Gravity wave observations in the middle atmosphere at a mid-latitude southern-hemisphere site

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LPMR
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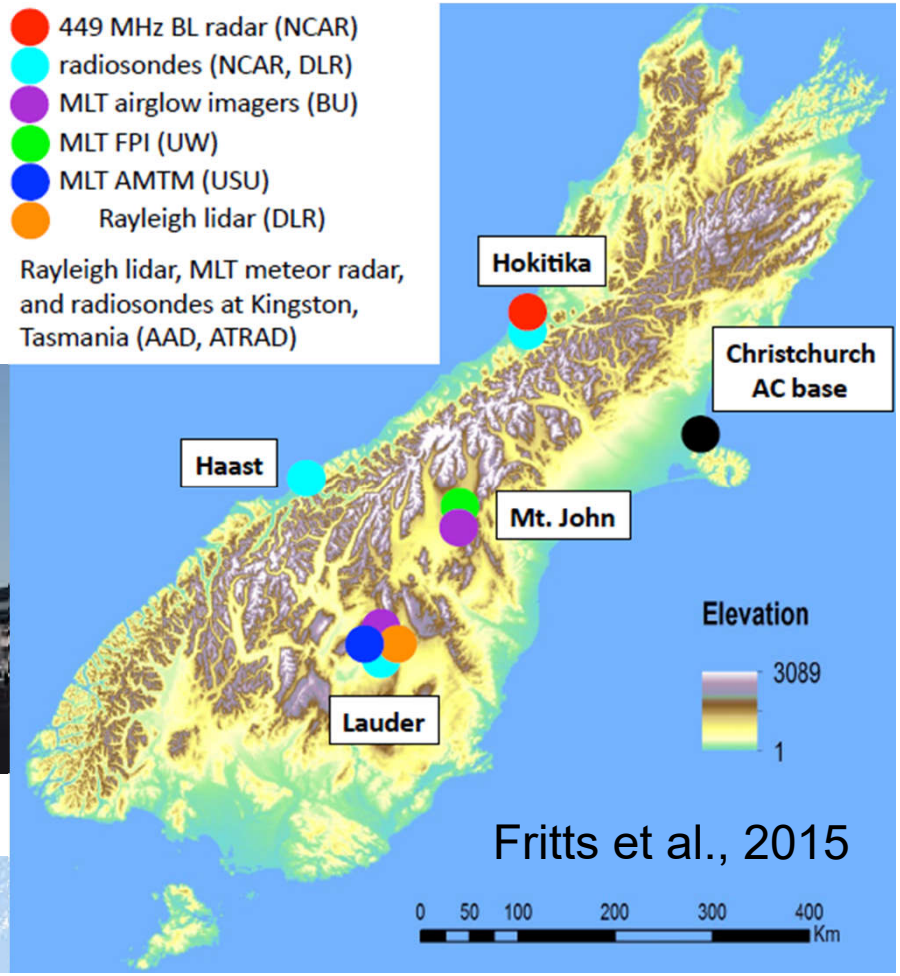
International DEEPWAVE campaign, New Zealand

- 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



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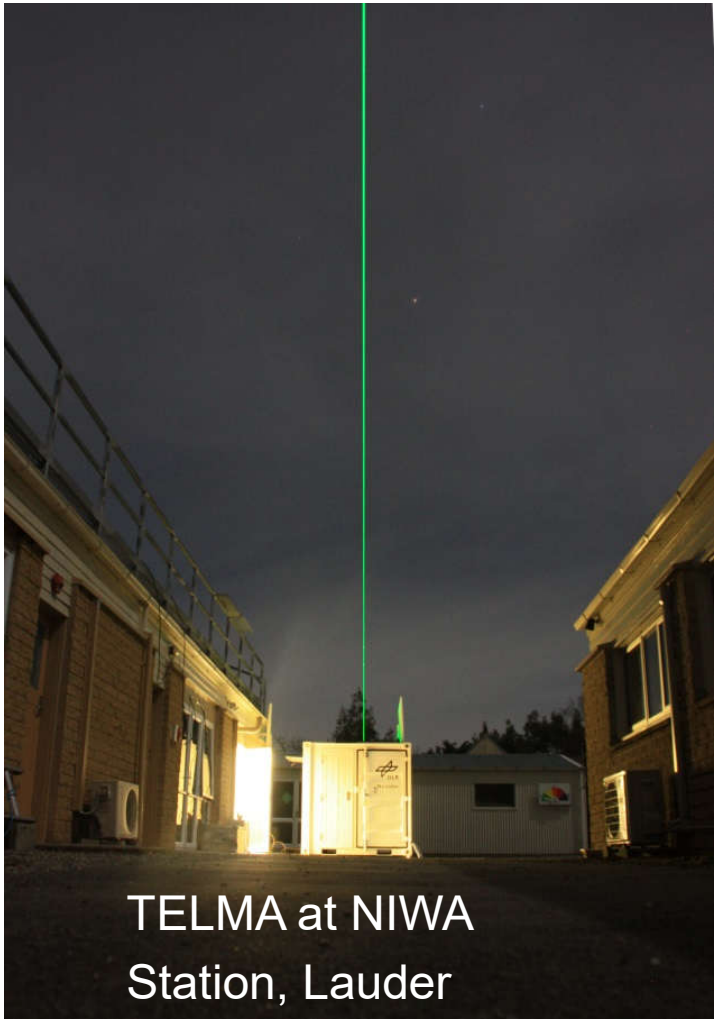
TEmperature Lidar for Middle Atmosphere research


