GPS Geodetic Reference System WGS 84

International Committee on GNSS

Working Group D

Saint Petersburg, Russia

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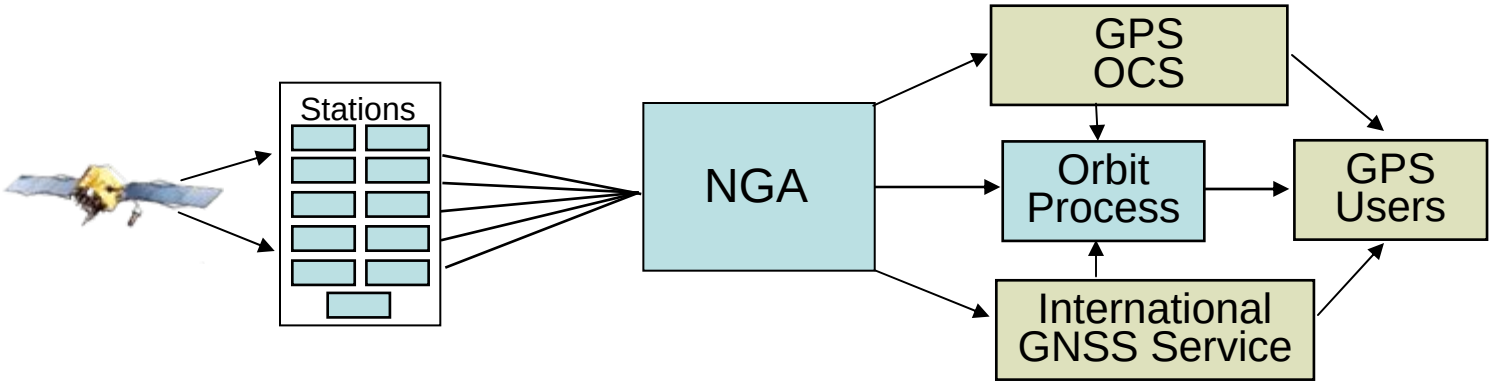
Barbara Wiley

National Geospatial-Intelligence Agency

United States of America

GPS Reference Frame

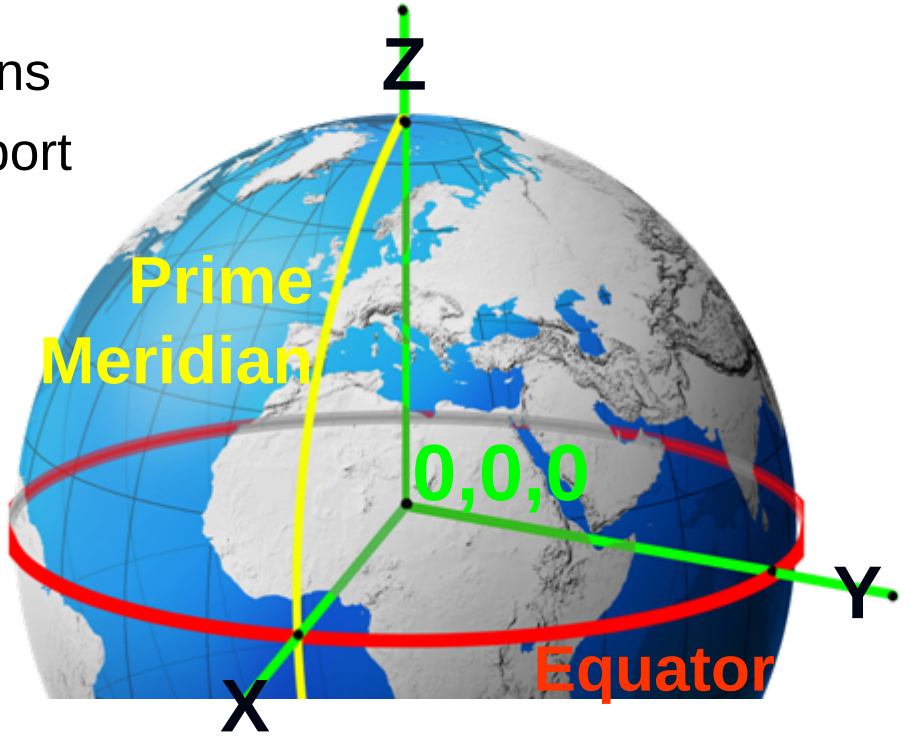
- **World Geodetic System 1984 (WGS 84)**
  - Reference for Positioning and Navigation
  - Aligned to International Terrestrial Reference Frame (ITRF)
  - Consistent with international standards
  - Supports GPS Operational Control Segment (OCS)



