# Airborne Gravity for an Improved Vertical Datum

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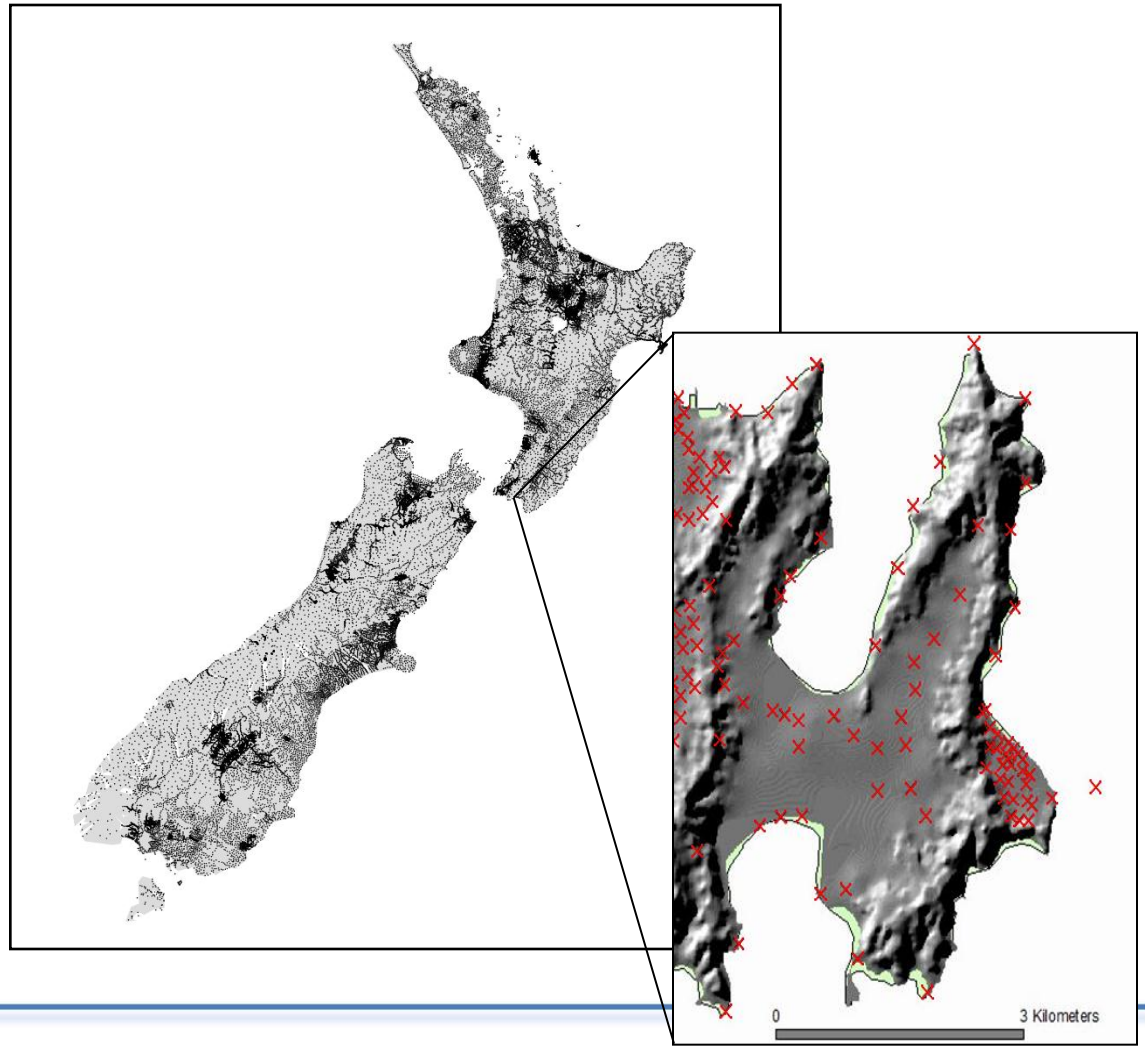
# Why airborne gravity?

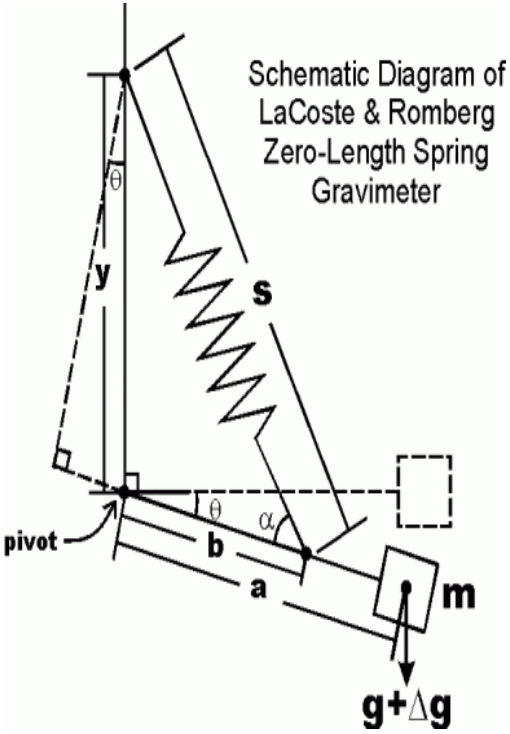
- Provides gravity data for geoid computation
- Determines medium wavelength components of the gravity field (eg 10-20km and greater)
  - Satellites for long wavelengths (eg 100-200km and greater)
  - Topographic models for short wavelengths
- Low cost compared with collecting evenly distributed terrestrial data
- Quick – provides a snapshot of gravity field at a particular time
- Data collected to consistent standards
- Covers land/sea interface (coastal areas) which other techniques do not
- No requirement to physically occupy points – useful for difficult terrain

# Terrestrial gravity limitations

- Irregular gravity coverage
- Collected over many decades
- Often uncertain/poor quality data
- Expensive to collect data



