

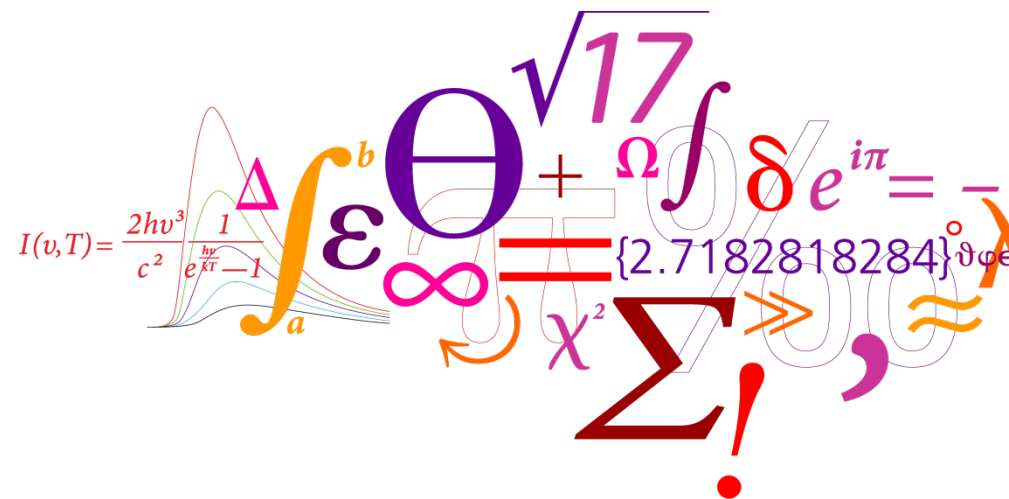
# The DTU Space high precision geomagnetic field model

Jürgen Matzka and Nils Olsen

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nio@space.dtu.dk



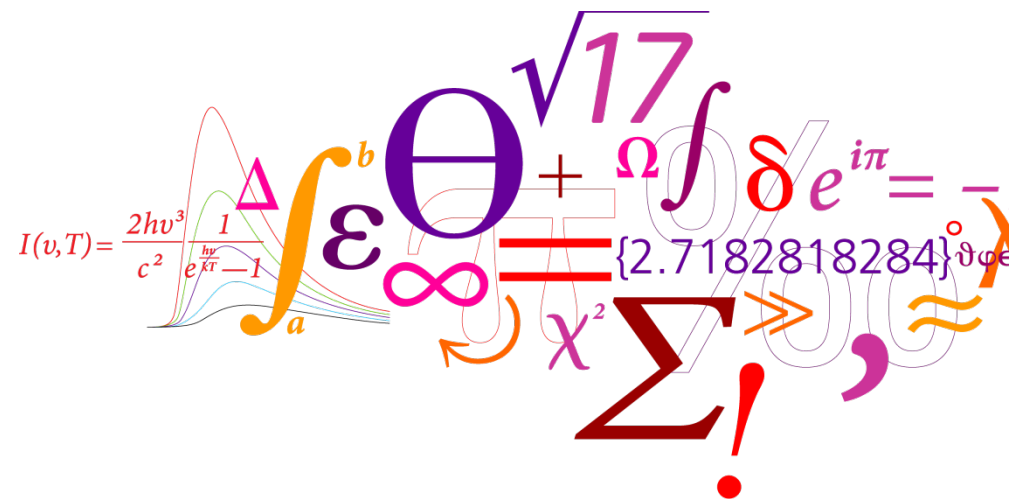
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# About this presentation

DTU Space contribution to

- global geomagnetic observatory network,
- geomagnetic monitoring for MWD,
- monitoring of current systems (magnetospheric/ionospheric),
- satellite-based geomagnetic observations.

Geomagnetic models:

- History of DTU's geomagnetic models
- Examples for of DTU's models
- Influence of current systems (magnetospheric/ionospheric)

Please note:

- Expertise in geomagnetism: observation, calibration, real-time operations, data analysis and geomagnetic modeling.
- Electromagnetic induction is not discussed here.

# Geomagnetic observatories and magnetometer stations

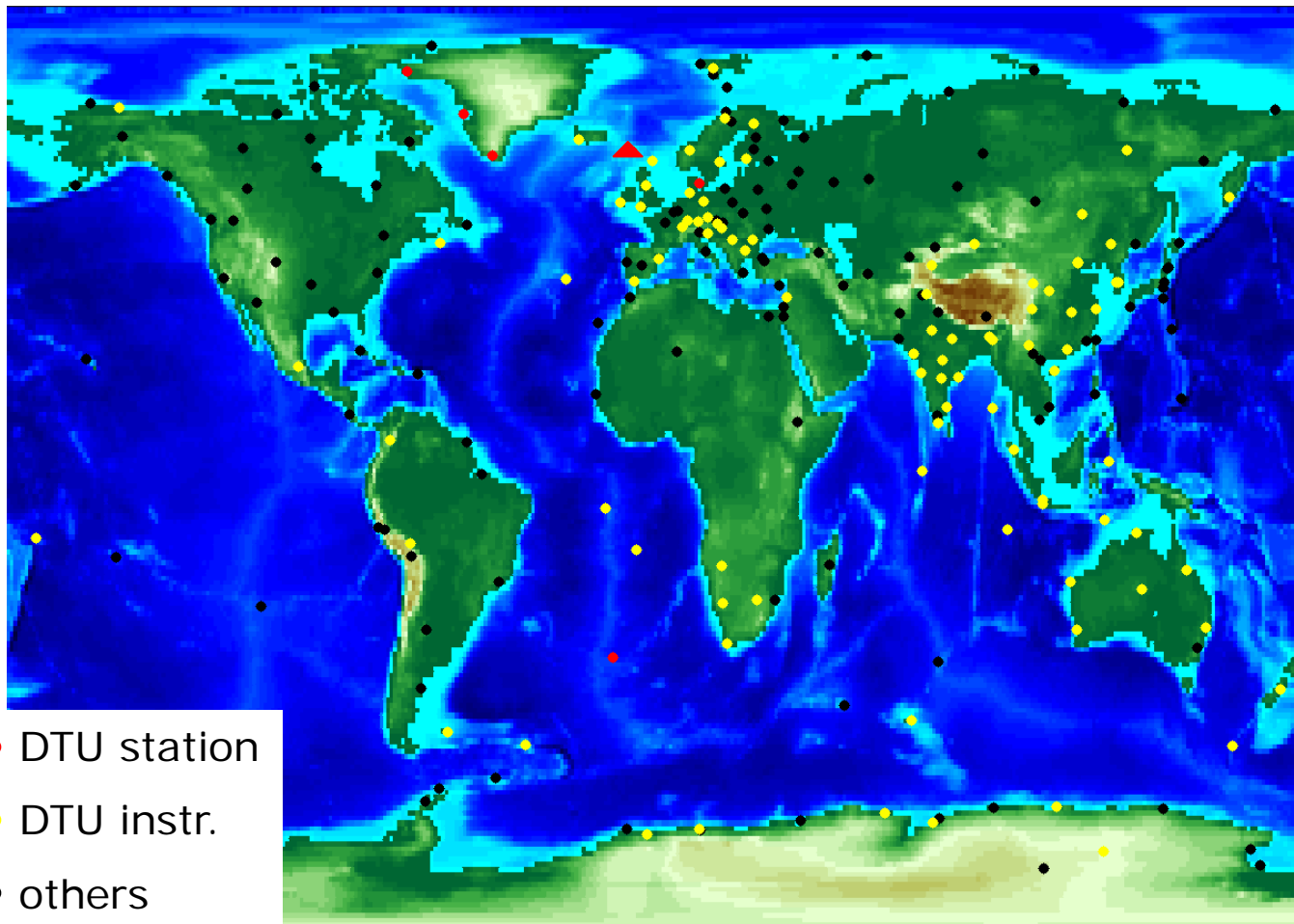
Operating in the following areas:

- West and East Greenland
- North Sea: Denmark
- South Atlantic Ocean
- Soon to come: Faroe Islands in the Norwegian Sea/North Atlantic
  
- All 5 observatories fulfil Intermagnet-standards
- Calibration and near-realtime data transmission in cooperation with Truls Hansen from University of Tromsø, Norway
- Are used for monitoring the geomagnetic field during MWD, as base station for exploration

