

Overview - GV AMTM Data + Some Research Topics...



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DEEPWAVE Science Team Meeting, Boulder, 4-6 May, 2015

Research Topics and Activities

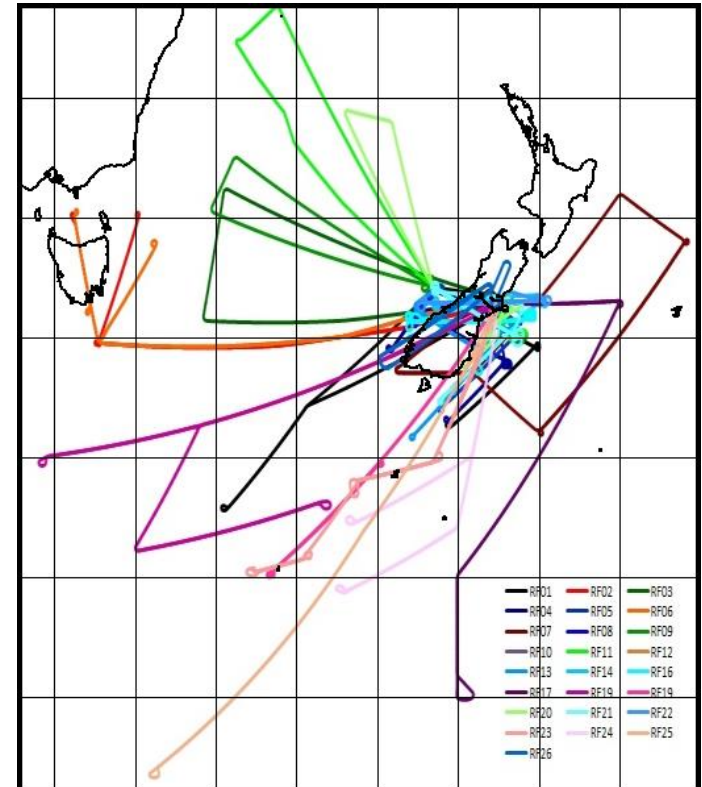
DEEPWAVE

- Explore GW generation, characteristics and propagation to high altitudes.
- Investigate impact of various sources and different forcing conditions on MLT region.

Research Topics

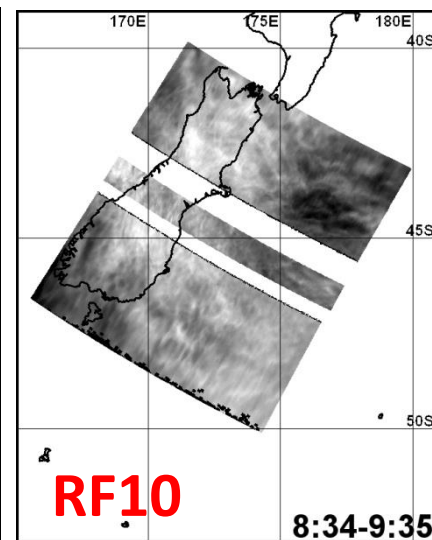
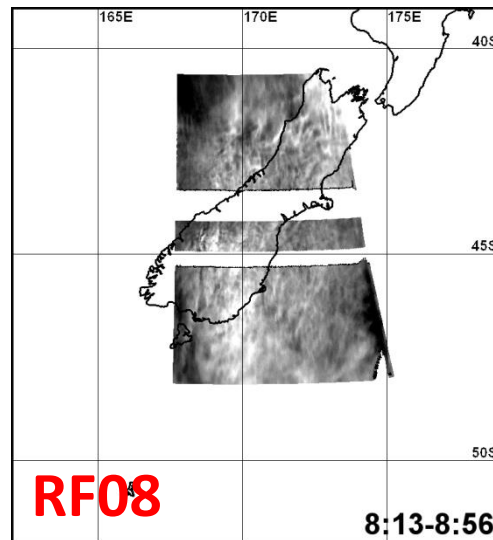
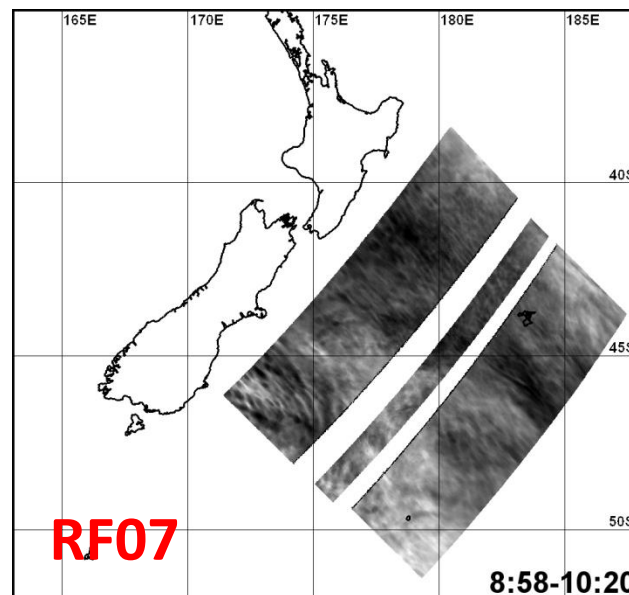
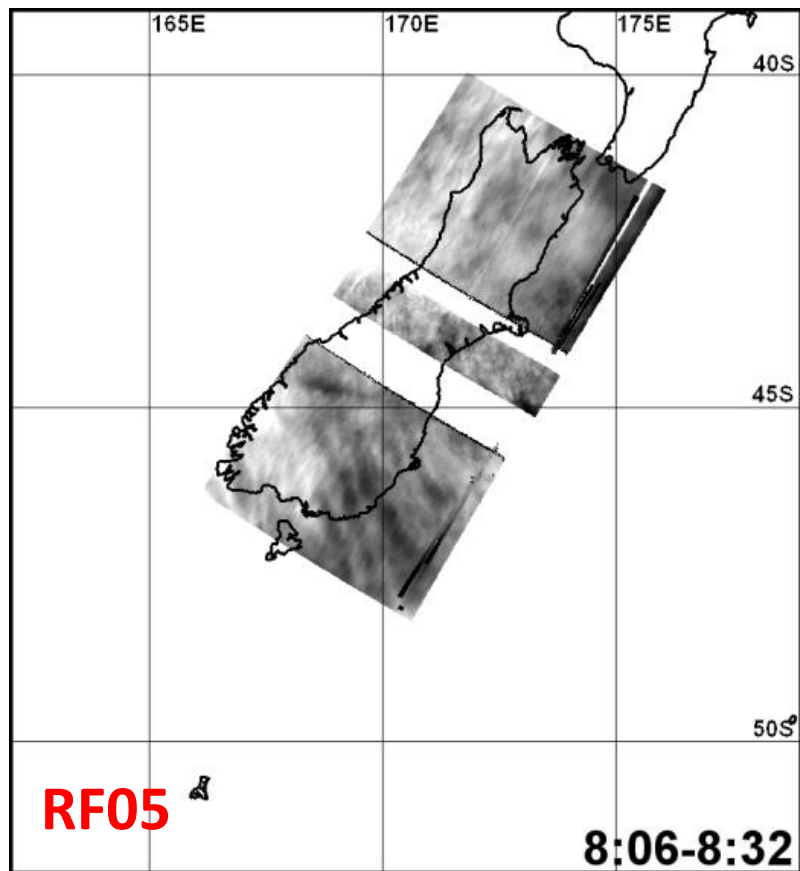
- Mountain Waves (MW) –quantify properties and estimate momentum fluxes
- Open Ocean waves
- Island sources and MLT responses
- Land vs. ocean wave differences (T variances)
- MLT response to flight level forcing
- Modeling/predicting wave driven mesospheric weather?

26 flights



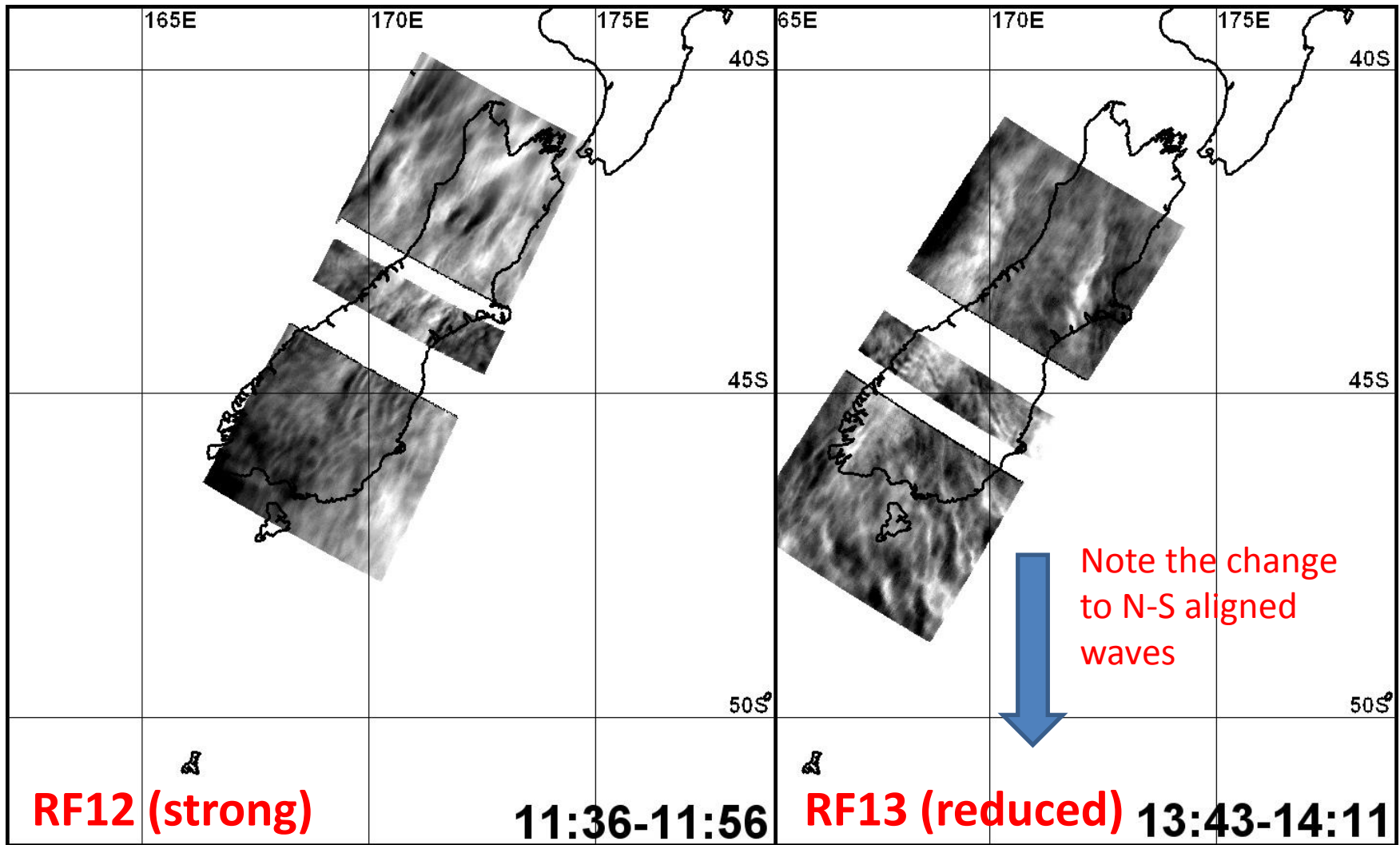
- **14 flights** with multiple crossings over NZ South Is.
- **11 extended flights** over open ocean.

Mesospheric GW over New Zealand



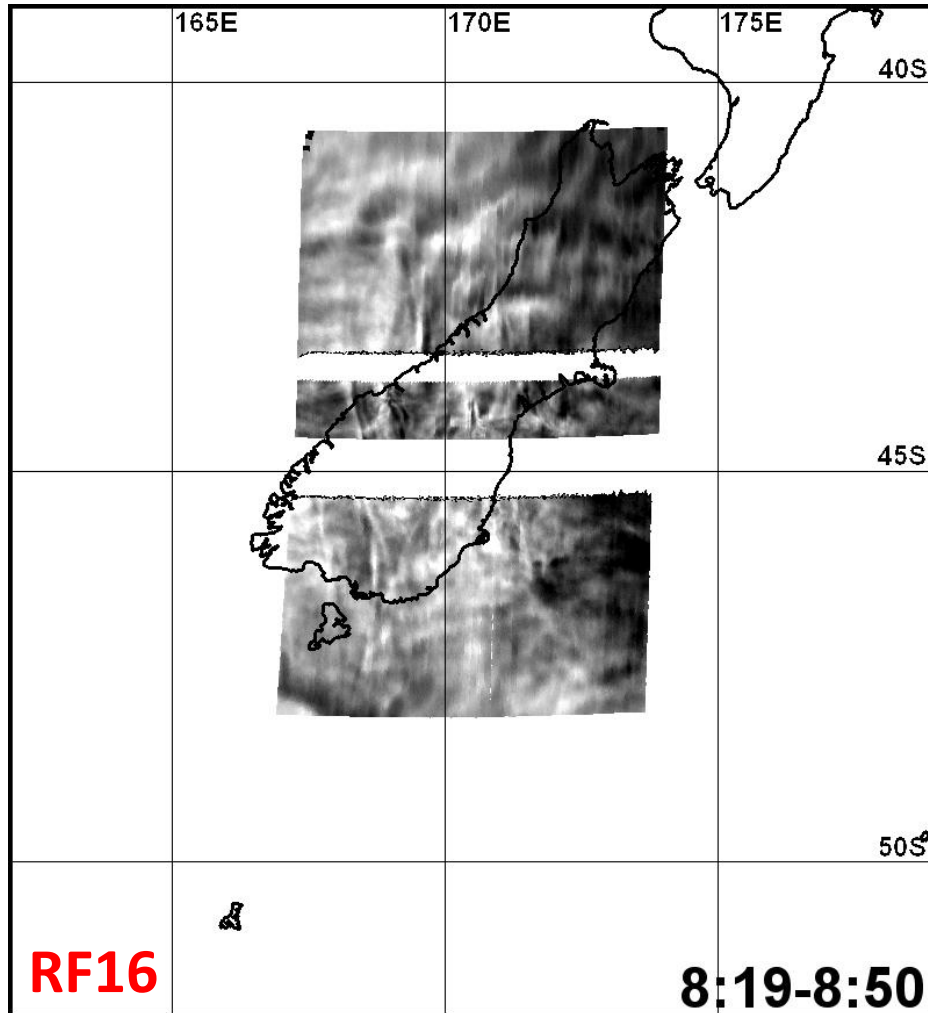
- 14 flights with legs over South .Is.
- Extensive wave activity **always present**.
- Variety of small and large-scale GW at MLT altitudes.
- Not always coherent.
- (e.g., RF04, 05, 07, 08, 10, 20, 21)

