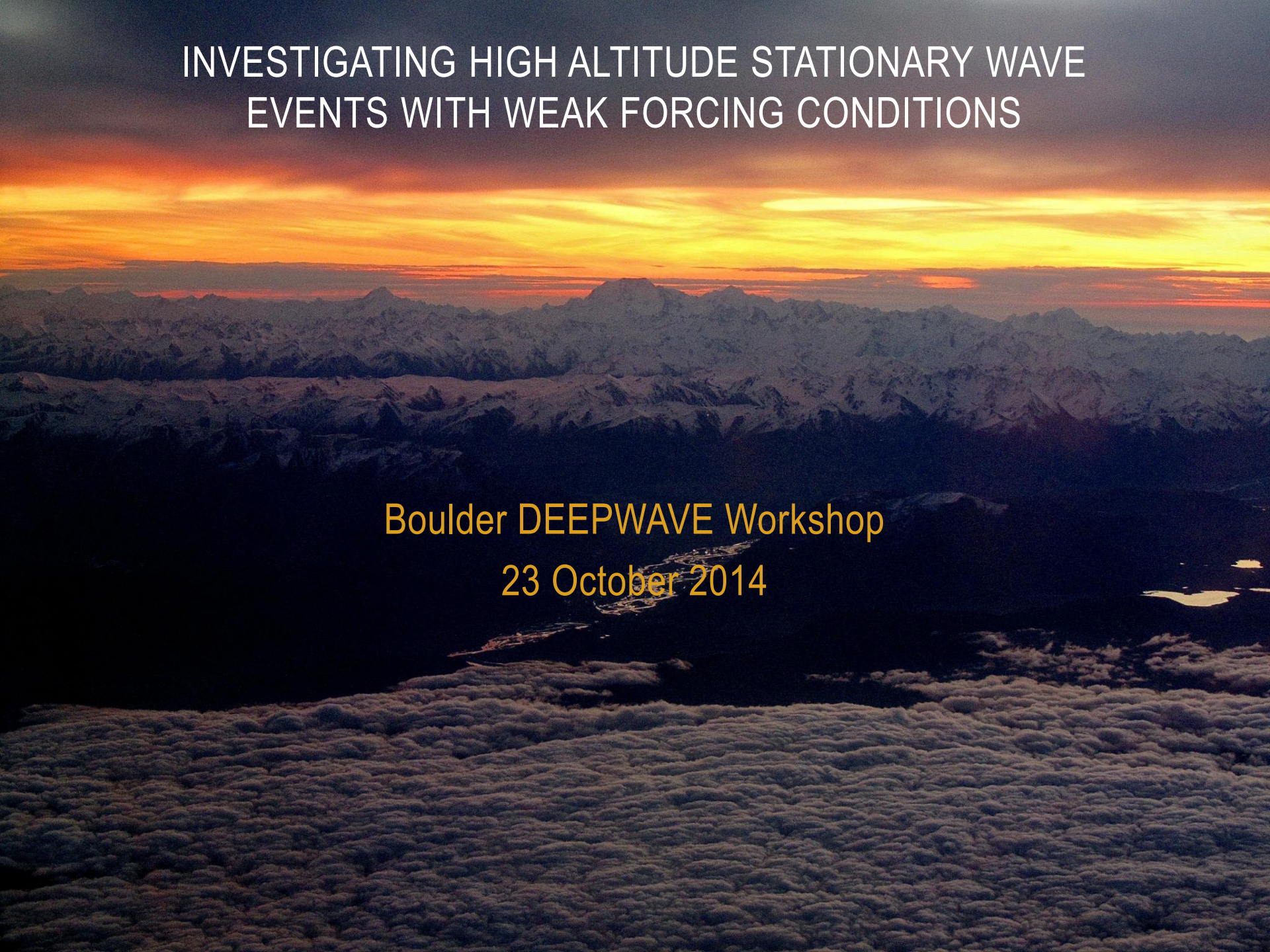


INVESTIGATING HIGH ALTITUDE STATIONARY WAVE EVENTS WITH WEAK FORCING CONDITIONS

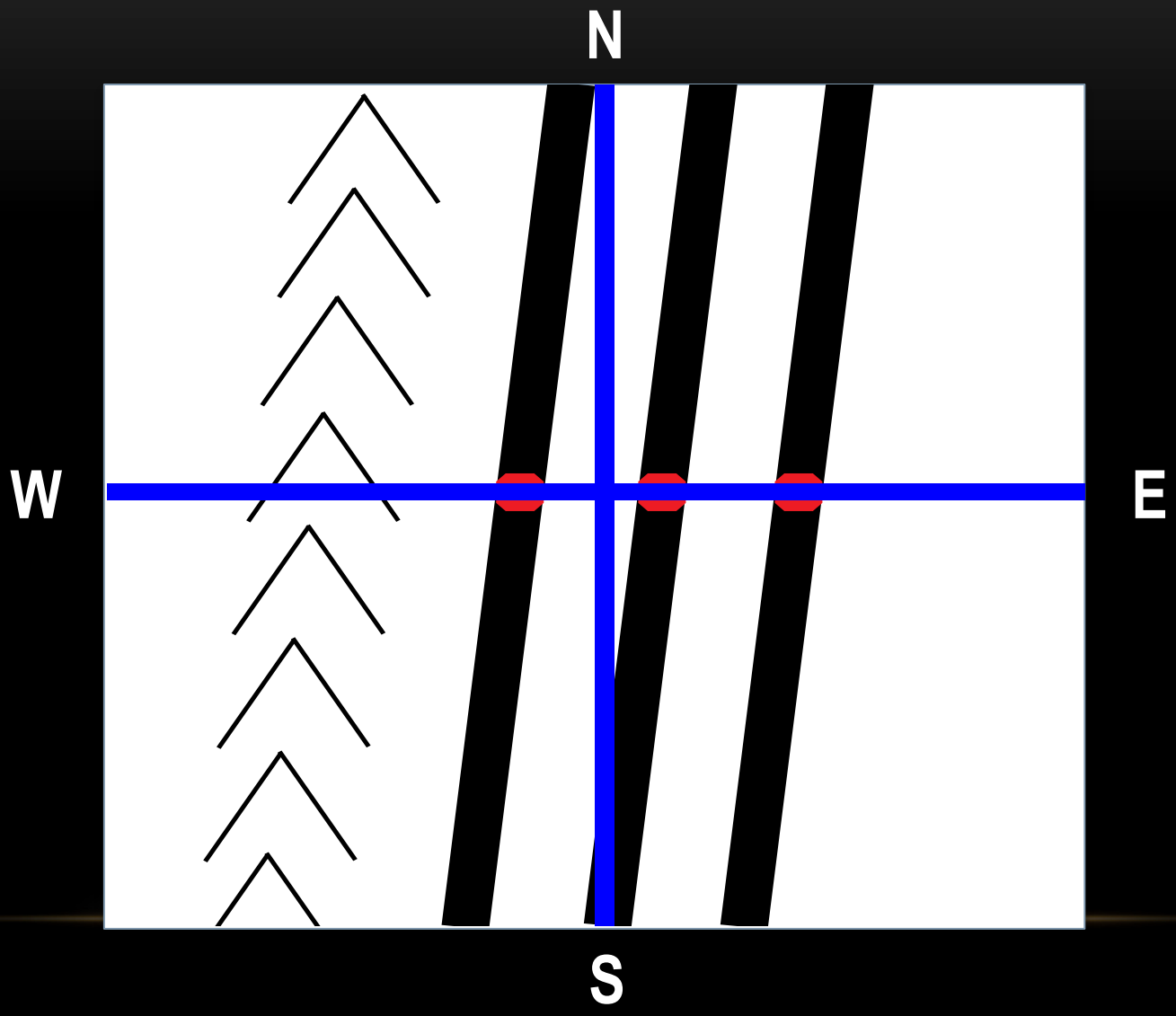
Boulder DEEPWAVE Workshop

23 October 2014

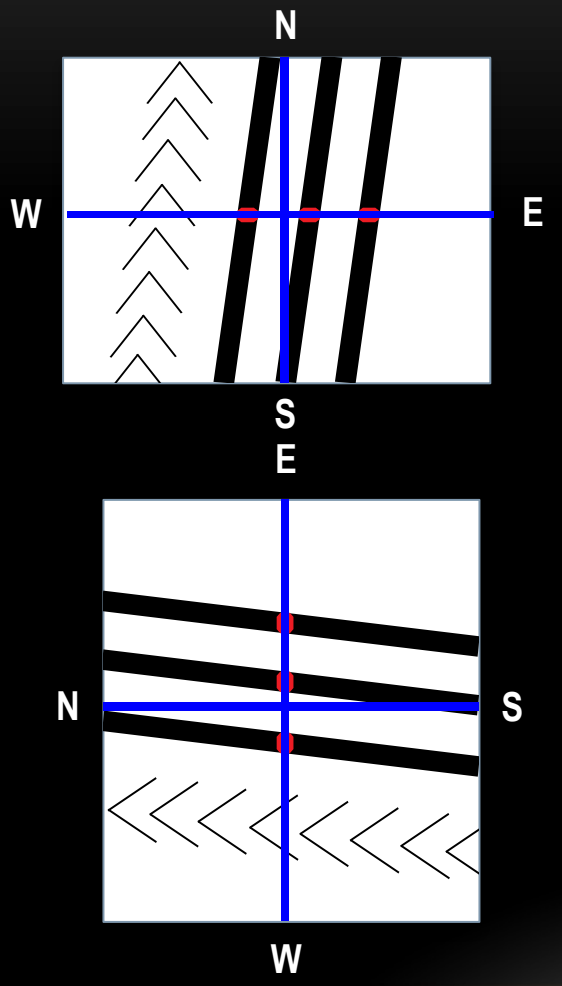
