Accident at Sellafield - consequences for Norwegian food production

Losby Gods , 14.04.2010

www.nrpa.no

Statens strålevern
Norwegian Radiation Protection Authority

- Sellafield – source of radioactivity
- Accident scenario at sellafield
- Simulated deposition in Norway

Part II

- The Stratos model
- Stratos used on the Sellafield scenario
- Affected foodstuff

Sellafield

Scenario details

- The chosen worst case scenario is an explosion in B215 facility at Sellafield which contains Highly Active Liquor (HAL) stored in Highly Active Storage Tanks (HASTs).
- The explosion is assumed to be due to a malicious act targeting the facility.
- The direct cause of the explosion is not speculated upon though it is recognised that such an event will be of low probability.
- The explosion and heat generated from a subsequent fire are such that a percentage of the assumed HAL radionuclide inventory is released into the atmosphere.

The source term

- The scenario considers a source term of between ~0.1 % and 10 % of the total HAL volume.
- The source term is therefore defined as a release of 1 to 100 m^3 of HAL.
- For simplification, only ^{137}Cs considered in this scenario. A ”real” release of HAL would contain many different radionuclides.

The source term

Source term used in the scenario compared to the assumed releases from the Chernobyl accident.

Radionuclide	**source term**	**Releases from Chernobyl (**UNSCEAF
	PBq	PBq
^{137}Cs	9.4 - 940	85

(1 PBq = 10^{15} Bq)

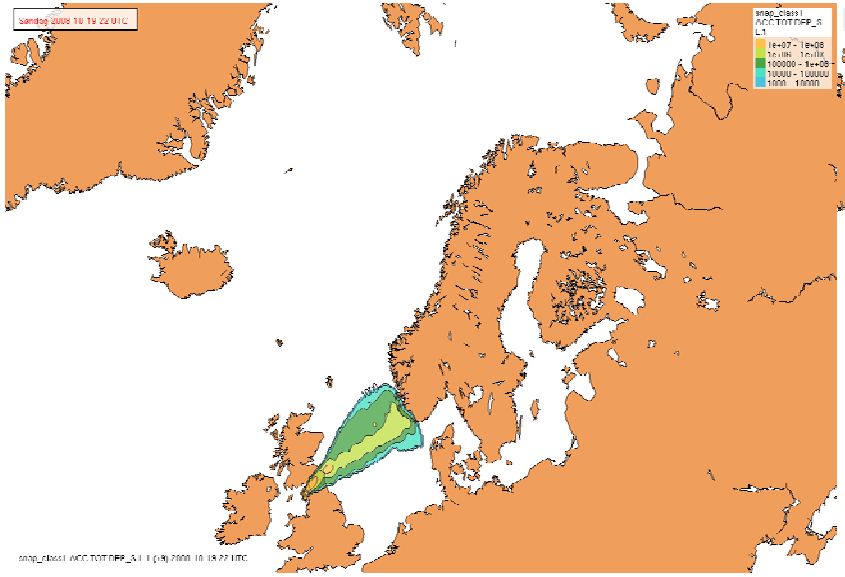
The dispersion model used

- The original model was developed at the Norwegian Meteorological Institute, based on the UK Meteorological Office model NAME via collaboration between the two partners.
- Three basic processes are taken into account:
  - emission from a point-source
  - transport/dispersion
  - deposition of radioactivity.
- Releases of ^{137}Cs are assumed to be in an aerosol form.

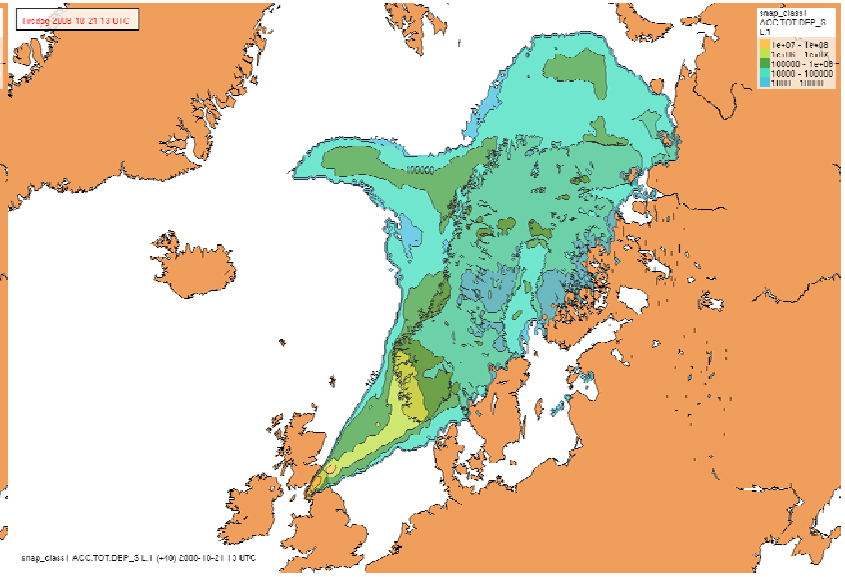
Weather during scenario

- The weather situation was dominated by southwest winds from the UK blowing across the North Sea towards Scandinavia leading to extensive precipitation on Norway's western coast.
- This weather type is considered typical in the studied area.
- Weather data corresponds to the weather situation that occurred starting 22 October 2008 at 09:00 am.
- The observed weather 19-23 October, 2008

