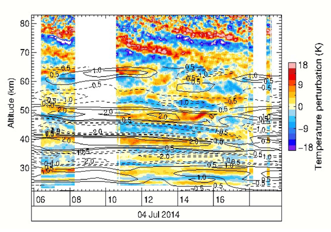
P2.21

Does strong tropospheric forcing cause large amplitude mesospheric waves? A Deepwave Case Study

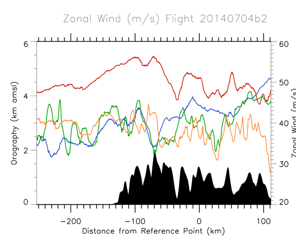
Martina Bramberger (1,2), Andreas Dörnbrack (2), Sonja Gisinger (2), Bernd Kaifler (2),Tanja Portele (1,2), Markus Rapp (2), Ivana Stiperski (1), Johannes Wagner (2)
(1) Institut für Meteorologie und Geophysik, Universität Innsbruck, Innsbruck, Austria
(2) Institut für Physik der Atmosphäre , Deutsches Zentrum für Luft- und Raumfahrt , Weßling, Germany

Motivation

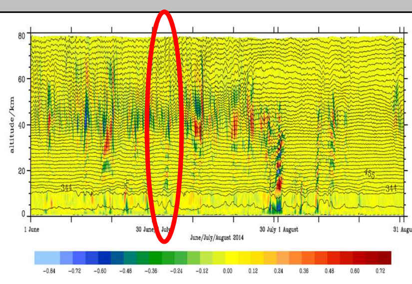
Ground-based lidar measurements show stationary gravity waves up to ~50 km and strong T-fluctuations (starting at 65 km)



Strong zonal wind with wave activity at flight-level



High resolution ECMWF 1 hourly analyses and forecast above Lauder suggest wave propagation up to 50km for 4 July.

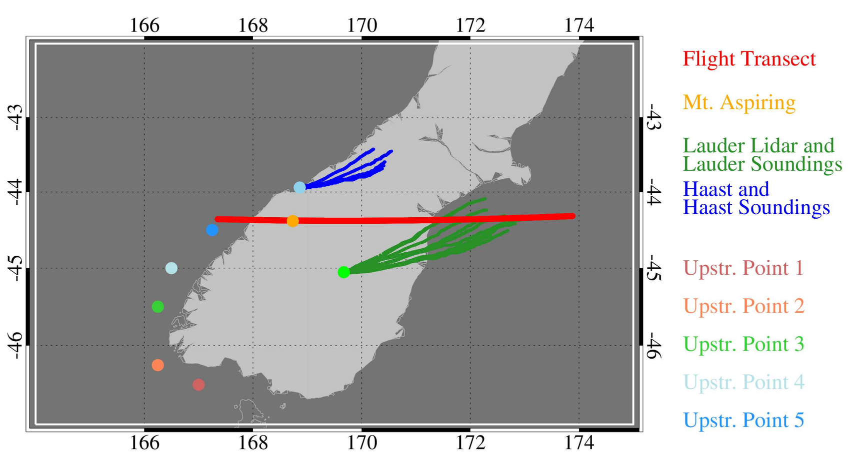


DEEPWAVE (DEEP propagation gravity WAVE experiment)

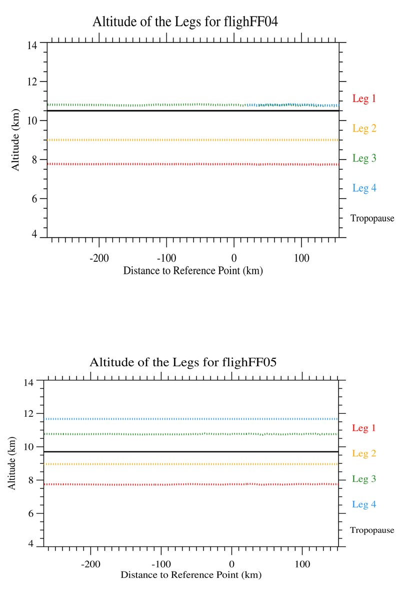
- Took place in June/July 2014 in NZ
- Extensive ground-based and airborne measurements
- Goal: Investigation of gravity wave propagation from generation to their dissipation

Overview of Intensive Observing Period (IOP)10 (4 July 2014)

