Sander Geophysics

Some Examples of AIRGrav Vector Gravity Data and Comparison with Ground Truth

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Sander Geophysics

Presentation Outline

- About Sander Geophysics
- AIRGrav System
- Comparison to ground truth (Kauring Test Area)
- AIRGrav results of the “Geodetic Slope Validation Survey 2014” test line

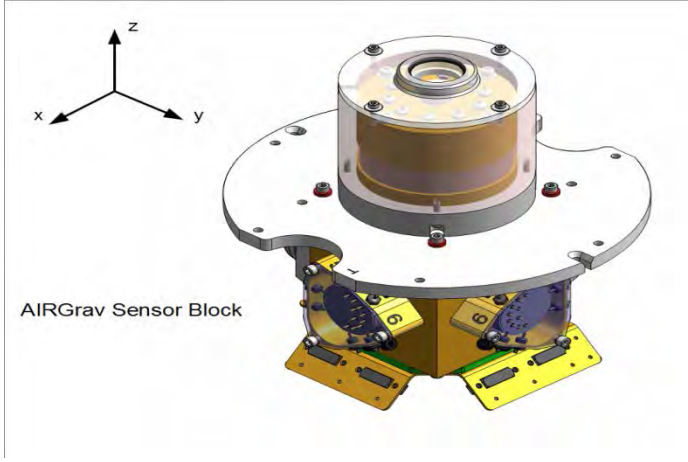
Sander Geophysics

- High resolution airborne geophysics – petroleum, mineral, environmental
- Founded in 1956 currently 150 employees, 17 aircraft
- Head office at the Ottawa International Airport, Canada
- World-wide operations – fixed-wing and helicopter

AIRGrav System

Airborne Inertially Reference Gravimetry

- AIRGrav designed and built specifically for airborne gravity surveying by SGL
- 10 years of R&D following by 16 years of survey flying, 12 gravimeters
- Three axis (x y z) gyro stabilized platform, three (x y z) accelerometers
- Dual frequency GPS receivers
- Gravity = inertial accelerations – GPS accelerations
- Raw gravity data sampled at 128 Hz



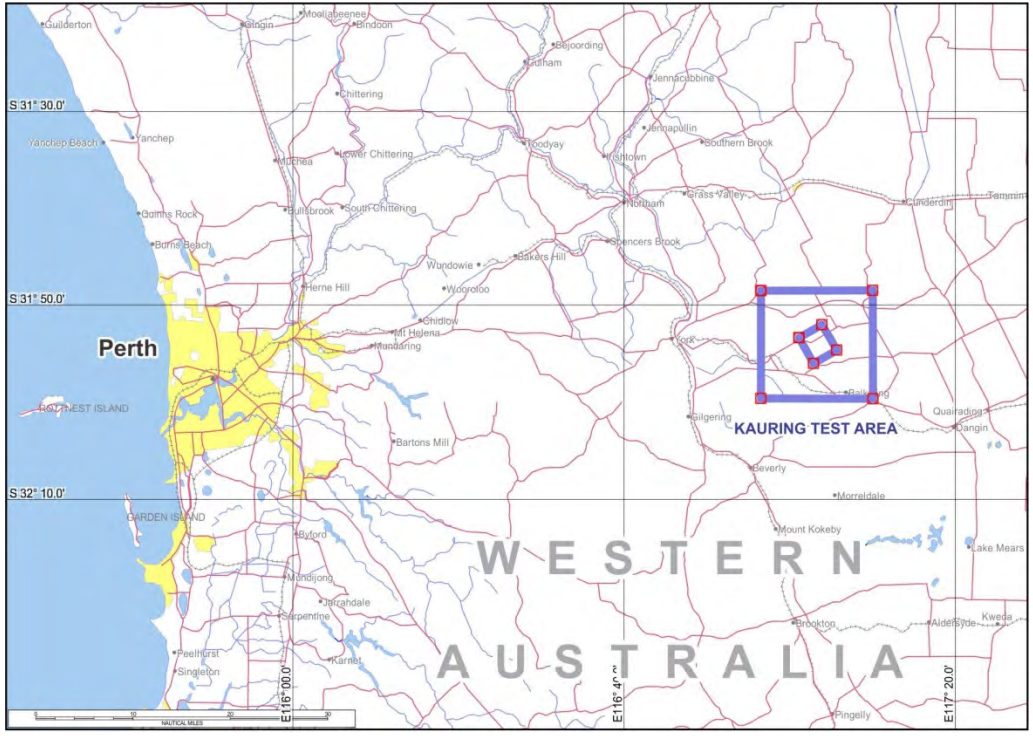
AIRGrav Sensor Block

AIRGrav Operations

- < 100 kg – can be used in any of SGL's aircraft and others
- Concurrent magnetic, radiometric, methane sensing, LIDAR, etc.
- Height above ground level: 60 m to 1000 m or higher
- Operate under normal flight conditions
- Short lead-ins to lines
- Drape surveys – unaffected by horizontal accelerations and turbulence

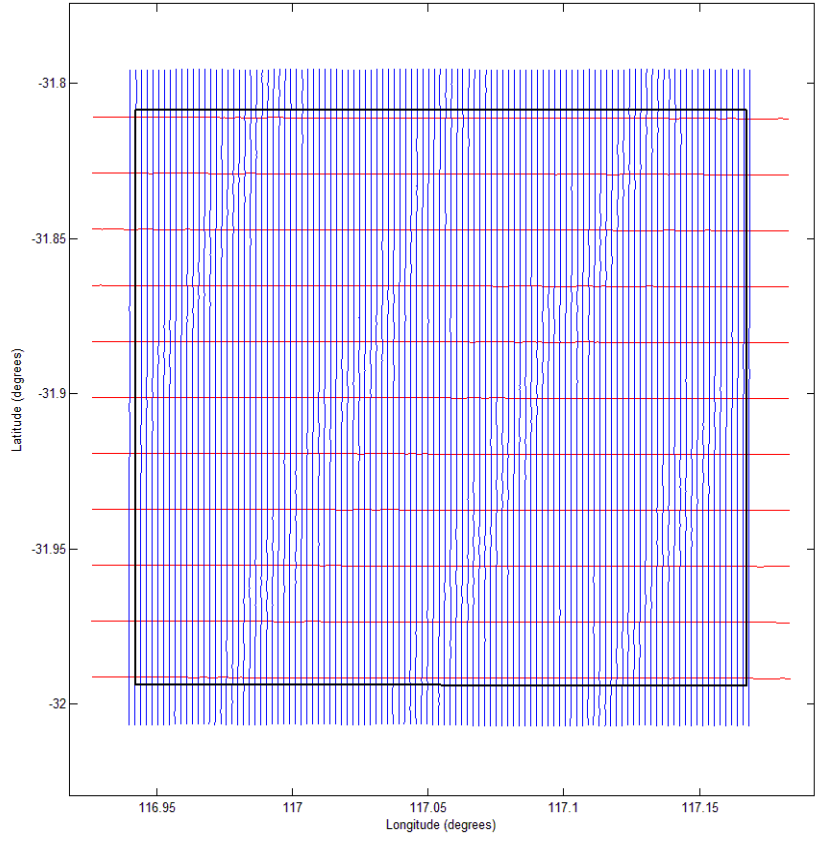
Comparison to Ground Truth

- Kauring Test Area
  - Established by Geoscience Australia, Geological Survey of Western Australia, Rio Tinto Ltd. And CGG-Airborne
  - Located approximately 100 km East of Perth, Australia
  - Gently rolling topography, 200 – 400 m ASL
  - Larger “AG” area is ~21 km E-W and 20 km N-S
  - Ground data spaced at ~500 m
  - Smaller “AGG” area is ~5.6 km by 5 km, centred in the AG area
  - AGG area has dense ground data to allow airborne gradiometer testing