Mountain Waves!.. over New Zealand

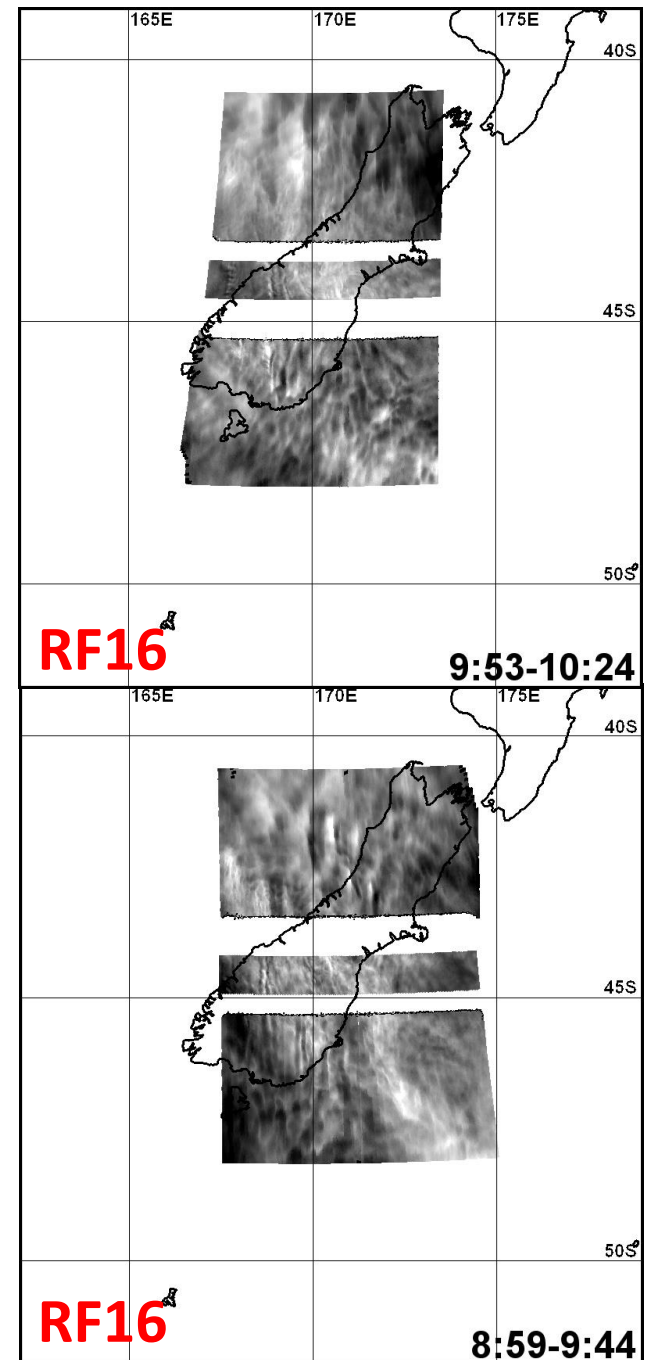


GWs aligned parallel to the mountain range (e.g., RF12, RF13)

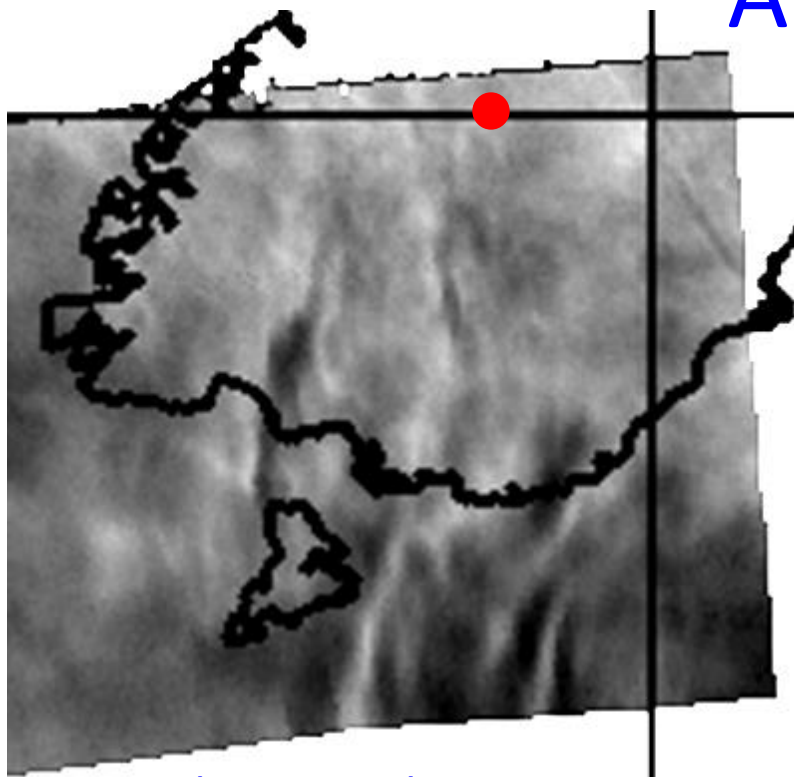
N-S Mountain Waves



Extensive ~N-S aligned GWs
(e.g., RF08, RF14, RF16, RF22)

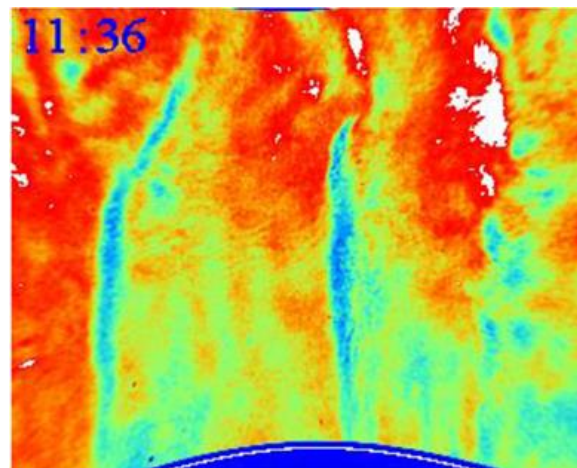


N-S MW Captured by GV and Lauder AMTM

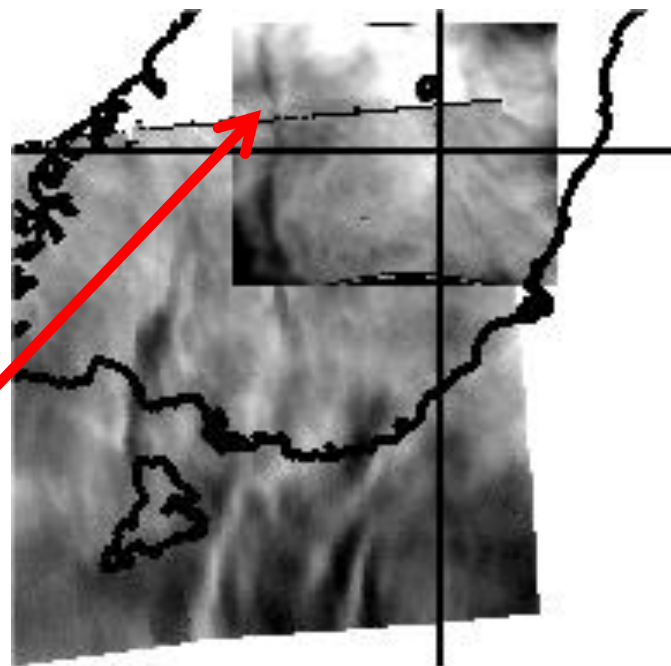


RF03 (June 12): returning from flight over Tasman Sea

Bad weather at Lauder but standing wave detected around 12UT

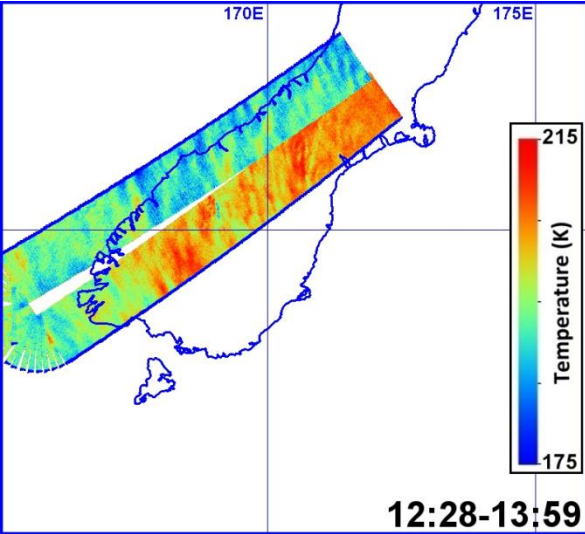
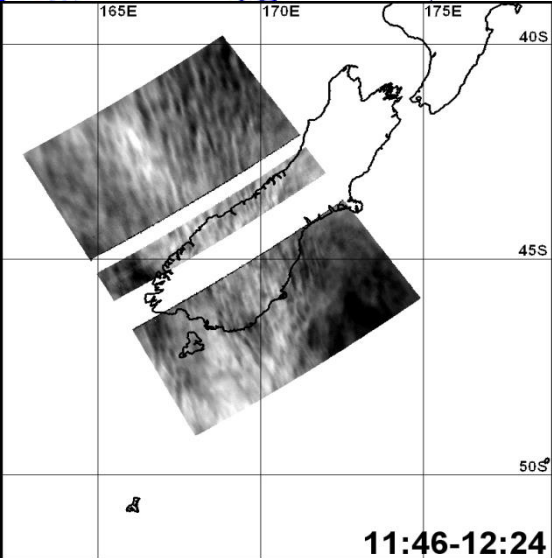
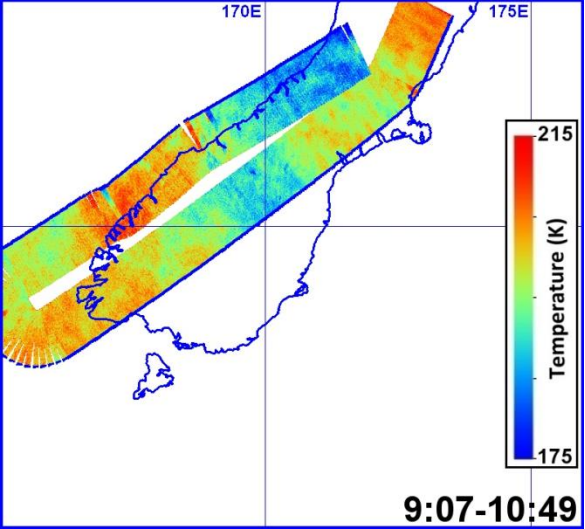
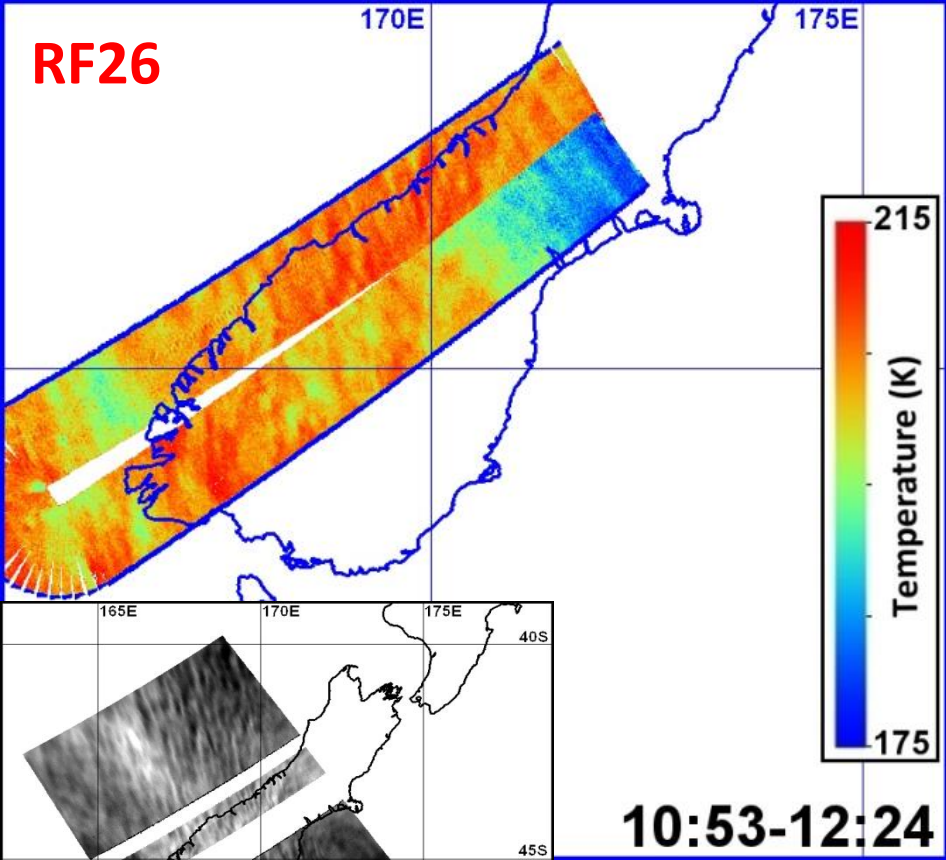


MW from Lauder on June 21-22



Extensive Coherent Mesospheric Waves over NZ

GWs more perpendicular to the South Island (e.g., RF01, RF07, RF26)



Mountain Wave Studies

Involve:

- Flight level measurements
- Mid-atmosphere measurements (Rayleigh lidar)
- Upper atmosphere measurements (Na lidar, AMTM)
- Satellite data (AIRS...)
- Extensive modeling

Questions:

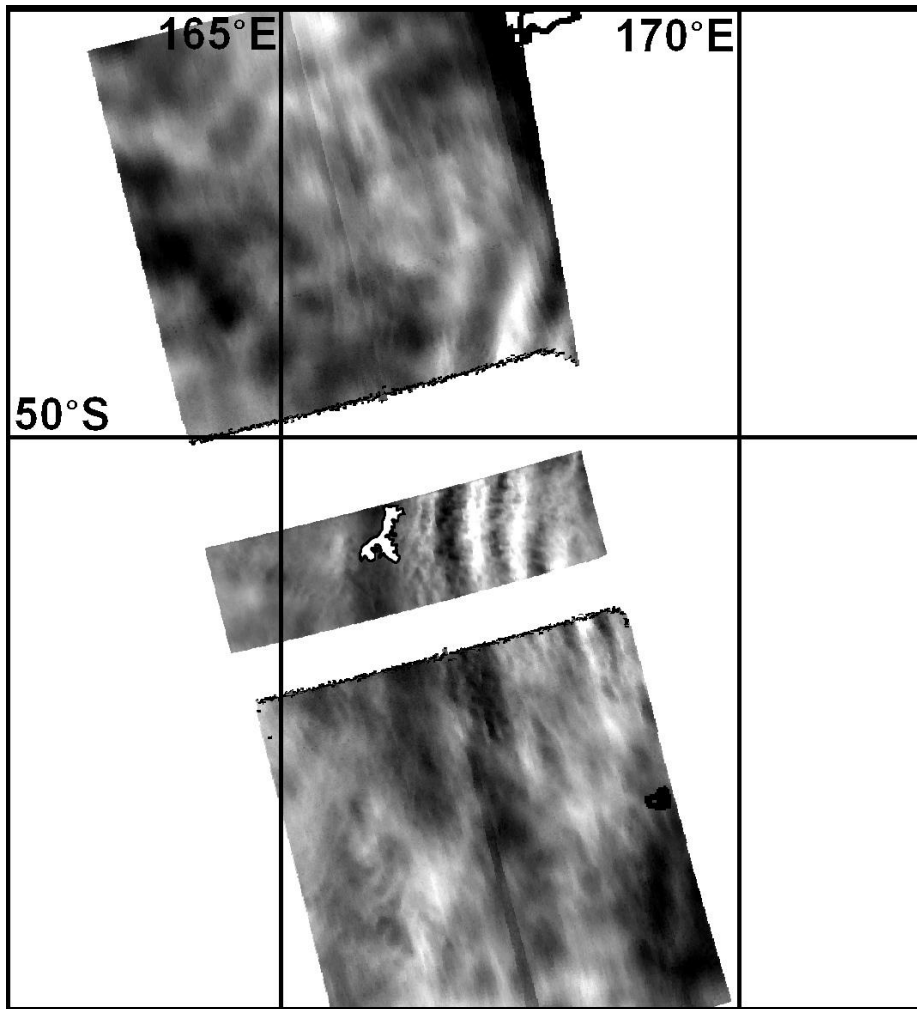
- What are the dominant scale sizes of the MW over NZ?
- What are the tropospheric conditions giving rise to MWs - relation with the wind direction/ strength.
- What are the middle atmosphere conditions enabling deep propagation?
- What are the impacts of MW in this region?

