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NKS-125
ISBN 87-7893-187-8

Area Specific Stripping factors for AGS. A method for extracting stripping factors from survey data

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April 2006

Abstract

In order to use Airborne Gamma-ray Spectrometry (AGS) for contamination mapping, for source search etc. one must to be able to eliminate the contribution to the spectra from natural radioactivity. This in general is done by a stripping technique. The parameters for performing a stripping have until recently been measured by recording gamma spectra at special calibration sites (pads). This may be cumbersome and the parameters may not be correct when used at low gamma energies for environmental spectra.
During 2000-2001 DTU tested with success a new technique for Carborne Gamma-ray Spectrometry (CGS) where the spectra from the surveyed area (or from a similar area) were used for calculating the stripping parameters.
It was possible to calculate usable stripping ratios for a number of low energy windows - and weak source signals not detectable by other means were discovered with the ASS technique.
In this report it is shown that the ASS technique also works for AGS data, and it has been used for recent Danish AGS tests with point sources. (Check of calibration of AGS parameters.) By using the ASS technique with the Boden data (Barents Rescue) an exercise source was detected that has not been detected by any of the teams during the exercise. The ASS technique therefore seems to be better for search for radiation anomalies than any other method known presently.
The experiences also tell that although the stripping can be performed correctly at any altitude there is a variation of the stripping parameters with altitude that has not yet been quite understood.
However, even with the oddly variations the stripping worked as expected. It was also observed that one might calculate a *single common set* of usable stripping factors *for all altitudes* from the entire data set i.e. some average a, b and c values. When those stripping factors were used the stripping technique still worked well.

Key words

AGS, area specific spectrum stripping, point sources, stripping factors, altitude variation

NKS-125

ISBN 87-7893-187-8

Electronic report, April 2006

The report can be obtained from
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NT-62

Area Specific Stripping factors for AGS

A method for extracting stripping factors from survey data

by

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and

Uffe Korsbech

July 2003

Summary

This report describes the major results of the first part of an NKS supported project on "Area Specific Stripping", ASS, carried out in the spring and summer of 2003. This first half of the project was carried out mostly by DTU with support from DEMA. Project observers were NGU, SGU, SSI, STUK and NRPA. It is expected that the final half of the project will be done in the of 2004 with participants also from SGU, NGU and SSI and with NRPA and STUK as observers. During the new project AGS data from NGU and SGU will be analysed – and perhaps also CGS data from SSI will be investigated. Also new Danish AGS data will be investigated.

In order to use Airborne Gamma-ray Spectrometry (AGS) for contamination mapping, for source search etc. one must to be able to eliminate the contribution to the spectra from natural radioactivity. This in general is done by a stripping technique. The parameters for performing a stripping have until recently been measured by recording gamma spectra at special calibration sites (pads). This may be cumbersome and the parameters may not be correct when used at low gamma energies for environmental spectra.

During 2000-2001 DTU tested with success a new technique for Carborne Gamma-ray Spectrometry (CGS) where the spectra from the surveyed area (or from a similar area) were used for calculating the stripping parameters.
It was possible to calculate usable stripping ratios for a number of low energy windows - and weak source signals not detectable by other means were discovered with the ASS technique.

In this report NT-62 it is shown that the ASS technique also works for AGS data, and it has been used for recent Danish AGS tests with point sources. (Check of calibration of AGS parameters.) By using the ASS technique with the Boden data (Barents Rescue) an exercise source was detected that has not been detected by any of the teams during the exercise. The ASS technique therefore seems to be better for search for radiation anomalies than any other method known presently.

The experiences from the first part of the NKS project also tell that although the stripping can be performed correctly at any altitude there is a variation of the stripping parameters with altitude that has not yet been quite understood. However, even with the oddly variations the stripping worked as expected. It was also observed that one might calculate a *single common set* of usable stripping factors *for all altitudes* from the entire data set i.e. some average a, b and c values. When those stripping factors were used the stripping technique still worked well.

The major part of the first report is a description in great detail of the examinations of different sets of data - with tables, figures, and maps. Furthermore discussions on those results are presented - not always with a clear-cut conclusion. Due to the size of the project it was decided that some "problems" should be kept open for additional/ new information gained during the second part of the project.

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Appendices

Area Specific Stripping of AGS spectra

Introduction

Airborne Gamma-ray Spectrometry (AGS) can be used for mapping concentrations of natural and artificial radioactivity and at searching for radiation anomalies as for example lost or orphan radioactive sources. Both for mapping and for source search one must be able to extract the correct information from the measured spectra. One method is to “strip away” the contribution from natural radiation to the count rates of spectrum windows covering gamma energies corresponding to those emitted from the sources searched for. This method is discussed in greater detail in this report, and a new technique – already developed for CGS (Carborne Gamma-ray Spectrometry) measurements (Ref. 1) - is here developed for AGS. Other methods – developed both for AGS and CGS and not discussed here – are based on examining the measured sequence of spectra with the “rainbow screen method” (Ref. 1, 2, 3) or by performing a Noise Adjusted Singular Value Decomposition of the measured spectra (Ref. 1, 4, 5) aiming at detecting unusual spectra. Also the “fixed background” and “moving background” amongst the methods presented by Hjerpe et al (Ref. 6) can be used for point source search with CGS systems.

The spectrum stripping technique has for many years been used with AGS measurements for a determination of the concentrations of natural radioactive nuclides Th, U, and K (Ref. 7, 8, 9). The equations used here are:

$$\begin{aligned} r_{Th} &= s_{Th}c_{Th} + a\, s_U c_U + b\, s_K\, c_K \\ r_U &= \zeta s_{Th}c_{Th} + s_U c_U + g\, s_K\, c_K \\ r_K &= \eta s_{Th}c_{Th} + \nu\, s_U c_U + s_K\, c_K \end{aligned} \qquad (1)$$

Here r_X is the background corrected count rate of the spectrum window “X” centred around a characteristic full energy peak of nuclide X.
c_X is the concentration of nuclide X in the ground
s_X is the system sensitivity for nuclide X i.e. the count rate in window “X” caused by a unit concentration of nuclide X
ζ, η, ν, a, b, and g are the stripping ratios. ζ is for example the ratio between the count rate in the U-window caused by Th and the count rate in the Th-window caused by Th. The background correction is based on subtraction of the signals caused by cosmic radiation and radioactivity in the detector system itself – including the aircraft. In general the background rates should be measured when flying over the sea or a large lake at some hundred meters from shore avoiding shallow water.

[It should be stressed that accurate background measurements for the examined area are not "a must". One may in general even perform the calculations on gross count rates. The reason is that the general shape of typical background spectra often is similar to that of the natural radiation spectra with count rates per keV that are 5-6 times higher at 400 keV than at 1500 keV.)

For AGS measurements both sensitivities and stripping ratios are height dependent. The sensitivities are often assumed to have almost exponential decreasing values (Ref. 3, 8) with the height. For ordinary survey altitudes – 30m to 120m - the stripping ratios ζ, η, and ν are slowly increasing with the altitude, whereas a, b, and g in general are assumed to be constants (Ref. 3, 7, 8, 10).

For some AGS data processing systems a fourth energy window centred around the ^{137}Cs 662 keV full energy peak is included (Ref. 2, 10) The equation governing the count rate of this "^{137}Cs window" is:

$$r_{Cs} = s_{Cs}c_{Cs} + s_{Th}c_{Th}\,\iota + s_U c_U\,\kappa + s_K c_K\,' \qquad (2)$$

Here ι, κ, and $'$ refer to the count rates in the ^{137}Cs window caused by Th, U, and K in the ground. The product $s_{Th}c_{Th}$ – sometimes termed $r_{Th,Th}$ (Ref. 2, 3) - is the count rate in the Th window caused by Th. The sensitivity s_{Cs} usually refers to some "equivalent surface concentration" of ^{137}Cs (Bq/m^2 or similar). Similar equations can be set up for other energy windows i.e. windows placed at energies where signals from artificial radioactivity are expected to show up. Usually the signals from artificial radioactivity will show up at energies well below the energies of the characteristic peaks of Th (^{208}Tl at 2615 keV), U (^{214}Bi at 1765 keV), and K (^{40}K at 1461 keV). This window is in the following termed the *low energy window with the (background corrected) count rate r_L*.

From the equations (1) one observes that there is a linear relation between the count rates r_{Th}, r_U, and r_K on one side and $s_{Th}c_{Th}$, $s_U c_U$, and $s_K c_K$ on the other side.(Also see Appendix B.) Therefore Eq. (2) for the ^{137}Cs window and any other "low energy" window can also be written as:

$$r_L = s_L c_L + a r_{Th} + b r_U + c r_K \qquad (3)$$

HEre a, and b have another meaning than when using Eq. (1).

When no artificial radioactivity is present the equation becomes:

$$r_L = a r_{Th} + b r_U + c r_K \qquad (4)$$

This equation merely states that when no artificial radioactivity is present then the count rate of any window can be written as a linear combination of the count rates r_{Th}, r_U, and r_K. All count rates should be net count rates i.e. the background count rates should be subtracted.

When searching for radiation anomalies one may investigate the count rate difference:

$$\div r_L = r_L - (a r_{Th} + b r_U + c r_K) \qquad (5)$$

In areas where no anomaly is present $\div r_L$ will scatter around zero; where a strong anomaly is present $\div r_L$ will be positive. A minor anomaly will be observed if its signal exceeds the statistical noise of Eq. (5). The task now is to find the correct (best) values for a, b, and c. One might use the same technique as has been used for a determination of ι, κ, and $'$ in Eq. (2) above namely to perform measurements on calibration blocks or pads with either Th, U, or K (Ref. 3, 9, 10, 11, 12), and then calculate a, b, and c. However, such measurements refer to specific "laboratory" environments with less scattered radiation than is experienced at field measurements. Therefore the best solution would be to use the searched area itself or a similar area for the determination of a, b, and c; and this is the technique described below and in Appendix A.

First it is assumed that the survey altitude has been kept constant and that all other parameters that could influence the values of a, b, and c also have been kept constant. It is also at first assumed that no artificial radioactivity is presents within the surveyed area. Therefore a least squares method should be used for calculating the best a, b, and c values for a given set of data.

Although there is only natural radioactivity present the $\div r_L$ of Equation (5) will not be zero. Due to the statistical fluctuations of all window count rates there will be a scatter of the $\div r_L$ around zero. The best values for a, b and c are found when the summed squared error F is minimised i.e.:

$$F = \mathrm{O} \div r_L^2 \, w = \mathrm{O} (r_L - a r_{Th} - b r_U - c r_K)^2 \, w \qquad (6)$$

should be as low as possible by selecting the best a, b, and c values. w is a weight factor that should be assigned to each $\div r_L$ value. In theory the weight factor is dependent of r_L, r_{Th}, r_U, and r_K as well as on a, b, and c. By not knowing a, b, and c one has in principle to calculate at first some preliminary values of a, b, and c without including a weight factor in Eq. (6) and then one should calculate new values of a, b, and c by including the preliminary values in the weight factor. However, experiences have shown that the preliminary values can be used with success in Eq. (5). Calculations with an almost correct weight factor can, however, also be carried out.

The mathematics for calculating the best a, b and c values for a specific area - with or without including a weight factor in Eq. (6) - are described in detail in Appendix A.

Errors and uncertainties for a, b, and c

The value of the stripping factors a, b, and c depends on the flying altitude as well as on other parameters that influence the recorded spectra. A dense cover of vegetation will increase the amount of scattered radiation in the air relative to the primary radiation i.e. both a, b and c will increase somewhat. A varying amount of moisture in the upper soil also influences the spectrum shape. Geometric factors as flying in a valley or above a hill may also change the spectrum shape in a similar way. In addition the energy dependence of the detector efficiency often has some angular dependence, and therefore a horizontally inhomogeneous distribution may generate a spectrum shape that differs from that for a homogeneous distribution.

Therefore even the use of the best a, b, and c values will not everywhere generate $\div r_L$ values that scatter around zero. Somewhere a negative average $\div r_L$ value will be obtained for a sequence of spectra; and sometimes a positive average $\div r_L$ value is obtained even if no artificial radioactivity is present. However, if a significant amount of artificial radioactivity is present the $\div r_L$ value will be positive.

If the set of spectra used for a determination of a, b, and c covers an area where the ratios between the concentrations of Th, U and K in the ground are constants, it may be impossible to calculate correct a, b, and c values. However, this does not matter. The total stripping yet will become correct. (In principle one only needs one stripping factor related to a wide natural radiation window if the ratios between Th, U and K are constants.)

Constant ratios between the concentrations of Th, U and K are not common for Nordic geological conditions. But an almost constant ratio between Th and U is common (Ref. 13, 14) Therefore the stripping ratios a and b are related. Sometimes an a value may be somewhat too high together with a b value that is somewhat too low or *vice versa*. Also see the discussion in Appendix C.

This phenomenon may also show up when the stripping ratios a, b and c for different altitudes are compared. Ideally one would in general expect that the values of both a, b and c would increase (a little) with the height. However, when the concentrations of Th and U are almost proportional one may observe "oscillating" values of a and b with the height. Also see Appendix E for a discussion of the stripping factors for nuclides emitting gamma lines of different energies.

In general the concentration of K does not vary proportional to the concentration of Th and U. Therefore the stripping ratio c in general "behaves well" i.e. the c value in general is increasing a little with the altitude.

The altitude dependence of a and b may also be influenced by other factors. Radon (daughters) in the air could be such a factor. Radon daughters in the air around the aircraft generate (in the detector) an "uranium spectrum" that differs a little from the "uranium spectrum" generated by radon daughters in the ground. In addition the concentration of radon daughters in the air may vary (a little) with then height. This may cause the calculations to generate a and b values that vary with the height in an unsystematic way.

The inclusion of a source signal in the calibration data set might generate "false" stripping factors. For determination of alarm levels for Early Warning Stations (Ref. 19) it was found that when signals from sources emitting multiple gamma lines were included it would lead to spectrum shape distortion. However, signals from sources of low source strength did not provoke any significant changes. It is therefore to expect that sources strong enough to be spotted from an ordinary rainbow plot are strong enough to introduce calculation errors, whereas sources barely or not at all detected in this "first" data examination round could be included in the data set without introducing significant errors.

For stripping factors calculated for a very small group of spectra (<30) it has been observed on two occasions that the value b (uranium) for high energy windows become negative at large altitudes. See appendix H2 and H3.

Data material

Several sets of area specific stripping factors were calculated for different altitude intervals and different geographic locations.

The first calculations were made on AGS measurements performed in 1999 (DEMA/DTU) during mapping of natural radionuclides on the Danish island Bornholm (Ref.16). The data material from Bornholm was found to include signals from ^{137}Cs. (Fallout from the atmospheric nuclear weapon testing and from the Chernobyl accident.) However, those signals were so weak that it was not possible to perform a mapping, not even using the pseudo-concentration method (Ref. 5, 16). The measurements from Bornholm can therefore be said, with high confidence, not to contain disturbing radiation from manmade radionuclides. The data from Bornholm were gathered during four days. The weather conditions were reasonably good with a few summer showers now and then. It was observed anyhow that the background window count rates showed a variation of 10-15%, changing from day to day. Where it has been possible, a set of individual background measurements (made over the sea a couple of hundred metres from land) was used in the stripping factors calculations.

Next the same calculations were made on data from the Barents Rescue (Ref. 1, 17) exercise in Boden, Sweden 2001. No background measurements were available and therefore an average of the background measurements from Bornholm 1999 was used. This may introduce minor errors into the calculations. Regarding this, it can be mentioned that the system energy calibration was the same and that the very same equipment, crew and helicopter type that operated on Bornholm also operated in Boden.
All measurement series (files) from Boden included signals from point sources and it was therefore necessary initially to remove these. This was done using visual inspection of the measured data with the tool NUCSpec (Ref. 2, 18) and checking the ”clean” data sets using NASVD processing (Ref. 4, 5, 15).

Data formats

For the calculations of stripping factors a program in the language BASIC was written. This program has previously been used for calculation of CGS area specific stripping factors (Ref. 1, 18) and uses the Danish CGS format which is a 512-channels Exploranium format (Ref 2). Area specific stripping factors for CGS have been used with success in the after-processing of CGS-data from the Barents Rescue exercise (Ref. 1, 18). In order to use to the program on AGS data, that despite also being a 512-channels Exploranium format have a different layout, a small programme in C^{++} was written for this purpose. Data layouts for Danish AGS and CGS files can be found in Appendix F.

Energy ranges

A set of stripping factors a, b, and c was calculated for every data set in question for nine different windows. The lower (LL) and upper (UL) channels and corresponding energies are shown in Table 1. The windows limits were chosen in

order to include radionuclides that might be(come) of interest. The knowledge of the type of isotopes and source strength of the sources used in the Barents Rescue exercise (Ref. 17) made it sensible also to include windows covering those isotopes (^{99m}Tc, ^{60}Co ^{131}I, and ^{137}Cs).
It is not possible to define a window containing no contribution to the count rate from Th, U, or K. This means that some of the windows partly (or fully) overlap with naturally occurring gamma lines. For example should be mentioned the contribution from ^{214}Pb (352 keV) to the ^{131}I window, ^{214}Bi (609 keV) contributes to the ^{137}Cs window, and ^{40}K contributes to the ^{50}Co window. Please confer with Appendix E for a discussion on the influence of different factors on the values of a, b, and c.

Table 1. Window limits, channel and energy, and nuclide.
The energy intervals refer to channel endpoints.

Channel	keV	Nuclide
24-28	128-156	^{99m}Tc
46-62	251-347	^{192}Ir
60-72	330-403	^{131}I
78-88	431-493	^{192}Ir
80-100	443-562	Annihilation
(97-116)	(544-652)	(^{134}Cs)
110-130	613-732	^{137}Cs
130-154	732-870	^{134}Cs
174-198	985-1123	^{136}Cs
193-243	1089-1385	^{60}Co (2 peaks)
238-271	**1350-1546**	**K**
290-323	**1655-1850**	**U**
416-483	**2407-2815**	**Th**

Stripping factors

Bornholm 1999
Four different locations on Bornholm were examined including one location where it was known that natural anomalies exist (Alum shale with some uranium). The locations were at first examined individually, later all measurements were pooled to produce one set of data on which the calculations were performed anew. Measurements made over the sea were removed. The majority of those measurements were made at a survey height of more than 100m. Also measurements made above shallow water were removed from the data set (although most of those were made at normal survey altitude) to eliminate awkward fields of view due to the helicopter not flying horizontally but more or less sideways during the turns.

The data files used were 621a, 622a, 622b, and 623b. Background window count rates can be found in Appendix G and maps of the natural radionuclides in those areas are found in Appendix H. The same background count rates were used for

622a and 622b (both 6 June, 1999). For the composite file including all measurement from those four files an arithmetic background mean was used.

The Bornholm measurements were sorted in 5m-flight height intervals and each interval was treated separately. Also, for each file, a set of mean stripping factors covering the entire height interval, 70m-100m was calculated. The figures 1 to 3 show the calculated stripping factors as a function of actual survey height (i.e. no attenuation from equipment was included in the calculations) for the composite file measurement series. Tables are found in Appendix I; additional figures are shown in Appendix J. The mean survey height for all measurements was 84 m.

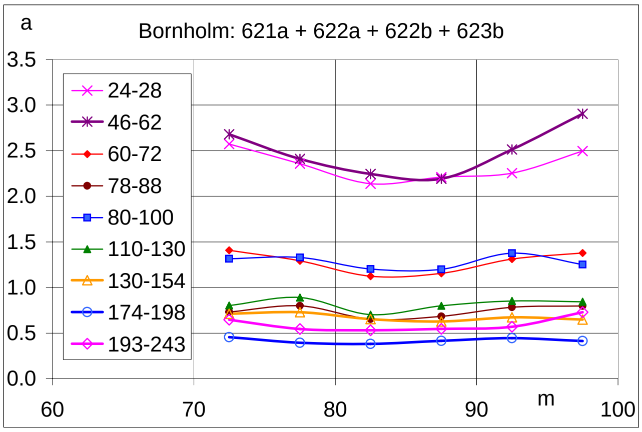

Figure 1. Average Th stripping factors versus survey height, Bornholm.

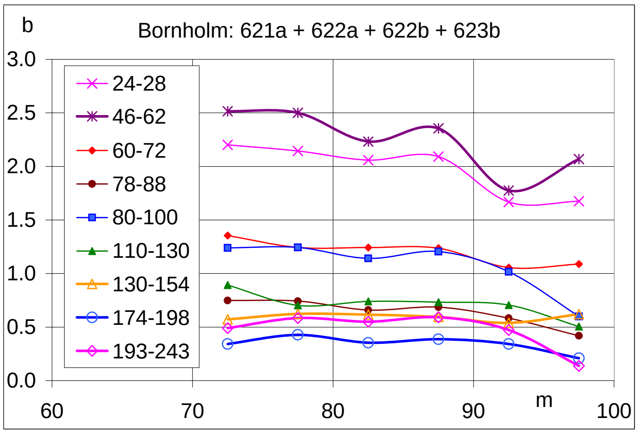

Figure 2. Average U stripping factors versus survey height, Bornholm.

The contribution, c, from the potassium window to the low energy window was found to be only slightly dependent on survey height, but very dependent on the examined channels intervals (gamma energy) of the low energy window in question. Please note that the windows are of different width. c increases with the survey height.
The calculations of the contribution, a, from the thorium window to the low energy window show that for the Bornholm measurements the value of a at first decreases with the survey height, flattens out, and the increases again. The flattening of the curves happens at approximately the average survey height.

It should be noted that the statistic significance in the intervals 80-85 m and 85-90 m is the better by having here the largest number of measurements. It is also noteworthy that the uranium stripping factors, b, seem to “mirror” the thorium stripping factors, i.e. when a goes up, b typically goes down.

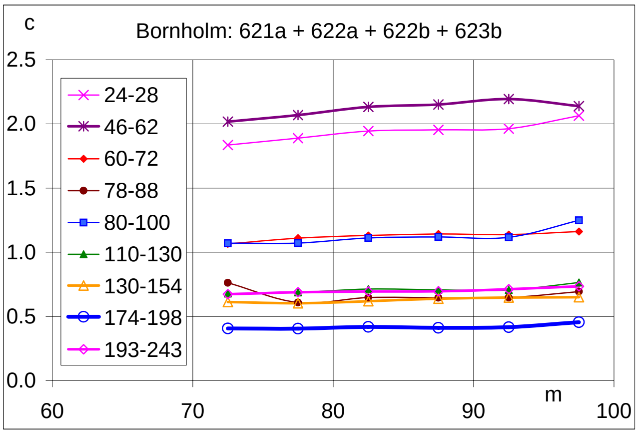

Figure 3. Average K stripping factors versus survey height, Bornholm.

Boden 2001

Stripping factors were calculated for two of the areas surveyed by the AGS teams during the Barents Rescue exercise, A1 and A2. Area A1 included strong sources of ^{131}I and ^{60}Co whereas area A2 included weak or heavily shielded sources of ^{99}Mo, ^{60}Co, and ^{137}Cs. Most teams, including the Danish team, participating in the exercise were able to locate and identify all sources in Area A1. Only 3 out of 5 teams, however, found a source in area A2 and all teams wrongly identified it. The types and activities of the sources (Ref. 17) can be found in Appendix K.

The survey in Boden took place at a much lower altitude than used on Bornholm. Due to terrain features the survey heights ranged from 30-70 m. No background measurements were included in the data series and an average Bornholm back-ground was used in the calculations.

Initially a set of stripping factors for area A1 was calculated for the survey height 55-60m. Those factors were calculated from a modified data set where measure-ments during helicopter turns had been removed together with measurements showing significant point source signals. The resulting data set was NASVD pro-cessed to check for source signals in the form of spectral shapes. No significant spectral shapes or amplitude values were found.
Next, the measurements related to helicopter turns were put back into the data set. This only changed the values of the calculated stripping factors slightly. It was therefore decided to keep the helicopter turn measurements in the data set on the grounds that it did not seem significant whether they were there or not and it would be more realistic to include them. The NASVD spectral components and their amplitudes for the raw data file and for the data set of the measurements in the interval 55-60m (including turns) are shown in Appendix L.
The raw data file spectral components clearly shows the presence of the three ɔ-emitters in area A1 and also their location (amplitude number). These signals are not found in the modified data set.

Figure 4 to Figure 6 show the stripping ratios for area A1 as a function of altitude. Most measurements were found in the intervals 50-55m and 55-60 m.

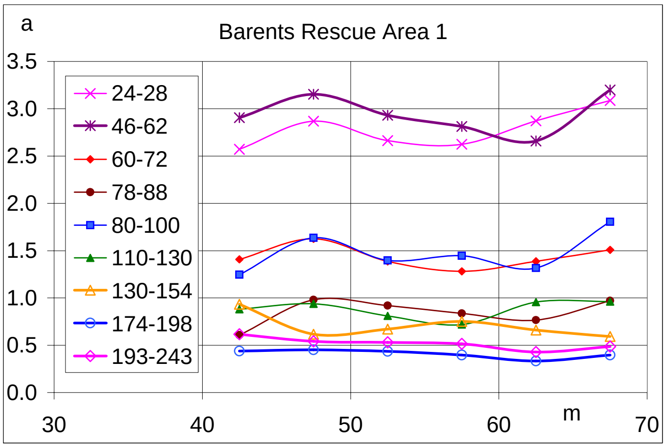

Figure 4. Average Th stripping factors versus survey height, Boden.

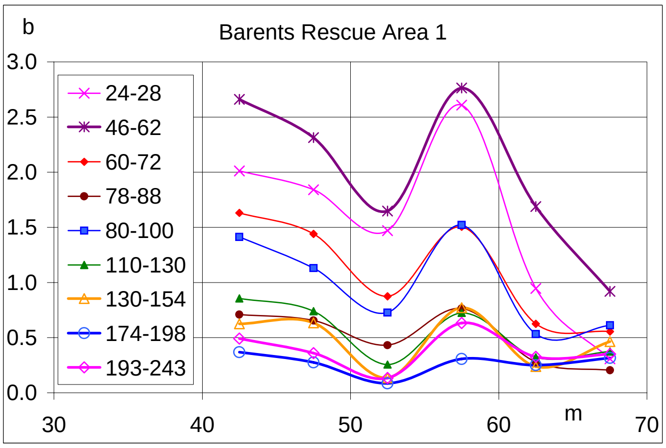

Figure 5. Average U stripping factors versus survey height, Boden.

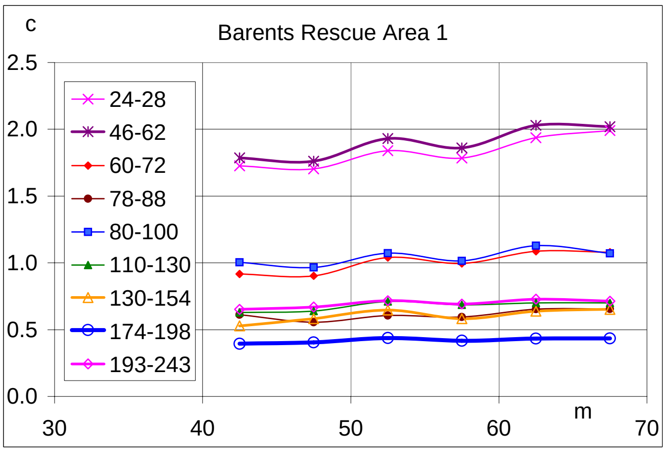

Figure 6. Average K stripping factors versus survey height, Boden.

The potassium stripping factors show approximately the same trend as seen for the Bornholm results.

There seems to be a slight tendency for the thorium stripping factors to increase with the survey height. However, for the uranium stripping factors the curves look very odd. This could partly be due to variations of radon daughters in the air or natural anomalies. Please confer “Discussion” and Appendix E”.
For area A2 only a set of average stripping factors were calculated. All results for area A1 and A2 are shown in Appendix I (tables) and Appendix J (plots).

Measured and stripped counts

The aforementioned BASIC program also includes a calculation of the stripped counts for each measurement (according to Equation 5). The results for each height interval were plotted as a function of spectrum number together with the calculated statistic error (±ů) of each measurement. It is seen from those plots that for several measurements there are observed stripped counts outside the 2ů-interval. The stripped counts in general fluctuate around zero and are thus sometimes positive and sometimes negative. This is seen both for the Bornholm results, which basically includes no manmade signals, and for the Boden results. Figure 7 to Figure 10 show some examples of the stripped counts for the Bornholm measurements from file 622b. Additional plots of measured counts, stripped counts and statistical errors are found in Appendix M. Statistical errors are calculated according to Eq. 7, where n_X is the window counts:

$$\sqrt{n_L \; 2 \; a^2 n_{Th} \; 2 \; b^2 n_U \; 2 \; c^2 n_K} \qquad (7)$$

Figure 7 and Figure 8 show the results for the ^{137}Cs window (613 keV to 732 keV) for survey height 80-85m. It should be noted, that this window also partly covers the 609 keV (^{214}Bi) line from the uranium series.

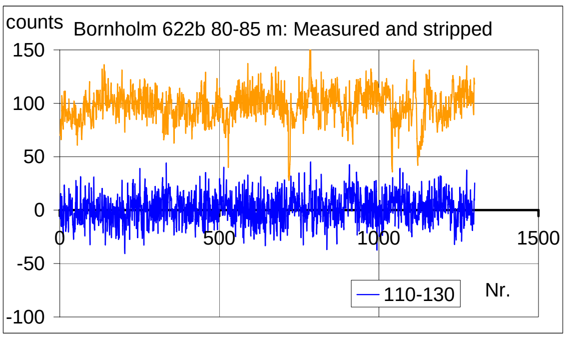

Figure 7. ^{137}Cs window, 622b, 80-85m. Measured and stripped counts.

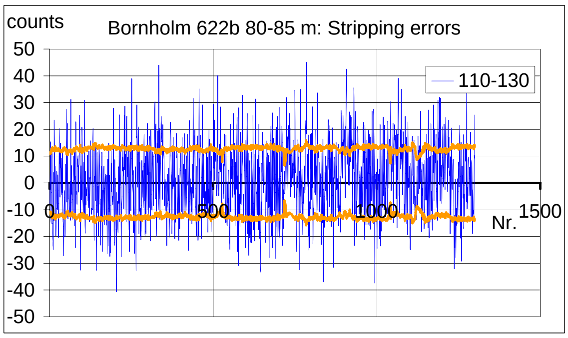

Figure 8. ^{137}Cs window, 622b. 80-85m. Stripped counts and 2ů-intervals”.

Figure 9 and Figure 10 show the results for one of the ^{192}Ir windows (251 keV to 347 keV) for survey height 75-80m. This window also contains contributions from the 295 keV (^{214}Pb) from the uranium series.

When the results are plotted in a colour XY plot it becomes apparent that the largest values of the stripped counts are found in the “plot centre”. This is also where one will find two plantations (Åker and Pederskjær) for which the ratios U/Th and U/K both are above normal (Ref. 16). Modified error colour plots are shown as Figure 11 (^{137}Cs window) and Figure 12 (^{192}Ir window).
Modified in this respect means that negative results cannot be plotted and therefore a linear displacement has been done by adding a “correction constant” to all results. The correction constant has been chosen so as to create the best possible colour plot with a reasonable colour scale. A few results may still be negative as a result of this. For the plots shown here the following has been done: Figure 11, ^{137}Cs window: +30, colour scale 0-70 and Figure 12, ^{92}Ir window: +80, colour scale 0-150).

Figure 13 shows a corresponding RGB map of the natural radionuclides (Ref.16). The dark blue areas (forest) where uranium dominates fit well with the calculated error colour maps.

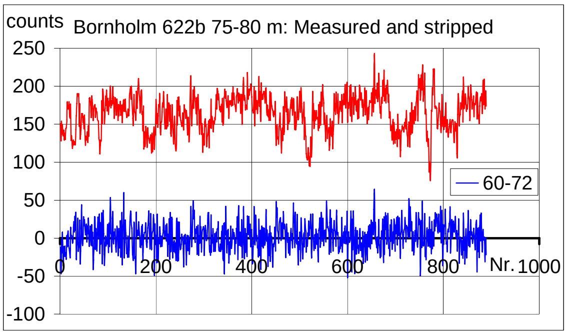

Figure 9. ^{192}Ir window, 622b, 75-80m. Measured and stripped counts.

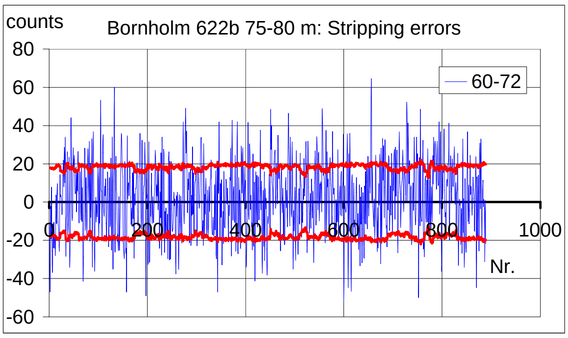

Figure 10. ^{192}Ir window, 622b. 75-80m. Stripped counts and 2ů-intervals”.

The modified Boden measurement sets do not include any visible (Ref. 1, 2, 5, 16) significant manmade signals, however these might still exist because they were present in the original data sets. As a matter of fact the calculated results for area A1, Boden, at the survey heights 45-50m, 50-55m, and 60-65m show the presence of “spikes” particularly in the ^{60}Co window (channels 193-243 covering both full energy peaks). Despite this the stripping does produce results that fluctuate around zero (small positive mean). The majority of the stripped counts are within the statistical error range. An inclusion of a weak source signal therefore does not seem to matter for the calculation of an adequate set of area specific stripping factors.

The Figures 14 to 17 show some results for Boden, Area A1. It should be remembered that the spectrum numbers for the detected peaks cannot be compared because the interval data sets does not have the same number of measurements. Additional plots of measured counts, stripped counts and errors are found in Appendix M.

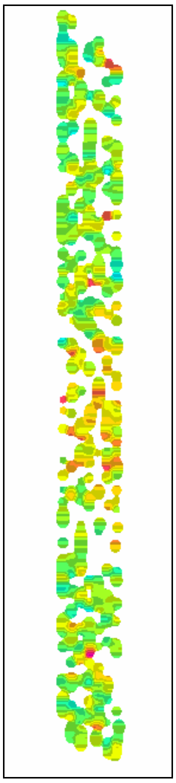

Figure 11.
^{137}Cs window
(incl. 609 keV)

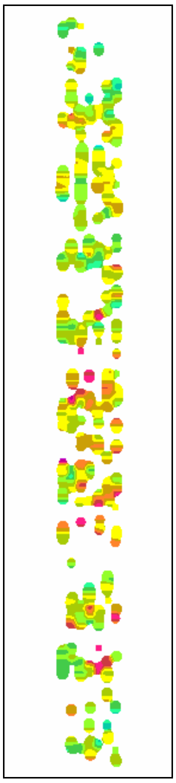

Figure 12.
^{192}Ir window
(incl. 295 keV)

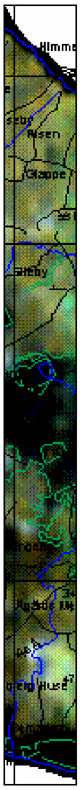

Figure 13. Part of RGB map for Bornholm, measured 1999 (Ref. 16) K(red), Th(Green), U(Blue)

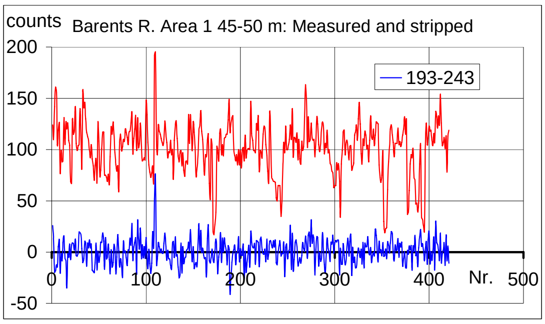

Figure 14. Cobalt window. A1, 45-50m. Measured and stripped counts.

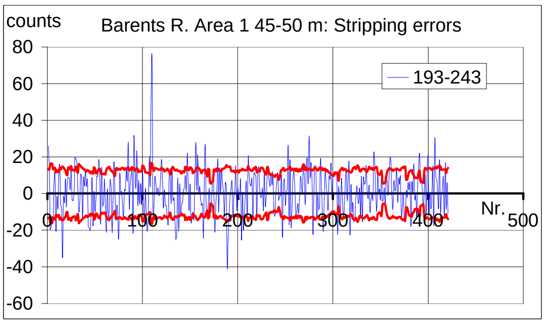

Figure 15. Cobalt window. A1, 45-50m Stripped counts and 2ů-intervals".

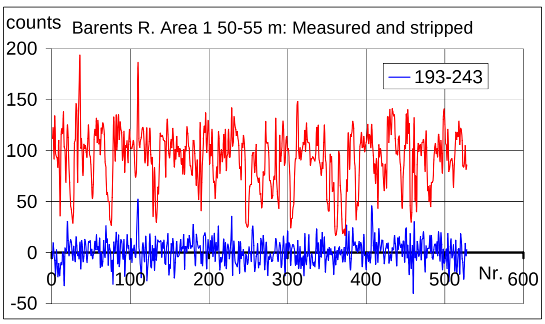

Figure 16. Cobalt window. A1, 50-55m. Measured and stripped counts.

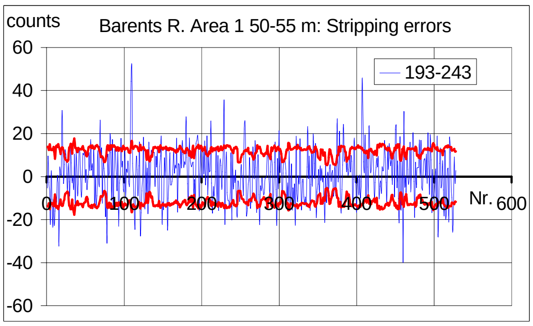

Figure 17. Cobalt window. A1, 50-55m Stripped counts and 2ů-intervals".

Measurements including strong source signals

Stripping factors calculated from the modified data set (source signals removed) from Area A1, 55-60m, were used to strip all the 55-60m measurements (including source signals) in Area A1. Figure 18 shows an XY-plot of the measurements used to calculate a, b, and c. Figure 19 shows an XY plot of all the measurements in Area A1 in the same height interval.
Tables with the ten largest errors for the isotope windows ^{131}I, ^{60}Co, and ^{137}Cs are shown in Appendix O.

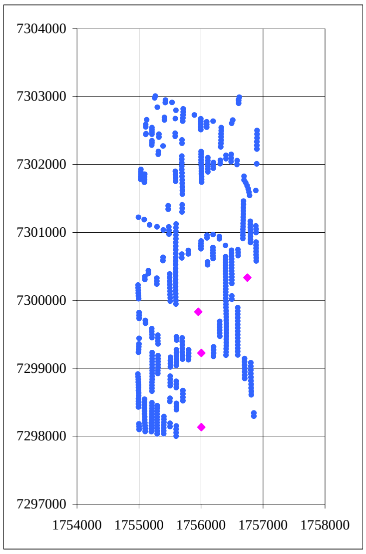

Figure 18. A1, 55-60 mod.

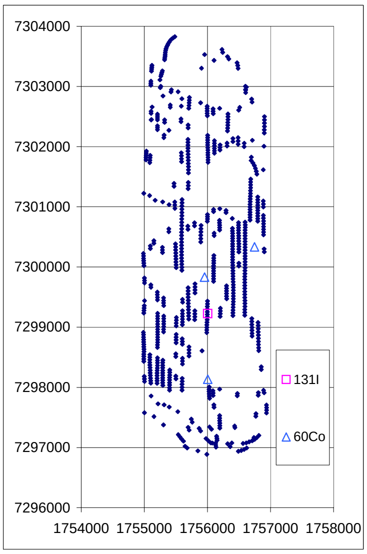

Figure 19. A1, 55-60.

The Figures 20 to 22 show the source positions (cobalt and iodine) together with the five largest errors (represented by the D symbol) in an RT90 co-ordinate plot.

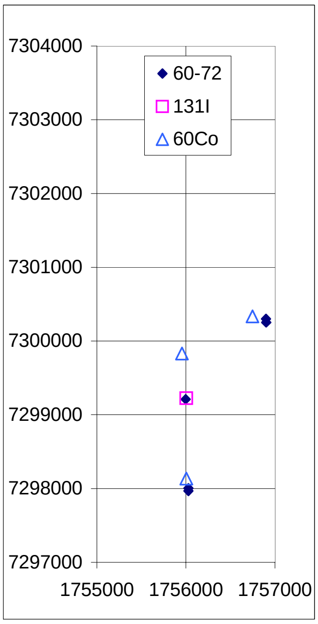

Figure 20. ^{131}I window. Five largest errors. A1.

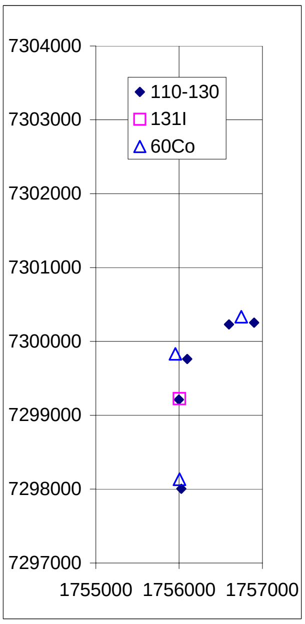

Figure 21. ^{137}Cs window. Five largest errors. A1.

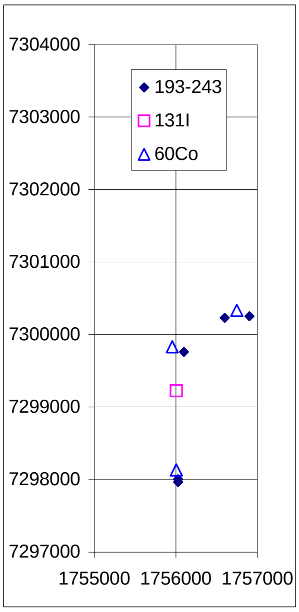

Figure 22. ^{60}Co window Five largest errors. A1.

The source strengths of these sources were very high and there is no problem in locating the sources using only 20-25% of the measurements in that area (20-25% of the measurements were performed at survey height 55-60 m).
In Appendix Q colour plots of the (linear displacement) errors are shown.

It is noticed that the ^{131}I source also creates a large error in the ^{137}Cs window. This is caused by the 637 keV gamma line (yield 7%, versus 82% for the 364 keV line). The ^{131}I source is indicated by a black arrow in the NUCSpec plot in Figure 23.

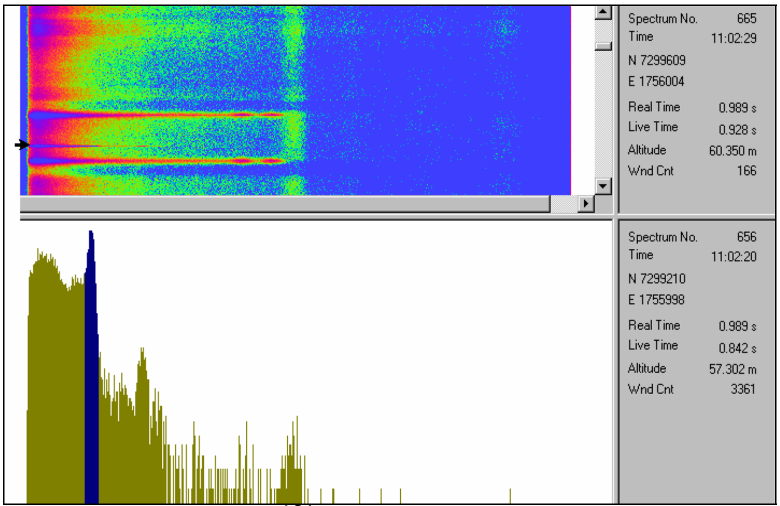

Figure 23. Area A1 ^{131}I source. Window from channel 60 to channel 72 shown.

Reusing area specific stripping factors on other areas

The set of stripping factors calculated from the Area A1 height interval 55-60m was used on Area A2 for the same height interval. Area A2 included weak(er) sources and only a few measurements were removed from the A2 measurement set. The measurements removed were all related to source 2:4 (^{99}Mo). Figure 24 shows the source in a NUCSpec colour plot indicated by an arrow.

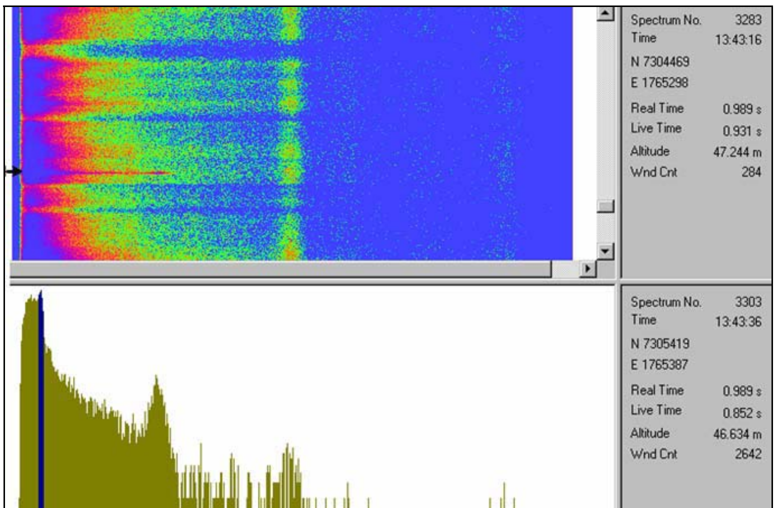

Figure 24. Area A2 ^{99}Mo source. Window from channel 24 to channel 28 shown.

The window in the lower half of the figure shows the ^{99m}Tc window (channels 24-28). The wide peak in channel 131 (of 512) is the 740 keV gamma line (12%) overlapped by the 778 keV line (4%). It is therefore expected that if one has a ^{99}Mo source there will be errors in the ^{134}Cs window also, whereas a ^{99m}Tc source will produce significant errors in the window covering the channels 24-28 only.

Tables with the ten largest errors for the isotope windows ^{99m}Tc, ^{60}Co, and ^{137}Cs are shown in Appendix O. In this case the positions of the sources are known and it is observed that the three XY plots presented as Figure 25, Figure 26, and Figure 27, (five largest errors only, represented by the Dž symbol) all points to errors in approximately the same location: close to the ^{60}Co sources. To identify the source as cobalt more than one window must be examined. The bottom triangle in the figures is the location for the source for which measurements were removed and therefore no errors occur around this source.

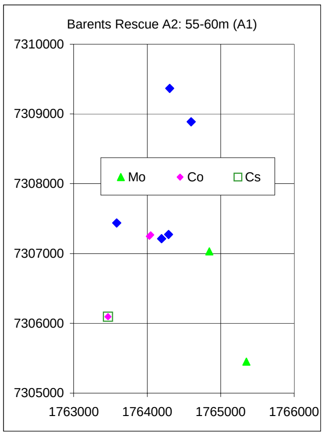

Figure 25. ^{99m}Tc window. Five largest errors. A2.

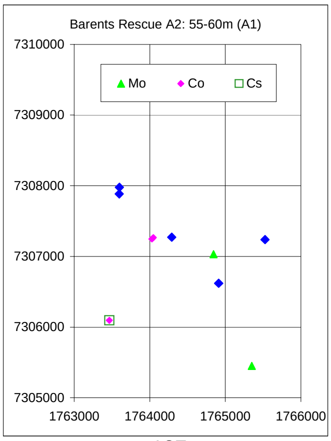

Figure 26. ^{137}Cs window. Five largest errors. A2.

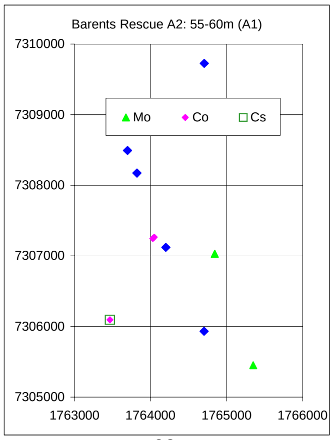

Figure 27. ^{60}Co window Five largest errors. A2.

Next the same stripping factors (A1 55-60m) were used on all the measurements in Area A2 in the height interval from 30-80m. This means that the examined measurements included the ^{99}Mo measurements on source 2:4. Tables with the ten largest errors for the nine isotope windows defined previously are shown in Appendix O together and XY plots showing the five largest errors are found in Appendix P. Some of the figures from Appendix P are shown here as Figure 28 to Figure 30. Source types and positions are shown in the plots, too.

For all windows below 870 keV the ^{99}Mo source (2:4) a small cluster of errors is seen. The ^{60}Co source is indicated by two errors close to the source position, but only in the cobalt-window. From the tables, show in graphic display in Figure 31, one notices that the ^{99}Mo errors are significantly large.
Only a small rise in error is seen for cobalt, however when more than the ten largest errors are plotted this error becomes significant, Figure 32. Using the area specific stripping method one is therefore be able to find this cobalt source signal, that was not found during the Barents Rescue Exercise.
It is also noticed that the error in the ^{134}Cs window (and to some extent the second ^{192}Ir window) follow the ^{99m}Tc error (confer previous discussion on ^{99}Mo gamma energies).

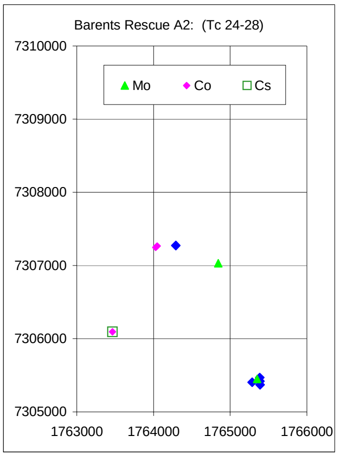

Figure 28.
A2. ^{99m}Tc window errors.

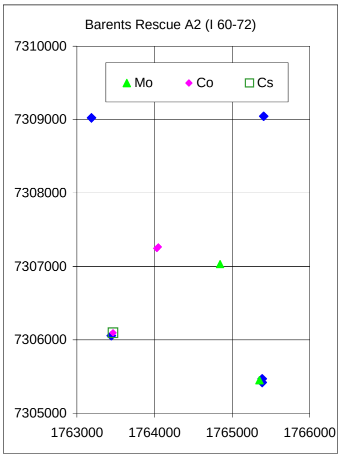

Figure 29.
A2. ^{131}I window errors.

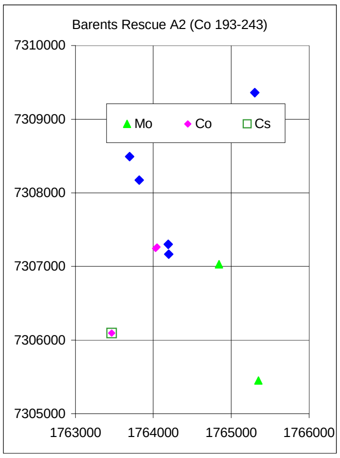

Figure 30.
A2. ^{60}Co window errors.

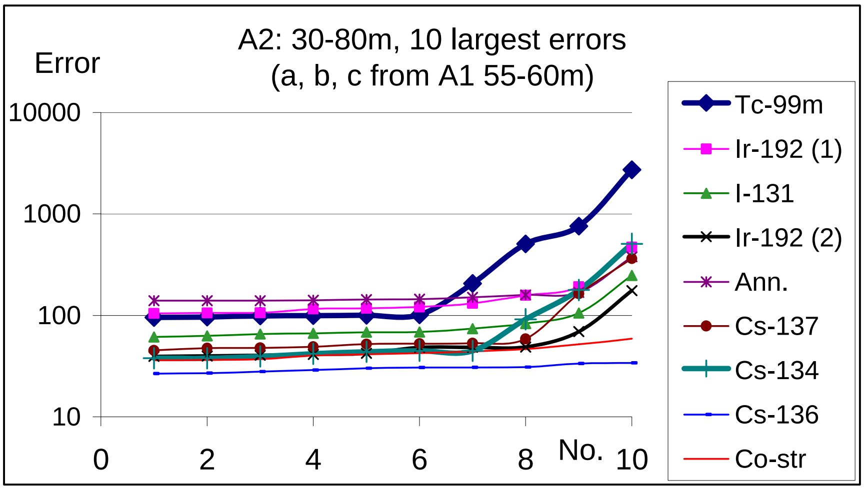

Figure 31. Log. scale plot of the ten largest stripping errors for 30-80m survey height in Area A2. Stripping factors from Area A1 55-60m.

