detailed assessment of the quality of the model for the Chernobyl case is difficult to achieve. This is due both to uncertainties in the emission estimates and lack of observational data. It is evident, however, that significant discrepancies exist between the model results and observed data.

Using only meteorological information from the HIRLAM run, the calculated plume appears to be located too far to the east and north during the initial part of the episode when the radioactive cloud affected Scandinavia. This results in too low concentrations over eastern Svealand. The calculated deposition over Sweden is located too far south.

The use of observed instead of model calculated precipitation for the first part of the episode improves the simulation results over Scandinavia considerably. The resulting deposition field over Sweden is in much better agreement with the observations. This result emphasizes the critical importance of the precipitation fields when simulating the dispersion from accidental releases.

Although using observed precipitation improves the simulation, the plume is still located too far east and north and the calculated concentrations over eastern Svealand are too high. Several factors may contribute to the noted disagreement between model calculations and observations.

The temporal resolution of the wind fields may be of importance. Some improvement of the movement of the plume during the first day of transport could be noted when changing from six to three hourly wind fields. An even better temporal resolution might have improved the simulations.

Another important factor may be that the present dispersion model only has two layers to describe the transport in the boundary layer. While this saves computer time it also means that the model can not make use of the wind fields at all the levels provided by HIRLAM (every second layer was used in this study). Since the winds in adjacent layers usually differs somewhat, this can lead to underestimation of the spread of the plume.

The most important factor to the discrepancy between model calculations and observations seems, however, to be that the HIRLAM wind analysis did not capture a low level wind band on the night of the accident. The reason for that seems to be that some correct radio-sonde information over Belarus were rejected in the HIRLAM wind analysis.

A detailed presentation of this case study is given in **Appendix D**.

7. UTILIZATION OF HIRLAM WEATHER MODEL DATA IN THE METEOROLOGICAL DATA BASE OF THE TRADOS MODEL

(This chapter has been prepared by Ilkka Valkama, Air Quality Department and Mika Salonoja, Weather Department of the Finnish Meteorological Institute.)

The trajectory model of the Finnish Meteorological Institute (the trajectory model is part of the TRADOS model, see **Appendix B** for description) utilizes the meteorological forecasts of the Finnish version of the Nordic HIRLAM (High Resolution Limited Area Model) weather prediction model for its dispersion calculations. To facilitate this, a special data-base containing the first six hour forecast of each HIRLAM-run is being routinely compiled.

The development of the data-base routines was partially financed by the NKS as part of the BER cooperation.

The HIRLAM weather model is run four times a day. At these times the latest weather analyses based upon observation data and a fresh set of forecasts are available for operational emergency applications. From each HIRLAM run the first 6 hour forecasts of temperature, humidity and three dimensional wind fields on 8 levels from surface up to 16 km in the vertical, together with the forecasted precipitation, are being stored to the data base. The area being stored covers some 3800 km x 4800 km, reaching from Iceland to the Ural mountains and from Italy up to Novaja Zemlya.

Table 1. The meteorological data base of the TRADOS model.

Parameter (unit)	Surface data (ref. height)				Pressure level data (height in hPa in upper row and in ca. km in lower row)						
					1000	925	850	700	500	300	100
	0 m	2 m	10 m		0.1	0.5	1.5	3.0	5.5	9.0	16.0
Precipitation (mm/6h)											
- frontal type	x										
- convective type	x										
Surface pressure (Pa)	x										
Air temperature (K)		x			x	x	x	x	x	x	x
Surface tem-perature (K)	x										
Relative humidity (%)					x	x	x	x	x		
Wind vector component											
- horizontal com-ponent (u, m/s)			x		x	x	x	x	x	x	x
- horizontal com-ponent (v, m/s)			x		x	x	x	x	x	x	x
- vertical compo-nent (ω, Pa/s)					x	x	x	x	x	x	x
Geopotential height (gpm)					x	x	x	x	x	x	x

The data base contains forecasted data only. In the TRADOS model the analyzed weather observation data is not used in transport or dispersion calculations mainly for three reasons:

(i) Some meteorological parameters, such as the vertical velocity, are not observed, but always computed. By adopting a short time forecast we ensure the physical balance of the data fields.

(ii) With forecasts short gaps in the data can be covered e.g. by using the next 12 hour forecast instead of a missing six hour one. On the other hand one can not mix analyzed and forecasted data without losing the physical balance between the computed meteorological parameters.

(iii) The analyses are valid for analyses time only. Thus, at any given time between the HIRLAM runs the forecasts has to be used, anyway.

To use the HIRLAM data and not the similar, but larger area meteorological data from the European Center for Medium Range Weather Forecasts (ECMWF) was decided upon for the following reasons:

(i) The ECMWF data is routinely received at the FMI once a day (at 12 UTC) via the meteorological workstation of the FMI, which makes it difficult to use.

(ii) The workstation resolution (150 km x 150 km) compares rather unfavorable with that of the HIRLAM (55 km x 55 km). An even finer HIRLAM mesh (20 km x 20 km) will be available in the future.

(iii) The lowest level routinely obtainable by FMI from ECMWF is 850 hPa, which is much too high for dispersion calculations.

(iv) The HIRLAM forecasts are run only for 48 hours with 6 hour intervals. In comparison the ECMWF forecast period is 10 days, with 6 hour intervals up to 84 hours (3.5 days), after which they are available at 12 hour intervals. The shorter time range of the HIRLAM forecasts was not thought to be as important, as a fresh set of forecasts is available at every 6 hours.

(v) Real-time access of data from the ECMWF is not a very practical solution in case of an emergency, because the amount of data is very large and the links are very crowded.

(vi) One feels much more at home with a weather model run at ones own Institute.

The data-base routine has been running since the beginning of 1993.

8. FUNCTIONAL EMERGENCY EXERCISES (BER-1.1)

Two so-called functional emergency exercises have been conducted as part of project BER-1.1. The purpose of these exercises has been to test information transfer, information clarity and to compare the results calculated by the different models. The exercises were carried out on the 16 January 1992 and the 21 June 1993. Denmark, Finland, Norway and Sweden participated in both exercises, and Iceland participated in the second one.

All participants in these functional exercises found them to be both useful and interesting. Apart from the benefit of the various institutions getting to know and better understand the models utilized by other institutions, errors in some of the models were spotted both times, errors that otherwise could have remained undetected for some time to come.

Detailed descriptions of both exercises are included in this report as **Appendix E**.

9. RECOMMENDATION ON MANNER OF PRESENTATION OF DISPERSION MODEL RESULTS

It became evident in the two emergency exercises carried out as part of this project, that the manner in which the results of the predictions, that were to be transmitted to the emergency organization (in this case the Exercise Secretariat), were presented was not satisfactory. In many cases important details were lost in the transmission by telefax, because e.g. unsuitable shading was used or characters were too small. Case identification was often incomplete (in some cases even the name of the institution was lacking). It was often not clear what assumptions had been made, exactly what results were given (e.g. whether the different trajectories in one figure were for different levels in the atmosphere or differed in some other parameter). And results from different institutions were not easy to compare, since the scales chosen differed and the geographical areas shown were not the same. Accordingly it was decided to develop, as part of this project, a presentation scheme for use by all the institutions. The task of developing a proposal for a scheme was given to the Finnish Meteorological Institute. The name chosen for the scheme is NORVIEW, and after a couple of "brainstorm" sessions a version was proposed and sent to the potential user institutions for comment. Based upon the comments received, an updated version was developed, and a description of the newest version of NORVIEW is included in this report as **Appendix F**.

10. WHAT HAS BEEN ACHIEVED WITHIN PROJECT BER-1.1 ?

The more tangible results of this project are the rapid development of prognostic tools available in the Nordic countries during the project period, a certain degree of mutual harmonization concerning the manner in which prognoses are performed, improved confidence gained in the results of the predictions as a result of intercomparisons, and mutual agreement on the desirability of improvements in the manner in which the results of predictions are presented to the user (authority, decision maker) and to a certain extent agreement upon how this is to be achieved.

The less tangible, but equally important, results of the project are the increased mutual understanding of all the models currently in use in the Nordic countries, increased mutual respect and interest in the approaches adopted in the other countries and markedly increased interest in close cooperation in all aspects of the work.

The first achievement within the project was to compile a very useful worldwide survey of models for atmospheric dispersion calculations with particular emphasis on medium to long range models. This survey had the immediate practical purpose of making it easier for the institutes in Denmark and Norway to choose which of the available models/systems/approaches upon which to base their own future systems.
A survey of this type would have had to be carried out in any case. By combing forces in a project group, one could produce a more complete overview than what would otherwise have been possible. The survey is incorporated in the present report as **Appendix A**.

One of the original major aims of the project should be to achieve harmonization among the methods adopted in the Nordic countries. In the end, it may appear that such harmonization has not been achieved, since the systems adopted differ considerably between all four countries. Harmonization, however, has been achieved in another and more meaningful manner. By means of intercomparison calculations, validation exercises and increased understanding by all project participants of the methods utilized by the other participants, one has come much closer to what is the underlying purpose of harmonization; namely to assure that predictions performed by different institutions for the same situation will not differ significantly. Utilization of different models in the different countries under such positive circumstances of close and confident cooperation, rather than being a disadvantage, is a strong advantage. When good agreement is achieved between results arrived at by use of different predictive tools, this will add to the confidence in the predicted results.

Only two actual validation efforts have been performed within the project. The comparison of results predicted with SMHI's MATCH model with Chernobyl data can only be said to be partially successful, but the reasons for the discrepancies observed seem to have been identified, and are in the weather observation data rather than in the dispersion calculations. The results of the validation involving the Danish RIMPUFF model were received long after the project period was expired, and an evaluation is not included here in the main text. However, since the report had not yet been entirely completed, it was possible to include the validation (in an un-edited form) as an appendix.

The two emergency exercises carried out within the project were very successful, and all participants in the exercises, including Iceland which took part in the last exercise, strongly recommend that such exercises are carried out at least annually in the future. The format of the exercises also seems to be eminently suited for the purpose, and it is recommended that this should not be drastically changed in eventual future exercises.

One of the main conclusions from the exercises was that the manner in which the results of the predictions are presented needs to be significantly improved. In some cases it was not possible to identify results received by the Exercise Secretariat with absolute certainty (for which release they were calculated, at what time the predictions had been performed, etc.), and in some cases the graphical representations were difficult to read after having been transmitted by telefax (small letters and numbers blurred, parts of lines obliterated). But above all it was confusing that results from different institutions differed considerably in layout and also in scale. To change this situation a smaller group within the project has met a couple of times to discuss how the layout can be improved, and made a proposal for a presentation scheme called NORVIEW. This scheme is a large improvement over the existing presentations. It is now submitted for further discussions, as there are undoubtedly room for additional improvements. The actual software is also being programmed at the Finnish Meteorological Institute. It is not possible to develop software which is immediately applicable to the different systems in the different countries, but the aim is to make implementation at other institutions as simple as possible. Further work, however, is needed before the aim of this part of the project can be achieved.

In main conclusion it can be said that through project BER-1.1 a very solid foundation for further cooperation between the Nordic meteorological institutes in this area has been built. Much can be achieved by continuing this close cooperation, especially when considering that continued development of these methods will take place for many years to come. One important aspect to mentioned in this connection is so-called data assimilation; that is improvement of predictions by incorporating results of environmental monitoring. In a real accident situation monitoring data from geographical position between the release and potentially threatened areas will become available. There is great potential for improving predictions by taking these data into consideration. This can now be done only in a rather arbitrary and primitive manner, but this is a problem intensely investigated at many research institutions at present, and this development ought to be followed closely.

11. ENVIRONMENTAL CONSEQUENCES, PROJECT BER-1.2

Although many different types of consequences to the environment may result from releases of radioactive materials (e.g. to flora and fauna), the focus is traditionally on health consequences to humans, and the work in this project has also mainly been concerned with exposure pathways and mechanisms that may be important in this context. Possible economic consequences of mitigating actions are also covered, though this problem area has been more thoroughly treated in another project within the Nordic Safety Research Program, BER-3 (Intervention Principles and Levels in the Event of a Nuclear Accident).

Much information on the behavior of radioactive materials in the environment is available. For descriptions of the exposure pathways and the numerous mechanisms, processes and parameters that describe the movement of radioactive materials in the various parts of the environment, the reader is referred to standard literature. Some key references with particular relevance to Nordic environments are (GA92, MO91, ST94, STUK and TV90).

Data relevant to these exposure pathways has been collected since the early 1950's, when attention was brought to the possibly harmful consequences of nuclear weapons fall-out, which was particularly pronounced in Northern Scandinavia. As weapons fall-out diminished throughout the 1970's, the measurement programs were also reduced drastically, in spite of the fact that there were still large information gaps. The accident at Chernobyl in 1986 lead to renewed activity in this field, also by many institutions that had not previously been engaged in this subject area. Some years of intense data collection followed. In the Nordic countries much of this work was performed within the framework of the so-called AKTU project, which was managed by the Nordic Liaison Committee for Atomic Energy and partly funded by the Nordic Council of Ministers. The results of the AKTU project are reported in (TV90). The following subject areas were investigated in this project:

- atmospheric dispersion
- deposition and weathering
- sheltering in houses
- winter aspects
- resuspension of deposited activity
- nutrition pathways
- physico/chemical form of radionuclides
- short-term and long-term mitigating actions
- economic consequences of nuclear accidents

- sensitivity and uncertainty of consequence analyses
- the Nordic Chernobyl Data Base

Other extensive research efforts relevant for Nordic conditions were also carried out in all Nordic countries, and some of the most important references are given on the previous page.

At present, however, the experimental programs have again been severely reduced. This is very regrettable, since there are still large uncertainties in the knowledge of many important processes. In a Nordic context it is particularly unfortunate that almost all available information and data has been collected in parts of Europe and the USA with temperate climate, and almost exclusively address summer conditions. Information relevant to winter conditions and arctic conditions (summer as well as winter) is insufficient at best, or non-existent. The same is, by the way, true for tropical areas, although a data collection program under the leadership of the International Atomic Energy Agency has been initiated, particularly focused on conditions in countries of the Far East. The lack of data for Arctic environments is particularly worrying, however, when considering the present situation at the Kola peninsula.

It was clear from the mandate of the BER-1.2 project, as well as from the size of the budget for the project, that the purpose was not to create additional exposure pathway information, but to gather and evaluate relevant available information. Much of the information gathered during the project period had already been published elsewhere, but is scattered over a large number of publications; but some of the information from Nordic countries is previously unpublished material.

When the project was initiated, a project group was formed, consisting of the following four persons:

- Per Hedemann Jensen, Risø National Laboratory, Denmark
- Seppo Vuori, Technical Research Centre of Finland
- Ulf Tveten, Institutt for energiteknikk, Norway
- Ulla Bergström, Studsvik Eco & Safety AB, Sweden

The project was divided into four separate subject areas:

- radiation from a plume
- deposition, run-off and wash-off
- terrestrial exposure pathways
- aquatic exposure pathways

Reports were written more or less covering three of these wide subject areas. These reports contained large amounts of important information which had not previously been presented in such a concentrated form. Nevertheless it was felt by the project group that the task the group had set out to solve had still not been solved in a satisfactory manner. The group did not feel that the desired level of accessability of the information had been reached. During an emergency situation, when one is in a hurry, nerves are on edge, and lots of information of widely varying character will be received and redistributed, it would still be too time-consuming to find the information desired, even from these concentrated reports. A different approach had to be adopted.

During a "brainstorming" session in the project group, in which representatives of the Swedish Radiation Protection Institute (SSI) also took part, the idea of a computerized handbook was born. SSI sponsored the development effort, and the handbook is now available on diskette. The structure embraces all types of areas found in the Nordic countries, but much of the factual information (data, formulas and general information) still needs to be fed in. Collection and evaluation of all the factual information required is very time-consuming, and could not be completed within the frame of this project.

12. WHAT HAS BEEN ACHIEVED WITHIN PROJECT BER-1.2 ?

The tangible results of the work in project BER-1.2 are the three reports (BE91, HE92 and VE94) and the Handbook. Some preparatory work was also performed concerning classification of agricultural areas in the Nordic countries. A draft report covering Finland and Sweden was prepared (VU90), and some material on the geographical distribution of production of various important (in a radiological context) agricultural products in Denmark and Norway was collected. This work has, however, not been completed, as other tasks within the project were given higher priority.

The layout of the Handbook was developed at Studsvik Eco & Safety AB, Sweden, and it is described in **Appendix G**. The Handbook itself is available as a file on data diskette. It is very user-friendly and quite self-explanatory.

The three reports are summarized in the following:

Exposure from radioactive plume pathways: Methods are described for assessing early radiation doses due to atmospheric releases of radionuclides, i.e. inhalation and external exposure from the plume and from deposited activity. Data to be used in these assessments are presented. The purpose of the work performed in this part of the project has been to evaluate methods and data that could be used in emergency situations as well as for emergency planning purposes. The most important direct pathways following a release of airborne radionuclides to the atmosphere are the inhalation pathway and the external exposure pathway from ground-deposited activity. For long-lived radionuclides like Cs-134 and Cs-137 the committed effective dose from deposited activity is 1 - 2 orders of magnitude larger than the committed effective dose from inhalation. Similarly, the committed effective dose from inhalation is 1 - 2 orders of magnitude larger than the external γ-dose originating directly from the plume.

Removal of deposited cesium: This report is a summary of a number of reported experiences (including work performed at Studsvik, Sweden, where the report was written) obtained from studies of Chernobyl fallout of Cs-137 regarding processes affecting deposited activity. Three different types of ecosystems (urban, agricultural and forest) are discussed. The report treats the subject areas of deposition on different types of surfaces, migration in soil (including the effect of plowing), run-off, wash-off and resuspension. Data on the effect of traffic and street cleaning on activity-levels are given. Data on the efficiency of a number of different remedial actions (sweeping, vacuuming, fire hosing, removal of surfaces, plowing, defoliating) are also given.

Aquatic environments: The report concentrates on analysis of the main effects of radioactive deposition on Nordic aquatic environments. A modeling approach is applied for predicting the temporal behavior of concentrations of radioactivity in fish in inland freshwater ecosystems. In parallel with the calculations, the observed values are considered. Three representative examples of lake systems were selected for closer consideration: small forest lakes, medium-sized forest lakes and mountain lakes. The effects of differences in the trophic levels of lakes are also tentatively accounted for. The results of the analyses indicate that the radiological consequences in shallow forest lakes are greater than in mountain lakes, which usually have shorter turnover times of water. In the long term the fish ingestion pathway may be very important, and may give a contribution to individual doses in some population groups equal to or larger than the contribution due to external radiation from radioactive materials deposited on the ground in the area.

The report on classification of agricultural areas in Finland and Sweden, which only exists in a draft version, contains much useful information on yields of all types of grain crops, milk, beef, veal, pork, poultry, mutton, horse meat, reindeer, wild berries and mushrooms. It contains production data in each community, as well as farm sizes. The agricultural data collected in Norway (roughly for the same products, but also for fruit and domestic berries) is stored in computer files in graphical form. The output is maps of the country with color codes indicating production intensity in the different areas of different products. It was the intention to collect all this information for Denmark, Finland, Norway and Sweden in one report, but this task was given lower priority and it was not possible to complete it within the project.

The structure of the handbook was developed by Studsvik Eco & Safety AB, Sweden as part of the project. However, it was not possible within the restraints of the project budget to fill in all of the factual information required. It is felt that the structure covers all of the aspects one could desire to have included, but in many cases data or formulas have not yet been entered. This is usually not because there is a lack of information on the particular topic, but because no information should be entered into such a system without careful evaluation, and such evaluation is obviously a very time consuming task. It is hoped that this work will be carried to completion by the Nordic national authorities responsible for handling nuclear emergencies.

13. REFERENCES TO THE MAIN SECTION OF THIS REPORT

BE91 Bergström, Ulla: Removal of deposited cesium. A literature survey. STUDSVIK/NS-91/74 (BER-12(91)1). Studsvik AB, Sweden. 1992.

GA92 Garmo, Torstein H. and Gunnerød, Tor B. (Editors): Radioactive fall-out from the Chernobyl accident. The consequences for Norwegian agriculture, environment and food supply. (In Norwegian with English summaries of each chapter). The Norwegian Agricultural Research Council. (ISBN 82-7290-5777-9). 1992.

HE92 Jensen, Per Hedemann: Atmospheric dispersion and environmental consequences. Exposure from radioactive plume pathways. Risø-M-2849(EN) (BER-12(92)1). Risø National Laboratory, Roskilde, Denmark. November 1992.

KA87 Karppinen, A., Nordlund, G., Rossi, J., Valkama, I. and Vuori, S.: Description and application of a system for calculating radiation doses due to long range transport of radioactive releases. Finnish Meteorological Institute, Report No. 1987:1. Helsinki, Finland. 1987.

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NO85 Nordlund, G., Partanen, J., Rossi, J. and Savolainen, I.: Radiation doses due to long range transport of airborne radionuclides released by reactor accidents; effects of changing dispersion conditions during transport. Health Physics 49, pp. 1239-1249. 1985.

OE87 OECD/NEA: CSNI Report No. 167. Emergency Response Assisting Systems (ERAS). A review performed by an OECD/NEA Group of Experts. Paris. December 1989.

ST94 Strand, Per: Radioactive fallout in Norway from the Chernobyl accident. Studies on the behaviour of radiocaesiums in the environment and possible health impacts. NRPA Report 1994:2 (ISBN 82-7633-034-7/ISSN 0804-4910). Norwegian Radiation Protection Authority. Østerås, Norway. 1994.

STUK Numerous publications in the STUK report series. Finnish Centre for Radiation and Nuclear Safety. Helsinki, Finland.

TV90 Tveten, Ulf (Editor): Environmental consequences of releases from nuclear accidents. A Nordic perspective. NORD 1990:46 (ISBN 87 7303 439 8). Institutt for energiteknikk, Kjeller, Norway. March 1990.

TV92 Tveten, Ulf: Worldwide status of long range atmospheric transportation models for use in emergency situations. IFE-KR-E-92/002, Institutt for energiteknikk, Kjeller, Norway. February 1992.

VE94 Suolanen, Vesa: Consequences of radioactive deposition on aquatic environments. Research Notes 1612 (BER-12(93)1), Technical Research Centre of Finland, Espoo, Finland, December 1994.

VU90 Vuori, Seppo: Calssification of agricultural areas in Finland and Sweden. Draft report. Technical Research Centre of Finland (VTT). Helsinki, Finland. November 1990.

Appendix A

WORLDWIDE STATUS OF
LONG RANGE ATMOSPHERIC TRANSPORTATION MODELS
FOR USE IN EMERGENCY SITUATIONS

A status report prepared by the BER-1.1 project group

February 1992

Appendix A

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Appendix A

A.1 INTRODUCTION

This status report is the result of work in a project within the Nordic Nuclear Safety Research program. The project is referred to as BER-1.1.1 in the project description (Plan for nordisk kjernesikkerhetsprogram (Plans for the Nordic Nuclear Safety Research program) 1990-1993. NU1989:5, Nordic Council of Ministers, May 1989) prepared when the outline of the present program period 1990 - 1993 was prepared. The title of the project is: "Survey of Capabilities and Available Models". It is part of project BER-1.1 "Real-Time Dispersion Models", which is part of project BER-1; "Dispersion Prognoses and Environmental Consequences".

The purpose of the BER-1.1.1 sub-project, according to the original description, was to prepare a survey of Emergency Response Assisting Systems (ERAS) worldwide, but with special emphasis on systems available in the Nordic countries. Operative systems as well as systems under development should be included in the survey. Only medium- to long-range systems should be included, and the focal point is on their applicability and usefulness in an emergency situation.

An Emergency Response Assisting System should not only encompass an atmospheric dispersion model, but also capabilities for basing the prognoses on current weather (e.g. weather data linked directly into the calculation model), preparation of results in a manner well suited to assist in decision making, iterative improving of prognoses as environmental monitoring data becomes available (also referred to as "data assimilation", and subsequent (and complete) documentation of the manner in which the whole emergency situation has been handled, including all prognoses calculated and the corresponding assumptions.

The survey shows that a full Emergency Response Assisting System, as described in the preceding paragraph, does not seem to exist at present.

This survey has been performed based upon available information rather than extensive distribution of questionnaires, which is the usual approach. Our approach was chosen simply to save time and money. Experience shows that collection of information via questionnaires is very costly. Follow-up has to be intense, as the response otherwise is quite weak. And the most important models are the ones for which information is hardest to obtain, because the developers have little time to spare.

Because there has not been direct contact, within the scope of this project, to all countries and all potentially relevant institutions, some information may have been missed. However, the personal contacts of the persons who have been directly involved in the project are so extensive, that the probability of an important model having been overlooked is very small.

The survey is based upon information collected at some recent important meetings/partial surveys within the subject area, mainly the following:

Chernobyl Data Evaluation for Accident Consequence Assessment. A Survey conducted by an OECD/NEA Group of Experts. SINDOC(89)26. Working Document. Paris, France. October 1989.

Second International Workshop on Real-Time Computing of the Environmental Consequences of an Accidental Release to the Atmosphere from a Nuclear Installation. Decision Aids to Offsite Emergency Management. Luxembourg. 16 to 19 May 1989. EUR 12320. Commission of the European Communities.

Specialists' Meeting on Advanced Modeling and Computer Codes for Calculating Local Scale and Meso-Scale Atmospheric Dispersion of Radionuclides and their Applications. Saclay, France. 6 - 8 March 1991. OECD/NEA Data Bank.

ATMES (Atmospheric Long-Range Transport Model Evaluation Study) Workshop. Belgirate, Italy. 12 - 14 March 1991. International Atomic Energy Agency/World Meteorological Organisation/ Commission of the European Communities.

This information was then supplemented and evaluated at a project work meeting held in Oslo at the 10. and 11. September 1991. The participants were:

Torben Mikkelsen,	Risø National Laboratory, Denmark.
Christer Persson,	Meteorological and Hydrological Institute of Sweden.
Volker Herrnberger,	Paul Scherrer Institute, Switzerland.
Jørgen Salbones,	Meteorological Institute of Norway.
Ulf Tveten,	Institutt for energiteknikk, Norway.

It should be pointed out that the evaluations performed by the group above of the various models is subjective, and in some cases may be unfair, because the information available may have been outdated or seriously deficient.

It was decided by the project group that it would be valuable to obtain information, in addition to that which was already available, for the models in use in the Nordic countries and a few particularly interesting non-Nordic models. Questionnaires were sent to the developers of these models. The developers kindly supplied the requested information (as far as the questions were relevant to the particular model), and this information is summarized in a separate chapter.

A.2 MODELS, ALPHABETICALLY BY COUNTRY

The results of the survey are presented in the following, country by country:

Austria:

The person of interest is Dr. Kolb, and the reason for Austrian interest is the proximity of a Hungarian nuclear power plant; about 100 km from the Hungarian-Austrian border. However, they do not have any operational model. They have expressed interest in RIMPUFF and complex terrain.

Belgium:

Potential persons of interest are Ludo van der Auwera and R. Vanlierde, Royal Meteorological Institute. They reputedly have a Lagrangian model, but it is evaluated to be of little interest.

Paul Govaerts and Dr. Sohier, Mol have a model called CAERS, which is said to be capable of some type of backfitting, but is for short-range only.

There is also a Belgian model called NOODPLAN. It is only short-range.

Canada:

Person of interest is J. Pudykiewicz, Canadian Meteorological Centre, Atmospheric Environment Service. Dorval, Quebec. The model is called CANERM (Canadian emergency response model), and is a global scale, Eulerian, regional to hemispherical (nested models on different scales), real-time forecasting model. It is similar to the model developed at the Meteorological and Hydrological Institute of Sweden. This model is thought to be very good, and it would be interesting to obtain more detailed information. The model is still under development, and is continually being updated. Pudykiewsicz, who is French/Polish, has visited Christer Persson in October, so that additional information can now be obtained via Christer.

There are two other Canadian models called AQPAC and NEADM (Ontario Government). They were not known to the participants of the work meeting, but are believed to be local.

CEC:

A "comprehensive" model is under development at Karlsruhe, to be completed in 1993. No additional information available. (Added later: The model is called RODOS, is a very ambitious project, and is intended to be a true ERAS model. Planned completion in 1995).

Czechoslovakia:

Persons of interest are Stefan Skulec, Jozef Slaby, Anna Janekova, Juraj Duran, Slovak Hydrometeorological Institute, Bohunice, Czechoslovakia. The name of the model is either TURBO or BASIC, and is a Lagrangian Trajectorial Model running on a PC. It is Gaussian in the horizontal direction and uses the diffusion equation in the vertical direction. The available information indicates an extremely long running time (50 hours for an ATMES calculation). The model is not thought to be of interest in the present context.

Denmark:

The Meteorological Institute of Denmark has a simple trajectory model, but are interested in, and are directly supporting (through BER-1.1) the combined model of RIM-PUFF with RAM (Regional Air pollution Model) from the Meteorological and Hydrological Institute of Sweden (Added later: This model is now called MATCH), in conjunction with the HIRLAM regional forecast model.

Finland:

The persons to contact are Jukka Rossi from the Technical Research Centre of Finland (VTT) and Ilkka Valkama from the Finnish Meteorological Institute (FMI). Finland intends to use the TRADOS model, which is a combined development project of the FMI and VTT. The model is originally a research tool in which form it has been used both for regional and long range transport studies. A real-time version using the HIRLAM data is under development and is expected to be operational in summer/fall 1992. The concentration distribution part of TRADOS is relatively simple, with a Gaussian distribution (sy based on the horizontal spread of trajectories) in the horizontal, and a Kz-profile in the vertical direction.

France:

G. Bousqet-Clayeux, M. Monfort, B. Crabol at CEA, Fontenay-aux-Roses have the model SIROCCO-LD. This is a so-called Doury-approach model, which is an alternative Gaussian scheme. It is a long-range model. The meteorology is created by PERIDOT, which is a meteorology-model similar to HIRLAM.

A. Albergel, R.D. Wendum from Electricité de France, Chatou Cedex have the model MIRAGE. This is a segmented plume Lagrangian long-range model (said to be based upon the pioneer work of Eliassen). Gaussian distribution in the horizontal direction.

F. Bompay, L. Musson-Genon from Direction de la Meteorologie, Paris have the model MEDIA. This is an Eulerian model, but information on the range is missing. Like SIROCCO-LD it uses PERIDOT to forecast the wind field. A global alternative to PERIDOT is the model EMERAUD.

The model MINERVE is a long-range Gaussian segmented transport model. Responsible person is J.Y. Caneill at Electricité de France. Meso-scale forecast is performed by HERMES, nested on PERIDOT. A three- dimensional Monte Carlo particle model is under development (Brusasca and Tinarelli).

Dr. Mussafir, formerly Electricité de France, but now private consultant firm, has a model on local to meso-scale named ADRIC. Further information is not now available, except it must be assumed that this model is strictly commercial.

Germany:

H. Hass, H. Jacobs, Universität zu Köln have the model EURAD, which is an Eulerian model. It is primarily an air pollution model; not specifically developed for calculating dispersion of radioactive materials. Contains an extensive chemical part. In the opinion of the participants of the work meeting this is a very good program.

Deutches Wetter Dienst has an air pollution model made by Ingo Jacobsen. It is a Lagrangian particle model, but trouble with particles piling up in the bottom layer has been observed for non-homogenous turbulence. It is a real-time model and it is supposedly operational. The range is not known.

The system DAISY, which consists of RESY and RADE-AID and is really a decision support system. RESY uses wind fields, and has a dispersion model, either Gauss, puff or Lagrange.

Greece:

J.G. Bartzis, Demokritos Research Center near Athens, has a model called ADREA, which is for short-range and the smallest meso-scale.

Israel:

H. Kaplan, Israel Institute for Biological Research, Ness-Ziona has a model called LORA. It is Gaussian in the lateral direction and homogenous in the vertical, which is perhaps not as peculiar as it sounds at large distances from the release point. Nevertheless it can not be a particularly advanced model.

Italy:

A. Bargagli, A. Carrillo from ENEA/PAS (Ente Nazionale Energie Alternative/Divisione Protezione dell'Ambiente e Salute dell'Uomo), Roma have a model which is derived from the American model STEM, developed by Carmichael at Iowa University. STEM is a large Eulerian model with complicated chemistry. Hardly seems probable that it can be useful in real-time applications.

F. Desiato, Alfredo Bottino from ENEA/DISP (Ente Nazionale Energie Alternative /Divisione Modelli e Usi del Territorio), Roma have the model APOLLO/ARIES, which originates from the ARAC model from Lawrence Livermore Laboratory, California. It is a medium-range Lagrange particle model with Gaussian horizontal distribution. This model participated in the ATMES study.

Japan:

Shigeru Moriuchi, JAERI (Japan Atomic Energy Research Institute), Tokai has the model SPEEDI, which is a particle random walk model. It is long-range, but probably also exists in versions for shorter ranges.

T. Satomura, Japan Meteorological Agency, Meteorological Research Institute, Nagamine has a model which is a random walk type. The name of the model is not known, nor is the range, but it participated in the ATMES study.

Shinichi Yamada, Japan Meteorological Agency, Forecast Department, Tokyo has the model JMA, which is a Lagrangian global tracer transport model. The name of the model is not known. It participated in the ATMES study.

Netherlands:

G.H.L. Verver, Aad van Ulden et al., heading a collaboration between RIVM (National Institute for Public Health and Environmental Protection) and KNMI (Royal Netherlands Meteorological Institute) have a long range dispersion model, which is a Gaussian puff model coupled to either the ECMWF or the Dutch weather forecast models.
A report on this model is available.

F. de Leeuw, R. van Aalst, H. van Dop at RIVM seem to have a model called GRID, which is Eulerian and uses ECMWF pseudo-spectral fields. The range is not known.

At KEMA, a consultant company, a model called MAKRO has been developed. We have no information on this model; neither on type nor on range.

South Africa:

A. Grundling, L. Burger from Atomic Energy Corporation of South Africa Limited, Pretoria have a model called WIZARD, which is described as Lagrangian puffs in a Eulerian reference frame.

Sweden:

Christer Persson, SMHI (Meteorological and Hydrological Institute of Sweden) has the model RAM (Regional Air pollution Model) operational (Added later: The present name of this model is MATCH), though further development is also carried out. It exists in versions on different ranges up to continental scale. It is a fast Eulerian model, and is suited for real-time application.

Switzerland:

The Swiss participant in the work meeting says that nothing exists on long-range.

United Kingdom:

R.H. Maryon, Barry Smith from the United Kingdom Meteorological Office, Bracknell have developed a model called NAME. It is Lagrangian Monte Carlo; plume or puff dispersion. It uses the Met. Office's own wind fields or ECMWF. The participants of the work meeting are of the opinion that this is one of the best models around, although it did not perform that well in the ATMES study.

Helen ApSimon at Imperial College, London has developed the model MESOS. It is a Lagrangian type model, but the developer claims it is now outdated.

Outline of a system at NRPB (National Radiological Protection Board) has been published, but the planned development evidently has not yet been initiated.

USSR:

M.I. Pekar from Meteorological Synthesizing Centre - East EMEP, has used a Eulerian model as participant in the ATMES study. No further information on the model available.

V.N. Petrov, D.A. Severov, Institute of Applied Geophysics, Moscow, Hydrometorological Office, have used a Lagrangian model as participants in the ATMES study. No further information on the model available.

USA:

The most prestigious US model is evidently RADM (Regional Acid Deposition Model), originally University of North Carolina, now State University New York (SUNY). This, however, is a very large model, with chemical reactions in the atmosphere included, and not practical for real-time application. May become so on next-generation computers.

ADPIC and/or ARAC (we are not sure of the distinction between these) from Lawrence Livermore Laboratory are also very well-known. The developers are Gudiksen, Rolf Lange, Dickersen, Sullivan (group leader). The model is Eulerian/particle-in-cell. Not quite sure of the range, but ADPIC participated in the ATMES study, but did not do particularly well. Crister Persson claims that at least the global version of ADPIC does not contain precipitation.

M. Pendergast from Savannah River National Laboratory has a model, with which he participated in the ATMES study. It is a rather standard trajectory model. It uses "adjusted" geostrophical winds, and the model seems to be somewhat like MESOS. Mixing height and wind field only from pressure data at ground level, which must involve quite a bit of guessing. Christer Persson is rather skeptical to this model. A model called US WIND, also Pendergast, Savannah may be the same model or a previous version.

Ted Yamado, Los Alamos has a meso-scale model (not long-range) suitable for real-time application on a SUN work station, but it is said that it is only four times faster than "real" real- time. When time needed for data preparation is taken into account, this may be too slow. Torben Mikkelsen has numerous publications concerning this model.

United States Nuclear Regulatory Commission has three models, for which only the names are known: IDAS, IRDAM, MESO/RAD.

Yugoslavia:

L. Lazic, B. Telenta from the Federal Hydrometeorological Institute have a Eulerian model, with which they participated in the ATMES study. No other information available.

A.3 PRESENT SITUATION IN THE NORDIC COUNTRIES

In this chapter is presented the situation in the Nordic countries concerning Emergency Response Assisting Systems at the time when this report is written. The necessary tools for calculation of trajectories are available in all Nordic countries except Iceland, but only Finland and Sweden possess codes for real-time calculation of concentrations at present. The available systems are all under development, so the situation is rapidly changing. As in the rest of this report, only medium- to long-range systems are considered.

All of the systems considered here and used at present in the Nordic countries, have meteorological data on-line; none have environmental survey data on-line, and the results of radiological environmental surveys can not be taken into account in a systematic manner for improving previously performed prognoses. Storage of calculated prognoses, documentation of information received and information given is not part of the system, but is done manually.

Denmark:

At the Meteorological Institute of Denmark forecasting of trajectories can be performed at a work station. The system is quite user-friendly, but are at present run only by the staff that has developed the program. Transfer to the weather service department, so that prognoses can be performed by the meteorologist on duty, is planned for the relatively near future. Build-up of capability for calculating concentrations in air and of deposited materials on ground is planned in collaboration with Risø National Laboratory and the Meteorological and Hydrological Institute of Sweden. Calculation of doses will not be performed at the Meteorological Institute of Denmark.

At Risø National Laboratory it is at present not possible to perform real-time calculations at long range. This could become possible, at least for medium-range calculations, if access to the appropriate meteorological data was obtained. Their system could then include calculation of doses and, in the same calculation system, evaluation of mitigating actions.

Finland:

The Finnish Meteorological Institute and the Technical Research Centre of Finland have cooperated in developing the code TRADOS. A version for calculating trajectories is now available. Further development of this system in order to make it operational as a long-range Emergency Response Assisting System is under way, and a version is expected to be operational in Summer/Fall of 1992. With TRADOS it will be possible to calculate doses as well as concentrations.

Iceland:

There is at present no data system for making prognoses of atmospheric dispersion in Iceland, nor any known plans for obtaining such a system.

Norway:

A program for calculating trajectories is at present available at the Norwegian Meteorological Institute. Agreement has been reached for obtaining the UK code NAME, and it is expected to be operational in late Summer 1992, and it will then be possible to calculate concentrations and deposition. The Institute will not attempt to calculate doses. NAME has a possibility for "data assimilation" for improving prognoses by taking into account data from radiological environmental monitoring. The Institute will not, at least at present, attempt to use this option.

Sweden:

The Meteorological and Hydrological Institute of Sweden has the only operational system in the Nordic countries at present for calculating concentrations and deposition as well as trajectories in real-time. The system is, however, still under development. The present version of the dispersion model is called RAM.

One important part of the plans is to replace the present model for meteorological analysis and forecast, LAM (which supplies the wind fields etc.) with the program HIRLAM. HIRLAM is a joint Nordic, Dutch, Irish model, which during 1992 will be started to be used in routine in all participating countries. At present it is only run in Denmark and Finland. The Meteorological and Hydrological Institute of Sweden will not calculate doses.

A.4 SUMMARY OF LIMITED SURVEY USING QUESTIONNAIRES

Questionnaires were sent out to obtain additional information on a few Nordic as well as non-Nordic models:

- TRADOS. Finnish Meteorological Institute and Technical Research Centre of Finland.

- RAM. Meteorological and Hydrological Institute of Sweden.

- NAME. UK - Meteorological Office, Bracknell, United Kingdom.

- KNMI/RIVM puffmodel. Royal Netherlands Meteorological Institute and Rijksinstituut voor Volksgezondheid en Milieuhygiene.

The questionnaire was based upon a questionnaire used by the OECD/NEA expert group GRECA in a quite extensive survey performed in the years 1987 -89 (OE89). This report unfortunately contains very little detailed information on specific codes or systems, and the response sheets collected in the survey are evidently lost. The BER-1.1 project group has made a number of aborted attempts to obtain this information.

The questionnaire used this time was designed by the project group. It is difficult to formulate a questionnaire properly, and it is found that several of the questions were too vague, so that they were either not answered or that they were misunderstood.

Here follows a summary of the responses:

Purpose of the system:

All four systems are designed to provide information to emergency response organizations as an aid in decision making during emergency situations. Though the programs have been designed primarily with radiological emergencies in mind, they are applicable to other situations. As an example can be mentioned that RAM has been applied to calculate spread of smoke from fires in the Persian Gulf.

Personnel needed to operate the system:

Trained personnel/specialist is to operate these systems. For NAME and KNMI/RIVM puff model it is mentioned specifically that meteorologist on duty should be able to operate the system. It may, however, be costly to keep this option functional, as there are quite a large number of persons who alternate as meteorologist on duty, as well as new persons entering the service. It may prove very difficult to keep all these persons properly trained in using the programs.

Response time:

Is said to be about 15 minutes (NAME and RAM), from 20 to 60 minutes (TRADOS) depending on the length of the desired forecast (60 minutes corresponding to a few days), and 0.5 to 3 hours (KNMI/RIVM). The response time will obviously depend upon the whole emergency situation and accessibility, adaptability and completeness of incoming data.

Operation of system:

All systems except RAM are/will be permanently manned. See, however, the concerns mentioned above in connection with using meteorologist on duty to operate the system.

Hardware:

The programs run on quite a variety of different mainframe computers and work stations: VAX (RAM and TRADOS), CONVEX and HP (KNMI/RIVM) and IBM (NAME), although the Norwegian Meteorological Institute will have it running on a work station or a Cray in the future. Core memory requirements range from 4 Mbyte (KNMI/RIVM) and 10 Mbyte (RAM) up to about 20 to 100 Mbyte (various versions of NAME). Core requirements are not yet known for TRADOS, which is under development.

Input/output:

Input is from disks or tapes, output to graphic units. It should not be difficult to change these characteristics to be optimal in each environment in which the code will operate.

The input that should be provided by the operator is or is planned to be interactive. Default values of many parameters are built-in or values can be chosen from menus.

Programming language:

All four systems are programmed in FORTRAN. For NAME the version is not mentioned. The other three are in version 77.

Atmospheric dispersion model:

The four systems use different dispersion models. RAM is Eulerian, NAME is Lagrange puff or plume, KNMI/RIVM is Lagrange puff, and TRADOS has uniform horizontal spread (sy based on spread of successive trajectories) and a Kz profile in the vertical direction.

Deposition:

All four systems allow for wet and dry deposition.

Dosimetry:

Only TRADOS calculate doses, and even TRADOS does not calculate doses via nutrition exposure pathways except in assessment mode.

Atmospheric stability:

The atmospheric stability is derived in the following manners: RAM from LAM/ HIRLAM plus use of observed temperature on ground. NAME from NWP-field s-layers (20 layers). KNMI/RIVM Monin-Obukhov- length from wind and cloud cover. TRADOS uses a Pasquill-Turner scheme using an hourly calculated sun's elevation modified by HIRLAM-cloudiness plus orography data and surface wind.

Updating frequency:

RAM and TRADOS 6 hours. NAME about 3 hours. KNMI-LAM new analysis every 3 hours and new analysis plus forecast every 6 hours (ECMWF new analysis plus forecast every 24 hours).

Release magnitude and nuclide composition:

TRADOS and NAME have default values from which the user can choose, or he can select different values. For KNMI/RIVM the operator shall specify all values. In RAM unit emissions are used.

A.5 CONCLUSIONS

The immediate result of the discussion of all the models in the preceding chapter was that two models seem to stand out as likely candidates for implementation in the Nordic countries:

1) The Dutch model which has been developed in cooperation between RIVM and KNMI.

2) The NAME model developed at UK Meteorological Office.

Although it was originally not the intention of this BER-1.1 project to implement a non-Nordic long-range model, this seems at present one possible manner in which to realize the intentions of the project. The project work over the last two years has shown that adoption of one of the Nordic models as a common Nordic model is totally unrealistic. It is also evident that independent development of a model in Norway and in Denmark is not likely to take place. The Norwegian Meteorological Institute will prefer to implement the NAME model or a similar model. Denmark may prefer to purchase the RAM model from SMHI. Sweden will base their predictive capability on RAM, and Finland on TRADOS.

The situation from 1993 and on may change, as the new common CEC-model in real-time is then expected to become operational (Added later: The model is called RODOS, and it will not be ready till probably 1995). It is developed at Kernforschungszentrum Karlsruhe. At that time it will be available to all members of the Community. It is not clear whether it will also be available to non-Community-members associated to CEC's Radiation Protection Programme or perhaps to all countries.

The participants in the work meeting recommend that part of future BER-1.1 funds are set off to implement and test one or both of the models mentioned above as a common Nordic effort, and make the model(s) operational at the meteorological institutes in all four countries.

Appendix A

Appendix B

TECHNICAL DESCRIPTIONS OF THE MODELS MATCH, TRADOS AND SNAP

Appendix B

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Appendix B

B.1 THE MATCH MODEL. A REAL-TIME DISPERSION MODEL ON THE EUROPEAN SCALE

(This description has been prepared by Christer Persson, Swedish Meteorological and Hydrological Institute.)

