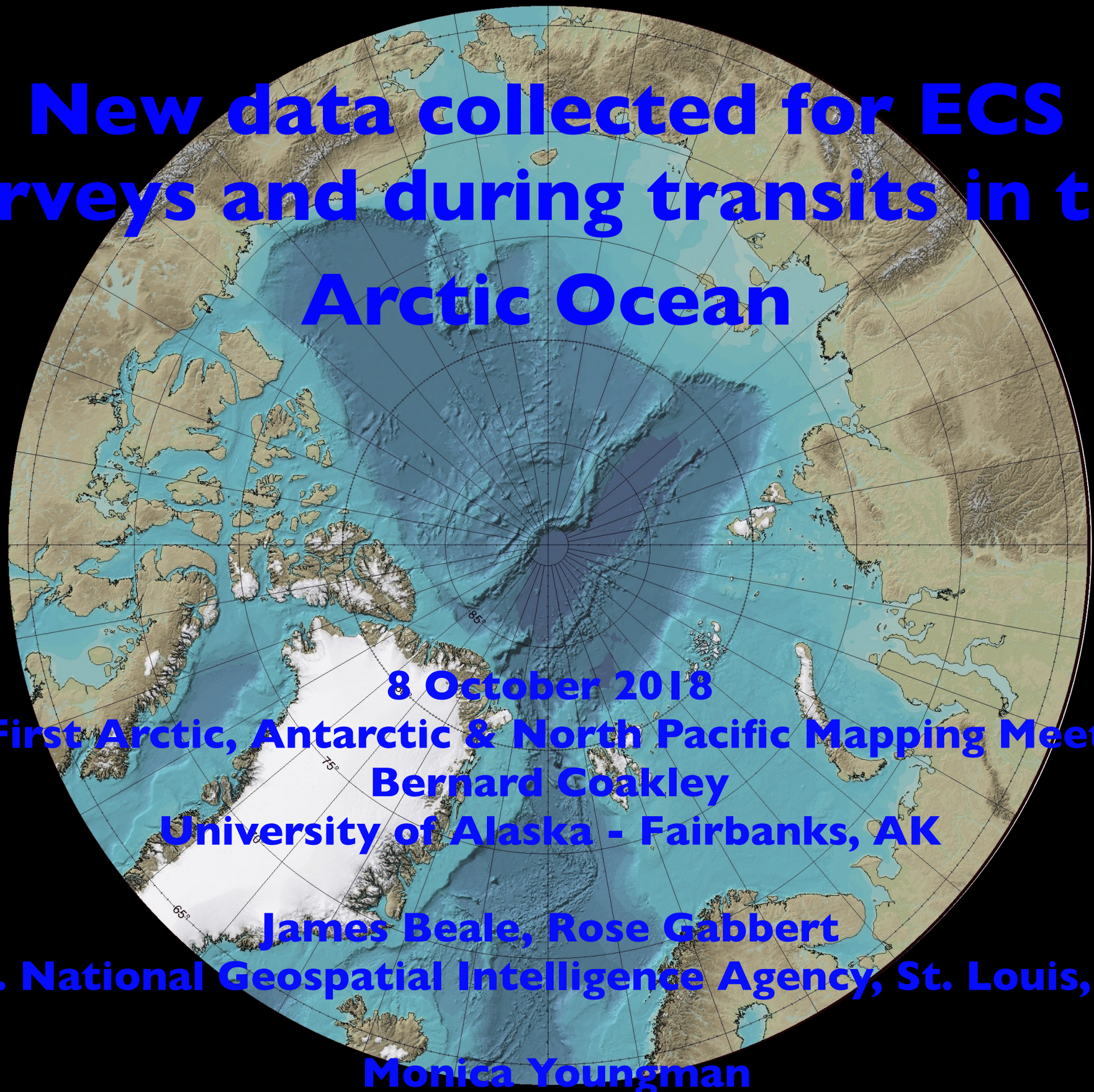
New data collected for ECS surveys and during transits in the Arctic Ocean



8 October 2018
at First Arctic, Antarctic & North Pacific Mapping Meeting

Bernard Coakley
University of Alaska - Fairbanks, AK

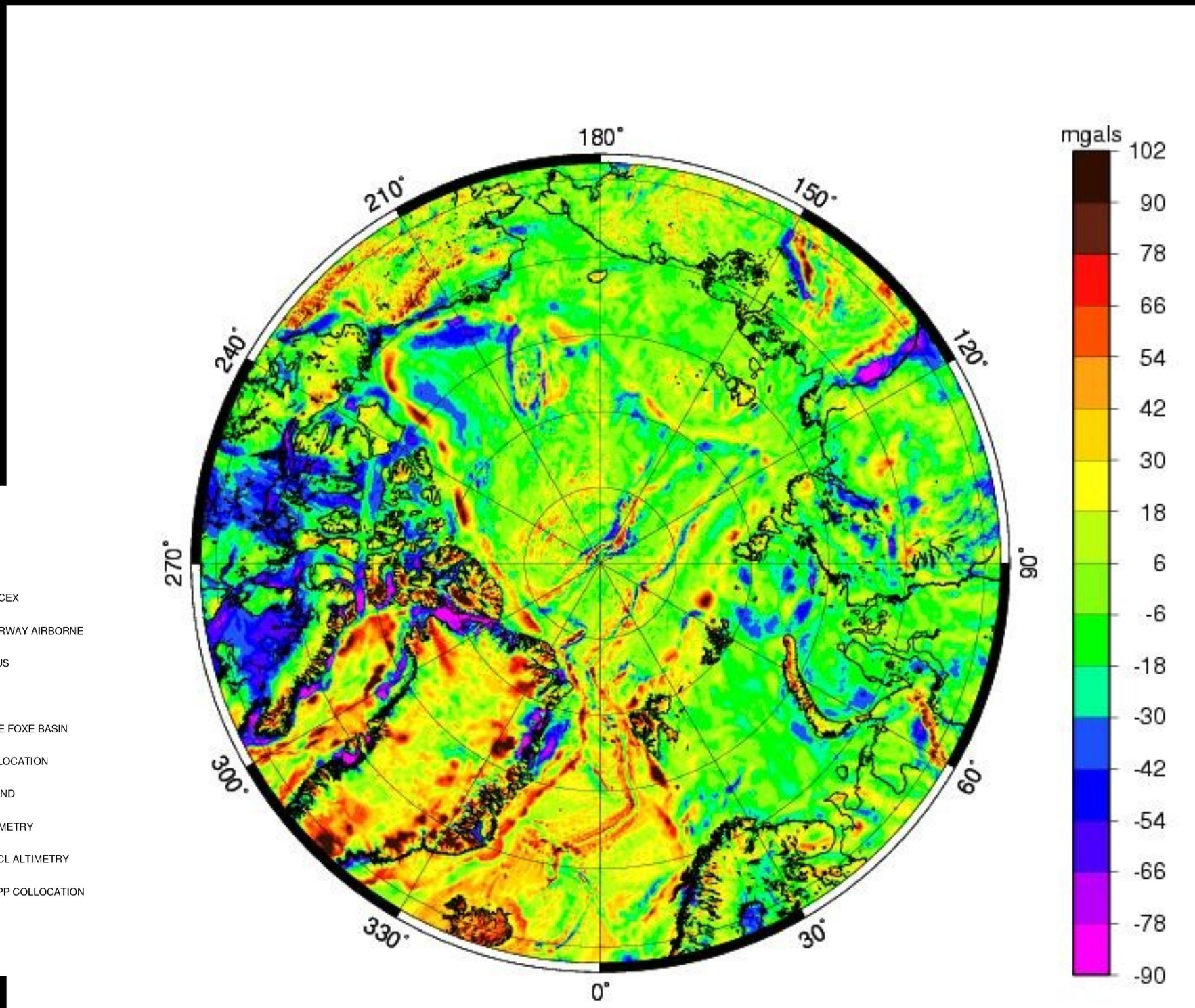
James Beale, Rose Gabbert
U.S. National Geospatial Intelligence Agency, St. Louis, MO

Monica Youngman
U.S National Geodetic Survey, Washington, D.C.

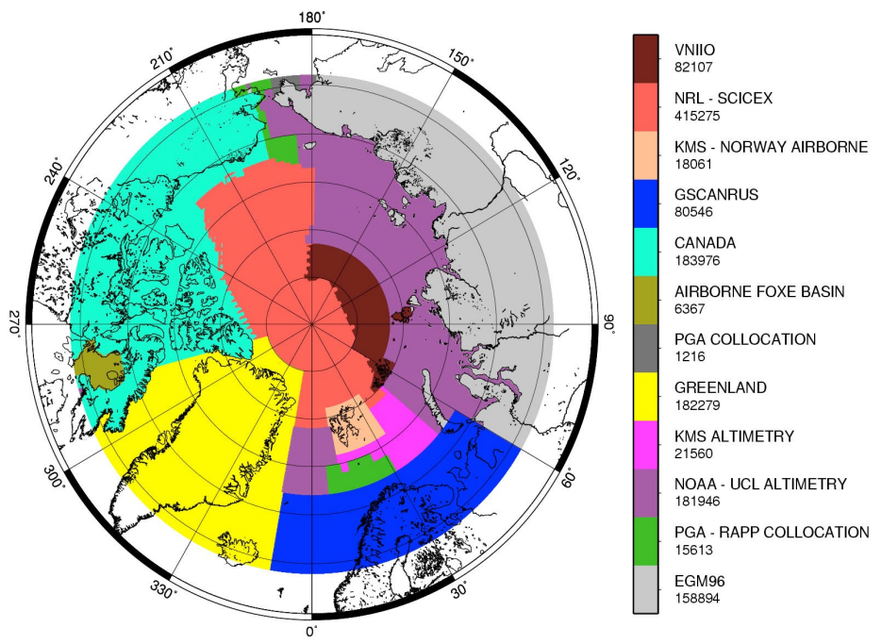
Arctic Gravity Project

v. 2.0 - 2008

Submarine, airborne, ice island and satellite data are included in this map.

