Lidar observations of gravity waves in the middle atmosphere over Lauder, New Zealand

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26th IUGG
June 29, 2015
Prague

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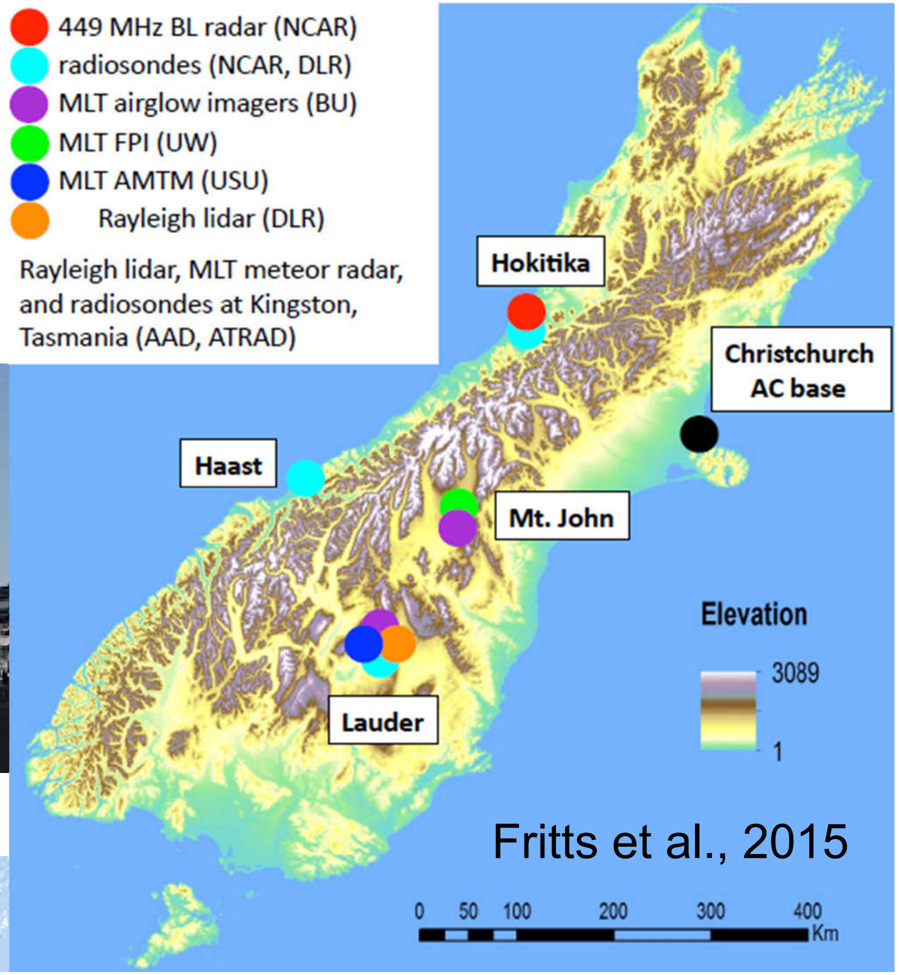
International DEEPWAVE campaign, New Zealand

- Study dynamical coupling processes by gravity waves (GW) from 0-120 km
- Characterize the life cycle of GW: excitation, propagation, and dissipation
- Combining various instruments and models