- **GPS References WGS 84**
  - Interoperability requires relationship between WGS 84 and other GNSS reference systems

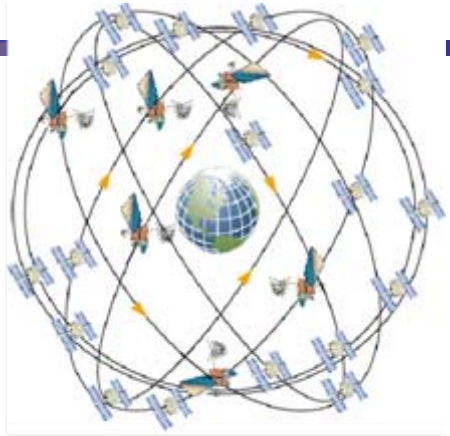
WGS 84 Support for Positioning and Navigation

- Safety of Navigation
  - Maps, Charts, Grids, Publications
  - Inertial Navigation System support
- Reference system WGS 84
  - Reference Frame
    - Network solution
    - Grids and coordinate system
    - Relationship to local datums
  - Gravity and magnetic models
  - Elevations and bathymetry



- GPS coordinates tie WGS 84 to physical Earth
- Key component for interoperability

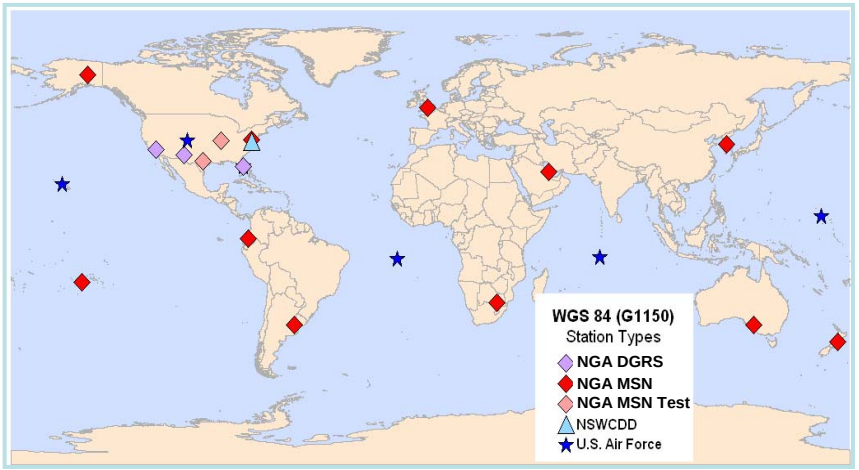
WGS 84 Historical Accuracy



Reference Frame: Global network of control stations that binds an Earth-centered, Earth-fixed 3-D coordinate system to the earth

Control Station Position Accuracy

Transit (1 - 2 m)	Jan 1987
G730 (~10 cm)	Jun 1994
G873 (~5 cm)	Jun 1997
G1150 (~1 cm)	**Jan 2002**



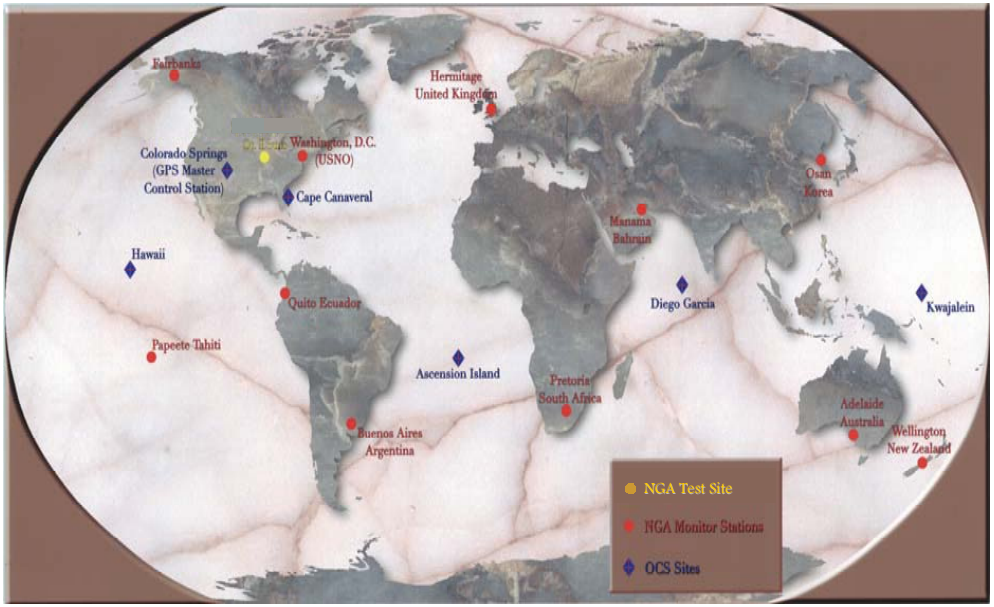
Ensure the WGS 84 Reference Frame errors are negligible in the GPS ephemeris error budget