Isolated Mountain Effects

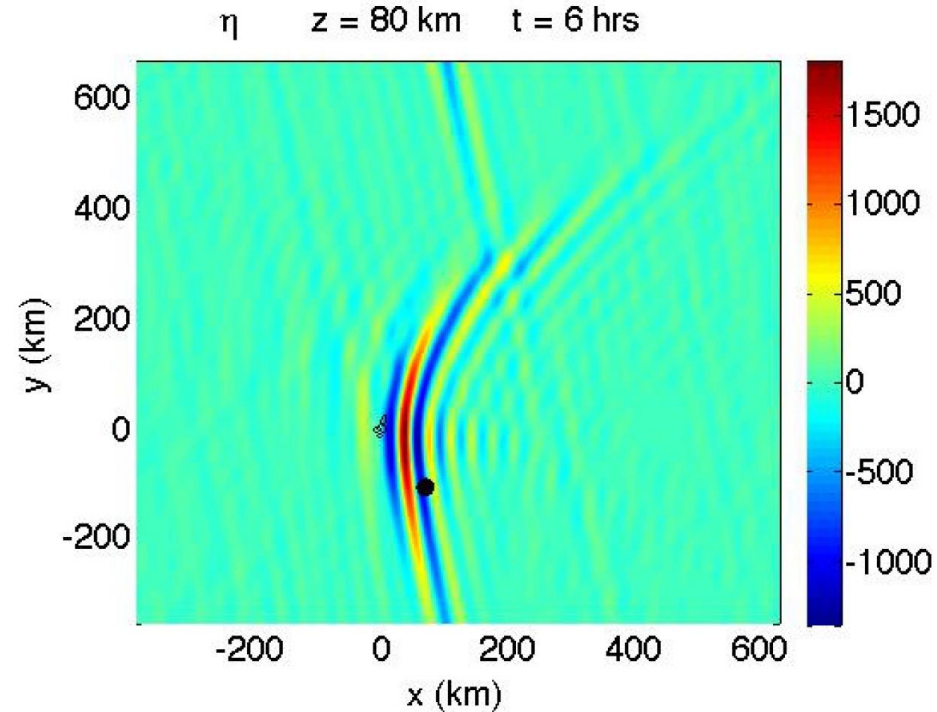


ISS 0306 cloud image, (courtesy NASA)

Discovery! Isolated Mesospheric MW

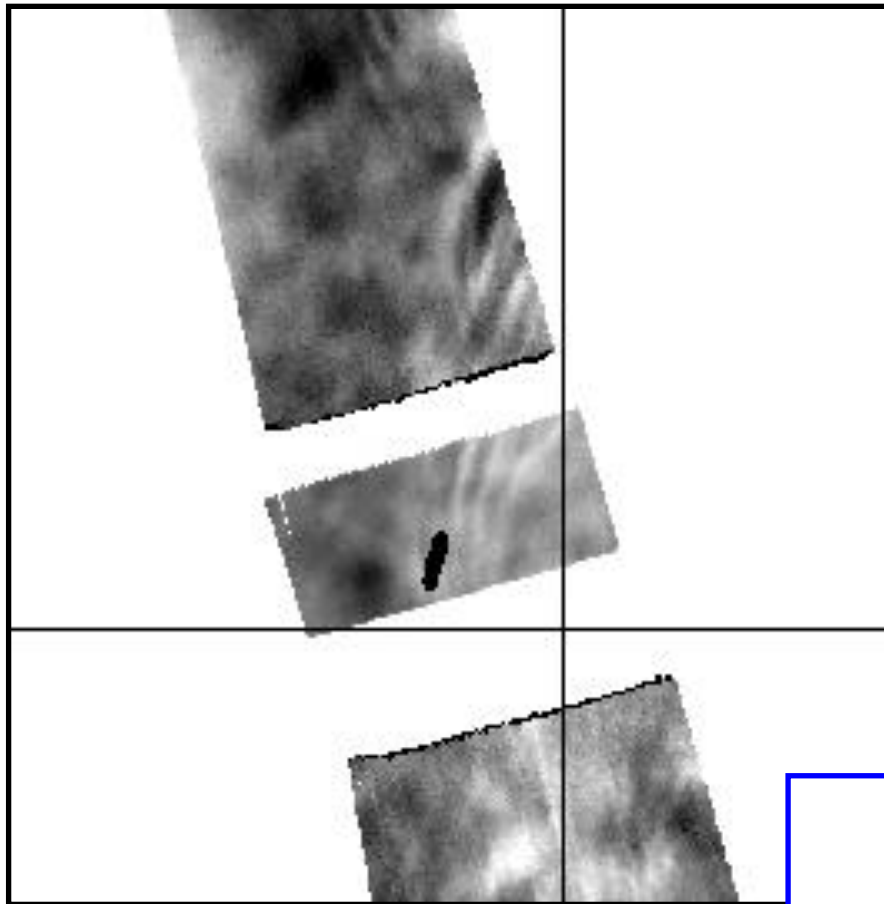


RF23: Auckland Islands (660m)

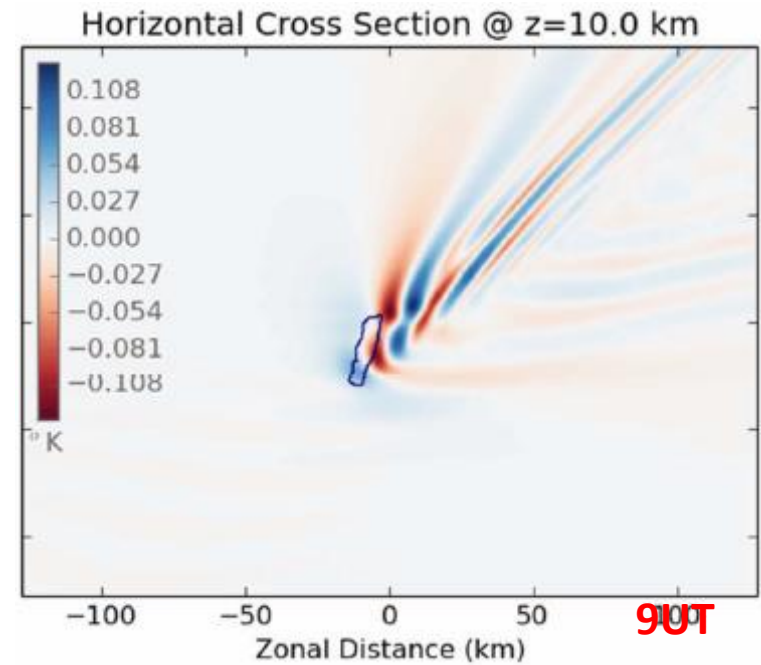


Fourier-Ray model simulation
(Courtesy D. Broutman)

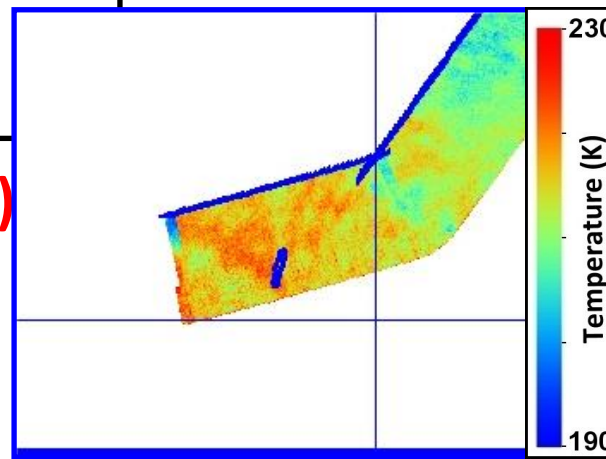
More Mountain Waves: Macquarie Island



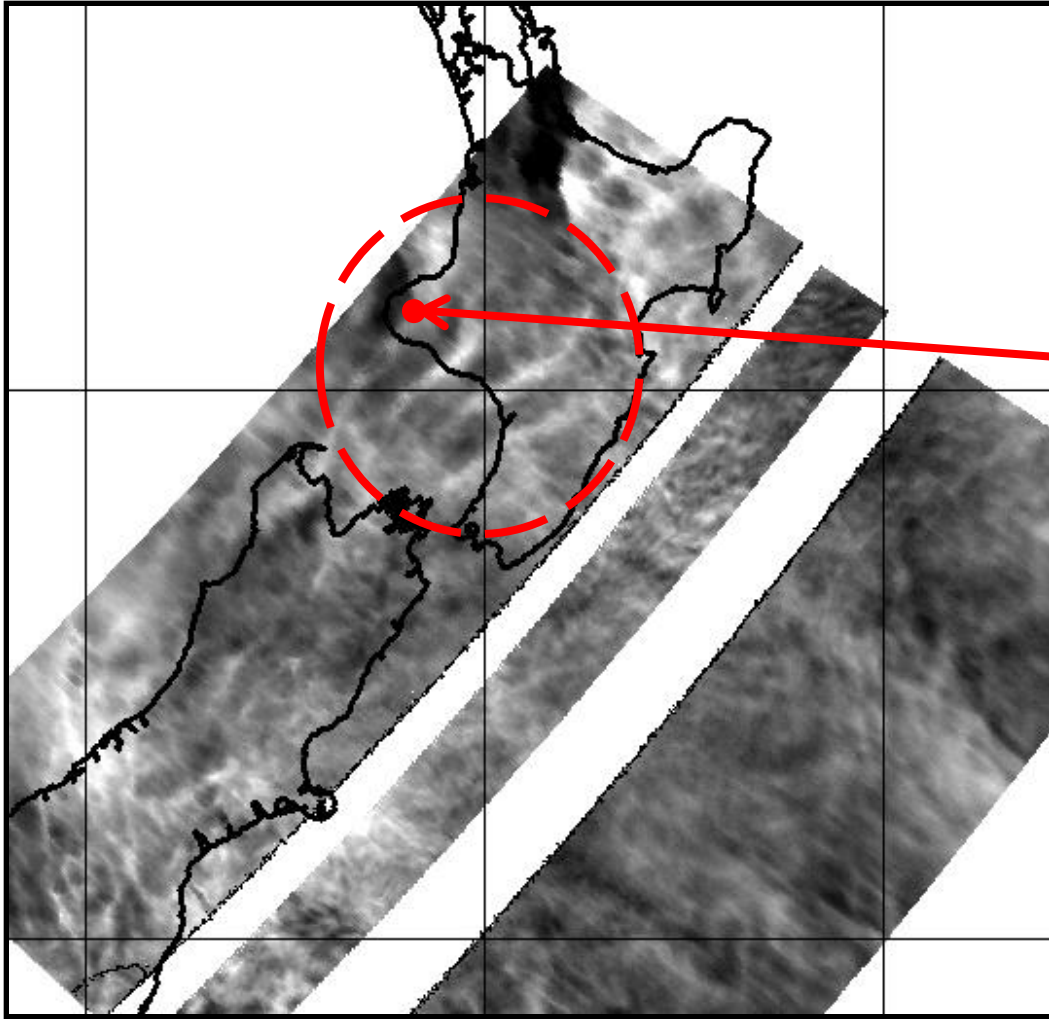
RF23: Macquarie Island (410m)



Fourier-Ray model simulation
at 10km
Courtesy J. Ma)



MW from Other Isolated Sources?



Mount Taranaki or
Egmont (1966m)
North Island.

RF07 - June 19th

Isolated Mountain Wave Studies

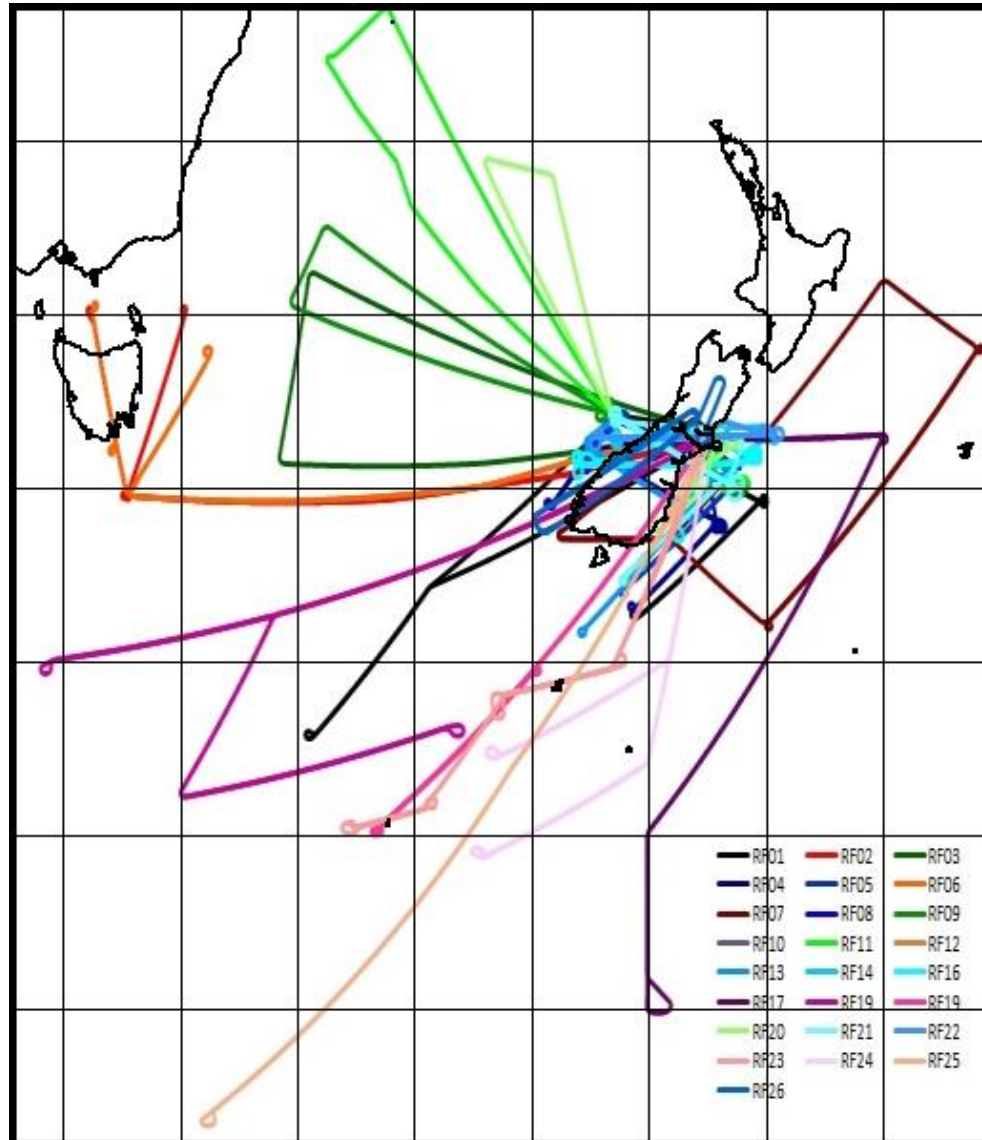
Involve:

- Flight level measurements
- Mid-atmosphere measurements (Rayleigh lidar)
- Upper atmosphere measurements (Na lidar, AMTM)
- Satellite data (Suomi NPP VIIRS +...)
- Extensive modeling

Questions:

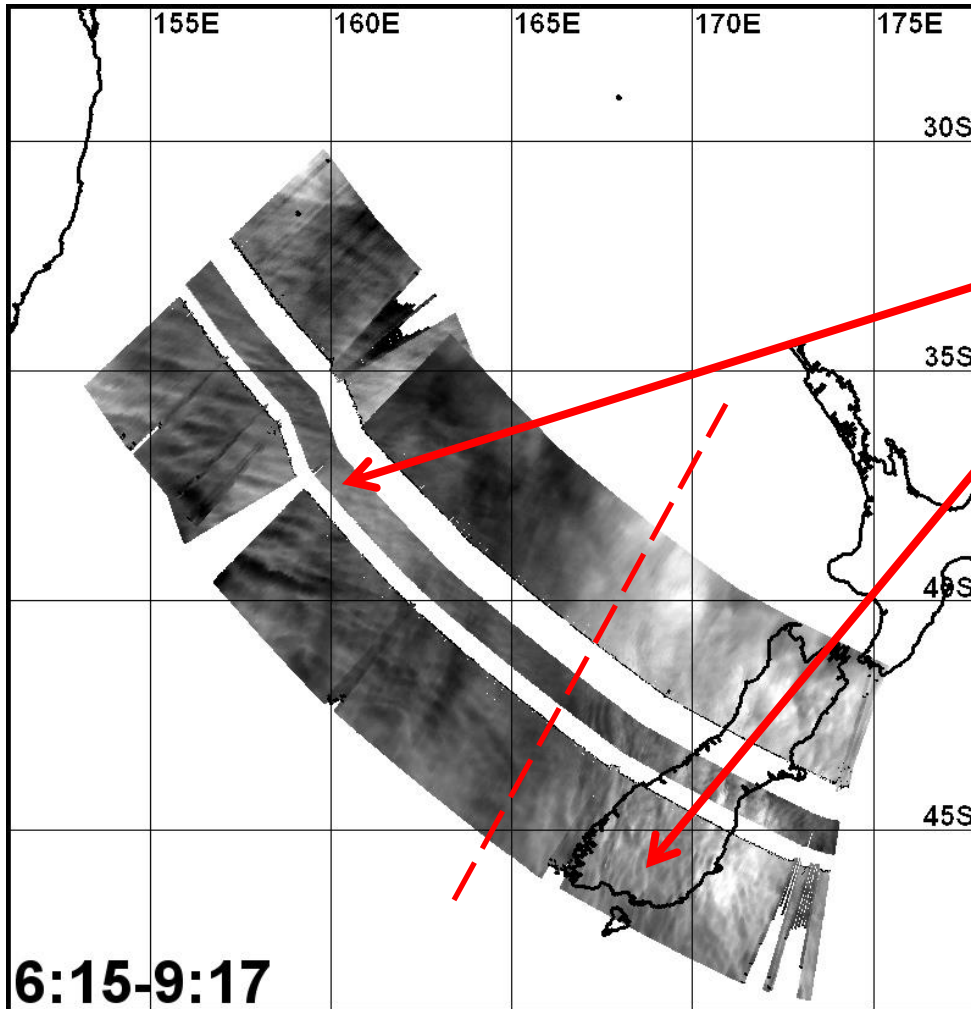
- How often do they occur?
- What are their dominant scale sizes?
- What are the range of tropospheric conditions that give rise to isolated MW penetration into the MLT region?
- How small an island can have and impact on MLT?
- What is their impact on the mid/upper atmosphere?

Comparison Land vs. Open Ocean



11 extended flights over open ocean

Comparison Land vs. Open Ocean



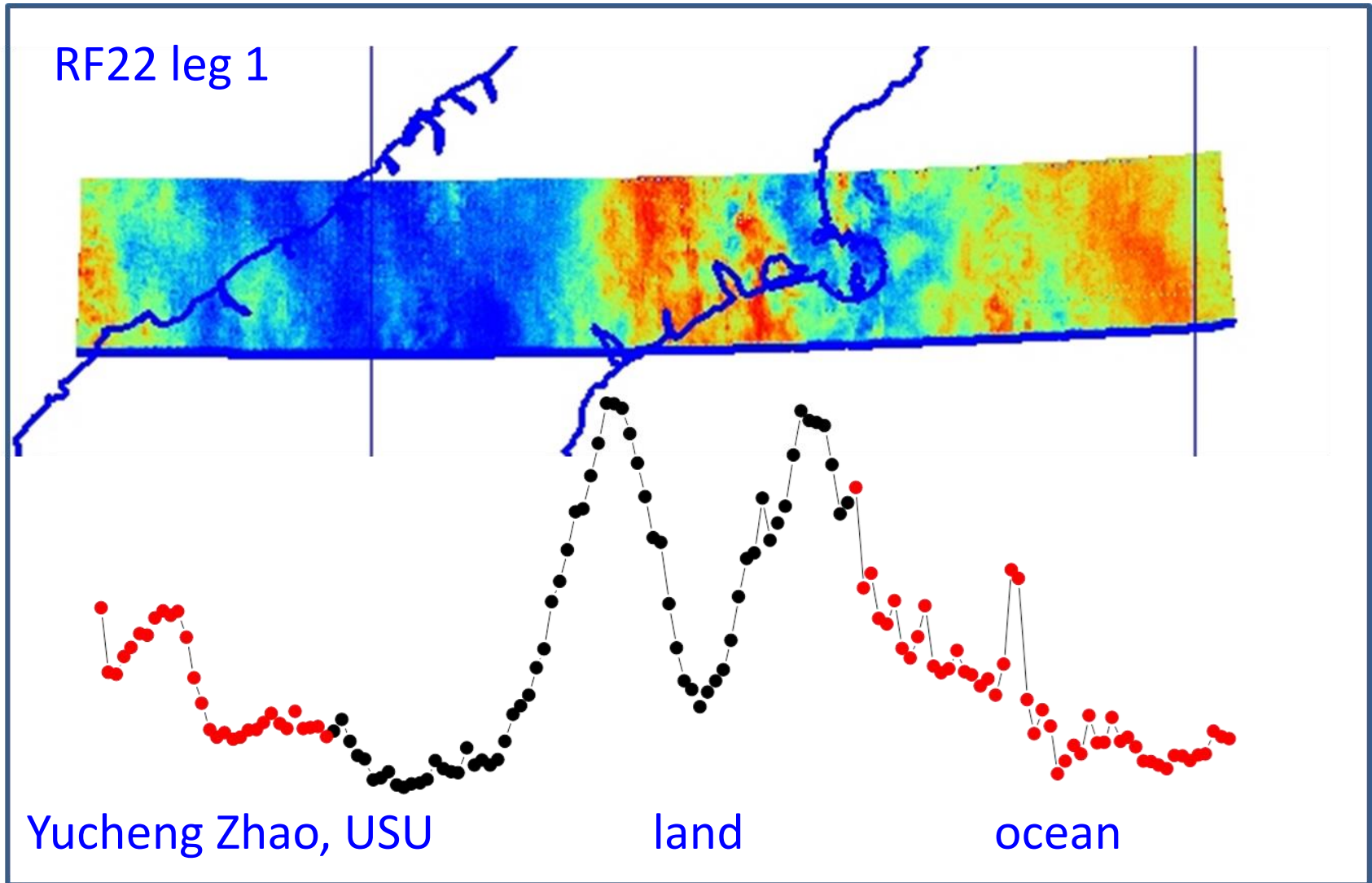
Two different regions

- Over Tasman Sea
- Over South Island, NZ

Two different extensive small-scale GW patterns

Example: RF11

OH Temperature Variances (~87 km)



Comparison Land vs. Open Ocean

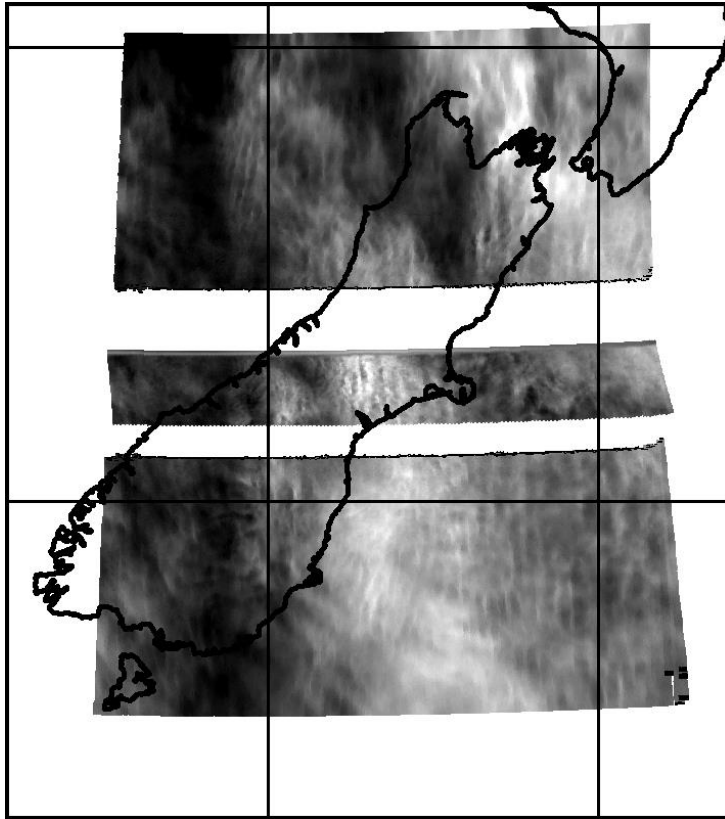
Involvement:

- Flight level measurements
- Upper atmosphere measurements (Rayleigh lidar + AMTM)
- Satellite data (AIRS)
- Extensive Modeling

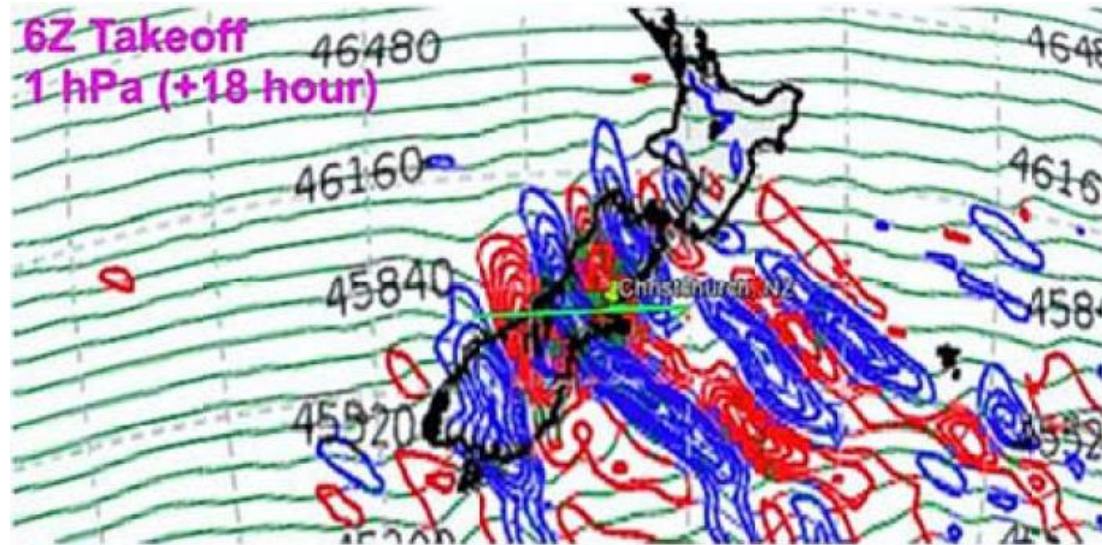
Questions:

- What are the characteristics of the GWs at MLT heights over the land? Over the ocean?
- What are correlations/connections of wave activity at different altitudes?
- Are there any major differences (wave parameters, temperature variance)?
- What are the dominant sources of GWs over open ocean?

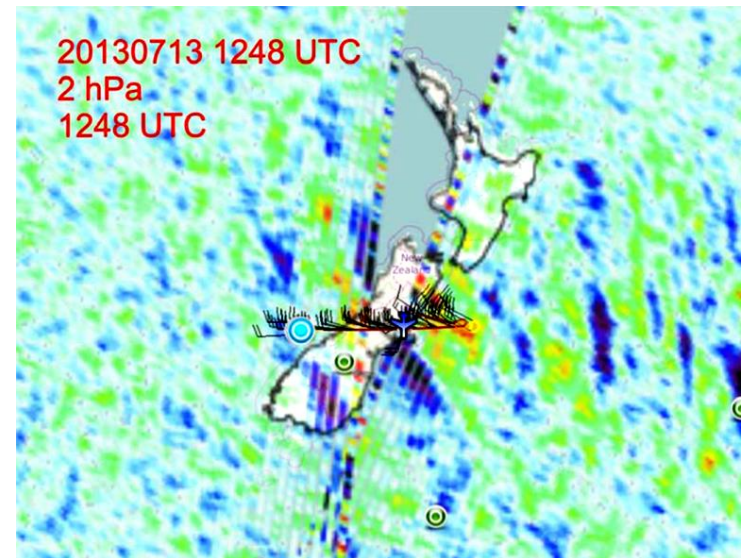
Comparison of Mesospheric and Model/Measured Stratospheric Waves



RF22 – South Island (~87 km)

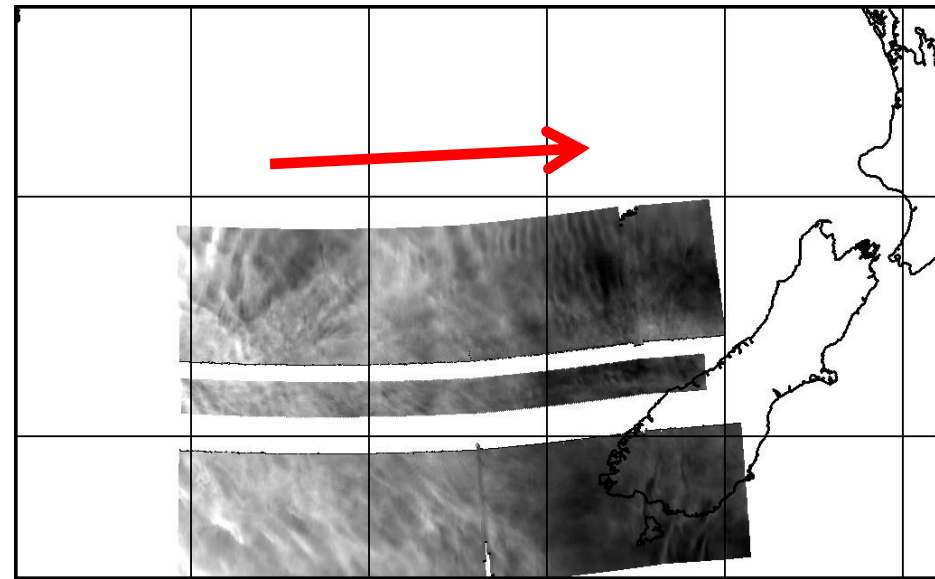
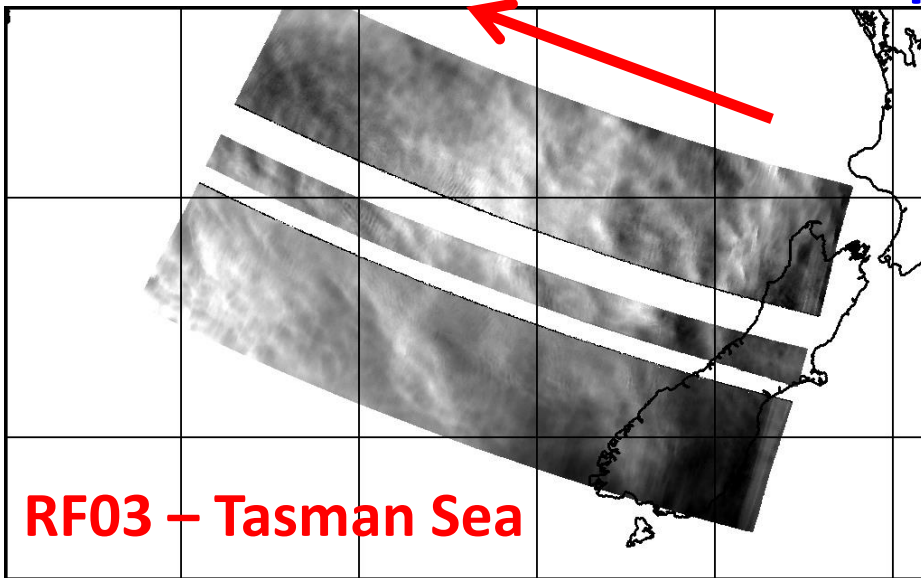


