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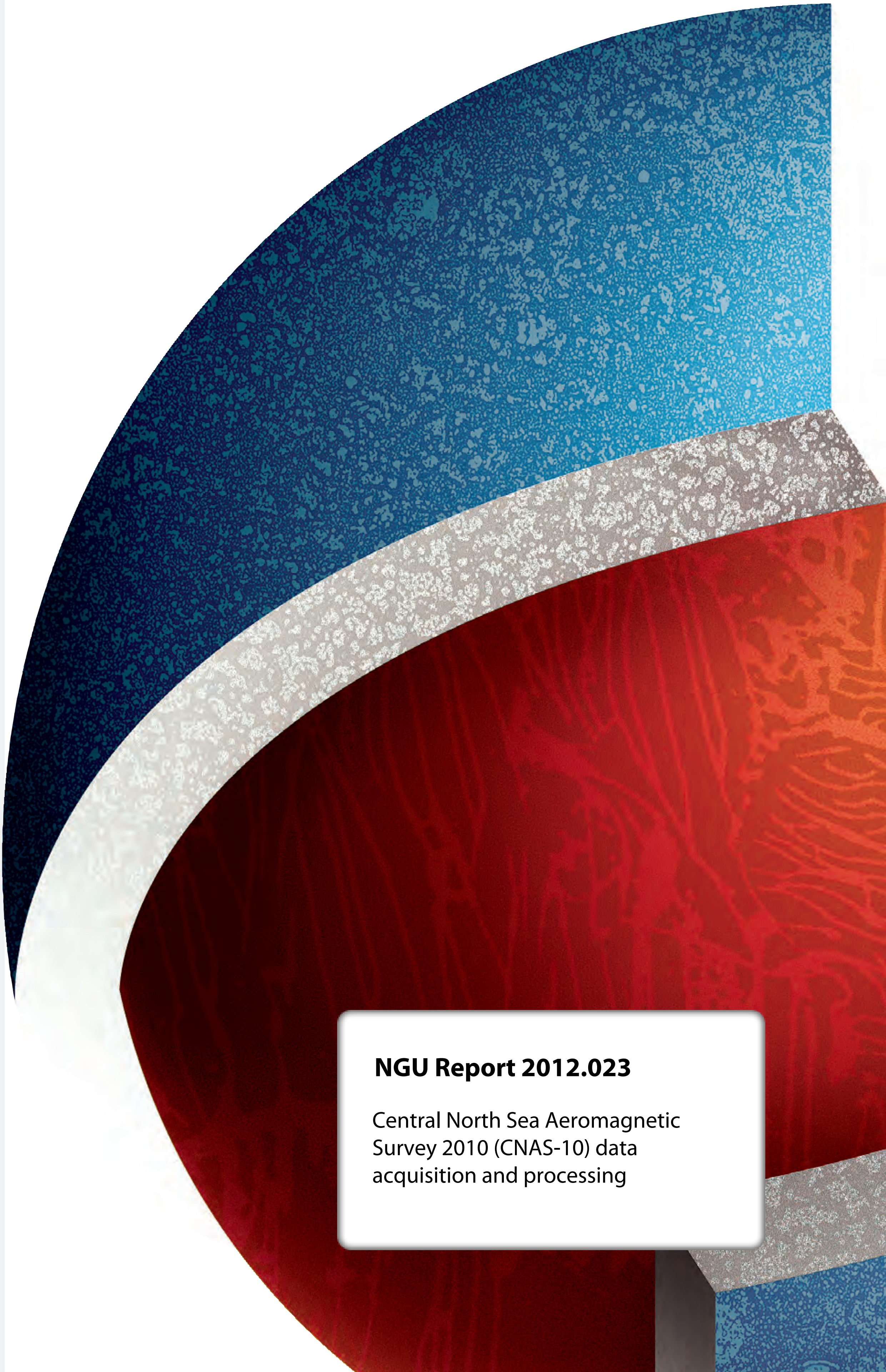

NGU Report 2012.023

Central North Sea Aeromagnetic Survey 2010 (CNAS-10) data acquisition and processing

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REPORT

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Title:
Central North Sea Aeromagnetic Survey 2010 (CNAS-10) data acquisition and processing

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Summary:
A regional aeromagnetic survey has been carried out in the North Sea called the Central North Sea Aeromagnetic Survey 2010 (CNAS-10). The acquisition was carried out during the period 26 May – 12 October 2010. The airborne magnetic survey was conducted with constant flight-line orientations. In-lines were running E-W-oriented with perpendicular tie-lines N-S (c. -6° off geogr. N). Line spacing was set to 1 km for the profiles and 4 km for the tie lines to achieve a good control on the diurnal variations of the magnetic field during the data processing.
For the data acquisition a caesium magnetometer was installed in a so-called 'bird' and towed approximately 70 m below and behind the aircraft, giving a sensor altitude of about 115 ± 10 m. For the onshore areas, flight clearance was naturally greater due to the topography and poor weather conditions. The flying speed was 225 km/h and magnetic data were sampled at a rate of 5 Hz, giving an approximate spatial sampling interval of 7-15 m along the lines.
The data were processed in 2010 and reprocessed in 2011 to improve the results. The present report describes the applied acquisition and processing techniques to produce the final aeromagnetic map of the area.

Keywords: Geophysics	Aeromagnetic	Data acquisition
Magnetometry	Processing	

CONTENTS

FIGURES

Tables

1 SURVEY CHARACTERISTICS AND ACQUISITION

1.1 Survey area and equipment

The survey area is approximately 482 km long and the width varies from c. 253 km in the south to c. 183 km wide in the north. The acquisition was carried out during the period 26 May – 12 October 2010. A total of 71 flight-days were necessary to cover the proposed area. For the data acquisition a caesium magnetometer was installed in a so-called 'bird' and towed at a sufficient distance from the aeroplane (70 m) to render the plane's magnetic effects negligible (Figure 1.*1*).

Figure 1.1 Piper Chieftain from Fly Taxi Nord AS with the towed Scintrex Caesium Vapour MEP 410 high-sensitivity magnetometer. (Photo: Aasmund Gylseth)

The entire system was run by the pilots to save costs and time no additional NGU personnel was required on board. The data were stored on an USB memory stick was sent to NGU by email after to each flight, for instantly quality controll and pre-processing. Before and during flights, NGU staff was permanently controlling the magnetic diurnals through the web page of the Tromsø Geophysical Observatory (http://flux.phys.uit.no/geomag.html) and could redirect or abort the flight at any time using a satellite telephone when required.

1.1.1 Personnel

Participants from NGU:

Project leader:	Odleiv Olesen
Senior engineer:	Janusz Koziel and Torleif Lauritsen
Engineer:	Thomas Møller
Geophysicist:	Marianne Aarset, Aziz Nasuti and Marco Brönner

Participants from Fly Taxi Nord:

Captain:	Ronny Thorbjørnsen
Captain:	Ole Thorbjørnsen
Co-pilot:	Andreas Drevvatne
Co-pilot:	Gard Pettersen

1.2 Equipment and technical specification

The following equipment was used in the survey:

- Aircraft: Piper Chieftain PA-31-350 (registration. LN-ABZ) with long-range fuel tanks from Fly Taxi Nord in Tromsø (Figure 1.1).

- Navigation: An Ashtech G12, 12 channel GPS receiver combined with a Trimble Navbeacon DGPS correctional receiver (SATREF) with a flight guidance system from Seatex ASA was used for real time differential navigation. The navigation accuracy was better than ±5 m throughout the survey.

- Altimeter: A KING KRA 405 radar altimeter is an integrated instrument of the aircraft and the data were both recorded and shown on the pilot’s display. The altimeter has an accuracy of 0.25% with a resolution of 1 foot (0.3048 m)

- Magnetometer: A Scintrex Caesium Vapour MEP 410 high-sensitivity magnetometer with a CS-3 sensor was employed in the data acquisition. The noise envelope of the onboard magnetometer was 0.1 nT. Most of the data fell within the limits of ±0.04 nT.

- Data logging: NGU data logger was used to record the different datasets from the survey.

1.3 Acquisition

The airborne magnetic survey was conducted with constant flight-line orientations. In-lines were running almost E-W with perpendicular N-S oriented tie-lines (Figure 1.*2*).
Table 1.*1* shows the coordinates of CNAS survey area and Table 1.*2* summarizes the main characterization of the survey. Line and tie line spacing were set to 1 km and 4 km to achieve a good control of diurnal variations of the magnetic field during the data processing.

The whole area was covered with both tie-lines and traverse lines (Figure 1.2). The total survey area covers was c. 64,500 km^2 and consists of 13,029 km tie-lines and 52,893 km ordinary profiles. The aircraft altitude in the offshore area was 185 m a.s.l. on average (600 feet) (Figure 1.3). The magnetic sensor was towed approximately 70 m below and behind the aircraft, giving a sensor altitude of about 115 ± 10 m. For the onshore areas, flight clearance was naturally greater due to topography and poor weather conditions. The flying speed was 225 km/h and magnetic data were sampled at a rate of 5 Hz, giving a spatial sampling interval of 7-15 m along the lines.

The acquisition was planned and carried out within c. 20 weeks from May to October 2010.

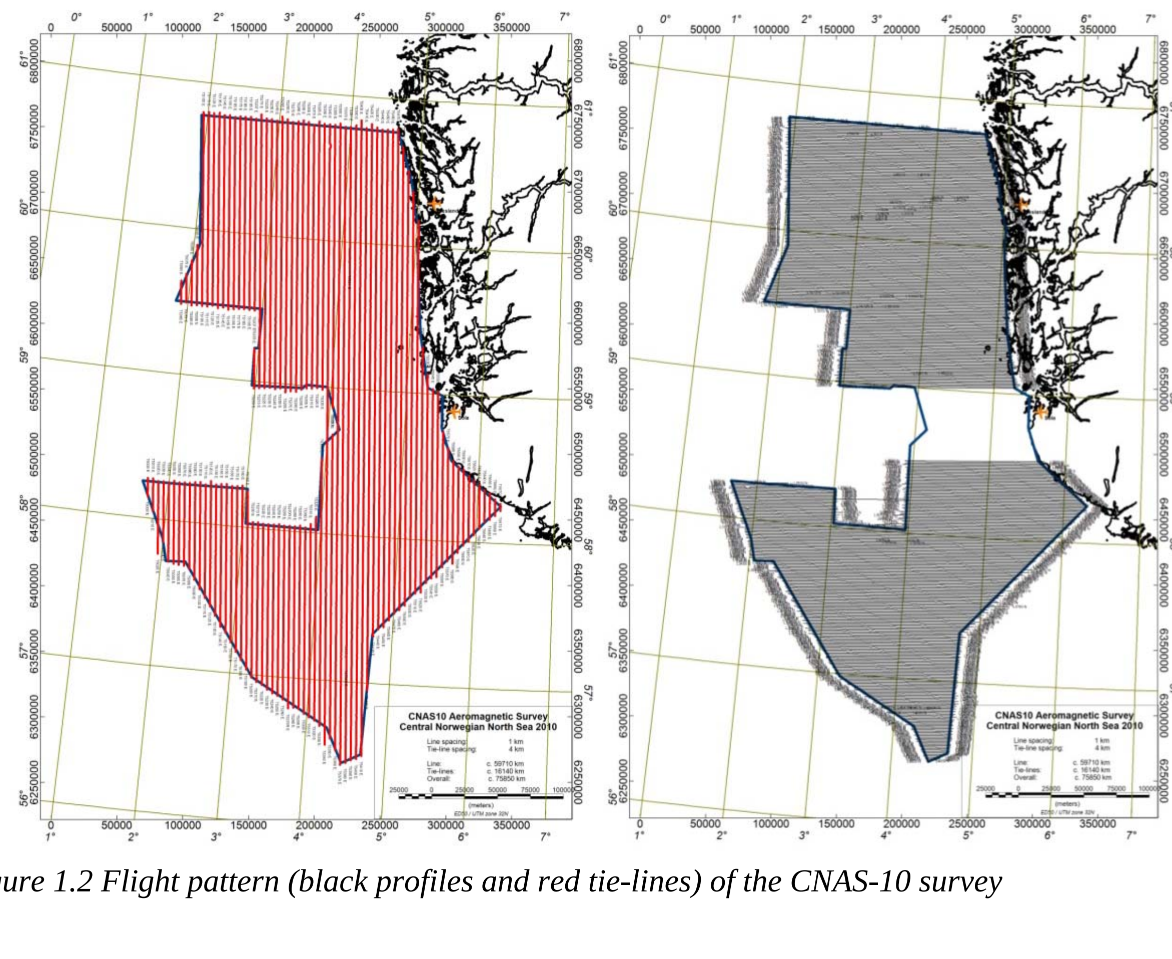

Figure 1.2 Flight pattern (black profiles and red tie-lines) of the CNAS-10 survey