Fallout patterns over time



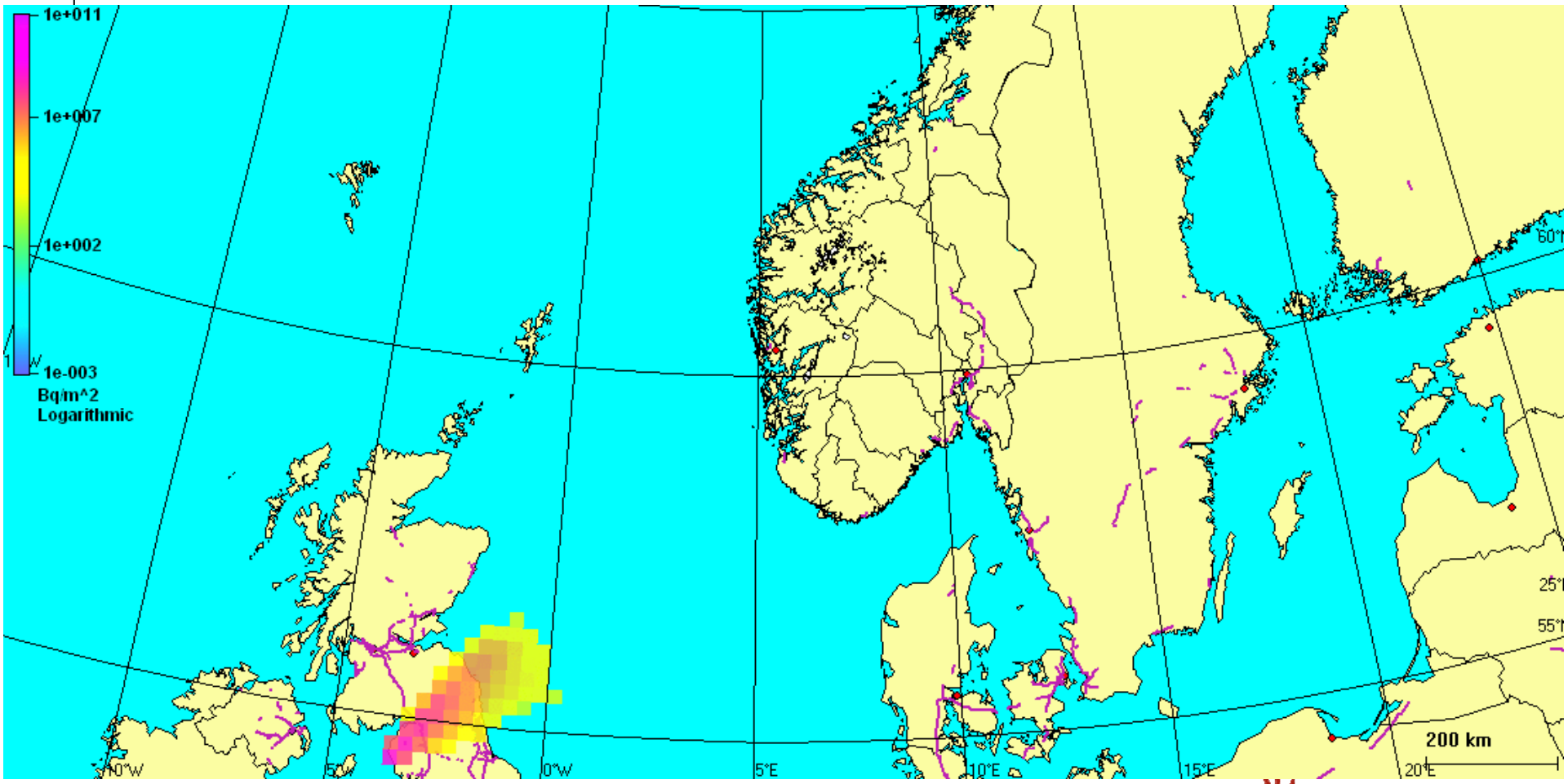
9 hours



48 hours

Accumulated total deposition for 2.2 µm particle radius

Fallout animation



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