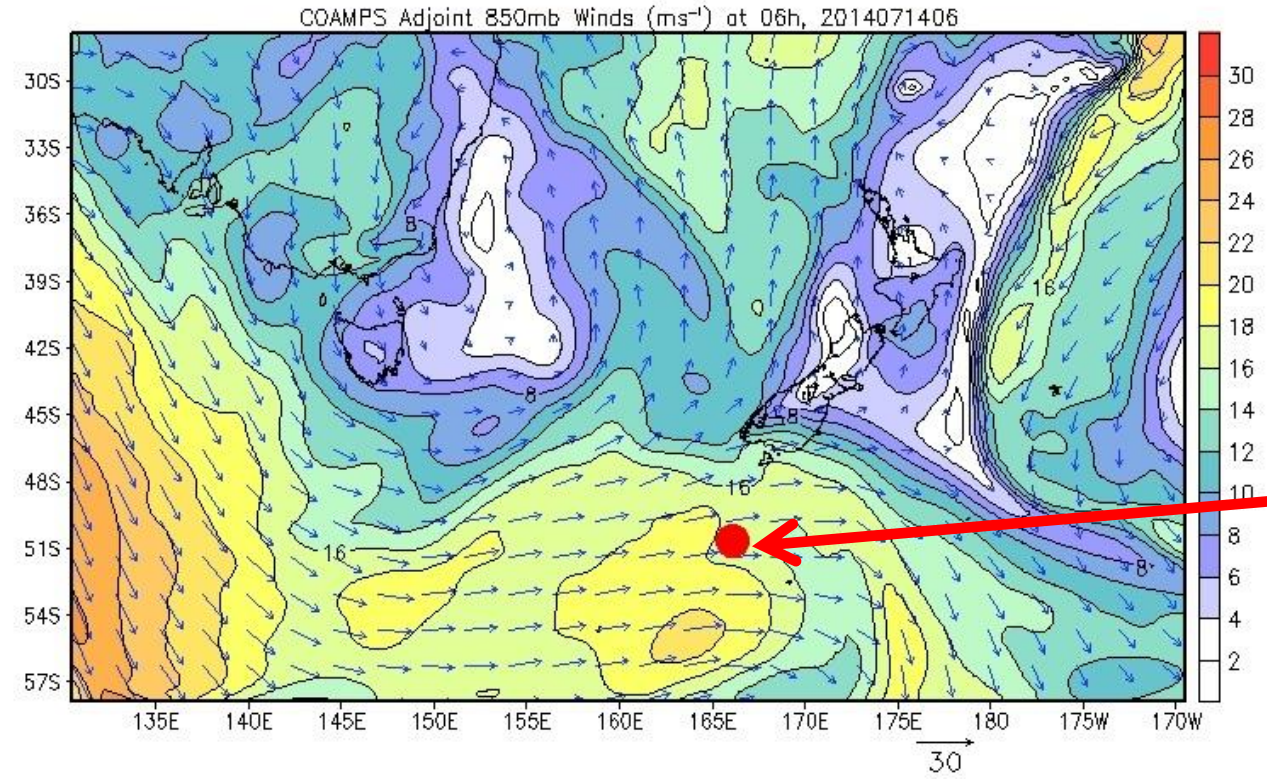
Mesospheric Response to an Orographic Wave Generated over the Auckland Islands (50.7°S)

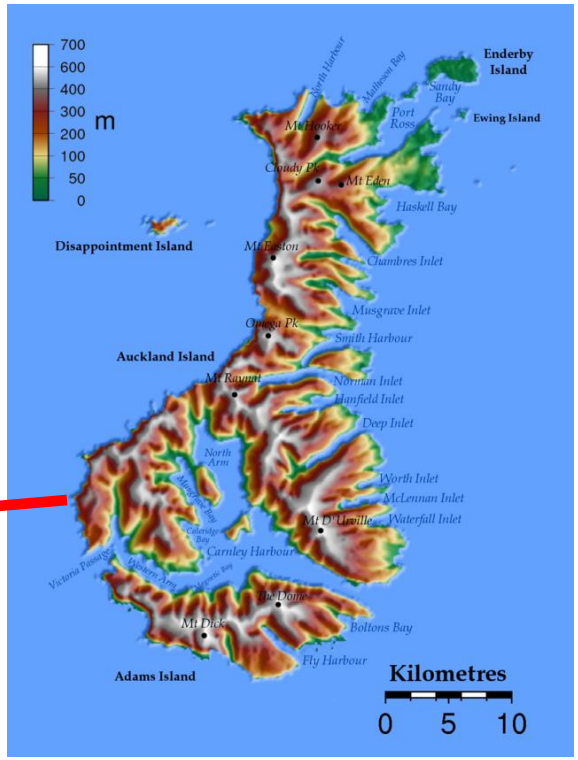
P.-D. Pautet[1], M.J. Taylor[1], K. Bossert[2], B.P. Williams[2], and D.C. Fritts[2] , D. Broutman[3], J. Ma[3], S.D. Eckermann[4], and J.D. Doyle[5]

[1]CASS, Utah State University, Logan UT
[2]GATS Inc., Boulder CO
[3]CPI, Springfield VA
[4]Naval Research Laboratory, Washington DC
[5]Naval Research Laboratory, Monterey CA