X	Y	LONG	LAT
115478	6758689	1.930557	60.776983
264988	6746775	4.681590	60.786799
274518	6705079	4.903834	60.418912
276305	6687210	4.956086	60.259859
279879	6678275	5.030213	60.181775
280475	6587735	5.135966	59.370983
286431	6550805	5.276798	59.043099
300131	6543657	5.521588	58.985658
296557	6520426	5.480764	58.775741
304897	6493622	5.647876	58.53927
342423	6460265	6.314574	58.255210
245331	6363173	4.767495	57.340130
235800	6270846	4.705843	56.50766
220909	6264890	4.471009	56.445731
210187	6291694	4.267741	56.679270
153004	6329816	3.286971	56.981188
101182	6417973	2.297336	57.726082
87482	6419165	2.066939	57.724356
85099	6434056	2.001460	57.854932
70804	6476348	1.685546	58.218263
70804	6479922	1.678955	58.250102
148239	6473965	2.999608	58.265570
148835	6447160	3.049932	58.026598
203039	6442991	3.969190	58.028836
206613	6507322	3.947842	58.606794
219122	6519235	4.147524	58.721671
211379	6550805	3.973450	58.999016
194104	6553187	3.670770	59.008325
191126	6550209	3.623310	58.97955
151813	6552592	2.939390	58.970699
154791	6579992	2.947788	59.21781
158365	6580587	3.009113	59.226026
160748	6610966	3.002782	59.499259
94034	6617518	1.820828	59.498485
112500	6661001	2.064480	59.903577
114882	6757497	1.922056	60.765794

Table 1.1 Coordinates of the CNAS-10 survey area.

Base of operation	Bergen and Stavanger airports
Tie line spacing and trend	4 km, north – south
Traverse line spacing and trend	1 km, east – west
Flying height /sensor altitude	~185 m/115 m.
Speed	~225 km/h
Total line kilometres (in contract)	82,000
Total line kilometres (acquired)	~82,000
Total flight-days	71
Data recorded	Magnetic field intensity, radar altitude and GPS positioning data

Table 1.2 Main characteristics of the CNAS-10 survey.

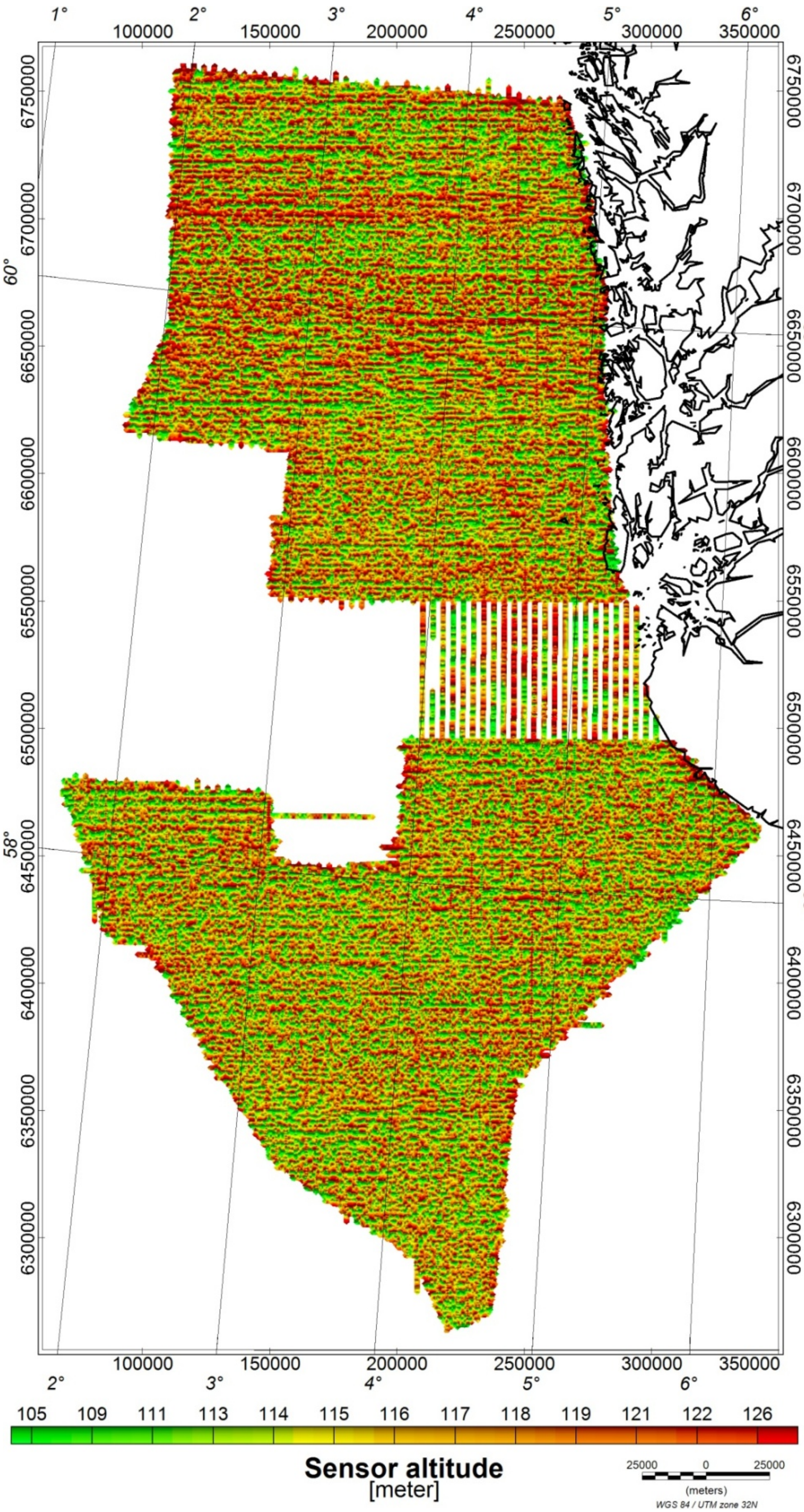

Figure 1.3 Sensor altitude (airplane radar altitude – 70 m).

1.4 Magnetic conditions

The most complex problem during magnetic acquisition is probably the diurnal variation of the Earth's magnetic field influenced by solar storms, which are particularly active at high latitudes (i.e. aurora borealis). This usually causes tie-lines and regular survey lines to have different readings at the same geographical point (crossover point). Such misfits can produce artefacts during interpolation and consequently, erroneous interpretations if no suitable corrections have been applied.

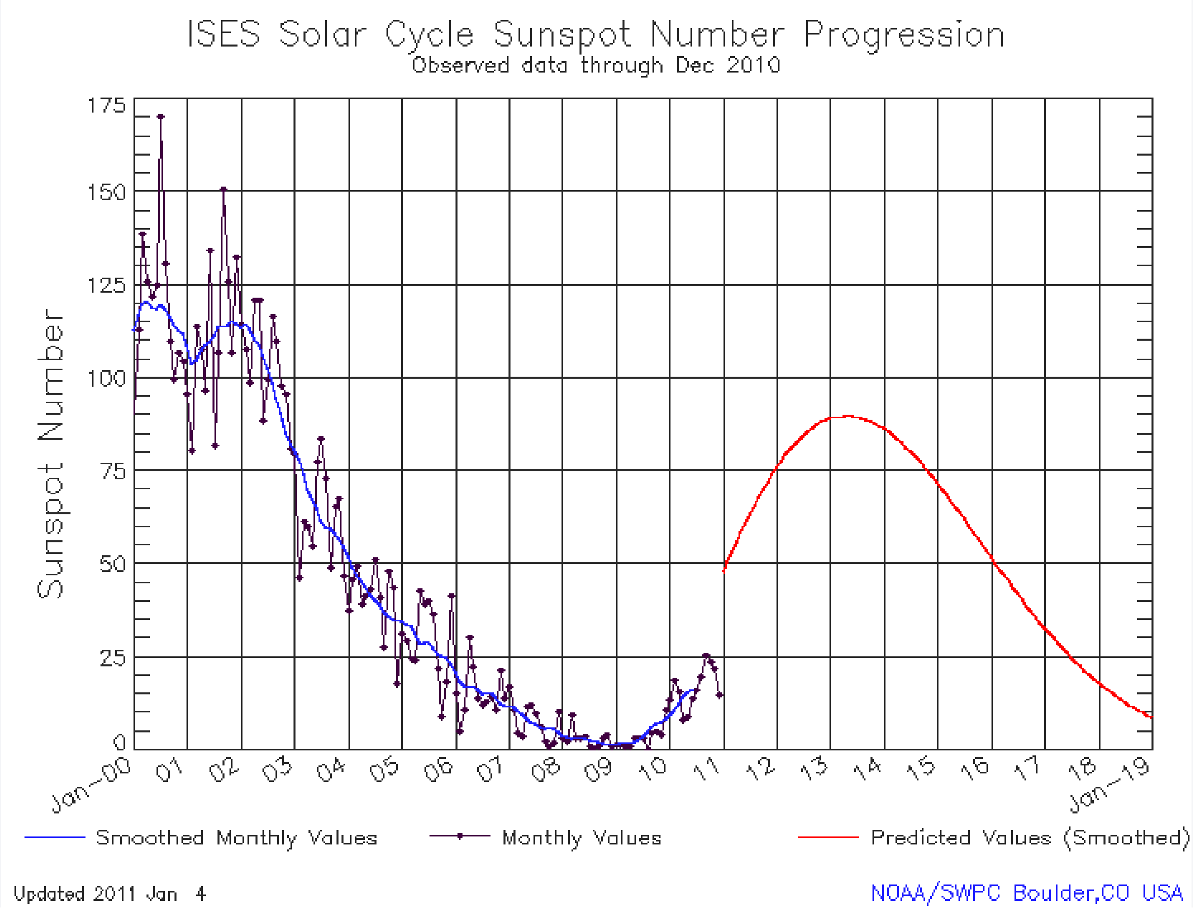

Figure1.4 Observations and prediction models of sunspot numbers from the US National Oceanic and Atmospheric Administration (NOAA)(http://www.swpc.noaa.gov/SolarCycle). Monthly averages (updated monthly) of the sunspot numbers show that the number of sunspots visible on the sun waxes and wanes with an approximate 11-year mega cycle. The CNAS-10 survey was carried out during a period of low solar activity, which presented excellent conditions for the aeromagnetic acquisition.

If the survey is located close to a magnetic base station site, the lines can be directly corrected for diurnal variation. However, most of the offshore acquisition extends far away from land stations and is then liable to experience different diurnal variations. Efficient statistical algorithms and filtering are usually required to solve this issue and to 'level' in an acceptable way all the magnetic profiles. The sunspot cycles strongly influence the geomagnetic field and diurnals. The CNAS-10 was acquired during a relatively quiet period. Solar cycle predictions suggest that the sunspot activity is increasing after a minimum in 2009 (Figure1.*4*, Figure 1.*5*), thus providing relatively good magnetic conditions at the time of acquisition. However, we applied several steps of quality control to minimize the amount of data affected by these variations:

- The daily flight-plan was made under consideration of the recorded Earth's magnetic field variations from base-stations in the area, e.g. Solund, Karmøy and Dombås (Recordings in real-time provided by the University of Tromsø: http://flux.phys.uit.no/).
- The daily data QC was carried out using base-mag data from these three stations to classify the data quality and to plan possible reflys (Table 1.3).
- Tie-line levelling was carried out in conjunction with the recorded variations in the Earth's magnetic field.