B.1.1 MODEL

The MATCH model (Mesoscale Atmospheric Transport and CHemistry model) is a 3-dimensional Eulerian atmospheric dispersion model, which can be used for nuclear emergencies on the European scale, for diagnoses as well as forecasts of dispersion and deposition of radionuclides. It has been developed and is in use at the Swedish Meteorological and Hydrological Institute (SMHI).

B.1.1.1 Horizontal and vertical structure

In its standard configuration the model has three levels in the vertical. A basic feature of the model is a time and space variable vertical resolution. The advantage with this approach is that detailed information about the physical dispersion processes can be obtained within the frame of a limited computing volume. The horizontal resolution and the coverage of the model are variable. For applications over Europe with a European meteorological database, a 55 by 55 km or 40 by 40 km grid is used. For applications based on global meteorological data bases even larger model areas, but with a coarser resolution, can be applied. The horizontal advection is calculated using a fourth order flux correction scheme (Bott). The scheme utilizes polynomial fitting between neighboring grid points of the concentration field in order to simulate the advective fluxes through the boundaries of adjacent grid boxes. It is a positive definite mass conserving scheme with low numerical diffusion.

B.1.1.2 Emission

Emission rate for each point or area source is given for each of the studied radionuclides. In case no emission rate is known, a default unit emission rate of 10^{10} Bq/s for the total emission of each radio nuclide is used. Physical emission height (stack height), exhaust gas flux and exhaust gas temperature is given for each point source. In case these data cannot be estimated in the initial part of an emergency situation, a default total emission height of 200 m is used.

B.1.1.3 Deposition

Wet scavenging of trace species is proportional to the precipitation rate and a species specific scavenging coefficient. Dry deposition is proportional to the concentration and a species specific dry deposition velocity at 1 m height. Since the lowest model layer has a height of 75 m, the dry deposition flux calculation is transformed to the middle of that layer (37.5 m) using standard similarity theory for the atmospheric surface layer. The dry deposition velocity can be specified as a function of the surface characteristics (fraction forest, open land etc.) that are available in the model. In the case of large particles a settling velocity can be specified.

B.1.2 TOPOGRAPHY AND LAND USE DATA

Topography and roughness information is available from the meteorological forecast model. Land use data, which can be of value in improving the meteorological input data and the dry deposition calculations, are at present not available at SMHI for areas outside Sweden and consequently not included in the European scale model.

B.1.3 METEOROLOGICAL INFORMATION

Meteorological data needed for near real time long-range transport modeling can be obtained from Numerical Weather Prediction (NWP) models on the European scale, in which intermittent data assimilation combines, in an optimal way, meteorological observations with short-term model predictions. Thus, observations are included in a way that does not contradict the physical laws of nature. For some parameters, also direct observations can be used. However, in forecast mode only meteorological information from NWP-models is available.

For the European scale version of the MATCH model, meteorological data can be readily obtained at SMHI from two different NWP models, HIRLAM and ECMWF.

The High Resolution Limited Area Model (HIRLAM) is an analysis and forecast system, covering Europe and some surrounding areas, in progress as a joint research program among the Scandinavian, Dutch and Irish countries. An operational version of the HIRLAM system is in routine use at the weather services in most of the participating countries, including Sweden.

At SMHI, for the time being, a HIRLAM model version with 16 vertical levels and a horizontal grid size of 55 km is used for the operational weather forecasts. During 1994 probably a higher resolution in the horizontal as well as in the vertical will be introduced in the routine applications. Weather forecasts for 48 hours are obtained and new model forecasts are available every 6 hour.

Input data are provided by the HIRLAM system both as analyses and forecasts. The parameters obtained from each vertical level of HIRLAM is:

- 3-dimensional winds (u, v, w)
- temperature
- moisture (not in use in MATCH at the moment).

Also the following parameters from HIRLAM are used: precipitation, sensible heat flux at ground, friction velocity, Monin-Obukhovs length and mixing height. Post processing of some parameters is, however, necessary in order to derive the dispersion parameters needed by MATCH. Data extraction from HIRLAM is made for very 3h. For emergency application, data extraction intervals of 1h would be beneficial but cannot at present be used due to economic reasons.

For weather analyses and forecasts extended over larger regions and/or for forecast periods up to 7-10 days the global meteorological data base at the European Centre for Medium Weather Forecasts (ECMWF) can be used. For applications outside Europe, the ECMWF analyses and forecasts is the only source of weather information readily available at SMHI. Only a limited amount of the available ECMWF data is transferred to SMHI in routine. The geographical resolution of the transferred data from ECMWF can, however, be increased in situations with specific needs.

B.1.3.1 Precipitation observations

At present, for near real time applications of MATCH, the best and most reliable precipitation information available in routine at SMHI, is obtained from synoptic weather observations. Over Sweden about 150 synoptic stations can be used for the precipitation analyses at SMHI. Of certain interest in the research activities are precipitation analyses including radar and satellite data. However, this type of precipitation data is not reliable enough for routine use in the MATCH model at present.

For the forecast mode only information from HIRLAM or the ECMWF model can be used in MATCH. The uncertainty in predicted precipitation information is, however, quite large.

B.1.4 MAP PROJECTIONS

The MATCH model has been coded to be independent of projection. But, of course, the map projections used have to be specified, and at present the following projections are accounted for:

- regular equally spaced grid
- latitude-longitude grid
- rotated latitude-longitude grid.

Other projections are easily implemented in the system, and the system therefore has a great feasibility to use analyzed or forecast meteorological input fields from various data sources. However, the interface to such data has to be carefully specified.

B.1.5 PRESENTATION OF RESULTS

Results for concentration and deposition of different radionuclides are presented on a map over Europe, where coastlines and some latitude/longitude lines are indicated. The concentrations in the air near ground are normally given as 1h or 3h mean values. The deposition values are given as accumulated total depositions (wet plus dry deposition), or accumulated wet and dry deposition separately, from the emission start time. Also other integration times can be used.

B.2 TRAJECTORY, DISPERSION AND DOSE MODEL TRADOS

(This description has been prepared by Ilkka Valkama, Finnish Meteorological Institute.)

B.2.1 INTRODUCTION

Responsibility for the dispersion forecasts during accidental releases of radioactivity is one of the duties of the Finnish Meteorological Institute as one of the radiation control authorities in Finland. In addition to the normal weather forecasts the Institute maintains a workstation based three dimensional trajectory model and a short range dispersion model. For long range transport forecasting an operational Gaussian trajectory model is employed. This model, which is called TRADOS (TRajectory, Dispersion and dOSe model) runs in VAX and UNIX environments. The operational emergency version is based on the earlier statistical model, developed in cooperation with the Technical Research Centre of Finland. The statistical version of the TRADOS has been employed in risk assessments and probabilistic estimates of population doses due to hypothetical accidents at commercial nuclear power plants.

B.2.2 THE MODEL

The TRADOS is an air parcel trajectory model of the Lagrangian type. The horizontal dispersion of material is described by Gaussian distribution and the vertical concentration profile by gradient-transfer approach. For each one hour trajectory segment the horizontal dispersion, the dynamical mixing height, the time integrated air concentration at ground level as well as dry and wet deposition for selected groups of radionuclides are computed. From these external and internal dose rate estimates are made. As meteorological input the numerical forecast fields from the High Resolution Limited Area Model (HIRLAM) weather prediction model are utilized. The trajectory and dispersion modules of the TRADOS model are currently running in VAX-environment. The dose calculations are computed in UNIX environment. The whole model will be installed on UNIX workstation under a common Windows-based graphical user interface in the near future. The graphical presentation formats will be designed to be compatible with the proposed Nordic graphical presentation standard.

B.2.3 TRANSPORT AND DISPERSION

The transport of radioactive material is described in the TRADOS-model by three-dimensional air-parcel trajectories. The trajectories and dispersion parameters are computed using numerical meteorological forecasts of the Finnish version of the Nordic HIRLAM weather prediction model. The grid resolution in the HIRLAM is 55 km x 55 km and fresh forecasts are available four times a day. At any given time the latest 48 hour forecast is operationally available. A special data-base has been created to enable statistical evaluations and risk analyses to be computed. The TRADOS computational area covers some 3800 km x 4800 km reaching from Iceland to the Ural mountains and from Italy up to Novaja Zemlya.

In the TRADOS the total release of radioactivity is divided into three-hour segments. The plume width is the quadratic sum of the spread due to internal turbulence of the plume and the external force due to meandering and wind veering. The latter is computed on the basis of three subsequent trajectories. The mixing height is a dynamical function of boundary layer stability. The stability parameter is at present estimated over land from solar elevation and the surface wind and temperature data using a modified Pasquill-Turner-method. Estimates of the total cloudiness are obtained from the respective values of relative humidity and temperature at constant pressure levels and from the vertical air velocity in the lower troposphere. Numerical cloudiness data will be included in the meteorological data-base in the future as soon as it becomes available from HIRLAM. An iterative method, based upon the surface drag-coefficient (as function of wind speed and the state of the sea) and sea surface temperature is used over sea. The effects of the long summer nights at high latitudes are taken into account, as are those caused by the snow during winter time and ice cover of the Baltic Sea. The mixing height is estimated from the stability class by employing an empirical relation.

The occurrence and type of precipitation is obtained from the HIRLAM forecasts. Both the convective and the large scale frontal precipitation is considered. Unfortunately only six hour cumulative fields are available. The hourly values are computed as a function of vertical velocity, relative humidity and temperature data as well as total cloud cover. The wash-out parameter is then computed from the estimated rain-fall rate and type of precipitation (water/snow).

B.2.4 AIR CONCENTRATIONS, DEPOSITION AND DOSE RATES

The vertical extent of the radioactive plume is governed by the mixing height. The vertical concentration profile is described by gradient-transfer approach. By this method the dry deposition can be treated in a physically more realistic way than in Gaussian models. At present steady state Kz-profiles are used, but the possibility to utilize an analytical solution for Kz-profiles is being studied. Parts of the cloud can become isolated into a reservoir layer above the mixing height, where they are not allowed to be affected by dry deposition. At present only one constant value of dry deposition velocity could be employed at one run. In the future individual dry deposition velocities will be employed for gaseous (e.g. Iodine) and particulate (e.g. Cesium) radionuclides. Depletion of radioactive material from the cloud by wet deposition is described by scavenging coefficient approach. Contrary to dry deposition the wet deposition removes material from all layers of the cloud, with the exception of noble gases. Only three values for the scavenging coefficient can be employed in the present version. The time integrated air concentrations at ground level as well as dry and wet deposition on the ground for each three hour trajectory segment are computed in a geographical grid of 1300 points with a grid mesh of 0.5 degrees both in latitude and longitude. The total deposition for each grid point can then be summed up from these three hour values.

In the real time version of the TRADOS for operational emergency applications only external dose rates are computed. In the statistical version also individual and population dose estimates via several external and internal pathways can be made.

B.3 SNAP, A REAL-TIME DISPERSION MODEL FOR SYNOPTIC SCALE SIMULATIONS.

(This description has been prepared by Jørgen Saltbones, The Norwegian Meteorological Institute (DNMI). A more complete description of the model SNAP will be worked out in the near future.)

B.3.1 MODEL

Severe Nuclear Accident Program (SNAP) is a three dimensional Lagrangian atmospheric dispersion model, using 'marked particles' to carry the 'load' from the source and transport the material in the atmosphere until it is deposited onto the surface. The mathematical method used can be described as - Monte Carlo - and Particle - model technique. The model was developed to perform real-time simulation of atmospheric transport of radioactive pollutants in connection with nuclear accidents. SNAP operates on the synoptic scale.

The model has been developed to its present state by DNMI, on the basis of a scientific cooperation with UK Meteorological Office, Bracknell. The model will be developed further as part of the Eureka project (507) MEMbrain/NORMEM.

B.3.1.1 Horizontal and vertical structure

The structure of the model is very similar to the 'NAME' model, developed and used by UK Meteorological Office in its function as Regional Specialized Meteorological Centre (RSMC).

The horizontal structure of the SNAP model is described in the same grid system as the meteorological input data supplied by DNMI's operational Numerical Weather Prediction (NWP) model. At the time of writing, the NWP model used is LAM50S, in which the distance between the gridpoints is 50 km at 60^0 N. The area covered by the LAM50S is most of Europe and North Atlantic Ocean (see more details about the LAM50S in the attached technical annex).

At present, the model uses 14 σ-layers in the vertical, from the surface to approximately 5000 m, to describe the motion of the particles. Special emphasize is paid to the treatment and development of the Atmospheric Boundary Layer (ABL) and its variation in space and time. A basic assumption is that the ABL is in a turbulent and well mixed state. The depth of the ABL is determined by the vertical temperature stratification and the vertical distribution of horizontal wind, (Critical Richardson number formulation). The top of the ABL is characterized by a temperature inversion, which partly limits the exchange of mass between the ABL and the layers above.

B.3.1.2 Emission

In operational mode; performing real-time dispersion model calculations using SNAP, we can choose from a set of preset emission rates and profiles, given as functions of time and vertical coordinate. The quantity released is mass/time, for example, 1 g/s of an unspecified tracer material. Depending on the information available about the accident and the local weather conditions at the site of release, we choose from this set the profile that seems most likely to match the information characterizing the emission.

B.3.1.3 Deposition

A new formulation for the depletion processes is under testing. Both for wet and dry deposition a probabilistic approach has been taken as a basis. These processes are applied to each particle for each timestep. In the following section, we will outline the depletion processes in some details:

Dry deposition

A particle carry an initial mass - $M_p(t_0)$ - from the source point. This mass is sub-divided into smaller units. Particles located above the atmospheric boundary layer, are not subject to the dry deposition process. For particles in the boundary layer, the situation is different. We assume that the boundary layer consists of - n - 'fictitious layers' or n $< z_b >$, where z_b is a number set from one to the number of meters of the boundary layer thickness. The particle is now randomly assigned a number - n_p -from the number set $< z_b >$. If $n_p > n_{crit}$, no mass is lost by this particle. If $n_p \leq n_{crit}$, a certain fraction of the particle s mass is deposited onto the ground.

The 'adjustable' probabilistic parameters for the process, are given numerical values corresponding to a rate of efficiency that can be compared with the more common parametrization of the process through the use of the dry deposition velocity concept.

Wet deposition

In the parameterization of the wet deposition process, we use 'probability curves'. The 'probability curves' can be explained as follows: If we choose an arbitrary point (x,y,z,t) in a grid-volume ($\Delta x, \Delta y, \Delta z, \Delta t$), a 'probability curve' will tell us: "What is the probability for real precipitation to occur in this specific point in space and time, - given we have access to the amount of precipitation (Prec) predicted by DNMI s operational NWP model".

For Prec= 0, no wet process acts on the particles. For Prec > 0, we have two-step process. First step: We read from the probability curve for the precipitation amount in question, what the probability is for a 'real' precipitation to occur.

$$P_w = \text{Prob(Prec)}$$

Next step: We use a random-generation to assign '0' or '1' to each particle. The '1' value is chosen with a probability P_w, and '0' value with a probability (1 - P_w). It means, that if the total number of particles is N in the grid-volume in question, then P_wN particles are affected by the wet deposition.

A certain fraction of the 'wet' particle's mass is deposited to the ground. The 'adjustable' probabilistic parameters for the process, are given numerical values corresponding to a rate of efficiency that can be compared with the more common parametrization of wet deposition through the use of the 'scavenging ratio' concept.

B.3.2 METEOROLOGICAL INPUT DATA

DNMI operates a system of Numerical Weather Prediction Models - run on a regular operational schedule. The main NWP model is (*at the time of writing - Nov. 94*) LAM50S (Limited Area Model) with 50 km grid size. The technical characteristics of this model are listed, in the form of an attached technical appendix, in subchapter B.3.5. LAM50S is run on the Cray Computer Centre in Trondheim (The Foundation for Science and Industrial Research at the Norwegian Institute of Technology - SINTEF) where DNMI is one of the main users.

Meteorological input data for the SNAP model are provided by LAM50S. The most important parameters from this NWP model for use in the SNAP model are:

- 3-dimensional winds (u, v, σ-dot) in 14 σ-layers
- temperature in 14 σ-layers
- precipitation

The SNAP model can take data either from the most recent updated forecast (up to 48 hr. ahead) or from a regularly updated archive file, giving access to analysis (and short forecasts) of the meteorological data from the near past, (up to one week back in time). At the time of writing, we store input data for the SNAP model every 6 hr. (3 hr. for precipitation). For data fields needed between the 6 hourly stored values, interpolation in time is used. SNAP operates with a timestep of 1/4 hour (900 sec.).

B.3.3 MAP PROJECTION

Both for presentation of the output and for the input data, the SNAP model works in a Cartesian coordinate system (gridnet) on a Polar Stereographic Projection, cutting through the globe at 60^0 North. In the past, this projection has been mostly used in mapping meteorological data for areas at high latitudes. This projection gives no angular errors in transformation from 'sphere' to 'plane'. Errors in measuring distances are easily corrected. We may, in the future apply the SNAP model on maps based on other projections.

B.3.4 PRESENTATION OF RESULTS

Different ways of presenting output from the model calculations have been worked out. Our most common way is presentation of a sequence of fields on maps. We use isoline plots, drawn on the basis of instantaneous (in time) mean values for grid squares. This is especially useful in presenting the concentration of mass of the emitted tracer material. We also use isoline plots for mapping accumulated deposition fields. Another popular output from the model are 'time plots for concentrations' at places of interest. This was used quite frequently in the evaluation process of the European Tracer EXperiment (ETEX).

Up to now, SNAP works with 'mass fields'. We have found that transformation from units of mass to isotope specific activity may best be performed as a post-processing procedure. In this process, scaling of the output may also be performed if new information concerning the emission has become available.

B.3.5 TECHNICAL APPENDIX ON LAM50S:

Forecast model LAM50S:

Basic equations:	Primitive equations with hydrostatic assumption.
Independent variables:	x, y (Cartesian coordinates on polar stereographic projection), σ, time.
Dependent variables:	u, v, Θ, q and p_s.
Diagnostic variables:	Geopotential, σ-dot.
Integration domain:	191 x 145 gridpoints.
Horizontal grid:	Arakawa D-grid.
Mesh width:	50 km at 60^0 North.
Vertical grid:	31 levels in σ coordinates.
Integration scheme:	Explicit with interpolation of tendencies (Bratseth, 1983) and pressure averaging. Timestep = 90 s. Asselin time filter.
Boundary values:	Specified from ECMWF model for 00, 06, and 12 UTC, from UK Met.Off. model for 18 UTC run. Linear interpolation in 6 hour intervals.
Horizontal diffusion:	Second order Shapiro filter every 6 hour.
Surface classifications:	Land: forest and tundra. Sea: open or ice. Analyzed sea surface temperature and sea ice cover.
Orography:	Envelope orography from information in 0.5 x 0.5 degree resolution, and from information in 1 x 1 km resolution for Norway.

Physical parameterization:

1) Surface processes: Vegetation is included over land. Surface fluxes of heat and moisture are a linear combination from bare land and vegetation. Stability and roughness dependence as in ECMWF. Canopy resistance depends on moisture availability and solar radiation. Charnock relation used for sea points. Sea ice is assumed snow covered and treated as land points.

2) Soil processes: Three soil layers over land where temperature and soil moisture obey prognostic equations in two uppermost layers. Temperature is parenthesized as in ECMWF model. Soil moisture follows (Deardorff, 1978), but it is assumed that a fraction of the evapotranspiration comes from the second layer due to root uptake. In the case of sea ice the 'deep soil temperature' is taken as -2^0 C.

3) Vertical diffusion: Exchange coefficients as in (Blackadar, 1979). The vertical diffusion equation is solved implicitly.

4) Radiation/clouds: Long wave radiation from an emissivity approach (Nordeng, 1986) with full interaction with clouds (determined diagnostically from relative humidity and vertical velocity). Short wave radiation does not take back-scattering into account.

5) Condensation: Cloud liquid water is a prognostic variable (but not advected). Resolved precipitation when the relative humidity exceeds 100%. The condensate is added to existing cloud liquid water. Convective processes according to a modified version of the Kuo scheme (Geleyn, 1985 with modifications). The condensate is added to existing cloud liquid water. Precipitation release according to the Bergeron process and to coalescence. Not precipitated cloud liquid water is stored until next time step. Evaporation of fallen precipitation due to Kessler. Evaporation of possible cloud liquid water if condensation is not taking place. Shallow convection if the cloud extent is shallower than 150 hPa. In this case the condensate is instantaneously evaporated so that there is a net upwards transport of moisture, but no net heating.

Initial times:	00, 06, 12, 18 UTC.
Forecast length:	48 h (00 and 12 UTC runs), 54h (06 and 18 UTC runs).

Data assimilation scheme:

Analyzed variables:	u, v, z and RH at 11 standard pressure levels.
Analysis method:	Based on successive correction schemes (Bratseth, 1986).
Assimilation method:	Data grouped in 3-hour time windows centered on 00, 06, 12 and 18 UTC. Model first guess updated by multivariate statistical interpolation by successive corrections based on Bratseth (1986). Crosscorrelations are functions of iteration number. Separate update assimilation with late data cut-off for 00 and 12 UTC. For this update the first guess in the Atlantic Ocean is replaced by analyzed wind and geopotential from the ECMWF model.
First guess:	6 hour forecast from previous initialized analysis.
Data used:	SYNOP (pressure only) SHIP (pressure only) DRIBU (pressure only) TEMP (T, u, v, q at standard p-levels)

	PILOT (at standard p-levels) AIREP (wind)
Data cut-off times:	0215 (00 UTC assimilation for 00 UTC forecast) 0900 (06 UTC + 6 h, update assimilation for 06 UTC run) 0900 (06 UTC assimilation for 06 UTC forecast) 1415 (12 UTC assimilation for 12 UTC forecast) 2230 (12 UTC +6 h, update assimilation for 18 UTC run) 2230 (18 UTC assimilation for 18 UTC forecast)
Initialization Method:	Dynamical initialization (Bratseth, 1987)

For further information, see (J. E. Haugen and A. Foss, 1993).

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Appendix B

Appendix C

COMPARISON OF DISPERSION MODEL RESULTS FROM THE BER-1 EMERGENCY EXERCISE, 21 JUNE 1993

A report by Christer Persson, Joakim Langner and Lennart Robertson

Swedish Meteorological and Hydrological Institute

August 1994

Appendix C

C.1 INTRODUCTION

Numerical dispersion models can in nuclear safety work be of great value to estimate the concentration in air and deposition to ground of emitted radionuclides. The models are of special importance during the first stage of an accident, when no or very sparse measured data of radionuclides from the environment are available and when the need for forecasts are of special importance. In a later stage, when substantial data from air concentration and deposition are available, the dispersion models can be used in combination with measurements to make detailed analyses of the development of the distribution of radionuclides in air and on ground.

There has been a discussion about the quality of the results from real-time forecast numerical dispersion models. Therefore, as an example, it can be of interest to present a comparison of the results from the different models, which took part in the latest Nordic real-time exercise. In this study only a tentative comparison, concentrated on qualitative information, will be presented. However, also in real accident situations, before emission data are available, qualitative descriptions are of greatest importance.

The real-time exercise for numerical dispersion models was a part of Nordic Nuclear Safety Research. The national weather services of Denmark, Finland, Iceland, Norway and Sweden took part. The U.K. Meteorological Office also took part in the exercise, as consultant to the national weather service of Iceland.

Parts of this Nordic numerical model exercise have already been presented by (Saltbones and Fors, 1994) and (Valkama, 1993). We will here concentrate on the comparison of model results, which was not included in the earlier papers.

C.2 DISPERSION MODELS INCLUDED IN THE COMPARISON

In this tentative comparison we have only included models which were used in real time during the exercise.

The models included in the comparison are:

- TRADOS (Finnish Meteorological Institute) is a Lagrangian model (Rossi and Valkama, 1991) based on calculated trajectories. The trajectory calculations are based on meteorological data from the Finnish weather prediction model HIRLAM.

- NAME (U.K. Meteorological Office) is a particle (sometimes called Monte-Carlo) model (Maryon, Smith, Conway and Goddard, 1992).

- SNAP (Norwegian Meteorological Institute) is a particle (Monte-Carlo) model (Saltbones and Fors, 1994) which is based on the NAME model from the U.K. Meteorological Office. The horizontal grid size is 50 · 50 km, and 14 layers are used in the vertical. Meteorological input data for SNAP are taken from the Norwegian weather prediction model LAM 50.

- MATCH (Swedish Meteorological and Hydrological Institute) is an Eulerian model (Persson, Langner and Robertson (1994) with - in this case - a 55 · 55 km horizontal grid and 3 vertical layers. The depths of the vertical layers are continuously variable in space and time, depending on the meteorological conditions. Meteorological input data for MATCH are taken from the Swedish weather prediction model HIRLAM.

Both in SNAP and in NAME, a Lagrangian frame of reference is used in handling diffusion and transport processes in the atmosphere.

Dispersion model calculations were made on the basis of:

1) real-time weather forecasts,
2) weather analyses made from meteorological observations.

The dispersion calculations based on weather analyses were, of course, made after the real-time exercise, when weather observations for the studied event were available.

C.3 EMISSION

The conditions for the exercise were the following: At position (73° N, 40° E) a first release from a 1200 MWe reactor into the atmosphere started at 06 UTC on 1993-06-21. The emission lasted 1 hour and the released mass contained $2.0 \cdot 10^{16}$ Bq Cs-137, $4.0 \cdot 10^{16}$ Bq Cs-134 and $4.0 \cdot 10^{17}$ Bq I-131. The heat emission was 2.0 MW. The different weather services were informed by a telefax at about 7.15 UTC on 1993-06-21.

A second release from the same position took place during 8.45 and 9.30 UTC on 1993-06-21, and this second release contained $5 \cdot 10^{15}$ Bq Cs-137, $1 \cdot 10^{16}$ Bq Cs-134 and $1 \cdot 10^{17}$ Bq I-131. Heat emission this time was 0.2 MW.

The emissions were, however, not used exactly in the same way in all dispersion models. The deviations were the following. In NAME and SNAP a continuous emission between start of first release and stop of second release was used. NAME also used a default emission level instead of the emission levels given above. For TRADOS separate calculations were made for first and second release and the results were presented separately.

The dispersion model exercise finished at about 12 UTC on 1993-06-21.

C.4 COMPARISONS OF RESULTS FROM DIFFERENT DISPERSION MODELS

In this tentative comparison only concentration and deposition maps produced in connection to the Nordic exercise will be included. We emphasize that this is only a qualitative comparison.

There are three main problems when making a comparison from this exercise:

- All models did not use exactly the given emission times and emission levels; see Section C.3.
- The presentation of results are made on maps with different geographical projections and scales and with different types of shadings.
- The presentation of results are not always made for the same time of the day.

C.4.1 Real-time dispersion forecasts

In Figures C.1 - C.7, the real-time 48 h forecasts (valid 1993-06-23, 06 UTC or as close to that as possible) for concentration of Cs-137 in air and accumulated deposition, which were sent to the BER-1 Exercise Secretariat, are presented. (In one case I-131 has been used in lack of information for Cs-137.) Since the results from the different models were presented for somewhat different times, it has not been possible to use exactly the same time for all models. The largest time difference is for the SNAP model, the results of which refer to a situation 9 h earlier. It is also important to remember the differences in emission data which were used (see Section C.3).

The vertical plume rise which was used in this run of the MATCH model, was later found unrealistic and changed. No deposition was included in SNAP, giving a somewhat overestimated concentration.

We can see from Figures C.1 - C.7 that the real-time 48 h forecasts of concentration in air and accumulated deposition (valid 1993-06-23, 06 UTC) agree qualitatively fairly well between the different models, although the MATCH model has the cloud center somewhat further to the west compared to the other models.

C.4.2 Dispersion simulations based on meteorological analyses

In Figures C.8 - C.11, 48 h concentration simulations, valid for the same time as the forecasts presented above, are given.

The 48 h simulations were made a couple of days after the real-time exercise and based on meteorological analyses. It is obvious from Figures C.8 - C.11 that the 48 h simulations of dispersion, which are based on meteorological analyses, agree qualitatively very well between the different models. The areas influenced by the emitted cloud are very similar for the different models. The outer isoline is for the

MATCH model results equal to 1 Bq/m^3, while it is 2 Bq/m^3 for SNAP and about 50 Bq/m^3 for TRADOS. The size of the indicated cloud area is, of course, influenced by this. A lower concentration for the outer isoline gives a larger cloud area.

There is also a fairly good qualitative agreement between the 48 h forecasts and the 48 h simulations. A quantitative comparison is in this case difficult to perform due to differences in emission data and presentation forms. Also the differences in including plume-rise calculations in the models can be important.

It should be pointed out, as by (Saltbones and Fors, 1994), that the prime importance for a dispersion calculation is the meteorological input data used by the dispersion model. Differences in meteorological input data give larger differences in the output from the dispersion models compared to using dispersion models of different types. Also identical weather prediction models, like HIRLAM run in different countries, can give different results due to differences in e.g. the available weather observations used to initialize the weather prediction model.

C.5 CONCLUSIONS

This tentative comparison of model results from just one exercise can not be used to draw any firm conclusions. However, there are some points which we find important to stress:

- The real-time 48 h forecasts of concentration in air and accumulated deposition (valid 1993-06-23, 06 UTC) agree qualitatively fairly well between the different models.
- The 48 h simulations of dispersion which were made after the real-time exercise and based on meteorological analyses, agree qualitatively very well between the different models. The areas influenced by the emitted cloud are closely the same for the different models.
- There is a fairly good agreement also between the 48 h forecasts and the 48 h simulations.
- There is a need for a more detailed comparison to find the reasons for the quantitative differences in the calculated concentration levels.
- Using results from more than one real-time dispersion forecast model can give valuable information about the uncertainty of the dispersion forecasts.
- It is very desirable to improve the clearness of the presentations of results.
- It is desirable that the Nordic countries have a similar design of the presentations.
- There is a need for more Nordic real-time exercises of the same type as arranged by BER-1 in this case.

- It is desirable not only to compare different model results with each other, but to compare with measurements. The planned ETEX (European Tracer Experiments) will give such an opportunity.

C.6 REFERENCES TO APPENDIX C

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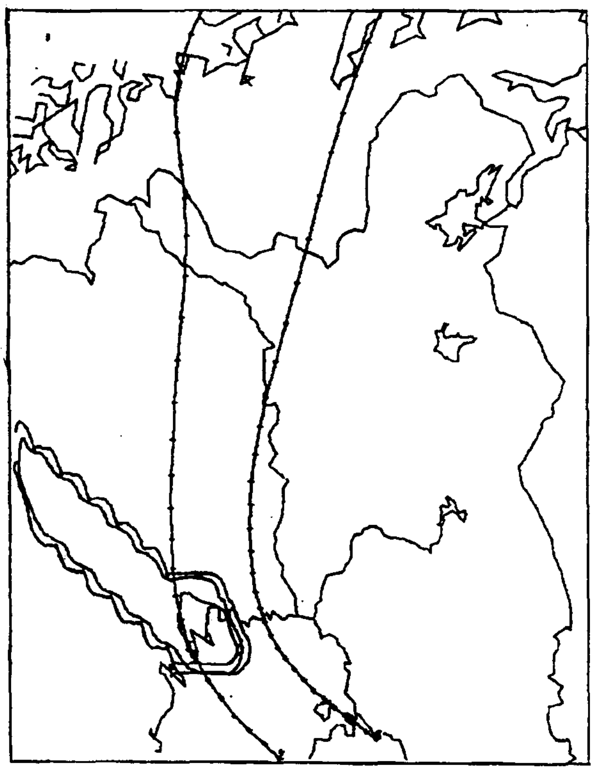

Figure C.1.

TRADOS — Real-time forecast of Cs-137 concentration, valid on 1993-06-23 at 03 UTC. This map refers to the second emission only. If the concentrations are recalculated to be valid for the total emission of Cs-137, the highest concentration isoline is 8 Bq/m^3 and maximum value is below 46 Bq/m^3. Maximum is situated near Luleå in northern Sweden.

Figure C.2.

NAME — Real-time forecast of Cs.137 concentration, valid on 1993-06-23 at 09.30 UTC. Concentrations are only expressed in relative units, since default emissions were used. Calculations were made with the global scale version of the model.

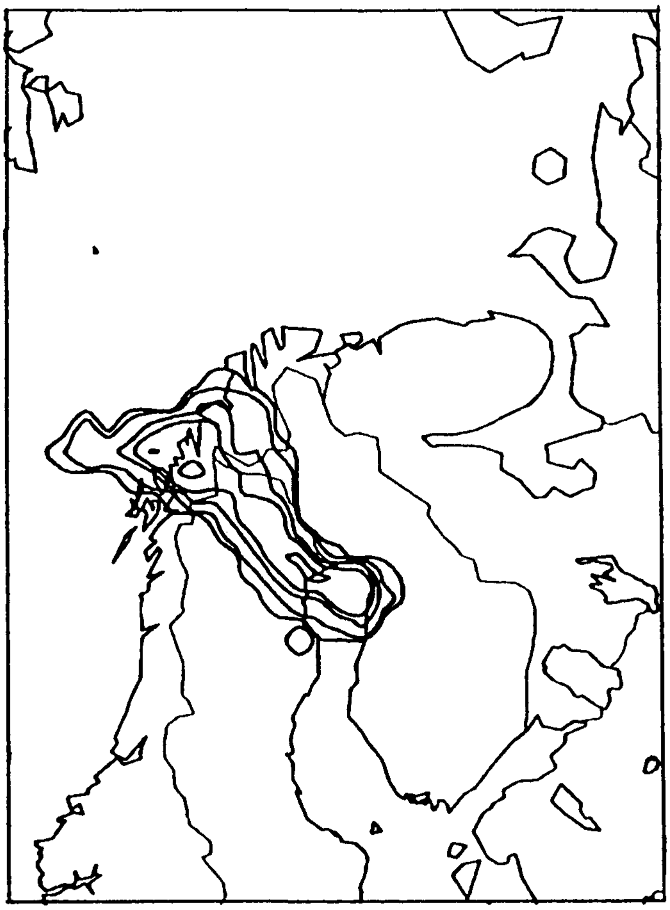

Figure C.3.

SNAP — Real-time forecast of Cs-137 concentration, valid on 1993-06-22 at 21 UTC. Highest isoline concentration value is 400 and maximum value is below 1000 Bq/m^3. Second highest isoline is 200 Bq/m^3.

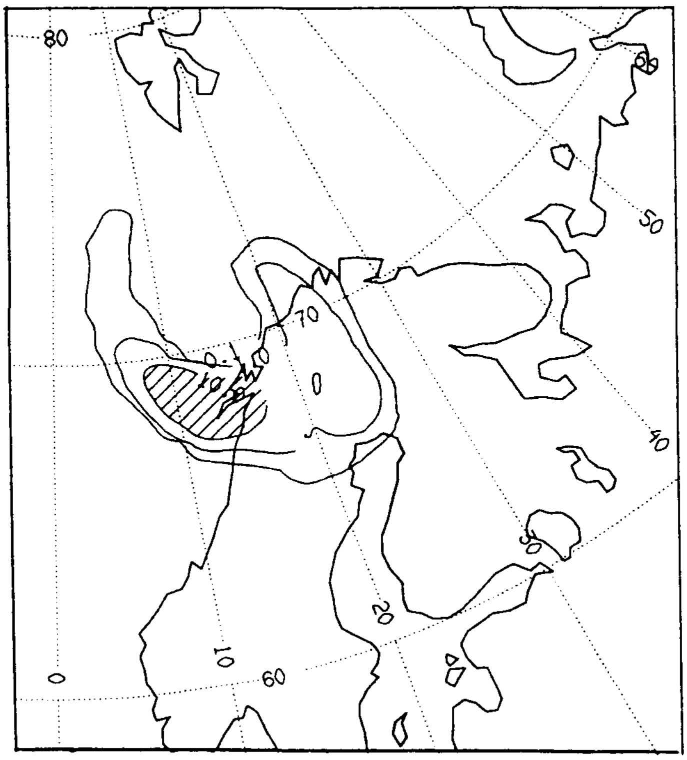

Figure C.4.

MATCH — Real-time forecast of Cs-137 concentration, valid on 1993-06-23 at 06 UTC. Concentrations in shaded area are between 10 and 100 Bq/m^3.

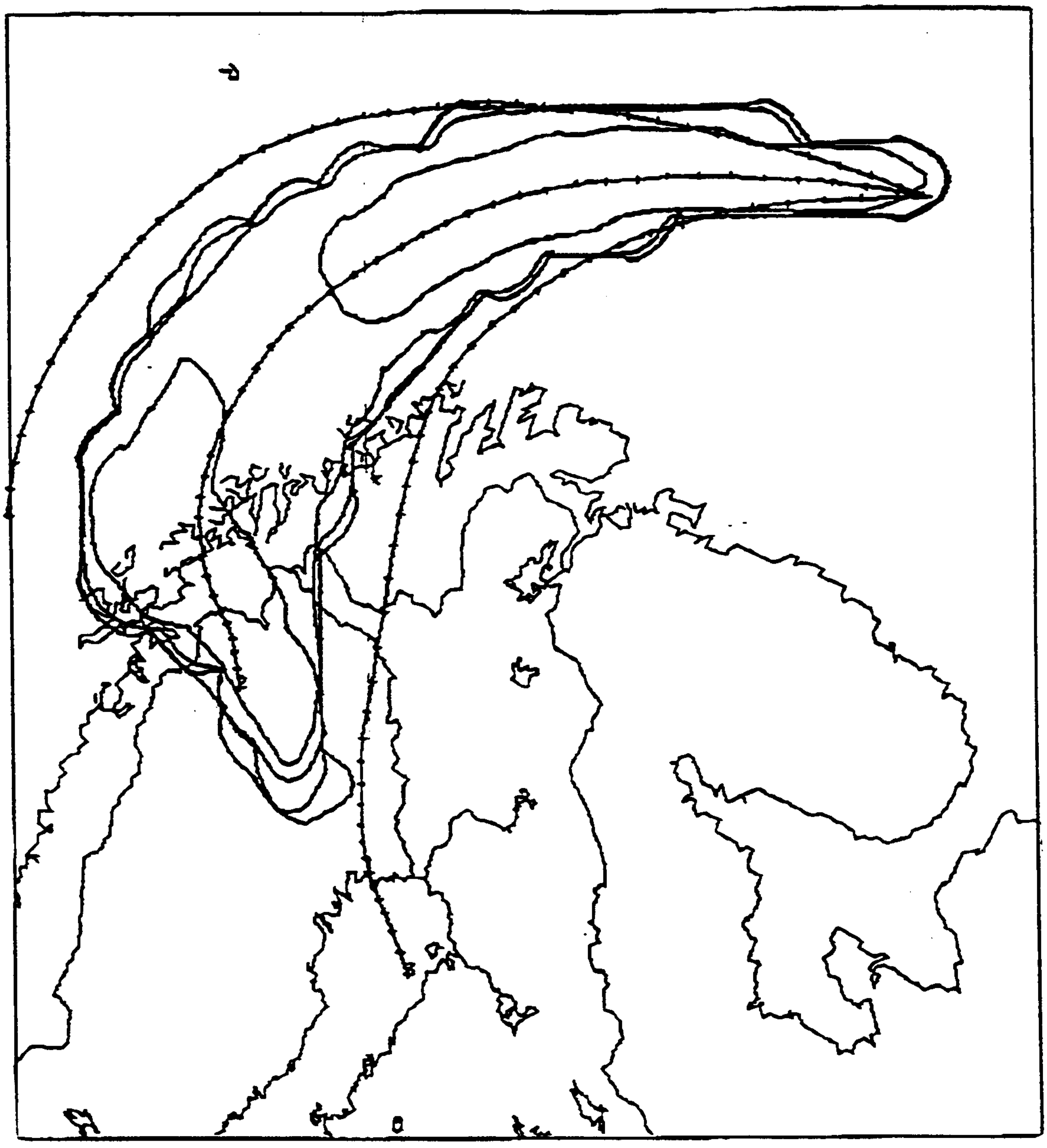

Figure C.5. TRADOS — Real-time forecast of I-131 accumulated deposition, valid at 1993-06-23, 00 UTC. Highest isoline deposition value is 1000 kBq/m^2, maximum is less than 10 000 kBq/m^2.

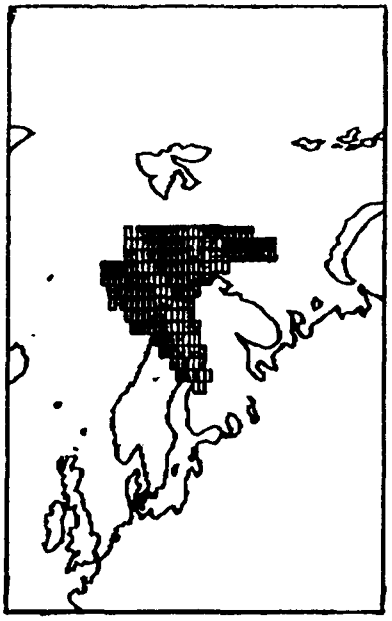

Figure C. 6.

NAME — Real-time forecast of Cs-137, accumulated deposition valid at 1993-06-23, 06 UTC. Depositions are only expressed in relative units, since default emissions were used. Calculations were made on the global scale version of the model.

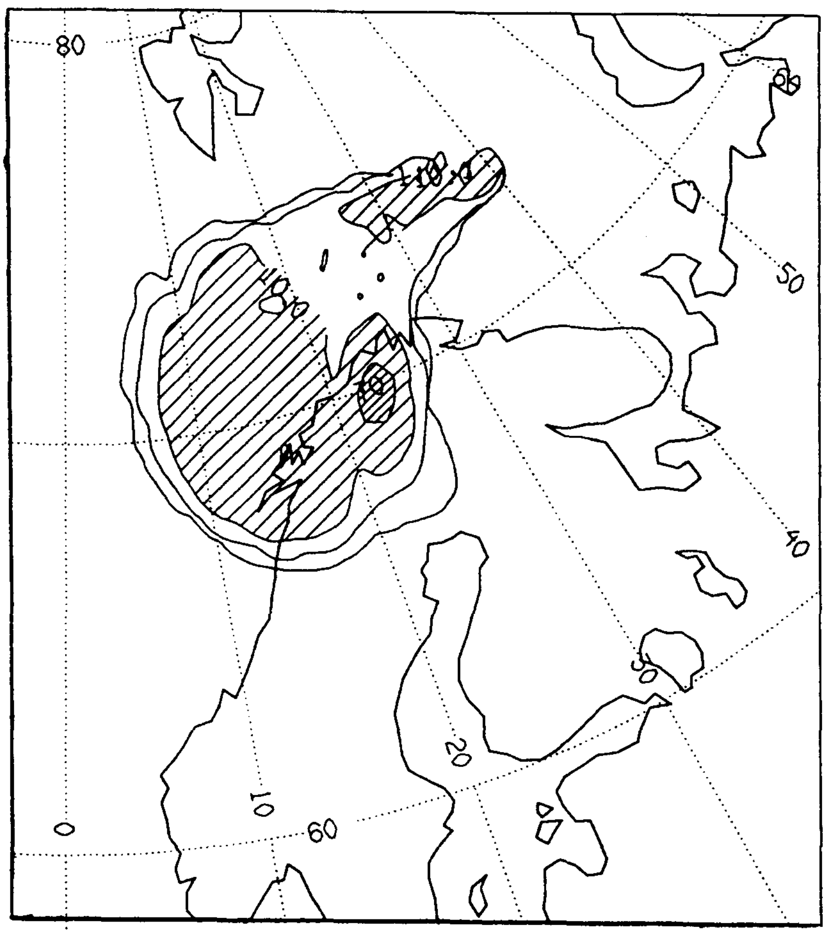

Figure C.7.

MATCH — Real-time forecast of Cs-137, accumulated deposition valid at 1993-06-23, 06 UTC. Areas with accumulated depositions 10 - 100 kBq/m^2 are light shaded and areas with more than 100 kBq/m^2 are dark shaded.

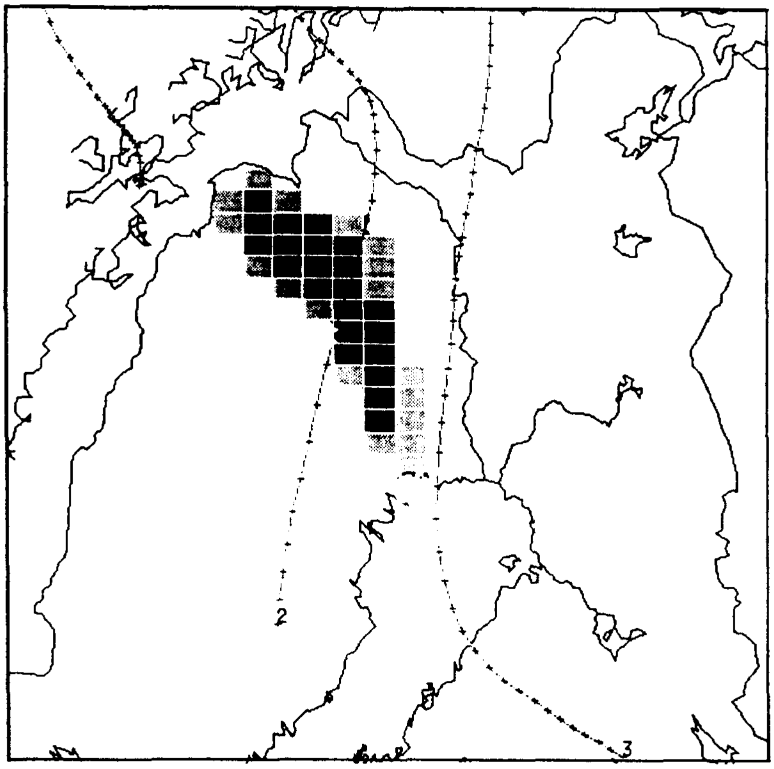

Figure C.8.