TELMA at 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

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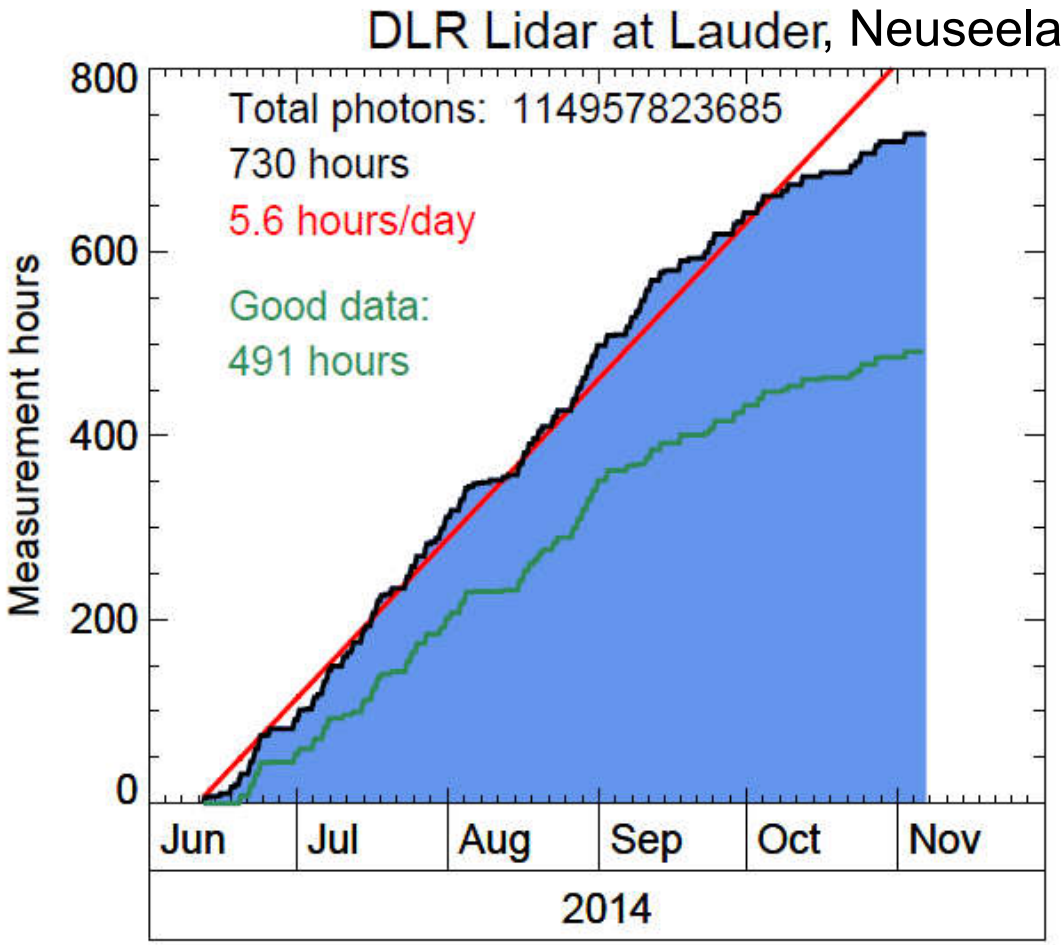
Lidar dataset



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

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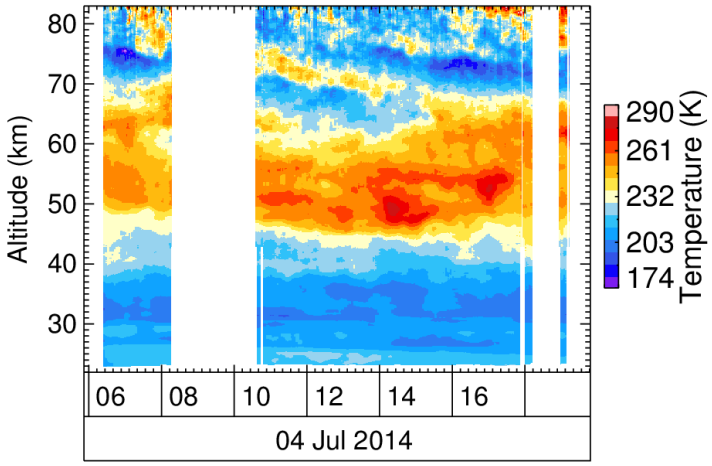
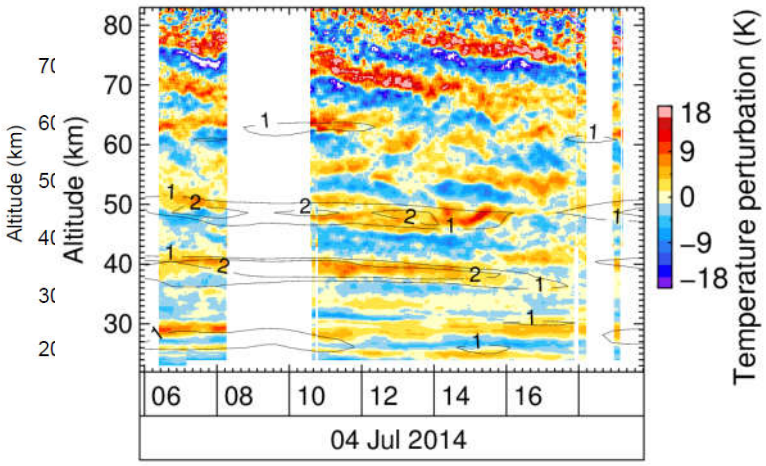
Derivation of T‘ and E_p from temperature profiles

Temperature T

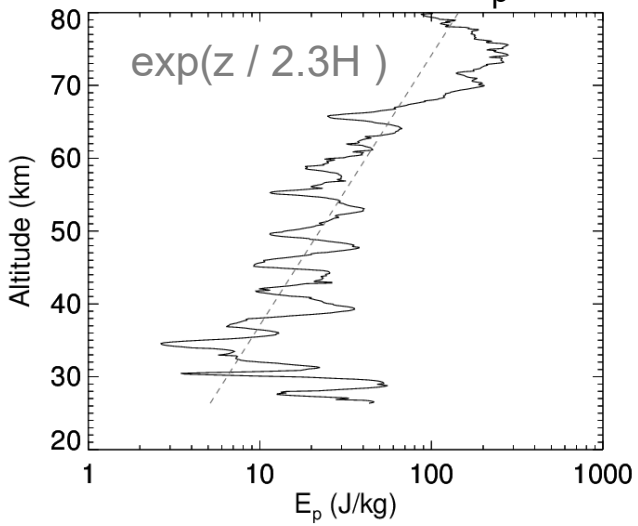


Removal of back-ground temp-erature T_0 by polynomial fitting method

Temperature perturbation T’



