Characterizing Trailing Waves:

Characteristic wave numbers
Wave source?
Deep propagation (vertical and lateral shear)
Momentum/energy transfer
Energy exchange with sheared flow

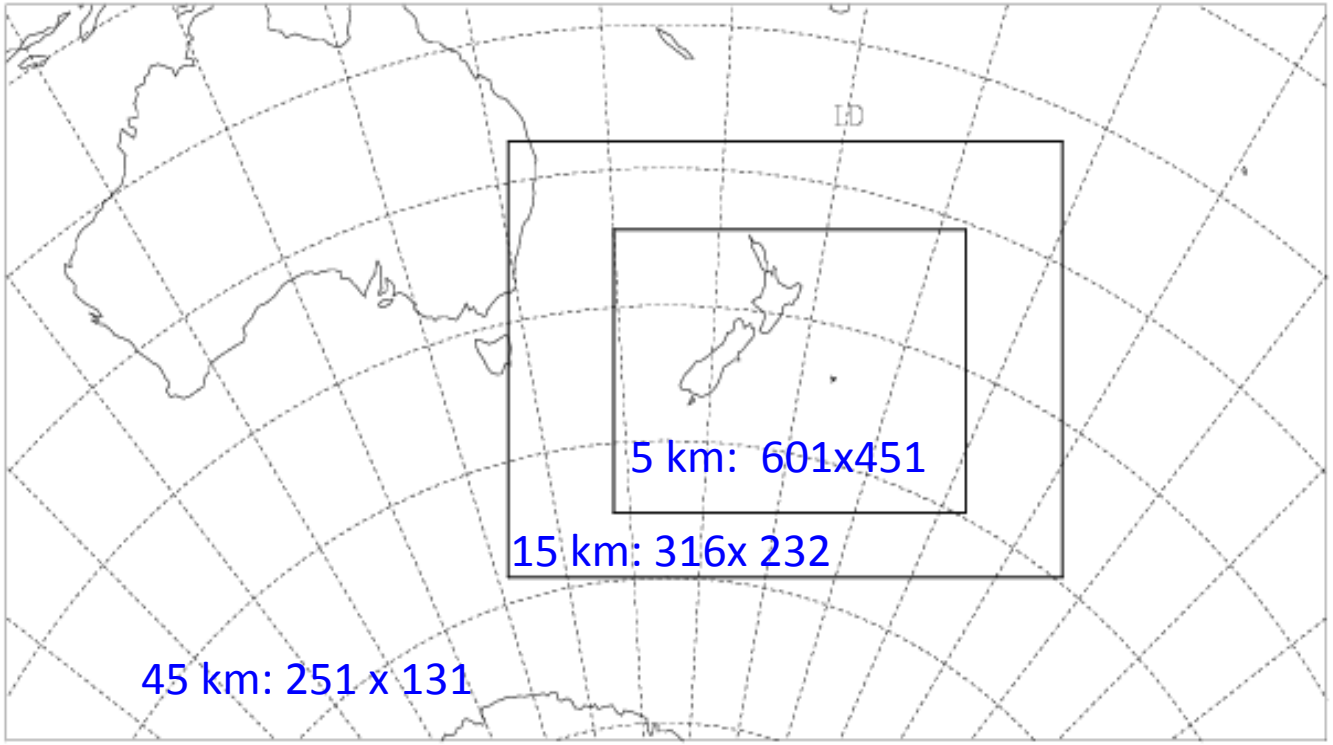
Q. Jiang et al., NRL Monterey, CA

Boulder, October 2014

DEEPWAVE Trailing Wave IOPS

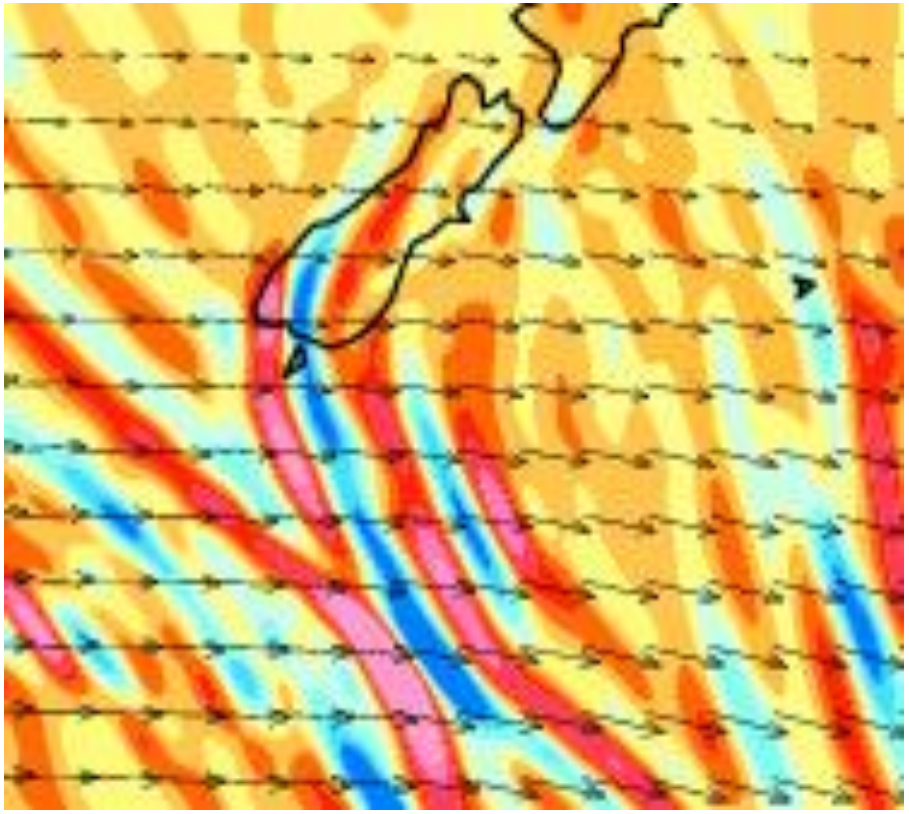
IOP/RF#/Date	Objectives	COAMPS Simulations
IOP3 (RF03) 0755-1230 UTC, 13 June 2014	Predictability	48-h forecast cold-started from 1200 UTC 12 June 2014
IOP3 (RF04) 0700-1445 UTC, 14 June	Trailing Waves over S. Island	
IOP06 (RF07) 0555-14:56 UTC, 19 June	GW generated by terrain and frontal system	48-h forecast cold-started from 1200 UTC 18 June 2014
IOP07 (RF08) 0653-1346 UTC, 20 June	Trailing Waves over S. Island	
IOP09b (RF12) 0753-1709 UTC, 29 June	I) GWs over SI II) Trailing Waves in the lee	48-h forecast cold-started from 1200 UTC 28 June 2014
IOP09c (RF13) 0548-15:30 UTC, 30 June	Same as RF12	

