Mesospheric GW Activity During DEEPWAVE 2014

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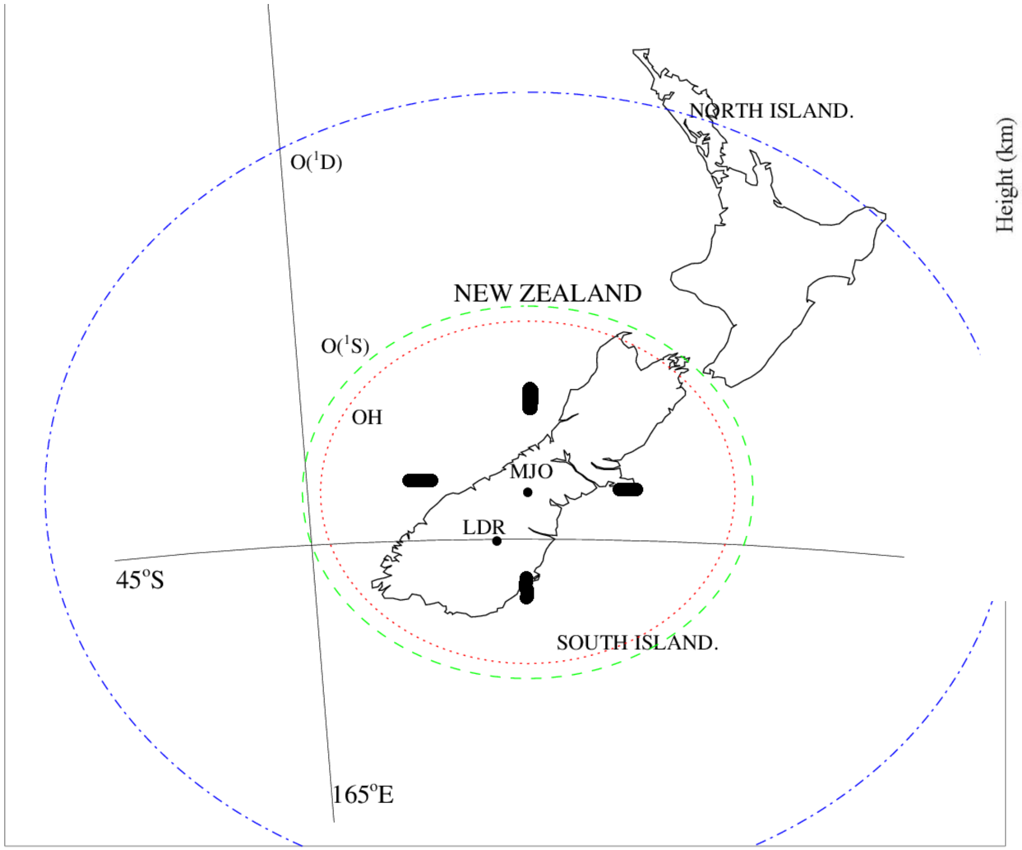
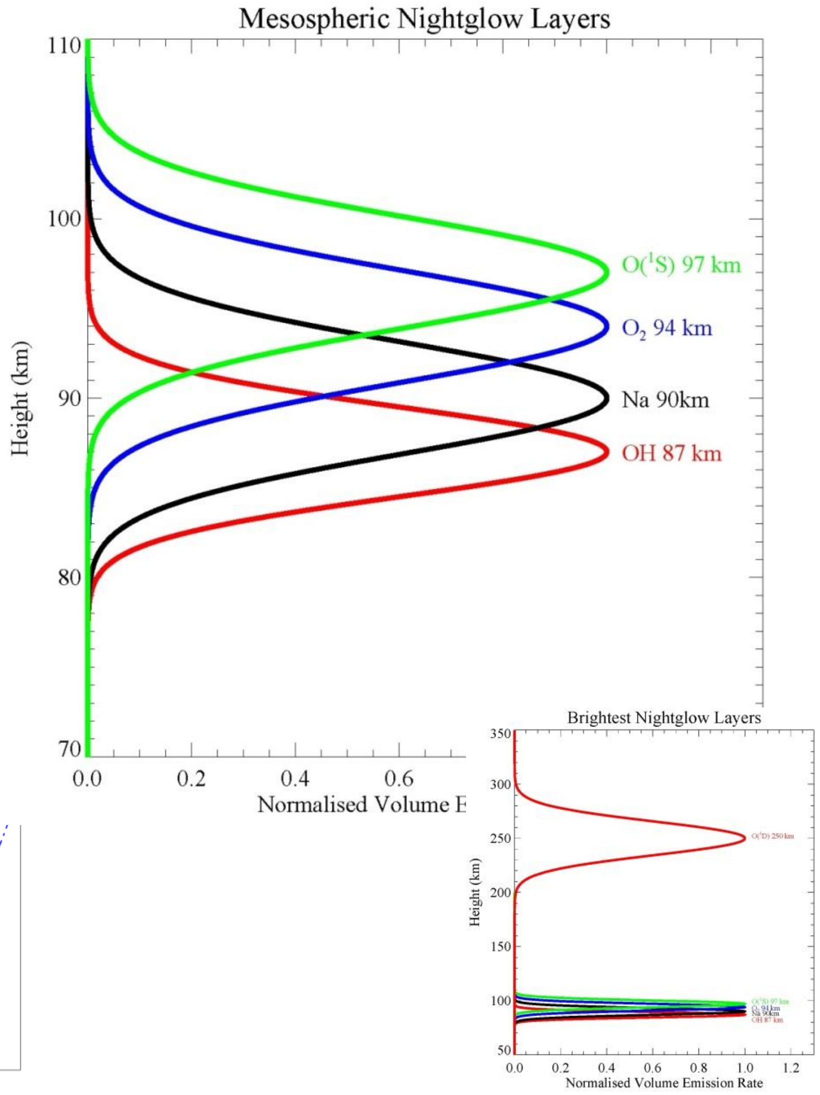
All-sky imagers:

Mt John Observatory OH, Na, O_2, O(^{1}S), O(^{1}D)

NIWA Lauder, Otago





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MLT Imaging Summary:

- 20 useable nights (14 of 26 RF nights).
- Many exhibit GW breaking with broad range of scale-sizes in the horizontal and vertical.
- Large momentum fluxes associated with GW events (FPI winds).
- Frequent complex vertical structures associated with GW event.
- Evidence of dynamic coupling between mesosphere (~100 km) and the thermosphere (~250 km) in the form of secondary GW's – 2-3 nights.

Useable nights during Deepwave 6 June – 20 July

Mt John/Lauder	**20 nights (45%)**	**6**	**19**
Lauder	**17 nights (38%)**	**11**	**17**
RF nights	**14 nights (54%)**	**5**	**8**

RF 1 4 6 7 10 11 13 14 15 16 17 18 24 25 26

RF 2 5 8 12 23

RF 3 4 9 19 20 21 22

21 June 2014 Breaking mountain waves

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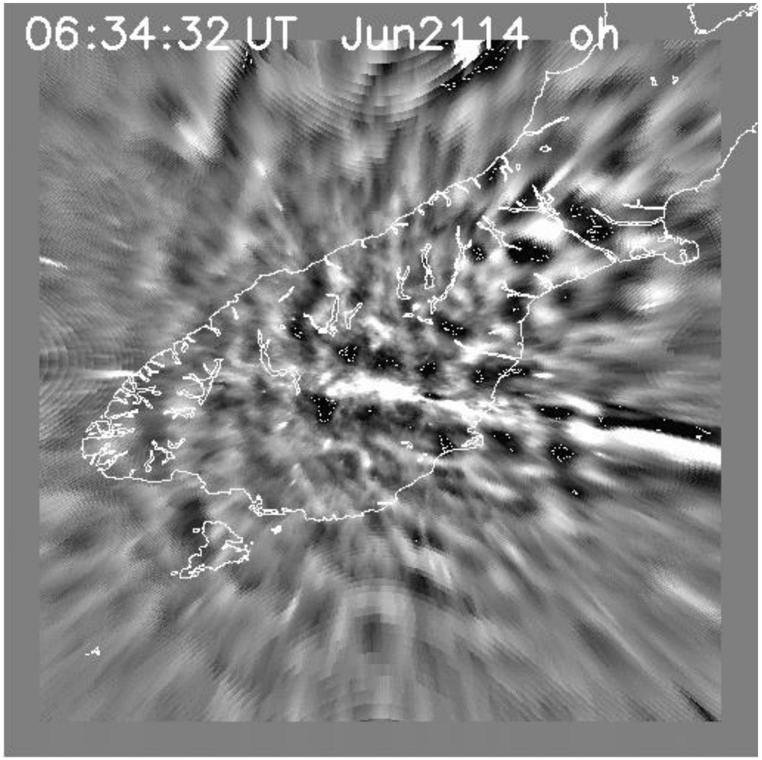