- 2 consecutive Falcon flights (FF04 and FF05)
- 1 GV flight at 12 and 13km altitude (RF16)
- DLR Rayleigh lidar located in Lauder
- 15 Soundings launched in Haast and Lauder

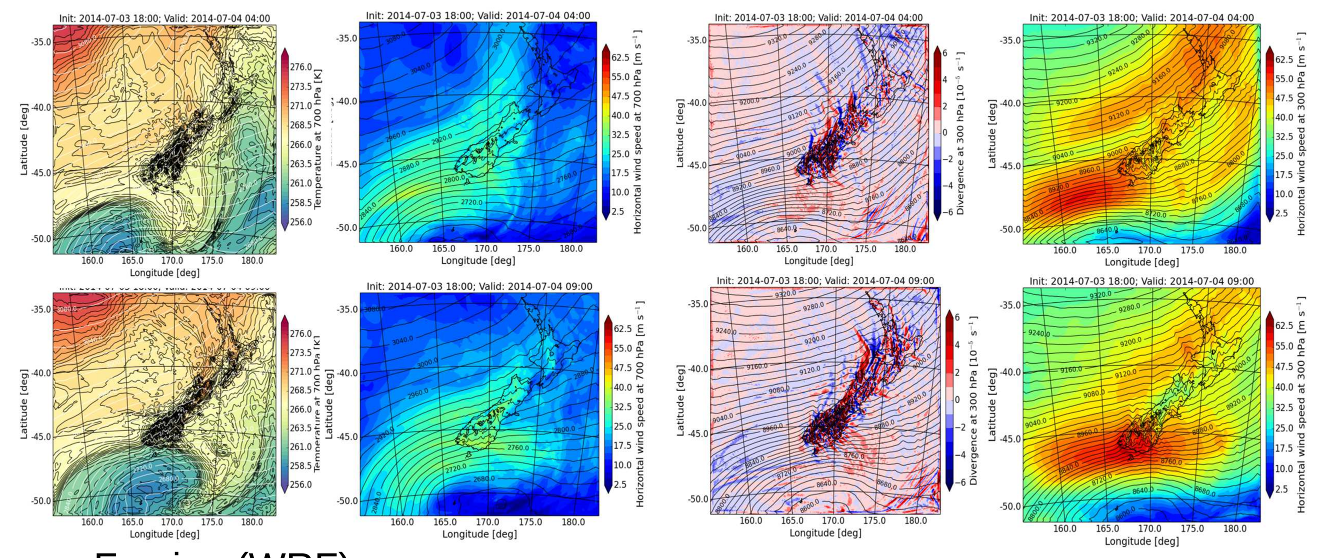


Leg Altitudes

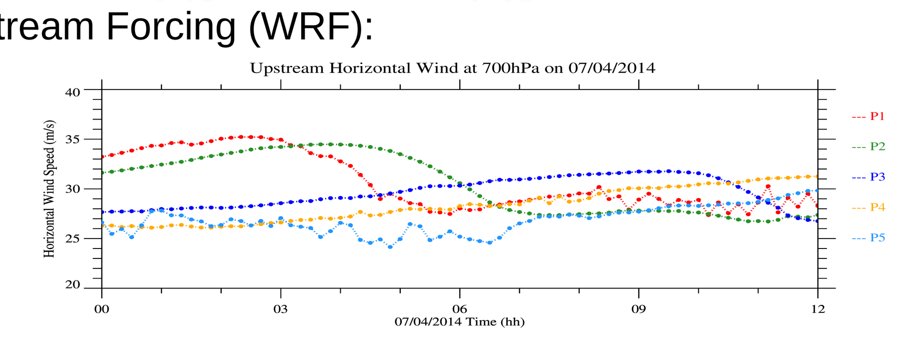


Synoptic Situation and Upstream Forcing

WRF Simulations show a low-pressure system south of NZ which causes WSW flow towards the Alps



Upstream Forcing (WRF):



Permanent favorable upstream wind conditions

Methodology

Calculation of Fluxes after Smith et al. (2008)