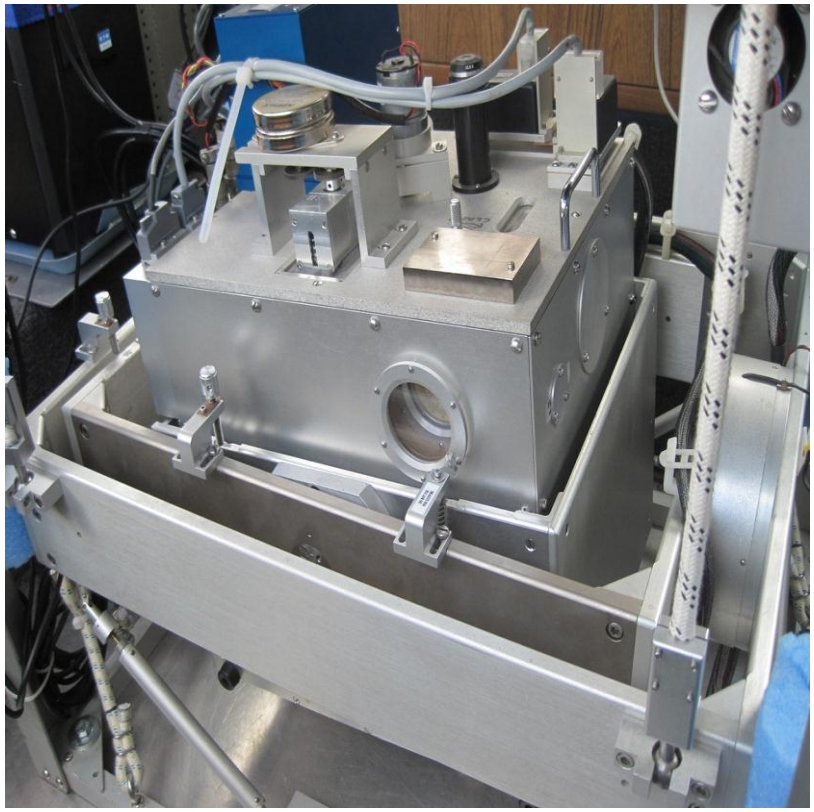
# What is a gravity meter?




$\delta g \propto s_0$ errors in reading y (1-20 μgal) + drift, i.e. $F=k(s- s_0)$

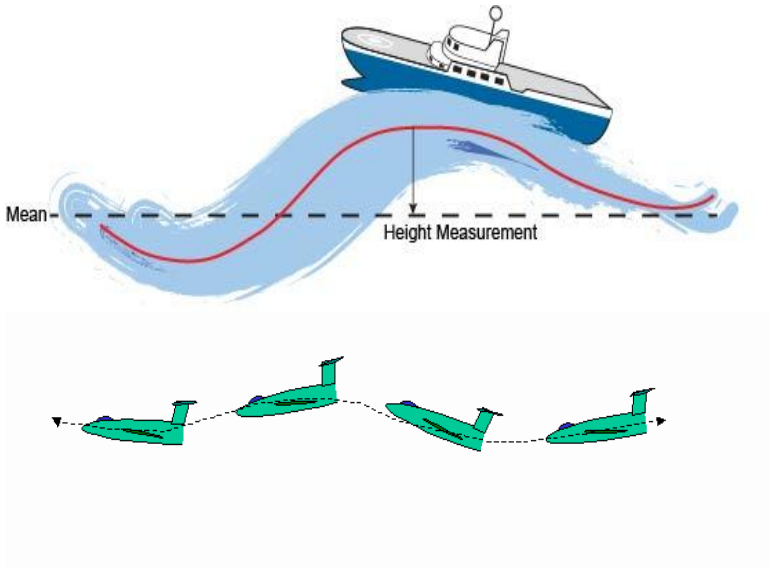
1 gal = 1cm/s$^2$ $g \cong 10^3$ gal, i.e. sensitivity up to $10^{-9}$

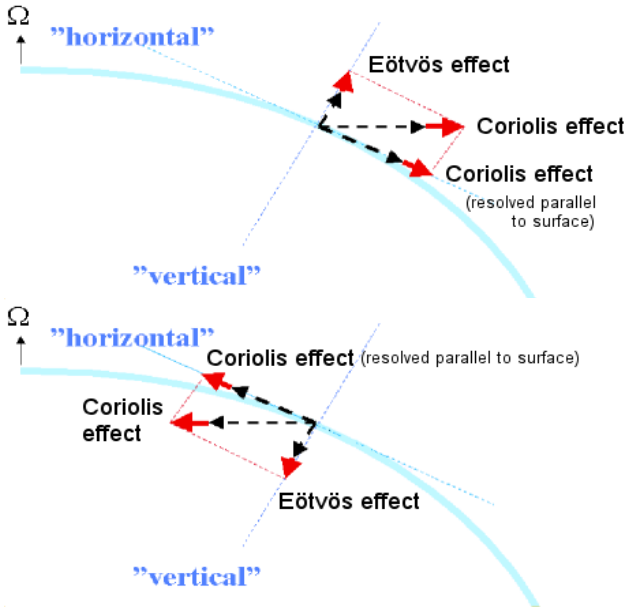
# What is a dynamic gravity meter?



# What is a dynamic meter measuring?

- It is measuring the total vertical acceleration, not just g;
- g + a: g ≅ 1-100 mGal, but a ≅ 100,000-1,000,000 mGal
- a is due to aircraft/ship motion + Eötvos