Radiosondes, Lauder

DEEPWAVE NZ 2014



DLR Falcon, NCAR GV in CHC, 28. June 2014

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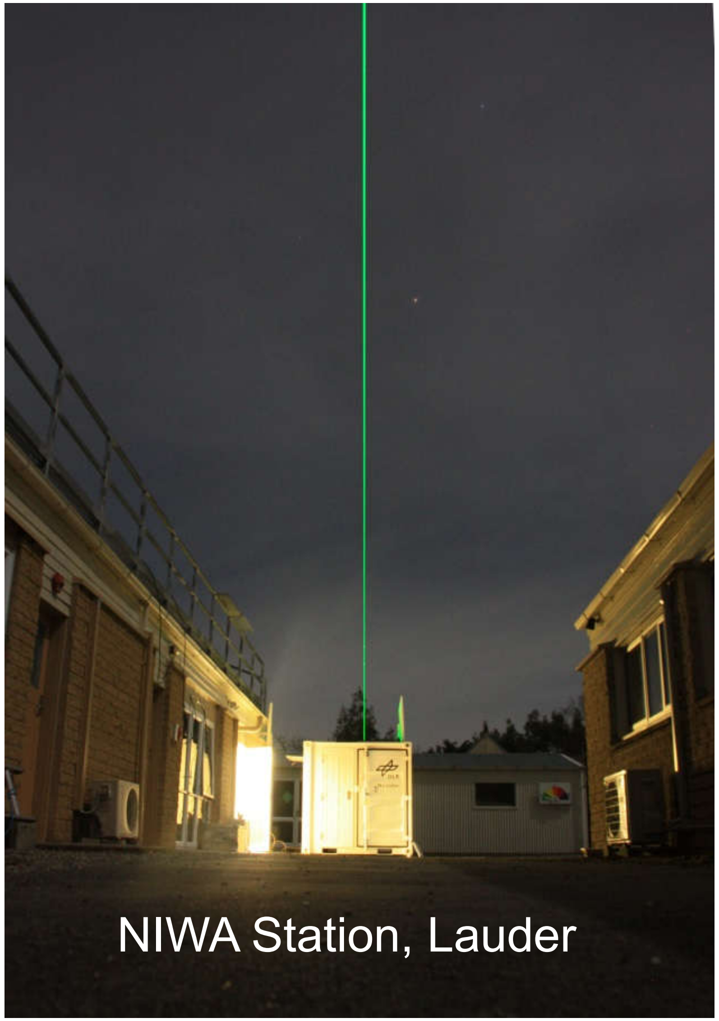
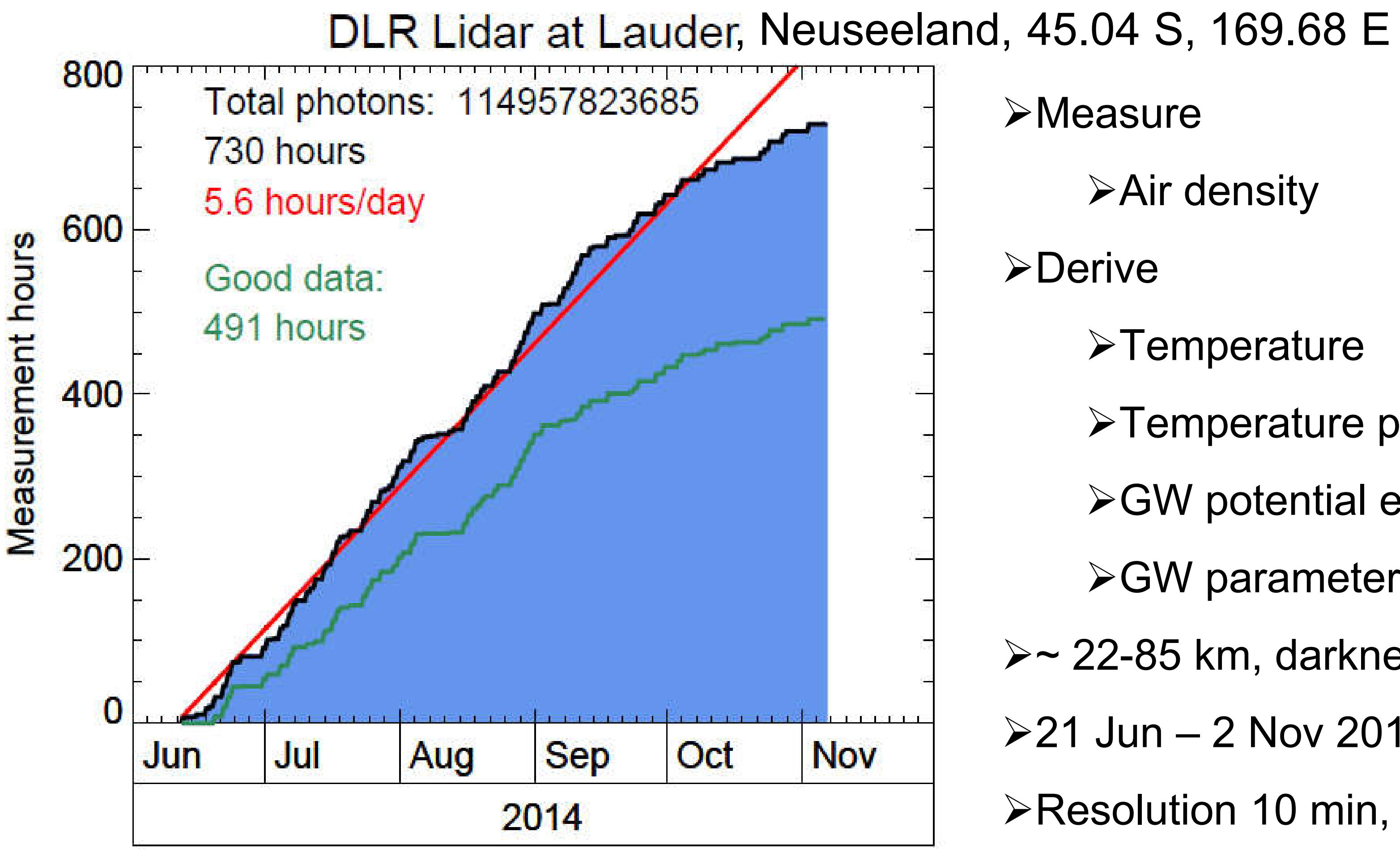
TELMA – new DLR Rayleigh-Lidar


NIWA Station, Lauder

- Active optical measurement of atmospheric Rayleigh backscatter
- Sender: 12 W-Laser, 532 nm, 100 Hz
- Receiver: 63 cm telescope, 200 µrad FOV; 2 Rayleigh and 1 Raman-channel
- Built into customized 8-foot-container

