

New advances in geomagnetic field modeling

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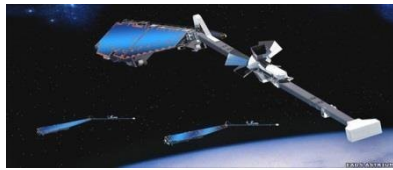
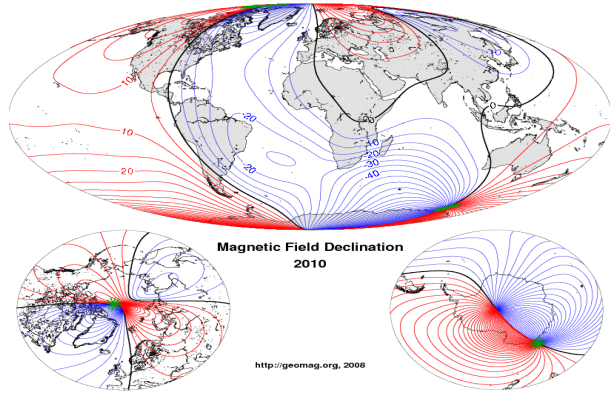
Outline

- Introduction
- Disturbance field correction (magnetosphere)
- Disturbance field correction (ionosphere)
- EMAG2 crustal grid update