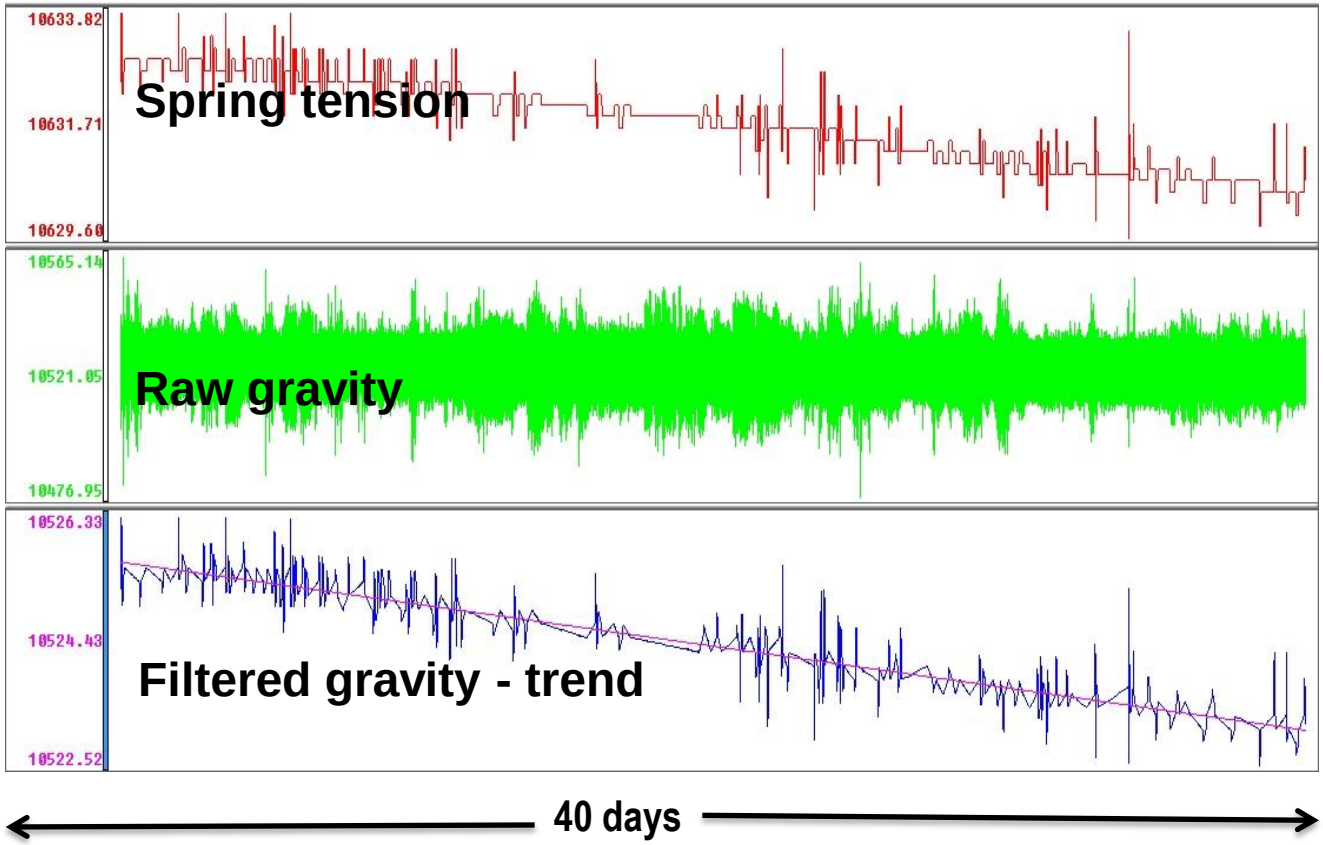


# Airborne acquisition

- Stable power supply to keep the meter continuously running
- Try to help the spring tension feedback loop to be close to the null beam position
- Disengage torque motors during turns, take-off and landing (they may break)
- Disengage spring tension motors and clamp beam during turns, take-off and landing
- Use DGPS/PPP for accurate positioning and vertical acceleration decoupling