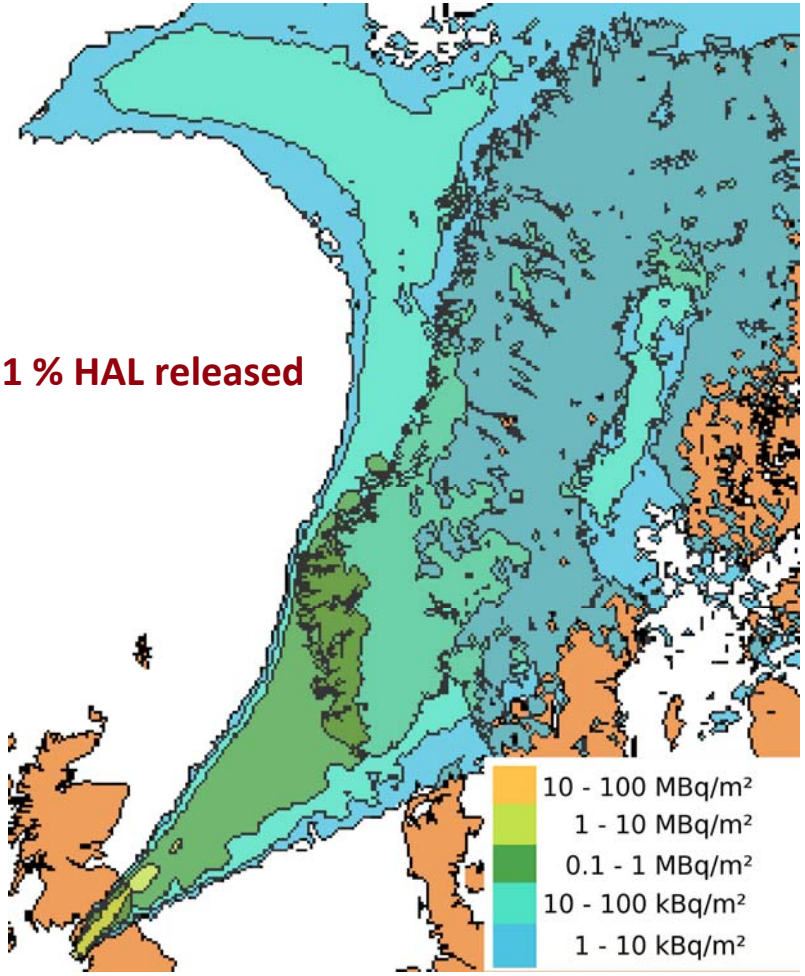
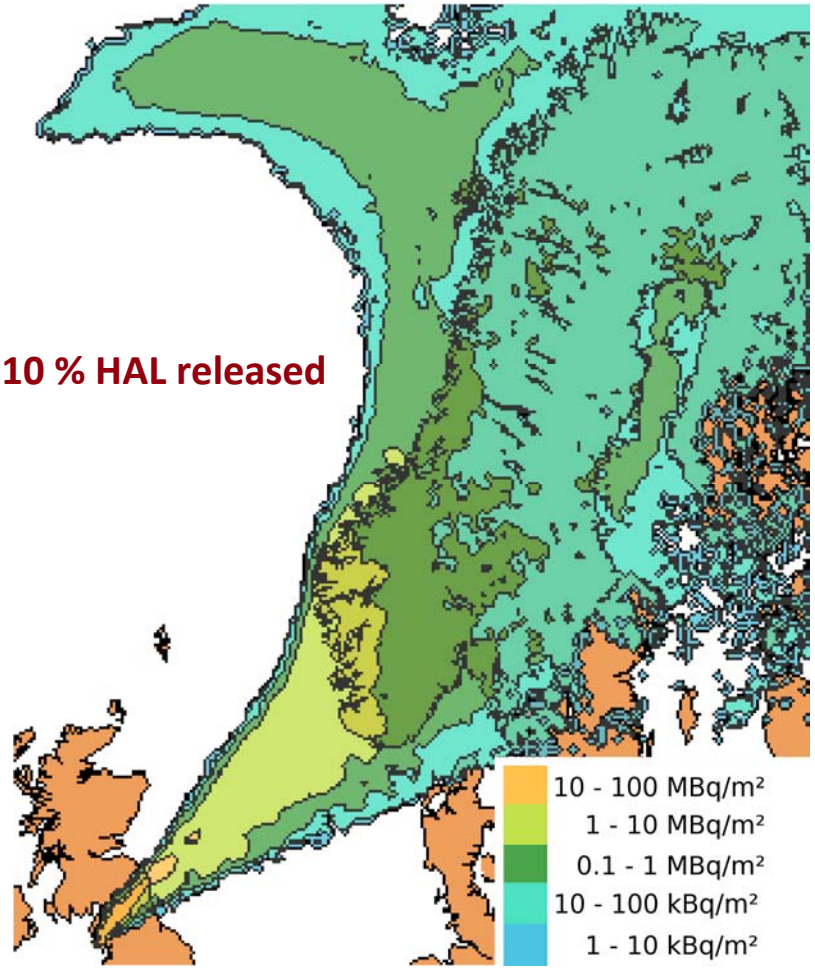
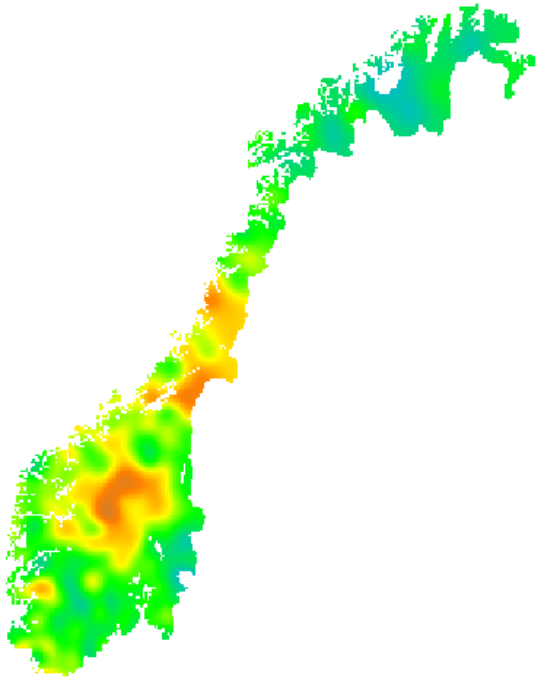
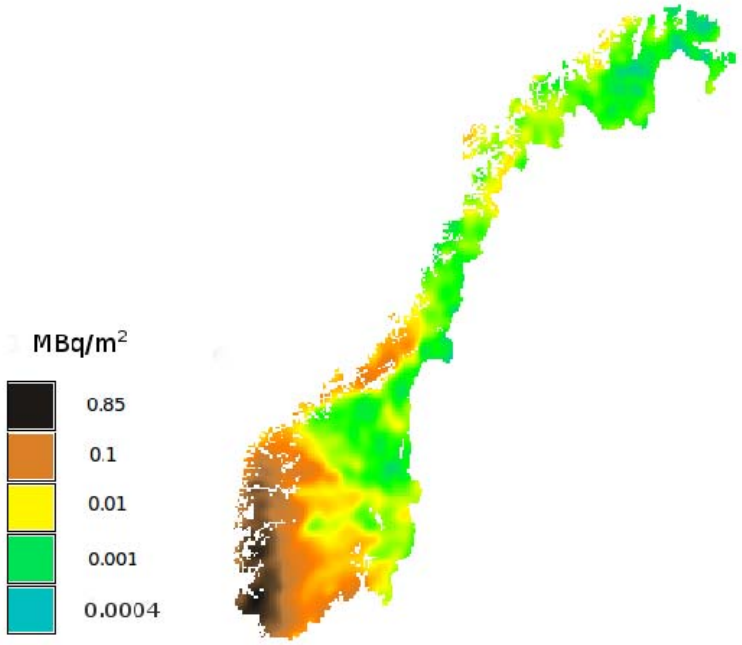
Fallout pattern after 48 hours