Deepwave meeting, Boulder, May 2015

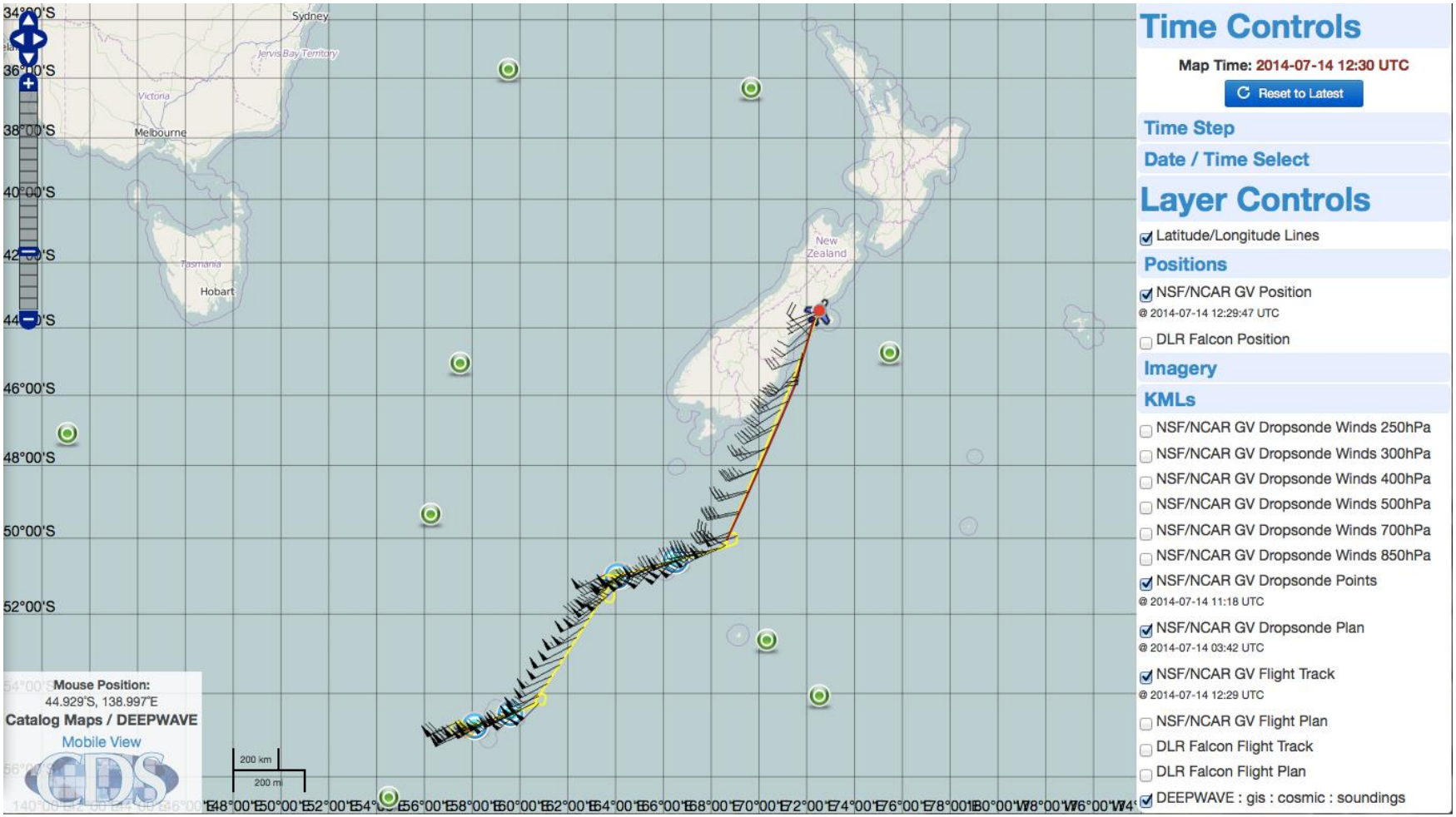
July 14th, 2014 (Bastille Day)
Geopotential Winds at 850mb