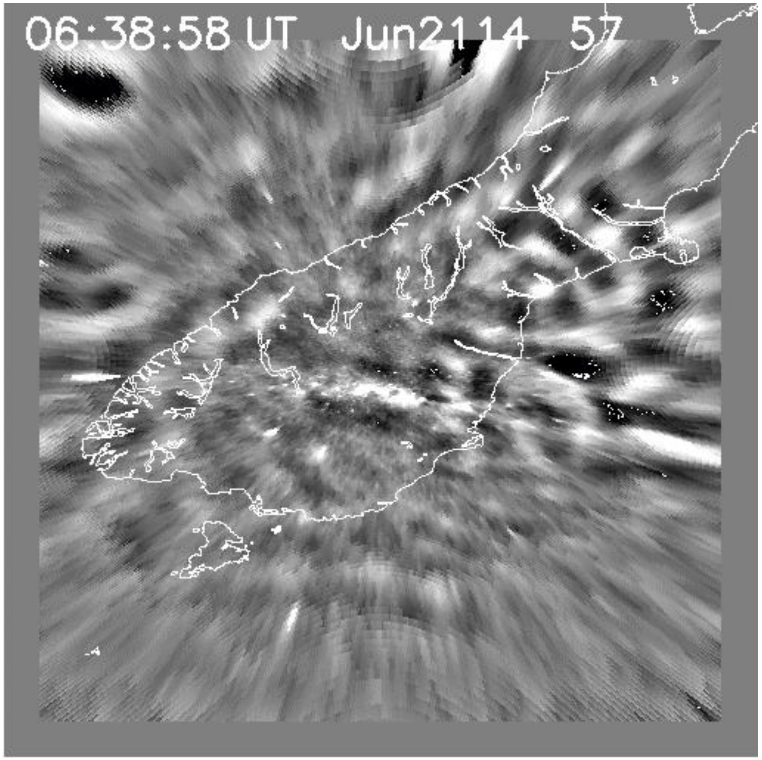

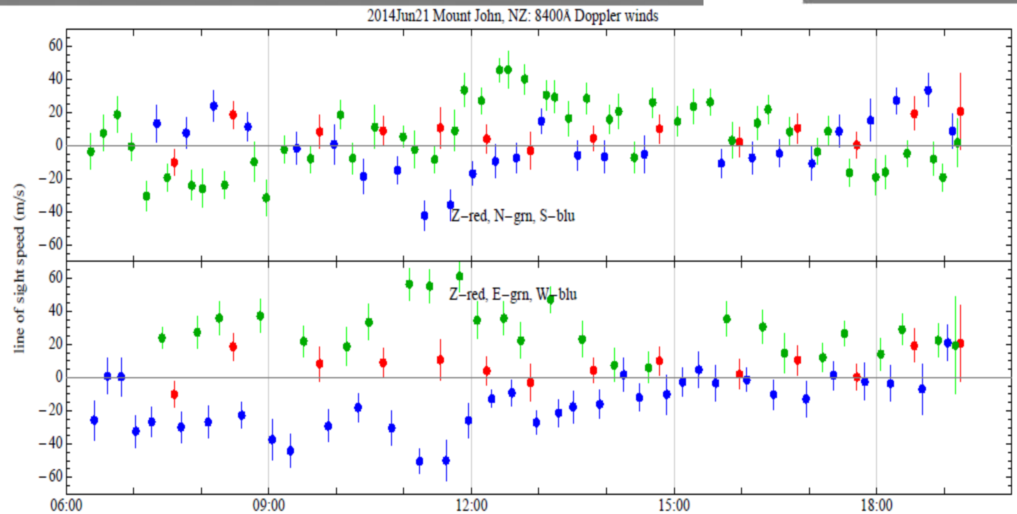

OH: λ_h= 98 km I/I_0 = 8%

O_2: λ_h= 108 km I/I_0 = 16%

Using OH & O(^{1}S) FPI winds:

λ_z= 15-18 km (N=0.025 s^{-2})

OH: F_m = 150 – 300 m^2s^{-2}

O_2: F_m = 40 – 60 m^2s^{-2}

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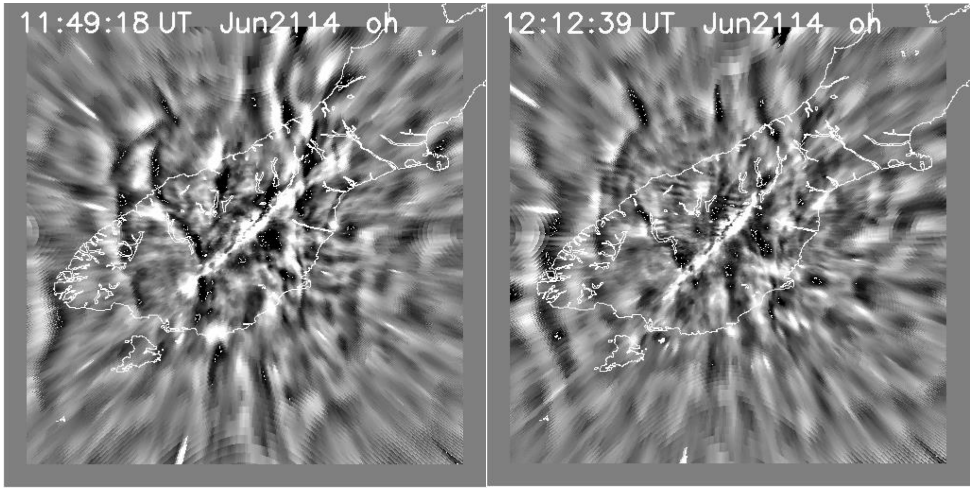
21 June 2014



Lauder: $c_{obs} = 2.7 \pm 0.8\ \mathrm{ms^{-1}}$

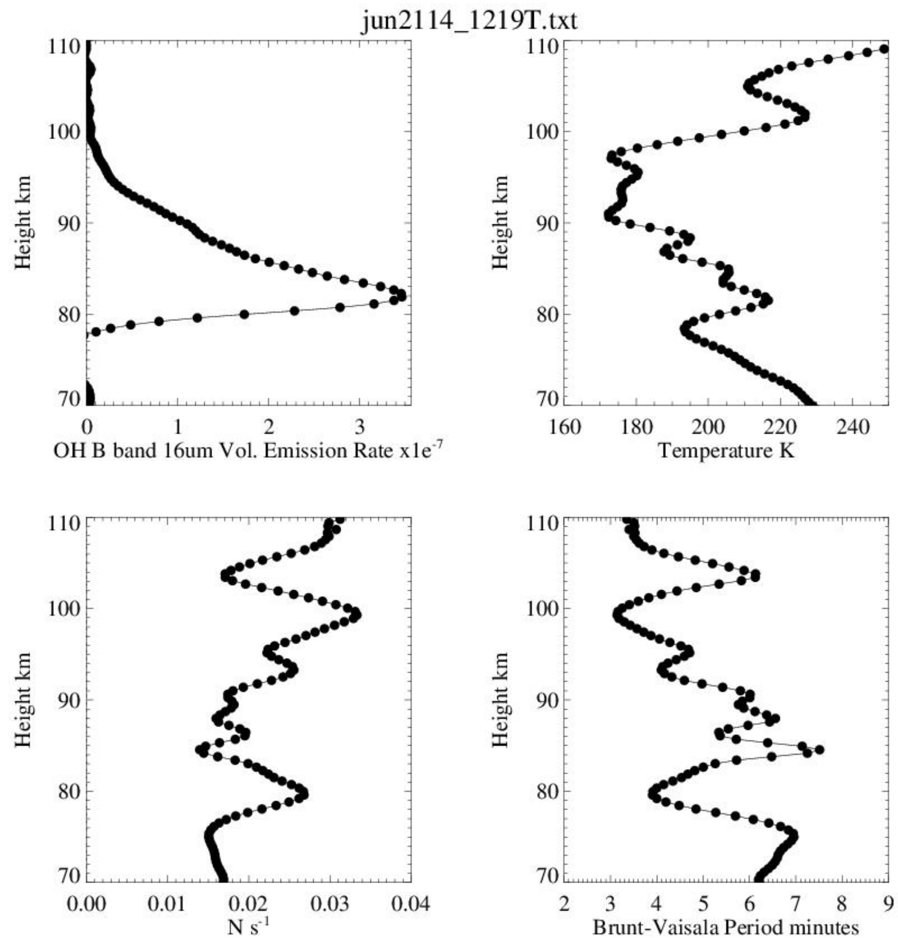
$\lambda_h = 48$ km

I/I_0 = 8-10%

OH layer ~82 km – lower than nominal altitude.