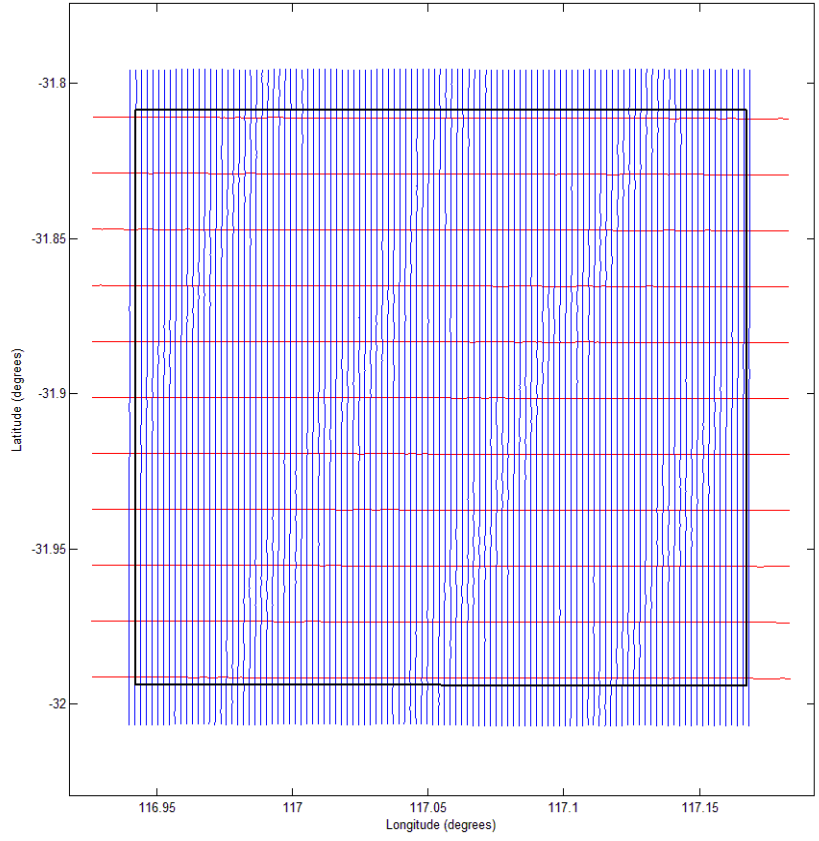
Comparison to Ground Truth

- Survey Description
  - Approx 21 km x 20.5 km
  - 200 m line spacing
  - 2 km control line spacing
  - Flown in 2012 for Victoria Department of Primary Industries
  - Nominal clearance of 80 m
- AIRGrav Data
  - Line data low pass filtered to 40 sec full wavelength
  - Gridded with 50 m cell size
  - Traverse and control line data adjusted at intersections

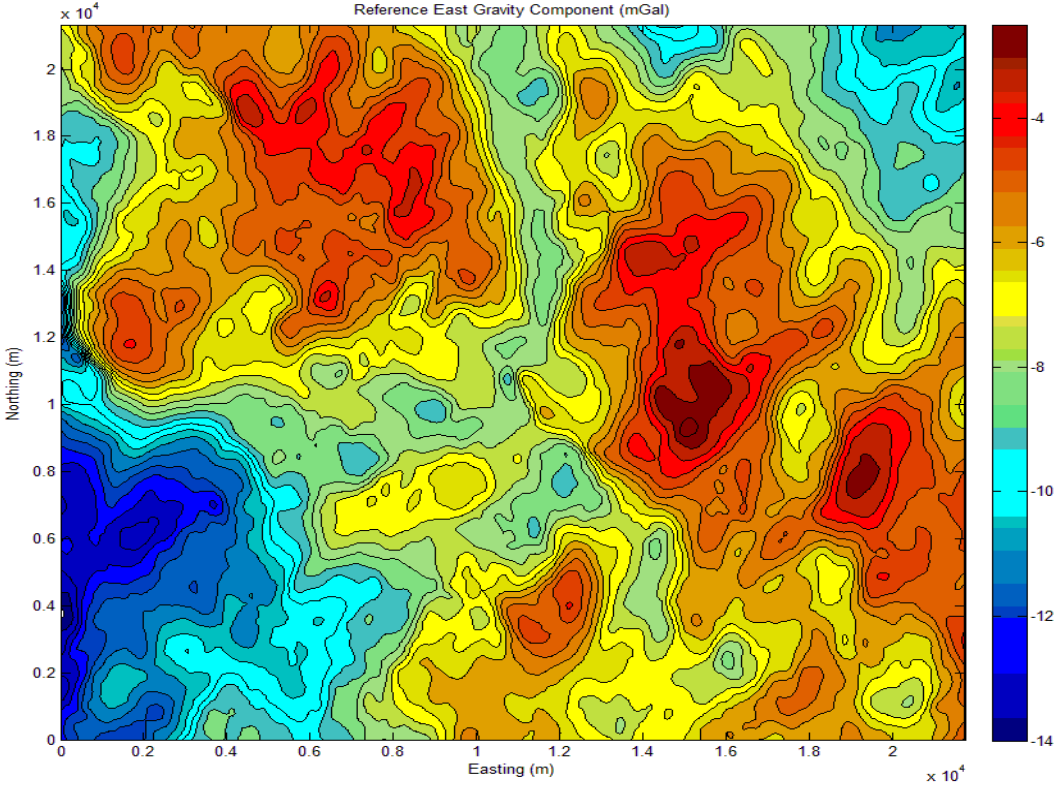


Comparison to Ground Truth

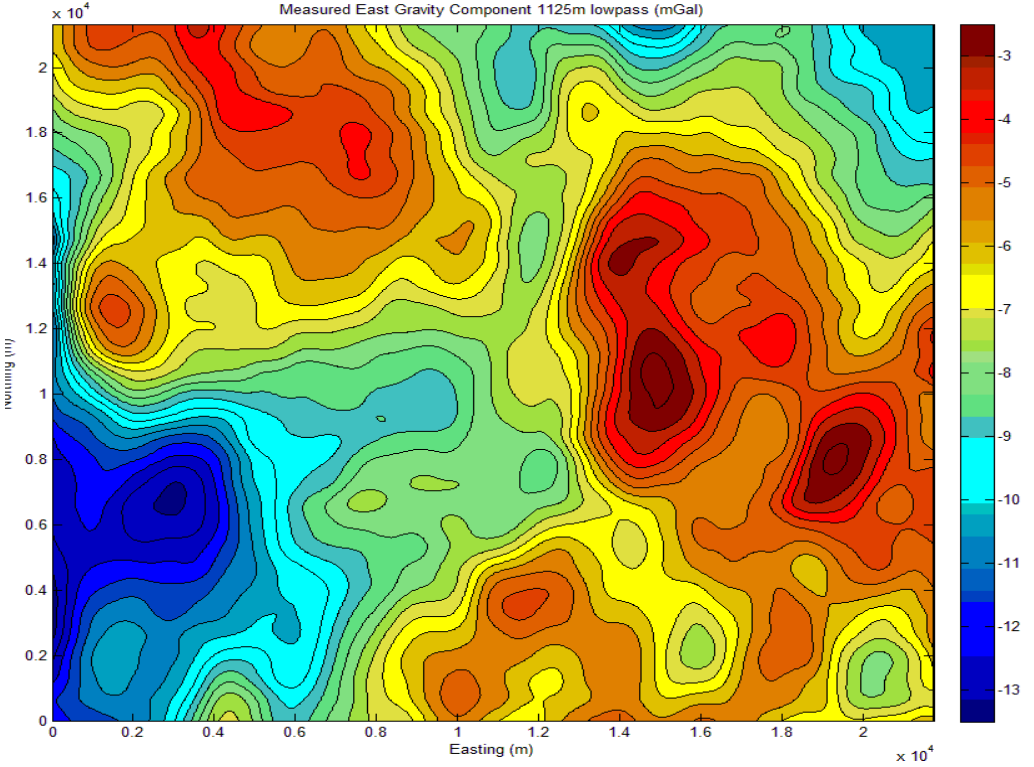
- Reference Data
  - Grid all available ground data at 50 m interval
  - Upward continue to surface defined by flight data, using frequency domain method
  - Vertically integrate Gz at flight height and create horizontal derivatives
  - Correct for long wavelength errors using EGM2008