Comparison with Chernobyl fallout in Norway





The Chernobyl accident fallout

The 1 % accident scenario fallout

Part II
A model for rough grazing

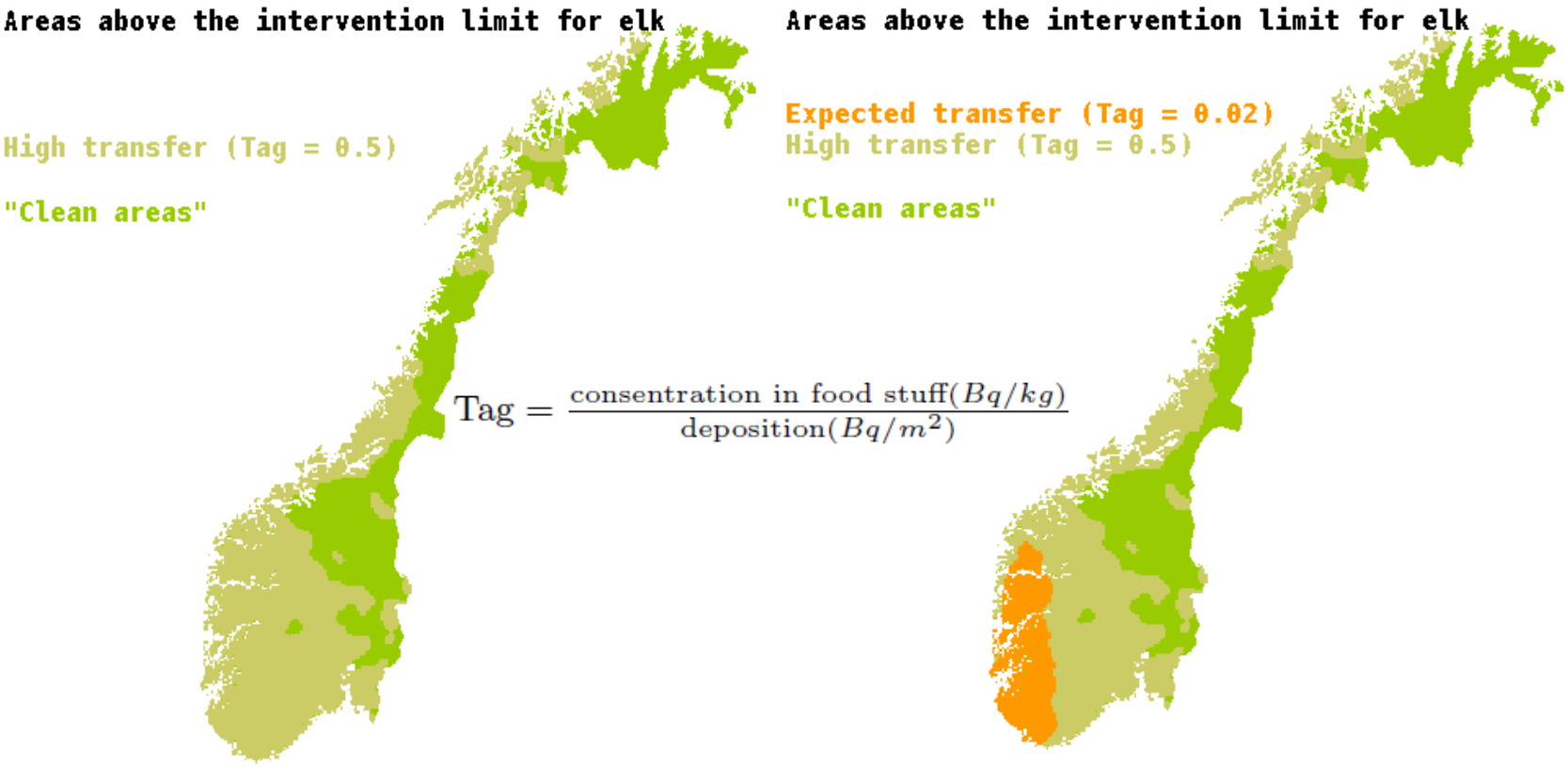
- Need for a model that could estimate the consequences for the Norwegian rough grazing animals.
- We are now developing the Stratos model

- We would like Stratos to:
  - Be a model for the Norwegian foodstuff in alpine and forest areas
  - Be a tool for consequence analysis and a tool for stakeholders in case of a sever nuclear accident
  - Be simple, flexible and alive
  - Be database and GIS based
  - Contain a substantial amount of relevant geographical data for Norway
  - Be developed and maintained locally with close cooperation between the developers and the scientists and users

Stratos –Tag based

- We have limited information on rough grazing animals diet
  - What do they prefer
  - How much do they eat
  - How does it change with season
  - How a $\frac{\text{consentration in food stuff}(Bq/kg)}{\text{deposition}(Bq/m^2)}$s
- Thus, we choose to use Tag values, or more precise: Tag ranges
- Tag =
- We define three Tag values from the Tag distribution:
  - expected Tag: the mean
  - high Tag: the 95 % percentile
  - low Tag: the 5 % percentile
- Together with these Tag values we apply the intervention levels for foodstuff in Norway.