TRADOS — Dispersion calculations based on meteorological analyses. Concentrations of Cs-137 at 1993-06-23, 06 UTC are presented. Darkest shading has a concentration of 240 - 1200 Bq/m^3. Only the first release is included in the calculation.

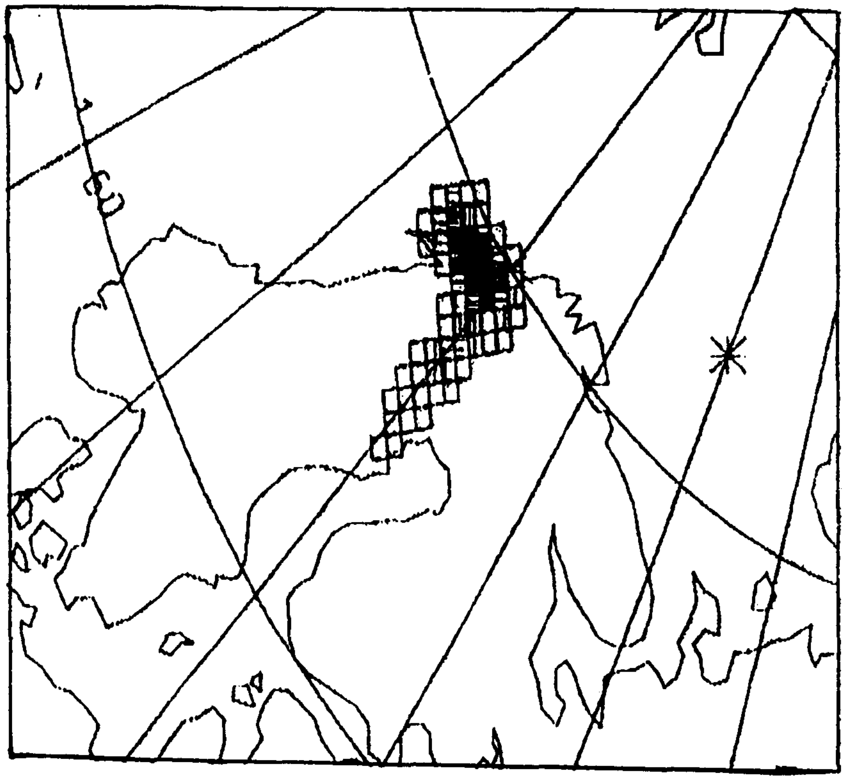

Figure C.9.

NAME — Dispersion calculations based on meteorological analyses. Concentrations of Cs-137 at 1993-06-23, 06 UTC. Concentrations are only expressed in relative units, since default emissions were used.

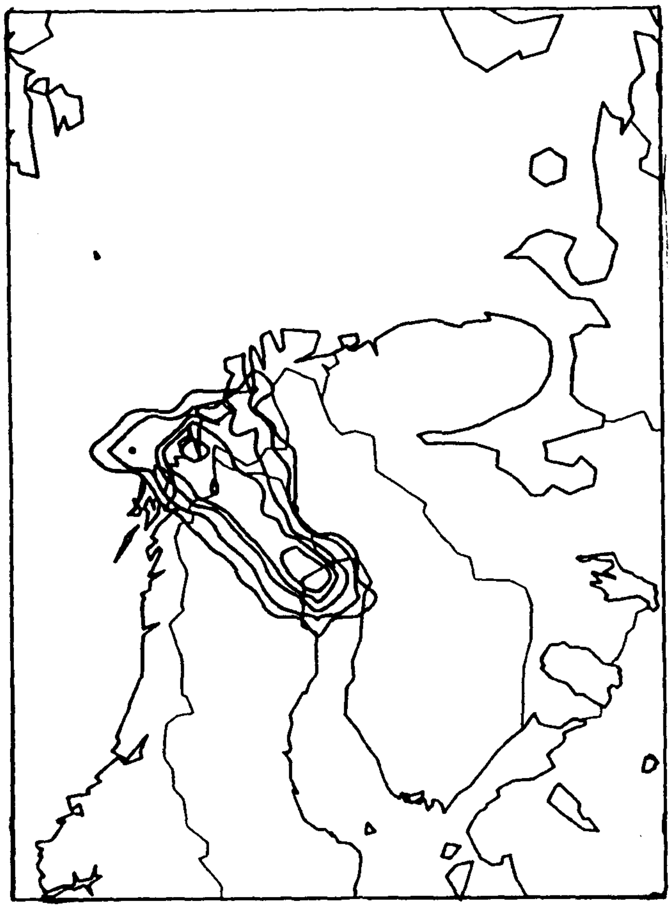

Figure C.10.

SNAP — Dispersion calculations based on meteorological analyses. Concentrations of Cs-137 at 1993-06-23, 03 UTC. Concentrations in the two maxima are in the range 400 - 1000 Bq/m^3.

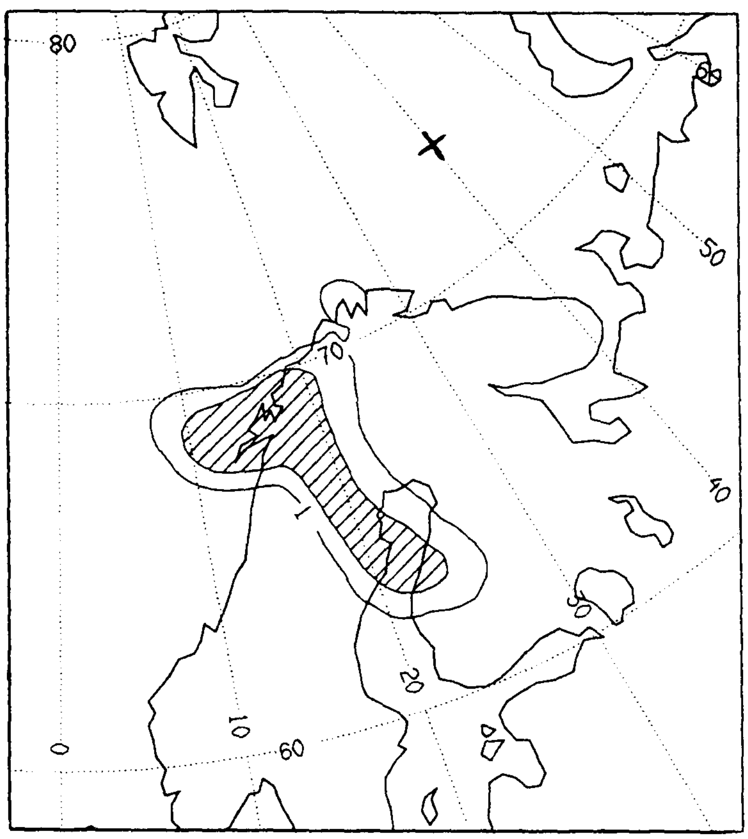

Figure C.11.

MATCH — Dispersion calculations based on meteorological analyses. Concentrations of Cs-137 at 1993-06-23, 06 UTC. Concentration in the shaded area is 10 - 100 Bq/m^3.

Appendix D

THE CHERNOBYL ACCIDENT: A CASE STUDY OF DISPERSION OF CS-137 USING HIGH RESOLUTION METEOROLOGICAL DATA

A report by Joakim Langner, Christer Persson and Lennart Robertson

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May 1993

Appendix D

ABSTRACT

The MATCH model (Mesoscale Atmospheric Transport and CHemistry model) developed at The Swedish Meteorological and Hydrological Institute (SMHI) has been used to simulate the dispersion and deposition of 137Cs from the Chernobyl accident (April-May 1986). Meteorological data from the numerical weather prediction system HIRLAM (High Resolution Limited Area Model) was used to drive the MATCH model. The simulations were compared with available data on concentration and deposition of 137Cs in Scandinavia. The results indicate that the model captures major features of the observed concentration and deposition fields of 137Cs over Scandinavia. However, some significant discrepancies can also be noted and several experiments were performed in order to study the sensitivity of the modeling system to different modeling assumptions and input data.

D.1 INTRODUCTION

The Chernobyl accident, April 25th 1986, provides a unique opportunity to test models of atmospheric transport and deposition of trace elements. The size and location of the emission is fairly well known and a substantial amount of observations on air concentrations and deposition is available. In this case study the MATCH model (Mesoscale Atmospheric Transport and CHemistry model) developed at The Swedish Meteorological and Hydrological Institute (SMHI) has been used to simulate the dispersion and deposition of 137Cs from the Chernobyl accident. The purpose of this exercise was to validate the model and to test different parameterization schemes used in the model. Comparison with observations was restricted to the period when the radioactive cloud affected Scandinavia. In section two the model is described briefly. In section three, four and five emissions, meteorological input and radiological data are discussed. In section six results from the several experiments are presented and comparisons with observed data are discussed. A summary and some conclusions are given in section D.7.

D.2 MODEL

The MATCH model (Persson et al., 1990) is an Eulerian atmospheric dispersion model. The horizontal resolution and coverage of the model is variable but for the present study a 55 by 55 km grid covering most of Europe was used (Fig. 2.1). Horizontal advection is calculated using a flux correction scheme (Bott, 1989a, 1989b). In its standard configuration the model has three levels in the vertical. The first layer has a fixed height of 75 m. The two following layers are variable in thickness. The top of the second layer is taken to be the same as the mixing height, and the top of the third layer is fixed at a certain level, in this case 2500 m. The mixing height is derived from standard meteorological fields and varies in both space and time inducing vertical transport between layer two and three. Vertical transport due to vertical advection as well as turbulent diffusion is also included. It is possible to include additional layers if necessary.

Emissions from point sources are treated as Gaussian puffs which are advected until they have reached the size of the horizontal grid. They are then merged into the concentration field. Emissions can be specified at all levels in the model. Plume rise is calculated for each source from source characteristics that are input to the model.

Wet scavenging of trace species is proportional to the precipitation rate and a species specific scavenging coefficient. Dry deposition is proportional to the concentration at 1 m and a species specific dry deposition velocity. The 1 m concentration is calculated using standard similarity theory for the atmospheric surface layer. The dry deposition velocity can be specified as a function of surface characteristics (fraction forest, open land etc.) that are available in the model. In the case of large particles a settling velocity can be specified. Further details regarding the model formulation can be found in (Persson et al., 1990).

D.3 EMISSION DATA

Emission data were taken from the ATMES-report (Klug et al., 1992). Figure C.3.1 shows the evolution of the emission of 137Cs over time as given by (Persson et al., 1986). The total emission is estimated to have an uncertainty of +/- 50% (Persson et al, 1986). The emission was distributed between the three layers following the recommendation in the ATMES-report. The distribution of the emissions at different levels is given in Table C.3.1.

Table D.3.1. Emission characteristics used in the model for each day of emission.

Date	Level of release (m)	Fraction emitted (%)
86-04-25 21-24	1500	100
86-04-26 00-06	375 750 1500	25 25 50
86-04-26 06-24	400 600 800	25 50 25
86-04-27	400 600 800	25 50 25
86-04-28 - 86-05-04	300	100

D.4 METEOROLOGICAL DATA

Meteorological data from the numerical weather prediction system HIRLAM (High Resolution Limited Area Model, Kållberg, 1989) was used to drive the MATCH model. Since the HIRLAM system was not operational at the time of the accident the HIRLAM system was run on archived data to produce analyzed and forecast meteorological fields used in the dispersion calculations. This HIRLAM run was performed by DMI (The Danish Meteorological Institute) for the period 1986-04-23 to 1986-05-09. A selection of fields from this period was stored on magnetic tape. Analyzed fields were stored every 6 hour (00, 06, 12, 18 GMT). 3 and 6 hour forecasts starting at 00, 06, 12 and 18 GMT were also stored. The various fields available from the tapes are listed in Table C.4.1.

The winds from the lowest model level in HIRLAM corresponding to approximately 30 m was used for the first level in the dispersion model (0-75 m). For the second and third layers winds from level 14 and 12 in HIRLAM were used. These levels correspond to approximately 350 and 1350 m respectively. Roughness, 10 m wind, surface and 2 m temperature and humidity were used to derive turbulence parameters for the surface layer (friction velocity, u* and Monin-Obukhovs Length, L) and mixing height.

In addition to the meteorological information provided by the HIRLAM system, analyzed precipitation fields were used in some of the experiments. This information was drawn from (Persson et al., 1986).

Table D.4.1. Meteorological fields available from the HIRLAM run over the period 1986-04-23 to 1986-05-09.

Parameter	**WMO code***	**Note**
Surface pressure	101	
Geopotential	102	
Temperature	104	16 model levels + soil, surface and 2 m
Humidity	112	16 model levels + 2 m
Horizontal wind, x-component	123	16 model levels + 10 m
Horizontal wind, y-component	124	16 model levels + 10 m
Soil wetness	147	3 soil levels
Stratiform precipitation	150	6 hour forcast in case of analyzed fields
Snow cover	151	
Convective precipitation	153	6 hour forcast in case of analyzed fields
Sea surface temperature	161	
Roughness	180	
Fraction of land	181	
Fraction of ice at sea	183	
Albedo	184	

*These codes are from an old code table. WMO has recently issued a revised table.

D.5 RADIOLOGICAL DATA

The judgment of the quality of the simulations performed in this study was made using the radiological data compiled by Persson et al. (1986). Figure D.4.1 shows the available observations of 137Cs over Scandinavia for the period April 27th to 30th. Figure D.4.2 shows the measured total (wet+dry) deposition of 137Cs over Sweden. According to the observations the plume reached Sweden during April the 27th. The plume arrived to eastern Götaland during the morning while the arrival to eastern Svealand was later during the afternoon and evening. During the 28th the plume was located over central Sweden and southern Norway. When rain fell during the night to the 29th it caused substantial deposition of 137Cs in parts of eastern Svealand and southern and central Norrland (Fig. D.4.2). On the 29th the concentrations started to decrease and continued to decrease on the 30th. A second episode of enhanced concentrations of 137Cs was observed over southern Sweden during May the 8-10th.

D.6 RESULTS

Several experiments were run in order to test different aspects of the modeling system and input meteorological data. The experiments together with their characteristics are listed in Table D.6.1.

Table D.6.1. Model experiments performed.

Experiment	Characteristics
Operational03	Mixing height and turbulence parameters calculated from meteorological input data. Analyzed and forcast windfields used in combination to get the best temporal (3 hour) resolution of the windfield. Forcast precipitation.
Precipitation03	Same as Operational03 but with analyzed precipitation for the period 86-04-27 - 86-04-30 (see text).
Precipitation06	Same as Precipitaton03 but for analyzed windfields (6 hour time resolution).
Surface03	Prescribed diurnal and seasonal variation of turbulence parameters. Mixing height determined from observed temperature stratification along the transport path, otherwise same as Precipitation03.

D.6.1 Operational03 experiment

The setup used for the Operational03 experiment is almost the same as would be used in a real time emergency situation. The main difference is that longer forecast periods would be used in the real time case. A better temporal resolution (1 hour) would probably also be available.

D.6.1.1 Air concentrations and deposition, Operational03 experiment

Figure D.6.1 shows the evolution of the surface concentration field of 137Cs at 24 hour intervals from the time of the accident to April the 29th. The arrival of the plume to the east coast of Svealand on April 27th is in good correspondence with the measurements in Stockholm (Persson et al., 1986). The simulated plume appears however, to be located too far to the east and north and does not reach southern Sweden were enhanced concentrations were measured on the 27th. On the 28th the calculated concentrations over southern Sweden are still lower than observed. Over Svealand on the other hand the calculated concentrations are higher (by at least a factor of two) than observed. The calculated plume extends quite far to the west on the 28th but not as far as observed over southern Norway. On the 29th the calculated concentrations over Sweden are lower in agreement with the observations, but the higher concentrations over southern Norway can not be found in the simulations.

Figure D.6.2a-b shows the calculated accumulated total deposition for the period 1986-04-25 to 1986-04-30 and for the whole period of simulation (1986-04-25 to 1986-05-09). Accumulated dry and wet deposition for the whole period is shown in Figure D.6.2c-d. For this experiment the maximum calculated deposition over Sweden is too small and located too far south. The calculated deposition over eastern Svealand is of about the observed magnitude (c.f. Fig. D.4.2), but the deposition along the coast of southern Norrland is much lower than observed. It is interesting to note the large deposition values calculated close to the reactor site. This high deposition is due mainly to wet deposition (Fig. D.6.2) in convective showers on the 26th. Although a few isolated showers were observed in this area the precipitation amounts calculated there by the HIRLAM model are much larger than observed.

The differences between the observed and calculated concentration and deposition fields noted above are probably due to a combination of:

a) inaccurate wind fields

b) inaccurate precipitation fields

As discussed by (Persson et al., 1986), the generally weak winds prevailing in the Chernobyl area at the time of the accident makes the calculations especially sensitive to errors in the wind fields. Also during the first night after the initial explosion a strong wind band appeared at around 500 m altitude. An accurate simulation of this wind band is probably of great importance for bringing the plume to the west during the first night after the explosion. Since the network of upper air observations is sparse it is likely that the strength of this wind band is not accurately represented in the HIRLAM wind analysis.

D.6.2 Precipitation03 experiment

To investigate the importance of the precipitation estimates calculations were made using analyzed precipitation fields based on a large number of precipitation stations, over the Scandinavian part of the model domain. Analyzed daily precipitation fields for the period 1986-04-27 to 1986-04-30 were drawn from (Persson et al., 1986). The precipitation was distributed over three hour intervals according to synoptic observations. Over the remaining part of the model domain the precipitation was set to zero. This is a good approximation judging from observations along the transport path of the radioactive cloud (Persson et al., 1986). For the period after April the 30th model calculated (HIRLAM) precipitation was used.

D.6.2.1 Air concentrations and deposition, Precipitation03 experiment

Figure D.6.3 shows the evolution of the surface concentration field of 137Cs at 24 hour intervals from the time of the accident to April the 29th. The concentration fields for April the 26th and 27th are very similar to those for the Operational03 experiment (Fig. D.6.1) although the surface concentrations are higher and the arrival time to the Swedish east coast somewhat earlier. On the 28th and 29th the differences are larger and the plume extend much further to the north and west compared to the Operational03 simulation. This results in a much more realistic total deposition field (Fig D.6.4) with a maximum along the coast of southern Norrland. The large deposition maxima close to the reactor site are eliminated and it appears that it was the model calculated precipitation in this area that spoiled the Operational03 simulation. Still the Precipitation03 simulation is by no means perfect. The calculated concentrations over Eastern Svealand are too high while concentrations over southern Sweden and Norway are too low. The maximum calculated deposition over Sweden is also too low.

The dispersion of radioactivity to western Europe will not be discussed in detail here but it appears as if the calculated plume does not extend as far west as observed. However, the second episode during May the 8-10th when enhanced concentrations of 137Cs were observed over southern Sweden is captured by the model (not illustrated).

D.6.3 Precipitation06 and Surface03 experiments

Two additional experiments were performed to test different aspects of the modeling system. The Precipitation06 experiment was made to investigate the impact of using six instead of three hourly wind fields. The Surface03 experiment was made to see the effect of prescribing the mixing height based on observed temperature soundings along the path of the radioactive cloud. The concentration and deposition fields resulting from these two experiments are documented in Figure D.6.7-D.6.9. The differences compared to the Precipitation03 simulation are small in both cases. Although some improvement of the movement of the plume during the first day of transport can be noted when changing from six to three hourly wind fields. For the episode discussed in this study it therefore seems that the results are not critically dependent on the temporal resolution (three or six hours) of the wind field. Also the model derived mixing heights are similar to those obtained from observed temperature profiles.

D.7 DISCUSSION

In this study a first attempt has been made to validate the MATCH dispersion modeling system on the European scale using data from the Chernobyl episode. The results indicate the ability of the model to capture major features of the observed concentration and deposition fields of 137Cs over Scandinavia. The study was focused on the initial dispersion from Chernobyl when the radioactive cloud affected Scandinavia. Several alternative simulations were performed to study the sensitivity of the modeling system to different model assumptions and input data. A detailed assessment of the quality of the model for the Chernobyl case is difficult to achieve. This is due both to uncertainties in the emission estimates and lack of observational data. It is evident however, that significant discrepancies exist between the model results and observed data.

Using only meteorological information from the HIRLAM run, the calculated plume appears to be located too far to the east and north during the initial part of the episode when the radioactive cloud affected Scandinavia. This results in too low concentrations over southern Sweden and Norway and too high concentrations over eastern Svealand. The calculated deposition over Sweden is located too far south.

Using observed instead of model calculated precipitation for the first part of the episode improves the simulation results over Scandinavia considerably. The resulting deposition field over Sweden is in much better agreement with observations. This result emphasizes the critical importance of the precipitation fields when simulating the dispersion from accidental releases.

Although using observed precipitation improves the simulation the plume is still located too far east and north and the calculated concentrations over eastern Svealand too high. The effect of changing the temporal resolution of the wind field from three to six hours or prescribing the mixing height from observed temperature profiles are small and the discrepancies remain.

Several factors may contribute to the noted disagreement between model calculations and observations. The possibility that the HIRLAM wind analysis did not capture a low level wind band on the night of the accident may be of importance. Trajectories calculated using wind fields from ECMWF indicate a more southerly transport path than obtained here.

Another important factor may be that the present dispersion model only has two layers to describe the transport in the boundary layer. While this saves computer time it also means that the model can not make use of the wind fields at all the levels provided by HIRLAM (every second layer was used in this study). Since the winds in adjacent layers usually differs somewhat this can lead to underestimation of the spread of the plume.

The temporal resolution of the wind fields may also be of importance. Some improvement of the movement of the plume during the first day of transport could be noted when changing from six to three hourly wind fields. An even better temporal resolution might have improved the simulations.

Finally, the tendency towards too high concentrations in the areas affected by the calculated plume could in part be due to lack of a description of vertical transport in convective clouds in the model. During daytime the first days after the accident the convective activity was strong over White Russia. The convection mixed the plume to higher levels in the atmosphere. The effect of this mixing is two-fold. The concentrations near the surface are reduced, and the transport takes a different direction due to different winds at higher levels. Attempts will be made to include this process in future versions of the dispersion model.

D.8 ACKNOWLEDGMENTS

Financial support for this study was received from the National Institute for Radiation Protection in Sweden and from Nordic Nuclear Safety Research program.

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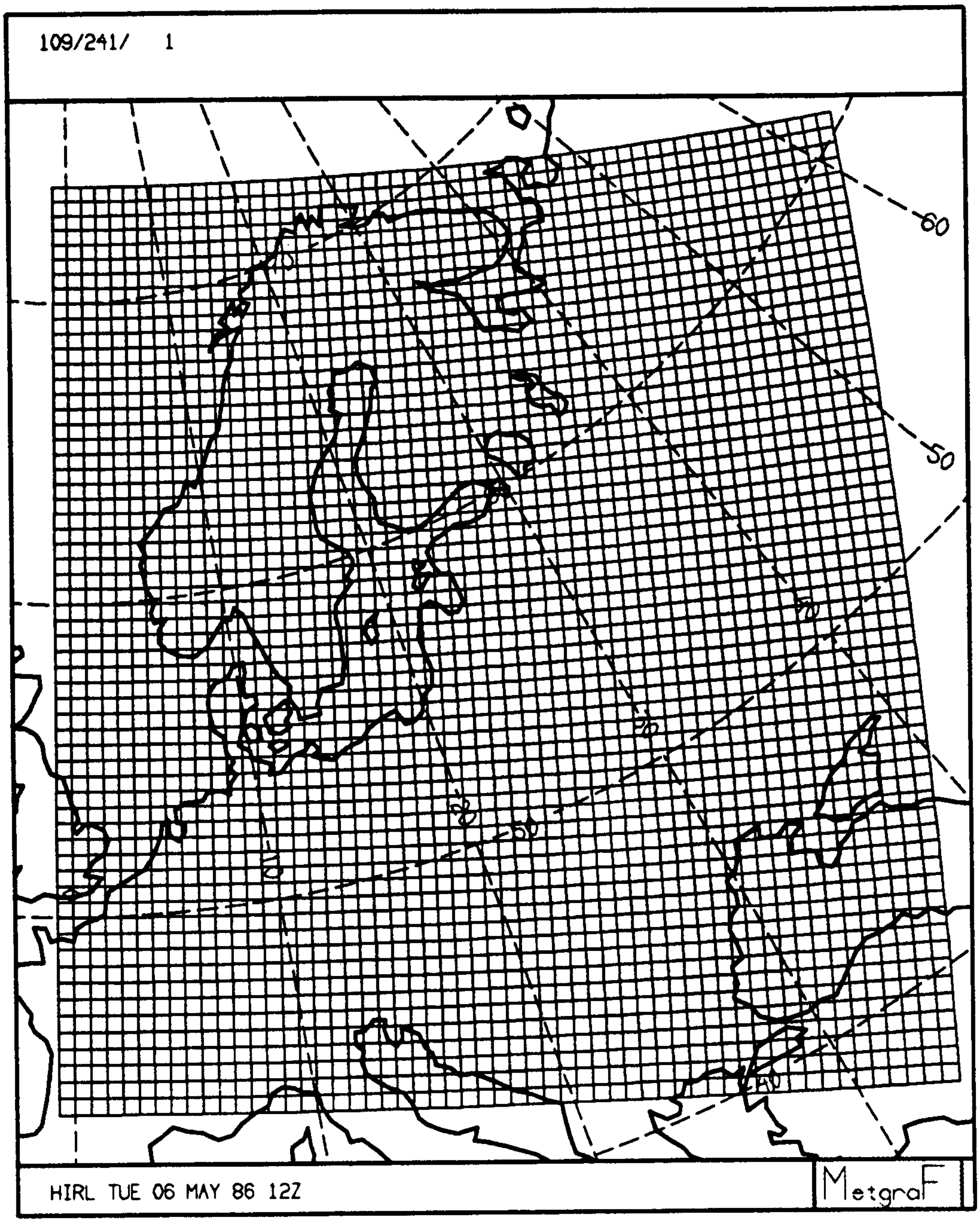

Figure D.2.1 Coverage and horizontal grid used in the dispersion model.

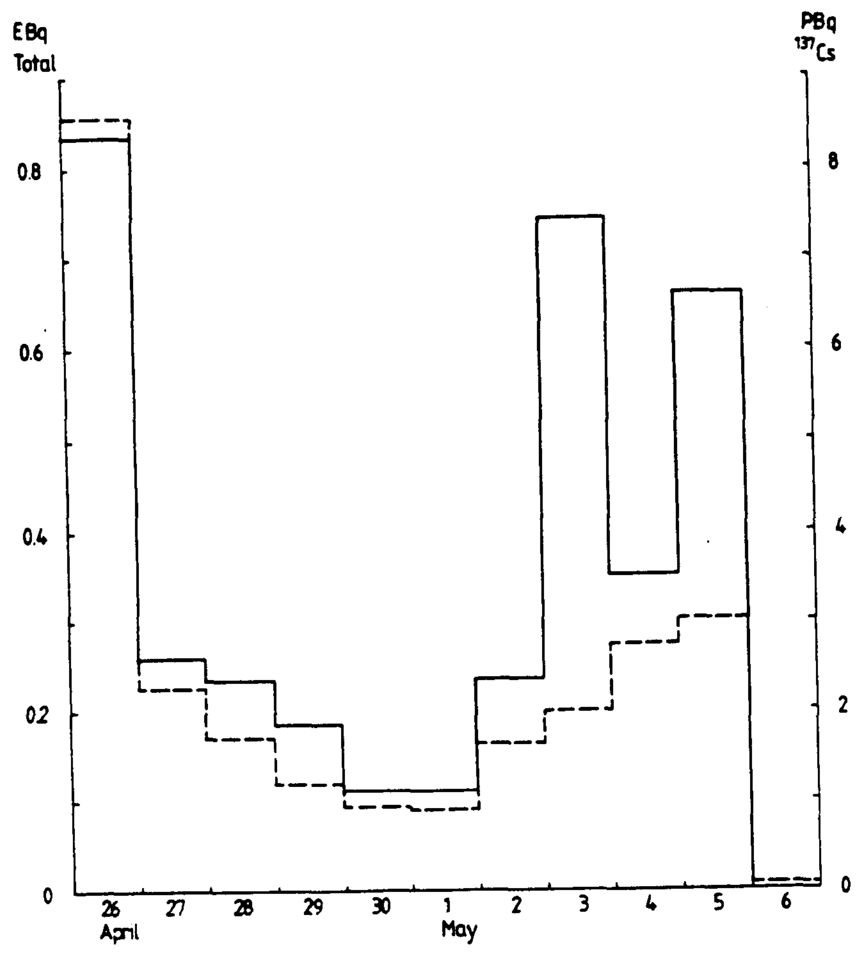

Figure D.3.1 Daily emissions from Chernobyl 4 according to the Soviet report to IAEA. The broken line indicates the total activity excluding inert gases (left-hand scale) while the solid line indicates the emissions of 137Cs (right-hand scale). (From Persson et al., 1986).

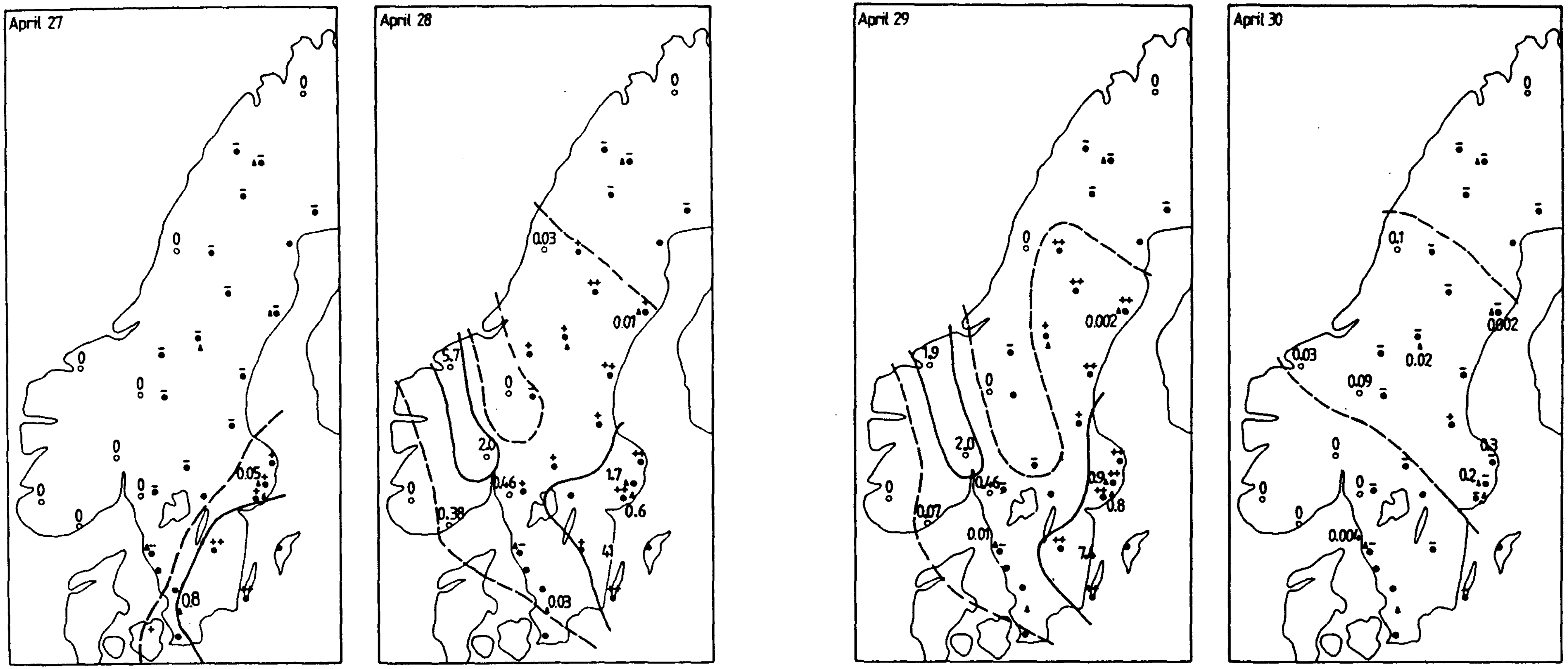

Figure D.4.1 Schematic chart of 137Cs air concentration near the ground. Available measured concentrations (Bq m-3) are marked. In addition the gamma radiation at SSI stations marked with a solid circle is indicated as follows:

- \- = no change or a reduction since the preceding day
- \+ = slight increase since the preceding day
- ++ = large increase since the preceding day

In the outline chart, --- indicates "slightly increased" concentration of 137Cs and --- "higher" concentration. The survey covers the period 27-30 April.
(From Persson et al., 1986).

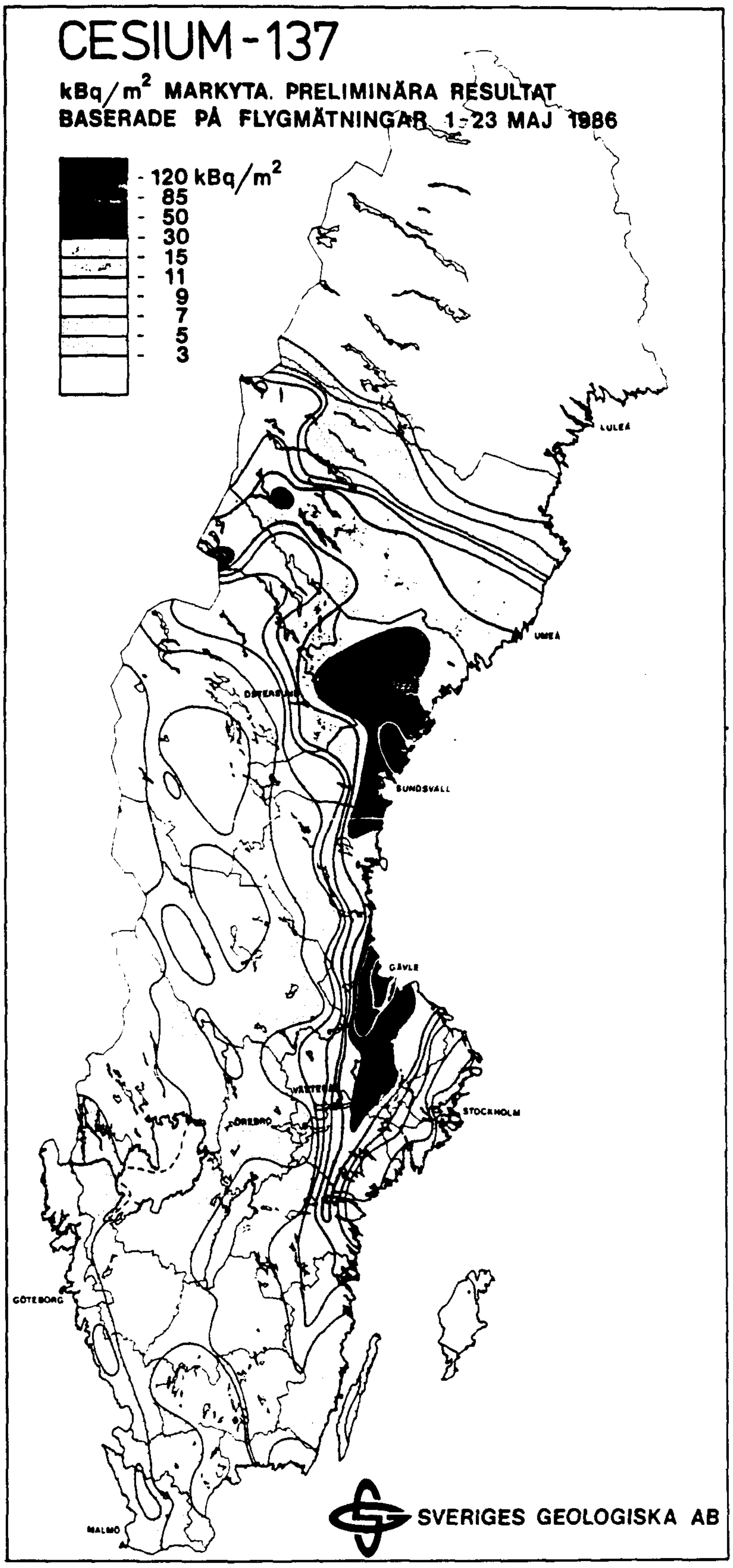

Figure D.4.2 Recorded deposition of 137Cs over Sweden. Measurements made by the Swedish Geological Company. (From Persson et al., 1986).

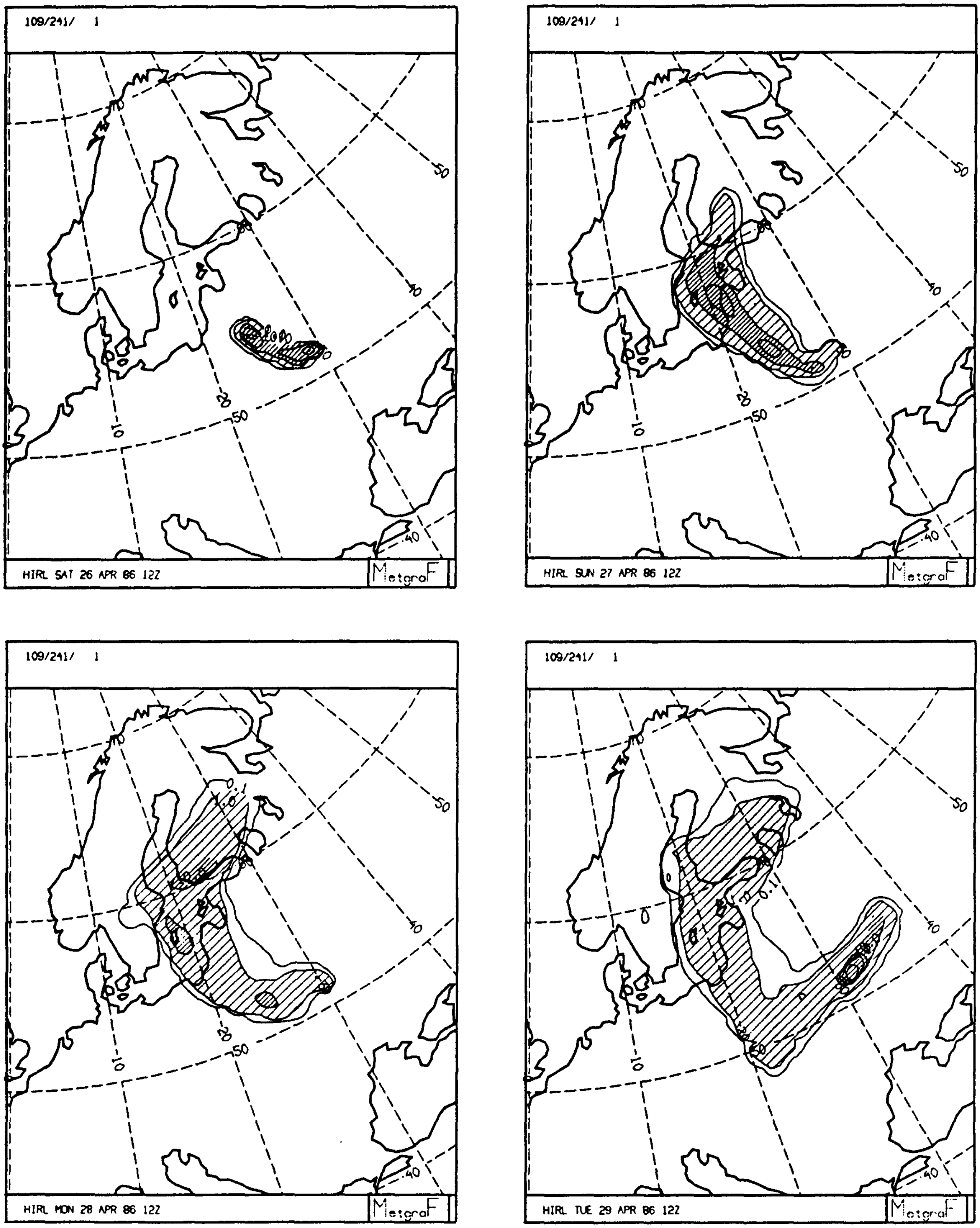

Figure D.6.1 Calculated surface concentrations of 137Cs for the Operational03 experiment. The maps show the concentration at 12 GMT for April the 26-30th. Isolines are: 0.1, 1, 10, 25, 50, 100 Bq m-3. Light shading for values larger than 1 and heavy shading for values larger than 10 Bq m-3.

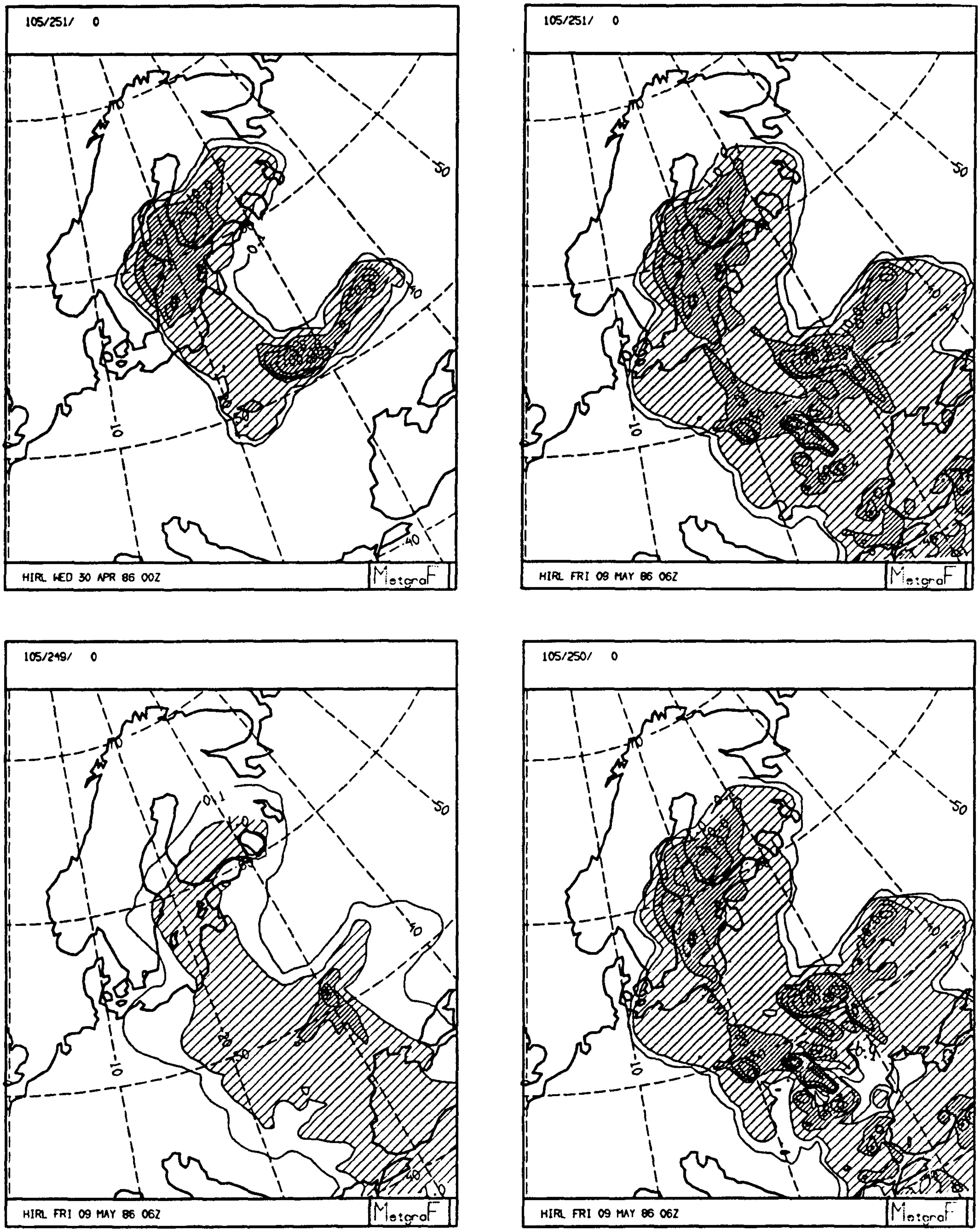

Figure D.6.2 Calculated deposition of 137Cs for the Operational03 experiment.
a) Accumulated total deposition 1986-04-30,
b) Accumulated total deposition 1986-05-09,
c) Accumulated dry deposition 1986-05-09 and
d) Accumulated wet deposition 1986-05-09.
Isolines are: 0.1, 1, 10, 25, 50, 100 kBq m-2. Light shading for values larger than 1 and heavy shading for values larger than 10 kBq m-2.