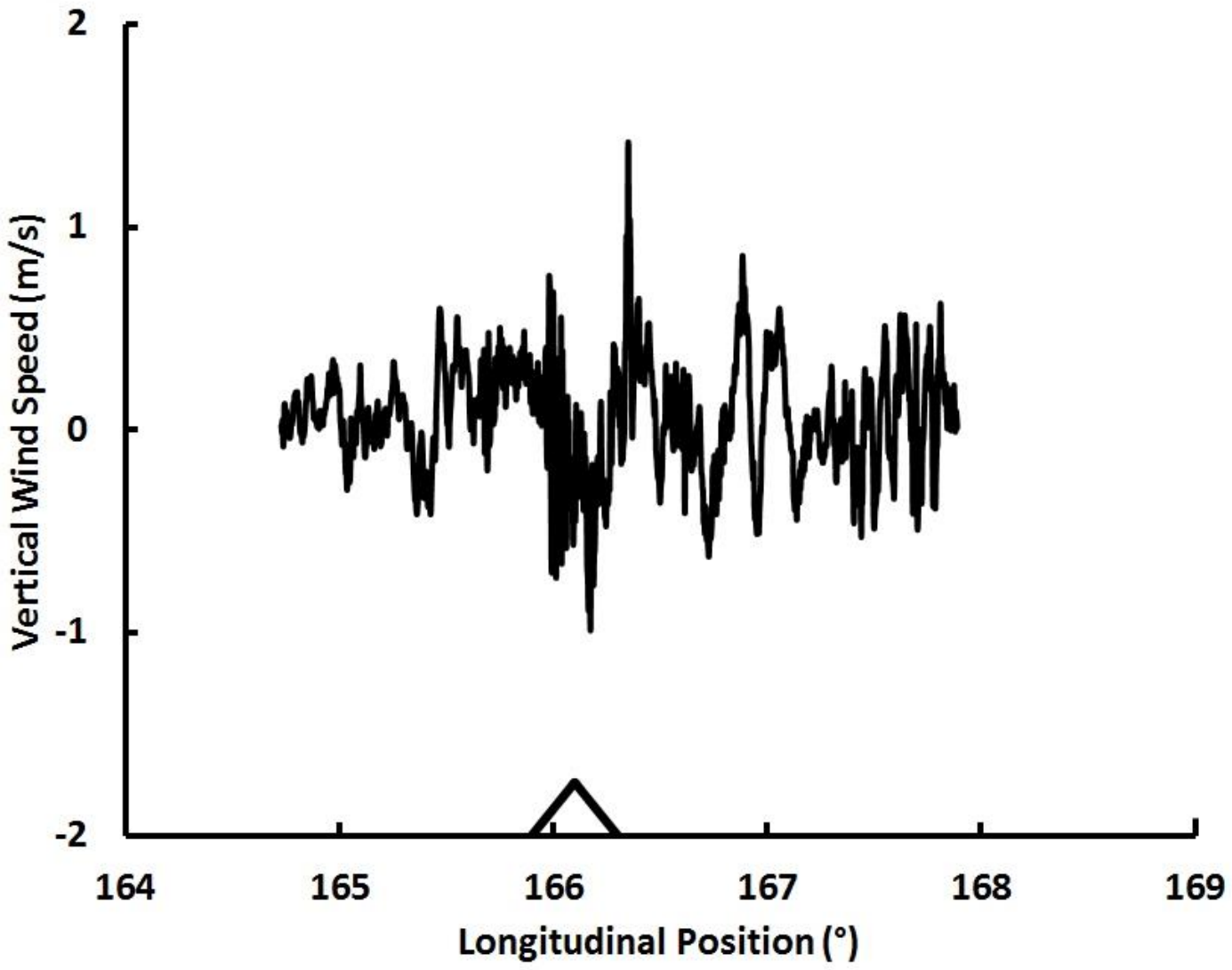


Auckland Islands
Maximum altitude 660 m

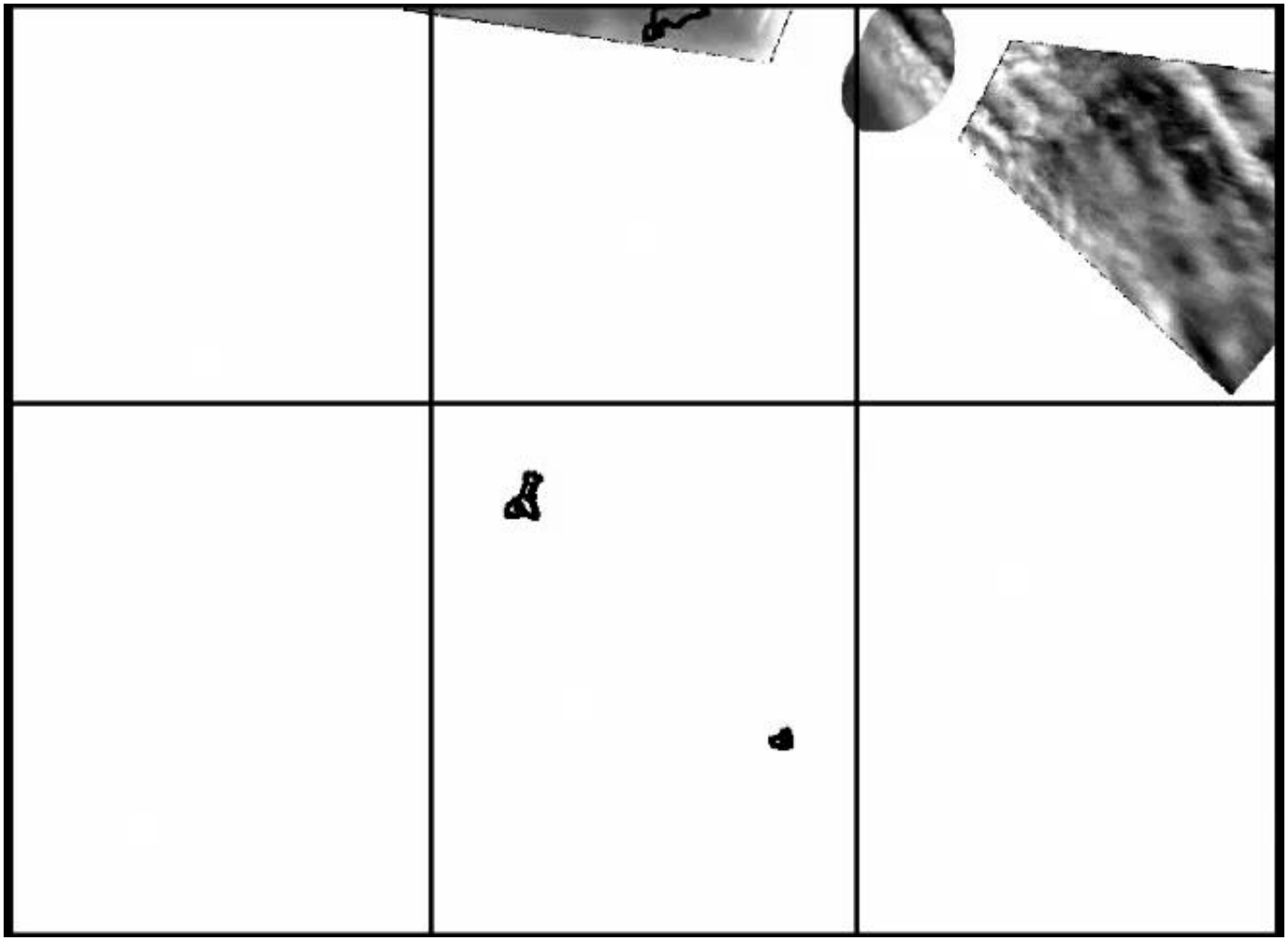
RF23 Flight Path



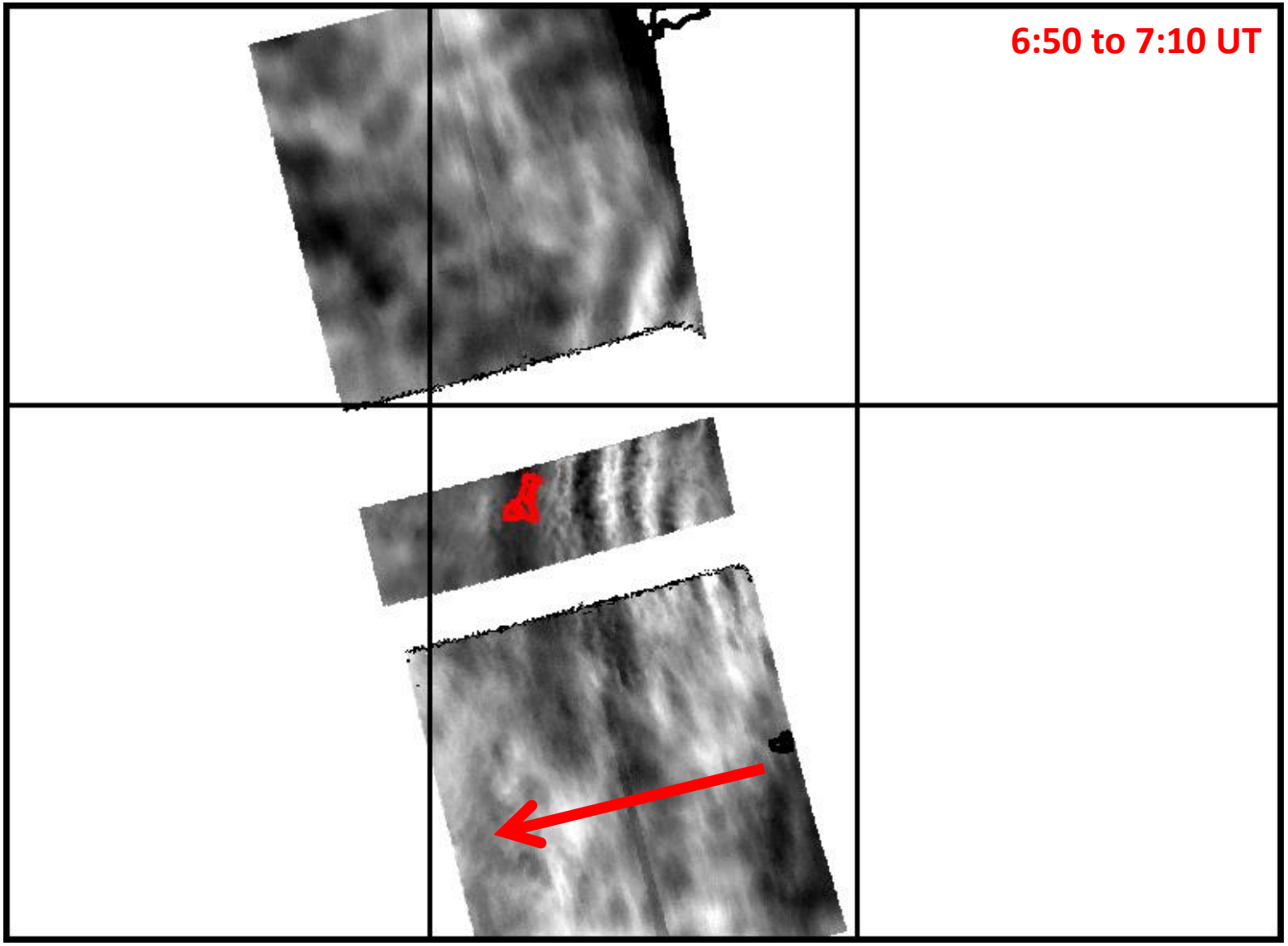
Vertical Wind Velocity at 11,900ft (Leg 1)