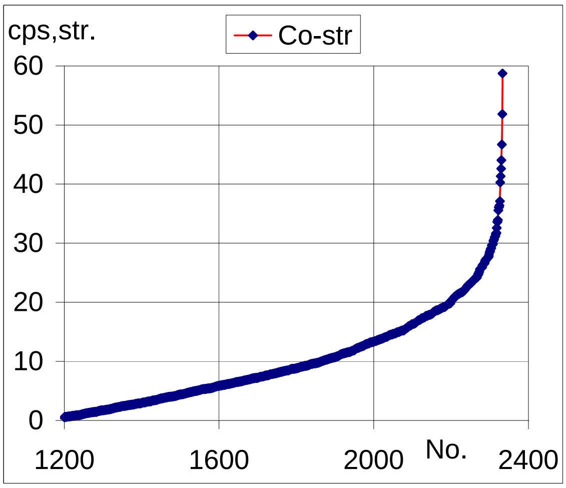

Figure 32. Sorted error plot (positive half) of the stripping errors for the ^{60}Co window for 30-80m survey height in Area A2. Stripping factors from Area A1 55-60m.

Average area specific stripping factors

To check the importance of using area specific stripping factors for small height intervals compared to using a set of average stripping factors for a wide range of survey height a set of stripping factors for Area A2 for measurements in the range 30-80m was calculated. (Measurements from source 2:4 were not included.) This set was used on all measurements in Area A2.
Tables with the ten largest errors for the nine isotope windows defined previously are shown in Appendix O and XY plots showing the five largest errors are shown in Appendix P. Again the ^{99}Mo source is found easily in all windows below 870 keV, Figure 33. The cobalt window shows larger errors than when stripping factors for a single height interval were used.

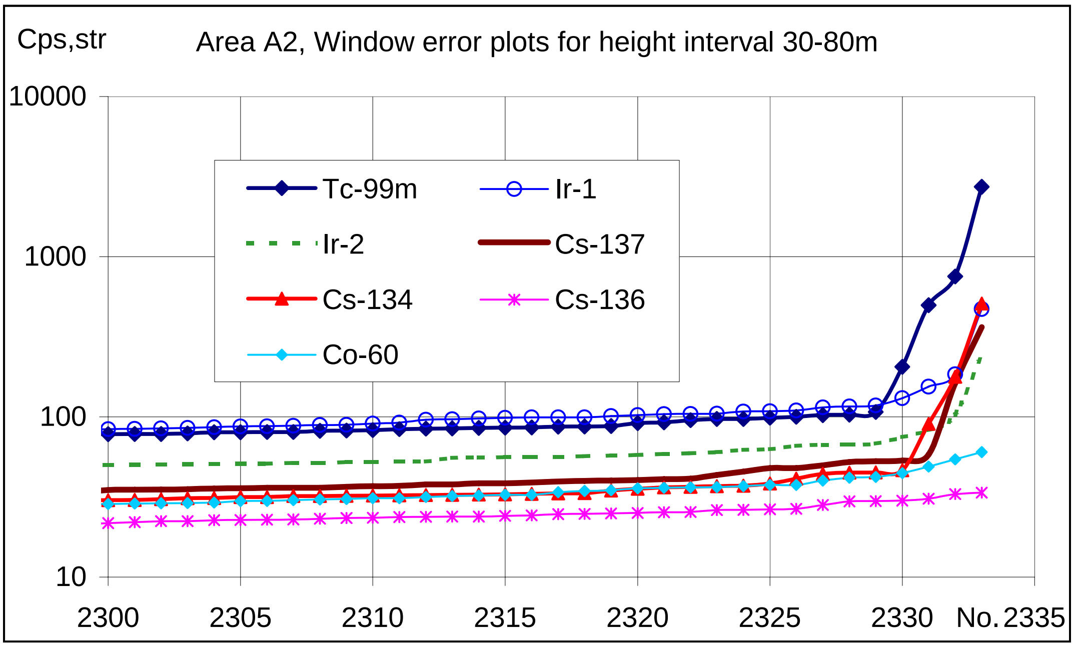

Figure 33. Log. scale plot of largest errors for Area A2 30-80m when average stripping factors for the same area is used.

To obtain a picture of the errors in all windows a normalised colour plot was made. For each window the errors were normalised to cover the range from 0% (lowest value) to 100% (highest value). For each measurement the normalised errors in the nine windows were added together. This produced errors larger than 100 for some of the measurements and once again all windows errors for each measurement were normalised to cover the range from 0% to 100%. Figure 34 shows this plot. The (white) circle shows the position of the two ^{60}Co sources now clearly identified (as one source) and the (brown) triangle shows the position of the previously identified ^{99}Mo source.
Error colour plots for all windows (separate windows) are shown in Appendix Q.

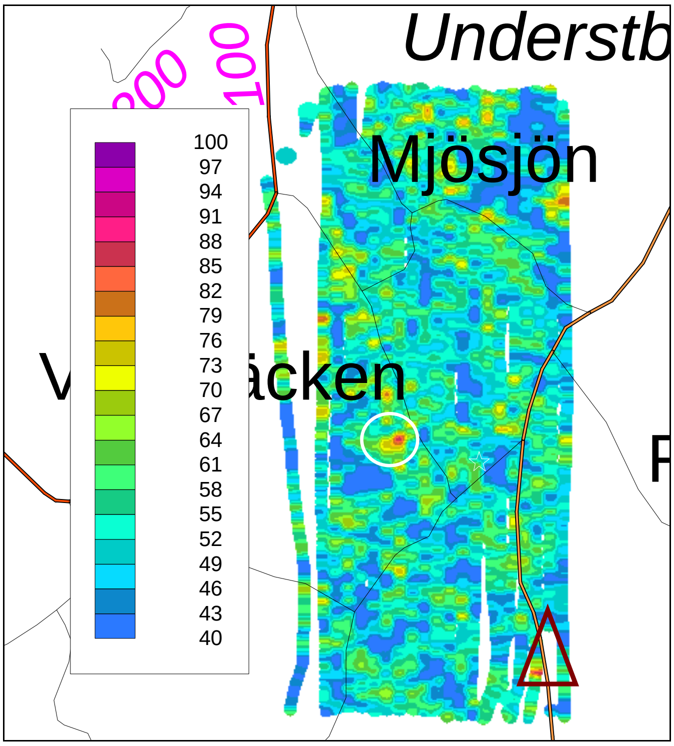

Figure 34. Normalised error colour plot for Area A2.
Plot interval 40-100%.

Discussion

The method of area specific stripping has proved to be an efficient tool in localising point sources. Whether the method can also be used for mapping area contaminations from fallout has yet to be investigated. From the results for measurements made in Boden, Area A1 and A2, the stripped counts in the ^{137}Cs window fluctuates around zero (with some spikes) just like it does for the other windows. It therefore seems that for old fallout, at least, the method is not applicable for mapping area contamination. Here ^{137}Cs fallout is "assumed" to be part of the natural environment.

The measurement sets from A1 and A2 do not include significant spectrum drift among the first 7 spectral components. It therefore cannot be said to what extent spectrum drift could influence the values of a, b, and c. However, this influence is expected to be of minor importance compared to other factors. Other factors could be the existence of natural anomalies. It has been shown that a U/Th, U/K anomaly on the island Bornholm does show up in the error plots.
Depending on the energy intervals chosen the presence of radon daughters in the air is likely to introduce a stripping error for low energy window. Figure 35 shows a radon daughter spectrum for a 3" * 3" NaI detector.

From the results from the Boden Area A1 measurements where area specific stripping factors were calculated from a modified data set originally including source signals it is concluded that the inclusion of a few weak source signals in the data set only has a minor, not detectable effect. Also it was shown that for localising point sources one might apply stripping factors calculated for a small survey height interval (e.g. 5 m) to the entire data set and still be able to identify the correct coordinates for the sources. Seemingly area specific stripping factors calculated for one area (A1, specific for that area) can also be used in another search area (A2) with success. For areas that are not too different regarding terrain features one should therefore be able to use pre-calculated area specific stripping factors directly on a newly recorded spectrum file. However, this manner should be investigated further.

As a very coarse estimate for stripping factors a set of average area specific stripping factors has been used on an entire file (A2) with success. Previously unnoticed source signals then appeared.

The method has only been tested on a few Danish measurement files and it is recommended that is should be tested also on measurements performed in areas where close-to-surface contamination is found to investigate if the method is applicable to mapping surface concentrations, too.

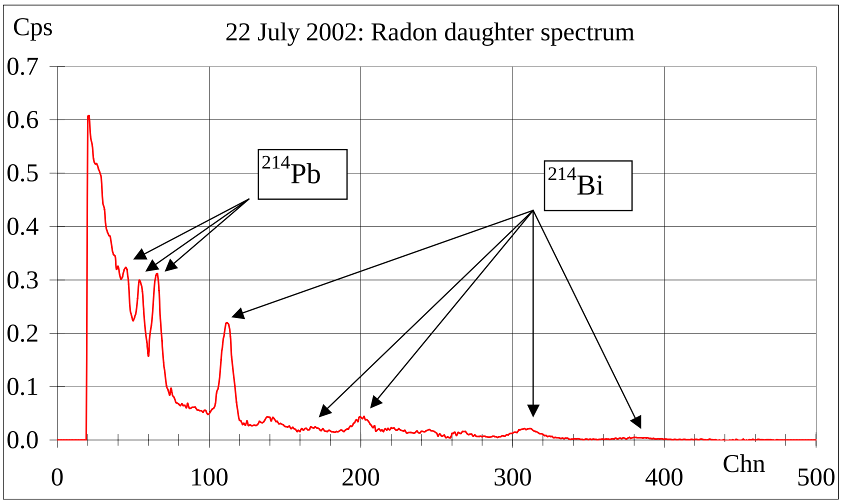

Figure 35. Radon daughter spectrum. Peaks at 242 keV, 295 keV, and 352 keV from ^{214}Pb and at 609 keV, 934 keV, 1120 keV, 1765 keV, and 2204 keV from ^{214}Bi (Ref. 19).

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List of symbols used

a, b, and g: Stripping factors (or ratios) used for "upward stripping" within the K, U, and Th windows

a, b, and c: Stripping factors used for stripping low energy window count rates for the contribution from Th, U, and K. The basis is the background corrected count rates for the Th, U, and K windows

ζ, η, and ν: Stripping factors used for "downward stripping" within the K, U, and Th windows

ι, κ, and $'$: Stripping factors used for stripping low energy window count rates for the contribution from Th, U and K. The basis is the count rate contributions to the Th, U, and K windows caused by Th, U and K respectively

n_{Th}, n_U and $n_{K.}$: The background corrected count for the natural nuclides ^{208}Tl (2615 keV, ^{214}Bi (1765 keV) and ^{40}K (1461 keV)

r_L: The background corrected count rate for a low energy window i.e. a window covering energies below the lower limits of the ^{40}K window i.e. below some 1300 keV

r_{Th}, r_U and $r_{K.}$: The background corrected count rates for the natural nuclides ^{208}Tl (2615 keV, ^{214}Bi (1765 keV) and ^{40}K (1461 keV)

s_x : Sensitivity for a detector. Describes the count rate in window No. X caused by one unit concentration of nuclide X in or on the ground. Unit for example cps per kBq m^{-2}

$s_x c_x$: Count rate in window No. X caused by nuclide X in or on the ground. Unit cps

Appendix A. The mathematical background

The determination of the best a, b and c values to be used for a specific area is based on minimising the error F described by Eq. (6).:

$$F = \Sigma \Delta r_{L,i}^2\, w_i \;= \Sigma(r_{L,i} - a r_{Th,i} - b r_{U,i} - c r_{K,i})^2\, w_i \qquad (6)$$

The subscript "i" has been included in order to indicate that each spectrum should be included with its own weight w_i.
In general all spectra have been measured for at same real time – typically 0.5 s to 2 s for AGS. The live time will differ a little due to having a higher dead time for high count rates. (For the Danish AGS system the live time typically varies from 0.901 s to 0.979 s with an average of 0.941 s.) However, in order to simplify the calculations of a, b and c it is assumed that all spectra are recorded with the same live time. Hereby one can use the recorded counts instead of using the calculated count rates. Equation (6) therefore is changed to:

$$F = \Sigma \Delta n_{L,i}^2\, w_i \;= \Sigma(n_{L,i} - a n_{Th,i} - b n_{U,i} - c n_{K,i})^2\, w_i \qquad (A.1)$$

where n refers to the background corrected window counts.

According to standard theories w_i should be selected as being inverse proportional to the variance var_i of ($n_{L,i} - a n_{Th,i} - b n_{U,i} - c n_{K,i}$) i.e.:

$Var_i = n_{L,i} + a^2 n_{Th,i} + b^2 n_{U,i} + c^2 n_{K,i}$, and the sum of squared errors becomes

$$F = \Sigma(n_{L,i} - a n_{Th,i} - b n_{U,i} - c n_{K,i})^2/(n_{L,i} + a^2 n_{Th,i} + b^2 n_{U,i} + c^2 n_{K,i}) \qquad (A.2)$$

It is not a simple matter to calculate the correct var_i value. In principle it is possible to minimise F from Eq. (A.2) but the calculations are cumbersome. Simpler calculations are obtained by calculating at first preliminary values for a, b, and c by neglecting the weight factor (i.e. $w_i = 1$ for all spectra). The preliminary a, b, and c values are then used for the weight factor in Eq. (A.2) and better a, b, and c values are determined. However, experience has shown that the preliminary a, b, and c values can be used for stripping. The only problem seemingly is that the average of Δn_L differs a little from zero. Typically the average of Δn_L is ½% to 1% of n_L.

For low energy windows for which it is expected that both a, b, and c are close to 1.0 one may replace (A.2) with

$$F = \Sigma(n_{L,i} - a n_{Th,i} - b n_{U,i} - c n_{K,i})^2/(n_{L,i} + n_{Th,i} + n_{U,i} + n_{K,i}) \qquad (A.3)$$

or even simpler (still for a, b, and c close to 1.0 and thus $n_{L,i} \approx n_{Th,i} + n_{U,i} + n_{K,i}$)

$$F = \Sigma(n_{L,i} - a n_{Th,i} - b n_{U,i} - c n_{K,i})^2/(2\, n_{L,i}) \qquad (A.4)$$

The calculation of the preliminary a, b and c values from the equation (A.1) with w = 1 is carried out as follows:

The summed, squared error F should be minimised by varying the values of a, b, and c one gets:

$$dF/da = 2 \Sigma(-n_{Th,i}) \cdot (n_{L,i} - a \cdot n_{Th,i} - b \cdot n_{U,i} - c \cdot n_{K,i}) = 0 \quad \text{(A.5a)}$$
$$dF/db = 2 \Sigma(-n_{U,i}) \cdot (n_{L,i} - a \cdot n_{Th,i} - b \cdot n_{U,i} - c \cdot n_{K,i}) = 0 \quad \text{(A.5b)}$$
$$dF/dc = 2 \Sigma(-n_{K,i}) \cdot (n_{L,i} - a \cdot n_{Th,i} - b \cdot n_{U,i} - c \cdot n_{K,i}) = 0 \quad \text{(A.5c)}$$

The equations can now be rewritten to:

$$a \cdot \Sigma n_{Th,i}^2 + b \cdot \Sigma n_{Th,i} \cdot n_{U,i} + c \cdot \Sigma n_{Th,i} \cdot n_{K,i} = \Sigma n_{L,i} \cdot n_{Th,i} \quad \text{(A.6a)}$$
$$a \cdot \Sigma n_{Th,i} \cdot n_{U,i} + b \cdot \Sigma n_{U,i}^2 + c \cdot \Sigma n_{U,i} \cdot n_{K,i} = \Sigma n_{L,i} \cdot n_{U,i} \quad \text{(A.6b)}$$
$$a \cdot \Sigma n_{Th,i} \cdot n_{K,i} + b \cdot \Sigma n_{U,i} \cdot n_{K,i} + c \cdot \Sigma n_{K,i}^2 = \Sigma n_{L,i} \cdot n_{K,i} \quad \text{(A.6c)}$$

The practical way of solving the equations by a computer program is to calculate a set of new parameters, namely:

$$\begin{array}{lll} TT = \Sigma n_{Th,i}^2 & UU = \Sigma n_{U,i}^2 & KK = \Sigma n_{K,i}^2 \\ TU = \Sigma n_{Th,i} \cdot n_{U,i} & TK = \Sigma n_{Th,i} \cdot n_{K,i} & UK = \Sigma n_{U,i} \cdot n_{K,i} \\ LT = \Sigma n_{L,i} \cdot n_{Th,i} & LU = \Sigma n_{L,i} \cdot n_{U,i} & LK = \Sigma n_{L,i} \cdot n_{K,i} \end{array} \quad \text{(A.7)}$$

Finally one may define a matrix **H** and the column vectors **v** and **w** by:

$$\mathbf{H} = \begin{matrix} TT & TU & TK \\ TU & UU & UK \\ TK & UK & KK \end{matrix} \qquad \mathbf{v} = \begin{matrix} a \\ b \\ c \end{matrix} \qquad \mathbf{w} = \begin{matrix} LT \\ LU \\ LK \end{matrix} \quad \text{(A.8)}$$

Now (A.6) can be written as:

$\mathbf{Hv} = \mathbf{w}$ or $\mathbf{v} = \mathbf{H}^{-1}\mathbf{w}$, from where a, b, and c can be determined.

Next consider Eq. (A.4) and perform similar calculations for minimising F. The equation is rewritten as:

$$F = O\tfrac{1}{2} \cdot (1 - a\,(n_{Th,i}/n_{L,i}) - b\,(n_{U,i}/n_{L,i}) - c\,(n_{K,i}/ n_{L,i}))^2 \quad \text{(A.9)}$$

$$dF/da = \Sigma(-n_{Th,i}/ n_{L,i}) \cdot (1 - a\,(n_{Th,i}/n_{L,i}) - b\,(n_{U,i}/n_{L,i}) - c\,(n_{K,i}/ n_{L,i})) = 0 \quad \text{(A.10a)}$$

$$dF/db = \Sigma(-n_{U,i}/ n_{L,i}) \cdot (1 - a\,(n_{Th,i}/n_{L,i}) - b\,(n_{U,i}/n_{L,i}) - c\,(n_{K,i}/ n_{L,i})) = 0 \quad \text{(A.10b)}$$

$$dF/dc = \Sigma(-n_{K,i}/ n_{L,i}) \cdot (1 - a\,(n_{Th,i}/n_{L,i}) - b\,(n_{U,i}/n_{L,i}) - c\,(n_{K,i}/ n_{L,i})) = 0 \quad \text{(A.10c)}$$

and neglecting the minus sign:

$$\Sigma[n_{Th,i}/ n_{L,i} – a\ (n_{Th,i}/n_{L,i})^2 \quad - b\ (n_{U,i}\, n_{Th,i}\ /n_{L,i}^2) - c\ (n_{K,i}\ n_{Th,i}/n_{L,i}^2)] = 0 \qquad \text{(A.11a)}$$

$$\Sigma[n_{U,i}/ n_{L,i} – a\ (n_{Th,i}\ n_{U,i}/n_{L,i}^2) - b\ (n_{U,i}/n_{L,i})^2 \quad - c\ (n_{K,i}\ n_{U,i}\ /n_{L,i}^2)] = 0 \qquad \text{(A.11b)}$$

$$\Sigma[n_{K,i}/ n_{L,i} – a\ (n_{Th,i}\ n_{K,i}/n_{L,i}^2) - b\ (n_{U,i}\ n_{K,i}/n_{L,i}^2) \quad - c\ (n_{K,i}/n_{L,i})^2)] \quad = 0 \qquad \text{(A.11c)}$$

or

$$a\ \Sigma(n_{Th,i}/n_{L,i})^2 \quad + b\ \Sigma(n_{U,i}\, n_{Th,i}\ /n_{L,i}^2) \ + c\ \Sigma(n_{K,i}\ n_{Th,i}/n_{L,i}^2) = \Sigma(n_{Th,i}/n_{L,i}) \qquad \text{(A.12a)}$$

$$a\ \Sigma(n_{Th,i}\ n_{U,i}/n_{L,i}^2) \ + b\ \Sigma(n_{U,i}/n_{L,i})^2 \quad + c\ \Sigma(n_{K,i}\ n_{U,i}\ /n_{L,i}^2) = \Sigma(n_{U,i}/n_{L,i}) \qquad \text{(A.12b)}$$

$$a\ \Sigma(n_{Th,i}\ n_{K,i}/n_{L,i}^2) \ + b\ \Sigma(n_{U,i}\ n_{K,i}/n_{L,i}^2) \ + c\ \Sigma(n_{K,i}/n_{L,i})^2 \quad = \Sigma(n_{K,i}/n_{L,i}) \qquad \text{(A.12c)}$$

Again we may define new parameters as:

$$\begin{array}{lll} TT = \Sigma(n_{Th,i}\ /n_{L,i})^2 & UU = \Sigma(n_{U,i}/n_{L,i})^2 & KK = \Sigma(n_{K,i}/n_{L,i})^2 \\ TU = \Sigma(n_{U,i}\, n_{Th,i}\ /n_{L,i}^2) & TK = \Sigma(n_{K,i}\ n_{Th,i}/n_{L,i}^2) & UK = \Sigma(n_{K,i}\ n_{U,i}\ /n_{L,i}^2) \quad \text{(A.13)} \\ LT = \Sigma_i(n_{Th,i}/ n_{L,i}) & LU = \Sigma(n_{U,i}/n_{L,i}) & LK = \Sigma(n_{K,i}/n_{L,i}) \end{array}$$

Now the equations (A.8) can be used for a determination of a, b, and c.

Finally consider a low energy window for which the a, b, and c values are well above 1.0. If for example both a, b and c are appr. 3 then Eq. (A.2) will be somewhat like:

$$F = \Sigma(\ n_{L,i} – an_{Th,i} - bn_{U,i} - cn_{K,i})^2/(n_{L,i} + 3^2 n_{Th,i} + 3^2 n_{U,i} + 3^2 n_{K,i}) \qquad \text{(A.14)}$$

or

$$F = \Sigma(\ n_{L,i} – an_{Th,i} - bn_{U,i} - cn_{K,i})^2/(n_{L,i} + 3 \cdot (3n_{Th,i} + 3n_{U,i} + 3n_{K,i}) \qquad \text{(A.15)}$$

and with $n_{L,i} = 3n_{Th,i} + 3n_{U,i} + 3n_{K,i}$ one gets:

$$F = \Sigma(\ n_{L,i} – an_{Th,i} - bn_{U,i} - cn_{K,i})^2/(n_{L,i} + 3 \cdot n_{L,i\ i}) \qquad \text{(A.16)}$$

or

$$F = 1/4 \cdot \Sigma(\ n_{L,i} – an_{Th,i} - bn_{U,i} - cn_{K,i})^2/n_{L,i} \qquad \text{(A.17)}$$

Minimising F from Eq. (A.16) will give the same a, b and c values as minimising F from Eq. (A.4). Therefore the calculations described by the equations (A.9) to (A.12) also apply here. The same will be the case if both a, b, and c are smaller than 1 – but of almost the same value.

In cases where a, b, and c do not have almost the same value this method will not generate the very best a, b, and c values. However, experiences have shown that even the preliminary values of a, b, and c based on Eq. (A.1) with the weight factor w = 1 can be used for detecting radiation anomalies.

Appendix B. Relations between new and old stripping factors.

The stripping of a low energy window as for example the ^{137}Cs window is based on an equation similar to Eq. (2) i.e.

$$r_L = s_L c_L + s_{Th} c_{Th}\, \iota + s_U c_U\, \kappa + s_K c_K\, ' \qquad \text{(B.1)}$$

The equations (1) (in the main part of this report) tell that the products $s_{Th}c_{Th}$, $s_U c_U$ and $s_K c_K$ can be replaced by linear combinations of r_{Th}, r_U, and r_K i.e. the background corrected window count rates for the windows for Th, U, and K. This can be described as a linear function f of the window count rates:

$$\begin{aligned} s_{Th}c_{Th} &= f_{Th}(r_{Th}, r_U, r_K, \zeta, \eta, \nu, a, b, g) \\ s_U c_U &= f_U(r_{Th}, r_U, r_K, \zeta, \eta, \nu, a, b, g) \\ s_K c_K &= f_K(r_{Th}, r_U, r_K, \zeta, \eta, \nu, a, b, g) \end{aligned} \qquad \text{(B.2)}$$

When (B.2) is introduced in (B.1) one gets[1]:

$$\begin{aligned} r_L = s_L c_L &+ \iota\ f_{Th}(r_{Th}, r_U, r_K, \zeta, \eta, \nu, a, b, g) + \kappa\ f_U(r_{Th}, r_U, r_K, \zeta, \eta, \nu, a, b, g) \\ &+ '\ f_K(r_{Th}, r_U, r_K, \zeta, \eta, \nu, a, b, g) \end{aligned} \qquad \text{(B.3)}$$

Then by sorting one gets Eq.(3) i.e.:

$$r_L = s_L c_L + a' r_{Th} + b' r_U + c r_K \qquad \text{(B.4)}$$

In Eq. (B.4) the symbols a' and b' are used in order to indicate that they are not the same as a and b of the equations (1). However, in the remaining part of this report the symbols a' and b' are replaced by a and b.

[1] The function $f_{Th}(r_{Th}, r_U, r_K, \zeta, \eta, \nu, a, b, g)$ for example is:
$s_{Th}c_{Th} = [(1 - \nu g)\, r_{Th} + (b\nu - a)\, r_U + (ag - b)\, r_K] / (1 + ag\eta + b\zeta\nu - \eta b - \zeta a - \nu g)$

Appendix C. Reasons for oddly stripping factors.

The following discussion is included in order to give an understanding of the reasons for sometimes getting sets of a, b, and c values that look oddly. For low energy windows close to each other the a, b, and c values may differ in a way that is at first not easily understood.

Consider a hypothetical area. Half of the area only includes Th in the ground and the other half only includes K. Within each half area the level of Th or K may vary. In this case theory says that only two stripping factors are needed - a and c. The calculations generate a common set of stripping factors that fits for both areas.

Within the K half area the stripping coefficient "a" does not matter, because there is not recorded any counts in the Th window. But the c value is fixed by the K half area data. Within the Th area there is registered counts in both the Th window and in the K window. The counts in the K window causes a stripping based on the stripping factor c determined from the K half area. Then the stripping factor a must ensure that the remaining counts in the low energy window are stripped away based on the Th window counts. In theory the stripping factor "a" may be negative namely if too many counts are stripped by "c" and the K window counts. In the real world this could not be the case; but assume for example that the K spectrum included a strong gamma line at 400 keV (or any other low gamma energy). Then the value of "c" would be high for a window around the 400 keV peak. If the Th spectrum does not have a gamma-line at 400 keV but a gamma-line within the K window then one would obtain a too strong stripping of the 400 keV window from the K-window - and the Th window counts should cause a negative stripping.

For a similar combination of Th and U the situation would be the same. However, uranium generates a low count rate in the Th window. In theory the stripping factor "b" could be negative if there was a strong stripping of a low energy window from the Th window. This would be the case if the Th included a strong gamma line in a low energy window - whereas U did not. Thus when U generates counts in the Th window a strong stripping of the low energy window is performed (due to a high stripping factor "a") although U does not cause high count rates here. Therefore, in order to compensate for the too strong stripping a negative stripping factor "b" must ensure that the total stripping of the low energy window causes zero counts here.

Similar considerations could be set up for stripping based on three windows - Th, U and K.

It should be stressed that in general one will not experience negative stripping factors due to the reasons discussed here. But the examples may explain (part of the reason) for sometimes getting a combination of a, b and c values that looks oddly.

Appendix D. The (missing) importance of using weight factors.

It is mentioned elsewhere in this report that the preliminary stripping factors a, b, and c determined without using a weight factor for each measurement have been used with success for “source search”. In order to test if some benefit – e.g. an increased sensitivity – could be obtained by using weight factors in the calculations an AGS file (7580.spc 75-80 m from 622b) from Bornholm was examined both with and without introducing the weight factor as described in the equations (A.9) to (A.16).

The calculated stripping factors differed a little for the two types of calculations. (See Table D1 below.) However, when the stripping factors were used for stripping away the influence from Th, U, and K the results were very similar. When plotted, as a function of the spectrum number one cannot visually discern between the two curves. Until now only one AGS file has been checked. The situation may be different for other files - but hardly much.

It was expected that the use of the weight factors would cause the average $\div n_L$ value to be closer to zero. This was not the case. The stripping factors based on a weighted calculation gave a slightly larger (positive) deviation. The reason for getting positive average $\div n_L$ values has therefore not been identified yet.

Table D1. Stripping factors with and without including a weight factor in the calculations. The stripping factors calculated with weighting are shown in parentheses. Numbers are based on 75-80 m altitude (file 7580.spc).

Window Ch. Nos.	a	b	c
60-72	0.9987734 (1.104880)	1.010971 (1.045317)	1.194222 (1.14619)
80-100	0.9701044 (1.106836)	1.076310 (1.175545)	1.169706 (1.095499)
110-130	0.6926388 (0.734838)	0.564408 (0.570642)	0.733160 (0.6969983)

For reasons that are not understood the stripping factors a and b go up somewhat when weighted calculations are carries out whereas the stripping factor c goes somewhat down.

Appendix E. Different factors influencing the values of a, b and c.

The Area Specific Stripping method has - when applied for Bornholm and Boden data - resulted in a height dependence of the stripping factors a and b (related to Th and U respectively) that was not expected. Then stripping factor c related to the K-window, however, had a height dependence similar to the expected namely a "slow" increase with the height.

Potassium deviates from Th and U in two significant ways.^{40}K emits only photons of one energy namely 1461 keV. Thorium and uranium emit - besides the characteristic energies 2615 keV (^{208}Tl) and 1765 (^{214}Bi) - also photons of a lot of other energies. Therefore the stripping factors a and b have to take into account not only down scattered photons (from 2615 keV and 1765 keV) but also primary photon of lower energies as well as down scattered photons from primary medium level energies.

In addition the concentration of K in nature varies less that the concentrations of Th and U. For the Bornholm measurements the concentration of Th and U varies a factor 3 whereas the concentration of K varies less that a factor 2 (except for the open quarries). Finally one has to consider that the measurable gamma photons of the uranium decay chain (due to ^{214}Pb and ^{214}Bi) all follow after the ^{222}Rn decay. Due to leakage of radon from the ground into the air one may observe an uranium "background signal" that varies with the altitude.

It should also be noticed that the "uranium spectrum" caused by radon daughters in the ground and measured in the air may differ from the "uranium spectrum" generated by radon daughters in the air.

The calculated values for the stripping factor c "behave" as they should i.e. they grow a little with the altitude. The model, the algorithms and the program - that process a, b, and c in the same way - and therefore seemingly are correct. The “low energy” gamma lines of the U and Th decay chains therefore may cause the “oddly” stripping factors and should be examined.

Table E1. Examined energy windows

Channels	Energy (keV)
24-28	128 - 156
46-62	251 - 347
60-72	330 - 403
78-88	431 - 493
80-100	443 - 562

Channels	Energy (keV)
110-130	613 - 732
130-154	732 - 870
174-198	985 - 1123
193-243	1089 - 1385
97 -116	544 - 652

The energy vs. channel number (k) formula is:

$$E(keV) = 0.00058*k*k + 5.5595*k - 3.1578$$

The energy refers to the centre of the channel. Each channel typically has a width of 5.8 keV.

Th and U gamma lines that may influence the window count rates are:

239 keV	^{212}Pb at channel 43
352 keV	^{214}Pb at channel 63
511 keV	annihilation - weak signal at channel 92 in addition a low level signal from ^{208}Tl at 510.8 keV
583 keV	^{208}Tl at channel 104. Overlap with ^{214}Bi at 609 keV
609 keV	^{214}Bi at channel 109. Overlap with ^{208}Tl at 583 keV
911 keV	^{228}Ac at channel 162
969 keV	^{228}Ac at channel 172
1120 keV	^{214}Bi at channel 198

In addition the primary gamma lines:

1461 keV	^{40}K at channel 256
1765 keV	^{214}Bi at channel 308
2615 keV	^{208}Tl at channel 450 (basis for the energy calibration)

In the natural gamma spectra the following "significant" gamma lines also are included - but they cannot in general be detected in the spectra:

295 keV	^{214}Pb at channel 53. Sometimes a trace signal is observed.
338 keV	^{228}Ac at channel 61. Cannot be observed due to the 352 keV peak from ^{214}Pb at channel 63
860 keV	Tl-208 at channel 153. Is "hidden" behind the 911 keV peak from ^{228}Ac at channel 162.
1238 keV	^{214}Bi at channel 218. Too weak signal.

The following windows may detect signals from the above-mentioned gamma lines.

24-28	128 - 156 keV. No full energy gamma line is in this window. It only detects scattered radiation from the radioactivity in/on the ground plus possibly signals from radon daughters in the air.
46-62	251 - 347 keV. Detects 295 keV photons from ^{214}Pb in channel 53
60-72	330 - 403 keV. Detects in channel No. 63 the 352 keV from **^{214}Pb** (strong line) together with the weaker 338 keV line from ^{228}Ac in channel No. 61.
78-88	431 - 493 keV. No significant lines in this window.
80-100	443 - 562 keV. Low level annihilation line and a weak ^{208}Tl line at 511 keV. The most powerful ^{228}Ac line (583 keV at channel 104) is placed a few channels outside this window.

110-130	613 - 732 keV. The powerful 609 keV line from **Bi-214** is placed just below the window limit. Spectrum drift may cause that a varying part of the corresponding full energy peak enters this window.
130-154	732 - 870 keV. The 860 keV line from ^{208}Tl (channel 153) is placed just inside the upper window limit, and the strong 911 keV line from ^{228}Ac (channel 162) is placed well above the upper window limit – but may generate some counts in the window.
174-198	985 - 1123 keV. The 969 keV line from ^{228}Ac (channel 172) is placed somewhat below the lower window limit. The line may give some counts in the window.
193-243	1089 - 1385 keV. The lines 1120 keV (channel 198) and 1238 keV (channel 218) from **^{214}Bi** are placed in the window.
97 -116	544 - 652 keV. Additional window. It includes the powerful 583 keV line from ^{208}Tl (at channel 104) and the powerful 609 keV line from **^{214}Bi** (at channel 109).

Influence from spectrum drift. (Estimates)
Some windows will have changed count rates if the energy calibration is changed due to spectrum drift. In the following is examined what will happen if spectrum drift causes the spectrum to move downwards relative to the window limits.
A significant drift of 1% is assumed.

The Th window count rate will go down 1-2% in case of a 1% drift corresponding to 4.5 channels at the Th peak.
The U window count rate will decrease about 1%.
The K window count rate probably will decrease 2%.

The count rate of the window at the channels 110-130 will be reduced 2-4% because the 609 keV line for ^{214}Bi will move out of the window.

For the window at the channels 80-100 the decrease will be only about ½%.
The count rate of all other windows typically will go down 1%.

The stripping factors therefore only will change a little – probably less than 1% for a spectrum drift of 1%, which is a very significant spectrum drift. Spectrum drift, therefore, cannot cause the observed variations that may exceed 20%.

For an “upward” spectrum drift the same is the case. It cannot explain the observed variations of the stripping factors.

Influence from RD (radon-daughters) in the air.
Assume that during a 1-2 hours survey there is a decrease in the amount of radon daughters (RD) in the air. The concentration may go down with 30% compared to the level at the beginning of the measurements.

The uranium signal to the uranium window count rate may go down 5%. (Normally the RD in then air only contributes a fraction of the counts in the uranium window.)

The thorium window may lose ½% of its count rate due to the reduction of the 2448 keV line from ^{214}Bi that is included in the Th-window.

The U-window typically will lose some 3% of its total count rate. (Th contributes also to the U-window count rate.)

The K-window count rate will go down ½-1%.

The window at the channels 60-72 may lose 3-6% of its count rate. This window counts the full energy events for the 352 keV line from ^{214}Pb.The count rate depends significantly on the amount of ^{214}Pb in the air, because 352 keV photons from the ground are strongly attenuated in the air at 70-100 m surveying height.

The same is the case for the windows at the channels 97-116 because of the reduction of the fluence rate of 609 keV photons from ^{214}Bi. Due to the slightly higher energy those photons are attenuated less in the air. So a 3-5% reduction in the window count rate may be expected.

The window covering the channels 110-130 will also experience a decrease in count rate. The 609 keV line is situated just outside the window limit. A decrease of 2-4% may be expected.

Besides that the windows 174-198 and 193-243 will lose some counts due to the 1120 keV line from Bi-214. This line is placed at the window limits and its energy is relatively high (= less attenuation in air). Therefore a count rate reduction of 1-3% could be expected.

Other low energy windows detecting Compton scattered photons will have a 1-1.5% reduction of their count rates. This concerns all low energy windows including those mentioned above that therefore will experience this additional count rate reduction. Windows without full energy events for ^{214}Bi and ^{214}Pb will only have a 1-1.5% count rate reduction.

The conclusion therefore is that for a "typical radon situation" a 30% reduction of the RD concentration in the air will have only a minor influence on the window count rates except for those windows that detect the strong 352 keV and 609 keV line from RD. For those windows the stripping ratio b will change in "parallel" with the changing RD concentration in air. The same will be the case if the RD concentration varies with then altitude. But this cannot explain the observed variations of both a and b with the height.

On some occasions one may experience higher RD concentrations in the air. This is the case in Denmark when a not too strong wind from Central or Eastern Europe transports radon from the continent to Denmark. It may also be the case if a strong and long lasting inversion is experienced. At the beginning and at the end of such a period one may see strong variations in RD concentration in the air. However, in both cases one would not expect variations with the height - except in case of an inversion layer at a very low height. But this was not the case during the surveying of Bornholm or Boden.

The overall conclusion therefore is that varying RD daughter concentration in the air can only "explain" a minor part of the variations of the stripping ratios a and b.

Other factors that may influence the stripping ratios a, b, and c.

Flying above a forest

When flying above a tall, dense forest one may observe that the radar altimeter indicates a height that is smaller than the actual height. (This probably was the case during the mapping of Bornholm.) The upper parts of the trees may reflect the radar pulse and, therefore a too low height is measured. (It is possible to adjust a discriminator level of the radar electronics and hereby better be able to measure the height above the hard ground.)

Assuming for a moment that the radar altimeter measures the correct altitude above the hard ground. The gamma photons from radioactivity in the ground in this case have to pass through forest floor, trunks, branches and leaves that interacts with the gamma photons as if an additional layer of air has been placed between sources and detector i.e. as if the altitude is higher than it actually is. This "additional height" may be 10 to 40 m!

Next assume that the radar altimeter measures the distance to the top of the trees. Hereby the recorded altitude may be about 10 m too low. In addition the same phenomenon as described above will come up here. Thus the recorded altitude may be 20 to 50 m lower than corresponding to total mass thickness of the absorber (and scatterer) between the detector and the sources in the ground. This means less primary radiation to the detector and relatively more scattered radiation are detected. The result is that one will calculate too large a, b, and c values when a large part of the surveyed area is covered with a dense forest.

When sorting the measured spectra into groups with different altitudes one may inadvertently also perform a sorting with respect to forest and open area. Consider a helicopter flying at 80 m altitude in an open area. When the helicopter crosses the border between the open area and a forest it will - at least for a while - continue at 80 m above the ground; but the altimeter now may measure 70 m altitude. Hereby the 70 m measurement becomes "forest measurements" whereas 80 m measurements means "open area measurements".

There is, however, a problem for this explanation. The potassium stripping factor "c" has an altitude dependency that fits the simple theory i.e. the c value in general increases slowly with increasing altitude. The "forest problem" therefore only may explain a minor part of the observed peculiar variation of the stripping factors a and b with the altitude.

Trees contain a tiny amount of potassium, but the concentration is much lower than the typical concentration of potassium (1% to 2% K) found in the ground.

Another (minor) "forest + radon problem" may exist. Dry deposition of radioactive fall-out generates higher contamination levels (Bq/m^2 ground area) in a forest than in an open area. In a similar way one may assume that dry deposition of radon daughters also generates higher RD levels in a forest than in an open area. This "contamination" of a forest with RD will - due to the limited live time of RD - depend both on the concentration of RD in the air and on the wind speed and mixing of the air near the ground. Some crops will also collect more RD than other types of crop.

In theory the accumulation of RD in a forest will generate an "uranium signal" that differ a little from the uranium signal for radioactivity in the ground. Especially one may detect more low energy full energy events from RD above the ground - similar to case for RD in the air around the aircraft.

Flying in a hilly terrain

When flying in a hilly terrain one will record altitudes that may not be the correct average altitudes for the area seen by the detector. When flying above a hill the "average height" above the radioactivity in the ground will be larger than the recorded altitude. When flying in a valley one similarly will record a too large altitude. For a set of data recorded in a hilly terrain one will during sorting get the low altitudes in a group that also contains the measurements above the hills whereas the measurements in valleys will be found in the high altitude groups.

One also should consider the geometry for photons to move from source to detector. When flying above a hill (elevated terrain) the photons originating from radioactivity in the slopes of the hill - and having a direction towards the detector - will have to pass through a larger mass thickness than if they had to pass a horizontal surface. For flying in a valley the opposite is the case. This also means that when flying above a hill one will get a higher scattered to primary photons ratio than when flying in a valley.

Miscellaneous

It is assumed that stripping factors calculated from measurements where old fallout is found in the ground would give higher stripping factors a, b, and c for the low energy windows

In a few cases it has been observed that the stripped count rate (Eq. 5) is positive for some low energetic windows for spectra recorded when flying above forests. The forest areas are only a small fraction of the area surveyed in all and, therefore, the stripping parameters a, b, and c have been fitted mostly to the non-forest areas. In this way the stripping factor values become (a little) too small for the forest areas. This demonstrates the "forest effect" described above i.e. the attenuation and scattering of photons in trees and forest floor generates spectra with a relatively large fraction of low energy photons.

Anti phase for a and b

It has sometimes been observed that the variation of the stripping factor a has varied with the height in "anti phase" with the stripping factor b. Seemingly uranium has at some altitudes taken over a larger fraction of the stripping compared to thorium and vice verse. The total stripping of the low energy windows has, however, been correct. The reason(s) for this "shared stripping" is not understood.

A mystery with minor importance

It was expected that the calculations (Eqs. A.1 to A.13) would generate stripping factors (a, b, and c) that when used with the measured data would generate stripped low energy window count rates that in average were zero. This is not the case. Both for the weighted calculations and for the non-weighted calculations the average stripped count rate is positive. The average corresponds to ½% to 3% of the window count rate itself - in most cases about 1%.

A 99% correct stripping is sufficient for the task. The zero level for the stripped count rate just is shifted a little; and the stripped count rate fluctuates around this shifted zero line due to counting statistics and due to varying measuring geometry. A radiation anomaly generating a significant amount of low energy radiation is detected also with a shifted zero level.

Seemingly the only problem may come up when stripping factors calculated for one area should be used for automatic "on line checking" of spectra during a survey of another area. One may have to use an alarm trigger level somewhat higher than otherwise needed. By not knowing on beforehand whether the new area has the same "stripping characteristics" as the area that formed the basis for the stripping factor determinations one has anyhow to use a raised trigger level in order to avoid too many false alarms.

ASS method compared to the "old" method.

When the ASS method is compared with the standard stripping method one should notice the following:

The standard stripping factors ι, κ, and ′ for stripping the ^{137}Cs window - or any other low energy window - are determined from measurements on calibration pads or other calibration set-ups. The geometry and the sources here are assumed to be known with good accuracy. One also may assume a homogeneous source distribution. The problem is that due to the limited (physical) size of the sources one will miss a fraction of the Compton scattered radiation; and the lower the energy is the larger a fraction of the scattered radiation is missing.

If one wants to generate similar ASS parameters from calibration measurements one has to have available large areas (200-500 m diameter) with plane, horizontal surfaces – all with a homogeneous distribution of Th, U, and K – and at least three (linearly) different mixtures of Th, U, and K should be available. In this case it is a simple matter to convert the stripping factors a, b, and c to ι, κ, and ′ if one prefers that. Those values of ι, κ, and ′ will include the correct amount of Compton scattered radiation.

Areas as those described above are not common in nature. Therefore one has to accept stripping factors a, b, and c based on measurements performed when flying above non-horizontal, non-plane area with an inhomogeneous distribution of natural radioactivity. However, when using the stripping factors a, b and c for processing data from a similar area the correct average stripping anyhow is performed.

During a survey the detector may be tilted somewhat compared to a horizontal level. The attitude of the helicopter body will depend on speed, wind direction and intensity.) This means that the detection efficiency and its energy dependency may change a little. This is automatically taken into account by the ASS method. At measurements with/at calibration set-ups the detector in general is placed with its large cross section area in a horizontal position. This will - even if everything else could be similar to the field conditions - cause slightly different spectra and stripping factors.

Statistical scatter

Typically the values of a, b, and c are in the order of 1 or somewhat larger. From Eq. (5) one therefore notices that the statistical scatter of r_{Th}, r_U, and r_K has a significant influence on the uncertainty of ÷r_L for the low energy window. Therefore a reduction of the statistical scatter of r_{Th}, r_U, and r_K would improve the results. For an area without extreme variations in the concentrations of Th, U and K one may for the count rates r_{Th}, r_U, and r_K use a moving average over 3 or 5 measurements. Hereby the scatter for the count rates is reduced a factor · 3 or · 5.

An even better reduction of the statistical noise could be obtained by using NASVD reconstructed spectra for calculating r_{Th}, r_U, and r_K. However, in order to avoid the influence from the low energy gamma emitter searched for the NASVD processing should only include the channels above the channels influenced by the low energy emitter.

Appendix F
File formats for Danish AGS and CGS systems

AGS binary data layout used by DEMA/DTU (Ref. KB).

typedef	unsigned char	byte;
typedef struct	{	
	float	Time
	float	X
	float	Y
	float	Z
	byte	Error
	byte	Down
	byte	Up
	unsigned int	RTC
	unsigned int	LTC
	unsigned int	COC
	unsigned int	FWHM
	unsigned int	SPC[512]
	}	
	DataLayout	

Old CGS binary data layout used by DEMA/DTU (Ref. KB).

380	Size of header	
1120	Struct size	
typedef struct	{	
	unsigned long 4	record_number
	unsigned long 4	line_number
	float 4	UTC_time
	double 8	X
	double 8	Y
	double 8	Z
	short int 2	DPGS
	short int 2	PDOP_error
	float 4	PDOP
	float 4	live_time
	float 4	ralt
	float 4	balt
	float 4	roi[10]
	unsigned int 2	spec[512]
	}GR660_data	

New CGS binary data layout used by DEMA/DTU (Ref. KB).

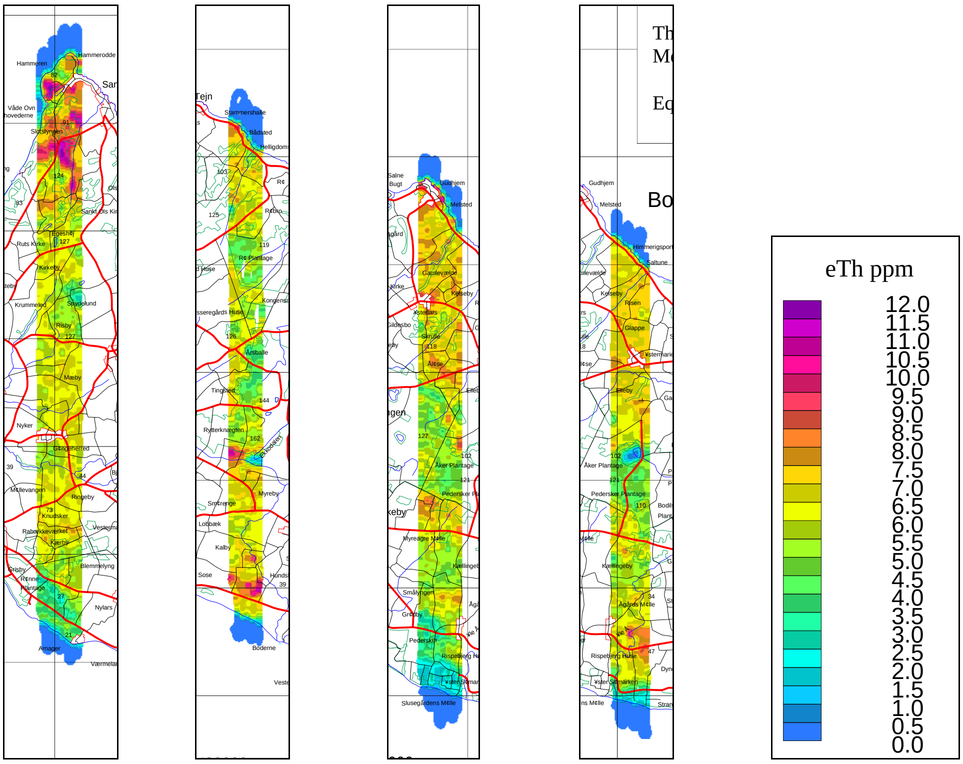
487	Size of header	
1152	Struct size	
typedef struct	{	
	unsigned long	record_number
	unsigned long	line_number
	double	UTC_time
	double	X
	double	Y
	double	Z
	double	Northing
	double	Easting
	float	PDOP
	long	DGPS
	float	ralt
	float	live_time
	float	roi[10]
	char	spare[10]
	}GR660_header	
typedef struct	{	
	GR660_header	H
	unsigned short int	spec[512]
	}GR660_data	

Appendix G
Window backgrounds for Bornholm AGS survey 1999

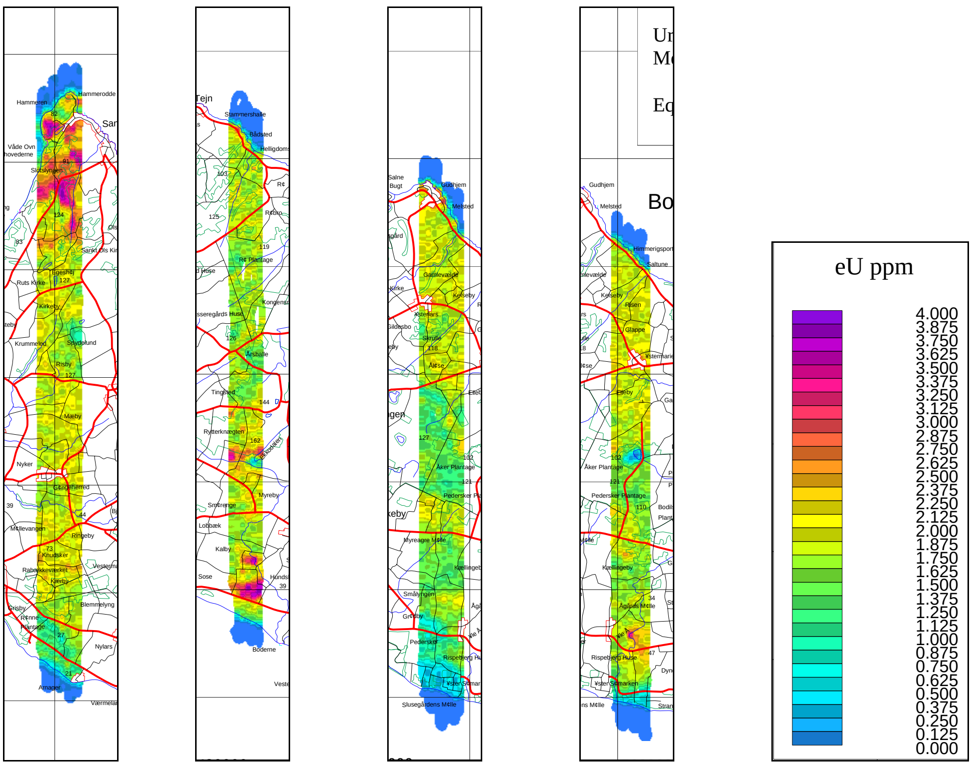
LL	UL		**621a**	**622b (622a)**	**623b**	**624a**	**Ar. Mean**
24	28	Tc-99m	47.805	50.716	46.172	50.669	49.768
46	62	Ir-192	75.529	79.364	71.141	79.554	77.120
60	72	I-131	41.861	45.123	40.064	44.563	43.414
78	88	Ir-192	20.294	20.392	18.527	19.087	19.717
80	100	Annihil.	36.639	37.055	34.256	36.101	36.213
97	116	Cs-134	35.903	38.439	34.161	38.651	37.349
110	130	Cs-137	21.115	25.240	21.886	24.513	23.702
130	154	Cs-134	19.643	19.234	17.325	19.299	19.103
174	198	Cs-136	13.685	13.754	12.528	13.737	13.603
193	243	Co-60 (2)	22.785	23.131	20.658	23.597	22.832
238	271	**K**	**17.180**	**18.085**	**16.105**	**17.651**	17.280
290	323	**U**	**9.623**	**9.593**	**8.039**	**9.822**	9.269
416	483	**Th**	**4.981**	**5.206**	**5.074**	**5.166**	5.185

Appendix H
Natural radionuclides

Natural radionuclides on the Danish island Bornholm (1999).