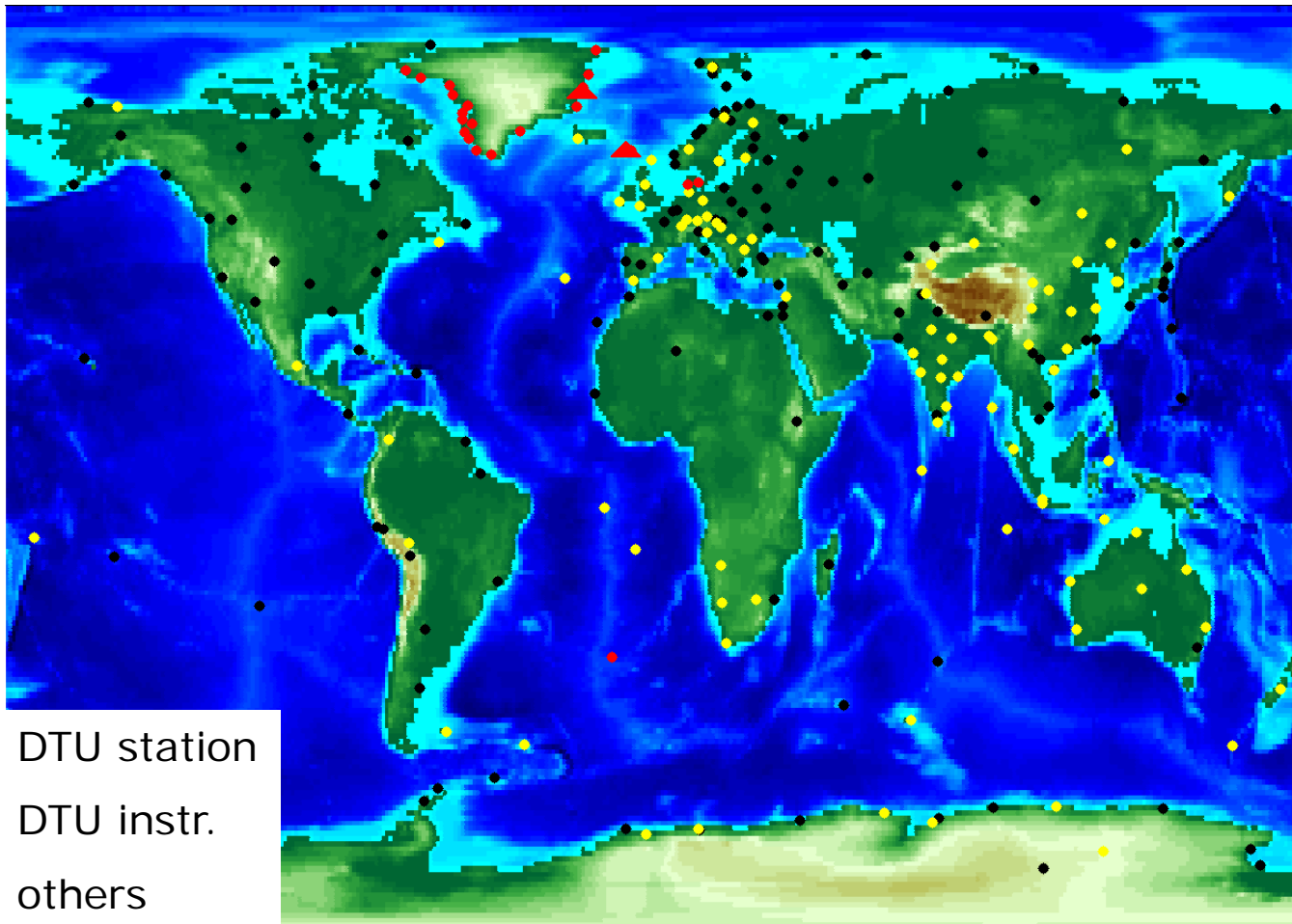
Geographic distribution is designed to

- Monitor the main field (secular variation) as part of the global system
- Investigate current systems that contribute to the geomagnetic field

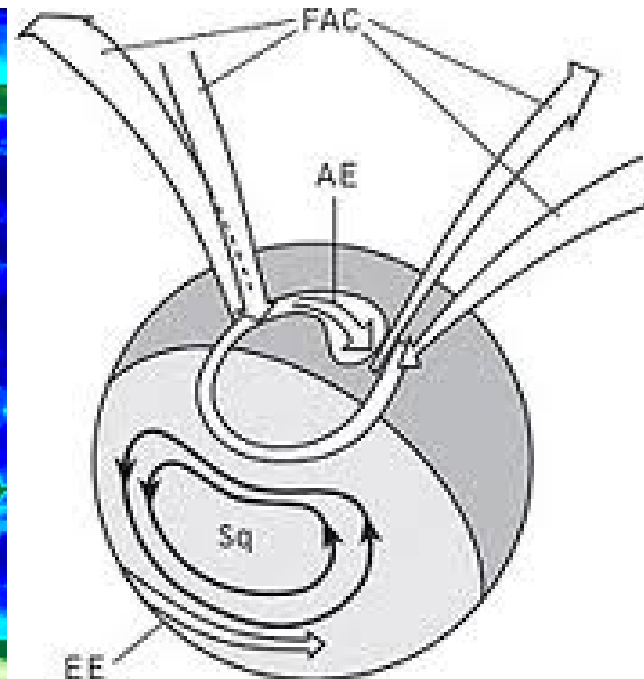
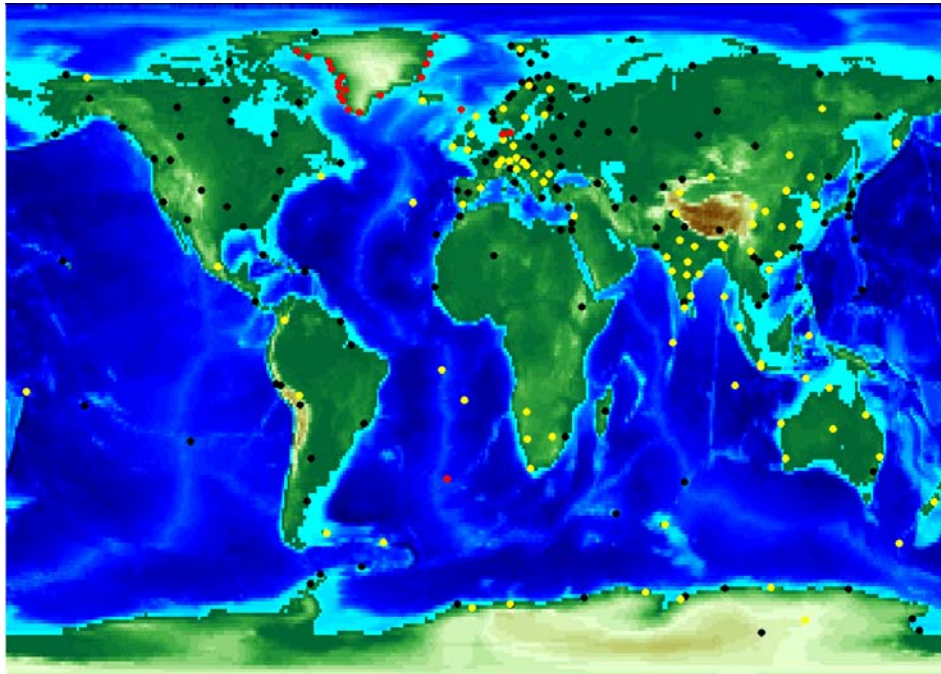
# Global distribution of geomagnetic observatories