LAUDER ADVANCED MESOSPHERE TEMPERATURE MAPPER

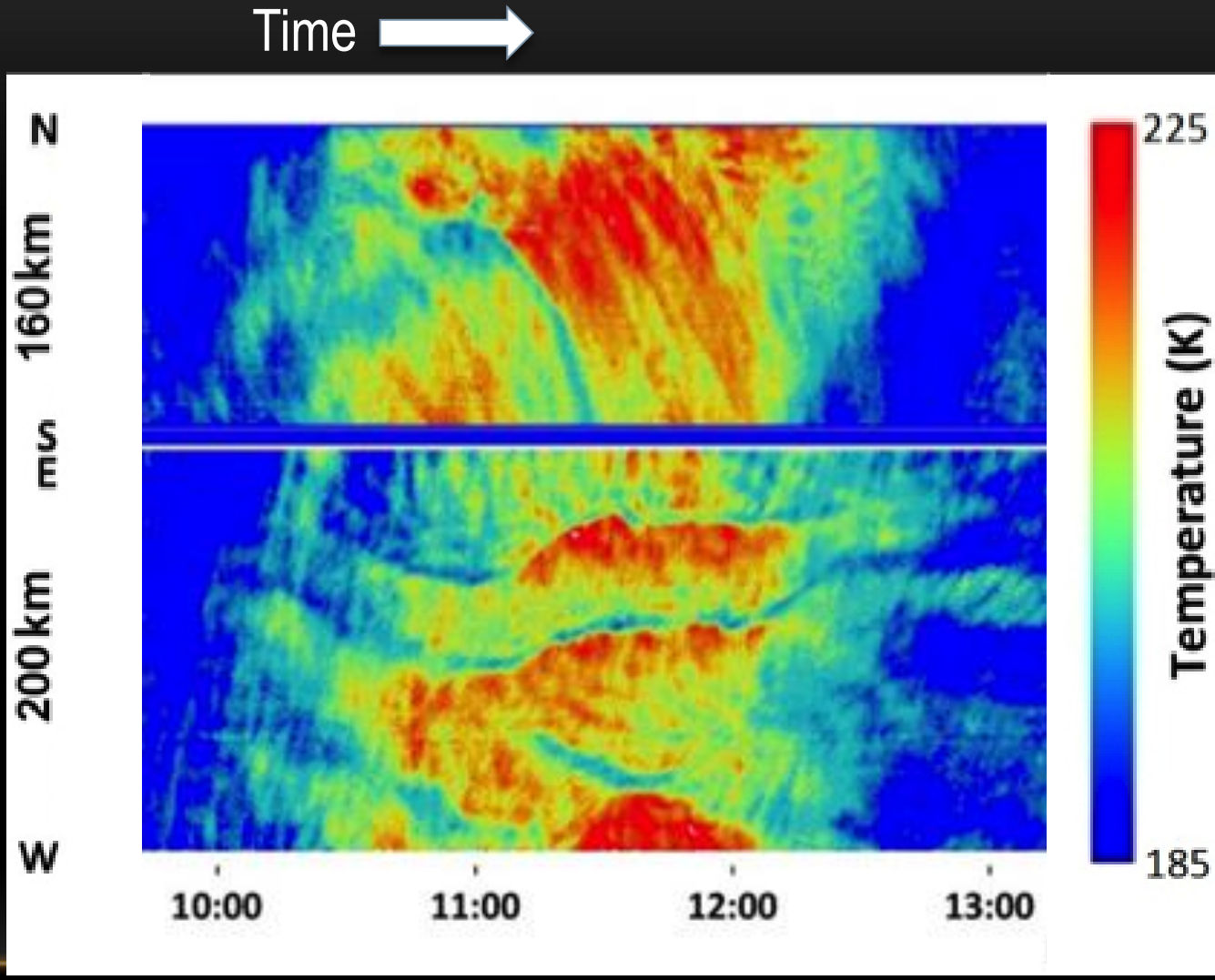
- Measures OH intensity and rotational temperature at ~87km
- Data collected over 200km x 160km region over Lauder, NZ