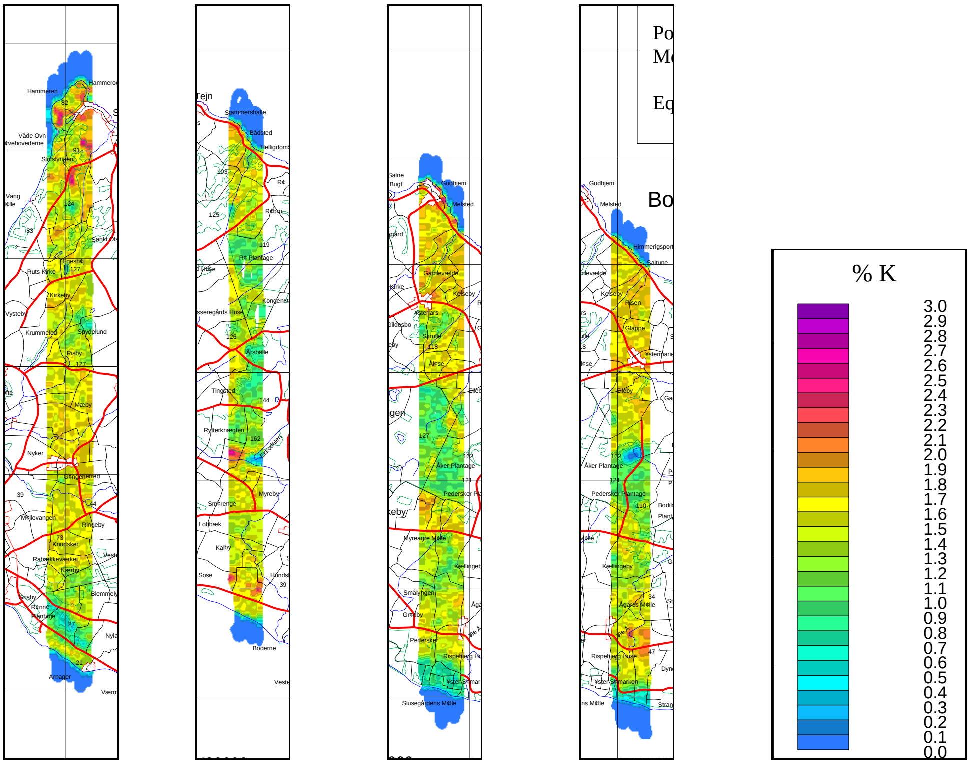


623b 621a 622a 622b Range



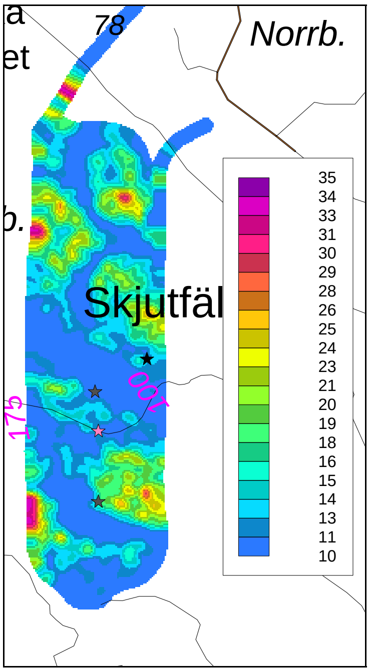
623b 621a 622a 622b Range

Natural radionuclides on the Danish island Bornholm (1999)

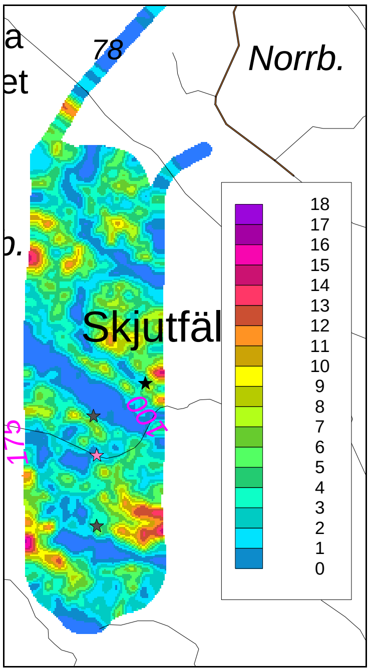


623b 621a 622a 622b Range

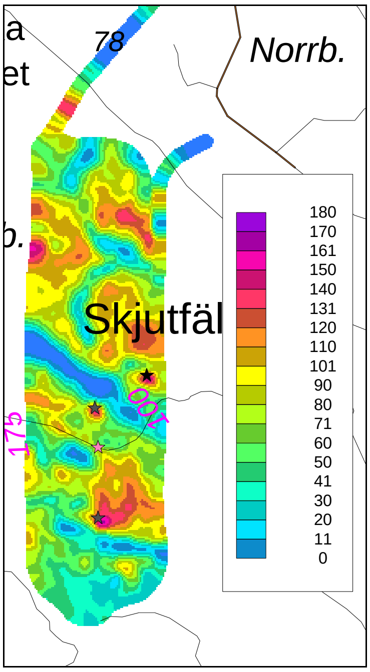
Natural radionuclides, Barents Rescue Area A1 (2001)



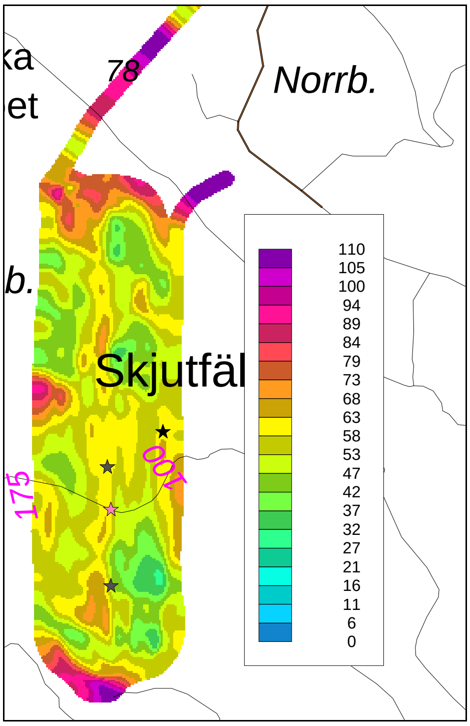
Th, stripped count rates.



U, stripped count rates.



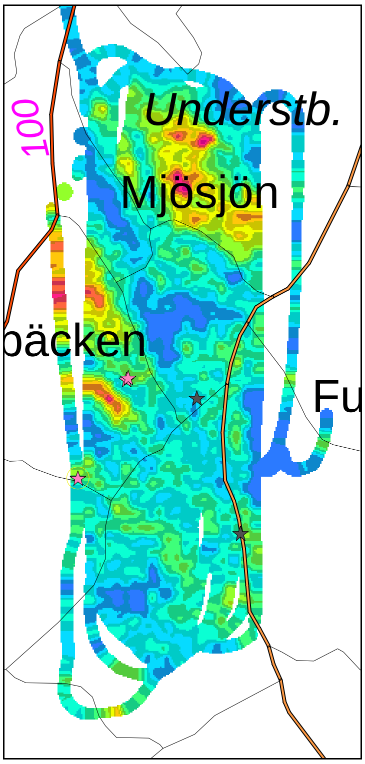
K, stripped count rates.



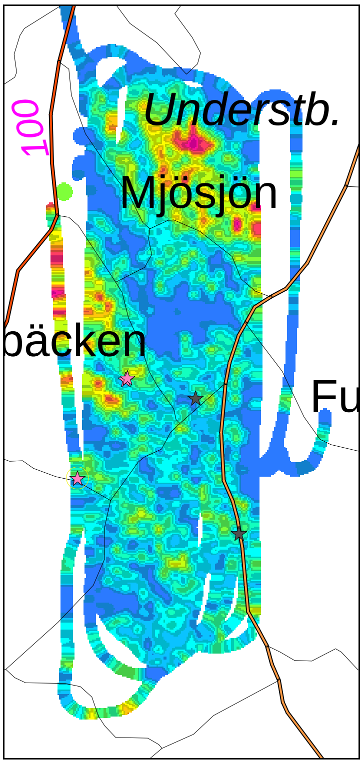
Survey heights, (m).

No attenuation from helicopter or equipment taken into account.
Stripped count rates are stripped at the actual survey height (not equivalent survey height).

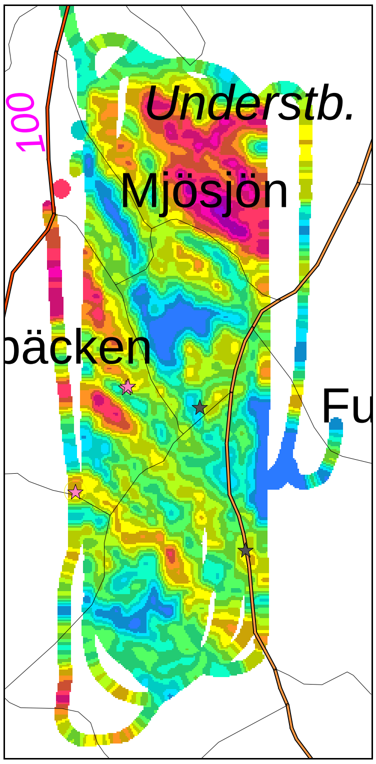
Natural radionuclides, Barents Rescue Area A2 (2001)



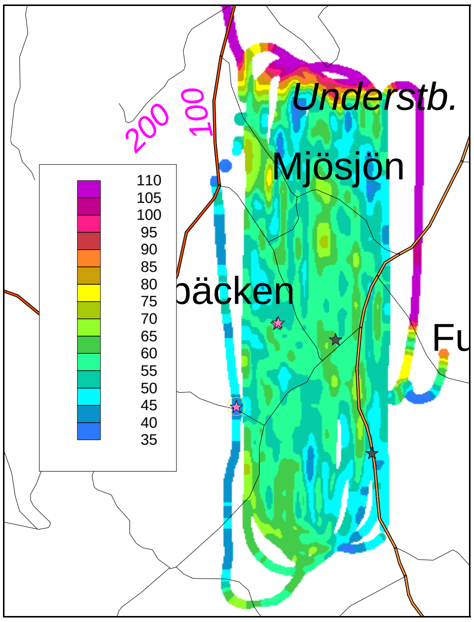
Th, stripped count rates.



U, stripped count rates.



K, stripped count rates.



Survey heights, (m)

No attenuation from helicopter or equipment taken into account.
Stripped count rates are stripped at the actual survey height (not equivalent survey height).

Bornholm	File 621a									
Interval	Nos. Spectra	LL-UL	24-28	46-62	60-72	78-88	80-100	110-130	130-154	174-198
		a	2.823	3.122	1.590	0.805	1.546	1.038	0.718	0.461
70-75	323	b	2.087	2.150	1.238	0.782	1.202	0.937	0.432	0.437
		c	1.798	1.993	1.076	0.611	1.040	0.663	0.621	0.380
		a	1.925	2.199	1.170	0.750	1.272	0.993	0.647	0.385
75-80	795	b	2.577	3.273	1.752	0.837	1.438	0.910	0.834	0.567
		c	1.950	2.056	1.104	0.625	1.094	0.673	0.595	0.392
		a	1.868	1.892	0.769	0.561	1.027	0.684	0.641	0.318
80-85	888	b	2.616	2.814	1.693	0.836	1.462	0.893	0.705	0.460
		c	1.967	2.187	1.183	0.650	1.127	0.739	0.617	0.423
		a	1.915	1.953	0.970	0.620	1.087	0.748	0.507	0.400
85-90	750	b	2.543	3.102	1.638	0.873	1.568	0.798	0.647	0.498
		c	1.985	2.142	1.155	0.643	1.109	0.753	0.657	0.402
		a	2.250	2.217	1.268	0.858	1.358	0.781	0.569	0.432
90-95	477	b	1.855	1.681	1.041	0.725	1.187	0.641	0.584	0.403
		c	2.010	2.319	1.180	0.607	1.101	0.781	0.648	0.400
		a	1.478	2.882	1.528	0.482	0.915	0.608	0.899	0.579
95-100	89	b	1.323	1.185	0.725	0.100	-0.072	0.148	0.421	-0.231
		c	2.341	2.373	1.244	0.802	1.422	0.911	0.652	0.492
		a	2.021	2.152	1.064	0.678	1.186	0.826	0.614	0.385
70-100	3322	b	2.441	2.794	1.561	0.817	1.408	0.835	0.680	0.478
		c	1.959	2.141	1.147	0.636	1.107	0.725	0.625	0.405
Back-	(cps)		47.805	75.529	41.861	20.294	36.639	21.115	19.643	13.685

ground
Bornholm File 622a

Interval	Nos. Spectra	LL-UL	24-28	46-62	60-72	78-88	80-100	110-130	130-154	174-198
		a	3.372	3.445	1.719	0.950	1.672	0.951	1.066	0.603
70-75	307	b	1.841	1.896	1.000	0.429	0.943	0.657	0.409	0.231
		c	1.760	1.981	1.060	0.625	1.049	0.689	0.594	0.403
		a	2.787	2.705	1.439	0.937	1.498	0.933	0.874	0.408
75-80	1003	b	1.912	2.095	0.925	0.646	1.043	0.578	0.494	0.283
		c	1.802	2.036	1.096	0.592	1.064	0.672	0.593	0.419
		a	2.377	2.509	1.346	0.695	1.321	0.778	0.723	0.370
80-85	1482	b	2.137	1.922	1.030	0.667	1.015	0.678	0.510	0.360
		c	1.808	2.099	1.102	0.643	1.108	0.688	0.623	0.423
		a	1.912	2.098	1.191	0.661	1.190	0.790	0.544	0.384
85-90	1207	b	1.911	2.141	0.975	0.601	1.048	0.721	0.620	0.422
		c	1.969	2.169	1.150	0.658	1.136	0.682	0.647	0.410
		a	2.650	2.144	1.185	0.786	1.378	0.765	0.647	0.396
90-95	519	b	1.380	1.337	1.017	0.494	1.006	0.690	0.613	0.309
		c	1.967	2.318	1.152	0.660	1.119	0.692	0.643	0.430
		a	2.182	3.384	2.017	0.567	0.676	0.724	0.279	0.467
95-100	26	b	0.607	1.268	0.517	0.438	1.102	0.446	0.576	0.658
		c	2.358	2.190	1.086	0.710	1.227	0.819	0.766	0.407
		a	2.524	2.489	1.338	0.775	1.362	0.823	0.724	0.403
70-100	4544	b	1.835	1.983	1.000	0.617	1.034	0.673	0.552	0.350
		c	1.890	2.109	1.113	0.633	1.099	0.683	0.621	0.417
Back-ground	(cps)		50.716	79.364	45.123	20.392	37.055	25.240	19.234	13.754

Bornholm File 622b

Interval	Nos. Spectra	LL-UL	24-28	46-62	60-72	78-88	80-100	110-130	130-154	174-198
		a	2.111	2.437	1.159	0.728	1.260	0.791	0.622	0.450
70-75	345	b	2.382	2.962	1.570	0.780	1.238	0.977	0.634	0.541
		c	1.922	2.018	1.087	0.621	1.104	0.663	0.625	0.386
		a	1.917	1.786	0.999	0.589	0.970	0.693	0.514	0.330
75-80	889	b	1.871	1.959	1.011	0.689	1.076	0.564	0.486	0.370
		c	2.024	2.273	1.194	0.661	1.170	0.733	0.672	0.424
		a	1.899	2.071	0.974	0.534	1.024	0.687	0.552	0.433
80-85	1300	b	1.857	2.157	1.153	0.579	1.072	0.742	0.627	0.329
		c	2.016	2.155	1.147	0.678	1.149	0.691	0.639	0.409
		a	2.034	2.096	1.123	0.658	1.143	0.780	0.637	0.491
85-90	843	b	1.729	1.573	0.865	0.247	0.963	0.636	0.485	0.274
		c	2.015	2.257	1.183	0.669	1.160	0.698	0.652	0.410
		a	2.375	1.921	1.411	1.029	1.724	0.920	0.616	0.538
90-95	236	b	1.806	2.140	0.700	0.371	0.903	0.657	0.494	0.372
		c	1.962	2.247	1.163	0.632	1.062	0.692	0.675	0.395
		a	3.256	2.626	1.489	1.103	1.118	1.131	0.710	0.095
95-100	28	b	0.464	1.813	0.914	0.366	1.094	0.141	0.547	-0.207
		c	2.195	2.306	1.206	0.706	1.274	0.782	0.649	0.606
		a	1.996	2.045	1.068	0.629	1.107	0.742	0.578	0.427
70-100	3641	b	1.871	2.036	1.052	0.599	1.051	0.683	0.550	0.345
		c	2.005	2.201	1.163	0.663	1.147	0.700	0.650	0.411
Back-ground	(cps)		50.716	79.364	45.123	20.392	37.055	25.240	19.234	13.754

Bornholm File 623b

Interval	Nos. Spectra	LL-UL	24-28	46-62	60-72	78-88	80-100	110-130	130-154	174-198
		a	2.359	2.337	1.384	0.631	1.107	0.728	0.606	0.413
70-75	529	b	2.304	2.713	1.411	0.829	1.369	0.873	0.686	0.232
		c	1.836	2.028	1.037	0.613	1.071	0.667	0.611	0.425
		a	2.552	2.740	1.474	0.858	1.466	0.932	0.809	0.439
75-80	1070	b	1.977	2.295	1.068	0.662	1.178	0.624	0.571	0.446
		c	1.876	2.011	1.088	0.599	1.032	0.676	0.590	0.393
		a	2.289	2.367	1.244	0.766	1.348	0.659	0.687	0.387
80-85	1555	b	2.020	2.024	1.117	0.572	1.042	0.615	0.607	0.277
		c	1.913	2.133	1.119	0.637	1.094	0.729	0.612	0.427
		a	2.580	2.551	1.290	0.775	1.345	0.857	0.771	0.414
85-90	1234	b	2.057	2.306	1.298	0.672	1.132	0.654	0.591	0.314
		c	1.900	2.092	1.106	0.632	1.101	0.705	0.623	0.425
		a	2.650	3.109	1.382	0.658	1.282	0.916	0.782	0.465
90-95	653	b	1.739	1.917	1.161	0.618	0.913	0.732	0.488	0.328
		c	1.932	2.034	1.099	0.668	1.147	0.677	0.641	0.420
		a	2.972	2.878	1.174	0.942	1.523	0.915	0.529	0.358
95-100	122	b	2.107	2.568	1.327	0.513	0.723	0.680	0.742	0.446
		c	1.859	1.997	1.133	0.644	1.169	0.695	0.636	0.418
		a	2.492	2.604	1.339	0.767	1.346	0.814	0.739	0.420
70-100	5163	b	2.031	2.236	1.198	0.653	1.114	0.677	0.598	0.329
		c	1.889	2.065	1.096	0.627	1.085	0.696	0.611	0.416
Back-ground	(cps)		46.172	71.141	40.064	18.527	34.256	21.886	17.325	12.528

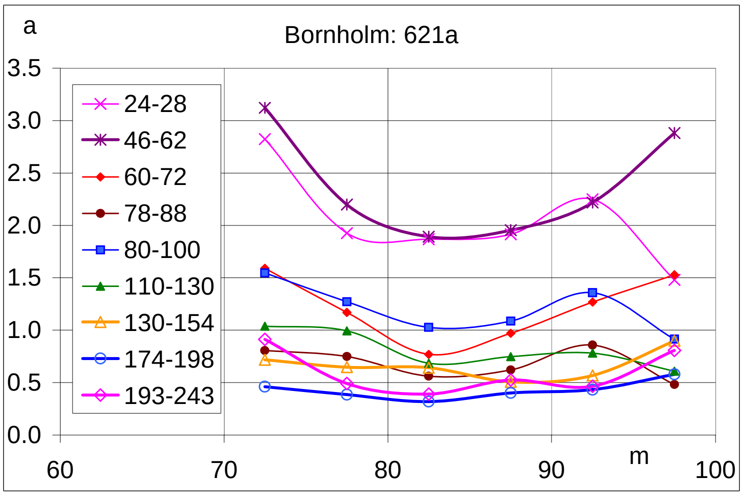
Bornholm	Files	621a	+ 622a	+ 622b	+ 623b					
Interval	Nos. Spectra	LL-UL	24-28	46-62	60-72	78-88	80-100	110-130	130-154	174-198
		a	2.574	2.681	1.408	0.732	1.314	0.804	0.711	0.455
70-75	1504	b	2.200	2.514	1.356	0.749	1.240	0.894	0.573	0.343
		c	1.836	2.018	1.065	0.762	1.070	0.678	0.612	0.405
		a	2.358	2.410	1.292	0.799	1.329	0.889	0.729	0.393
75-80	3757	b	2.144	2.500	1.245	0.743	1.245	0.703	0.624	0.428
		c	1.890	2.069	1.110	0.608	1.071	0.687	0.603	0.404
		a	2.137	2.246	1.124	0.654	1.202	0.702	0.654	0.381
80-85	5225	b	2.059	2.232	1.243	0.659	1.142	0.740	0.616	0.354
		c	1.945	2.133	1.130	0.647	1.112	0.712	0.619	0.418
		a	2.210	2.193	1.154	0.684	1.200	0.800	0.627	0.415
85-90	4034	b	2.092	2.355	1.238	0.686	1.206	0.733	0.596	0.387
		c	1.954	2.152	1.143	0.646	1.118	0.707	0.639	0.411
		a	2.253	2.513	1.312	0.783	1.377	0.853	0.674	0.445
90-95	1885	b	1.668	1.774	1.055	0.584	1.017	0.706	0.540	0.342
		c	1.964	2.194	1.138	0.647	1.116	0.706	0.647	0.415
		a	2.496	2.904	1.379	0.798	1.252	0.844	0.649	0.414
95-100	265	b	1.675	2.068	1.088	0.420	0.599	0.506	0.620	0.210
		c	2.064	2.139	1.161	0.692	1.248	0.764	0.649	0.455
		a								
70-100		b								
		c								
Back-ground	(cps)		48.231	75.344	42.350	19.737	35.983	22.747	18.734	13.322

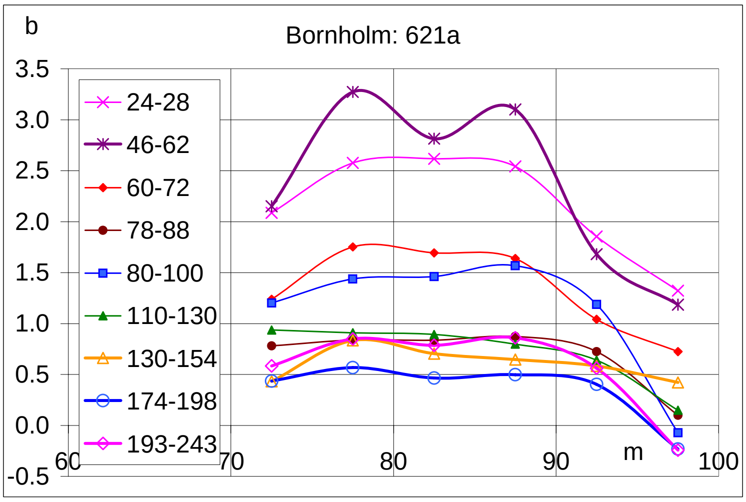
Barents Rescue	Area A1									
Interval	Nos. Spectra	LL-UL	24-28	46-62	60-72	78-88	80-100	110-130	130-154	174-198
		a	2.572	2.906	1.408	0.608	1.246	0.881	0.934	0.439
40-45	226	b	2.012	2.660	1.630	0.710	1.413	0.855	0.625	0.368
		c	1.726	1.786	0.916	0.612	1.003	0.628	0.528	0.394
		a	2.868	3.154	1.626	0.981	1.636	0.938	0.617	0.453
45-50	421	b	1.842	2.312	1.439	0.655	1.130	0.739	0.635	0.275
		c	1.703	1.761	0.903	0.556	0.966	0.639	0.582	0.405
		a	2.663	2.933	1.386	0.919	1.397	0.809	0.671	0.436
50-55	528	b	1.469	1.648	0.874	0.432	0.728	0.255	0.135	0.085
		c	1.839	1.931	1.039	0.606	1.073	0.711	0.646	0.438
		a	2.625	2.812	1.281	0.837	1.447	0.719	0.752	0.398
55-60	476	b	2.608	2.762	1.505	0.765	1.521	0.724	0.771	0.307
		c	1.785	1.861	0.996	0.595	1.016	0.685	0.581	0.417
		a	2.872	2.660	1.386	0.767	1.316	0.957	0.661	0.334
60-65	461	b	0.946	1.687	0.625	0.280	0.532	0.322	0.237	0.251
		c	1.937	2.030	1.087	0.654	1.129	0.700	0.638	0.433
		a	3.087	3.200	1.508	0.971	1.805	0.962	0.593	0.398
65-70	238	b	0.307	0.920	0.855	0.201	0.612	0.374	0.464	0.315
		c	1.990	2.020	1.079	0.654	1.071	0.700	0.652	0.435
		a								
40-70		b								
		c								
Back-ground	(cps)		49.768	77.120	43.414	19.717	36.213	23.702	19.103	13.603

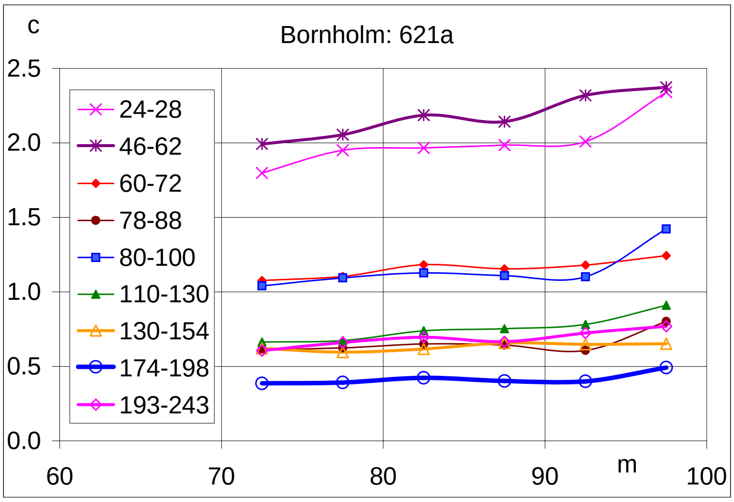
Barents Rescue	Area A2									
Interval	Nos. Spectra	LL-UL	24-28	46-62	60-72	78-88	80-100	110-130	130-154	174-198
		a								
40-45		b								
		c								
		a								
45-50		b								
		c								
		a								
50-55		b								
		c								
		a								
55-60		b								
		c								
		a								
60-65		b								
		c								
		a								
65-70		b								
		c								
		a	2.993	3.016	1.452	0.859	1.534	0.818	0.797	0.429
30-80	2321	b	1.484	2.122	1.205	0.490	0.901	0.472	0.479	0.245
		c	1.848	1.913	1.007	0.621	1.056	0.700	0.598	0.424
Back-ground	(cps)		49.768	77.120	43.414	19.717	36.213	23.702	19.103	13.603

Appendix J
Area specific stripping factors as a function of height

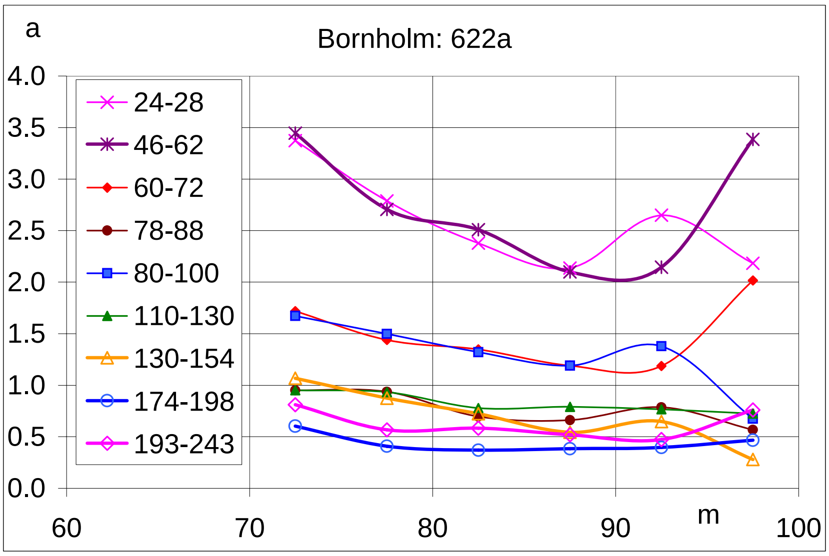
File 621a from the survey of the Danish island Bornholm

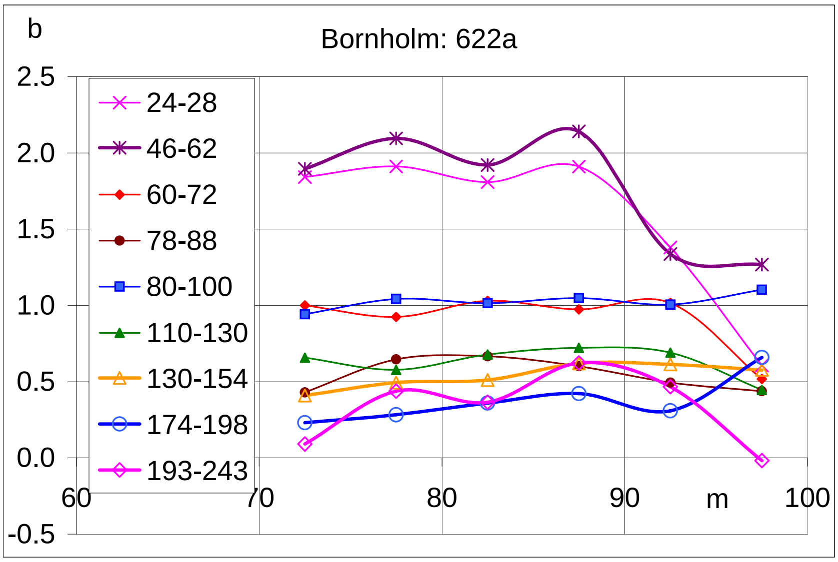


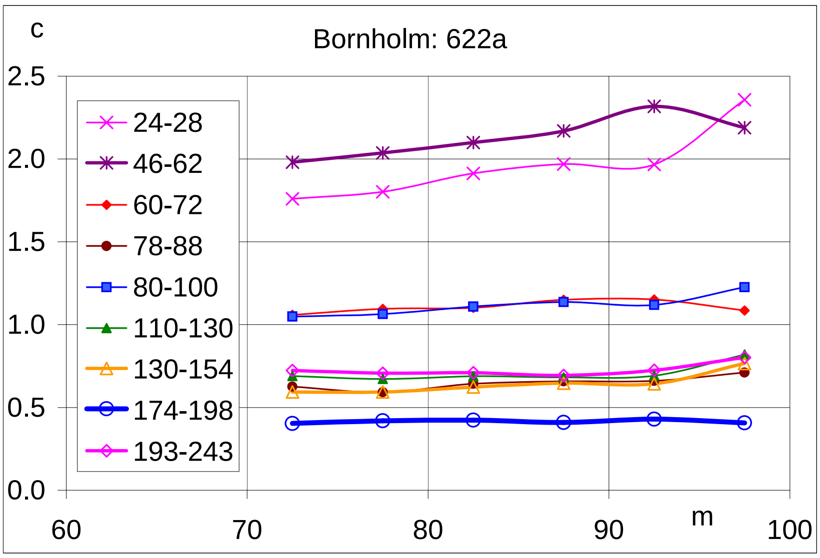




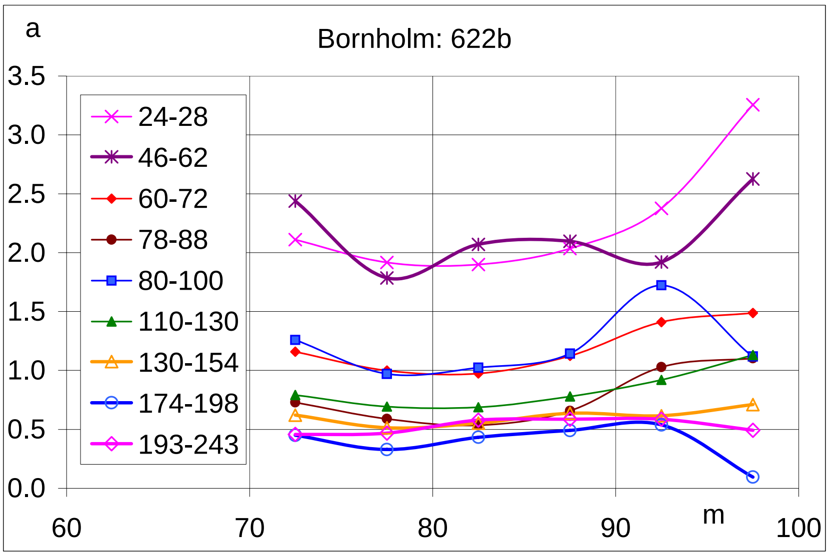
File 622a from the survey of the Danish island Bornholm

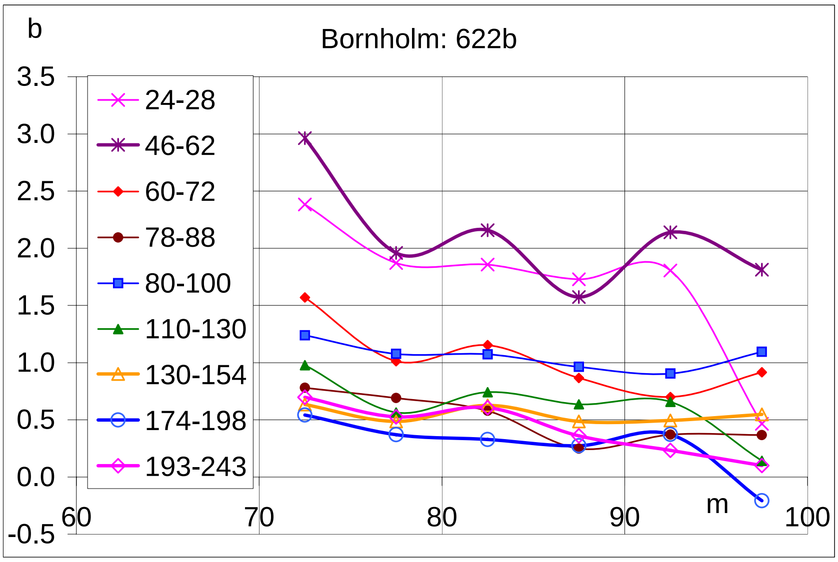


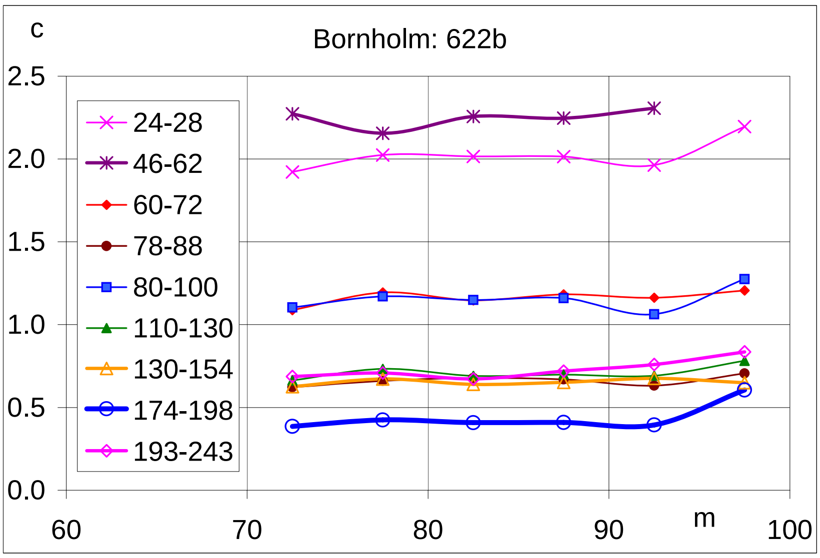




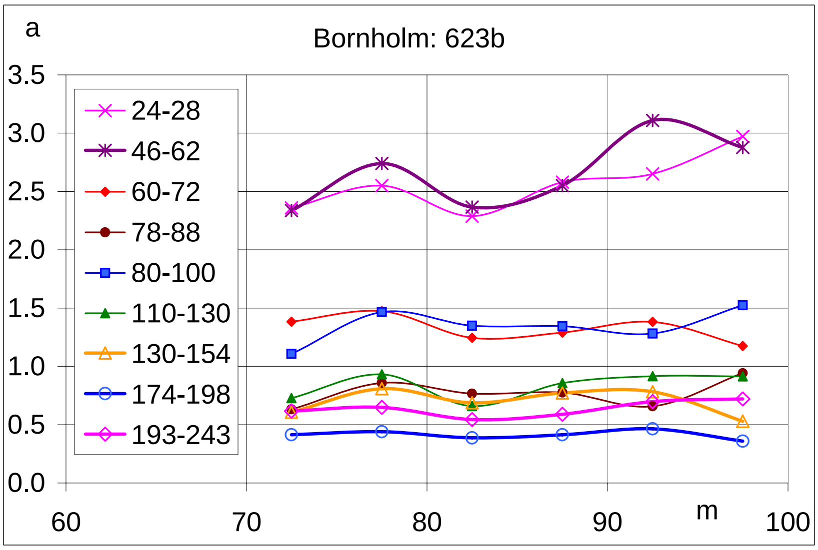
File 622b from the survey of the Danish island Bornholm

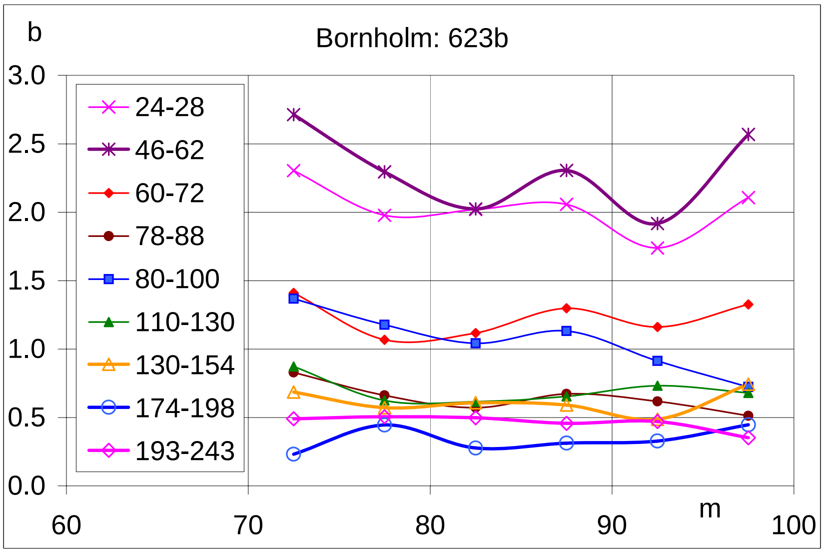


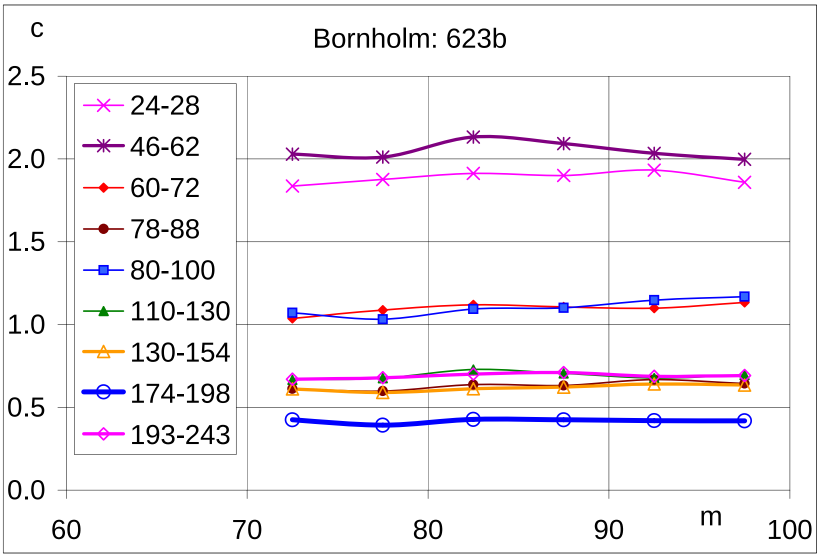




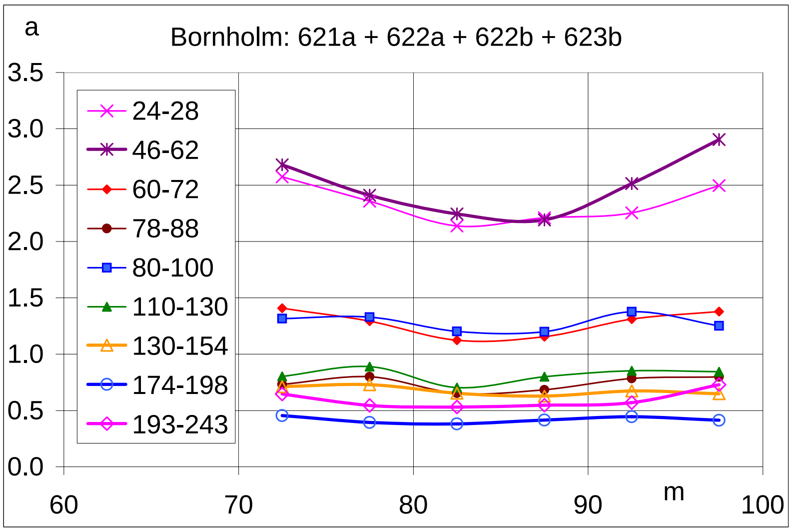
File 623b from the survey of the Danish island Bornholm

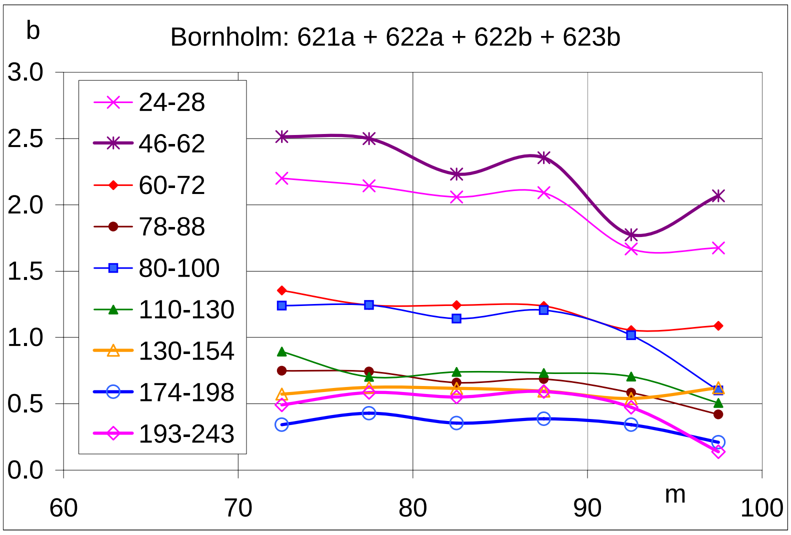


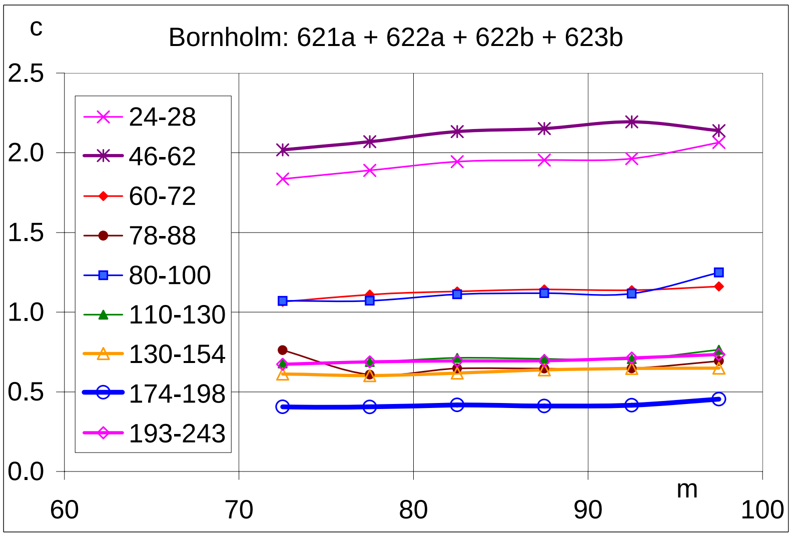




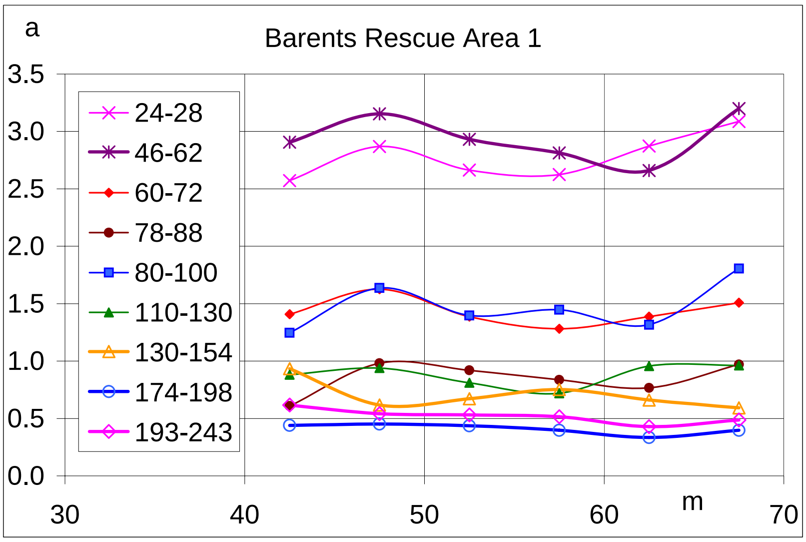
File “621a + 622a + 622b + 623b” from the survey of the Danish island Bornholm

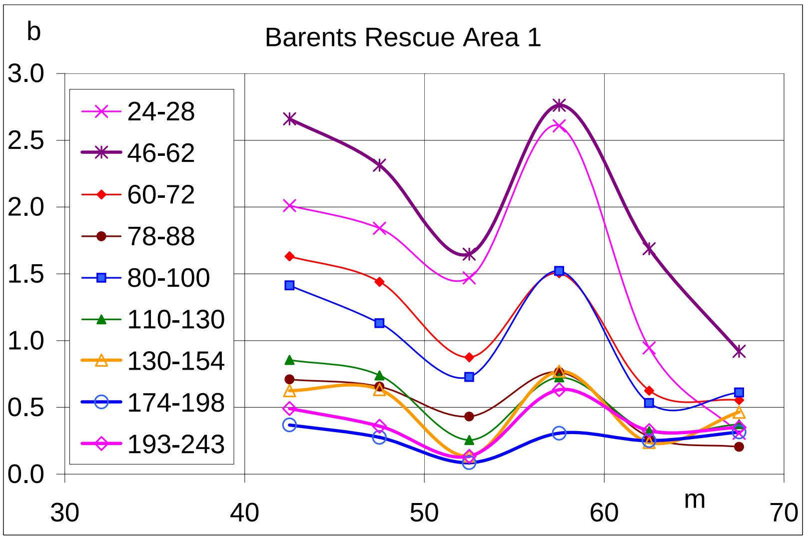


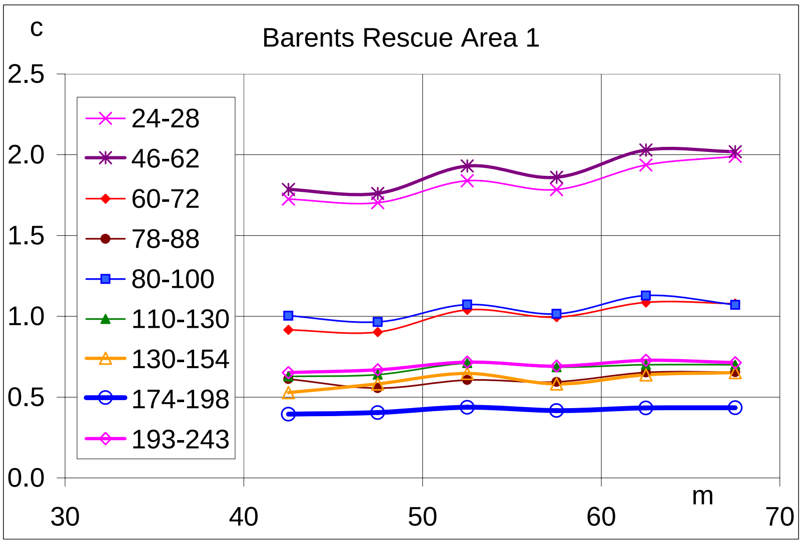




Barents Rescue Area A1 (2001)







Appendix K
Sources used in the Barents Rescue Exercise Area A1 and A2

Sources in Area A1 (Ref. NKS Barents Rescue report)

Source No.	Isotope	Activity GBq	East	North
1:1	^{60}Co	4.9	1756005	7298134
1:2	^{131}I	10.3-8.5	1756005	7299224
1:3	^{60}Co	4.9	1755956	7299830
1:4	^{60}Co	4.9	1756747	7300334

All sources in Area A1 found and reported correctly by team DKA.

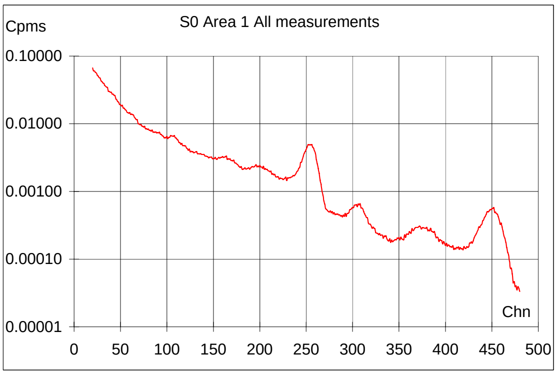
Sources in Area A2 (Ref. NKS Barents Rescue report)

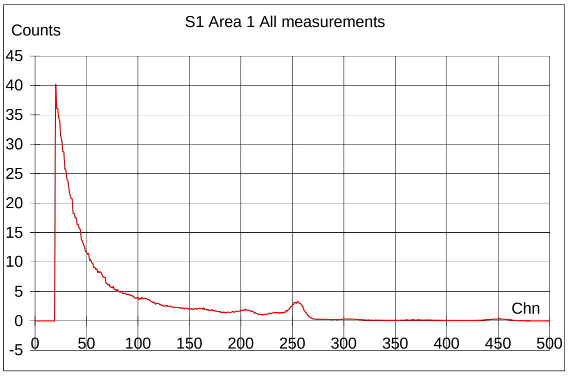
Source No.	Isotope	Activity GBq	East	North
2:1	^{60}Co	4.9	1764029	7307246
2:2	^{60}Co	4.9	1764048	7307266
2:3	^{99}Mo	0.9-0.5	1764844	7307031
2:4	^{99}Mo	5.5-3.0	1765350	7305451
2:5-1	^{137}Cs	3*0.5	1763466	7306095
2:5-2	^{60}Co	3* 0.02	1763466	7306095

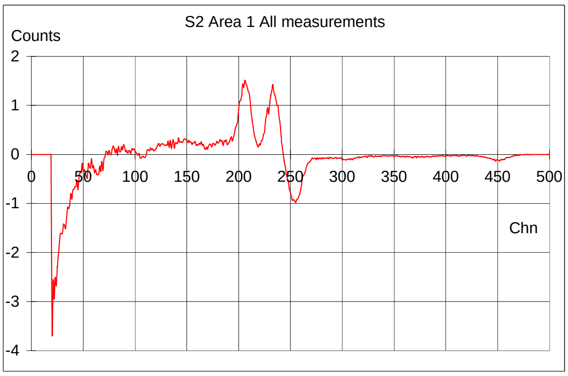
Source 2:4 found and reported by team DKA. Source identified wrongly.