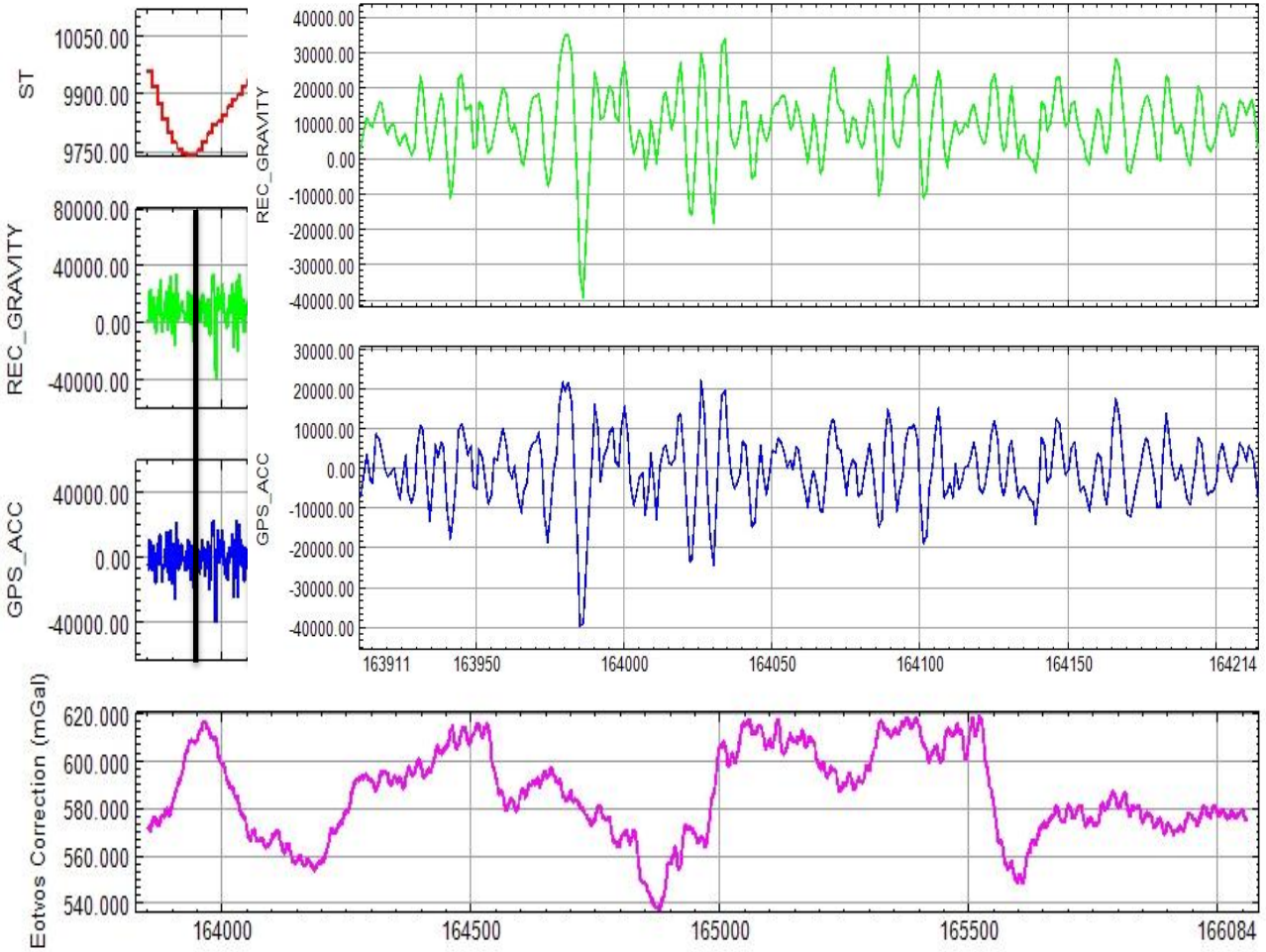
# Gravimeter drift




Drift is ~ -0.062 mGal/day, i.e., ~ 1.9 mGal/month

# Gravity tie

# Example

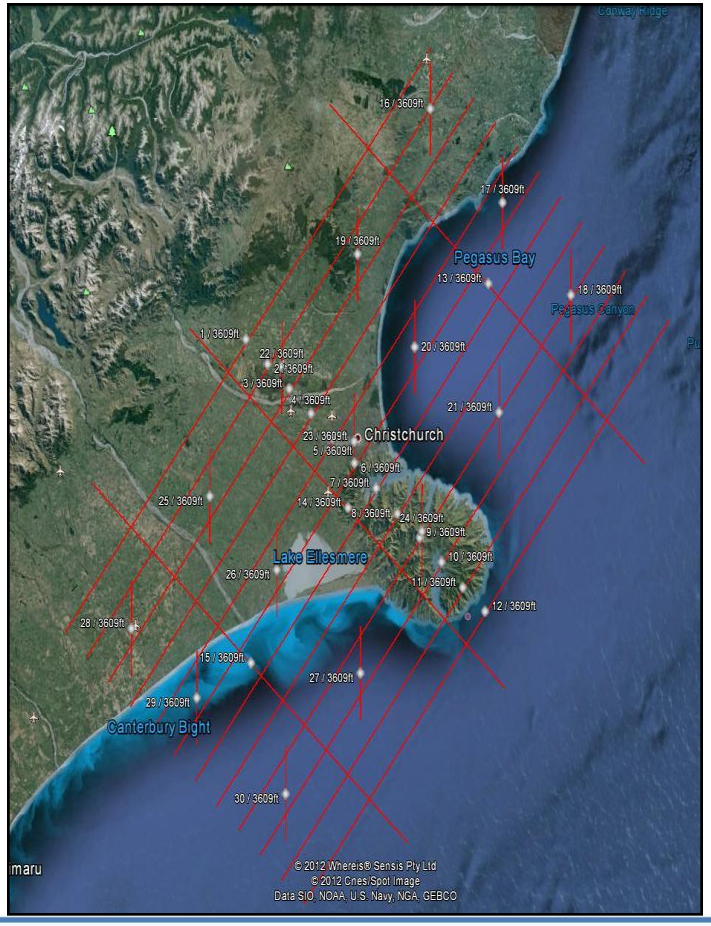

ST
10050.00
9900.00
9750.00
REC_GRAVITY
80000.00
40000.00
0.00
-40000.00
GPS_ACC
40000.00
0.00
-40000.00
REC_GRAVITY
40000.00
30000.00
20000.00
10000.00
0.00
-10000.00
-20000.00
-30000.00
-40000.00
GPS_ACC
30000.00
20000.00
10000.00
0.00
-10000.00
-20000.00
-30000.00
-40000.00
163911
163950
164000
164050
164100
164150
164214
Eotvos Correction (mGal)
620.000
600.000
580.000
560.000
540.000
164000
164500
165000
165500
166084

# Trial survey

- Evaluate gravimeter
  - Equipment operation
  - Line spacing and elevation
  - Feasibility of national survey

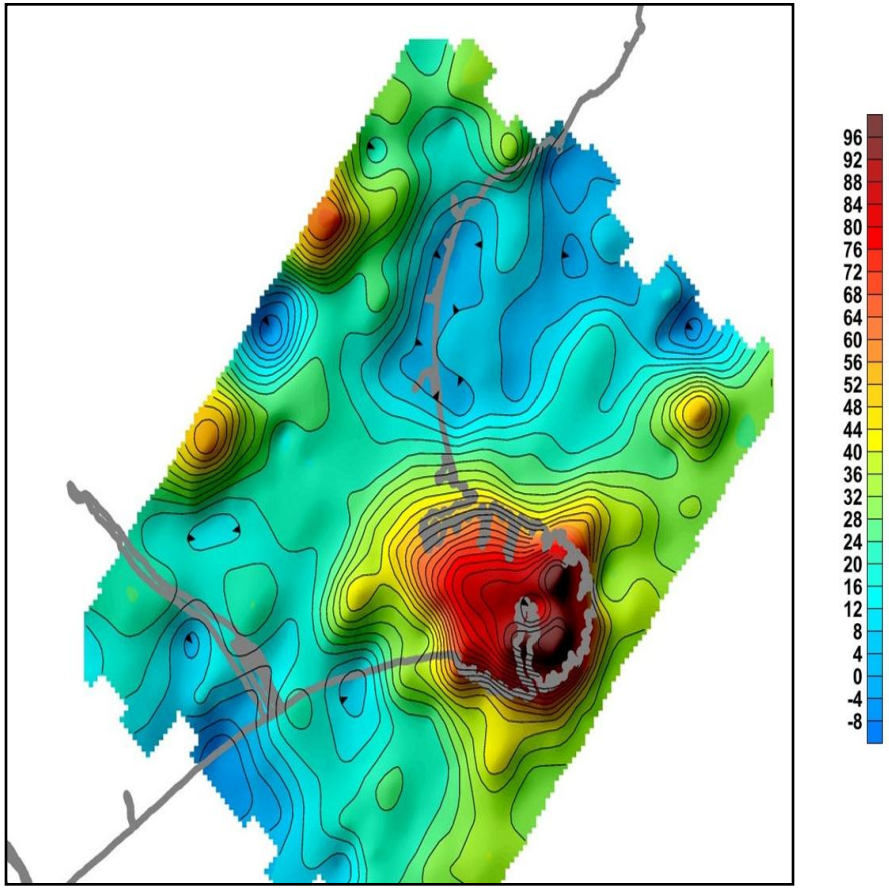
# Trial survey

- Canterbury region of New Zealand chosen due to variety of terrain/geology
- Flown in April 2012
  - 12 x 150 km lines
  - 10 km spacing
  - 3,400 ft elevation



# Trial survey results

- 2 mGal accuracy
- Turbulence doubled errors
- Higher altitude is ok
- Greater aircraft endurance needed for national survey
- Successful demonstration of gravimeter capability




Reduced gravity anomalies (mGal)

# Flight lines

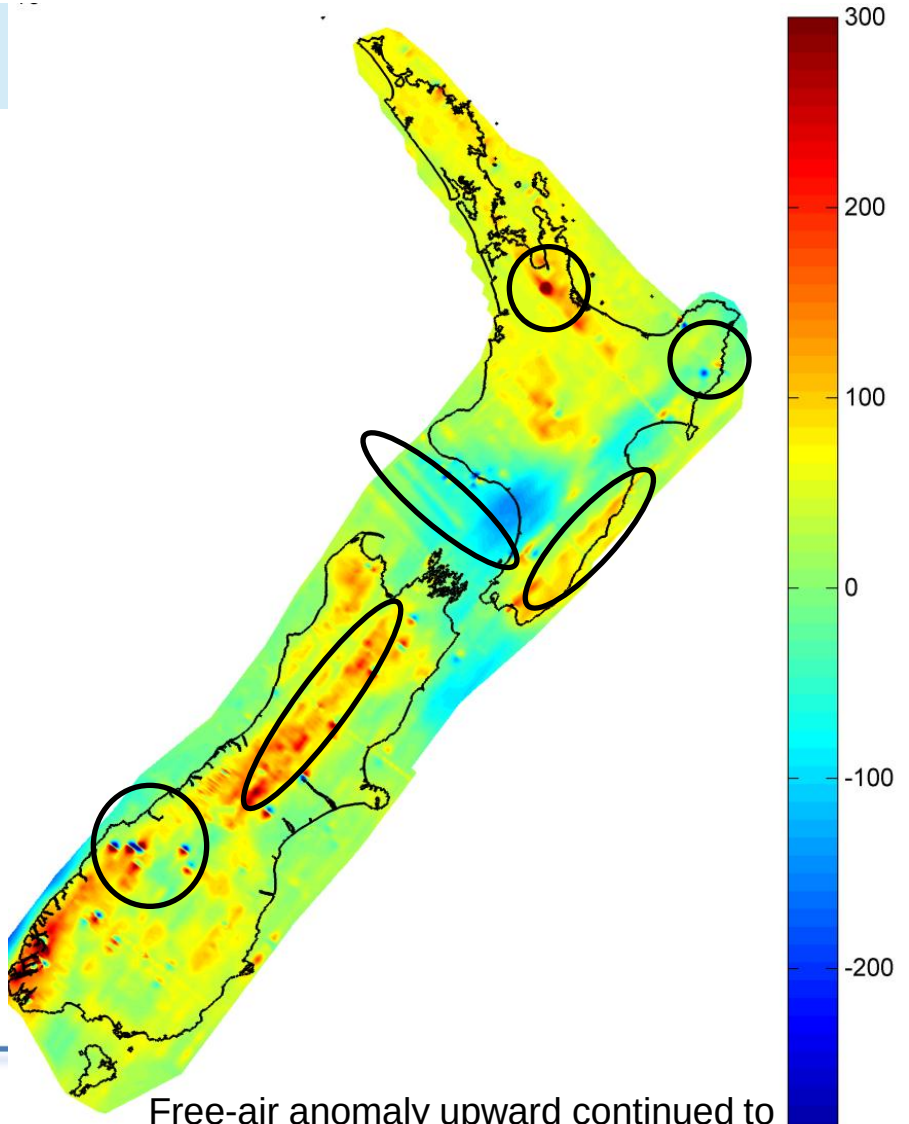
- Consider location of airports
- Distance between parallel flight lines
- Cross ties for validation
- Night flights?

