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

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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)

6:50 to 7:10 UT
Evolution of the Orographic Waves Generated over Auckland Islands

6:50 to 7:10 UT

9:45 to 10:10 UT

10:15 to 10:50 UT

11:05 to 11:25 UT
Temperature Keograms

a) 165°E 50°S

b) 165°E 50°S

c) 165°E 50°S

d) 165°E 50°S

Temperature (K)
Comparison with Na Lidar Mixing Ratio
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
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)

\( \omega_i \), 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 \( \sim \) twice the OH layer FWHM:

\[
C = \frac{< T' >}{T'(z_0)} = \exp \left( -3.56 \frac{Z_{\text{FWHM}}^2}{\lambda_z^2} \right)
\]

\( dT \sim 10K \)
\( T \sim 210K \)
\( dT/T \sim 4.8\% \)

\( < u'_h w' > \sim 200 \text{ m}^2/\text{s}^2 \)
FR Model (Broutman et al., 2015)

Observations ~$85\text{km}$
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