SABER overpass at 12:19UT (range 225 km)

OH emission and temperature profiles ⟶



21 June 2014 (cont.) Concentric Gravity Waves over South Island

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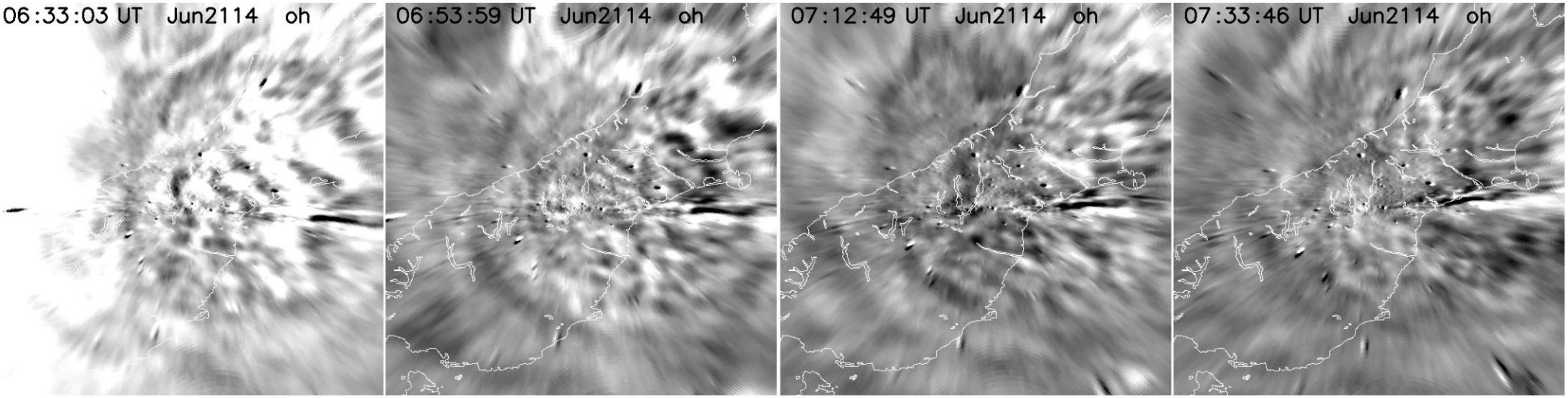


OH/O_2 phase: λ_z = 56 km. Upward propagating.

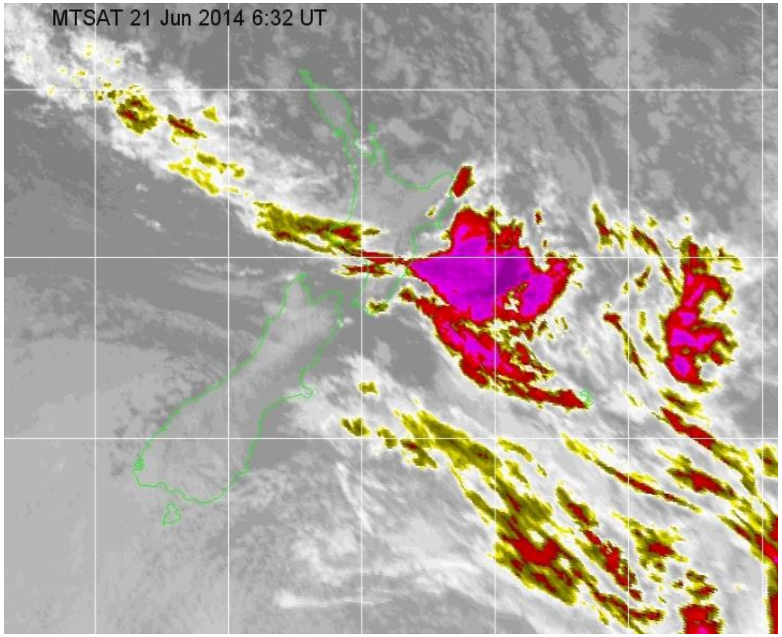
Observed at MJ and Lauder

OH: $\lambda_h = 98.7 \pm 4.7$ km $v_{obs} = 48.0 \pm 6.8\ ms^{-1}$

I/I_0 = 1-2% Fm = 10-20 m^2s^{-2}

O_2: $\lambda_h = 107.8 \pm 12.6$ km $v_{obs} = 52.4 \pm 3.2\ ms^{-1}$

I/I_0 = 1-2% Fm = 15 m^2s^{-2}



30 May 2014 Large-scale standing mountain wave breaking

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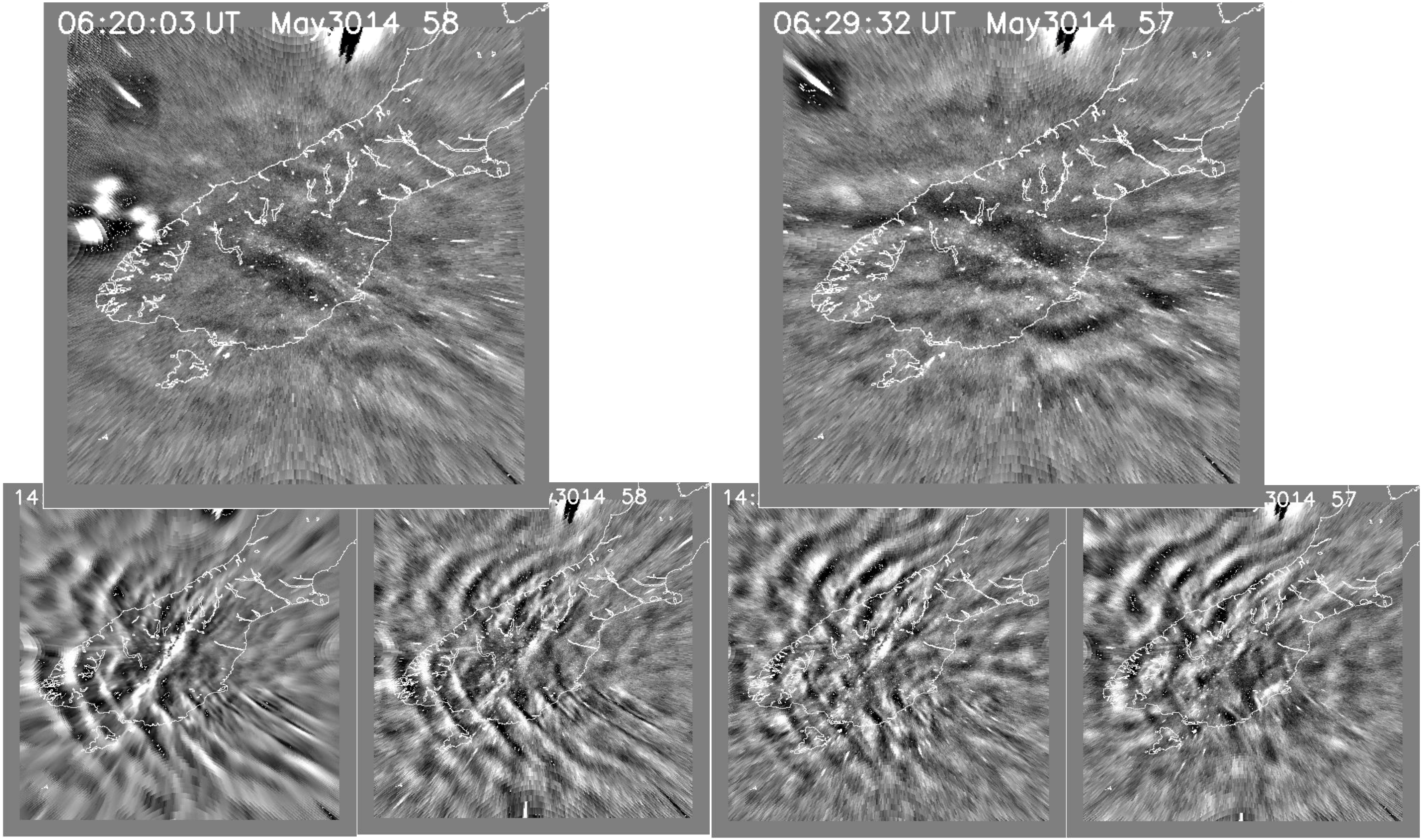