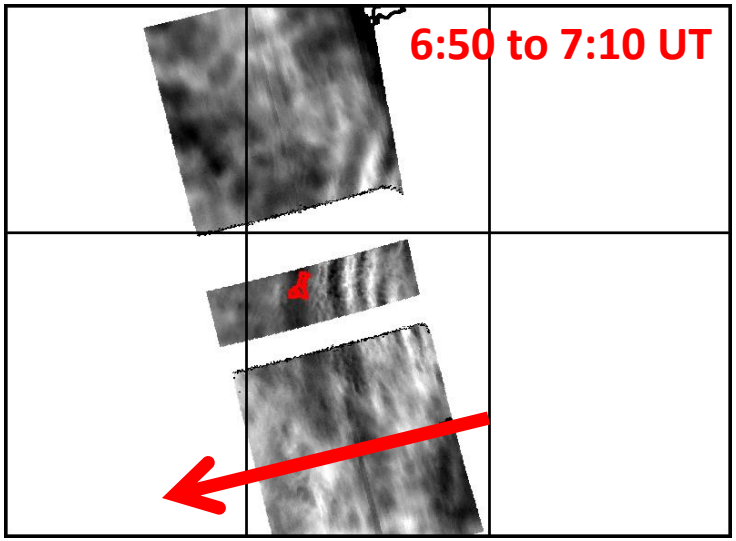
Orographic Waves over Southern Ocean Islands - RF23

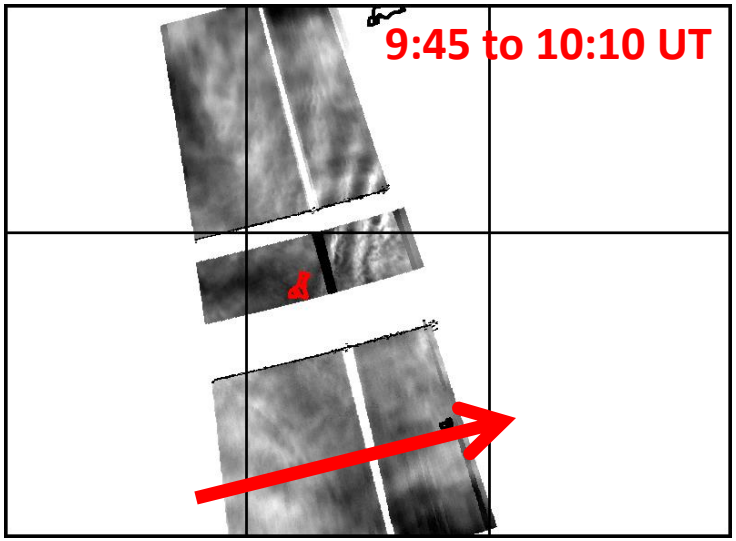


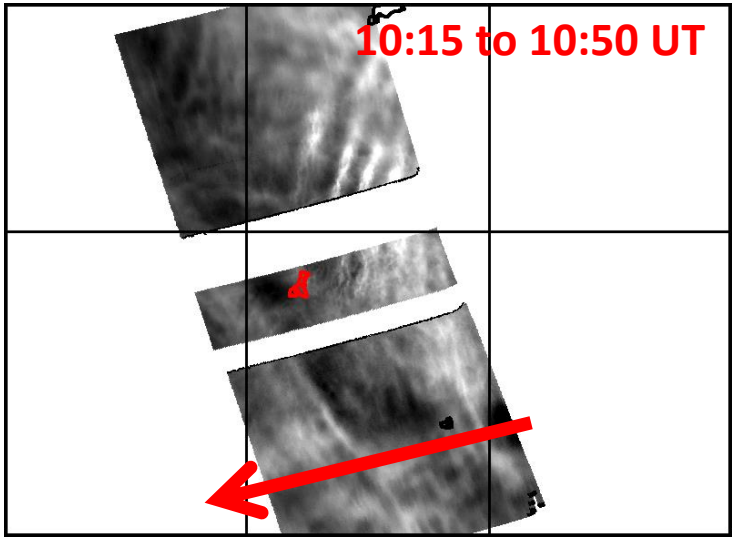
OH Brightness Mapping (87km)