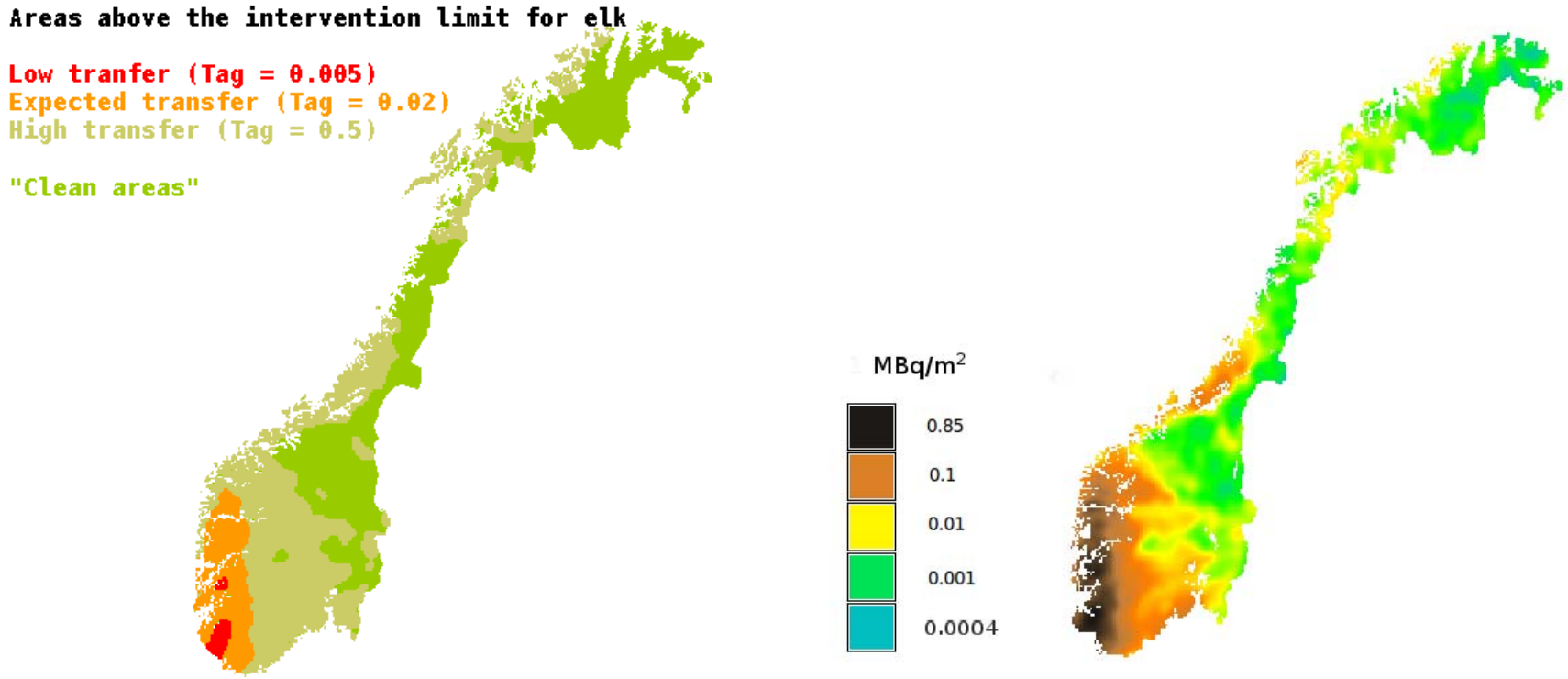
Stratos – Tag based



$$\text{Tag} = \frac{\text{consentration in food stuff}(Bq/kg)}{\text{deposition}(Bq/m^2)}$$

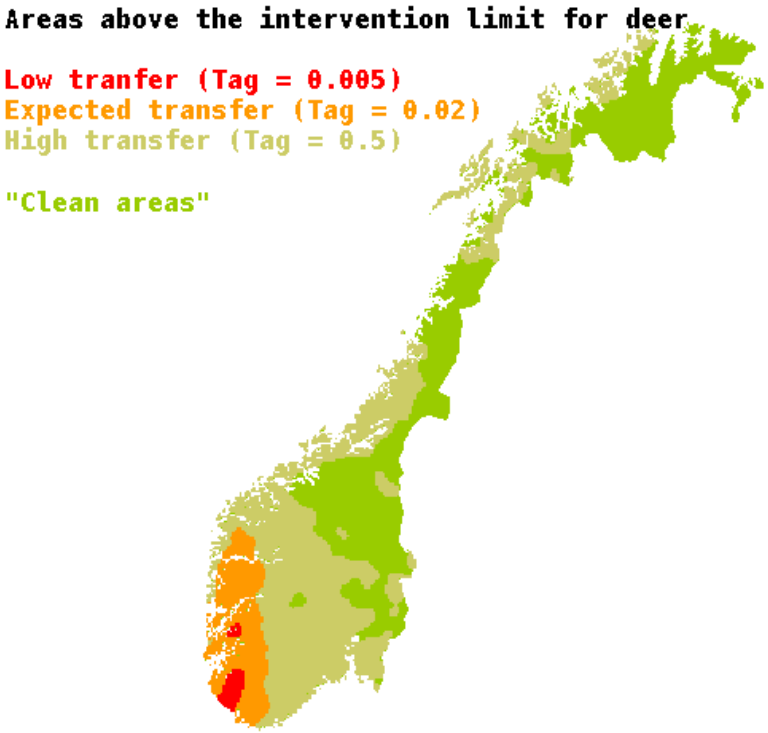
Tag values changes in time and space.

