

Geodetic Activities in Denmark 1999 – 2002

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This report to the International Association of Geodesy (IAG), within the International Union of Geodesy and Geophysics (IUGG), covers main scientific activities in Denmark regarding geodesy during the 4-year period at the following institutions:

National Survey and Cadastre, Denmark (KMS),

www.kms.dk

University of Copenhagen, Department of Geophysics (UOC), www.gfy.ku.dk

Danish GPS Center, University of Aalborg,

www.gps.auc.dk

Technical University of Denmark (DTU),

www.dtu.dk

The geodetic research activities in Denmark are to a large extent carried out at these institutions. A number of projects are carried out within the framework of the Nordic Geodetic Commission (NKG), which facilitates the geodetic work going on in Iceland, Norway, Sweden, Finland and Denmark.

For particular research projects in more detail look at the respective web sites given above.

Due to governmental considerations on the relation between university and sector specific research e.g. geodesy at National Survey and Cadastre (KMS), the research activities at KMS is going to be separated from KMS and placed elsewhere at an independent research organisation.

A governmental decision on this matter will probably be taken within year 2003.

In the last four years the geodetic activities have been continued both in Denmark and Greenland by providing new observational infrastructure for new geodetic reference frames and research.

This has included field operations and establishing new networks as well as calculations and reordering of old observations to create geodetic models of more integrity and robustness and adapted to the use of GPS in surveying and mapping.

The institutions have participated in several international projects, more of the projects are still ongoing, especially regarding research in gravity, GPS, GALILEO, altimetry and mapping of polar ice.

Geodetic Activities

New coordinate and height system in Denmark

In Denmark the work of introducing a new reference system based on European Terrestrial Reference Frame (EUREF89/ETRS89) and a new height system Danish Vertical Reference 1990 (DVR90) is in progress.

Three municipalities and KMS have started a pilot project in the autumn 2001 to identify the problems changing all spatial data in the three municipalities to the new systems. Just now the main problem is how the different GIS systems handles transformation from the old local Danish system to the new systems. As a result KMS is involved in preparing tools that allows batch transformation directly in ESRI-, MapInfo- and Bentley products, using correct transformation formulas.

All levelling observations, gathered in the last 30 years (data for 43.000 stations) has been recalculated in the new height system DVR90, and the remaining 37.000 points has been transformed to DVR90. The same transformation parameters used for this purpose are now available for use when changing all other heights to

DVR90 and in May 2002 new heights were released for use in Denmark.

Permanent GPS reference stations in Denmark

Data from 3 permanent GPS stations in Denmark are now collected on-line.

In cooperation with Norway and Sweden a network of permanent GPS stations is set up to test a possible Nordic Position Service based on stations in the three countries. The private sector in Denmark has established two RTK services, including local permanent GPS stations covering the entire Denmark. KMS act as a consulting part and calculate the positions of the local stations in relation to the national geodetic reference frame.

A new 3D GPS reference network with a spacing of 10 km is under construction. The network is ready for use at Sjælland, Fyn and the southern part of Jylland. About 500 – 600 stations will be established in the new network. Approximately 150 of these stations will be located near nodal points in the precise levelling network, and act as reference points for this network.

The combined network will be used for determination and control of the geodetic reference networks and constitute the backbone for surveying activities in Denmark and for GPS data recording for geodetic research and geodynamic studies.

Several research projects and studies are carried out at the universities not only covering GPS, but also preparing the introduction of GALILEO and new satellites as CHAMP and GOCE.

Levelling

The precise levelling in Denmark has long been completed and the levelling in Denmark is afterwards continued in cooperation with the municipalities. The local levelling networks are renewed and in total 40% of all benchmarks in Denmark have now been updated with new height information.

A Nordic computing centre (NCC) for Precise Levelling is set up in Denmark. The main idea is to use the existing facilities in KMS database administration and adjustment system for all levelling in the Nordic area. A test with all the Swedish data has been carried out successfully, and a primary adjustment of all Norwegian levelling data from 1927 to 2001 has been calculated in actual version.

Geoid

KMS has in cooperation with the NKG working group for geoid determination made initial preparation for a new joint Nordic geoid model - NKG2002. New data have been acquired. Sweden has provided a new, very dense digital elevation model (DEM). The gravity data collect phase is currently put on hold, awaiting the completion of Swedish gravity measurements in the missing regions of northern Sweden. KMS have in cooperation with University College, London been awarded a contract to compute a new reference geoid of the British Isles on behalf of the Ordnance Surveys of Britain, Northern Ireland and Ireland. This geoid model is completed in February 2002, and - provided permit is given - data from this project will strengthen the NKG2002 geoid, especially in the North Sea.