- Mountain waves readily identifiable in E-W keograms due to stationary appearance

KEOGRAM DIAGRAM



KEOGRAM DIAGRAM





CASE 1: JUNE 26, 2014

700 hPa

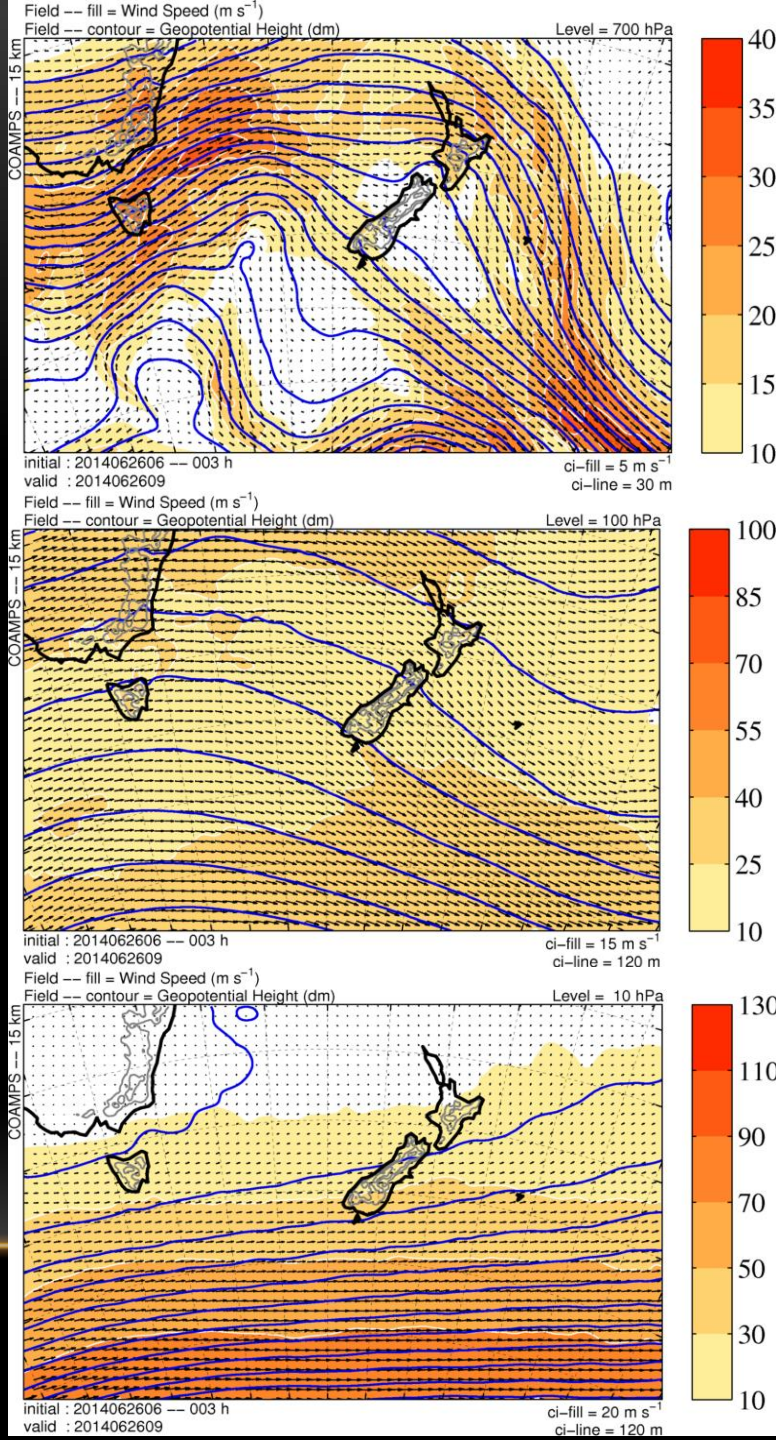
- Low-Altitude Forcing Characteristics: <10 m/s winds in cross-mountain direction