OH 80-85 km

Na 90 km

O_2 94 km

$O(^1S)$ 96 km

Small-scale OH waves: λ_h = 20 ± 2 km I/I_0 = 3-5%

Large-scale OH waves: λ_h = 51 ± 2 km I/I_0 = 3-17%

F_E = 15 – 45 Wm^{-2} (λ_z= 13 km, N=0.025 s^{-2})

F_M = 55 – 180 m^2s^{-2}

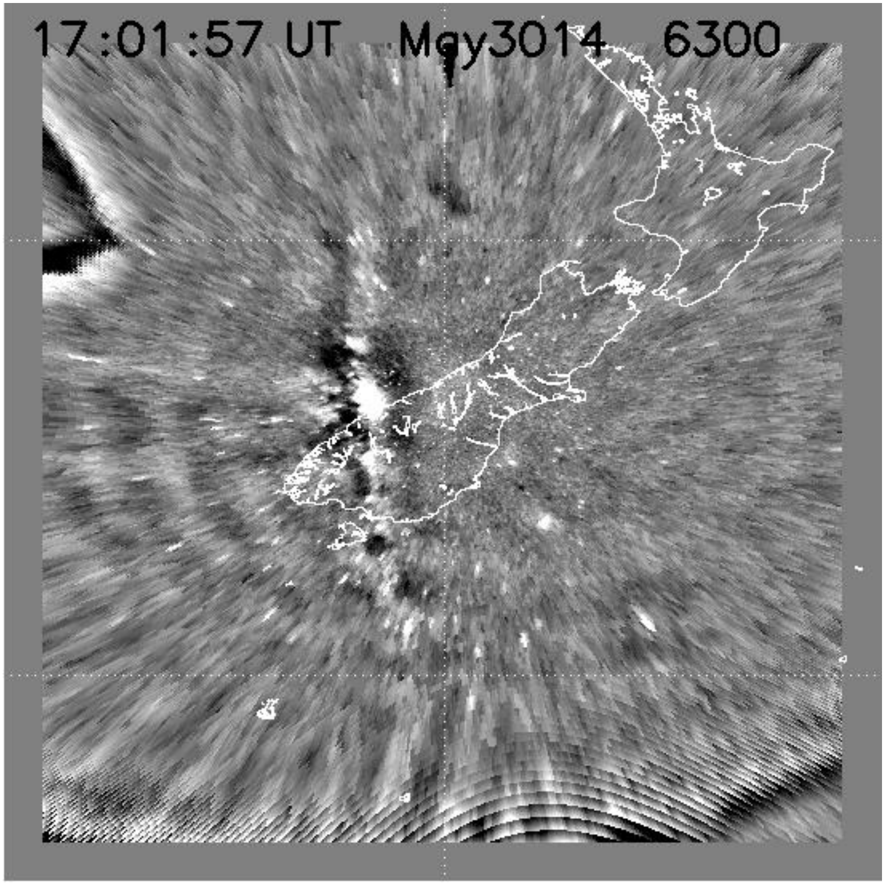
Large-scale $O(^1S)$ waves: λ_h = 43 ± 4 km I/I_0 = 3-18%

F_E = 5 – 80 Wm^{-2}

F_M = 10 – 345 m^2s^{-2}

30 May 2014

Evidence of dynamic coupling between the mesosphere ~100 km and thermosphere ~250 km



GW’s in 630.0 nm emission in the thermosphere. Altitude 250 km.

Propagating south-eastward.

$c = 178 \pm 13\ ms^{-1}$

$\lambda_h = 157 \pm 8$ km

$I/I_0 = 2.5\%$

Secondary GW’s.

Similar to event reported by Smith et al. (2013).

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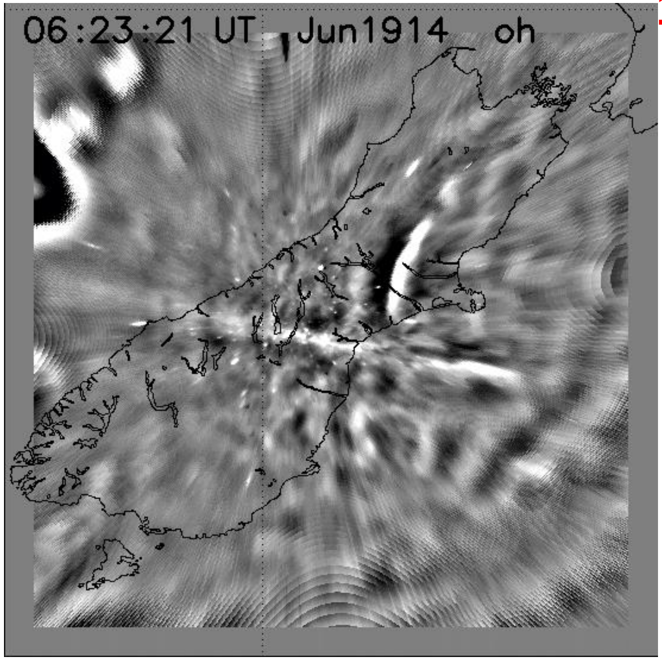
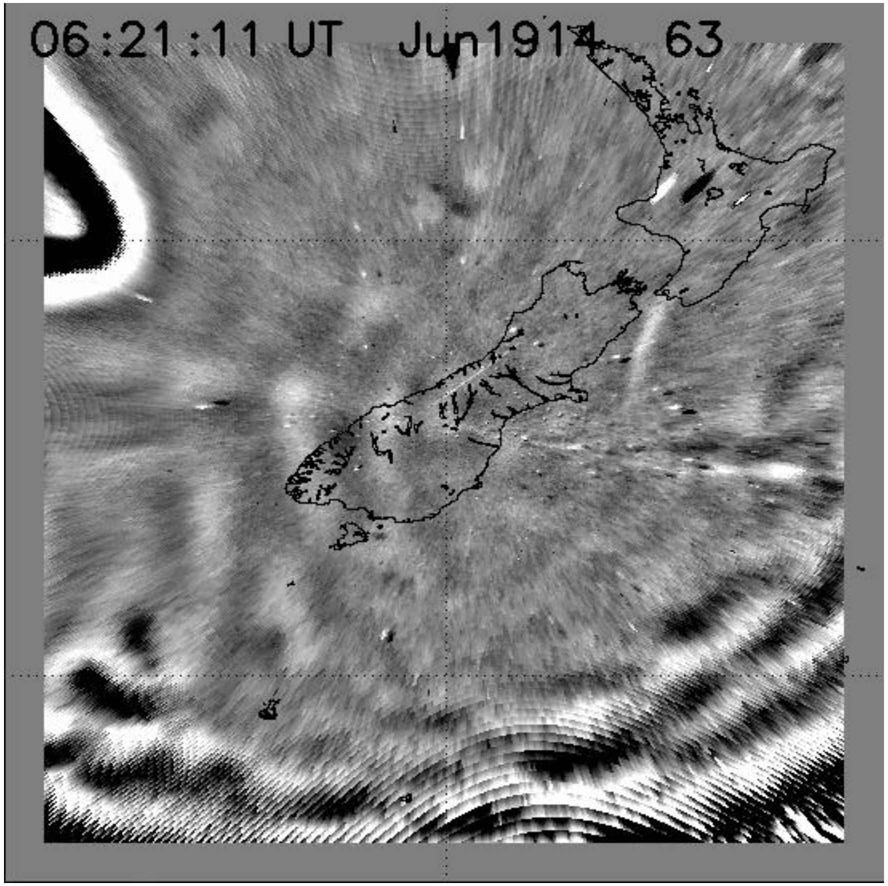
19 June 2014 RF7