Stratos - tags



Areas above the intervention limit for elk in Norway. The different colours reflect the different Tag values. Note that the red areas are "on top of" the yellow areas which again is "on top of" the green areas. This is a logical consequence of the definition of the areas. The figure does not say how high levels we might expect, only if the levels are above the intervention level for a given Tag

Stratos -tags

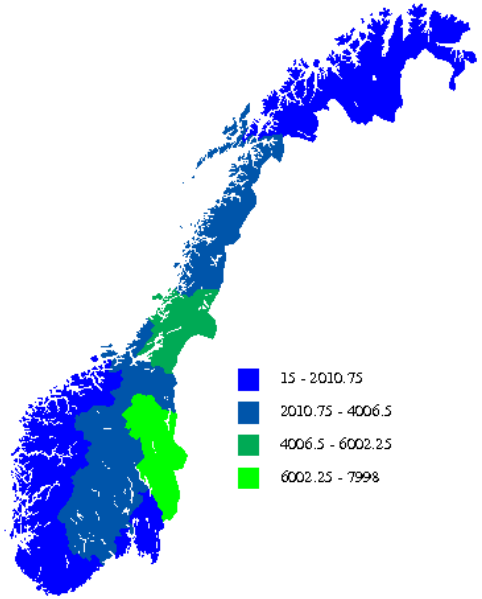


- Red: high probability for exceeding the intervention level
- Orange: Areas expected to exceed the intervention level
- Kaki: Some areas here might exceed the intervention level; Areas with high transfer.

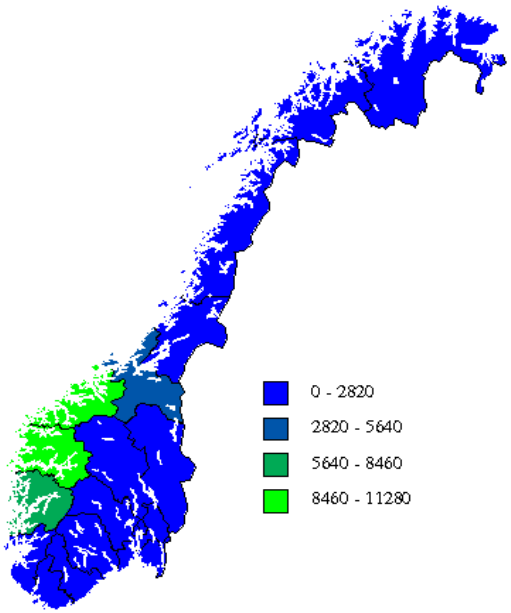
For deer we get the same figure as for elk

Stratos – affected foodstuff

- The previous maps don't say how many deer or elk that are affected
- Thus, we apply geographical information