# Gravity collection

- Type of aircraft
- Maintenance issues
  - Eg regular maintenance schedules
- Personnel issues
  - Eg Required breaks for pilots
- Regulatory issues
- Flight velocity
- Flight height
- Weather conditions
  - Rain
  - Fog
  - Wind

# Initial processing

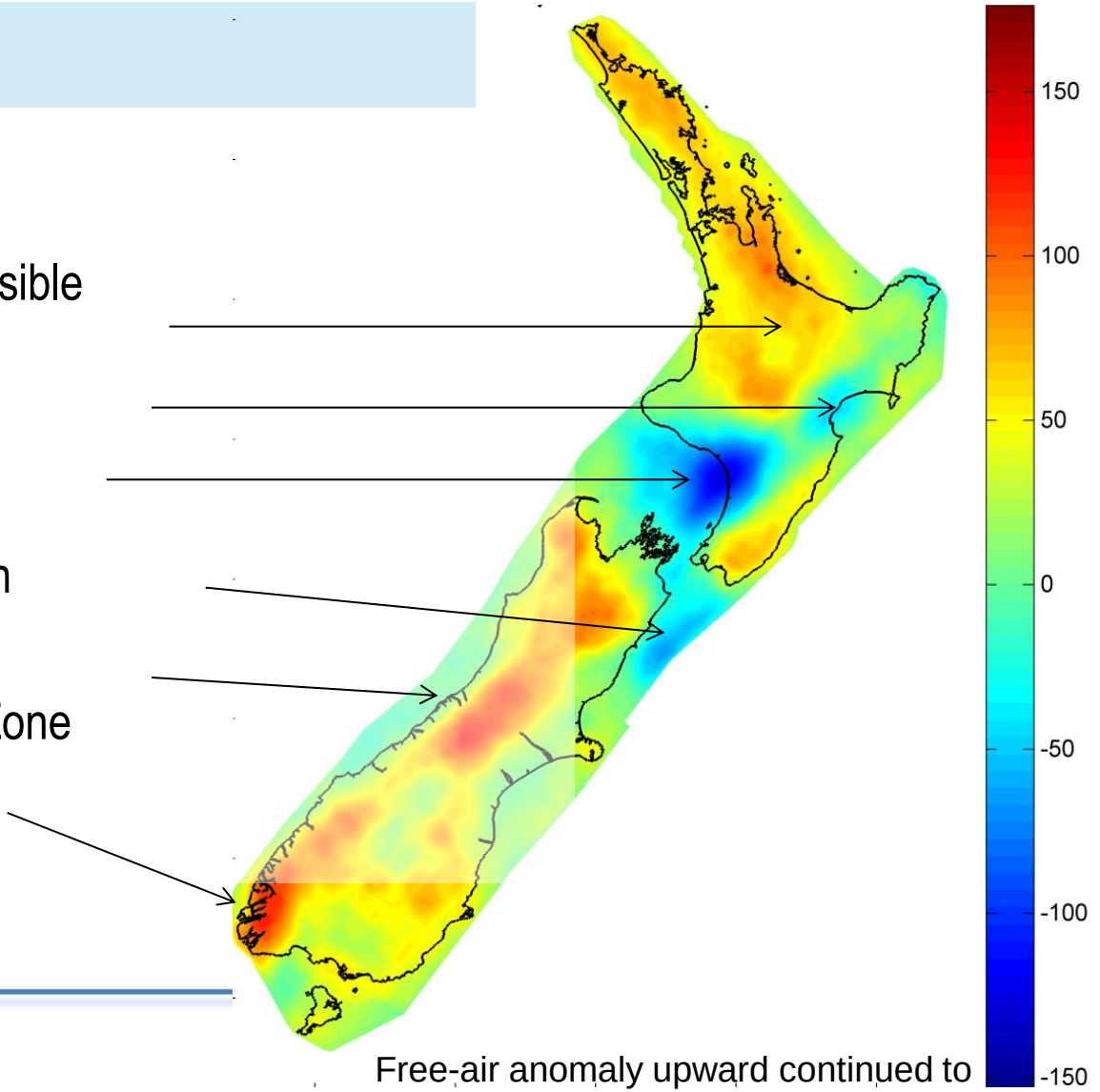
- Observations corrected for aircraft motion and Eötvös
- Some inconsistencies remain:
  - Along track biases (operator error)
  - High frequency amplitude “blips” (turbulence)




Free-air anomaly upward continued to 5000m

# Cleaned data

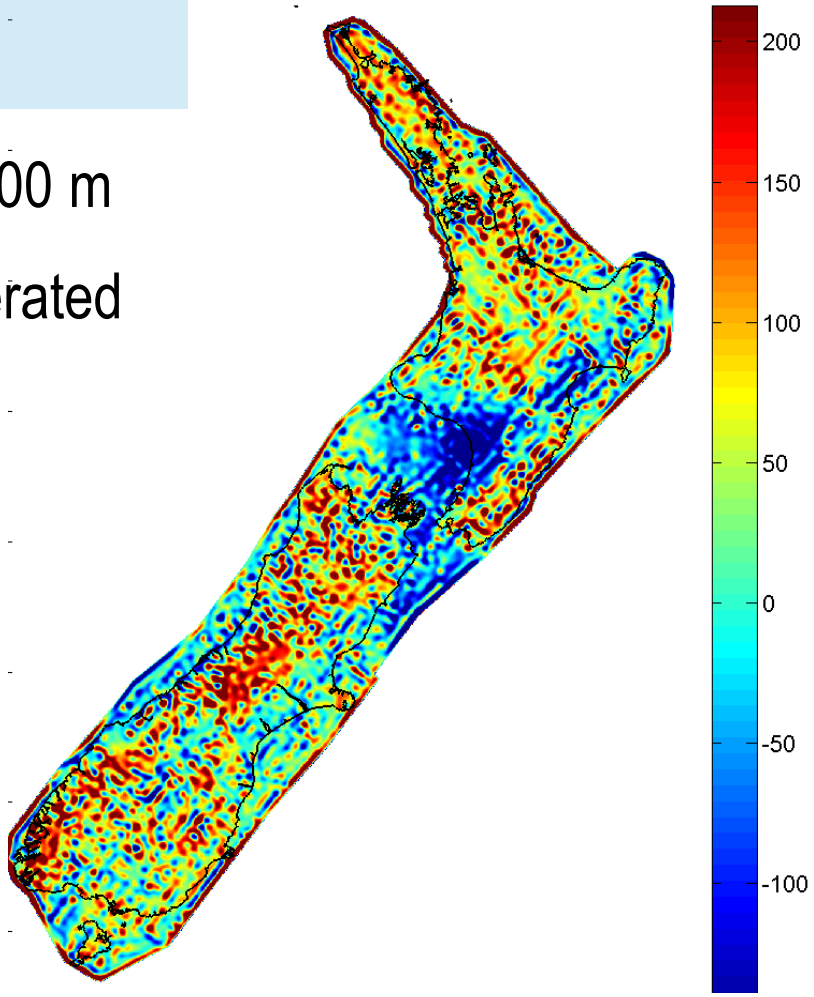
- Most anomalies removed
- Major geological features visible
  - Taupo Volcanic Zone
  - Wairoa Basin
  - Whanganui Basin
  - South Hikurangi Trough
  - Central Southern Alps
  - Fiordland Subduction Zone