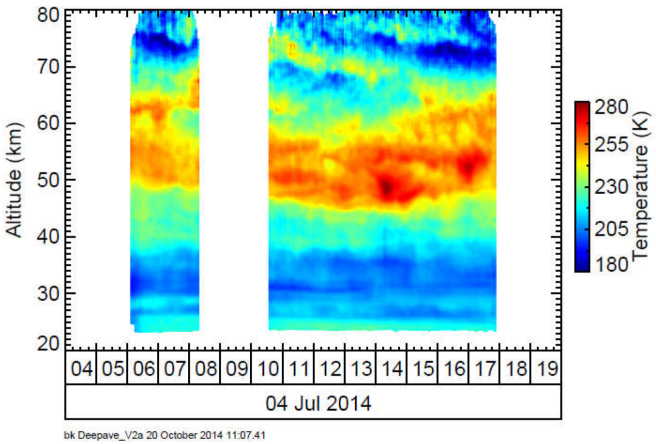
Lidar dataset



- Measure
    - Air density
- Derive
    - Temperature
    - Temperature perturbation
    - GW potential energy density
    - GW parameters
- ~ 22-85 km, darkness
- 21 Jun – 2 Nov 2014
- Resolution 10 min, 900 m

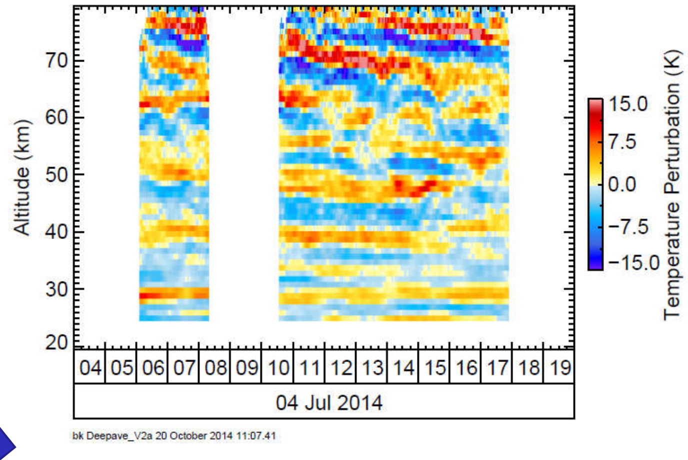
Derivation of temperature perturbation and GWPED