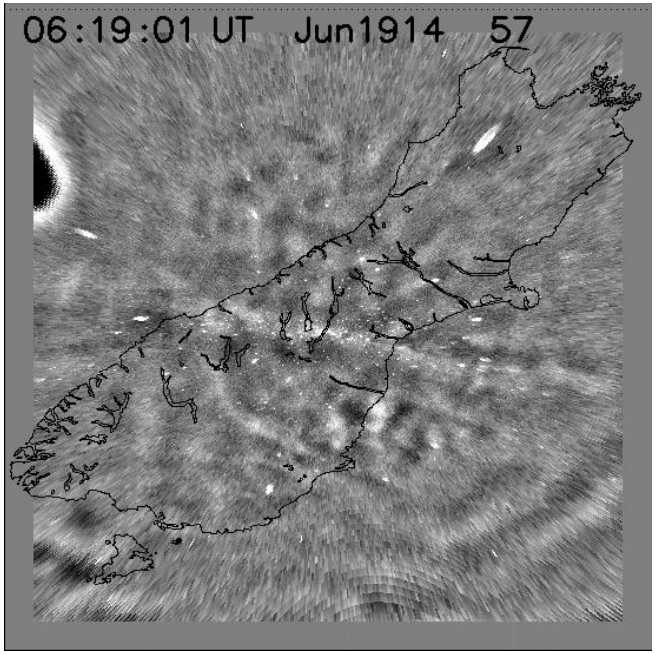
Further evidence of mountain wave-breaking with subsequent M-T coupling



OH 87 km

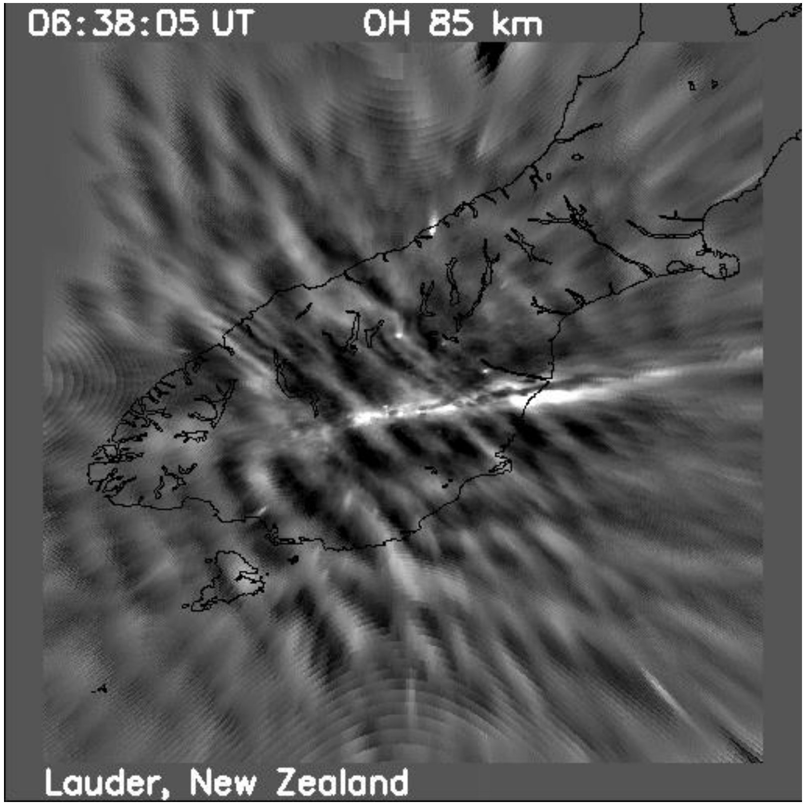


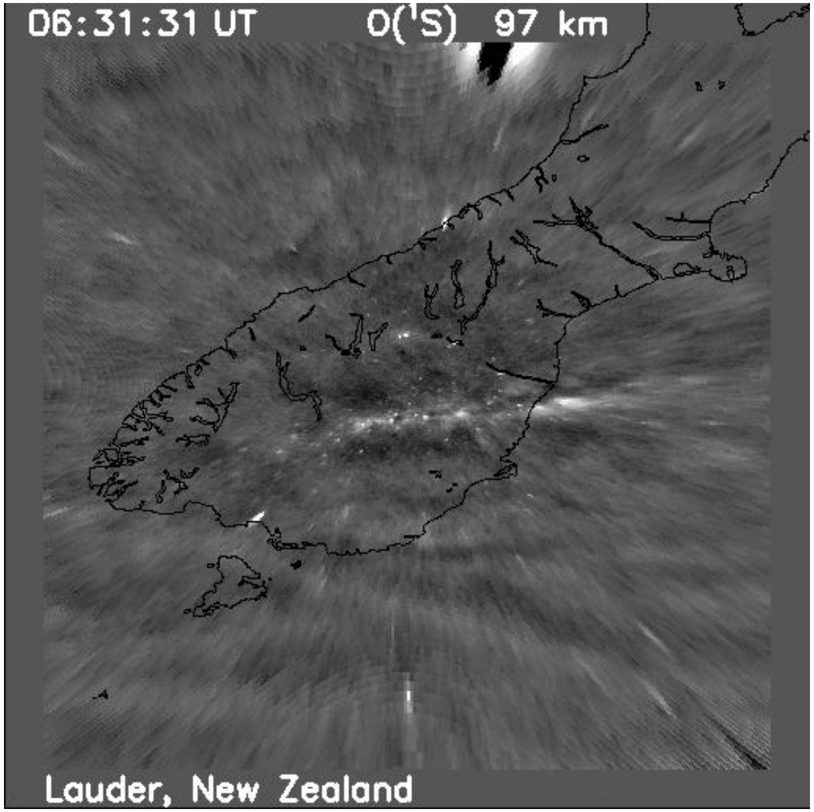
O(^{1}D) 630.0 nm emission ~250 km altitude



O(^{1}S) 557.7 nm 97 km

18 July 2014 RF25 Small-scale Vertical Filtering





OH:

Slow-moving mountain waves propagating SW.

Az = 235°

c = 12.6 ± 0.5 ms^{-1}.

λ_h = 49.0 ± 4.8 km.

OH λ_z = 40 – 87 km (depending on OH/Na layer separation) OH at 84.5 km (SABER).

5577:

Less-defined, surge-like GW's propagating northwards.

Az = 7°

c = 42.0 ± 5.2 ms^{-1}.

λ_h = 49.8 ± 8.0 km.

18 July 2014 RF25

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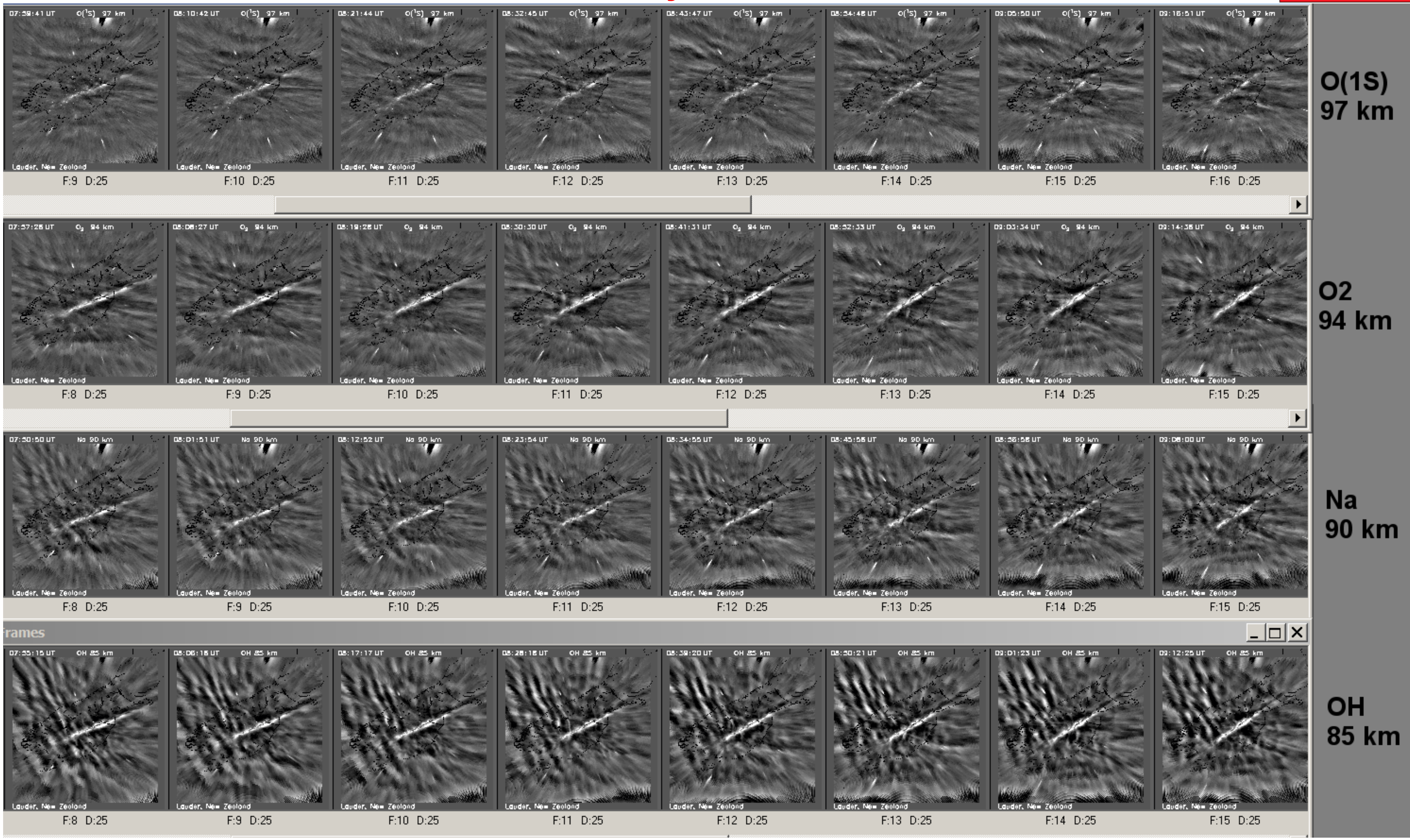