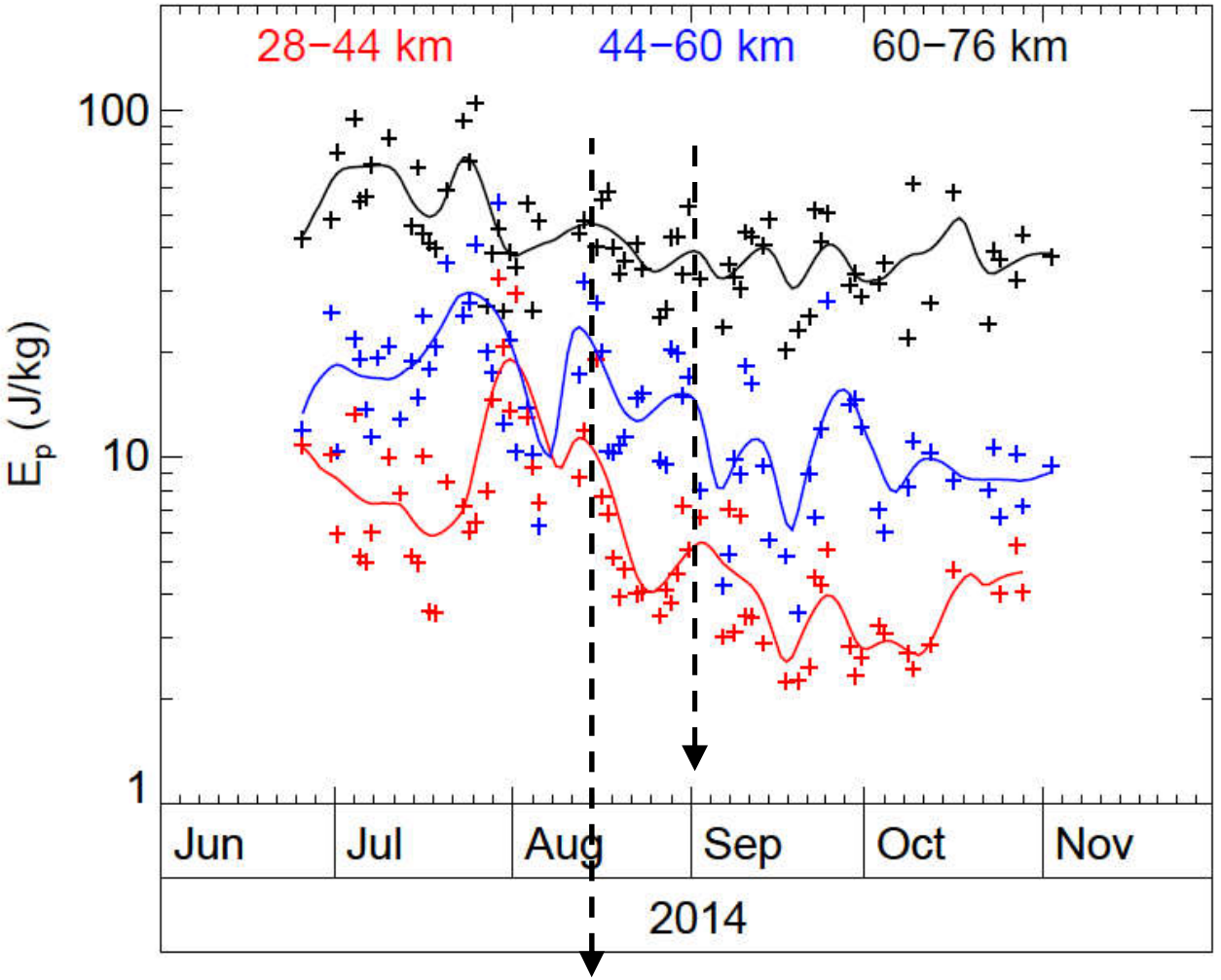
E_p



Gravity wave potential energy density:

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

Gravity wave potential energy density



Mountain waves: No „deep propagation“?

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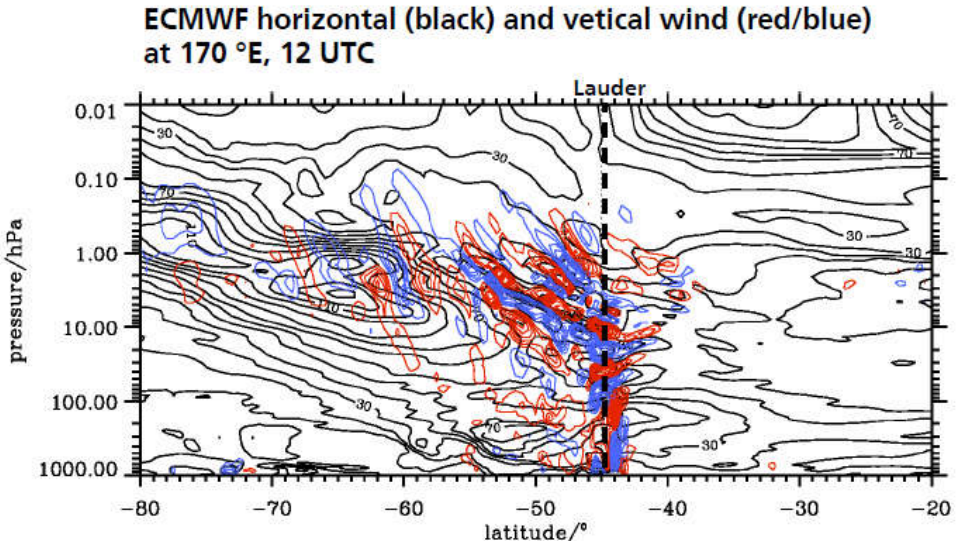
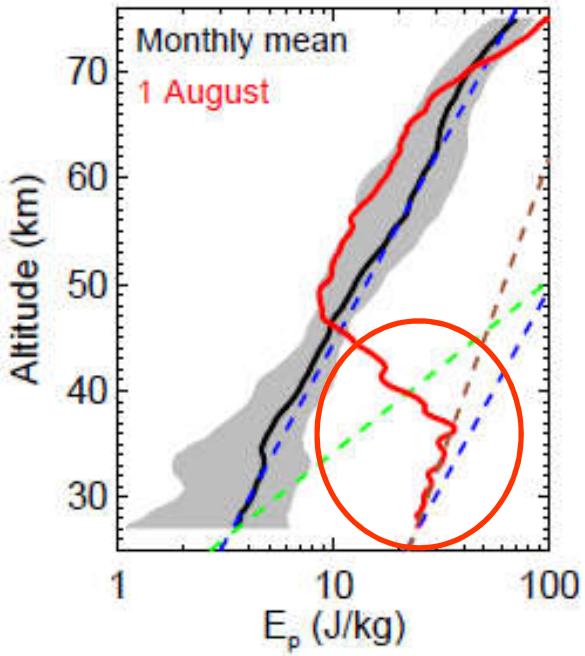
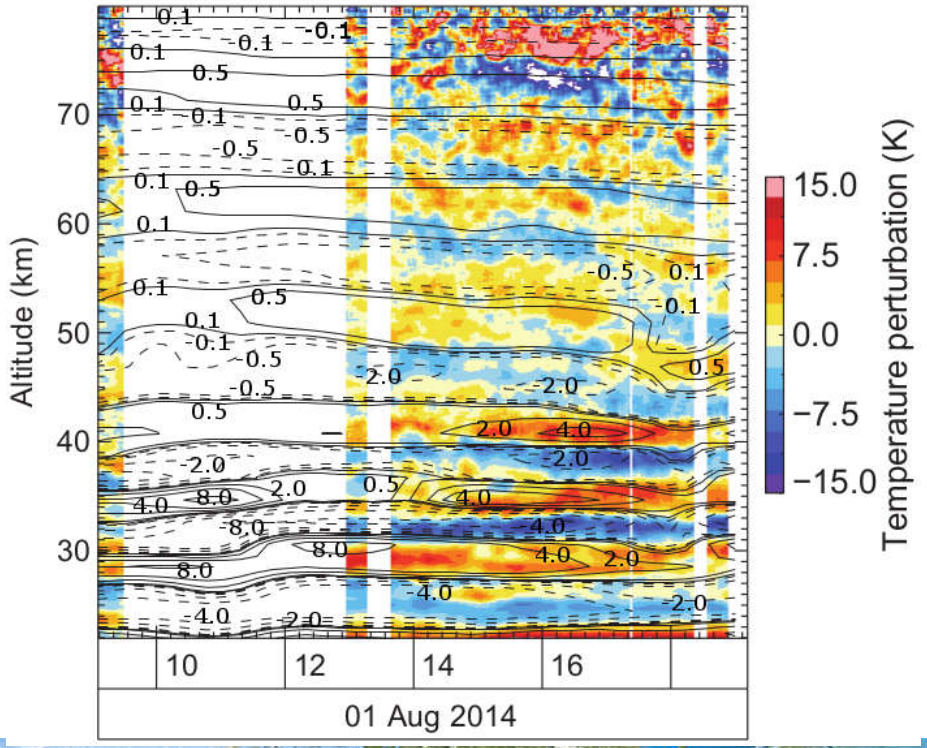
Mountain waves on 1 Aug 2014 (GB21)