COAMPS Model Domain

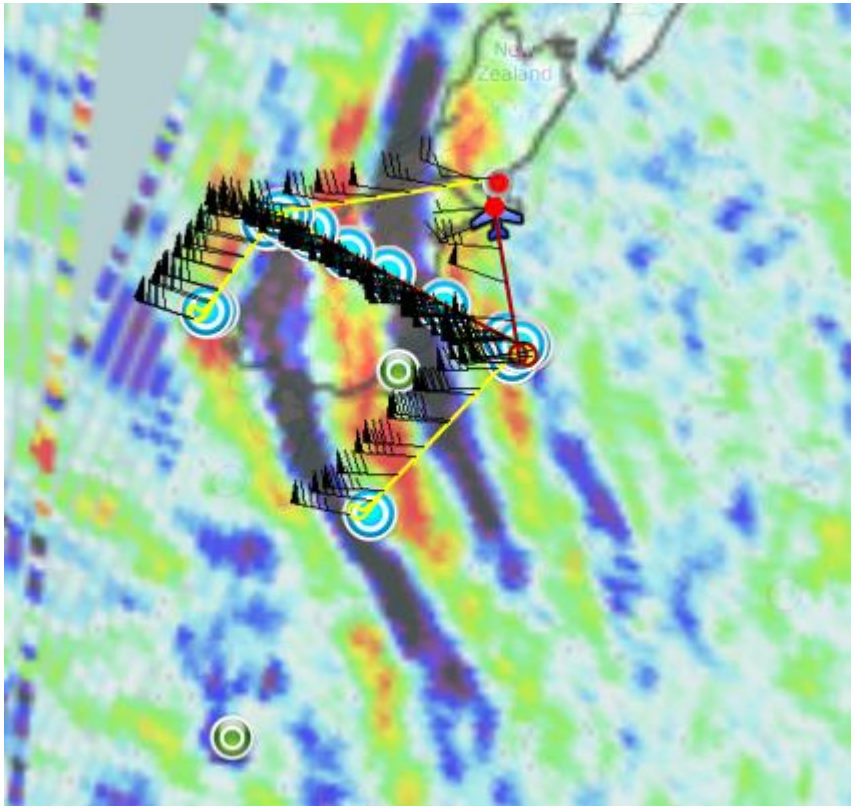


- Three-level nested grids: 45, 15, and 5 km
- In vertical: 86 levels up to 0.2 mb (~ 60 km)

Simulation I: IOP 3 (RF 4)

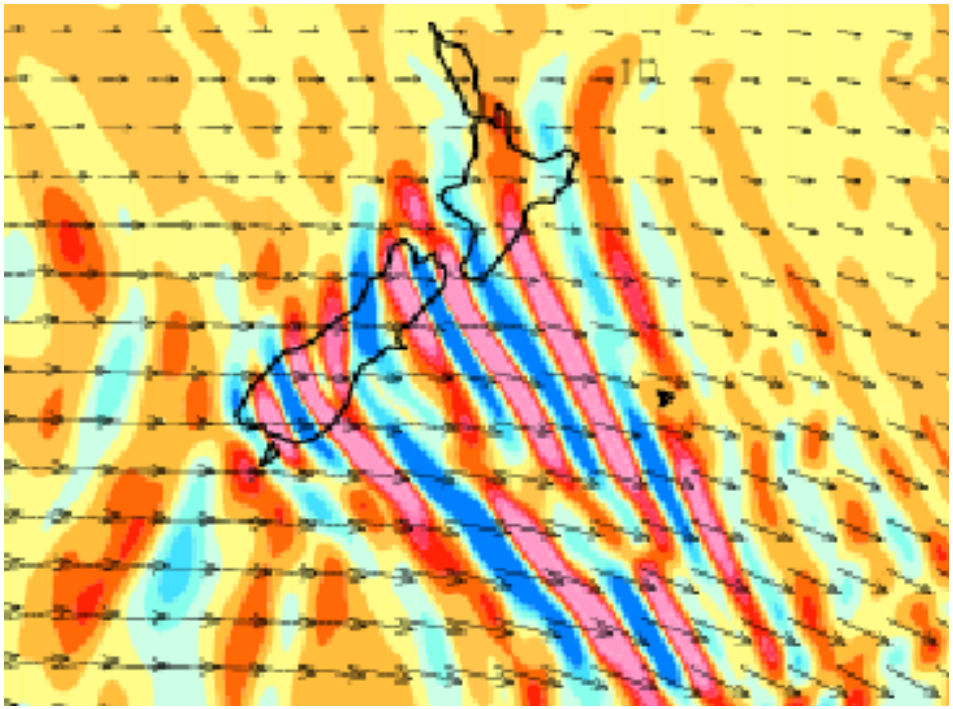


W @ 30km from 15-km grid, valid at 1200 UTC, 14 June 2014

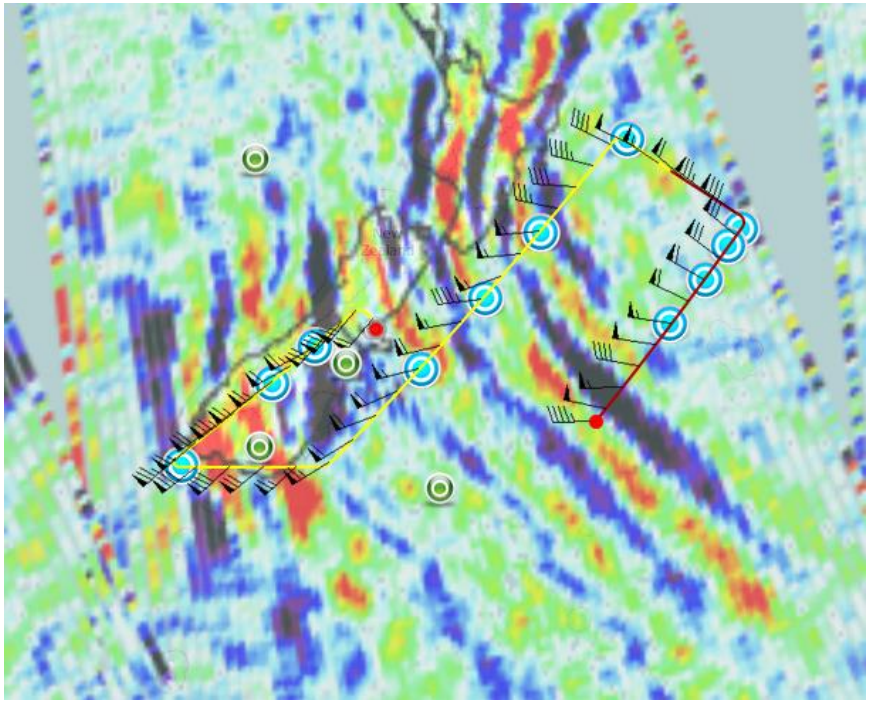


Valid at 1319 UTC 14 June 2014 (2mb)

Simulation II: IOP 6 (RF 7)