Reference East Gravity Component



Measured East Gravity Component

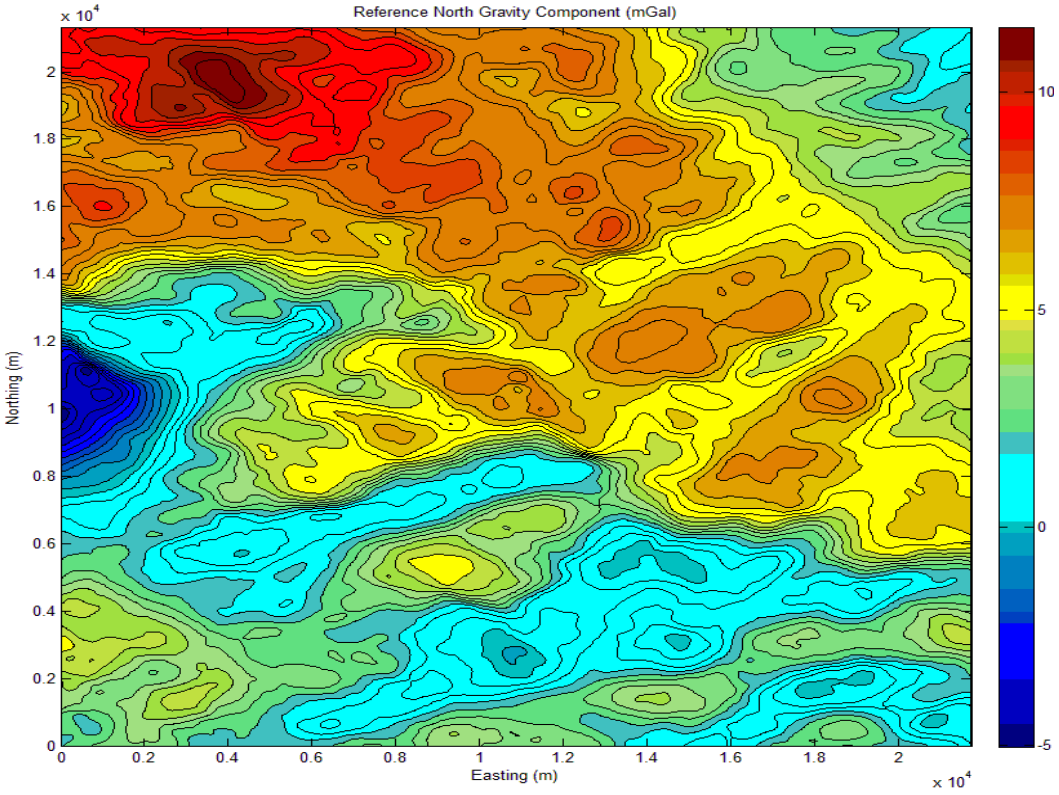


East Gravity Component Comparison with Reference

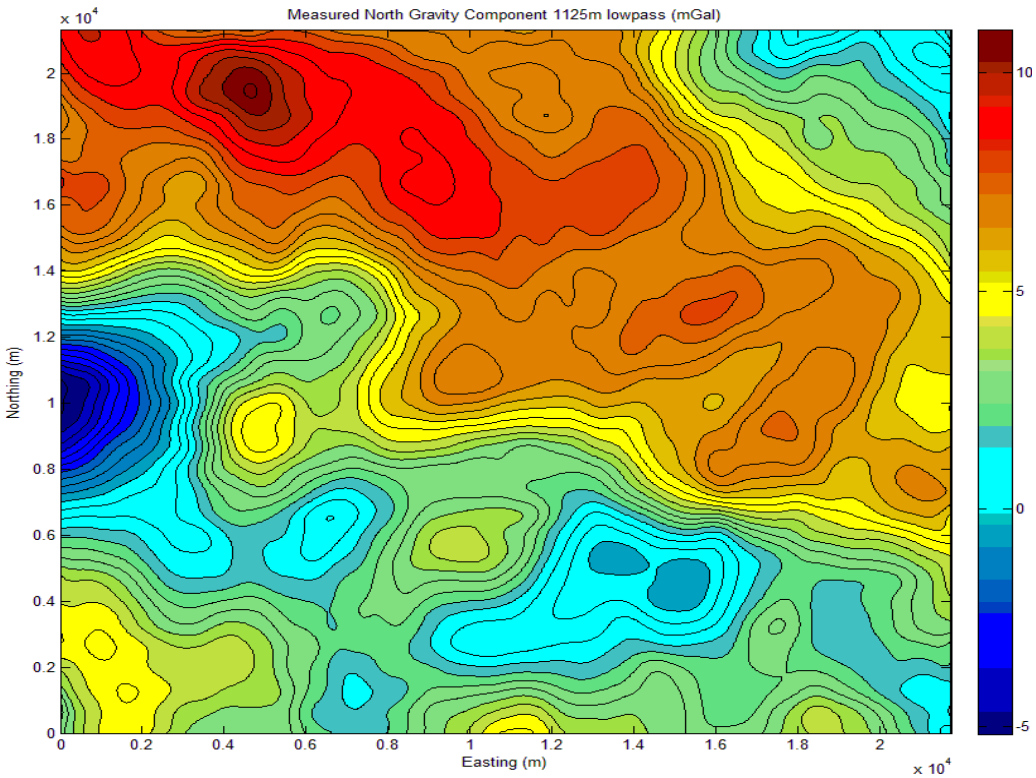
Filter (m)	Lowpass (G_E – Ref) (mGal)	Lowpass (G_E)– Ref (mGal)
750	0.61	0.62
1125	0.59	0.60
1500	0.57	0.59