Free-air anomaly upward continued to 5000m

# Downward continuation

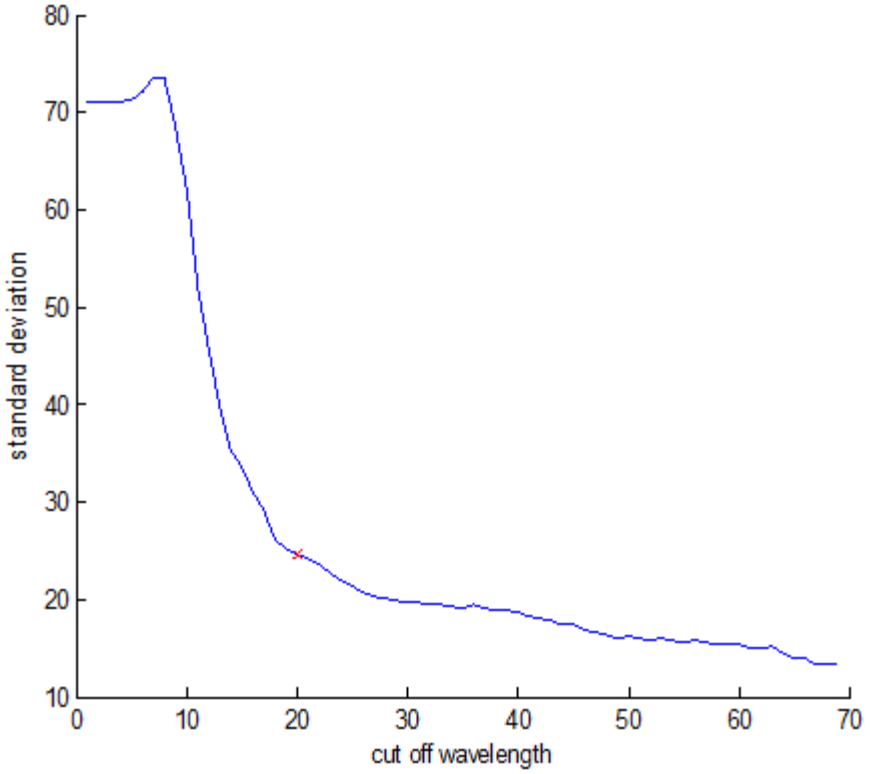
- Initial downward continuation from 5000 m
- Erroneus high frequency data exaggerated
- Resulting image not very pretty




Free-air anomaly downward continued to reference ellipsoid (full frequency)

# Downward continuation

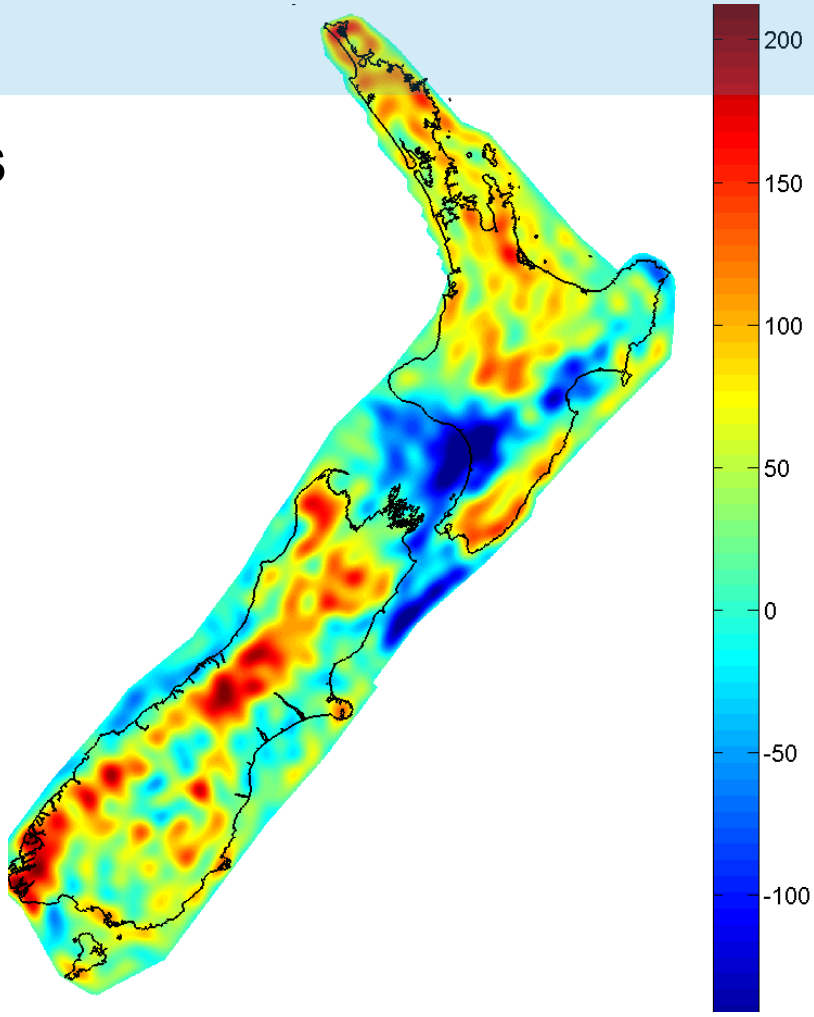
- High frequency large amplitude errors reduce with increasing cut-off wavelength