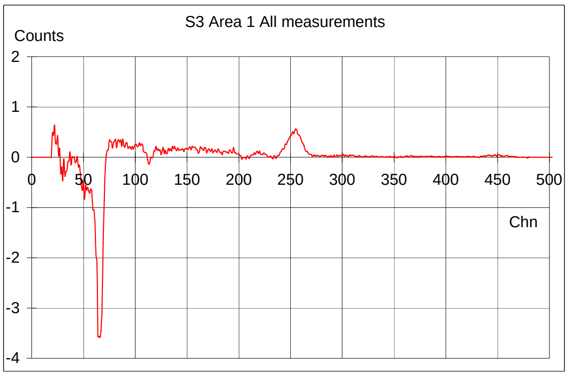
Appendix L: Spectral components and amplitudes from NASVD processing

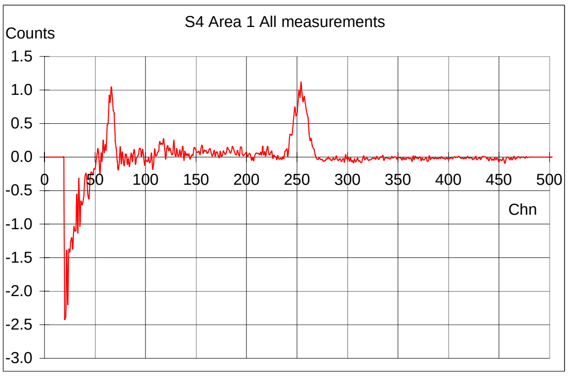
Spectral components for Barents Rescue Area A1: All measurements

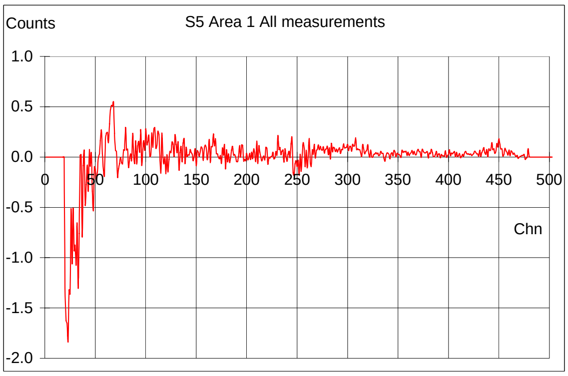


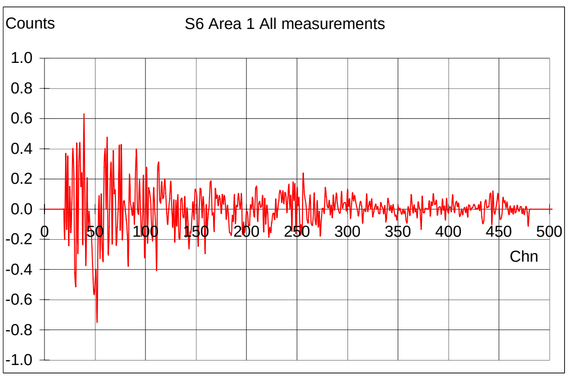


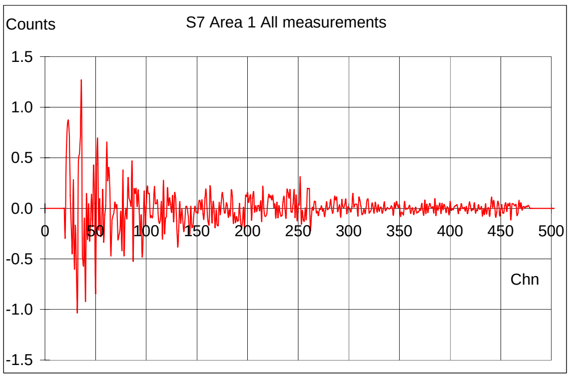




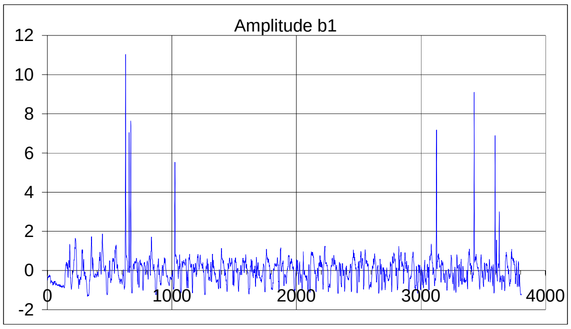


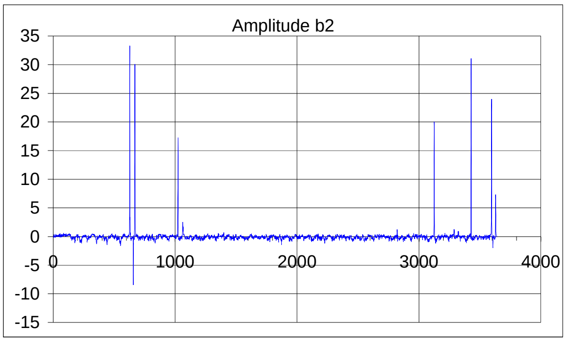


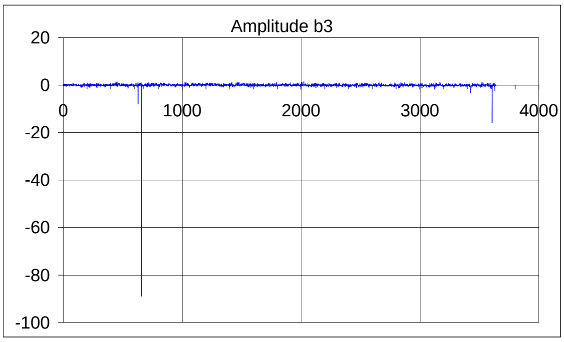


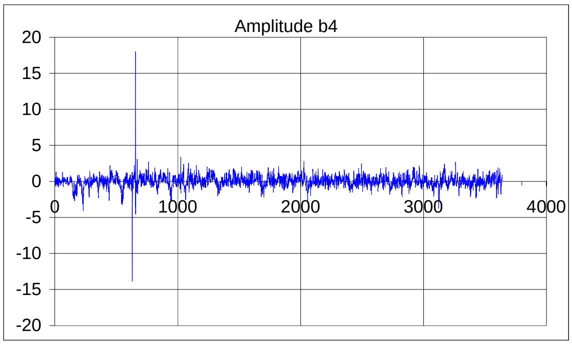


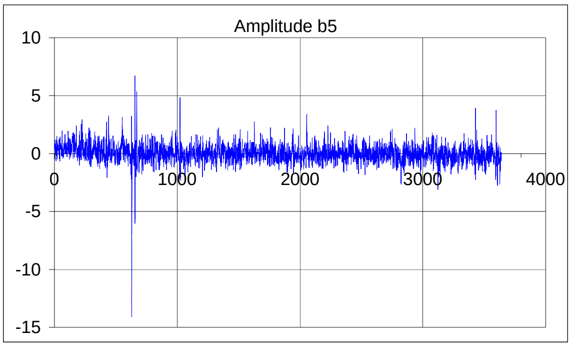
Amplitudes for Barents Rescue Area A1: All measurements

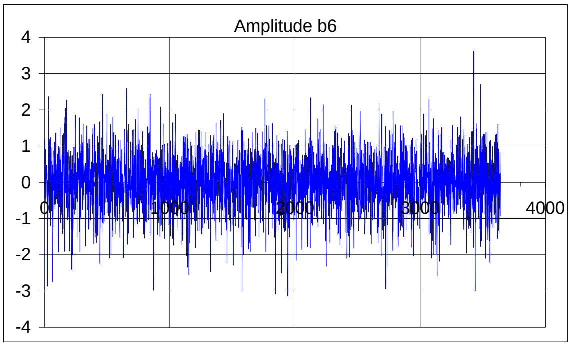


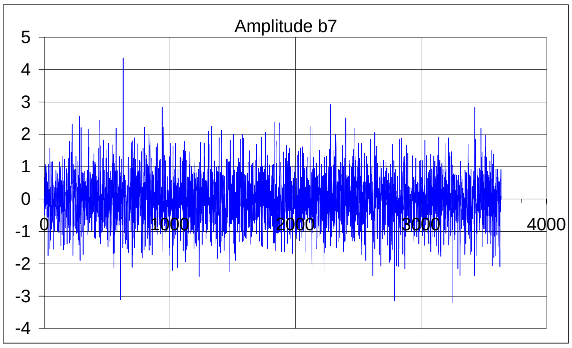




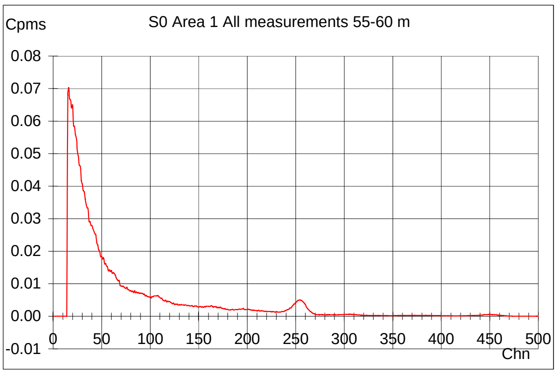


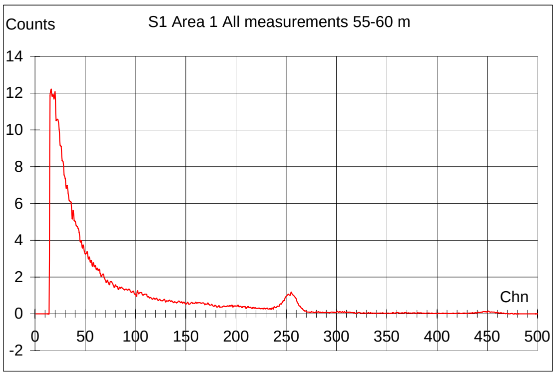


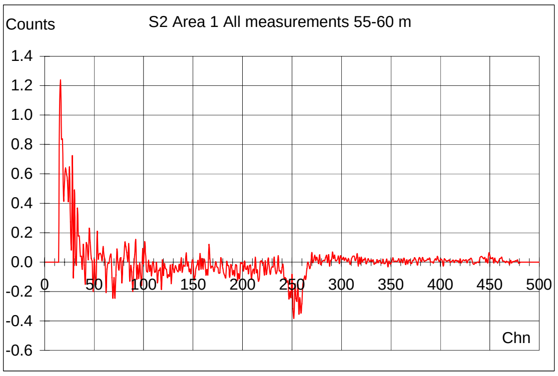


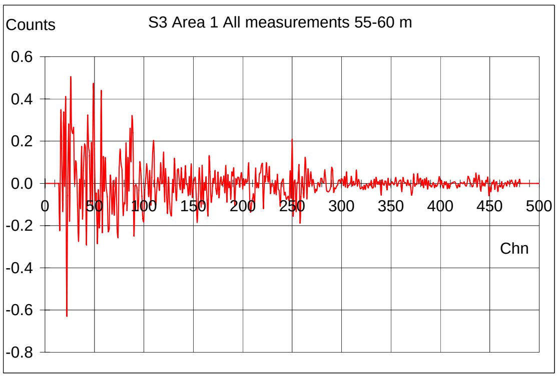


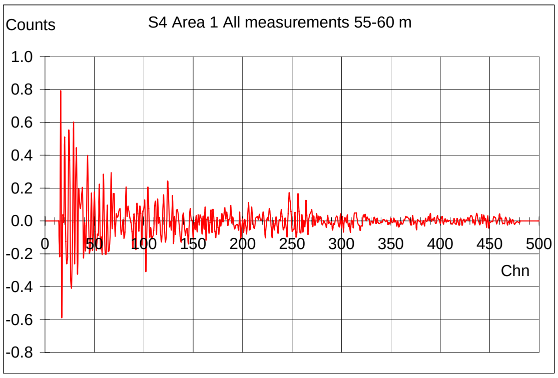
Spectral components for Barents Resuce Area 1 55-60m.
Signals from helicopter turns included.

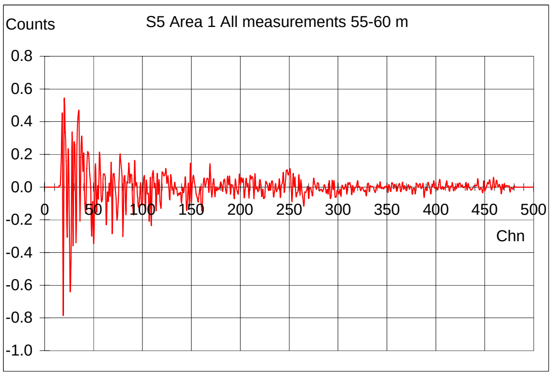


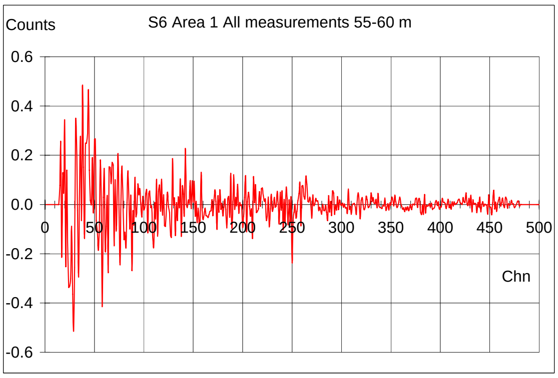


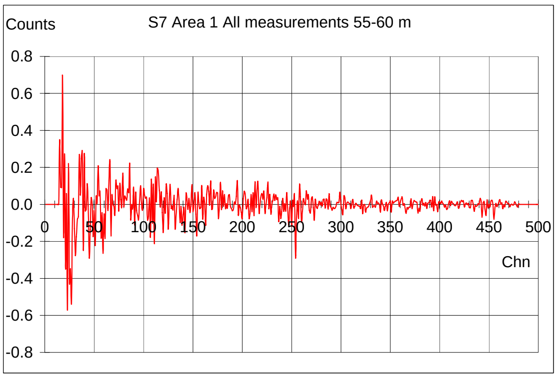




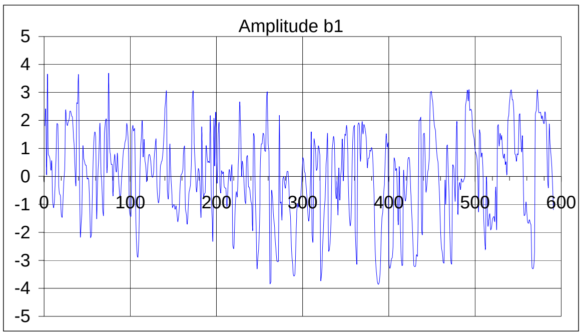


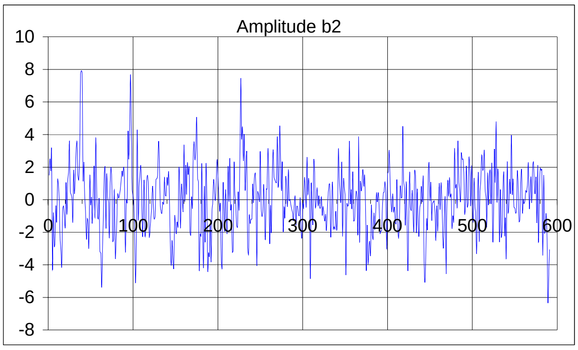


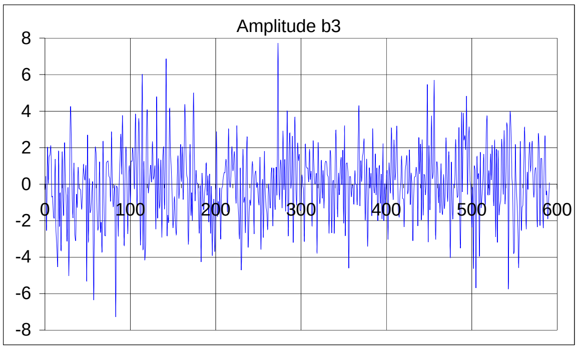


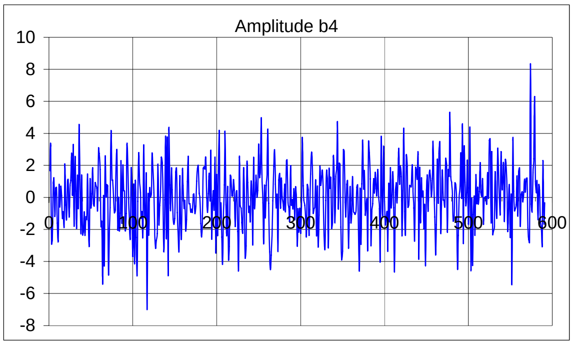


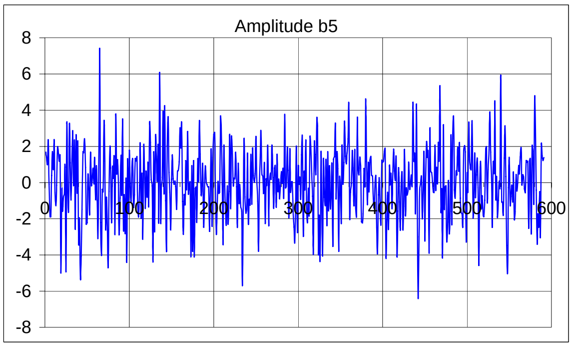
Amplitudes for Barents Resuce Area 1 55-60m.
Signals from helicopter turns included

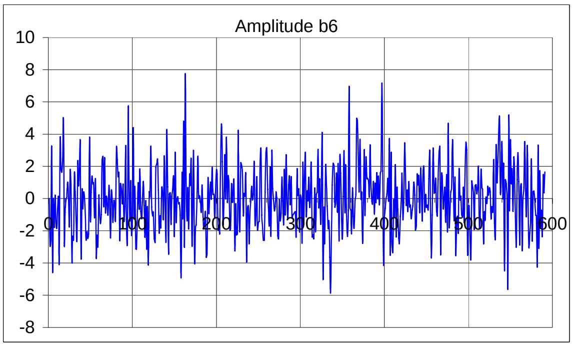


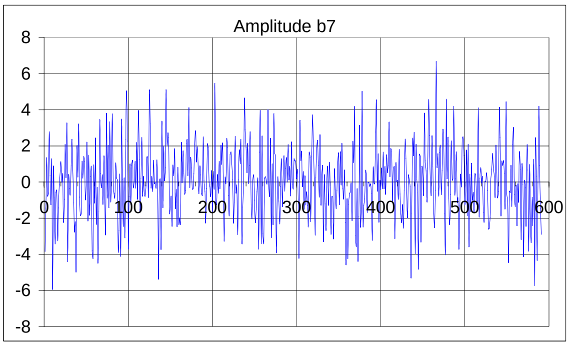




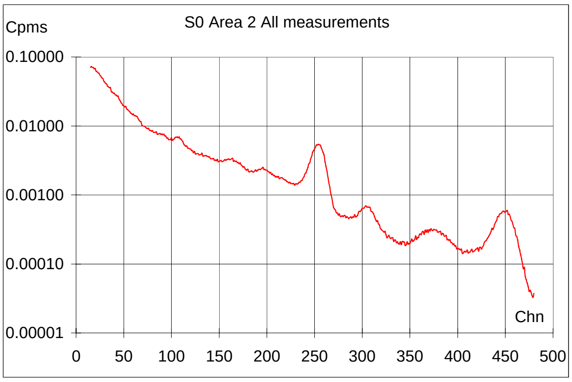


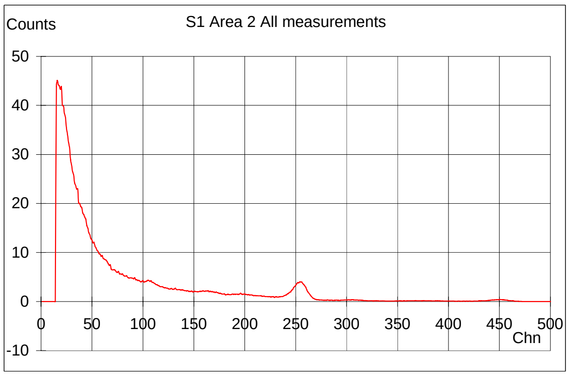


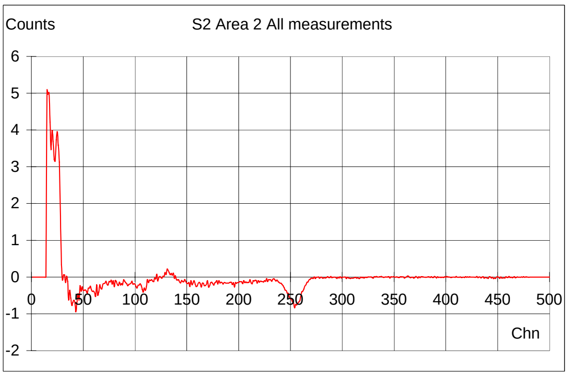


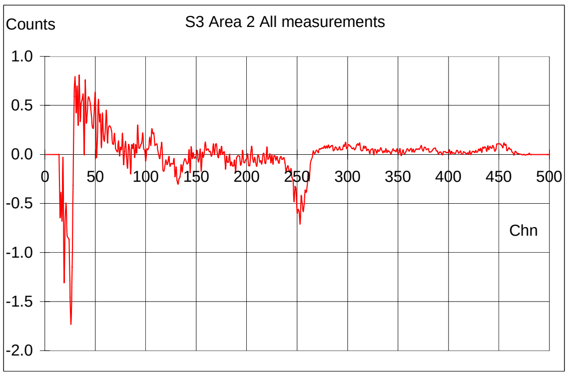


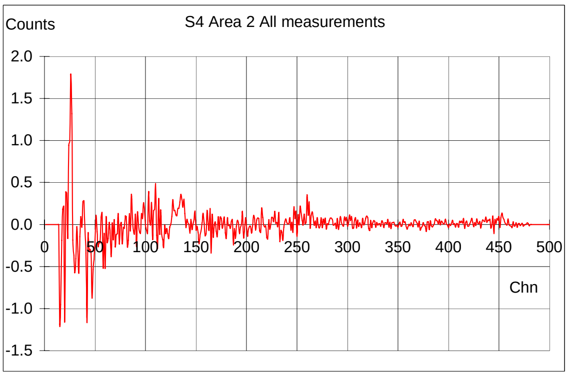
Spectral components for Barents Rescue Area A2: All measurements.

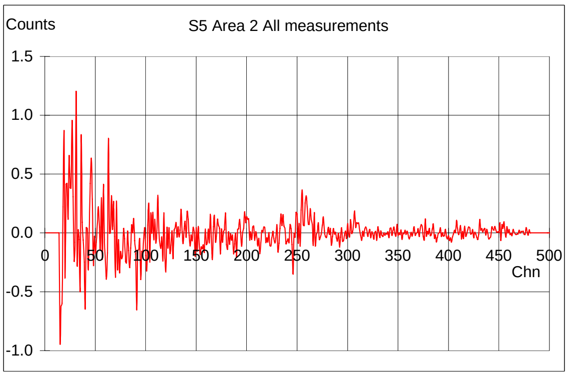


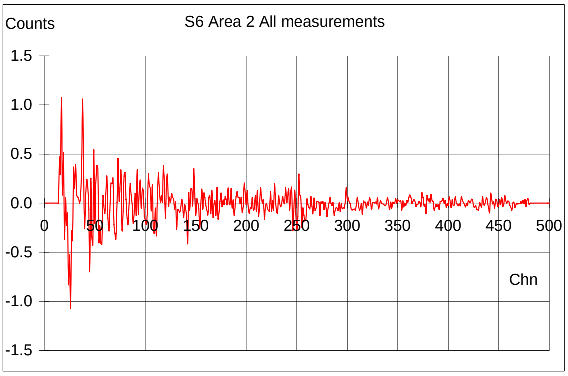


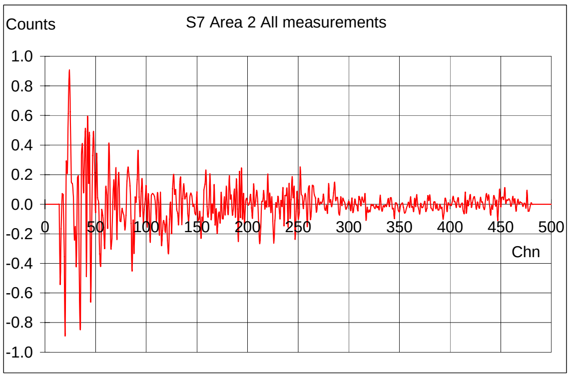




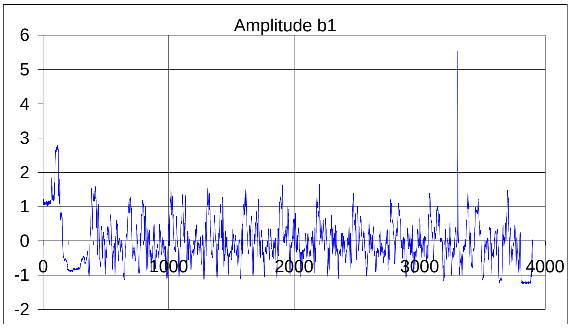


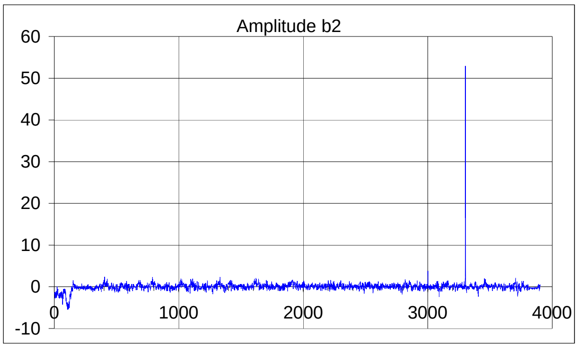


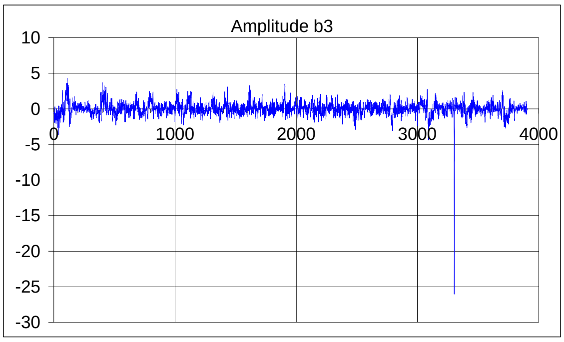


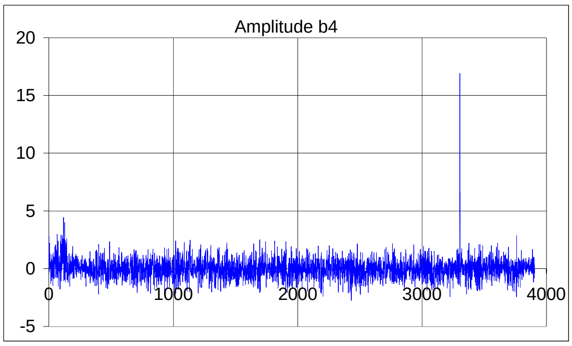


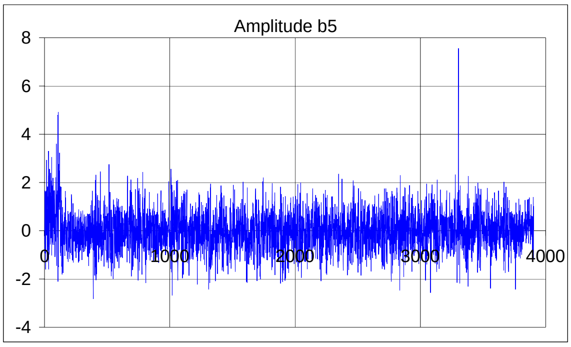
Amplitudes for Barents Rescue Area A2: All measurements.

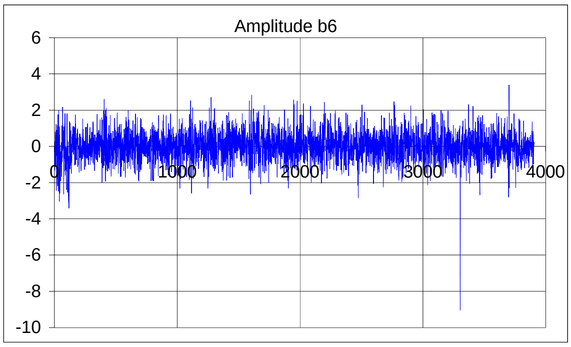


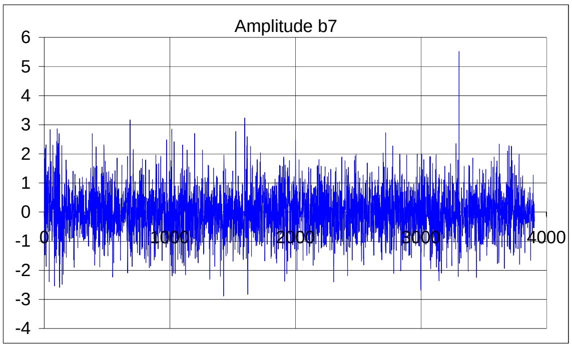






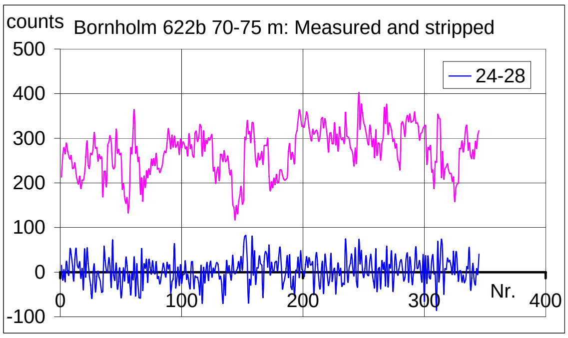


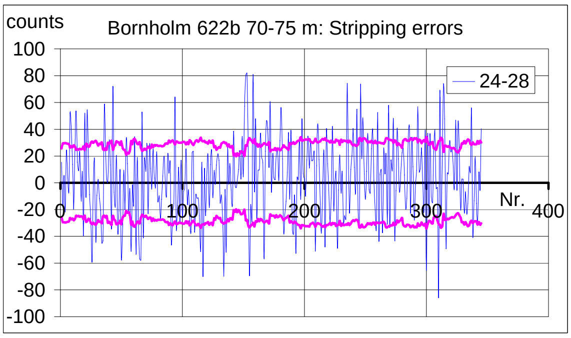


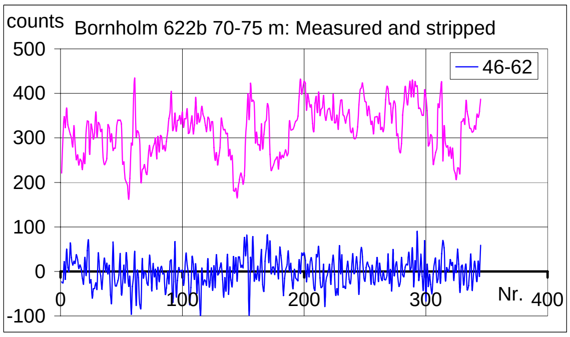


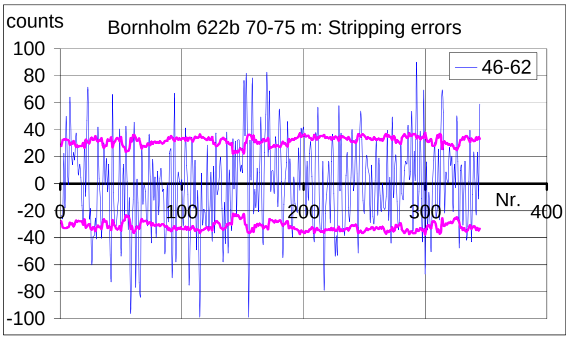
Appendix M
Stripped and measured counts, statistical errors (± ů).

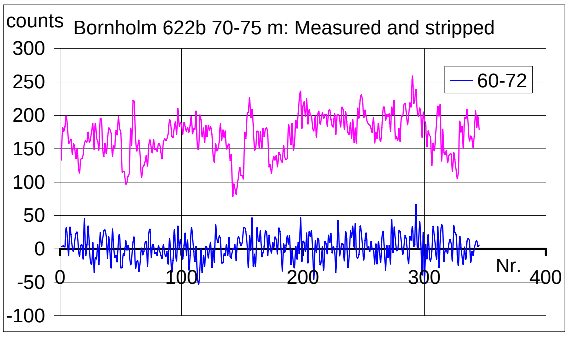
Bornholm file 622b: 70-75 m

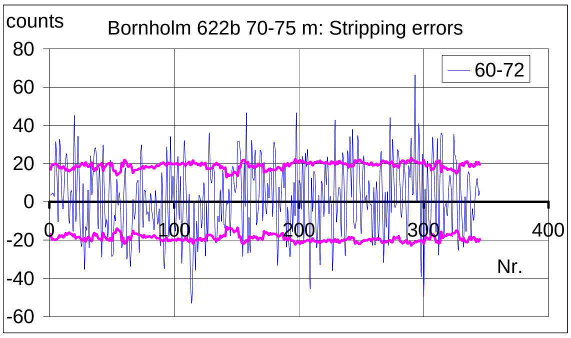


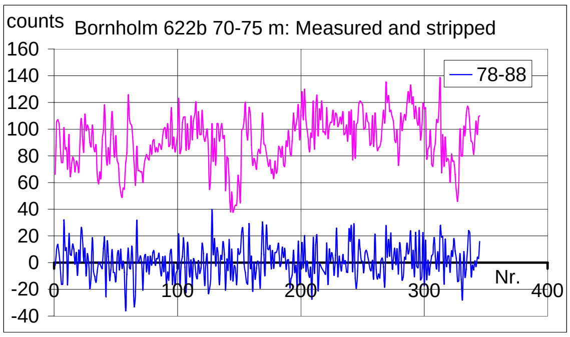


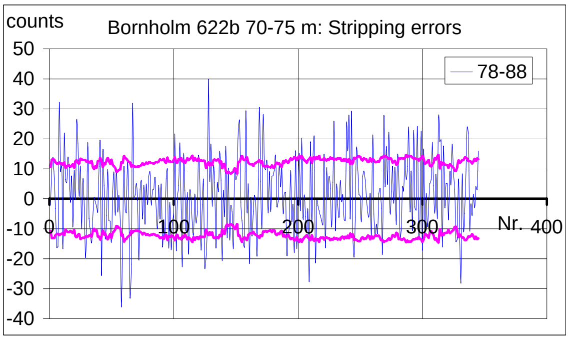




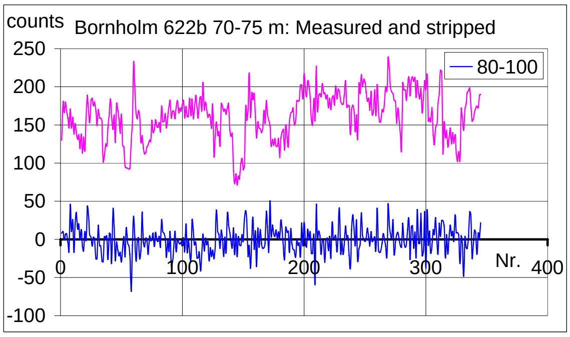


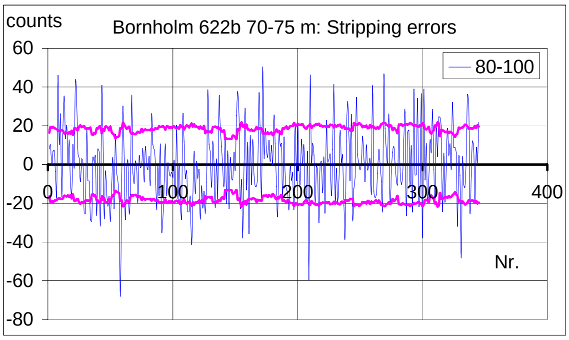


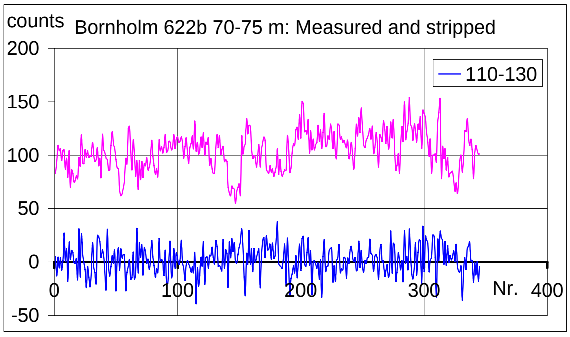


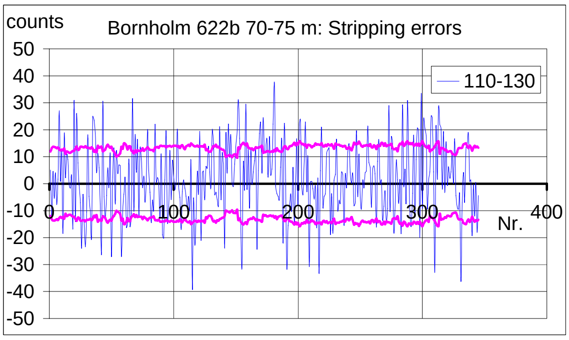


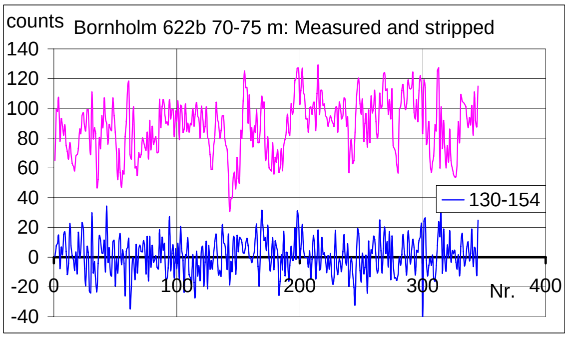
Bornholm file 622b: 70-75 m

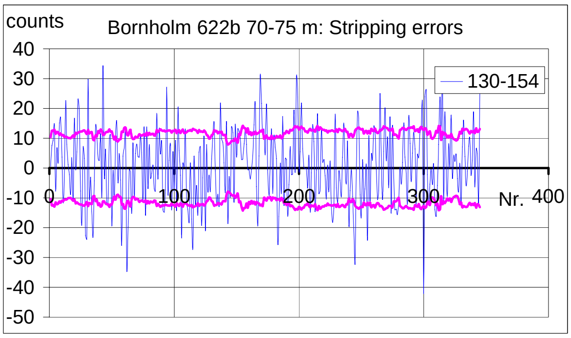


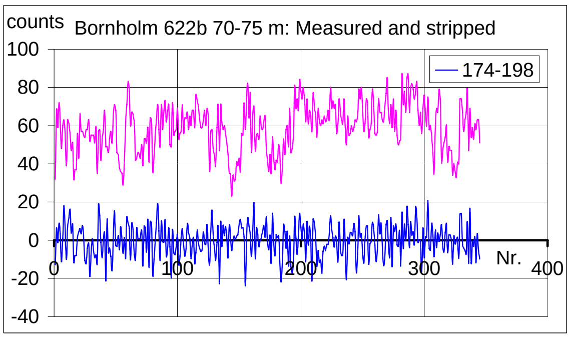


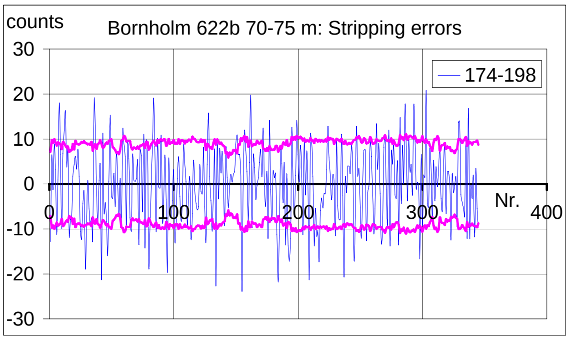


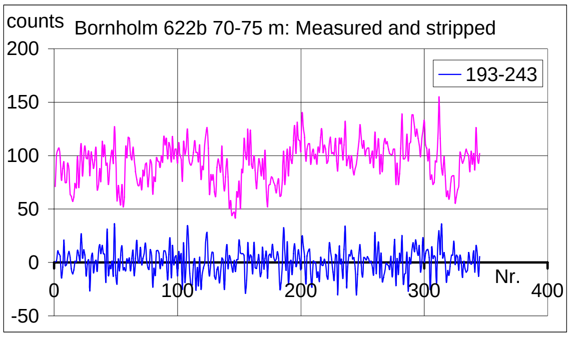


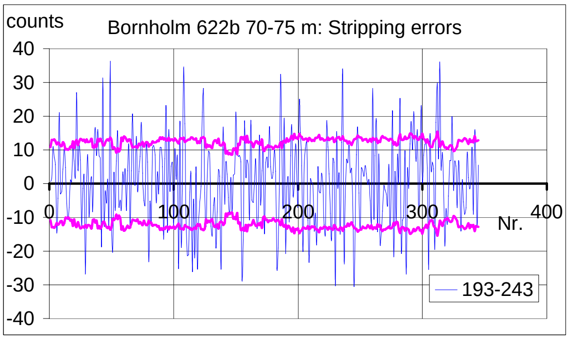




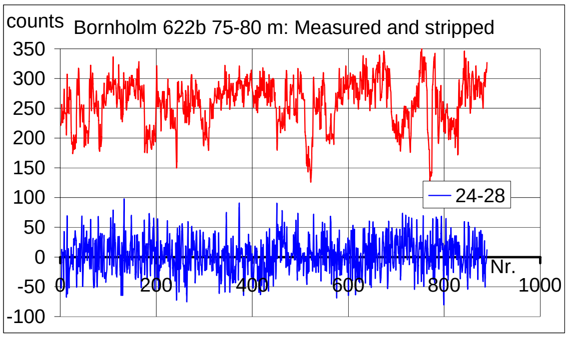


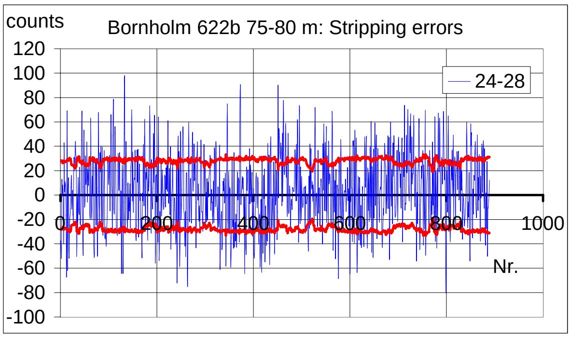


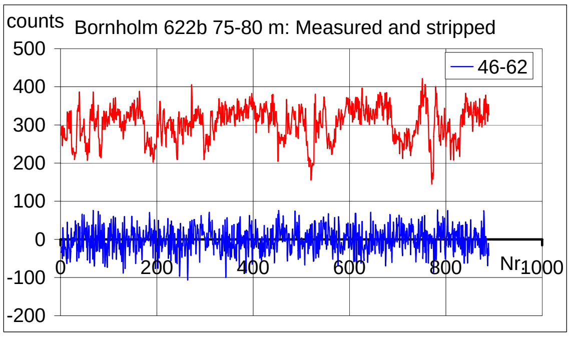

counts
Bornholm 622b 70-75 m: Measured and stripped
193-243
200
150
100
50
0
-50
0
100
200
300
400
Nr.

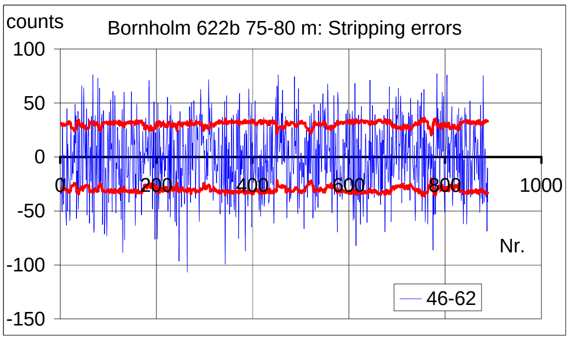

counts
Bornholm 622b 70-75 m: Stripping errors
40
30
20
10
0
-10
-20
-30
-40
0
100
200
300
400
Nr.
193-243

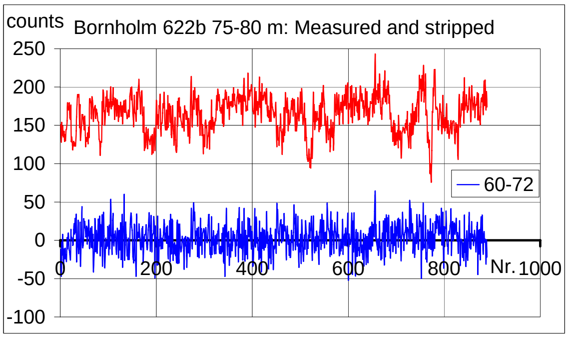
Bornholm file 622b: 75-80 m

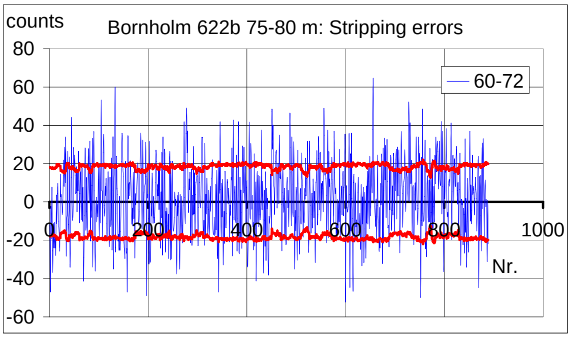


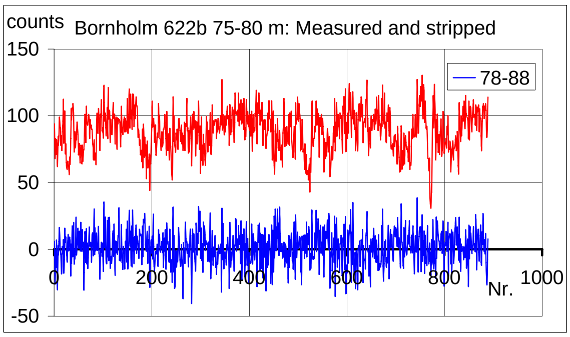


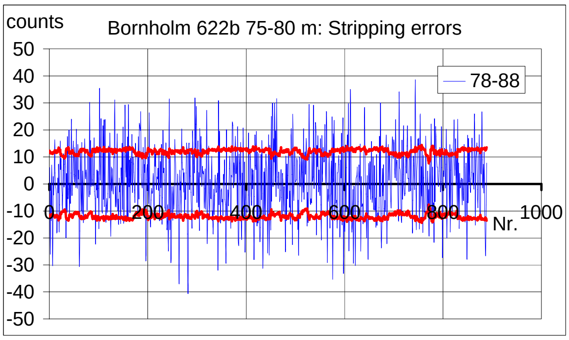




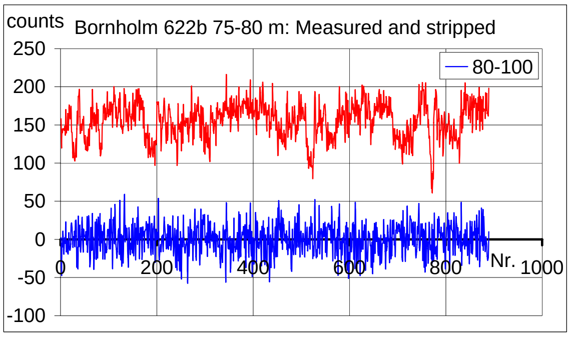


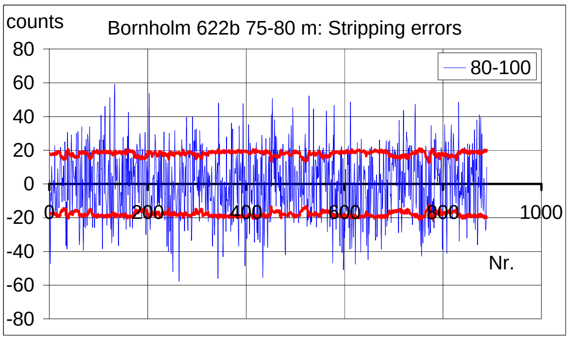


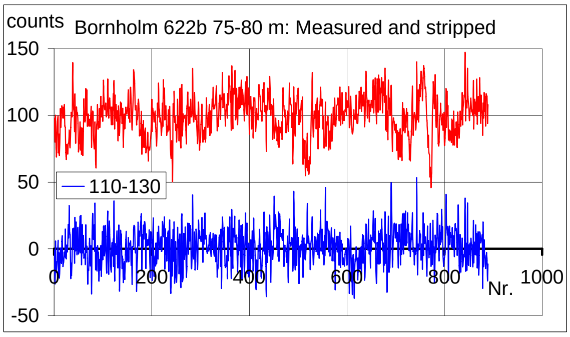


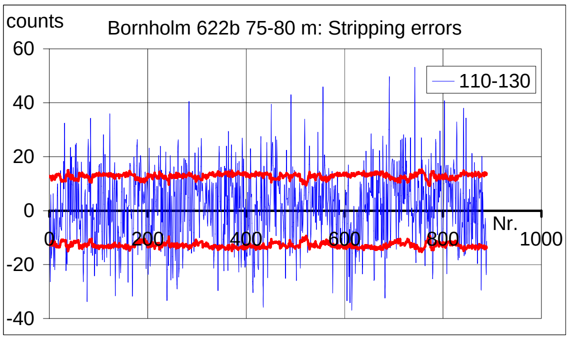


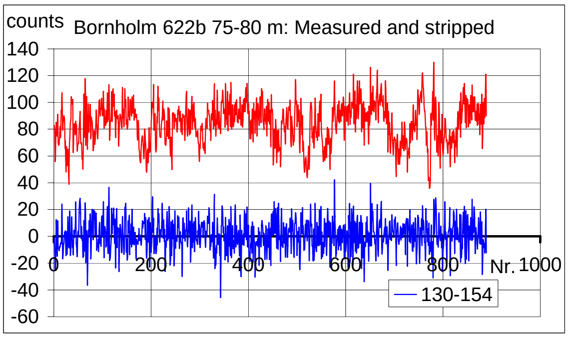
Bornholm file 622b: 75-80 m

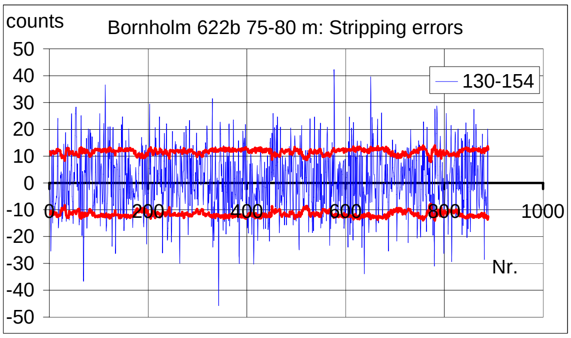


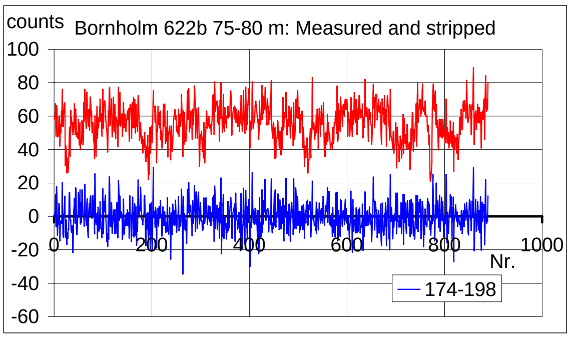


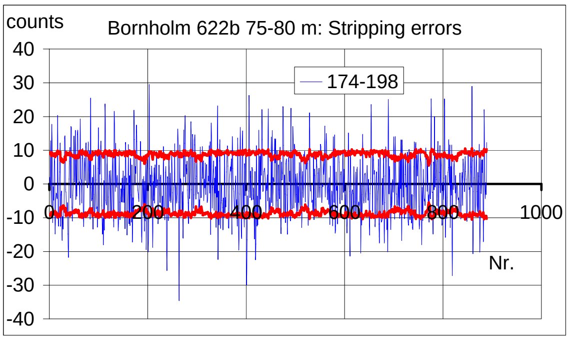


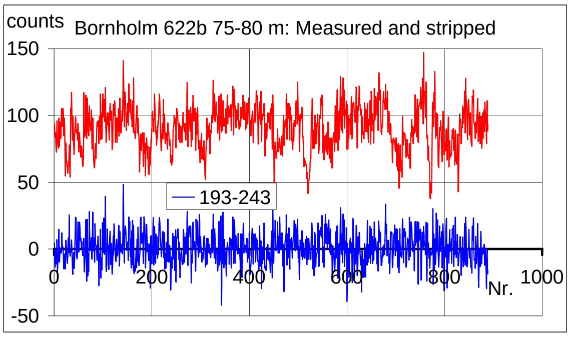


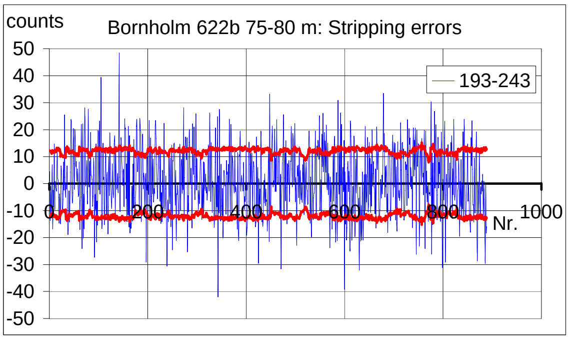




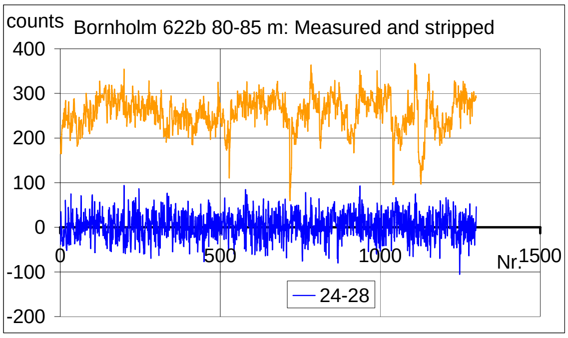


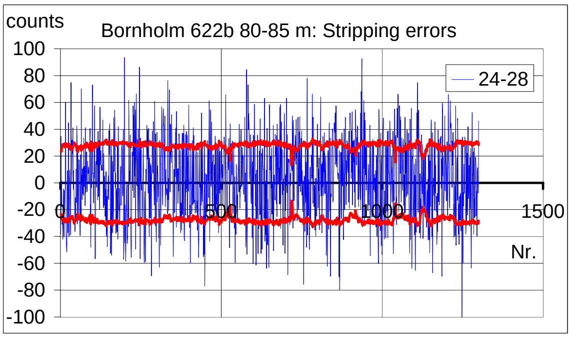


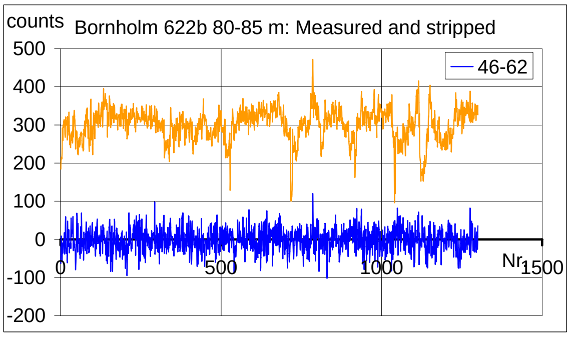

counts
Bornholm 622b 75-80 m: Measured and stripped
150
100
50
0
-50
193-243
0
200
400
600
800
1000
Nr.