**ECMWF Div at
1hPa (~48km)**

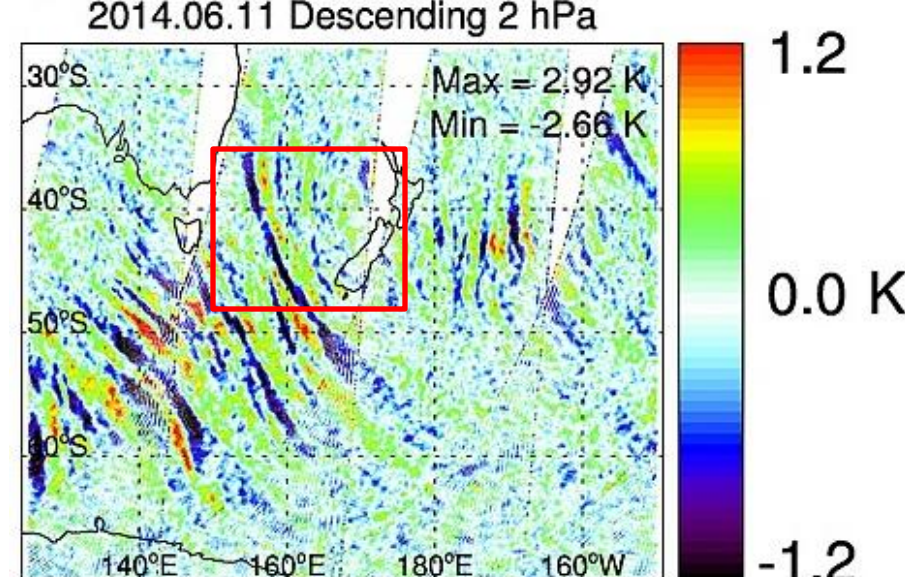
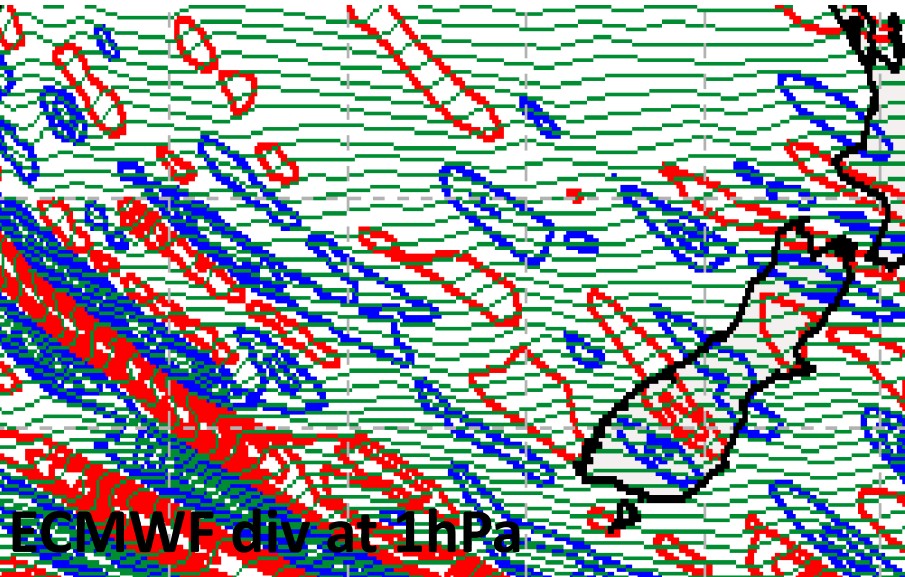
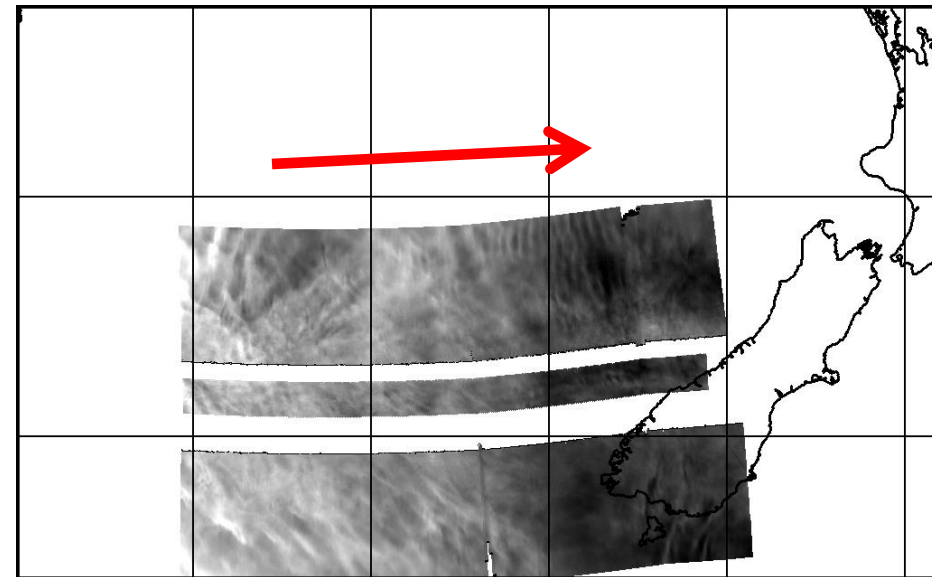
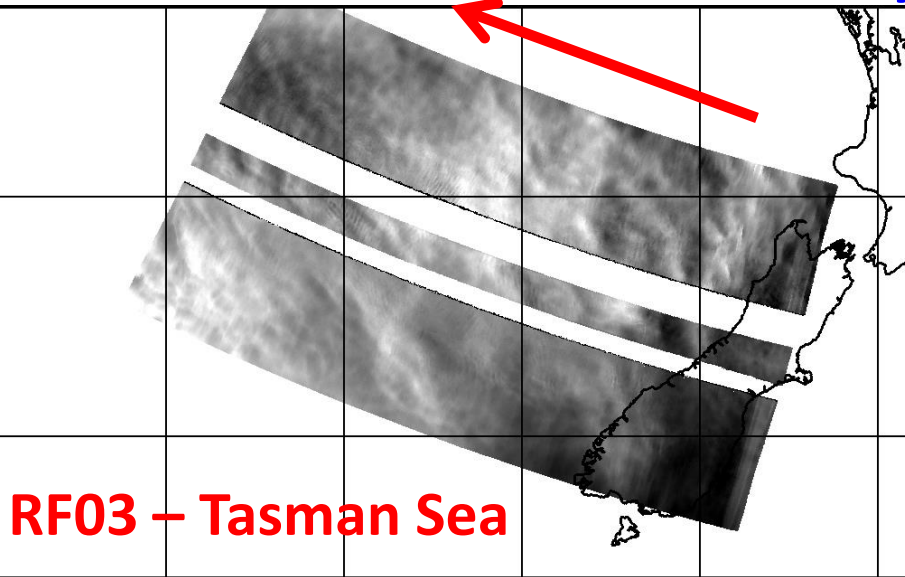


**AIRS Upper stratosphere
radiances (~42km)**

Open Ocean Comparison of Mesospheric and Stratospheric Waves

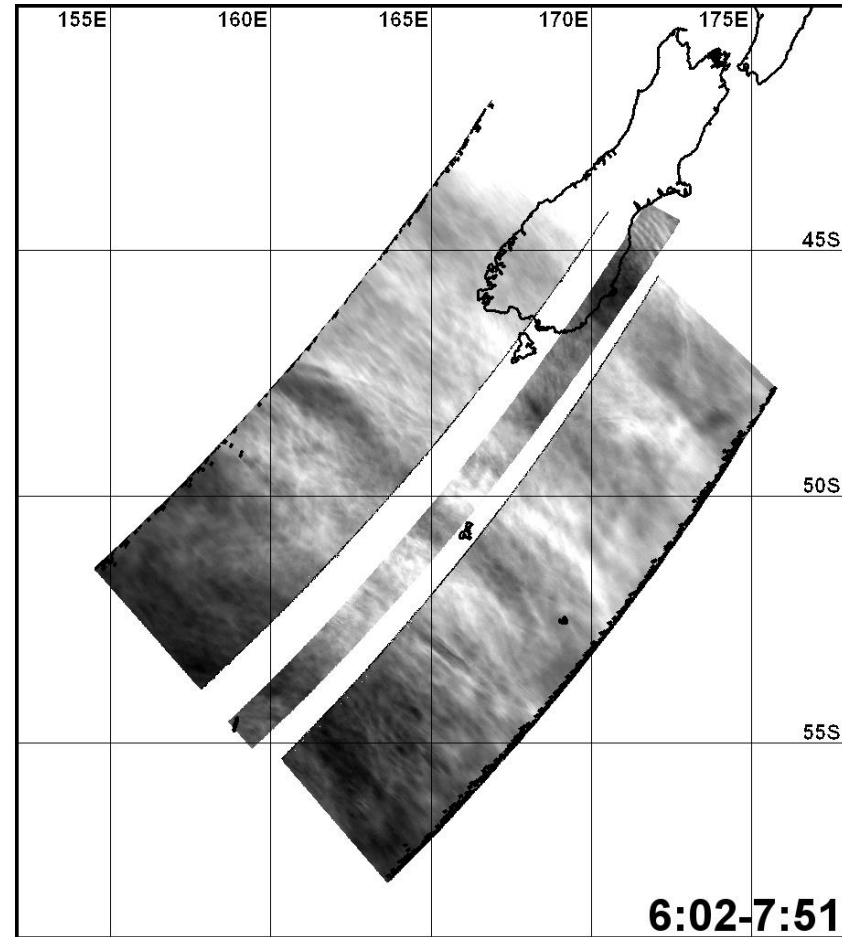
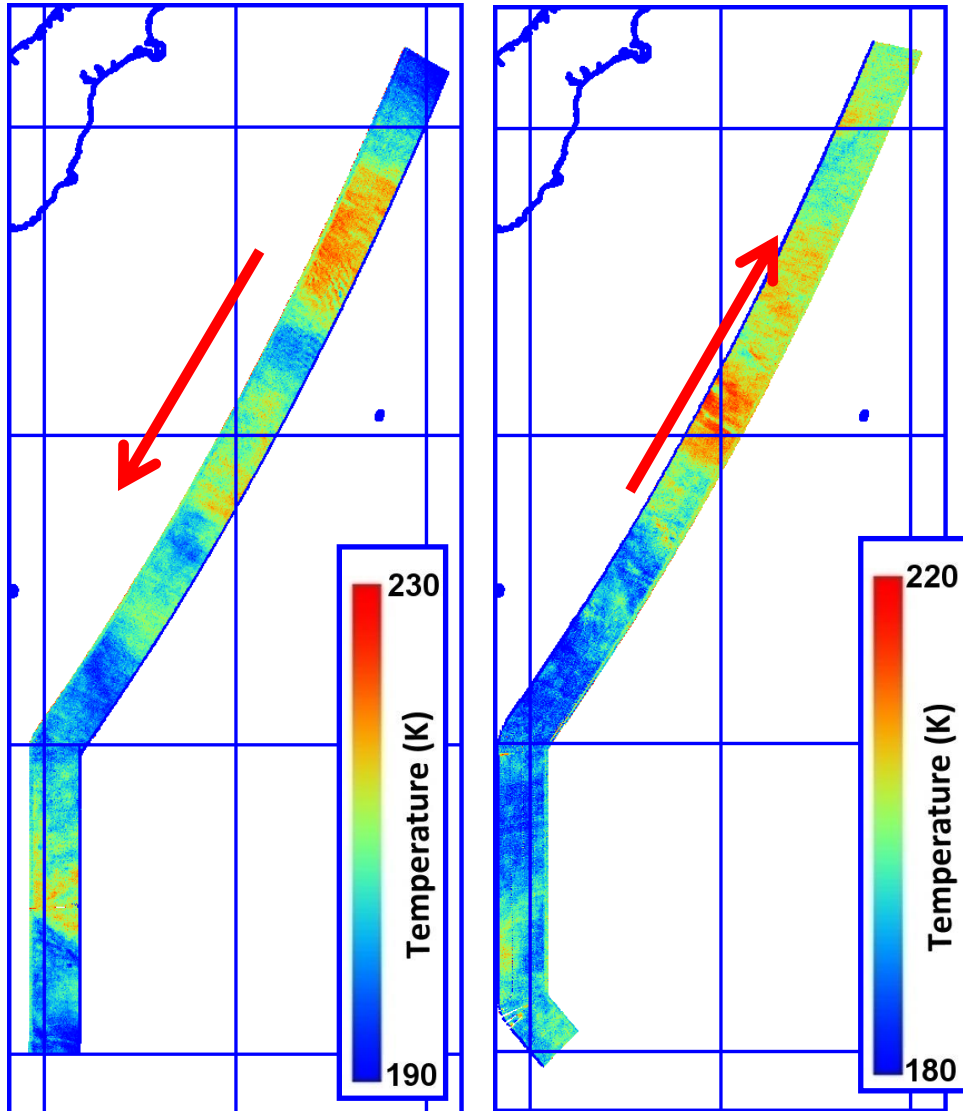