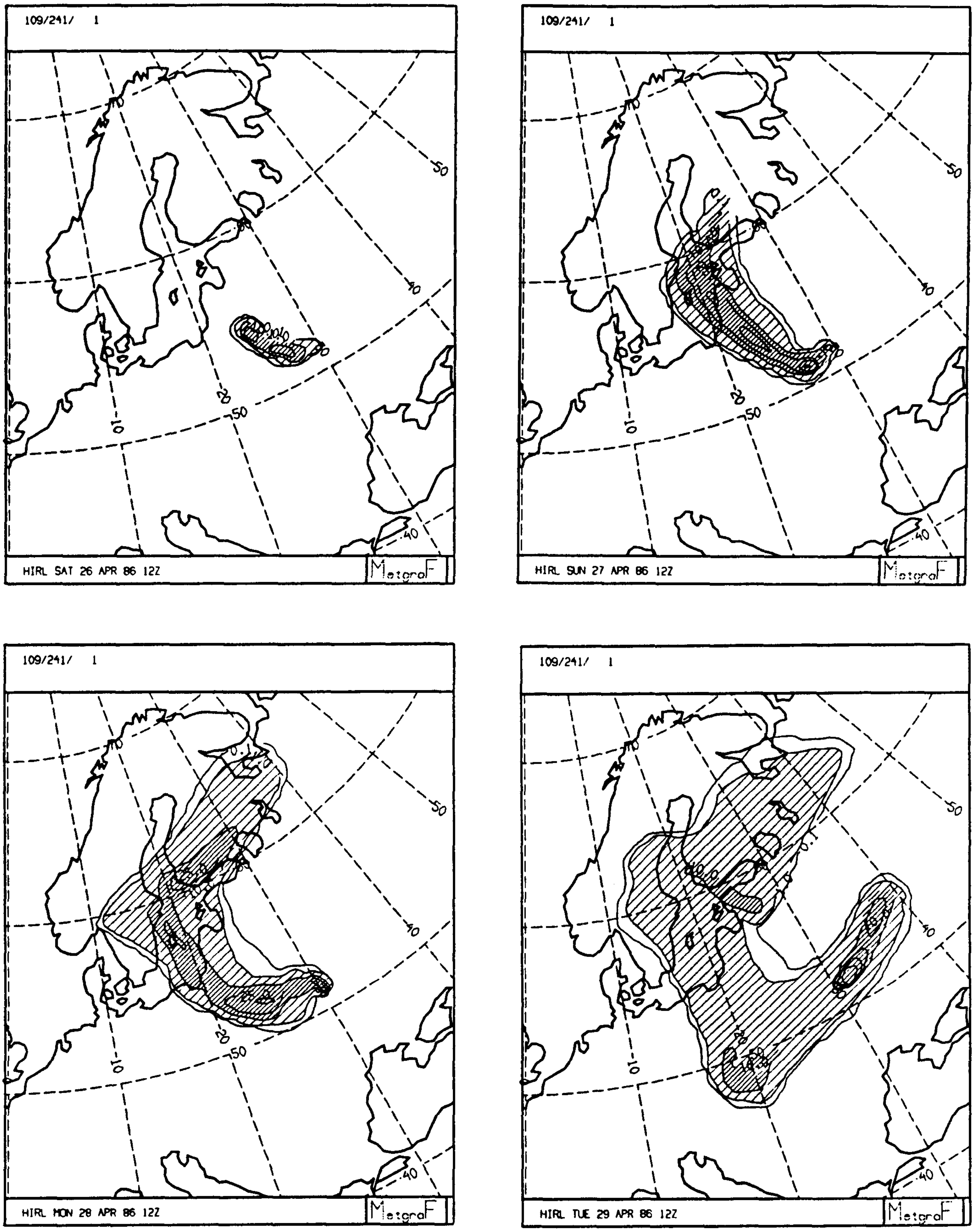

Figure D.6.3 Calculated surface concentrations of 137Cs for the Precipitation03 experiment. The maps show the concentration at 12 GMT for April the 26-30th. Isolines are: 0.1, 1, 10, 25, 50, 100 Bq m-3. Light shading for values larger than 1 and heavy shading for values larger than 10 Bq m-3.

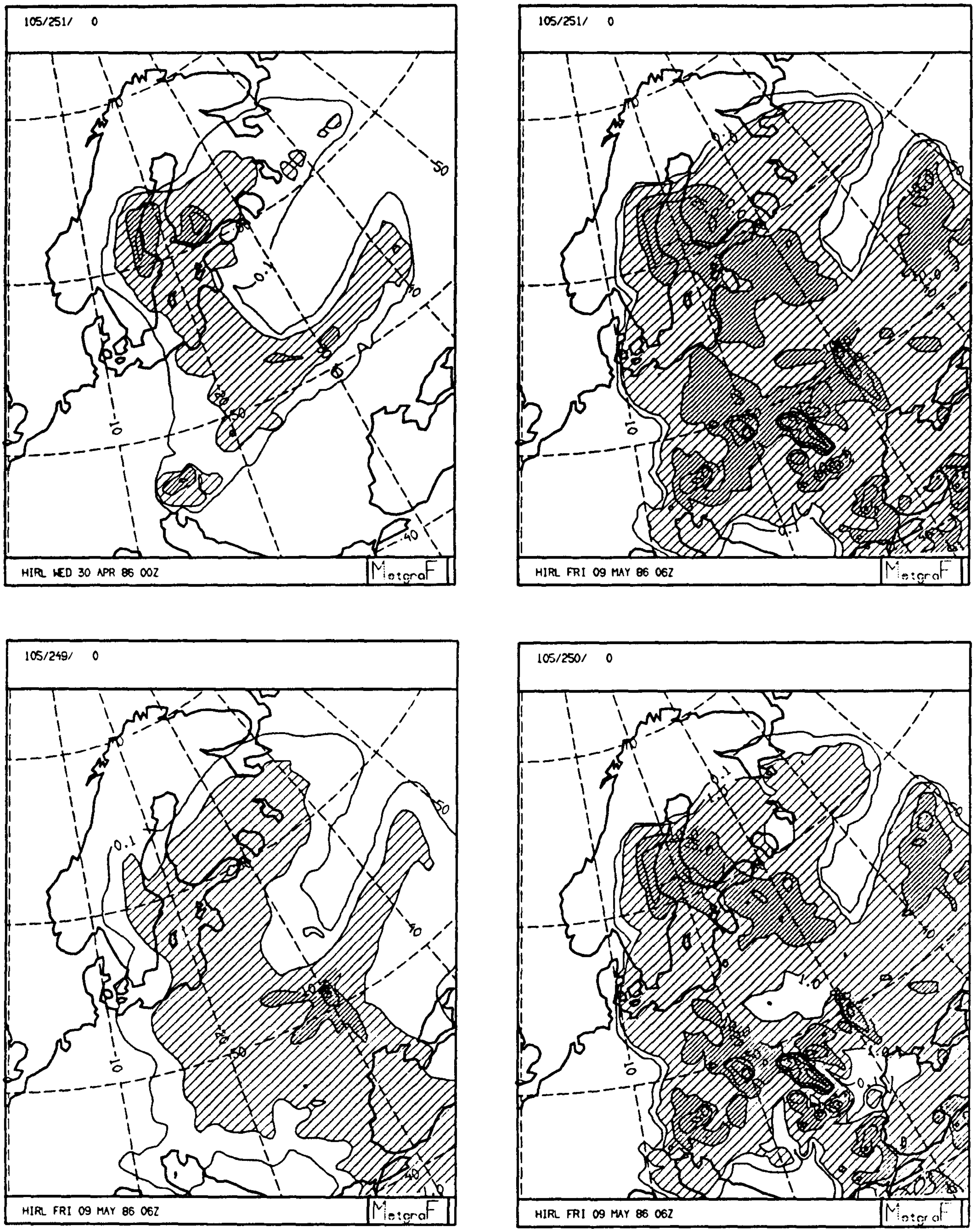

Figure D.6.4 Calculated deposition of 137Cs for the Precipitation03 experiment. a) Accumulated total deposition 1986-04-30, b) Accumulated total deposition 1986-05-09, c) Accumulated dry deposition 1986-05-09 and d) Accumulated wet deposition 1986-05-09. Isolines are: 0.1, 1, 10, 25, 50, 100 kBq m-2. Light shading for values larger than 1 and heavy shading for values larger than 10 kBq m-2.

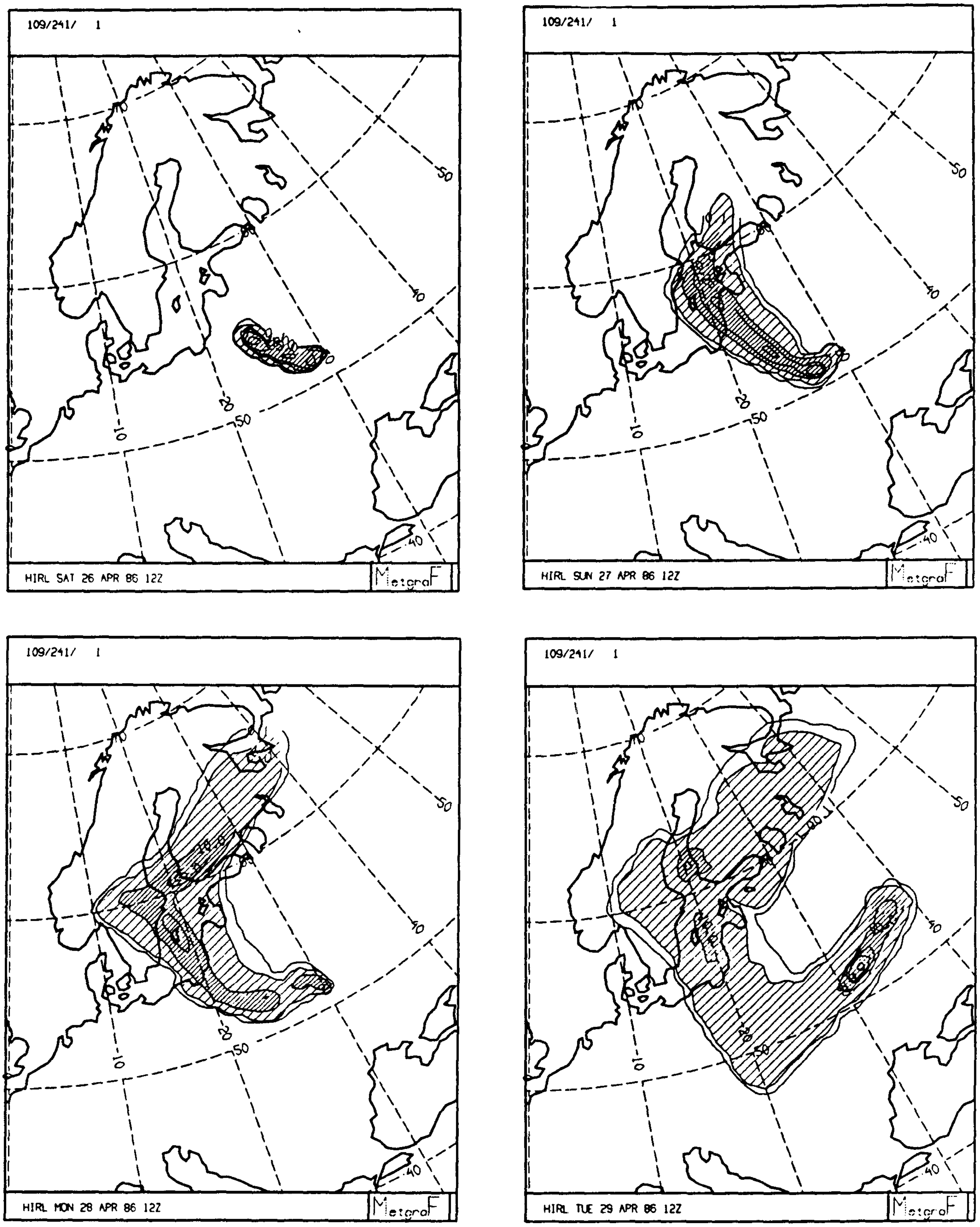

Figure D.6.5 Calculated surface concentrations of 137Cs for the Precipitation06 experiment. The maps show the concentration at 12 GMT for April the 26-30th. Isolines are: 0.1, 1, 10, 25, 50, 100 Bq m-3. Light shading for values larger than 1 and heavy shading for values larger than 10 Bq m-3.

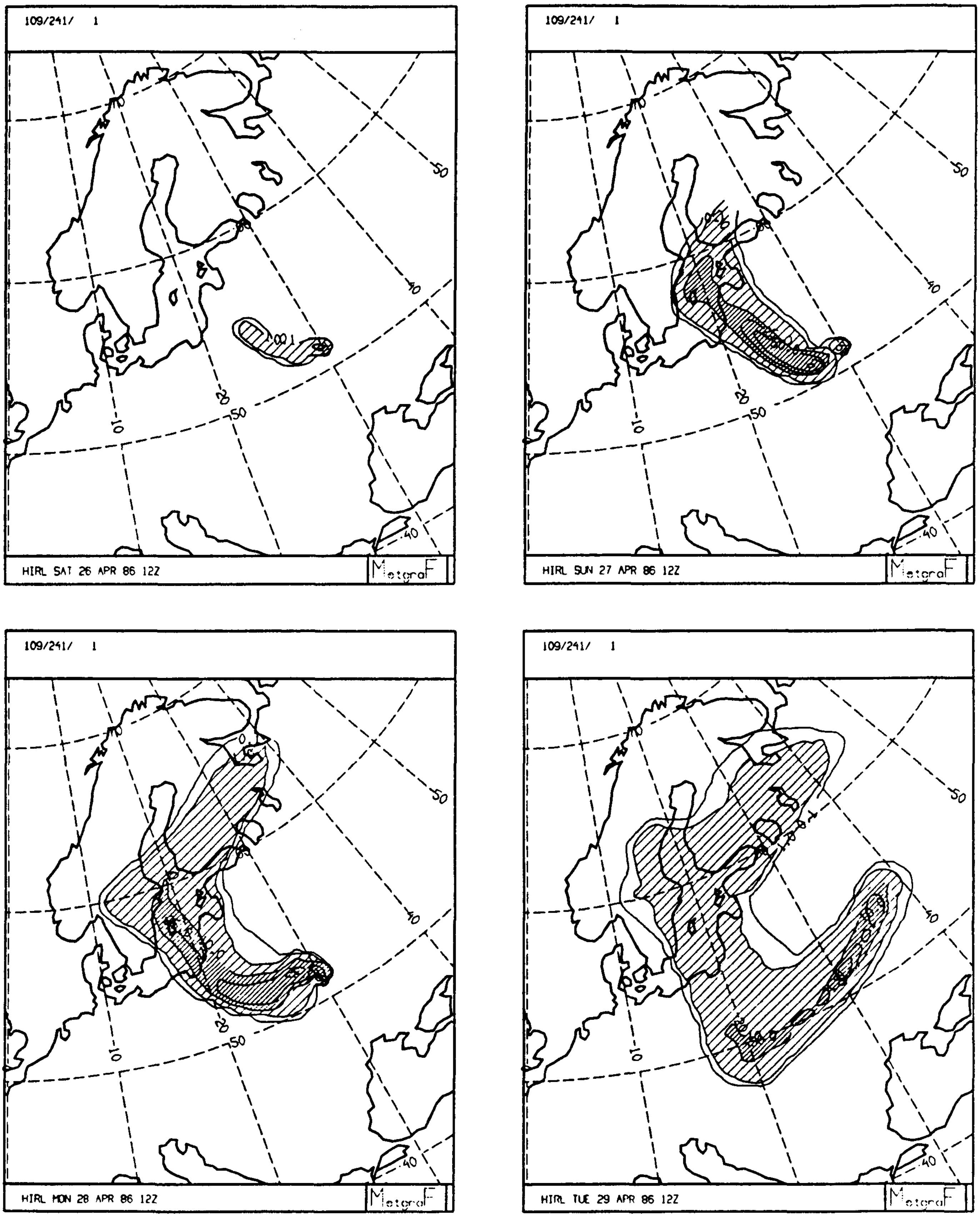

Figure D.6.6 Calculated surface concentrations of 137Cs for the Surface03 experiment. The maps show the concentration at 12 GMT for April the 26-30th. Isolines are: 0.1, 1, 10, 25, 50, 100 Bq m-3. Light shading for values larger than 1 and heavy shading for values larger than 10 Bq m-3.

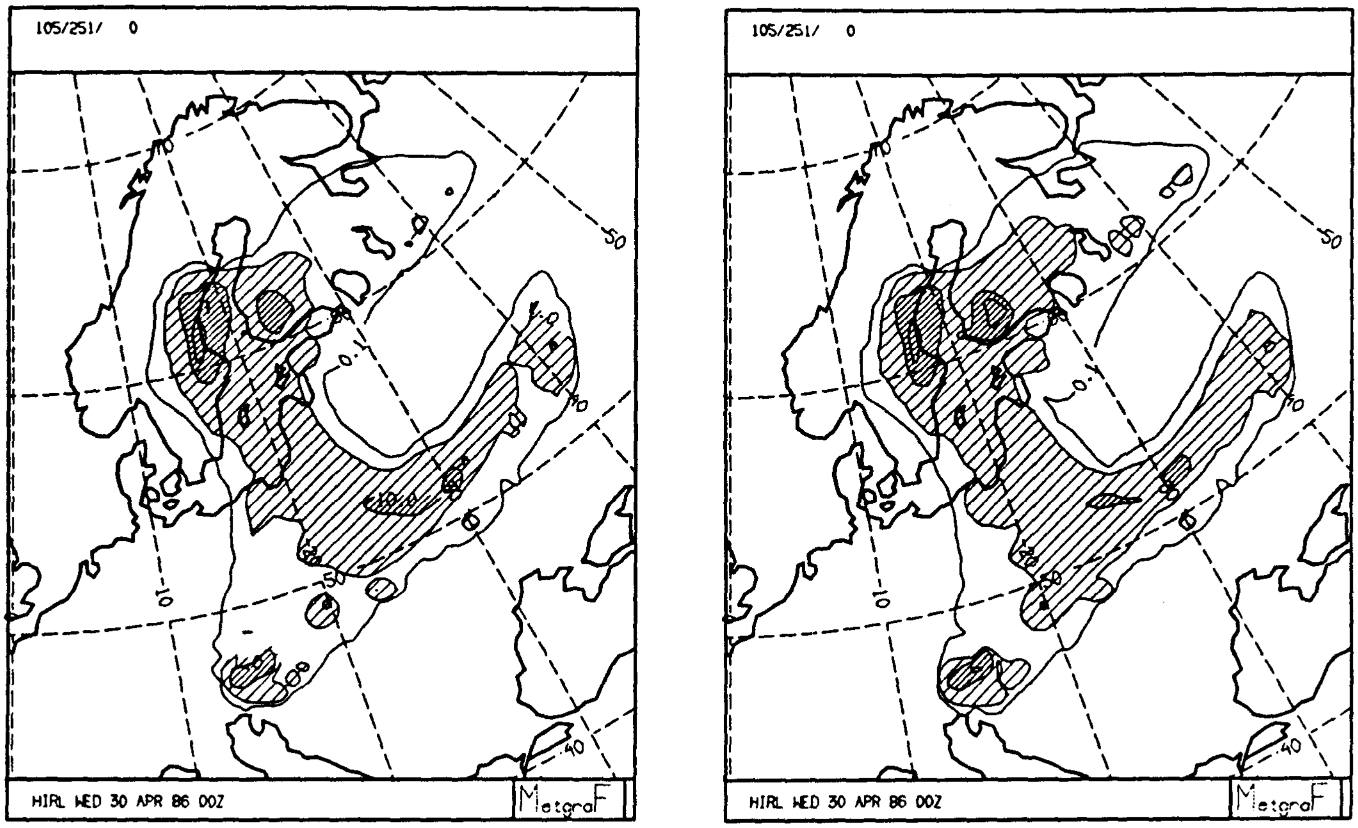

Figure D.6.7 Calculated accumulated total deposition 1986-04-30 of 137Cs for the Surface03 experiment (left) and b) the Precipitation06 experiment (right). Isolines are: 0.1, 1, 10, 25, 50, 100 kBq m-2. Light shading for values larger than 1 and heavy shading for values larger than 10 kBq m-2.

Appendix DD

USING A COMBINATION OF TWO MODELS IN TRACER SIMULATIONS

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ABSTRACT

The use of a combination of two models, a Lagrangian meso-scale model and a long-range transport Eulerian model, in a model for studying the air pollution caused by a single but strong emission source is discussed. It is explained why it is worthwhile to apply a combination of two models in such a situation. The rules that can be used in the coupling procedure are described. The reliability of the combined model is tested both by using the well-known rotation test and by applying it to study the Chernobyl accident. The results obtained by the combined model are visualized by using modern graphic tools. The distribution of the radioactivity from the Chernobyl accident has been animating by producing a short movie that shows the levels of the radioactivity in Europe after the accident. The plans for the future research are briefly discussed.

ACKNOWLEDGEMENTS

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DD.1 WHY IS A COMBINATION OF TWO MODELS NEEDED?

Sometimes it is necessary to study long-range transport from a single but strong emission source. The radioactive accidental releases from nuclear power stations (for instance, the Chernobyl catastrophe in April 25 1986) are typical situations where such studies are needed. Models for studying long-range transport and dispersion from single and strong sources will be called tracer models in this report.

It is not an easy task to develop a reliable tracer model. The traditional Eulerian models have difficulties to deal with this situation, because a single strong source creates rather sharp gradients. Therefore it is important to carry out some of the computations with a short-scale (or meso-scale) model that can describe in a reliable way the transport in a relatively small sub-domain around the emission source. The sub-domain should be sufficiently large, so that the gradients of the concentrations obtained by the short-scale (meso-scale) model are not very sharp. If this procedure is properly done, then a large-scale Eulerian model can be used to calculate the long-range transport in the whole space domain of interest.

A simple test-example can be used in order to illustrate the fact that a large-scale Eulerian model cannot be used if the emission is coming from a strong point-source. This test is a simple modification of the well-known rotation puff test that has been proposed simultaneously by Crowley and Molenkampf in 1968 ([5],[17]) and used in many hundreds of scientific publications after that (see, for example, [2]-[4], [7], [10], [12] [18]-[20], [23]). The idea is very simple. A velocity field, in which the trajectories of the winds are concentric circles around the centre of the space domain, is defined. Moreover, the velocity field should have a constant angular velocity. Assume now that the concentrations in the whole space domain G, excepting some sub-domain $G_1 \subset G$, are equal to some background concentration c_0. Assume also that the concentrations in G_1 are different from c_0 (say, much higher than c_0). If the above conditions are satisfied, then it is clear that after some prescribed time t_1 (which can be calculated exactly) the parcels containing high concentrations will accomplish a full rotation around the centre of the space domain and will return at the same place where these were at the starting time t_0. The advantages of using such a test-problem are clear:

(1) its analytic solution is known,

(2) the trajectories, along which the concentrations are transported, are not trivial (the transport is not carried out along straight lines, but along circles).

Therefore such a test-problem is very useful and the accuracy of the advection algorithms that are implemented in the model could be checked by using such a test-problem.

The Crowley-Molenkampf puff-test is defined by

(1.1) $\partial c/\partial t = -(y-1)\,\partial c/\partial x - (1-x)\,\partial c/\partial y,$

where

(1.2) $x \in [0,2]$, $y \in [0,2]$, $t \in [0,2\pi]$.

Note that the wind velocities in (1.1), $u = y-1$ and $v = 1-x$, are very special. When the wind velocities are defined in this way, the requirements stated above are satisfied. That is, (1) the wind trajectories are circles around the centre of the domain ($x_1=1$, $y_1=1$) and (2) the motion is performed with a constant angular velocity.

The initial distribution, $c(x,y,0)$, can be defined in many different ways. The distribution given below has been used in many papers; see, for example, Crowley [5], Molenkampf [17], Zlatev et al. [23], as well as the references in the last paper.

Consider the space domain G that is defined by (1.2) and assume that the sub-domain G_1 is a circle defined by its centre $x_0=0.5$, $y_0=1.0$ and its radius $r=0.25$. The distance from an arbitrary point (x,y) to the centre of G_1 is given by

(1.3) $r^* = [(x-x_0)^2+(y-y_0)^2]^{0.5}$.

Then the initial distribution of the concentrations can be introduced by

(1.4) $c(x,y,0) = c_0+99c_0(1-r^*/r)]$ as $r^* < r$ and $c_0 > 0$

on G_1 and by

(1.5) $c(x,y,0) = c_0$ as $r^* \geq r$,

on $G - G_1$, where c_0 is some background concentration; $c_0 = 0$ is often used in the experiments. If $c_0=0$, then $100(1-r^*/r)$ should be used in the right-hand side of (1.4).

The puff test described above can easily be modified to handle a plume.

(1.6) $\partial c/\partial t = -(y-1)\,\partial c/\partial x - (1-x)\,\partial c/\partial y + E(x,y,t)$,

The initial distribution of the concentrations can be defined by

(1.7) $c(x,y,0) = c_0$ for $\forall\, x \in [0,2]$ and $\forall\, y \in [0,2]$

when one or several sources are introduced in the space domain of the model.

Assume that only one source is to be used. Then it could be introduced as follows:

(1.8) $E(x,y,t) = 100a(1-r^*/r)$ as $r^* < r$,

where a is a constant chosen so that the concentrations at the top of the plume have the same order of magnitude as the concentration at the top of the cone in the previous test example, and

(1.9) $E(x,y,t) = 0$ as $r^* \geq r$.

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If the sub-domain G_1 is sufficiently large (or, in other words, if r is sufficiently large), then a long-range transport model will be able to describe well the rotation of the plume defined by (1.6)-(1.9). In the case where

(i) the Danish Eulerian model, see [8], [22], [24] and [25], is used

and

(ii) the radius of G_1 is r=0.41,

the fact that the transport can be described very well is demonstrated in Fig. DD.1. The results shown in Fig. DD.1 (as well as the results shown in Fig. DD.2 - Fig. DD.4) are obtained by discretizing the regions with a 32x32 grid.

Consider now the situation where the sub-domain G_1 is approximately 20 times smaller (r=0.09). Then the Danish Eulerian model has problems. This is demonstrated in Fig. DD.2. It should be noted that any Eulerian model handled by traditional numerical methods will have problems in this situation.

The performance of the Danish Eulerian Model could be improved either if some kind of smoothing is used or if some diffusion is added in (1.6). The effect of filtering is shown in Fig. DD.3, which is obtained by a filter similar to that used in the well-known Forester algorithm (see [6], [12]). The effect of using diffusion is shown in Fig. DD.4. It is seen that the results are indeed improved in both cases. At the same time, however, it should be admitted, that the results are still far from satisfactory. Therefore it is worthwhile to use a combination of two models in the latter case. The RIMPUFF model ([13]-[16], [21]) and the Danish Eulerian Model ([8], [22], [24] and [25]) will be used in this study. Combinations of other models can also be applied.

Appendix DD

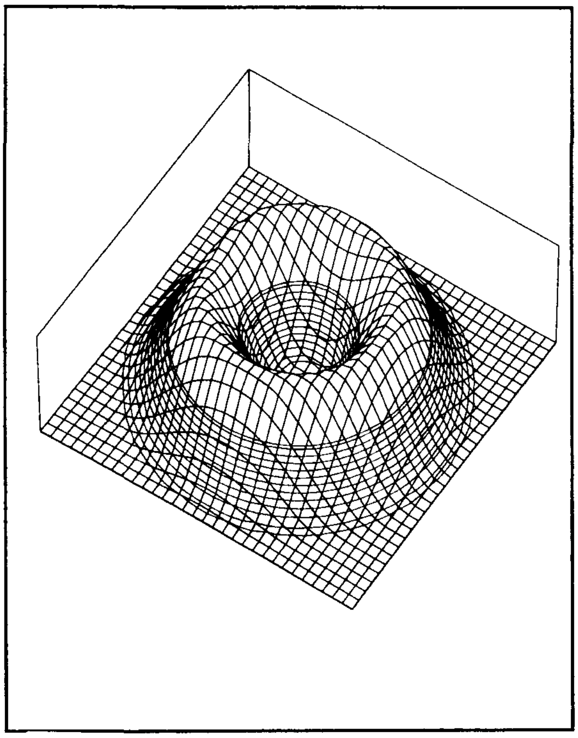

Figure DD.1
Rotation of plume (r=0.41).

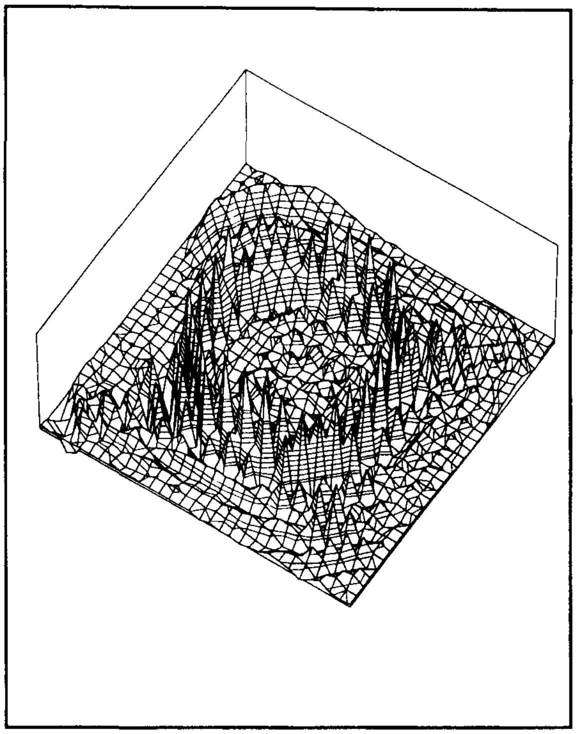

Figure DD.2
Rotation of plume (r=0.09).

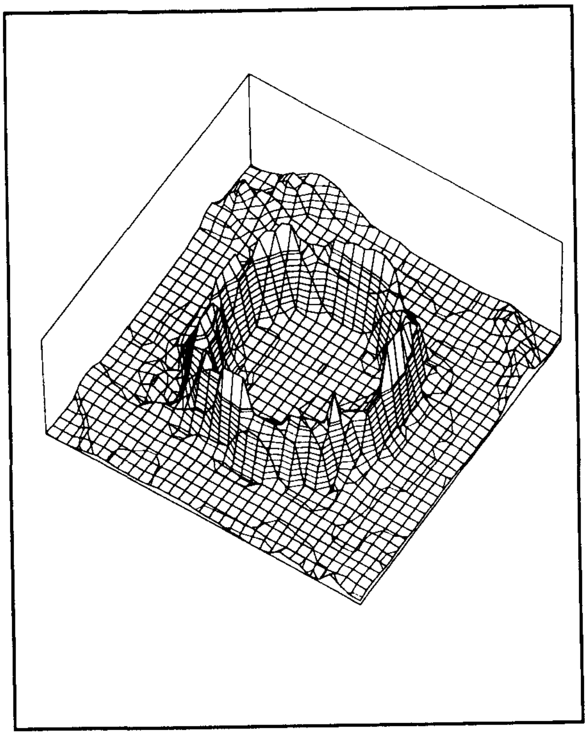

Figure DD.3
Rotation of plume (r=0.09);
with filtering, no diffusion

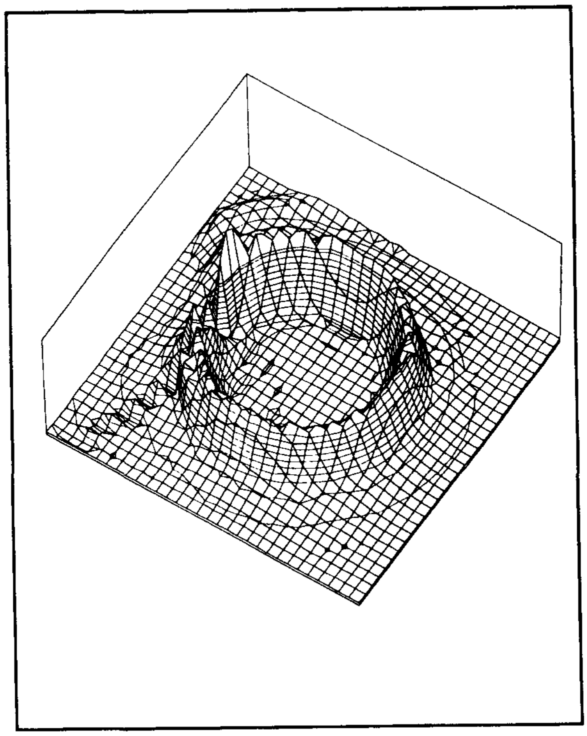

Figure DD.4
Rotation of plume (r=0.09);
with diffusion, no filtering

DD.2 SPACE DOMAINS OF THE TWO MODELS

Both models, RIMPUFF and the Danish Eulerian Model, as well as the combined model are rather flexible and can be used on different space domains. In the case where tracer studies of situations in Europe are of interest, it is appropriate to use a space domain that contains the whole continent of Europe together with some neighbouring parts (parts of Africa, Asia and the Atlantic Ocean) for the Danish Eulerian Model. The sub-domain G_1 where RIMPUFF is used is determined by the location of the emission source studied; there is a requirement to put the emission source in the centre of the sub-domain. It should be mentioned that in this section the sub-domain G_1 is a square. The actual sizes of the domains used in the two models are given in Table DD.1.

Model	Area
RIMPUFF	G_1 = 325 km x 325 km
Danish Eulerian Model	G = 4800 km x 4800 km

Table DD.1
The space domains of the two model when European sources are studied.

It should be emphasized that the part of the space domain used in RIMPUFF is relatively small compared with the space domain used in the Danish Eulerian Model; see Table DD.2. This is necessary, because the work with RIMPUFF is only needed in order to calculate the plume in the sub-domain G_1 (or, in other words, to smooth the concentrations emitted from the source and to prepare them to be used in the Danish Eulerian Model). The whole concentration field in the space domain G is after that calculated by the Danish Eulerian Model. Such a double action is normally carried out at every time-step. This means that the calculations on the whole space domain are the basic part of the computational work. The global computational work is minimized when the sub-domain is as small as possible (but large enough to smooth the field that has to be used by the Danish Eulerian Model).

Measured quantity	Relative part of the small area	The small area in percent
G_1/G	0.005	0.5%

Table DD.2

The relative part of the space domain used in RIMPUFF compared with the space domain used in the Danish Eulerian Model.

DD.3 DISCRETIZATIONS USED IN TREATMENT OF THE MODELS

It is difficult to find the proper discretization. The use of a too fine grid during the discretization may cause difficulties, because the amount of the computer time needed becomes very large in this case and, therefore, it may be difficult to run the model even if modern high speed computers are available. On the other hand, the grid should not be very coarse, because this may lead to large numerical errors. Many experiments are needed in the efforts to find proper discretizations for the two models. The results of these experiments indicate that the discretization shown on Table DD.3 seems to be a good one. These discretizations are used in the whole paper.

Discretization parameters	RIMPUFF Model	Danish Eulerian Model
Configuration	65 x 65	192 x 192
Number of grid-squares	4225	36864
Size of a grid-square	5 km x 5 km	25 km x 25 km

Table DD.3

The discretizations used when the two models are treated numerically.

It should be emphasized here that the two models are treated on different grids. The experiments showed that it is necessary to use a finer grid when the RIMPUFF Model is treated on the small area. Of coarse, it would be possible to perform the computations with the Danish Eulerian Model on the same grid. However, this will not be very efficient (with regard to the computing time used. Therefore a coarser grid is the better choice when the latter model is used. Some price has to be paid when the two models are not used on the same grid; one has to perform some kind of interpolation during the coupling procedure. However, it is much better to perform some interpolation instead of using the finer grid also when the Danish Eulerian Model is treated numerically. The results in Table DD.3 show that

25 small grid-squares in the RIMPUFF discretization correspond to one big grid-square in the Danish Eulerian Model discretization.

DD.4 MAIN PRINCIPLES USED IN THE COMBINATION OF THE TWO MODELS

Three tasks are to be performed in the end of every period of at most three hours. These tasks are described in Table DD.4. It should be noted that both the RIMPUFF Model and the Danish Eulerian Model are run with a time-step Δt that is much smaller than three hours (Δt=32s for the RIMPUFF Model and Δt=96s for the Danish Eulerian Model). This means that both the RIMPUFF Model and the Danish Eulerian Model perform many time-steps during Task 1 and Task 3 (see again Table 4). The choice of a period of three hours in the coupling procedure has been determined after some experiments. This value is chosen so that the plume both remains in the sub-domain G_1 (in the most of the cases, at least) and is sufficiently large. In the experiment with the Chernobyl data (see Section DD.7) the plume remained in G_1 after every period of three hours. If the plume reaches the boundary of G_1 after a period of less than three hours, then the calculation with the RIMPUFF Model is stopped and the coupling procedure is performed. It is perhaps possible to use other values, instead of periods of three hours (say, 2.5 or 3.5 hours).

Task	Action during the task
Task 1: RIMPUFF in action	**Compute the contributions for the sub-domain G_1 by RIMPUFF.**
Task 2: Coupling procedure	**Incorporate the contributions from G_1 into the space domain G of the Danish Eulerian Model.**
Task 3: The Danish Eulerian Model in action	**Calculate the changes of the concentrations in the whole domain G by the Danish Eulerian Model.**

Table DD.4

The computational tasks that are successively carried out at every time-step.

The main idea used during Task 2 is very simple. The concentrations calculated by the RIMPUFF Model (which are first modified for the coarser grid used in G by taking mean values over the 25 grid-squares of G_1 corresponding to one grid-square of G) are added to the corresponding concentrations calculated by the Danish Eulerian Model. The Danish Eulerian Model continues with the concentrations so obtained, while the RIMPUFF Model is re-initialized by assigning zero-concentrations to each of the small grid-squares in G_1.

If the wind-velocities are constant then the amount of computations can be reduced by using the observation made below:

If the wind velocities and the source(s) in the small area are constant during several time-steps, then Task 1 should be accomplished only during the first period of three hours (this is exploited in the experiments described in Section DD.6).

DD.5 TESTING THE RELIABILITY OF THE COMBINED MODEL

The reliability of a mathematical model is an important issue. Models are normally used to predict results in some critical situations. Therefore the reliability of any model must be checked very carefully.

The reliability of the combined model described in the previous sections depends mainly on two factors:

(i) on the reliability of the two particular models that are used in the combined model (the RIMPUFF Model and the Danish Eulerian Model)

and

(ii) on the reliability of the coupling procedure (see Section DD.4).

The reliability of the two particular models that are used in the combined model has been studied in many works; see, for example, [8], [10], [22], [24] and [25]. Therefore this issue will not be discussed in this report. On the other hand, the reliability of the combined model (of the coupling procedure) must be checked carefully, because the fact that both participating models perform well does not mean that the combined model also perform well.

Two types of experiments are commonly used in testing the reliability of a mathematical model. The first type of experiments is based on the use of typical (for the situation studied) test-examples with known analytical solution. If such an example is used, then one can compare the approximate solution calculated by the model with the analytical solution and judge the potential ability of the model to solve successfully the physical problems for which it has been developed. It is important here to have representative test-examples which are similar (in some sense, at least) to the problems that will be handled with the model. The rotation test proposed by Crowley and Molenkampf (see Section DD.1) is such a typical example.

The second type of experiments consists of problems that have been studied many times by using other models and for which some measurements are available. A typical such problem is the distribution of the radioactivity after the Chernobyl accident. This problem has been studied by many scientists; see, for example, [9], [11].

Both the rotation Crowley-Molenkampf test-example and data from the Chernobyl accident will be used in the experiments by which an attempt to verify the applicability of the combined model in some typical situations are used in the experiments which will be discussed in the following two sections.

DD.6 EXPERIMENTS WITH THE ROTATION TEST

The rotation test has been discussed in Section DD.1. It has been shown there that the Danish Eulerian Model is able to solve rather successfully this test in the case where the sub-domain where the sources are located is sufficiently large. It has also been shown there that the Danish Eulerian Model has difficulties when this sub-domain becomes small. Therefore the Danish Eulerian Model alone is not very suitable in situations where the long-range transport caused by a release of a single but strong sources is to be studied. This means that one of the first tasks is to check whether the combined model can tackle such situations.

The rotation test with a single but strong source has been used in several experiments. The RIMPUFF Model has been used in a small sub-domain with the source in its center. The results of all tests indicated that the combination of the RIMPUFF Model and the Danish Eulerian Model works satisfactorily well. The good performance of the combined model is illustrated in Fig. DD.5. It should be mentioned here that the combined model has been run in circumstances that are very similar to those in a real run with meteorological data. Therefore some diffusion has been added to the model; this means that (1.6) has been replaced by

$$(2.1) \quad \partial c/\partial t = -(y-1)\,\partial c/\partial x - (1-x)\,\partial c/\partial y + K_x\,\partial^2 c/\partial x^2 + K_y\,\partial^2 c/\partial y^2 + E(x,y,t),$$

and the rotation test has been run with

$$(2.2) \quad K_x = K_y = 90000\ m^2/sec.$$

It has also been assumed here that the same space domain as in the Danish Eulerian Model has been used, i.e. the space domain is a 4800 km x 4800 km square. This can be achieved by a simple transformation of the spatial variables, which will not be discussed here. Much more important in the context of this report is the fact that such a space domain covers the whole of Europe + parts of the Atlantic Ocean, Africa and Asia. This fact is illustrated in Fig. DD.6.

Fig. DD.6 is a two-dimensional analog of Fig. DD.5. Instead of showing the concentrations in the third dimension, the different levels of concentrations are given by different raster (different colours if a colour plot is used). In this way a part of the information is lost (comparing with the three-dimensional plot). It should be stressed that there are some advantages also. For example, the map can easily be incorporated when a two-dimensional plot is used. In this test this addition has no practical meaning. However, this is an important issue when real concentration fields obtained by the combined model are to be visualized. The importance in the latter situation is clearly shown in the figures presented in the next section; Section DD.7. The fact that it is easy to show the small sub-domain (where the RIMPUFF Model is applied) is another advantage when two-dimensional plots are properly used.

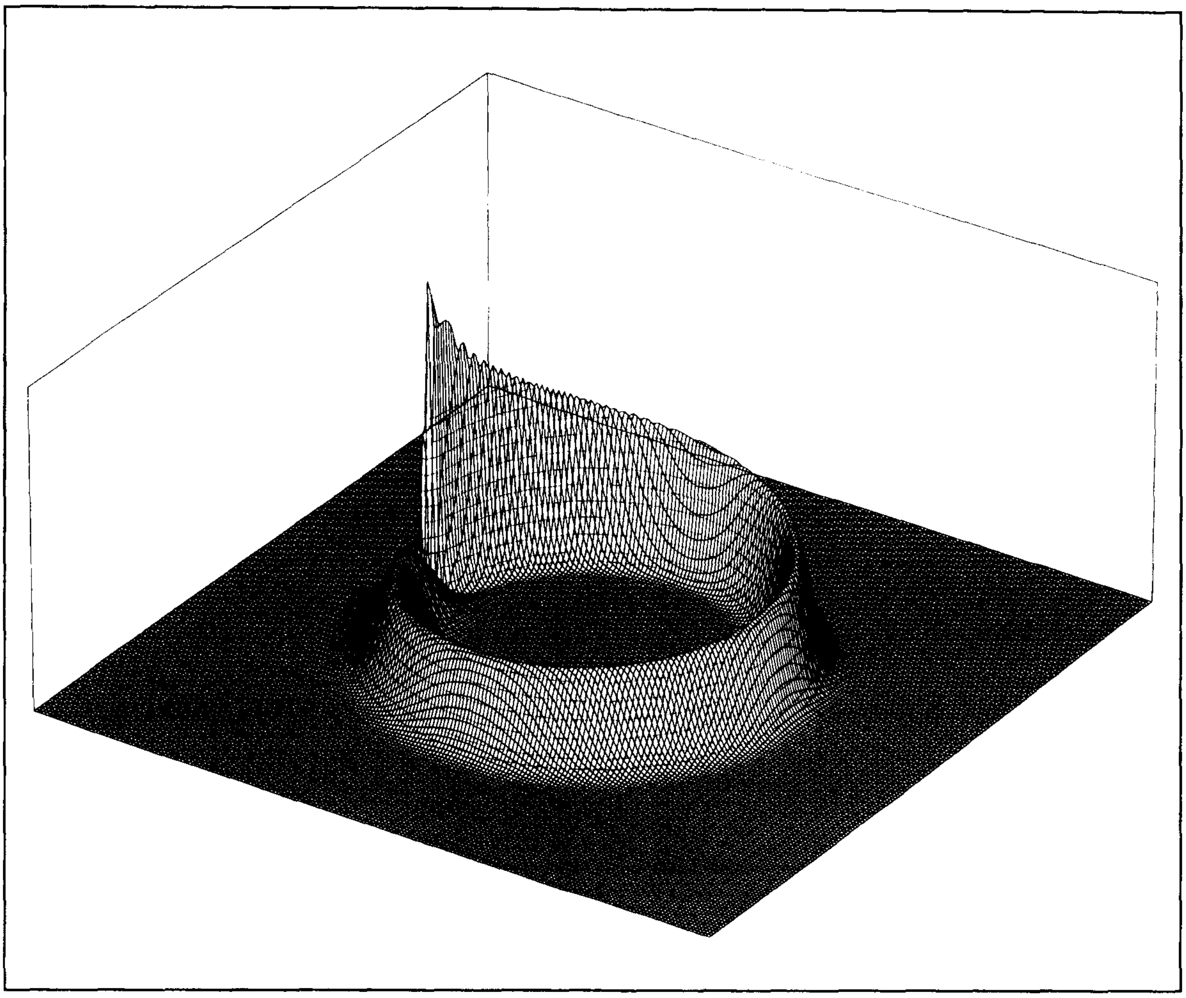

Figure DD.5
Rotation of plume (with diffusion, no filtering) from a single source by using the combined model. This figure should be compared to Figure DD.4.