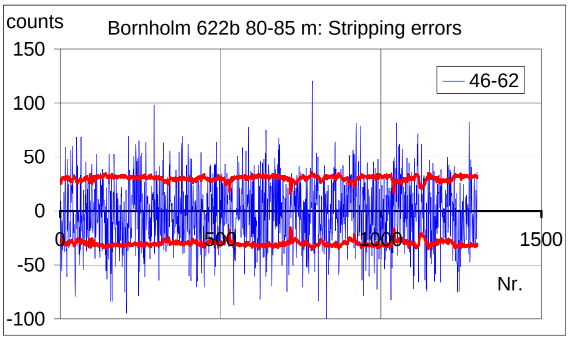

counts
Bornholm 622b 75-80 m: Stripping errors
50
40
30
20
10
0
-10
-20
-30
-40
-50
193-243
0
200
400
600
800
1000
Nr.

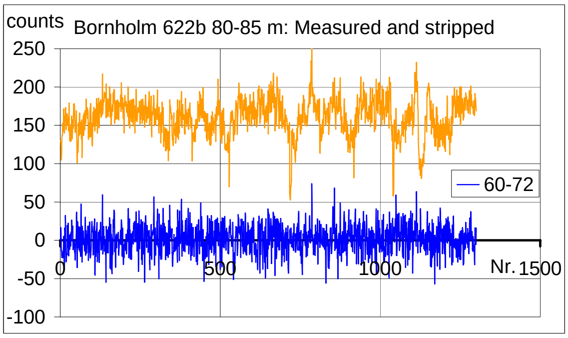
Bornholm file 622b: 80-85 m

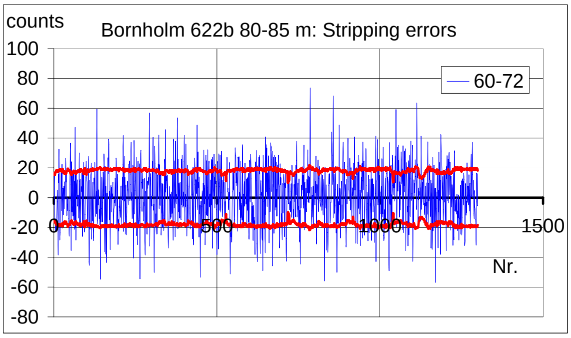


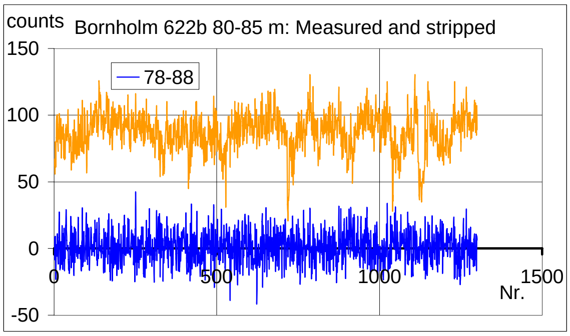


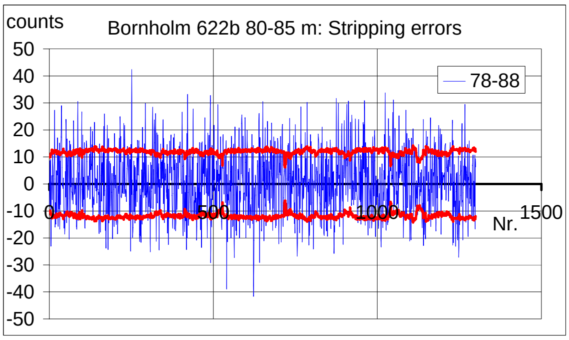




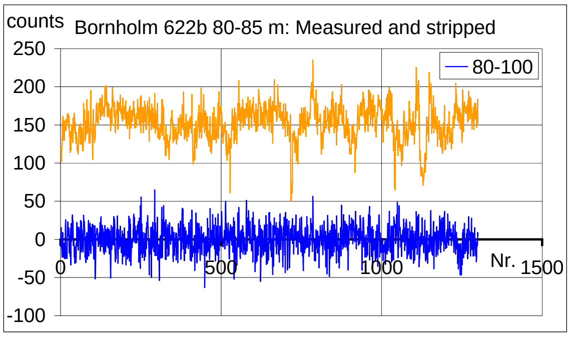


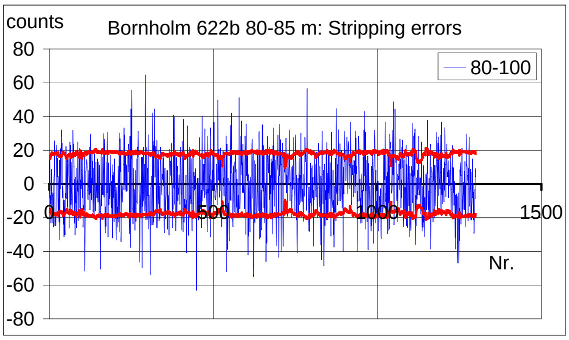


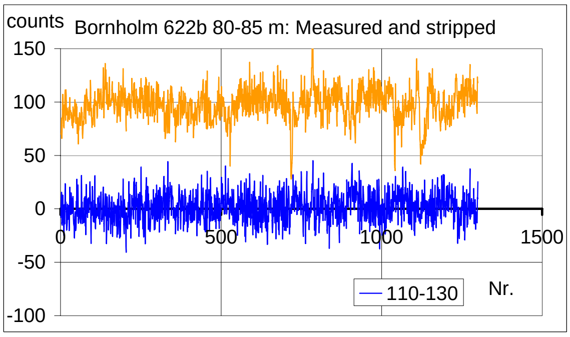


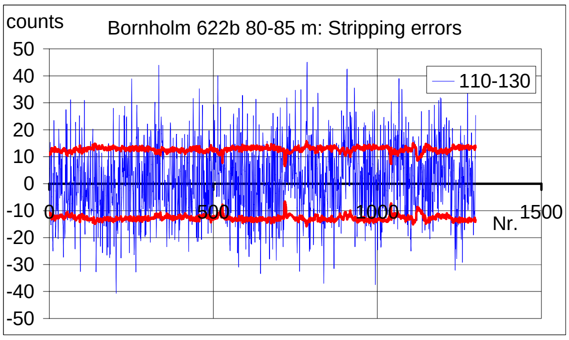


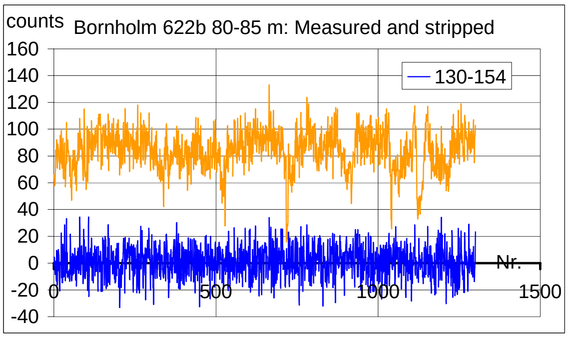
Bornholm file 622b: 80-85 m

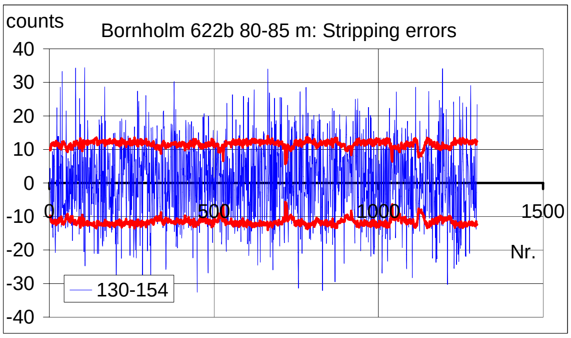


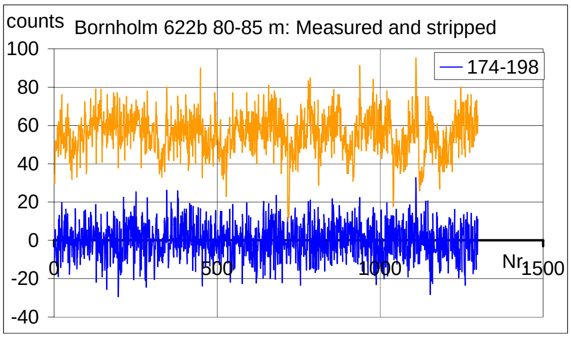


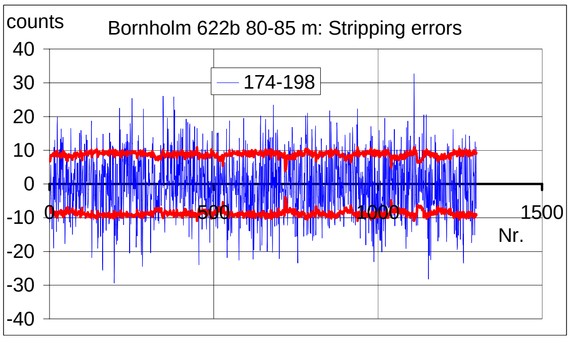


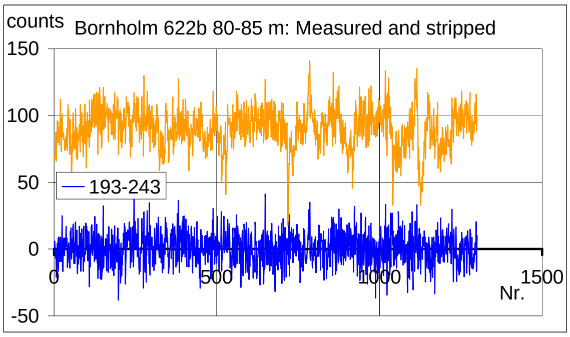


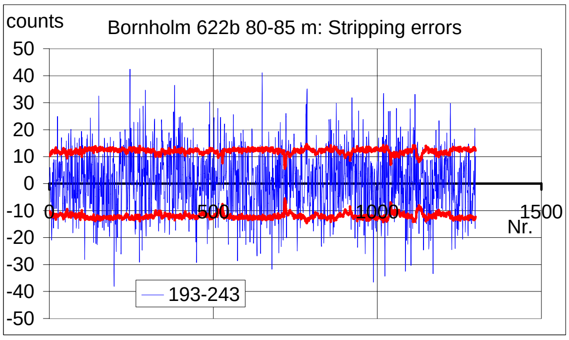




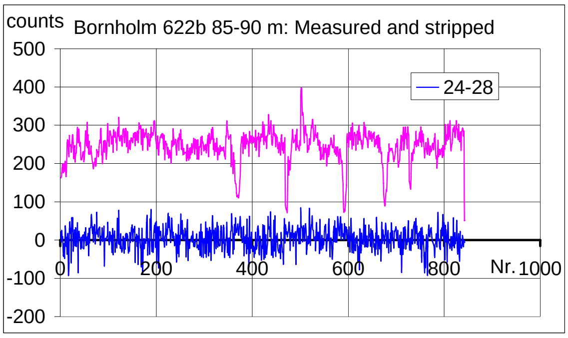


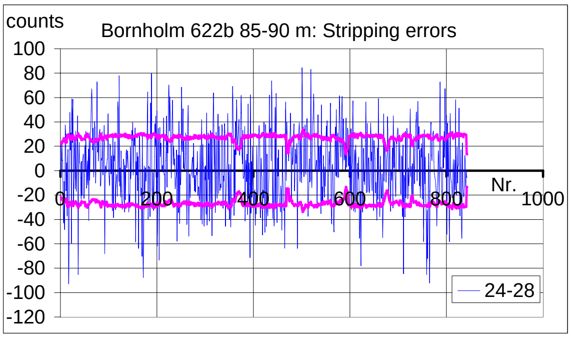


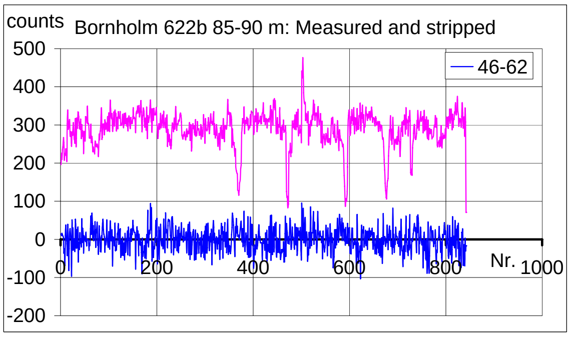

counts
Bornholm 622b 80-85 m: Measured and stripped
150
100
50
0
-50
193-243
0
500
1000
1500
Nr.

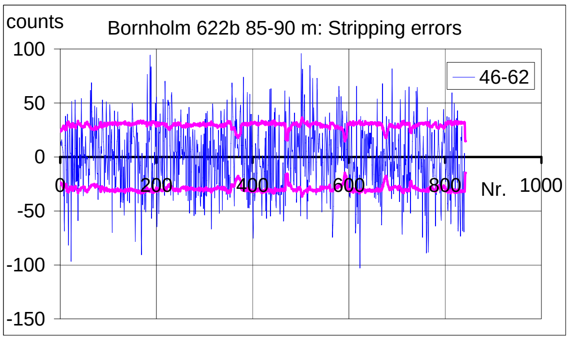

counts
Bornholm 622b 80-85 m: Stripping errors
50
40
30
20
10
0
-10
-20
-30
-40
-50
193-243
0
500
1000
1500
Nr.

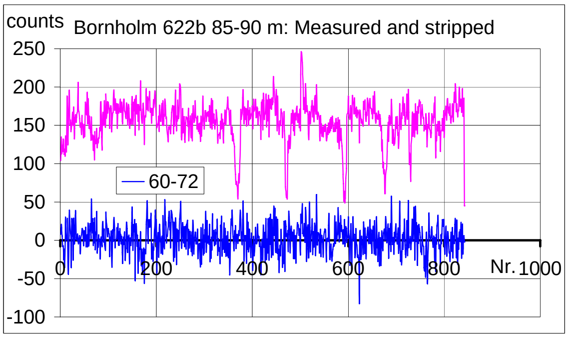
Bornholm file 622b: 85-90 m

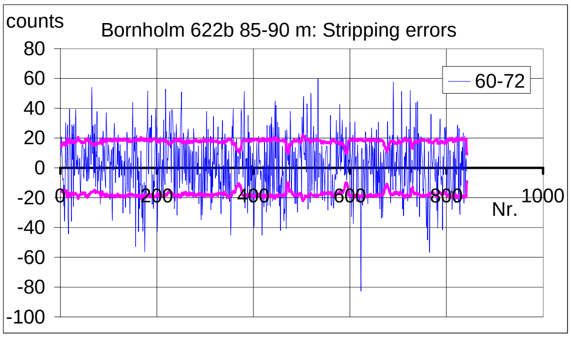


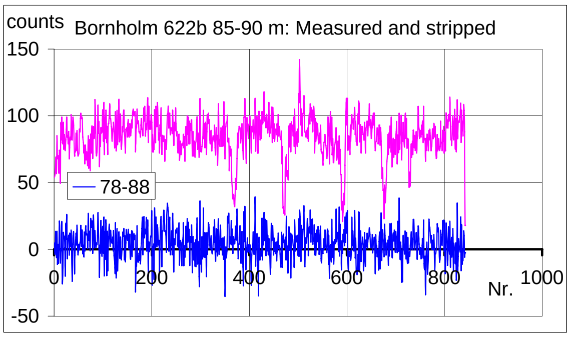


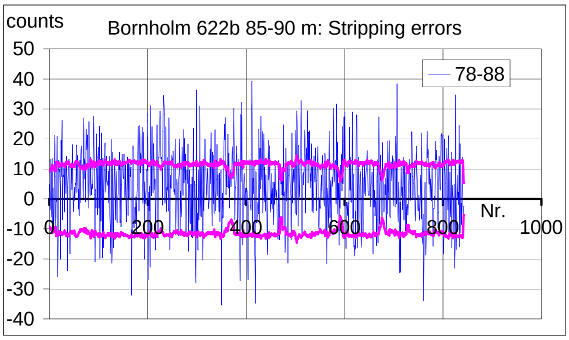




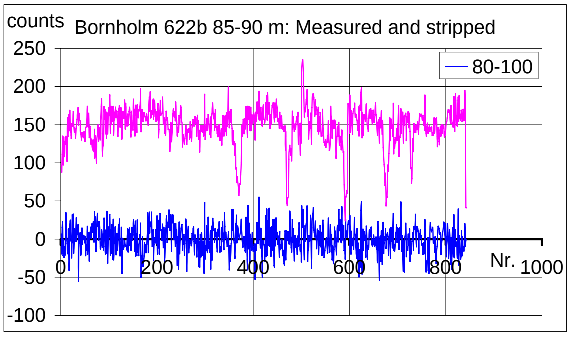


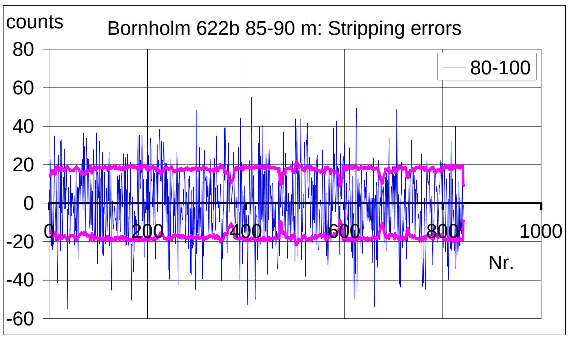


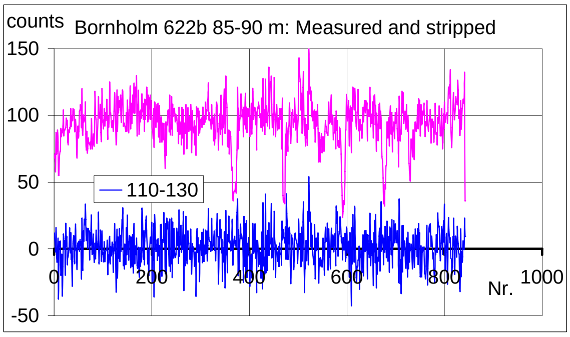


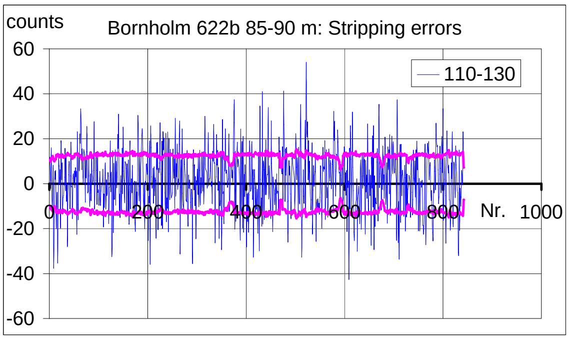


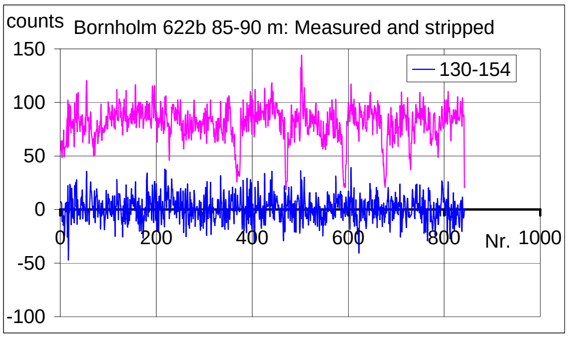
Bornholm file 622b: 85-90 m

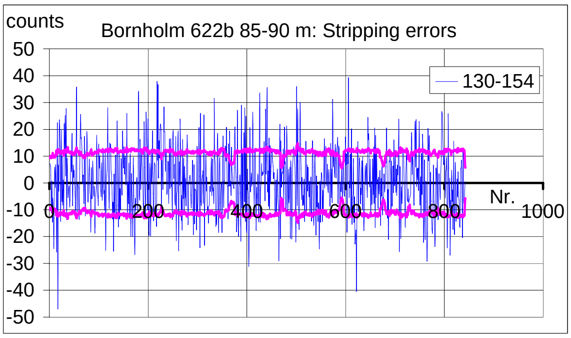


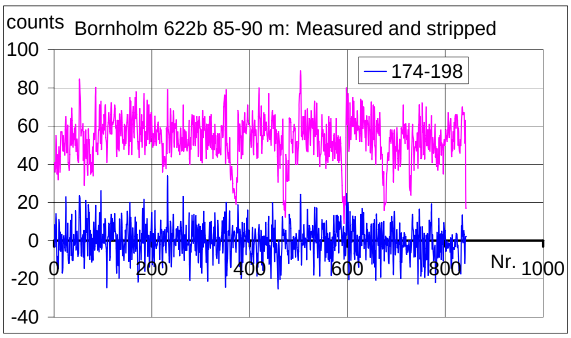


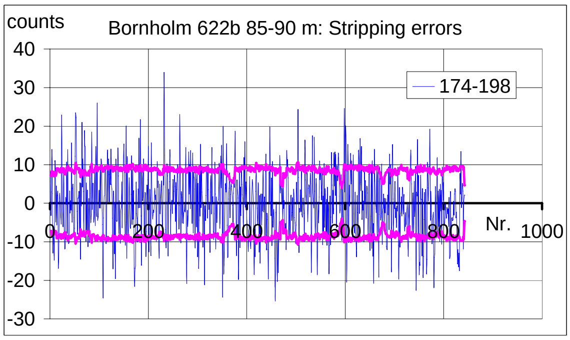


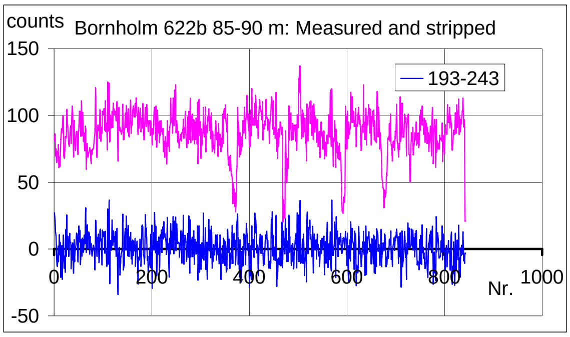


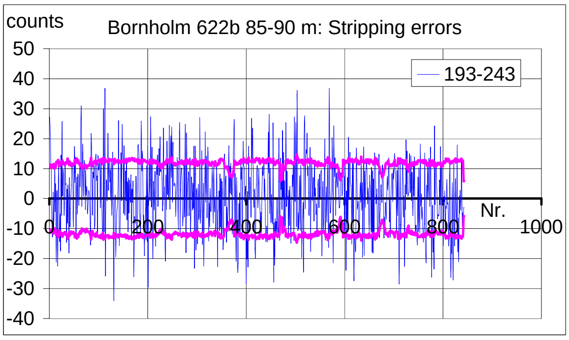




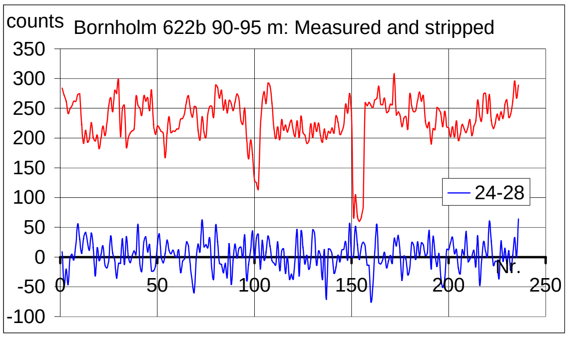


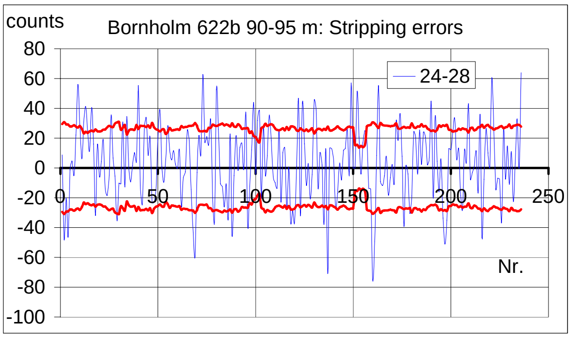


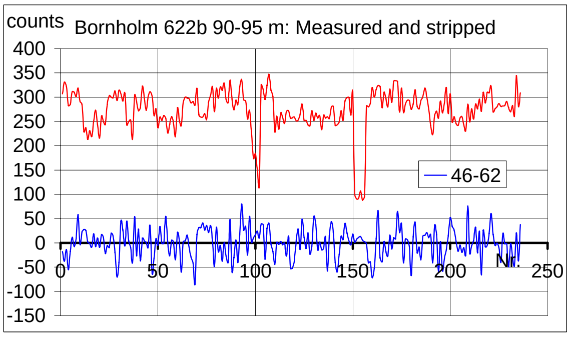

counts
Bornholm 622b 85-90 m: Measured and stripped
193-243
150
100
50
0
-50
0
200
400
600
800
1000
Nr.

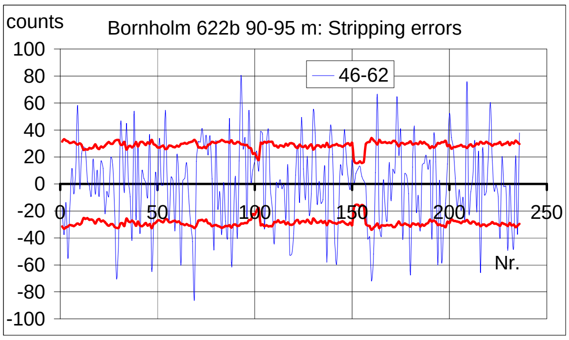

counts
Bornholm 622b 85-90 m: Stripping errors
193-243
50
40
30
20
10
0
-10
-20
-30
-40
0
200
400
600
800
1000
Nr.

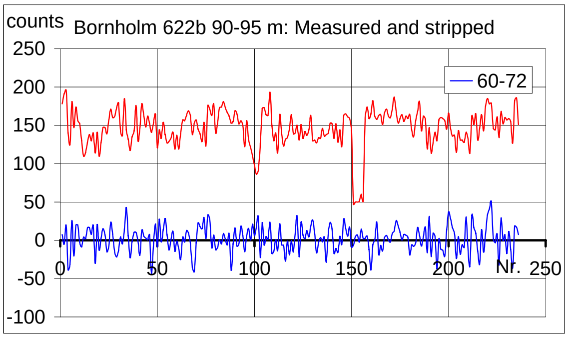
Bornholm file 622b: 90-95 m

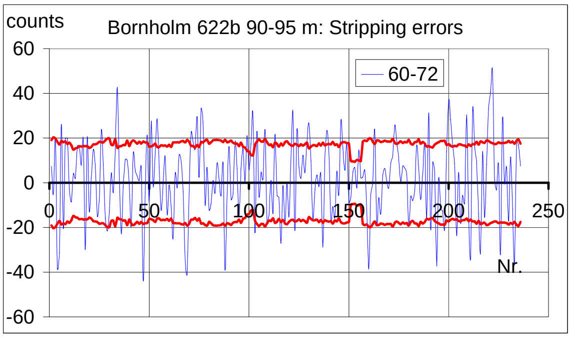


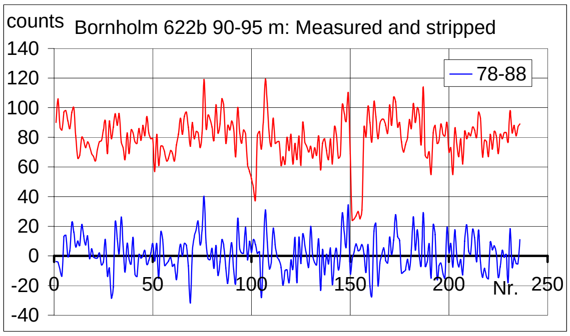


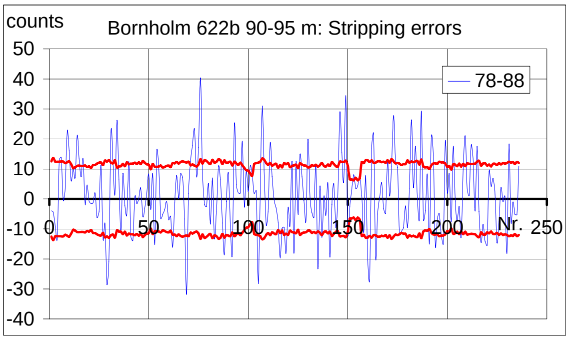




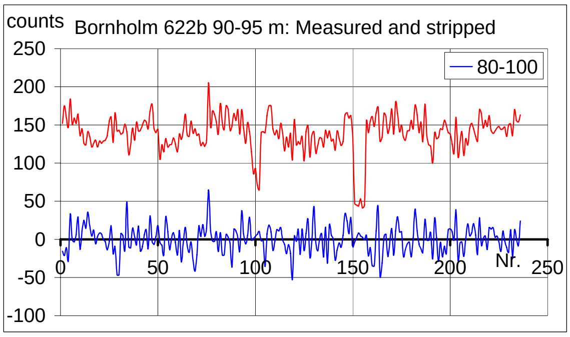


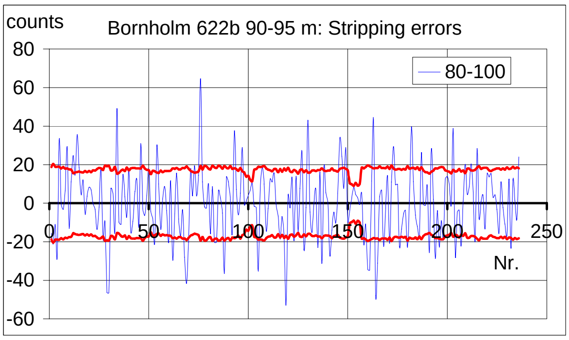


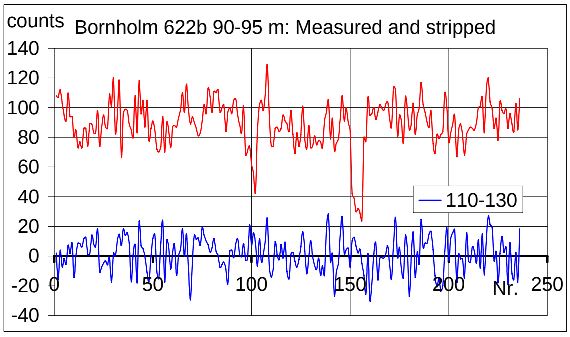


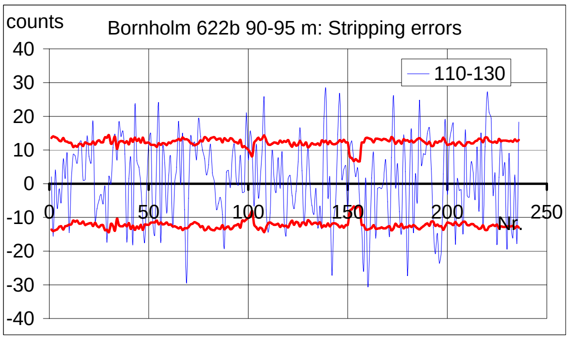


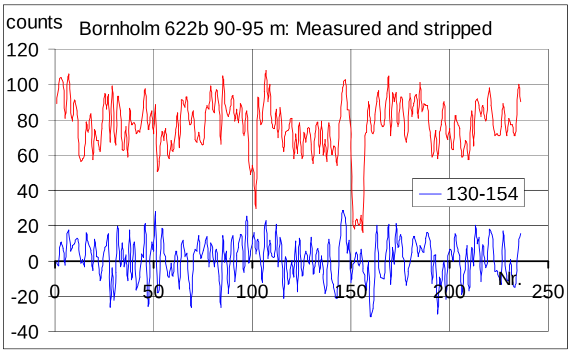
Bornholm file 622b: 90-95 m

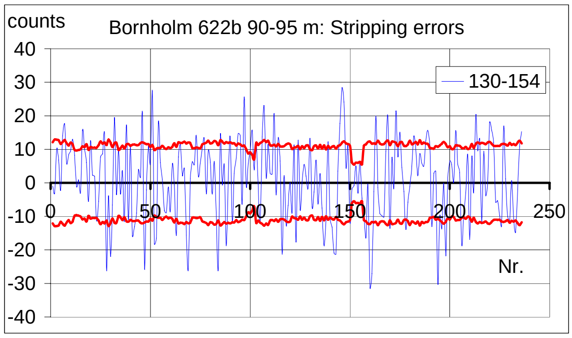


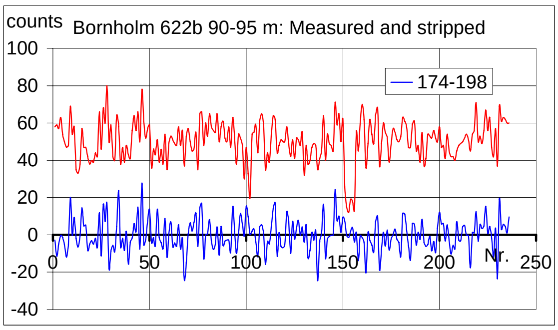


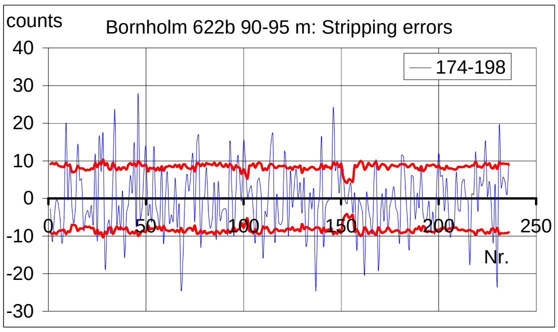


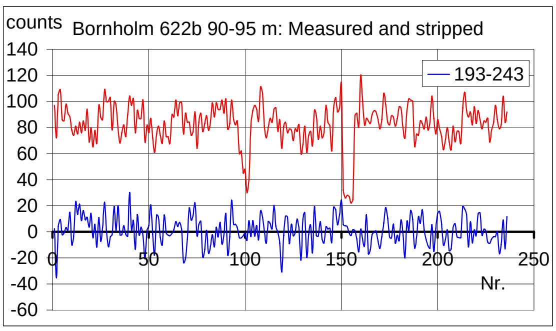


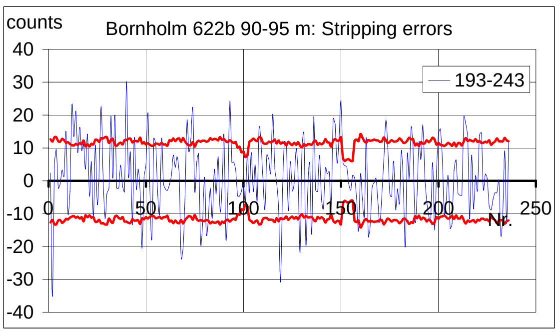




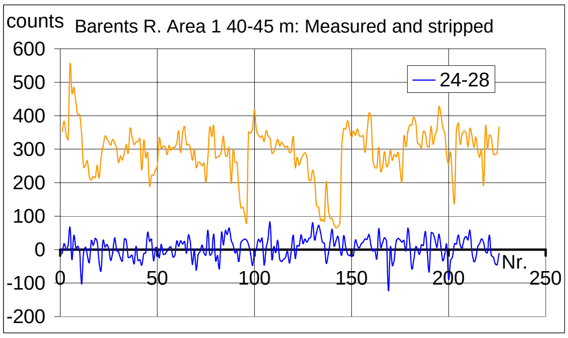


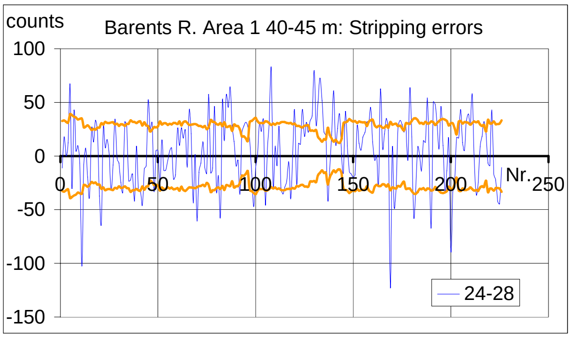


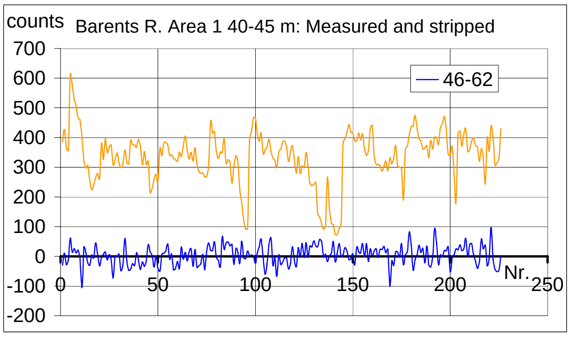


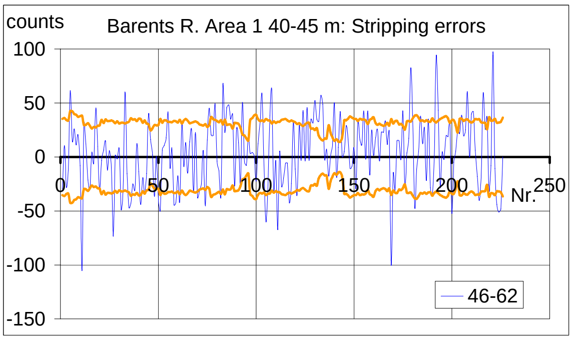


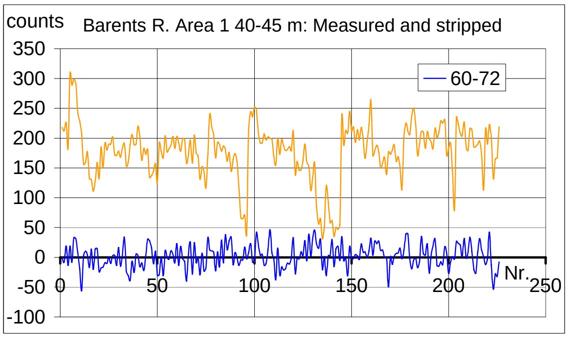
Barents Rescue Area A1: 40-45 m

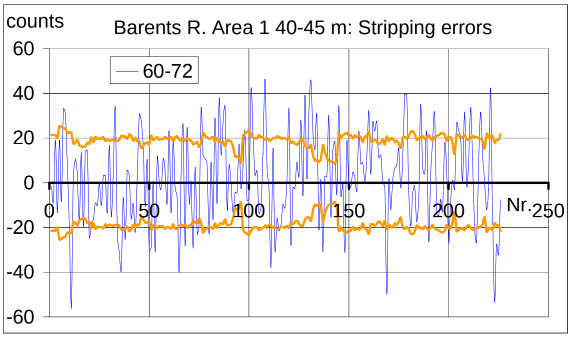


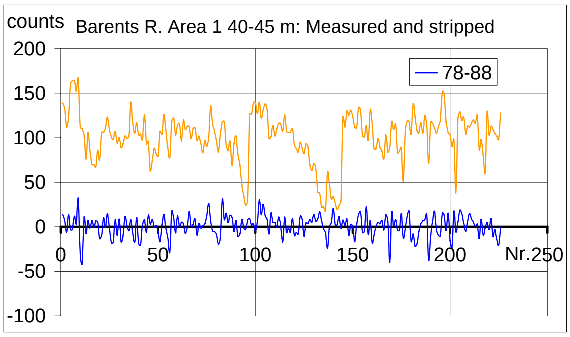


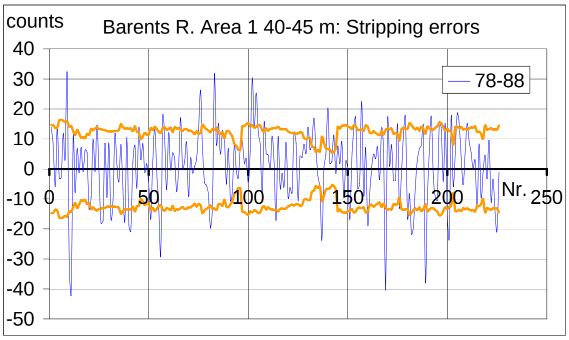




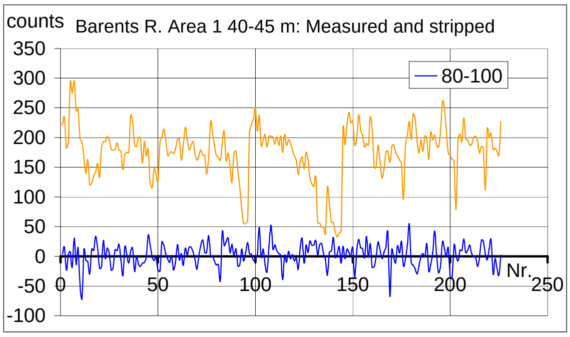


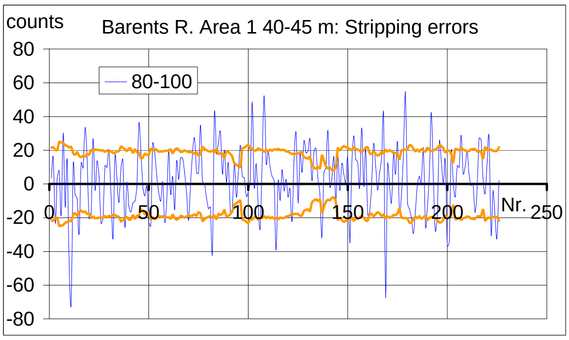


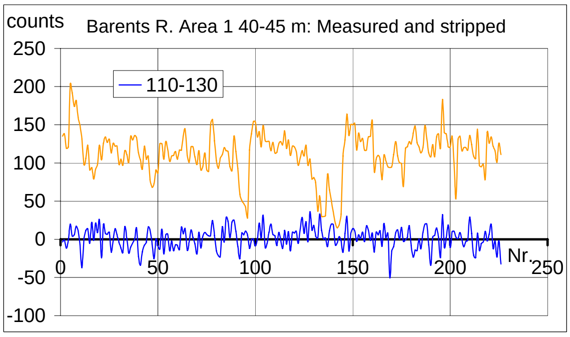


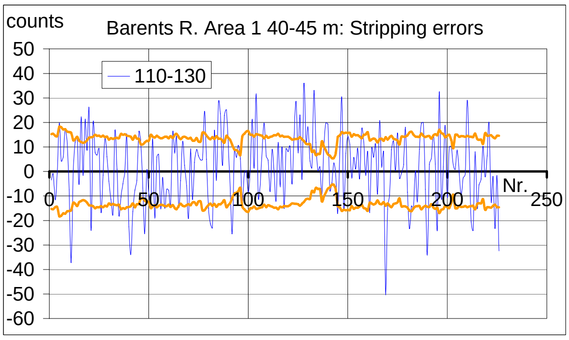


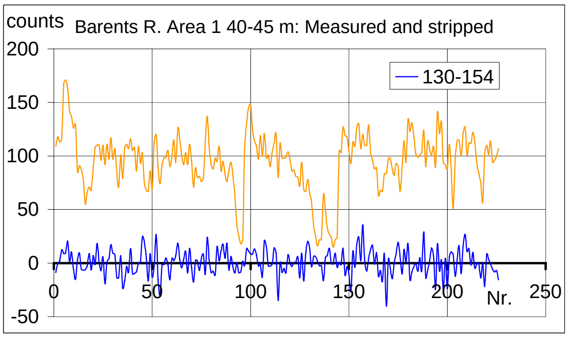
Barents Rescue Area A1: 40-45 m

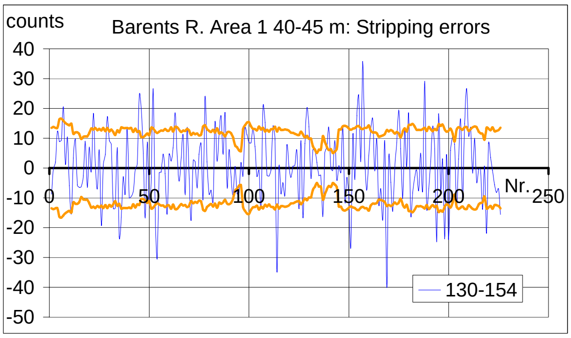


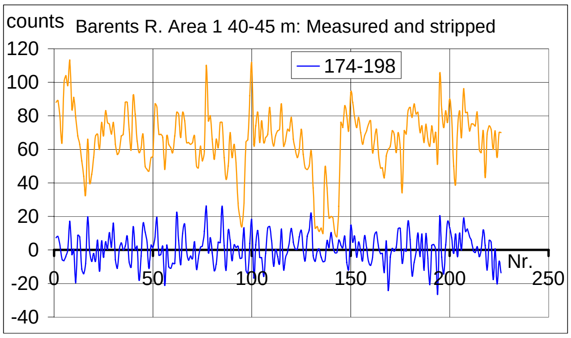


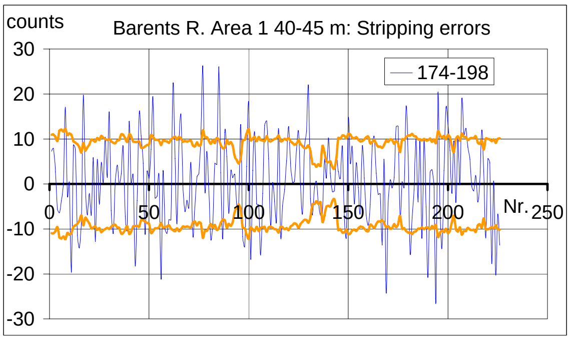


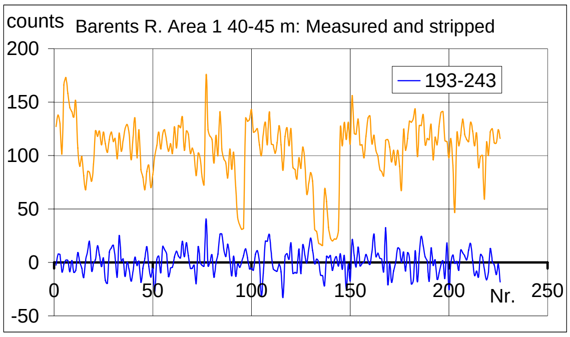


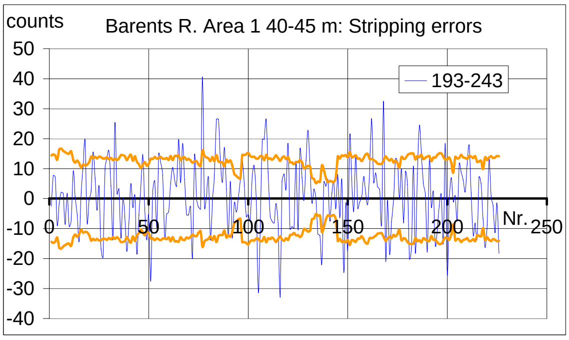




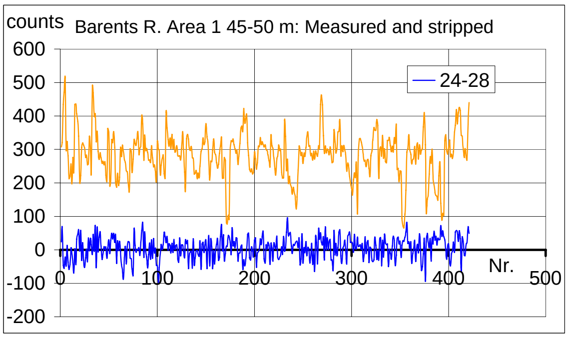


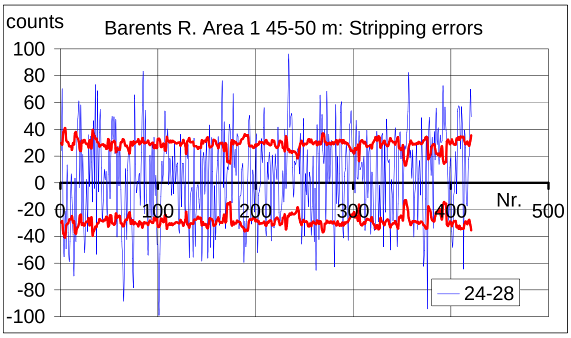


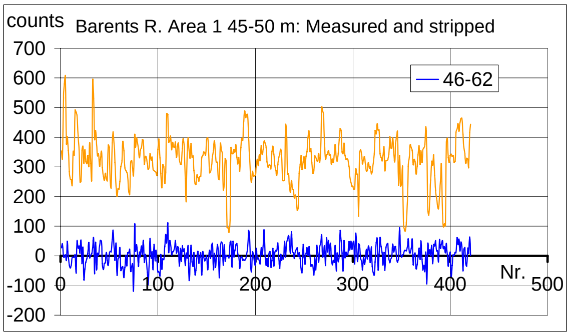


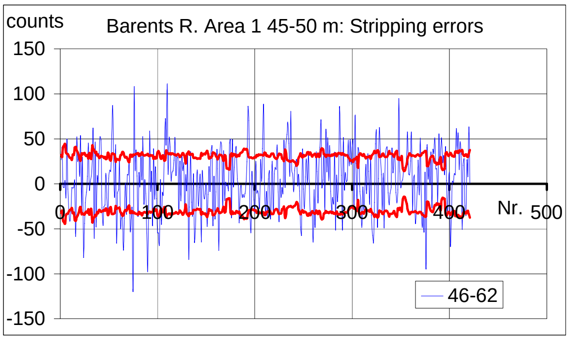


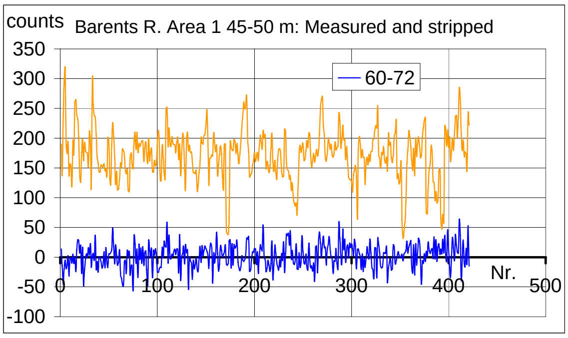
Barents Rescue Area A1: 45-50 m

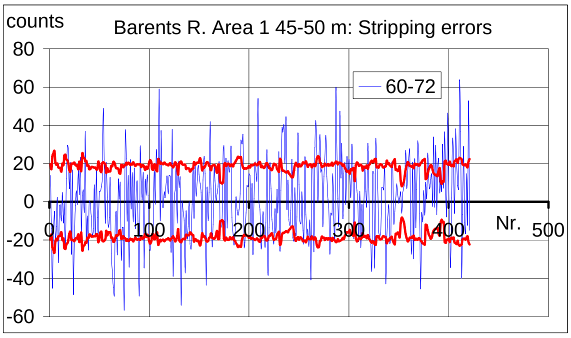


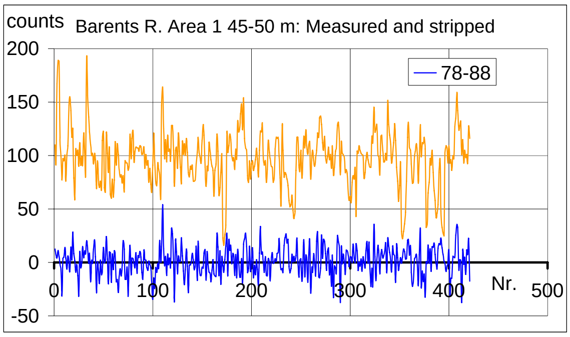


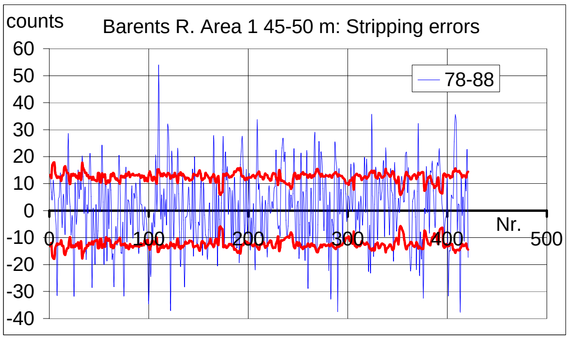




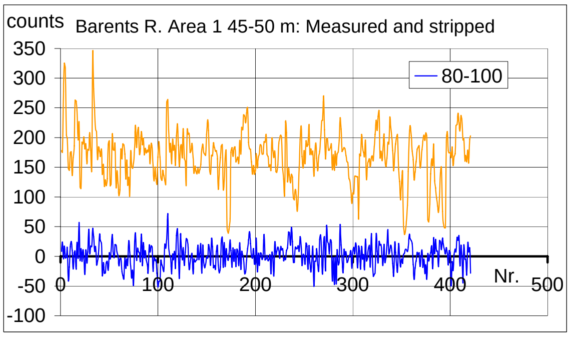


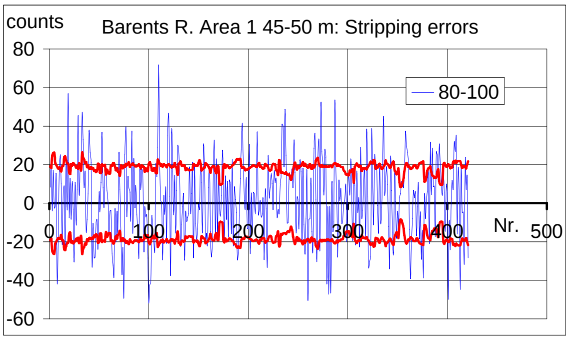


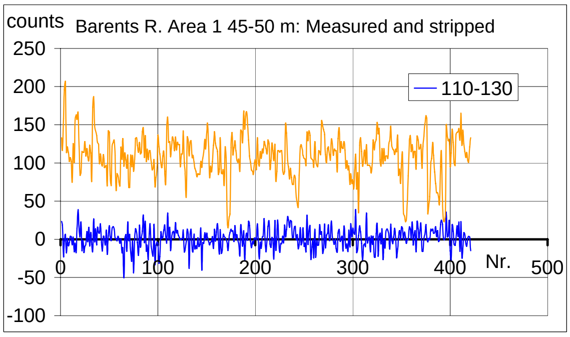

counts
Barents R. Area 1 45-50 m: Measured and stripped
78-88
200
150
100
50
0
-50
0
100
200
300
400
500
Nr.