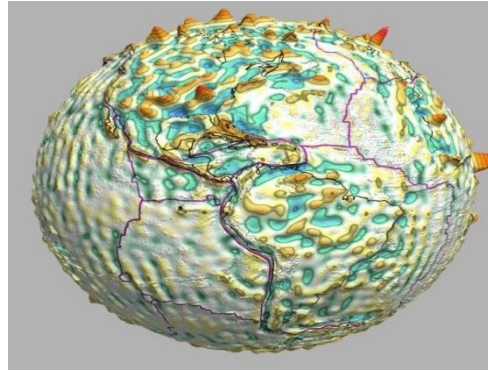


Introduction

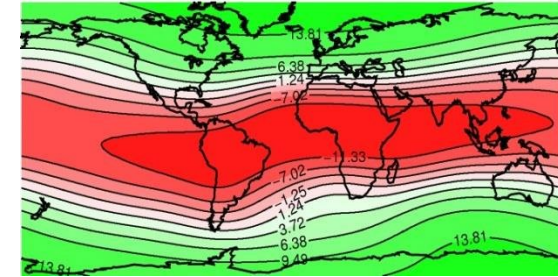
Main field



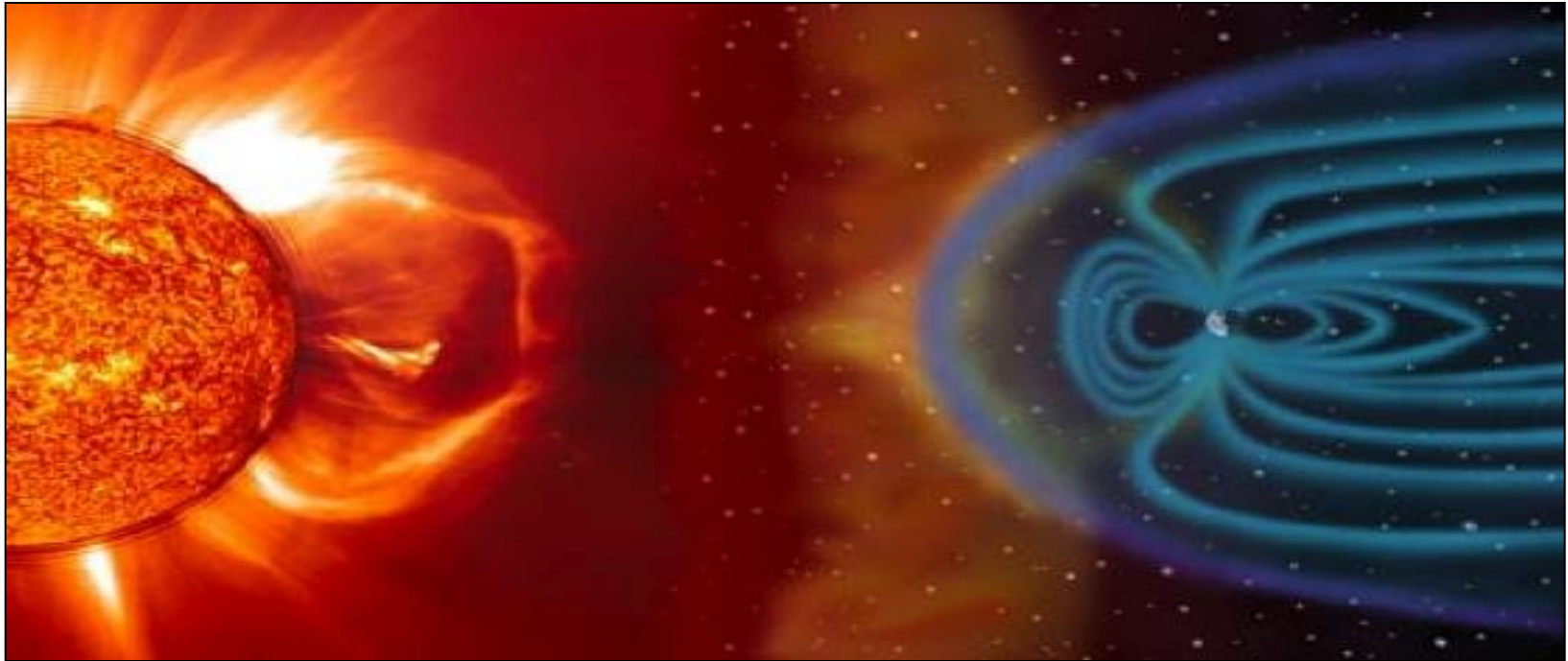
Crustal field



Disturbance field

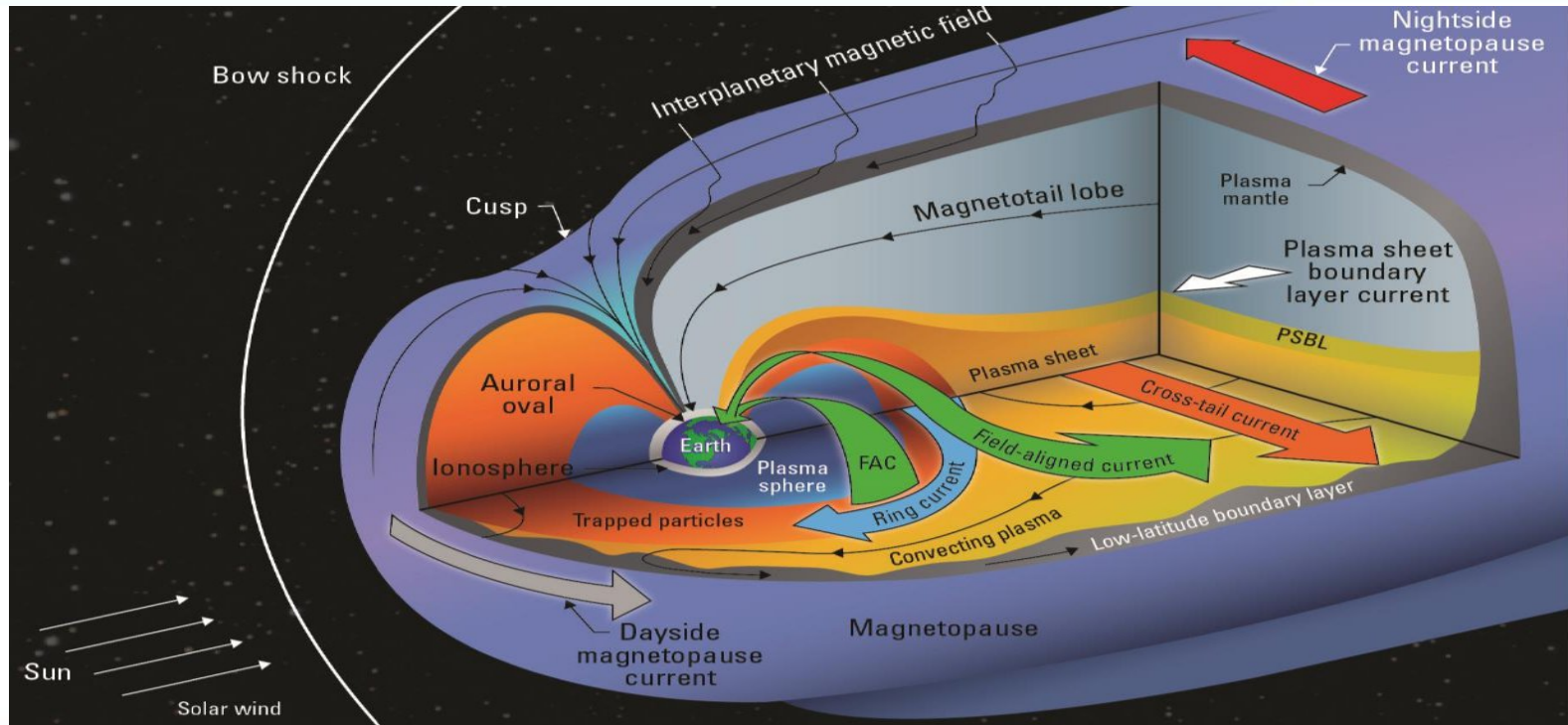


Part 1: Disturbance field from the magnetosphere



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Magnetospheric current systems

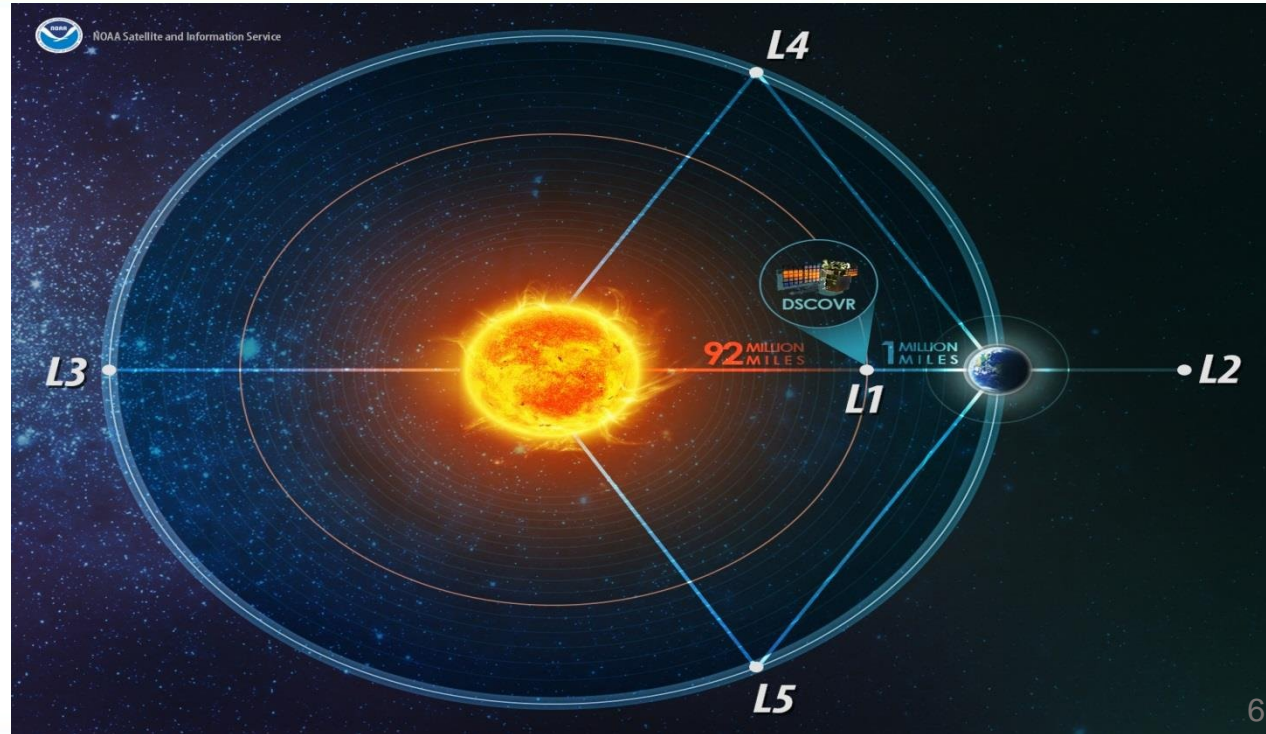


How to model the magnetosphere?