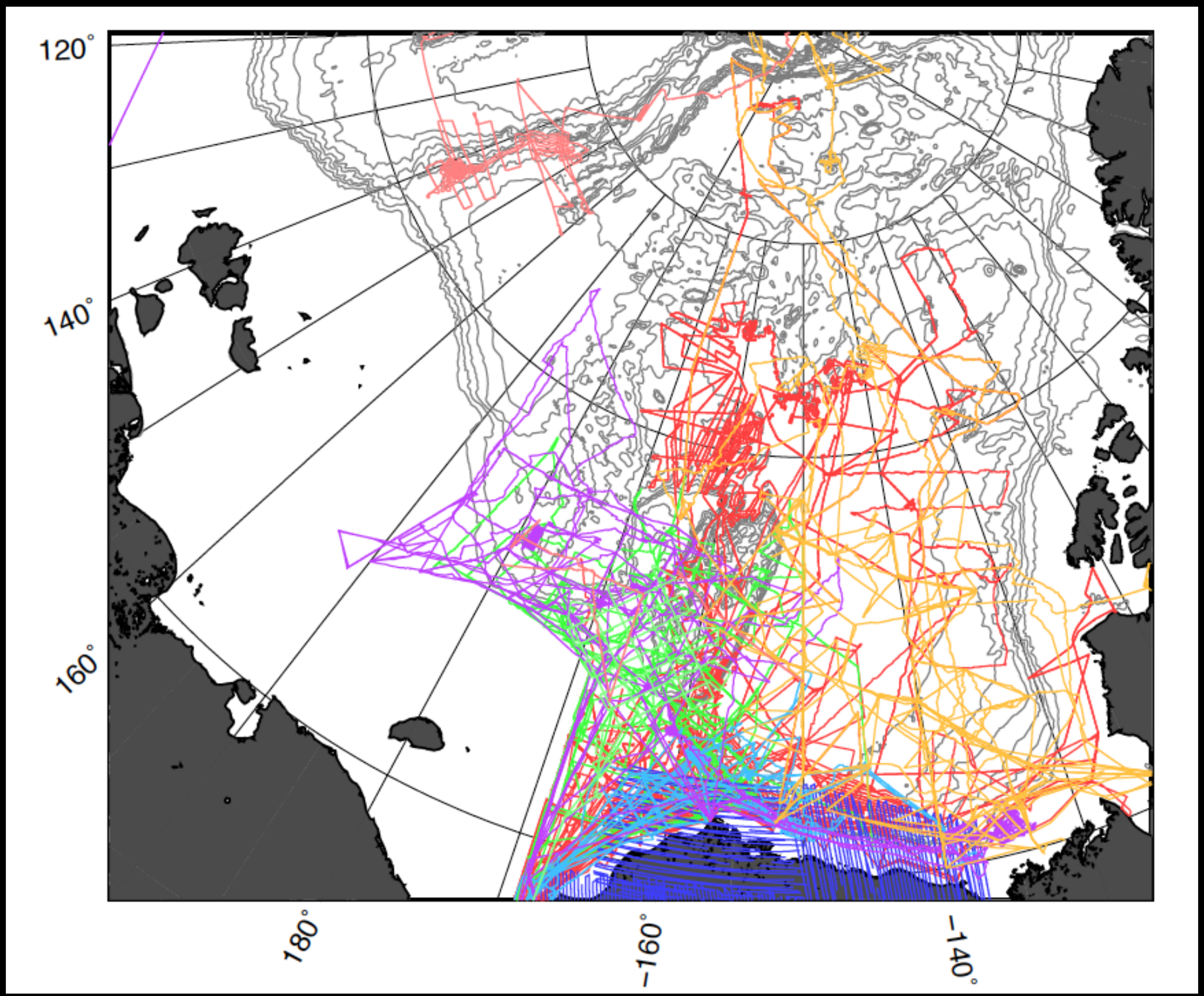


ArcGP 5x5 Minute Source Codes

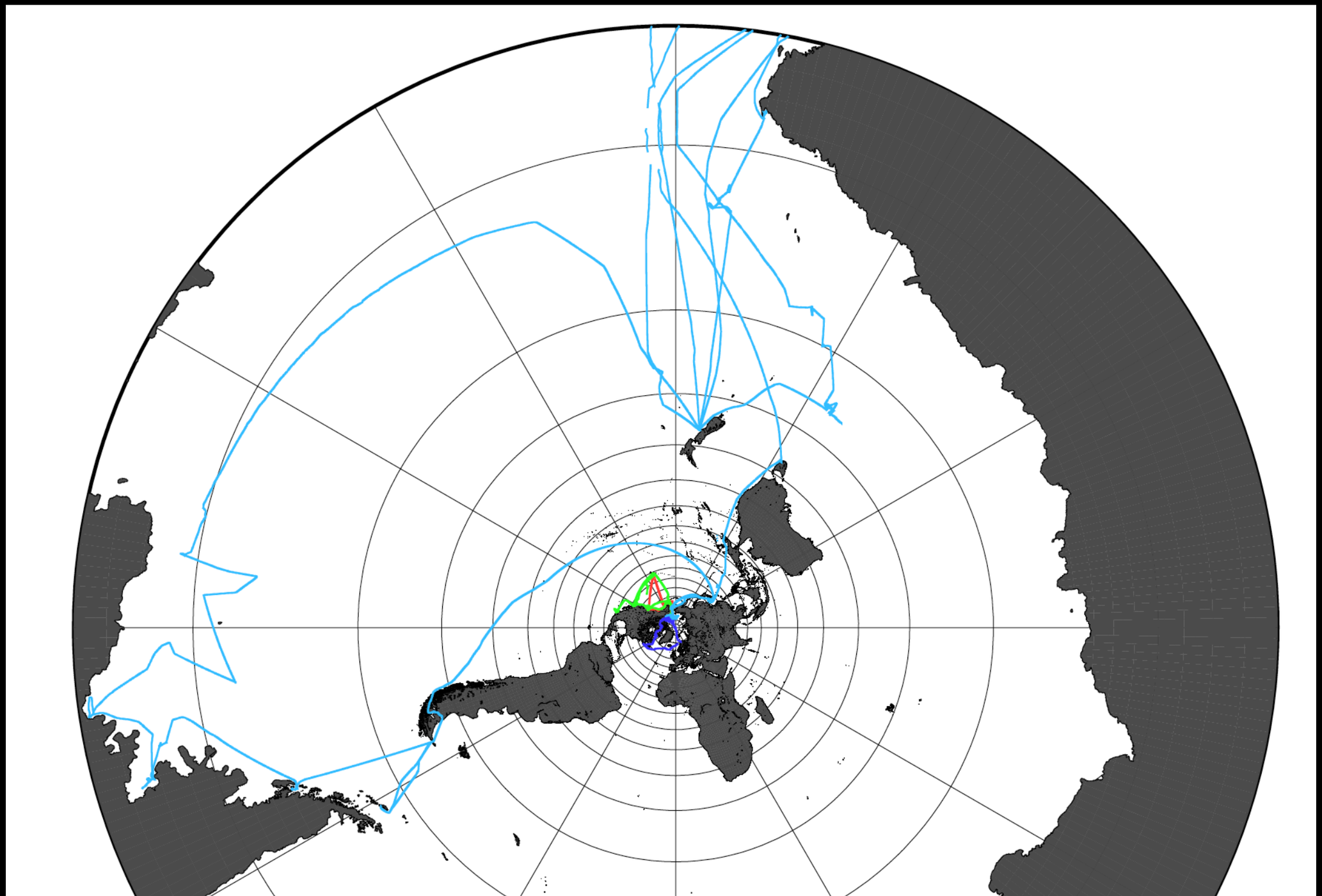


New Gravity Anomaly Data

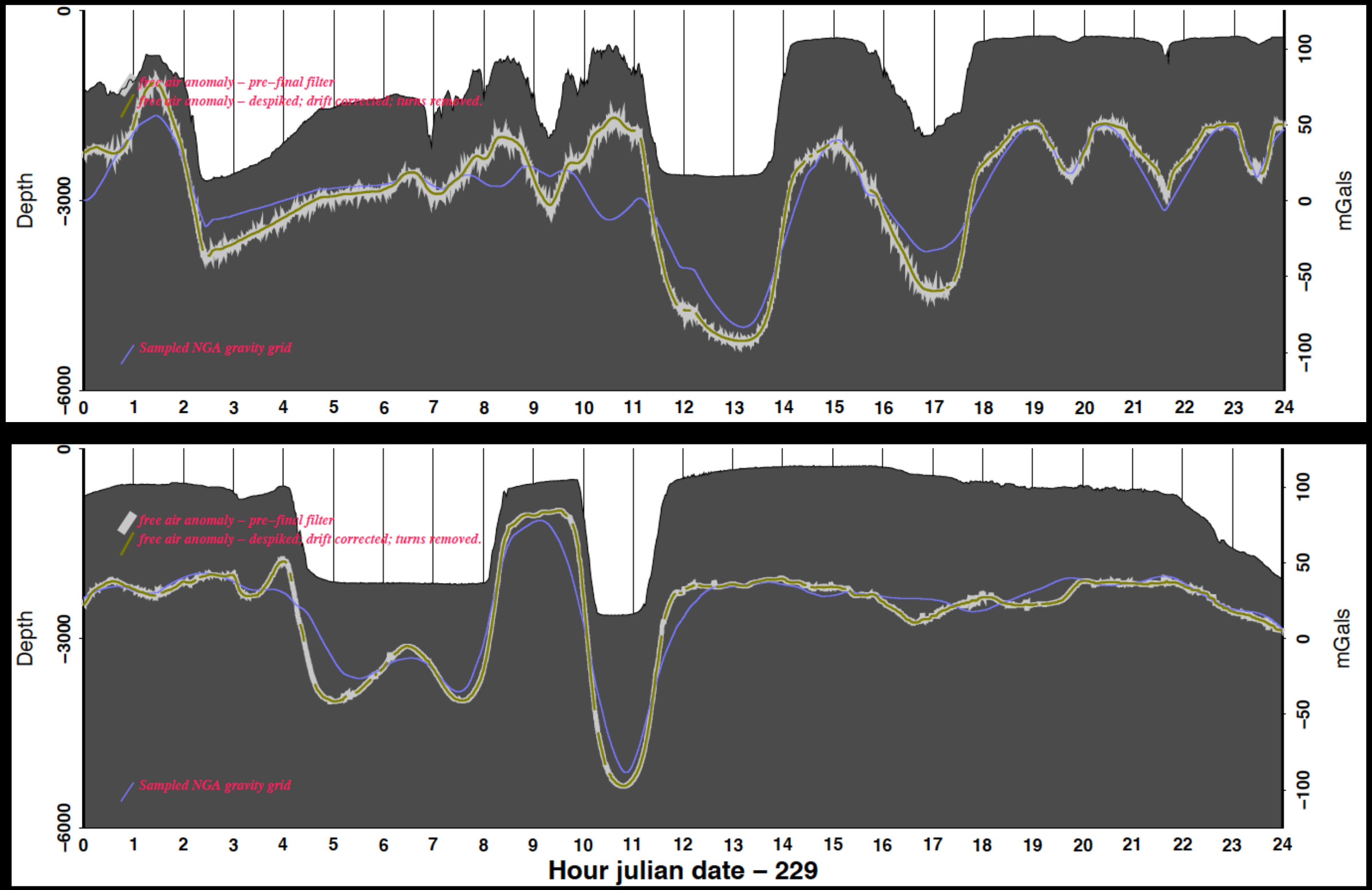
since 2008



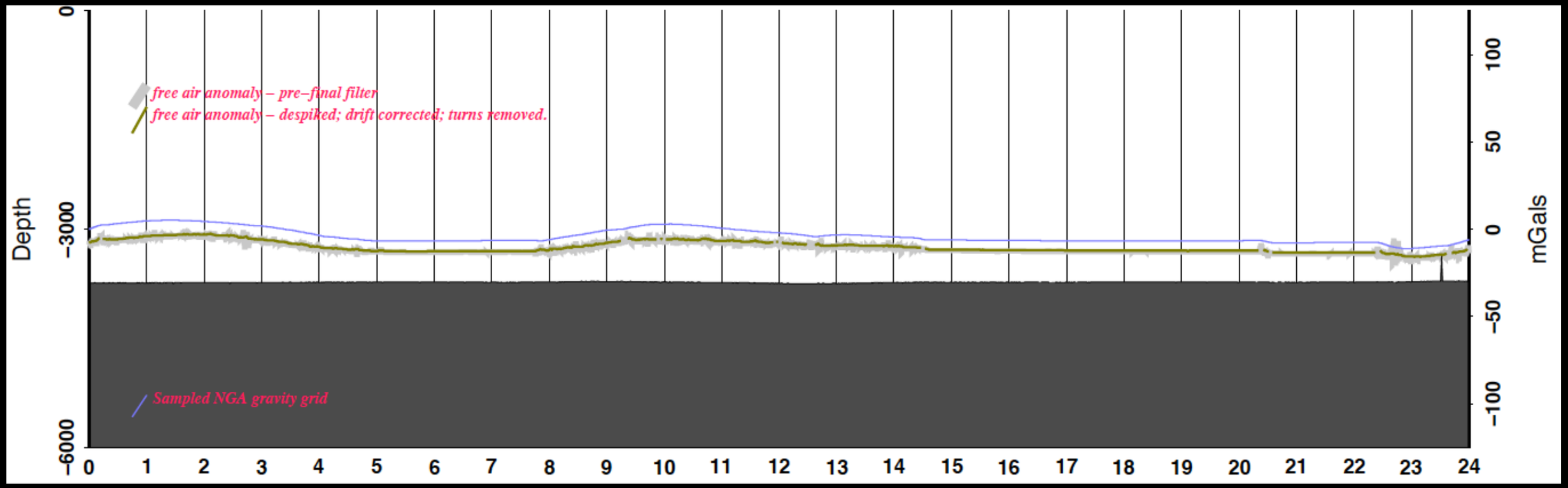
Why waste the time?