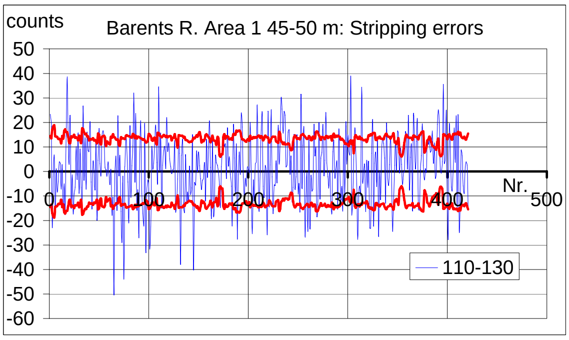

counts
Barents R. Area 1 45-50 m: Stripping errors
78-88
60
50
40
30
20
10
0
-10
-20
-30
-40
0
100
200
300
400
500
Nr.

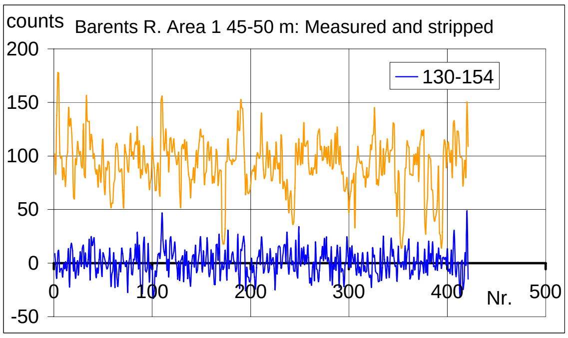
Barents Rescue Area A1: 45-50 m

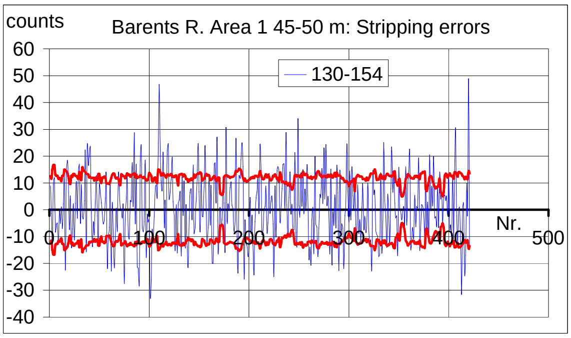


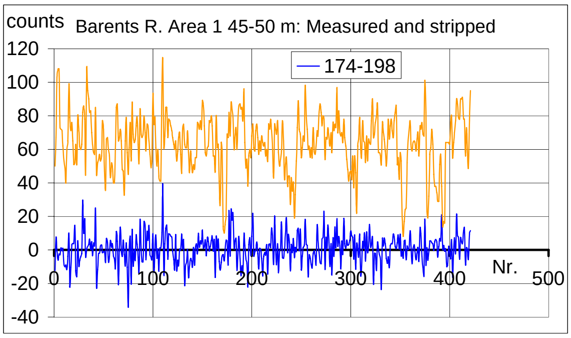


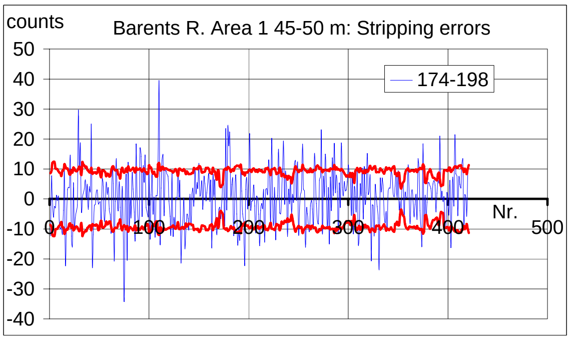


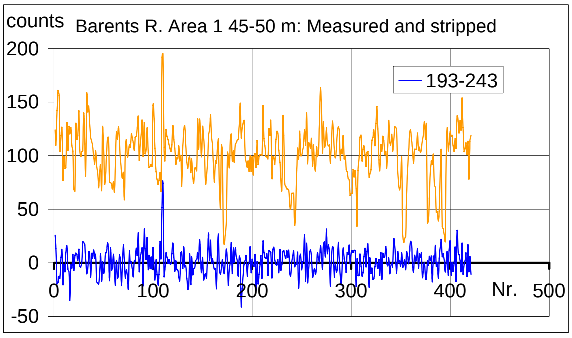


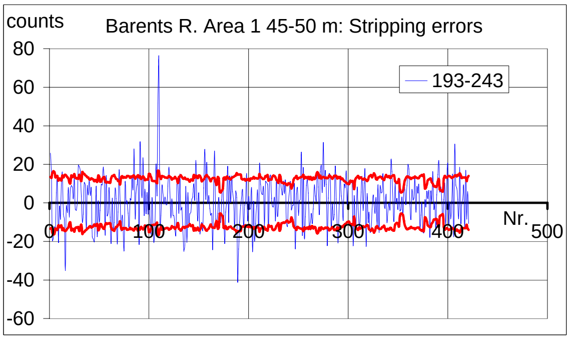




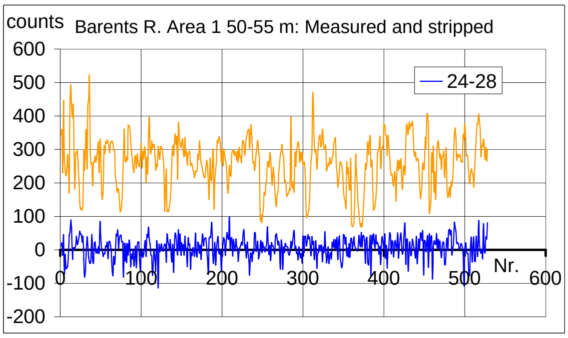


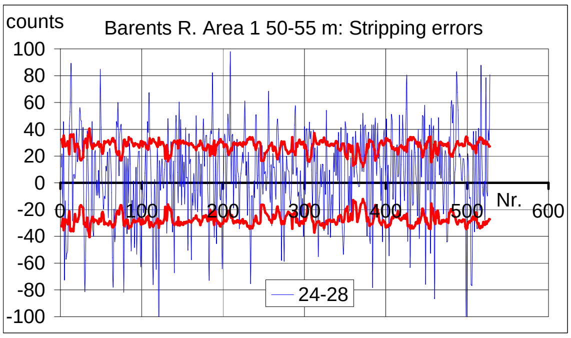


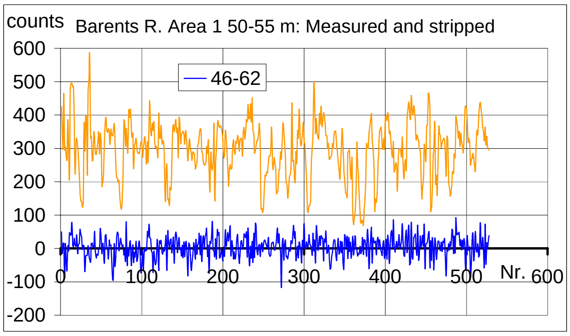


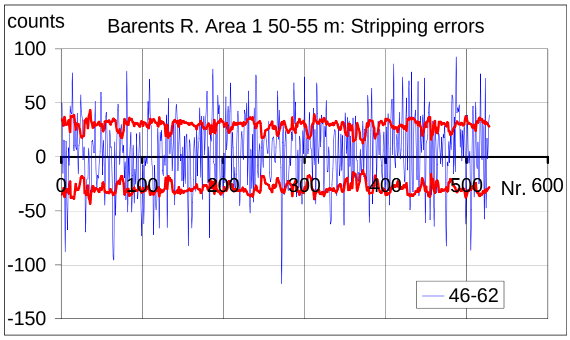


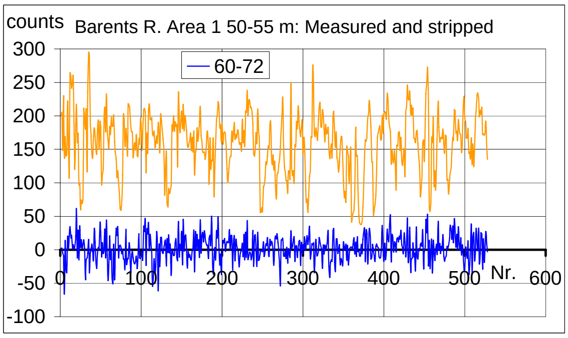
Barents Rescue Area A1: 50-55 m

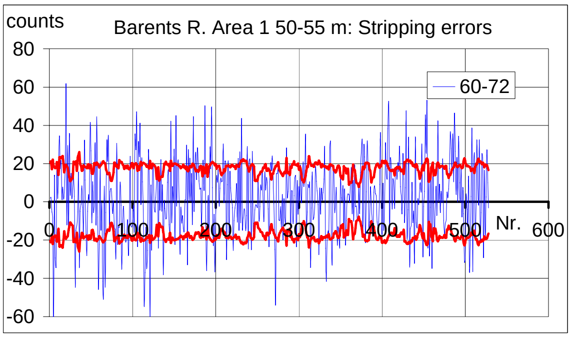


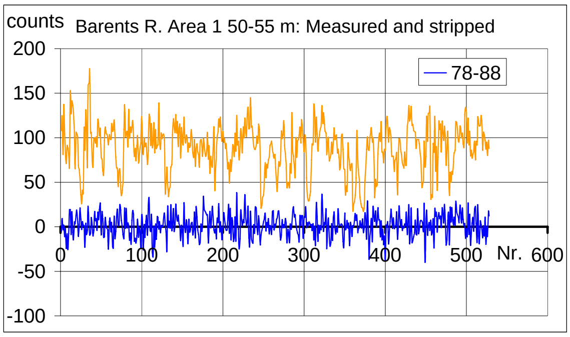


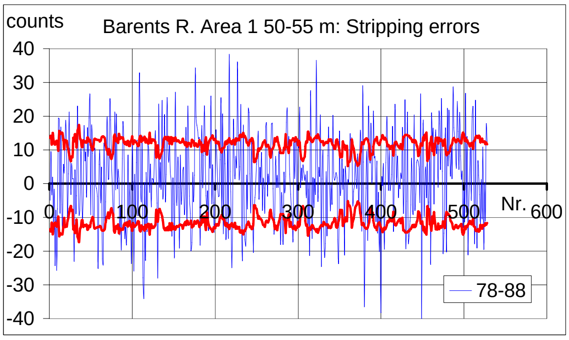




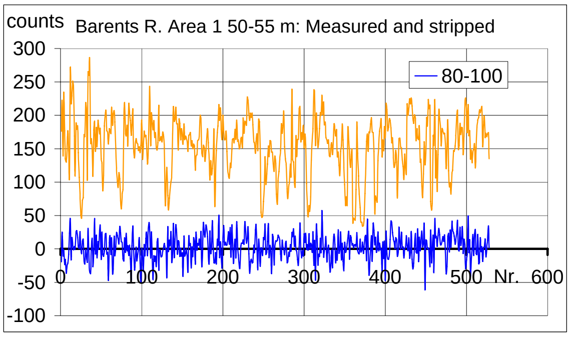


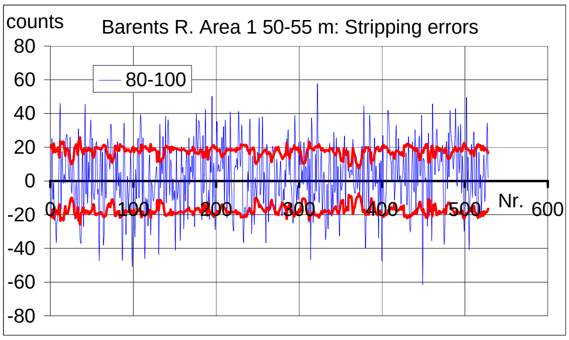


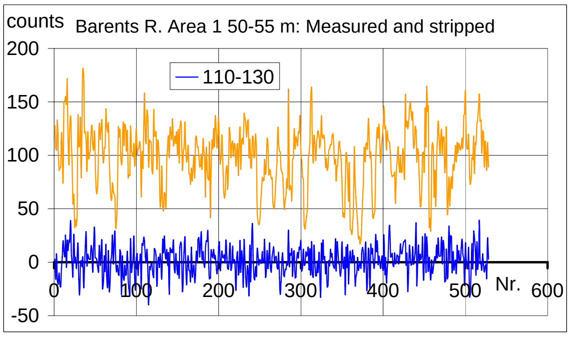

counts
Barents R. Area 1 50-55 m: Measured and stripped
78-88
Nr.

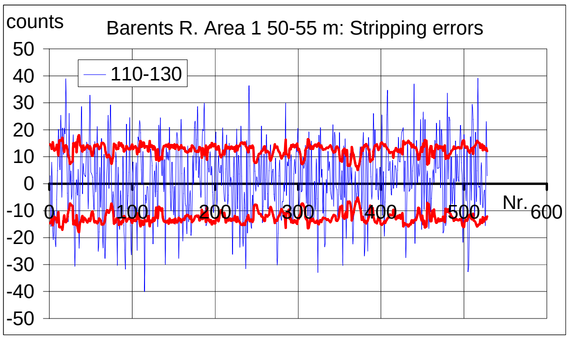

counts
Barents R. Area 1 50-55 m: Stripping errors
78-88
Nr.

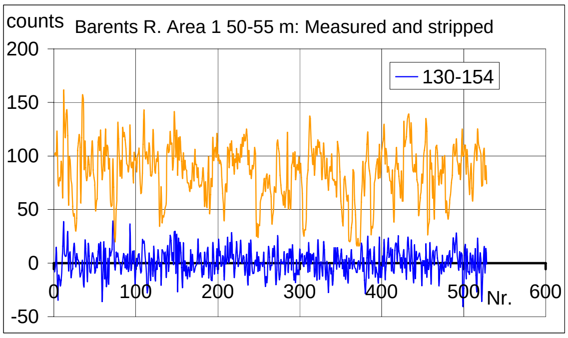
Barents Rescue Area A1: 50-55 m

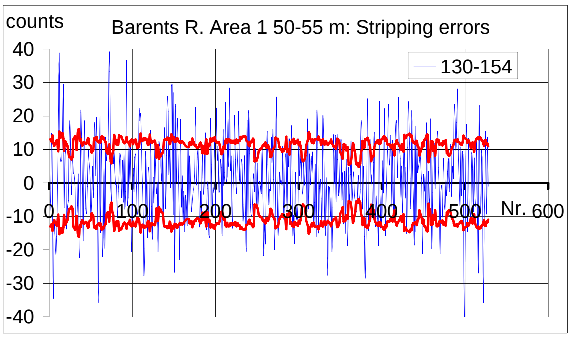


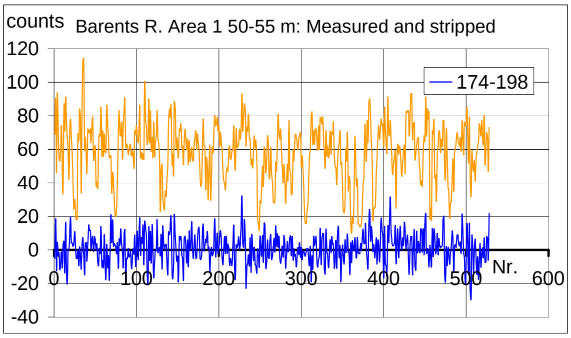


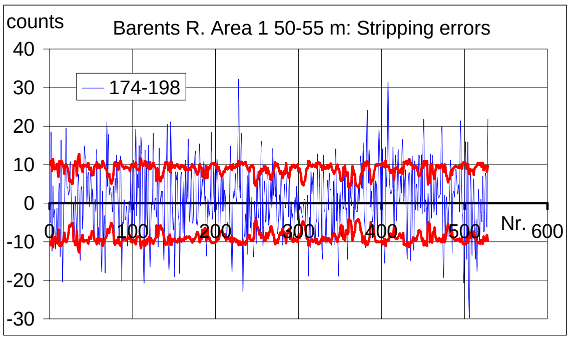


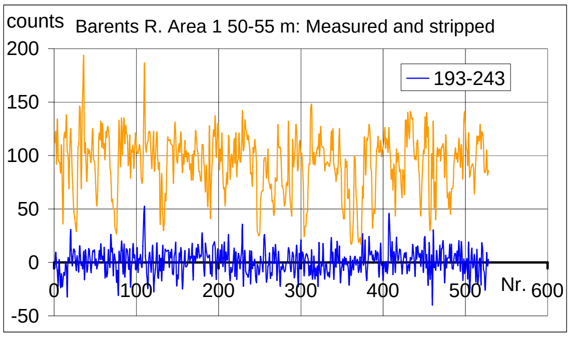


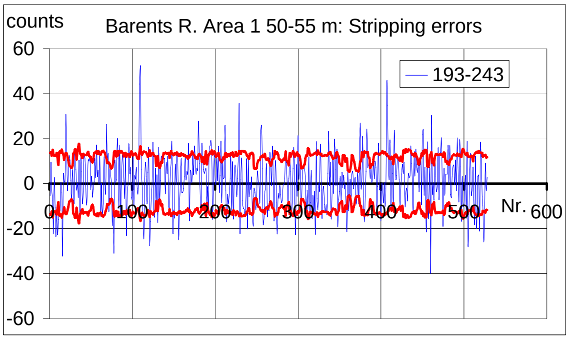




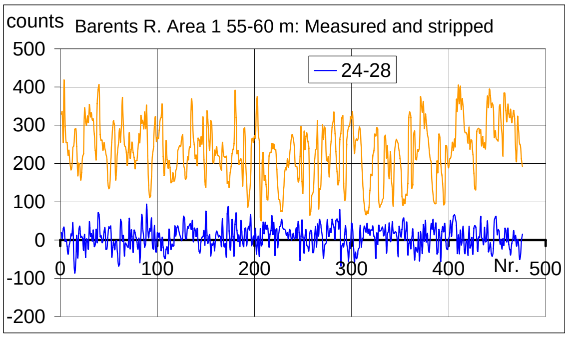


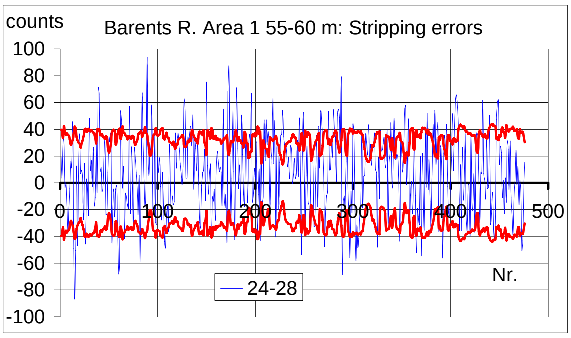


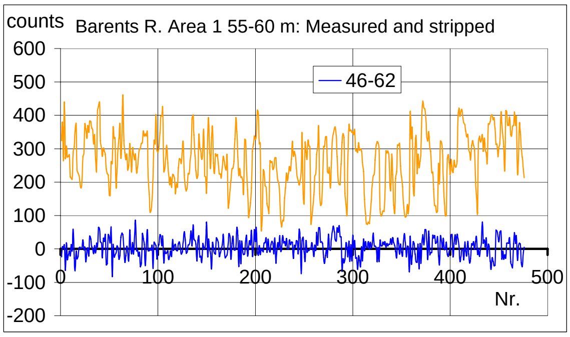

counts
Barents R. Area 1 50-55 m: Measured and stripped
193-243
Nr.

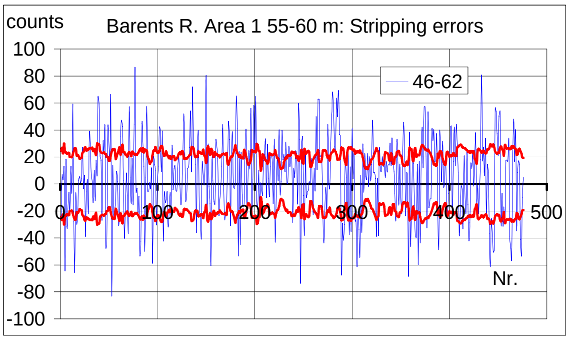

counts
Barents R. Area 1 50-55 m: Stripping errors
193-243
Nr.

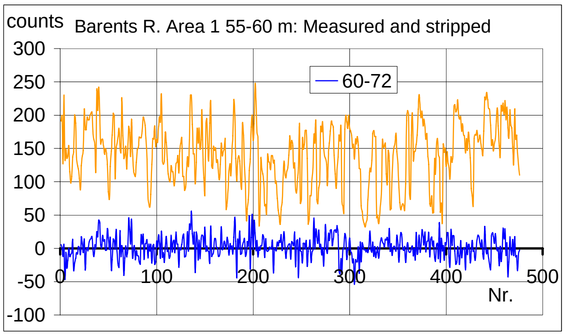
Barents Rescue Area A1: 55-60 m

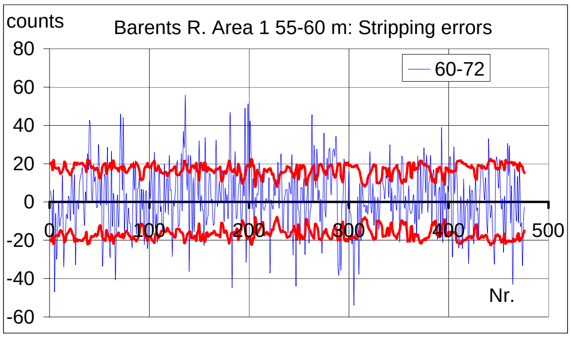


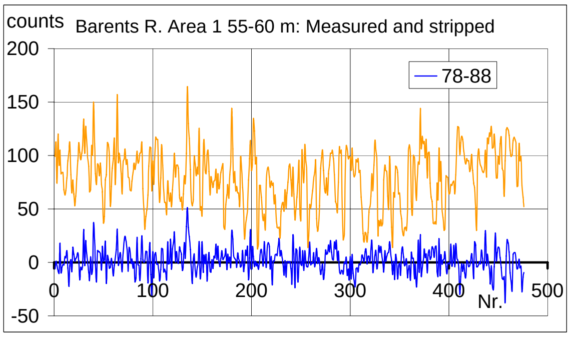


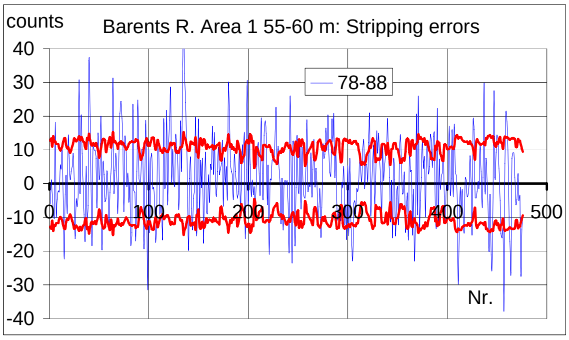




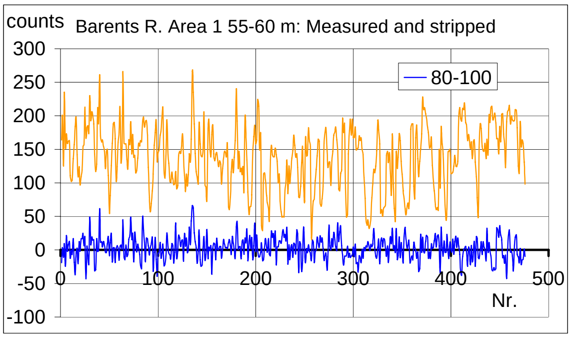


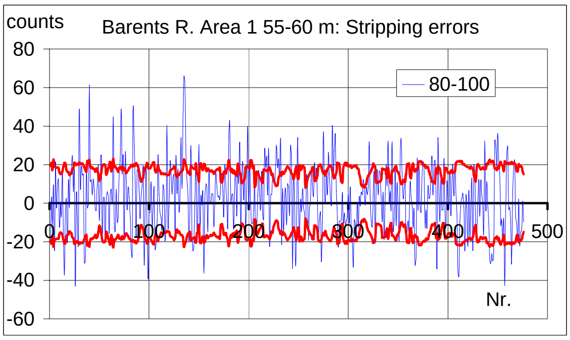


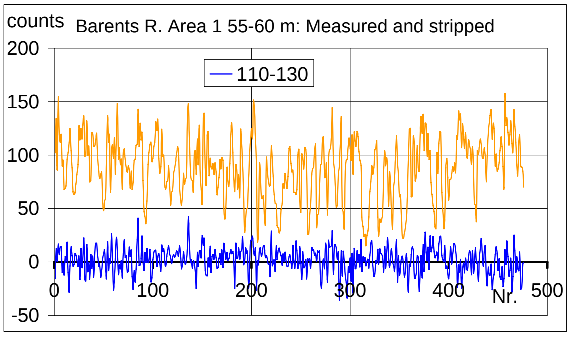


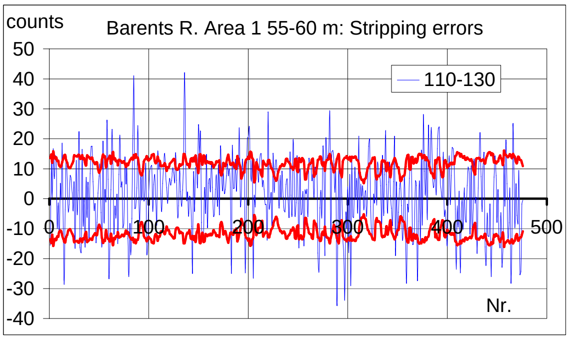


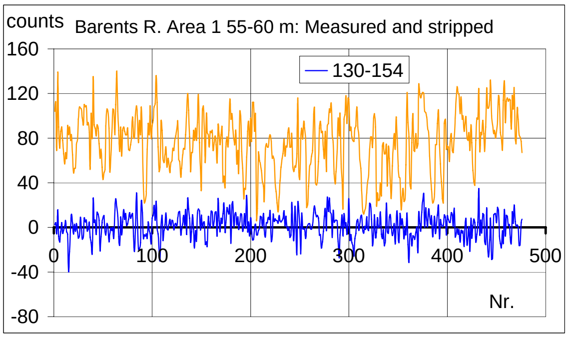
Barents Rescue Area A1: 55-60 m

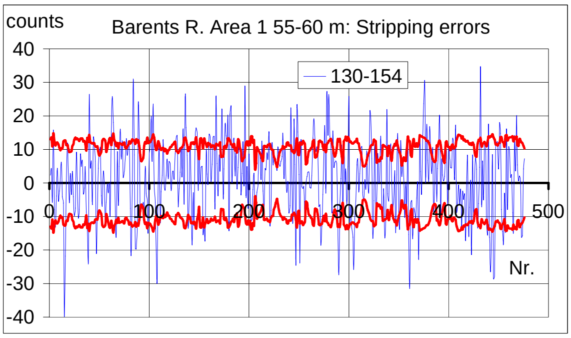


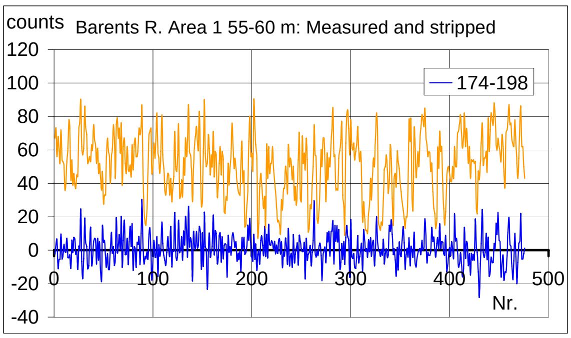


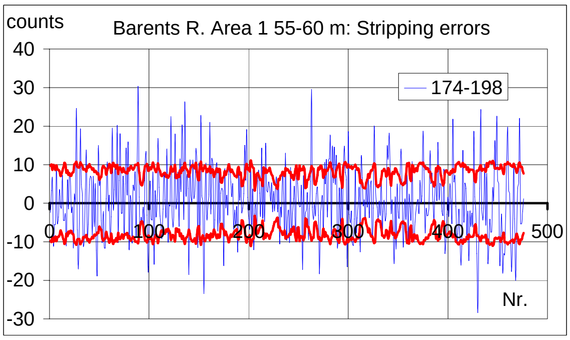


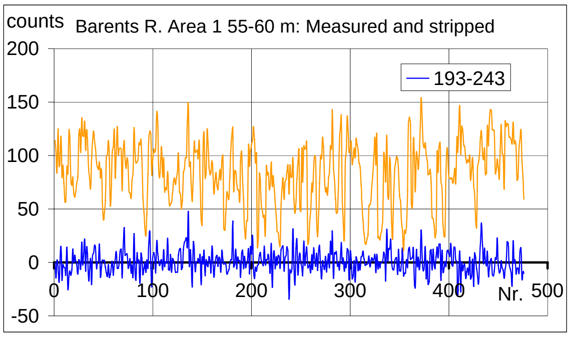


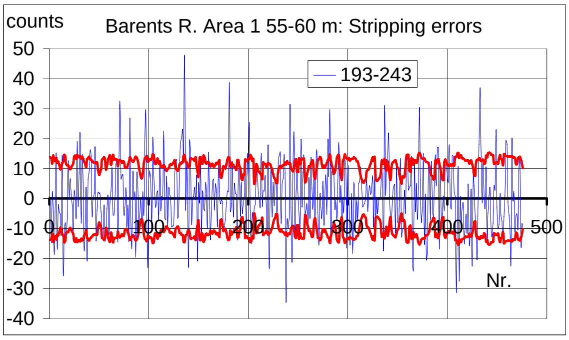




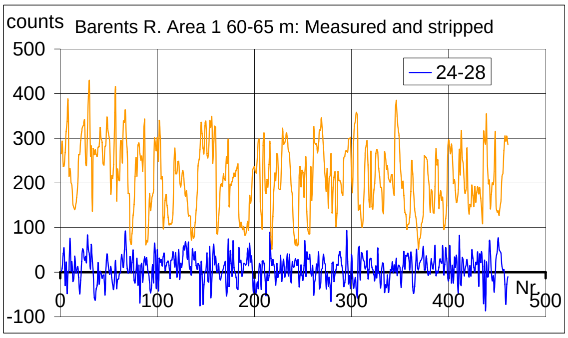


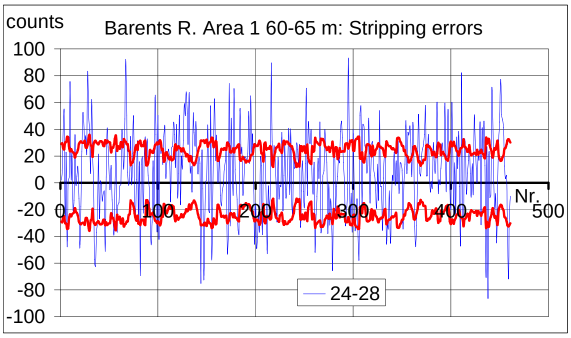


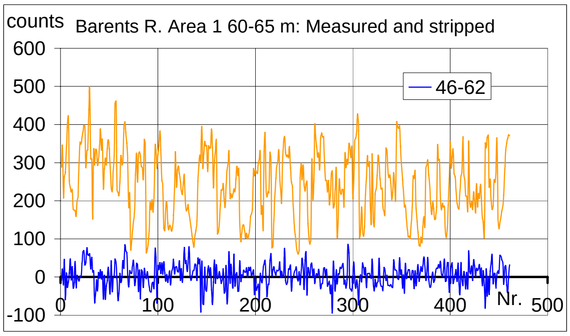


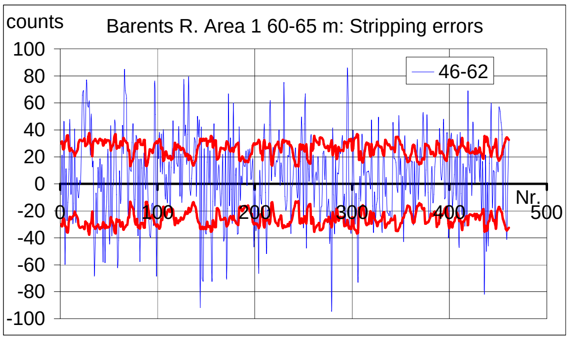


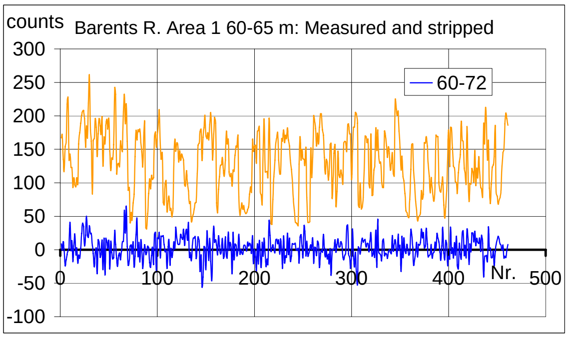
Barents Rescue Area A1: 60-65 m

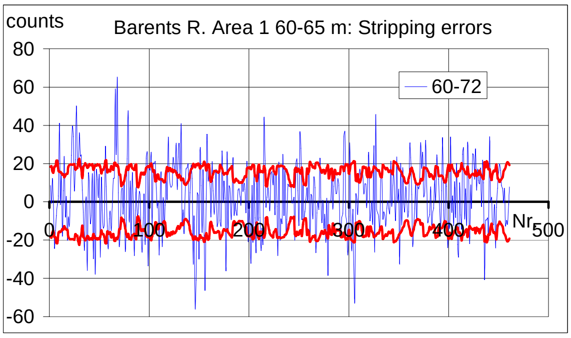


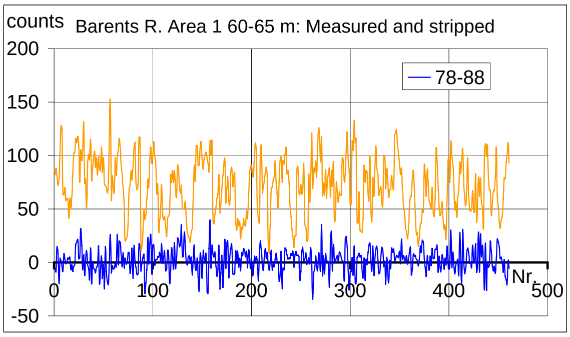




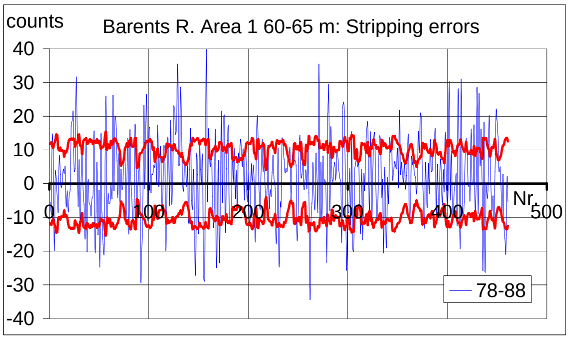






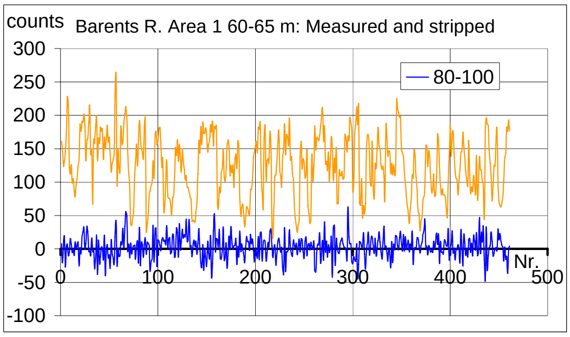


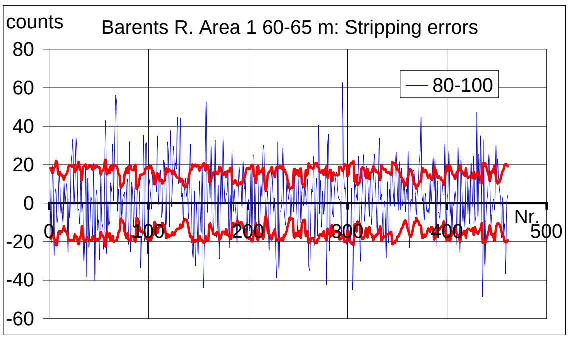
counts
Barents R. Area 1 60-65 m: Measured and stripped
200
150
100
50
0
-50
0
100
200
300
400
500
Nr.
78-88

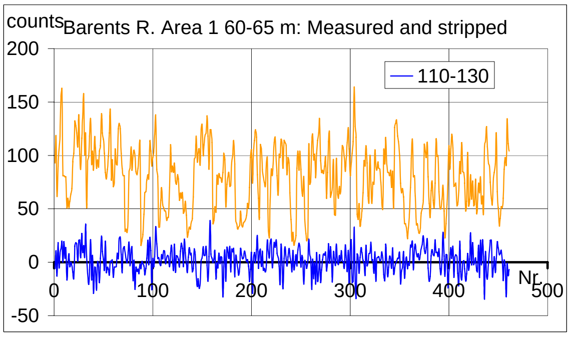


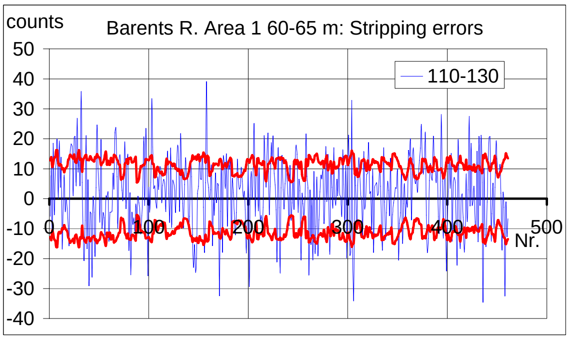
counts
Barents R. Area 1 60-65 m: Stripping errors
40
30
20
10
0
-10
-20
-30
-40
0
100
200
300
400
500
Nr.
78-88

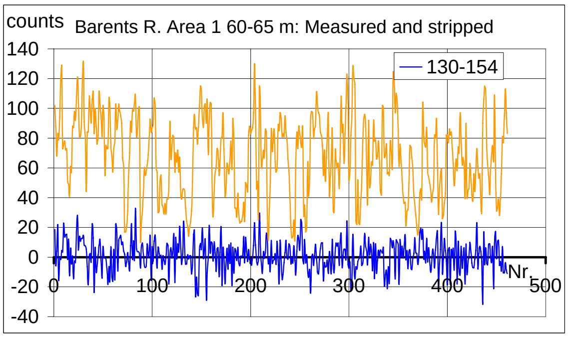
Barents Rescue Area A1: 60-65 m

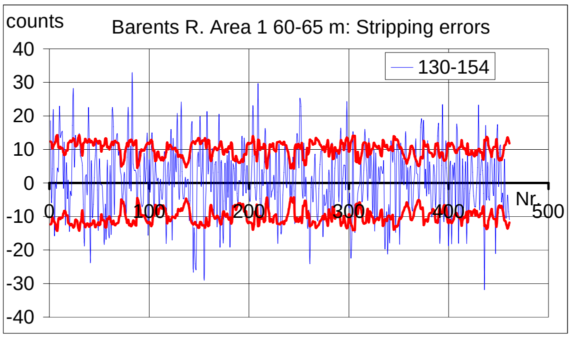


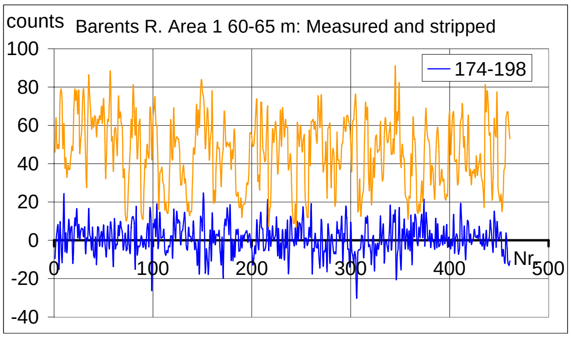


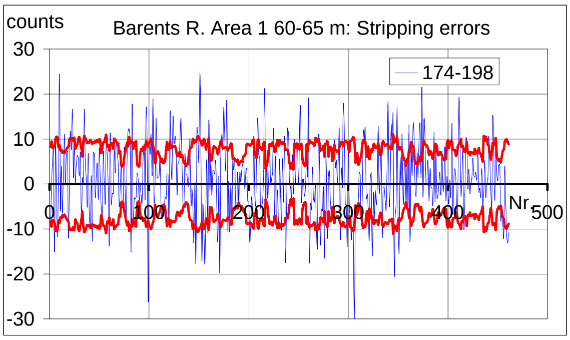


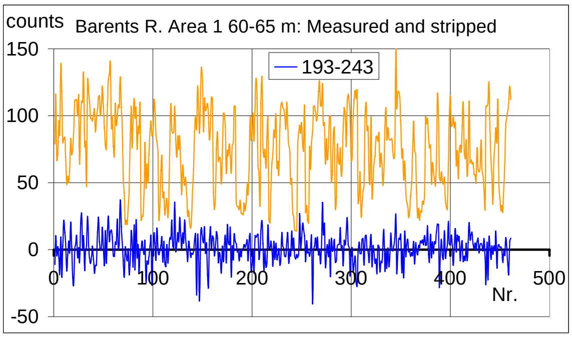


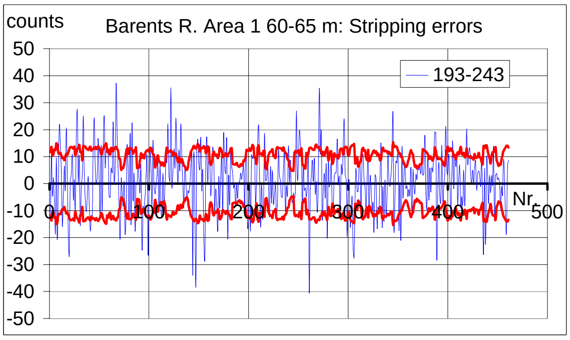




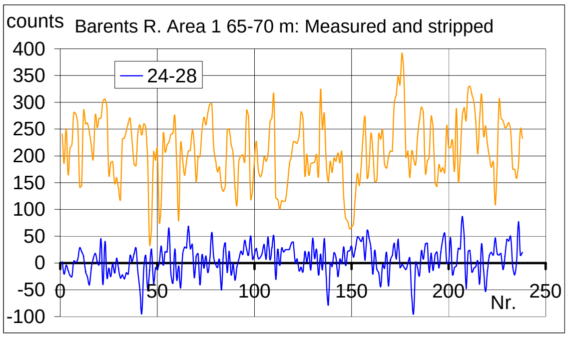


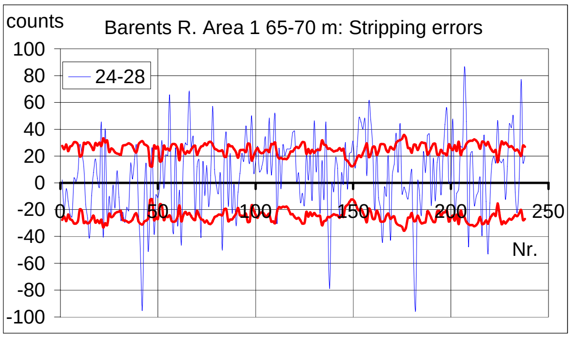


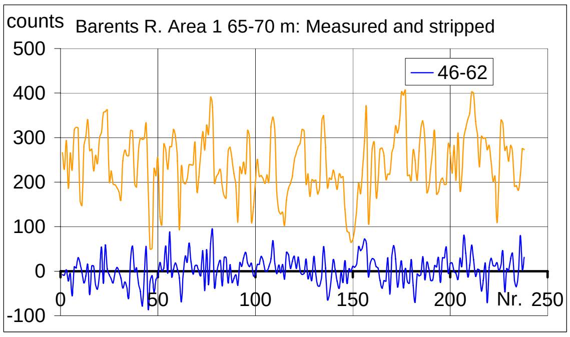

counts
Barents R. Area 1 60-65 m: Measured and stripped
193-243
150
100
50
0
-50
0
100
200
300
400
500
Nr.

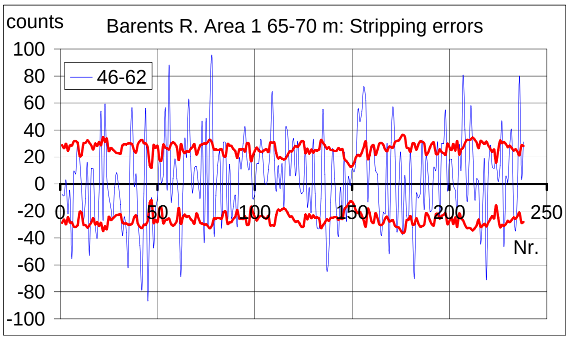

counts
Barents R. Area 1 60-65 m: Stripping errors
193-243
50
40
30
20
10
0
-10
-20
-30
-40
-50
0
100
200
300
400
500
Nr.