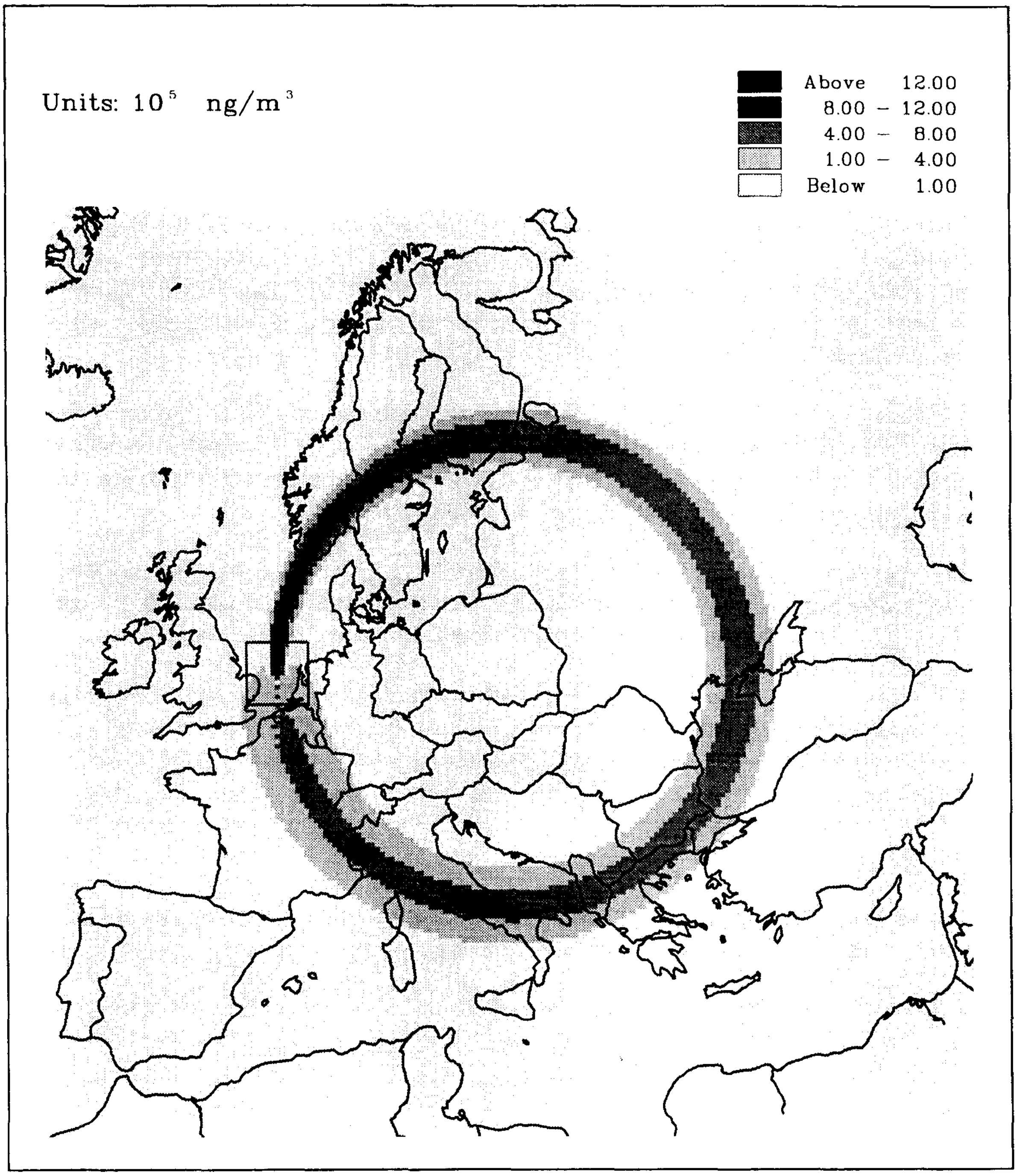

Figure DD.6
A two-dimensional version of the plot given in Figure DD.5.
The square shows the sub-domain in which the RIMPUFF model is in action.

DD.7 EXPERIMENTS WITH CHERNOBYL DATA

The Chernobyl accident has been studied by many long range transport models; see, for example, Hass et al. [9] or Klug et al. [11]. There are a lot of measurements also. This means that data from the Chernobyl accident can successfully be used to test the model. This has been done. The meteorological data for the period of the accident (from April 23 1986 to May 8 1994) and emission data (from the start of the accident, April 25 to May 6 1986) has been received from H. Hass (Institut für Geophysik und Meteorologie der Universität zu Köln).

An animation programme has been developed and used to represent the development of the radioactive plume from the Chernobyl catastrophe. Some snap-shots from the movie prepared by this animation programme are given in Fig. DD.7 - Fig. DD.10. It should be mentioned here that the distributions of the Cs_{137} concentrations are given in these four figures.

It is seen (see Fig. DD.7) that the radioactive pollution was transported to North-West in the first days (covering Poland, the Baltic republics, Sweden, Finland and Northern Russia). The first messages about increased radioactivity were from Finland. The maximum concentrations close to the source are about 500 Bq/m^3.

The situation at the sixth day (May 1) is shown in Fig. DD.8. It is seen that there are three major plumes at that time. Increased radioactivity occurs in most of the European countries (excluding Great Britain, Ireland, Portugal, Denmark and Greece).

The situation at the ninth day (May 4) is presented in Fig. DD.9. Increased radioactivity is now seen also in Great Britain, Ireland, Denmark and Greece (Portugal is still not touched by the increased radioactivity). The radioactivity is spread to parts of Asia, Africa, the Atlantic Ocean). It should be noted that the wind velocities in the area around Chernobyl are relatively high in this day. This explains why the radioactivity is relatively low.

The last snap-shot, Fig. DD.10, is from May 7. The source is closed. The increased radioactivity is still covering a large area in Europe and Asia.

It should be noted that these are still some preliminary results. Nevertheless, some comparisons with results obtained with other models (see Hass et al. [9] or Klug et al. [11]) indicate that the model is able to predict in a reasonable way the distribution of the increased radioactive concentrations.

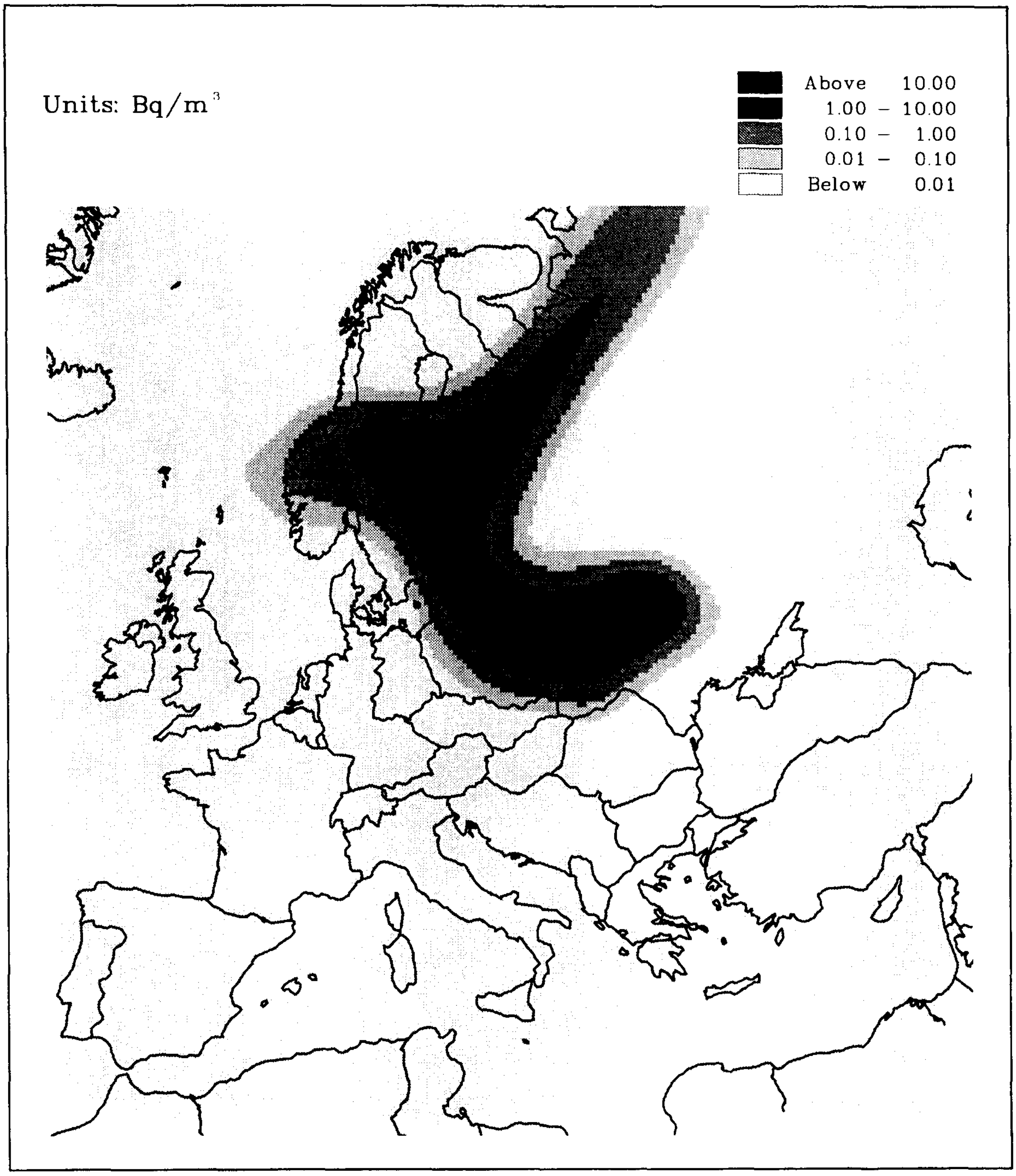

Figure DD.7
Snap-shot from the movie animating the Chernobyl accident.
This situation occurred on April 28 at 12:00 UTC;
the accident started at 21:23 UTC on April 25.
The results are calculated by the combined model;
RIMPUFF calculates contributions from the small square,
while the concentrations in the whole region are calculated
by the Danish Eulerian Model (a long-range transport model).

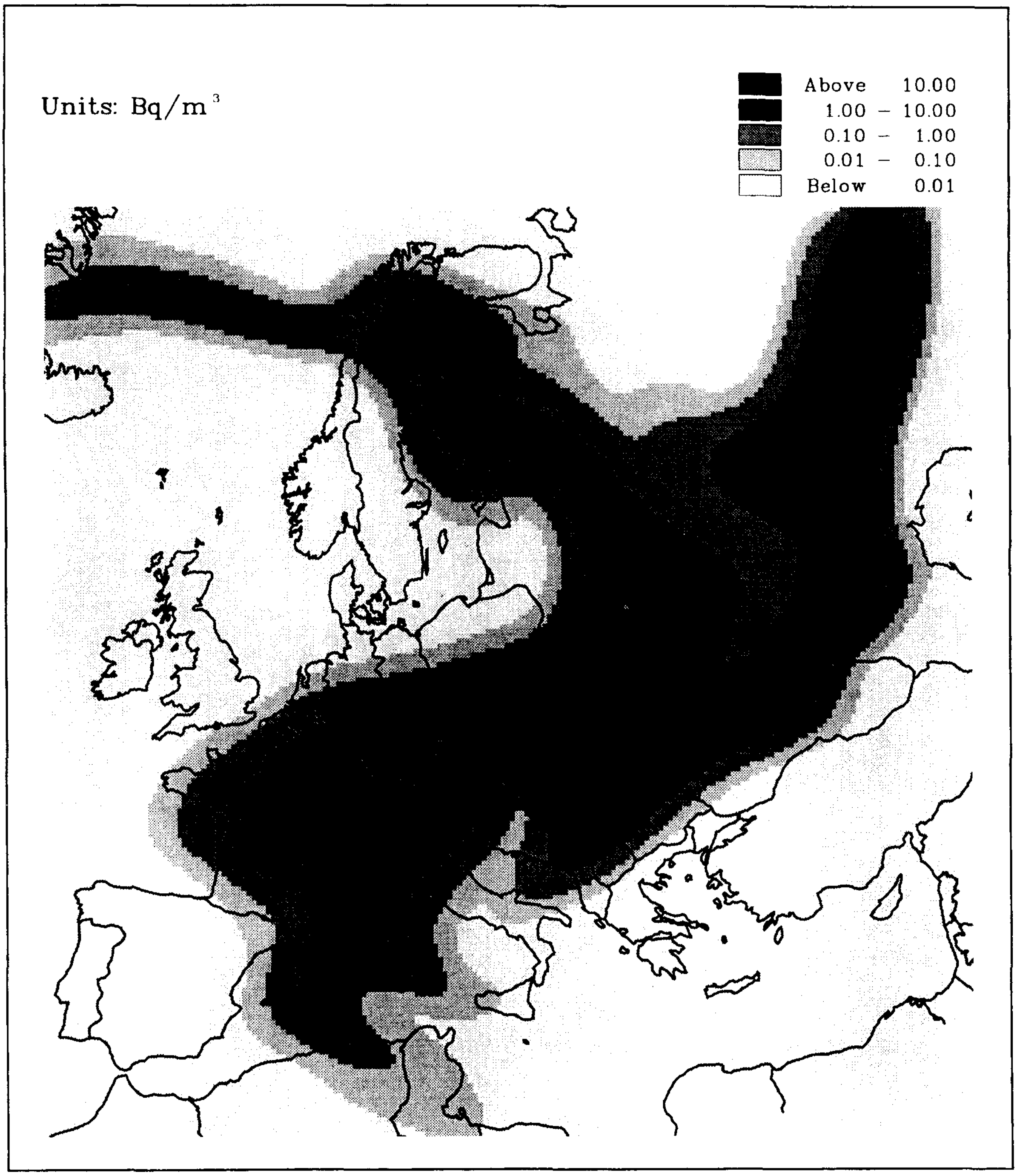

Figure DD.8
Snap-shot from the movie animating the Chernobyl accident.
This situation occurred on May 1 at 12:00 UTC;
the accident started at 21:23 UTC on April 25.
The results are calculated by the combined model;
RIMPUFF calculates contributions from the small square,
while the concentrations in the whole region are calculated
by the Danish Eulerian Model (a long-range transport model).

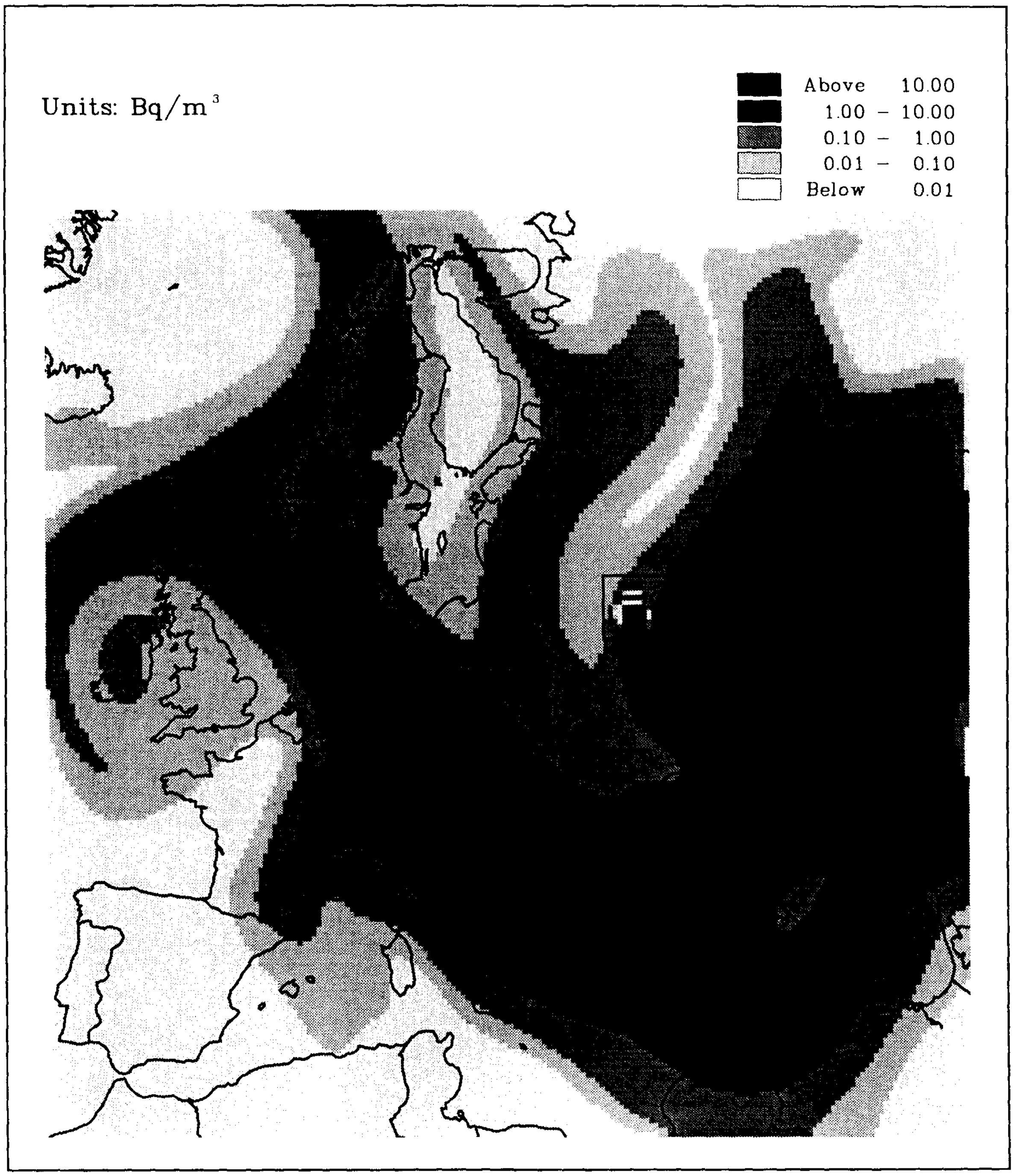

Figure DD.9
Snap-shot from the movie animating the Chernobyl accident.
This situation occurred on May 4 at 12:00 UTC;
the accident started at 21:23 UTC on April 25.
The results are calculated by the combined model;
RIMPUFF calculates contributions from the small square,
while the concentrations in the whole region are calculated
by the Danish Eulerian Model (a long-range transport model).

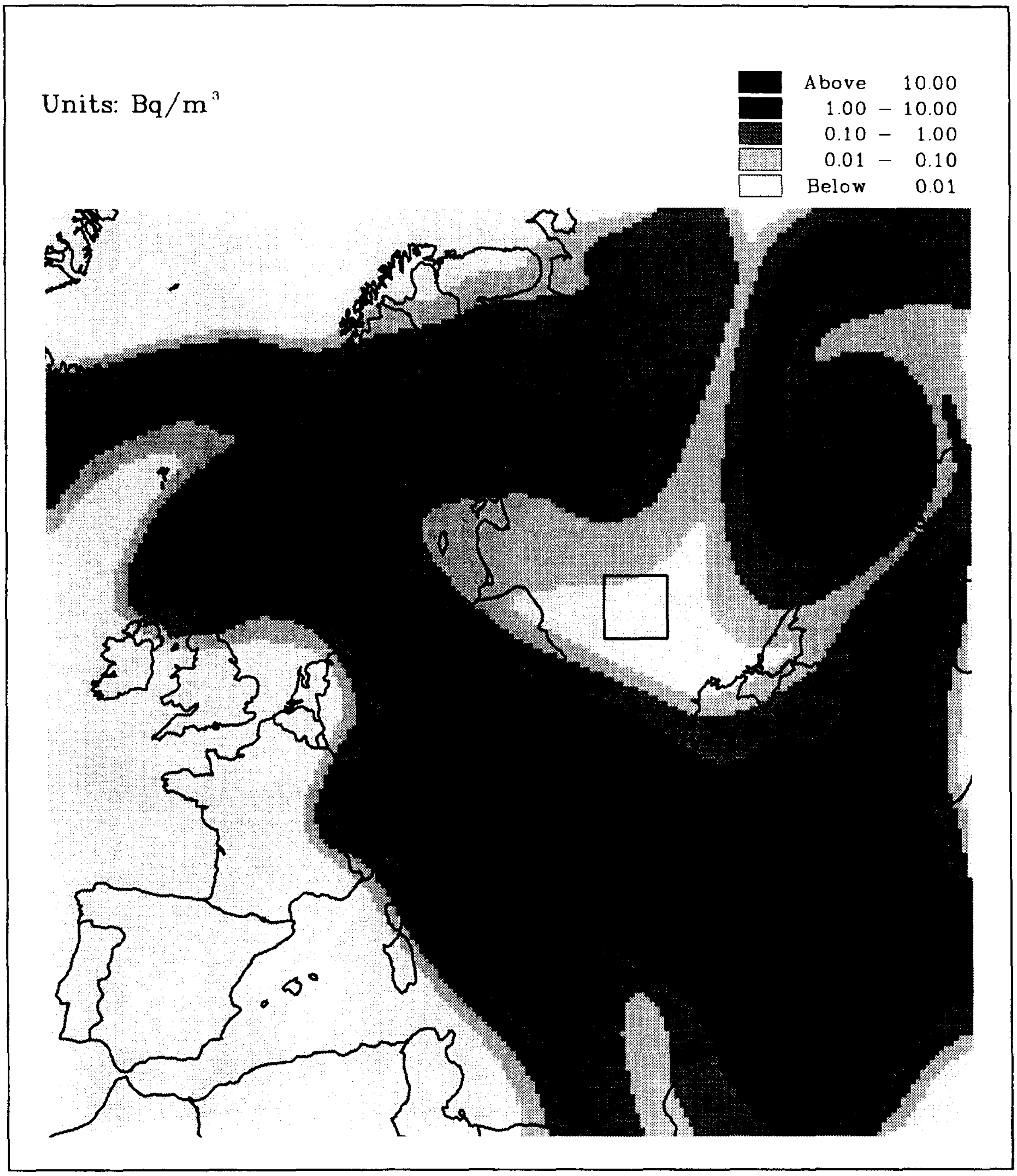

Figure DD.10
Snap-shot from the movie animating the Chernobyl accident.
This situation occurred on May 7 at 12:00 UTC;
the accident started at 21:23 UTC on April 25.
The results are calculated by the combined model;
RIMPUFF calculates contributions from the small square,
while the concentrations in the whole region are calculated
by the Danish Eulerian Model (a long-range transport model).

DD.8 FUTURE PLANS

Several improvements of the existing combined model are needed and will be carried out in the near future. These improvements are listed below.

DD.8.1 Improvements in the coupling procedure

The procedure used to couple the two models, the RIMPUFF Model and the Danish Eulerian Model, which has been described in Section DD.4, could be improved. There are plans to perform some experiments with other procedures.

DD.8.2 Improvements of the physical mechanisms used in the coupled model (especially the diffusion part)

Perhaps some improvements of the diffusion mechanisms used in the Danish Eulerian Model are needed. The Danish Eulerian Model has been used on a rather coarse grids in the previous studies; a (150km x 150km) grid and a (50km x 50 km) grid have been used; see [8], [22], [24], [25]. The diffusion process is not very important when the grid is so large (the emissions are anyway equally distributed on the grid-squares, and this is causing a lot of artificial diffusion). However, the importance of the diffusion process in the particular situation studied here is increased significantly. There are two reasons for this. The first reason is the existence of only one source in the area. The second reason is the finer grid used in the combined model; a (25km x 25km) grid.

DD.8.3 Comparison of model results with measurements

Several checks of the reliability of the combined model have been discussed in the previous sections. However, it is necessary to continue the checks of the reliability by using measurements and comparing model predictions with the corresponding measurements.

DD.8.4 Experiments with ETEX data

A common European project, ETEX (European Tracer EXperiment) has been initiated in 1993. When the data from this project become available, the combined model will be run with these data. This will be a very valuable test of the new model.

DD.8.5 Three-dimensional version of the model

Three-dimensional models seems to be needed. The Chernobyl accident is a typical example that explains why this is so. A careful study of the trajectories over the source showed that the trajectories in the different vertical heights are in different directions; see, for example, Hass et al. [9, Fig. 5 on p. 682]. Therefore, the two-dimensional models will not be able to describe adequately some typical situations.

DD.8.6 Real time runs

This is also an important issue. In some situations it is necessary to be able to calculate the transport very quickly (by using data from meteorological forecasts). Here there are four issues that are important:

(i) the quick calculation of the meteorological data by some weather forecast model,
(ii) the quick calculation of emission data about the release,
(iii) the quick transfer of the data (both the meteorological data and the emission data about the release) to the computer that is to be used by the combined model

and

(iv) the ability of the model to perform quickly the calculations that are necessary in order to describe the transport of the emitted radioactivity (or any other kind of pollution.

Some work will be done in order to be able to solve the fourth task. The third task is not critical (very quick transfer of data can be achieved on the modern high-speed computers. It should also be possible to solve satisfactorily the first two tasks. It may be a good idea to carry out the computations with the combined model on the site where the meteorological data are calculated (by weather forecast models). In this way only the emission data are to be transferred.

It should be emphasized here that it is absolutely necessary to use high-speed computers and, what is even more important, to develop efficient codes that exploit fully the great potential power of the high-speed computers. Some work has already been done in connection of the Danish Eulerian Model (see [1], [26]-[29]). The principles used in the case where only the Danish Eulerian Model is used will be extended for the combined model presented in this report.

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Appendix DD

Appendix E

EMERGENCY EXERCISES CARRIED OUT AS PART OF PROJECT BER-1.1

Ulf Tveten, Institutt for energiteknikk, Norway

February 1992 and August 1994

Appendix E

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Appendix E

These descriptions of the two emergency exercises will primarily be of interest to the participants in the exercises, as documentation of what took place during those two days and in the subsequent follow-up. For this reason quite detailed information is supplied.

It is hoped that the descriptions can also be of help to those planning future exercises of this kind, by pointing out important decisions that have to be taken in the planning stage, by giving abundant examples of what can go wrong during an exercise, and by pointing out the many benefits to be reaped from such exercises.

E.1 THE FIRST EXERCISE, CARRIED OUT 16 JANUARY 1992

E.1.1 INTRODUCTION

The exercise was carried out as part of the sub-project BER-1.1.

E.1.2 ABOUT THE PREPARATIONS FOR THE EXERCISE

The first time the idea of carrying out a so-called functional emergency exercise within sub-project BER-1.1 was introduced was at the BER-seminar in the end of November 1990. At first it was the intention only to test the information flow to and from the institutions involved in preparing prognoses for atmospheric dispersion and transport of a release of radioactive materials in an emergency situation. It was not the intention to calculate prognoses in this first exercise.

The first step in the preparations was accordingly to collect all available information about this problem, and it was obvious that this information should first be sought in the Handbook for Nuclear Emergency Preparedness in the Nordic Countries which was published in December 1990, as part of the BER research program. Unfortunately it was found that the handbook was of little help in this connection. The information needed was instead collected in meetings with persons involved in the emergency preparedness organizations of the various countries and with the persons who would be responsible for calculations of the prognoses.

The Conclusions from these meetings were that: 1) The information routes are very different from country to country. 2) An exercise ought to incorporate calculations of prognoses; not be limited to testing the information flow only. 3) The potential benefits of such an exercise would be significantly larger if it was carried out somewhat later than originally planned (late summer/early autumn 1991), to fit better with the schedules for development of the prognosis programs. It was accordingly decided to carry it out in early 1992.

The more detailed planning of the exercise was initiated at a planning meeting at the Danish Civil Defence Authority in Birkerød, Denmark in July 1991. This was followed by meetings at the Norwegian Nuclear Inspectorate in September, at the Institutt for energiteknikk, Kjeller, Norway in November, and again at the Norwegian Nuclear Inspectorate in December.

At these meetings numerous large and small details of the exercise were discussed, and all important decisions regarding how it was to be carried out were taken. The most important points were:

- The exercise should take place during normal working hours.

- All (potential) participants should be advised about the fact that the exercise will take place in plenty of time before it takes place, and also be told at which day it will take place.

- Two types of exercise scenarios are relevant: The first type implies that abnormally high levels of radioactivity are observed at one or several measuring stations in the Nordic countries, or at a position outside of the Nordic countries in a critical wind direction, but with no knowledge of the position of the release. This situation will involve so-called backtracking. In the other type of scenario a message is received about an accident that has taken place at a specified position from a specific type of nuclear plant. It was decided to carry out this exercise based upon the second type of scenario.

- The postulated position of release will be chosen with no relation to existing nuclear installations, will be chosen to be outside of Nordic territory and at a distance of some 200 - 300 km from the closest area of a Nordic country.

- The exercise is meant to simulate a situation when an "early warning" has been received from the IAEA. The most proper manner in which to simulate such an "early warning" would be to send a message via the WMO's GTS (Global Telecommunications System) network. In an exercise like this, such an approach is, however, impossible, as the message would automatically be distributed to all countries of the world. A second-best approach had to be chosen, whereby the messages are sent to the telefax numbers in the respective Nordic countries that are given in IAEA's list over "Points of Contact, Pursuant to Article 7 of the Convention on Early Notification of a Nuclear Accident".

- Invitations to participate in the exercise was sent to all institutions in the Nordic countries that would potentially be involved in calculating prognoses or be in direct contact with institutions that would calculate prognoses in a real emergency situation.

- The information to the participants would not be supplied all at the same time. First the participants are only advised of the occurrence of an accident, the position and the type of nuclear installation that is found at this position. One to two hours later information is supplied about the duration of the release, amounts of different radioactive nuclides released and the heat content of the release.

- Information from the Exercise Secretariat to participants in Finland is sent both in Norwegian and English versions, but the Norwegian version is the valid one, if there is found to be inconsistencies.

- The prognoses shall be calculated based upon the actual weather of the day of the exercise.

Appendix E

- The exercise is lead by an Exercise Secretariat of 3 - 5 persons who will be stationed for the day at the Institutt for energiteknikk.

- The emergency preparedness organizations of the countries shall not be mobilized in connection with this exercise. Nevertheless it is desirable that at least one representative of each of these organizations would be available on the day of the exercise. This will be arranged beforehand, partly as a result of the distributed invitations, partly arranged separately by the project leader.

- The institutions that calculate prognoses shall send these via telefax to the Exercise Secretariat. At the same time the institutions are requested to inform the Secretariat where the prognoses would have been sent in a real emergency situation. Otherwise the institutions are free to decide whether and to which extent they desire to involve the emergency preparedness organizations of their own country, a long as it is made absolutely clear that what is taking place is an exercise and that the accident is a postulated one.

- The exercise shall be followed by a meeting where the calculated prognoses as well as all other aspects of the exercise can be discussed in detail. This meeting shall be scheduled to take place shortly after the exercise, preferably within 1- 3 weeks.

- It is imperative for the subsequent evaluation of the success of the exercise that all participants write detailed log books. This aspect will be specifically mentioned in the invitations to the exercise.

- The Exercise Secretariat, and in particular the project leader, is responsible for writing a report about the exercise.

E.1.3 INVITATION TO THE EXERCISE

The invitations to the exercise were sent out 3 December 1991. They were sent to the institutions listed in Enclosure 1. The information in this list is actually for the second exercise. Though invitations were, for all practical purposes, sent to the same institutions in the two exercises, a few of the names and addresses had been changed in the meantime. The names and addresses in the list are correct at the time when this is written. Enclosure 2 is the invitation (to the second exercise), translated into English. The original was in Norwegian. The invitations were in the first exercise addressed to the institutions, though in most cases the name(s) of the person(s) who would participate in the exercise was (were) known beforehand. In the second exercise the invitation was sent attention of the relevant person when his name was known. The invitations to the two exercises were very similar in content.

E.1.4 THE DAY OF THE EXERCISE

In the following is summed up the most important events of the day of the exercise. The information is gathered in part from the log book of the Exercise Secretariat, written by Torkel Bennerstedt, and in part from the material which was sent to the

Exercise Secretariat from the participants. The complete logg-book of the Exercise Secretariat may be made available upon request.

All times in the following are given in Norwegian local time, except when otherwise specified.

In the early morning (ca. 07:15) on the day of the exercise, the 16 January 1992, the project leader contacted the meteorologist on duty at the Norwegian Meteorological Institute by phone, to get rough information about the weather of the day. This information should be used to choose a release position which was likely to bring a potential release over Nordic territory, preferably so that it would cross at some point an imaginary line drawn through Oslo-Stockholm- Helsinki. A number of alternative release positions, all around the Nordic area, had already been chosen by the project leader.

When this information had been gathered, the telefaxes to be sent out could be prepared. While this was being done (from about 08:00 till 08:20) the other members of the Exercise Secretariat arrived at Institutt for energiteknikk (IFE). The following persons made up the Exercise Secretariat:

Ulf Tveten	Institutt for energiteknikk, Norway. (Project leader BER-1)
Franz Marcus	Nordic Nuclear Safety Research (NKS)
Erling Stranden	Nuclear Inspectorate of Norway (SAT)
Torkel Bennerstedt	TeknoTelje, Sweden.

Johs Jensen from the Danish Civil Defence Authority had originally also planned to be a member of the Exercise Secretariat, but was unfortunately unable to attend. An open invitation had also been given to all the invited institutions to nominate additional members of the Exercise Secretariat if desired.

The telefax machine which should be used during the exercise was then tested, both for receiving and transmitting. The latter test was achieved by sending a message to another telefax machine at the Institute.

At 09:00 the first telefax was sent out to IAEA's contact points in Finland, Norway, Sweden, Denmark and to the Radiation Protection Institute in Iceland. All the telefaxes sent as information to all participants from the Exercise Secretariat throughout the day in English versions are included in Enclosure 3. During the actual day of the exercise the English versions were sent only to Finland, while all countries received the Norwegian versions. The faxes in Enclosure 3 are the faxes used during the second exercise, in June 1993. The faxes of the two exercises differ only in the geographical position given for the release point, that times are given in UTC in the latter exercise, that information is included in the latter exercise to the effect that the wind direction is such that Iceland will not be affected, and that phone numbers in Norway had been changed to eight digits in the time between the two exercises.

At 09:37 Ulf Tveten called the Norwegian Department of Foreign Affairs, the Norwegian contact point, to make sure that the message would not be misunderstood so that the emergency preparedness organization would be mobilized. Tveten's contact person in the Department, Torbjørn Norendal had not yet received the fax, and it had accordingly not been forwarded to the Meteorological Institute (DNMI). At 09:46 Jørgen

Saltbones from DNMI called the Exercise Secretariat to ask whether the exercise had been started. He had not received any messages, which was not so strange, since the standard procedure is that DNMI shall receive the messages from the Department.

In the meantime (at 09:42) the first results, from the Meteorological Institute of Denmark (DMI), arrived to the Exercise Secretariat. The results contained trajectories for the front end of the release, that is the time given for start of release. The Exercise Secretariat, however, had not been sufficiently careful in giving this time, as no indication was given as to the time reference; whether the time given was local time or UTC (Universal Time Coordinate) (previously referred to as GMT). The Exercise Secretariat had intended the time coordinates to be local Norwegian time, but DMI had carried out the trajectory calculations for a release at 08:00 UTC. DMI gave trajectories for five different elevations in the atmosphere, drawn on maps over Europe. The trajectory positions each third hour was marked. It was said that if this had been a real accident, the results would have been sent to the Police Headquarters in Copenhagen.

At 09:49 Anna Liisa Savolainen from the Meteorological Institute of Finland (FMI) called, as she was uncertain about the time coordinates, whether it was referred to Norwegian time, Finnish time of something else.

From the logg-books can be seen that DNMI received the first fax around 10 o'clock, but it was received from the Swedish Meteorological and Hydrological Institute (SMHI). SMHI forwarded all faxes to their Nordic sister institutions, evidently following an established routine which was even not known to the persons at SMHI who were calculating the prognoses. Torbjørn Norendal at the Norwegian Department of Foreign Affairs eventually also received the faxes, but the logg-books show that the faxes he received were sent to him from DNMI. The telefaxes the Exercise Secretariat sent to the Norwegian Department of Foreign Affairs did not reach Torbjørn Norendal until after the exercise had been completed.

At 10:09 the second set of results, this time from SMHI, were received at the Exercise Secretariat. These results consisted of trajectories for the front end of the release at two elevations in the atmosphere, and calculations of integrated concentrations (relative concentrations) up to 16 January 12 UTC, 17 Jan. 00 UTC and 17 Jan. 12 UTC. As no information had yet been given concerning the duration of the release SMHI had assumed that the release had been continuos over the time period covered by the calculations. All results were drawn on maps of the Nordic countries and parts of Europe. The trajectory positions each hour were evidently marked, although this was actually not specified anywhere on the drawings. The concentrations were drawn as isoconcentration lines, but the specifications of numerical values written on or near the lines are impossible to read. In a real accident situation SMHI would have sent the results to the Swedish Radiation Protection Institute in Stockholm.

At 10:13 a new set of information from DMI arrived: It contained information already transmitted, but this time in tabular form: Coordinates of the trajectories as a function of time, for the same five elevations as previously. In addition this set contained maps of precipitation (forecasts covering all the North Atlantic area and Europe) summed over the times 16 January 00 - 06 UCT, 00 - 12 UTC and 00 - 18 UTC.

At 10:28 prognoses from SMHI of accumulated dry and wet deposition (each presented separately) up to 17 January 12 UTC arrived to the Exercise Secretariat. In these prognoses the release and deposition are in relative units and it is assumed that there has been a continuos release (of 106 relative units per second)over the duration of the release. It is stated on the result sheets that the calculations can be applied to either I-131 or Cs-137, so evidently the same deposition characteristics are assumed to be valid for both iodine and cesium nuclides. The results are presented as concentration contours on maps covering all of the Nordic area and part of Europe.

From 10:31 and on telefax number 2 was sent out by the Exercise Secretariat to Denmark, Finland, Sweden, Iceland and Norway (this and all following faxes were sent both to the Norwegian Department of Foreign Affairs and to the Norwegian Meteorological Institute). In addition to the information given in the earlier telefax, this fax also contained information on the release duration, the amounts released of the nuclides I-131, Cs-134 and Cs-137 and the heat content of the release.

At 10:46 a phone call from Johs Jensen Danish Civil Defence Authority was received at the Exercise Secretariat. He informed the Secretariat that he had been in contact with Risø Research Center in Denmark, and found out that the relevant experts at Risø were fully occupied with other tasks or on vacation.

At 10:56 trajectories from DNMI were received. They were drawn on maps of the Nordic countries and parts of Europe. On the figures is given the information that these are 50 km trajectories. This is somewhat confusing, since they are obviously longer than 50 km, but it is assumed that these 50 km refer to a network in the calculations. Trajectories for to different elevations are given, and there are two sets of calculations, for assumed release times 16 January 06 UTC and 16 January 12 UTC. Both of these releases are followed for 42 hours and the position every sixth hour is marked. For both of the elevations and both of the release times are shown trajectories for the specified release point, but in addition for four alternative release positions placed some kilometers from the specified position in the four directions of the compass. By this device a certain "feeling" for the horizontal spread is obtained, although an actual dispersion calculation has not been performed.

From 11:04 telefax number 3 was transmitted from the Exercise Secretariat to Finland, Denmark, Norway, Sweden and Iceland. Fax number 3 informs the participants about a new release which has taken place from the same position with start of release at 10:45.

Transmission of telefax number 3 was interrupted by an incoming telefax from FMI, containing trajectories for four alternative times for start of release; 16 Jan. 06 h, 10 h, 12 and 16 UTC. All trajectories were followed 48 hours after start of release, and they are drown on maps of the relevant area, which is from Mid-Scandinavia down to the Alps and Hungary. The trajectory positions are marked every sixth hour. FMI informed the Exercise Secretariat that in a real accident situation the results would have been sent to STUK (Strålsäkerhetscentralen, the Centre for Nuclear Safety), the Ministry of the Interior and (the following is the name of the administrative body responsible at the time this report is written, though the administrative structure was different at the time of the exercise) the Defence Staff, Engineering Section (Huvudstabens pionjäravdeling).

At 11:36 a fax was received from DMI containing trajectories, both drawn on maps and in tabular form, for the new release with time for start of release 10:45 UTC. (It had still not been made clear from the Exercise Secretariat that the times given were meant to be Norwegian local time. All the other participants had assumed that it was indeed Norwegian local time, and called the Exercise Secretariat and had this confirmed). The new calculations from DMI were for the same elevations as previously.

From 11:45 telefax number 4 was transmitted from the Exercise Secretariat to Finland, Norway, Denmark, Sweden and Iceland. This telefax contained, for the new release with start of release at 10:45, in addition to information transmitted earlier, also information about the duration of the release, about the amounts released of the nuclides I-131, Cs-134 and Cs-137, and the heat content of the release.

At 12:08 a fax from SMHI was received, which contained air concentrations and dry and wet deposition of I-131, Cs-134 and Cs-137. The air concentrations were given for three times; 16 Jan. 12 UTC, 17 Jan. 00 UTC and 17 Jan. 12 UTC (The air concentrations for Cs-137 were given only for the time 17. Jan. 12 UTC). The values for deposited activity are integrated up to 17 Jan. 12 UTC. Wet deposition of Cs-137 is not included. It is not clear from the transmitted material whether the calculations are for the first or the second of the releases specified by the Exercise Secretariat, but since this transmission was received only a short time after the fourth telefax had been sent out, it seemed unlikely that it would be for the second release.

At 12:21 the next fax from SMHI was received. It contained concentrations at two points in time, 16 Jan. 12 UTC and 17 Jan. 12 UTC. It also contained wet and dry deposition of I-131 and Cs-137 integrated up to 17 Jan. 12 UTC. These are results for the second release, as the time 10:45 is given as the time at which the prognoses start, but it is not specified whether this is Norwegian local time or UTC. The information used is obviously taken from telefax number 3, as it is assumed that the release is continuos up to the times which the results are given for. The first page of this transmission was a mystery. According to what is written on the page, it shows accumulated wet deposition of I-131 17 Jan. 12 UTC. This is the same specification as found on the last page of this transmission, but the two sets of results look completely different. The time of release is not given on the mysterious page. The transmission from SMHI which was received at the Exercise Secretariat at 12:08 contains a map which has the identical text of the mysterious page (except for the word "Prognosis" which is written on only one of the two pages), but the prognoses drawn on the two pages are quite different.

At 12:55 the Exercise Secretariat phoned the Institute for Radiation Hygiene in Iceland. No information at all had been received from Iceland, and it was important to know whether the transmissions from the Exercise Secretariat had been received. It was found that they had indeed been received, and also that in a real accident situation, the information would have been forwarded to the Meteorological Institute of Iceland.

At 13:00 the Exercise Secretariat attempted to contact Jørgen Saltbones at the DNMI, but the switchboard at the Institute was unable to locate him. Only when the person calling from the Exercise Secretariat suggested that they try the weather forecast room was he found. The purpose of this phone call was to "play" the Norwegian emergency preparedness organization and request the results of the calculations for the second release. Jørgen Saltbones informed the caller that the results that had already been submitted could be regarded as valid for both releases, with the prognoses for trajectory start time 06 UTC most relevant for the release at 08:00 and trajectory start time 12 UTC most relevant for the release at 10:45.

At 13:15 the Exercise Secretariat made a phone call to FMI. The purpose now was to "play" STUK (the Finnish Centre for Nuclear Safety), and ask for prognoses for the second release. At FMI the Exercise Secretariat was informed that they were working on the prognoses, but that there was a delay because the calculations were performed at two different locations in Helsinki.

From 13:32 telefax number 5 was transmitted to Denmark, Sweden and Iceland. This telefax only contained the information that the exercise was now terminated, invitation to the follow-up meeting and a request for submission by fax of the logg-books.

At 13:42 the transmission of telefax number 5 was interrupted by an incoming telefax from DNMI containing a very instructive and useful verbal meteorological evaluation of the accident situation. The transmission also contained two pages that seem to be identical to those received at 10:56 and two pages containing meteorological data (so-called meteograms) for Bergen, Ålesund and Jotunheimen in Norway. These can be difficult to understand without an accompanying explanation.

At 13:47 telefax number 5 was sent to Norway, both to the Department for Foreign Affairs and to the meteorological institute.

Once more the transmission of telefax number 5 was interrupted, by a couple of telephones, and at 14:01 by a telefax from FMI containing trajectories in tabular form for both releases; that is with trajectory start times at 07 UTC and 10 UTC. Here the position of the front end of the cloud is given every third hour as well as the "width" of the plume and the height (given both in hPa and in km) of plume centerline.

At 14:15 telefax number 5 was transmitted to Finland.

At 14:29 a telefax from STUK containing dose calculations was received. The doses in mSv via inhalation, external radiation from the plume, external radiation from deposited activity, as well as the sum of these for 14 distances from 7 - 1300 km are given. The calculated doses are to an unshielded person positioned under plume centerline at ground level. A release height of 100 meters is assumed. This probably means that the plume centerline is assumed to be at this altitude at all distances, and that the information about the heat content of the plume, resulting in plume rise, has been disregarded in this context. It is not clear whether the calculated doses are for the first release, the second release or the sum of the two.

At 14:32 came a telefax from DMI (previously received at 14:26, but illegible at that time). This telefax contained the logg-book of DMI.

From 14:53 telefax number 5 was sent to Torben Mikkelsen and Søren Thykier-Nielsen at Risø, Denmark, Åke Persson at the Radiation Protection Institute in Stockholm and Seppo Vuori, Technical Research Centre of Finland for information. None of the earlier telefaxes had been sent to these persons/institutions, but during the day of the exercise these persons had been or had been said to be involved in the exercise to a varying degree. The Exercise Secretariat accordingly thought it proper to inform them that no more initiatives would be taken on the part of the Exercise Secretariat on this day and to submit the invitation to the follow-up meeting.

At 15:00 the Exercise Secretariat closed its activities for the day.