Energy- and Momentum Flux:

$$EF = \int p'w'dx \; ; \quad MF_x = \bar{\rho}\int u'w'dx$$

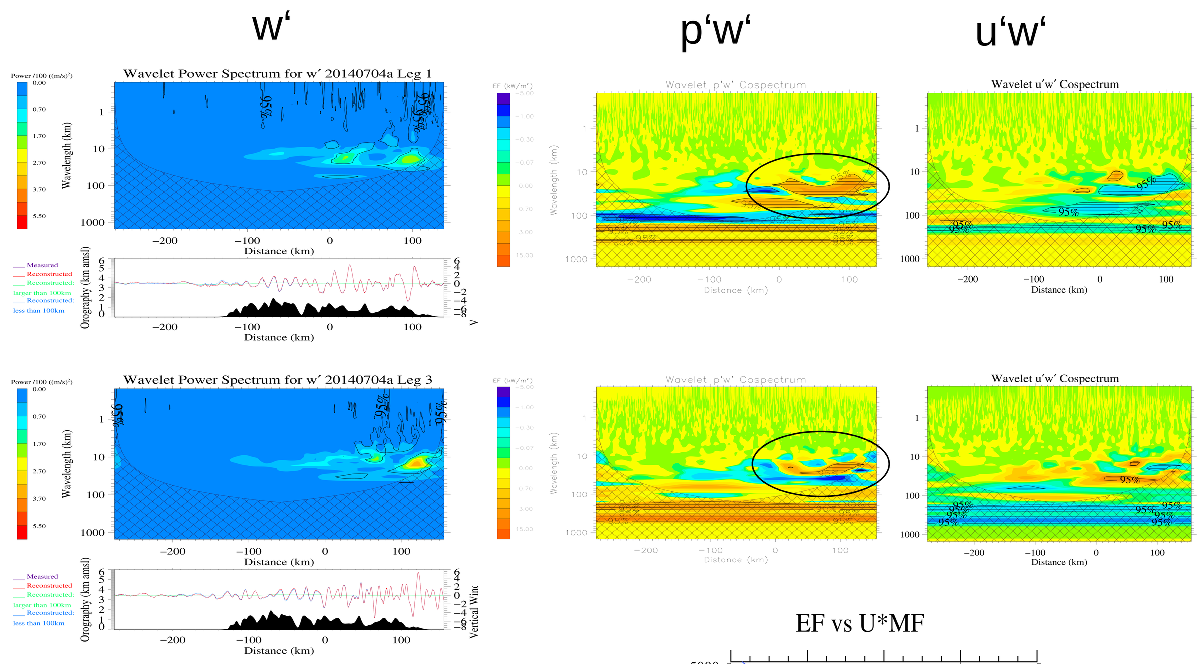
Eliassen Palm: $EF = -U * MF$

Wavelet Analysis after Woods & Smith (2010):

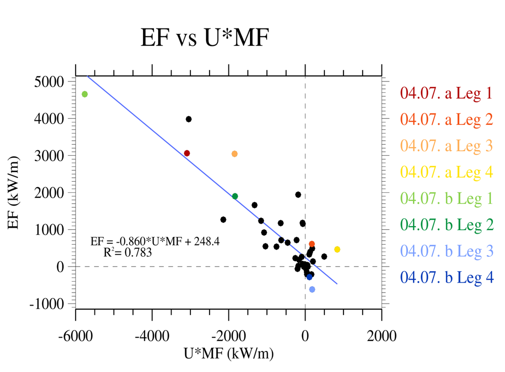
Calculation of the wavelet transforms of $(\widetilde{p'}, \widetilde{u'}, \widetilde{w'})$

$$\widetilde{EF}_z = \Re\{\widetilde{p'}\widetilde{w'}^*\}; \; \widetilde{EF}_x = \Re\{\widetilde{p'}\widetilde{u'}^*\}; \; \widetilde{MF}_x = \Re\{\widetilde{u'}\widetilde{w'}^*\}$$