Airborne gravity

KMS has in cooperation with University of Bergen developed an airborne gravity system, which has been used extensively in connection with airborne gravity survey operations in Greenland, Svalbard and the Baltic Sea, in close cooperation with Nordic/Baltic geodetic agencies and the Norwegian Oil Directorate. In 2002 the system has been used for preparatory surveys of the ESA GOCE and CryoSat missions, and to cover the last major gravity void in the Canadian Arctic (Foxe Basin).

The airborne gravity survey system has recently been expended with airborne scanning lidar capability, and survey have been done especially to map sea ice freeboard heights in the Polar Sea north of Greenland (ESA projects) and well as various applications in Denmark and Greenland relating to urban and coastal zone mapping pilot projects.



Survey aircraft at Station Nord Gravity data collection activities

In cooperation with Statens Kartverk, University of Bergen and NIMA, KMS has continued airborne gravity surveys in the Arctic, covering the Fram Strait region between Greenland and Svalbard, April-May 2001. The measurements are part of a circumarctic gravity project ("Arctic Gravity Project") which aim at compiling a new arctic geoid of all regions north of 64N by end of 2001. As part of the Greenland project sea-ice studies have been made by laser scanning in preparation for the ESA CryoSat mission, and GPS/laser survey of newly found islands off North East Greenland (Tobias Island) have been done.

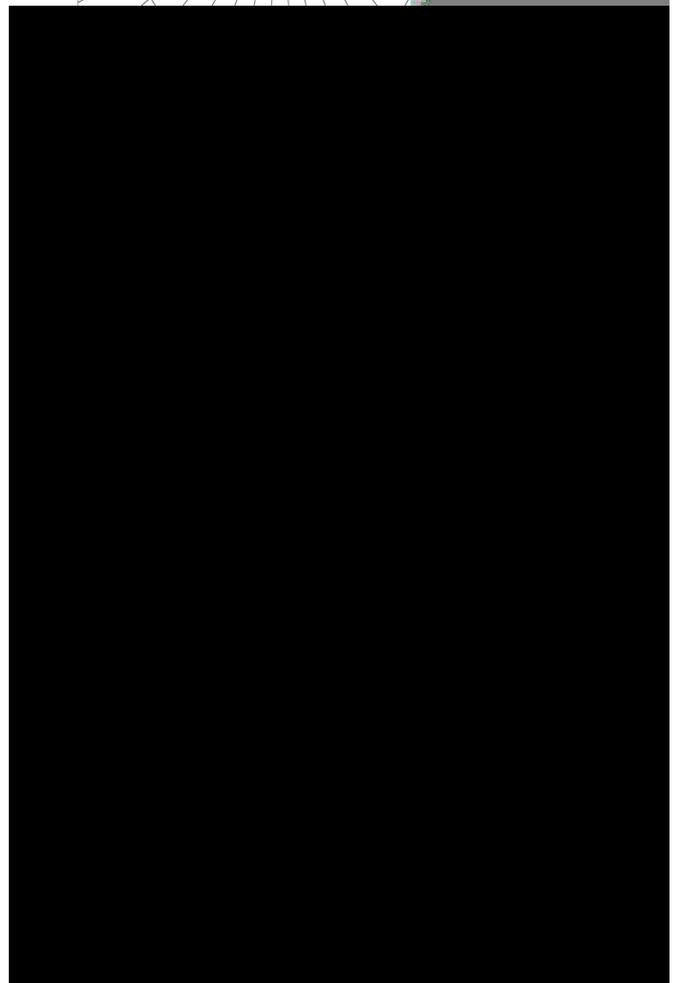
Remote sensing

Satellite altimetry has been used to model the marine gravity field in the world. Especially, the KMS99 solution has been used widely for both geodetic purposes and for geophysical exploration. The ongoing improvements focus on problems due to ocean tides and sea ice occurring in shallow seas and polar regions respectively. In 2002 those activities are supported by NIMA. Satellite altimetry has also been used for studies of sea level rise. The studies have focused on the regional description of the spatial scales of the decadal changes in sea level and their correlations with changes in the sea surface temperature. Those studies are associated with activities carried out by the TOPEX/POSEIDON and the JASON science working teams.