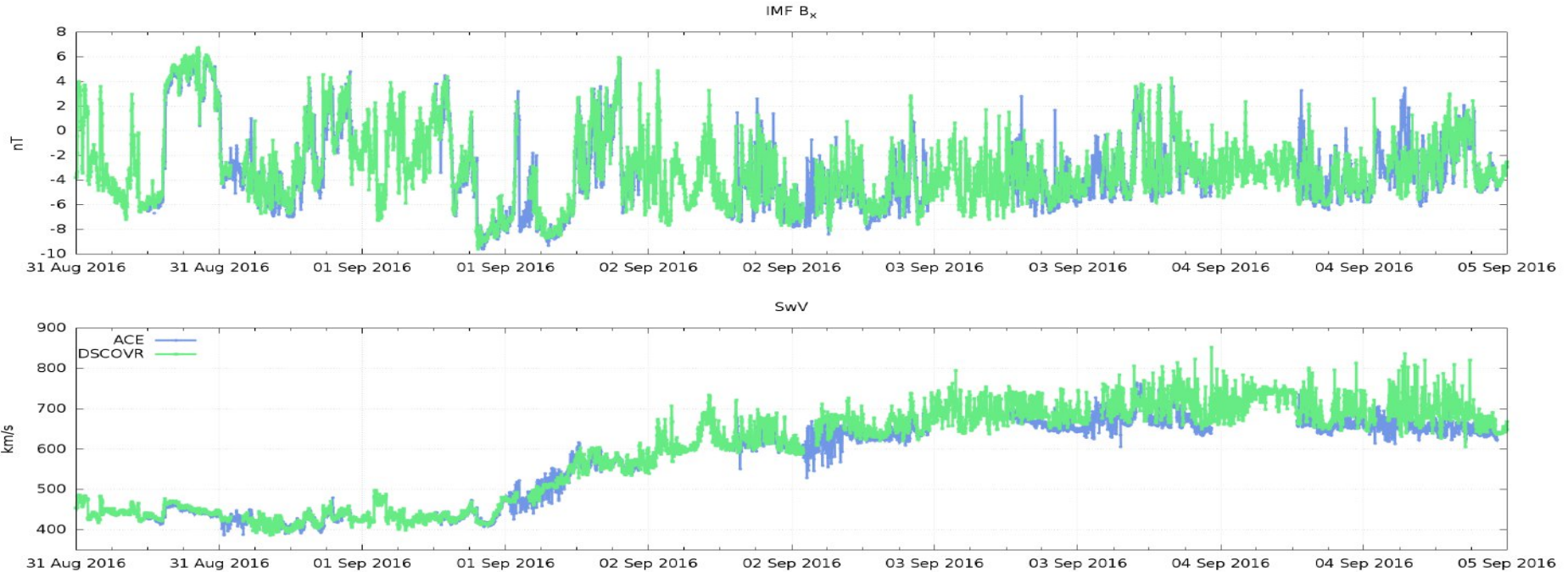
- Model the “average” behavior of the various magnetospheric sources, and then modulate this with real-time indices such as
 - Dst (derived from ground observatories)
 - Solar wind data (ACE/DISCOVER)
 - F10.7 (solar flux)
 - Modeling approach from Maus and Lüher, GJI, 162, 2005.

Solar forecasting: Migration from ACE to DSCOVR

- ACE (Advanced Composition Explorer) launched Aug 1997
- Quality of ACE data quickly degrading due to aging instruments and the space environment
- DSCOVR (Deep Space Climate Observatory) launched Feb 2015
- Purpose: provide early warning of geomagnetic storms here on Earth
- 15-60 minute warning time
- DSCOVR measures solar wind with a cadence 120 times faster than ACE