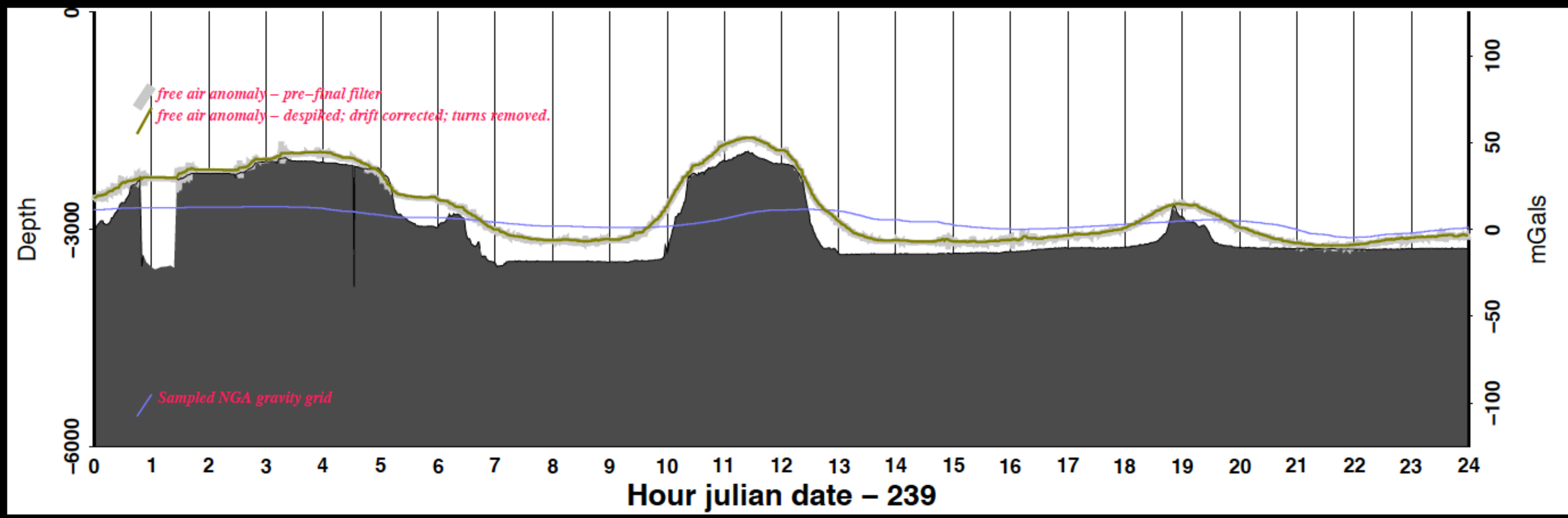
Differences in Wavelength and Amplitude



Differences in Level



Unmapped Features



GRAV-D and Free Air Anomalies

GRAV-D Survey Objectives

- **Overall Target**: 2 cm accuracy orthometric heights from GNSS and a geoid model