WGS 84 Maintenance

- Ensure scientific integrity
  - Align to ITRF
  - Use International standards and conventions
- GPS Monitor Station Coordinates
  - Next network adjustment 2011
- Earth Gravitational Model
  - EGM08 released
- World Magnetic Model
  - Next release Jan 2010
- NIMA Technical Report 8350.2
  - Defines WGS 84 Reference System
  - Update publication in 2011
- Information available via internet

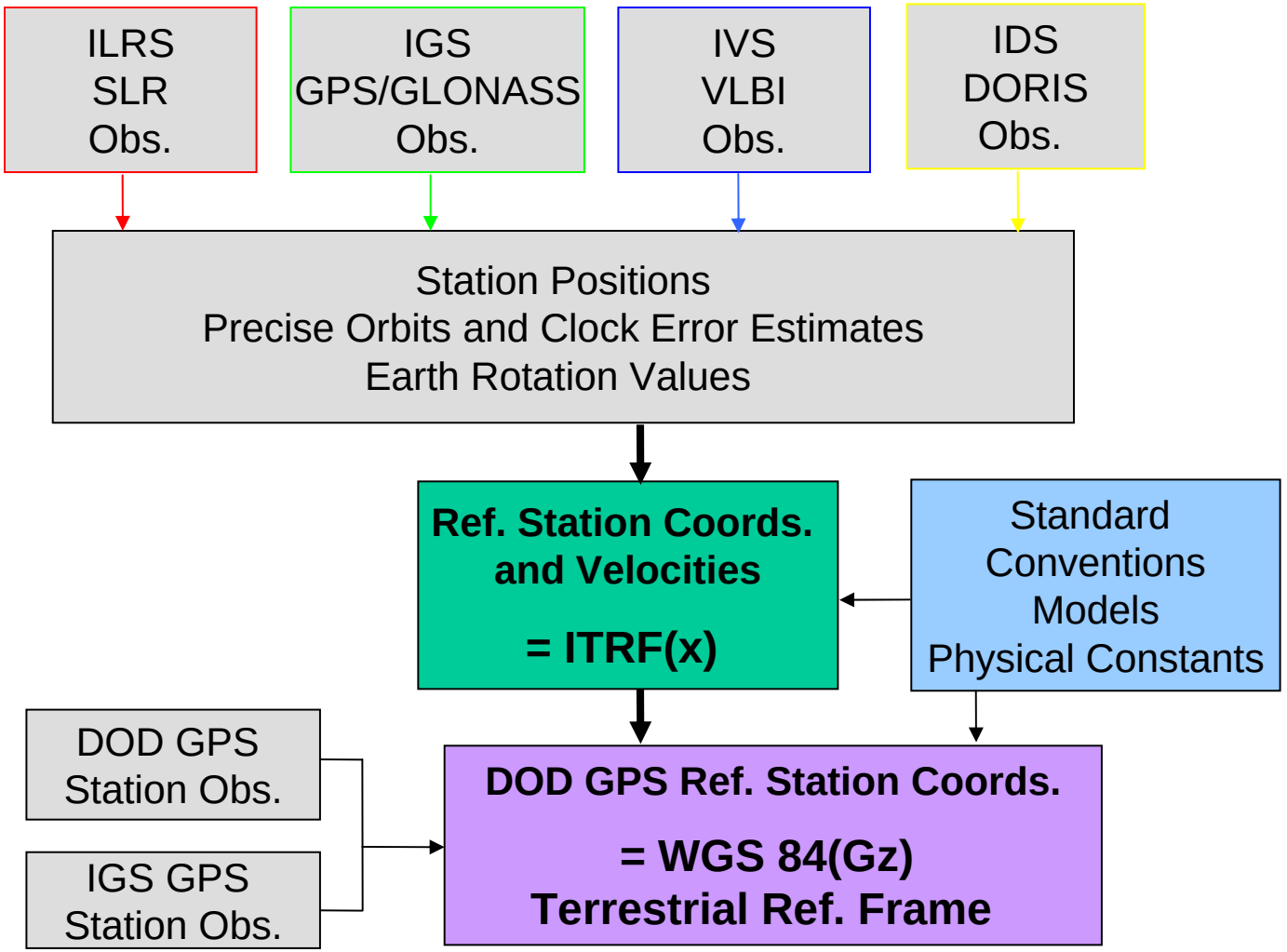
NGA Monitor Station Coordinates

- Next network adjustment 2011
  - –Ensure Geodetic quality
  - –Equipment changes
    - New antennas 2009/2010
    - Antenna calibration in work
    - New receivers 2010
  - –Add Reference Markers
    - With new antennas
  - –Align to IGS reference sites