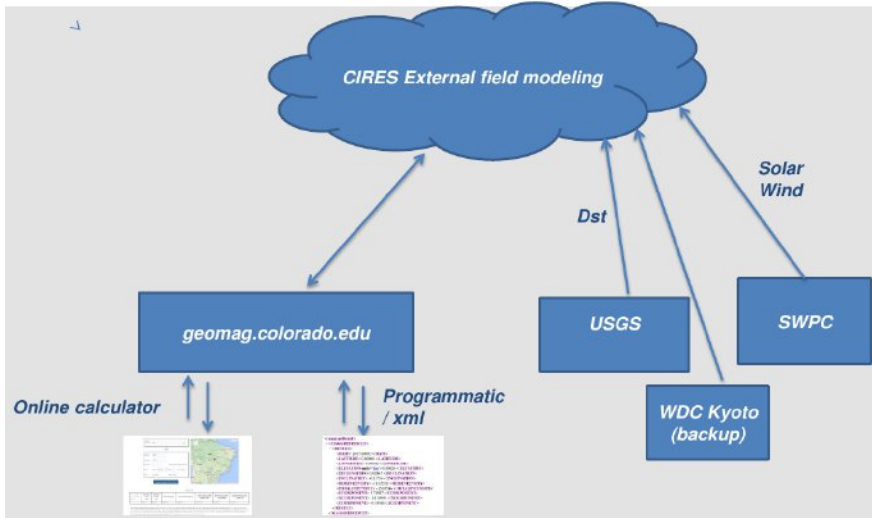


Migration from ACE to DSCOVR, cont'd

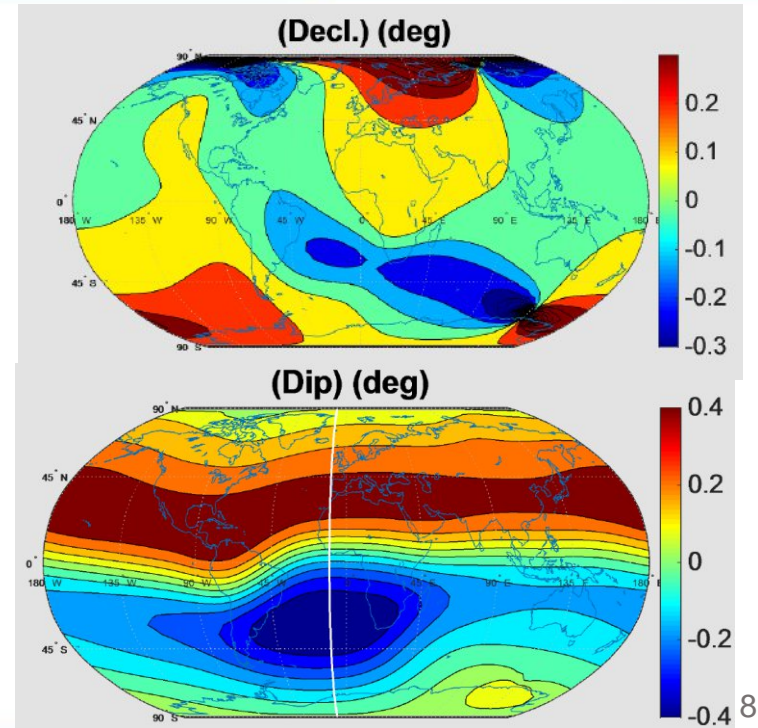


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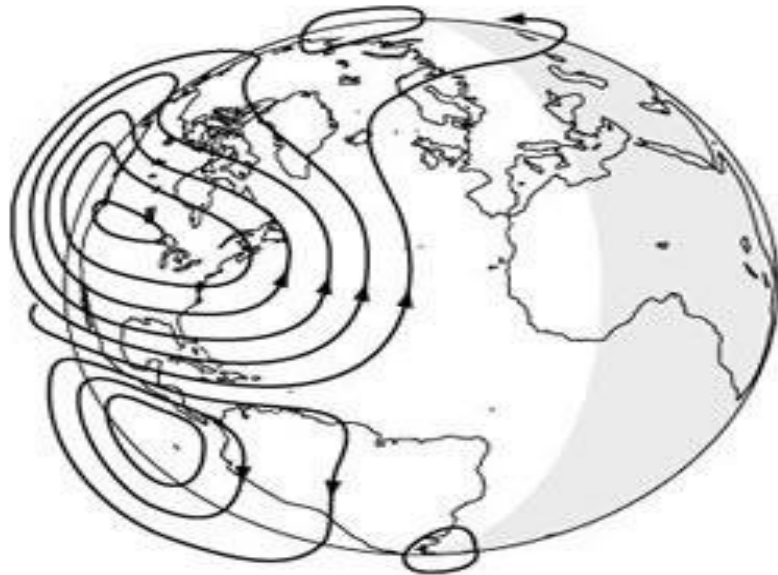
Real-time prediction of magnetospheric fields



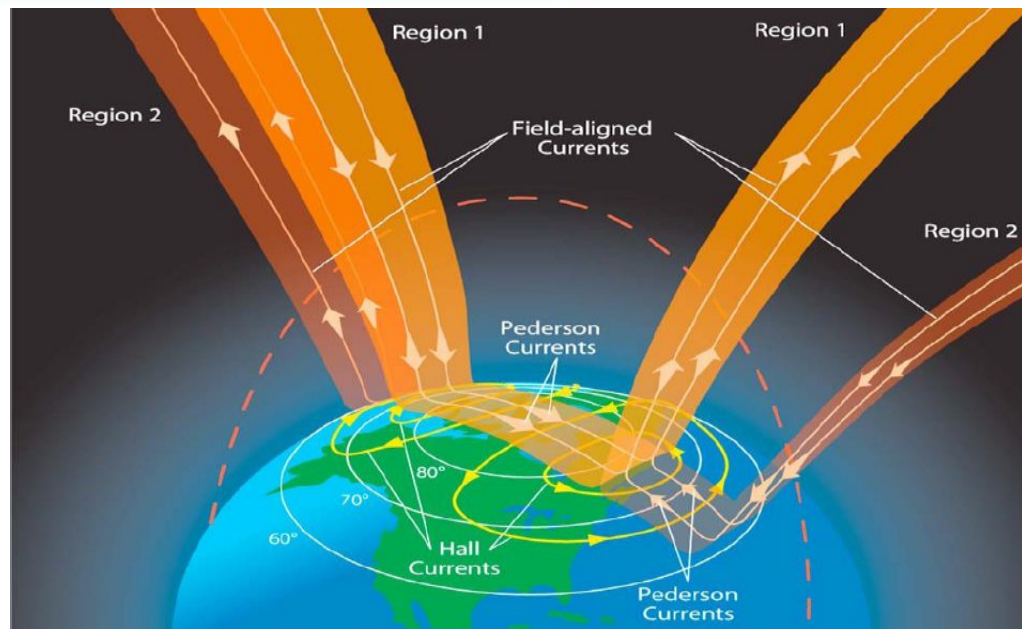
**Magnetic storm on 2015-03-17
(peak Dst -194 nT)**



Part 2: Disturbance field from the ionosphere



~80 nT variations



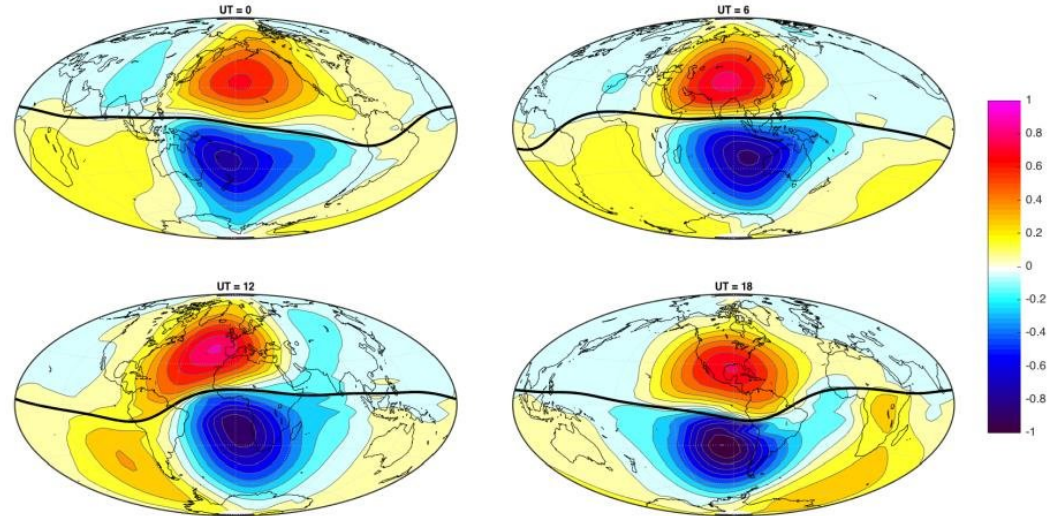
100-200 nT variations

Modeling the Sq current system

Swarm mission allows measuring ionospheric currents simultaneously at different longitudes