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

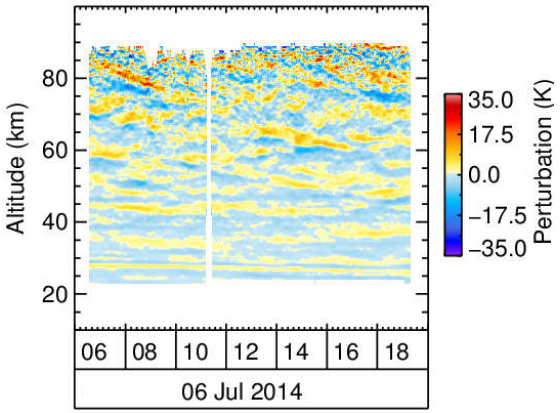






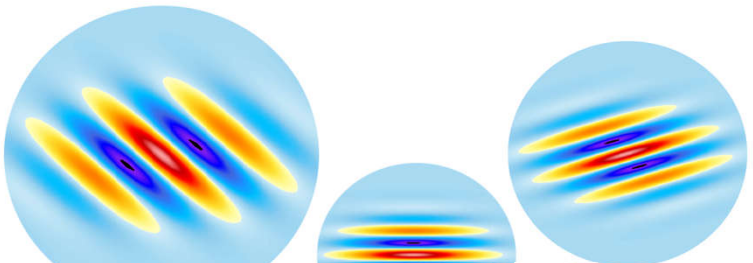
Distinction between GW types using 2d wavelets (I)

Temperature perturbation (K)

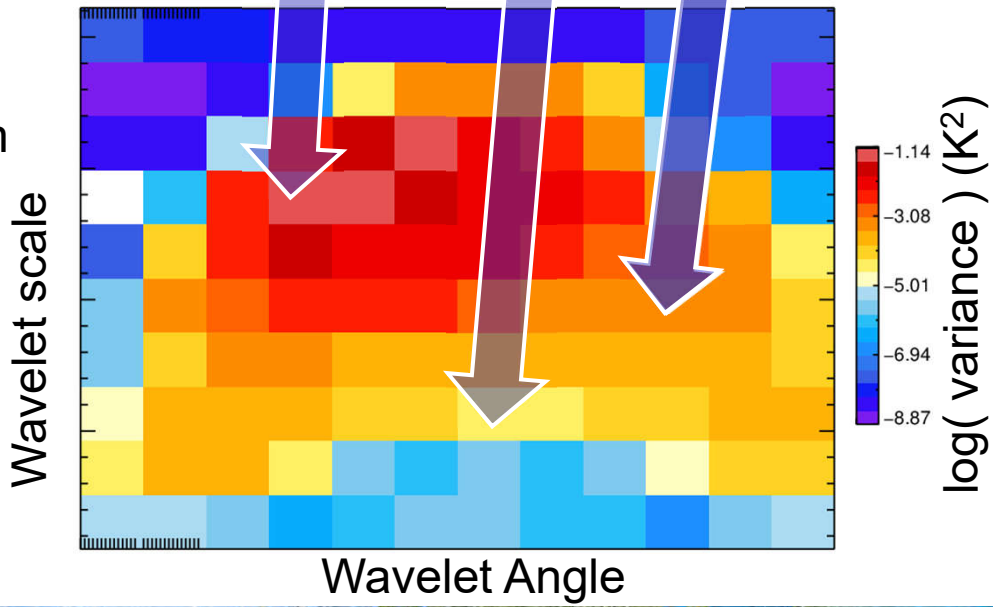


2d wavelet analysis

Directional 2d Morlet wavelets



Wavelet spectrogram



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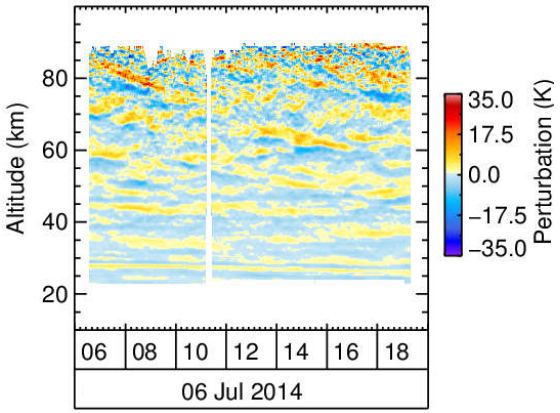