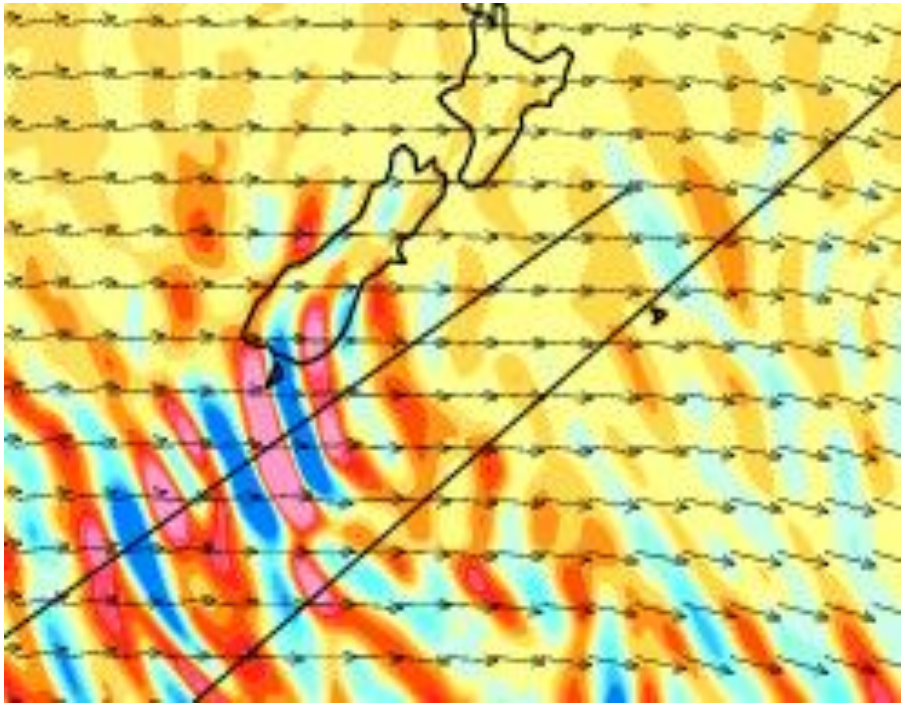


W @ 30km from 15-km grid, valid at 1200 UTC, 19 June 2014

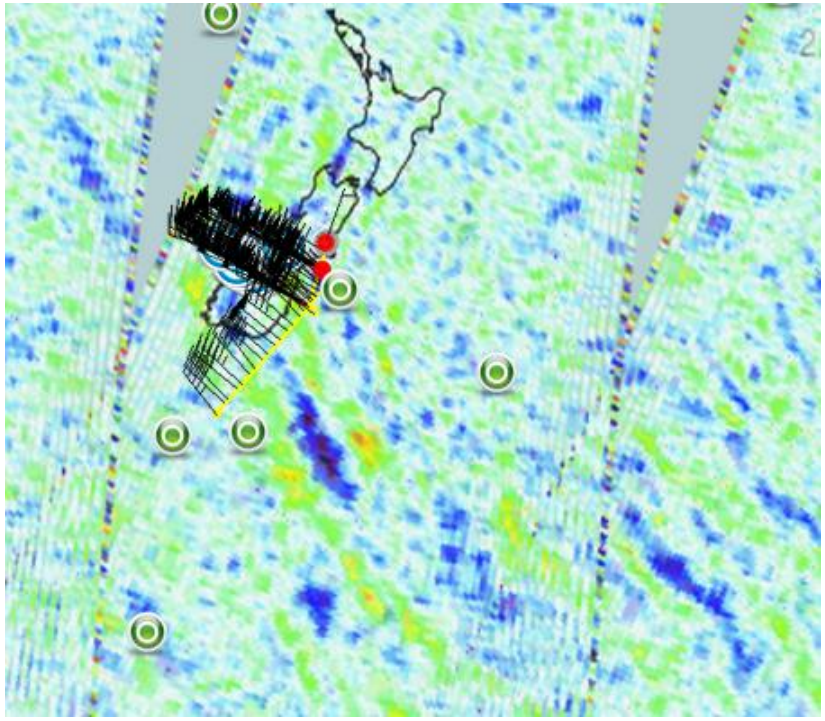


Valid at 0230UTC 19 June 2014 (2mb)

Simulation III: IOP 9 (RF12)



W @ 30km from 15-km grid, valid at 1200 UTC, 29 June 2014



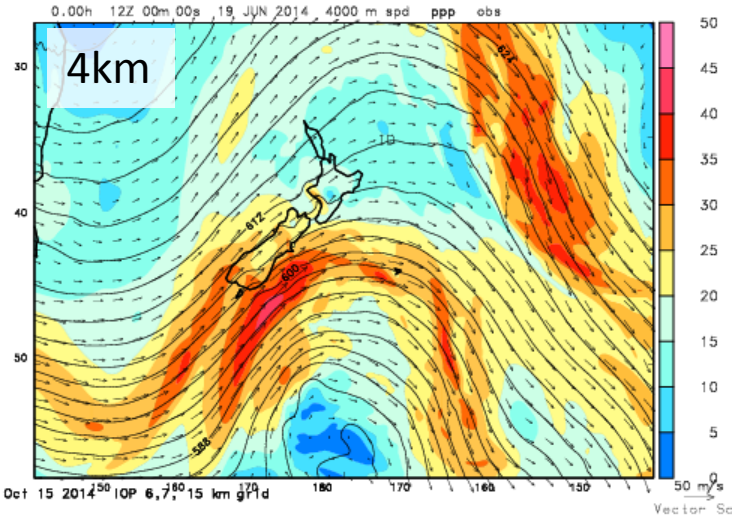
Valid at 1318 UTC, 29 June 2014 (2mb)

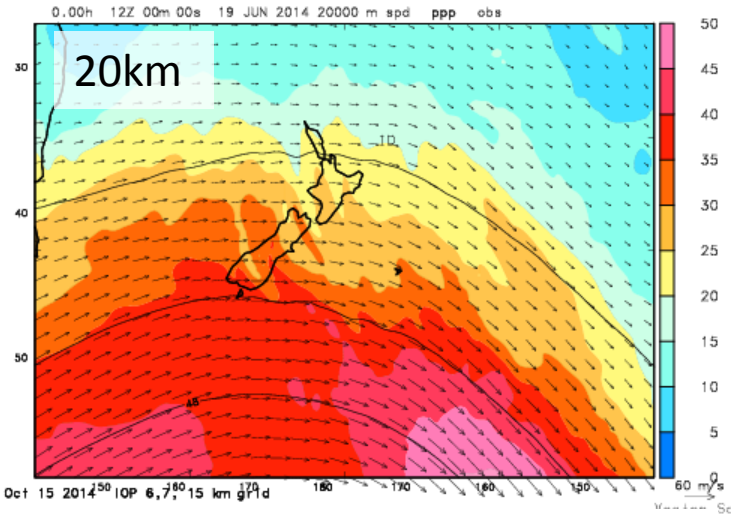
Science Issues

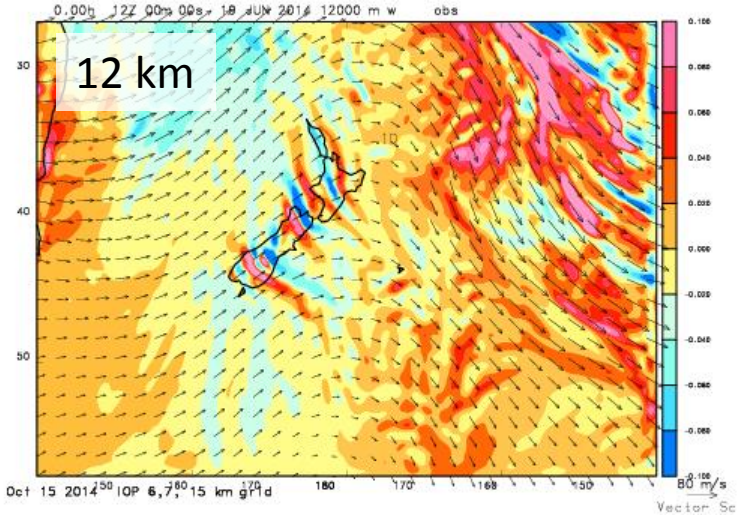
- Model validation:
  - Cold-start COAMPS simulations capture gross features of trailing waves revealed by AIRS.
  - More quantitative comparisons down the road