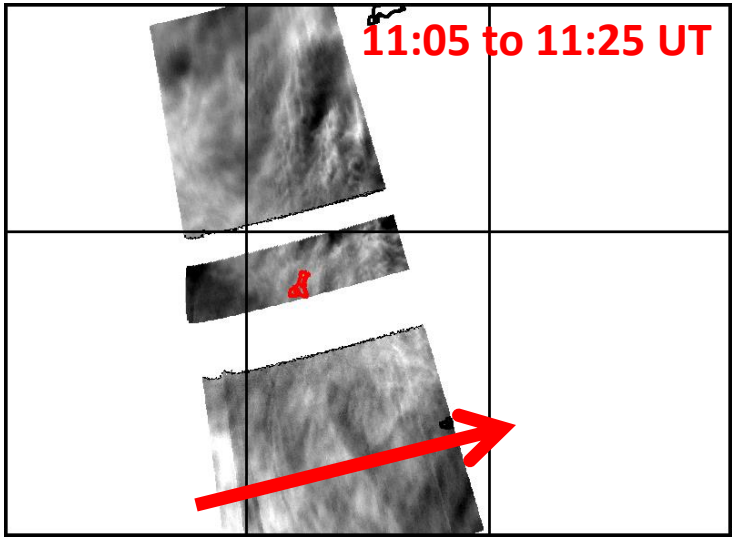


Evolution of the Orographic Waves Generated over Auckland Islands

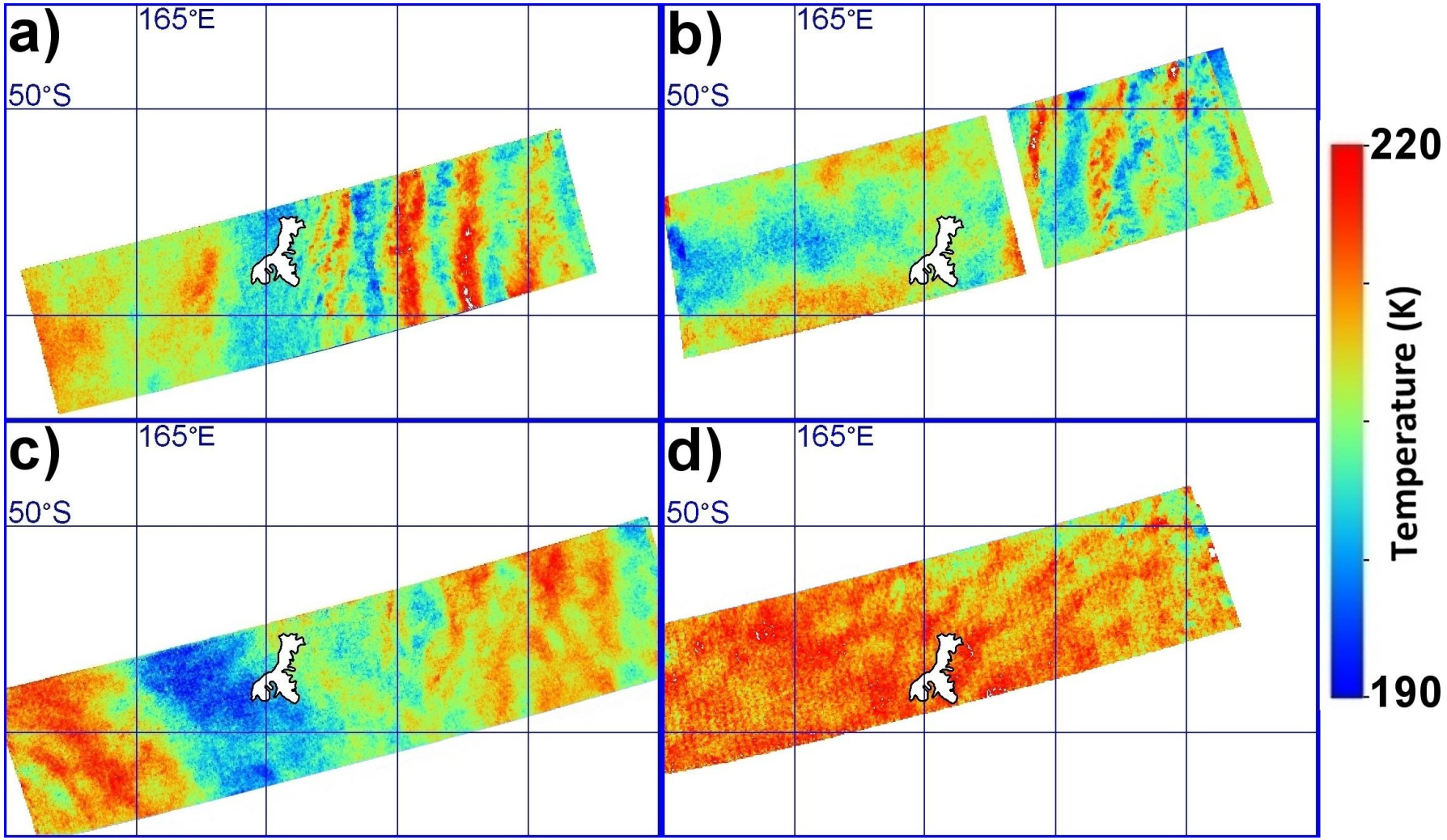




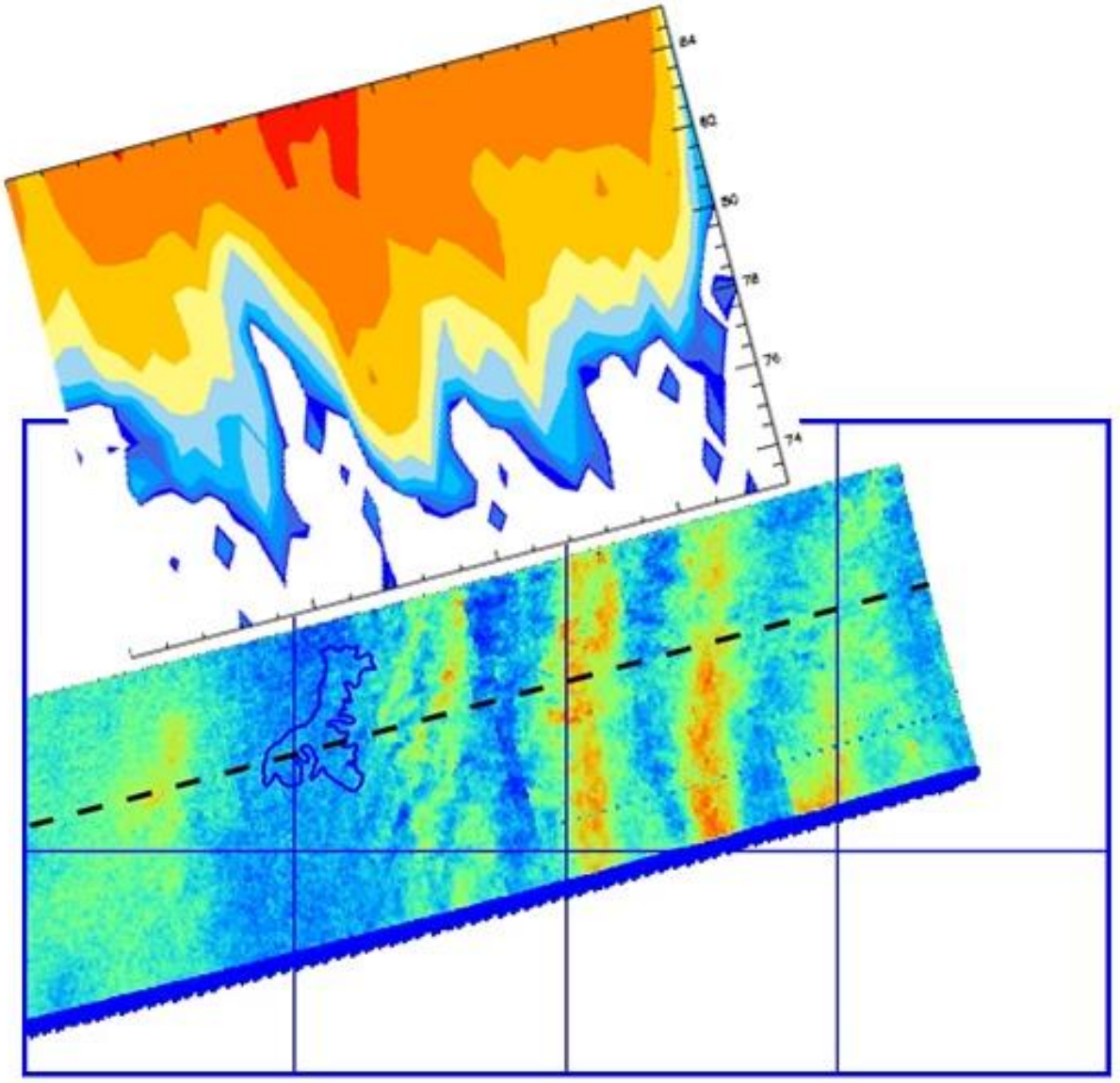




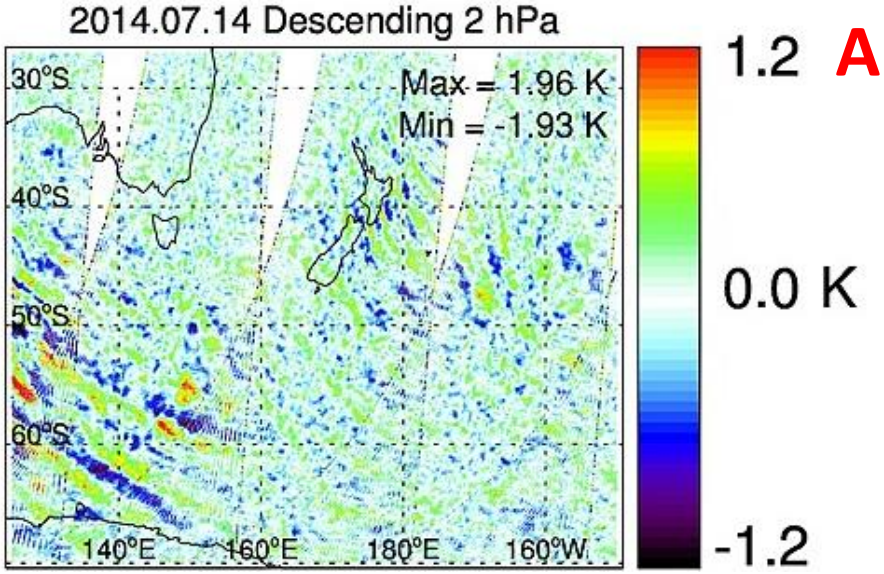
Temperature Keograms