*filters are stated as half-wavelengths

Reference North Gravity Component



Measured North Gravity Component

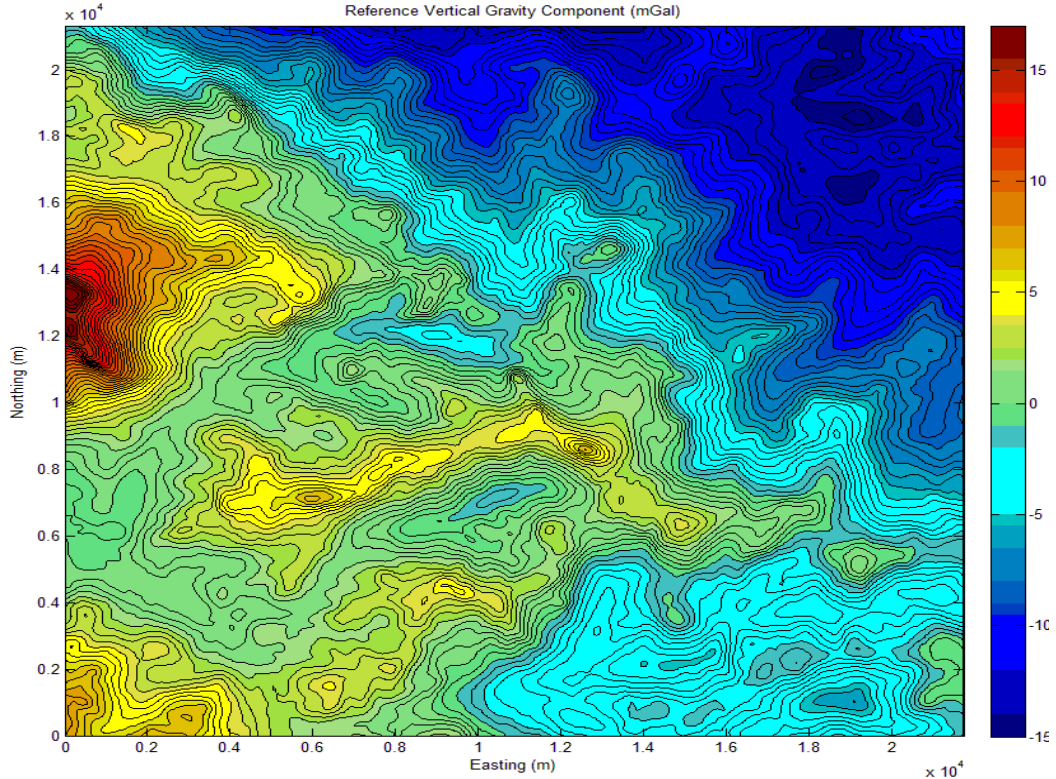


North Gravity Component Comparison with Reference

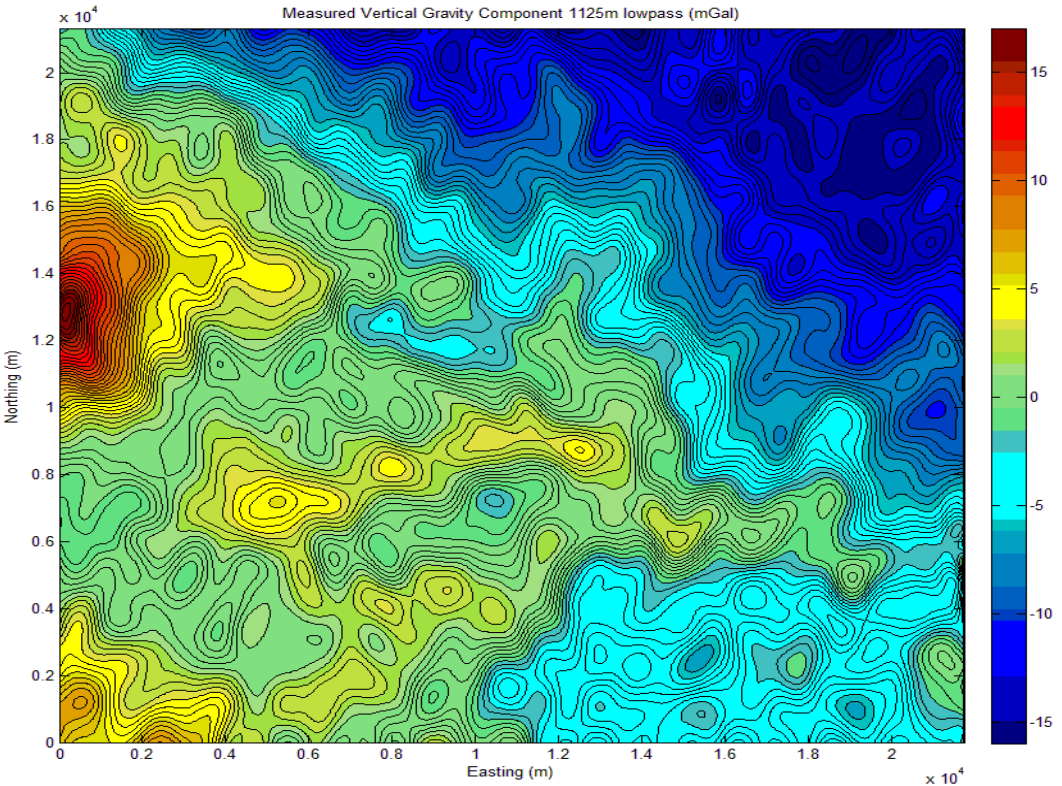
Filter (m)	Lowpass (G_N – Ref) (mGal)	Lowpass (G_N)– Ref (mGal)
750	0.85	0.85
1125	0.83	0.84
1500	0.81	0.83

*filters are stated as half-wavelengths

Reference Vertical Gravity Component



Measured Vertical Gravity Component



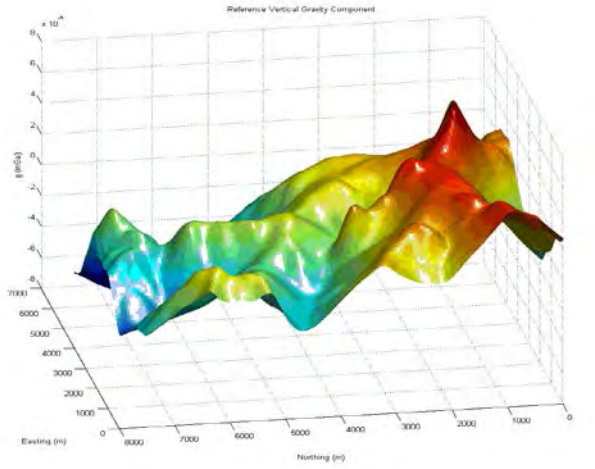
Vertical Gravity Component Comparison with Reference

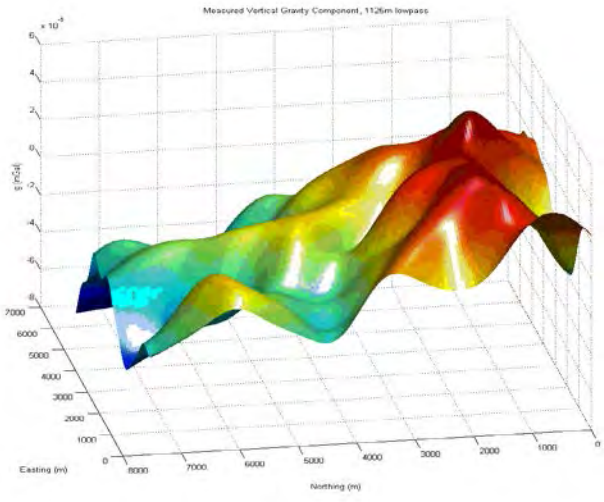
Filter (m)	Lowpass (G_U – Ref) (mGal)	Lowpass (G_U)– Ref (mGal)
750	0.63	0.63
1125	0.56	0.58
1500	0.49	0.54

*filters are stated as half-wavelengths

Kauring Conclusions

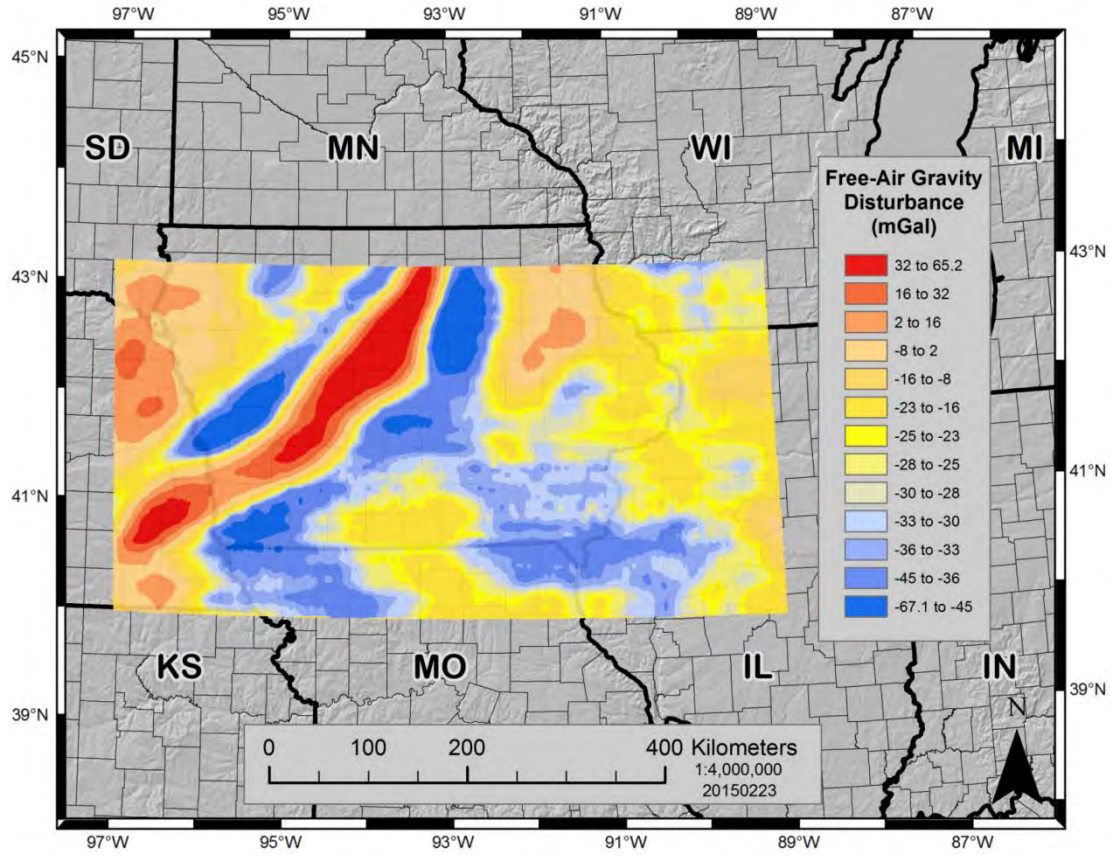
- Kauring area is probably the most accurate gravity test site available
- Contains challenging small anomalies suitable for testing gravity gradiometers
- AIRGrav matches reference data to ~0.6 mGal at 750 m wavelength, ~0.5 mGal at 1125 m wavelength
- Bouguer corrected gravity data produces slightly better results: matches reference data to ~0.4 mGal at 1000 m wavelength
- Horizontal components match to ~0.6 mGal (east) and ~0.8 mGal (north) at 1125 m wavelength
- Integral transform of east and north components produces independent estimate of the vertical gravity component to ~0.8 mGal at 1125 m wavelength