Open Ocean Comparison of Mesospheric and Stratospheric Waves



Extensive, Coherent Open Ocean GW

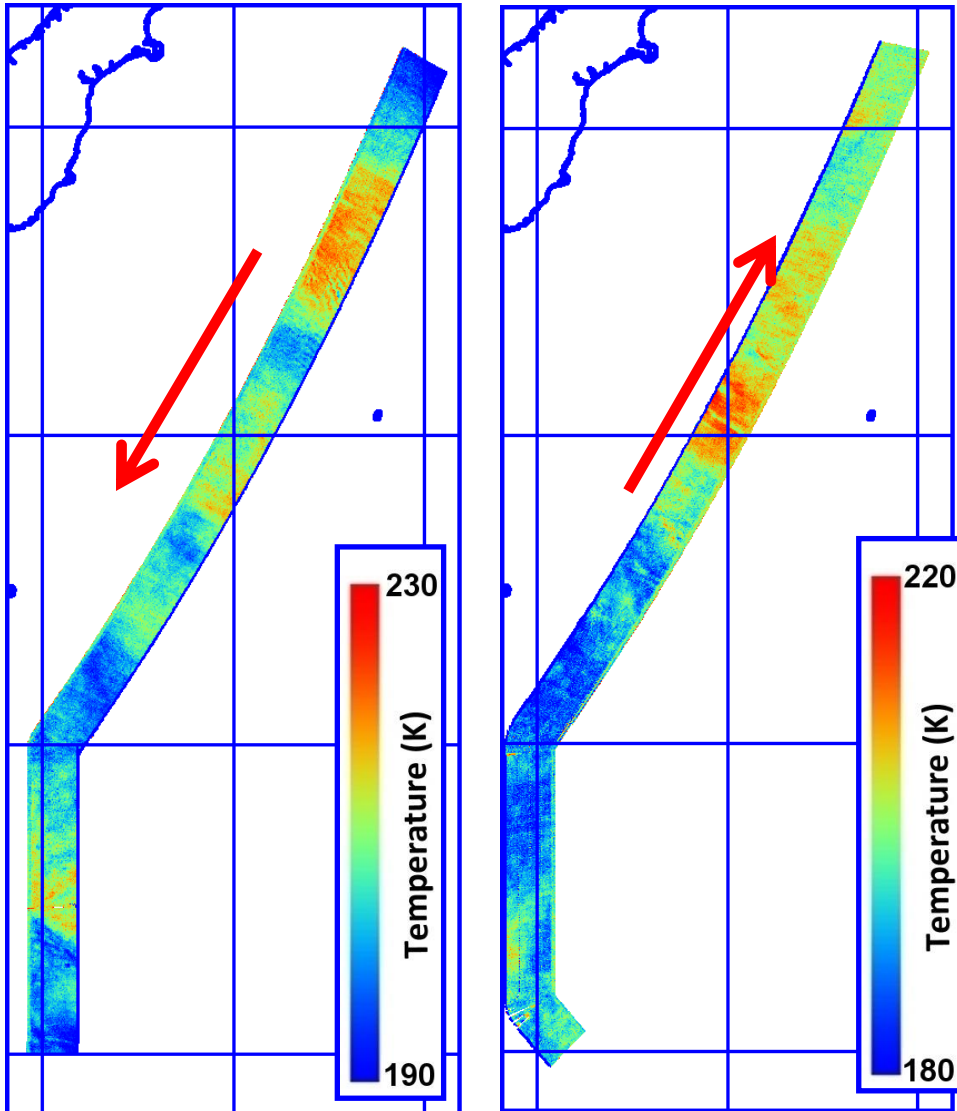
RF17 – Southern Ocean



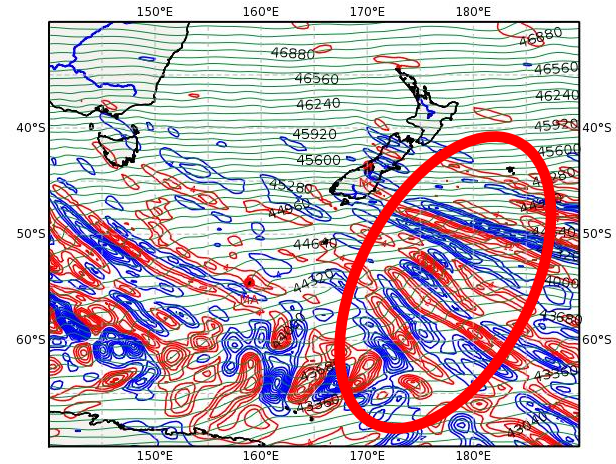
RF 19-Similar wave pattern

Comparison with Stratospheric Waves

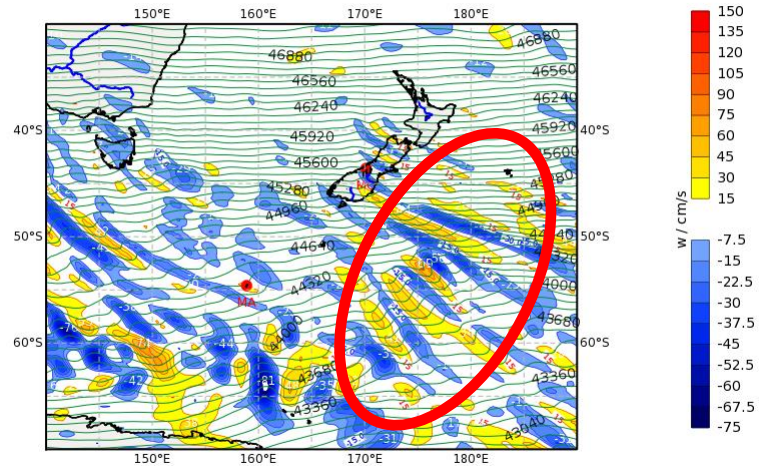
RF17 – Southern Ocean



DIV (10^{-5} s^{-1} , pos.: red, neg.: blue, Delta=4.) and Z (m) at 1 hPa
Valid: Sat, 05 Jul 2014, 12 UTC (step 000 h from Sat, 05 Jul 2014, 12 UTC)



Vertical velocity (cm/s) and Z (m) at 1 hPa
Valid: Sat, 05 Jul 2014, 12 UTC (step 000 h from Sat, 05 Jul 2014, 12 UTC)



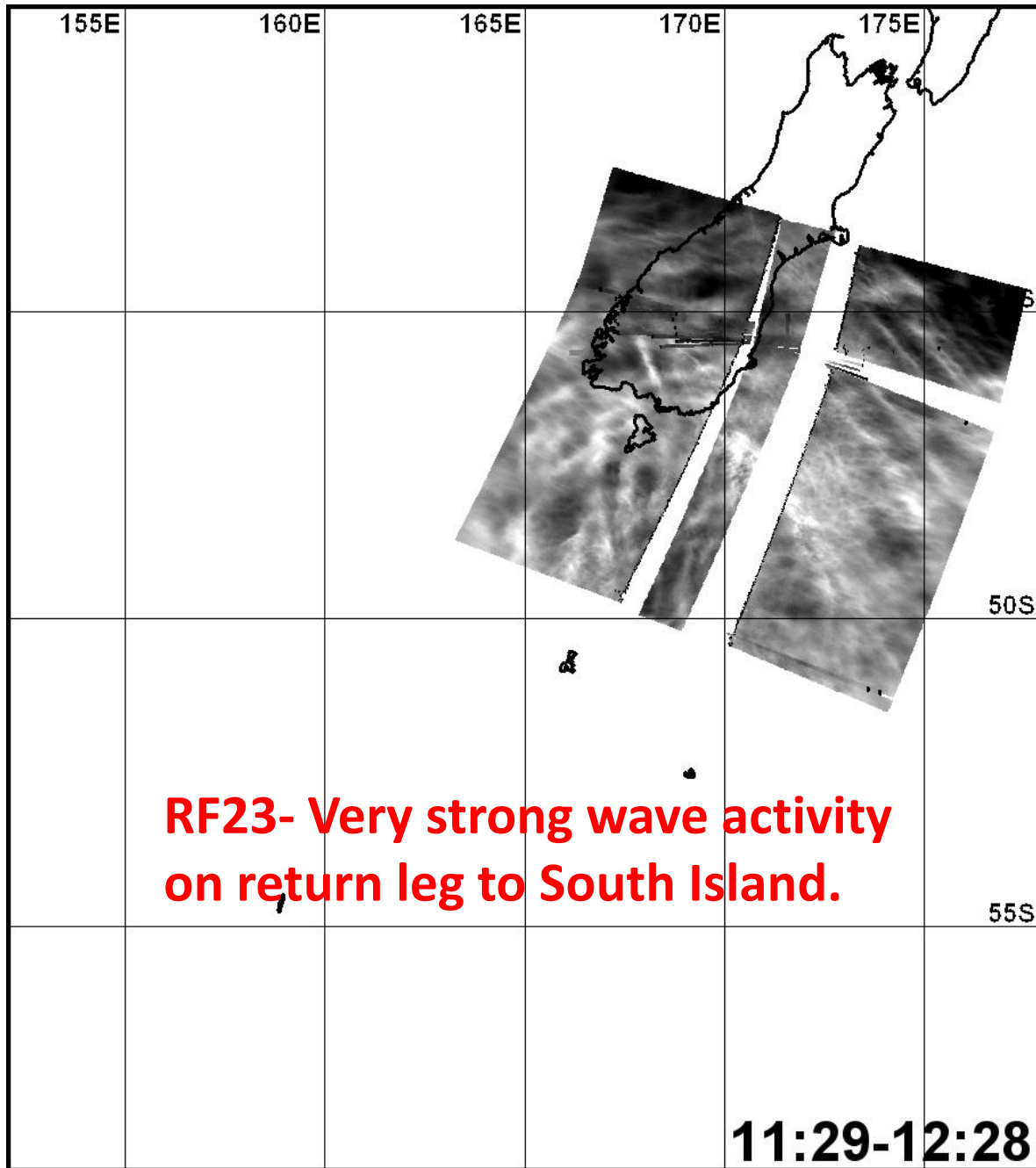
Comparison with Stratospheric Waves

Involve:

- Mid-atmosphere measurements (Rayleigh lidar + AIRS)
- Upper atmosphere measurements instruments (Na lidar + AMTM)
- Extensive Modeling

Questions:

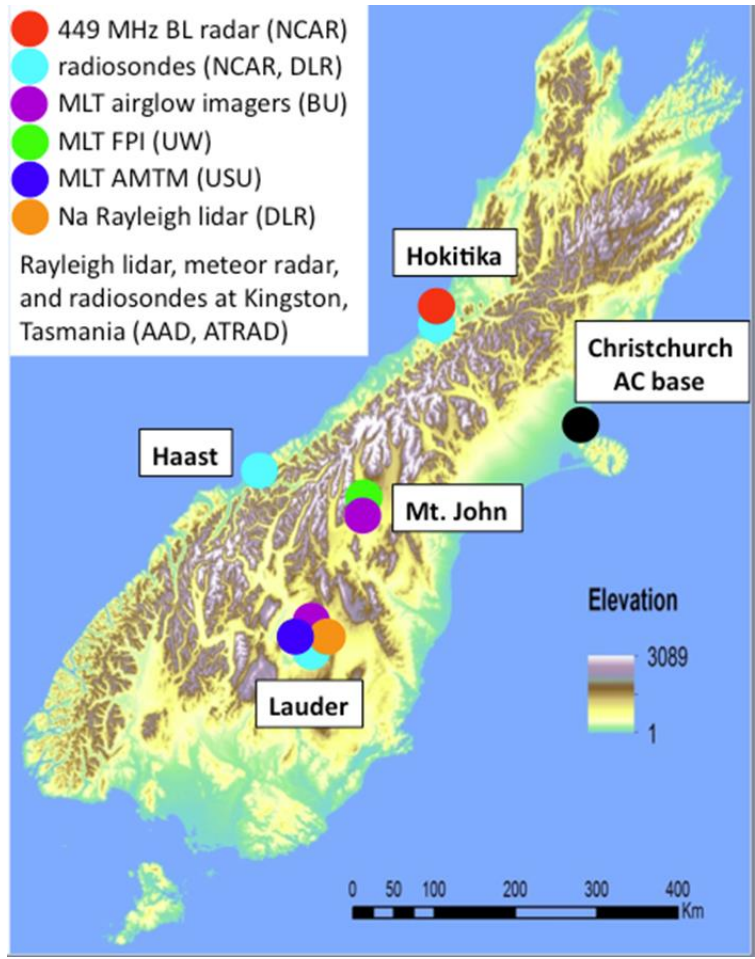
- How do the characteristics of the medium/large scale GWs observed in the stratosphere compare with the GWs observed at MLT altitudes?
- What are their dominant sources?
- Can we use these results to guide new modeling/ forecasting of wave driven upper atmospheric weather?



Summary

- The AMTM “T-Mapper” instrument suite captured characteristics and variability of GW for all RF night-time flights (lateral spatial coverage up to ~1000 km).
- Coordinated ground-based AMTM (and other) measurements at Lauder indicate Mountain Wave activity on multiple nights (18+) ...but not always during strong forcing!
- Lets discuss collaborations....

End



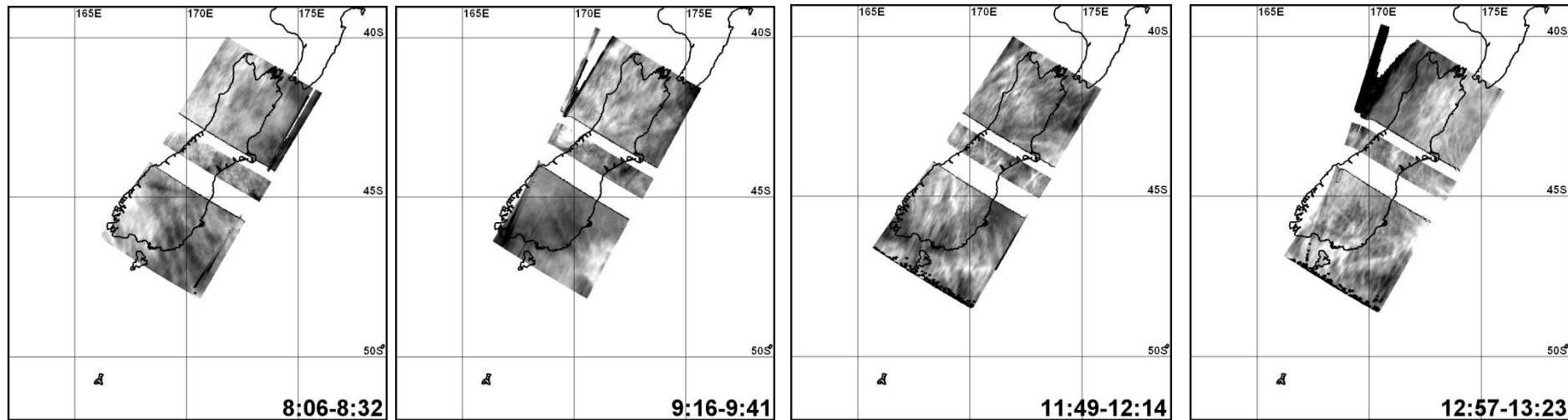
Summary

- Additional Ground based AMTM measurements from Lauder, NZ.
- "T-Mapper" instrument suite captured characteristics and variability of GW from the GV for all RF nighttime flights (lateral spatial coverage up to ~1000 km).
- Coordinated ground-based AMTM (and other) measurements at Lauder indicate Mountain Wave activity on multiple nights (18+) ...not always during strong forcing!
- Lets discuss collaborations....