Comparison with Na Lidar Mixing Ratio

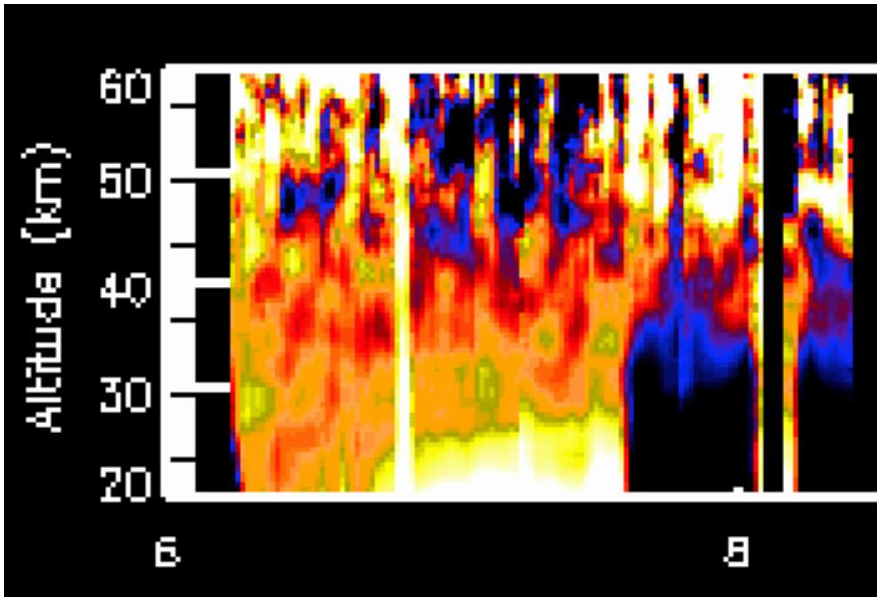


Middle Atmosphere Data



AIRS

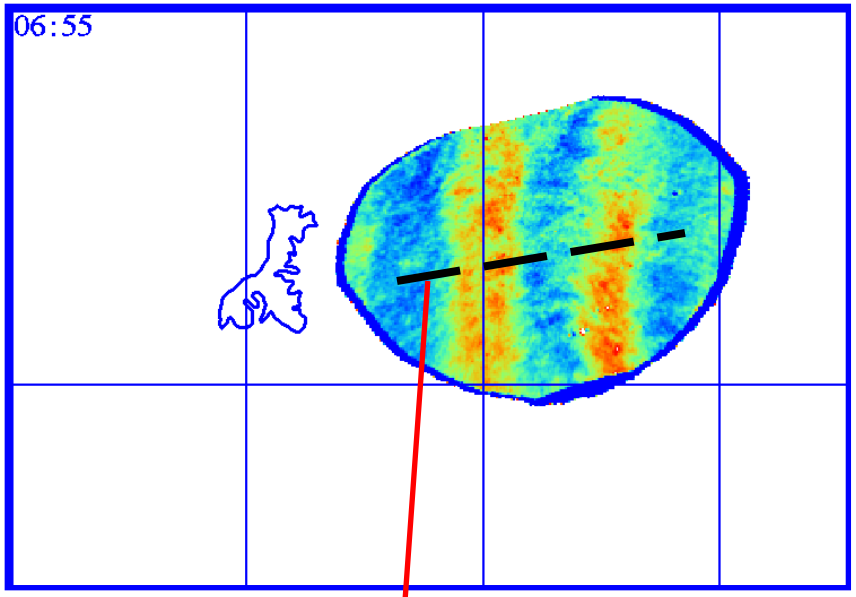
GV Rayleigh Lidar
(Off after the first leg)

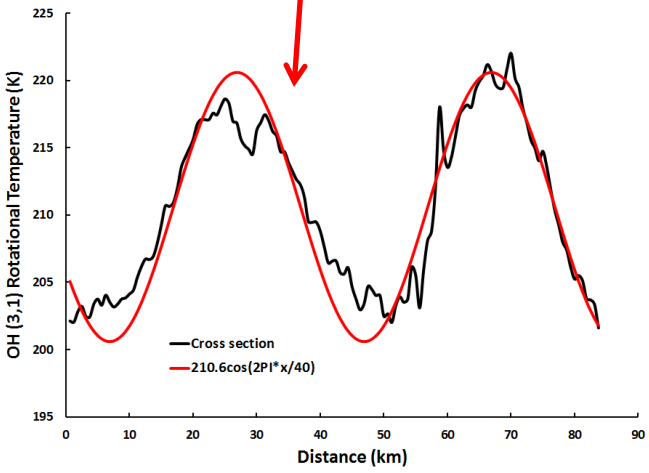


Nothing obvious in stratospheric data:

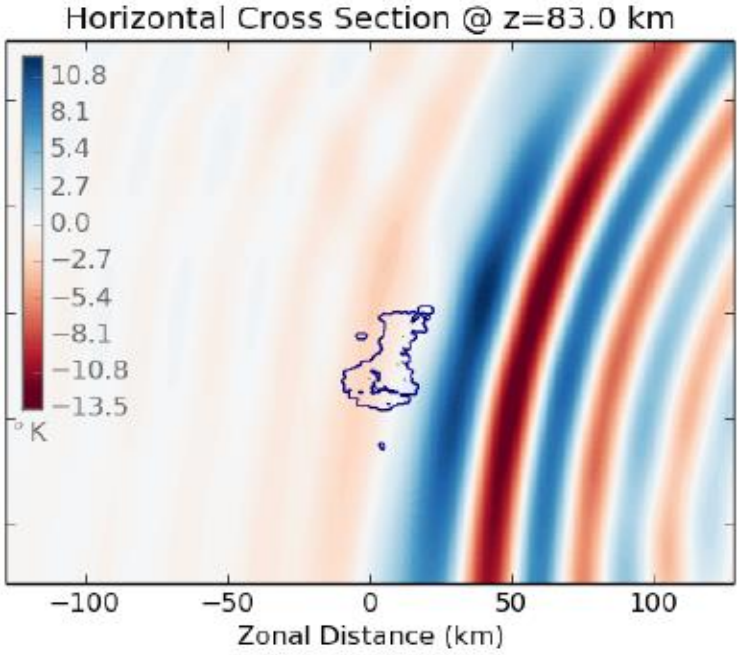
- **Amplitude too small (lidar)?**
- **Wavelength too short (AIRS)?**

Measured Temperature Perturbations

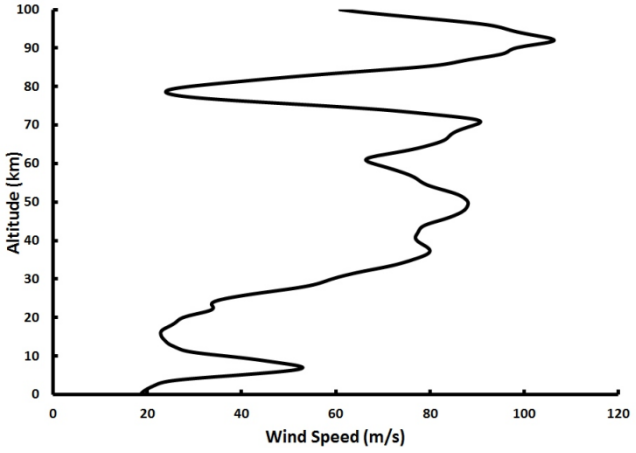


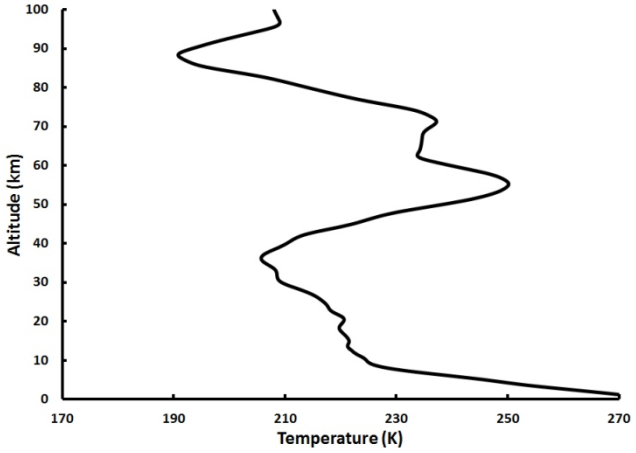


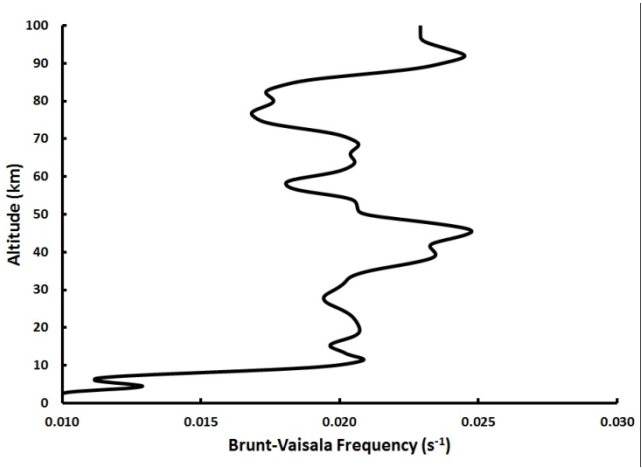
- 4 crests
- Horizontal wavelength ~40km
- Maximum temperature perturbation ~20K peak-to-peak (amplitude ~4.8%)
- Similar to FR simulation at ~83km



NAVGEM Re-Analysis Data







Wind speed in the direction of the wave

Temperature

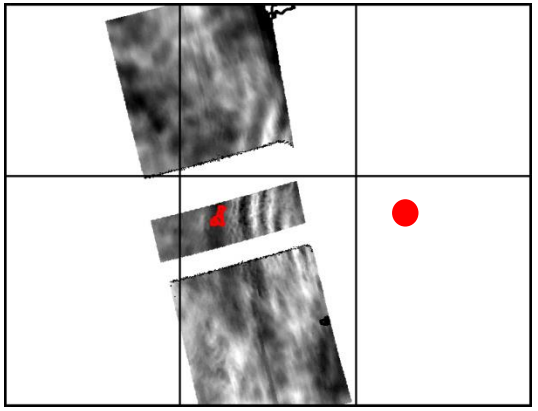
Brunt-Vaisala frequency

Momentum Flux Calculation

$$< u_h 'w' >= \frac{g^2 \omega_i}{2N^3} \sqrt{1 - \frac{\omega_i^2}{N^2}} \left(\frac{< T' >}{T_0} \right)^2 \frac{1}{C^2}$$

(Fritts et al., 2014)

ω_i, intrinsic frequency
N, Brunt-Väisälä frequency (from Na lidar)
$<T'>/T_0$, temperature perturbation (from AMTM)

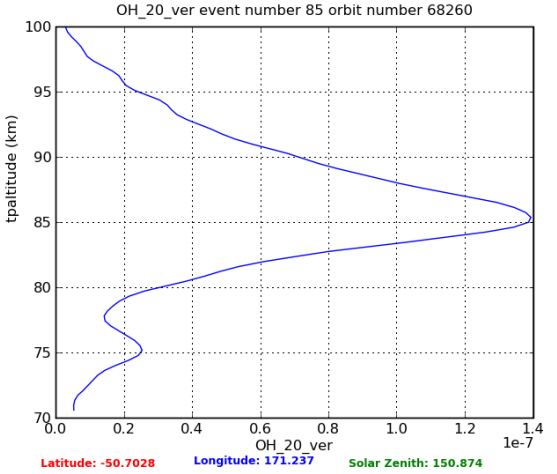


C^2, GW temperature variance reduction due to phase averaging for GW vertical wavelengths less than ~twice the OH layer FWHM:

$$C = \frac{< T' >}{T'(z_0)} = \exp\left(-3.56 \frac{z_{FWHM}^2}{\lambda_z^2} \right)$$