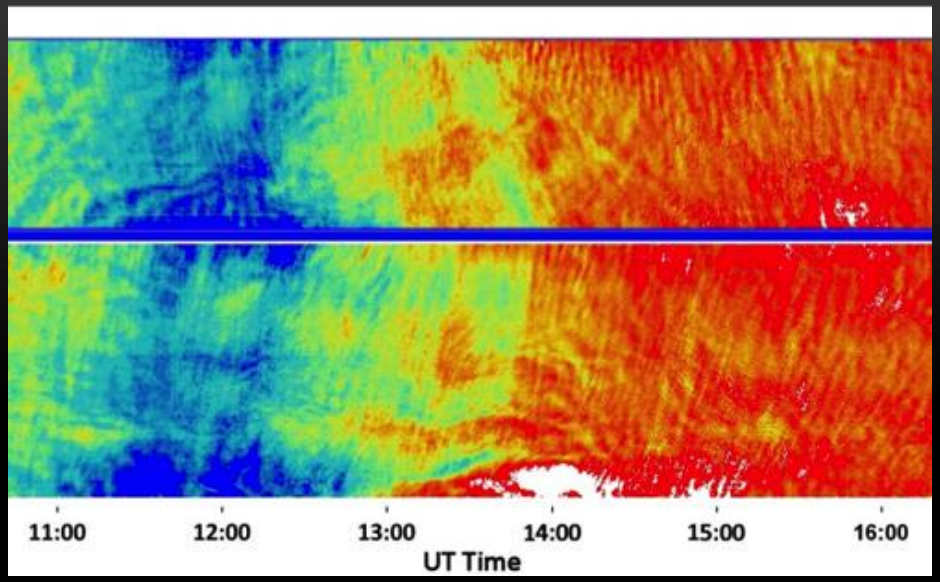
100 hPa

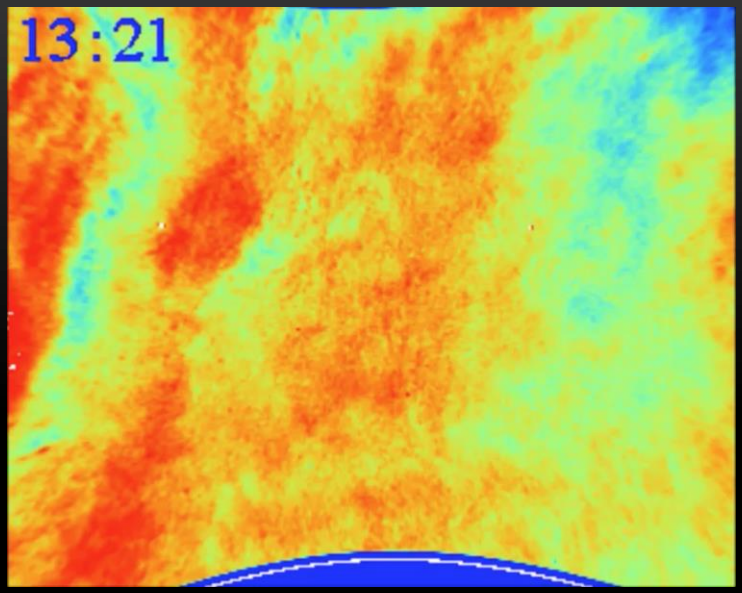
- 10-30 m/s winds at 100 hPa and 10 hPa in cross-mountain direction