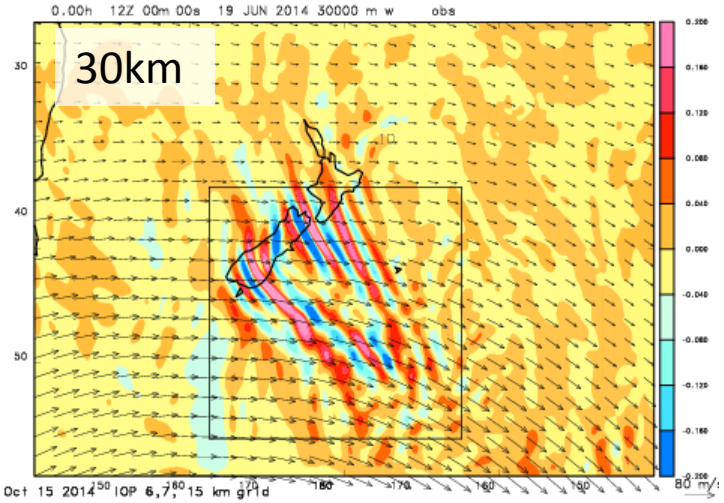
- Science Questions:
  - Is terrain the source of TW?
  - What determines TW characteristics (wavelength, number of wave banners…)
  - What's their role in vertical momentum transfer?
  - What are the roles of vertical and lateral shear in TW propagation?
  - ….
- Preliminary Diagnosis of IOP 6 simulation

Characteristics of Simulated Trailing Waves (IOP 6)

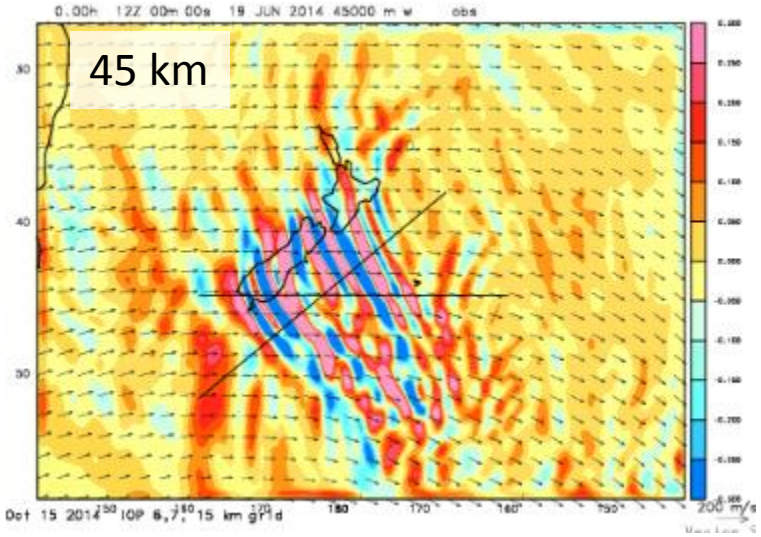


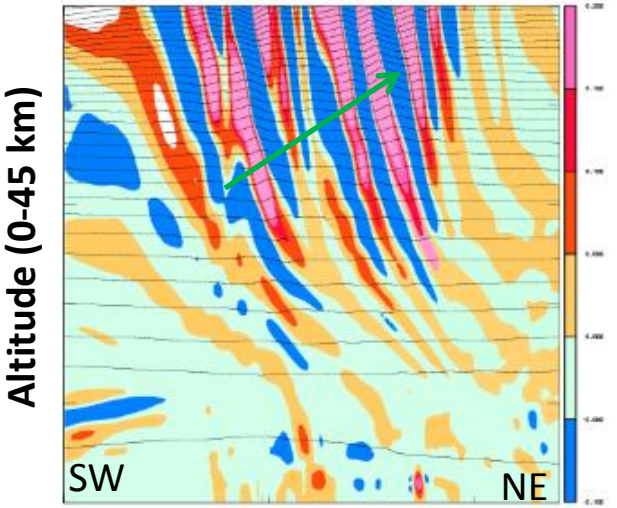




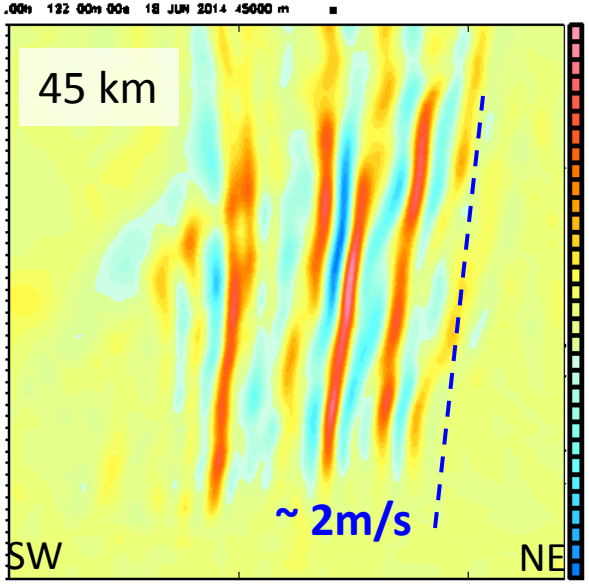


Characteristics of Simulated Trailing Waves (IOP 6)

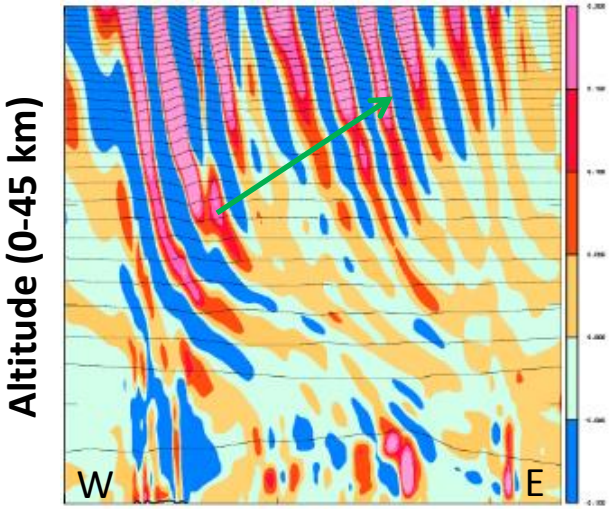




Distance (~2400km)

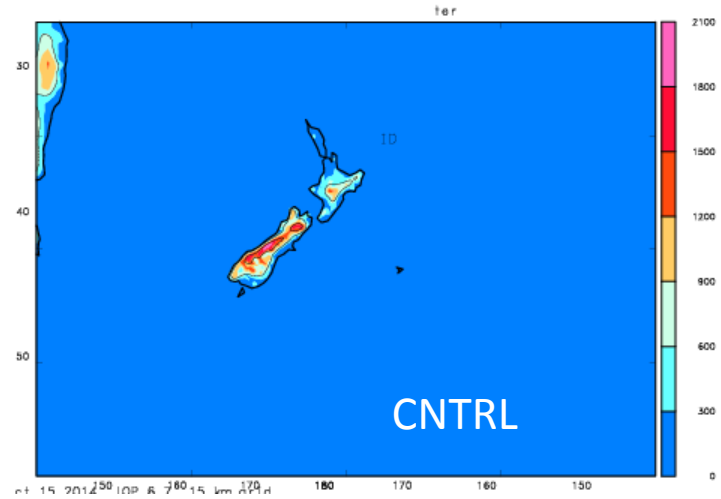


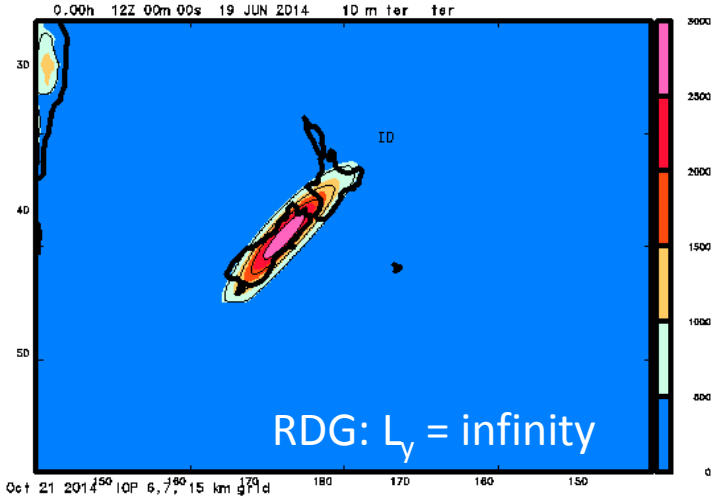
Distance (~2400km)