E.1.5 MATERIAL RECEIVED LATER

16 January

At 15:15 a telefax from SMHI was received. It contained air concentrations at two points in time, 17 Jan. 12 UTC and 17 Jan. 12 UTC for I-131, Cs-134 and Cs-137, and wet and dry deposition of the same nuclides integrated up to 17 Jan. 12 UTC. These were results for the second release. In these calculations one has not assumed continuos release, but used the specified release duration, given in telefax number 4. The Exercise Secretariat was also informed that the reception of this telefax had been delayed due to internal problems at SMHI (might have some connection with the lunch break). According to the logg-book telefax number 4 reached the persons calculating the prognoses as late as 13:40 (Swedish time or UTC?), although it was found that it was received at SMHI at 11:11 (this must be UTC, as fax number 4 was transmitted to SMHI at 11:52 Swedish time).

At 15:29 a telefax from FMI was received. It contained TRADOS-results for the first release. The first page of this transmission is a page with a useful form defining the release and a number of other important parameters relevant to the calculations in a very orderly manner. Then follows a page giving the position, "width" and elevation of the plume front end every third hour. This is in tabular form. This page is identical to a page received in the telefax received from FMI at 14:01. Then follows one page for Cs-137 and one page for I-131, containing the position, average horizontal σ_y, average elevation, concentration in air, deposition and doserate for the position of the plume front end every sixth hour up to 48 hours after release. The calculations of doserates (mSv/h) were carried out by VTT on the basis of FMI's three-dimensional trajectories. No information is given regarding how the limited release duration of the release has been taken into account, but it can be assumed that one has used the simplification of placing all the activity in the plume front end (in other words that the radioactive materials always follow the plume front end).

At 15:44 a telefax from SSI with their logg-book was received.

At 16:01 a telefax with the logg-book from SMHI was received.

17 January

At 08:35 was received a telefax containing the logbook from the Danish Civil Defence.

At 08:42 was received a telefax containing the logbook from the Norwegian Department of Foreign Affairs.

At 12:08 was received a telefax containing the logbook from FMI.

20 January

At 14:38 was received a telefax containing the logbook from DNMI.

A letter from DMI, dated 17 January 13:00 was also received. This letter contained trajectories drawn on maps, for the same five elevations (initial elevations) as previously, but for some additional starttimes: 16 January 07:00 UTC, 08:00 UTC (received before, at the 16 Jan. 09:42), 09:45 UTC and 10:45 UTC (received before, at the 16 Jan. 11:36). The new times are chosen to agree with the times in Norwegian local time. For the trajectories that had been received before, however, there is considerable difference between the old (16 Jan.) and new (17 Jan.) versions. It is not clear why this is so, but the reason is probably the new calculations are based upon a later HIRLAM-analysis, not yet available when the first calculations were run.

21 January

A letter from DNMI was received. It contained the originals of material previously sent by telefax.

E.1.6 GENERAL REMARKS ABOUT THE RESULTS RECEIVED BY THE EXERCISE SECRETARIAT

The short time lapse between the time when the participants in the exercise received the information and until the prognoses were transmitted to the Exercise Secretariat was impressive. The information received by the Exercise Secretariat gave a useful over-all picture of the situation; and even though there were significant differences between the different prognoses at long distances from the release point, there is reason to believe that the information given would have been of considerable value in a real accident situation.

Altogether the exercise was a considerable success, and the day of the exercise was very intense and exciting both for the Exercise Secretariat and the participants.

But the primary objective of the exercise was to identify weaknesses, and several weaknesses were found:

- Most of the transmitted results could have had better readability. There are, however, special problems when results have to be transmitted by telefax. The figures from DMI were probably the easiest ones to read.

- Trajectories are naturally easier to read than concentration maps. In the figures showing concentrations it was in most cases difficult to identify the different types of shading, as they tend to become blurred, and the numbers identifying the curves could often not be read because they were either too small or were partially covered by other features of the figure.

- Most of the figures transmitted could have contained clearer identification of the release, the time of release, nuclide(s) etc. In particular, it was often difficult to determine in what way a set of results were different from a similar set of results received previously from the same institution.

- It is important that it is easy to see which situation each page containing results relates to. There is no guarantee that pages transmitted together in a certain order continues to stay together, and certainly not that they continue to be arranged in the same order. In an emergency situation it is very likely that several persons will wish to examine the results, and that the pages of one transmission may be separated. Each and every page must be completely identifiable on the basis of information contained on that page.

- A situation survey, like the one received from DNMI, may undoubtedly be very useful in an emergency situation in addition to information in the form of trajectories and concentration maps. A translation of the situation survey is found in Enclosure no. 4.

- Meteorological data of the form transmitted from DNMI (meteograms) may be useful, but an explanation must be enclosed, as it is found that data on this form is not necessarily understood correctly by the uninitiated. It is to be expected, admittedly, that a meteorologist will be present in the emergency center, but his/her time could certainly be spent in a more efficient manner than by giving explanations that could just as well be prepared beforehand and be available in written form, as part of the standard output of data of this type. An example of the meteograms (without explanation) is included as Enclosure 5.

- Elevations in the atmosphere ought to be given primarily in meters or kilometers. Elevations are by meteorologists often given in hPa, the meaning of which eludes most non-meteorologists. It also makes it difficult to compare the different set of results when the different meteorological institutes choose different elevations in the atmosphere for the calculations. One ought to try to harmonize this.

E.1.7 ABOUT THE FOLLOW-UP MEETING

The follow-up meeting was held 4 February at the premises of the Meteorological Institute of Denmark in Copenhagen. The list of participants is included as Enclosure 6.

The purpose of the meeting was to

- attempt to find explanations for differences in the prognoses calculated

- discuss the presentation of results and whether it is difficult to understand them correctly in their present form

- discuss the manner in which the exercise was conducted and identify possible improvements in future exercises of this type

In alphabetical order the results from each of the countries were presented and formed the basis of discussions. The most important observations and/or conclusions are included in the relevant subchapters of this Appendix.

In the discussions of the day many interesting problem areas were touched upon, some central to the exercise, some more peripheral.

An important problem is the uncertainty of the prognoses; the fact that there are considerable uncertainties in the calculations of trajectories and concentrations, in the prediction of the wind fields etc. In this respect it is an advantage that several different calculational tools are utilized, usually giving somewhat different results. This will serve as a reminder that the result of any calculation does not represent the "absolute truth". The uncertainties are a caused both by weaknesses and simplifications in the calculation models and the impossibility of predicting the weather conditions accurately. It was brought up as an idea that a supplementary result of potential use to an emergency organization could be indication of an "risk sector" of e.g. 40 or 60^0 width. The meteorologists were asked to consider this proposal seriously.

When SMHI had received telefax number 1 (which contained no factual information on the release), the institution had been in contact with SSI to seek advice on possible type, magnitude and duration of the release. In a real accident situation these aspects would have to be considered very early. In this exercise, however, the information on the "plant" were so insubstantial that a discussion of this type was found to be meaningless. It was decided that one would probably not desire to put any more emphasis on this aspect in future exercises in BER-1, even though it is recognized as an important aspect. In the larger emergency exercise BER-5, however, this aspect should be remembered.

The Finnish Center for Radiation and Nuclear Safety (STUK) has a work station linked directly to the Meteorological Institute of Finland (FMI), where the prognoses calculated by FMI as well as various types of meteorological data can be brought in. A similar data link between FMI and the Technical Research Centre of Finland (VTT) exists, although at the time of the meeting it did not function quite satisfactorily. The usefulness of a data link of this type ought to be considered by all Nordic countries.

At the Meteorological Institute of Norway (DNMI) and at DMI it is possible to show a "movie" on the data screen of how the trajectories move and the movement of the radioactive plume and simultaneous development of the precipitation field. A demonstration of the DMI version was given after the meeting. The same option is probably available at the Swedish Meteorological and Hydrological Institute (SMHI) although this was not mentioned specifically. All the Nordic countries ought to have the possibility of transmitting the prognoses from the meteorological institutes to the emergency organization via data link.

A weakness in the calculation as they are performed at present, is that deposition over land and over sea is calculated assuming the same deposition characteristics. It is true that wet deposition will be the same when the precipitation intensity is equal, but dry deposition will be different over the two types of area. Another possible weakness is that the strong precipitation resulting when air masses meet the mountain areas along the Western coast of Norway does not seem to be represented appropriately, as wet deposition in the present predictions is not as strong in these areas as would be expected.

In Norway, the meteorologist on duty is assumed to be able to calculate trajectories without assistance from a specialist on such calculations. The exercise showed that in reality this may not function. Many different persons in turn have this position, and it seems to be difficult to keep the trajectory calculation capability operable at all times, at least within the present economical frames. Building up and keeping up the necessary capability is impossible without specific funds earmarked for the purpose.

E.1.8 DIFFERENCES IN THE PROGNOSES

There were significant differences between the calculated prognoses. The most marked difference was that the trajectories calculated by DMI passed by Denmark, far to the East of the country; even far East of Bornholm; while the trajectories calculated by all the other institutions did hit Denmark. The Finnish and Swedish calculation gave quite similar results, while the Norwegian results were somewhat to the West of these, particularly the parts of the trajectories over Norwegian territory.

Two possible explanations for these differences were identified. The Danish calculations are based upon meteorological analyses and predictions from the HIRLAM program, the Swedish calculations are based upon the LAM program, and the Norwegian calculations upon LAM50S. This is, however, probably not the explanation, as the Finish calculations are also based upon HIRLAM. The other possible explanation is that DMI used 3 hour intervals in the calculations, while the other institutions used 6 hour intervals. (Note added at a later date: The explanation for the differences was simply a programming error in the Danish program.)

It has already been mentioned that the weather situation at the 16 January was a very difficult one to predict, and that the results could be very sensitive to the assumed time of release. This fact could, however, not provide an explanation of the Danish results, as DMI's calculations for different times of release give quite similar trajectories.

The problem of 2-dimensional vs. 3-dimensional analyses was also discussed, but since the vertical wind is quite weak, this effect is of importance primarily for results on the local scale, and can not explain the large differences between the trajectories calculated.

It was not possible from the discussions at the meeting to conclude that some of the sets of results obviously were more correct that others.

Concentration distributions were only calculated by SMHI, so no basis for comparisons exists.

E.1.9 POSSIBILITIES FOR MISPERCEPTION OF THE RESULTS

Perhaps the most serious possibility for misperception of the results is caused by carelessness in not marking ALL communications during the exercise with the words

EXERCISE or ØVELSE (in Scandinavian). Every page transmitted in an exercise should be marked in this manner.

Trajectories may easily be misunderstood. Usually trajectories are valid for the front of the release. In a stress situation it is easy for members of an emergency organization to overlook that the later parts of the release may follow quite different trajectories. It could be an advantage to include an exact explanation in the result presentation, e.g. text like the following: "These trajectories are for the part of the release that took place at 07:00 UTC. Material released at other times may follow different trajectories."

The first set of concentration results from SMHI might also easily have been misunderstood. At the time when these calculations were carried out, no information had been given regarding the duration of the release. The correct approach in this situation is probably to assume a continuos release, continuing over the whole time period for which calculations are carried out. The results may, however, be confusing in this case, since the concentration maps (concentrations are integrated over the whole time period for which calculations are carried out) may cover areas quite different from the ones over which the trajectories pass (trajectories represent a specific part of the release, usually the front end of the release).

Since concentrations are integrated quantities, it is also easy to compare concentrations from one set of calculations and concentrations from another set of calculations, and forget that they may have been integrated over quite different time intervals and that a direct comparison is meaningless.

E.1.10 WEAKNESSES IN THIS PARTICULAR EXERCISE

The most blatant error committed by the Exercise Secretariat was to neglect to specify the exact time frame of the times referred to in the telefaxes transmitted to the participants. In the future all times ought to be given in UTC.

At certain times during the day of the exercise, it could be difficult for the participants to get through with their messages to the Exercise Secretariat. This, of course, was particularly a problem at the times when the Exercise Secretariat transmitted messages to the participants. This problem can be solved in future exercises by the Exercise Secretariat utilizing two telefax machines, one reserved for messages to the Secretariat and one for messages from the Secretariat. The problem, however, also goes the other way around. The Secretariat often found it difficult to get through to the participants. Each time the Secretariat should send out a new message to the participants, one or several of the numbers were busy.

A more severe problem was that the number of persons in the Exercise Secretariat was found to be insufficient. The tasks that had to be carried out by the Secretariat were quite time consuming, and there was little or no time left over to analyze the results received. When the exercise really got "off the ground", this task could have occupied one person full time.

It would be an advantage to have a loud speaking telephone available for the Exercise Secretariat. Now it was quite complicated to both carry out the conversation and assure that correct information was noted in the logg-book.

E.1.11 ORGANIZATIONAL WEAKNESSES FOUND

In several cases the efficiency of information flow was unsatisfactory. This was particularly true in the Norwegian Department of Foreign Affairs, the formal receiver of information of this kind in Norway. If we had relied on the Department alone, neither the pertinent person in the Department nor the Norwegian Meteorological Institute would have had any information about the exercise until after it was closed. The problem at the Department is probably the large amount of information of all types received. It may often be difficult to decide where inside the Department to forward information. This experience, however, makes it relevant to question whether another receiver (e.g. the Norwegian Radiation Protection Authority) might be more suitable.

The fact that many institutions have not entered receiver identification onto their fax machines is troublesome. When the sender is only told that the receiver is G3, instead of some identification of the institution, one is never quite sure that the message has reached the proper address. At the day of the exercise only a few of the institutions had entered identification. It might also be useful if all receivers of messages sent a receipt, so that one is sure that messages have arrived in a complete form. Twice during the day of the exercise the Exercise Secretariat received only a more or less legible front page of a much longer message, with the sender quite unaware that anything was amiss.

On the top of all telefaxes is a line containing various information concerning the transmission. This information is generated by the machine sending the information. One of these pieces of information is the hour and minute at which the message was sent. In practice this piece of information may cause more confusion than clarification. In our case the telefax of SMHI gave all times in UTC, while all the other institutions used local time. In no case was it possible to see what type of time it was. (In the second exercise, held one and a half year later, in June 1993, the fact that some had adjusted their telefax clocks to summer time and some had not, added to the confusion.) One should always define the time frame to which times refer.

The logg-books from the different organizations were not complete. They should not only contain information on incoming the sent telefaxes, but contain everything of importance, like phone conversations, discussions/meetings and other contacts in connection with the exercise.

In connection with this exercise we had some problems in utilizing the list from IAEA over "Points of Contact, Pursuant to Article 7 of the Convention on Early Notification of a Nuclear Accident". Several pieces of information from what was claimed to be the most up to date version of this list (from July 1989) were not correct. It now appears that a new version was prepared in summer 1991, in which the information concerning Denmark, Finland, Norway and Sweden is correct, and that there was prepared one more version in January 1992. The distribution of these lists does not seem to be sufficiently efficient. Iceland is not included in any of the lists mentioned.

The Norwegian Meteorological Institute use the official abbreviation DNMI (Det Norske Meteorologiske Institutt), which is misunderstood frequently, as it is so similar to the abbreviation used for the Danish Meteorological Institute, DMI (Danmarks Meteorologiske Institut).

E.1.12 GENERAL IMPRESSION OF THE EXERCISE

The response among the participants after the exercise was very positive. All participants, including those who before the exercise had been somewhat skeptical to the value of such an exercise, found that the exercise had been very rewarding, and they all expressed interest in a repetition. It must be mentioned in this connection that the word "repetition" is misleading, as an exercise of this type will never be a repetition of a previous one. The meteorological situations are bound to differ, and will pose new challenges to the calculation models every time. The weaknesses in planning of the exercise that were discovered are all concerned with details and do not reduce the value of the exercise as a whole. The most annoying weakness was the failure to specify in the messages sent from the Exercise Secretariat to the participants whether the times given were in Norwegian local time, Finnish time or UTC. Afterwards it was found that the differences between prognoses caused by this uncertainty in the time coordinates were minimal, since a release time one hour sooner or later gave very small differences in the calculated trajectories.

E.1.13 CONCLUSIONS

- The positive experience gained from the exercise was considerable, and many requests for a repeat exercise have been received. The autumn of 1992 could be a suitable time for a repetition. In a repetition one will have the possibility of observing how the calculation models handle different weather conditions, and one will also have the opportunity of testing the improved versions of the calculation models that will then be available.

- The response time, the time interval between the time when data were available until the time when prognoses were produced, was satisfactory for all four countries. However, at the time when the first exercise was performed calculation of concentrations could only be carried out in Sweden.

- Future exercises should also be announced well in advance.

- It was suggested that one in the future should use the format of the communications specified by IAEA.

- More effort ought to be spent to assure that the results transmitted to the Exercise Secretariat are readable even after transmission by telefax, that all information is understandable and concisely defined, and that all important conditions used in the calculations are specified on every page containing results (in a real emergency situations the pages of one transmission may easily be separated).

- Results transmitted in graphical form ought to be supplemented by sufficient text to make sure that misunderstandings are avoided. This is true both for text supplied to specify exactly what the different results are, which situation the results refer to, what conditions and assumptions have been adopted, uncertainty of the results and an explanation of what the results mean in practice (for an example of the latter, see the Situation Report appended).

- It is proposed that the meteorological institutions agree to use the same elevation and units for elevations for trajectory calculations.

- It is proposed that one, regardless how difficult or uncertain this may be, will attempt to specify a potentially threatened sector in collection with the release in question, e.g. an angle of 40 or 60°. This proposal is based upon the large uncertainty inherent in the calculated results, and the risk which accordingly exists of apparent inconsistencies between the results calculated by the different institutions, or in the worst case, between the emergency organizations to which they supply predictions.

- The Nordic nuclear emergency organizations ought to specify what information is desired from their consultants on dispersion prognoses and on what form it is desired to have the results of predictions presented. A harmonization of the presentation of the results will be attempted within the project BER-1.1, and it would of course be an advantage to know what the desires of the emergency organizations are before this work is concluded, some time during the autumn of 1992.

- The problems concerning the information flow within the Norwegian Ministry of Foreign Affairs, noted during the exercise, must be examined.

- The writing of a logg-book during an exercise may easily become somewhat neglected, among more important tasks. This is a problem worthy of some concern. In a real accident situation completely covering logg-books may be found to be very important at some later time, when it comes to explaining why decisions made at the time were taken and whether they made sense/not made sense considering the information available at that time. It is accordingly important to find functional routines concerning this problem.

Some other important conclusions/observations are found other places in this Appendix, particularly in the chapters E.1.9, E.1.10 and E.1.11.

E.2 THE SECOND EXERCISE, CARRIED OUT 21 JUNE 1993

E.2.1 INTRODUCTION

The exercise, like the first one, was carried out as part of the sub-project BER-1.1.

E.2.2 ABOUT THE PREPARATIONS FOR THE EXERCISE

During the discussions at the follow-up meeting after the first exercise, it was found that there was large interest for carrying out the second exercise in more or less exactly the same manner as the first one. Since the weather situation would not be the same, the results would be quite different, and it would not feel like a repetition. Furthermore, the predictive tools were expected to be developed further in the time period between the two exercises.

It was naturally much easier to prepare for the second exercise, as much of the information gathered for the first exercise was still valid.

E.2.3 INVITATIONS TO THE EXERCISE

The invitations to the exercise were sent out 31 March 1993, and a reminder was sent out on the 1 June 1993. They were sent to the institutions and persons listed in Enclosure 1. Enclosure 2 is the invitation translated into English. The original was in Norwegian.

E.2.4 THE DAY OF THE EXERCISE

In the following is summed up the most important events of the day of the exercise. The information is gathered in part from the log book of the Exercise Secretariat, written by Torkel Bennerstedt, and in part from the material which was sent to the Exercise Secretariat from the participants.

All times in the following are given in Norwegian local time, except when otherwise specified.

In the early morning on the day of the exercise, the project leader contacted the meteorologist on duty at the Norwegian Meteorological Institute by phone, to get rough information about the weather of the day. This information should be used to choose a release position which was likely to bring a potential release over Nordic territory, preferably so that it would cross at some point an imaginary line drawn through Oslo-Stockholm- Helsinki. A number of alternative release positions, all around the Nordic area, had already been chosen.

The meteorologist on duty had been briefed beforehand by the BER-1.1 project member from the Norwegian Meteorological Institute, and had done more than was expected of him. Unfortunately, what he had done was not what was needed. He had made a back-tracking to find where a release should have taken place, a day or two ago, that would cross the imaginary Oslo-Stockholm-Helsinki-line at the time I was calling him. Instead, what we wanted was the position in the morning of the day of the exercise of a release, that would cross this line a day or two later. The position the meteorologist on duty gave to the project leader sounded wrong when seen in conjunction with the weather forecast from television the previous evening, and it was quickly found out what the misunderstanding was.

The project leader then collected two members of the Exercise Secretariat from their hotel, and they arrived at the Institutt for energiteknikk, where the Exercise Secretariat should be located, shortly after 8:00. The last member of the Secretariat arrived about half an hour later. The following persons made up the Exercise Secretariat:

Ulf Tveten	Institutt for energiteknikk, Norway. (Project leader BER-1)
Franz Marcus	Nordic Nuclear Safety Research (NKS)
Erling Stranden	Norwegian Radiation Protection Authority (NRPA)
Torkel Bennerstedt	TeknoTelje, Sweden.

At 08:10 a phone from Johs Jensen from the Danish Emergency Management Agency (previously under the Civil Defence Authority) was received, informing the Secretariat that a large EU exercise was conducted this same day, and that it might prove difficult to reach the Danish IAEA fax contact point.

At 08:15 a phone was received from Sigurður Magnússon, Iceland, informing the Secretariat that he would not be present and that the contact person in Iceland would be Sigurður Emil Pálsson, and furthermore that the calculations for Iceland would be performed by the UK Met-office in Bracknell.

The pre-prepared (except for the actual location of the release) telefaxes to be sent out were printed, discussed, a few minor adjustments made, and printed in final form.

The telefax machine which should be used as receiver during the exercise was then tested by sending a message from another telefax machine at the Institute.

At 09:00 the first telefax was sent out to IAEA's contact points in Finland, Norway, Sweden, Denmark and Iceland. All the telefaxes sent as information to all participants from the Exercise Secretariat throughout the day in English versions are included in Enclosure 3. During the actual day of the exercise the English versions were sent only to Finland, while all countries received the Norwegian versions. The faxes in Enclosure 3 are the faxes used during the second exercise, in June 1993. The faxes of the two exercises differ only in the geographical position given for the release point, that times are given in UTC in the latter exercise, that information is included in the latter exercise to the effect that the wind direction is such that Iceland will not be affected, and that phone numbers in Norway had been changed to eight digits in the time between the two exercises. The first fax was also sent to the Norwegian Nuclear Inspectorate (SAT), which no longer exists. It was found that this fax was automatically forwarded to the Norwegian Radiation Protection Authority.

At 09:52 a fax from Finland was received, which contained a list of all contact points in Finland for the day.

The first results received (at 09:53) were from the Meteorological Institute of Denmark (DMI). The results contained trajectories for the front end of the release, that is the time given for start of release. In addition to a front page, this transmission consisted of two maps with trajectories for four different elevations in the atmosphere on the first map and five different elevations on the second map, drawn on maps over Europe, and three pages containing tables. The information contained on each separate page was far from complete. If these pages had become separated from each other or the front page, it would not even be possible to find out from which institution they had come, and not at all what they meant. The trajectories in the two maps are clearly different, but the text on these two pages is completely identical. The trajectory positions every six hours was marked, but this could also not be seen from the maps; only from the accompanying tables. It was said that if this had been a real accident, the results would have been sent to the Police Headquarters in Copenhagen and to the emergency organization in the Bernstorff bunker.

At 09:54 results were received from the Meteorological Institute of Finland (FMI). This transmission consisted of one map only, which seems to contain all information needed for complete identification, although some of it is difficult to understand; partially because it is hand-written and partly because it needs more explanation (this refers to an information box printed on top of the map). The release has been followed 36 hours, every six hours is marked, and the map covers only Northern Scandinavia; a scale evidently more suitable to the time scale in question than e.g. all of Europe.

At 10:02 one more phone was received from Johs Jensen, giving a more suitable fax number to be used for the remainder of the day, because of the problems caused by the EU exercise.

At 10:04 results from SMHI were received at the Exercise Secretariat. These results consisted of integrated air concentrations (relative concentrations) near ground up to 22 June 00 UTC and 23 June 00 UTC, as well as accumulated deposition up to 23 June 00 UTC. All results were drawn on maps of the Nordic countries and parts of Europe. The concentrations were drawn as isoconcentration lines, with the spaces between filled with different types of shading. The shadings were fine, except near the release point, where the drawing was blurred. A smaller scale map (covering a smaller geographical area) would have been more suitable to the scale of the results. In a real accident situation SMHI would have sent the results to the Swedish Radiation Protection Institute in Stockholm.

At 10:10 new trajectory calculations based upon ECMWF data were received from DMI. This was one page with a map and two pages with tables. The calculations were carried out for the first 72 hours from release time, and there were five trajectories on the map, for five levels in the atmosphere. This transmission had the same weaknesses mentioned in connection with the previous set of DMI results concerning lack of identification on each page. The first set of results in the tables is bound to cause confusion, as it seems that the plume mostly has been below sea level.

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At 10:13 new trajectories from FMI were received. This transmission also contained a page giving a verbal description of the weather conditions in the Nordic countries on the day in question. The map contained three trajectories, but it was not easy to see from the material received what was the difference between these trajectories, nor how they differ from the previously received trajectories.

At 10:35 one more set of trajectories from FMI were received. These were said to be more exact than the ones previously transmitted and to be based upon HIRLAM data. This map also contained three trajectories, and the levels in the atmosphere were given.

From 10:25 to 10:46 telefax number 2 was sent out by the Exercise Secretariat. From now on the faxes were not sent to SAT (Norwegian Nuclear Inspectorate). In addition to the information given in the earlier telefax, this fax also contained information on the release duration, the amounts released of the nuclides I-131, Cs-134 and Cs-137 and the heat content of the release.

At 10:39 trajectory results based upon HIRLAM were received from DMI. This transmission contained 7 maps, each containing trajectories at 13 levels in the atmosphere and also a sort of shading evidently indicating the extent of the "plume" (this shading is not mentioned nor explained anywhere in the transmission). The case and institute identification seems to be satisfactory on these maps, as opposed to the previously received results from DMI, but the amount of information drawn is too large, and it is mostly impossible to follow any separate trajectory. The trajectories overlap, and are in addition almost hidden by the shading indicating plume area.

At 11:03 the first set of results from DNMI was received. The first three pages contains explanations of what is contained in the following 10 maps together with very useful verbal situation descriptions. The calculations are evidently based upon LAM50. The first two maps contain trajectories at two different levels in the atmosphere, one level shown on each map. Each of the maps contain five trajectories, but these are trajectories from five different starting points: the specified release point, and four points placed a certain distance (this distance does not seem to be specified anywhere in the results) from the specified release point in directions North, East, West and South. The purpose of this approach is to give an impression of the horizontal dispersion. In these two maps the wind field is overlaid. Perhaps this gives useful information, but there is definitely the danger that it makes the picture more confused. The next four maps show the same trajectories as in map no. two together with prognoses for precipitation at four different times after the release. The last four maps show concentration plots; the results of calculations using the SNAP model, at four different times after the release. These are relative concentrations, as no information was available concerning source strength at the time when they were performed. However, it is not specified whether these are concentrations in air or concentrations of accumulated deposited activity on ground. Since areas that are affected in the first of these four figures are not affected in the last one, it seems probably that they are air concentrations.

At 11:11 one more fax from DMI was received. This transmission contained the results of calculations of the extent of the plume. A continuos release is assumed, and results are given for seven different times after release according to the front page, but in reality there are only six maps. No information is given on how these calculations differ from the ones transmitted at 10:37, though the results evidently differ. Inside the shaded areas are a large number of what appear as circles, and on each page is indicated that results are given for 13 different levels in the atmosphere, but not what type of results or how. The circles are actually letters from a to m, though this is very difficult to see. They are probably meant to show trajectories at different levels, but they are almost impossible to read.

From 11:10 to 11:24 telefax number 3 was transmitted from the Exercise Secretariat. Fax number 3 informs the participants about a new release which has taken place from the same position with start of release at 10:45.

At 11:25 a long fax was received from Veðurstofa Íslands (Iceland's Meteorological Institute), containing the results of calculations performed by the UK Met Office based on the specifications in the first telefax sent out by the Exercise Secretariat. They had used their limited area model. The transmission contained 11 maps, for three different times after release. Air concentration, dry deposition and wet deposition has been calculated for each of these times. In addition total deposition and dosage (in Bq-h/m^3) has been calculated for one of these times. The concentrations are drawn on maps showing the whole of the Northern hemisphere, which is quite unsuitable to the scale of the results. Six different shadings can be (have been?) used, but it is impossible to distinguish them.

At 11:55 a telephone from Iceland was received. They had decided to not let the UK Met Office make further calculations until the Exercise Secretariat had sent out all faxes giving information on the release, for cost reasons. He was informed that the fourth fax, which was soon to be transmitted from the Exercise Secretariat, would be the last one containing such information.

From 11:44 to 12:06 telefax number 4 was transmitted from the Exercise Secretariat. This telefax contained, for the new release with start of release at 10:45 h, in addition to information transmitted earlier, also information about the duration of the release, about the amounts released of the nuclides I-131, Cs-134 and Cs-137, and the heat content of the release.

At 12:03 a fax from the Swedish Defence Research Establishment (FOA) was received. According to their preliminary calculations fall-out could be expected in Sweden on Wednesday morning, 23 June, at the earliest. If this had been a real emergency situation, this message would have been sent to the Swedish Radiation Protection Institute (SSI). Actual results of calculations were not included.

At 12:04 results were received from DNMI. These were updated calculations of concentrations where the limited duration of the release has been taken into account. It is still not clear whether these results are air concentrations of concentrations of accumulated deposited activity on ground. The calculations have been performed for six different times after release. A verbal situation report is also included, and it includes remarks valid for areas in Sweden and Finland.

At 12:05 results from SMHI were received. There were two maps showing the air concentrations at ground level at two times, one hour apart, and one map showing the accumulated concentration of deposited activity on the ground.

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At 12:12 a fax was received from VTT (the Finnish Research Centre). These are results of TRADOS calculations performed in cooperation between FMI and VTT. One map is included, showing three trajectories and air concentrations at one specific time (the time when the trajectory reaches the Norwegian coast). The concentration calculations are evidently based upon one of the trajectories. Concentration isolines are given for four different concentrations spanning a range of almost two orders of magnitude. The isolines, however, almost exactly overlap and all have an odd rhomboid shape. This is caused by the mesh structure in the calculations.

At 12:13 a fax was received from DMI containing the trajectories for the second release. There are three sets of results; two where the trajectories have been followed 39 hours, using HIRLAM data, and one where the trajectories have been followed 75 hours, using data from ECMWF. It must be assumed that the trajectories are for the front end of the release, although this is not said. Each set contains a map and a set of tables. The first set based upon HIRLAM is said to show "trykflader (pressure surfaces)" and the other sets are said to show "modelflader (model surfaces)". It is doubtful whether the implications would have been properly understood by an emergency organization.

At 12:33 a fax from DNMI was received. A new SNAP has been performed, taking the second release into account. It has been assumed that there has been a constant release over six hours. The transmission contains two pages of verbal situation report; no maps or numerical results. The conclusions regarding the situation are identical to the ones drawn from the earlier calculations.

At 12:34 a fax from SMHI was received. It should have contained 7 pages, according to the front page, and should have given the prognoses for Cs-134 and I-131 for the second release, but it contained only 3 pages that were impossible to read.

At 12:39 a fax from FMI was received. It contained one page of TRADOS/HIRLAM trajectories. There were three trajectories, all at the same level in the atmosphere, but for three different start times: 06:10 UTC, 09:10 UTC and 12:10 UTC. They are said on the front page to be calculations for the second release, but are evidently meant to represent the first release, the second release and possibly the final phase of the second release (before information on duration of the second release was received) respectively.

At 12:40 the Exercise Secretariat contacted SMHI by phone with the message that the fax sent to the Secretariat at 12:34 did not come through.

At 12:57 SMHI made one more failed attempt at sending the fax from 12:34.

From 12:58 the fax from SMHI finally was received. It was sent in two batches. It contained eight pages, not seven, but this was because the second page had slipped (with a resulting distortion of the map) and was received on two pages. The maps showed concentration profiles for air concentrations for two different times, 24 hours apart, and accumulated deposited ground concentration for the latter of these times. There were a full set of maps for Cs-134 and for I-131. Although the maps show most of Northern Europe and the scale is not optimal, the shading for different concentrations is quite clear on these faxes.

Appendix E

From 13:30 to 14:40 (!!) a fax from Veðurstofa Íslands was received. The transmission was interrupted many times. It contained 39 pages of results from UK Met Office based upon the first release. The map on which the results were drawn showed practically the whole globe and the predictions were drawn very far into the future, almost a whole week. By this time some of the activity had reached Iceland. Actually it is shown to reach the Eastern coast of Iceland early on Friday 25 June. The results are, as in the previous set received from the UK Met Office, air concentrations, dry and wet and total deposition and "dosage", but the shadings used to indicate concentrations are impossible to read, probably because the scale of the map is so wrong compared to the mesh used for presentation of these results. It is also doubtful whether an emergency organization would find predictions so far into the future to be of value. Sometimes too much information can be given, and this is probably one of these times.

At 13:42 the logg-book from the Emergency Management Agency of Denmark was received. The last point in the logg-book is that a fax has been received from the Exercise Secretariat saying that the exercise is completed, and that there will be a follow-up meeting on the 25 August. This is peculiar, since this fax was actually sent out 14:00.

At 13:46 a fax of six pages (though the front page claims it should contain seven) was received from DMI. It contains "snap-shots" of the plume from the first release at five different times after release. Each of these maps also contain trajectories at 13 different levels in the atmosphere, but these are impossible to read, or even identify as looking like trajectories.

At 13:57 a similar fax was received from DMI, but this contained "snap-shots" of the plume from the second release. These results were given at seven different times after release.

From 14:00 to 14:13 the last fax from the Exercise Secretariat was sent out. It informs that participants that the exercise is completed and also contains an invitation to a follow-up meeting to be held 25 August.

At 14:29 a fax from SMHI is received. Once more the paper had slipped (at the sender machine), so that the second page was received as two pages. In spite of this the transmission contained only nine pages, though the front page claims it shall contain ten. Two pages are probably missing. This was not observed at the time when the fax was received, partially because the order of the results was illogical. The first and last of the received pages contained results for I-131, while there were some Cs-137 and Cs-134 results in between. The results are concentration profiles, but it is not clear whether they refer to the first release, the second release or both, nor how these results and/or assumptions differ from similar results received earlier in the exercise.

At 14:30 was received from FMI the front page of a transmission, but not the accompanying pages.

At 14:31 a fax was received from VTT. This was probably the fax FMI did not succeed in sending one minute earlier. The fax contains five maps with trajectories and concentration profiles for the first release. The trajectories are the same in all five maps. There are three trajectories on each map, but it is not said what they represent; whether they are for three different start times or for three different levels in the atmosphere. The concentrations are concentrations of accumulated deposited iodine on the ground and the five maps represent five different times after release. Four different concentrations, spanning three orders of magnitude, are shown on each map.

At 14:46 a fax from DNMI was received. This fax contained the results of one more update of the SNAP calculations, performed after they had received the information on the limited duration of the second release. A constant release over four hours starting at 06:00 UTC has now been assumed. In addition, a more recent weather prognosis (from 06:00 UTC) than the one used in the previous calculations has been used. The transmission contains one page of verbal situation and case description and six maps containing concentration profiles at different times after release.

At 14:47 a fax from FMI was received. VTT evidently had attempted to send this fax for quite some time, but had problems with their fax machine, so it was sent from FMI instead. This transmission contains results for the second release. There are eight maps, four showing surface concentrations, and four showing air concentrations, of I-131. The last four are on a map of a different scale, showing only the Northern parts of Norway, Sweden and Finland and cut off South of the release point. This seems to be very sensible for the scale of the results obtained and the fact that concentrations over the ocean are usually not of very much interest. Every map contains the identical same three trajectories (except that one falls outside the map on the ones which cover the smaller area), and the identification of these trajectories is missing.

At 14:59 the missing two pages of the transmission from SMHI at 14:29 was received.

At 15:10 a fax containing complementing information from DMI was received. This transmission contained a page missing from an earlier transmission (an early "snap-shot" of the plume from the first release), and replacements for the maps in the two first transmissions from DMI with corrected coordinates for the release point. (It is very confusing that in the two types of figures from DMI (trajectories and "snap-shots") the longitude and latitude coordinates are listed in opposite order.)

At 15:55 the exercise was considered completed and the last members of the Exercise Secretariat left the office. Some faxes were, however, received later on during the day, and they are listed below.

At 15:56 the logg-book from SMHI was received.

At 15:58 DNMI's logg-book was received.

At 16:02 a fax from DMI was received which contained "snap-shots" based upon data from ECMWF both for the first and the second release. Here are also included in the upper right-hand corner the list of 13 levels in the atmosphere mentioned in connection with earlier maps of this type from DMI, but in this case there are definitely no trajectories, since the area around the release point is quite empty. But inside the shaded areas can still be seen some letters referring to the levels. What do they mean? Are they parts of trajectories?

At 16:37 the logg-book from FMI was received.

Appendix E

At 16:39 the same logg-book from FMI was received at a different fax machine at IFE; the one normally used by Ulf Tveten.

E.2.5 MATERIAL RECEIVED LATER

22 June

At 02:34 (00:34 Icelandic time) two logg-books were received from Geislavarnir Ríkisins, one from Geislavarnir Ríkisins and one from Veðurstofa Íslands.

At 14:21 the logg-book from DMI was received, together with six pages of maps containing trajectories for the first and the second release calculated at noon UTC on the day after the exercise, the 22 June. These trajectories are followed further than the ones previously received, but the parts that can be compared to the predictions from the earlier calculations show some difference.

23 June

At 10:24 was received from DMI a set of "snap-shots". These appear to be identical to the ones received at 16:02 on the 21 June.

At 10:40 the logg-book from FOA was received.

24 June

From 14:06 to 14:51 a fax from Geislavarnir Ríkisins was received, containing 38 pages of results from calculations performed at the UK Met Office. The 38 pages contained maps with air concentrations, dry, wet and total deposition patterns and "dosages". This is actually two pages less than in the previously received set of results, but otherwise it is difficult to tell in what manner these results are different from the ones received earlier on. A set of results for the second release was actually expected from Iceland, but the set received on the 24 June rather seems to be a set of results for the two releases combined, as the release has been assumed to have been constant from 06:00 to 09:30 (presumably UTC though this is not stated). In the results received on 21 June it had been assumed that the release continued indefinitely.

E.2.6 GENERAL REMARKS ABOUT THE RESULTS RECEIVED BY THE EXERCISE SECRETARIAT

Once more the exercise was a considerable success. All participants have indicated that they found the exercise both very useful and exciting, and have expressed a strong desire to have regular repetitions of this type of exercise every year or so.

The first prognoses were received by the Exercise Secretariat quite soon after the "accident warning" had gone out. Throughout the day the Secretariat received very much information in a variety of formats, which gave a useful over-all picture of the situation. The different prognoses seemed to be in better agreement than in the first exercise, and there is reason to believe that the information given would have been of considerable value in a real accident situation.

But the primary objective of the exercise was to identify weaknesses, and several weaknesses pinpointed in the first exercise were still found to be present. There is little help in identifying weaknesses if nothing or not enough is done to remove them. At least, no new weaknesses were found. The weaknesses:

- Most of the transmitted results could have had better readability. We should by now be quite aware of the special problems encountered when results have to be transmitted by telefax.

- Trajectories are naturally easier to read than concentration maps. In the first exercise only SMHI submitted concentration maps. This time all the meteorological institutes sent concentration maps. The concentration figures from SMHI were this time much improved. Otherwise these figures ranged from being of questionable quality to being quite impossible. Detailed remarks are found in chapter 2.4.

- Just like in the first exercise, most of the figures transmitted could have contained clearer identification of the release, the time of release, nuclide(s) etc. In particular, it was often difficult to determine in what way a set of results were different from a similar set of results received previously from the same institution. It is important that it is easy to see which situation each page containing results relates to. There is no guarantee that pages transmitted together in a certain order continues to stay together, and certainly not that they continue to be arranged in the same order. In an emergency situation it is very likely that several persons will wish to examine the results, and that the pages of one transmission may be separated. Each and every page must be completely identifiable on the basis of information contained on that page.

- A situation survey, like the one received from DNMI, may undoubtedly be very useful in an emergency situation in addition to information in the form of trajectories and concentration maps. A translation of a situation survey from DNMI from the first exercise is found in Enclosure 4. In the second exercise several participants sent information on this form.

- This time the Exercise Secretariat did not receive so-called meteograms, which were received in the first exercise, and which were a complete mystery to all members of the Secretariat. But some figures received from FMI contained some meteorological information that was equally difficult to understand fully.

- Elevations in the atmosphere are still given mostly in hPa, although there was full agreement at the follow-up meeting after the first exercise that meters or kilometers would be more appropriate information vis-à-vis an emergency organization.

E.2.7 ABOUT THE FOLLOW-UP MEETING

The follow-up meeting was held 25 - 26 August at the premises of the Meteorological Institute of Norway in Oslo. Ilkka Valkama of FMI wrote a memorandum from this meeting, and this memorandum is included in this report in full, as Enclosure 7.

E.2.8 DIFFERENCES IN THE PROGNOSES

The different calculated prognoses were in better agreement than in the first exercise. An analysis of how predictions from the different models compare, particularly with reference to the results obtained in the second exercise, is found in **Appendix C** of this report.

E.2.9 POSSIBILITIES FOR MISPERCEPTION OF THE RESULTS

Perhaps the most serious possibility for misperception of the results is caused by carelessness in not marking ALL communications during the exercise with the words EXERCISE or ØVELSE (in Scandinavian). Every page transmitted in an exercise should be marked in this manner. The participants only marked the front page of each transmission to show that this were results for an exercise. **They did not mark every page**. This must be done in future exercises. The pages may easily become separated, and if some results come into the wrong hands a very difficult situation may arise.

Trajectories may easily be misunderstood. Usually trajectories are valid for the front of the release. In a stress situation it is easy for members of an emergency organization to overlook that the later parts of the release may follow quite different trajectories. It could be an advantage to include an exact explanation in the result presentation, e.g. text like the following: "These trajectories are for the part of the release that took place at 07:00 UTC. Material released at other times may follow different trajectories."

Since concentrations are integrated quantities, it is easy to compare concentrations from one set of calculations and concentrations from another set of calculations, and forget that they may have been integrated over quite different time intervals and that a direct comparison is meaningless.

E.2.10 WEAKNESSES IN THIS PARTICULAR EXERCISE

This time the Exercise Secretariat gave all times in UTC in the messages sent to the participants, and times were given in UTC on the result sheets. The times on the telefax machines, however, are set to a number of different time options. This problem is mentioned in some more detail in chapter 2.11.

At certain times during the day of the exercise, it could be difficult for the participants to get through with their messages to the Exercise Secretariat, even though we used separate machines for sending and receiving. Very long sets of results are difficult to transmit, as the transmission often gets interrupted. One fax from Iceland kept the line busy for almost one hour.

The number of persons in the Exercise Secretariat was not sufficient to leave time to analyze the results received. When the exercise really got "off the ground", this task could have occupied one person full time. In an exercise of this type, however, it does not really matter, since the task of the Secretariat is to keep the exercise running smoothly, not to evaluate the emergency situation.

The need for a loud speaking telephone at Exercise Secretariat was not felt to the same extent as in the first exercise, probably because there were fewer incoming telephones.

E.2.11 ORGANIZATIONAL WEAKNESSES FOUND

The Norwegian Department of Foreign Affairs (UD) is the formal receiver of information of this kind in Norway, and from there the information shall be forwarded to the Norwegian Meteorological Institute (DNMI). In the first exercise it was found that this link did not function satisfactorily. The delay was so long that the information from UD to DNMI did not reach DNMI until after the exercise was terminated. In the second exercise this link functioned even worse. Apparently the information was never forwarded from UD to DNMI at all. Since this problem was anticipated, all information from the Exercise Secretariat was sent both to UD and directly to DNMI. It should be questioned again whether another receiver in Norway (e.g. the Norwegian Radiation Protection Authority) might be more suitable.

The fact that many institutions have not entered receiver identification onto their fax machines was pointed out after the first exercise. When the sender is only told that the receiver is G3, instead of some identification of the institution, one is never quite sure that the message has reached the proper address. This situation was not much improved on the day of the second exercise. It might also be useful if all receivers of messages sent a receipt, so that one is sure that messages have arrived in a complete form. Several times during the day of the exercise the Exercise Secretariat received incomplete sets of results, with the sender quite unaware that anything was amiss. It was not possible, however, to find time for this at the Exercise Secretariat on this day, particularly since the fax machine used to send messages from the Secretariat was in a different building.

On the top of all telefaxes is a line containing various information concerning the transmission. This information is generated by the machine sending the information. One of these pieces of information is the hour and minute at which the message was sent. In practice this piece of information may cause more confusion than clarification. Some of the machines seem to use UTC, but mostly they are in local time, but in some cases these had not been set to summer-time (DNMI and the Emergency Management Authority of Denmark). SMHI has used UTC in some of the faxes sent and Swedish summer time in others. In no case was the time frame specified.

The logg-books from the second exercise were much more informative than those from the first exercise.

The Norwegian Meteorological Institute use the official abbreviation DNMI (Det Norske Meteorologiske Institutt), which is misunderstood frequently, as it is so similar to the abbreviation used for the Danish Meteorological Institute, DMI (Danmarks Meteorologiske Institut). It would be so much simpler if the Norwegian Meteorological Institute adopted the abbreviation NMI.

E.2.12 GENERAL IMPRESSION OF THE EXERCISE

All the participants who had taken part in the first exercise had expressed strong interest in participating in further exercises of this type, and the response after this second exercise was equally enthusiastic.