Comparison of large amplitude errors with terrestrial observations

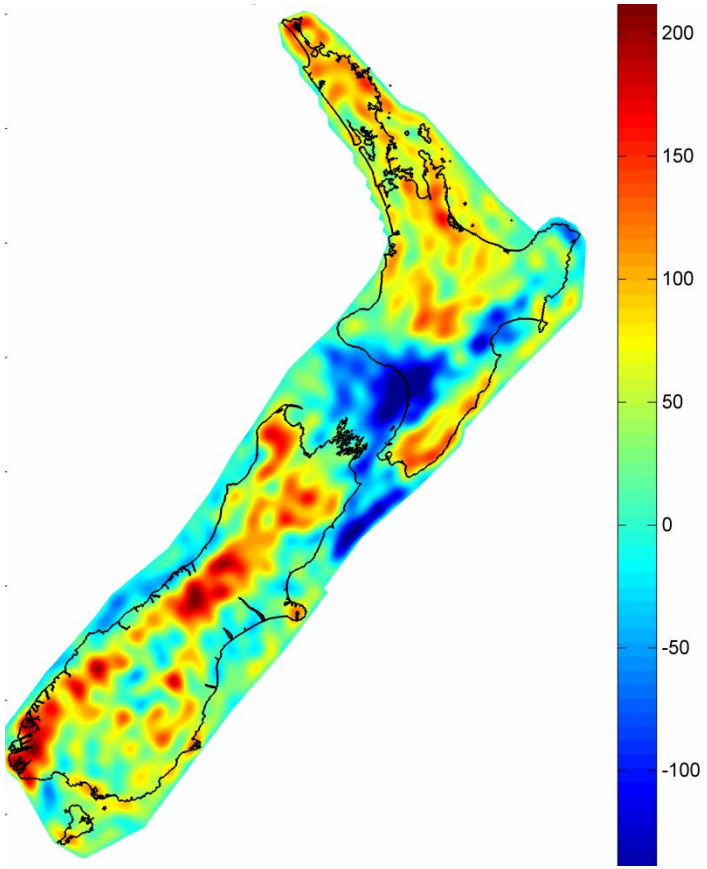
# Downward continuation

- High frequency large amplitude errors reduce with increasing cut-off wavelength
- 20 km spatial filter gives good result
- Aim to reduce filter size with further processing

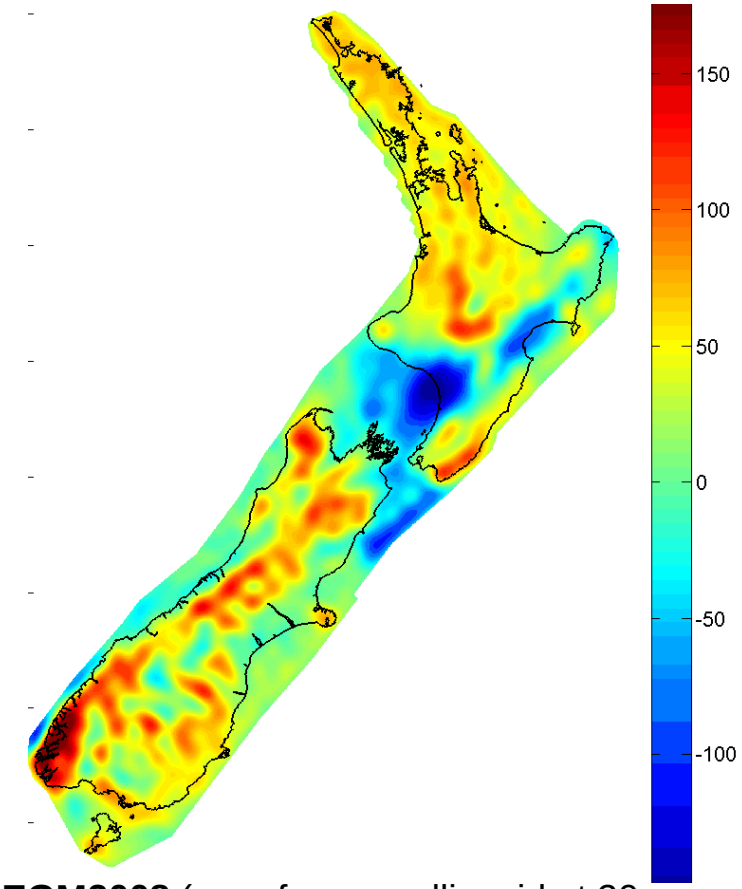



Free-air anomaly downward continued to reference ellipsoid (20 km spatial filter)