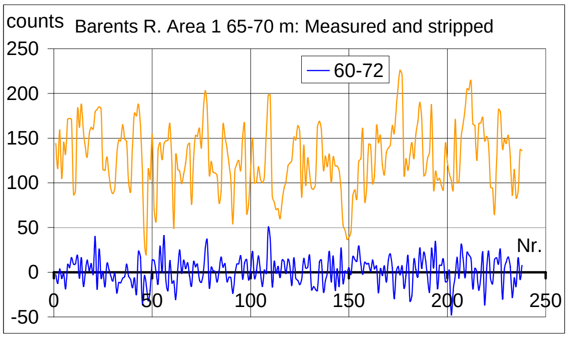
Barents Rescue Area A1: 65-70 m

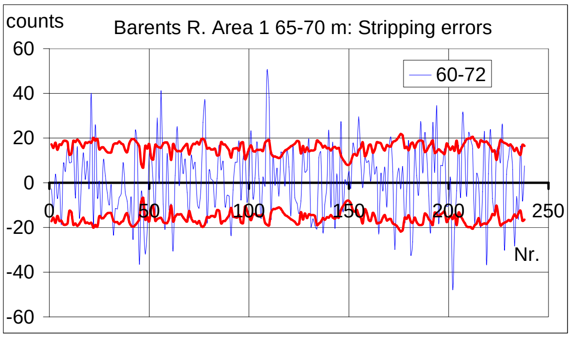


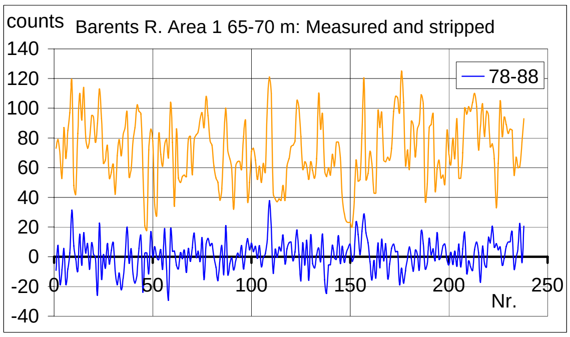


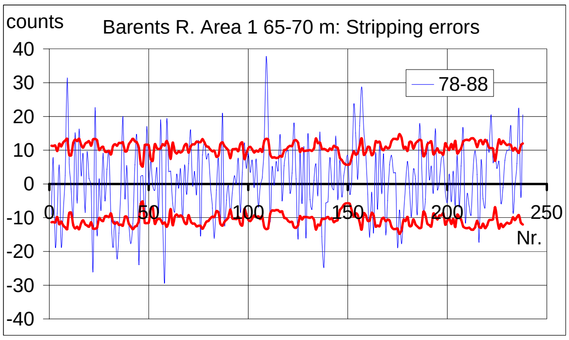




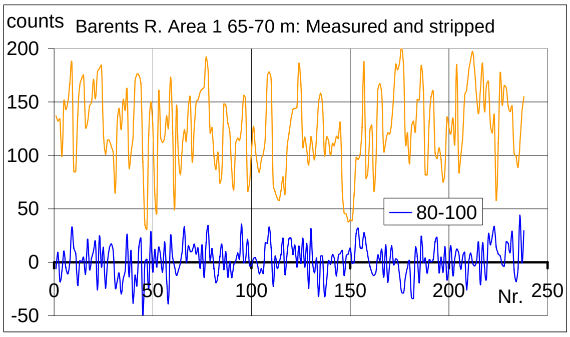


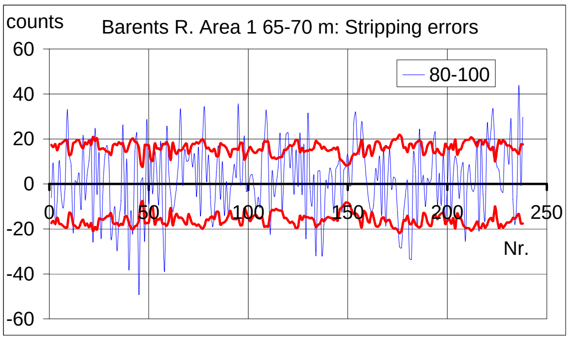


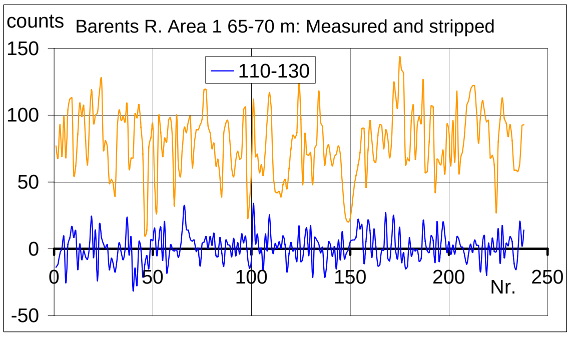


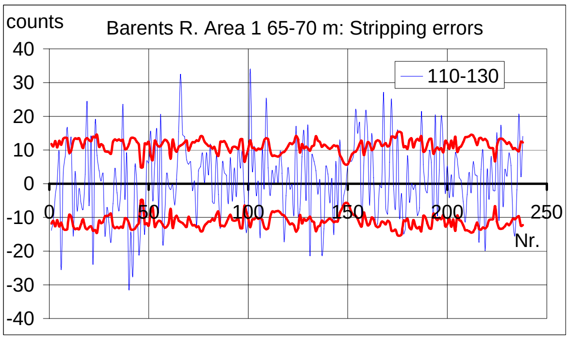


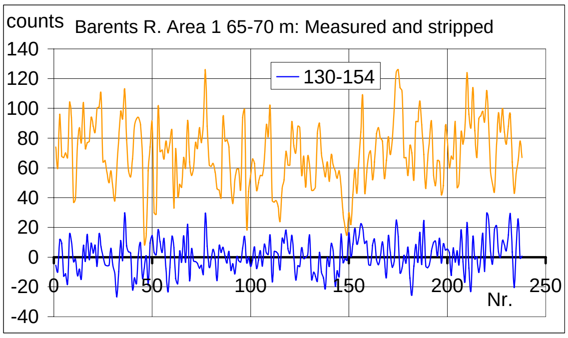
Barents Rescue Area A1: 65-70 m

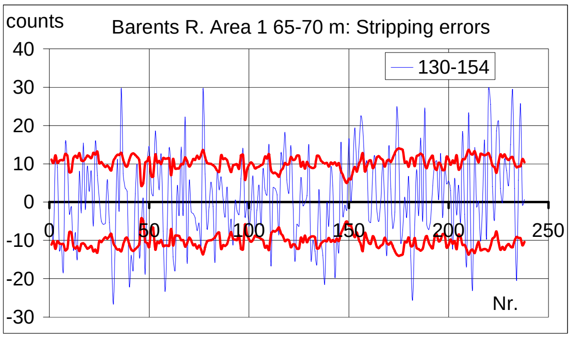


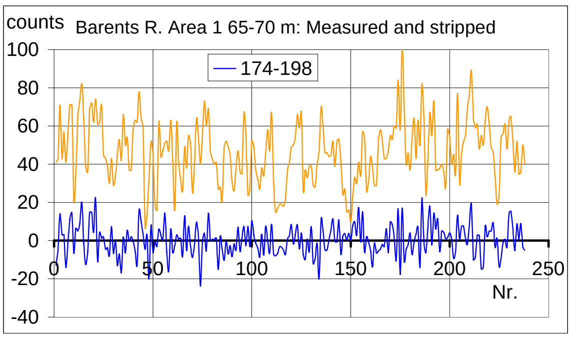


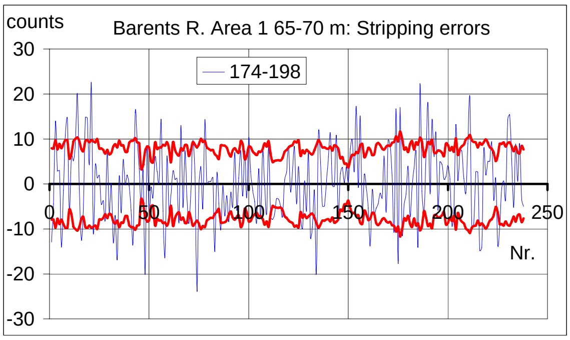


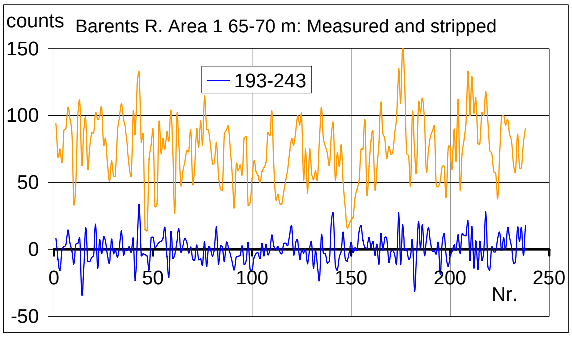


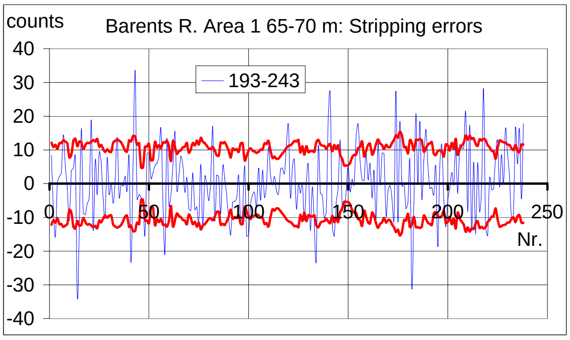




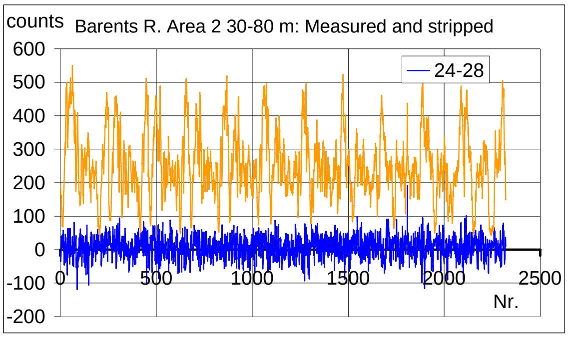


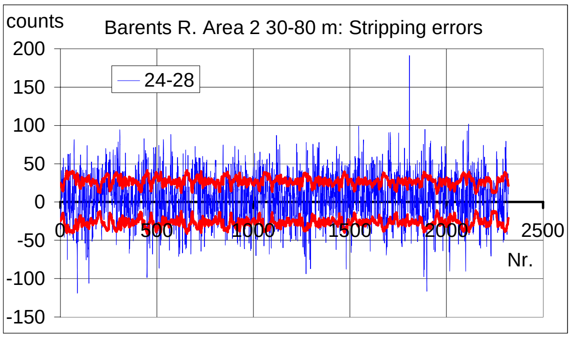


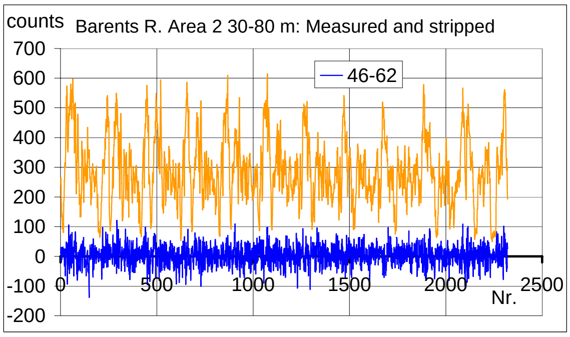

counts
Barents R. Area 1 65-70 m: Measured and stripped
193-243
150
100
50
0
-50
0
50
100
150
200
250
Nr.

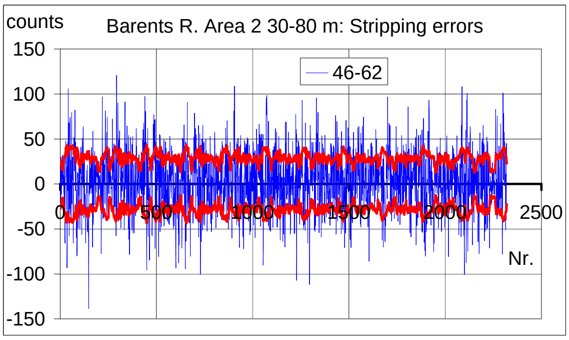

counts
Barents R. Area 1 65-70 m: Stripping errors
193-243
40
30
20
10
0
-10
-20
-30
-40
0
50
100
150
200
250
Nr.

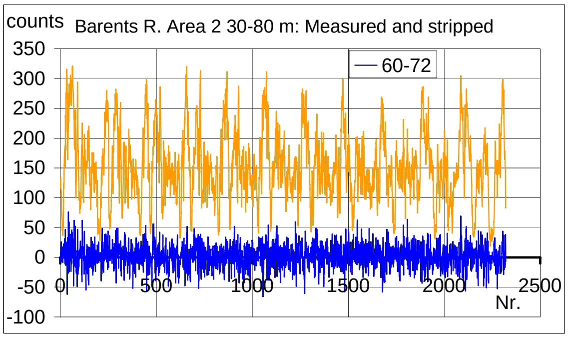
Barents Rescue Area A2: 30-80 m

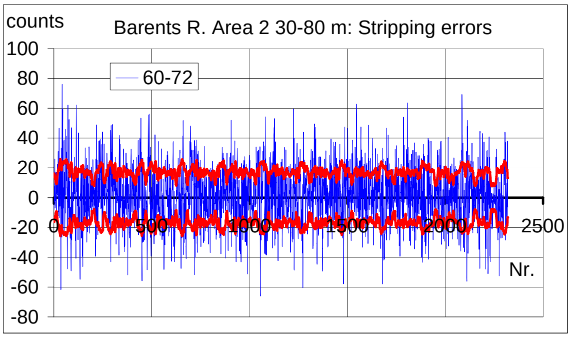


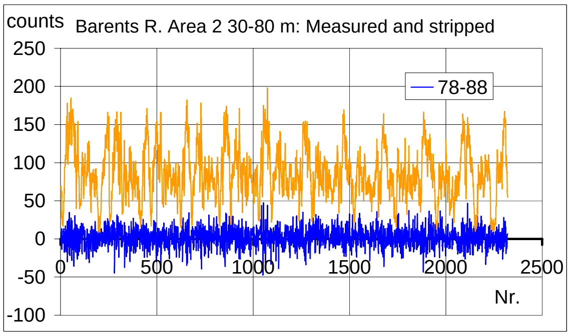


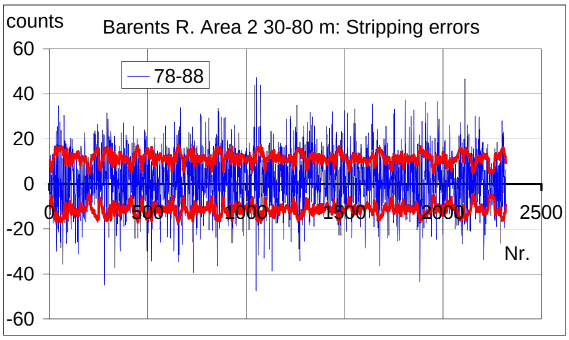




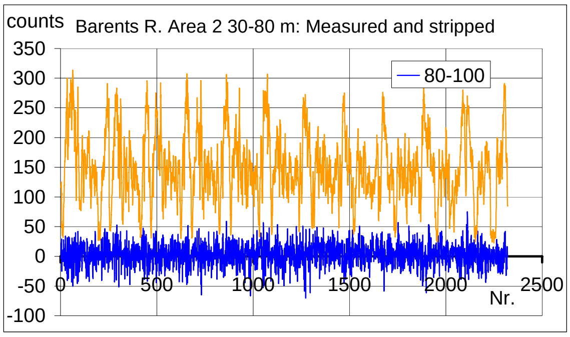


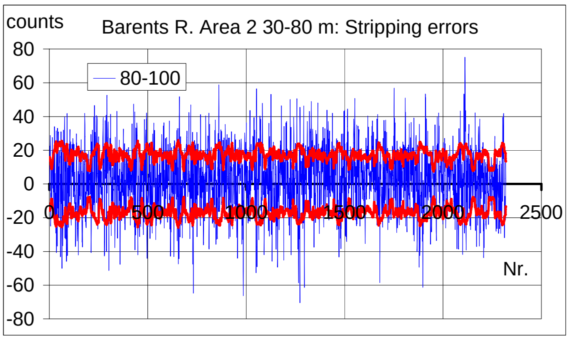


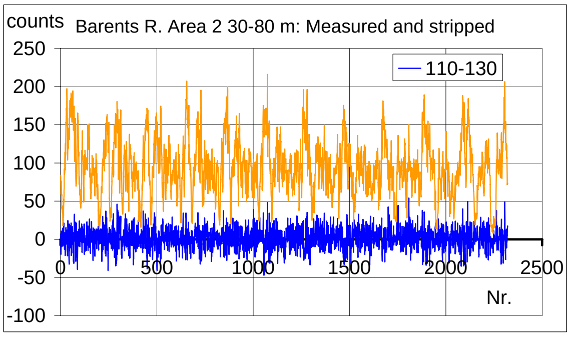


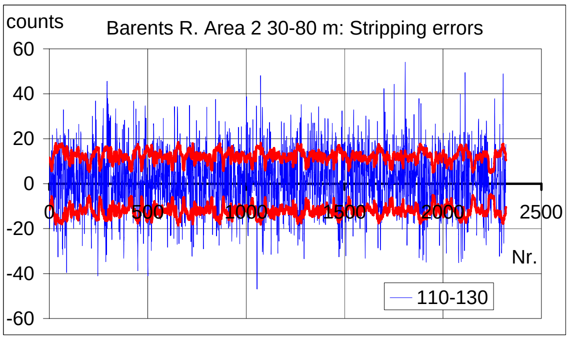


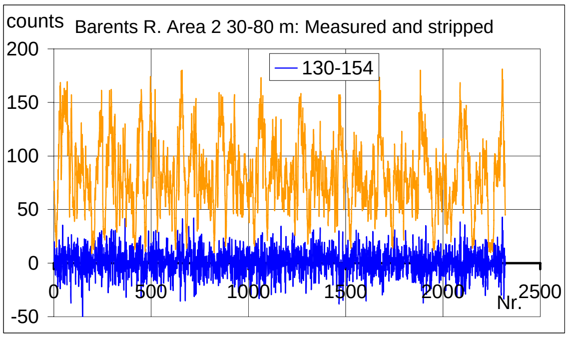
Barents Rescue Area A2: 30-80 m

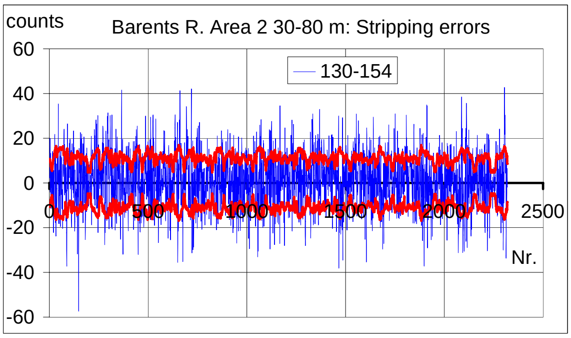


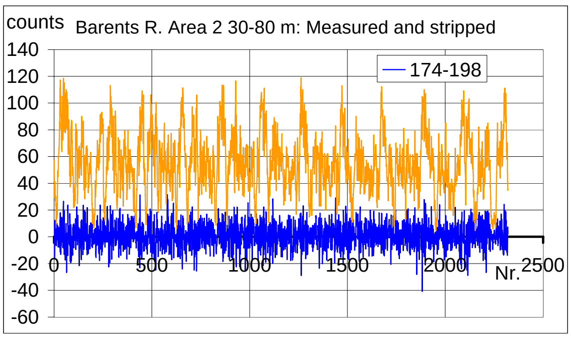


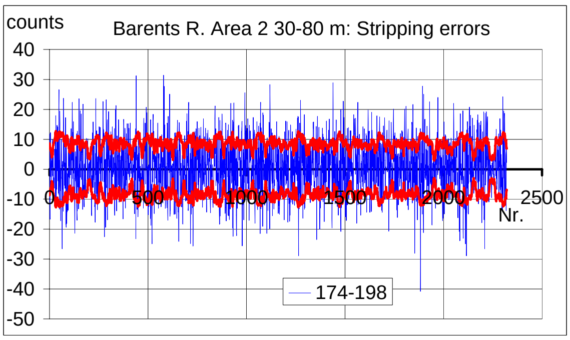


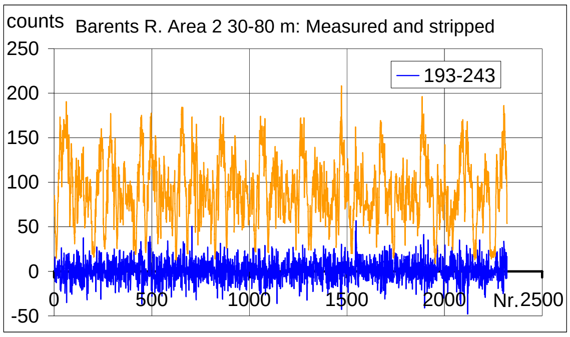


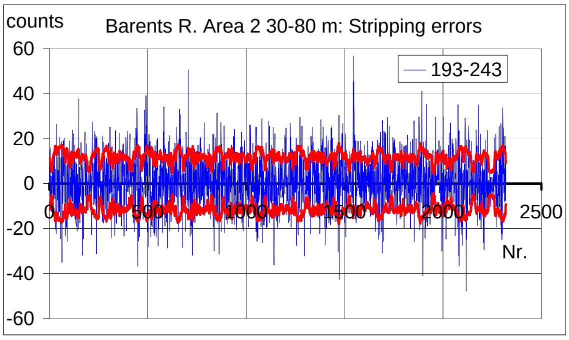








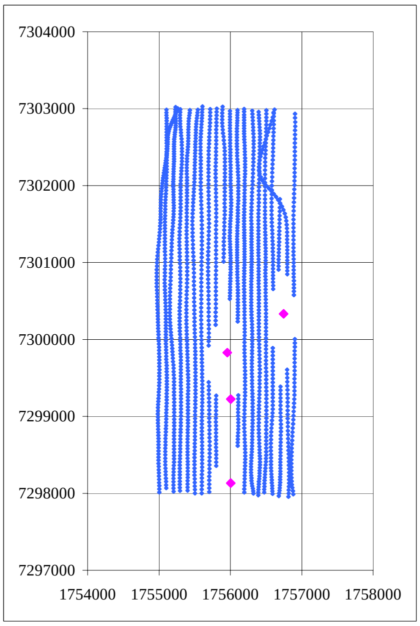

counts
Barents R. Area 2 30-80 m: Measured and stripped
250
200
150
100
50
0
-50
193-243
0
500
1000
1500
2000
Nr.
2500


counts
Barents R. Area 2 30-80 m: Stripping errors
60
40
20
0
-20
-40
-60
193-243
0
500
1000
1500
2000
2500
Nr.

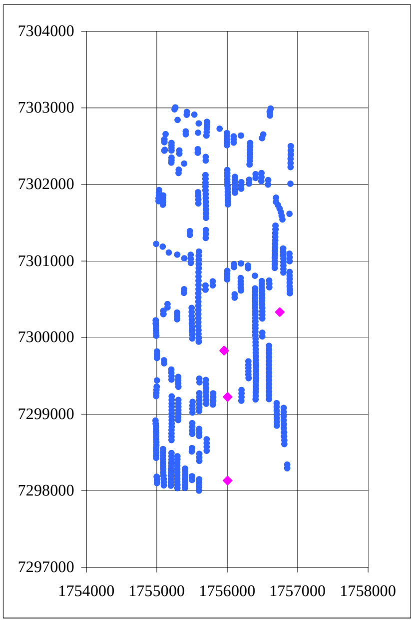
Appendix N: XY plots (RT90) of measurements sorted in height intervals. Barents Rescue Area A1 and A2.

Barents Rescue Area A1 Measurements. Sources shown on plots.

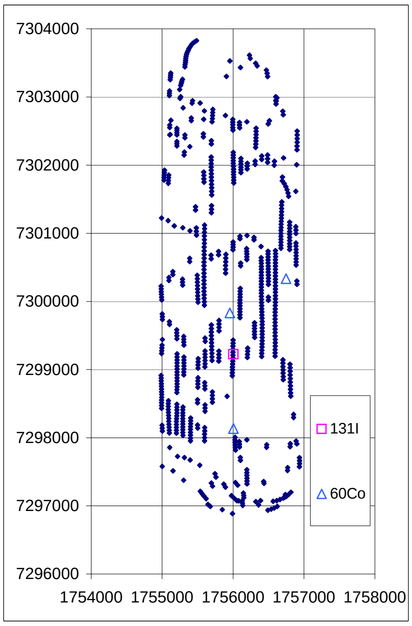
Confer Appendix K for source information



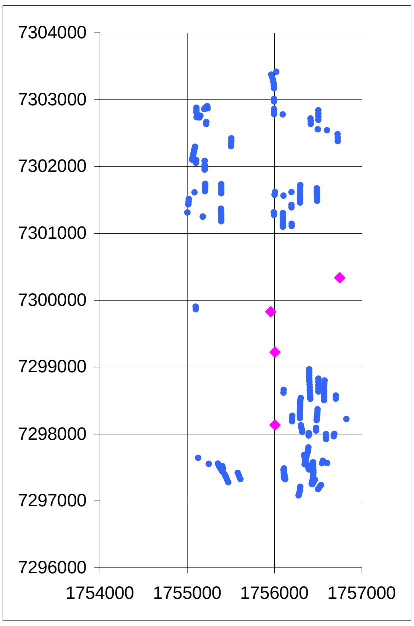
A1. All measurements (helicopter turns not showed). Modified data set. (Modified = source signals removed)



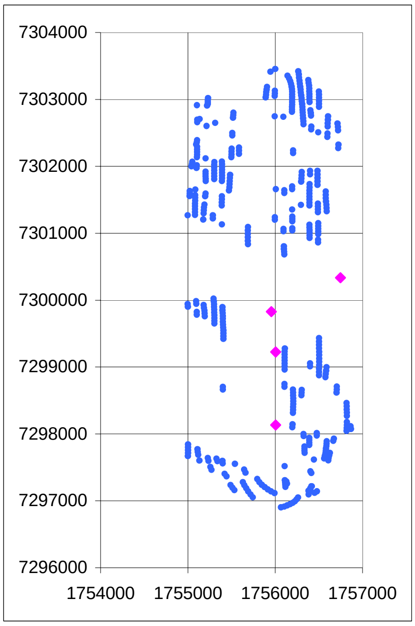
A1. Height 55-60m for a, b, and c. Modified data set. (Modified = source signals removed)



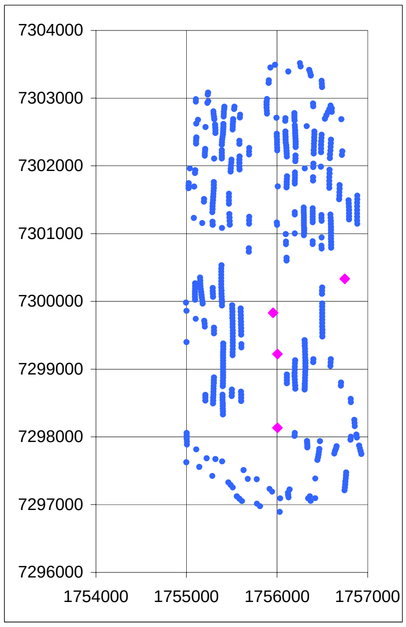
A1. Height 55-60m. Entire data set. (Source signals included)



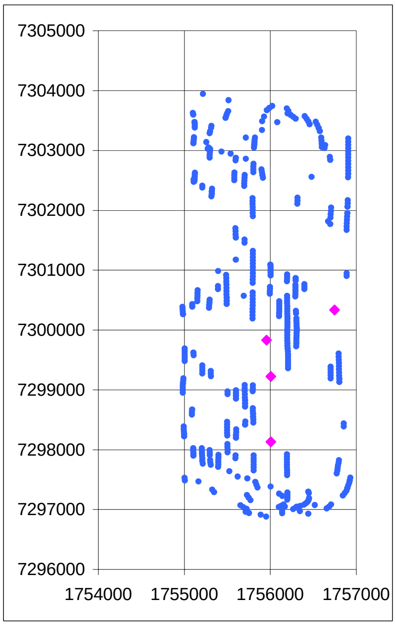
A1. Height 40-45m. Entire data set. (Source signals included)



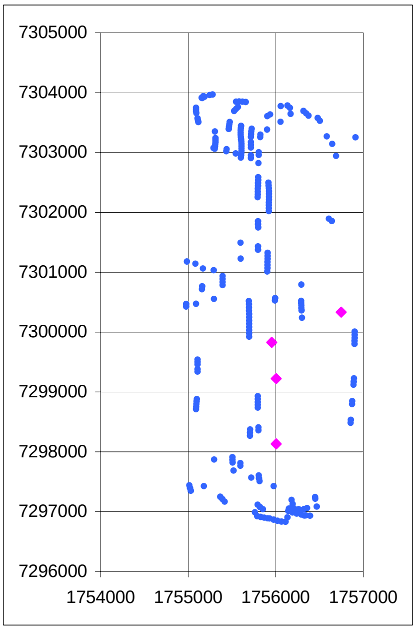
A1. Height 45-50m.
Entire data set.
(Source signals included)



A1. Height 50-55 m.
Entire data set.
(Source signals included)

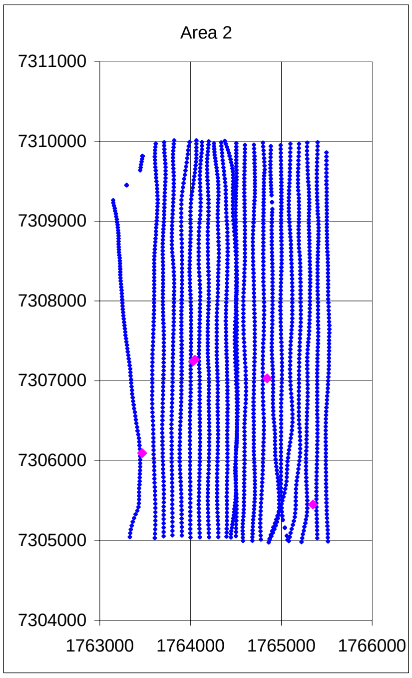


A1. Height 60-65m.
Entire data set.
(Source signals included)

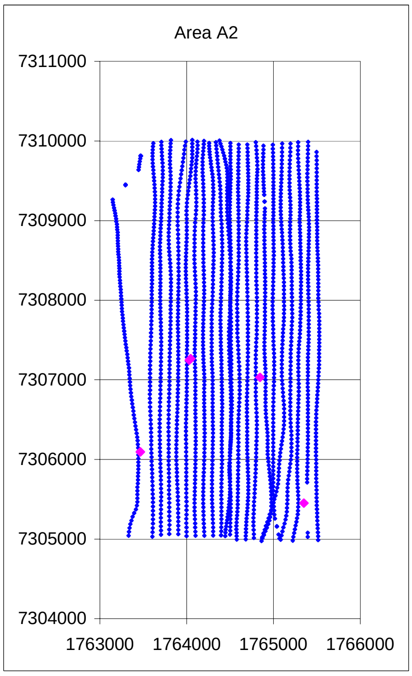


A1. Height 65-70m.
Entire data set.
(Source signals included)

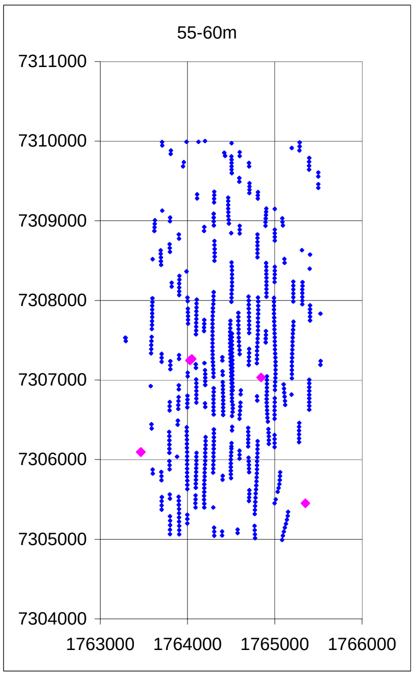
Barents Rescue Area A2 Measurements. Sources shown on plots.
Confer Appendix K for source information



A2. All measurements in data set excluding helicopter turns.



A2. Height 30-80 m. Modified data set for calculation of mean stripping factors.



A2. Height 55-60 m.
Measurements in modified data set

Modified data set: The visually detectable signals from source 2:4 ^{99}Mo were removed.

Appendix O
Barents Rescue results for Area A1 and A2: Ten largest errors

Barents Rescue Area A1:
Tables with 10 largest errors and co-ordinates in RT90. Height 55-60m (677measurements). (LL-UL in channels)

^{131}I-window 60-72	North	East
85.45	1756598	7300134
88.46	1756099	7299762
88.73	1756027	7297930
89.00	1756598	7300279
92.37	1756598	7300230
97.52	1756899	7300300
120.7	1756027	7297968
122.2	1756901	7300252
207.8	1756028	7298005
3825	1755998	7299210

^{137}Cs-window 110-130	North	East
48.90	1756027	7297968
49.34	1756097	7299892
51.64	1756899	7300300
59.64	1756098	7299805
60.82	1756598	7300182
65.01	1756901	7300252
71.58	1756598	7300230
72.65	1756099	7299762
166.7	1756028	7298005
359.8	1755998	7299210

^{60}Co-window 193-243	North	East
89.90	1755803	7299719
91.50	1756598	7300279
93.00	1756097	7299935
99.69	1756098	7299805
122.5	1756097	7299892
130.9	1756598	7300230
143.2	1756901	7300252
164.9	1756027	7297968
186.3	1756099	7299762
515.2	1756028	7298005

Barents Rescue Area A2:
Tables with 10 largest errors and co-ordinates in RT90. Height 55-60m (677measurements). (LL-UL in channels)

Errors calculated using 55-60m stripping factors from Area A1.

^{99m}**Tc-window 24-28**	North	East
80.26	1763596	7307837
81.95	1765005	7307332
82.56	1764204	7306086
84.58	1764707	7305525
85.13	1764307	7309321
92.09	1764599	7308888
94.42	1764307	7309366
96.25	1763585	7307438
100.2	1764195	7307212
101.5	1764290	7307273

^{137}**Cs-window 110-130**	North	East
34.13	1763595	7307789
35.61	1764200	7310001
36.97	1764895	7308983
37.12	1763627	7309005
38.61	1764096	7305697
38.74	1763597	7307885
41.16	1763598	7307978
41.81	1764911	7306621
42.01	1765525	7307238
49.91	1764290	7307273

^{60}**Co-window 193-243**	North	East
27.72	1765005	7307332
28.07	1764202	7307076
28.43	1765395	7306910
29.70	1764800	7306030
31.52	1764806	7309278
33.93	1764705	7309726
36.05	1764704	7305933
41.35	1764200	7307122
42.61	1763696	7308492
51.87	1763820	7308173

Barents Rescue Area A2:
Tables with 10 largest errors and co-ordinates in RT90. Height 30-80m. (LL-UL in channels)

Errors calculated using 55-60m stripping factors from Area A1.

^{99m}Tc-window 24-28	North	East
95.40	1764280	7309711
96.25	1763585	7307438
98.87	1764378	7310005
99.15	1764004	7307943
100.22	1764195	7307212
101.51	1764290	7307273
206.8	1765285	7305404
506.8	1765388	7305371
756.0	1765386	7305468
2727	1765387	7305419

^{192}Ir-window 46-62	North	East
104.4	1765501	7308965
105.8	1764883	7309845
106.2	1764506	7308618
115.9	1765401	7309131
117.3	1763187	7309024
120.8	1763903	7308018
131.1	1763599	7308162
157.8	1765386	7305468
190.9	1765388	7305371
471.1	1765387	7305419

^{131}I-window 60-72	North	East
61.38	1763692	7308675
63.00	1765005	7307332
65.52	1764198	7307167
66.45	1763252	7307937
68.31	1765285	7305404
68.52	1763443	7306056
73.87	1765406	7309046
83.19	1763187	7309024
105.4	1765386	7305468
247.3	1765387	7305419

Barents Rescue Area A2:
Tables with 10 largest errors and co-ordinates in RT90. Height 30-80m. (LL-UL in channels)

Errors calculated using 55-60m stripping factors from Area A1.

^{192}Ir-window 78-88	North	East
39.35	1763819	7310011
39.90	1764405	7306974
40.44	1764359	7309720
41.18	1765285	7305404
42.31	1764885	7309940
48.22	1764431	7309816
48.60	1764898	7308610
48.83	1764897	7309027
69.12	1765386	7305468
175.1	1765387	7305419

Ann.-window 80-100	North	East
139.6	1763330	7307192
139.6	1765501	7309097
139.9	1763147	7309263
140.7	1764506	7309642
143.1	1764885	7309940
144.5	1764897	7309027
150.8	1764431	7309816
159.4	1764816	7309646
168.2	1765386	7305468
378.1	1765387	7305419

^{137}Cs-window 110-130	North	East
45.18	1764280	7309711
47.47	1764885	7309940
47.77	1763599	7308117
49.04	1764290	7307273
52.02	1765388	7305371
52.71	1764440	7309777
53.05	1765500	7309185
58.64	1765285	7305404
163.2	1765386	7305468
362.4	1765387	7305419

Barents Rescue Area A2:
Tables with 10 largest errors and co-ordinates in RT90. Height 30-80m.
(LL-UL in channels)

Errors calculated using 55-60m stripping factors from Area A1.

^{134}**Cs-window 130-154**	North	East
37.82	1765401	7309131
37.92	1764359	7309720
39.38	1763997	7305525
41.95	1764705	7309726
43.76	1764589	7305483
44.64	1763810	7307540
44.83	1765501	7309141
91.74	1765388	7305371
177.7	1765386	7305468
507.8	1765387	7305419

^{136}**Cs-window 174-198**	North	East
26.61182	1764501	7309316
26.95445	1764933	7306152
27.89	1765291	7309635
28.96	1763206	7308817
30.06	1764704	7305933
30.63	1764004	7307943
30.79	1765304	7309361
30.92	1765119	7307736
33.47	1764708	7305795
33.99	1764596	7309173

^{60}**Co-window 193-243**	North	East
36.07	1764372	7309580
36.38	1765405	7308662
37.10	1764510	7306684
40.30	1764496	7305515
41.35	1764200	7307122
42.61	1763696	7308492
44.03	1765304	7309361
46.70	1764192	7307300
51.87	1763820	7308173
58.72	1764198	7307167

Barents Rescue Area A2:
Tables with 10 largest errors and co-ordinates in RT90. Height 30-80m, ^{99}Mo-measurements included.
(LL-UL in channels)

Errors calculated using 30-80m stripping factors from Area A2. (Significant Mo-measurements removed before calculation of a, b, and c).

^{99m}Tc-window 24-28	North	East
97.02	1764290	7307273
98.76	1763585	7307438
99.84	1764378	7310005
102.5	1765306	7309146
103.2	1764195	7307212
107.1	1764455	7309700
205.0	1765285	7305404
498.4	1765388	7305371
752.5	1765386	7305468
2728	1765387	7305419

^{192}Ir-window 46-62	North	East
107.9	1764885	7309940
108.2	1764455	7309700
109.5	1765501	7308965
114.5	1763187	7309024
116.1	1763903	7308018
117.6	1765401	7309131
130.5	1763599	7308162
154.4	1765386	7305468
184.3	1765388	7305371
469.9	1765387	7305419

^{131}I-window 60-72	North	East
38.17	1765206	7307532
38.61	1764405	7306974
39.09	1764359	7309720
39.95	1765285	7305404
46.96	1764898	7308610
48.26	1764885	7309940
49.82	1764431	7309816
51.01	1764897	7309027
68.87	1765386	7305468
175.5	1765387	7305419

Barents Rescue Area A2:
Tables with 10 largest errors and co-ordinates in RT90. Height 30-80m, ^{99}Mo-measurements included.
(LL-UL in channels)

Errors calculated using 30-80m stripping factors from Area A2.
(Significant Mo-measurements removed before calculation of a, b, and c).

^{192}Ir-window 78-88	North	East
62.17	1763202	7308885
62.70	1765005	7307332
65.96	1763443	7306056
66.74	1763252	7307937
67.10	1764198	7307167
68.07	1765285	7305404
74.67	1765406	7309046
82.56	1763187	7309024
103.2	1765386	7305468
246.7	1765387	7305419

Ann.-window 80-100	North	East
56.67	1764006	7307616
57.03	1764351	7309811
57.52	1764378	7310005
60.85	1764897	7309027
61.34	1764290	7307273
62.16	1764816	7309646
72.40	1765388	7305371
78.61	1764431	7309816
104.6	1765386	7305468
302.3	1765387	7305419

^{137}Cs-window 110-130	North	East
45.43	1764280	7309711
47.87	1764290	7307273
47.88	1763599	7308117
49.78	1765388	7305371
52.22	1765500	7309185
52.87	1764885	7309940
53.42	1764440	7309777
58.11	1765285	7305404
161.9	1765386	7305468
362.3	1765387	7305419

Barents Rescue Area A2:
Tables with 10 largest errors and co-ordinates in RT90. Height 30-80m, ^{99}Mo-measurements included. (LL-UL in channels)

Errors calculated using 30-80m stripping factors from Area A2. (Significant Mo-measurements removed before calculation of a, b, and c).

^{134}Cs-window 130-154	North	East
37.15	1764351	7309811
38.38	1763199	7308920
41.15	1765401	7309131
44.10	1764589	7305483
44.83	1764705	7309726
45.04	1763810	7307540
46.45	1765501	7309141
90.42	1765388	7305371
178.1	1765386	7305468
509.2	1765387	7305419

^{136}Cs-window 174-198	North	East
26.27	1764933	7306152
26.44	1764705	7307289
26.63	1765291	7309635
28.20	1763206	7308817
29.69	1764004	7307943
29.72	1764704	7305933
29.92	1765304	7309361
30.78	1765119	7307736
32.94	1764708	7305795
33.60	1764596	7309173

^{60}Co-window 193-243	North	East
36.90	1764510	7306684
37.51	1764372	7309580
37.58	1765405	7308662
40.02	1764496	7305515
41.69	1764200	7307122
42.11	1763696	7308492
44.45	1765304	7309361
48.96	1764192	7307300
54.23	1763820	7308173
60.32	1764198	7307167

Barents Rescue Area A2:
Tables with 10 largest errors and co-ordinates in RT90.
Height 30-80m, ^{99}Mo-measurements included.
(LL-UL in channels)

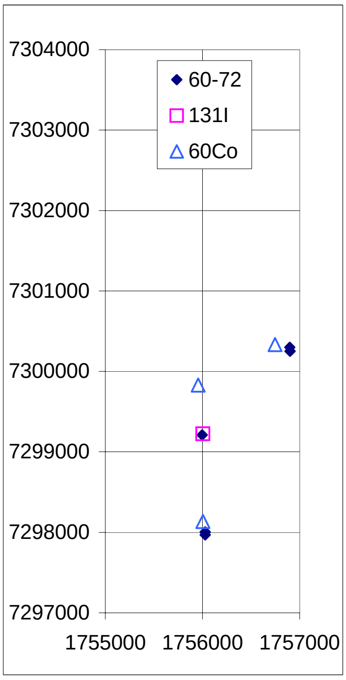
Errors calculated using 30-80m stripping factors from Area A2.
(Significant Mo-measurements removed before calculation of
a, b, and c).

All errors in each window summed and normalised (0-100%)
Normalised errors for all measurements for each window summed
All summed errors normalised (0-100%).

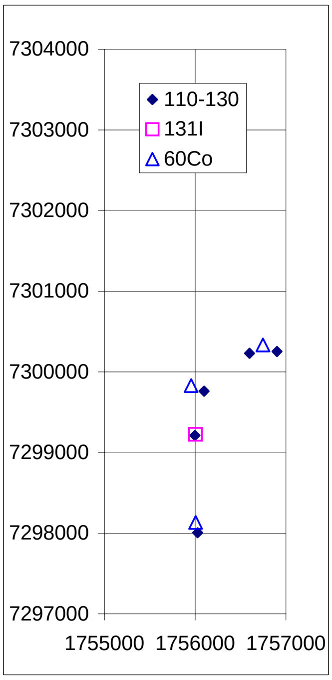
Normalised errors	North	East
26.15	1764998	7309666
26.51	1763696	7308492
26.89	1763820	7308173
27.15	1764704	7305933
27.24	1765119	7307736
28.00	1764708	7305795
31.38	1764596	7309173
32.11	1764198	7307167
40.96	1765386	7305468
100.0	1765387	7305419

Appendix P
XY error plots (RT90) of the five largest errors, sources shown

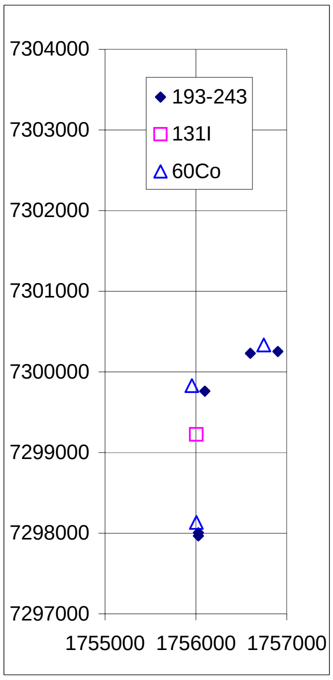
Barents Rescue Area A1: All measurements in the height 55-60 m. Stripping factors calculated from modified data set of measurements (A1) in the height 55-60 m.



A1. ^{131}I window.

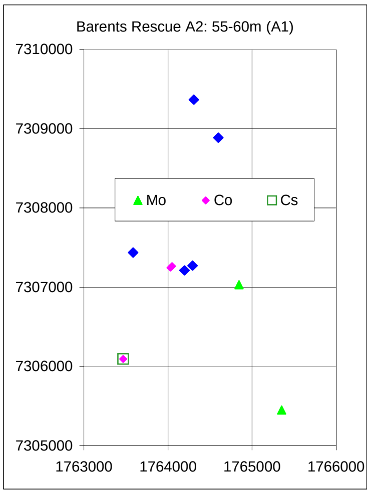


A1. ^{137}Cs-window.

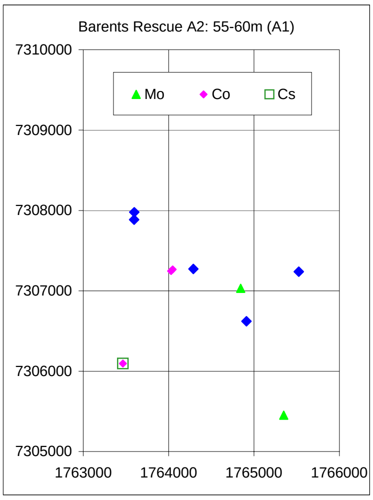


A1. ^{60}Co window.

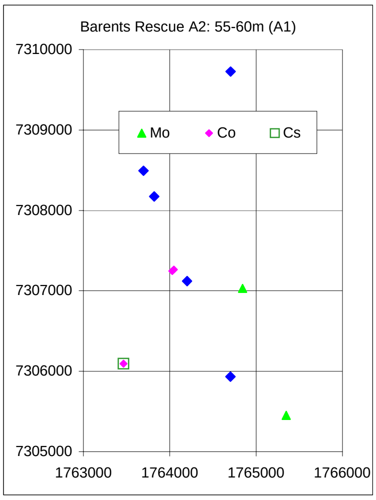
Barents Rescue Area A2: All measurements in the height 55-60 m. Stripping factors calculated from modified data set of measurements (A1) in the height 55-60 m.



A2. ^{99m}Tc window.

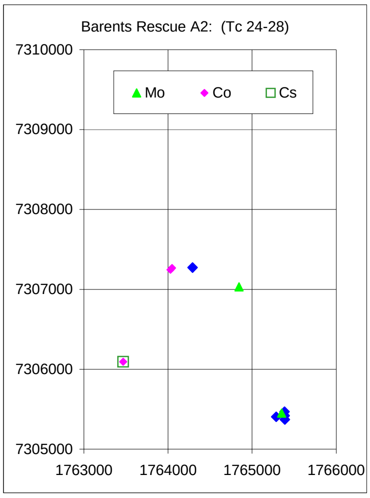


A2. ^{137}Cs window.

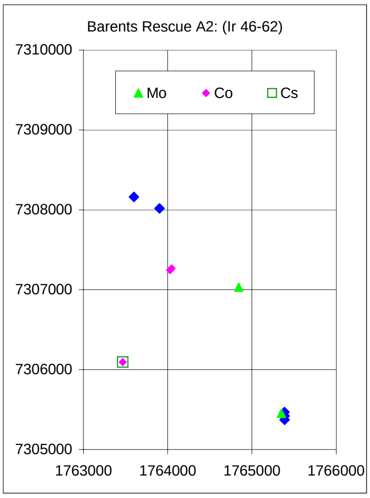


A2. ^{60}Co window.

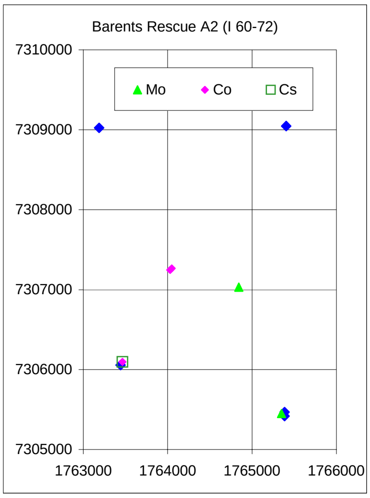
Barents Rescue Area A2: All measurements in the height 30-80 m. Stripping factors calculated from modified data set of measurements (A1) in the height 55-60 m.



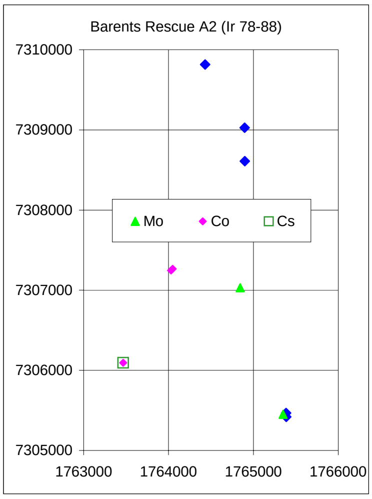
A2. ^{99m}Tc window.



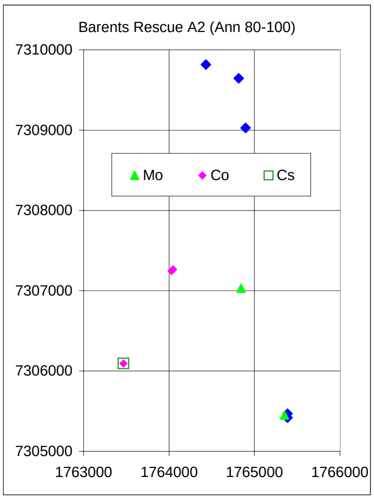
A2. ^{192}Ir window.



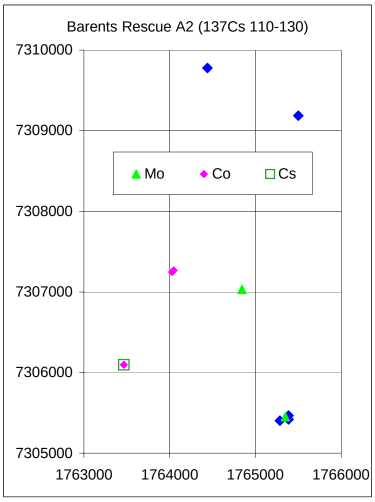
A2. ^{131}I window.



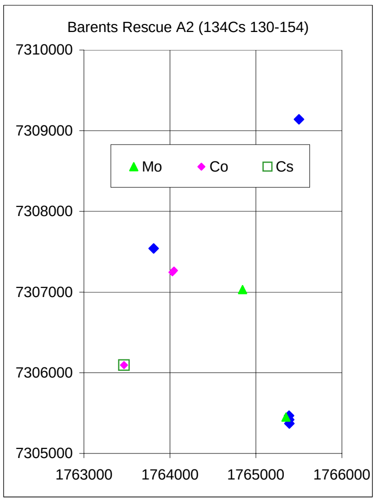
A2. ^{192}Ir window.



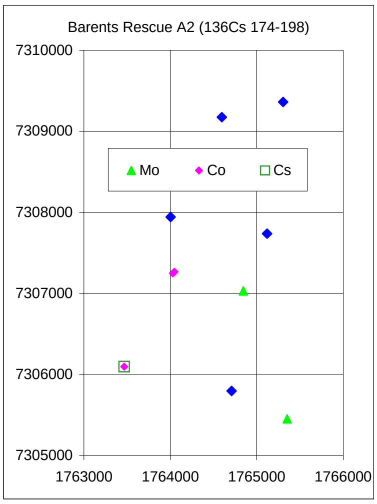
A2. Annihilation window.