# ... plus Norwegian and DTU Space variometers



# Ionospheric currents: >90 km height

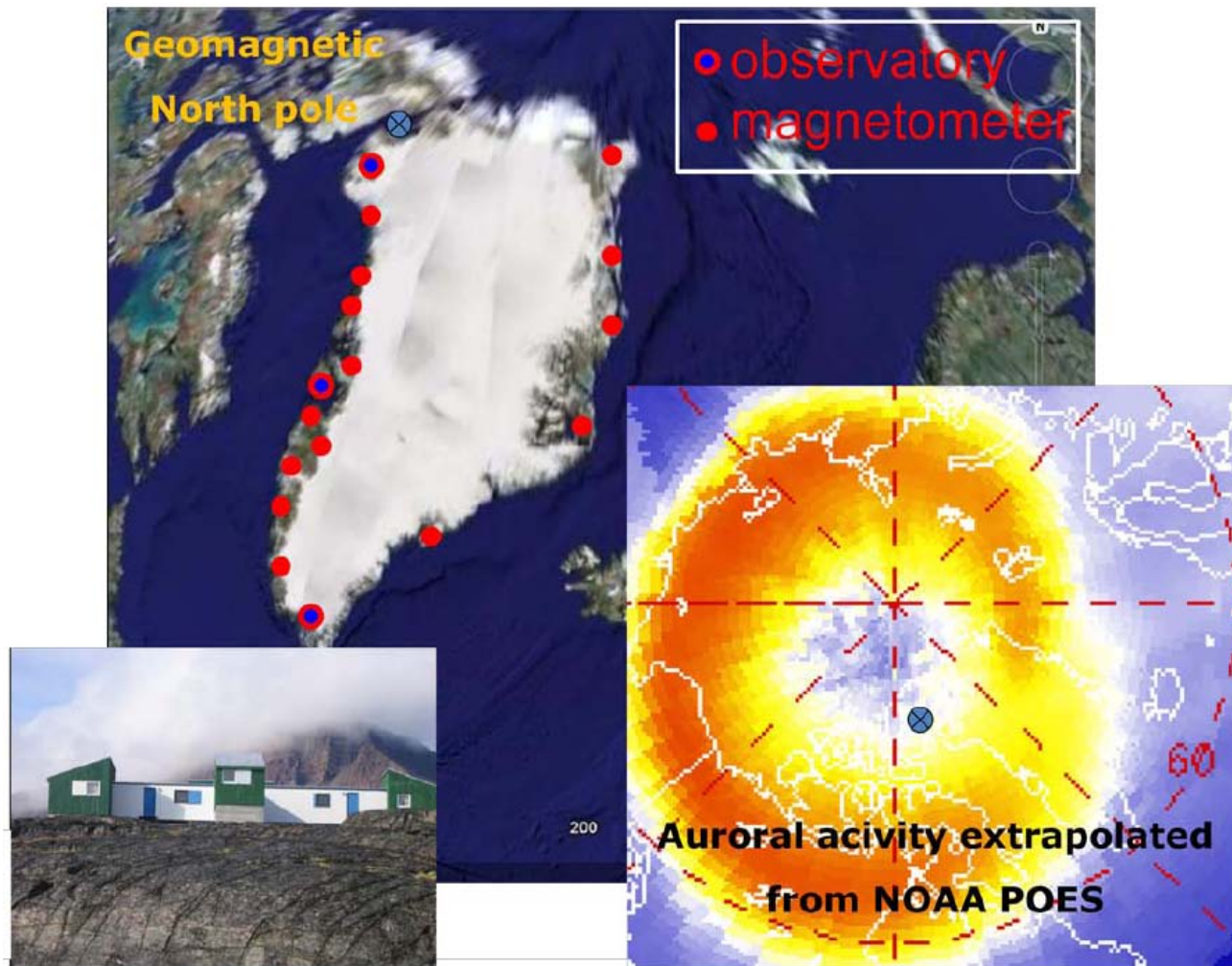


FAC: field aligned currents, feed the auroral electrojet

AE: auroral electrojet, very dynamic, very strong, centered at geomagnetic pole

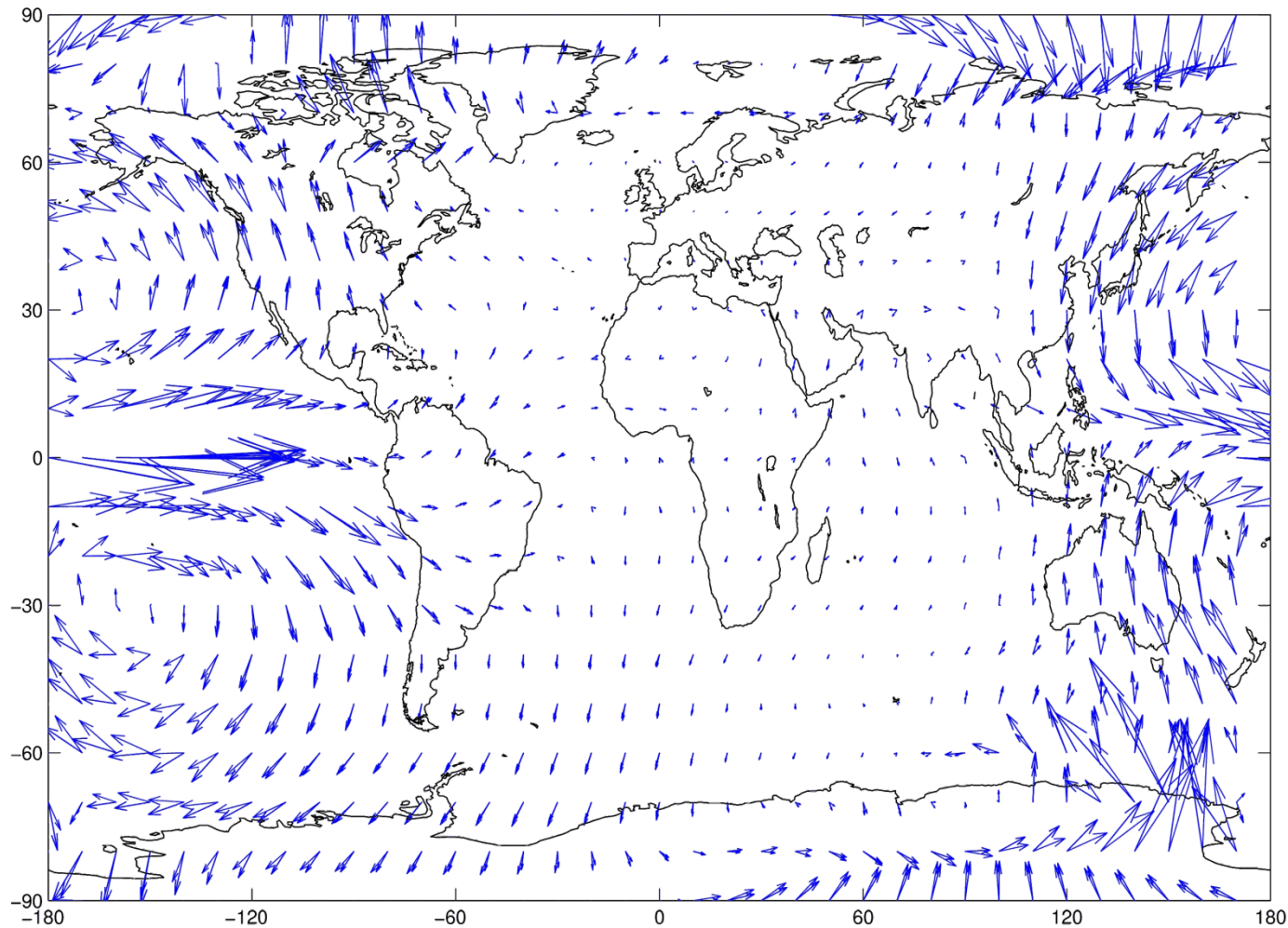
Sq: solar quiet current, on each hemisphere, centers (foci) move with sun