There were also a couple of new participants in the second exercise, and the response from these has also been very positive.

E.2.13 CONCLUSIONS

The conclusions from the second exercise are not very different from the ones from the first exercise, so this chapter will be rather similar to chapter 1.13.

- Unfortunately, it was found that many of the weaknesses identified in the first exercise had not been eliminated.

- The positive experience gained from the two exercises has been considerable, and the participants hope that it will be possible to have further exercises of this type in the future. In such exercises one has the possibility of observing how the calculation models handle different weather conditions, and one will also have the opportunity of testing improved versions of the calculation models as they become available.

- The response time, the time interval between the time when data were available until the time when prognoses were produced, was satisfactory for all four countries.

- More effort ought to be spent to assure that the results transmitted to the Exercise Secretariat are readable even after transmission by telefax, that all information is understandable and concisely defined, and that all important conditions used in the calculations are specified on every page containing results (in a real emergency situations the pages of one transmission may easily be separated).

- Results transmitted in graphical form ought to be supplemented by sufficient text to make sure that misunderstandings are avoided. This is true both for text supplied to specify exactly what the different results are, which situation the results refer to, what conditions and assumptions have been adopted, uncertainty of the results and an explanation of what the results mean in practice (for an example of the latter, see the Situation Report appended).

- It is proposed that the meteorological institutions agree to use the same elevation and units for elevations for trajectory calculations.

- It is proposed that one, regardless how difficult or uncertain this may be, will attempt to specify a potentially threatened sector in collection with the release in question, e.g. an angle of 40 or 60°. This proposal is based upon the large uncertainty inherent in the calculated results, and the risk which accordingly exists of apparent inconsistencies between the results calculated by the different institutions, or in the worst case, between the emergency organizations to which they supply predictions.

- The Nordic nuclear emergency organizations ought to specify what information is desired from their consultants on dispersion prognoses and on what form it is desired to have the results of predictions presented. A harmonization of the presentation of the results will be attempted within the project BER-1.1, and it would of course be an advantage to know what the desires of the emergency organizations are before this work is concluded, some time during the autumn of 1992.

- The problems concerning the information flow within the Norwegian Ministry of Foreign Affairs, noted during the exercises, must be examined.

- The writing of a logg-book during an exercise may easily become somewhat neglected, among more important tasks. This is a problem worthy of some concern. In a real accident situation completely covering logg-books may be found to be very important at some later time, when it comes to explaining why decisions made at the time were taken and whether they made sense/not made sense considering the information available at that time. It is accordingly important to find functional routines concerning this problem.

Some other important conclusions/observations are found other places in this Appendix, particularly in the chapters E.1.9, E.1.10, E.1.11, E.2.9, E.2.10 and E.2.11.

ENCLOSURE 1. INVITED INSTITUTIONS.

(The names and addresses here are given in the Scandinavian languages, as this specific list will probably only be of particular use to Scandinavians.)

Beredskabsstyrelsen
Postboks 186
DK-3460 Birkerød
Att: Johs Jensen

Danmarks Meteorologiske Institut
Lyngbyvej 100
DK-2100 København
Att. Alix Rasmussen

Risø Forskningscenter
Postboks 49
DK-4000 Roskilde
Att. Torben Mikkelsen

Statens Strålskyddsinstitut
Box 60204
S-104 01 Stockholm

Studsvik AB
S-611 82 Nyköping

SMHI
S-601 76 Norrköping
Att: Christer Persson

SKI
Box 27106
S-102 52 Stockholm

Forsvarets Forskningsanstalt
FOA 4
S-901 84 Umeå

VTT
Postbox 208
SF-02151 Espoo
Att: Seppo Vuori

STUK
Postbox 268
SF-00101 Helsingfors

Innenriksministeriet
Kirkkokatu 12
SF-00170 Helsinki

Meteorologiska Institutet
Postbox 503
SF-00101 Helsingfors
Att: Ilkka Valkama

Faglig råd for atomulykker
c/o Statens strålevern
N-1345 Østerås

Geislavarnir Rikisins
Laugavegur 118 d
IS-150 Reykjavik
Att: Sigurdur M. Magnússon

Statens Strålevern
Postboks 55
N-1345 Østerås
Att: Dir. Ole Harbitz

Det Norske Meteorologiske
Institutt
Postboks 43 Blindern
N-0313 Oslo 3
Att: Jørgen Saltbones

Utenriksdepartementet
Postboks 8114 Dep
N-0032 Oslo
Att: Torbjørn Norendal

Franz Marcus
NKS
Postboks 49
DK-4000 Roskilde

ENCLOSURE 2. INVITATION.

(This enclosure contains an approximate translation to English of the invitation sent to the institutions.)

INVITATION TO PARTICIPATE IN AN EMERGENCY EXERCISE WITHIN THE PROJECT BER-1

Within the Nordic BER program (Beredskap i unormale strålingssituasjoner (Emergency preparedness in uncommon radiation situations)) there will be conducted a Nordic emergency exercise on the 21 June 1993.

The exercise will be very similar to the one conducted in January 1992. The purpose of the exercise is to test calculation of prognoses for transport and dispersion of a release to the atmosphere of radioactive materials caused by a large reactor accident in a geographical position outside of the Nordic countries, and to test parts of the relevant information channels, though less emphasis will be laid on the latter aspect this time around.

The exercise is organized by the BER-1 project (Dispersion prognoses and environmental consequences), project leader Ulf Tveten, Institutt for energiteknikk (IFE).

The Exercise Secretariat will consist of the following persons: Ulf Tveten, IFE, Franz Marcus, Nordic Nuclear Safety Research (NKS) and three or four other persons. It has not yet been decided exactly who. Suggestions are welcome.

The exercise will take place within ordinary working hours on the 21 June 1993. The Exercise Secretariat will choose the release point, release magnitude and other characteristics on the day of the exercise. The Exercise Secretariat will send the information about the release via the IAEA contact points (telefax) according to the international agreements on mutual warning.

All messages from the Exercise Secretariat will start and end with the words "DETTE ER EN ØVELSE" ("THIS IS AN EXERCISE"). The accident scenario will be given when the exercise starts. The actual weather of the day shall by used to calculate the prognoses.

The calculated prognoses shall be sent to the Exercise Secretariat together with information on where the prognoses would have been sent if this had been a real accident. The prognoses could also be sent there, if this is found to be desirable.

This letter is sent to the meteorological institutions of the Nordic countries, but also to a number of Nordic institutions/organizations which would be involved, if an accident of this type really took place.

It is requested that the institutions which will take part in this exercise, write a detailed logg-book of the events of the day of the exercise, so that it will be easier to keep track of events afterwards. The Exercise Secretariat plans to use the logg-books to analyze the exercise. A follow-up meeting will be organized to evaluate the exercise and the prognoses obtained. All organizations which took part in the exercise may participate in this follow-up meeting, but this time the travel expenses can not be covered by the project.

Ulf Tveten, Institutt for energiteknikk, P.O.Box 40, N-2007 Kjeller, Norway, phone +47-63806000, fax +47-63812905, will function as contact person for the exercise and will give additional information upon request.

This letter has been sent to the institutions listed below, although not all of these institutions are expected to participate. The institutions that are most likely to be involved are marked with *, other institutions that are likely to take part, but to a lesser degree, are marked with (*).

Denmark:	Beredskabsstyrelsen	*
	DMI	*
	Risø	(*)
Sweden:	SSI	*
	Studsvik	
	SMHI	*
	FOA	
	SKI	
Finland:	STUK	*
	VTT	(*)
	FMI	*
	Innenriksministeriet	
Norway:	NRPA	(*)
	DNMI	*
	Utenriksdepartementet	*
	Faglig råd for atomulykker	*
Island:	Geislavarnir Rikisins	*

For the Exercise Secretariat

Franz Marcus   Ulf Tveten

Appendix E

ENCLOSURE 3. TELEFAXES SENT FROM THE EXERCISE SECRETARIAT.

(The faxes were transmitted in both Norwegian and English versions to Finland, only in Norwegian to the other countries)

THIS IS TELEFAX NO. 1. BER-1 EMERGENCY EXERCISE.

(THIS IS A TRANSLATION OF THE NORWEGIAN TEXT. IF THERE ARE ANY INCONSISTENCIES, THE NORWEGIAN TEXT IS THE VALID ONE.)

THIS IS AN EXERCISE to test the Nordic models for calculation of dispersion of radioactive materials in the atmosphere. THIS IS AN EXERCISE.

THIS IS AN EXERCISE. An accident at a nuclear power plant has been reported. The position of the power plant is at 73 degrees North and 40 degrees East. At this location there are two PWR power reactors of respectively 1000 MWe and 1200 MWe. The release started at 06:00 UTC this morning.
THIS IS AN EXERCISE.

THIS IS AN EXERCISE WITHIN PROJECT BER-1. As part of this exercise it is the intention that prognoses should be performed in each country, as far as possible, of trajectories, movement of the plume as a function of time, air-concentrations at ground level and concentrations of radioactive materials deposited on ground. All calculations shall be carried out based upon today's weather conditions. The Secretariat of the exercise requests that calculations are performed for the entire Nordic area including the countries Denmark, Finland, Norway, Sweden and Iceland.
THIS IS AN EXERCISE.

THIS IS AN EXERCISE WITHIN PROJECT BER-1. The institutions that perform calculations shall send all relevant results to the Secretariat of the exercise as soon as the results are available, to telefax no. +47 - 63 81 25 61. Include information on where this information would have been sent in a real emergency situation. Additional information on the magnitude of the release etc. will be given by the Secretariat of the exercise later this morning. Nevertheless it is requested that calculations based upon the information available till now are carried out, to the extent possible.
THIS IS AN EXERCISE.

THIS IS AN EXERCISE to test the Nordic models for calculation of dispersion of radioactive materials in the atmosphere.
THIS IS AN EXERCISE.

THIS IS TELEFAX NO. 2. BER-1 EMERGENCY EXERCISE.

(THIS IS A TRANSLATION OF THE NORWEGIAN TEXT. IF THERE ARE ANY INCONSISTENCIES, THE NORWEGIAN TEXT IS THE VALID ONE.)

THIS IS AN EXERCISE to test the Nordic models for calculation of dispersion of radioactive materials in the atmosphere. THIS IS AN EXERCISE.

THIS IS AN EXERCISE. An accident at a nuclear power plant has been reported. The position of the power plant is at 73 degrees North and 40 degrees East. At this location there are two PWR power reactors of respectively 1000 MWe and 1200 MWe. THIS IS AN EXERCISE.

THIS IS AN EXERCISE WITHIN PROJECT BER-1. As part of this exercise it is the intention that prognoses should be performed in each country, as far as possible, of trajectories, movement of the plume as a function of time, air-concentrations at ground level and concentrations of radioactive materials deposited on ground. All calculations shall be carried out based upon today's weather conditions. The Secretariat of the exercise requests that calculations are performed for the entire Nordic area including the countries Denmark, Finland, Norway, Sweden and Iceland.
THIS IS AN EXERCISE.

THIS IS AN EXERCISE WITHIN PROJECT BER-1. The release is reported to have taken place from the 1200 MWe unit. The release contains the following amounts of radioactive materials: 2.0E16 Bq Cs-137, 4.0E16 Bq Cs-134 and 4.0E17 Bq I-131. No other nuclides will be included in this exercise. The release started this morning at 06:00 UTC and was of one hour duration. The heat content was 2.0 MW.
THIS IS AN EXERCISE.

THIS IS AN EXERCISE WITHIN PROJECT BER-1. The institutions that perform calculations shall send all relevant results to the Secretariat of the exercise as soon as the results are available, to telefax no. +47 - 63 81 25 61.
THIS IS AN EXERCISE.

THIS IS AN EXERCISE to test the Nordic models for calculation of dispersion of radioactive materials in the atmosphere.
THIS IS AN EXERCISE.

<u>THIS IS TELEFAX NO. 3. BER-1 EMERGENCY EXERCISE.</u>

(THIS IS A TRANSLATION OF THE NORWEGIAN TEXT. IF THERE ARE ANY INCONSISTENCIES, THE NORWEGIAN TEXT IS THE VALID ONE.)

THIS IS AN EXERCISE to test the Nordic models for calculation of dispersion of radioactive materials in the atmosphere. THIS IS AN EXERCISE.

THIS IS AN EXERCISE. It is reported that an ADDITIONAL release has taken place in connection with the accident at the nuclear power plant at 73 degrees North and 40 degrees East. The additional release is reported to have started suddenly at 08:45 UTC this morning.
THIS IS AN EXERCISE.

THIS IS AN EXERCISE WITHIN PROJECT BER-1. As part of this exercise it is the intention that prognoses should be performed in each country, as far as possible, of trajectories, movement of the plume as a function of time, air-concentrations at ground level and concentrations of radioactive materials deposited on ground. All calculations shall be carried out based upon today's weather conditions. The Secretariat of the exercise requests that calculations are performed for the entire Nordic area including the countries Denmark, Finland, Norway, Sweden and Iceland.
THIS IS AN EXERCISE.

THIS IS AN EXERCISE WITHIN PROJECT BER-1. The institutions that perform calculations shall send all relevant results to the Secretariat of the exercise as soon as the results are available, to telefax no. +47 - 63 81 25 61. Additional information on the magnitude of the release etc. will be given by the Secretariat of the exercise later this forenoon. Nevertheless it is requested that calculations based upon the information available till now are carried out, to the extent possible.
THIS IS AN EXERCISE.

THIS IS AN EXERCISE to test the Nordic models for calculation of dispersion of radioactive materials in the atmosphere.
THIS IS AN EXERCISE.

THIS IS TELEFAX NO. 4. BER-1 EMERGENCY EXERCISE.

(THIS IS A TRANSLATION OF THE NORWEGIAN TEXT. IF THERE ARE ANY INCONSISTENCIES, THE NORWEGIAN TEXT IS THE VALID ONE.)

THIS IS AN EXERCISE to test the Nordic models for calculation of dispersion of radioactive materials in the atmosphere. THIS IS AN EXERCISE.

THIS IS AN EXERCISE. An accident at a nuclear power plant has been reported. The position of the power plant is at 73 degrees North and 40 degrees East. THIS IS AN EXERCISE.

THIS IS AN EXERCISE WITHIN PROJECT BER-1. As part of this exercise it is the intention that prognoses should be performed in each country, as far as possible, of trajectories, movement of the plume as a function of time, air-concentrations at ground level and concentrations of radioactive materials deposited on ground. All calculations shall be carried out based upon today's weather conditions. The Secretariat of the exercise requests that calculations are performed for the entire Nordic area including the countries Denmark, Finland, Norway, Sweden and Iceland.
THIS IS AN EXERCISE.

THIS IS AN EXERCISE WITHIN PROJECT BER-1. Both of the reported releases have taken place from the 1200 MWe unit. It is reported that the new release, which started at 08:45 UTC and was terminated at 09:30 UTC, contains the following amounts of radioactive materials: 5.0E15 Bq Cs-137, 1.0E16 Bq Cs-134 and 1.0E17 Bq I-131. No other nuclides will be included in this exercise. The heat content of the release that took place from 08:45 UTC to 09:30 UTC was 0.2 MW.
THIS IS AN EXERCISE.

THIS IS AN EXERCISE WITHIN PROJECT BER-1. The institutions that perform calculations shall send all relevant results to the Secretariat of the exercise as soon as the results are available, to telefax no. +47 - 63 81 25 61. Include information on where this information would have been sent in a real emergency situation.
THIS IS AN EXERCISE.

THIS IS AN EXERCISE to test the Nordic models for calculation of dispersion of radioactive materials in the atmosphere.
THIS IS AN EXERCISE.

THIS IS TELEFAX NO. 5.   BER-1 EMERGENCY EXERCISE.

(THIS IS A TRANSLATION OF THE NORWEGIAN TEXT. IF THERE ARE ANY INCONSISTENCIES, THE NORWEGIAN TEXT IS THE VALID ONE.)

The exercise is now terminated, and the Secretariat of the exercise wants to thank you for participating. All results received during the day will be distributed to all participants in the exercise within the next few days.

A meeting to discuss what can be learnt from this emergency exercise is planned. The Norwegian Meteorological Institute has kindly offered to host this meeting, and the 26 or 27 August has been proposed as alternative meeting dates. Please let us know as soon as possible whether this is suitable.

Please send a copy of the logg-book immediately to telefax no. +47 - 63 81 25 61.

ENCLOSURE 4. SITUATION REPORT RECEIVED FROM DNMI.

SHORT METEOROLOGICAL EVALUATION OF THE ACCIDENT (13^{30} local time)

- (According to our trajectory maps - from 1050 local time):

- 1. release: (0800 local time)
  Air masses from this release will reach the Norwegian coast at Møre about 6 - 8 hours after release (1400 - 1600 local time).
  There is significant precipitation (rain showers) in the area and the mountain areas inland from the coast. The following areas are therefore potentially threatened:

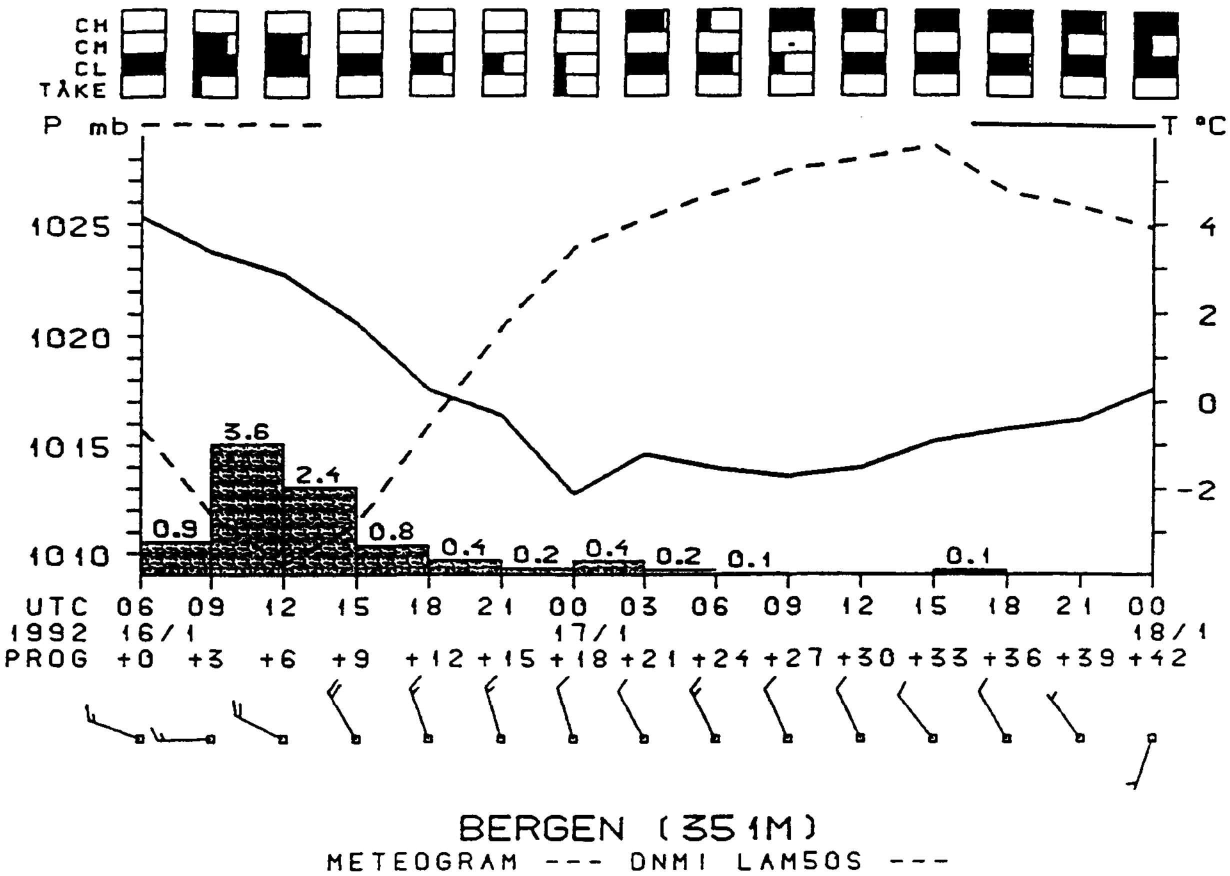
  Møre - Dovre - Jotunheimen (see Meteogram & traj.)

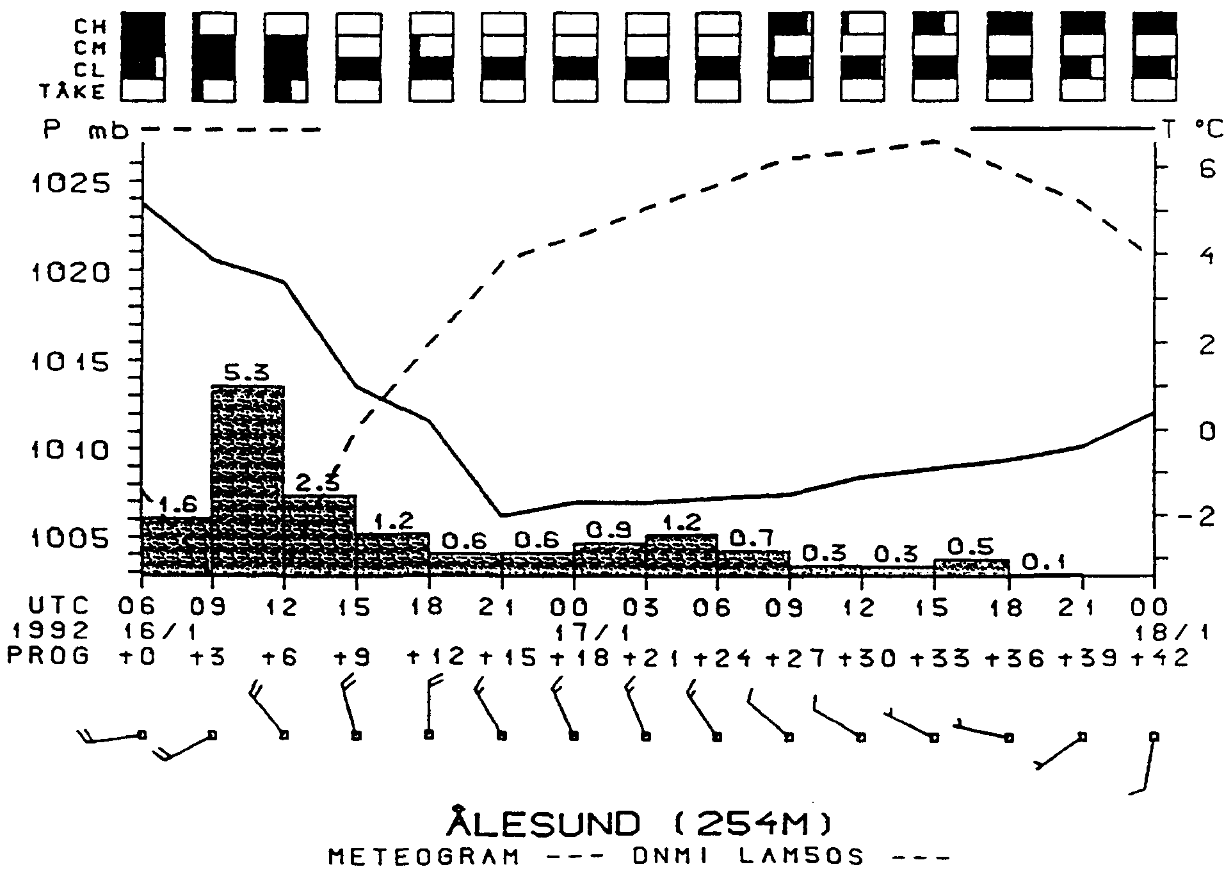
- 2. release: (1045 local time)
  Situation relatively similar to the one for 1. release, and the same areas are threatened, though gradually the whole of Western Norway from Stad to Stavanger are threatened (see Meteogram & traj.). Mountain areas somewhat in from the coast will have the highest precipitation and potentially the fall-out areas of highest concentrations.

In general:

Eastern Norway (east of the watershed) is less threatened, since there will be less precipitation, and since much activity will be washed out of the plume in the western part of the country.

ENCLOSURE 5. METEOGRAMS FROM DNMI.





ENCLOSURE 6. LIST OF PARTICIPANTS AT THE FOLLOW-UP MEETING AT THE METEOROLOGICAL INSTITUTE OF DENMARK, 4. FEBRUARY 1992.

Name	Address	Telephone/Telefax
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ENCLOSURE 7. MEMORANDUM FROM THE FOLLOW-UP MEETING AT DNMI, OSLO, NORWAY IN AUGUST 1993.

(This memorandum has been prepared by Ilkka Valkama, Air Quality Department of the Finnish Meteorological Institute the 23 September 1993.)

Seminar on the Nordic BER-exercise (June 21. 1993)
Place and date : DNMI, Oslo, Norway, August 25.-26.1993

A short summary

In the first part of the seminar the Nordic BER-exercise of June 21., 1993, was discussed. Each institute gave their general impressions and commented upon the problems encountered. The model results, both forecasts and analyses, of participant institutes were compared. In the second part of the seminar a proposal of a common Nordic standard for visualization of dispersion model results was presented and discussed. Finally the contents of the BER-1.1 Final Report was discussed.

The list of participants is given at the end of this enclosure.

Topic 1. The Nordic BER-exercise of June 21. 1993

Each participant institute was given the floor to comment upon the exercise. A summary of these is given below.

The Danish Meteorological Institute provided 2-D trajectories and "puff-forecasts" based on their "poor man's dispersion model". Time lags, up to 40 minutes, in communications between the institute and the Danish authorities had caused some problems. Also the BER-exercise telefax no. 3 was belated. In the future the Danish situation will improve as the institute has purchased the British NAME model. It will be installed during this year.

The Finnish Meteorological Institute found the exercise particularly rewarding. Some coding bugs has been identified in the user interfaces of the TRADOS-model. These bugs had delayed the Finnish response considerably during the exercise. The main problem was that the model was still run on two different computers located at two institutes (the FMI and the Technical Research Centre). This, however, has already been remedied, as the whole program can now be on FMI's UNIX-work station. The greatest practical problems were connected to the telefax-communications. For instance one of the telefaxes (some 6 pages) send to the Exercise Secretariat disappeared mysteriously enroute to Norway. Only the title page was actually received at the other end.

The lack of sufficiently large main-frame computer prevents the Icelandic Meteorological Office from running a meteorological forecast model of their own. Consequently the IMO acted only as a link between the Icelandic authorities and the British Meteorological Office at Bracknell, where a dispersion model was run on behalf of the IMO. This arrangement, which in a real situation could not be expected to work, caused some troubles during the exercise, too. First of course come the long response times. It took about one hour to get the dispersion forecast from Bracknell to the Icelandic authorities. The second and perhaps even greater handicap was the scale in which the UKMO delivered the forecasts. The pictures covered the whole of the Northern Hemisphere and practically no details could be identified, even in the originals. The telefax-copies were totally indecipherable. Finally the number of pages send from Bracknell was far too great. The total of forty pages took nearly an hour to send by the telefax. However the Icelandic representative at the seminar found the exercise worth while and interesting.

The Norwegian Meteorological Institute was one of the fastest to respond. The procedure followed during the exercise, and in any real situations as well, was described. The routine consists of some fast trajectory calculations on the meteorological workstation of the institute. The most probable trajectories are then linked to other relevant meteorological data, typically a short range (3 hour) precipitation forecast. The pictures, together with a written assessment, is then send to the authorities by telefax. Meanwhile a more concise assessment based upon the SNAP-model, a version of the British NAME, is being made by the experts. In the BER-exercise both assessments were made by the same people, but in a real situation the first part is performed by the duty forecaster.

The problems encountered include the partition of the two releases in one source term. Also the forecast mode of the model has as yet no removal mechanisms. Thus no deposition is given, only air concentrations. The problems of the conversion of the mass concentration (g/m3), which is the normal model output, into activity (Bq/m^3) was discussed. In runs based upon analyzed weather data the deposition is included. In these some abnormalities in the concentration fields were found after a few days of transport. Also the trajectories from the lowest layers of the model deviated more to the east than those of the other institutes.

The analyzed runs of the MATCH-model of the Swedish Meteorological and Hydrological Institute showed that the main deposition on the Norwegian coast was due to wet deposition. The dry deposition was significant only during the first hours of the release. The partition of the two releases in the model runs was discussed. There may be some difficulties with the vertical dispersion in the model. In the future the long term forecasts based upon weather data from the European Centre for Medium Range Weather Forecasts will become available as an optional input.

The UK Meteorological Office, while not a Nordic institute, was present as observer and their particle dispersion model (NAME) featured strongly in the exercise. The analyzed runs have revealed some interesting discrepancies between the two version of the NAME (British and Norwegian). The UKMO found it an interesting exercise and the results and comments will be discussed inside the UKMO as well.

General topics that came up during the discussion :

The BER-steering group found that the two telefax-machines reserved were not sufficient.

The DNMI was the only institute that provided a verbal description of the dispersion and of the danger areas. This is a procedure that the end-users , i.e. the authorities, strongly prefer. In the emergency response activities the principle "less, but in a more final form" is to be preferred.

In an exercise like this all pages should be clearly marked *"This is an exercise"*. In the June exercise only the cover pages were so marked.

The actual results, both the forecasts produced by the institutes during the exercise and the analyzed runs made afterwards, were compared and discussed on several occasions during the seminar. The general impression was that the output of various models based upon very different physical principles were remarkably similar. The air concentration and deposition patterns were located similarly and were of comparable magnitude. The lack of a common map-background makes the comparisons difficult, but especially the Norwegian and the Swedish deposition fields based on the analyzed weather data seemed to be close to each other.

Apart from the physical differences in the model parametrizations, the different versions of the Nordic weather forecast model (HIRLAM) in use in Finland and Sweden are of course responsible for some discrepancies. The Norwegian model runs in the forecast mode on their own LAM-50 model data. Also the time interval considered (48 hours) and distances covered (only up to c. 1000 km) must be kept in mind. In the long run the forecasts might be expected to disperse more.

All in all the outcome the exercise was found to be interesting and rewarding. A short report to compare the air concentration and deposition fields was proposed to be included in the final report.

Topic 2. The graphical visualization standard NORVIEW

During the Nordic exercises under the BER the lack of a common format to present the outputs of the various models have been commented upon on several occasions. As the result, and on the project leader's initiative, Mika Salonoja from the FMI presented a proposal for such a standard. The presentation format, to be called the NORVIEW, consists of two types of pictures and some rules to produce them. The general atmosphere during the following discussion was that of an approval towards a unified way to visualize and to present the model results.

The actual graphical package to produce such pictures was, however, not so favorably received. There seems to be a natural incline to keep to the proven systems already employed by the institutes. Especially the environment proposed (X-Windows upon UNIX) was received with some reticence. While all are using or starting to use UNIX, the institutes seem to be committed to some type of meteorological work station, usually of their own design, and all further systems must be in accordance with these. Most have also financing problems, the emergency response developments being on external project money basis in most institutes.

General comments upon the first type of NORVIEW-picture, "the trajectory picture".

- The English should be polished, e.g. "computed at" vs. "running time", "period" vs. "length" etc.

- The term "length" was also found confusing, as the authorities will tend to think of the "length of the release".

- The time signals should be exactly at the midnight (2400 UTC), instead of every 24 hours as proposed. As to shouldn't the SI-standard for time ("1993-06-21") to be followed, it was decided that the format "1993-JULY-21" could be preferable as a less confusing one.

- The type of computations, 2-D, 3-D, which levels etc., should be included in the header.

- Another "info window", relating the actual area covered in the picture to the map of Europe, should be included.

- The one of the main principles is that only one parameter should change in each picture. For instance the "trajectory clusters" will be OK. The precipitation fields, on the other hand, could not any more be presented in the same picture with trajectories. The DNMI seemed to find this unacceptable.

- The lack of standard format for giving the danger zones was criticized. It was proposed that such information should be included in the (flexible) info window.

The authorities will very much prefer the verbal interpretation of the picture, as this often saves a lot of valuable time.

General comments upon the second type of NORVIEW-picture, "the field picture".

- (Cross)hatchings could make the graphical representation more selective. The impression of e.g. the SMHI is that at the maximum two types of hatching supported by simple isolines will suffice on most occasions. In any case the maximum number of isolines should be limited (up to 4?).

- The preference of letters instead of numbers was discussed. The magnitude of values would not be the same on every picture, so it might cause some trouble to keep in mind which letter represents which value. On the other hand large numbers tend to become overprinted by the lines and by each other. It was agreed upon by the most that the trouble of finding the legend will not be a problem, as the quantity presented must in any way be checked from the info window.

- The type of deposition, dry or wet, was discussed. It was agreed that the total integrated deposition, perhaps with some optional averaging times (3h, 6h, 24h), will be the most informative one. This also forms the best bases for the counteraction options. More detailed information would probably be lost in any way.

- The "sampling time" or "the integration time" of the air concentration should be included in the info window.

- Regarding should the fields be preferred over the trajectories, it was thought that especially in the first stages, when the amount and the height of the release is not known, the trajectories could contain very valuable information. Also the various authorities are by now well accustomed to them and will actually demand such pictures.

- It was also suggested that a third type of NORVIEW-picture, a time series, should be included in the standard.

This brought up the broader question of "Who will be using this data?"

In most of the Nordic countries the experts will do the first screening and provide the authorities with assessed data. This would be an ideal situation. In actual life, however. it is very probable that not all end-users actually understand everything presented to them by the meteorological institutes. So it would be preferable to keep the information as clear and as "simple" as possible. Especially the trajectory pictures can be very misleading if interpreted by an inexperienced user. He will in all probability try to read "too much" in them. The visualization of the situation on hand should be the first aim of any standard. If there were always an expert on hand no standard would be necessary. The past experience has shown that regular briefing sessions are helpful in minimizing the confusion.

As for the possibility of trying out this standard e.g. in the coming ODIN-exercise (November 26. 1993), the meeting was informed that the ODIN exercise is mainly a counteraction exercise. The situation will be a given one and no forecasts will be included.

All in all it was found that a common presentation standard would greatly advance the Nordic cooperation and concentrated efforts during an emergency. The proposed format, with suitable modifications, was seen as a realistic basis for such a standard. Mika Salonoja will make an improved proposal to be circulated in the institutes. The greatest problems seem to be connected to the soft-ware. The institutes seem to prefer their existing systems. On the other hand it was pointed out that also other systems, for example those aimed for decision support, exist or are under development in the Nordic countries. It might be advisable to try and see what could be found out about these and if they could be utilized or harmonized with the effort in question. It was also commented by the representative of the NKS, that if such a standard were adopted by the Nordic countries, it might encourage other countries to join in, too.

Topic 3. Two demonstrations took place during the seminar

First Mika Salonoja from the FMI showed the present user interfaces of the Finnish TRADOS-model. The interfaces are written in C-code under OSF/Motif on X-Windows. The power of UNIX-environment was evident when these models were run in the UNIX in the FMI, Helsinki, through Internet from an work station in DNMI; Oslo. The only drawback was the very low speed, resulting of DNMI's network computer's limited capacity. The demonstration included a graphical presentation of the TRADOS results for the BER-exercise. The system was well received and various aspects were discussed. The graphics were thought to be generally visual, but the color schemes, including the number of colors were criticized. The idea of ready-made list of the nuclear power plants and other nuclear installations in Europe was received well.

Jørgen Saltbones from the DNMI demonstrated the meteorological work station of the institute and the procedure followed during the BER-exercise (see above). The trajectory model presented proved to be very fast and easy to use. The SNAP-model has a present no user interface as such. The input file must be created under a normal text editor. Other than that the model (air concentrations only) was surprisingly fast, 48 hour forecasts (6 pictures) taking some three minutes. The work station also automatically prints out the resulting pictures. The number of pictures (6) was discussed and found that not all should be send by telefax, as this would take almost 20 minutes.

A lively discussion of technical aspects and general principles of the modes followed.

Topic 5. The final BER-1.1 report

A preliminary text was presented by the project leader. The contents were discussed and accepted with some additions. Each institute will be required to provide a short description (max 2 pages) of their models to the project leader (deadline month : November). The FMI will include a separate page upon the implementation of the HIRLAM-data for the TRADOS, this being financed separately by the NKS.

A short comparison of air concentrations and deposition fields were agreed to be included. The other institutes will deliver their contributions in graphical form to Christer Persson, SMHI, who will be responsible for the text. The pictures should include the 48 hour forecasts for the air concentrations and total deposition fields of 137Cs for both releases. Additional results from runs with analyzed weather data can be included, if available. The forecasts and analyses should be valid for the date July 28. 1993, at 0600 UTC.

Topic 6. The follow up

The project leader stated that he had no knowledge of how this cooperation could be financed in the future. However, he found that the BER-1.1 had been a worthwhile enterprise. Such exercises between the Nordic countries should be continued, e.g. at every second year. The contacts with the radiation control and the emergency response authorities should also be continued. The follow up concerning the modeling cooperation will very much depend on the institutes themselves.

List of participants in the follow-up meeting 25 - 26 August 1993.

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Appendix E

Appendix E

Appendix F

NORVIEW, A PRESENTATION SCHEME

Mika Salonoja, Weather department, Finnish Meteorological Institute

October 1994

Appendix F

F.1 GENERAL INFORMATION AND BACKGROUND

The NORVIEW-standard has been created to harmonize the way dispersion model results are presented in the Nordic countries. The idea originally came from the project leader, Ulf Tveten, and FMI was chosen to create the standard. This paper presents the fourth and possibly last version of the standard. Several comments from different authorities and modellers have been taken into account, but there has also been some points where it has been impossible to find a full agreement.

The presentation standard includes all the necessary rules to define the appearance (lines, markers, map background, text areas etc.) of a dispersion model picture on a map background. The picture is black-and-white on an A4-sized paper, so it can easily be sent by fax. The main goal is to produce pictures, which are very simple and clear (even after being sent by fax) and easy to understand by all the authorities. In developing the presentation standard we have tried to take into account that an emergency situation is a hassle and psychologically really stressing and also that the amount of different kind of papers increases rapidly when the situation goes on for several hours or days.

At the moment the presentation standard includes only two kinds of pictures: trajectory picture and a so-called field picture, which presents field quantities (air concentrations, deposited amounts etc.) with iso-lines on a map background.

Originally the NORVIEW-standard was meant to include also a visualization and graphics package. However, we have learned that it is practically impossible to find any suitable solution for all the Nordic countries with the resources available for this project.

We hope that our work will be of some use to the modellers and that the recommendations of the standard will be taken into account in the future. At the moment the FMI TRADOS-model produces pictures which are quite close to this standard. This improvement has been realized during the summer of 1994. There are a few examples of TRADOS pictures at the end of this paper.

Sending pictures via telefax is, as we know, sometimes very problematic. Maybe in the near future it is possible to share the model result pictures with the other Nordic countries fast and easily via Internet. There are several ways and there has alreay been some discussions of this kind of project. One way would be by sending PostScript-coded colorpictures via ftp (file transfer protocol), or to send the model result pictures to the local WWW-server (World Wide Web, a rapidly growing hypertext protocol, that physically uses Internet) from where the modellers from other countries could watch and retrieve them using the very friendly Mosaic-program (which is available for PC, Macintosh and UNIX). At FMI several products, like radar and satellite pictures, stratosphere ozone level, HIRLAM-forecasts and UV-forecasts etc. are already available in the Mosaic. Propably there is or will be a WWW-server in all the Meteorological Institutes very soon.

F.2 GENERAL DESCRIPTION OF THE PICTURE

Here are the general rules of the picture. Some of them are absolute rules and some of them mainly recommendations.

a) This standard describes the visualization of the results of operative transport and/or dispersion models; meteorological fields are not presented.

b) The picture is **black-and-white on A4-sized paper**, so it can be sent by fax. The ability to use the fax is the main limitation of the standard: colours, different tones of gray, very small fonts etc. cannot be used.

c) The **amount of data** in one picture should be kept as little as possible to maintain the clarity. If the amount of data produced is too large, several pictures should be made instead.

d) The **language** in the picture is **english.**

e) Only **SI-units** are used in the picture. **Coefficients** of the units (kilo, milli, micro etc.) should be used so, that the values of numbers are reasonable.

f) **Special symbols** of meteorology, nuclear physics or radiology should not be used; the picture should be as widely understandable as possible.

g) **Date and time** is presented in the following form: day, month, year, hour, minute. Month should be presented in letters. Year should always be presented in four digits (year 2000 will be here so soon). Otherwise the format is not fixed, but it must be easy to understand. **Only UTC-time is used** in the picture; local time should never be used. The letters 'UTC' should always be marked after the time to avoid misunderstanding. Here are some examples:

30-MAR-1993 12:30 UTC	OK
30.03.1993 12:30 UTC	not good
9303301230	not good

h) The **coordinates** are normal latitude and longitude in degrees and minutes. Degrees and parts per hundred should not be used. There should be an uppercase letter 'N' after latitude value and an uppercase letter 'W' or 'E' after longitude value. The value of longitude must always be positive, and instead letters 'W' and 'E' should be used.

i) There are two kinds of pictures: the **trajectory picture** and the **field picture**. The latter is meant for presenting mainly radioactivity quantities, like air concentrations, deposited amounts and dose rates on a map background. **Trajectories and field quantites must never be presented in the same picture**, since trajectories represent a period of time, while field quantites represent values for one fixed time.

j) The picture is divided in three parts: the **header area, info area** and the **actual data** on a map background. The rules for the map background of both trajectory and field pictures are presented in chapter F.3. The rules for the other parts of the picture in the trajectory picture and the field picture are presented in chapters F.4 and F.5, respectively.

k) The place of the **header area** is at the upper edge of the picture. It contains general information like name of the model, name and logo of the institute, runtime, identification of the start point or incident and so on. The contents of the area is described in the following chapters.

l) The place of the **info area** is not fixed; it can be placed to the lower edge or somewhere else inside the picture. Especially in trajectory pictures there is almost always a place on the map for the info area, and thus the space can be used effectively and the map can be presented as big as possible. In many cases it is of course technically easier to create pictures with fixed position of text areas. The info area contains identification of the data presented on the map. The contents of the area is described in the following chapters.

F.3 THE MAP BACKGROUND

An absolutely rule is that the **map area should be recognizable**, even for a relative outsider. In addition, the following rules apply to both trajectory and field pictures.

i) The only obligatory part of the map are the **shorelines.** Also big rivers and lakes are presented. The type of line is continuous and rather thin. No shadings are used, so the sea and land are both just white.

ii) **Borders of countries** can be presented in the picture, but they are not obligatory. Usually it is recommended, however, that they are presented.

iii) The **latitude-longitude-grid** can be presented in the picture, but is not obligatory. Usually it is recommended that it should not be presented. If latitude-longitude-grid is presented, the values of the lines should be mentioned.

iv) Big **cities** can be presented with black dots, but usually their presence is not recommended, since they very easily make the picture messy. If cities are presented, their name should be given with very small letters, or maybe only a few letters from the beginning should be used.

v) **Topography** is not presented in any way.

vi) The **size and position of the map** should be chosen so, that the model results fill the whole map as well as possible. This greatly enhances the clarity of the picture. The scale of the map can, however, not be chosen freely. Instead there will be a set of fixed values of map scales to be used, so that we can have pictures, which are easy to compare.

vii) The projection of the map is either mercator or polar stereographic.

F.4 THE TRAJECTORY PICTURE

F.4.1 General rules

- The number of trajectories in one picture should be kept reasonable. This means usually 3-4 trajectories per picture. If large number of trajectories must be presented, several picures should be made instead.

- **If several trajectories are presented in one picture, only one parameter can change from trajectory to another.** For example, if trajectories start at different times, then the starting point and height must be same for all the trajectories. If trajectories start from different pressure levels, the start time must be same for all trajectories, and so on.

- If several trajectories are presented in one picture, the direction in time must be the same for all of them.

- If several trajectories are presented in one picture, the length should normally be the same for all of them.

F.4.2 Header area of the trajectory picture

- The header area is placed at upper edge of the picture. It is as wide as the paper, and about 4-5 cm high. Above the area should be left 2-3 cm empty space for fax-addresses, and other hand-written information.

- The header area must contain the following information: identification of the institute and model, runtime of the model, name of the weather data, identification of the start point or incident, identification of data presented on the map and the word 'NORVIEW'. The header area may also contain the logo (this is very advisable) and one line of free comment text.

- The identification of the information and the information itself should be written using different fonts if possible, for example:

  Name of the start point: **Chernobyl RBMK, Ukraine**

- **First line** consists of name of the institute and the identification of data (air trajectories and their dimension, particle trajectories etc.). The font must be big.

- **Second line** contains runtime of the model. The line begins with words 'Runtime' to emphasize that it is the runtime of the model, not the start time of trajectories or other calculations. Runtime must be presented in the form, which was described earlier. The font must be rather big.

- **Third line** contains the name of the start point or the incident. Examples: 'Sosnovy Bor, Russia', 'high I-131 measurements in Helsinki', and so on.

- **Fourth line** contains name of the model and identification of the weather data (name of the model, synoptic observations etc.). The words 'Weather data' must be put in front of the identification of the data. If numerical weather data on model levels is used, it should also be mentioned. If HIRLAM-data is used, it is recommended also to mention the institute that produced it, for example 'FMI-HIRLAM'.

- **Fifth line** contains contact information (telephone and fax numbers) and free comment text. It can be the name of the modeller etc. The form of this line is free and font rather small.

- If the **logo** of the institute is presented, its place is in the upper right corner of the area. Using the logo is very much recommended, since it very well distinguishes the picture from other papers.

- The word 'NORVIEW' is presented in small letters in the lower right corner of the area.