10 hPa

- No mountain waves forecasted due to weak low altitude forcing




11:00
12:00
13:00
14:00
15:00
16:00
UT Time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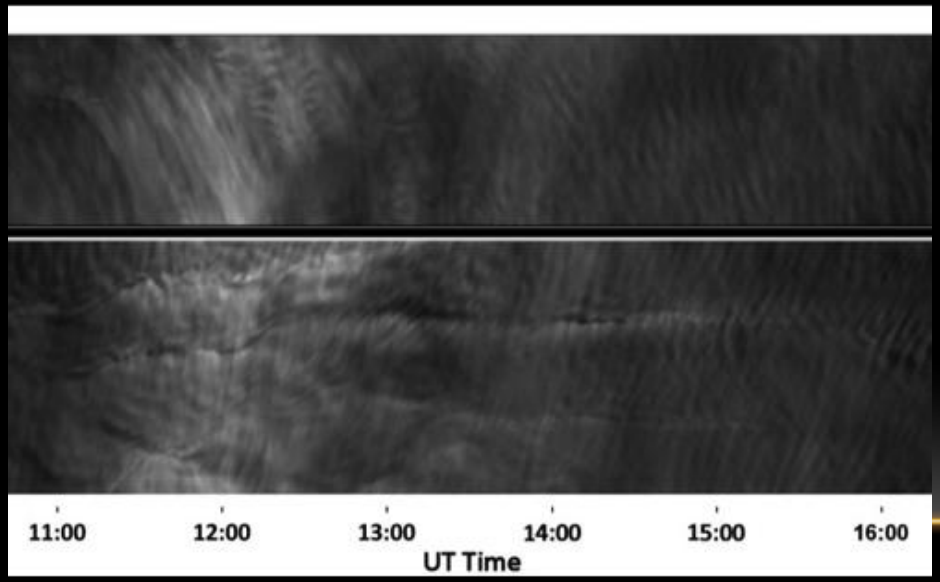
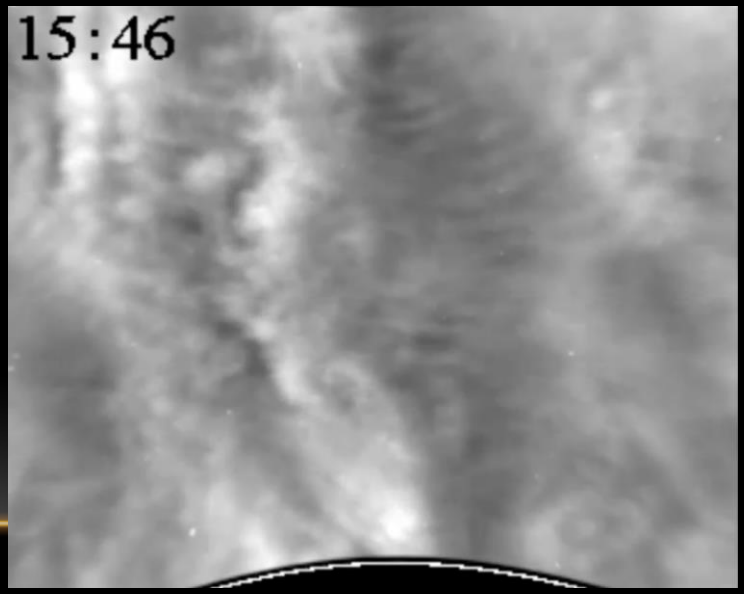