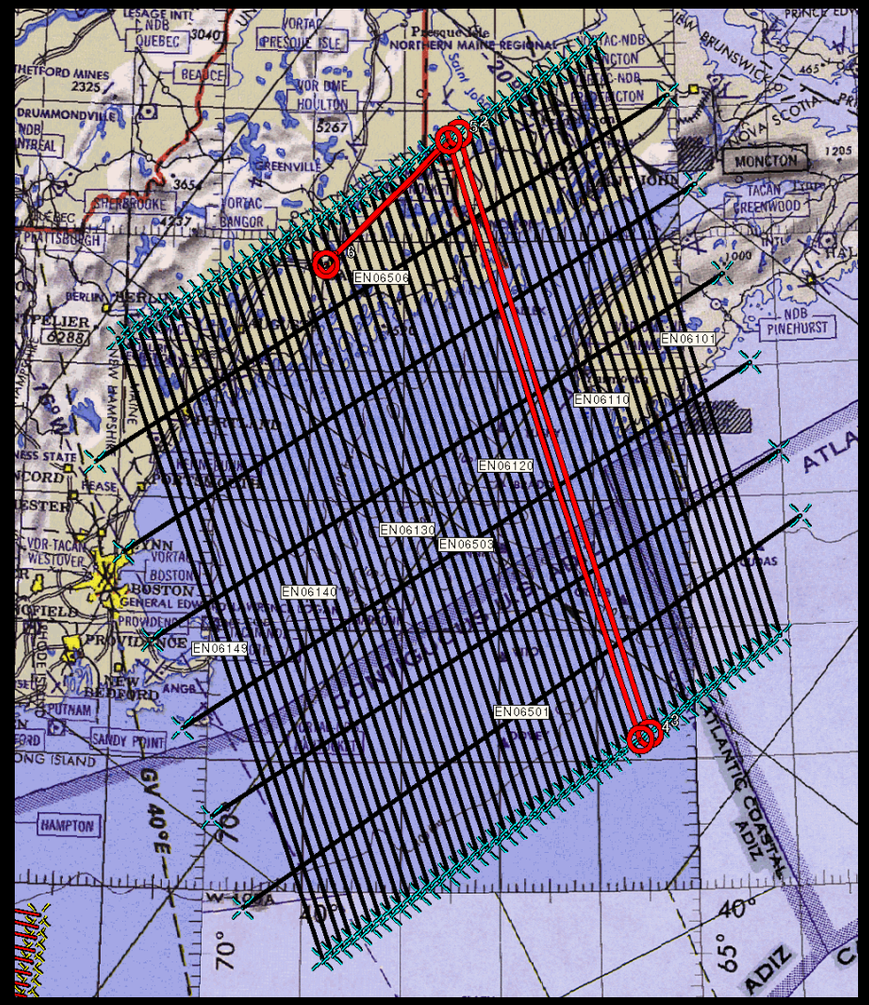
- **GRAV-D Goal**: Create gravimetric geoid accurate to 1 cm where possible using airborne gravity data

- **GRAV-D**: Two thrusts of the project
  - –Airborne gravity survey of entire country and its holdings
  - –Long-term monitoring of geoid change

- Leveraging partnerships to improve and validate gravity data

GRAV-D Survey Parameters

- Blocks designed based on aircraft capabilities, available airports, and target area
- Data lines spaced 10 km apart
- Cross lines spaced 60-80 km apart
- Flight altitude 20,000 ft (~ 6,000 m)
- Nominal speed 220-250 kts



Impacts to the Geoid in Alaska

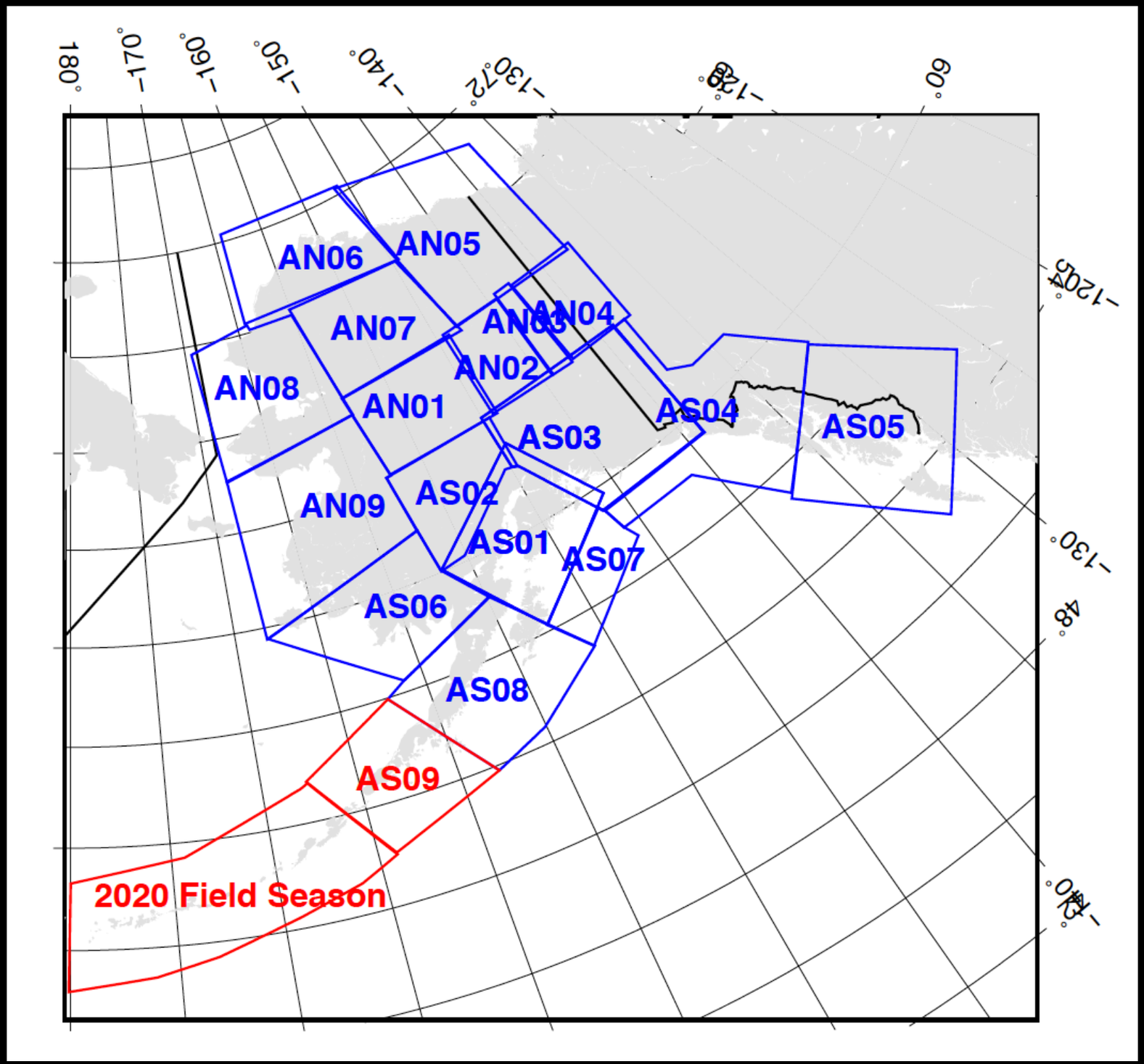
- GRAV-D is on track to finish data collection in 2022 (as of mid 2018)

- All studies show improvement with the airborne gravity data, although areas with current poor information show more improvement

- Expected height changes up to around 1 meter in CONUS and around 2 meters in Alaska

Survey Blocks

blue - reduced



These data are a bit different….

These are Free Air Disturbances, located ~6 km above the ellipsoid.

To use them with other data, we want them on the geoid.

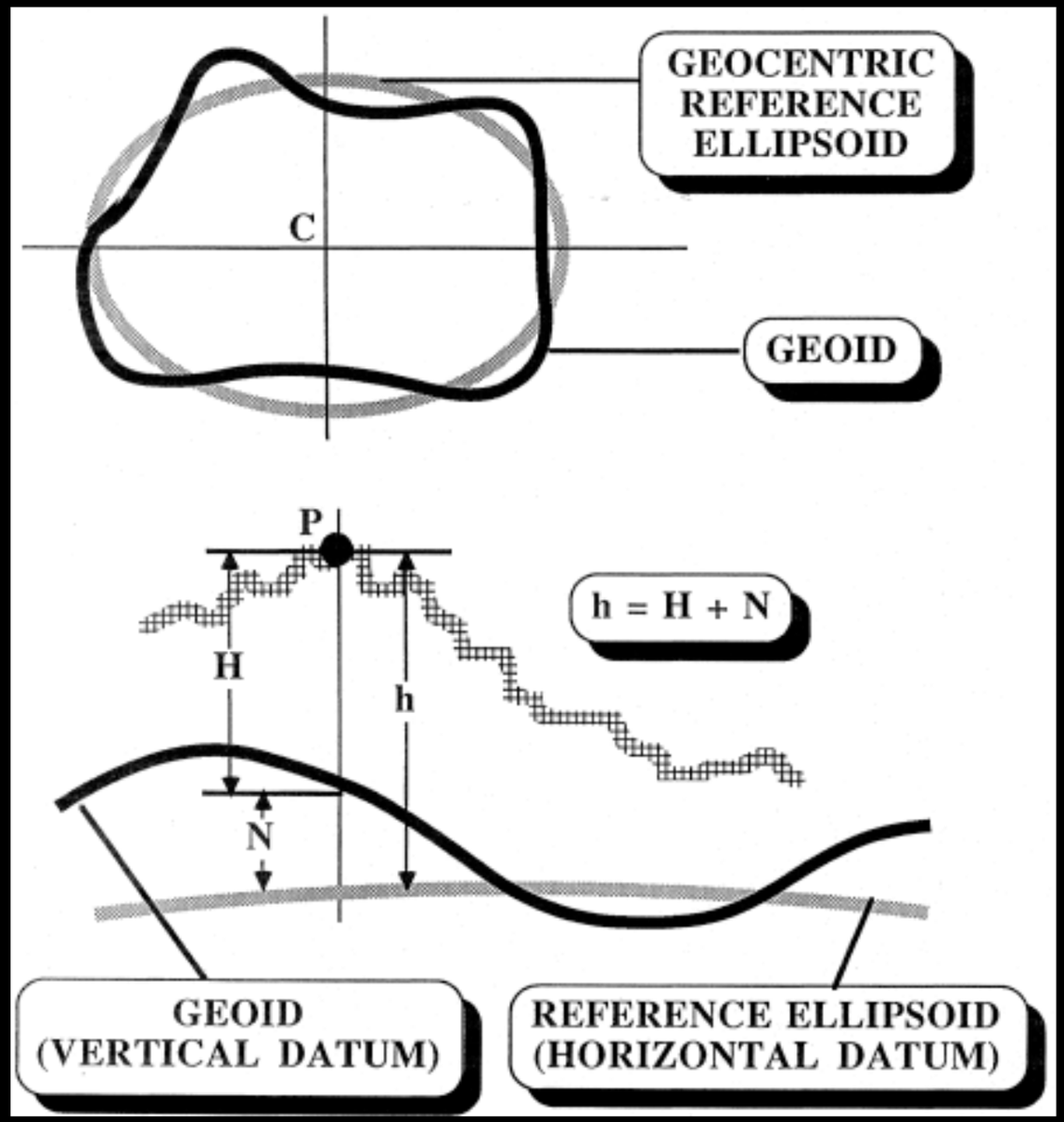
Gravity Corrections

"normal" gravity

$$g_{normal\_ellipsoid} = \gamma_e \frac{1 + \left[\frac{b\gamma_p}{a\gamma_e} - 1\right] \sin^2\phi}{\sqrt{1 - e^2 \sin^2\phi}} \quad (19)$$