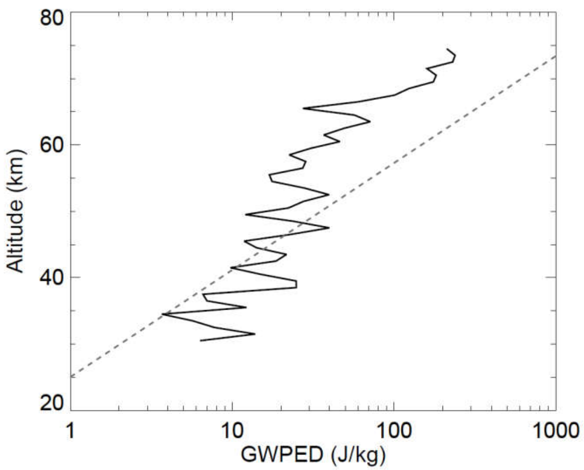
10 min x 900 m T-profile



Removal of background temperature

Temperature perturbation

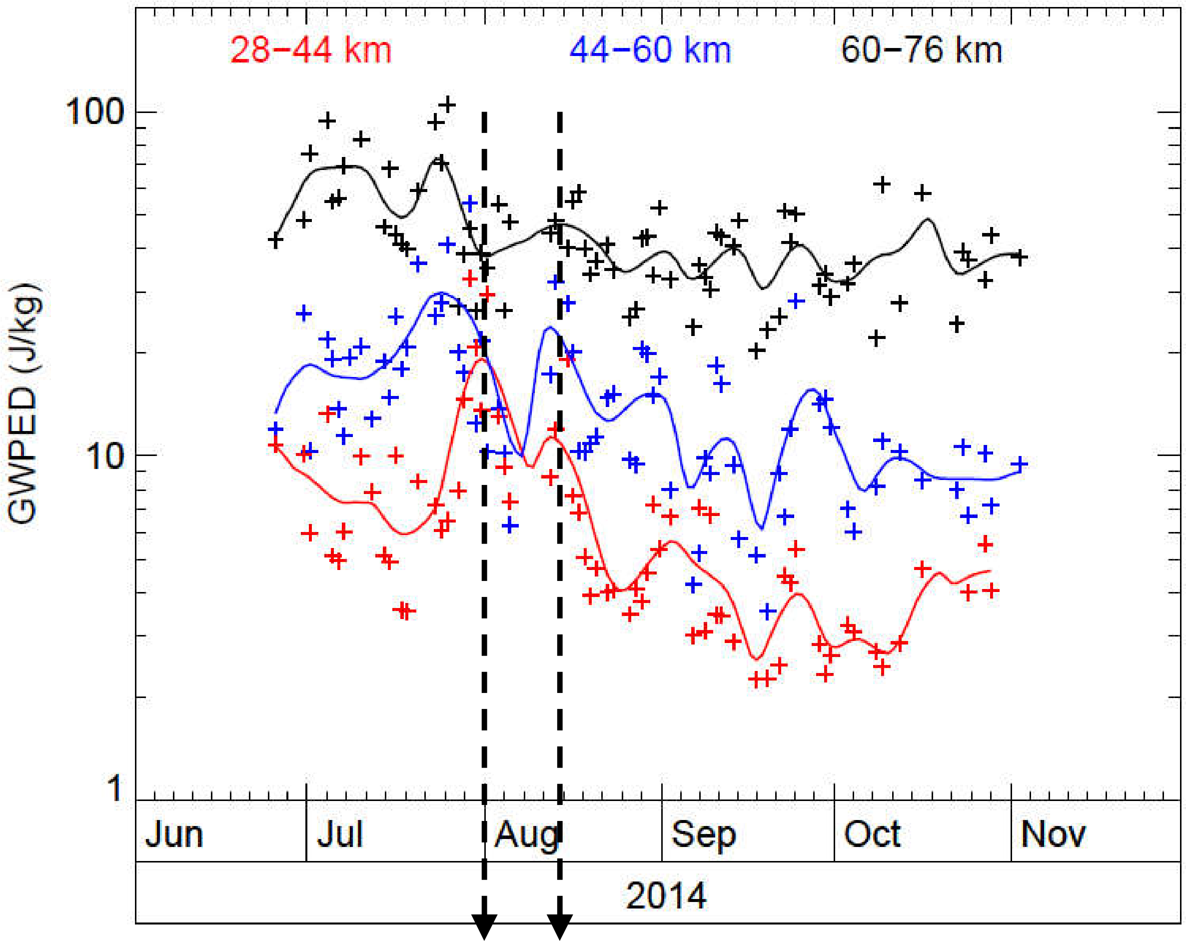




Gravity wave potential energy density GWPED:

$$E_p(z) = \frac{1}{2}\frac{g^2}{N^2(z,t)}\overline{\left(\frac{T'(z,t)}{T_0(z,t)}\right)^2}$$

Gravity wave potential energy density (GWPED)

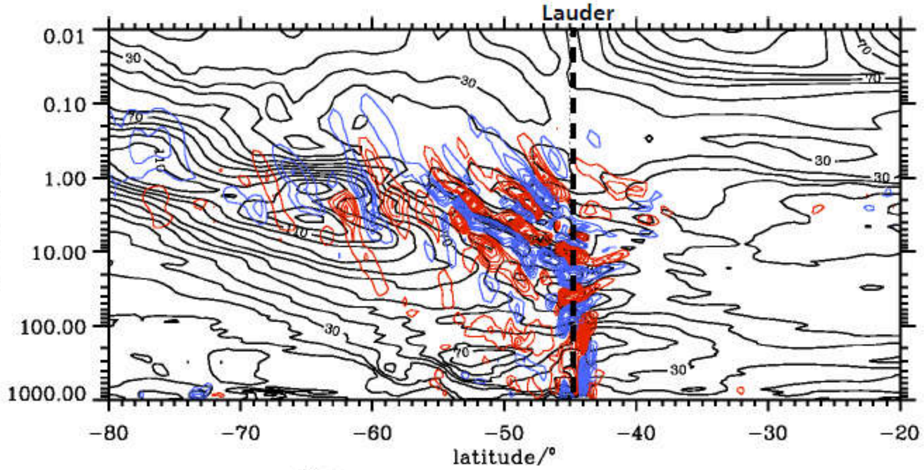


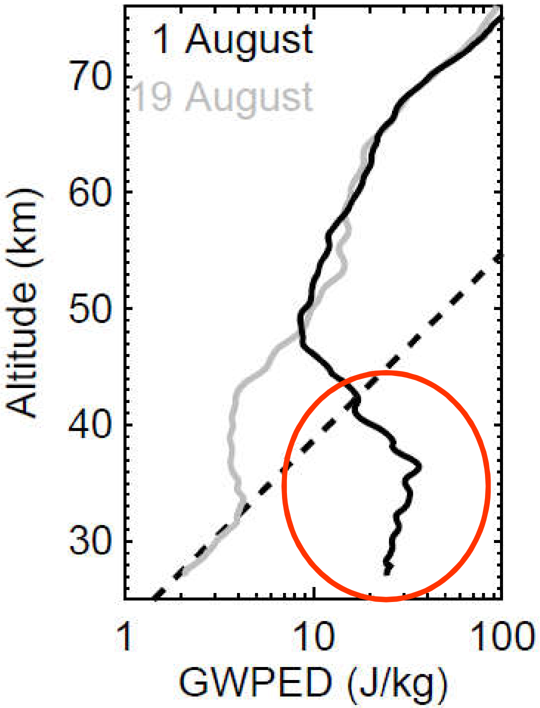
Mountain waves: No „deep propagation“?