Geoid Slope Validation Survey 2014

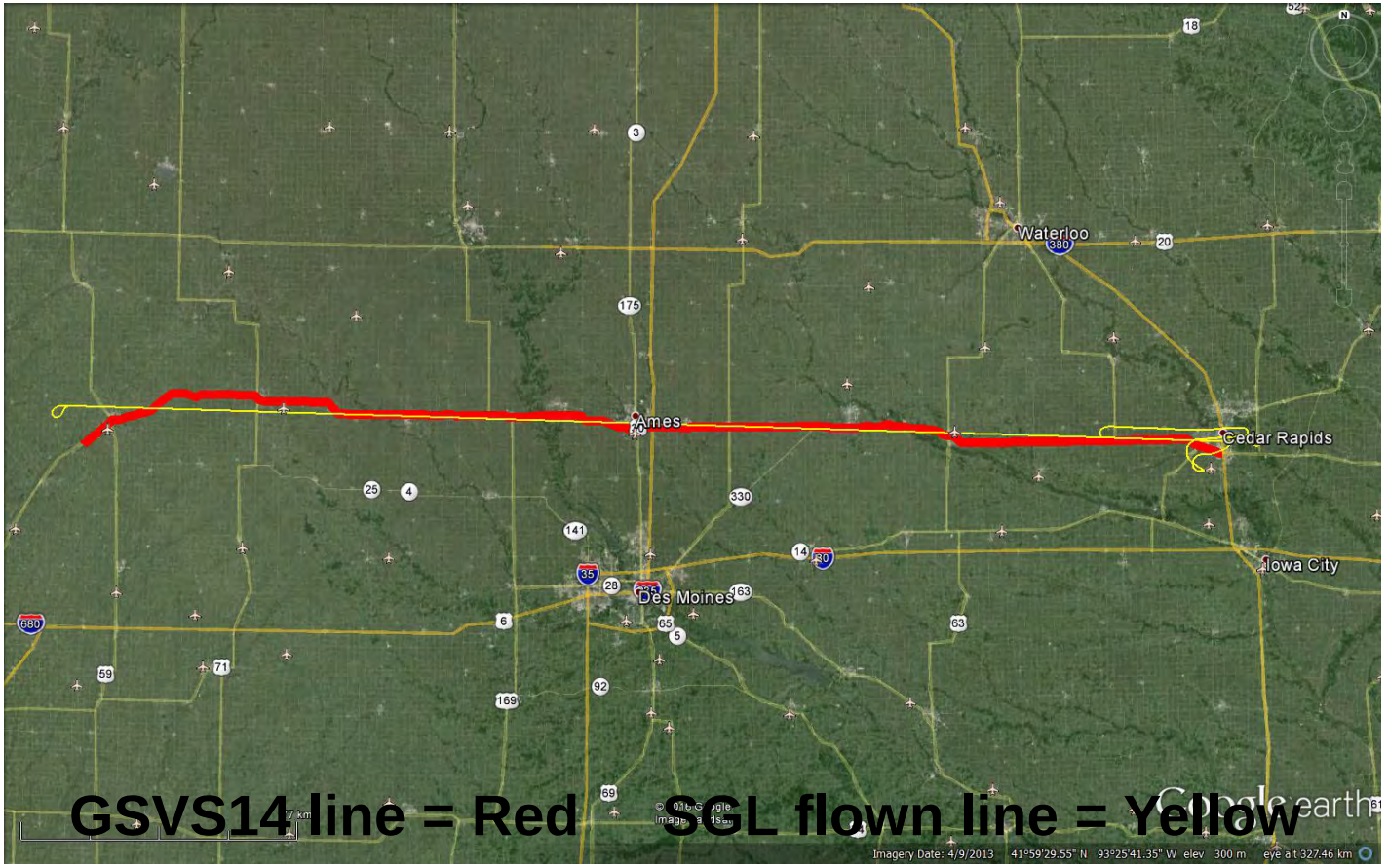
- GSVS14 represents the second survey conducted by the NGS to test the accuracy of the gravimetric geoid model, which will be the basis for the next American Vertical Datum
- It was conducted in Iowa, predominantly along Highway 30, from Denison to Cedar Rapids
- ~ 200 miles (325 km) long, 204 survey benchmarks
- Medium-high, relatively flat, and gravimetrically complex area ranging from 740 feet to 1,440 feet above sea level



SGL GSVS14 Survey

Flight Information

- June 28, 2015
- Repeat line flown West then East
- 600 m ellipsoidal (~ 400 m AGL at East end, ~200 m AGL at West end)
- 320 km long
- ~ 55 m/s (200 km/h)
- Also flown next day at 2185 m ellipsoidal, 58 m/s, West and East (results not presented here)

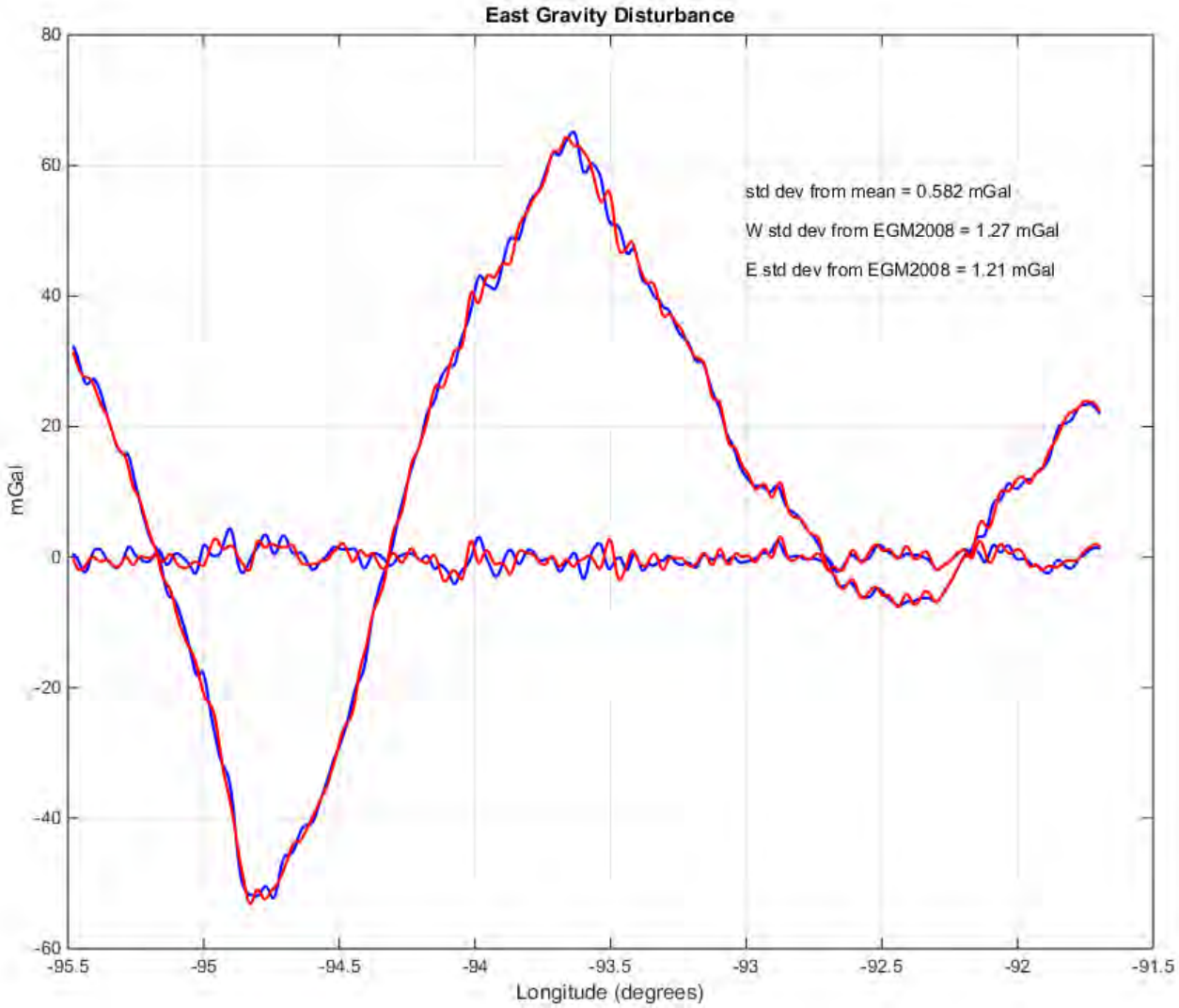


Processing Steps

- Kalman Filter combination of GPS positions and gravimeter accelerations
- EGM 2008 used during processing to loosely constrain horizontal component estimates, which are corrupted by uncertainty in gyro drift
- 100 s (5.5 km) full wavelength filter applied