Parameter	Description	GRS-80 value	WGS-84 value
γ_e	Equatorial normal gravity	9.780 326 7715 m/s^2	9.780 325 3359 m/s^2
γ_p	Polar normal gravity	9.832 186 3685 m/s^2	9.832 184 9378 m/s^2
e^2	First eccentricity squared	0.006 694 380 022 90	0.006 694 379 990 14
a	Semi-major axis	6 378 137 m	6 378 137.0 m
b	Semi-minor axis	6 356 752.3141 m	6 356 752.3142 m
f	Flattening	0.003 352 810 681 18	0.003 352 810 664 747
ω	Angular velocity of Earth	7 292 115 x10^{11} rad/s	7 292 115.0 x10^{11} rad/s
GM	Earth's gravitational constant	3 986 005 x 10^8 m^3/s^2	3 986 004.418 x 10^8 m^3/s^2

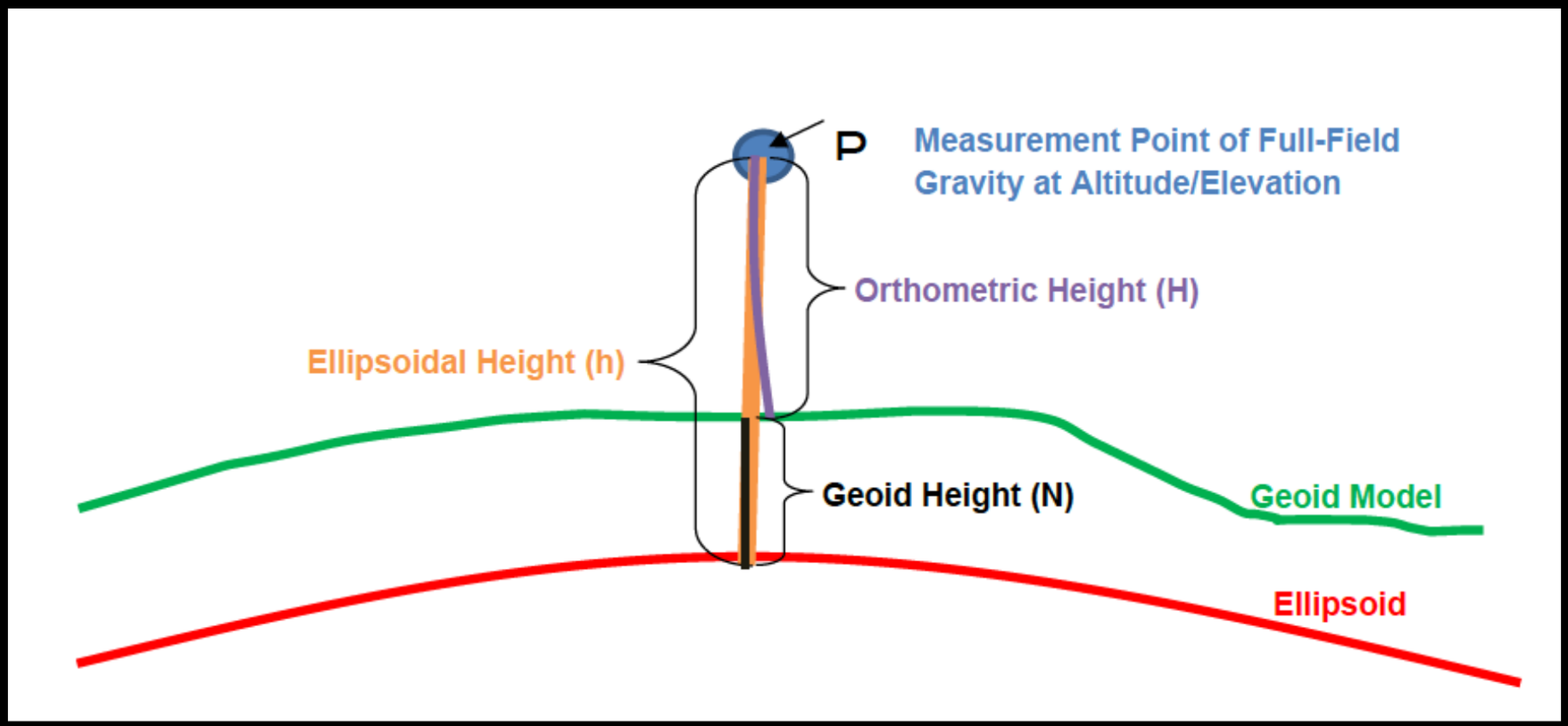
Geoid versus Ellipsoid



Gravity Corrections

2nd Order Free Air Correction, not 0.3086 x elevation

$$\delta g_F = \frac{\partial \gamma}{\partial h} h + \frac{1}{2} \frac{\partial^2 \gamma}{\partial h^2} h^2$$
$$= \frac{2\gamma}{a}(1 + f + m - 2f \sin^2 \phi)h - \frac{3\gamma}{a^2} h^2,$$



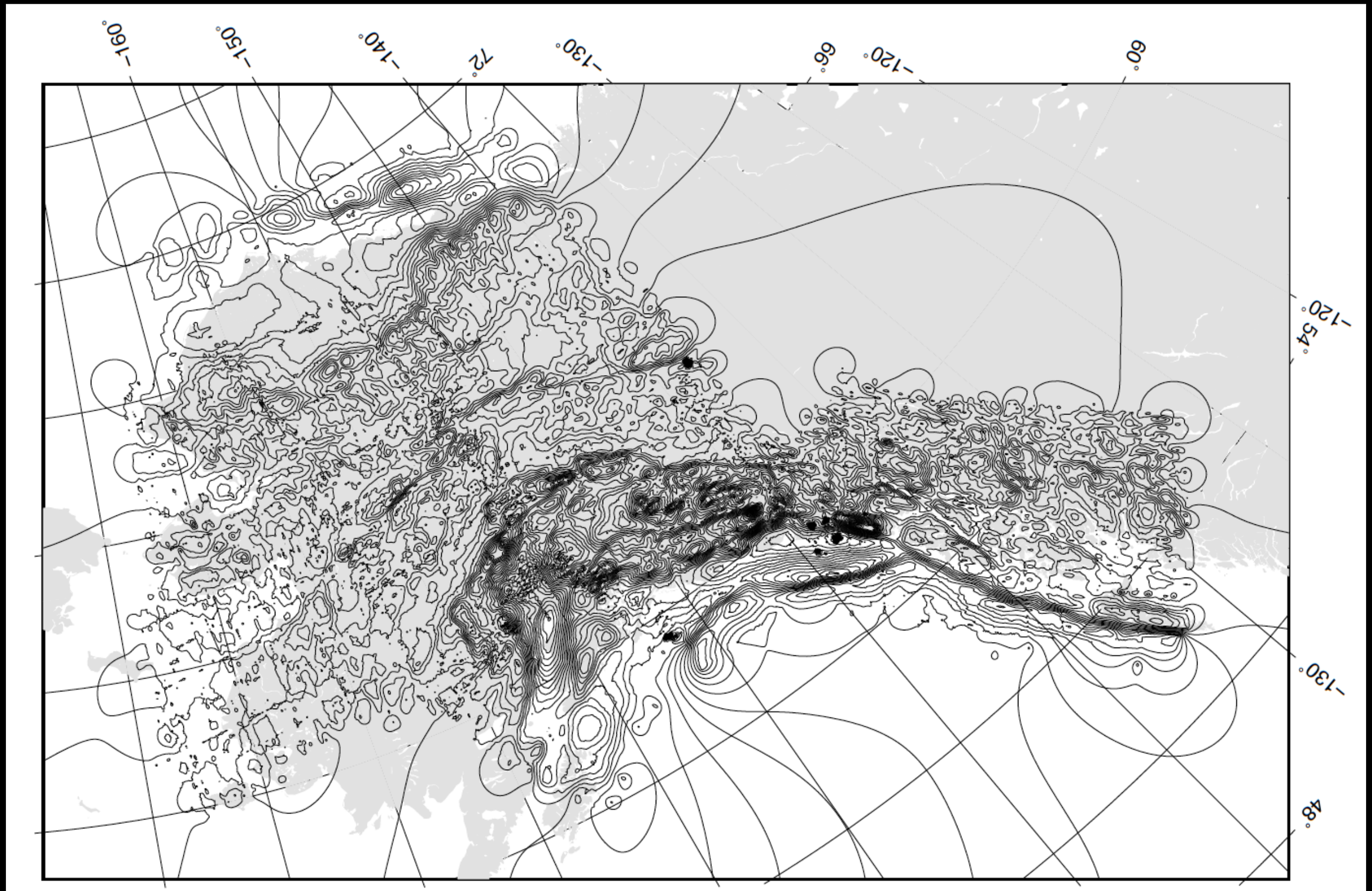
Gridding Process

using GMT

- Define grid parameters (e.g. bounds and interval)
- Collect Data
- Pre-process data using block median
- Fit tense surface
- Display