- Interim adjustments ongoing due to antenna replacement
- International Earth Rotation and Reference System Service (IERS)
  - – Plan to update NGA GPS operations to 2003 conventions
- Changes to NGA processes are coordinated with GPS OCS

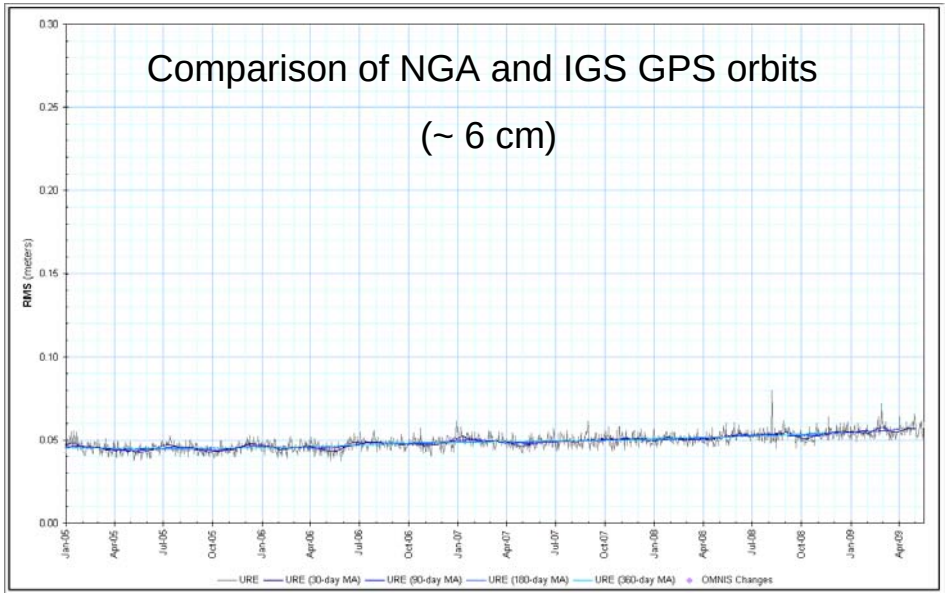
WGS 84 Aligned to ITRF



WGS 84 Aligned to ITRF

- WGS 84 (G1150) aligned to ITRF2000

- WGS 84 network solution
  - –NGA and US Air Force site coordinates solved using NGA orbits
  - –Solution constrained to ITRF network
  - –Validation: Hold WGS 84 sites fixed and allow IGS sites to adjust
  - –Direct comparison between NGA and IGS orbit solutions



- NGA contributes its GPS observational data to IGS
  - –Supports consistency between WGS 84 and ITRF