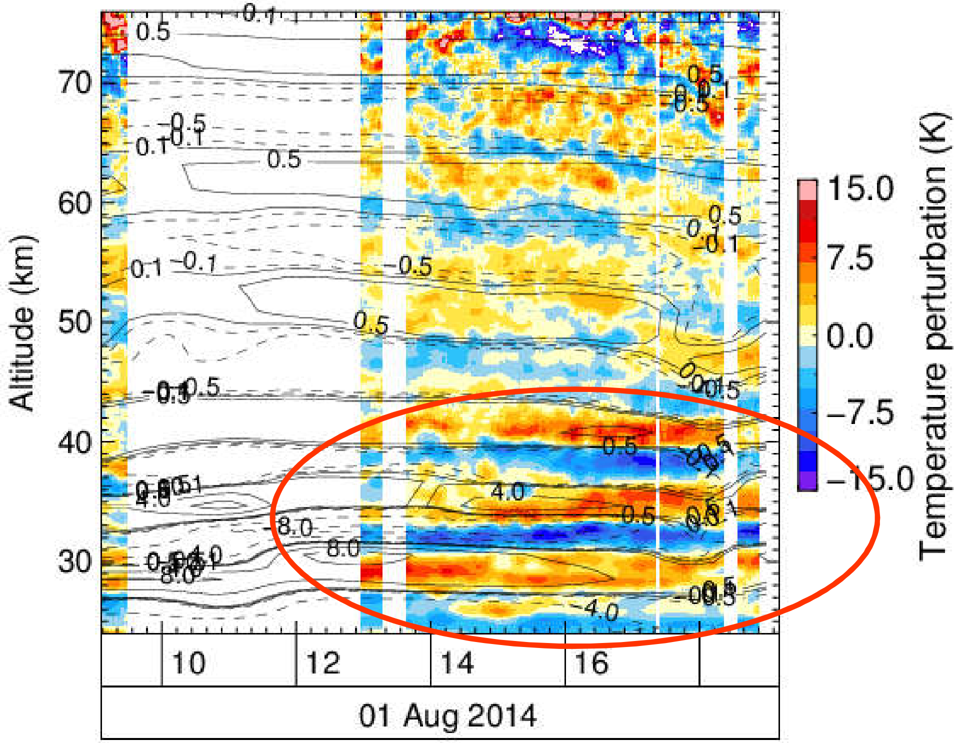
Mountain waves on 1 Aug 2014 (GB21)

- High tropospheric wind speed
- Enhanced stratospheric GWPED
- Stationary waves with short vertical wavelength (~ 6 km)

ECMWF horizontal (black) and vetical wind (red/blue) at 170 °E, 12 UTC







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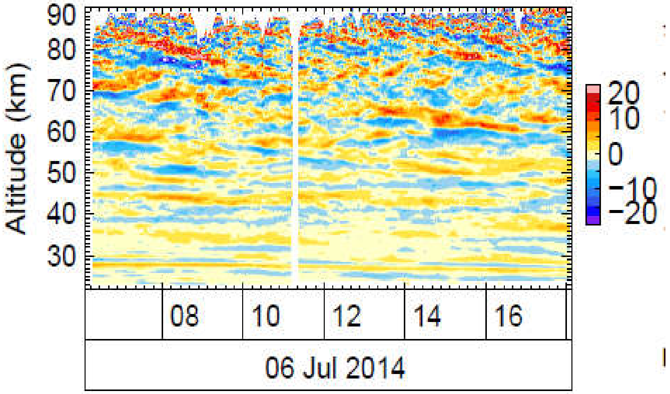
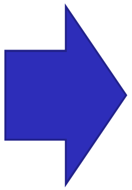
Distinction between GW types using 2d wavelets

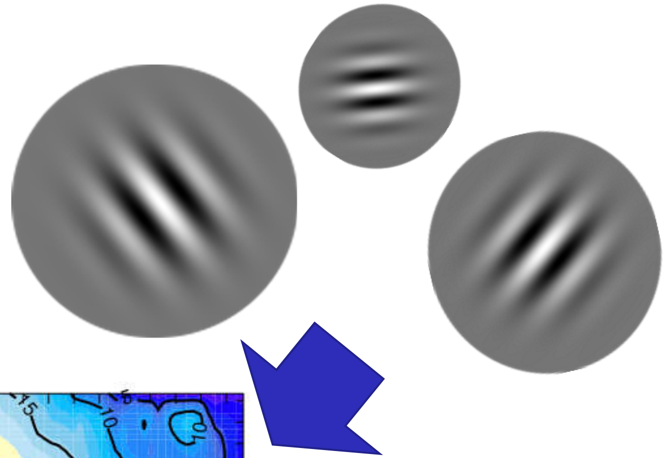
Temperature perturbation (K)