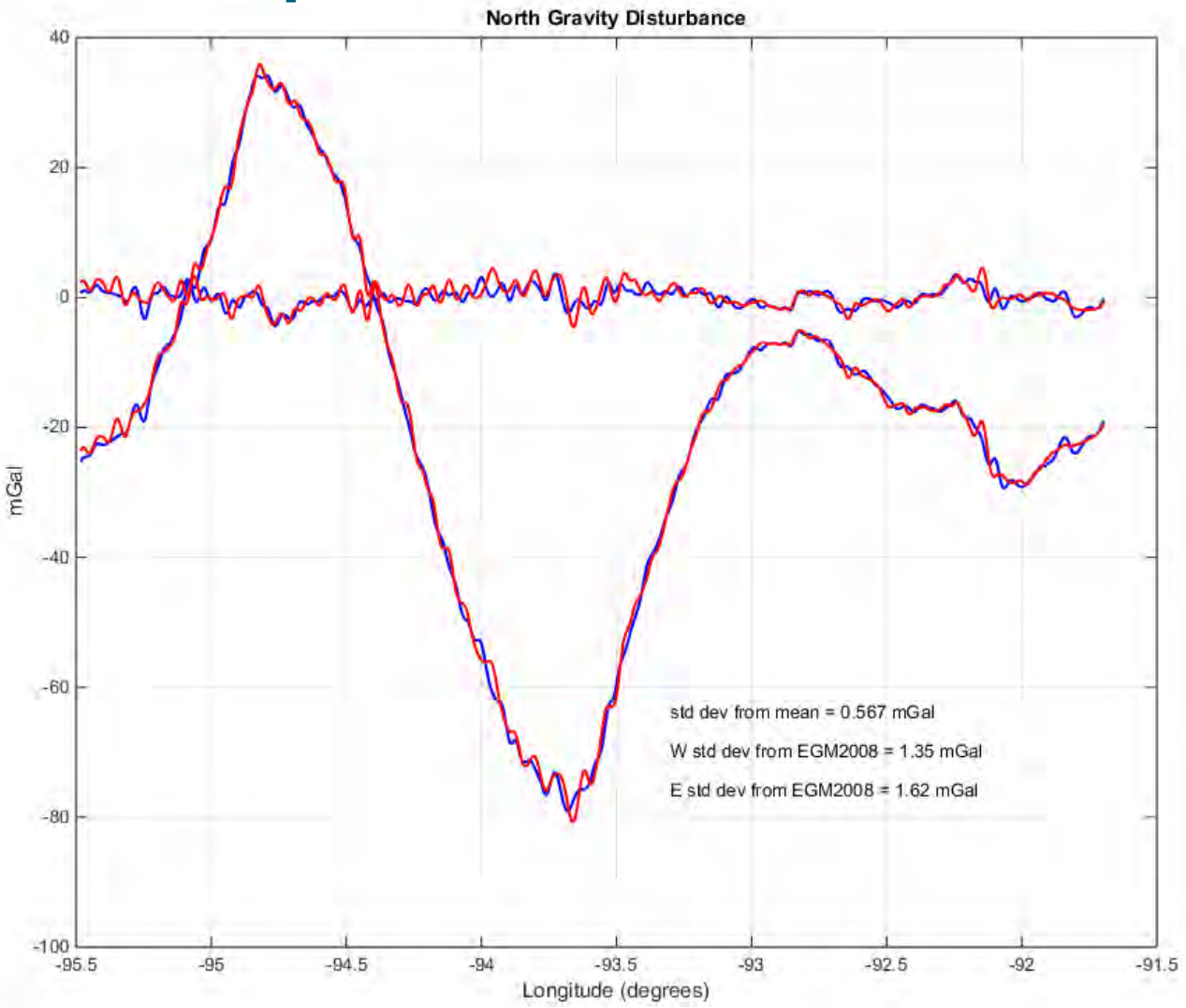
East Component

- Blue = Westward
- Red = Eastward
- Std dev from mean = 0.582 mGal
- W std dev from EGM2008 = 1.27 mGal
- E std dev from EGM2008 = 1.21 mGal



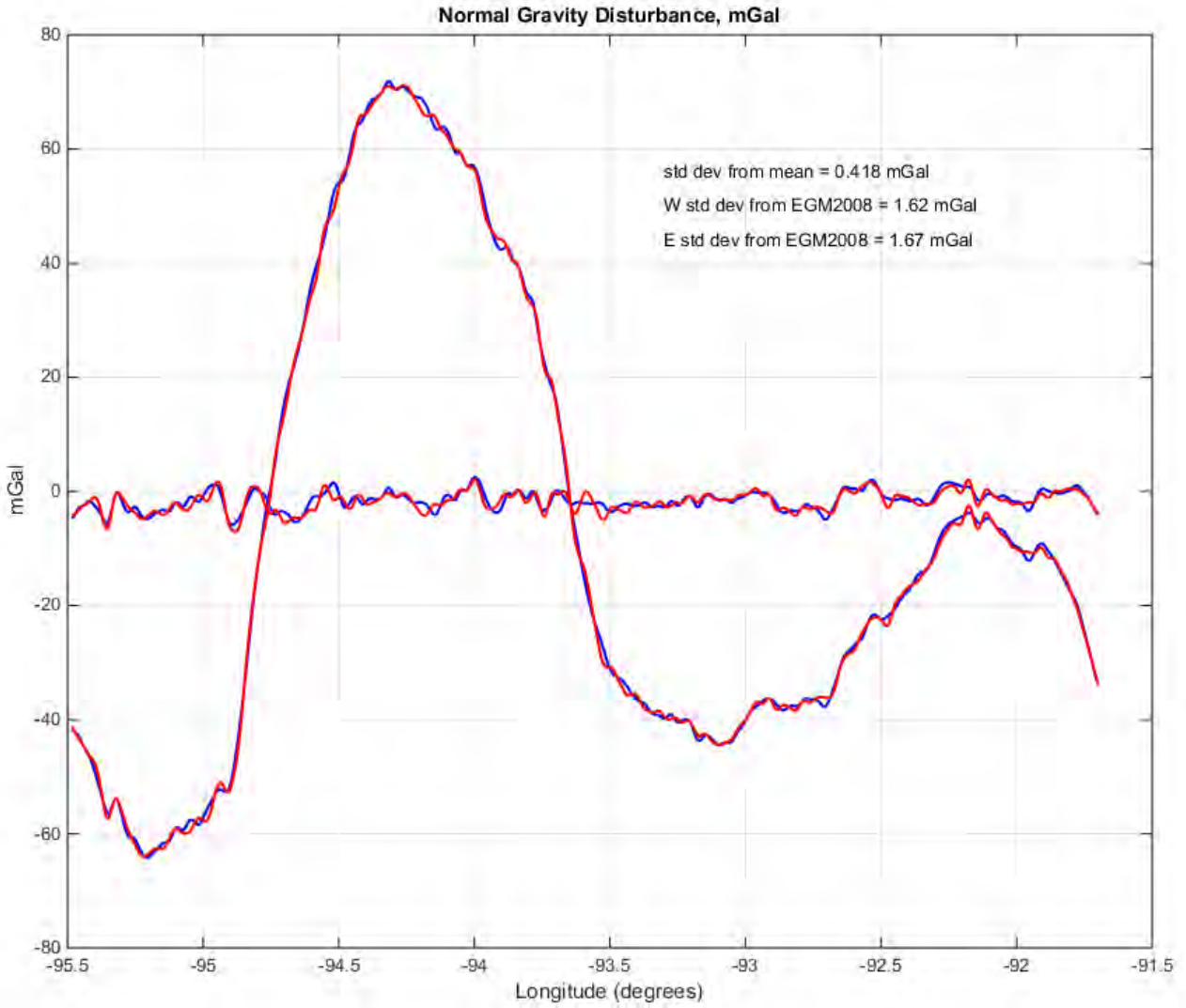
North Component

- Blue = Westward
- Red = Eastward
- Std dev from mean = 0.567 mGal
- W std dev from EGM2008 = 1.35 mGal
- E std dev from EGM2008 = 1.62 mGal