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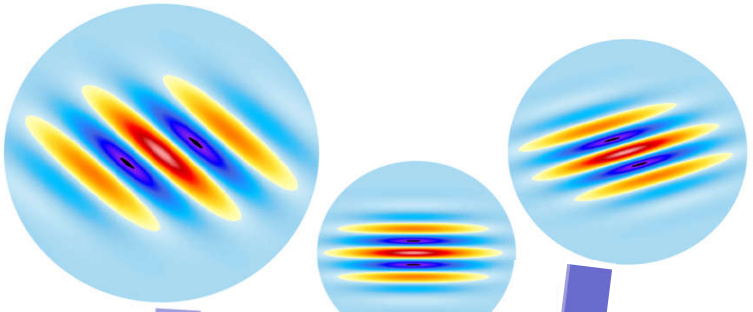
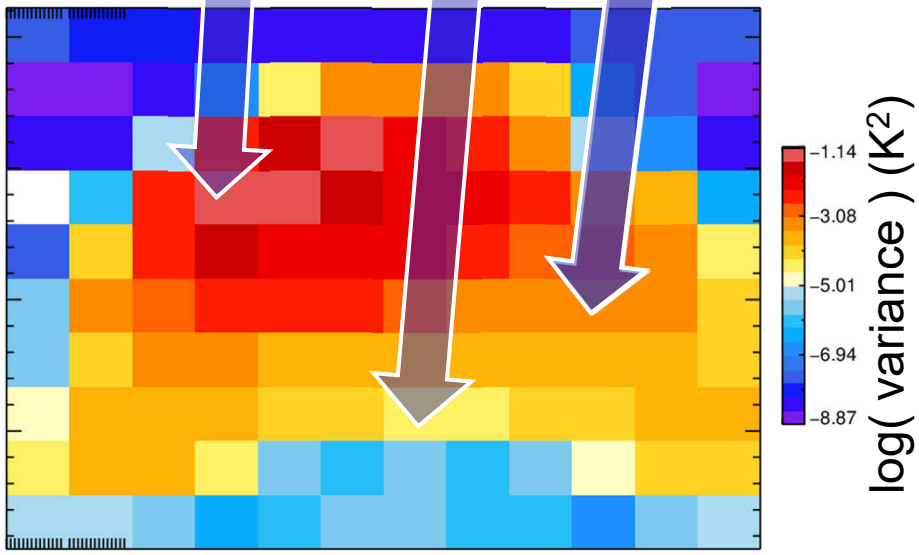
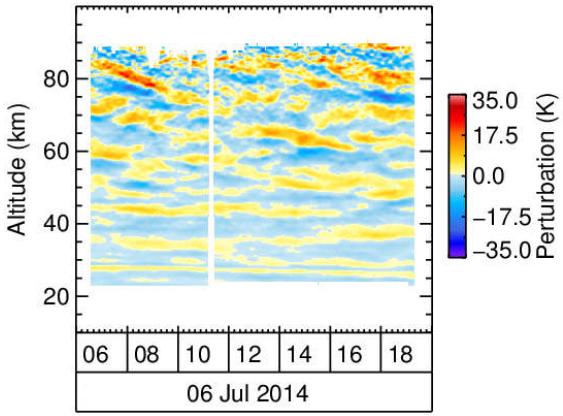


Variance normalized

Wavelet spectrogram



Back trans-formation



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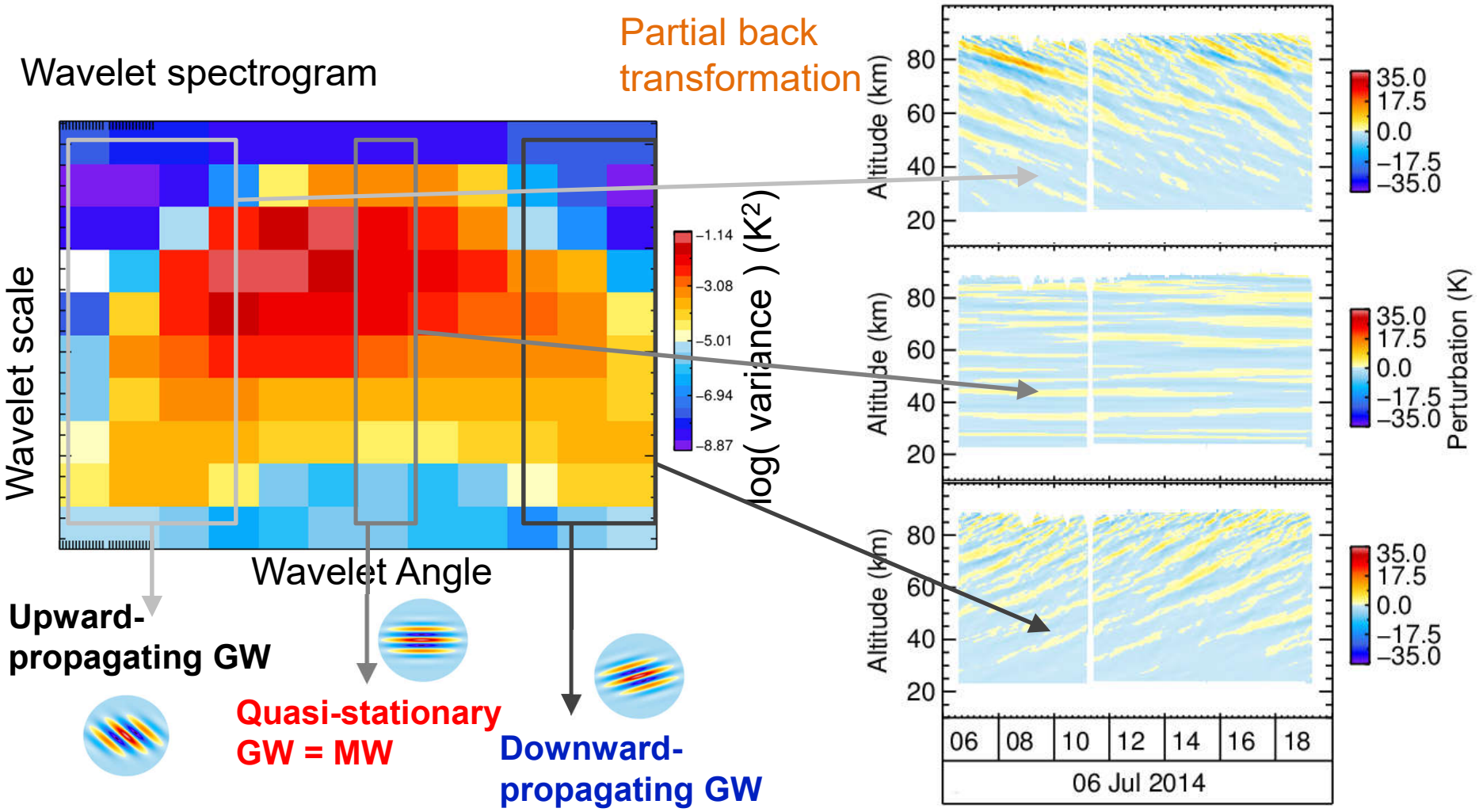
Distinction between GW types using 2d wavelets (II)