OH: Slow-moving mountain waves propagating SW ~13 ms^{-1}.

5577: Large-scale GW's propagating northwards ~42 ms^{-1}.

18 July 2014 RF25

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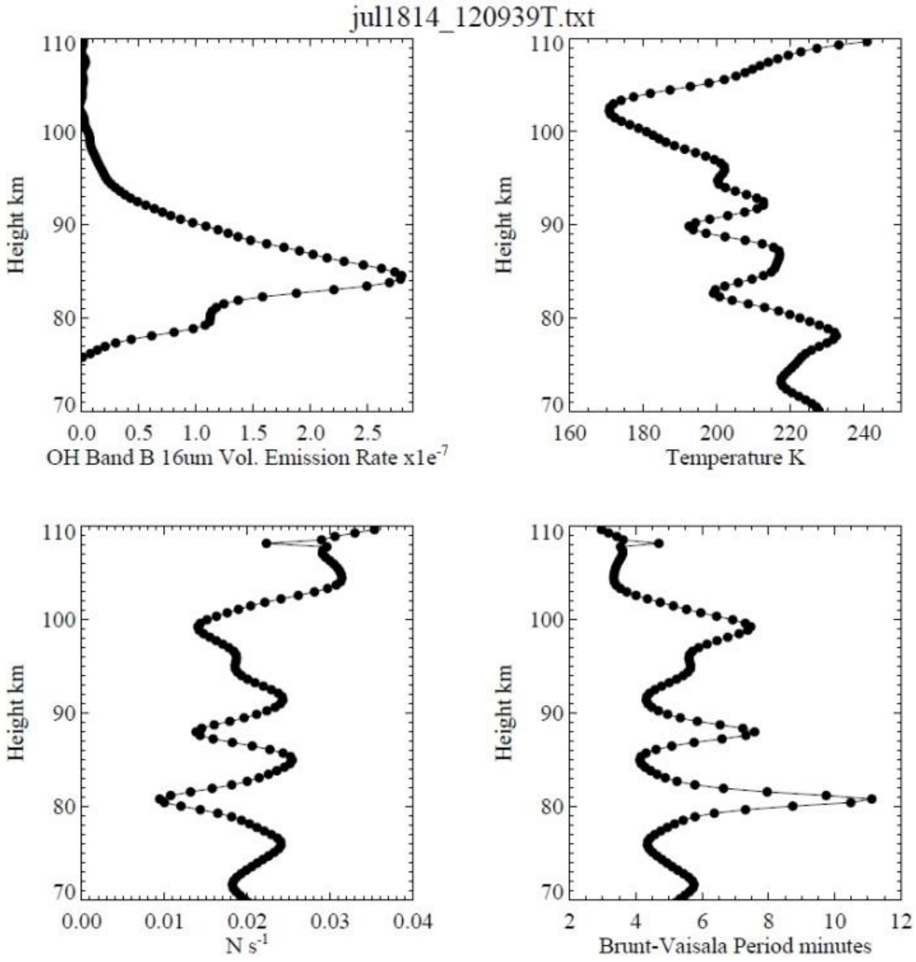

SABER overpass at 12:10UT (~1-2 hours later)

Range = 222 km.

OH emission and temperature profiles

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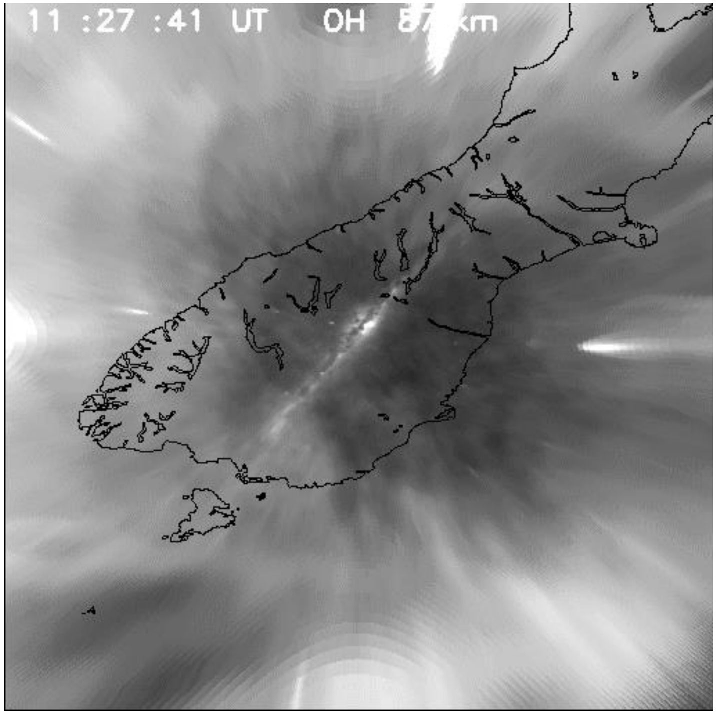
4 July 2014 RF16

Multi-scale gravity waves



←OH:

Small scale: 18 km

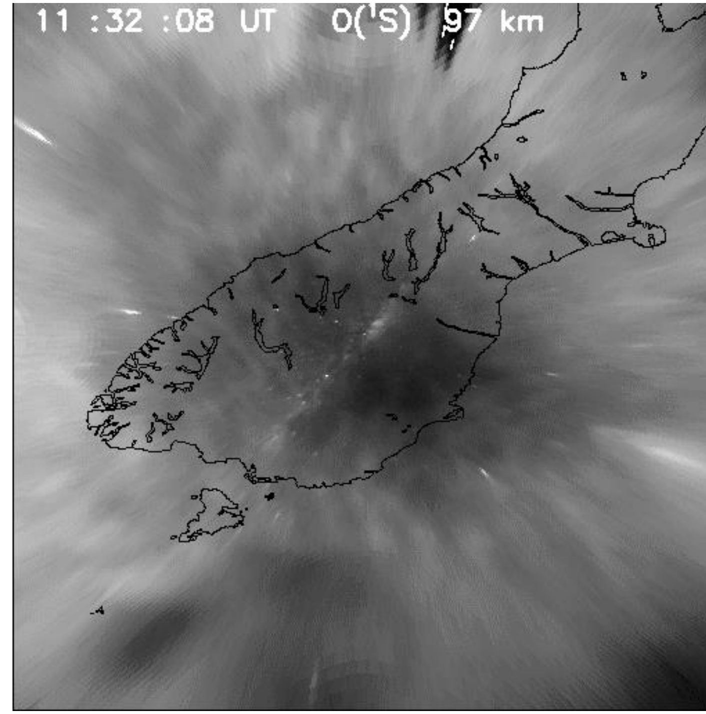
Large scale: 62 km

5577: →

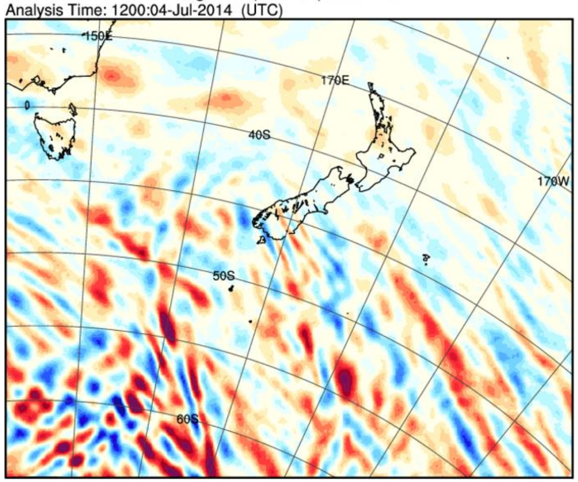
Large-scale: 99 km

Small-scale: 20 km

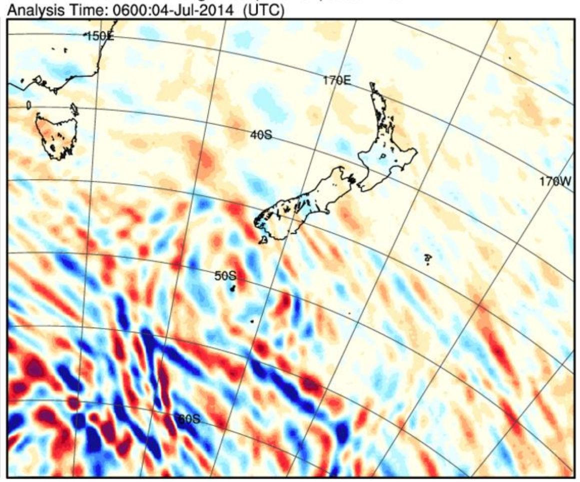
- atop larger-scale GW's



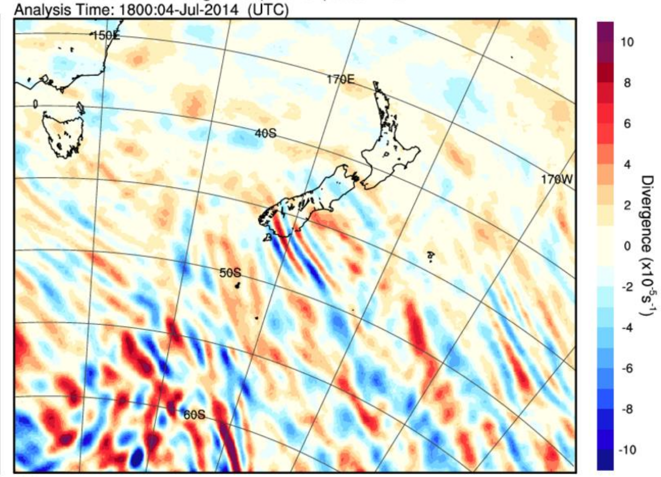
UKMO N768L70: Divergence ($x10^{-5}s^{-1}$) at 5 hPa
Analysis Time: 1200:04-Jul-2014 (UTC)



UKMO N768L70: Divergence ($x10^{-5}s^{-1}$) at 5 hPa
Analysis Time: 0600:04-Jul-2014 (UTC)



UKMO N768L70: Divergence ($x10^{-5}s^{-1}$) at 5 hPa
Analysis Time: 1800:04-Jul-2014 (UTC)



Turbulent mountain wave breaking

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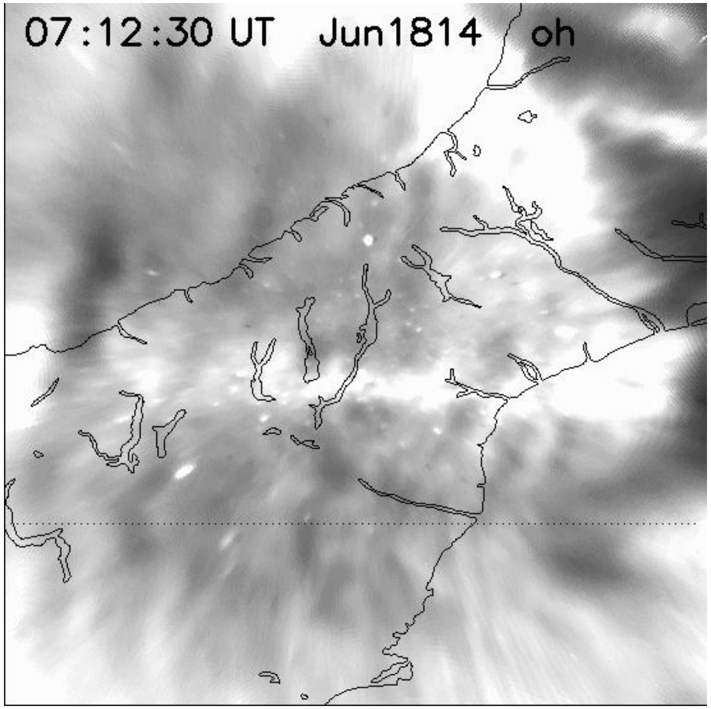
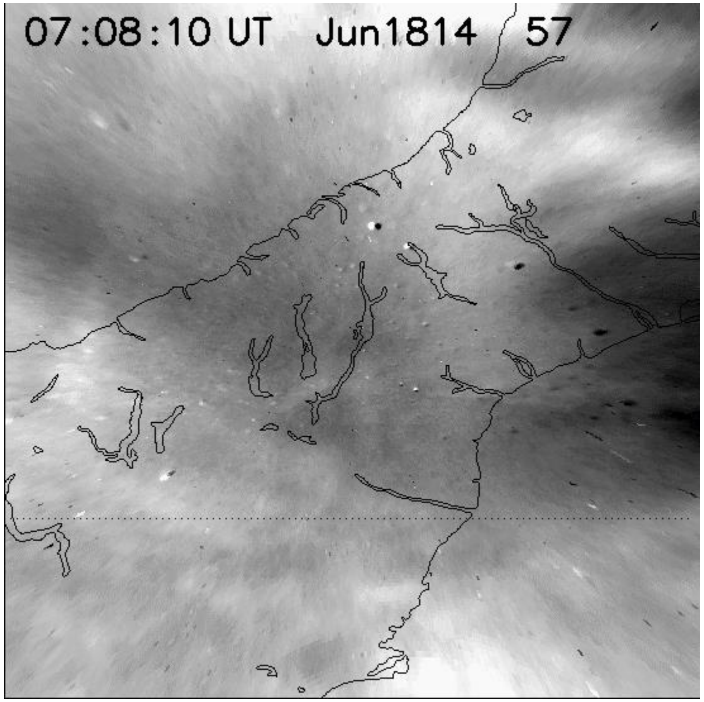
Small-scale 5577 wave activity is weaker and lags OH activity