2d wavelet analysis

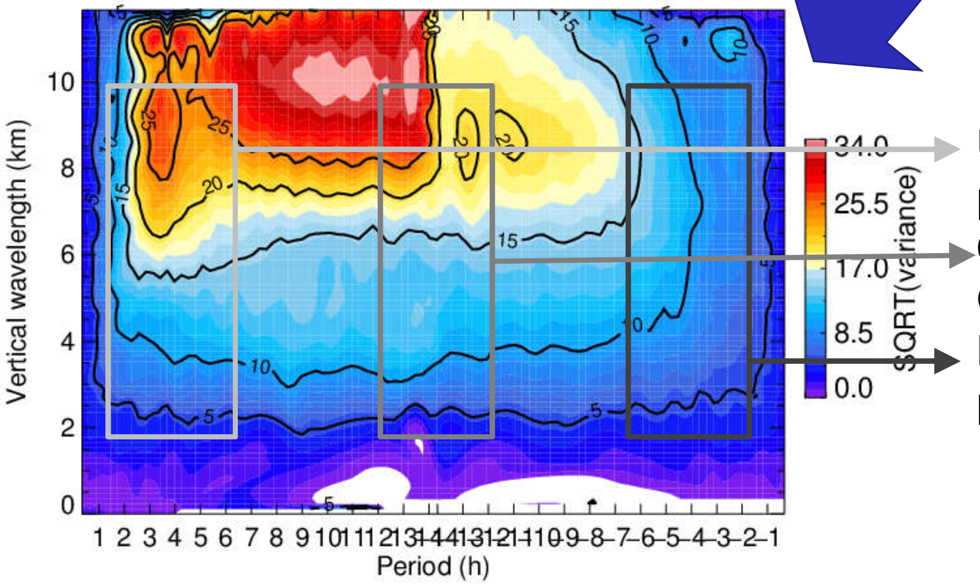


Directional 2d Morlet wavelets



Wavelet spectrogram

Variance as a function of
- Period (h)
- Vertical wavelength (km)



Upward-propagating GW

Quasi-stationary GW = MW

Downward-propagating GW

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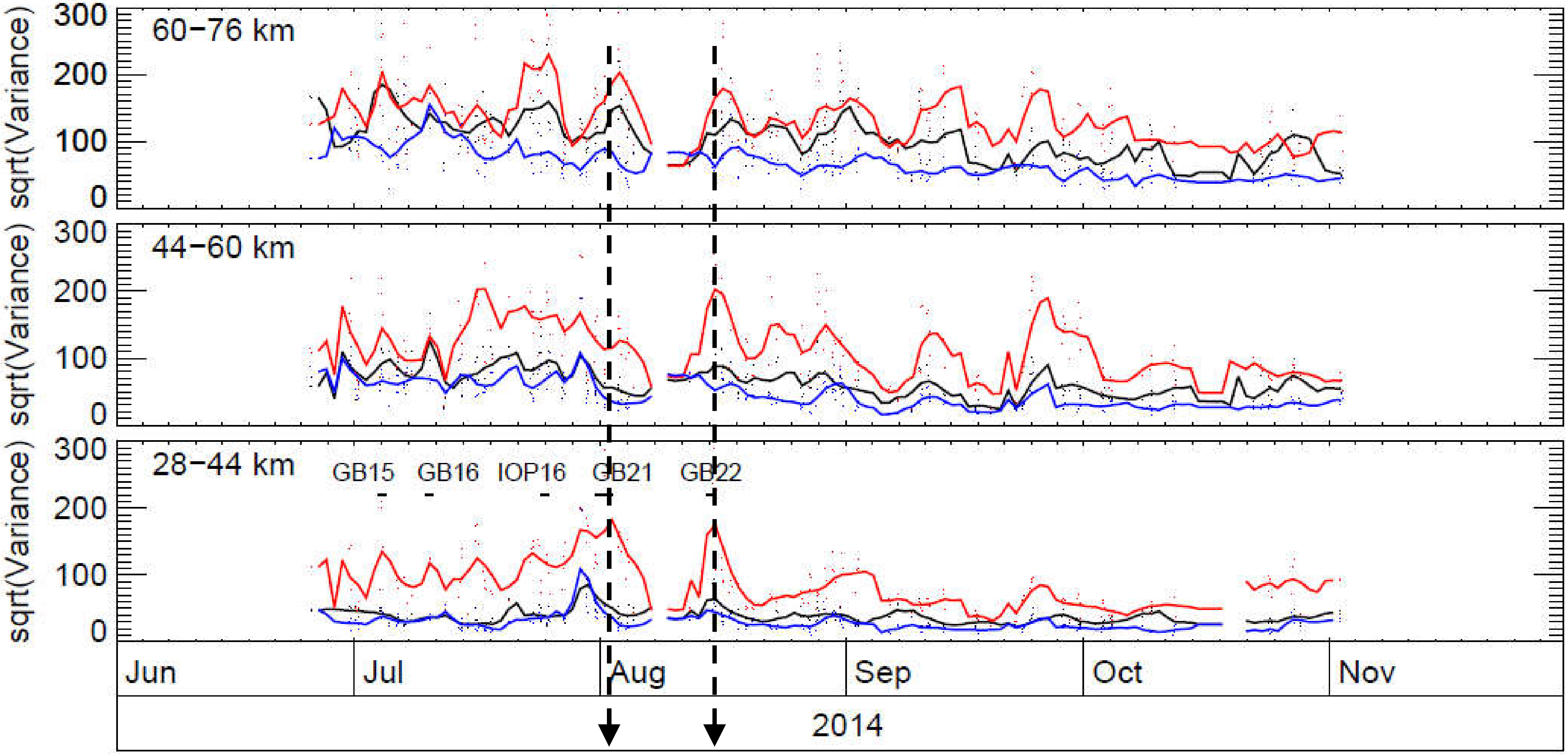
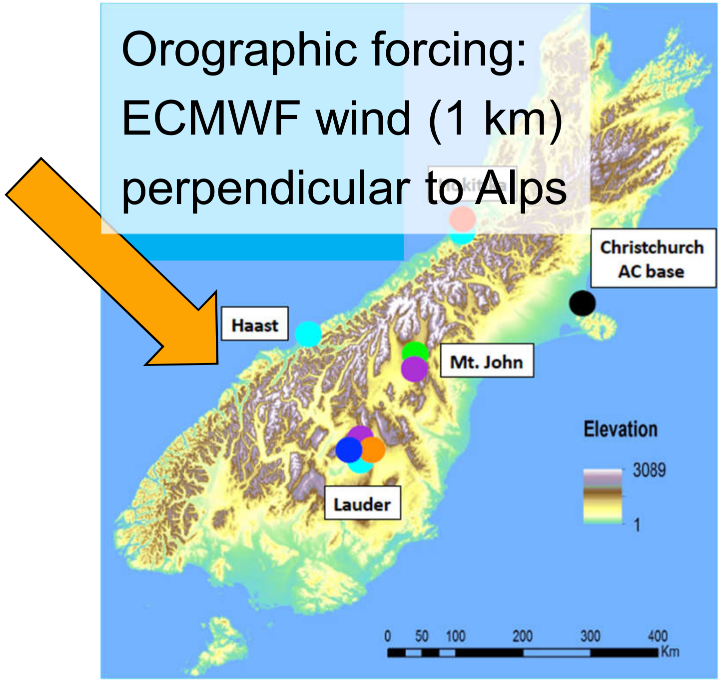
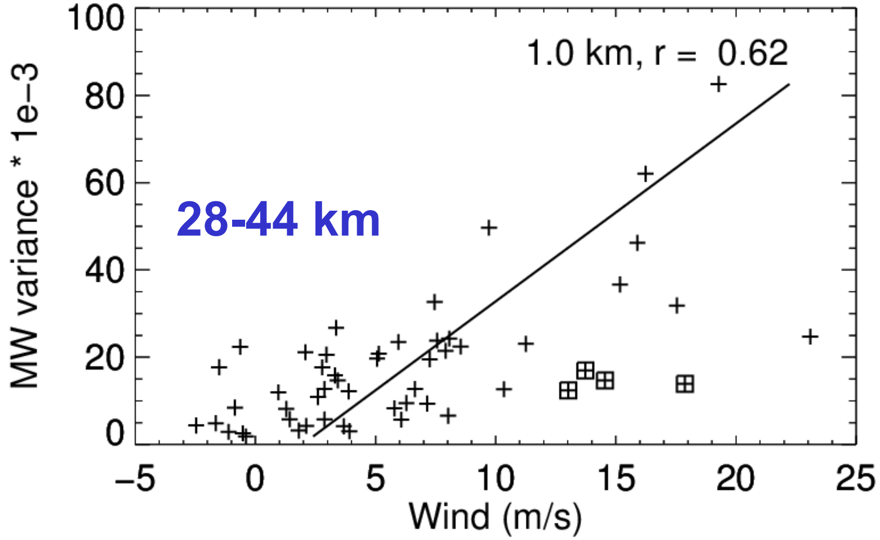
Lauder GW statistics