# Comparison with EGM08



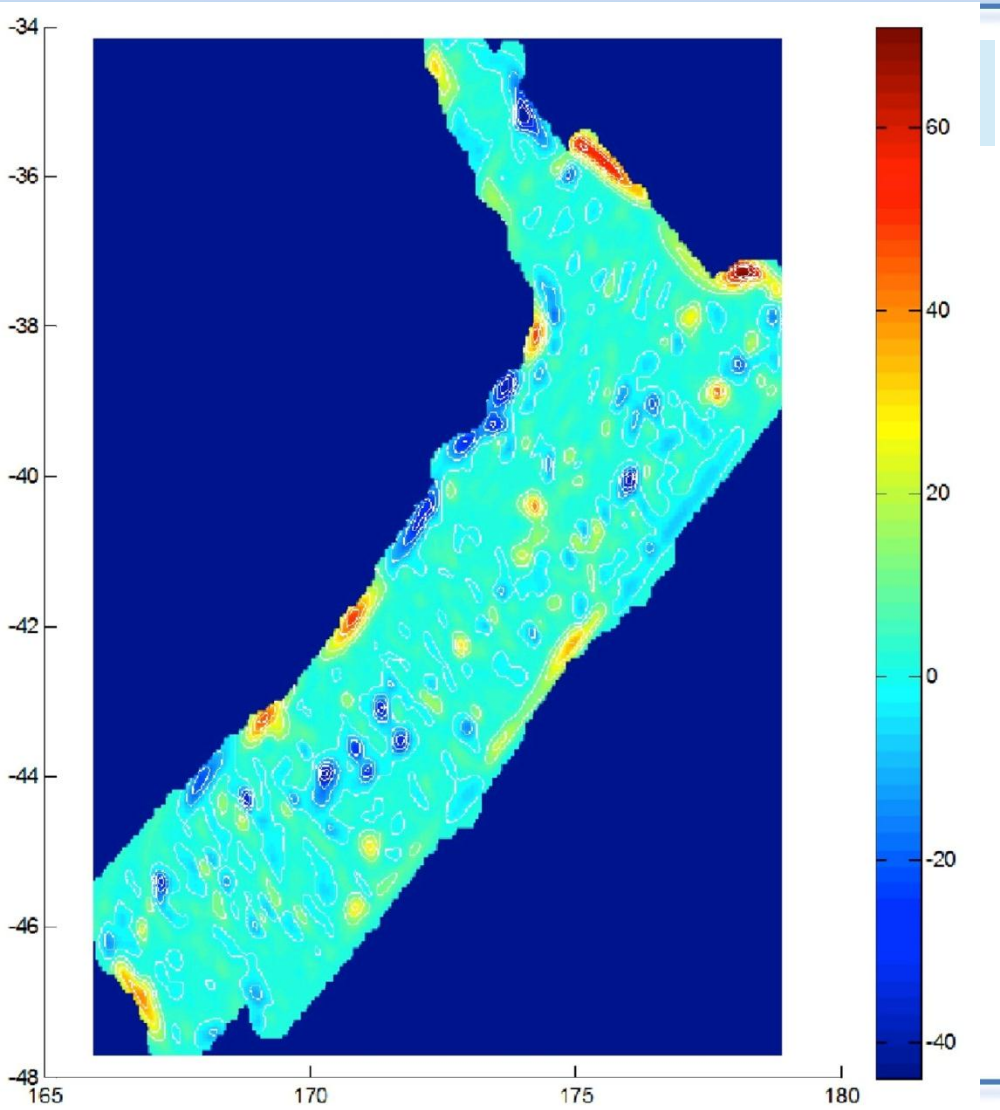

**Airborne data** on reference ellipsoid (20 km spatial filter)




**EGM2008** (on reference ellipsoid at 20 km wavelength)

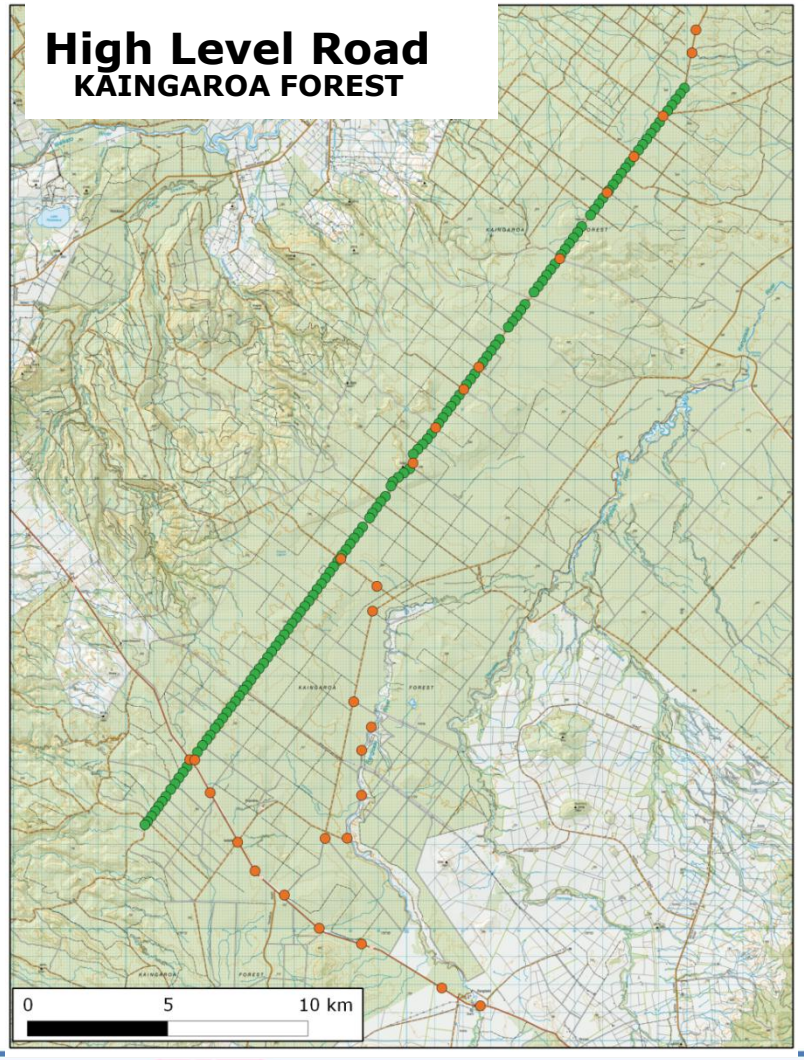
# Comparison with EGM08

- Difference to EGM2008
  - 10 km wavelength



# Calibration lines

- North and South Islands
- 35 & 50 km in length
- Ground-marks 350m apart
- Gravity, levelling and GNSS

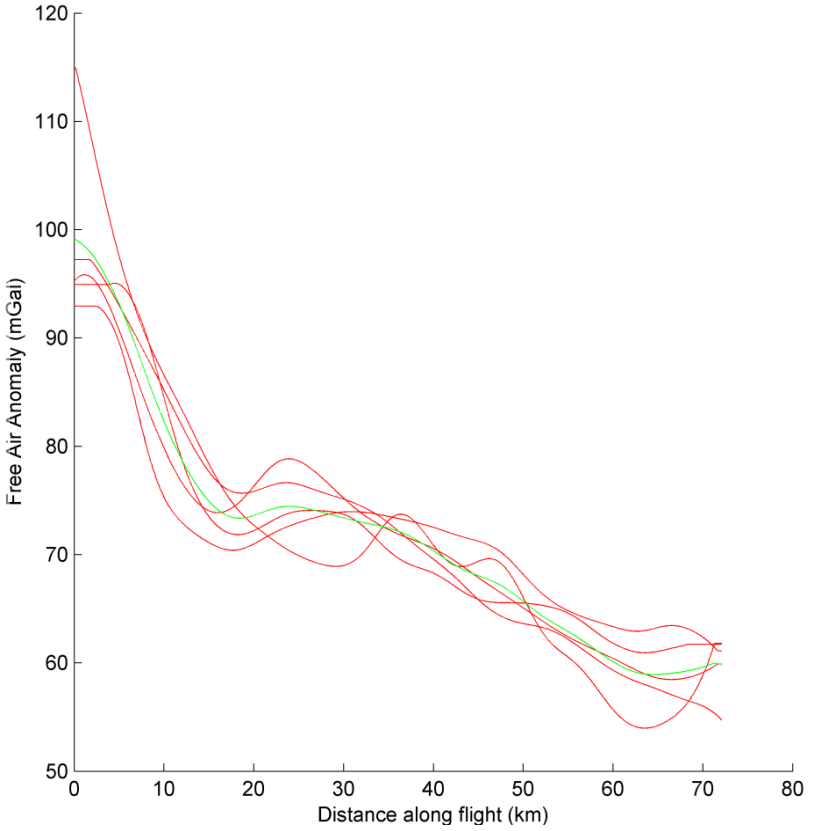



# Calibration Lines

- 30 & 50 km length
- Marks ~250m
- Flown at different heights
- Purpose to check
  - Repeatability
  - Downward continuation

# Calibration lines

- North and South Islands
- 35 & 50 km in length
- Ground-marks 350m apart
- Gravity, levelling and GNSS
- North Island line
  - 5 flights
  - Upward continued to 5000m
  - 2.6 mGal standard devation



# Key Points

- Airborne gravity collection can be an efficient way to collect data for geoid computation
- Care is required to select appropriate equipment and flight parameters
- Delays while collecting data are inevitable
- Data processing required to remove and reduce systematic errors
- Use cross-ties and calibration lines to assess accuracy
- NOTE: Examples are from NZ airborne gravity campaign, results will vary