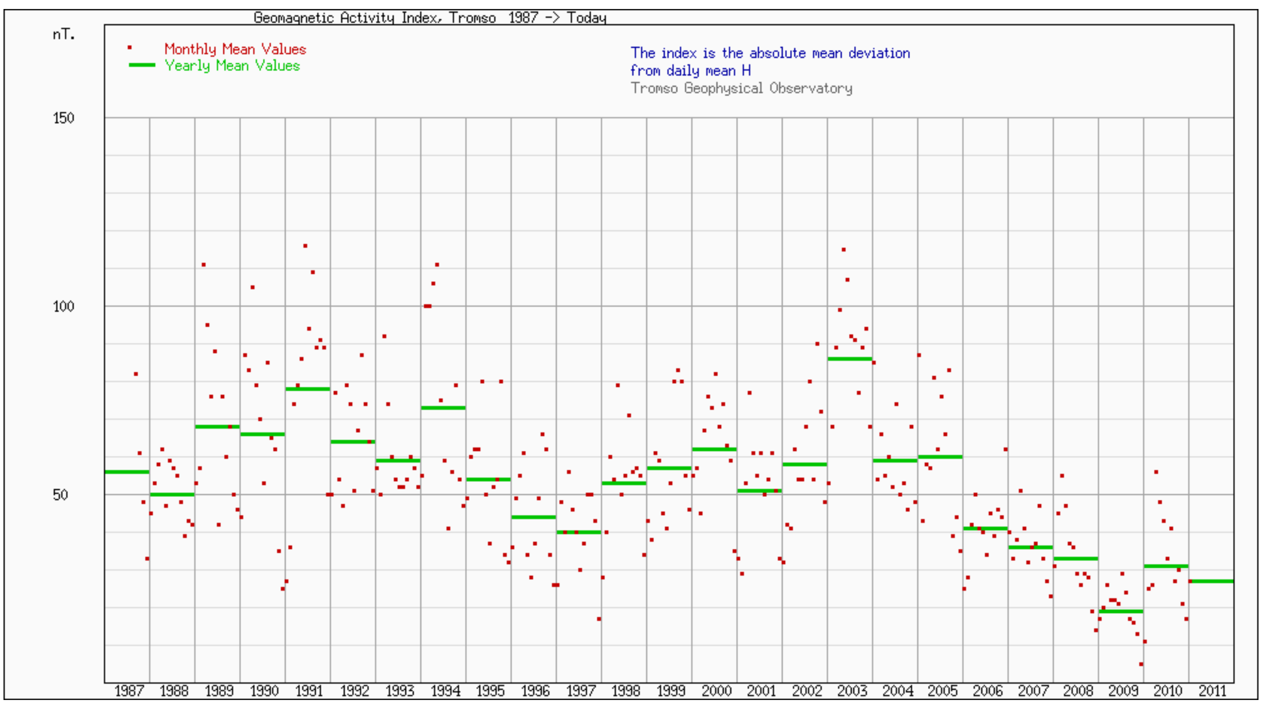

Figure 1.5 Diagram of the monthly and yearly mean values of the horizontal intensity of the geomagnetic field (H) observed at the Tromsø Geophysical Observatory from 1987 to 2010. This graph illustrates the good correlation between the periodic and semi-periodic evolution of the field and sunspot activity. Geomagnetic data derived from the Tromsø Geophysical Observatory (http://flux.phys.uit.no/geomag.html).

The diurnals for all flights are included in the database file delivered on the CNAS-10 archive CD. These plots ease the quality control of the acquired profiles. The data were classified into two quality groups according to the magnetic diurnals:

Class	Criteria	Profile length
1	< 10 nT/10 min. Linear	81,445 km
2	>30 nT/10 min. Linear	555 km
Total		82,000 km

Table 1.3 Results from data QC and the re-fly programme of CNAS-10.

A total of c. 555 line km was of poor quality (Figure 1.6) and reflown at the end of the acquisition. During the levelling process, all remaining effects from the background magnetic field variations were further removed or reduced to a minimum.

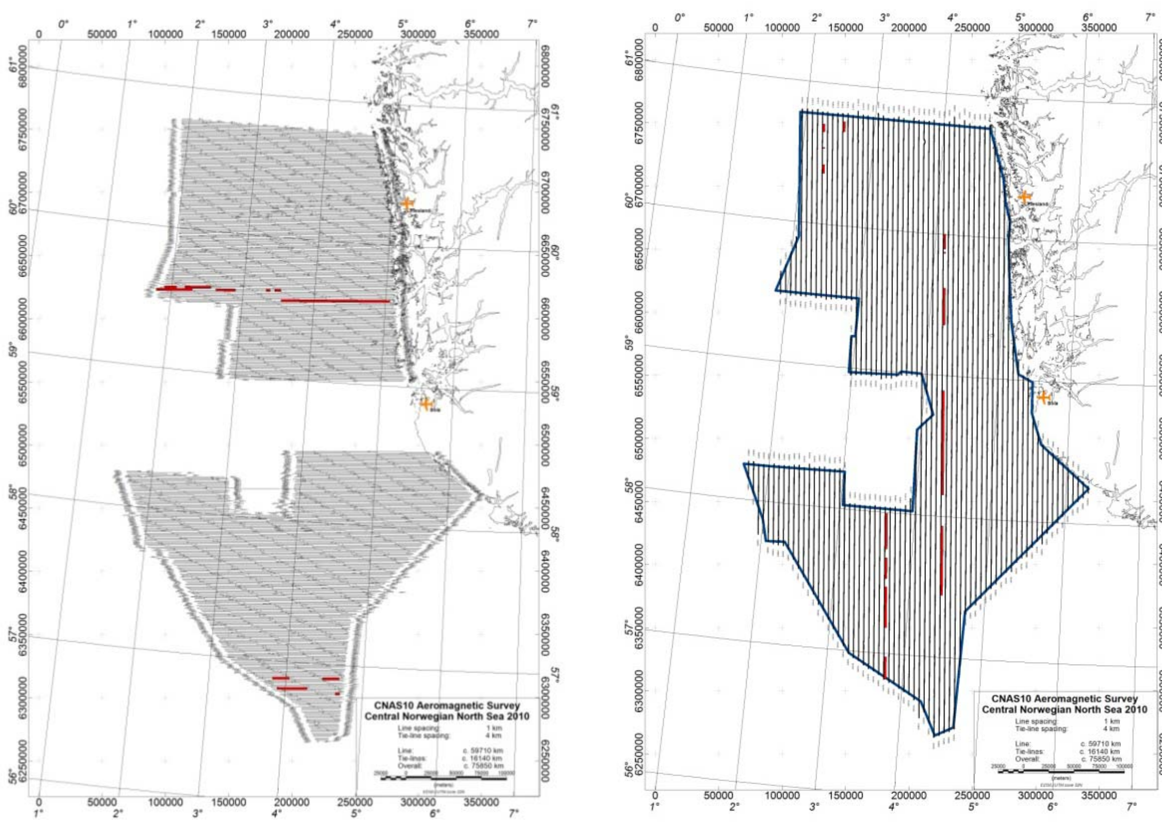

Figure 1.6 Profiles with locally poor quality due to strong diurnal variations (i.e. diurnal variation of more than 30 nT per 10 minutes) were selected for reflying. The total length of poor-quality data is 555 km (i.e. 0.67 % of the total survey). The red lines mark the profiles which were reflown.

To estimate the influence of the magnetic signature of the aeroplane, a magnetic heading test (clover-leaf test) was carried out in October 2006 in the Hammerfest region for the SNAS-06 and BAS-06 projects. The magnetic signature of the aeroplane also includes 1) its permanent magnetisation induced by its motion through the Earth's magnetic field, 2) a component due to the flow of electric current within the plane, and 3) the orientation of the magnetic sensor inside the bird. The permanent magnetisation of the plane varies as the plane changes its orientation, thus leading to heading errors. The maximum difference of magnetometer readings in the four different directions as it turned out from this test was small: 1.2 nT. We decided not to carry out another clover-leaf test in 2010 and considered the effect as negligible.

1.5 Gridding, map production, projection and archive CD

The Oasis montaj software (Geosoft 2010b) was used throughout for the map production. This software package has become a standard for many potential field experts in the mineral and petroleum industry. All databases and grids in Geosoft format are provided on the CNAS-10 archive CD. The grids are usually presented with a shaded relief technique (illumination from the north) and a non-linear colour scale. Gridding was performed using the minimum curvature gridding technique with a grid cell size of 200 x 200 m of the inline profile distance). Minimum curvature interpolation produces a smooth grid while attempting to honour the data as closely as possible. Presentation of the maps with the shaded relief technique enhances lineaments that trend oblique to the illumination direction. Colour scale and colour distribution for the datasets have been computed using a histogram equalisation technique. These maps have been produced in the Universal Transverse Mercator projection (UTM zone 32) using the WGS 84 datum.

On the CD we provide an Oasis montaj Viewer and its tutorial for companies that do not use Oasis montaj specifically. The Oasis montaj Viewer is a free and easy-to-use software that allows anyone to view, share and print published Geosoft grid (.grd) and database (.gdb) files. The viewer can also be used to convert grids and images to a variety of supported data formats, including AutoCAD, ArcView, ER Mapper, TIF and many more. The free software can also be shared and downloaded from
http://www.geosoft.com/pinfo/Oasismontaj/free/montajviewer.asp.

For specific questions on special needs, please do not hesitate to contact NGU (either Aziz.Nasuti@ngu.no , Marco.Bronner@ngu.no or Odleiv.Olesen@ngu.no).

2 DATA PROCESSING AND PROFILE LEVELLING

RAW-magnetic data cannot be used directly for gridding and require a number of processing steps before the production of the final aeromagnetic grid and the map of the total magnetic intensity (TMI) for interpretation use. Noise filtering and statistical levelling processing were carried out using the professional Oasis montaj software (Geosoft 2010a). Microlevelling was performed using the MAGMAP FFT package from Oasis montaj (Geosoft 2010a). The raw data have been processed using standard procedures and methodologies used in many other geological surveys (Luyendyk 1997). In the year 2011 a new microlevelling process was applied in order to improve the quality of the final product. The various processing steps and standard procedures are outlined below.

2.1 Preliminary noise filtering and basic corrections

2.1.1 Noise filtering

High-frequency noise is usually created as the aeroplane is manoeuvring. After acquisition, initial raw data were imported directly into an Oasis montaj database and subsequently interpolated to a regular grid of 200 x 200 m cells, to check the quality of lines and tie-lines (Figure 2.1). Spikes due to minor noise and artefacts were smoothed with a light low-pass filter (5 fiducials=35-75 m) in order to keep the signal intact. A map with an overview of platforms, pipelines, cables, subsurface installations, development wellbores and shipwrecks was produced (Figure 2.2). The pilots did also report when they spotted a boat during the acquisition. This information was used to remove man-made spikes from the data.