This has resulted in a climatological model of the Sq currents, called DIFI



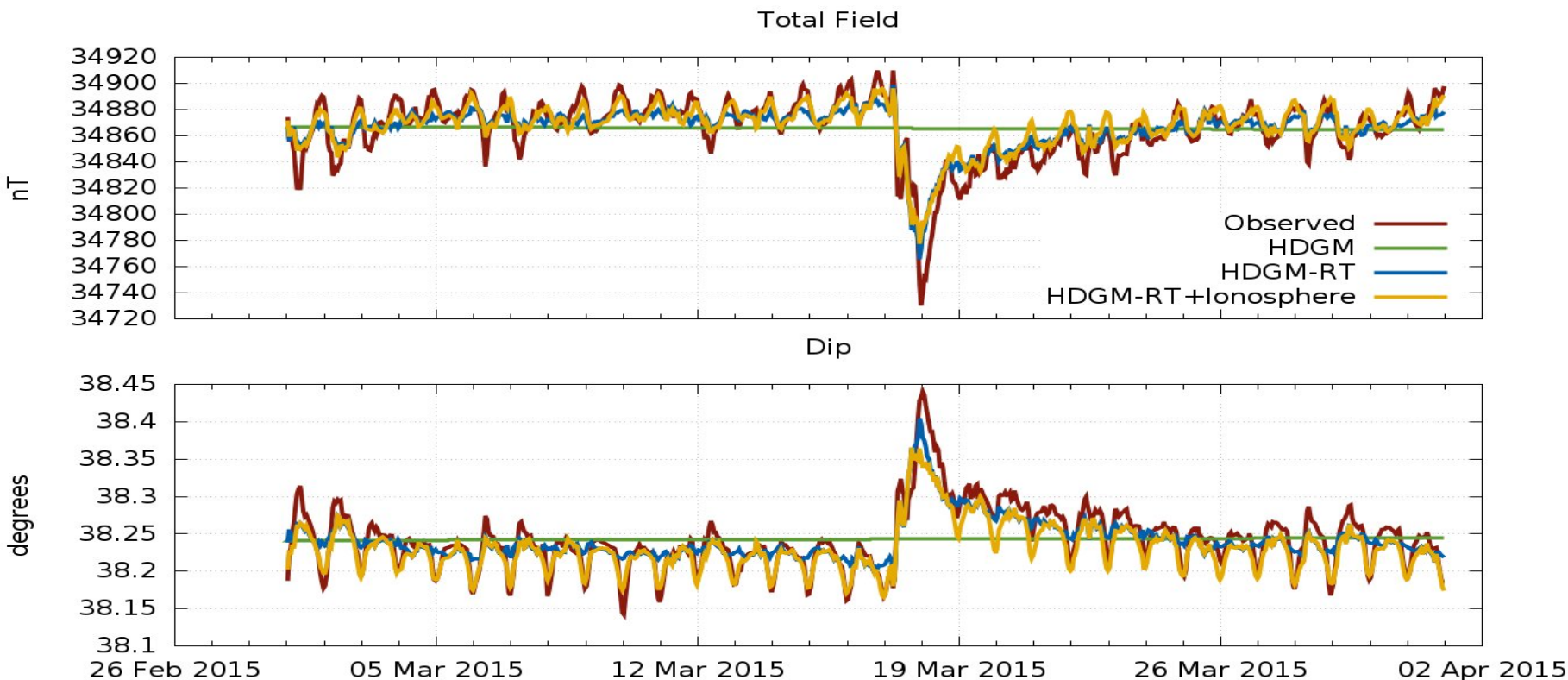
Chulliat et al, EPS, 2016

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The DIFI model

- DIFI (Dedicated Ionospheric Field Inversion)
- Derived from over 2 years of Swarm A, B, C and ground observatory data
- Includes effects of induced currents in the Earth (30% of observed field at surface)
- Driven by solar flux intensity data