# The polar ionosphere: auroral activity and monitoring of the auroral electrojet

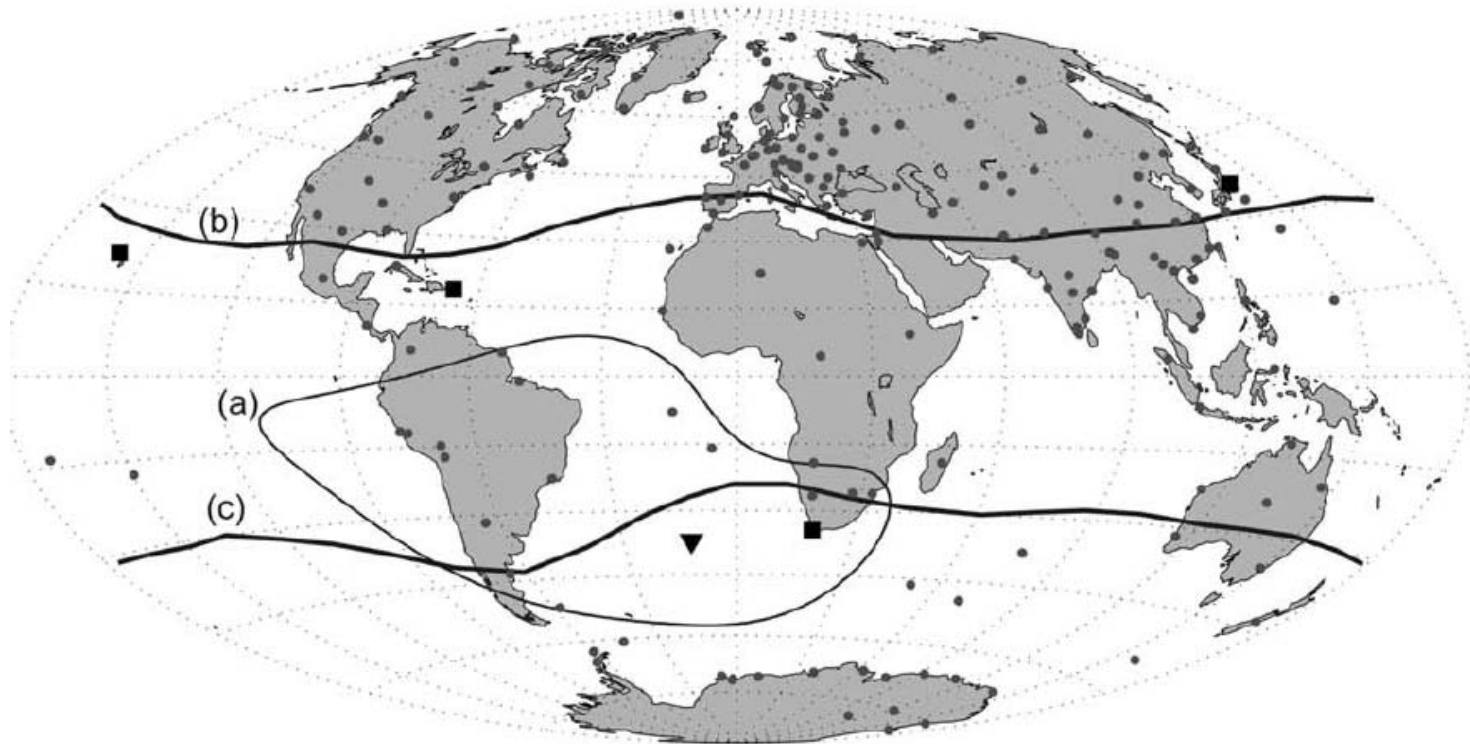




# Sq-currents: Daily movement computed from Comprehensive Model 4, Sabaka, Olsen and Purucker (2004)



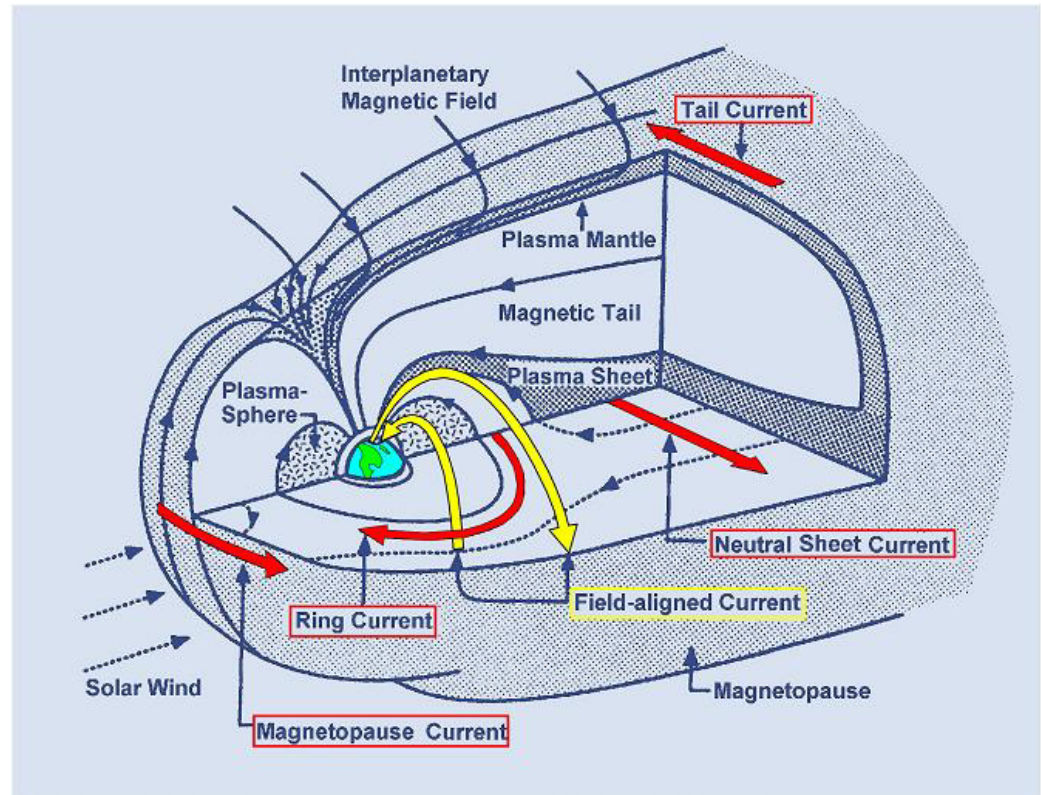
# The 'quiet' ionosphere: monitoring 'Sq' and magnetospheric contributions



**(a) 30.000 nT isoline; (b),(c) Sq focus track**

# Magnetospheric currents

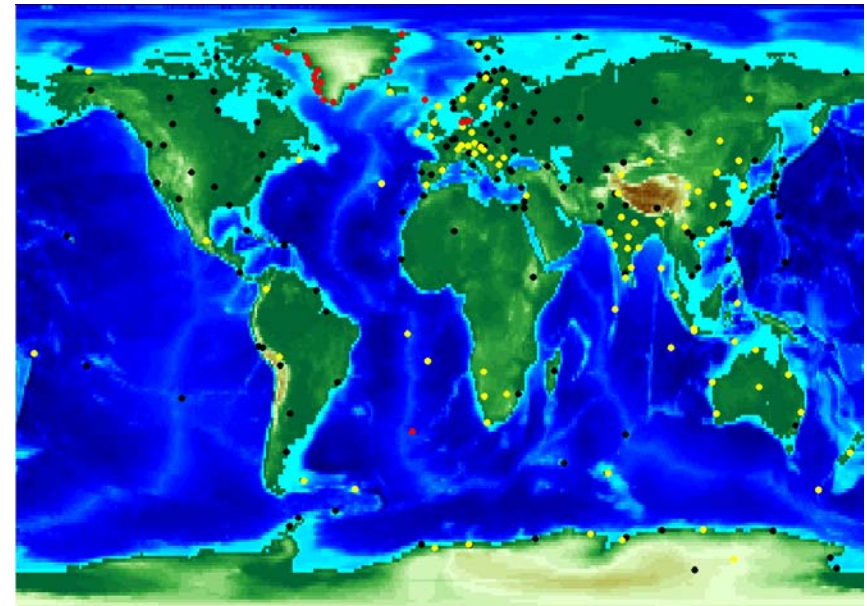
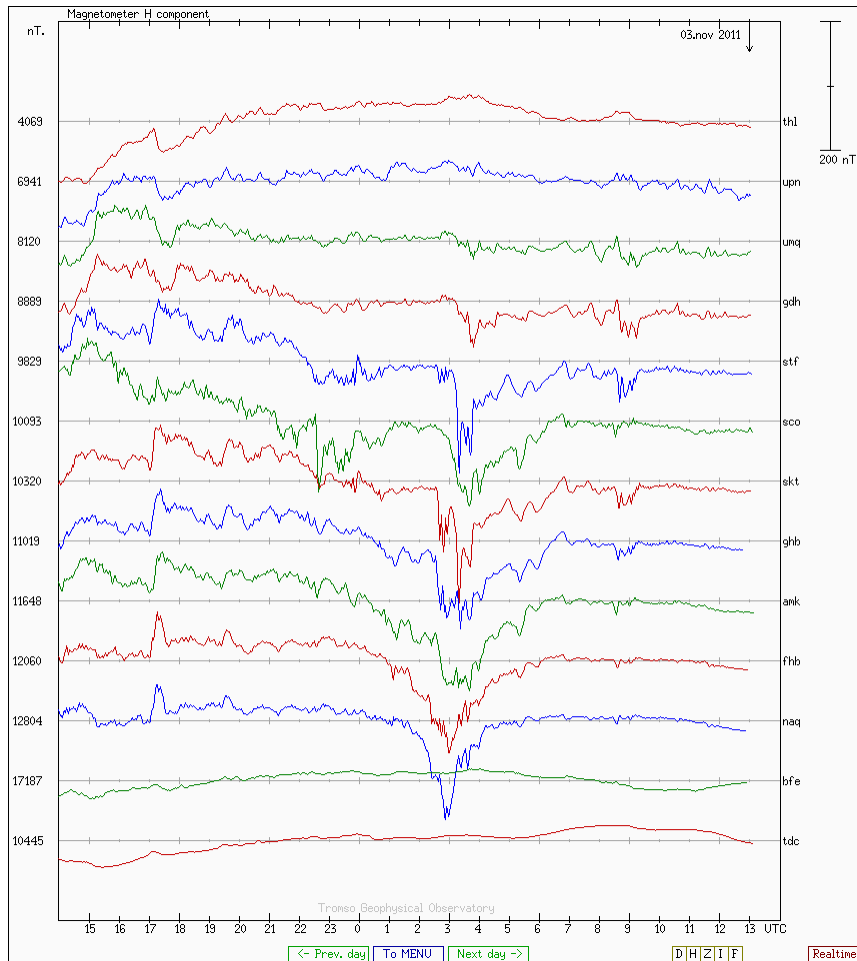
- Ring current organised in geomagnetic field.
- Tail current organised by the solar wind (directed away from sun).
- Apparent variations in Earth-fixed system (Maus and Lühr, 2005).
- **Observatories like Tristan da Cunha are ideal to pick up magnetospheric signals**
- **DTU geomagnetic field models are specialised on magnetospheric and main field contributions**



[Movie by Tsyganenko](#)

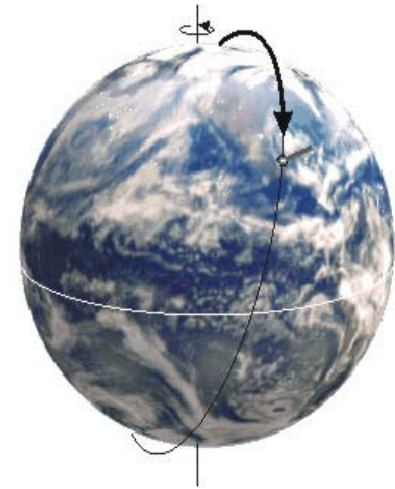
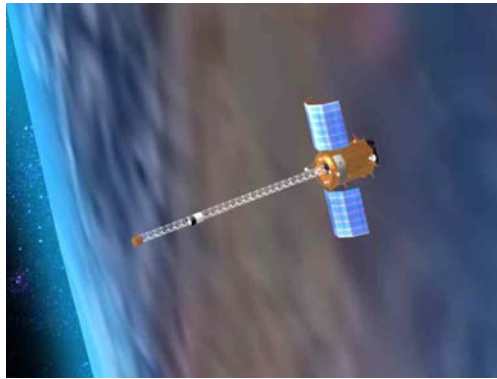
after Kivelson  
and Russel, 1995