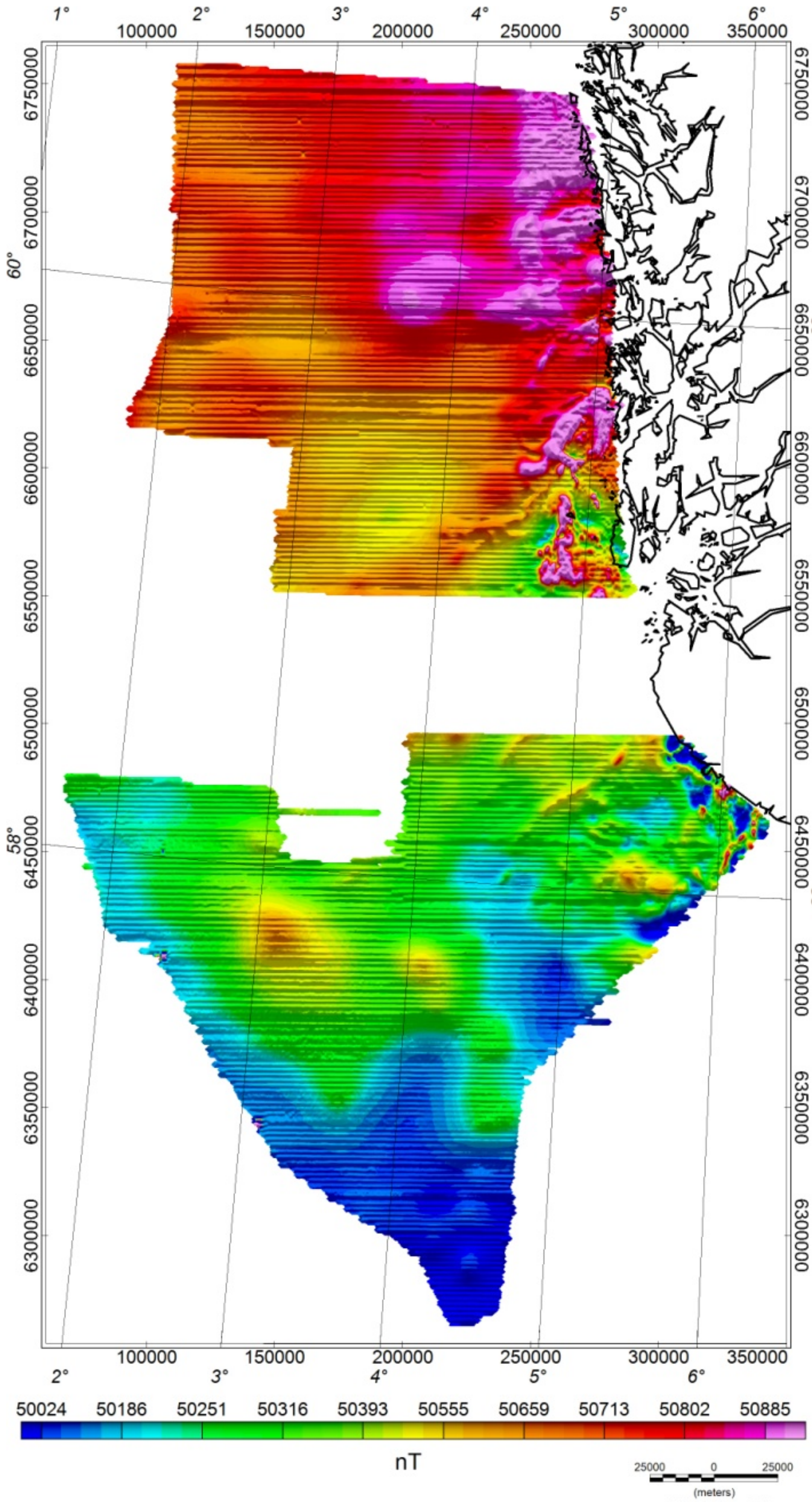

Figure 2.1 CNAS-10 TMI RAW magnetic profile data (without levelling) gridded by means of the minimum curvature algorithm (grid cell size at 200 x 200 m). Note that the artefacts are mostly parallel to the line profiles due to the magnetic diurnals. Projection UTM 32, WGS 84 datum.

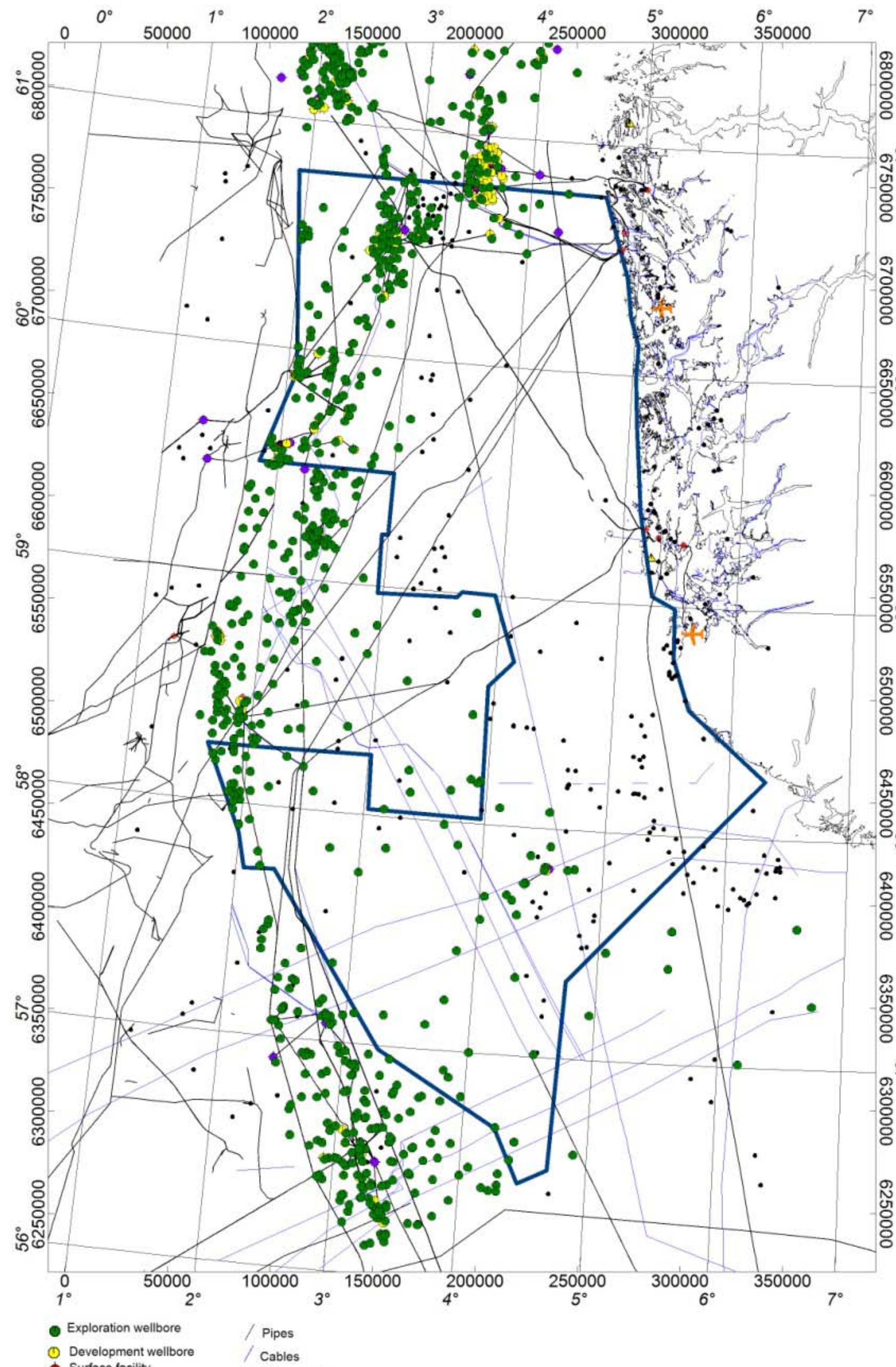

Figure 2.2 A map over all installations, wells and pipe lines/cables in the survey area.

2.1.2 Systematic lag corrections

A systematic lag correction for the CNAS-10 data were tested but not applied as it did not affect the data quality.

2.1.3 International Geomagnetic Reference Field (IGRF correction)

The total magnetic intensity (TMI) raw data reflect the recorded magnetic field, including the Earth's geomagnetic main field and all disturbances. The data are dominated by the Earth's geomagnetic field, observable by the increasing magnetics to the NNE.

As part of the processing, the magnetic anomaly is computed from the recorded magnetic field by subtraction of the International Geomagnetic Reference Field (IGRF2010) model (Figure 2.3). The IGRF is a mathematical representation of the undisturbed Earth's geomagnetic field. The annual change of the IGRF field in the CNAS-10 survey area is about +57 nT, on average.
The International Geomagnetic Reference Field for 2010 (IGRF-2010) was calculated using the Oasis montaj IGRF tool. The result of this subtraction isolates the component of the magnetic total field, which is dominated by the magnetic effects from the underlying crustal rocks.

The TGS data that were collected in 2009 were at this point merged with the CNAS-10 data. The whole dataset was corrected for IGRF and man-made spikes were removed. Some smaller adjustment to overlapping lines and removal of unregistered boats were carried out later in the process. Figure 2.4 shows the IGRF corrected data of the merged datasets.

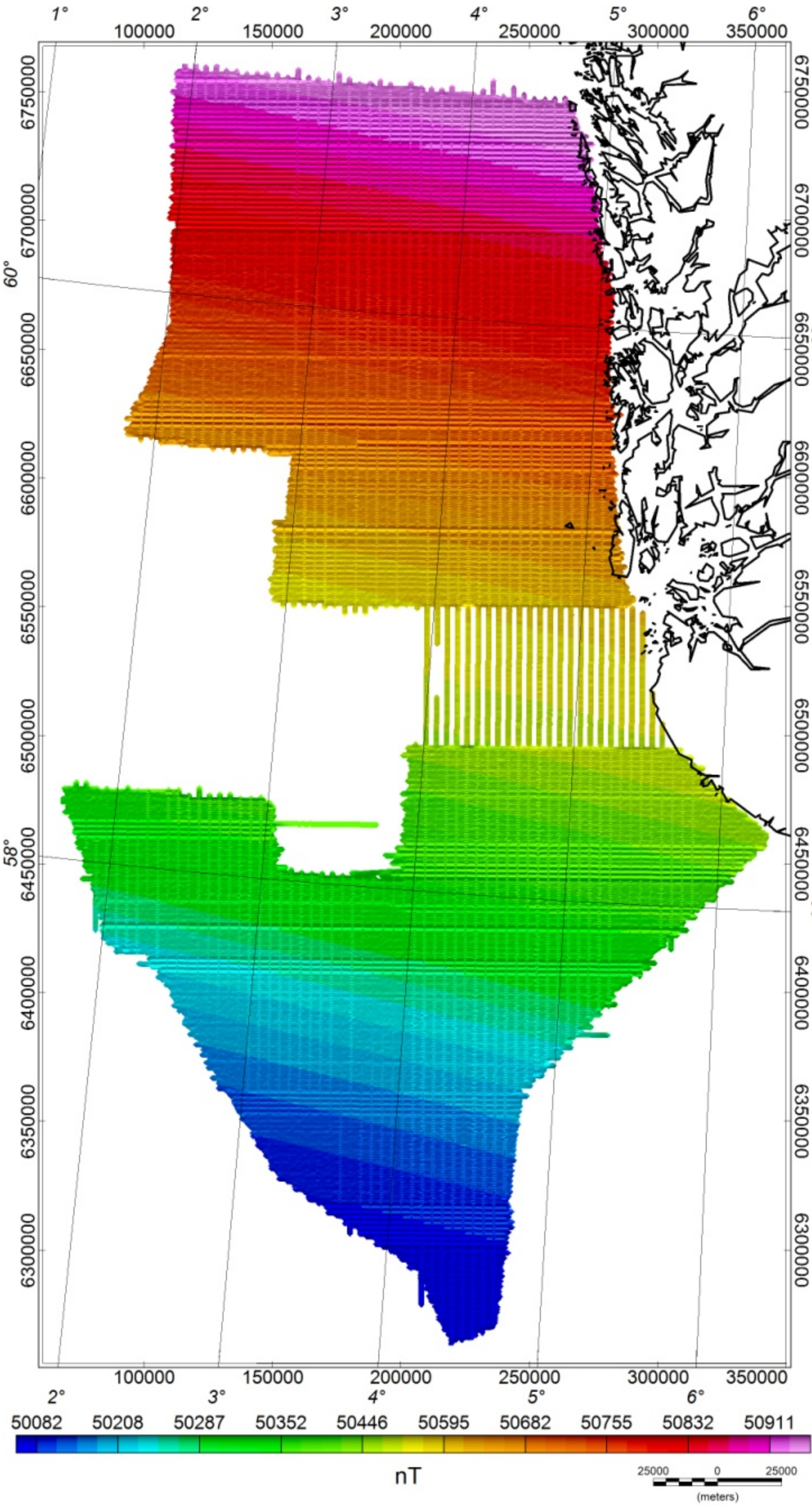

Figure 2.3 The IGRF-2010 model within the CNAS-10 survey area. The variable heights of the instrument were applied in the correction.