11:00
12:00
13:00
14:00
15:00
16:00
UT Time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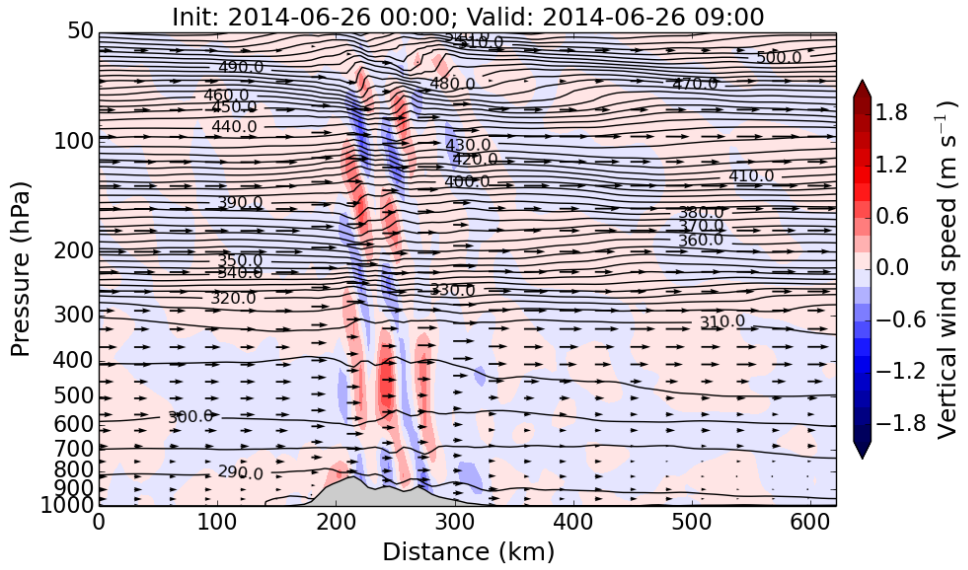
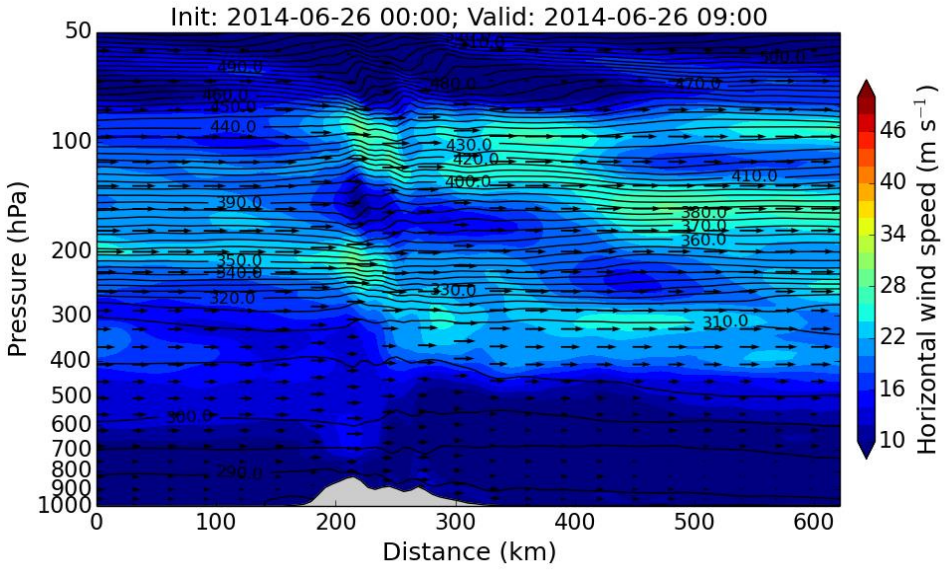
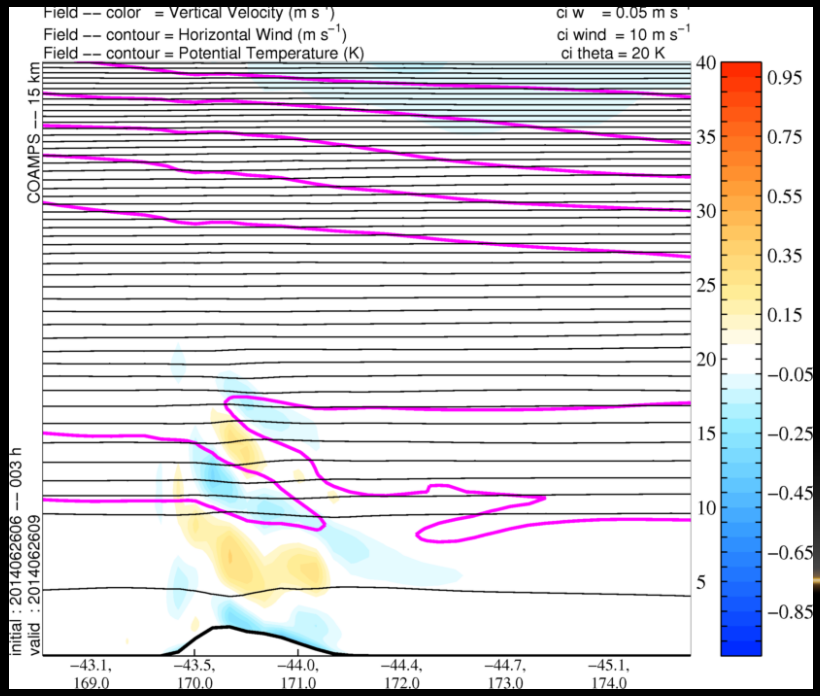
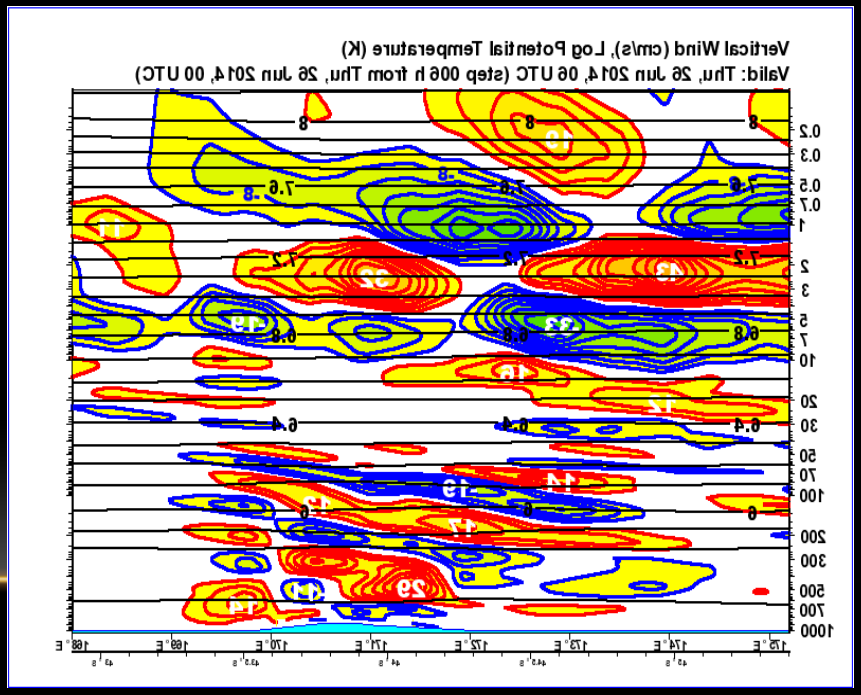

Init: 2014-06-26 00:00; Valid: 2014-06-26 09:00
Pressure (hPa)
Distance (km)
Vertical wind speed (m s^{-1})