# Near real-time data from DTU stations

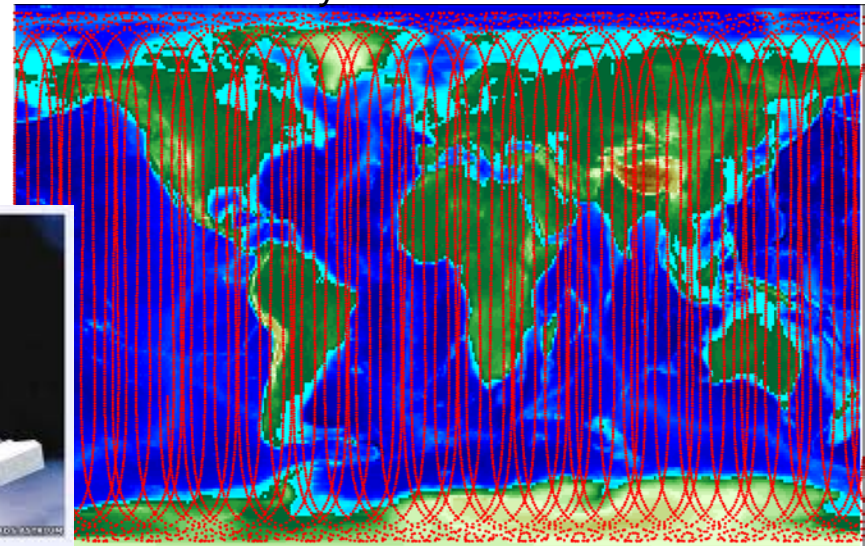
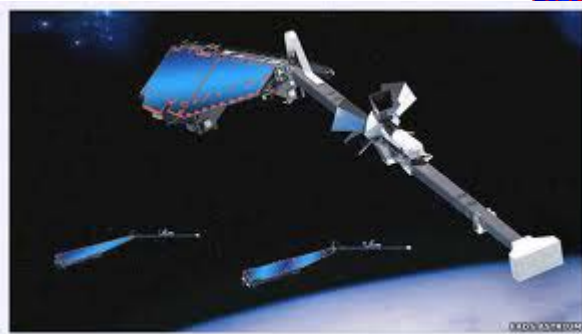


Near real-time data

# Satellites



3 days of satellite data:

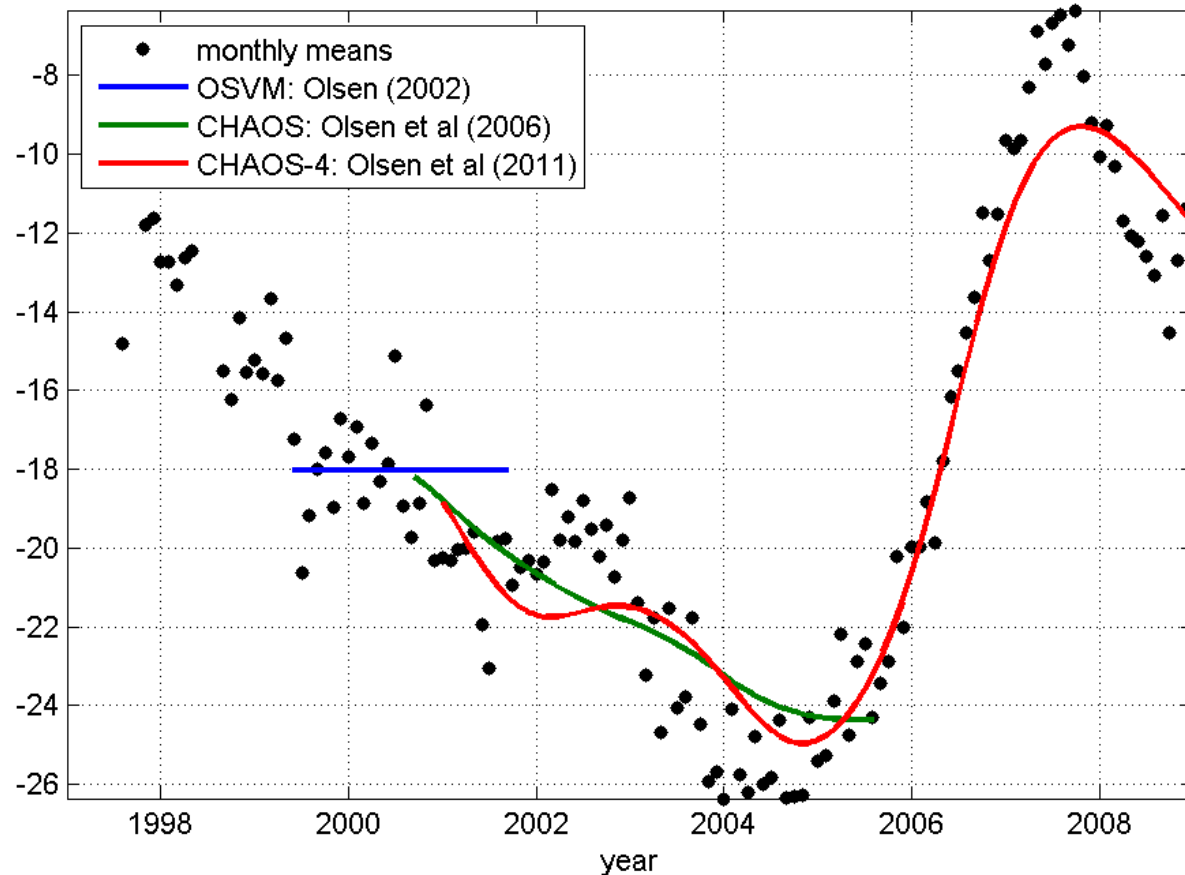


# DTU Space geomagnetic field models

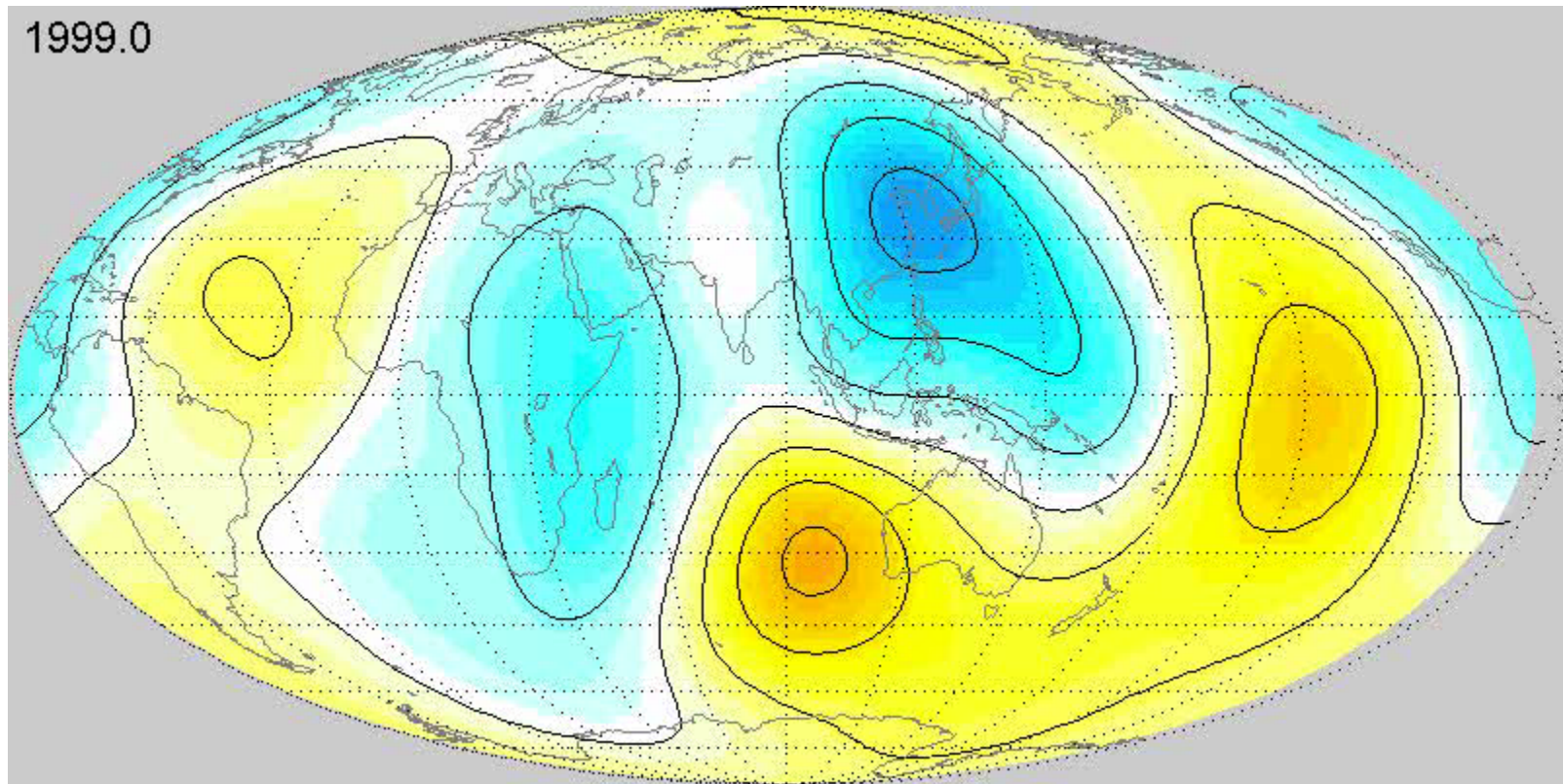
Model name	Description	Reference
CHAOS-4	<a href="#">The CHAOS-4 - A high resolution geomagnetic field model derived from low-altitude CHAMP data</a>	
CHAOS-3	<a href="#">The CHAOS-3 geomagnetic field model and candidates for the 11th generation IGRF</a>	<a href="#">Olsen et al. 2010</a>
CHAOS-2	<a href="#">CHAOS-2 - A Geomagnetic Field Model Derived from One Decade of Continuous Satellite Data</a>	<a href="#">Olsen et al. 2009</a>
xCHAOS	<a href="#">xCHAOS - the extended CHAOS model</a>	<a href="#">Olsen and Manda, 2008</a>
VM-CHAMP	<a href="#">Model based on CHAMP monthly mean values at a regular grid of "virtual observatories"</a>	<a href="#">Olsen and Manda, 2007</a>
CHAOS	<a href="#">CHAOS - A Model of Earth's Magnetic Field derived from CHAMP, Ørsted, and SAC-C magnetic satellite data</a>	<a href="#">Olsen et al., 2006</a>
Ørsted (09d/04)	<a href="#">Candidate Models for IGRF2005</a>	<a href="#">Olsen et al, 2005a</a> <a href="#">Olsen et al, 2005b</a>
	<a href="#">Candidates for DGRF1995 and DGRF2000</a>	<a href="#">Olsen et al, 2005</a>
CO2	<a href="#">CO2: A CHAMP magnetic field model</a>	<a href="#">Holme and Olsen, 2003</a>
OSVM	<a href="#">Ørsted Main and Secular Variation Model</a>	<a href="#">Olsen, 2002</a>
OIFM	<a href="#">Ørsted Initial Field Model</a>	<a href="#">Olsen et al, 2000</a>