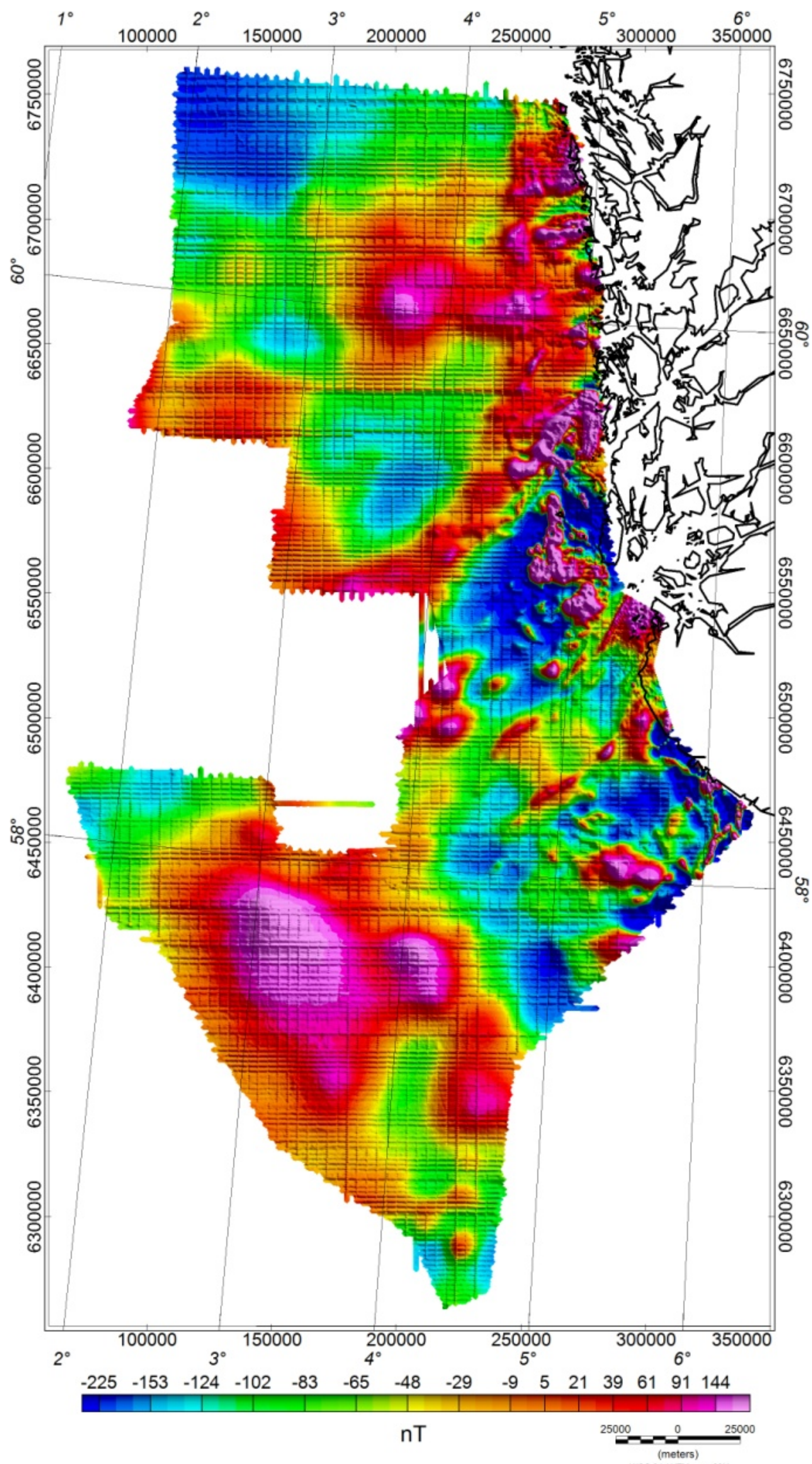

Figure 2.4 CNAS-10 IGRF-corrected total magnetic field (TMI RAW). Spikes from platforms and boats have also been removed. Shading from north-east.

2.2 Levelling and micro-levelling of the magnetic profiles

2.2.1 Diurnal variation and use of base-magnetometer readings

A variety of external, time-varying, field factors usually influence and cause| errors during aeromagnetic acquisition. This includes time variation (diurnal effects) in the magnetic field, altitude variation, ground clearance variation and magnetic effects of seawater swells). These factors are usually sufficient to explain the errors at crossover points between lines and tie-lines.
Even if they are small, these long-wavelength effects can be visually distracting, particularly on image-enhanced displays. Such misfits can also produce artifacts during interpolation and, consequently, erroneous interpretation if no suitable corrections has been applied. The most important reason for this is the time shift in the Earth's magnetic field variations between the offshore survey area and the onshore base station. There is normally a spatial difference in amplitude and frequency of these diurnals.

2.2.2 Statistical levelling

The purpose of levelling is to minimise the residual differences in a coherent way by proportioning them between lines and tie-lines. Proper levelling or micro-levelling algorithms usually require close and proper line spacing, and the quality of the final result is generally a function of this crucial parameter. The large line spacing of previous surveys did not allow proper levelling, and interpolation of raw data produced erroneous or factitious anomalies.

For this project, levelling was undertaken using a standard statistical levelling method of the tie-lines and survey lines, provided as part of the Geosoft Oasis montaj (Geosoft 2010b). The new aeromagnetic survey was processed using a statistical levelling method by which the discrepancies between the readings at each crossover point were reduced by systematically proportioning them between the tie and line profiles. 'Suspicious' crossover differences (outliers) were first removed manually before levelling and full-levelling of the tie-lines and line profiles. A first-order (linear) trend removal was applied during the tie-line levelling, but for one line in the central part of the survey an additional tension spline (b-spline) correction was necessary after several preliminary tests. The tie-lines located in the northern survey area and extending from north to south, were also microlevelled before performing line levelling. This was to remove noise along the flight lines before adjusting the in-lines (Figure 2.5). Extreme mis-tie values (outliers) were checked and removed again manually before calculating the next full-levelling correction, until convergence was achieved.

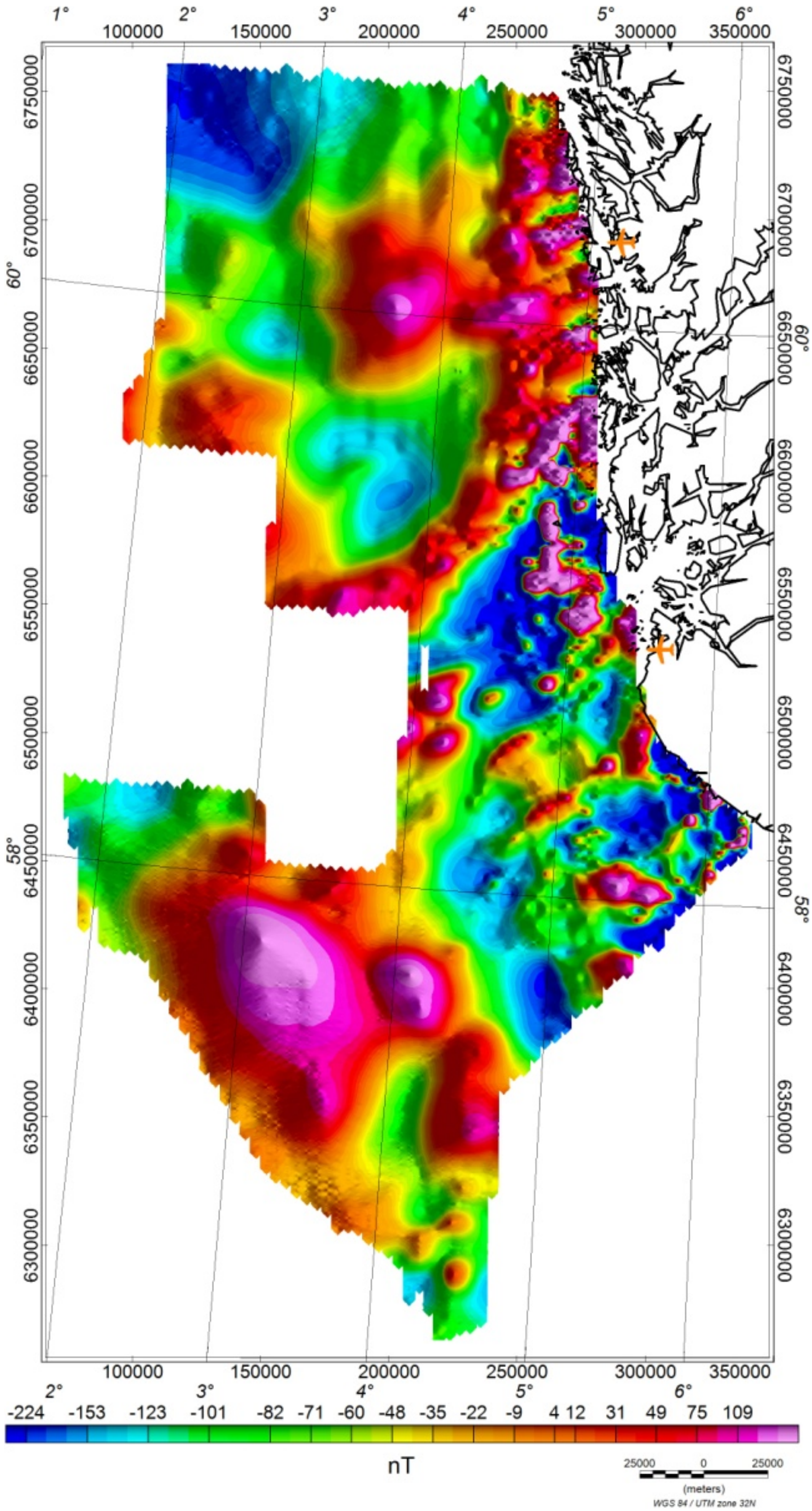

Figure 2.5 Statistical levelling of the magnetic profiles. Shading from north-east.

The final result has to be considered as the best compromise between the removal of levelling errors and anomaly preservation.

2.2.3 Micro-levelling

We performed micro-levelling to remove minor (‘micro’) levelling errors still remaining along parts of some profiles after the statistical levelling. To improve the levelling, the Geosoft micro-levelling approach using the PGW GX system of the available MAGMAP processing package of the Oasis montaj (Geosoft 2010a) was used. It proved to be better adapted to preserve geological information for this specific case where the remaining levelling errors are irregularly distributed. The PGW GX system applies a decorrugation process in the frequency domain to isolate the levelling corrections before applying them to the original data. The CNAS-10 data and TGS data have been decorrugated to reduce line-to-line levelling errors, which are visible as linear magnetic features parallel to the flight lines. Decorrugation is simply a frequency domain procedure based on a directional cosine filter. This filter retains anomalies, from gridded data, in the flight line direction only. First, a Butterworth high-pass filter is set to four times the line spacing to pass wavelengths on the order of two to four line separations. Such a process results from a line-to-line levelling error. In a second step, a directional cosine filter is set to pass wavelengths only in the direction of the lines. The microlevelled data is shown in the Figure *2*.6.

2.3 Final image

After microlevelling the data still were contaminated by some noise. To remove this noise a low pass filter with 30 fiducial lengths was used (approx. 210-450m) was used. Subsequent to gridding, we used the 5×5 symmetrical convolution filter to remove very short wavelength noise. The final product of the survey is shown in Figure 2.7.