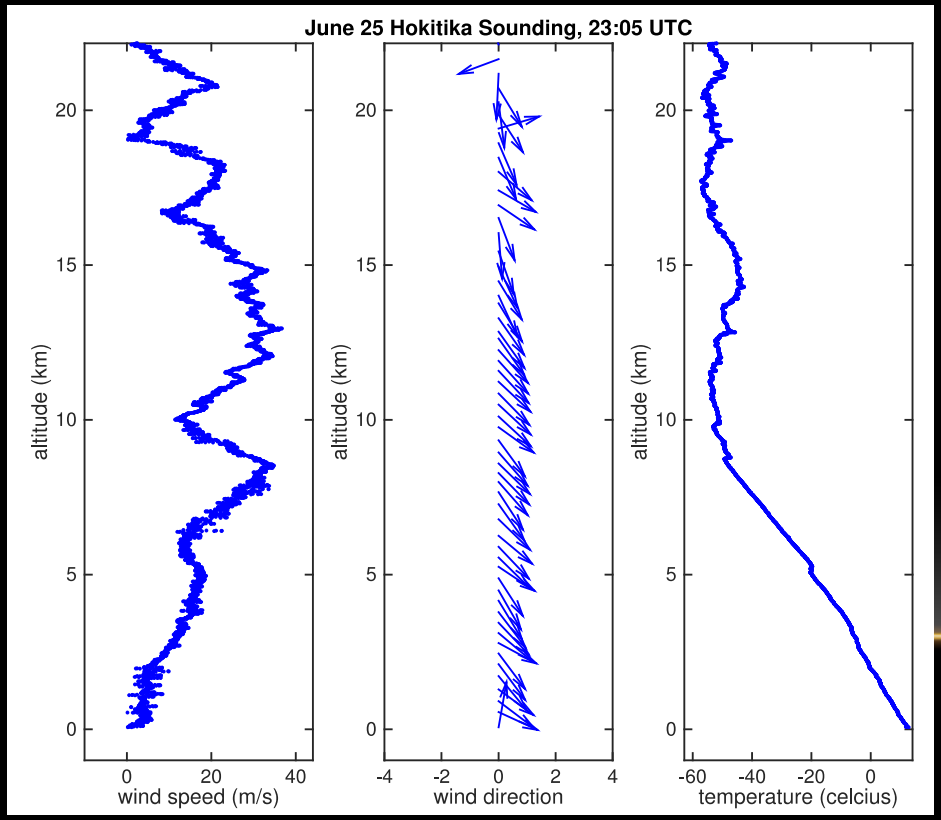

Init: 2014-06-26 00:00; Valid: 2014-06-26 09:00
Pressure (hPa)
Distance (km)
Horizontal wind speed (m s^{-1})

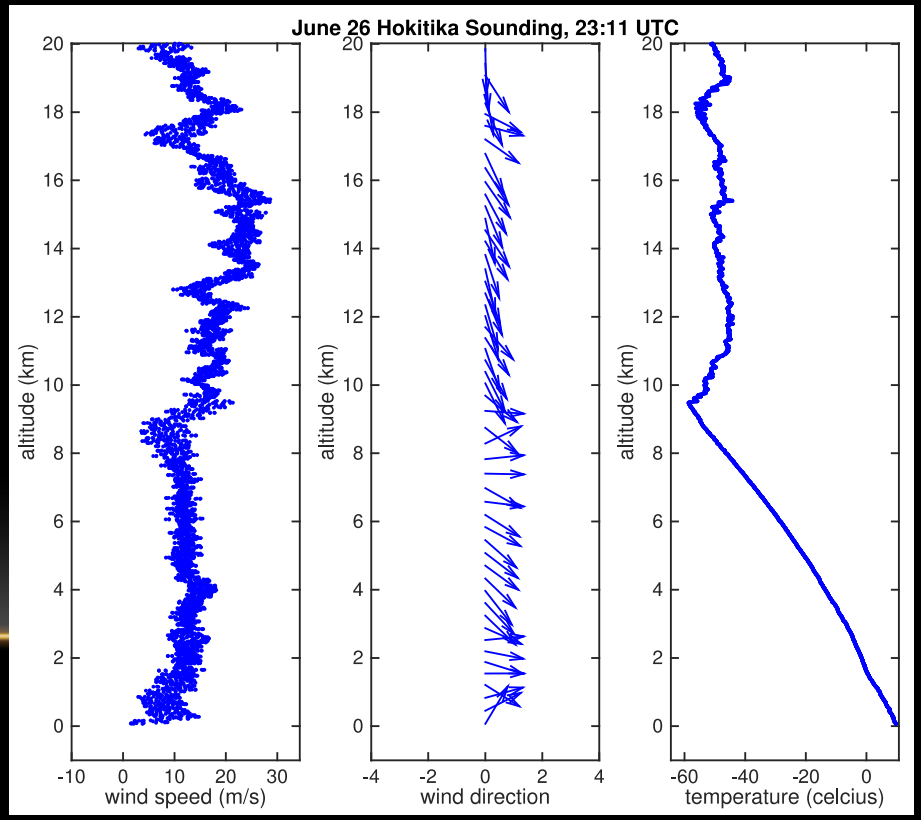

Field -- color = Vertical Velocity (m s^{-1})
Field -- contour = Horizontal Wind (m s^{-1})
Field -- contour = Potential Temperature (K)
ci w = 0.05 m s^{-1}
ci wind = 10 m s^{-1}
ci theta = 20 K
COAMPS --- 15 km
initial : 2014062606 --- 003 h
valid : 2014062609


Vertical Wind (cm/s), Log Potential Temperature (K)
Valid: Thu, 26 Jun 2014, 06 UTC (step 006 h from Thu, 26 Jun 2014, 00 UTC)

LIKELY CAUSE?

- Positive wind speed gradient in the vertical allows low-amplitude waves to propagate upward and gradually increasing in size
- Critical layer near 50 hPa dampens out larger scale waves at that altitude, but remaining small-scale waves continue to propagate upward - wave propagation appears to be more resistant to critical layers if wave amplitude is small when the layer is encountered