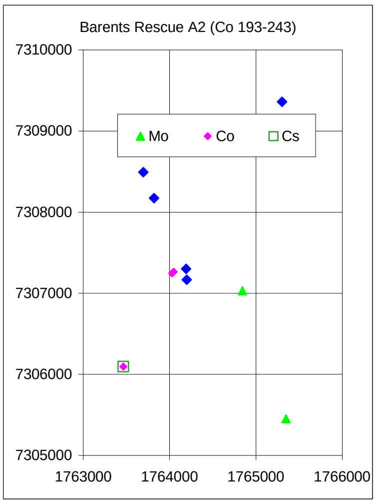
A2. ^{137}Cs window.



A2. ^{134}Cs window.

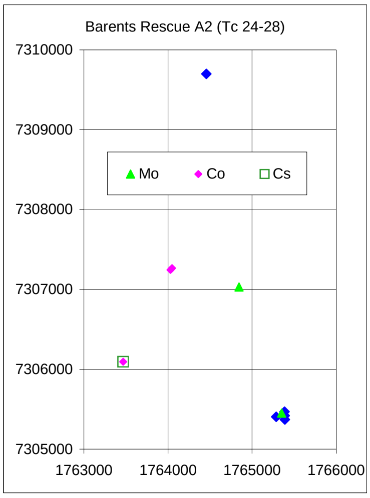


A2. ^{136}Cs. window.

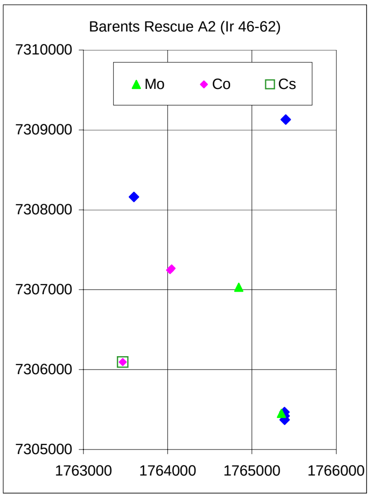


A2. ^{60}Co window.

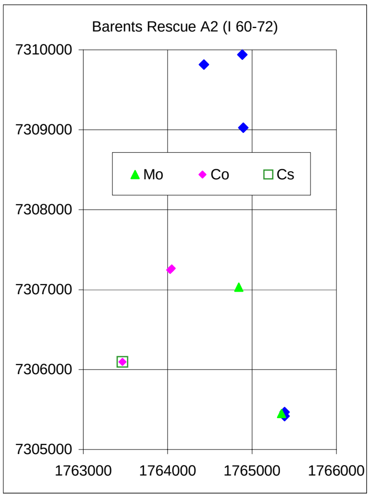
Barents Rescue Area A2: All measurements in the height 30-80 m. Stripping factors calculated from modified data set of measurements (A2, excluding visually detectable ^{99}Mo-measurements) for the height 30-80 m.



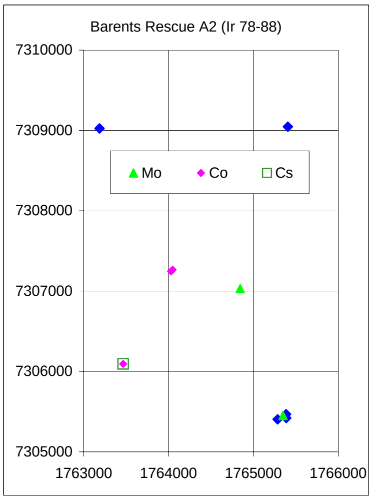
A2. ^{99m}Tc window.



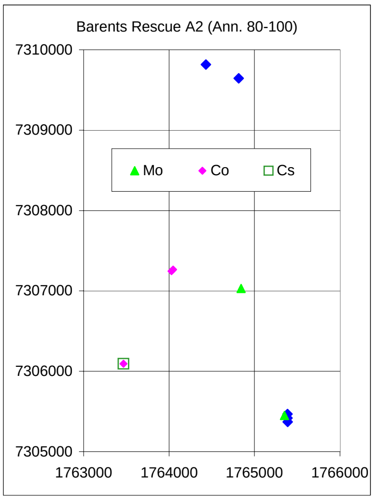
A2. ^{192}Ir window.



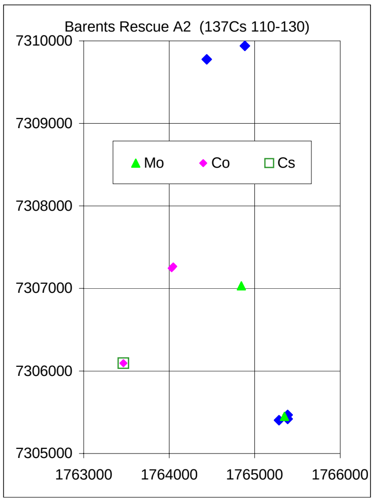
A2. ^{131}I window.



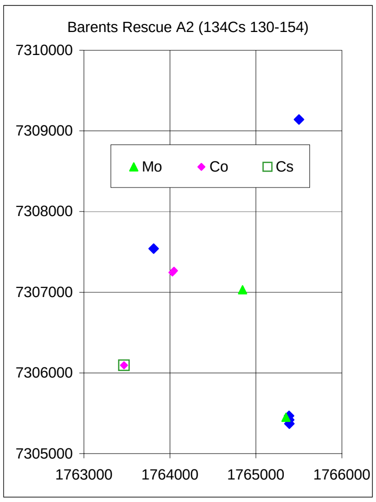
A2. ^{192}Ir window.



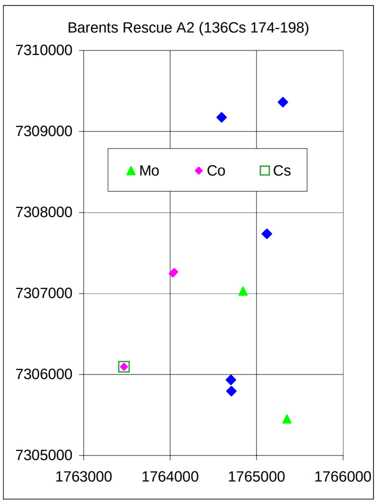
A2. Annihilation window.



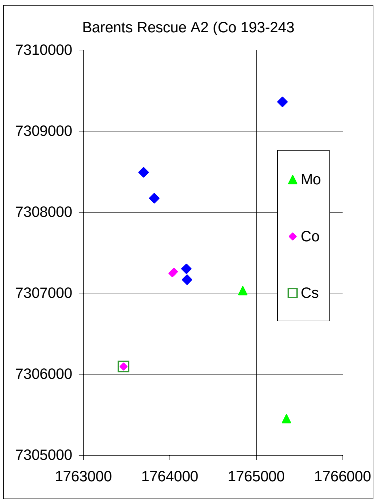
A2. ^{137}Cs window.



A2. ^{134}Cs window.



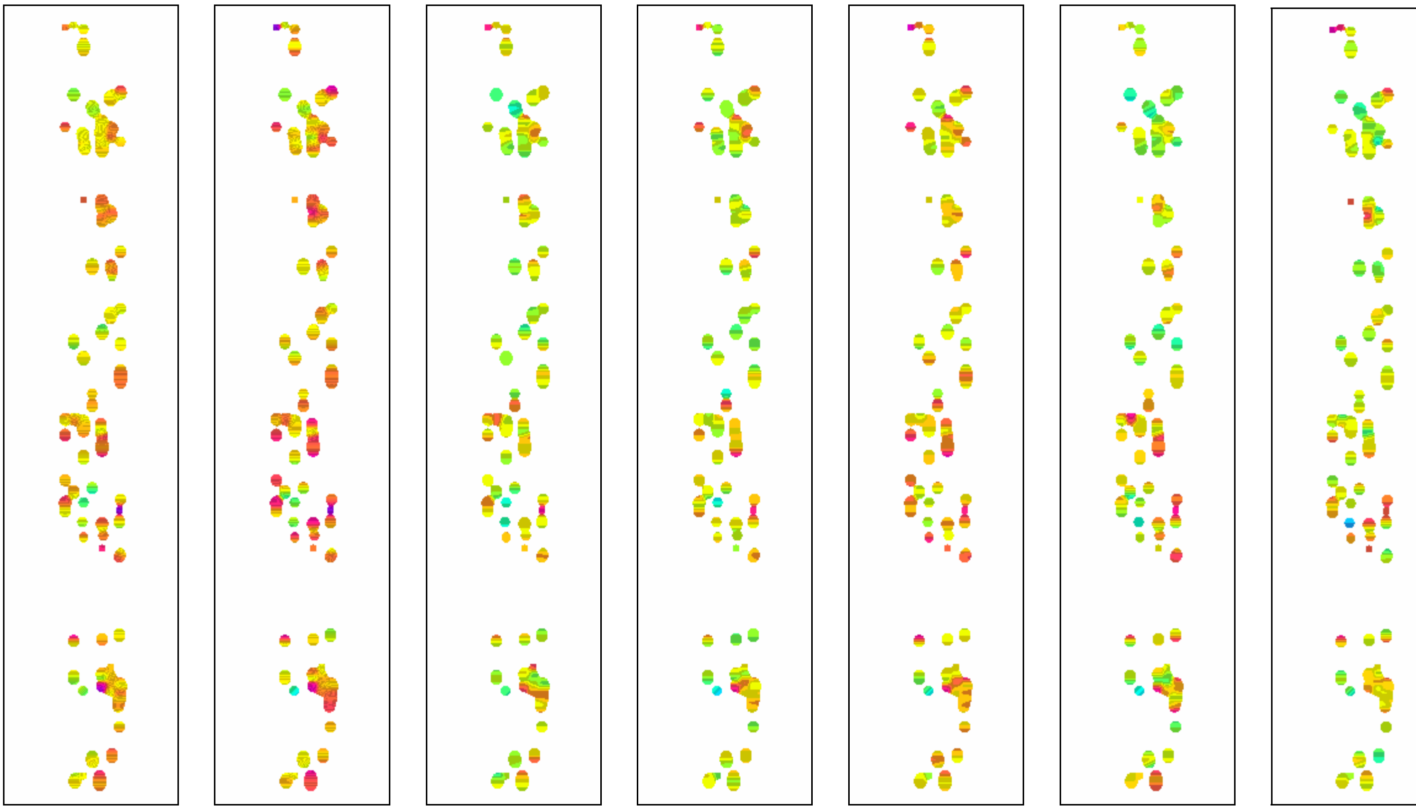
A2. ^{136}Cs. window.



A2. ^{60}Co window

Appendix Q. Stripped counts colour plots

Bornholm 622b: Stripped counts colour plots for window counts in height interval 70-7
Ranges are indicated below the figures. The map program plots all negative results as “0”.
To avoid this an adjustment constant has been added to all results. This is indicated by the constant

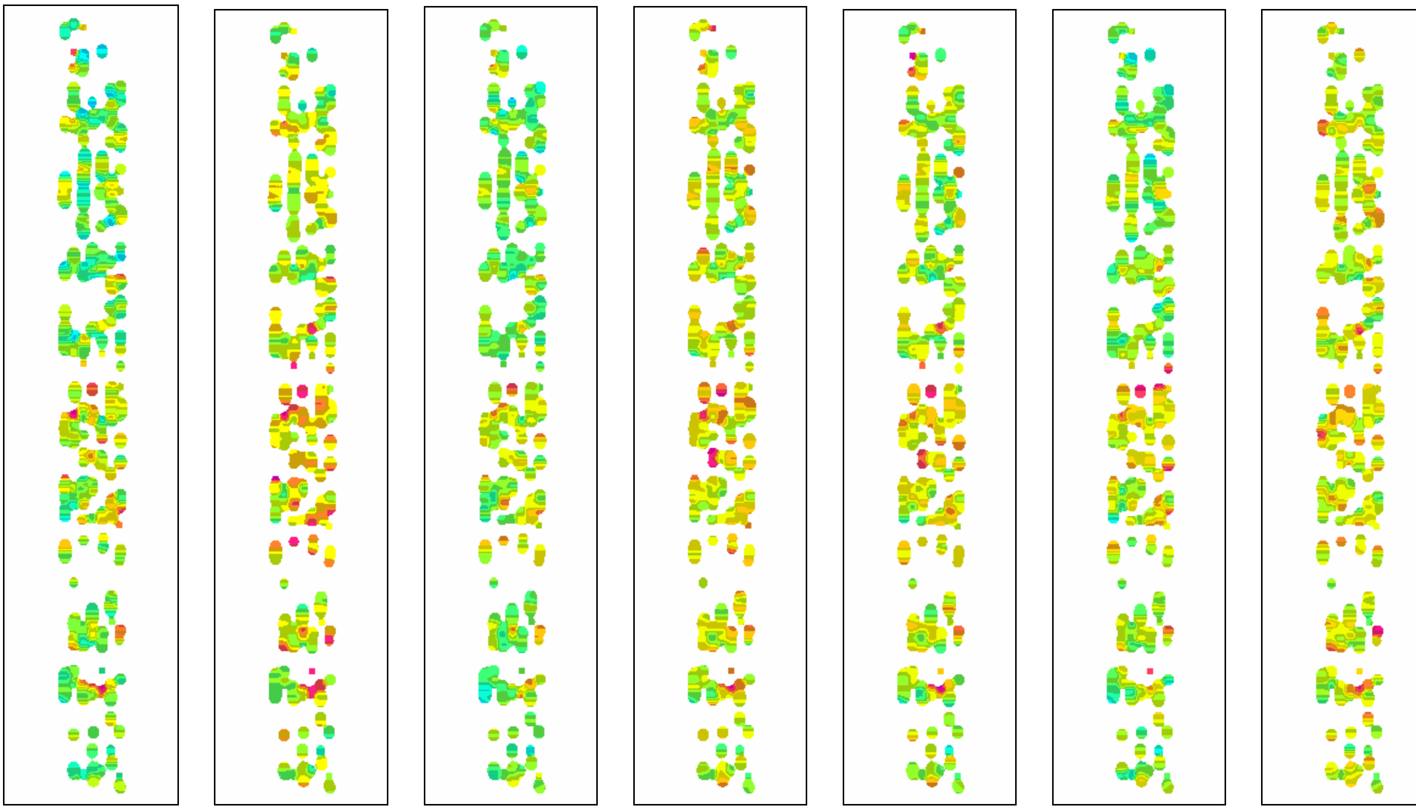


LL-UL	24-28	46-62	60-72	78-88	80-100	110-130	130-1
Range	0-160	0-160	0-100	0-60	0-100	0-60	0-60
Added	+90	+100	+50	+30	+60	+30	+30

Bornholm 622b: Stripped counts colour plots for window counts in height interval 75-8

Ranges are indicated below the figures. The map program plots all negative results as “0”.

To avoid this an adjustment constant has been added to all results. This is indicated by the constant

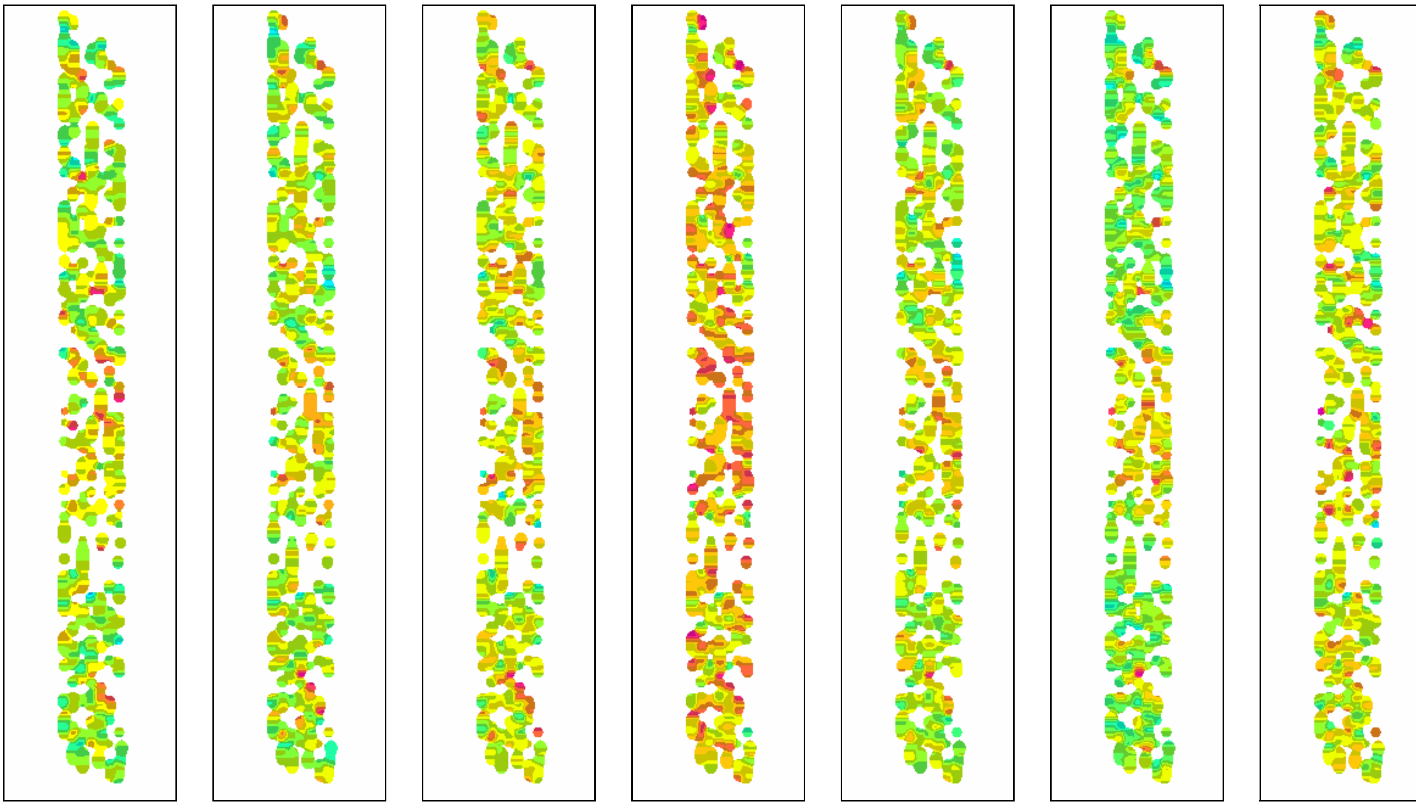


LL-UL	24-28	46-62	60-72	78-88	80-100	110-130	130-1
Range	0-130	0-150	0-100	0-70	0-100	0-70	0-70
Added	+50	+80	+40	+35	+50	+30	+35

Bornholm 622b: Stripped counts colour plots for window counts in height interval 80-8

Ranges are indicated below the figures. The map program plots all negative results as “0”.

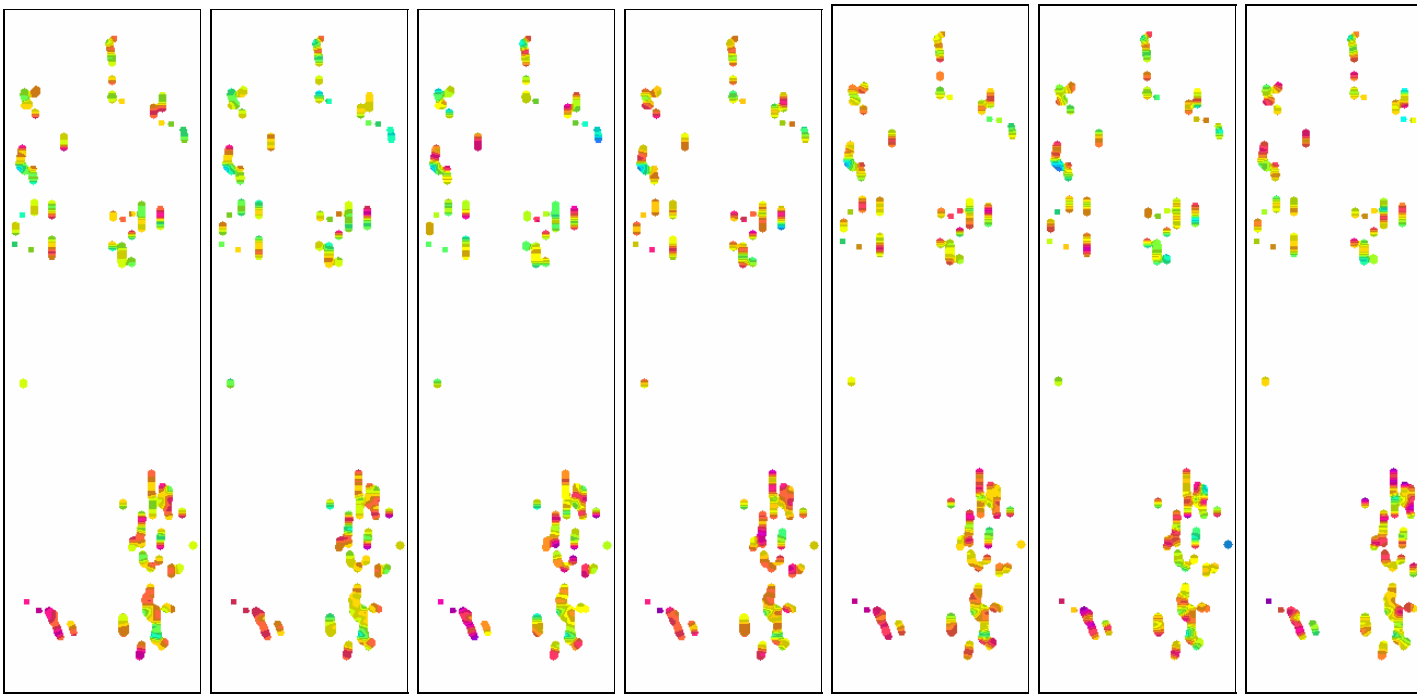
To avoid this an adjustment constant has been added to all results. This is indicated by the constant



LL-UL	24-28	46-62	60-72	78-88	80-100	110-130	130-1
Range	0-150	0-160	0-100	0-60	0-100	0-70	0-60
Added	+70	+80	+50	+35	+50	+30	+30

Barents Rescue Area A1: Stripped counts colour plots for window counts in height inte

Ranges are indicated below the figures. The map program plots all negative results as “0”.
To avoid this an adjustment constant has been added to all results. This is indicated by the constant

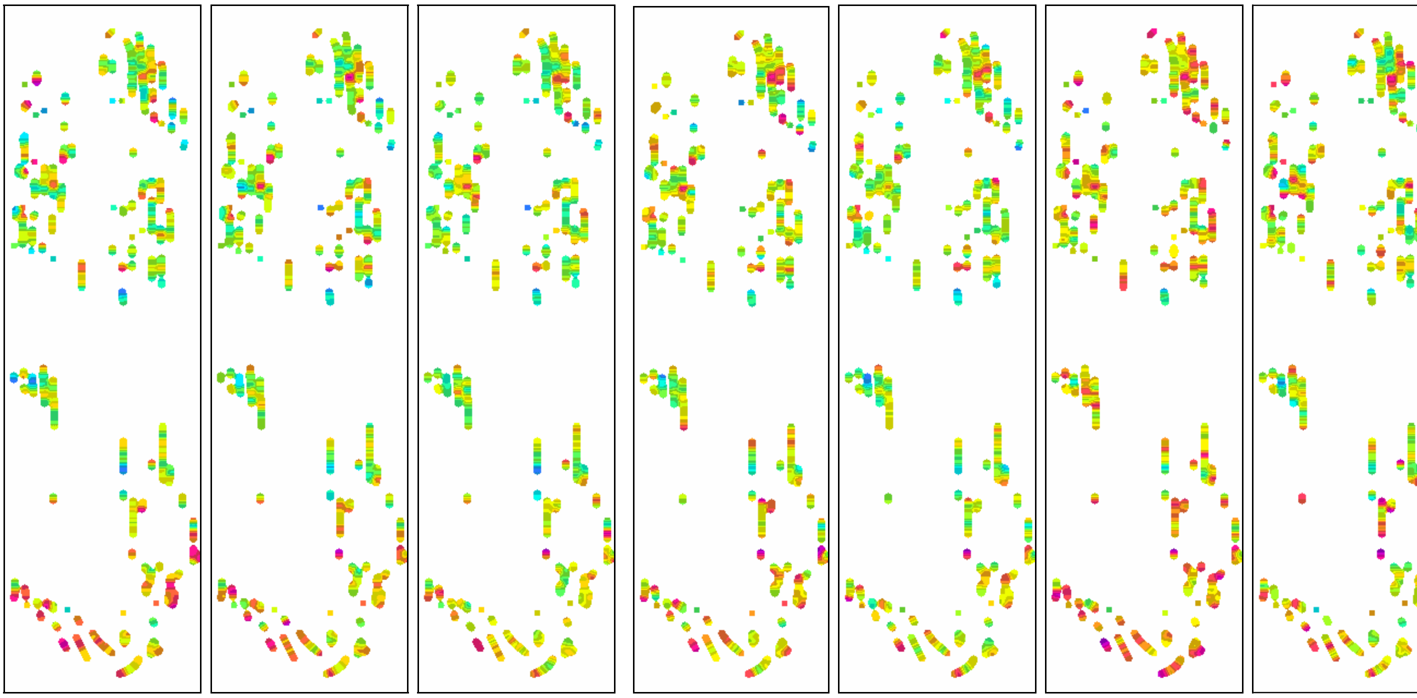


LL-UL	24-28	46-62	60-72	78-88	80-100	110-130	130-1
Range	0-170	0-170	0-90	0-65	0-110	0-65	0-60
Added	+95	+90	+50	+40	+65	+35	+35

Barents Rescue Area A1: Stripped counts colour plots for window counts in height inte

Ranges are indicated below the figures. The map program plots all negative results as “0”.

To avoid this an adjustment constant has been added to all results. This is indicated by the constant

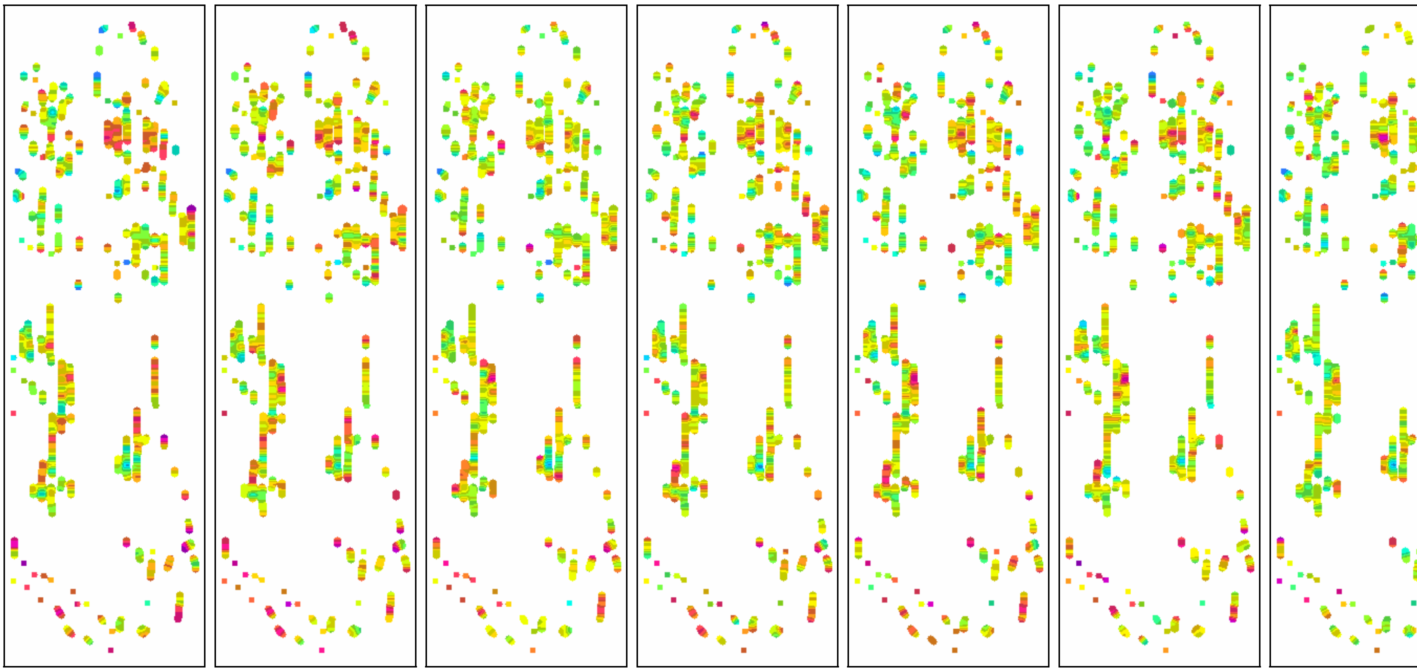


LL-UL	24-28	46-62	60-72	78-88	80-100	110-130	130-1
Range	0-150	0-170	0-110	0-70	0-110	0-75	0-70
Added	+70	+80	+50	+35	+50	+40	+30

Barents Rescue Area A1: Stripped counts colour plots for window counts in height inte

Ranges are indicated below the figures. The map program plots all negative results as “0”.

To avoid this an adjustment constant has been added to all results. This is indicated by the constant

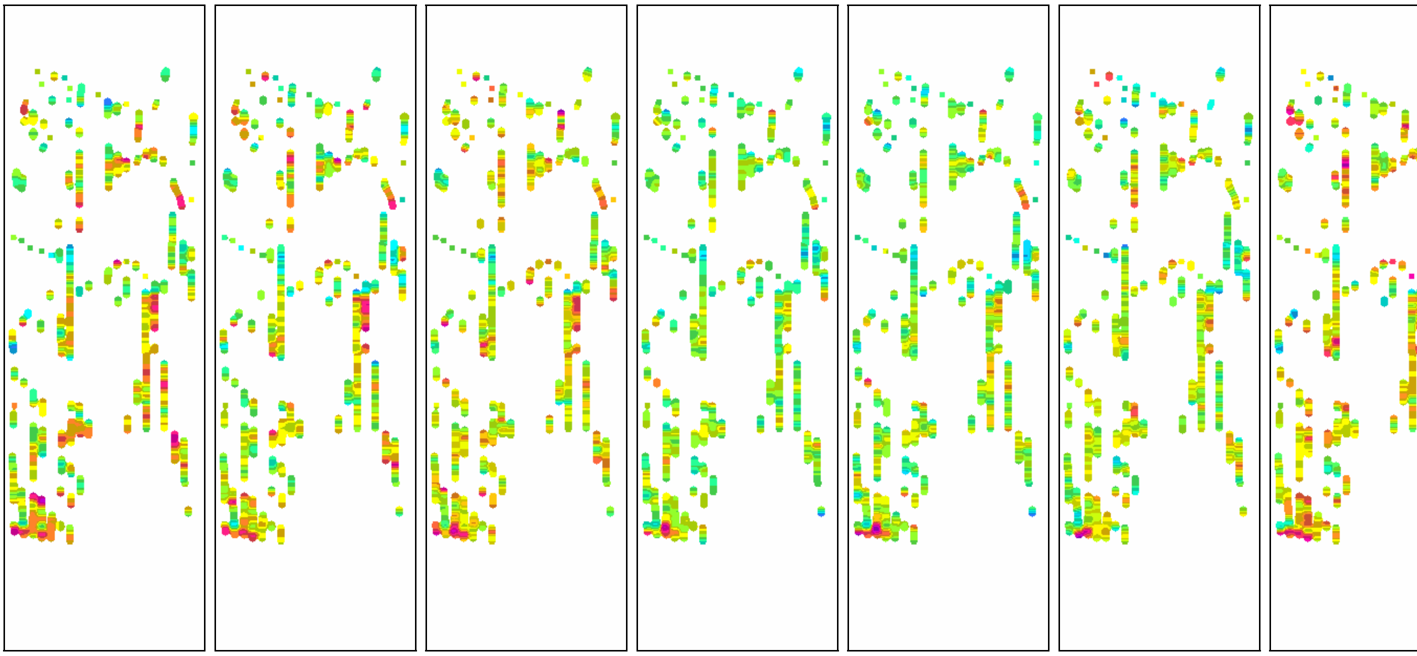


LL-UL	24-28	46-62	60-72	78-88	80-100	110-130	130-1
Range	0-160	0-170	0-110	0-70	0-100	0-70	0-65
Added	+80	+90	+55	+35	+50	+35	+30

Barents Rescue Area A1: Stripped counts colour plots for window counts in height inte

Ranges are indicated below the figures. The map program plots all negative results as “0”.

To avoid this an adjustment constant has been added to all results. This is indicated by the constant

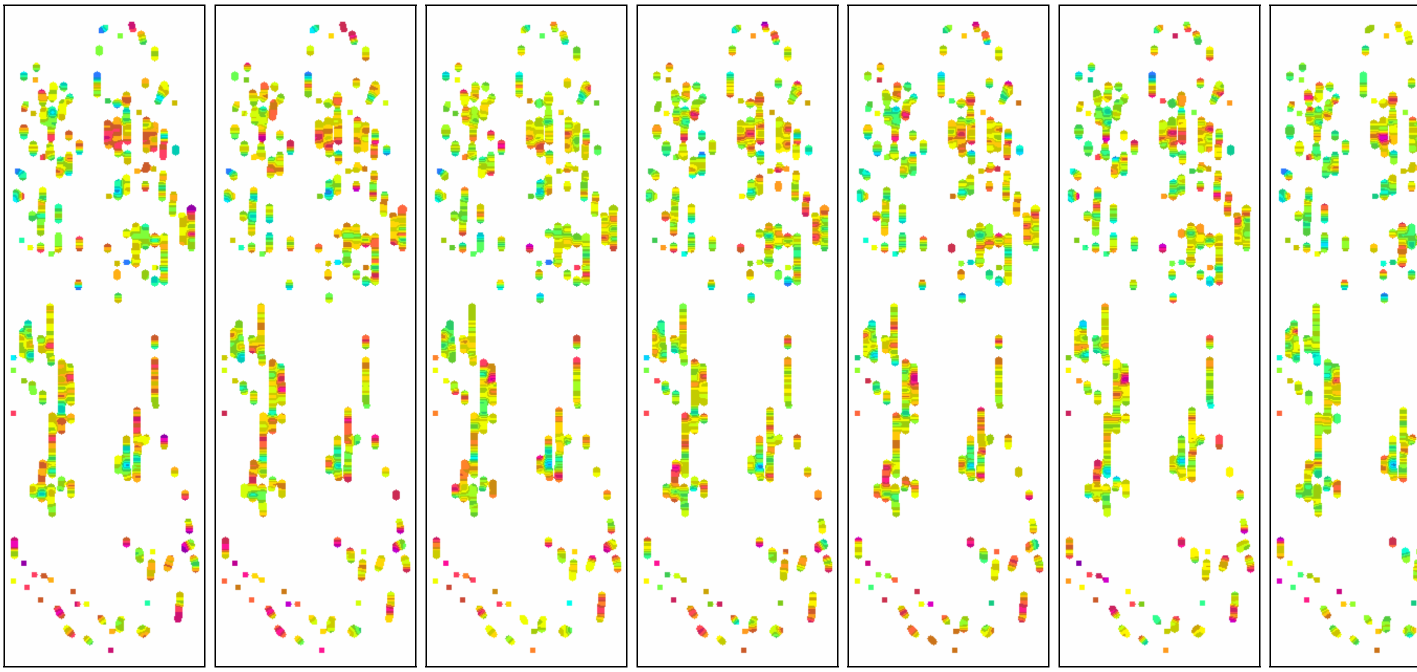


LL-UL	24-28	46-62	60-72	78-88	80-100	110-130	130-1
Range	0-150	0-150	0-110	0-75	0-100	0-70	0-60
Added	+70	+70	+50	+30	+40	+30	+30

Barents Rescue Area A1: Stripped counts colour plots for window counts in height inte

Ranges are indicated below the figures. The map program plots all negative results as “0”.

To avoid this an adjustment constant has been added to all results. This is indicated by the constant

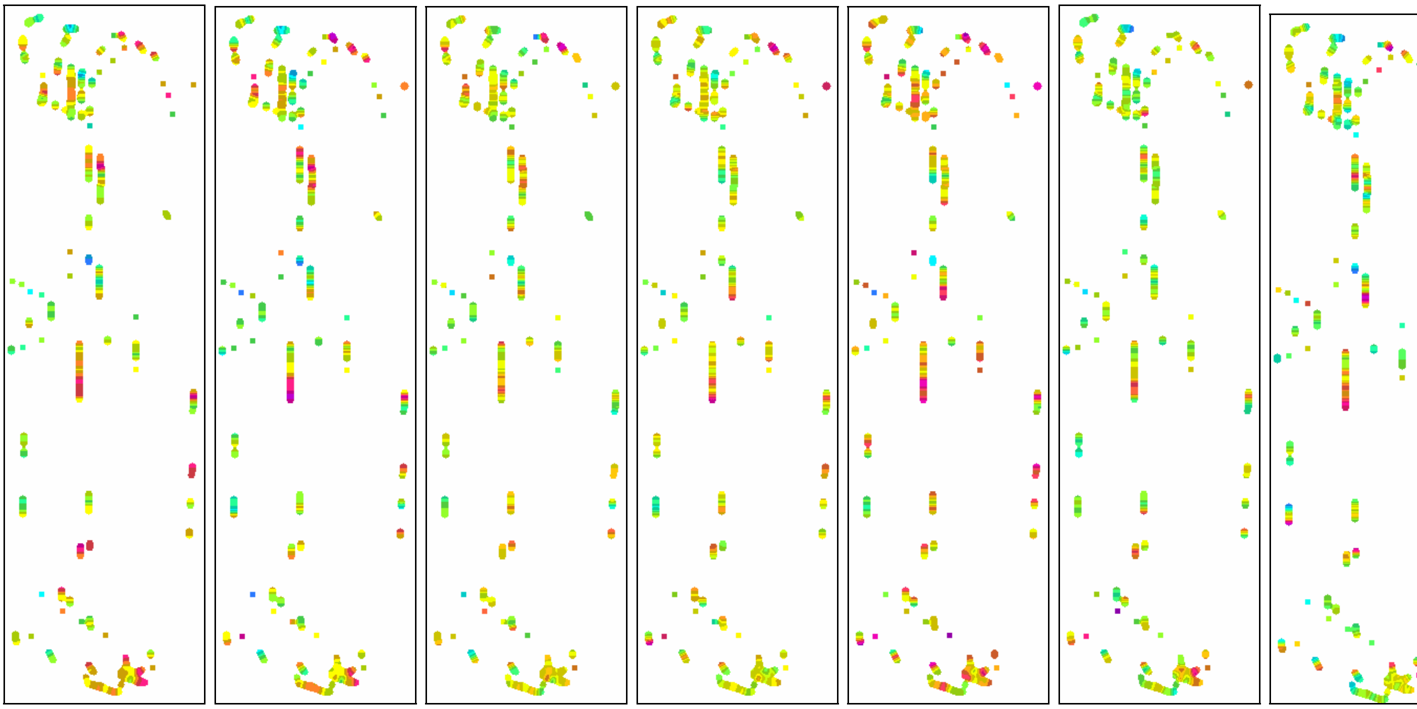


LL-UL	24-28	46-62	60-72	78-88	80-100	110-130	130-1
Range	0-150	0-150	0-110	0-70	0-100	0-70	0-60
Added	+70	+80	+50	+35	+45	+35	+30

Barents Rescue Area A1: Stripped counts colour plots for window counts in height inte

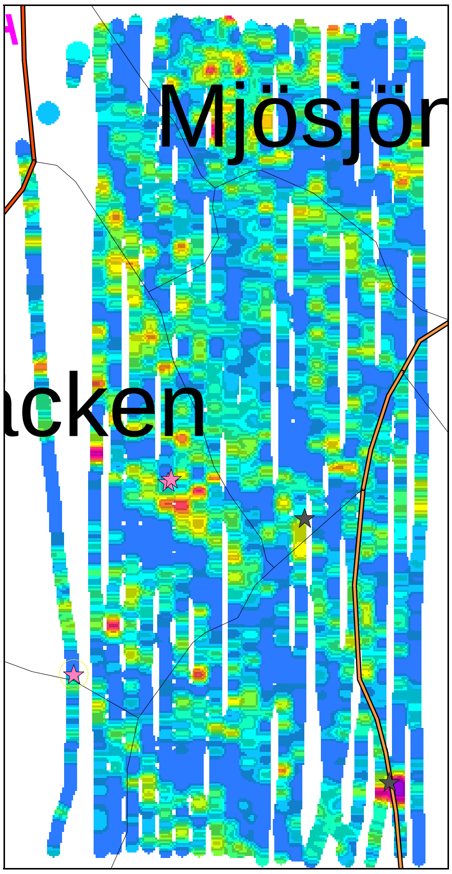
Ranges are indicated below the figures. The map program plots all negative results as “0”.

To avoid this an adjustment constant has been added to all results. This is indicated by the constant

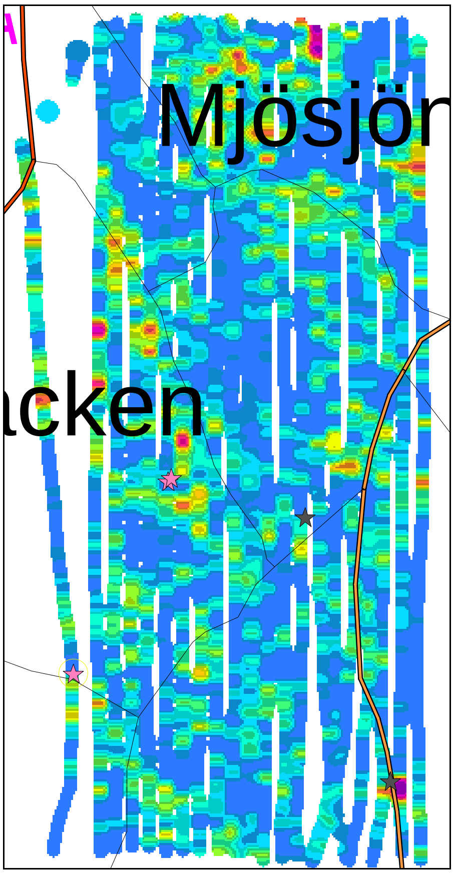


LL-UL	24-28	46-62	60-72	78-88	80-100	110-130	130-1
Range	0-150	0-150	0-100	0-70	0-80	0-65	0-55
Added	+75	+75	+50	+35	+45	+30	+35

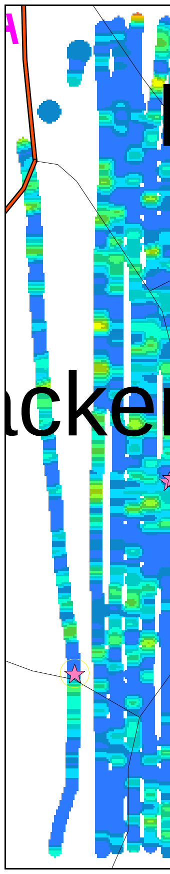
Barents Rescue Area A2: Stripped counts colour plots for window counts in height inte
Ranges are indicated below the figures. The map program plots all negative results as “0”.
NUCSpec outputs (all results > 0). No adjustment constants used. Sources (Appendix K) are indicat



LL-UL 24-28
Range 0-100

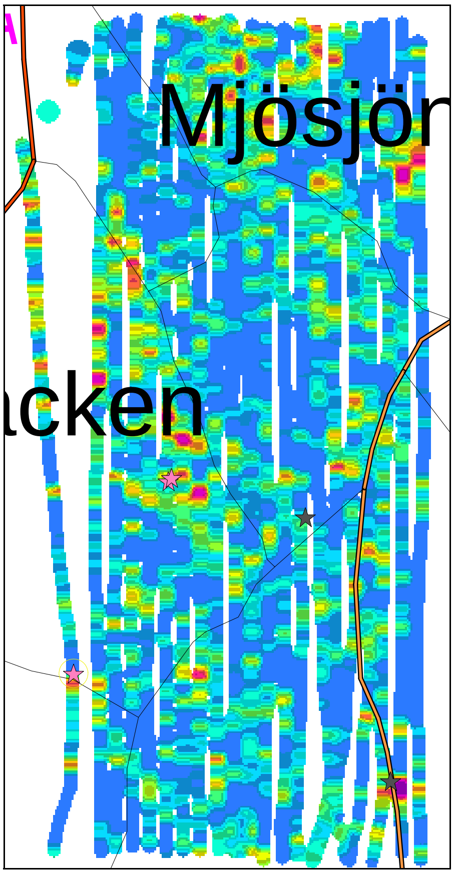


LL-UL 46-62
Range 0-100

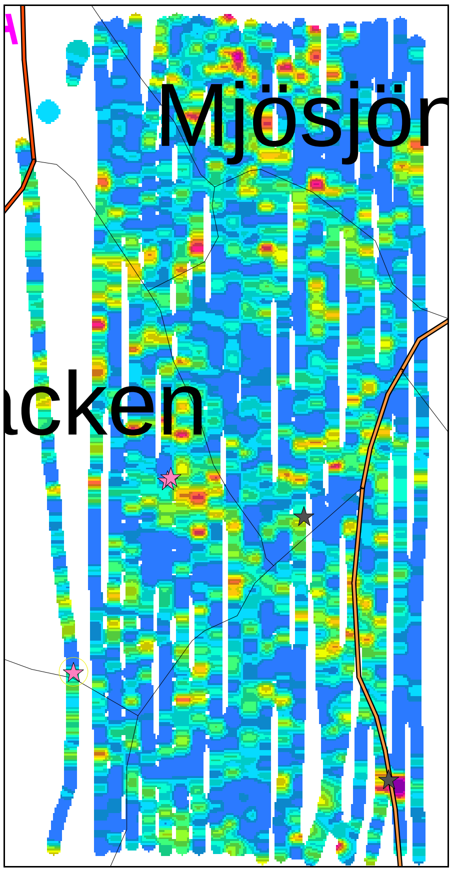


LL-UL
Range

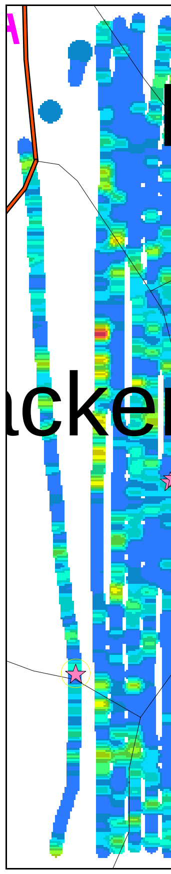
Barents Rescue Area A2: Stripped counts colour plots for window counts in height inte
Ranges are indicated below the figures. The map program plots all negative results as “0”.
NUCSpec outputs (all results > 0). No adjustment constants used. Sources (Appendix K) are indicat



LL-UL 78-88
Range 0-50



LL-UL 80-100
Range 0-50

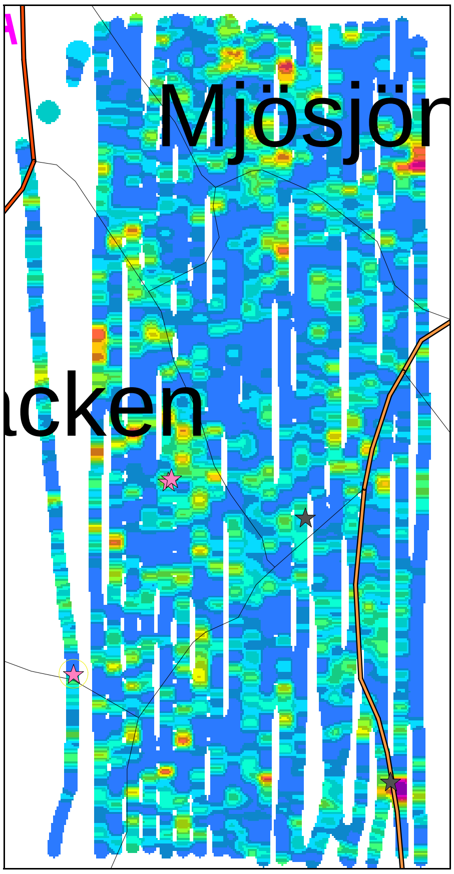


LL-UL
Range

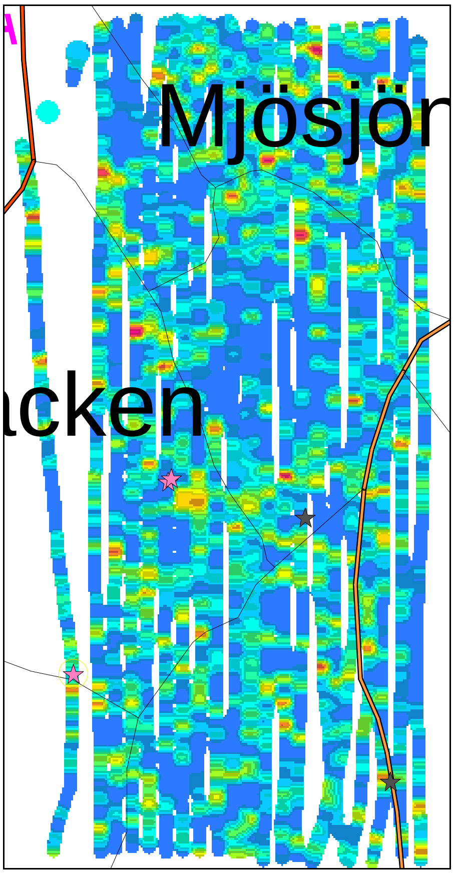
Barents Rescue Area A2: Stripped counts colour plots for window counts in height inte

Ranges are indicated below the figures. The map program plots all negative results as “0”.

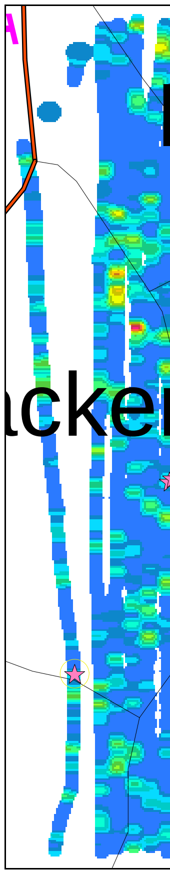
NUCSpec outputs (all results > 0). No adjustment constants used. Sources (Appendix K) are indicat



LL-UL 130-154
Range 0-40



LL-UL 174-198
Range 0-25



LL-UL
Range

Title	Area Specific Stripping factors for AGS. A method for extracting stripping factors from survey data
Author(s)	Helle Karina Aage and Uffe Korsbech
Affiliation(s)	Technical University of Denmark
ISBN	87-7893-187-8 *Electronic report*
Date	April 2006
Project/Sub Project	NKS-B / ASSa
No. of pages	128 (incl. 109 pages in appendices)
No. of tables	42 (incl. 41 tables in appendices)
No. of illustrations	471 (incl. 436 illustration in appendices)
No. of references	19

Abstract

In order to use Airborne Gamma-ray Spectrometry (AGS) for contamination mapping, for source search etc. one must to be able to eliminate the contribution to the spectra from natural radioactivity. This in general is done by a stripping technique. The parameters for performing a stripping have until recently been measured by recording gamma spectra at special calibration sites (pads). This may be cumbersome and the parameters may not be correct when used at low gamma energies for environmental spectra.
During 2000-2001 DTU tested with success a new technique for Carborne Gamma-ray Spectrometry (CGS) where the spectra from the surveyed area (or from a similar area) were used for calculating the stripping parameters. It was possible to calculate usable stripping ratios for a number of low energy windows - and weak source signals not detectable by other means were discovered with the ASS technique.
In this report it is shown that the ASS technique also works for AGS data, and it has been used for recent Danish AGS tests with point sources. (Check of calibration of AGS parameters.) By using the ASS technique with the Boden data (Barents Rescue) an exercise source was detected that has not been detected by any of the teams during the exercise. The ASS technique therefore seems to be better for search for radiation anomalies than any other method known presently.
The experiences also tell that although the stripping can be performed correctly at any altitude there is a variation of the stripping parameters with altitude that has not yet been quite understood.
However, even with the oddly variations the stripping worked as expected. It was also observed that one might calculate a *single common set* of usable stripping factors *for all altitudes* from the entire data set i.e. some average a, b and c values. When those stripping factors were used the stripping technique still worked well.

Key words: AGS, area specific spectrum stripping, point sources, stripping factors, altitude variation

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