Honolulu observatory storm measurements



Observed magnetic field at drill bit

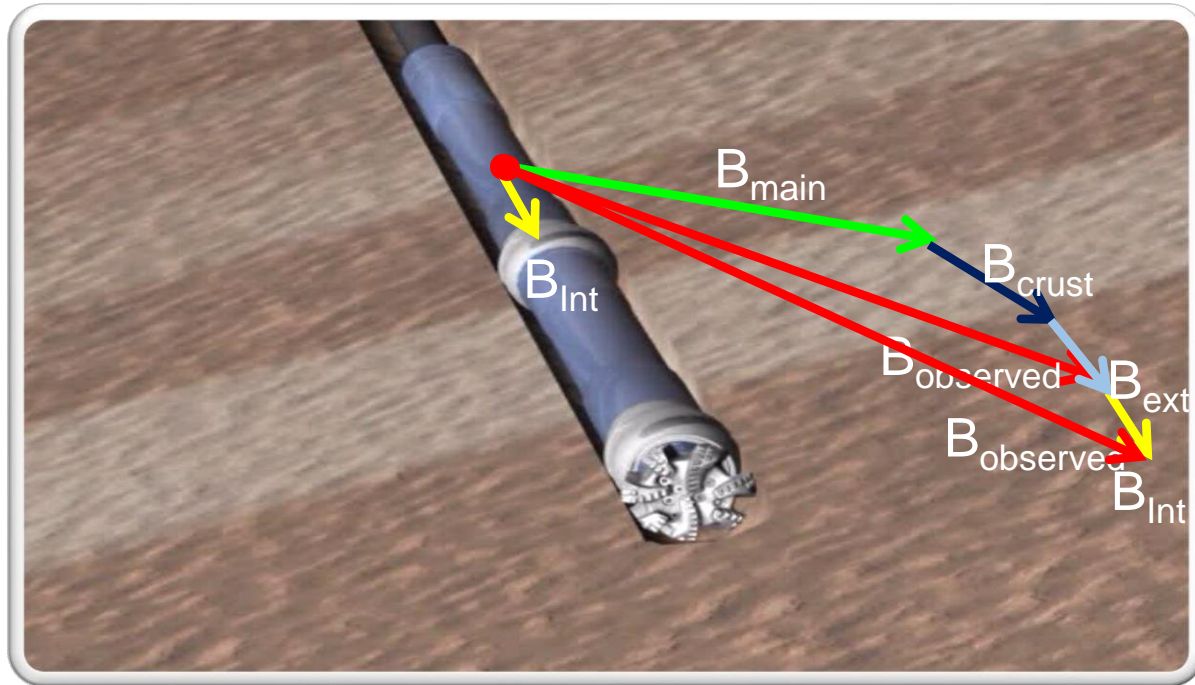


Image courtesy Schlumberger

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MWD Calibration: Brazil



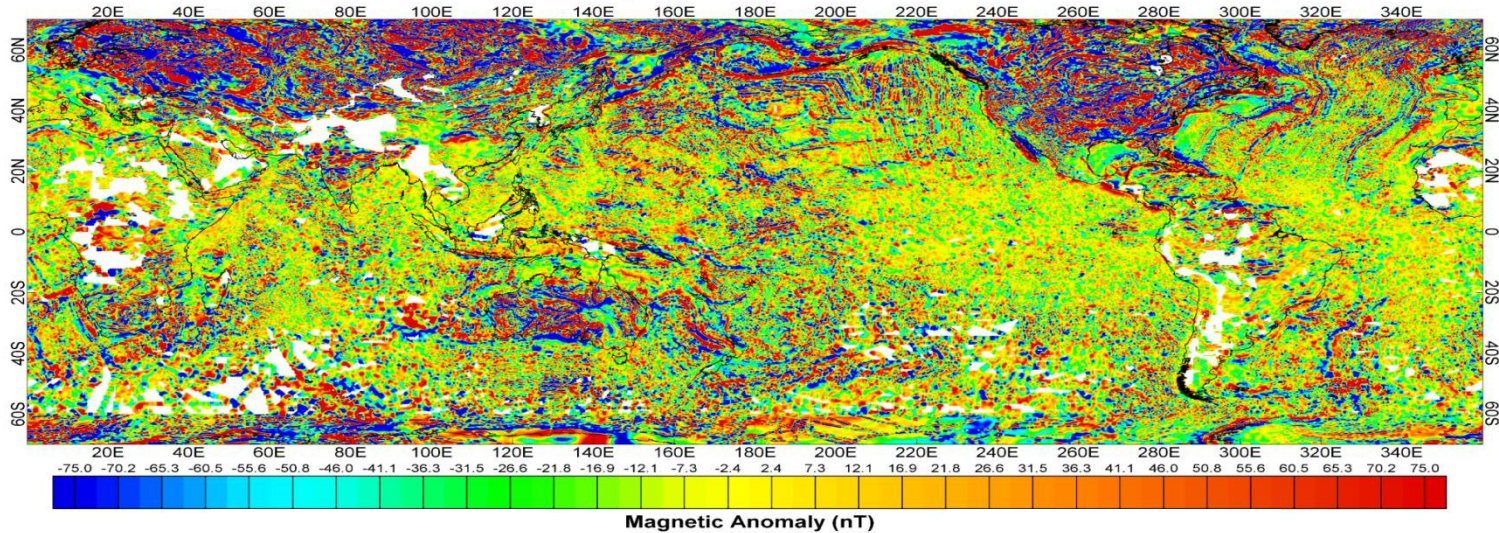
**MWD with HDGM
- Fixed reference**

**MWD with
HDGM-RT+DIFI
- Variable reference
- Better fit**

Data provided by Schlumberger

Part 3: EMAG2 crustal grid update

Earth Magnetic Anomaly Grid (EMAG2_V3)
2 arc-minute resolution
Upward Continue

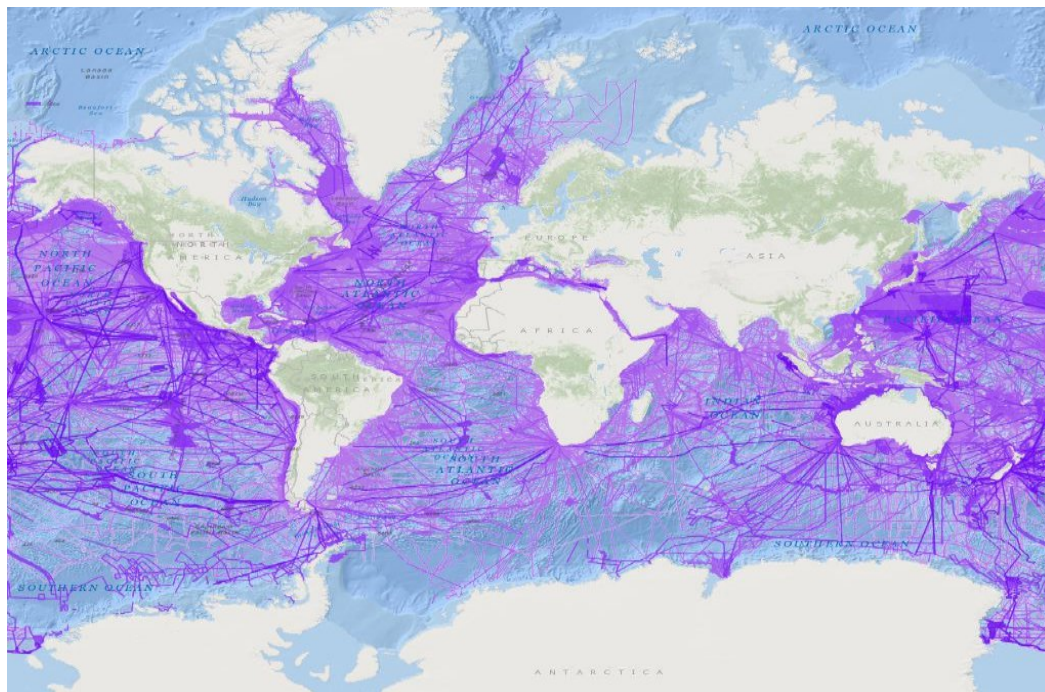


<https://ngdc.noaa.gov/geomag/emag2.html>

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Where does the data come from?

- **Primary source of data comes from marine and airborne tracklines**
 - **Over 100 institutions**
 - **Over 50 years**
 - **3255 surveys**
 - **75.9 million data points**
 - **10.5 million miles**
- **Precompiled grids over continental areas**
 - **Provided by Governments, Industry, and Academia**



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Send us your data!

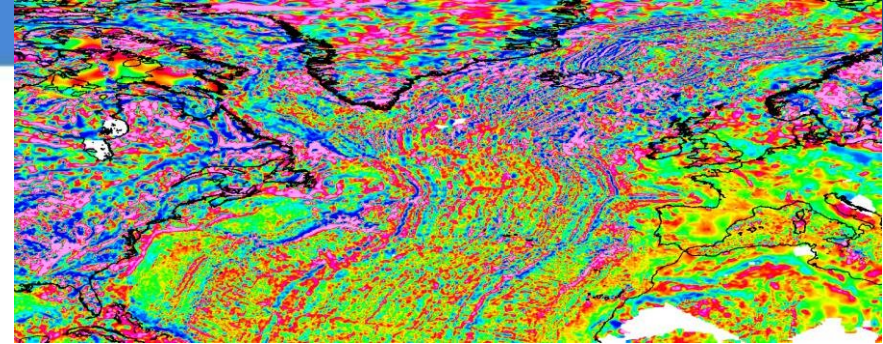
- More data will enable a more detailed grid and more accurate crustal field models
- NOAA can offer long-term archival
- Data can be flagged as private/proprietary (not for public download); we currently archive proprietary data
- Even decimated / lower-resolution datasets would be useful
- Contact us at geomag.models@noaa.gov