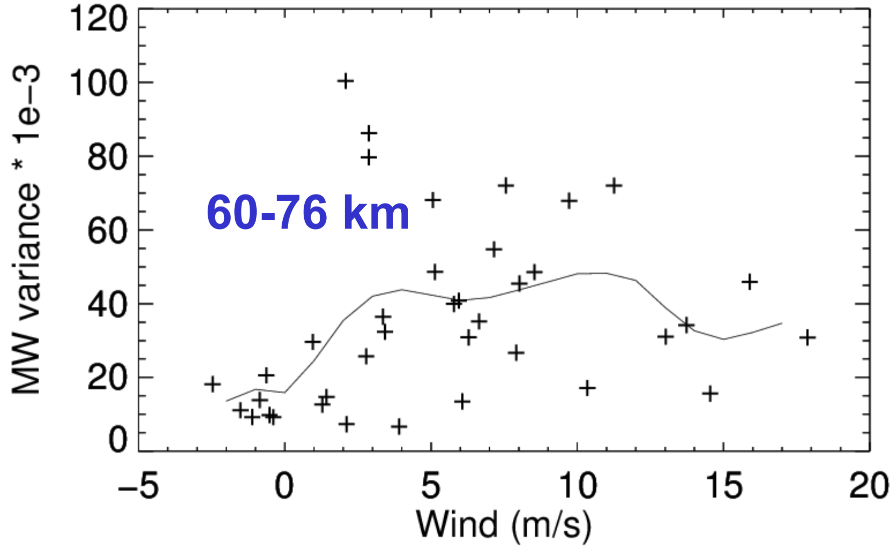
Quasi-stationary GW
Upward-propagating GW
Downward-propagating GW