F.4.3 Info area of the trajectory picture

- Info area contains the data which is needed to identify the data presented on the map. In the trajectory picture the info area contains height, coordinates and time of the start point, length and direction of trajectories.

- The place of the info area is at the lower edge below the map or somewhere on the map, where there is room for it. The size of the info area is not fixed.

- If several trajectories are presented in one picture, the contents of the area begins with the **identification of the quantity that changes from one trajectory to another.** The first line contains the name of the changing quantity. For each trajectory there is a line, which begins with the marker letter (see following section) followed by the value of the changing quantity (see example picture in the back of this appendix).

- Next in the info area there are identification lines for other quantities in the following order: start time, length and direction in time, start height, and coordinates of the start point (of course, if several trajectories are presented, then one of these quantities is presented first in the upper edge, and not here). Each one of these lines begins with the name of the quantity.

- The **unit of height** is normally hectopascal (hPa). If the height of the start point is known also in meters above ground, it might be a good idea to mention also that. If trajectories are calculated from observations or using model-level data, then some other unit than pressure can be used, for example meters above ground.

- The **unit of length** of trajectories is hour (h).

F.4.4 Trajectory lines

- The **start point** of calculations is marked with a special symbol: a cross surrounded by a circle (see the example picture in the back of this appendix).

- **The height of the trajectory is not presented in a graphical form in any way**. Only the start and final pressure levels are marked in info area or at the end of trajectory line (see last point in this chapter and previous chapter). This is for two reasons: first, presenting the height easily makes the picture messy or it requires a separate window, which makes the picture more complicated, secondly, it might be difficult for the authorities to obtain any usable information from the height of the trajectory line. Instead there is a great danger of misinterpreting the information ("the higher trajectories are less dangerous" etc.).

- There is only **one type of trajectory line**: a solid, rather thin one. It is decided to use only one kind of trajectory line to avoid the misinterpreting, that some trajectories drawn in solid line would be more important than ones drawn in dotted line.

- The **trajectories differ from each** other by lowercase letter-markers.

- In the trajectory line there are **time-markers** between every 6 hours. These markers also function as a way to separate trajectories from each other: the marker is a small lowercase letter, and the letter 'a' is used for the first trajectory, letter 'b' for the next and so on. Using letters is more clear than numbers. It is very important that the marker is placed inside the line, not beside it.

- Between **every 24 hours** the time-marker is surrounded by a circle.

- At either end there is a small **arrow-head** to point to the direction the trajectory. If trajectory is calculated forwards in time, the arrow head is placed at the end point. If trajectory is calculated backwards in time, the arrow-head is placed at the start point and pointing towards the start point.

- There can be a small text a few letters long at the end point of the trajectory. It can be the end time of a trajectory moving forwards, the start time of a trajectory moving backwars, or maybe the final pressure level of the trajectory. Using little text can enhance the clarity, because then some information is really connected with the trajectory, instead of putting it in the info area. However, if trajectories are very close to each other, the end text should not be used.

F.5 THE FIELD PICTURE

F.5.1 General rules

- The field picture is meant for presenting field quantities, which present one fixed time or time-integrated values up to one fixed time. Such quantities are at least the following: air concentration of a radionuclide/-nuclides, time-integrated air concentration of nuclides, deposited amount, external dose rate from cloud and ground, internal dose from inhalation and estimation of population dose.

- Fields are presented by **iso-lines** on a map background. The number of lines should be kept reasonable, typically 2-5 lines.

F.5.2 Header area

- The rules for the header area of the trajectory picture also apply to the field picture, except that the identification of the data in the header area is quite general (for example 'Air concentrations') and all further identification and units are given in the info area.

F.5.3 Info area

- Info area contains the data which is needed to identify the data presented on the map. In the field picture the info area contains coordinates and time of the start point, and identification of the quantity presented.

- The place of the info area is at the lower edge below the map or somewhere on the map, where there is room for it. The size of the info area is not fixed.

- The info area begins with a full identification of the data. It can take one or two lines. All information must be given, like name of the nuclides, units etc. For example 'Air concentration of Cs-137 at 2m level (Bq/m^3)'.

- Next in the info area there are the values attached with the different iso-lines. There is one line in the info area for every iso-line. Every line begins with identification letter (see following chapter) followed by the value.

- Next line contains the time the field is attached to. The line begins with words 'Time of the field'. At the end of line there is the time interval in hours between the start time and the time of the field.

- Next line contains the start time of the calculations. The line begins with words 'Release time:', to clarify that it is not the time the field is attached to.

F.5.4 Presenting the field with iso-lines

- The **number of iso-lines** must be reasonable, typically 3-6 lines. The values should be chosen so that the iso-lines can be separated. The maximum number of iso-lines depends on the situation and the size of the calculated area.

F.6 THE NORVIEW GRAPHICS PACKAGE

The idea of the NORVIEW-graphics is to provide modellers and end-users with simple tools for realizing pictures compatible with NORVIEW presentation standard. NORVIEW-graphics will not be a whole visualization program, but rather a small library or toolkit containing modules for plotting typical results of dispersion models and all the other necessary parts of the picture (map background, text windows etc.). At the moment the module package doesn't exist and there is a number of ways in which it could be created. It is then difficult to indicate when it may become available; maybe between one and two years from now is quite realistic. After we have found out what needs the users have and which is the best way to create the package, the work will be started as soon as possible.

Using the graphics package is, of course, not obligatory. If, in some country, there already exists a satisfactory system for plotting dispersion pictures, there is no reason to start to using this package. In such case we hope, however, that the rules of NORVIEW presentation standard are taken into account as well as possible.

We have thought of three different ways to create the package:

1. **Creating the package using objects from the new FMI meteorological workstation program.** This is the most sophisticated choice. The graphics code would be object-oriented code written in C++ -language. The package would run in X-windows using propably OSF-Motif. This choice takes more time than the others because the work for creating the meteorological class-library is just starting at FMI.

2. **Using tools from some of the many shareware-visualization programs available in X-windows/UNIX-world.** This choice looks very good. By using some existing package we could have a working system faster. Many of these programs include very sophisticated tools for handling the map background, but there are also some problems. Typically the existing packages require a lot of knowledge and experience from the user and they have too many unnecessary options.

3. **Creating the code from scratch using a graphics code generator.** This kind of stuff we have already done at FMI quite a lot for creating graphical user-interfaces for various programs. With this choice all parts of the package (for example creating, zooming and scrolling the map background) would have to be created ourselves. The package would be written in C and using OSF-Motif.

Using the final package would require the following:

1) a UNIX-workstation or X-terminal connected to UNIX-computer,

2) X-windows and OSF-Motif

3) maybe a C++ -compiler and

4) the ability to write fairly simple C or C++ -code for feeding the result data into the plotting program, and to control the way it is plotted.

In its simplest form the plotting program would read trajectories from a file, open a window and create a NORVIEW-compatible trajectory picture, which then could manually be dumped into a picture file (PostScript or LaserJet) and printed. In this form the end-user wouldn't have to perform any graphics programming at all.

Appendix F

SUMMARY

This report describes the work performed within the project "**BER-1.1, Dispersion prognoses**" during the program period 1989 - 1993. The project is part of the research program managed by and partially financed via the Nordic Nuclear Safety Research program.

The report contains a relatively short main section in which the whole project is described, followed by a number of extensive Appendixes that are in several cases whole reports on specific parts of the project. These might in many cases have been published as separate reports, but it has been chosen to compile them in one volume in this manner.

The type of dispersion prognoses addressed in this project are the type of prognoses that will be performed after a nuclear accident has taken place in a geographical position not within any of the Nordic countries, but sufficiently close to potentially affect these countries. Two different types of situations might have to be addressed:

a) Follow a reported release of radioactive materials until there is no further danger to Nordic territory.

b) Backtrack from abnormally high measured levels of radioactive materials in air, measured somewhere in the Nordic countries (or elsewhere), in order to identify a possible source from which the radioactive materials might have been released some hours to days earlier; and subsequently calculate prognoses into the near future.

Both of these situations may be addressed with basically the same type of tools for predicting the weather conditions and dispersion in the atmosphere. When the project described in this report was started, the tools needed to address these situations satisfactorily existed only at the Swedish Meteorological and Hydrological Institute. While the other Nordic meteorological institutes were capable of predicting the movement in the atmosphere of a release and of performing backtracking, concentrations of radioactive materials in air or deposited on ground resulting from a release, could not be calculated with the models available.

After analysis of the worldwide situation regarding the availability of suitable models, the four meteorological institutes (of Denmark, Finland, Norway and Sweden) involved in the project were in a position to choose systems/models upon which future development would be based, and start to implement these systems/models. In Sweden a model had already been chosen; the model developed at the Swedish Meteorological and Hydrological Institute. In Finland one chose to redesign an existing model already developed, although for a somewhat different purpose. This was done by the Finnish Meteorological Institute and the Technical Research Centre of Finland. In Denmark and Norway it was chosen to develop calculation systems based upon the British NAME model. Although the systems in Denmark and Norway will both be based upon the NAME model, the systems as a whole will differ.

Validation and intercomparison has also been carried out within the project; partially by comparing calculated results with measurements during and after passage of the plume

from Chernobyl over the Nordic countries, partially by intercomparing predictions from the different models now utilized in the Nordic countries. The latter has been achieved by carrying out so-called functional exercises in which a postulated release, taking place at a specified time and geographical position, is followed, using the actual weather and weather predictions, closely imitating an emergency situation. Two such exercises have been carried out within the project, and in addition to making the aforementioned inter-comparisons possible, these have also been very valuable in many other respects.

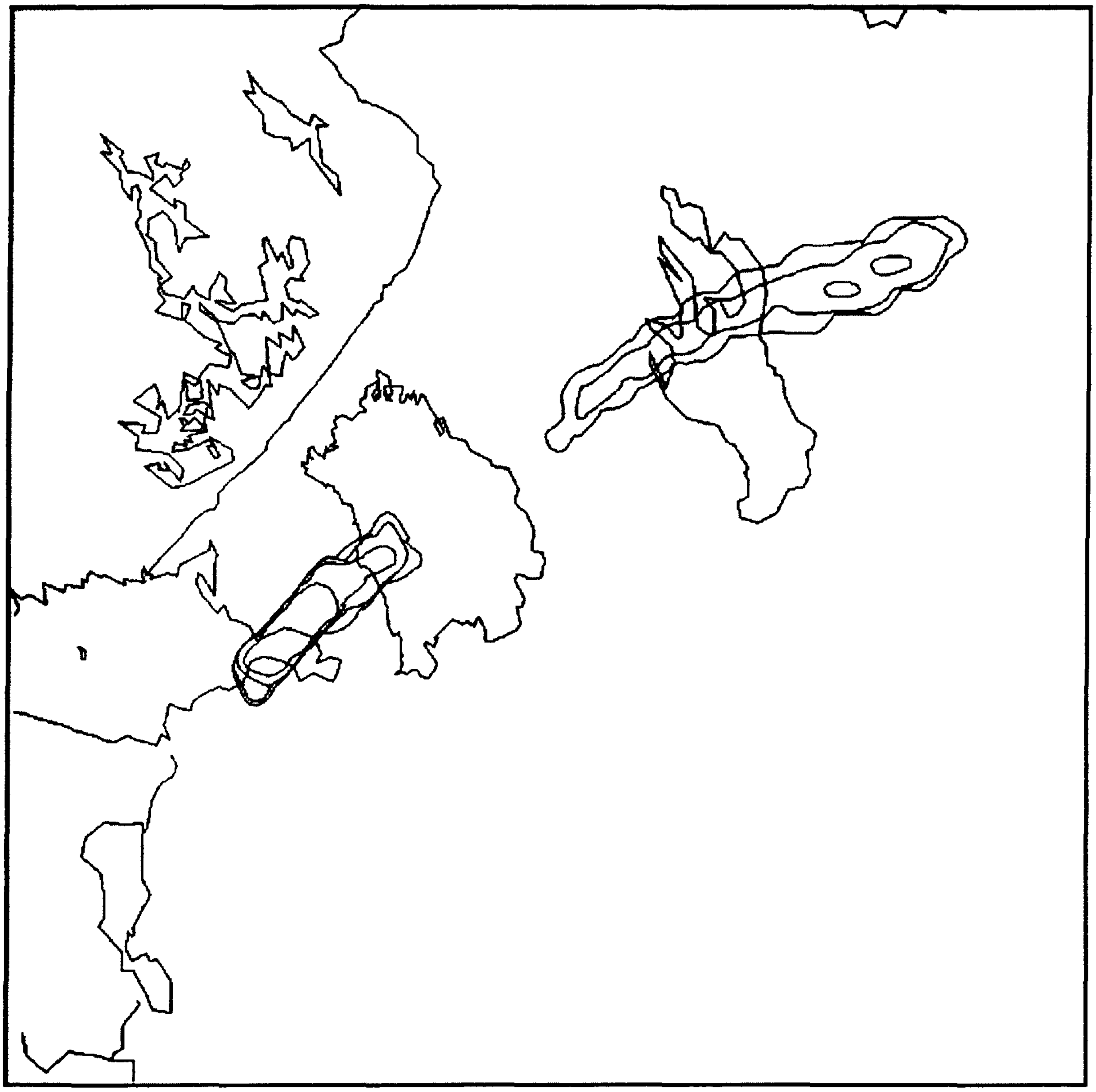
It became evident in the exercises that the way in which the results of the calculations are presented at present is not satisfactory. The graphical presentations of the results are difficult to understand and difficult to transmit by telefax. There are also severe problems with the case specifications. Many of the result sheets transmitted to the Exercise Secretariat contained only incomplete information on what the results actually represented. Accordingly, a proposal for a presentation scheme has been developed within the project, and it is proposed that all Nordic countries adopt this scheme. The computer software for this scheme is under development at the Finnish Meteorological Institute.

Appendix F

FINNISH METEOROLOGICAL INSTITUTE

RADIOACTIVE DEPOSITION

Runtime: 15-SEP-1994 12:15 UTC
Startpoint: Sosnovy-bor RBMK, Russia
Model: Trados Weather data: TRADOS-HIRLAM
The second "almost NORVIEW-compatible" example from the TRADOS-model

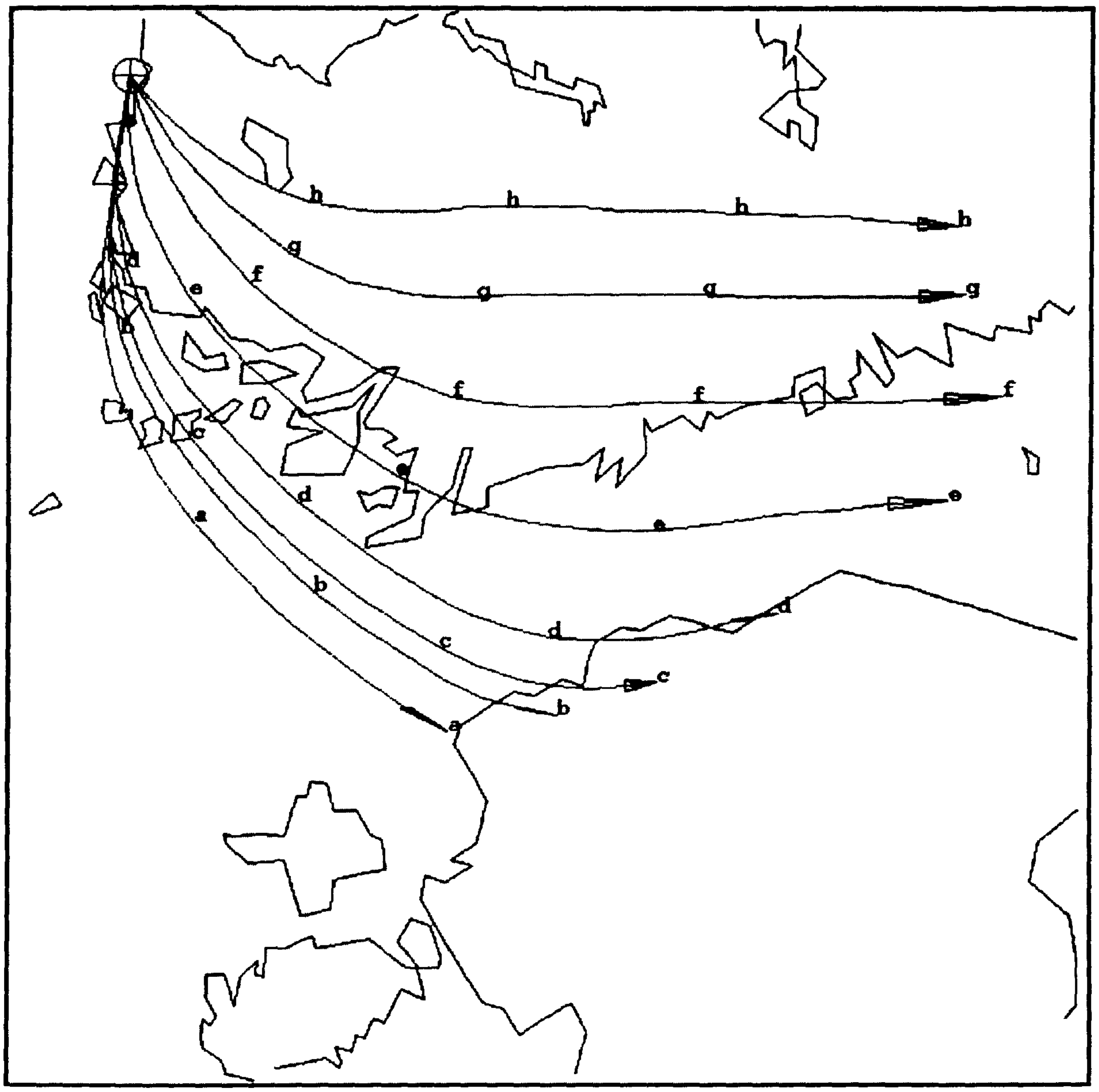


Radioactive deposition [Bq/m2]
Time of the field: 15 09 1994 07:30 UTC, +30 h
Release time: 14 09 1994 01:30 UTC Duration: 6 h

FINNISH METEOROLOGICAL INSTITUTE

FMI TRAJECTORIES

Runtime: 20-SEP-1994 11:43 UTC
Startpoint: Olkiluoto BWR, Finland
Model: Trados Weather data: TRADOS-HIRLAM
The "almost NORVIEW-compatible" example picture by Mika Salonoja



Air trajectories start height: 1005 hPa (c.20 m)
Start time: (start time difference between trajectories: 3h)
a 6.9.94 00:00 UTC b 6.9.94 03:00 UTC c 6.9.94 06:00 UTC
d 6.9.94 09:00 UTC e 6.9.94 12:00 UTC f 6.9.94 15:00 UTC
g 6.9.94 18:00 UTC h 6.9.94 21:00 UTC
Length: 24 h forward
Start point: 61.23N, 21.45E

Appendix G

HANDBOOK OF EXPOSURE SITUATIONS FOLLOWING ACCIDENTAL RELEASES OF RADIOACTIVE SUBSTANCES

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December 1994

Appendix G

ABSTRACT

This report describes a computerized database for radiological information concerning radioactive plumes from accidental releases reaching the Nordic countries. Due to available information the database focuses on I-131 and Cs-137 for exposure through the consumption of foodstuffs. It is a project within the Nordic co-operation work concerning nuclear safety studies with the basic purpose of creating a common basis for the Nordic Emergency Program (Plan for the Nordic Safety Program, 1990-1993, NU1989:5). During the process of these studies the need for creating a user-friendly, fast system to help in collecting radiological information for personnel at the Nordic Radiation Institutions was identified. The help system designed runs in the Windows environment on PCs.

Appendix G

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Appendix G

G.1 INTRODUCTION

In an emergency situation the need for appropriate tools for information support is obvious, as fast decisions may have to be made and a service provided to the general public. To meet these needs adequately, a computerized system has several advantages compared to commonly used "books". Compared to a reference book in paper format, the computerized format gives advantages, for example, in structuring and updating the information and in access time. Furthermore, it is possible to further develop the system and adding and updating are easy to carry out.

The primary objectives of the computerized "handbook" are to act as an appropriate tool for the radiation protection institutes concerning

- support for decision making
- all necessary information for making dose calculations
- information and communication to the general public

A secondary objective may be to use it as a comprehensive knowledge base for training purposes.

The database includes important aspects of different exposure pathways, processes influencing them, radiological data, suggestion for calculation formulae and, whenever possible, aggregated transfer factors relevant for Nordic conditions. In addition, some information is gathered about the importance of some simple counter-measures. This, however, is most for the purpose of information and not for decision making, since this involves several other aspects not covered in this base.

G.2 METHODOLOGY

The project is divided into three main parts

- design of a logical structure of the system, see below
- development of suitable code systems for creating the computerized help system, see below.
- collection and evaluation of text and data to enter in the system.

This latter part implies a lot of editorial work to obtain concise, relevant information. The review of information input and quality control are very important aspects of this work.

The information is mostly collected from Nordic studies such as

- The joint publication from the RAD program within the Nordic Safety Program.
- The Chernobyl fallout in Sweden, editor L Moberg, The Swedish Radiation Protection Institute.
- Radioaktivt nedfall fra Tjernobyl-ulykken, editors T H Gamo og T B Gunnestad, Norges Landbruksvitenskapelige forskningsråd.

- STUK report series, dealing with the radioactivity in Finland after the Chernobyl accident.
- RISØ reports about the radioactivity in Denmark after the Chernobyl accident.
- International model validation studies such as VAMP and BIOMOVS.

In addition, data has been taken from some subprojects within the BER1 program, which have focused on this type of background information.

G.2.1 Structure

The data base is hierarchically built, and the main division is given below.

Population	Direct exposure	All exposure pathways directly related to exposure from the radioactive plume and external exposure from varying types of surfaces.
Land use	Indirect exposure	All exposure pathways related to uptake and distribution in terrestrial food chains
Water	Direct and indirect exposure	All internal and external exposure pathways related to deposition on varying types of aquatic areas.

The structure reflects the fact that environment determines which pathways may cause exposure to man. This also makes it possible to develop the system further, for example to include population and yield value data. However, deviations from this structure may occur.

The structure is designed to give more detailed information the deeper you get in the data base.

From these three main paths different environments (types) are reached in the next level, see Figs. G.1 to G.3, with brief descriptions, which are connected to the main objective chosen. These types of areas are selected to be able to describe all varying conditions in the Nordic countries such as typical farming areas up to mountain areas when the entry is by land use. Beyond each type of area the base will give all potential exposure pathways which are linked to it. Some general information about the importance of the different exposure pathways is also given in combination with the listed pathways. Subsequent clicking on the pathways of interest gives further choice of obtaining more specific information about processes, formulae or dose-reducing activities for the pathway of interest. **Processes** describe processes that influence the dose from the actual path, **Formula** should give information about how to calculate doses from the selected path and **Reduction** provides information about how the dose can be reduced. The exposure pathway topic is a member of a logical structure (called browser sequence) together with the three topics mentioned: Processes, Formula and Reduction.

Several exposure pathways may be reached by different main paths and type of area, exposure from ground or vegetables growing in suburban or farming areas.

The data base contains an identification for each topic. Thus overviews of the latest updatings are easy to obtain.

G.2.2 Description of software

The help system is a hypertext system used for providing on-line help about an application.

The Help compiler from Microsoft Windows Software Development Kit version 3.1 is used to compile the textual and graphic information to a help file.

The help system consists of textual or graphic information organized into topics. The topics may be related hierarchically. In this structure the user navigates to deeper levels by clicking on marked items. Topics may also be grouped together into logical sequences, known as browser sequences, in which the user moves by clicking on one of two browser buttons. Lastly, topics can be temporary in the sense that they are not a member of a hierarchical structure or a browser sequence. The temporary topics are just visible between two mouse clicks.

Graphics, like icons, pictures and diagrams, in Windows bitmap or metafile file format, are included in the help system to support the text and explain screen elements.

Research on screen format and help systems has produced general guidelines for presenting information to users [MI90]. The results of these studies could be summarized as follows

-	use a language appropriate for the audience
-	use a minimum of text
-	use short paragraphs
-	group information visually with white space
-	use highlighting techniques sparingly and in a sensible way (highlighting can be done by the use of different fonts, sizes and color on text)
-	use graphics to support explanation of visual events
-	be rigorously consistent in the design and use of such things as titles, highlighting, fonts and text position

As previously mentioned, the Windows help system is used, in this case, as a dictionary for exposure situations following accidental releases. The system is a separate system and the information cannot be reached from other applications. It is started as a usual Windows application by clicking on an icon.

Besides these hierarchical and logical structures, there are temporal topics reachable from predefined positions in other topics. These temporal topics are used for **Definitions** and specifications of words and concepts used and to give **Data** or typical values of data for parameters used in formulae.

Graphics are used when necessary for explanatory purposes or for viewing data in a comprehensible way.

References are normally embedded in the text but can also be visualized from the Search menu.

Highlighting can be done in many ways, by fonts, size, color, italics, bold and underlining for example. It is very important to be consistent in highlighting and to use a small set of highlighting types. So far, the highlighting techniques used are

-	underlined by line to show items in the hierarchical structure
-	underlined by points to show temporal topics
-	italics to show important words
-	big and bold text for titles
-	small text for data and references

Graphics. The system contains two types of graphics, diagrams for visualizing data and icons to click on to enter the structure or to obtain temporal information.

A detailed description of how to install and run the base is given in Enclosure A.

G.3 CONTENTS

The main concern of the "handbook" is all radiological information for a radioactive plume reaching the Nordic countries. This includes, for example, all internal and external dose conversion factors for a number of radionuclides. However, where the ingestion pathways are concerned, the main focus is on I-131 and Cs-137. This reflects the information available, especially for the natural and aquatic environments.

The database contains information about all potential exposure pathways, irrespective of their relative importance. General comments on this are found in the base when reaching the exposure pathway of interest. For example, milk is a very important exposure pathway for I-131 and Cs-137 if contamination occurs during the grazing period.

Another example is that consumption of predator fish from oligotrophic lakes gives rise to the highest exposure from Cs-137 reaching fresh water systems.

Complementary definitions and actual parameter values, temporal topics, are included and can be reached by simply clicking on relevant word or data (colored, italics). This type of information contains definitions of a number of terms, such as, eutrophic, and data for several parameters such as dose conversion factors, uptake and distribution factors, consumption rates, shielding factors, etc. The former ones are given for most radionuclides of potential interest for emergency purposes.

Potential exposure pathways are shown, depending on type of area contaminated, whether urban, suburban, farming, forest, aquatic and so on. This is the first hierarchy, see G.2.1 Structure, and from there selections can be made for further information. This information is mostly divided into

A processes affecting the dose from the exposure pathway selected
B rough or more complicated formulae for estimating the dose via the selected pathways
C counter measures to reduce the exposure

G.3.1 Processes

For each exposure pathway brief information is given about the processes and conditions affecting it. This is called processes in the system. Whenever possible, resulting ecological half-lives are also given, which very briefly give an estimate about the time developments, taking implicit account of all processes. One major item in the short time is seasonality, which is very decisive for the contamination of agricultural foodstuffs. For these foodstuffs major processes are the initial retention and root uptake.

Descriptions of processes affecting radionuclides reaching aquatic systems are given, such as physical dilution, transfer to and from the sediments and uptake in the aquatic food chains. The latter is for Cs-137 strongly dependent upon the trophic status of the lakes. In general all these processes are described and, whenever possible, suggestions about parameter values with ranges are given.

G.3.2 Formulae

Under this subscript suggestions of how to calculate doses for respective exposure pathways are given. This includes suitable parameter values, whenever possible addressing different conditions in the environment such as type of soil for root uptake. In addition to more complicated formulae simple aggregated transfer factors are given. These give the resulting concentration in actual foodstuff only by multiplication with actual deposition value (Bq/m^2). For the seminatural environments only the latter are given.

G.3.3 Reduction

A summary information is given about how different actions, such as food preparations, may reduce the exposure or the activity content such as food preparation. Differences between outside and inside are given for the immediate exposure from the plume.

G.3.4 Specific features

Appropriate references are given in order to give the interested user advice for more detailed information. Summaries of aggregated transfer factors to a number of foodstuffs are also accessible in the base to provide a broad overview.

G.4 CONCLUDING REMARKS

The computerized handbook adequately achieves the objectives set up. The designed structure allows simple, flexible access to the topics required. Additional data and further information are easy to obtain. Important radiological data are included as well as guidelines of the relative importance of varying exposure pathways during different contamination conditions such as time of the year. The handbook is ready for installation but further data should be added. There are still areas where relevant information is under publication and it was not the scope of this study to deal with all details. In particular other radionuclides than I-131 and Cs-137 should be further addressed. It is therefore of major concern for the system and for the users to update continuously and add useful information to the base.

For continuous updating and the adding of data, a user group could be established to meet regularly and obtain a common census for the additional material to be added. However, the practical work should preferably be the responsibility of one group in order to avoid different copies. There are advantages in conducting the work as a Nordic co-operation both for providing similar information to the general public as well as for cost-effectiveness.

G.5 REFERENCE

MI90 Microsoft Windows Software Development Kit. Tools. Version 3.0. Microsoft Corporation, Redmond, USA. 1990.

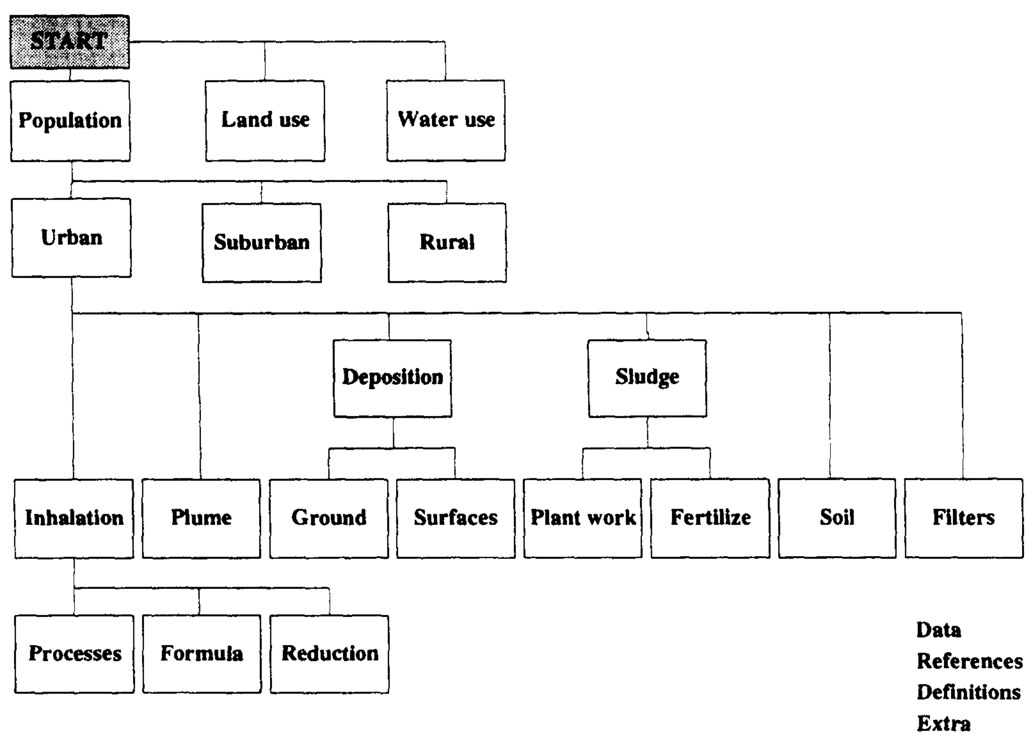


Figure G.1
Part of system structure, some branches under the "population" section.

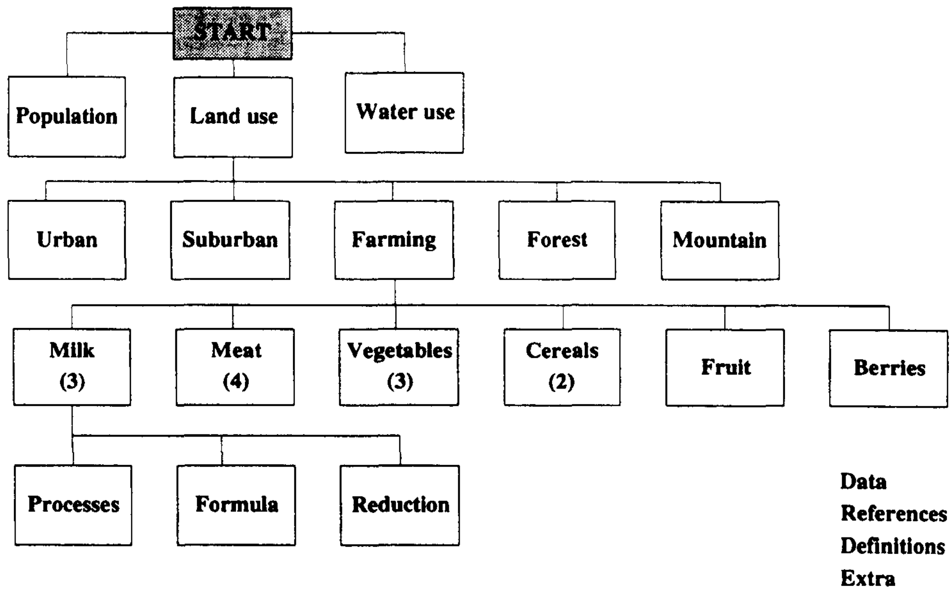


Figure G.2
Part of system structure, some branches under the "land use" section.

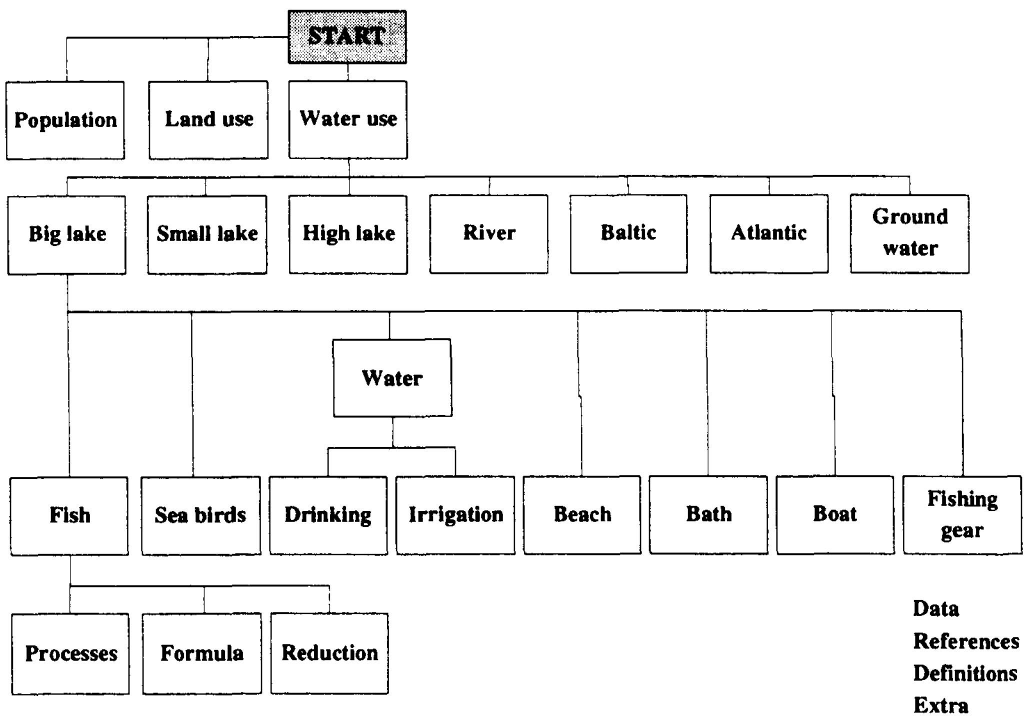


Figure G.3
Part of system structure, some branches under the "water use" section.

ENCLOSURE TO APPENDIX G

INSTALLING AND HANDLING THE BER SYSTEM

Installation

The BER system requires a PC with a mouse and Windows version 3.1 or higher.

Step 1	Make sure you see the DOS system prompt (usually C:\>).
Step 2	Insert the BER diskette in a floppy drive.
Step 3	Type a:install.

Creating an icon in the Windows program manager for the BER system

Step 1	Create a new program group using File > New... command in the Windows program manager and select the new program group or Select a program group from where you want to start the BER system.
Step 2	Use the File > New... -command to create a program item Type the following text in the dialog box Program Item Properties: Description: the text you want under your icon. Command line: c:\windows\winhelp.exe ber.hlp Working directory: c:\ber Select an icon by clicking on the Change icon... -button Finalize the Program item creation by clicking the OK-button.

Starting the BER system

Double-click on the BER icon to start.

Ending the BER system

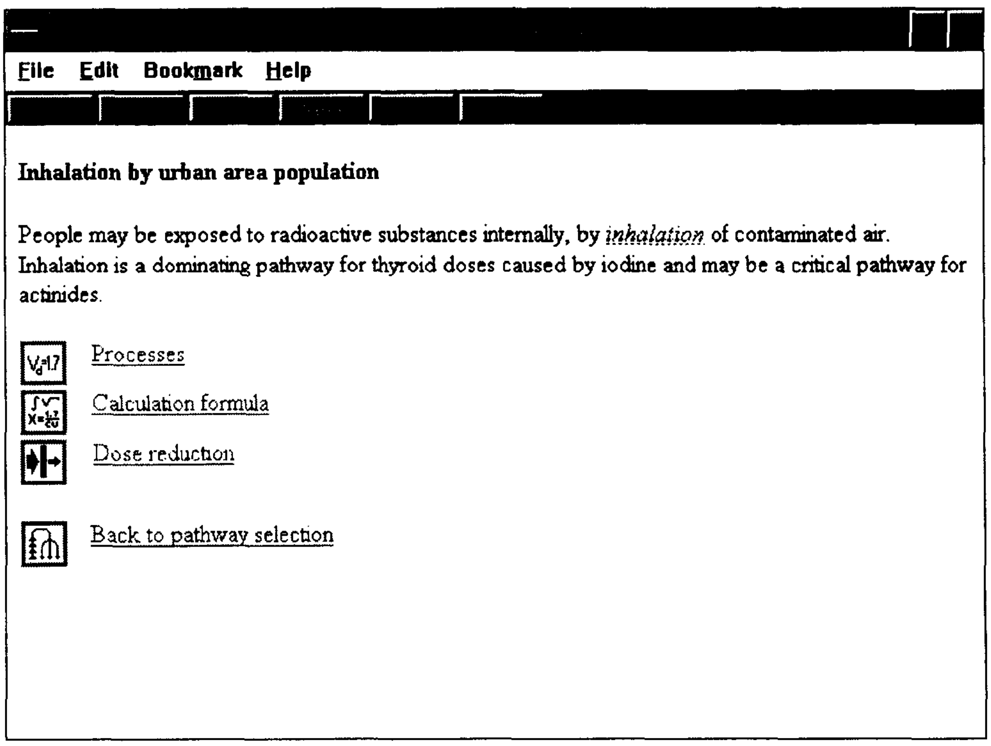
Alternative 1	Double-click on the control-menu box.
Alternative 2	Select File > Exit in the menu list.
Alternative 3	Select control-menu box and Close.
Alternative 4	Press the Alt-key and hold it down while pressing F4.

The control-menu-box is the square with the minus-sign (-) in the upper left corner of the window.

Handling the BER system

There are three parts to this description. Part 1 describes the options with the menu list (File, Edit, etc.), part 2 describes the button functions (Contents, Search, etc.) and part 3 describes the hot spots in the information area that link to other topics.

The BER system has the same structure as an ordinary window help system.



A typical view of a help window showing menu list, help buttons and text area.

Part 1 Menu list

The menu list in a system contains the items File, Edit, Bookmark and Help.

From File it is possible to set up the printer connected to the PC and to print the current topic. Closing the help session can also be done from the File menu.

From Edit you can copy text to the clipboard for pasting into the current or another document. It is also possible to insert own comments (Annotate) anywhere in the help file and to delete or modify existing comments. These comments will be marked with wire clips at the beginning of the topic and by clicking on these clips a window with the comments will pop up. The comments are stored for future sessions with the help system.

From Bookmark it is possible to mark places in the help text and later jump to these marked places which gives fast access to topics frequently used. The bookmarks defined in a session will stay as bookmarks until they are deleted by the user.

From Help the user can get assistance on the help system.

Part 2 Help buttons

The help system provides buttons for Content, Search, Back, History, << (backwards in a browse sequence) and >> (forward in the browse sequence).

The Content button brings you to the start, the first topic in the help system.

Clicking on the Search button will give a list of key words defined in the system. Selécting an item in the list by clicking gives a list of topics where the selected key word is defined and, finally, clicking on a topic title allows a jump to the selected topic.

The Back button moves you to the previous topic.

If a topic is a member of a browse sequence, the << and/or >> buttons will be highlighted to show that they can be used. The <<-button will go backwards in the sequence and the >>-button will go forward.

Part 3 Hot spots

Hot spots for the hierarchical topic structure are marked with underlined, green text. Small icons can also be a hot spot of this type. Clicking on these items causes a jump to a new level in the topic structure.

Italic text, underlined with dots, are hot spots for temporal topics. Clicking on these hot spots causes a temporal topic to appear. The next click erases the temporal topic.

Nordiske Seminar- og Arbejdsrapporter

1992

1992:530	Kostnadseffektive virkemidler for å redusere CO2 utslippene
1992:532	Information om lavtemperaturdrift for nordiske fjernvarmeværker
1992:539	Spesifikt energiforbruk i produksjonsprosesser
1992:548	Energi och miljö *- hovedrapport*
1992:549	Energi och miljö *- bilaga 1*
1992:550	Energi och miljö *- bilaga 2*
1992:551	Energi ocj miljö *- bilaga 3*
1992:557	Energieffektivitetenes betydning ved salg av større husholdnings-apparater i Norden
1992:558	Principels for efficill standards
1992:561	EFs indre marked og nordisk energipolitikk
1992:567	Seminar om energiplanlægning i de nordiske lande
1992:589	Energi og investering *- brugen af rentabilitetskrav i nordiske virksomheter*

1993

1993:521	ENØK i offentlige bygninger i Norden
1993:522	Energiforetagenes organisation *- mot en internationell og avreglerad energimarked*
1993:528	Elproduktion kontra elbesparelse
1993:534	Evaluering av Nordisk energiforskningsprogram
1993:536	Implementering af vedvarende energikilder i Norden *- hovedrapport*
1993:537	Implementering af vedvarende energikilder i Norden *- workshoprapport*
1993:569	Veier til en bærekraftig utvikling? *- konferanse om langsiktige energi- og miljøspørsmål i Norden*
1993:594	Alternative kølemidler 1:3 *- globala miljöaspekter på arbetsmedier i kyl- och värmepumpeanlegg*
1993:595	Alternative kølemidler 2:3 *- regler for miljø og sikkerhed for anvendelse af alternative kølemidler*
1993:602	Alternative kølemidler 3:3 *- FOU- og demoprosjekter innenfor kulde- og varmepumpeanlegg*
1993:627	A Nordic Test of the Energy Saving Potential of New Residential Billing Techniques
1993:630	Energi- og Miljøpolitikk i norden *- status og utfordringer*
1993:639	Energipolitik i plan och verkelighet *- i de nordiske länderna*
1993:640	Perspectives of Regional Coordinated Energy and Environmental Planning

1993:653 Energy, Environment and Natural Resources Management in the Baltic Sea Region
- 4th International Conference on System Analysis

TemaNord 1994

1994:544 Nordic Studies in Reactor Safety
1994:548 Strategier og kostnader ved å oppnå klimapolitiske mål i Norden
1994:556 Evaluation Report of the Nordic Emergency Exercise Odin
- November 26,1993
1994:559 Guidance on Clearance from Regulatory Control of Radioactive Materials
1994.567 Cleanup of Large Radioactive-Contaminated Areas and Disposal of Generated Waste
1994:594 Decommissioning of a Uranium Reprocessing Pilot Plant
- practical experiences
1994:595 Design and Safety Features of Nuclear Reactors Neighbouring the Nordic Countries
1994:613 Det nordiske kraftmarkedet
- under utvikling
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Dispersion Prognoses and Consequences in the Environment
- a Nordic development and harmonization effort

Various models are in use in the Nordic countries to calculate the transport of air masses over large distances. Such models help to evaluate possible consequences if a major release of radioactive material should occur. The models have been compared in two Nordic exercises, and two of them have also been compared to measurements following the Chernobyl accident. A "user´s manual" for a computerized handbook is described which can help to evaluate possible radiation doses to the population if fallout from a radioactive cloud should reach the Nordic area.

The Nordic Committee for Nuclear Safety Research - NKS
organizes pluriannual joint research programmes. The aim is to achieve a better understanding in the Nordic countries of the factors influencing the safety of nuclear installations. The programme also permits involvement in new developments in nuclear safety, radiation protection, and emergency provisions. The three first programmes, from 1977 to 1989, were partly financed by the Nordic Council of Ministers.

The 1990 - 93 Programme
Comprises four areas:

* *Emergency preparedness*	(The BER-Programme)
* Waste and decommissioning	(The KAN-Programme)
* Radioecology	(The RAD-Programme)
* Reactor safety	(The SIK-Programme)

The programme is managed - and financed - by a consortium comprising the Danish Emergency Management Agency, the Finnish Ministry of Trade and Industry, Iceland's National Institute of Radiation Protection, the Norwegian Radiation Protection Authority, and the Swedish Nuclear Power Inspectorate. Additional financing is offered by the IVO and TVO power companies, Finland, as well as by the following Swedish organizations: KSU, OKG, SKN, SRV, Vattenfall, Sydkraft, SKB.

ADDITIONAL INFORMATION is available from
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