# Geomagnetic Field – the last 12+ Years Improvement in Model Accuracy

Field change of magnetic vertical component at Hermanus (South Africa)



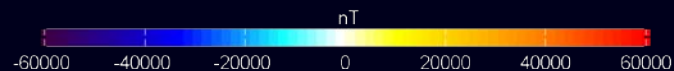
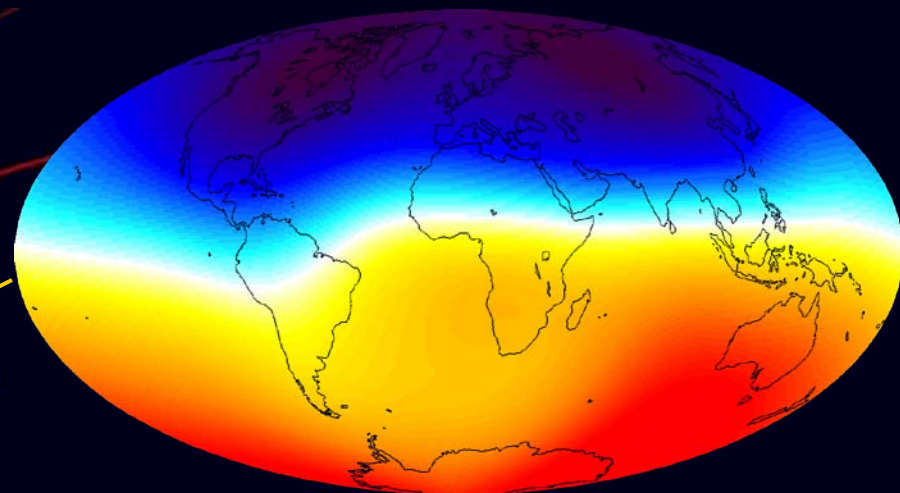
# Acceleration of the vertical field 1999 - 2008



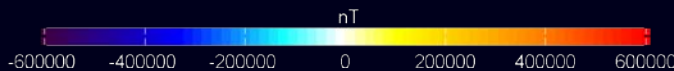
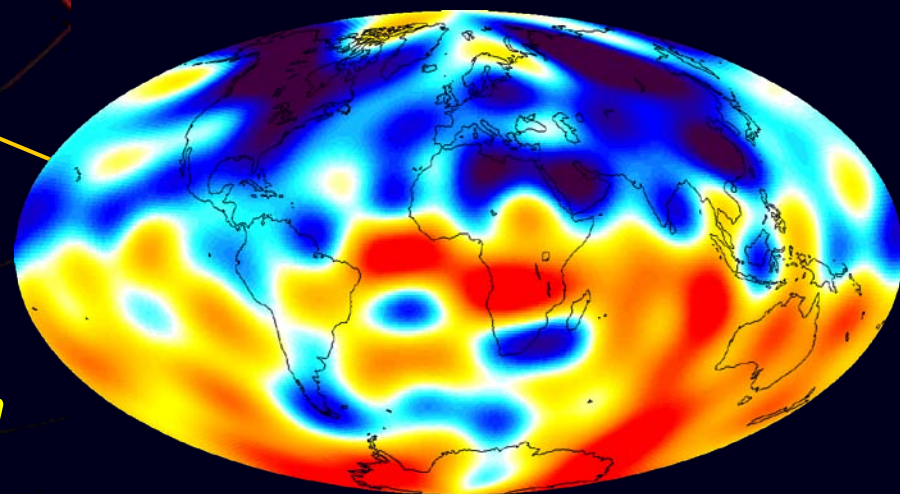


# Science: The Earth's core

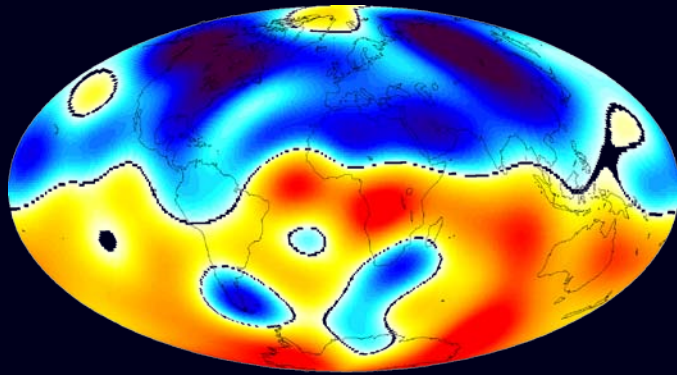
*Vertical magnetic field at Earth's surface...*



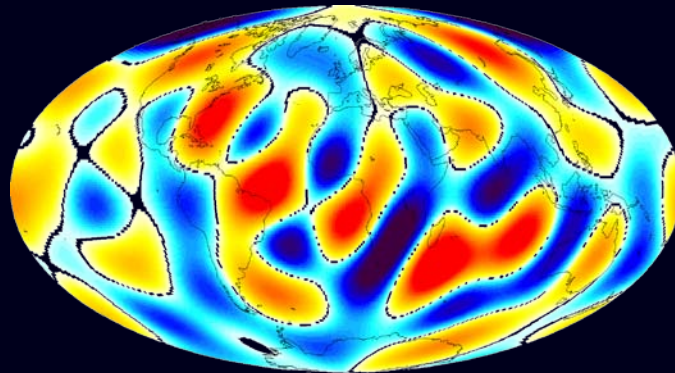
*... and in 3000 km depth*



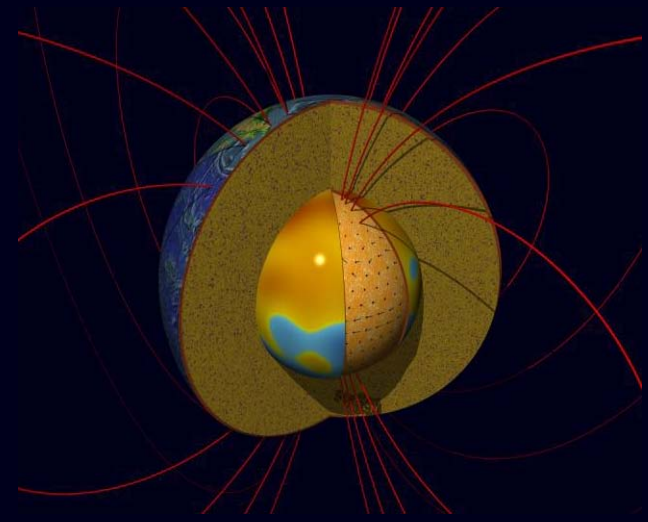
# Science: Movement of liquid iron in the core