Mesospheric Waves over New Zealand

14 research flights with legs over NZ South Island with many different cases

- Nothing special us (maybe large-scale GW) at MLT altitude
- (e.g., RF04, RF05, RF10, RF20, RF21)

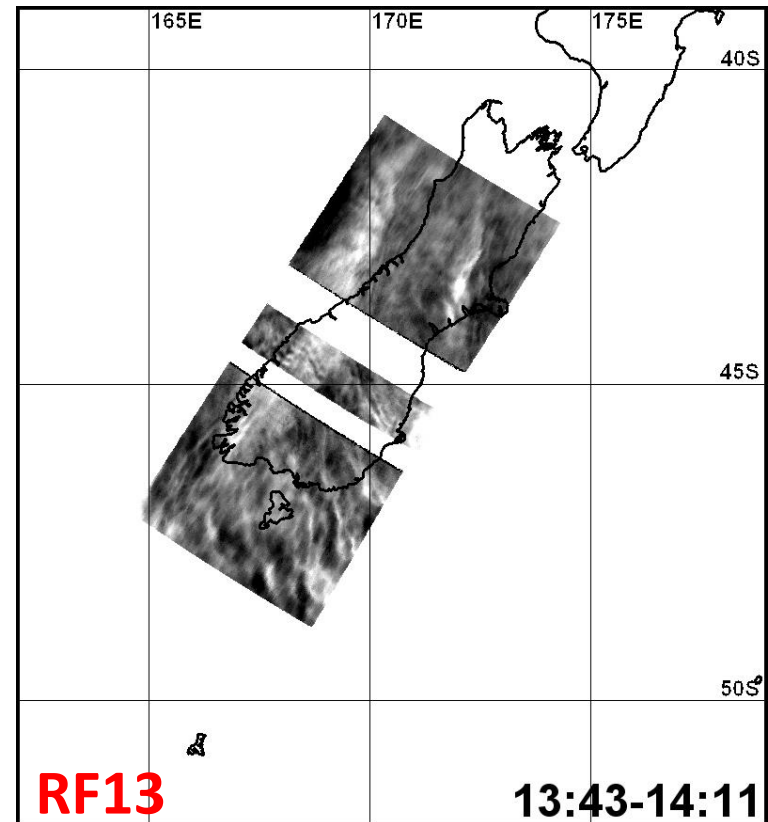
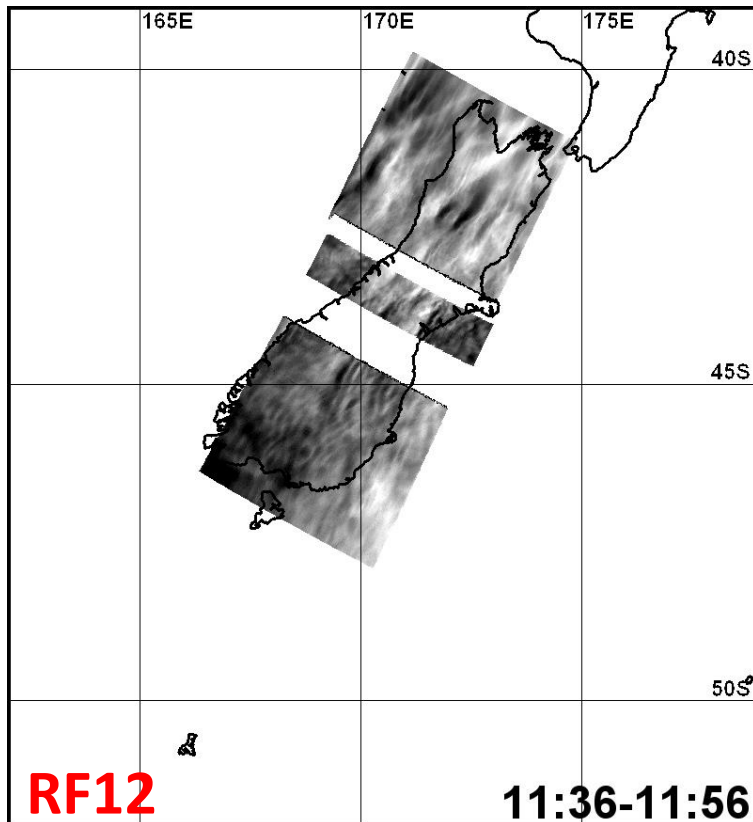


RF05

Mountain Waves over New Zealand

14 research flights with legs over NZ South Island with many different cases

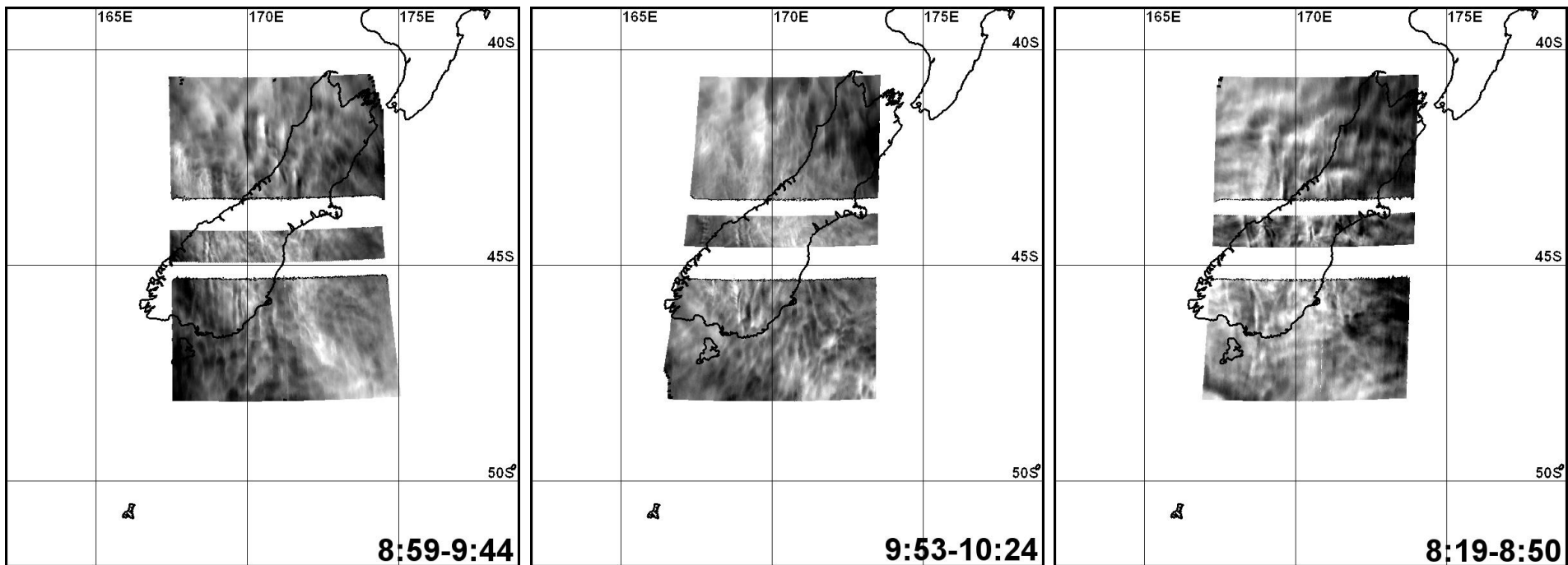
- GWs aligned with the mountain range (e.g., RF12, RF13)



Mountain Waves over New Zealand

14 research flights with legs over NZ South Island with many different cases

- N-S aligned small-scale GWs (e.g., RF08, RF14, RF16, RF22)

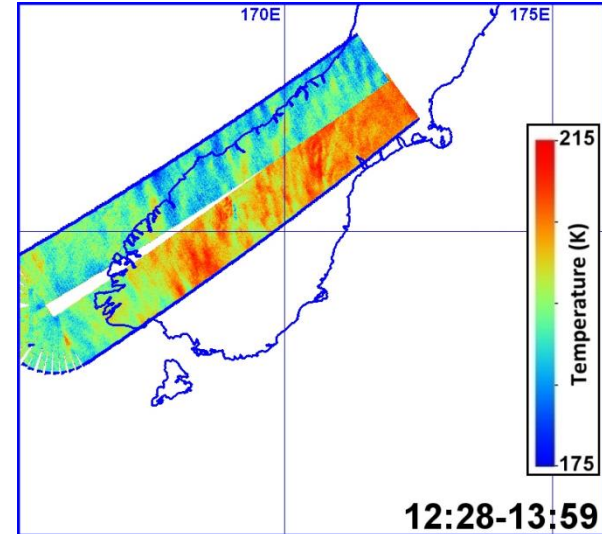
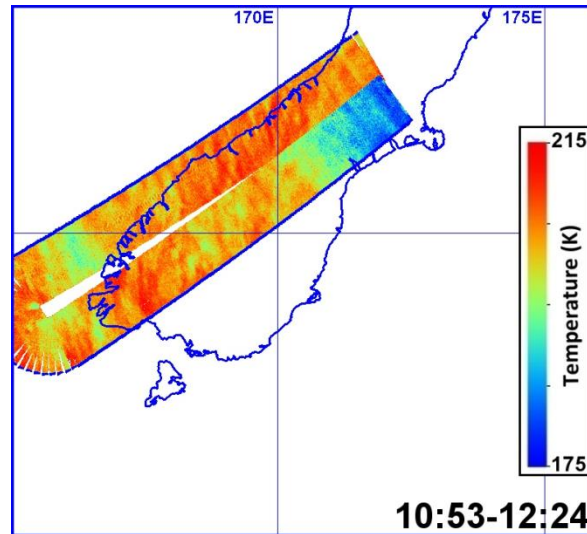
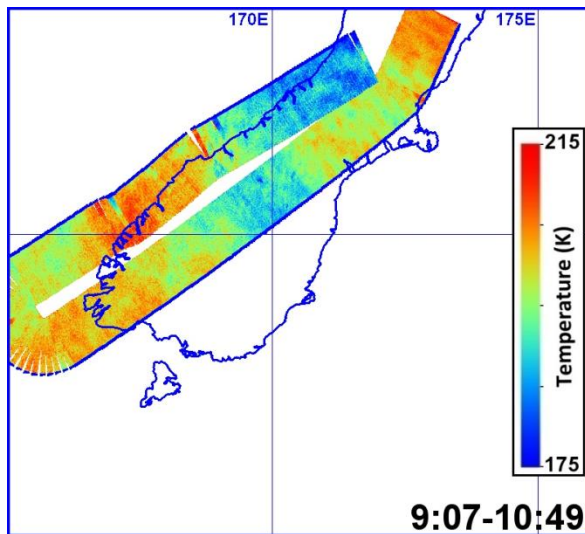


RF16

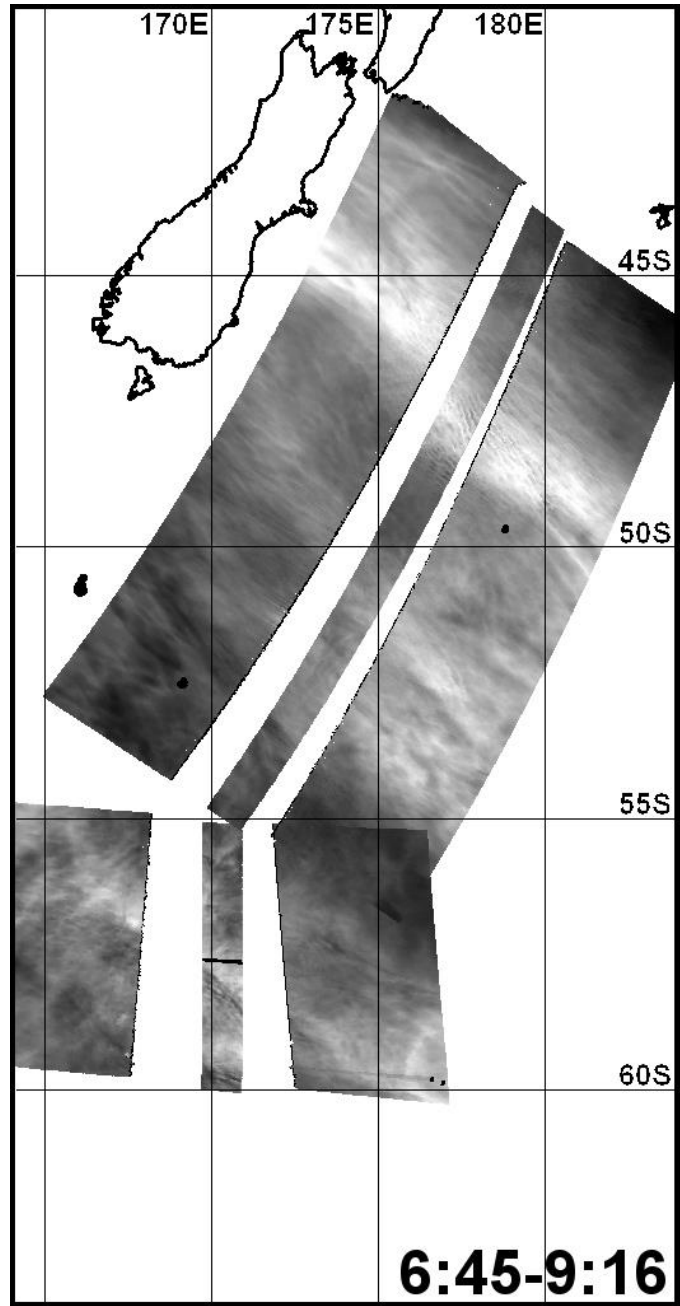
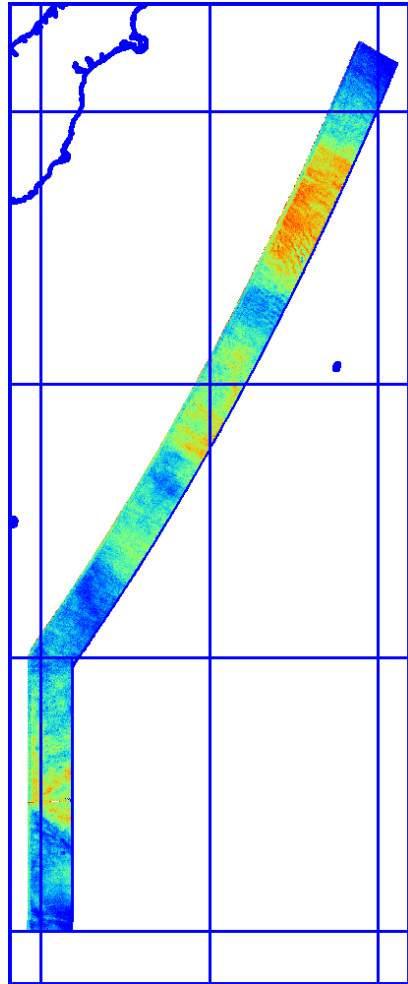
Mesospheric Waves over NZ