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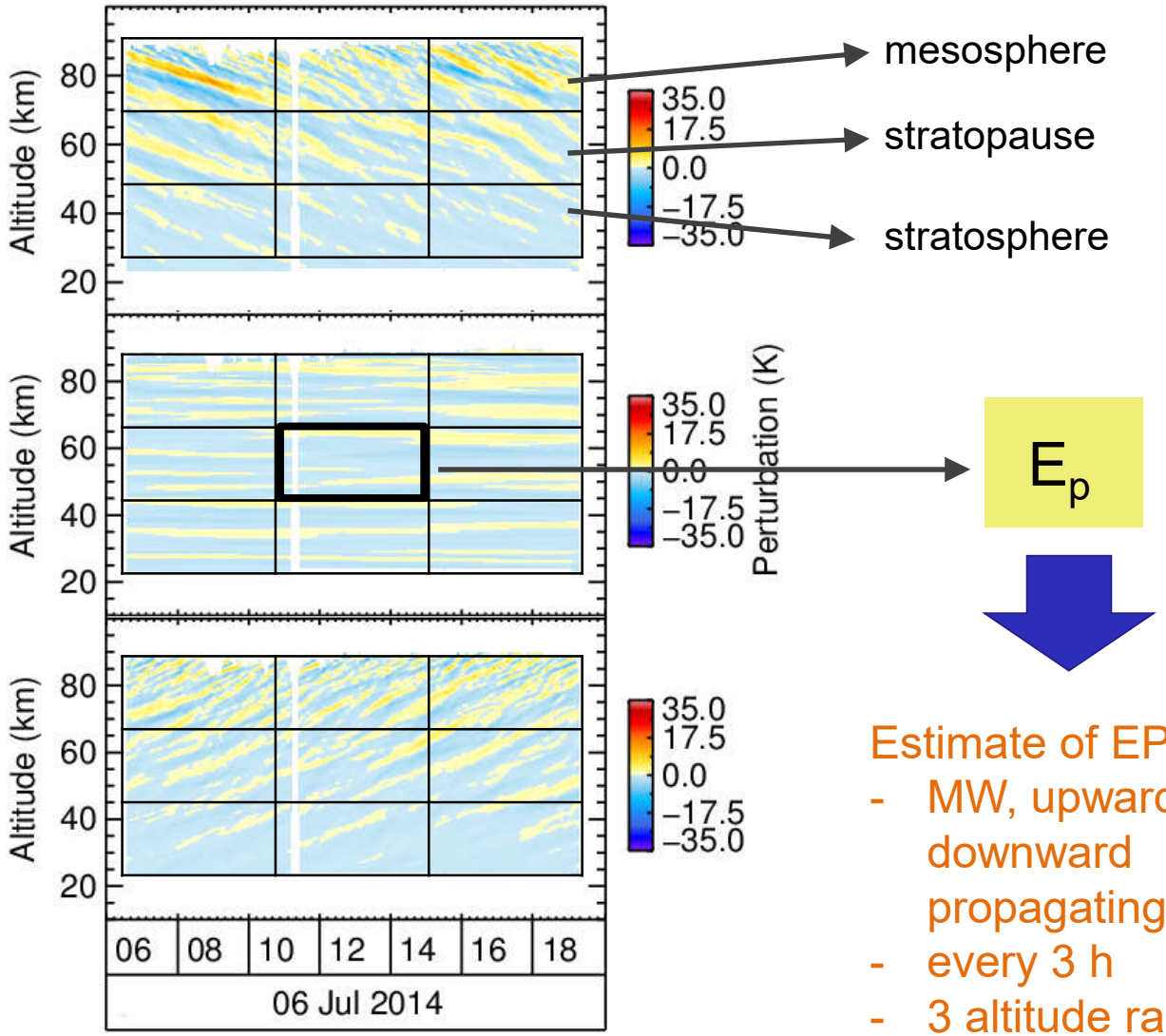
Distinction between GW types using 2d wavelets (III)

Upward-propagating GW

Quasi-stationary GW = MW

Downward-propagating GW



Estimate of EP for
- MW, upward and downward propagating GW
- every 3 h
- 3 altitude ranges

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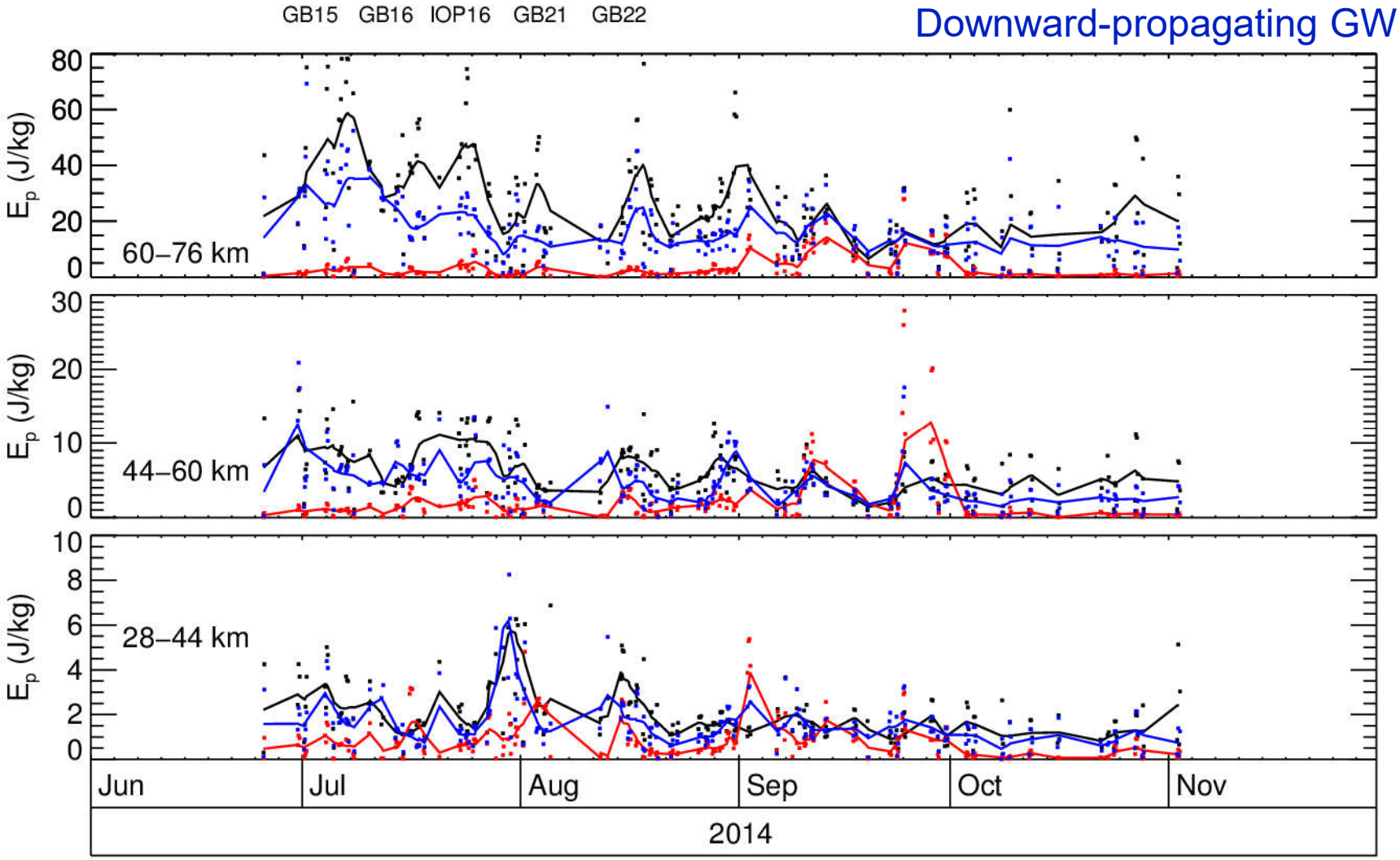
Lauder GW statistics