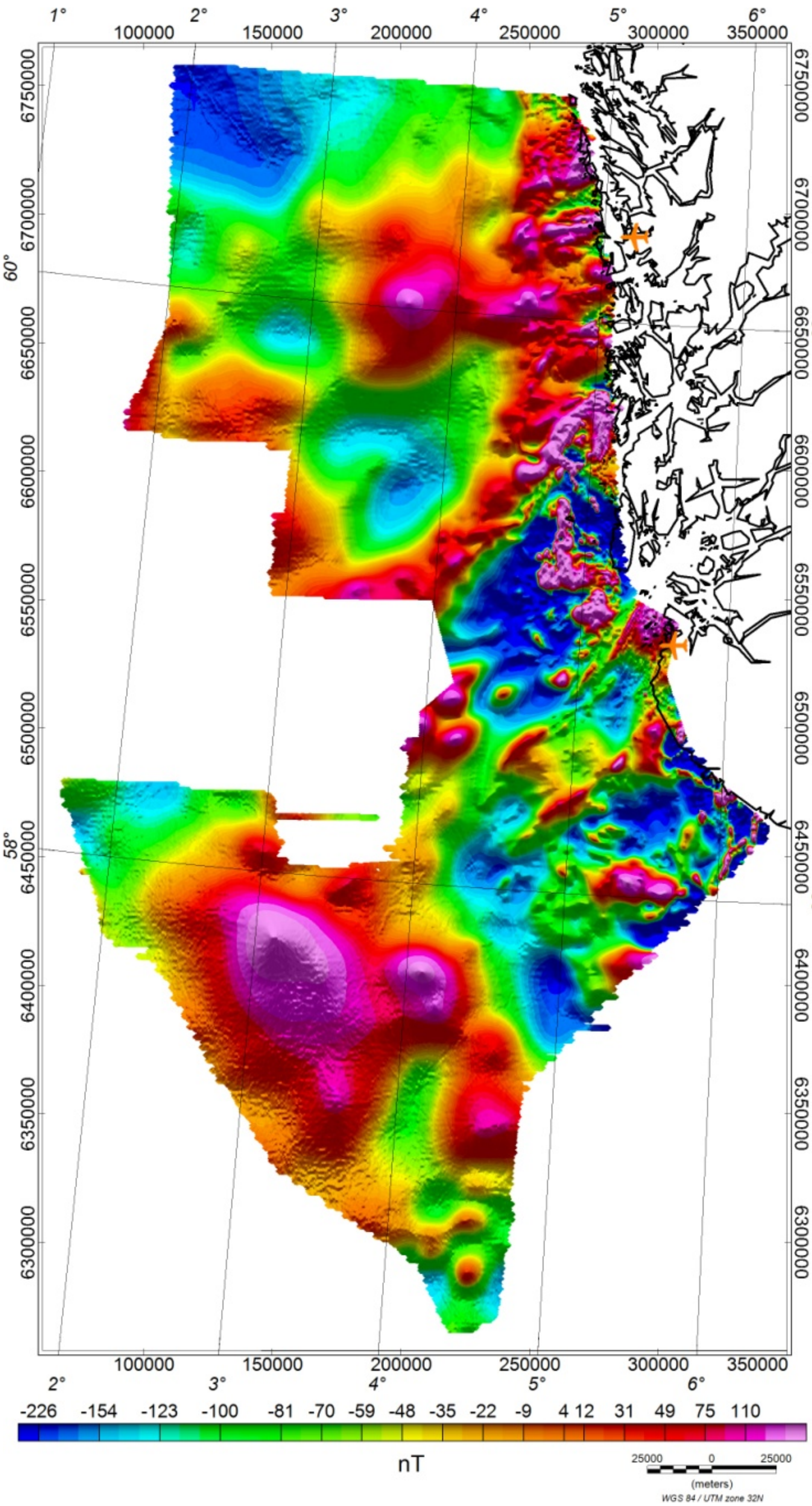

Figure 2.6 Full levelling of the magnetic data. Gridding of the profiles was carried out using the minimum curvature algorithm (grid resolution: 200 x 200 m).

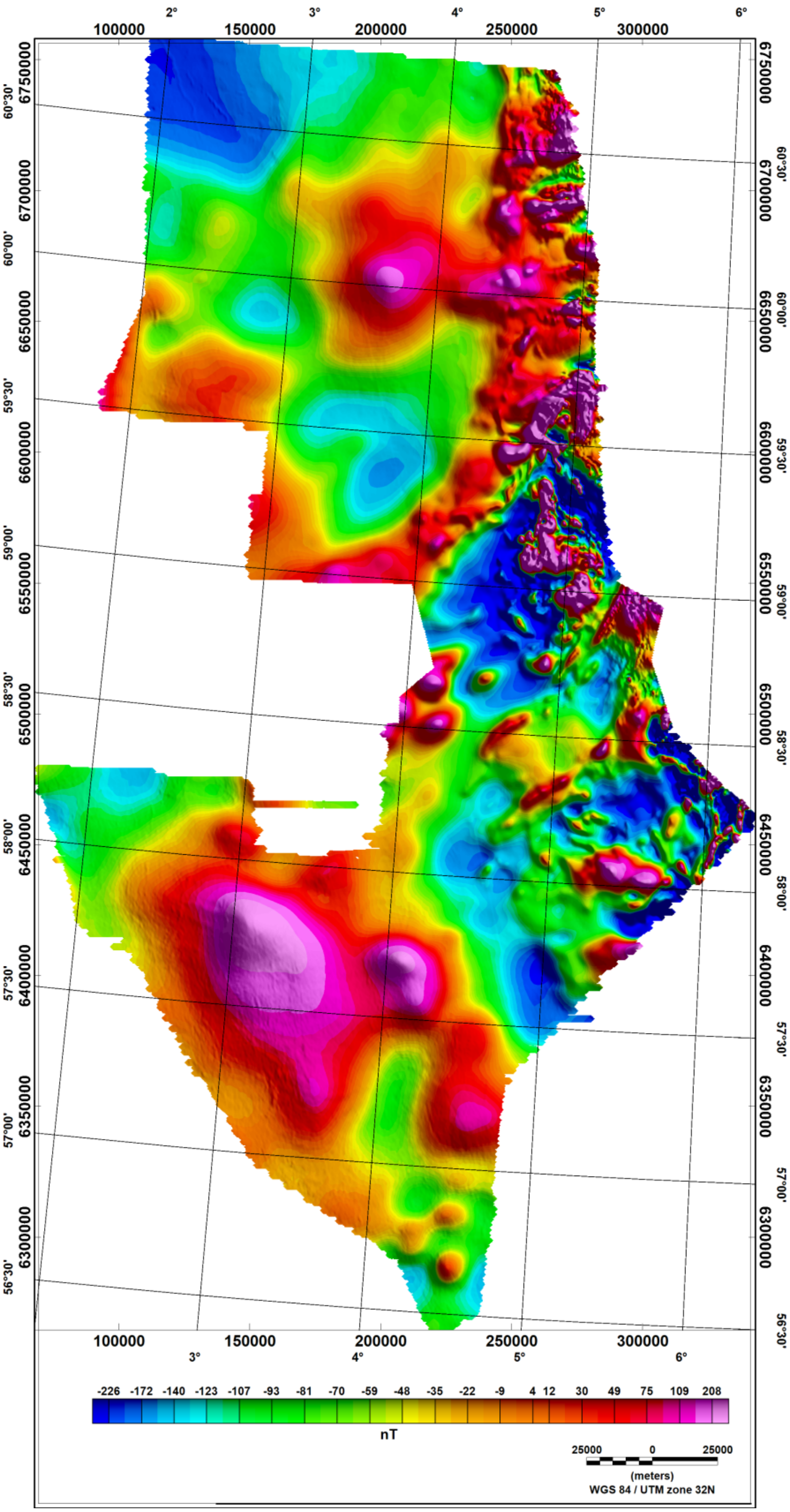

Figure 2.7 TMI field after microlevelling and noise reduction.

2.4 Data enhancement

In order to detect the main geological structures and alignments the aeromagnetic data are filtered as a qualitative aspect of interpretation. Horizontal gradient, analytical signal and the tilt derivative method are utilized to enhance magnetic anomalies associated with faults and other structural discontinuities.

The total horizontal gradient (THG) method is considered as one of the simplest approach to estimate the contact locations (e.g. faults). The method is the less susceptible to noise in the data, because it only requires the two first-order horizontal derivatives of the magnetic field. If $T(x, y)$ is the magnetic field and the horizontal derivatives of the field are ($\partial T / \partial x$ *and* $\partial T / \partial y$), then the horizontal gradient $HG(x, y)$ is given by:

$$THG = \sqrt{(\frac{\partial T}{\partial x})^2 + (\frac{\partial T}{\partial y})^2}$$

The result of horizontal gradient HG is shown in Figure 2.8 and its shaded relief version is depicted in Figure 2.9.

The analytic signal, although often more discontinuous than the horizontal gradient; however it can generate a maximum directly over discrete bodies as well as their edges. The width of a maximum, or ridge, is an indicator of depth of the contact, as long as the signal arising from a single contact can be resolved. The analytical signal is formed through a combination of horizontal and vertical gradients of a magnetic anomaly (Blakely 1996).

$$AS = \sqrt{(\frac{\partial T}{\partial x})^2 + (\frac{\partial T}{\partial y})^2 + (\frac{\partial T}{\partial z})^2}$$

The analytical signal maps in colored and shaded relief are shown in *Figure 2.10* & Figure 2.11.

We also used the tilt derivative method (TDR) in order to enhance the edge of sources. The tilt derivative is the angle between the total horizontal derivative (x and y directions) and the first vertical derivative and is defined by Miller and Singh (1994) as:

$$TDR = tan^{-1}(\frac{\frac{\partial T}{\partial z}}{\sqrt{(\frac{\partial T}{\partial x})^2 + (\frac{\partial T}{\partial y})^2}})$$

$T(x, y)$ is the magnetic field and the horizontal derivatives of the field are ($\partial T / \partial x$ *and* $\partial T / \partial y$) and the vertical derivative is $\partial T / \partial z$. Tilt angle responses vary between positive values over the source, zero over or near the edge, and negative values outside the body (Cooper and Cowan 2006). The results are depicted in *Figure 2.12* & Figure 2.13.