14 research flights with legs over NZ South Island with many different cases

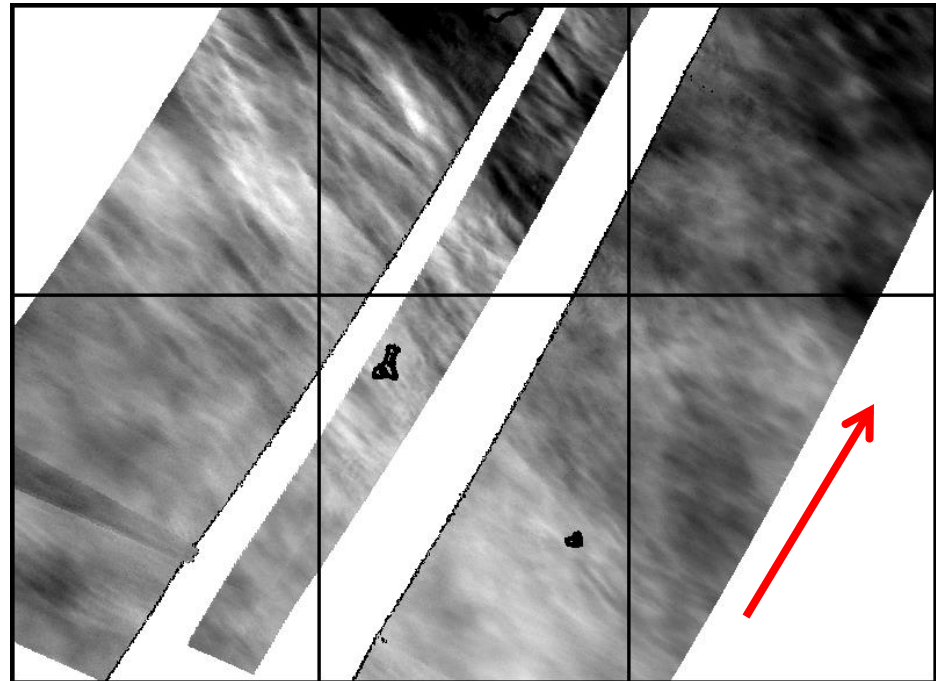
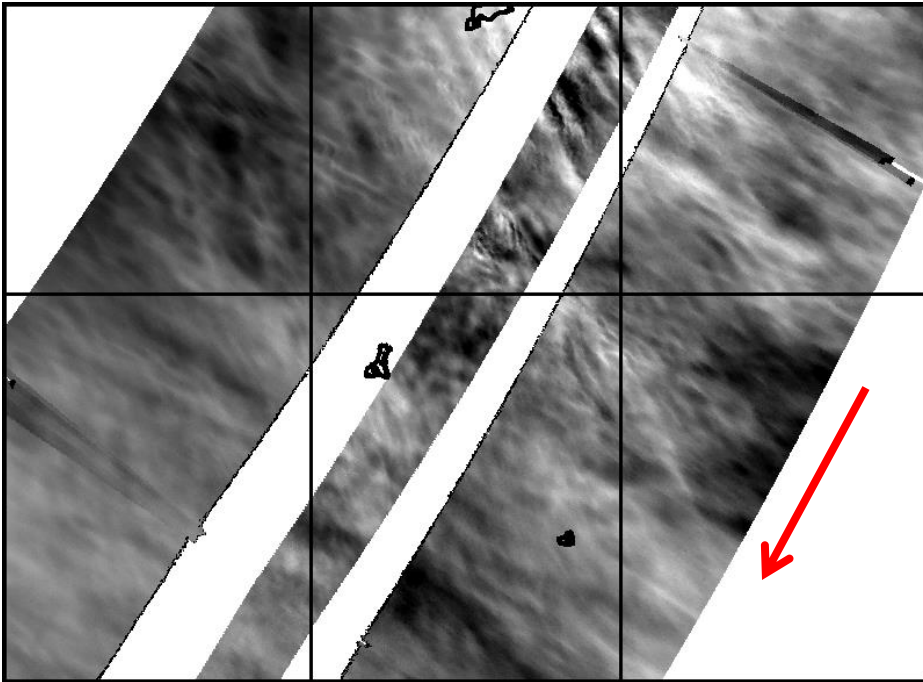
- GWs perpendicular to the South Island (e.g., RF01, RF07, RF26)



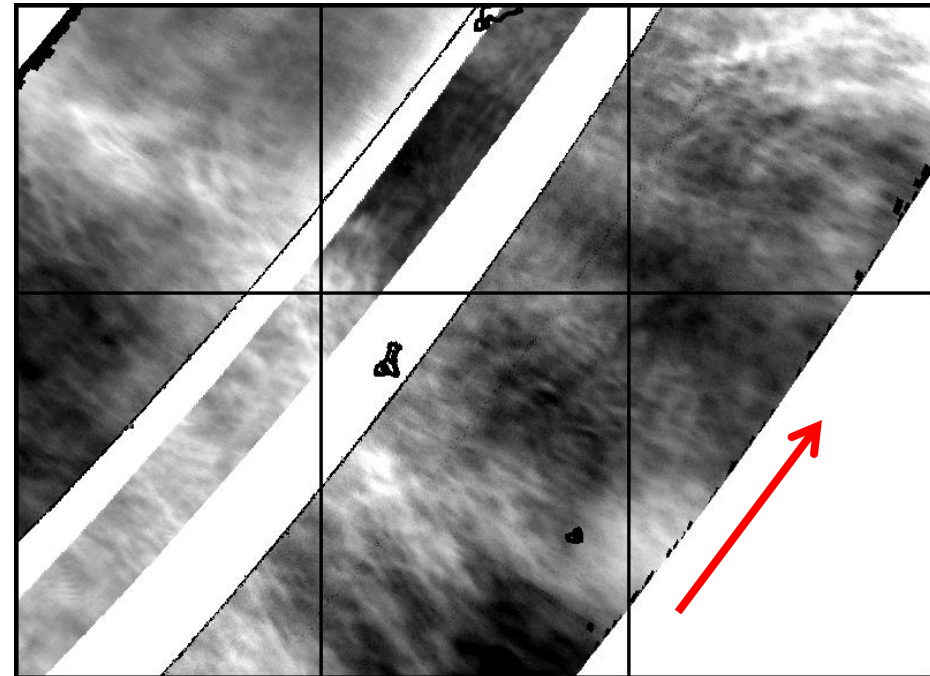
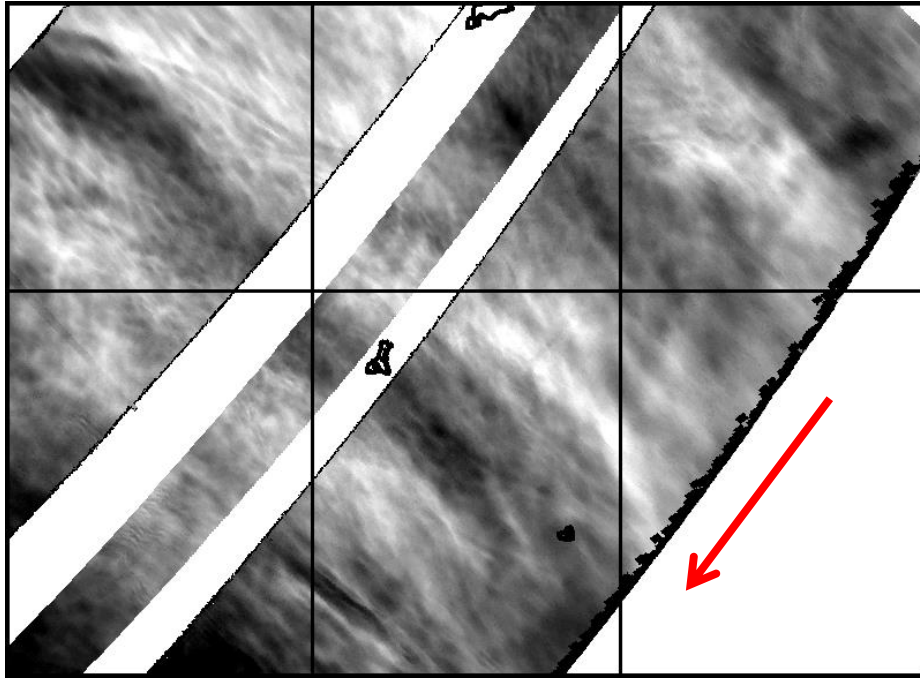
RF26



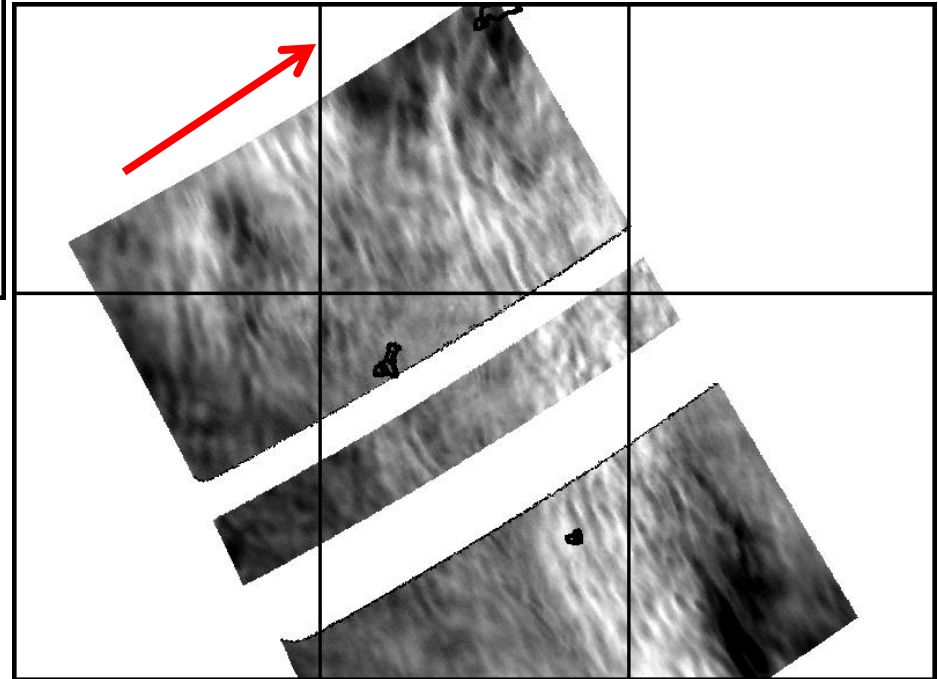
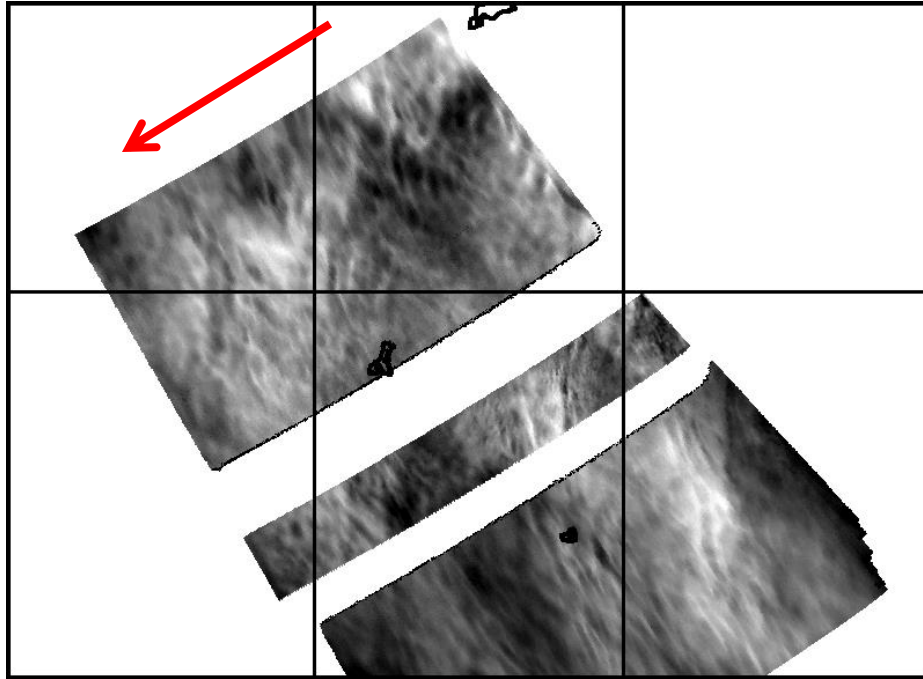
Other Flights over Auckland Islands - RF25



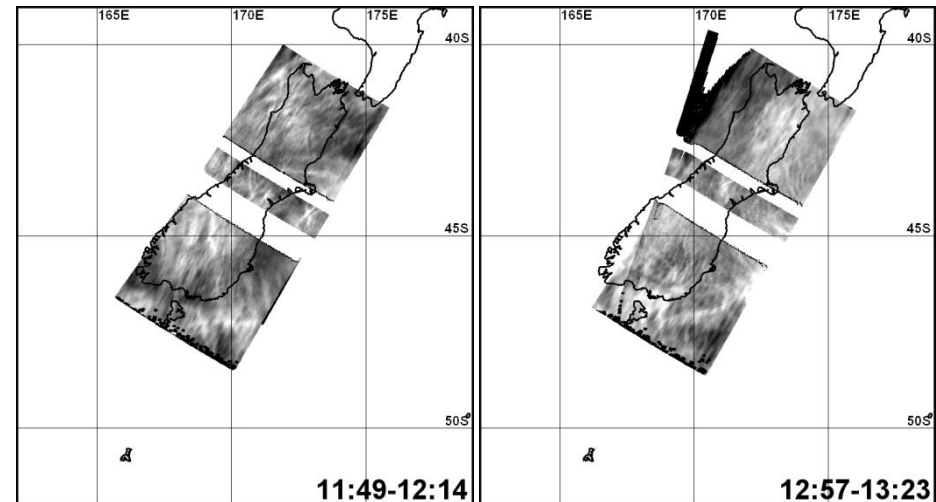
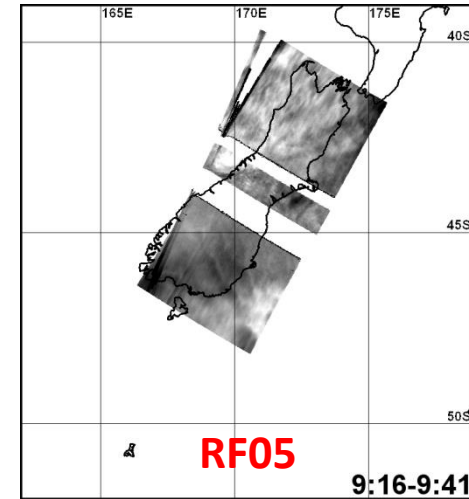
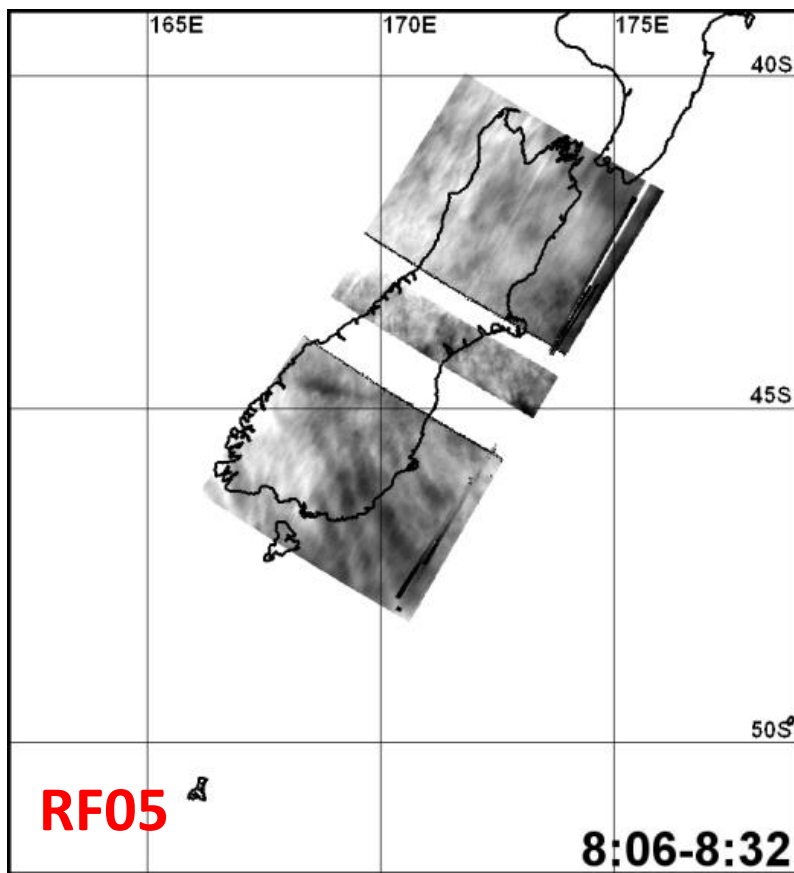
Other Flights over Auckland Islands - RF19



Other Flights over Auckland Islands - RF24



Mesospheric GW over New Zealand



- 14 flights with legs over South .Is.
- Extensive wave activity **always present**
- Variety of small and large-scale GW at MLT altitudes
- Not always coherent
- (e.g., RF04, RF05, RF10, RF20, RF21)

Extensive, Coherent Open Ocean GW

RF17 – Southern Ocean