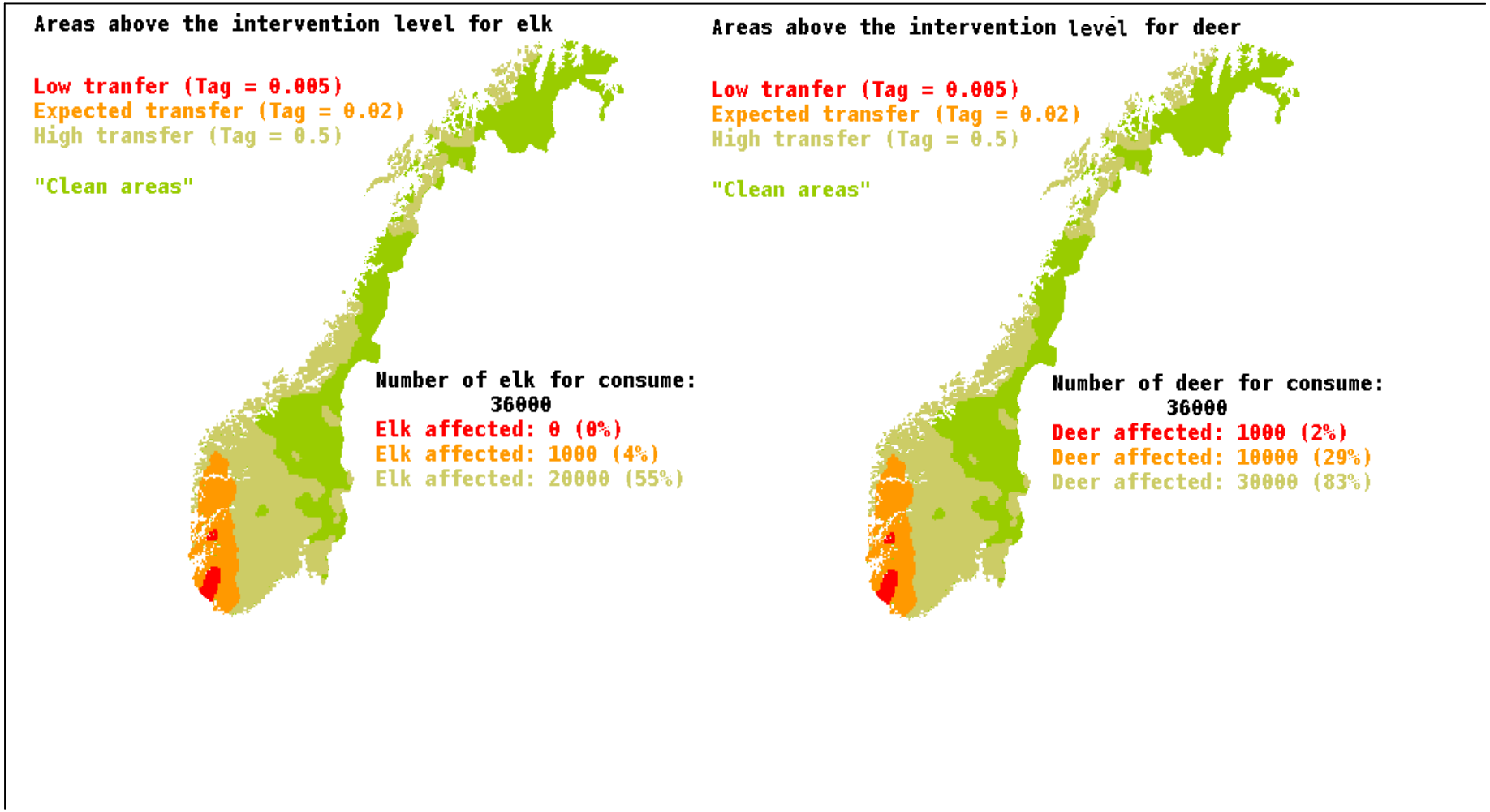
Elk



Deer

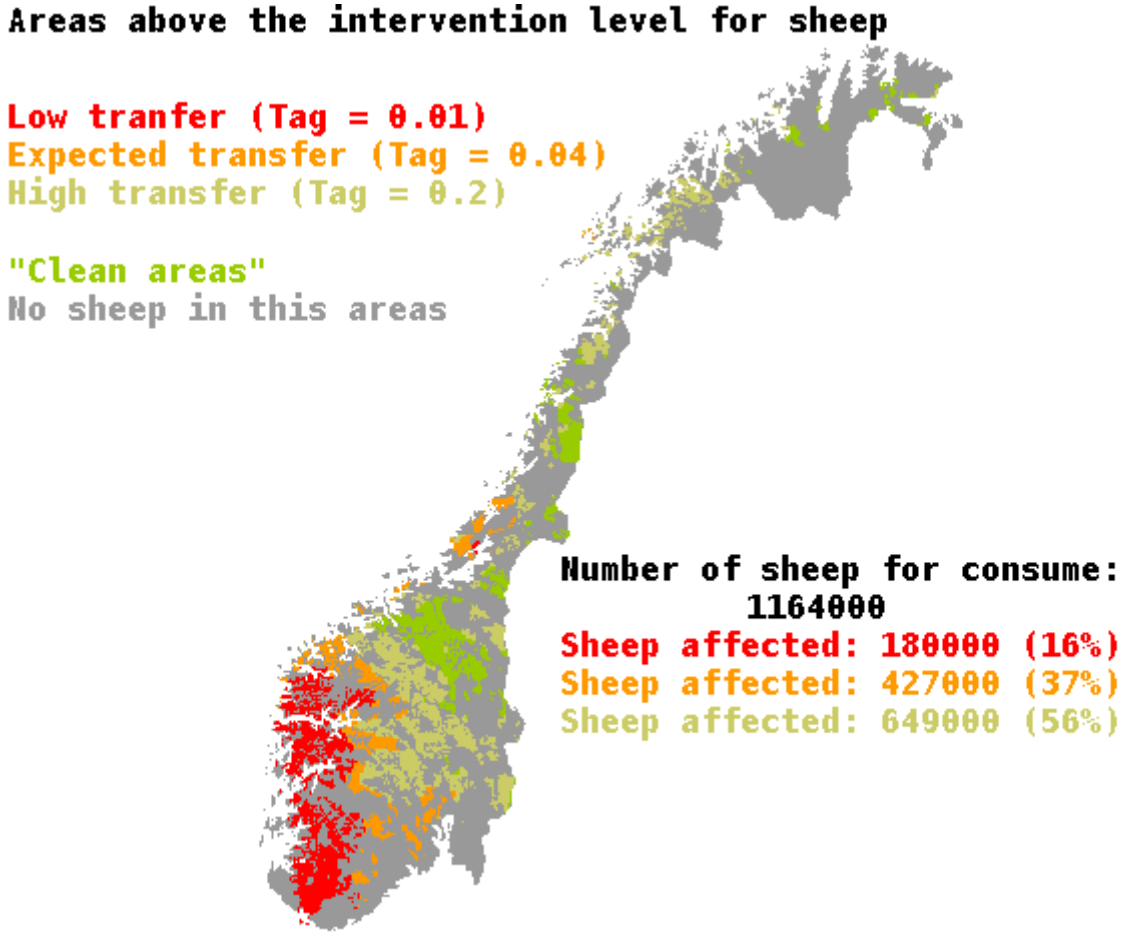
Number of animals slaughtered during hunting season

Affected foodstuff



Affected foodstuff

- If we also have information about the location of the animals



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Stratos

- Currently this method can be applied for: Elk, deer, sheep and reindeer
- Easily expand for other animal – just input Tag values and geographical information.
- Other animals that are of interest for Norway are: Gout, rough grazing cows,

- Can also be used to look at products from animals.

Sellafield - Stratos

Thank you!