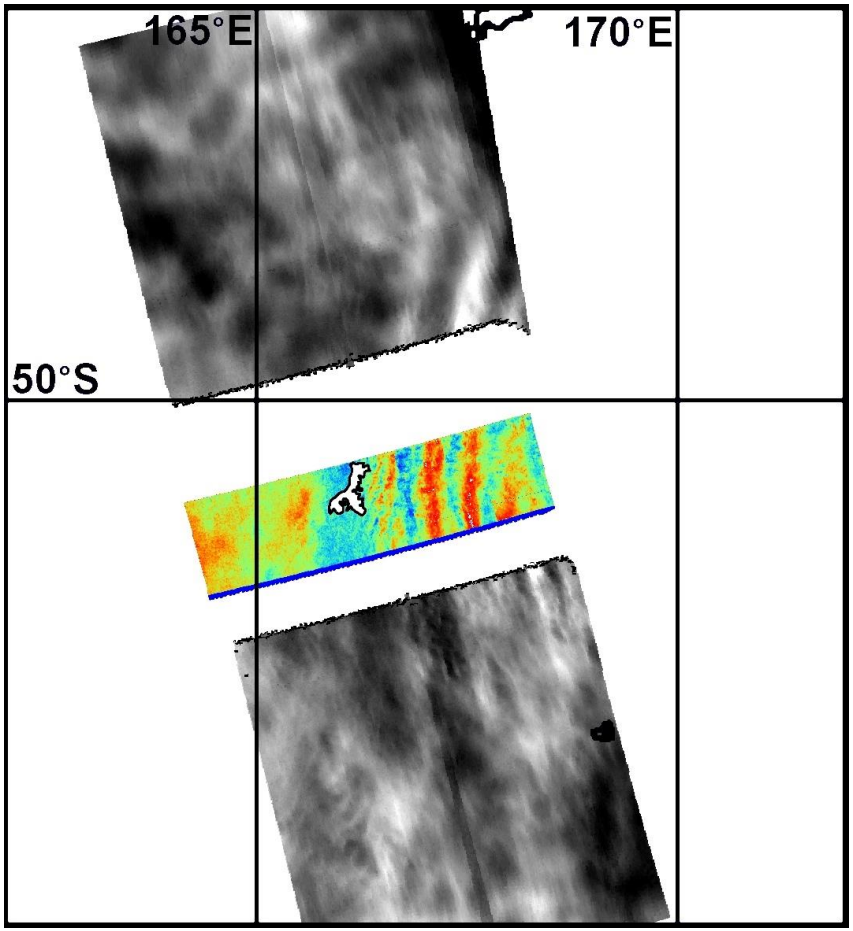
dT ~ 10K
T ~ 210K
dT/T ~ 4.8%

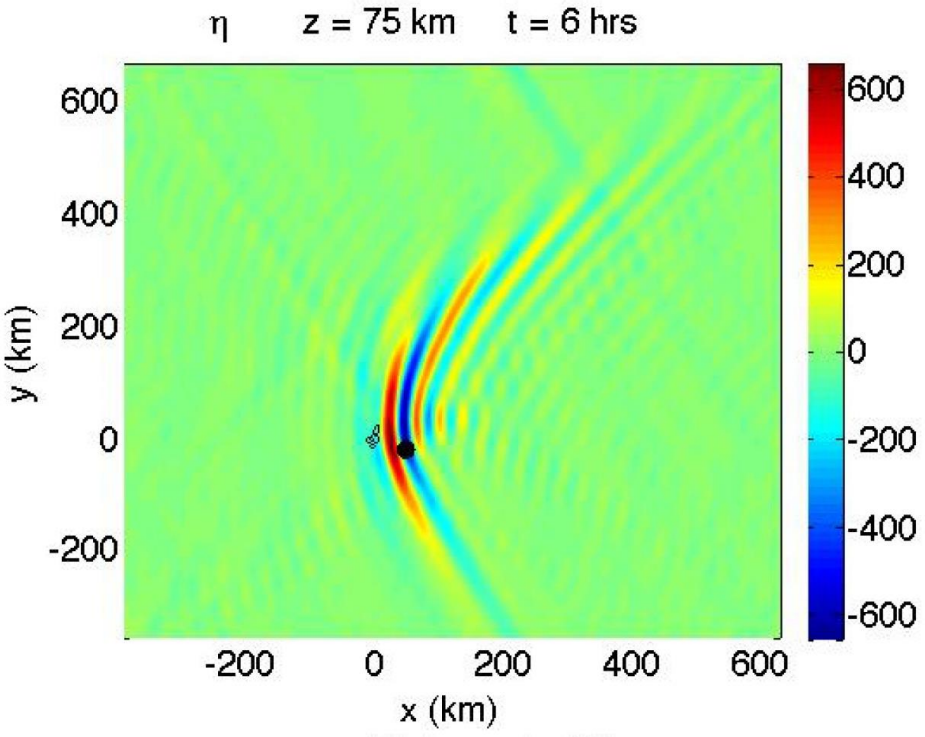
$<u'_h w'> \sim 200\ m^2/s^2$



SABER OH profile at 12:50:34

FR Model (Broutman et al., 2015)

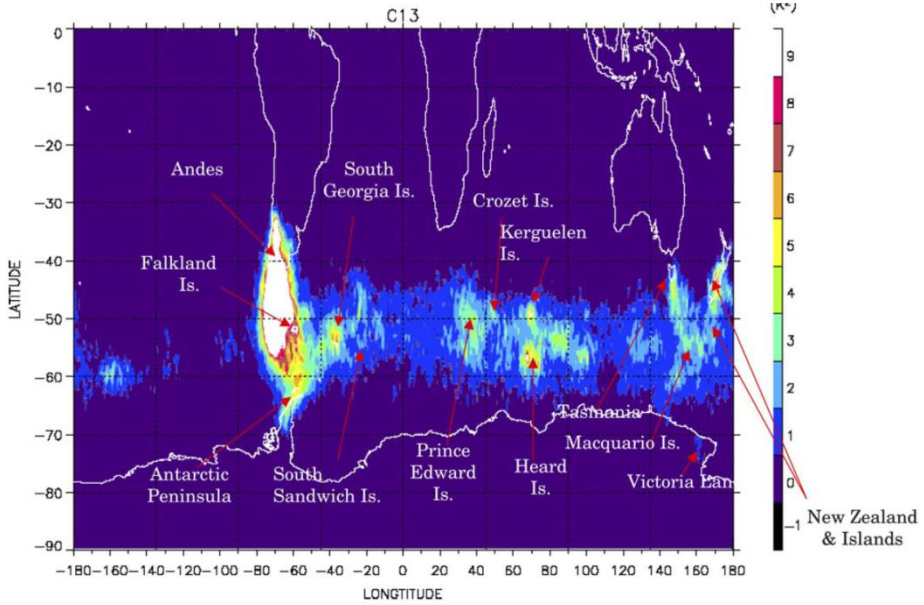




Observations ~85km

Summary

- Tropospheric wind blowing on a small isolated island can generate massive orographic wave responses in the mesosphere under the right conditions
- Evidence of wave breaking depositing large momentum fluxes
- Model simulation accurately reproduces observed gravity wave characteristics
- **Clear evidence for mountain wave deep propagation from the troposphere up to the MLT region**



AMSU-A GW variances at 5hPa
Wu et al., 2006