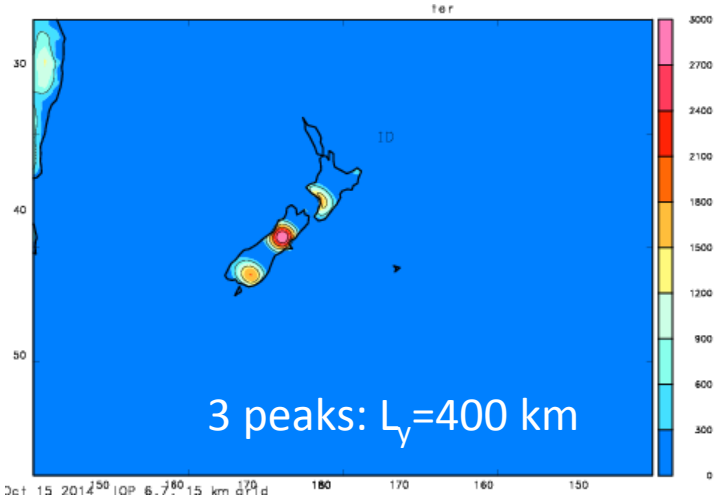
Distance (~2400km)

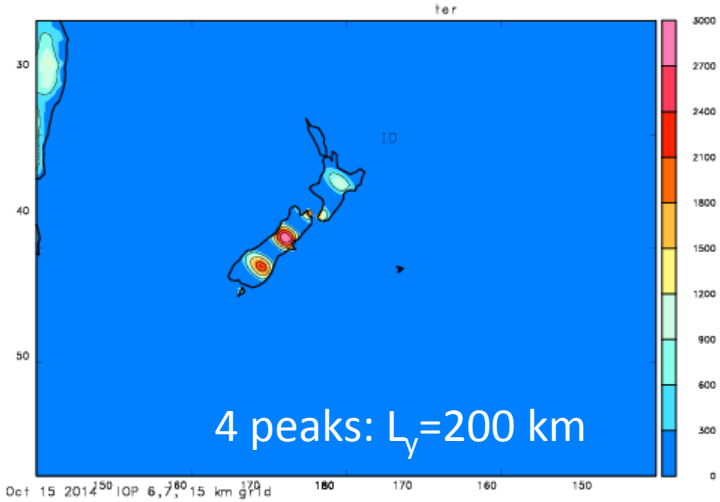
Terrain Sensitivity Simulations (IOP 6)





NTRN

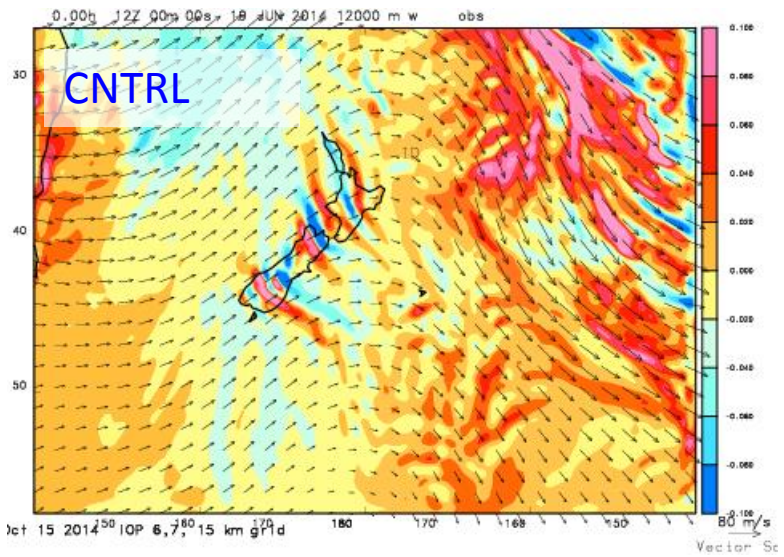


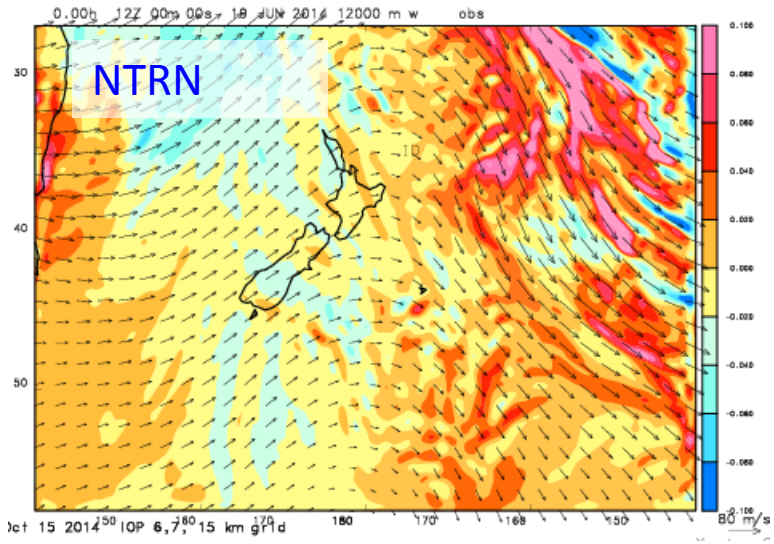


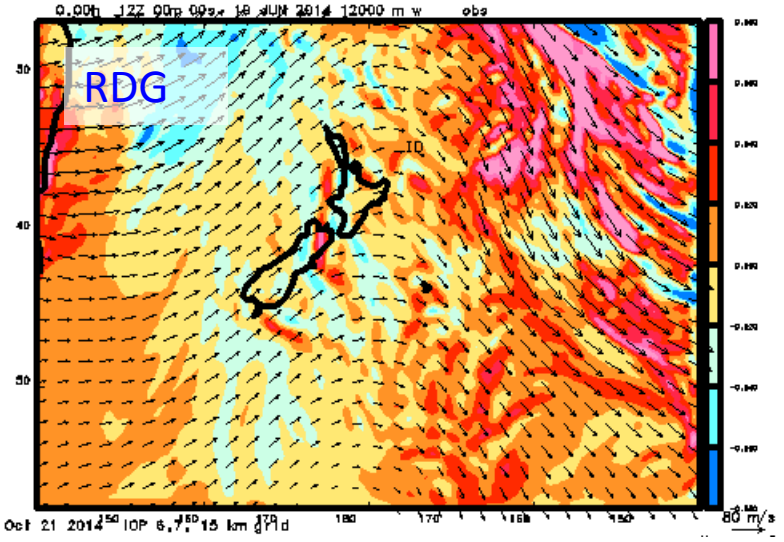
Idealized terrain:

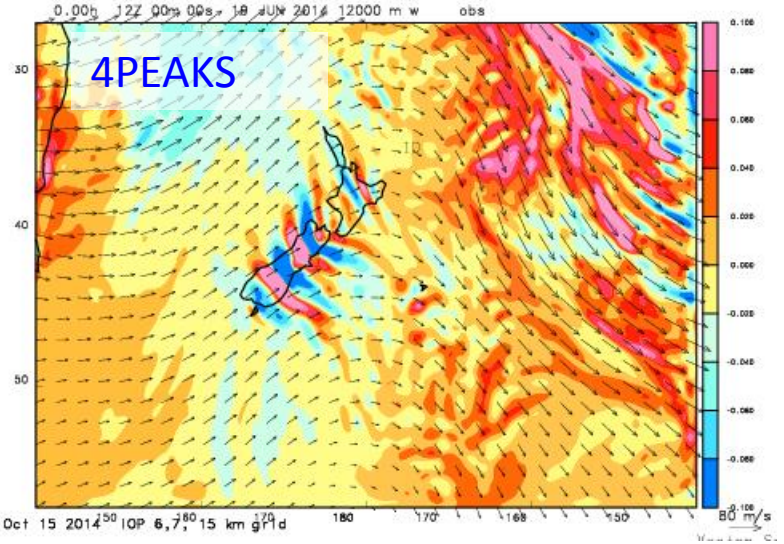
$$h(x',y') = \frac{h_m \cos^2(2\pi y / L_y)}{\left[1+(x'/a)^2+(y'/b)^2\right]^{3/2}}$$