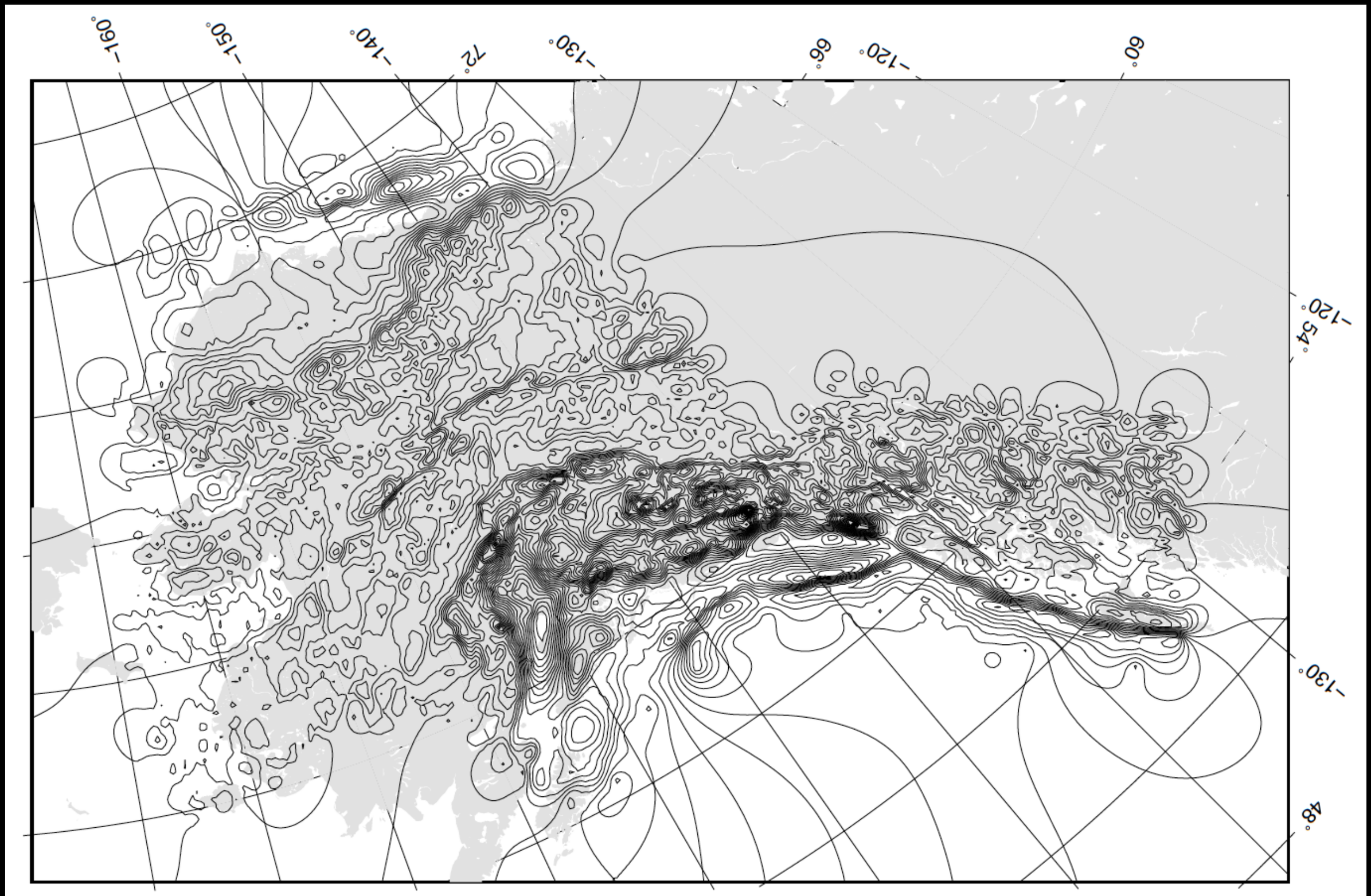
Free Air Disturbance

1 km grid - on the ellipsoid - Only GRAV-D Data



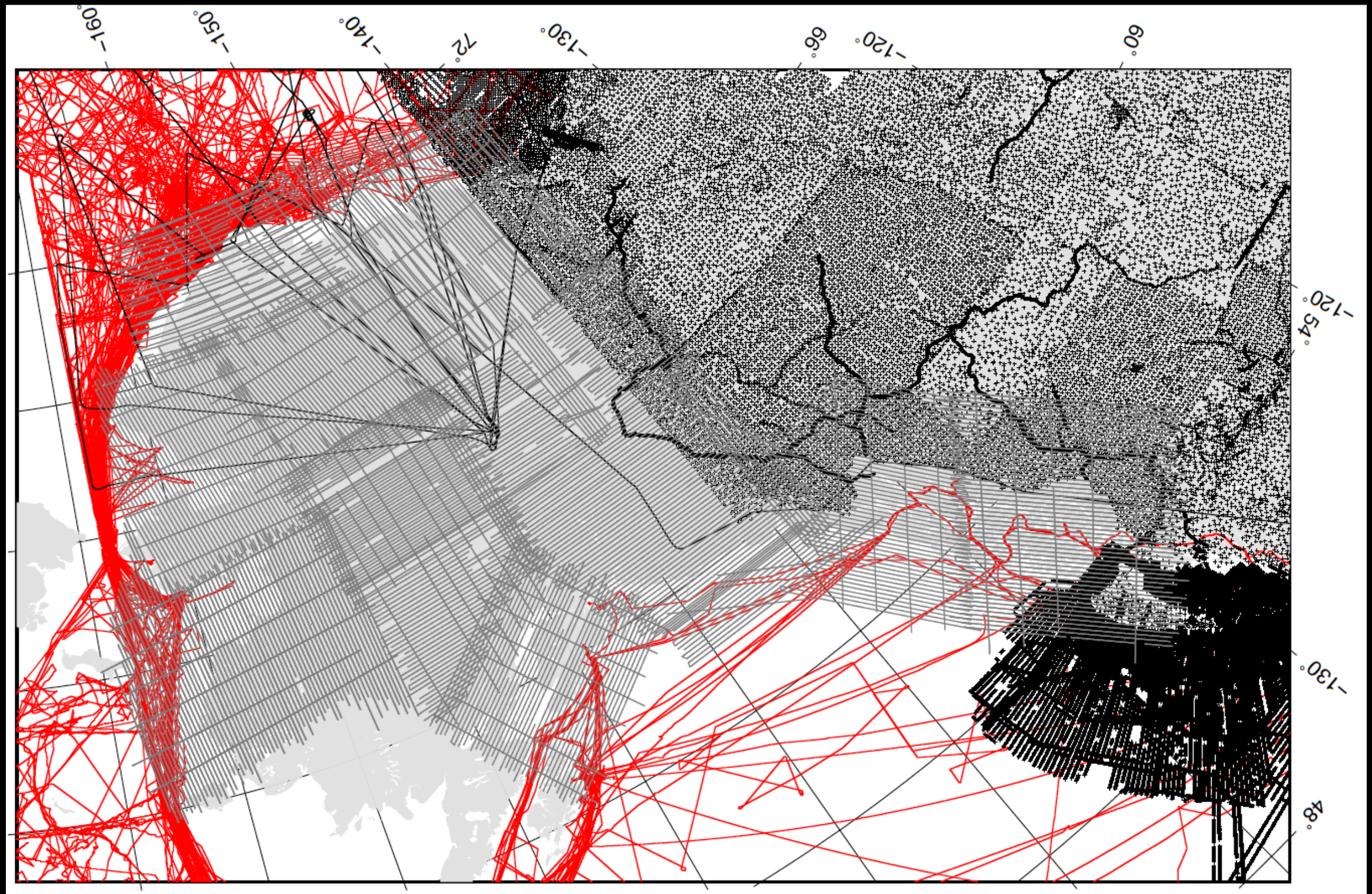
Free Air Disturbance

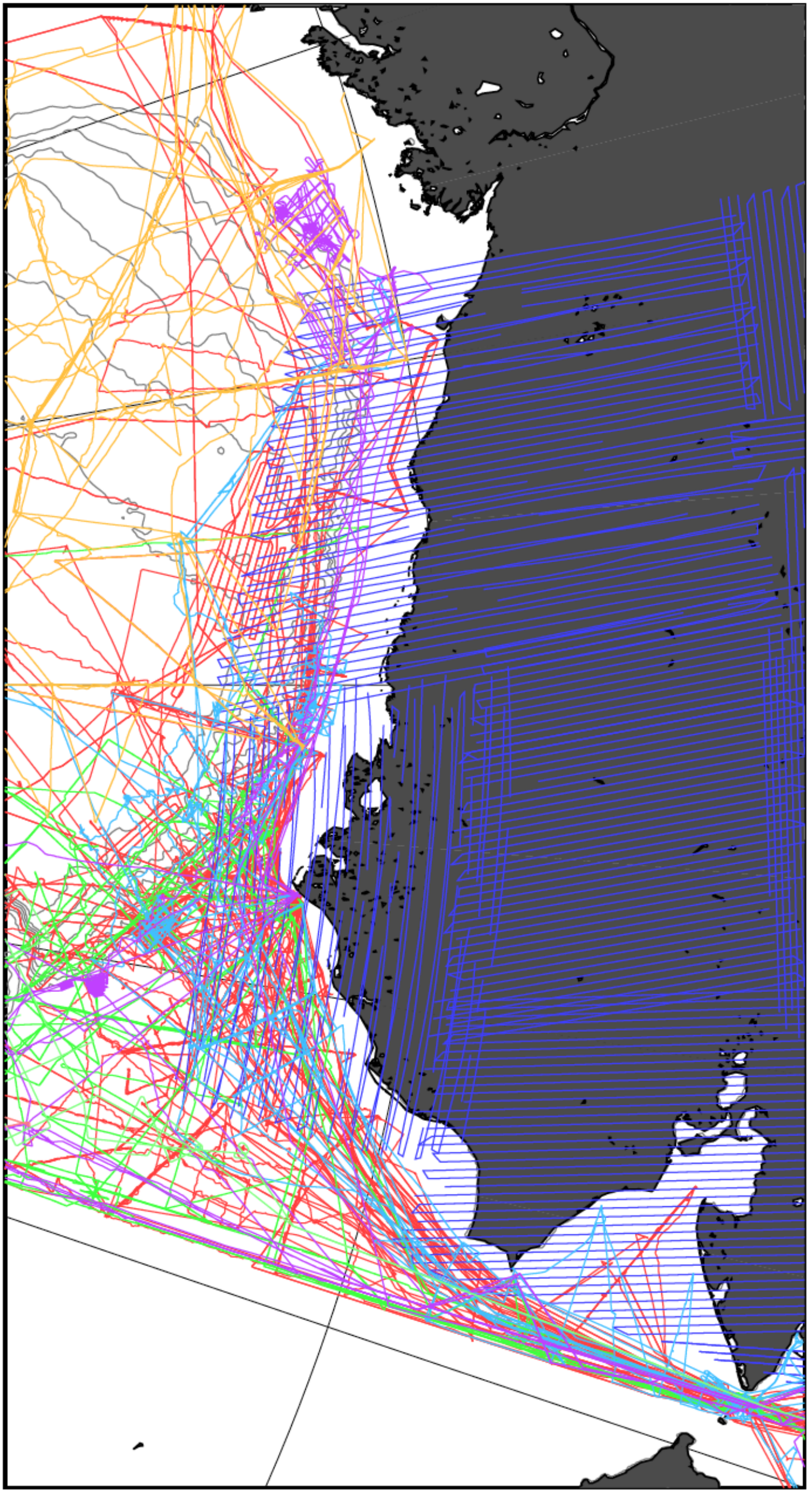
10 km grid - on the ellipsoid - Only GRAV-D Data