Correlation of MW with tropospheric forcing



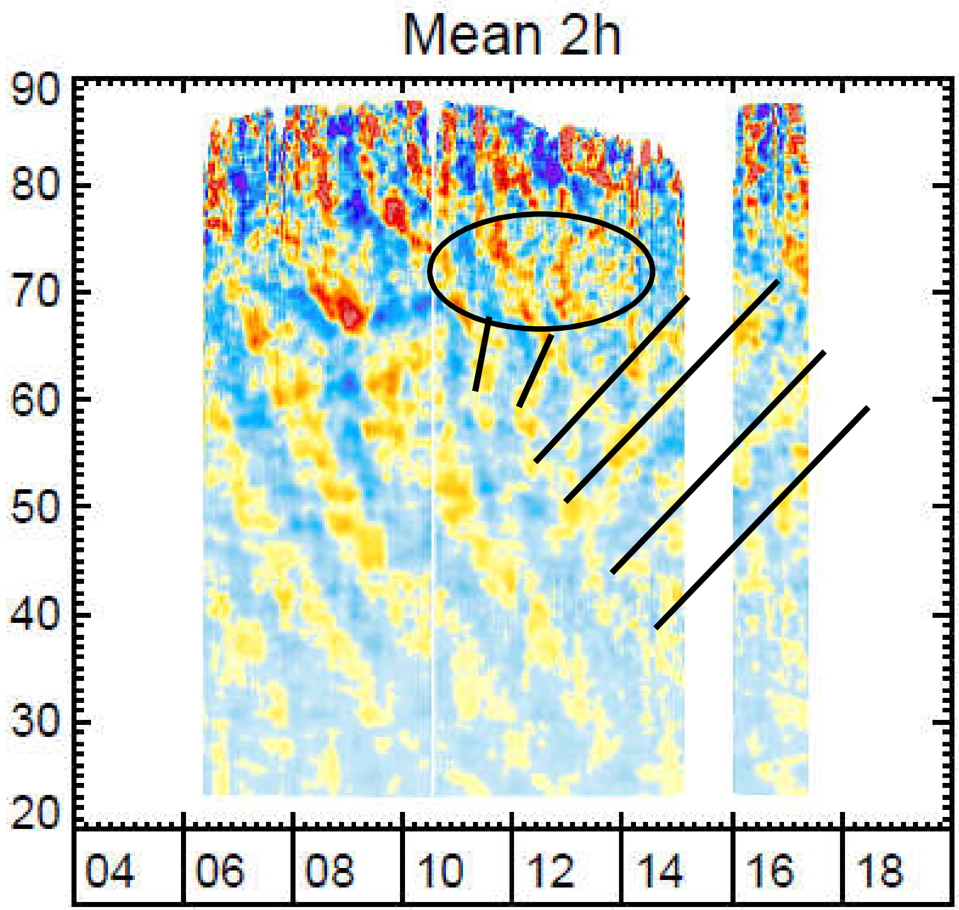




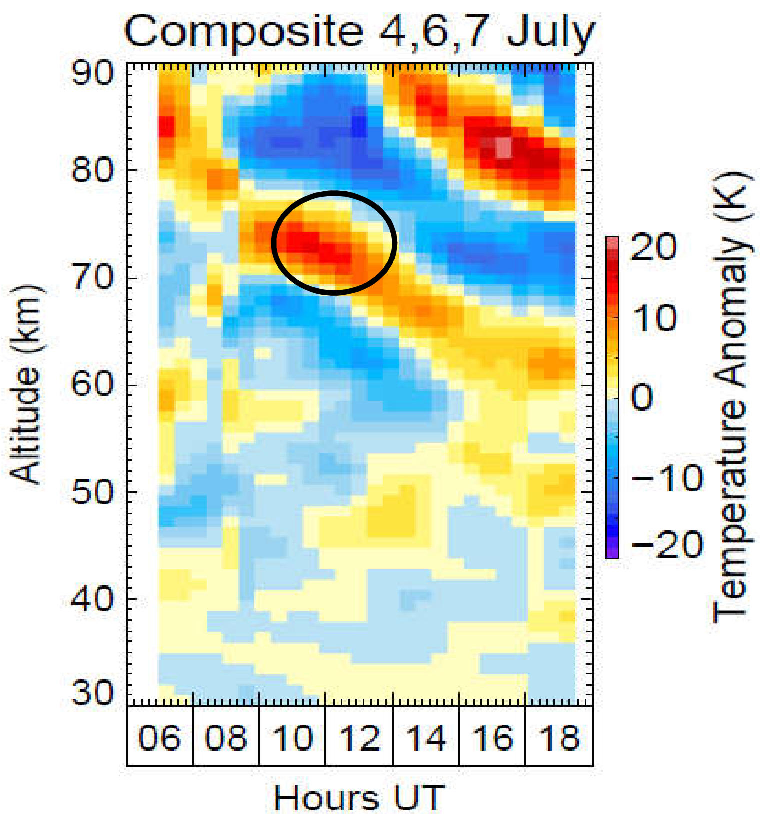
- ➢Stratospheric MW forced by upstream near-ground wind
- ➢Mesospheric MW during moderate forcing (2 m/s < w < 12 m/s)

Outlook: Secondary wave generation

➢Generation of secondary GW due to GW-tide interaction



7 July 2014



Summary

- Gravity wave observations by Rayleigh lidar during the DEEPWAVE campaign in winter 2014, New Zealand
- High-amplitude quasi-stationary GW in the stratosphere during strong tropospheric forcing
- Identification of mountain waves using 2d wavelet analysis
- Propagation of MW to mesopheric altitudes during moderate forcing

Thank you!