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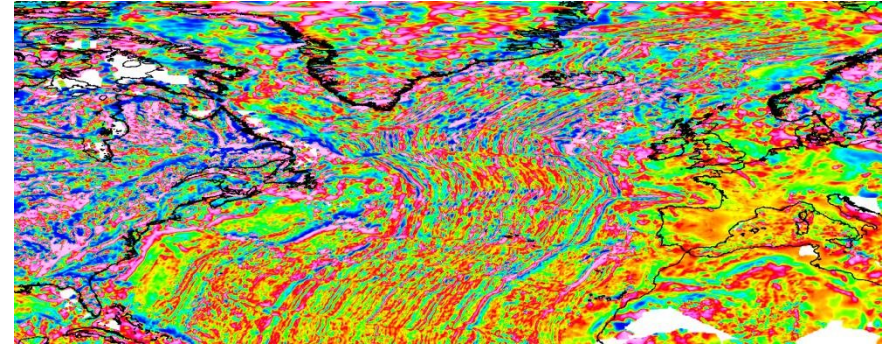


What has changed?

- 657 individual surveys
- 50.6 million data points
- 2.5 million miles
- No more “model-driven” data
- Represents greater complexity in oceanic regions
- Grids produced at sea level and at 4km altitude



Version 3



Version 2

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Summary

• Magnetospheric disturbance field modeling

- Real-time modeling capability
- Driven by USGS operational Dst index and DSCOVR satellite solar wind data
- Available to public at geomag.colorado.edu
- Manual and programmatic access

• Ionospheric disturbance field modeling

- Developing real-time modeling of Sq currents
- Transitioning from research to operations

• EMAG2_V3 crustal grid update

- Added 50 million new data measurements into a new crustal grid compilation
- Will enable next generation, higher resolution crustal field models
- <http://maps.ngdc.noaa.gov/viewers/geophysics>
- Please send us data!

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Introduction

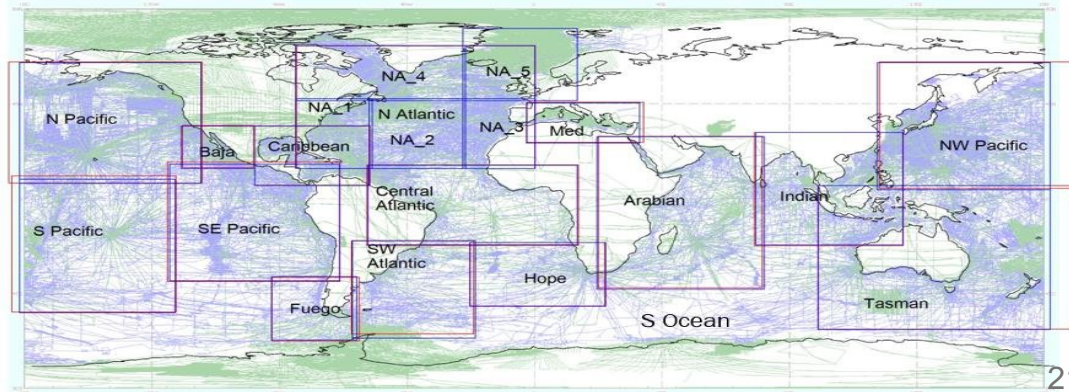
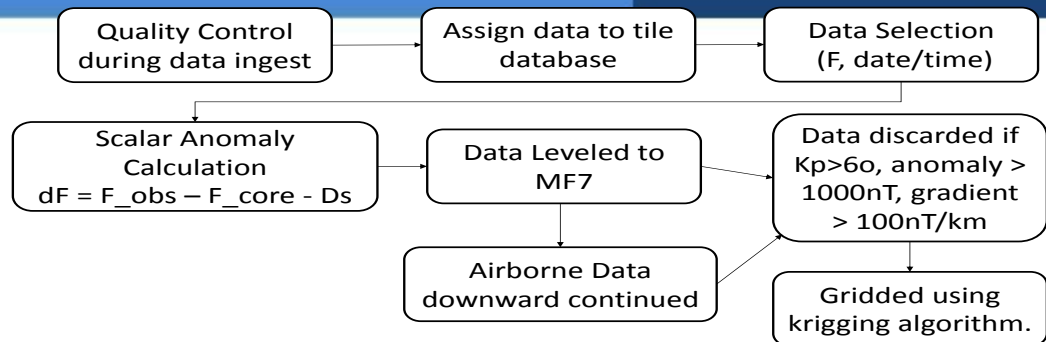
- Geomagnetic main field
 - Generated by convection in Earth's core
 - 95% of observed strength at Earth's surface
 - Slow changes due to secular variation
 - Accurate models with data from observatories and satellites
- External (disturbance) field
 - Generated from electric currents in Earth's magnetosphere and ionosphere
 - Significant effects near Earth's surface at all latitudes
 - Can change rapidly during storm conditions
 - Data from satellites and observatories
- Crustal field
 - Generated from magnetized rocks in Earth's crust
 - Significant localized effects near Earth's surface
 - Data from satellites, marine and aeromagnetic surveys

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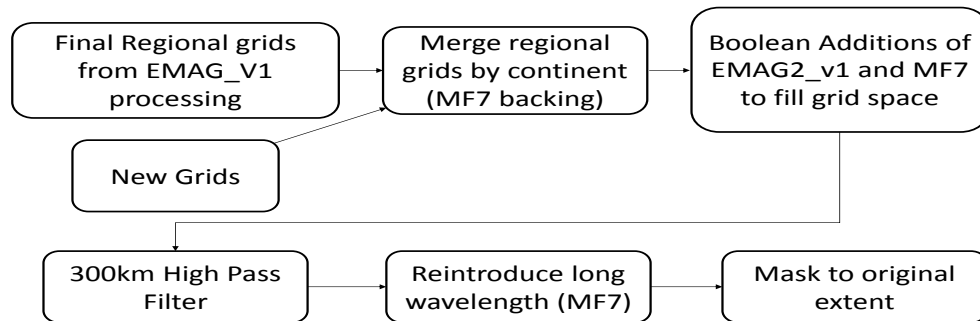
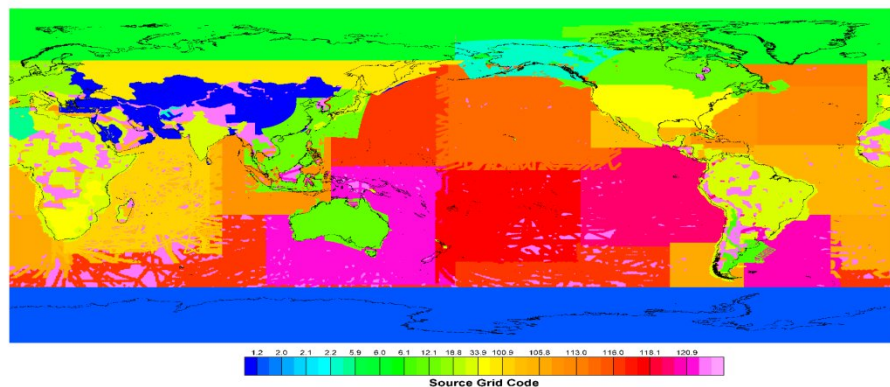
Processing trackline data