Characteristics of propagation

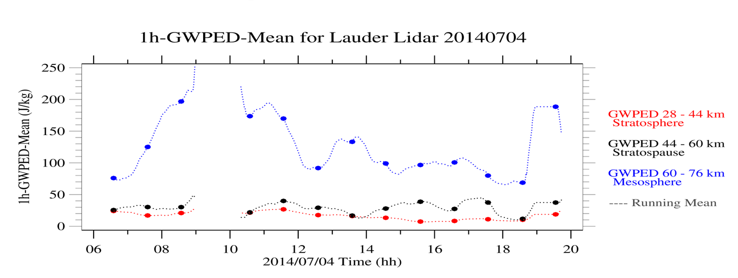


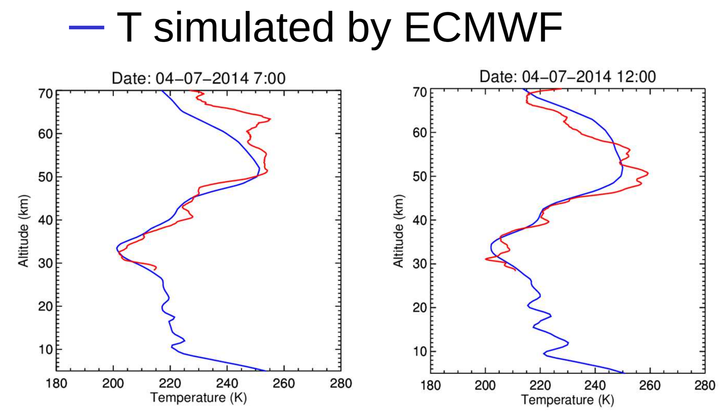
- Overall linear wave propagation in the troposphere
- Evanescent propagation across tropopause and in the troposphere



DLR Lidar

GWPED

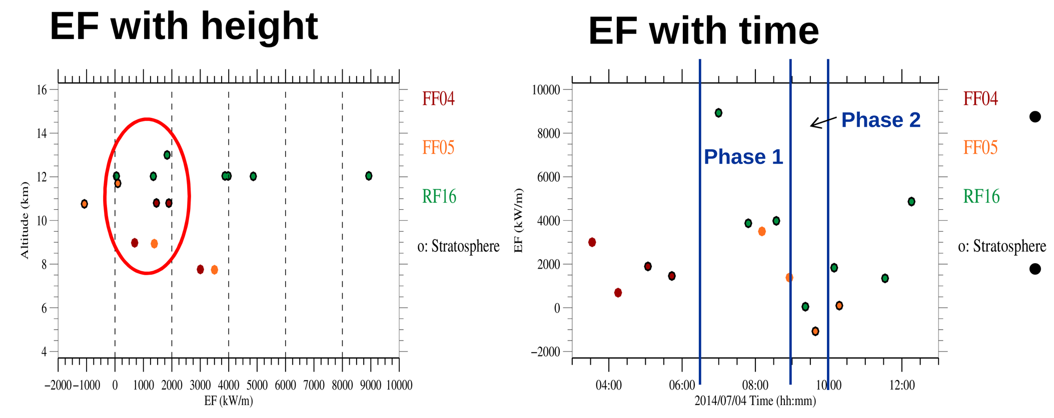




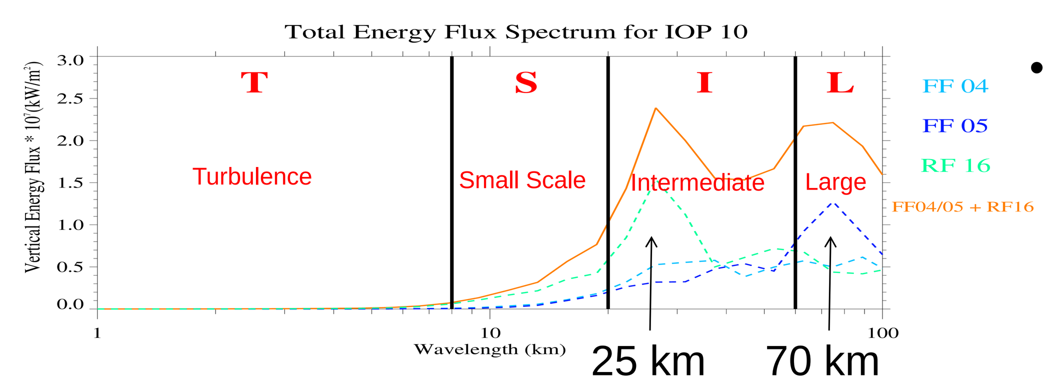
- Enhanced GWPED in mesospheric region at the same time of IOP
- No clear signal in mid and upper stratosphere
  - Due to influence of background conditions?
  - Due to stratopause?
  - Due to observational filter?

Energy Fluxes (EF) measured by GV and Falcon

Falcon measurements reveal highest fluxes during DEEPWAVE.