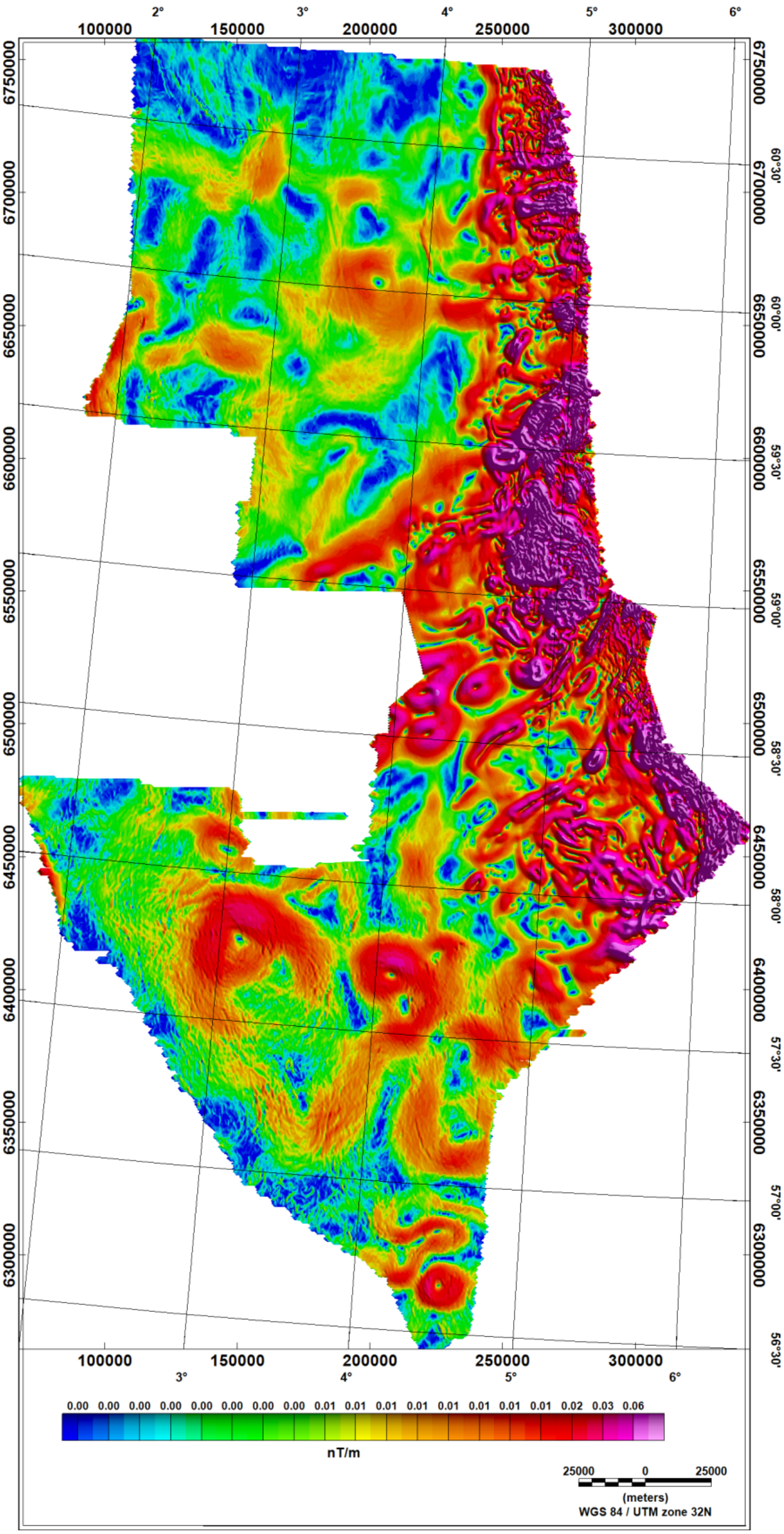

Figure 2.8 Total horizontal gradient map of the microlevelled data.

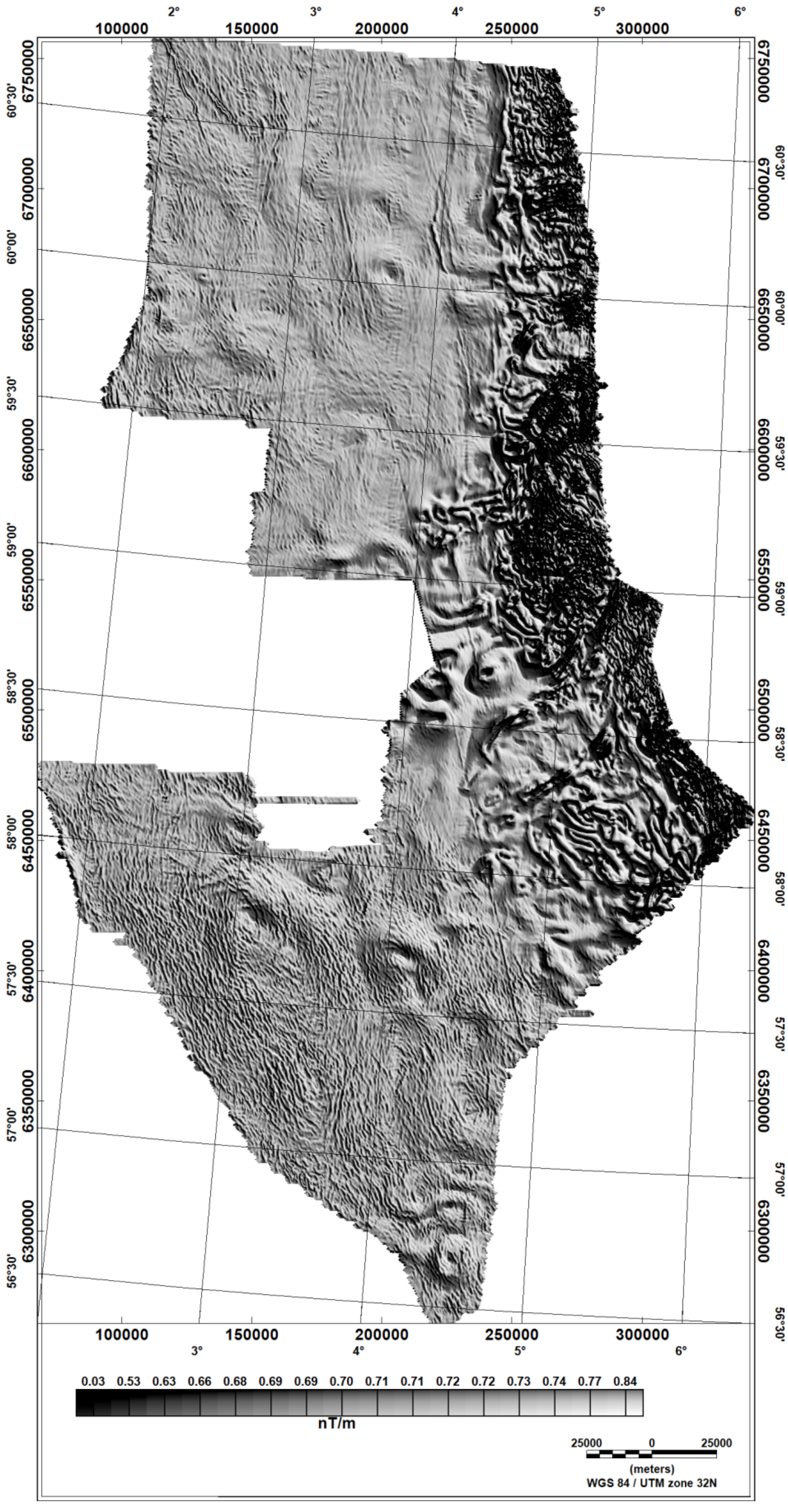

Figure 2.9 Grey tone shaded relief map of the total horizontal gradient of the magnetic data.

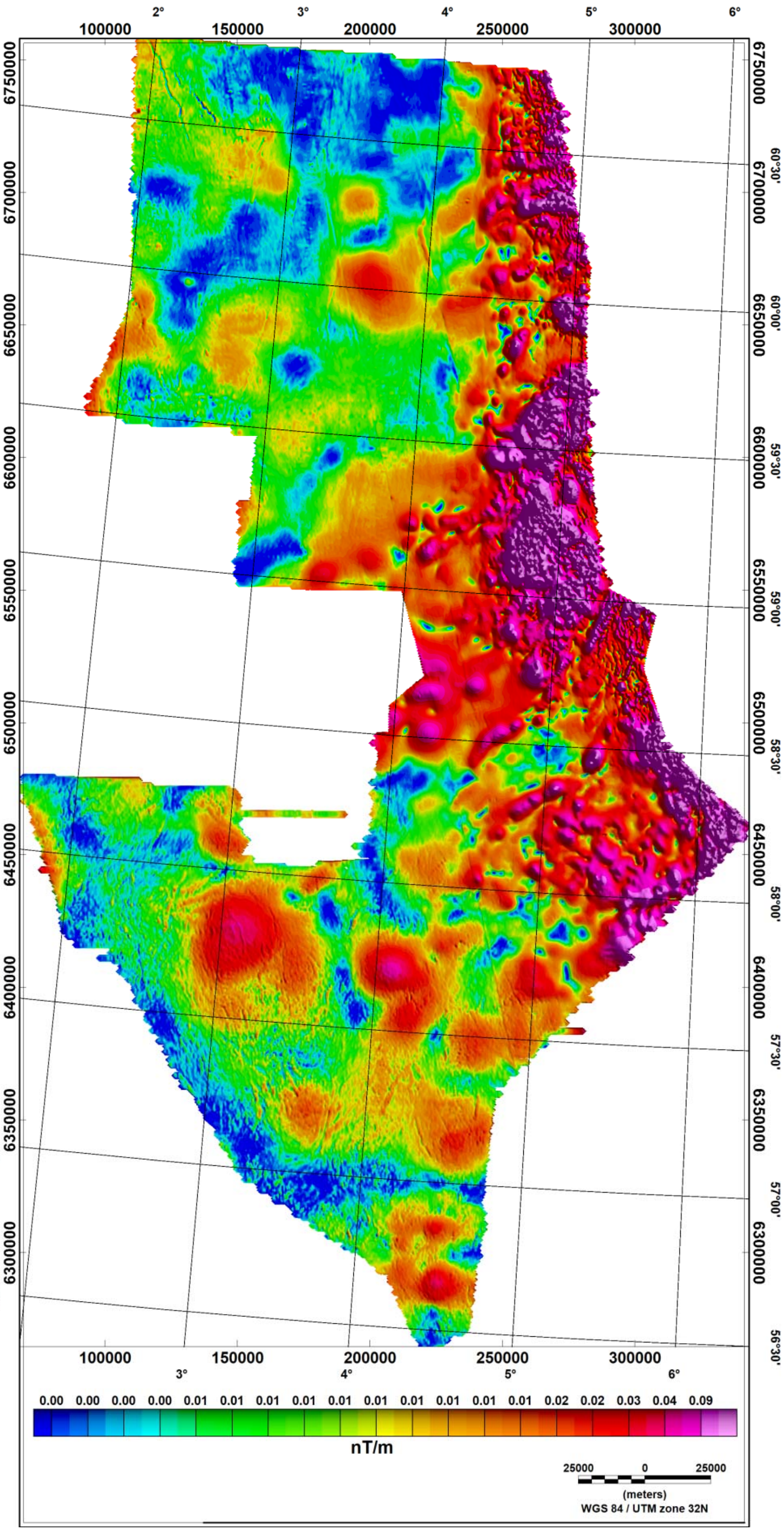

Figure 2.10 Analytical signal map of the CNAS-10 survey.

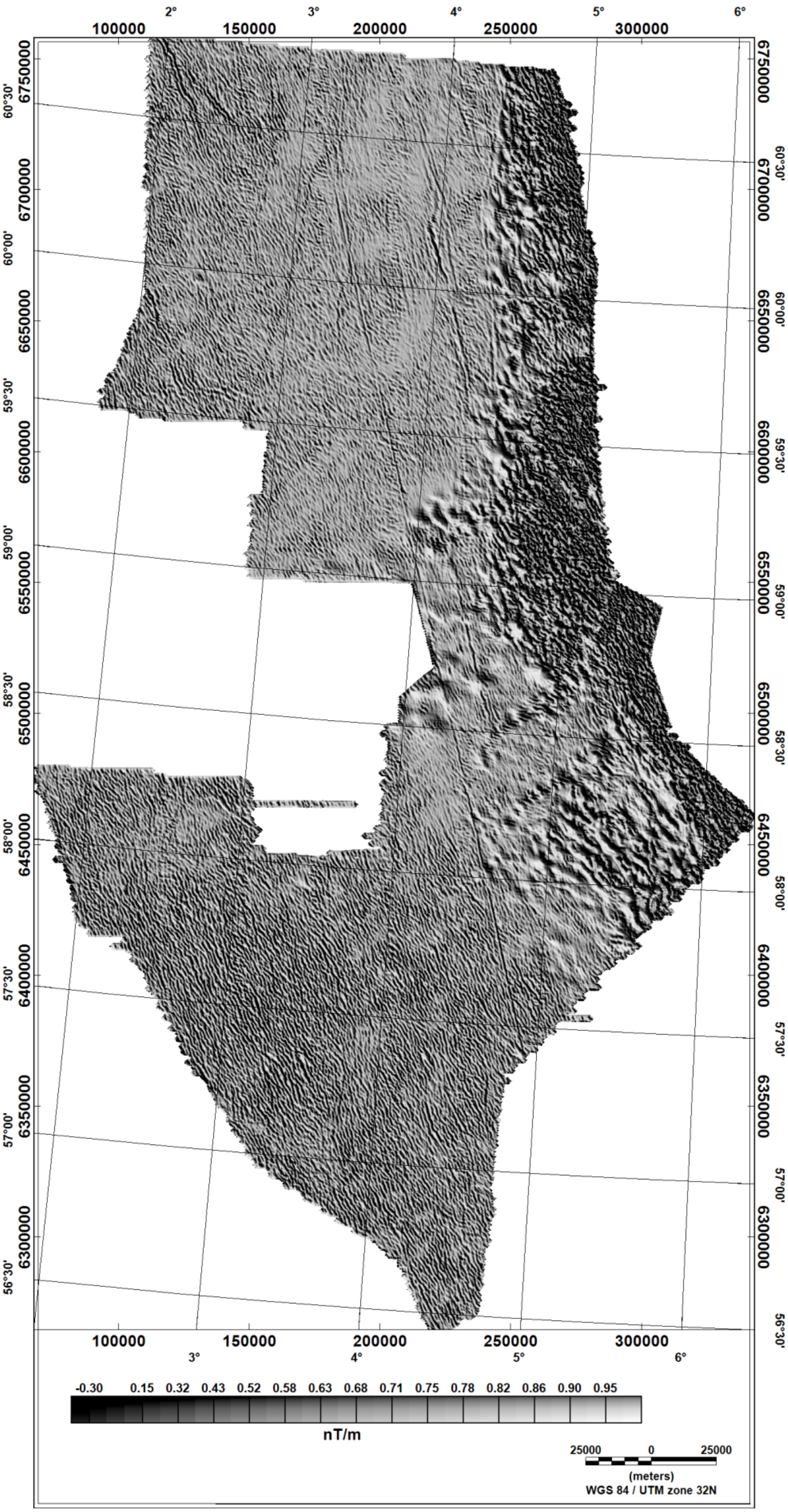

Figure 2.11 Grey tone shaded relief map of analytical signal (total gradient amplitude).