Stratos - Tags

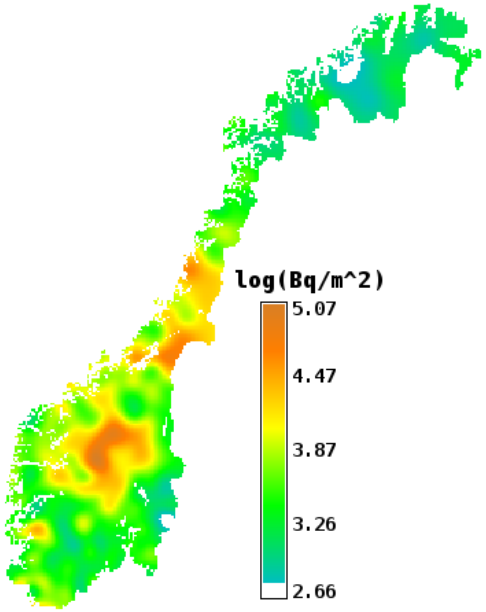
- Since the Chernobyl accident there has been done a lot of monitoring in the Norwegian foodstuff
- Stratos aims to use these data determine the sensitivity of the different areas
- For now, we use the data to derive some tag dispersions
- To derive these Tag values, a interpolated 5km * 5km raster map from about 430 soil samples from across Norway was made, a sort of artificial deposition map
- The gis function "v.rast.stats" is used on this interpolated map and a foodstuff region map, producing a new map containing the mean deposition values in each foodstuff region together with the monitoring values which we previously have added toour food stu region map.

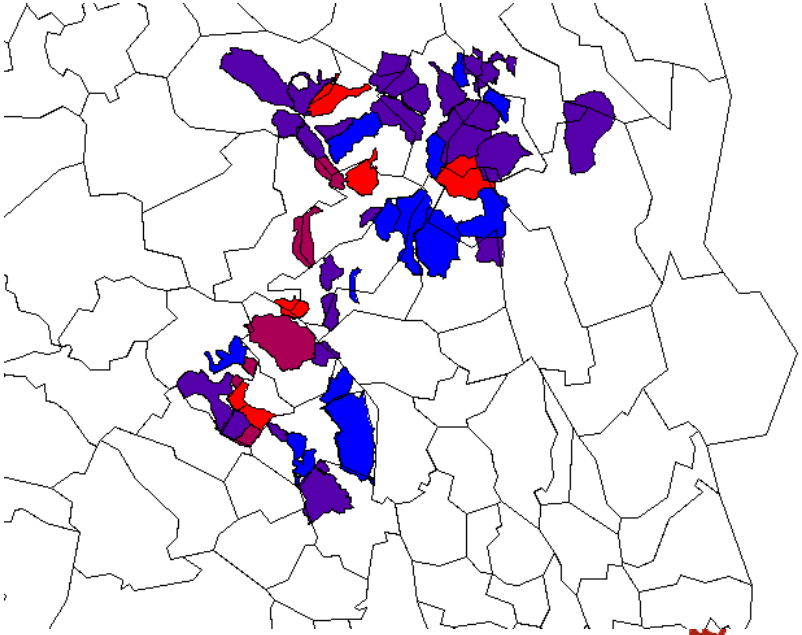
Stratos - tags

- A simple database operation of

$$\frac{\text{monitoring value } (Bq/kg)}{\text{mean deposition } (Bq/m^3)}$$

and a column with Tag values for all regions was made.





Stratos – tags

Thoughts for the future:

- Collect more of the monitoring data. – Challenging
  - They might not be digital
  - Personal calls
  - Names have changed

- Calculate tags for more years and look at time development
- Connect tags to environmental parameters in order to generalize tags for different environments. – Same environments have the same tag values.

Concluding remarks

- The meteorological model used is of a high quality, however:
  - Chosen weather conditions will affect fallout results.
  - All assumptions about the source term will also affect the predicted fallout.
- During typical weather conditions, an accidental atmospheric release from Sellafield could have consequences for Norway in the form of radioactive fallout after a time span of as little as nine hours.
- This is important with regard to emergency planning.
- The relevant authorities in Norway would therefore like to receive more information regarding UK accident scenarios & prompt notification of incidents at Sellafield.

Stratos

- The uptake of radionuclides in the food web varies from species to species and there can also be significant differences in the uptake at different location
- Monitoring reveals that we have geographical differences in uptake across Norway.
- Accounting for geographical differences by adding lots off different environmental parameters – Seems hopeless.
- Stratos uses, as other models, Tags for the Becquerel level estimates
- But instead of on Tag value, Stratos looks at tag range

Stratos -tags

- For some Tag values the method described has been used, but for now, with focus on the dispersion of the tags.
- For other Tag values we will refer to values derived in articles

Applying the tag values to Stratos

- In contrast to other models, Stratos don't look at one Tag value, but rather at the Tag value range.
- We define three Tag values from the Tag distribution, expected Tag, high Tag and low Tag, which reflect the mean, the 95 % percentile and the 5 % percentile respectively
- Together with these Tag values we apply the intervention limits for foodstuff in Norway.
- This gives us the opportunity to display which areas will have foodstuff which pas the intervention limit at different Tag values

Stratos - tags

- With this method we can derive regional Tag values for Norway and we can look at the dispersion of Tag values in Norway.

But....

- we do not have monitoring data for all of Norway
- the data we have is not uniformly dispersed but grouped at locations that were most affected by the Chernobyl accident.
- So applying Tag values from these parts of Norway to other parts, may not be a good assumption.

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