WGS 84 used World-wide

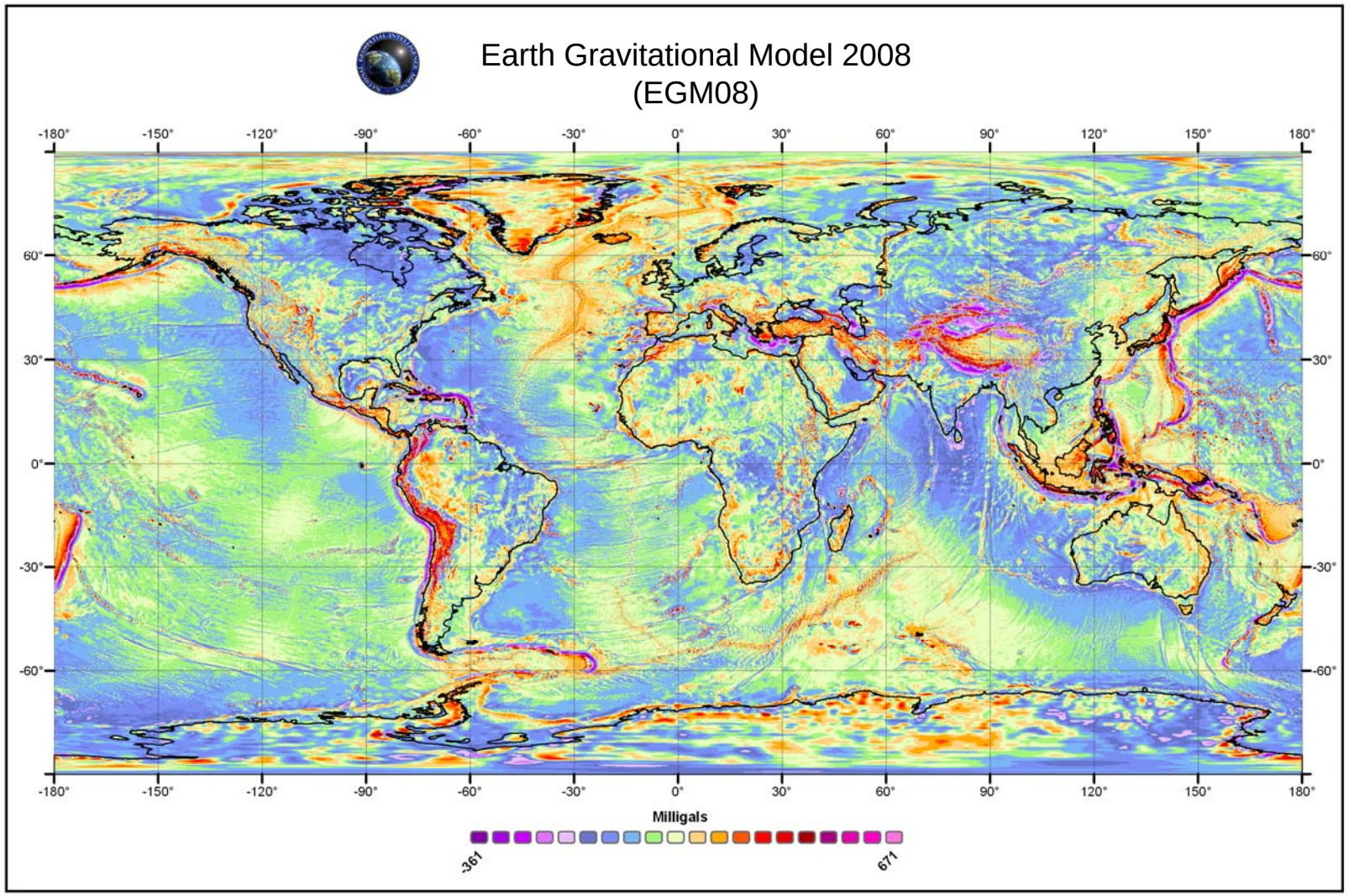
- Practical application
  - Reference frame for maps, charts, and GPS
  - International Organization for Standardization (ISO) certified process
- Referenced by multiple documents
  - US government
    - Department of Defense Master Positioning, Navigation and Timing Plan
    - Federal Radionavigation Plan
    - Technical manuals and Instructions
  - International documents that name WGS 84 as the standard
    - North Atlantic Treaty Organization Standardization Agreement
    - Spatial Reference Model
    - International Civil Aviation Organization Adopted
    - International Hydrographic Organization Technical Resolution

Discussion of Standards

- ITRF as the world standard proposed in multiple venues
- Points to Consider
  - A scientific standard is desirable
    - Best practices for constants, models, and methods
  - Practical applications have special needs
    - Frequent updates of constants and other values are undesirable
  - Interoperability requires relationships amongst reference systems