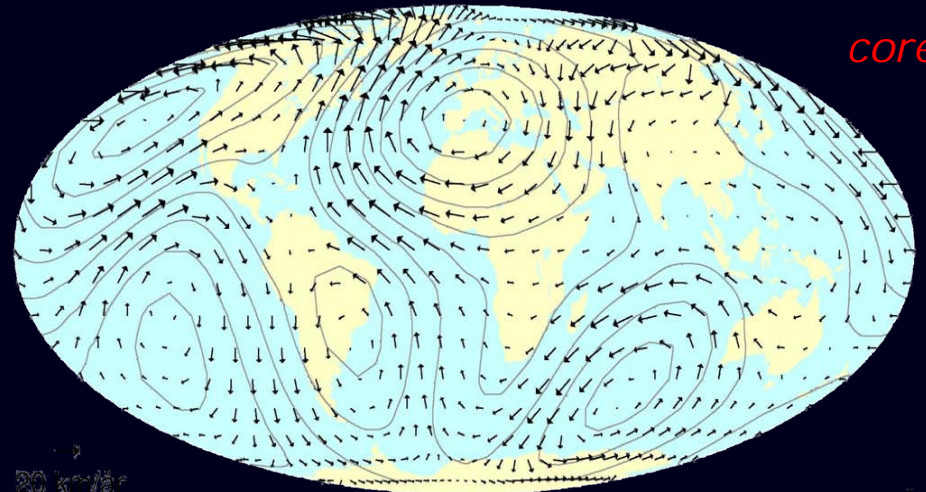
*Magnetic field at the core...*



*... and its change ...*

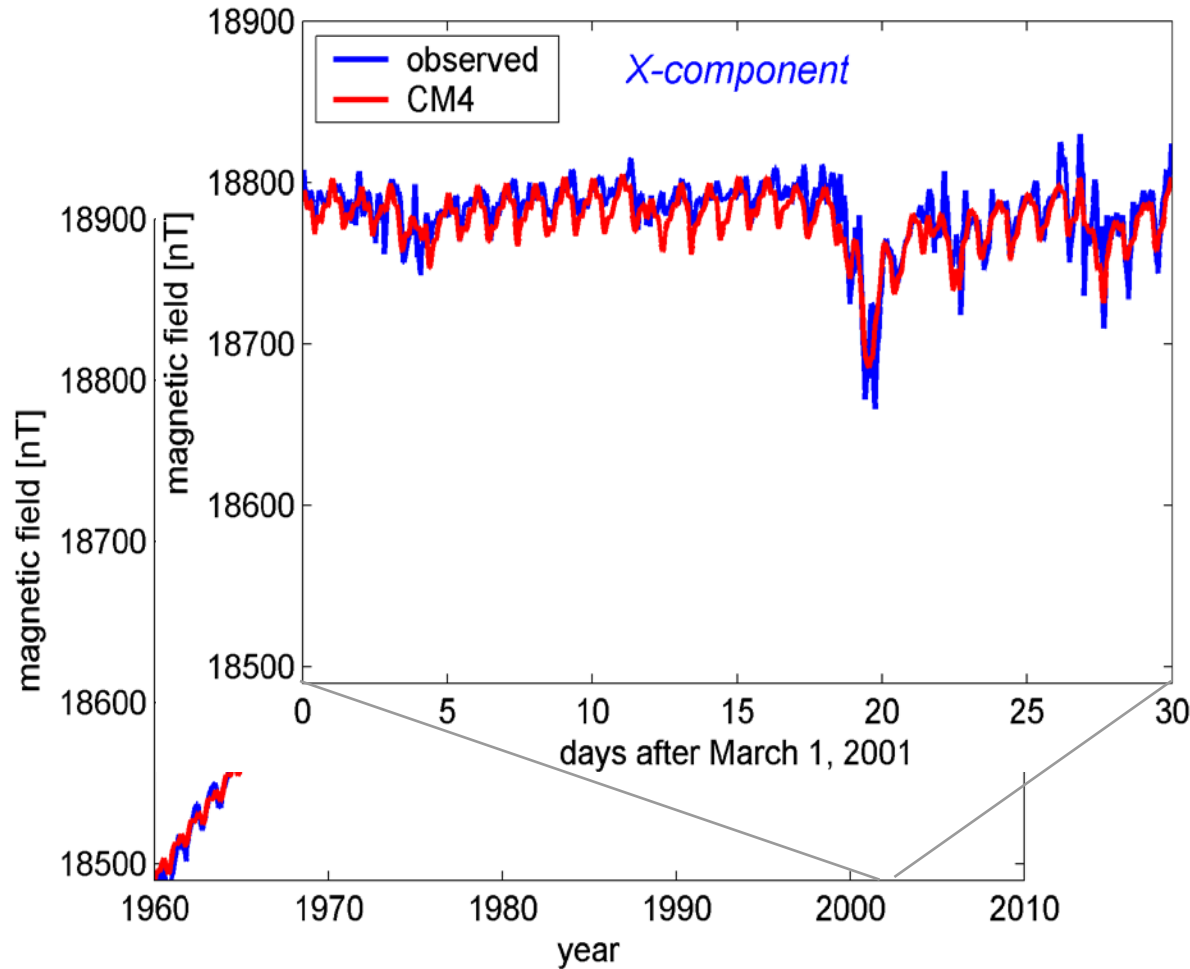


*... gives the flow velocity in the core!*

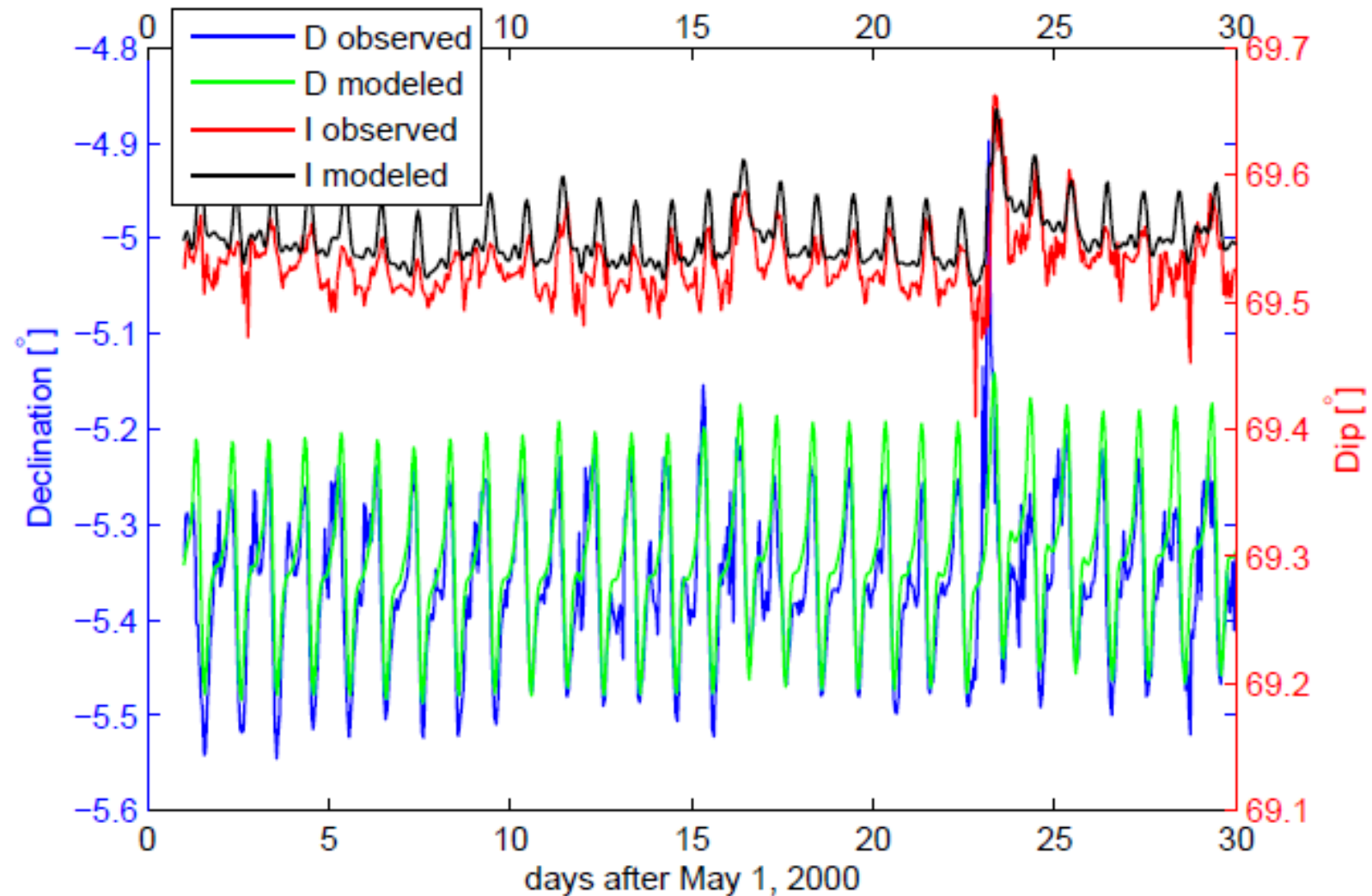


20 km/yr

# The last 50+ Years comparing Data and Model Predictions from CM4



# Observations at Eskdalemuir (Scotland) vs CHAOS and CM4 model predictions



# Summary

DTU has first class geomagnetic field models

- with yearly updates

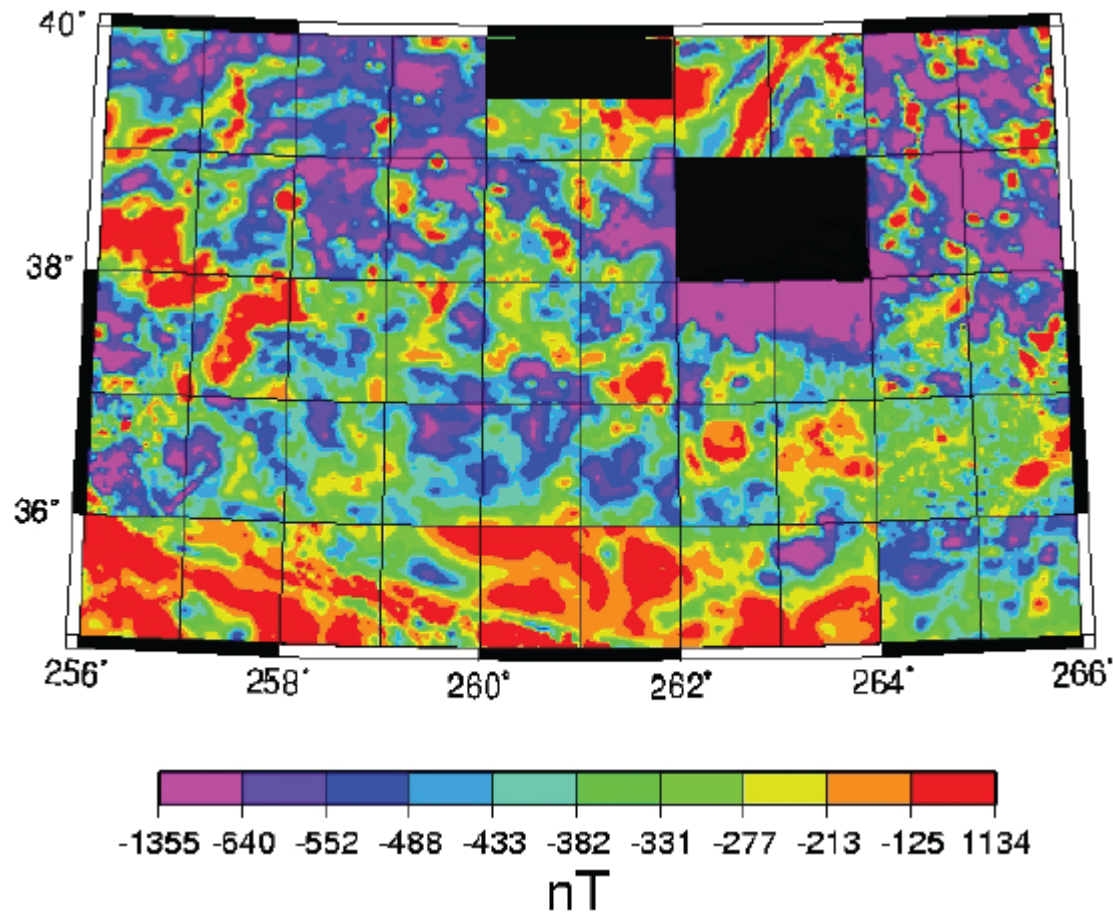
In the modeling process, not only the main field is described, but also the magnetospheric fields.

- This improves the quality of the main field.