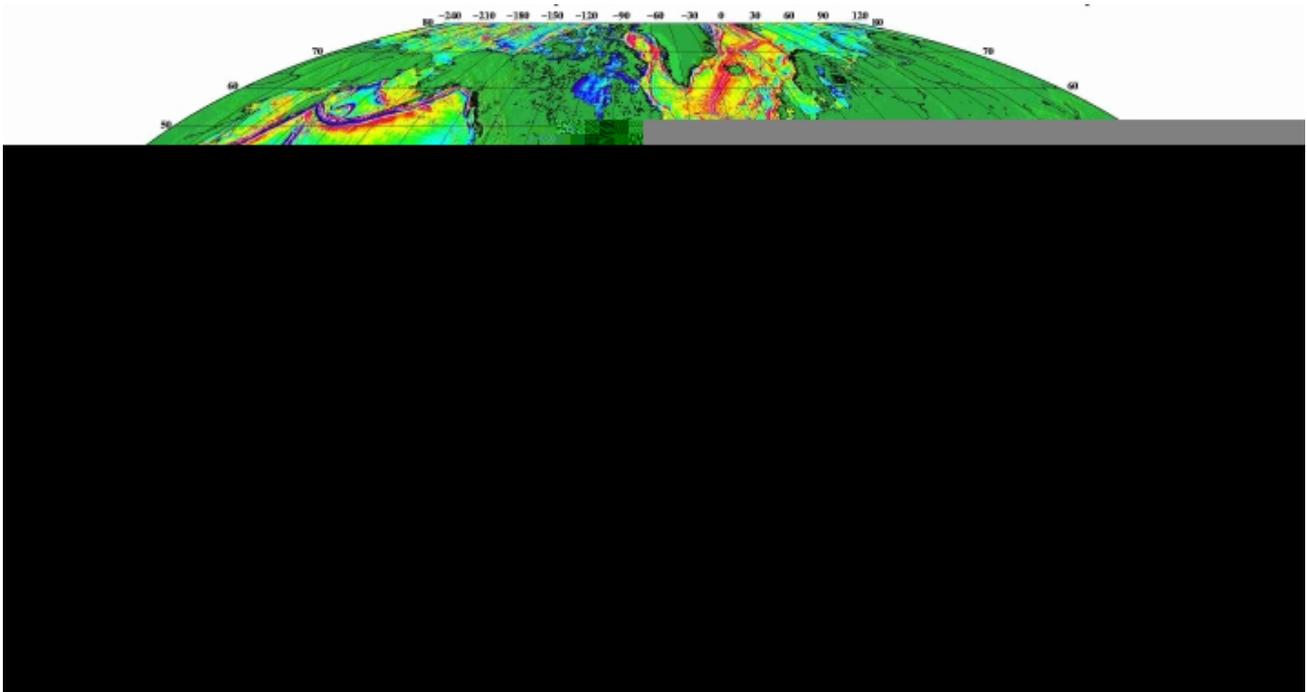
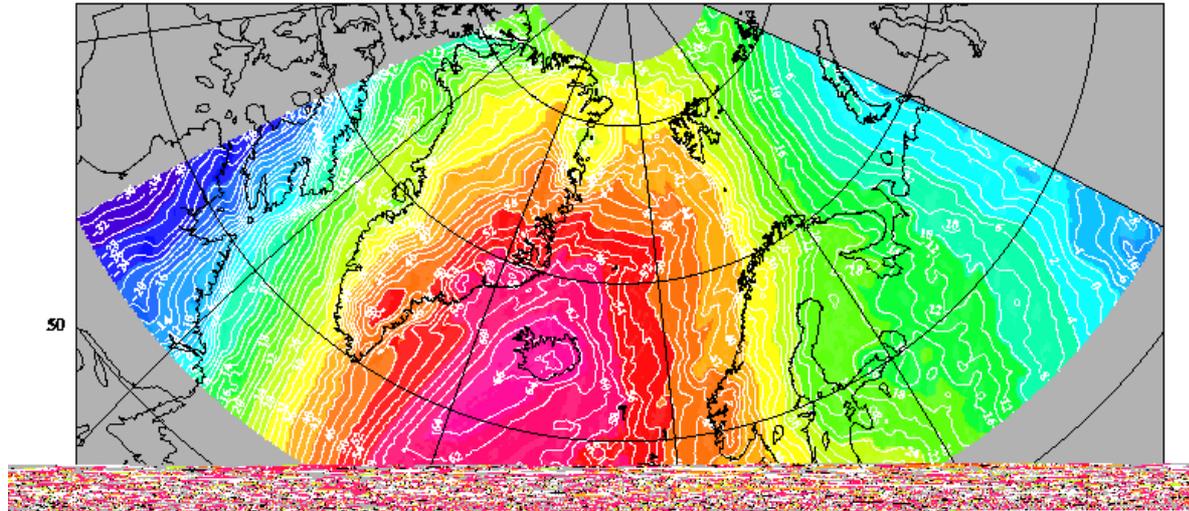
KMS is continuing development in airborne remote sensing. An operational laser scanning system has been developed based on the experience of the airborne gravity programme. The system, based on an Austrian laser unit and INS/GPS units, allow the mapping of

approximately 500 m wide swaths with a point density of 1 point pr 1.5 m at an accuracy of 3-5 cm, depending on GPS baselines. The system are mainly designed for use in Greenland for ice mapping, but tests in Denmark have shown a lot of potential for use in mapping control and coastal monitoring as well. The plan for 2002 include laser lidar in the Polar See in support of the ESA Cryosat satellite.