Quasi-stationary GW = MW

Upward-propagating GW

Downward-propagating GW



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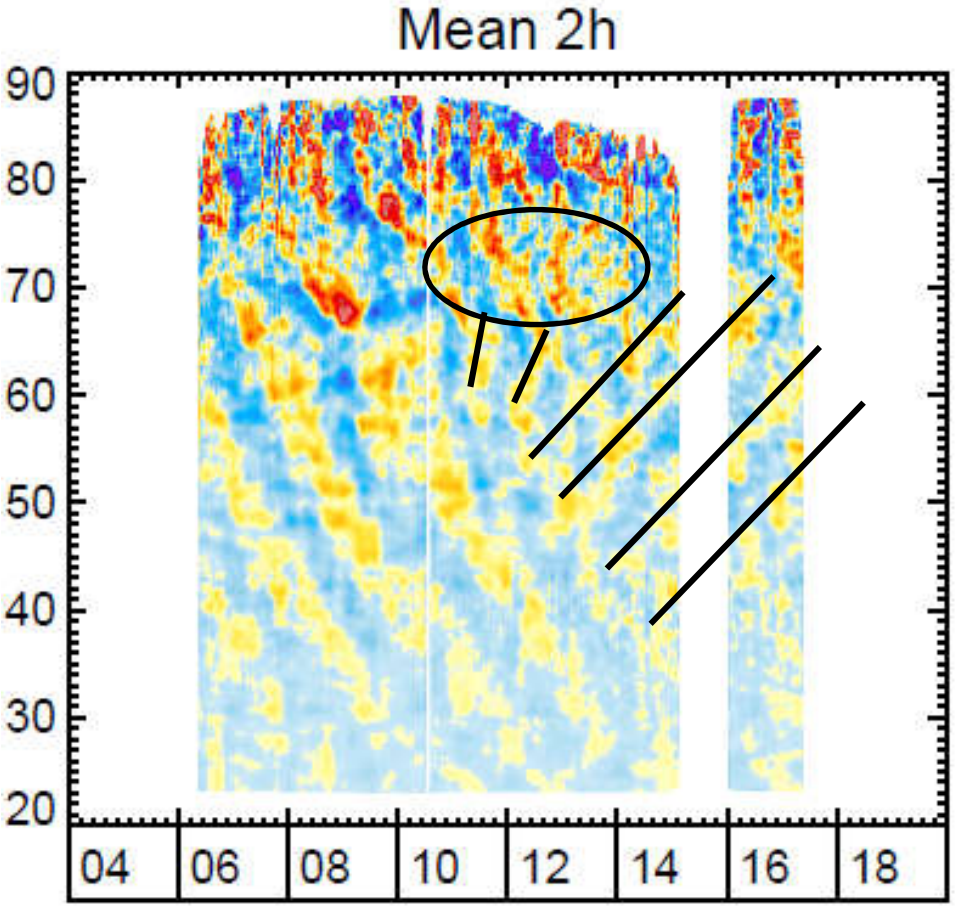
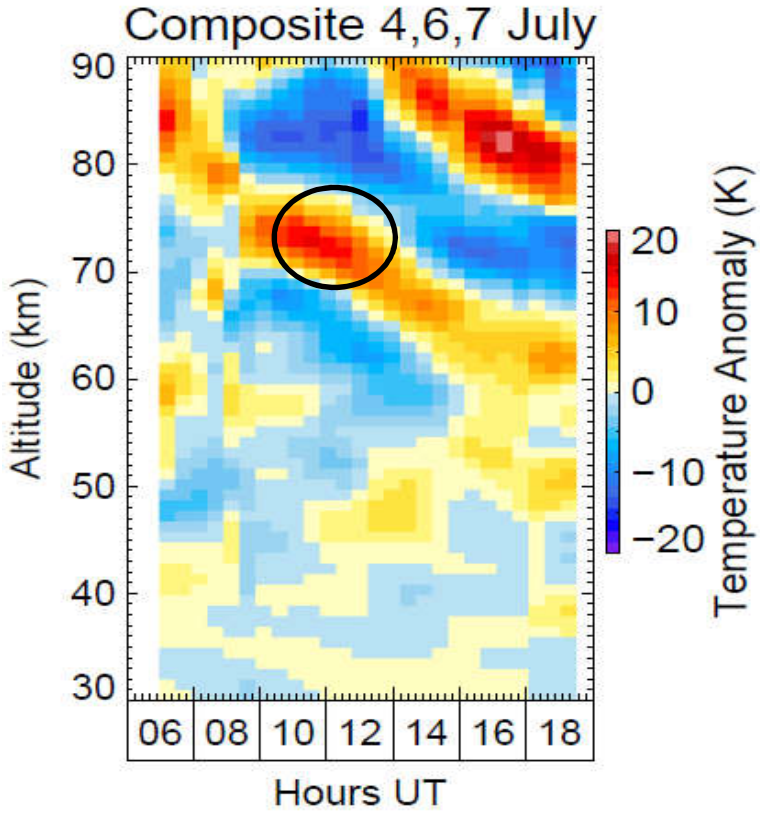
Example: Secondary wave generation