- And allows to calculate globally (outside the auroral electrojet) the magnetospheric contributions.
- Input-parameter: solar radiation, ring current strength.

Please contact us if you need geomagnetic field monitoring in:

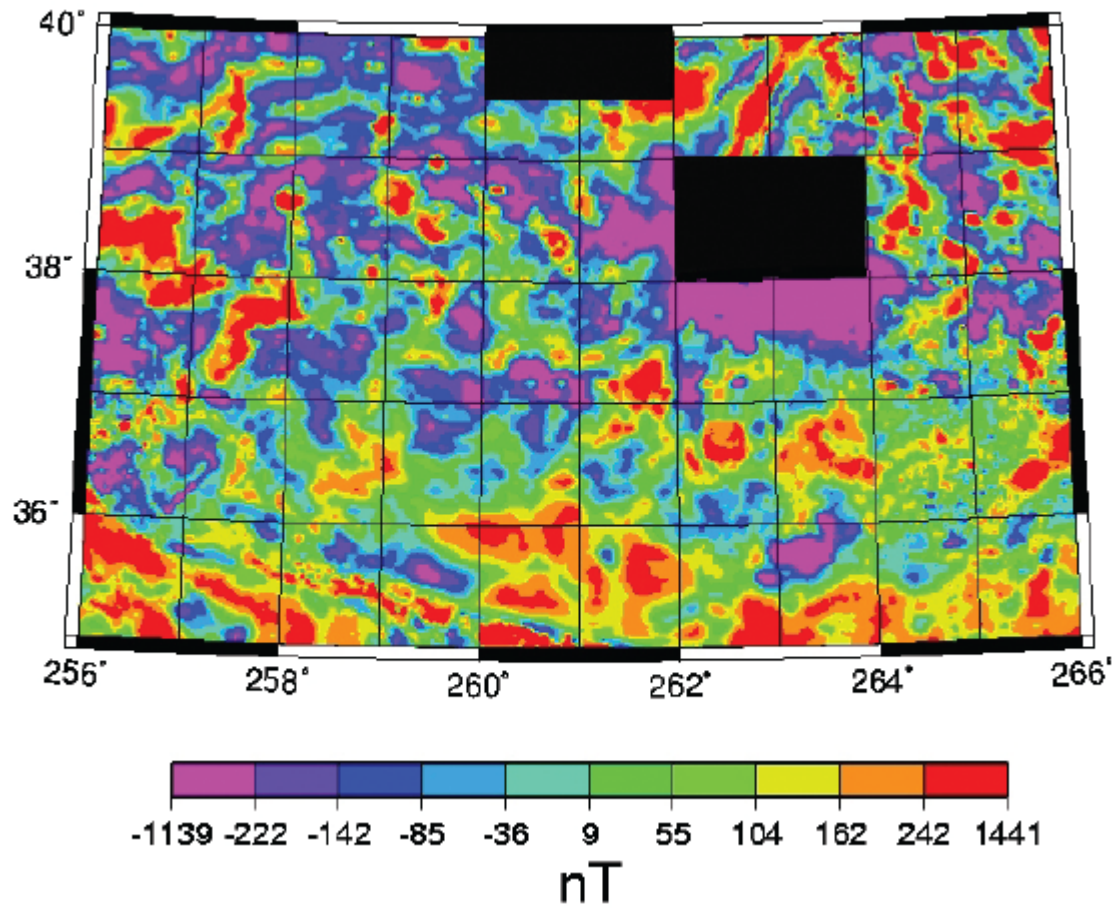
- North Sea
- Greenland
- South Atlantic
- Faroe Islands

# Aeromagnetic surveys, NURE, Kansas, IGRF



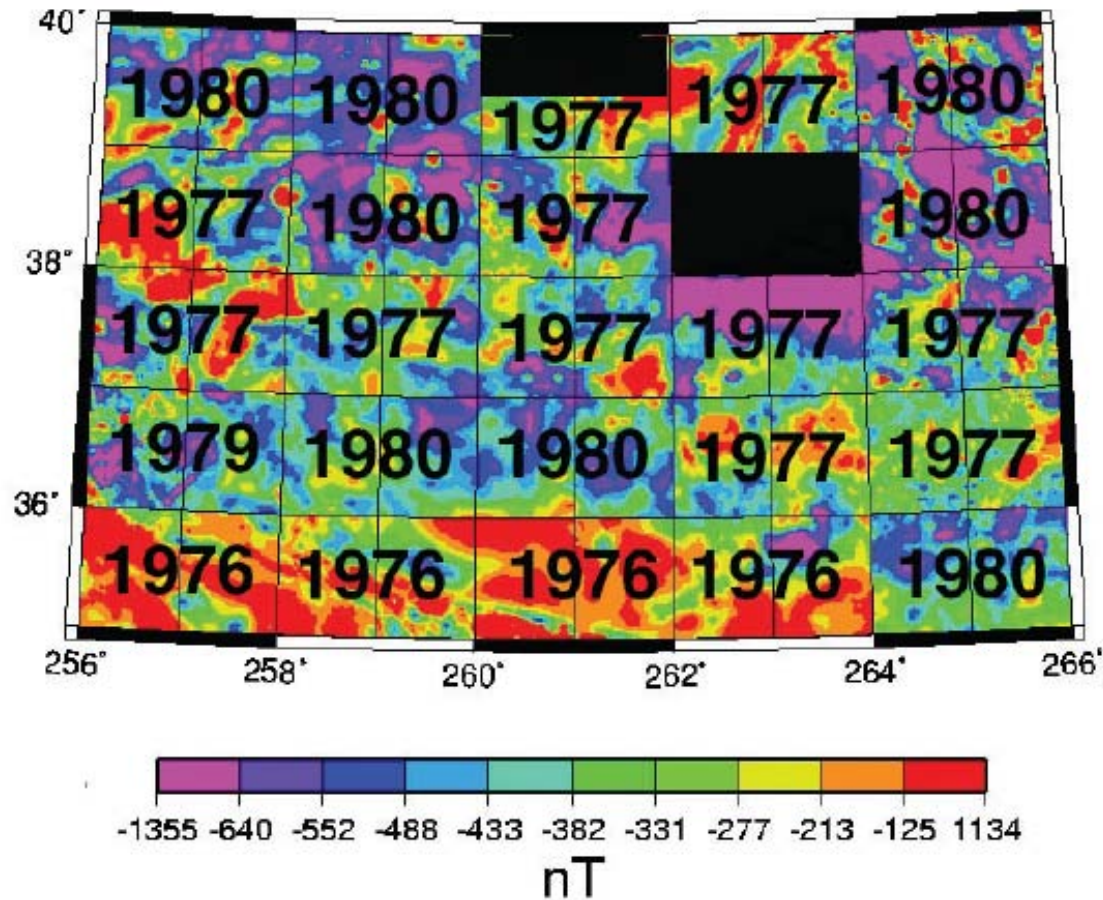
Ravat, Hildenbrand, Roest (The Leading Edge, august 2003)

# Aeromagnetic surveys, NURE, Kansas, CM3



Ravat, Hildenbrand, Roest (The Leading Edge, august 2003)

# Aeromagnetic surveys, NURE, Kansas, IGRF



Ravat, Hildenbrand, Roest (The Leading Edge, august 2003)