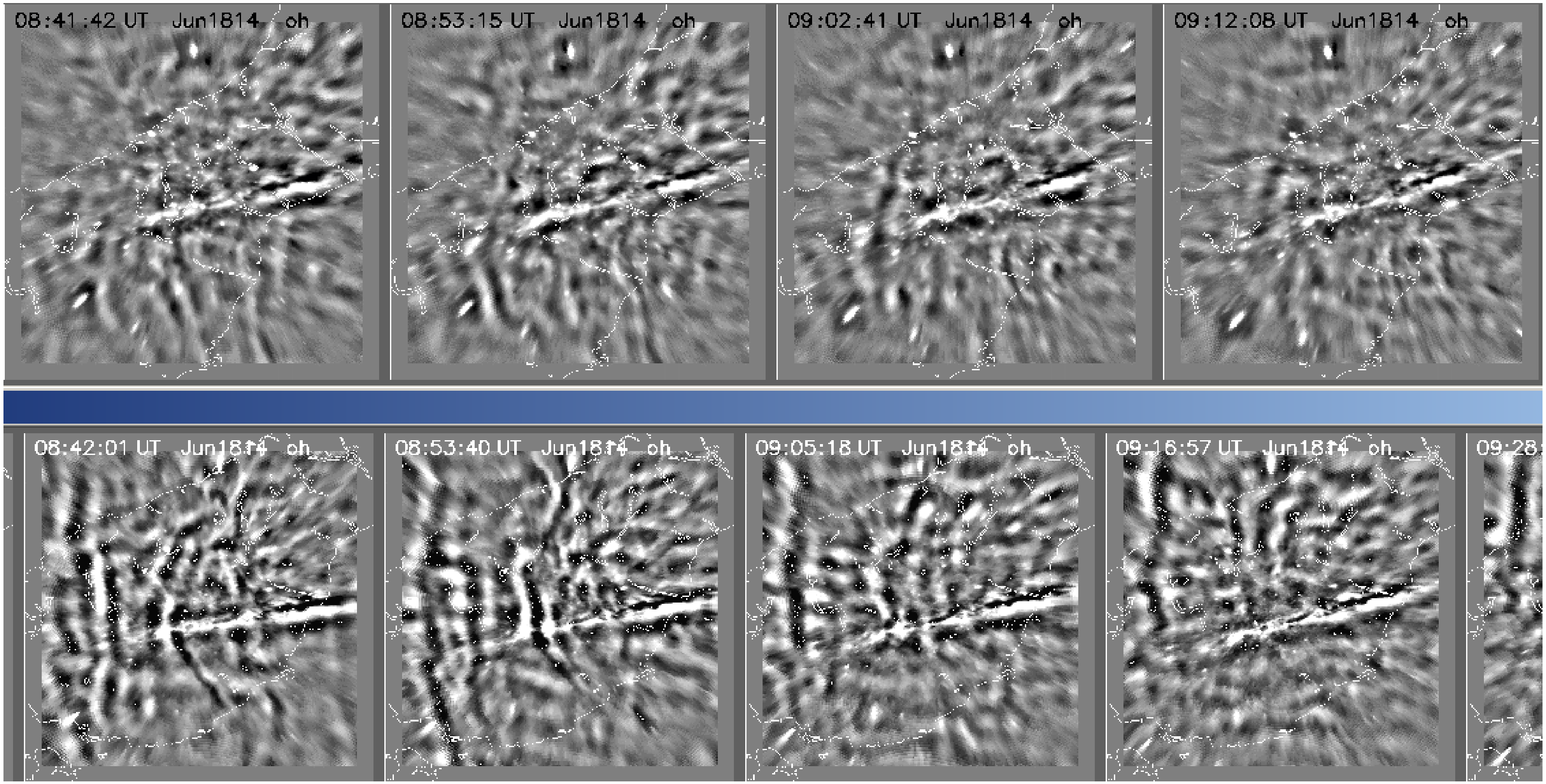
OH: λ_h = 42 ± 7 km
I/I_0 = 10-15%



5577: λ_h = 41 ± 8 km
I/I_0 = 10-18%

18 June 2014 RF6 Turbulent mountain wave breaking

Geographical variations in GW activity - OH at Mt. John and Lauder



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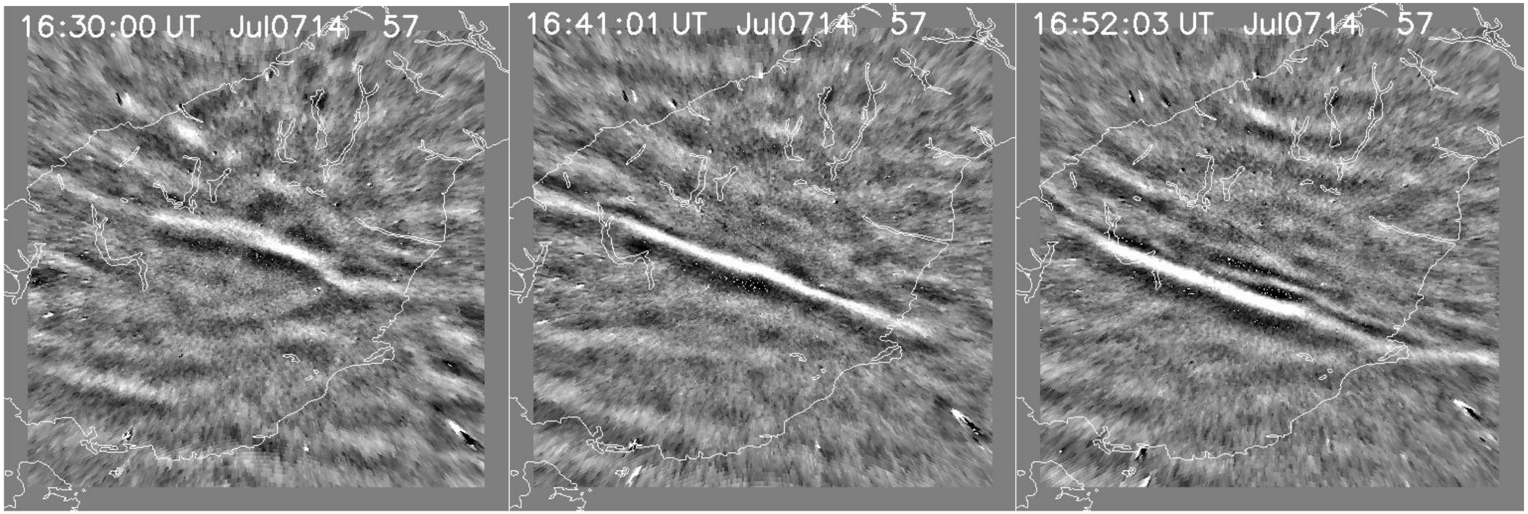
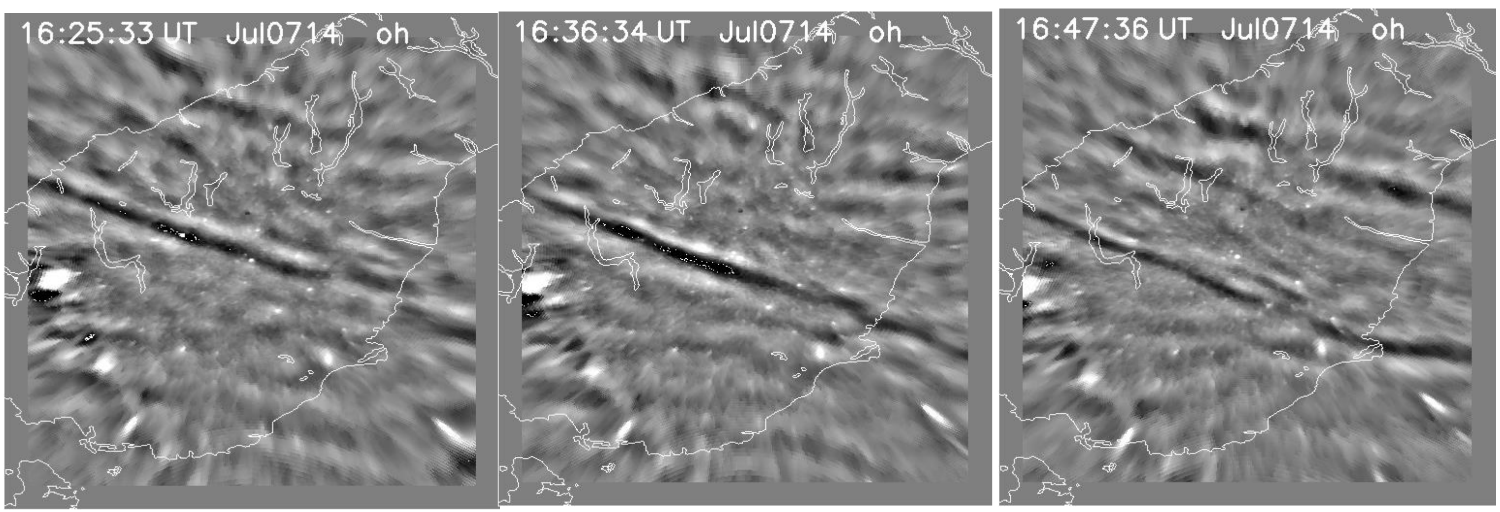
7 July 2014 RF18

Frontal gravity wave, Soliton-like bore disturbance



5577: v=38 ms^{-1} FWHM=6-9 km λ_h=18 km I/I_0=14-20%



OH: v=26 ms^{-1} FWHM=7-9 km λ_h=21 km I/I_0=12-19%

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- Large momentum fluxes associated with GW events (FPI winds).
- Frequent complex vertical structures associated with GW event.
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Acknowledgements:

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