Data Sources

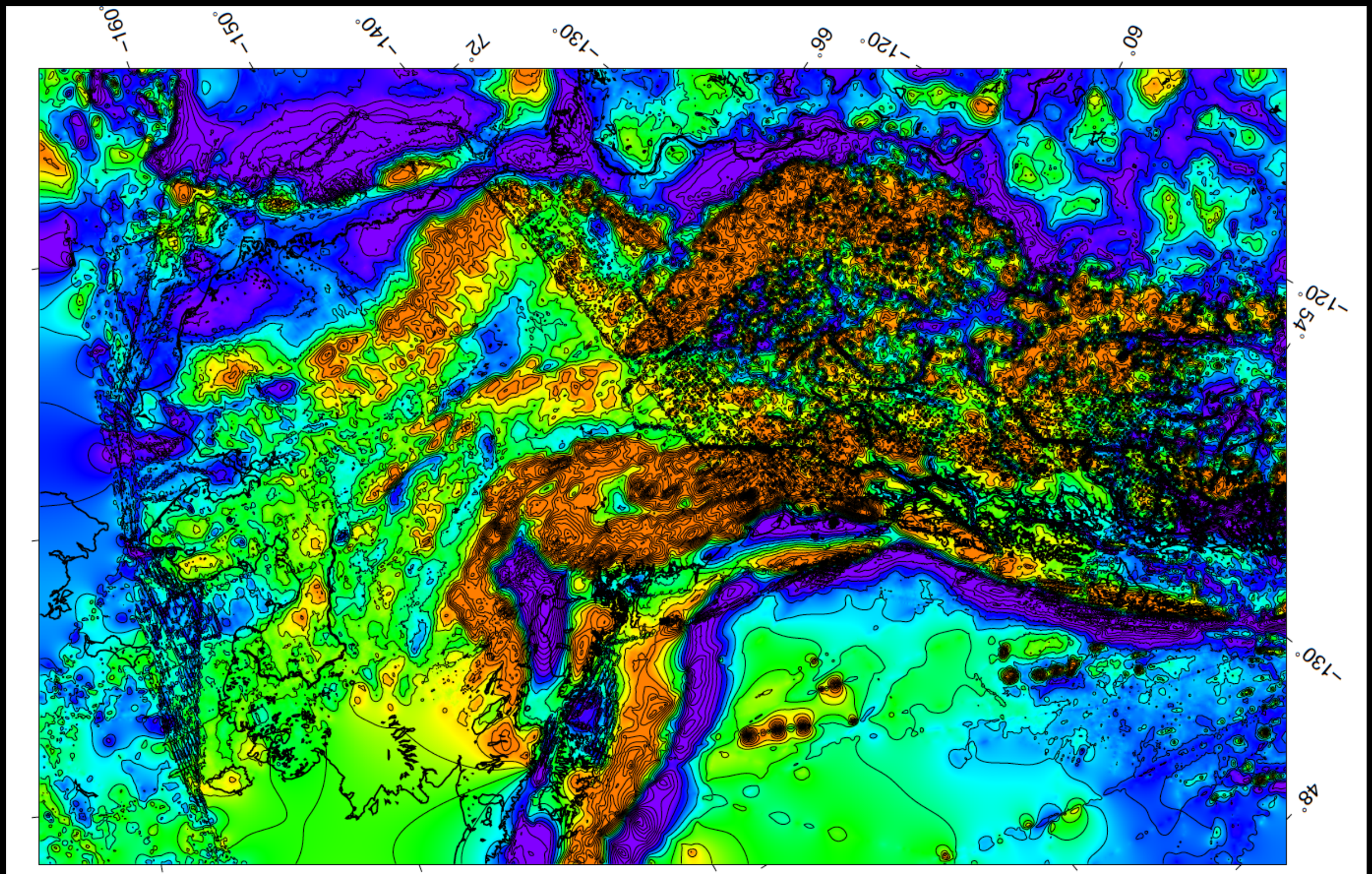
ship, airborne, land




−140°
−160°

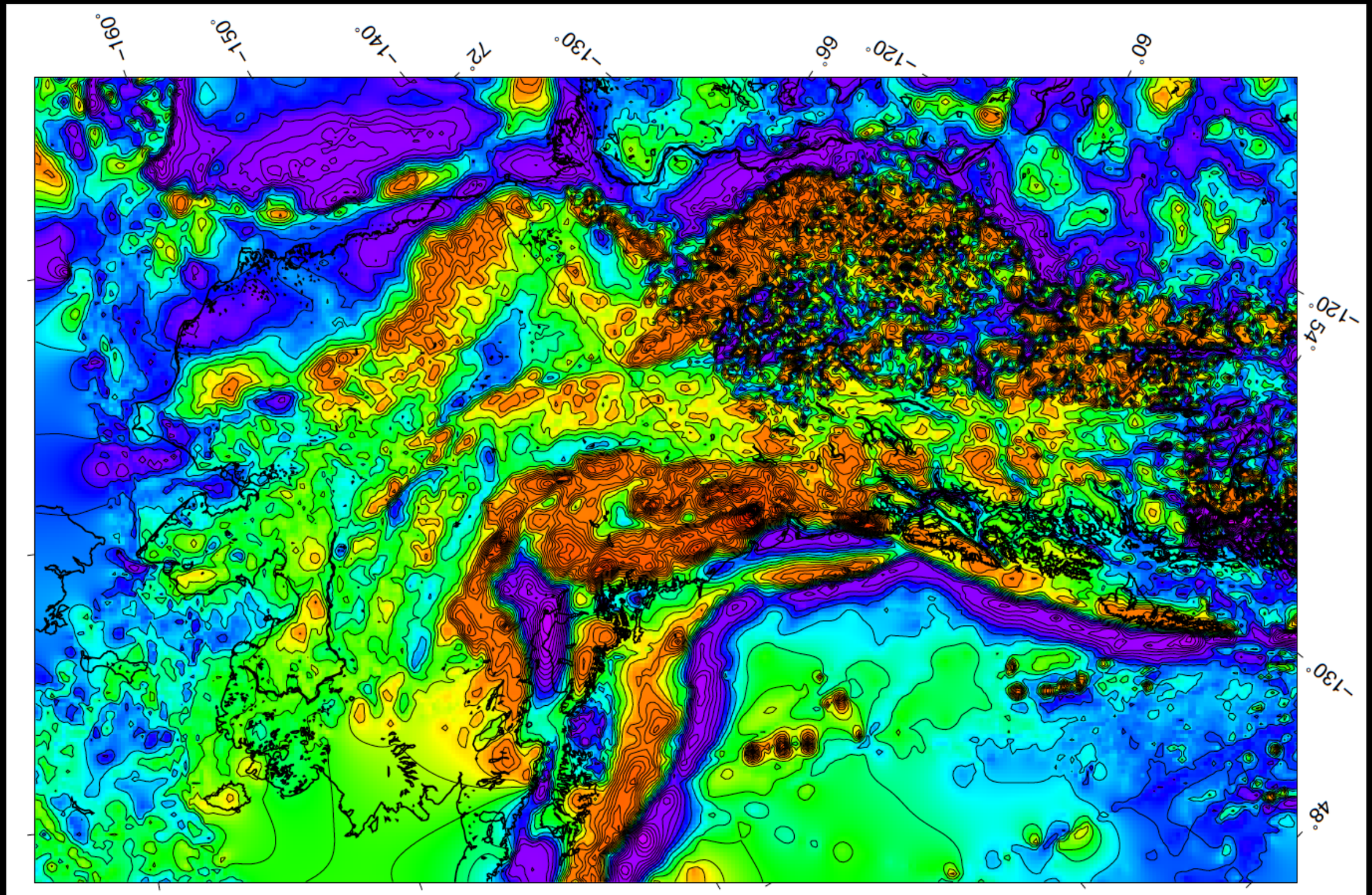
Free Air Anomaly

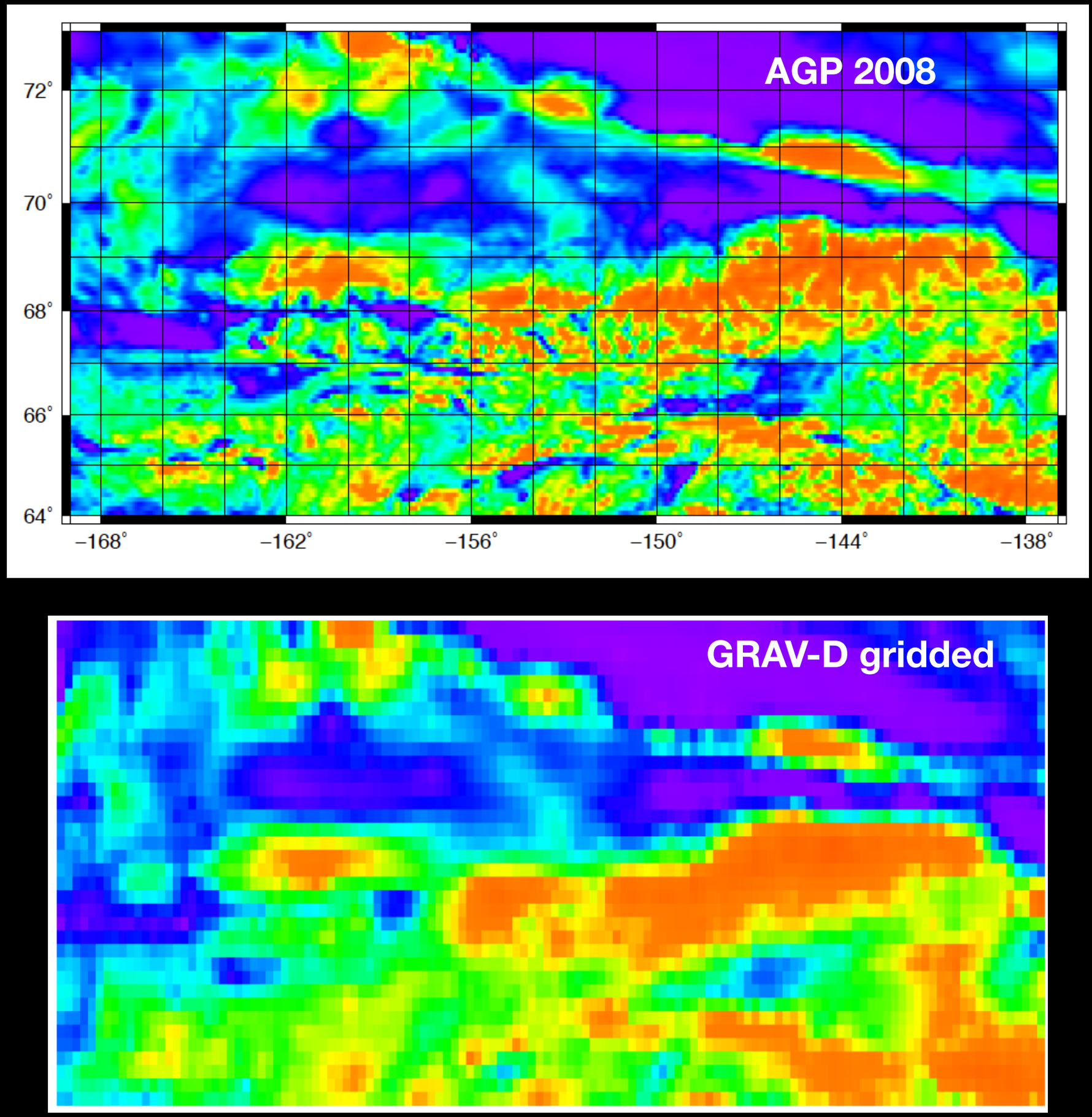
1 km grid - EGM 2008 + ship gravity + Canadian Land Data