Tropospheric Waves



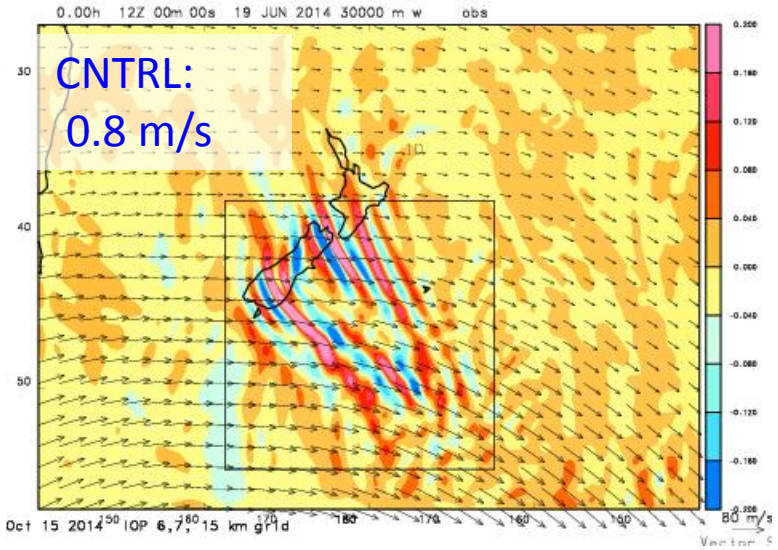


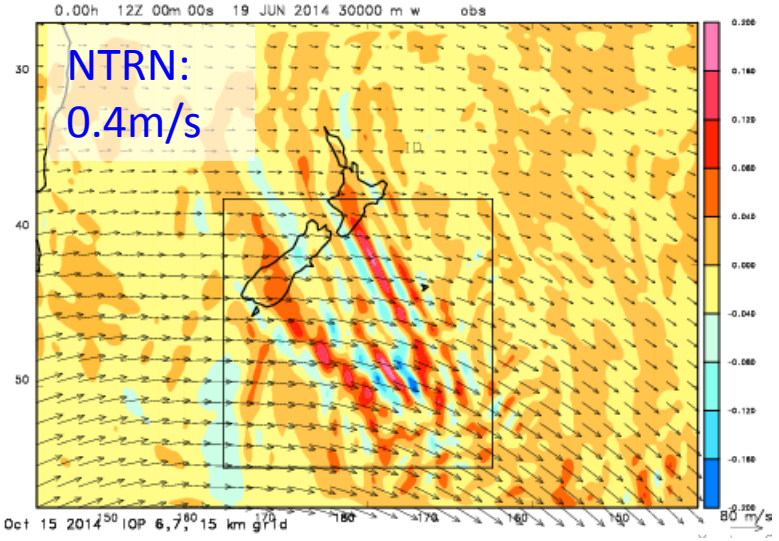


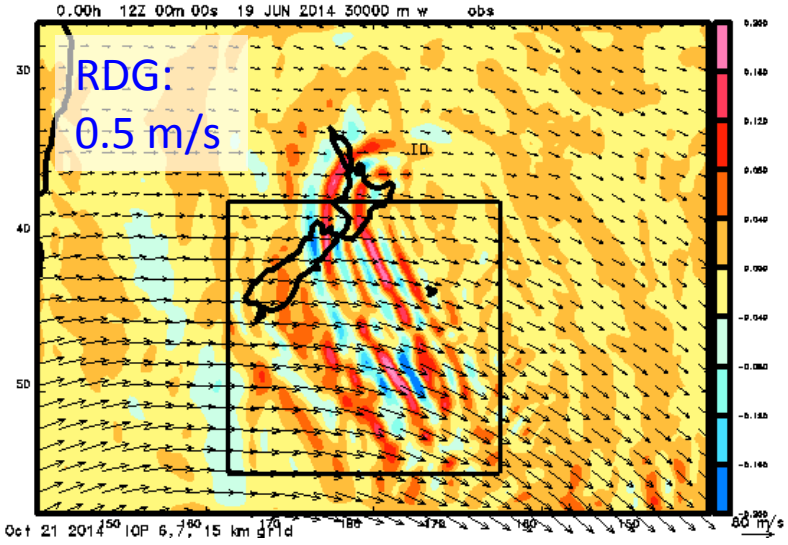


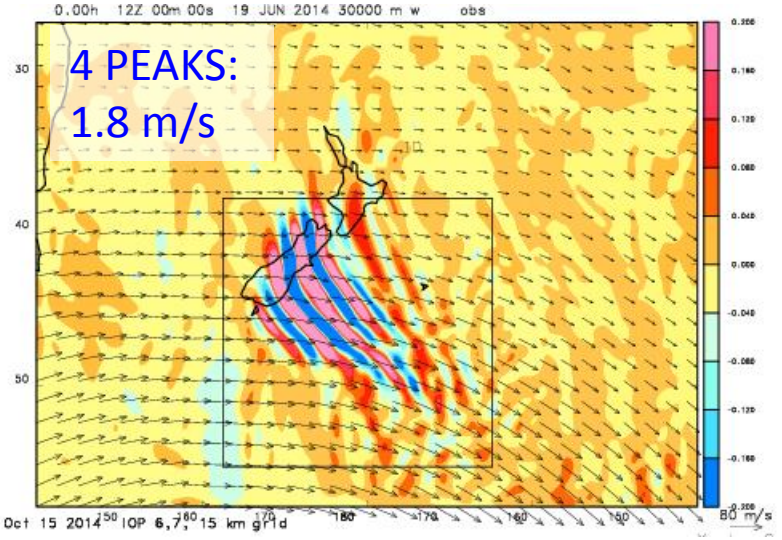
W @ 12 km ASL

Stratospheric Trailing Waves



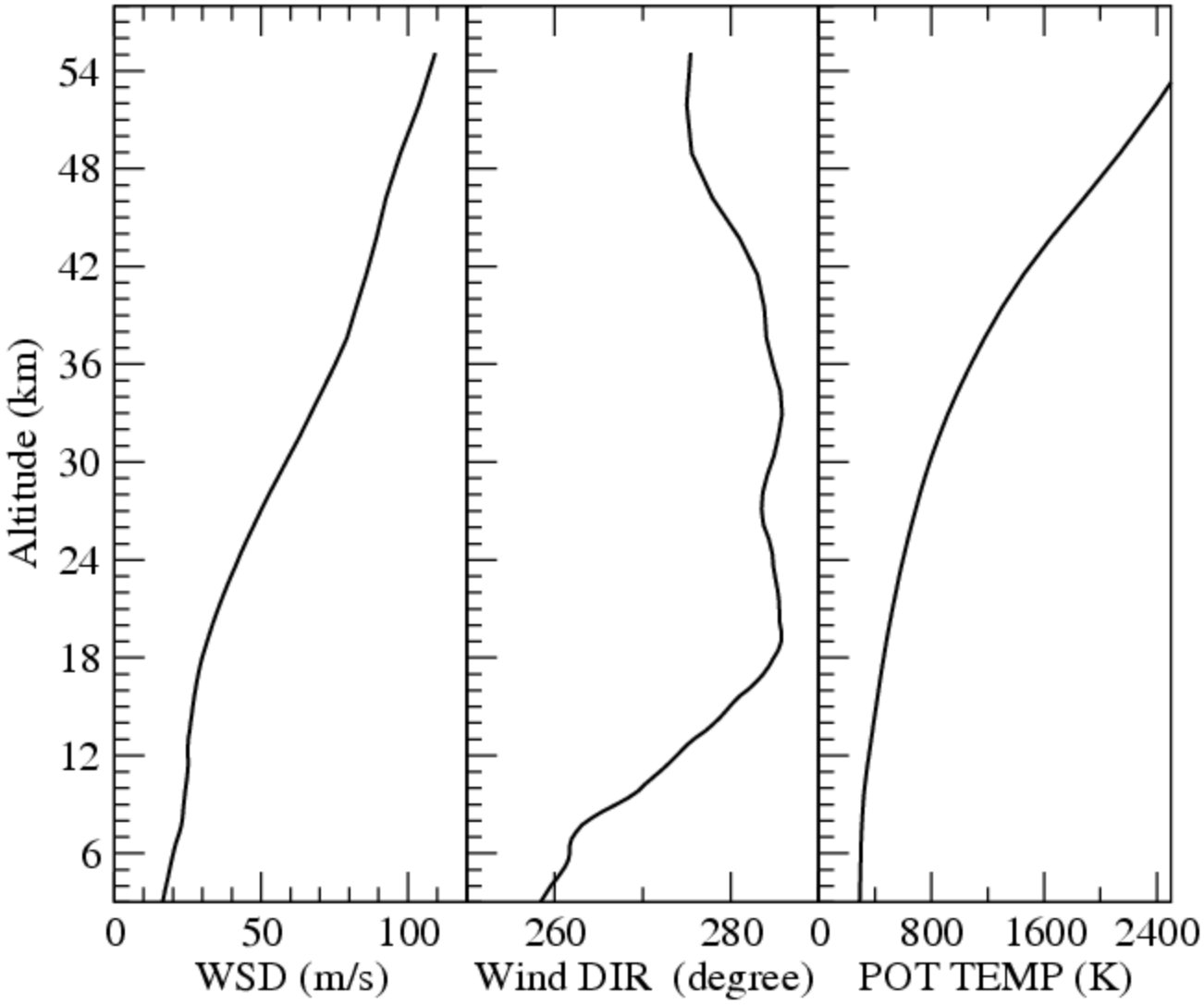




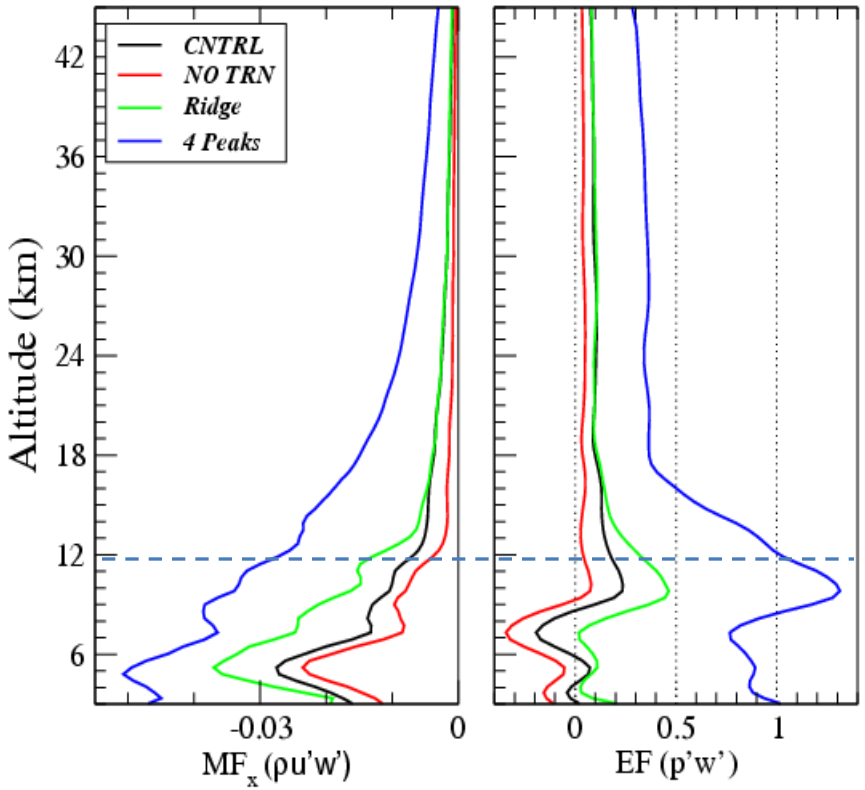


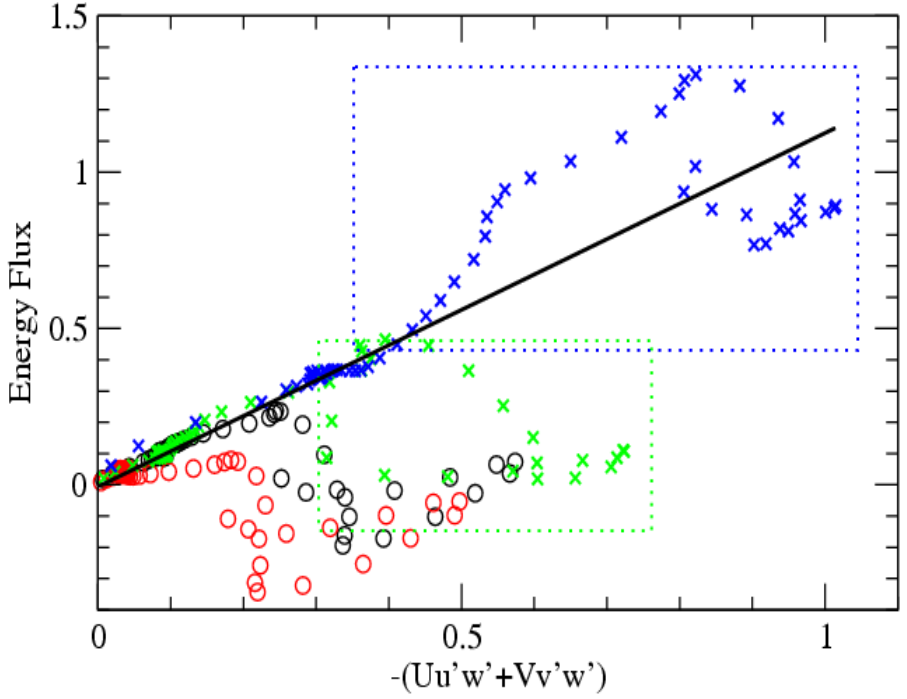
W @ 30 km ASL

Modelled Mean Profiles

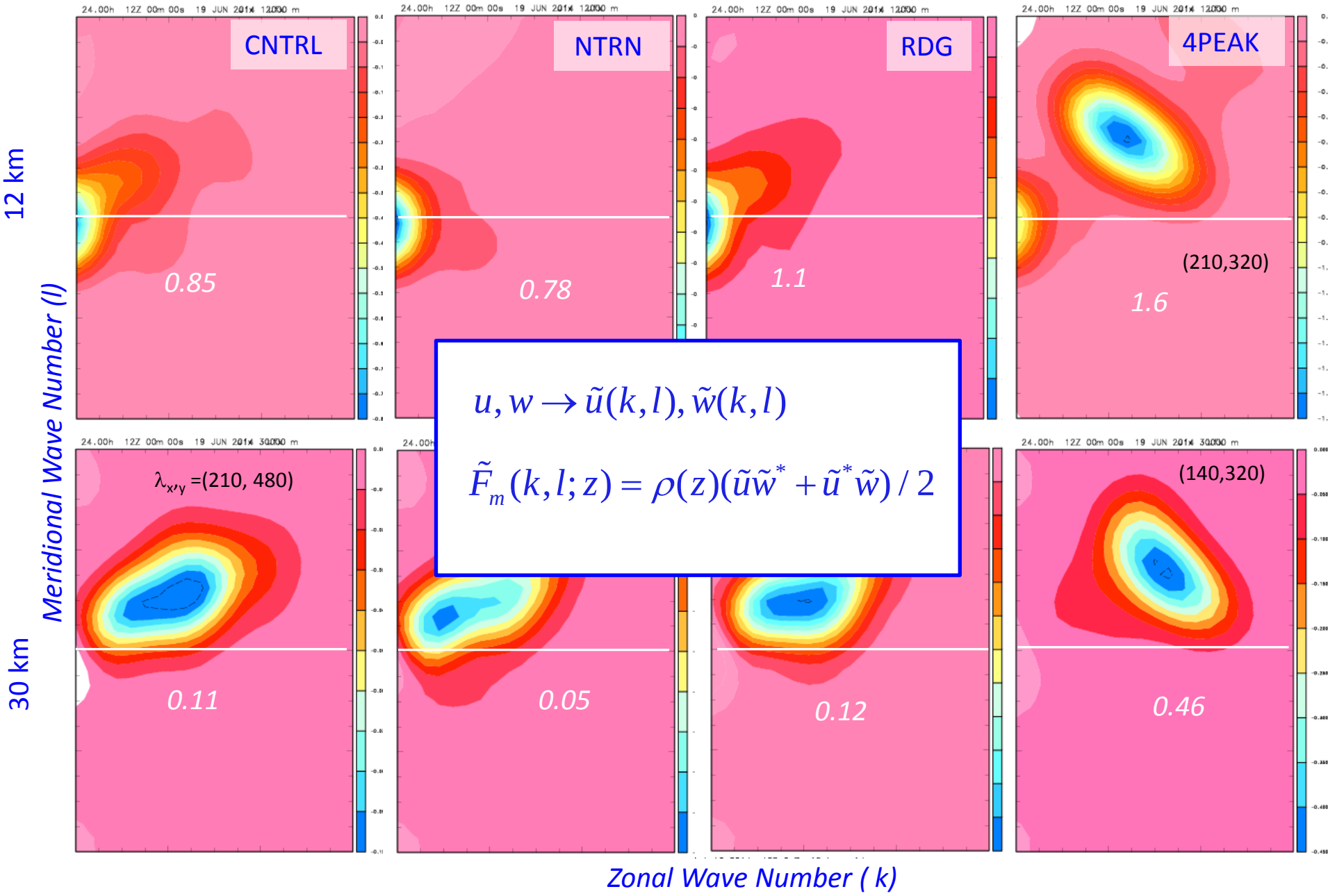


Wave Momentum/Energy Fluxes





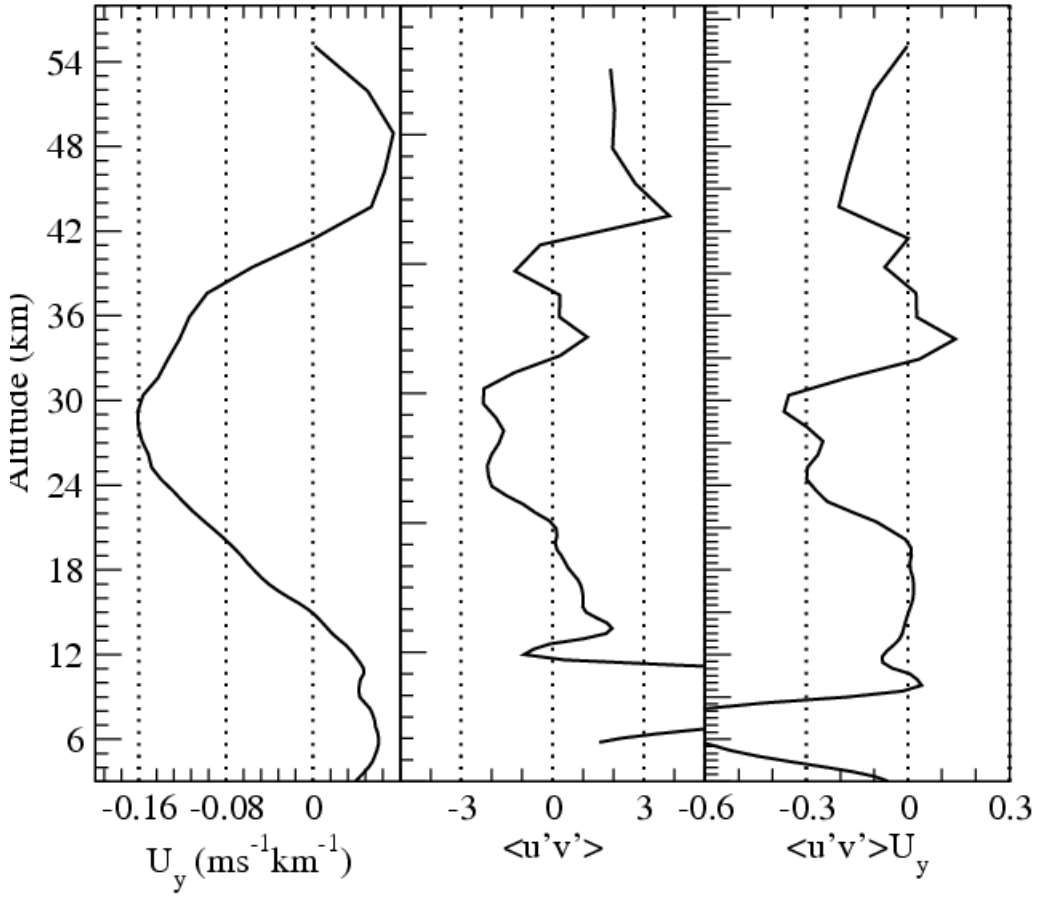
Momentum Fluxes in Wave Number Space



$$u, w \rightarrow \tilde{u}(k,l), \tilde{w}(k,l)$$

$$\tilde{F}_m(k,l;z) = \rho(z)(\tilde{u}\tilde{w}^* + \tilde{u}^*\tilde{w})/2$$

Waves in a Barotropic Jet



Wave kinetic energy gain from meridionally-sheared flow: $\frac{De}{Dt} \sim - < u'v' > \frac{\partial U}{\partial y}$

Summary

- Wave Source?
  - Terrain, but may not be just terrain
- Does TW transfer MF in the vertical?
  - Yes.
- What are the roles of vertical and lateral shear in TW propagation?
  - Vertical directional shear may be responsible for the decrease of wave momentum flux with height
  - Meridional shear shortens the zonal wave number
- What determines TW characteristics?
  - Terrain
  - Lateral/ vertical shear
  - What else?

Model Validation: Why not GV Measurements?