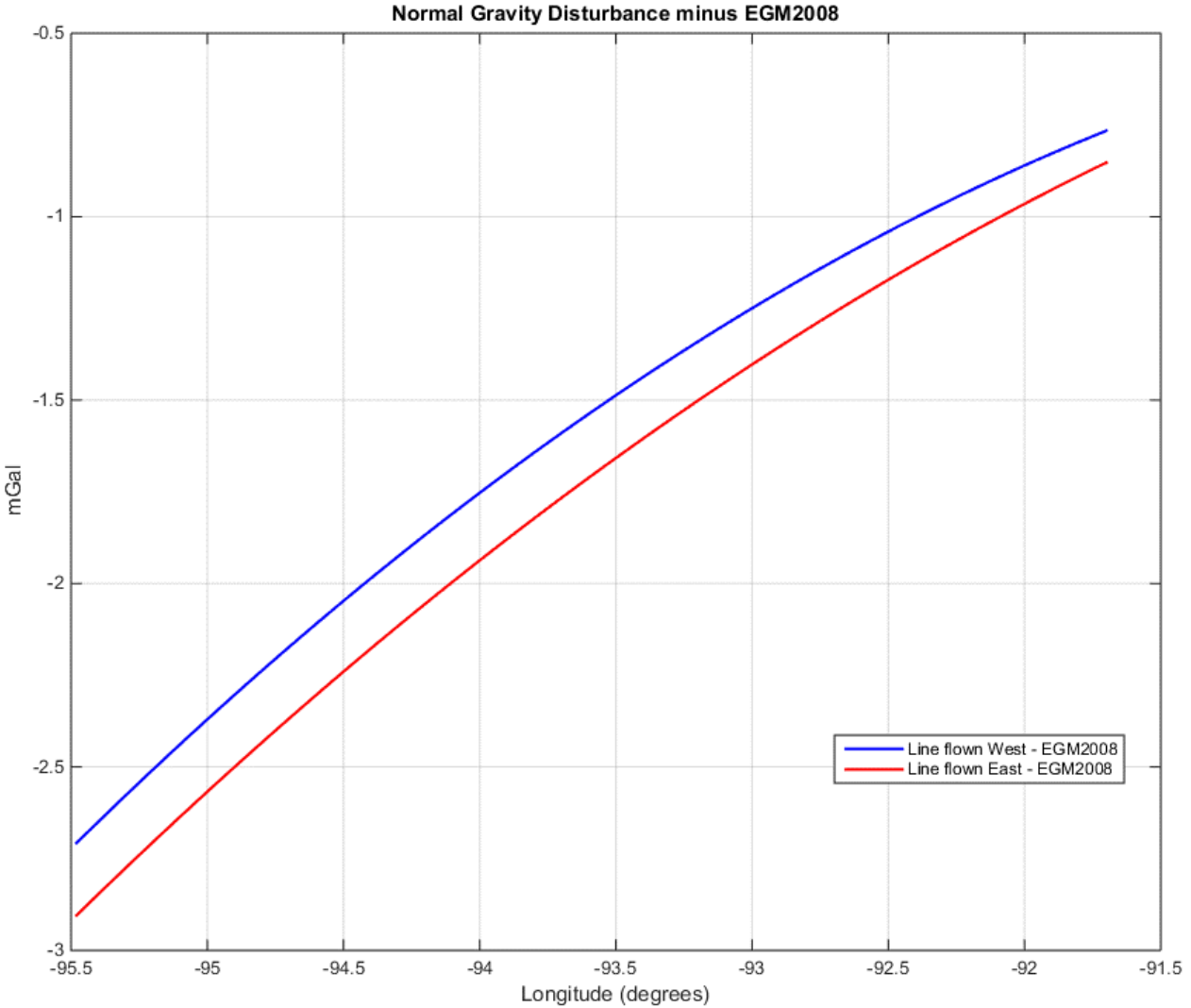
Normal Gravity Disturbance

- Blue = Westward
- Red = Eastward
- Std dev from mean = 0.418 mGal
- W std dev from EGM2008 = 1.62 mGal
- E std dev from EGM2008 = 1.67 mGal



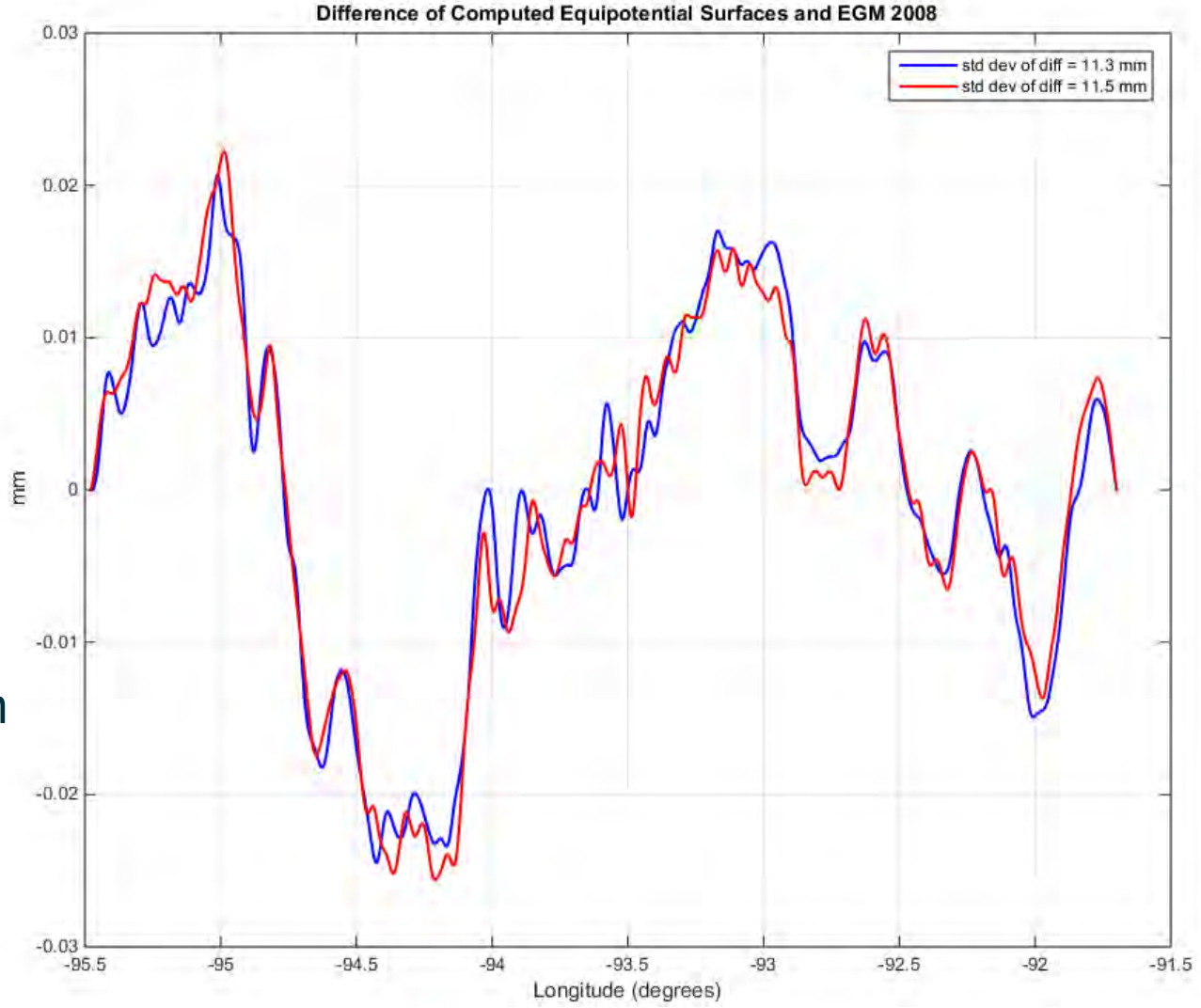
EGM 2008 error trend

- Comparison of EGM 2008 with both the Eastward and Westward passes indicates a sloping trend
- Likely indicates error in EGM 2008
- ~ 2 mGal error over 4° longitude