➢Generation of secondary GW due to GW-tide interaction



7 July 2014



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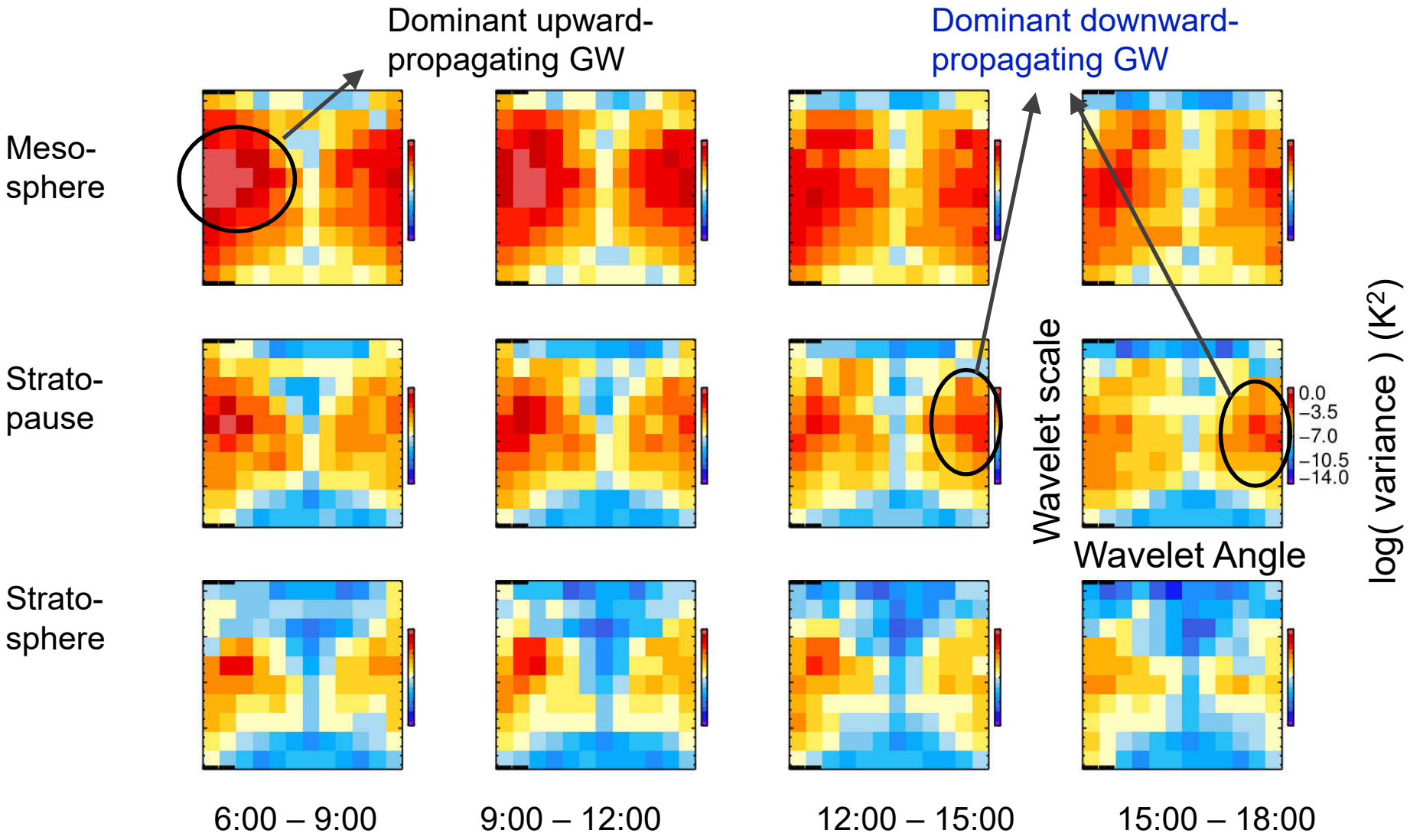
7 July 2014 wavelet spectrograms



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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

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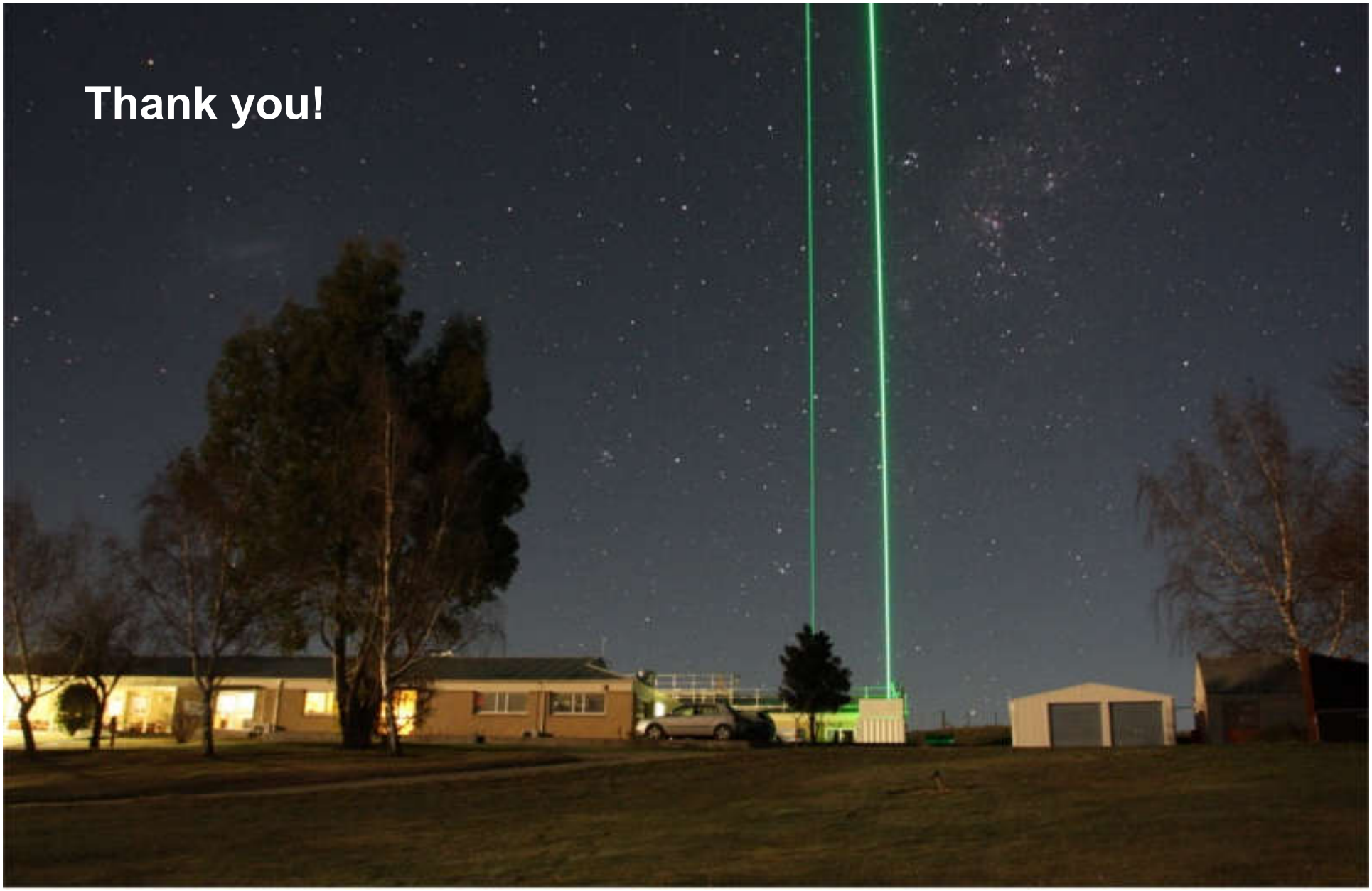
Thank you!



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