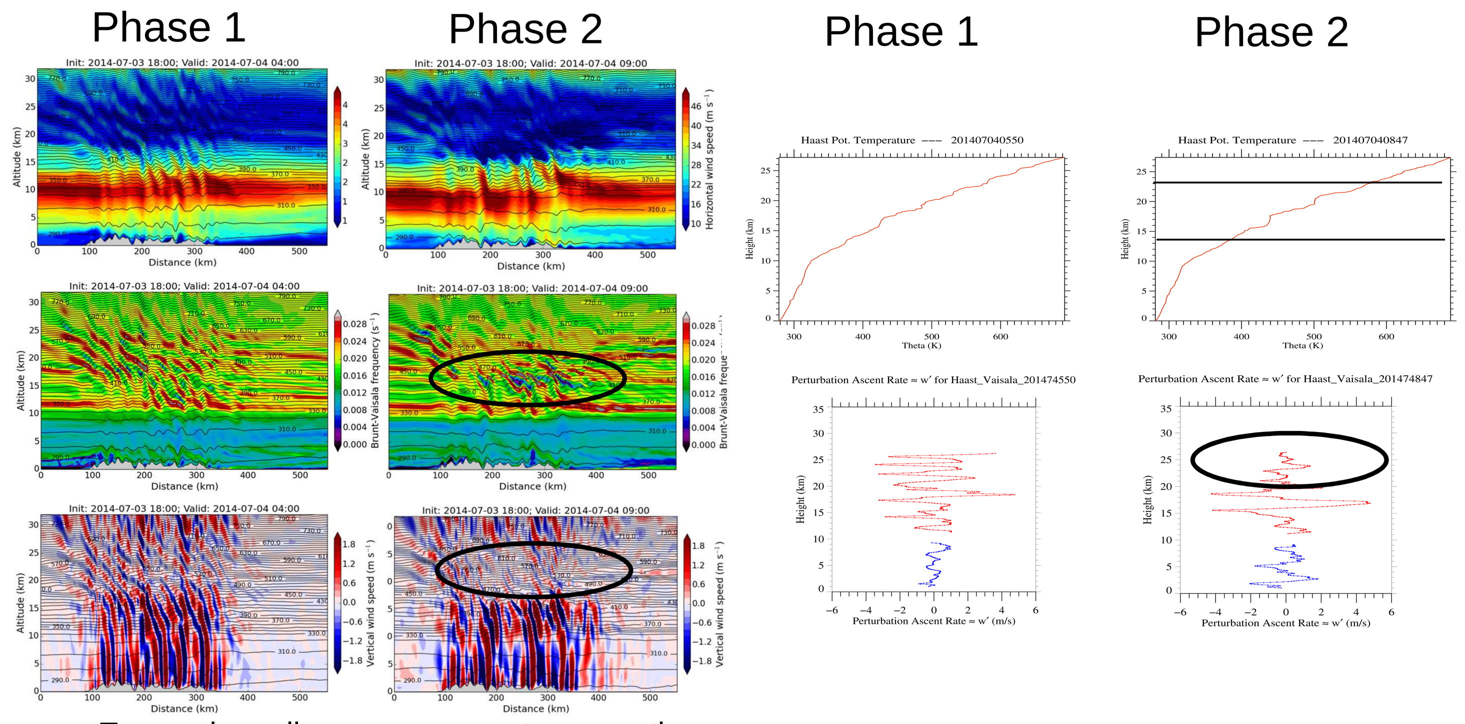


- EF starting at 8km constant with height
- EF decreases at ~9UTC



- Signal of individual mountain peaks contains slightly more energy than larger scales

WRF Simulations and Radio Soundings



- Troposphere: linear, evanescent propagation
- Stratosphere: steepening isentropes -> turbulent layer with reduced amplitudes in w
- Above turbulent layer: still remarkable amplitudes -> waves passing through layer and/or secondary wave generation
- Clearly visible are neutral, well mixed layers in sounding between 15 and 25km in phase 2

Summary

- Remarkable mountain wave activity was observed with EF maxima ~ 3500kW/m in Falcon flights.
- Evanescent and linear propagation across toposphere and tropopause
- Turbulent stratospheric layer between 15 and 25 km
- WRF simulation suggests that the turbulent layer is semipermeable to waves.
- Secondary wave generation cannot be excluded
- Enhanced GWPED in mesospheric region

Outlook

- Detailed study of wave characteristics below and above stratospheric turbulent layer
- Further regional simulation up to 80 km of the Unified Model (UK MetOffice)
- Analyse Falcon and GV lidar measurements as well as GV dropsondes