Free Air Anomaly

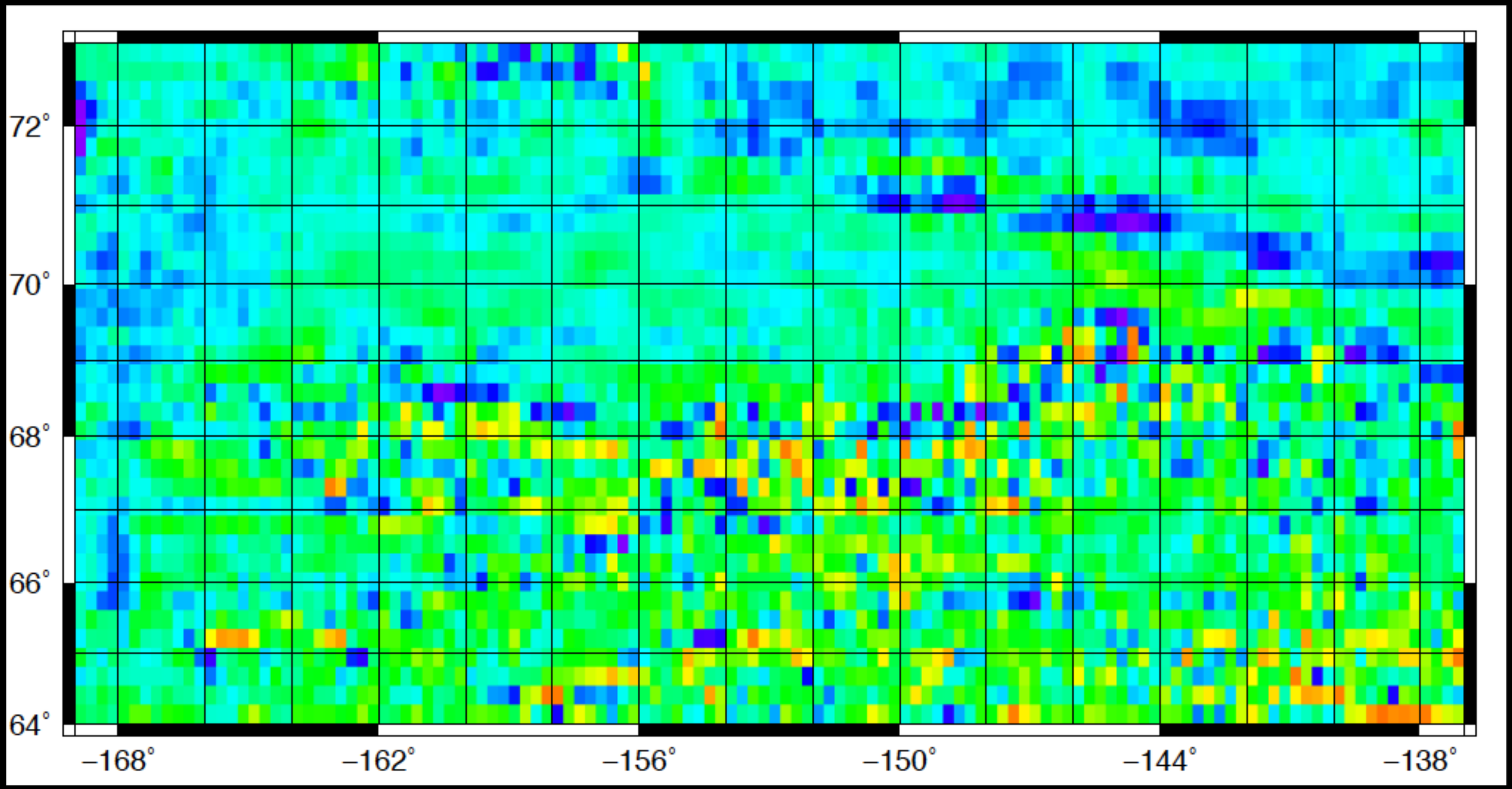
10 km grid - EGM 2008 + ship gravity + Canadian Land Data




AGP 2008
72°
70°
68°
66°
64°
−168°
−162°
−156°
−150°
−144°
−138°

GRAV-D gridded

AGP - GRAVD



Histogram of Differences