Airborne gravity tracks of Greenland and Svalbard 1998 - 2001



Geoid of North Atlantic (kernel mod 36)



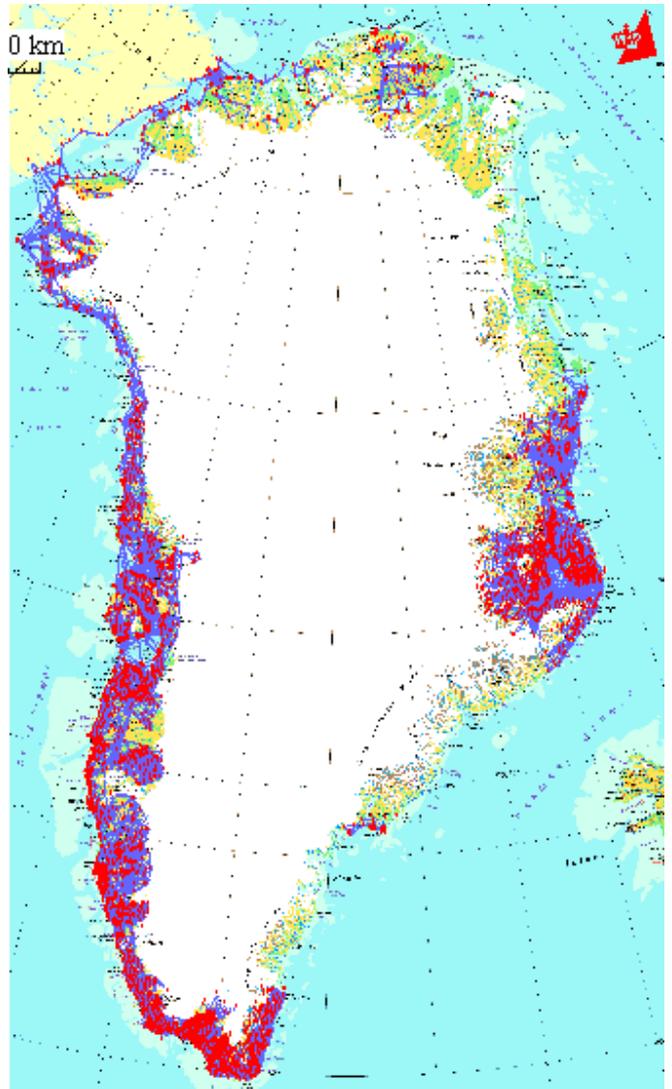
The KMS99 global marine gravity field derived from GEOSAT and ERS altimeter data

Greenland

Five geodetic permanent GPS stations are in operation in Greenland. KMS operates and maintains the stations at the Thule Airbase, THU2 and THU3, and the station SCOB in Scoresbysund. The University of Colorado operates the stations KELY in Kelyville and KULU in Kulusuk. The stations THU1 and KELY are included in the IGS global network. THU3 was established in 1998 as a long-term stable station to complement the THU1 station. THU2 is equipped with a GPS/GLONASS receiver and has contributed to the IGEX and the IGLOS campaigns. Recently THU2 was accepted for the IGS LEO network. A permanent GPS station in South Greenland, QAQ1 has been established in Julianehaab to complete the coverage in the region.

The activities associated with a new reference system (REFGR) by upgrading the geodetic network in Greenland have been going on for several years. In 1996 REFGR was defined including eight globally positioned reference points. Since then GPS points have been established throughout the populated parts of Greenland. Most new points are established at old reference points so it has been possible to recalculate the classic geodetic triangulation measurements in WGS84. In total 6500 points are recalculated in WGS84 and in a common general height system using classic observations and new GPS observations. Basis of the recalculation is 80 GPS points and approximately 40 heights coming from water level observations. The calculation covers most of the ice-free parts of Greenland.

KMS has in August 2001 carried out a GPS and sea-level survey in the Nares Strait between Greenland and Canada, in cooperation with Geodetic Survey of Canada and ASIAQ (Greenland Home Rule survey organization), to repeat measurements from 1995 and provide an improved base for future uplift studies in the region. Logistics was provided by a geophysical expedition based on the Canadian icebreaker R/V Louie St. Laurent.



Recalculation of the old triangulation Network in WGS84

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