- Tiles created to be relatively homogeneous data density
- Remove first order trend from tracklines
- Add first order trend from MF7
- Remove data collected during storms, and spikes
- Incorporate data into final grid
- Much of the data processing is automated, allowing for easy addition of new datasets



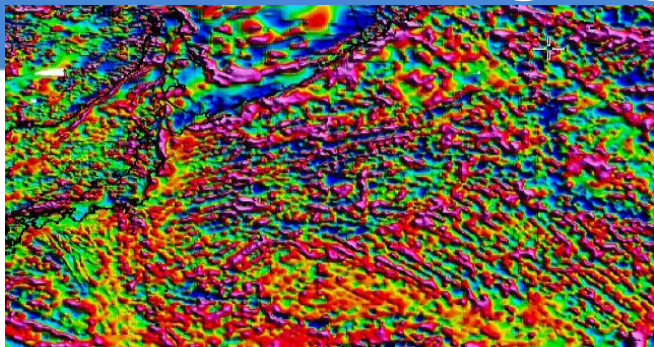
Processing precompiled grid data

- Continental Tiles assigned 1-38
- Marine Tiles assigned 101-121
- Highest energy grids given priority
- Fill grid space for effective fourier filtering
- Remove long wavelength component
- Use satellite model MF7 for latest long wavelength observation

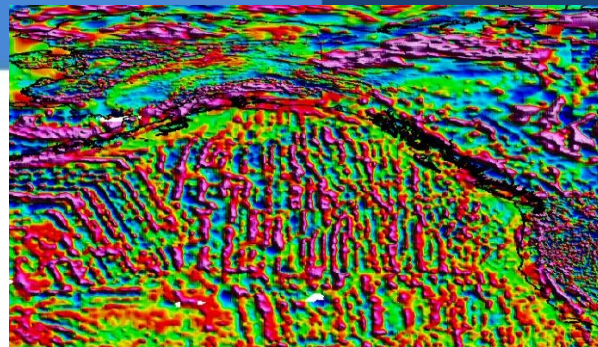


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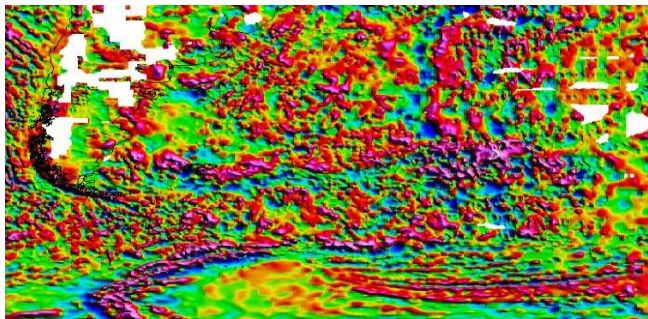
EMAG2_V3 Highlights



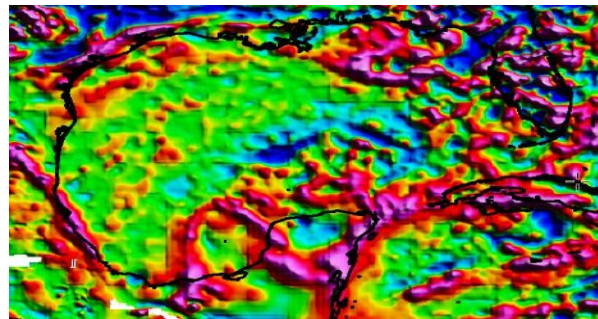
Japan and NW Pacific



Alaska and NE Pacific



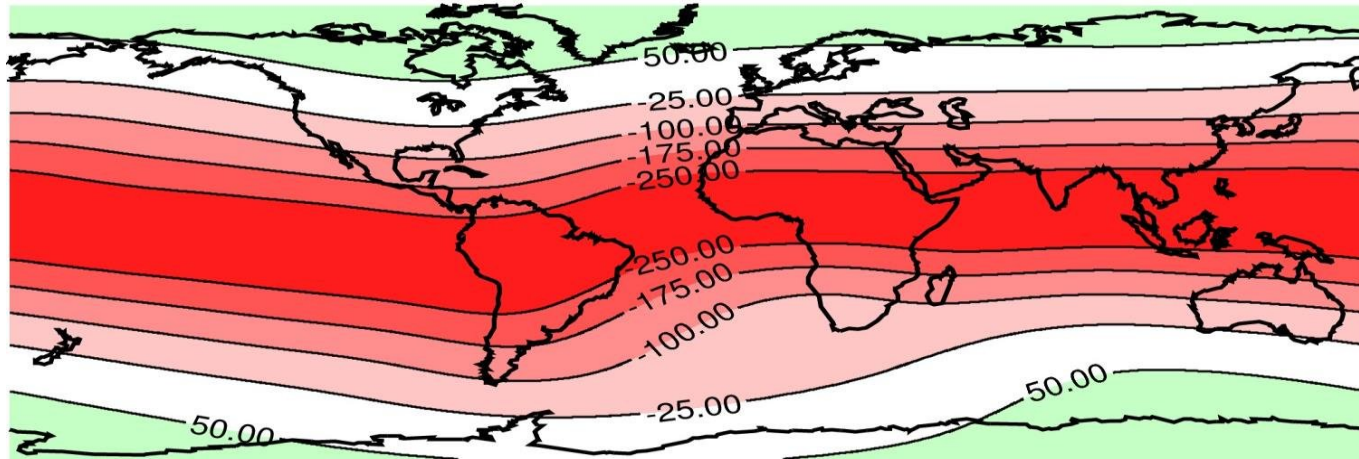
Shackleton Fracture Zone
and Scotia Plate



Chicxulub

Magnetospheric model: Real-time Maps

Calculator will show real-time maps of the declination, dip and total field



Total field at the Earth surface for a magnetic storm in October 2003