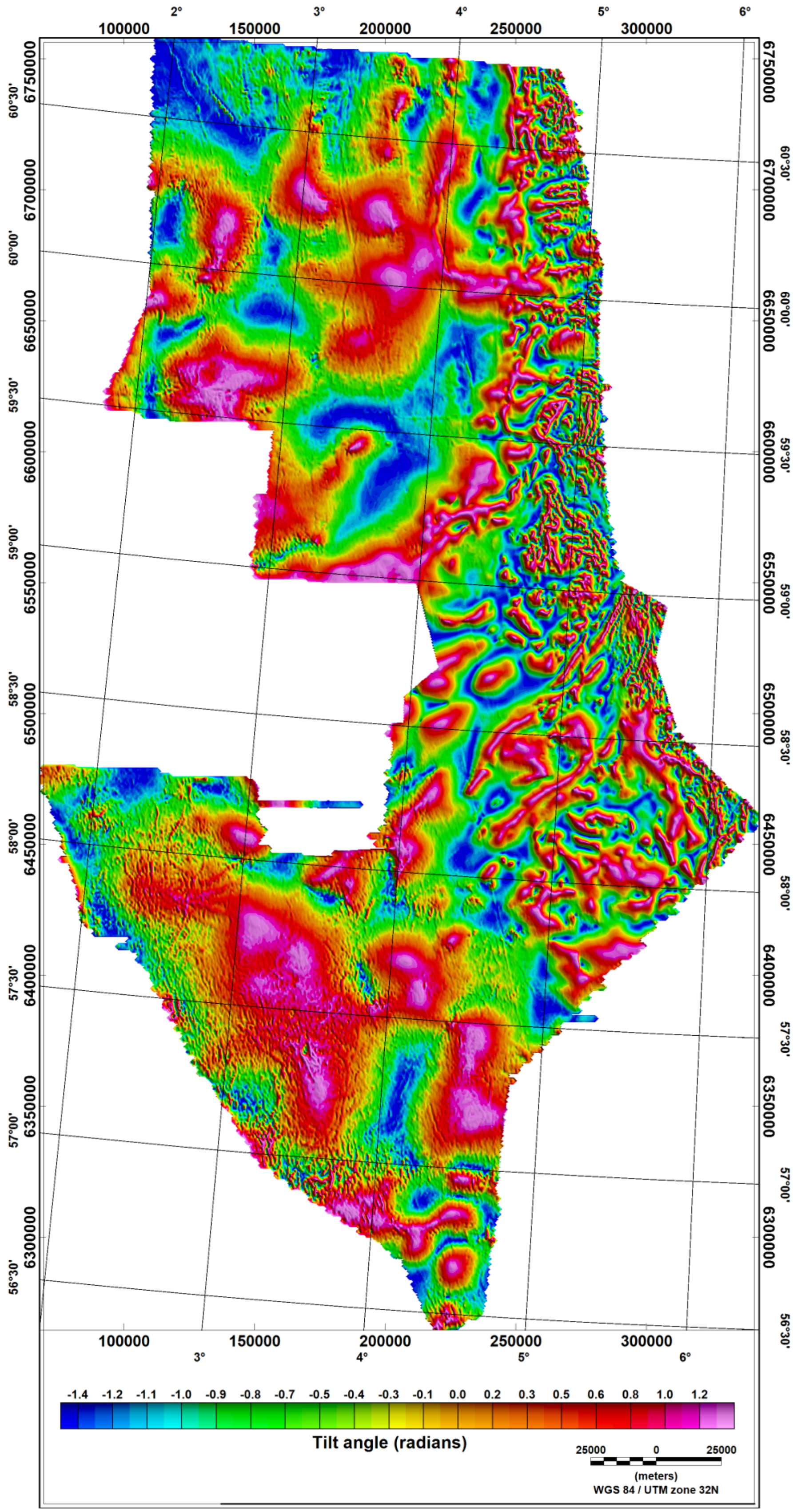

Figure 2.12 Tilt derivative map of the CNAS-10 aeromagnetic survey.

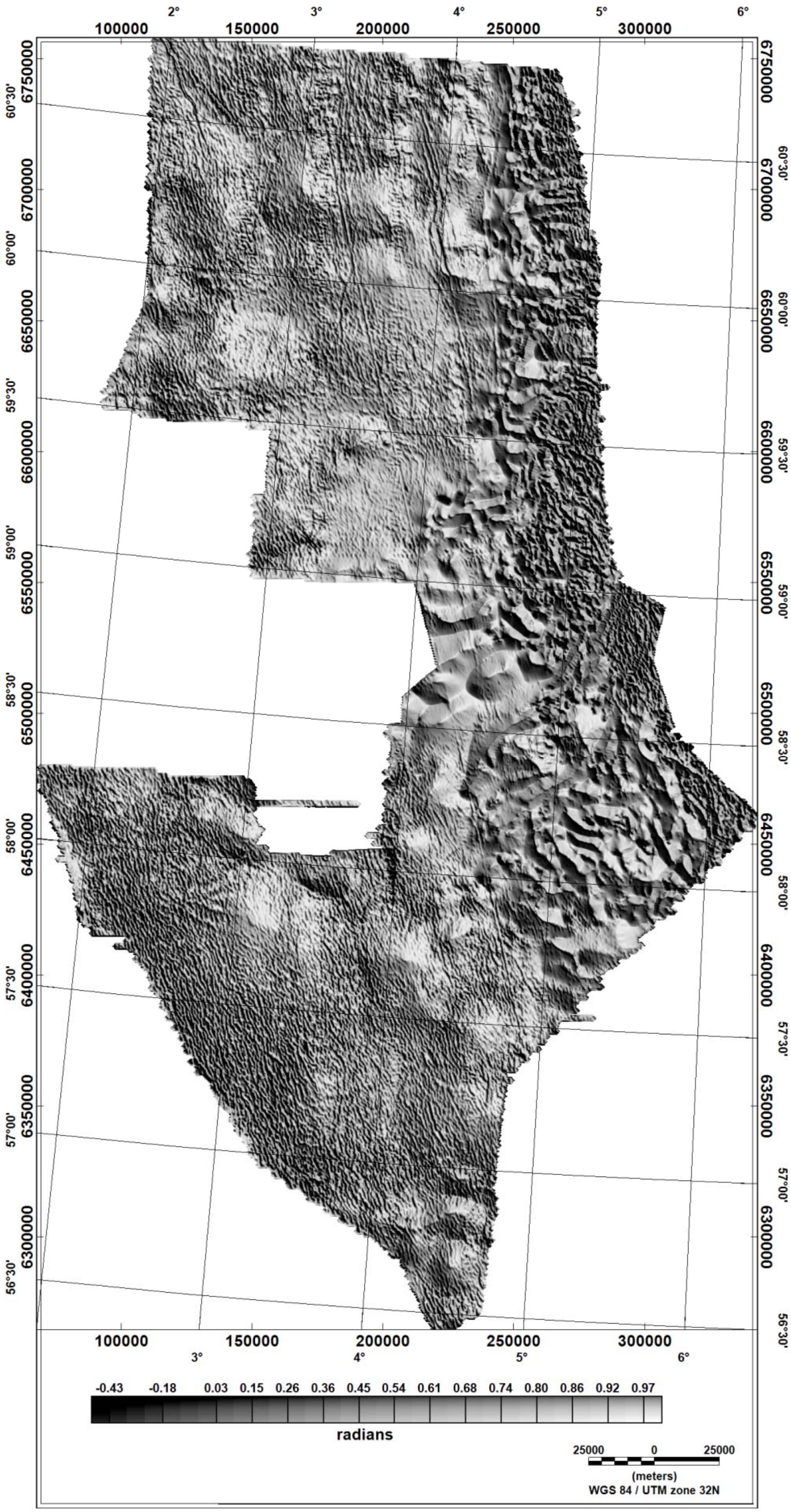

Figure 2.13 Grey tone shaded relief map of tilt derivative.

Channels in the CNAS-10 database

1-Line Name
2-X (X coordinate in WGS 84 / UTM zone 32N)
3-Y (Y coordinate in WGS 84 / UTM zone 32N)
4-LAT (Latitude)
5-LONG (Longitude)
6- R_ALT (Radar Altimetry in meter)
7-SALT (satellite Altimetry)
8- I_ALT (Instrument Altitude = (R_ALT- instrument hight)
9-GALT (Geoid altitude)
10-NSAT (Number of Satellite)
11-Time
12-Day
13-Mag_base-Solund (Basemag in Solund)
14-Mag_base_Karmoy (Basemag in Karmøy)
15-Mag_raw (Original data)
16-Mag_cult (spike removed and data interpolated)
17-Mag_IGRF (IGRF by considering information based on PGS lines)
18- Mag_anom (IGRF corrected data)
19-Mag_full (Full levelling of all Lines)
20-Mag_full_miclev (microlevelled data based on Paterson, Grant & Watson method)
21-Mag_ Mag_full_miclev_L30 (micro-leveled data based on Paterson, Grant & Watson method and Low pass filter with 30 fiducial length)

Suggestion for map production:

In order to get the final image that we produced we recommend using the channel Mag_full_miclev_L30 and subsequently a 5×5 symmetric convolution filter for final noise reduction.

List of Grids and maps:

I_ALT	Map and grid over instrument height.
Inlines	Map over inlines
Tie_lines	Map over tie-lines
Mag_Raw	Map and grid over Raw magnetic data
Mag_IGRF2	Map and grid over IGRF field of the area based on I_ALT
Mag_Full	Map and grid over Full leveling Tie and inline.
Tie-lines reflight	Map over tie lines that shows where the value exceeded 30 nT.
Lines_reflight	Map of lines where the value exceeded 30 nT.

Pipes_cables_osv.map Map of everything on the seabottom

Mag_full_miclev_L30 Map and grid of micro-leveled data based on Paterson, Grant & Watson method and Low pass filter with 30 fiducial length)

THG_Mag_full_miclev_L30 Map and grid of total horizontal gradient of the 'Mag_ Mag_full_miclev_L30' grid.

AS_Mag_full_miclev_L30 Map and grid of analytical signal of 'Mag_full_miclev_L30' grid.

TDR Mag_full_miclev_L30 Map and grid of tilt derivative of 'Mag_full_miclev_L30' grid.

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