BACKUP SLIDES

Earth Gravitational Model 2008



Earth Gravitational Model 2008

EGM96

30 min x 30 min resolution
50 cm RMS accuracy
70 x 70 error propagation
40 satellites used for long wavelengths
30 million surface gravity values
29 elevation codes
130K coefficients

EGM2008

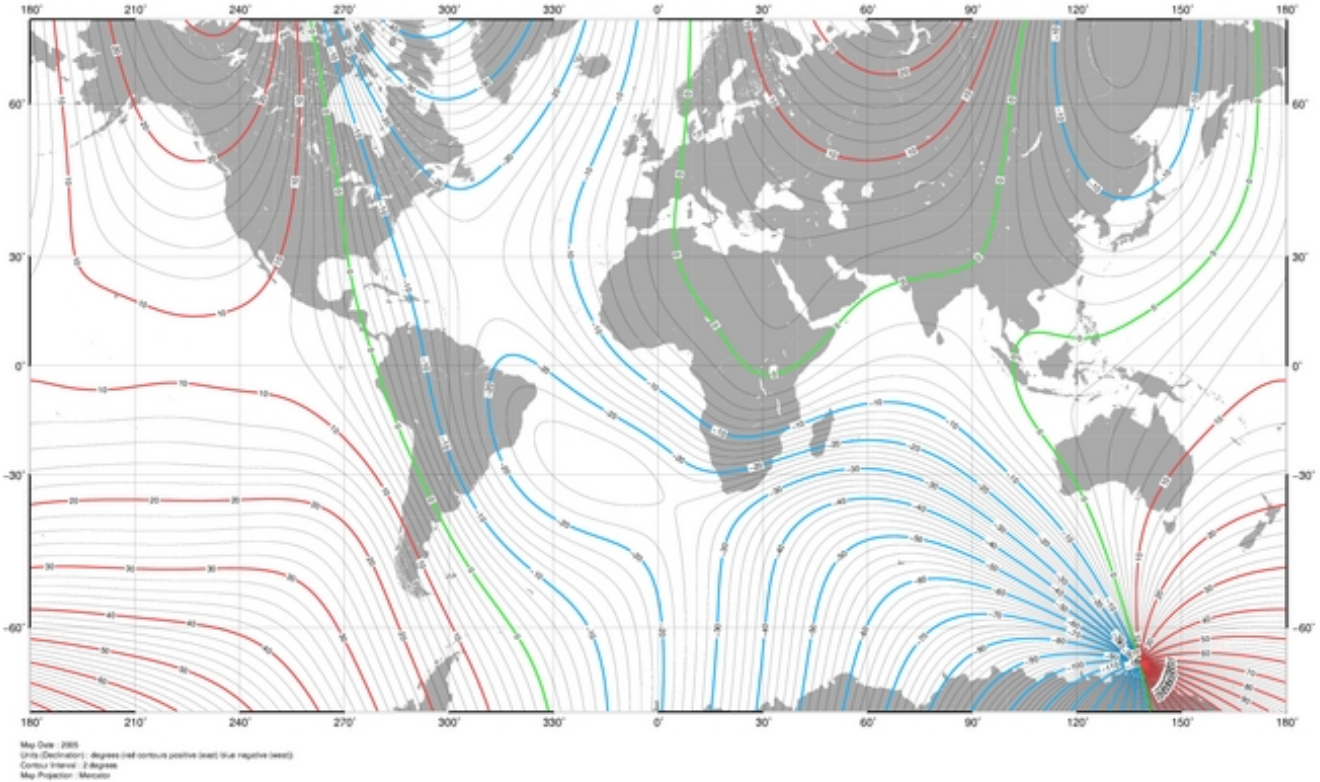
5 min x 5 min resolution
15 cm RMS accuracy
2160 x 2160 error prop
CHAMP and GRACE used for long wavelengths
54 million surface gravity values
SRTM, ICESAT for elevation
4.7 M coefficients

Applications

- More accurate geopotential surface to reference land elevations
- Improved reference frame for defining position coordinates
- Improved Satellite Orbits
- Enhanced gravity models
- Increased knowledge of ocean circulation

World Magnetic Model

US/UK World Magnetic Model -- Epoch 2005.0
Main Field Declination (D)



Next epoch - 2010.0

Main Field Model (12) and a Crustal Model (720)