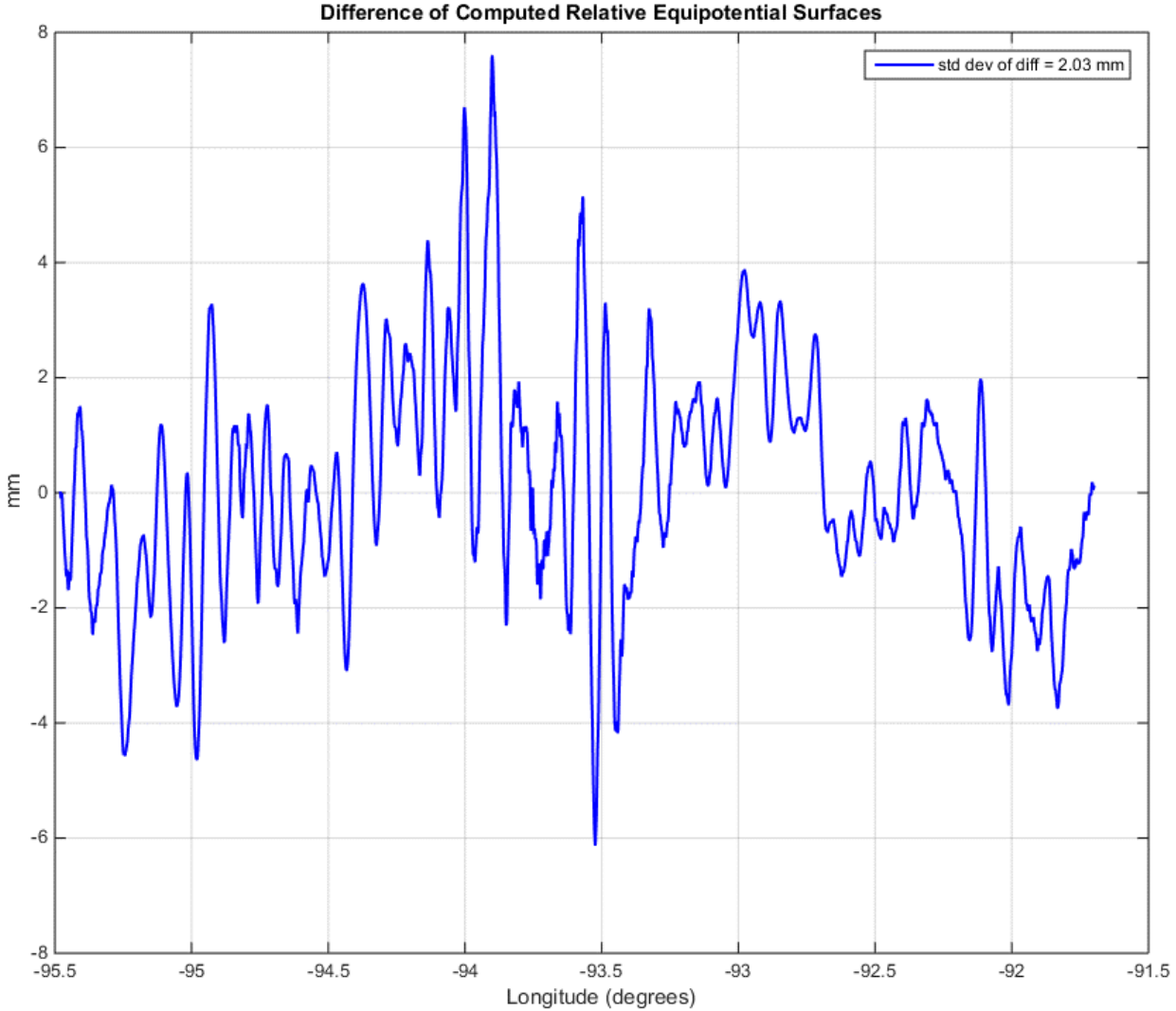
Difference of Equipotential Surfaces and EGM 2008

- Horizontal components corrected for remaining long wavelength error (600 km full-wavelength) using EGM 2008
- Integrate horizontal components along flight path (Westward and Eastward separately) to compute relative equipotential surfaces
- West std dev of diff = 11.3 mm
- East std dev of diff = 11.5 mm



Difference of Computed Relative Equipotential Surfaces

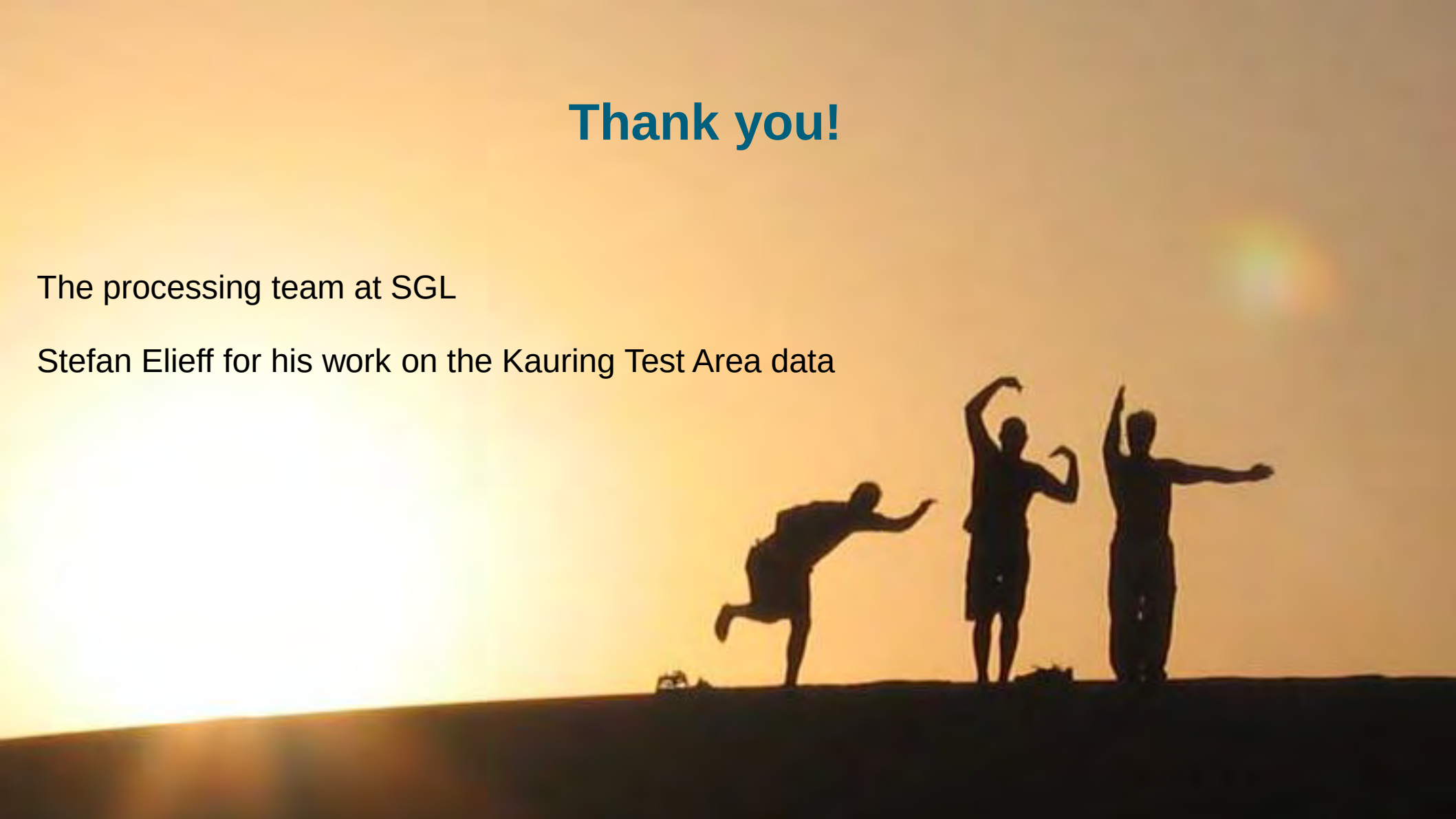
- Standard deviation of the difference between the Eastward and Westward computed relative equipotential surfaces = 2.03 mm



Conclusions

- AIRGrav produces measurements of three gravity components repeatable at the sub-mGal level
- Data is capable of extending the EGM2008 model to wavelengths as short as 5 km
- Capable of producing equipotential surfaces accurate to mm level
- Horizontal components can be used to verify geoid models – have provided data to Geodetic Survey Division of NRCan

Thank you!



The processing team at SGL

Stefan Elieff for his work on the Kauring Test Area data