CASE 2: JULY 14

700 hPa

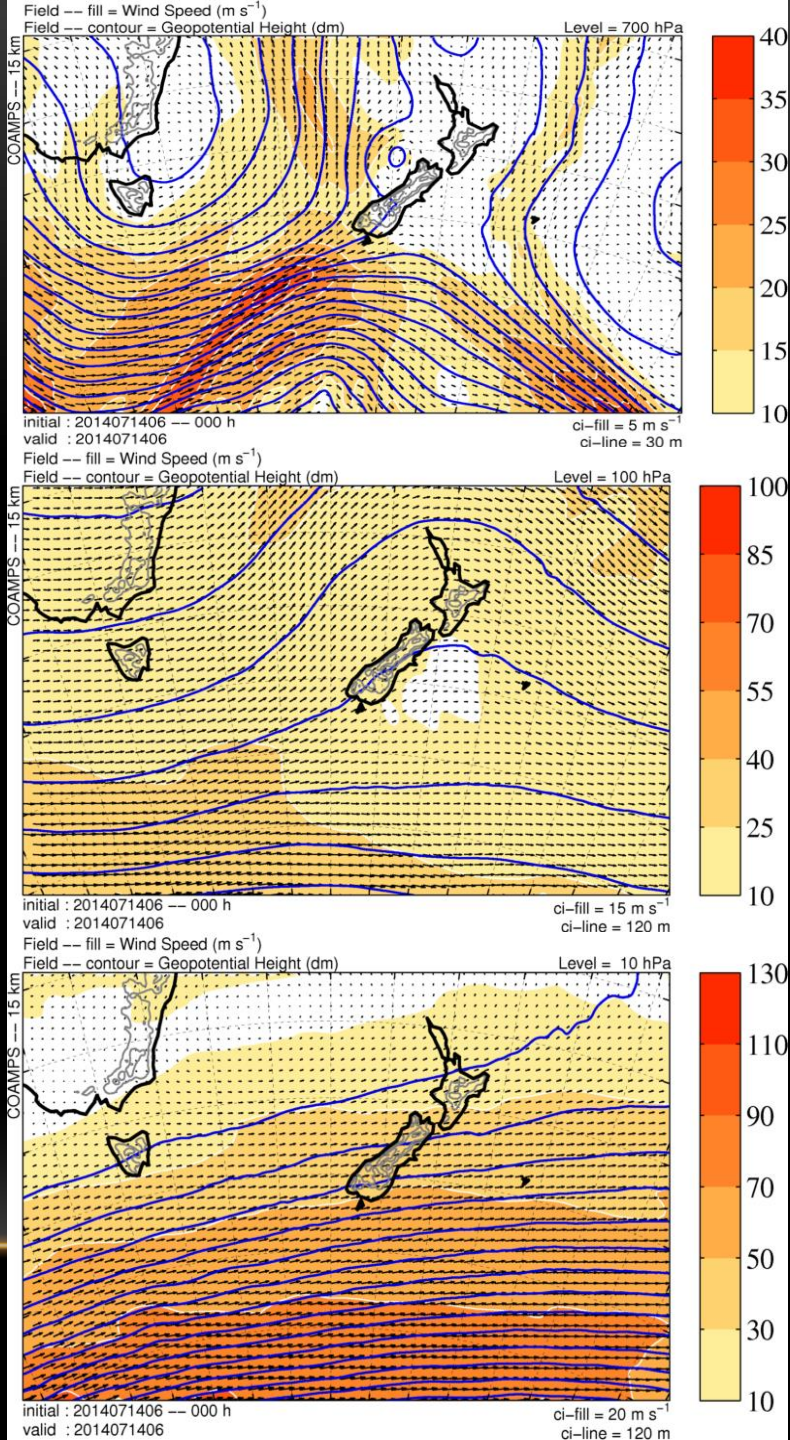
- Low-Altitude Forcing Characteristics: <10 m/s winds at ground level
  - wind diverges away from South Island with “dead zone” over mountains

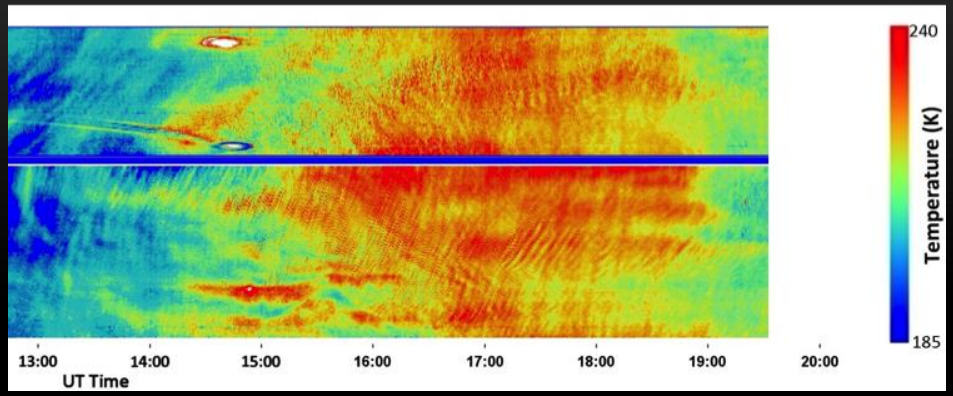
100 hPa

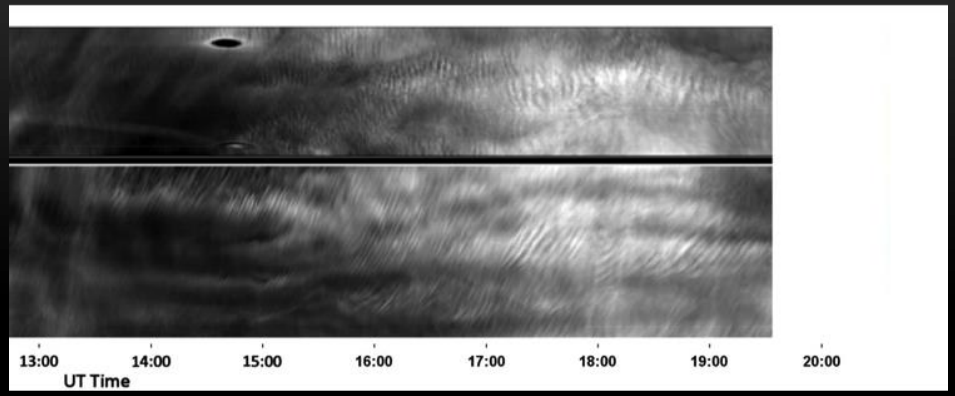
- Winds <20 m/s below 20 hPa

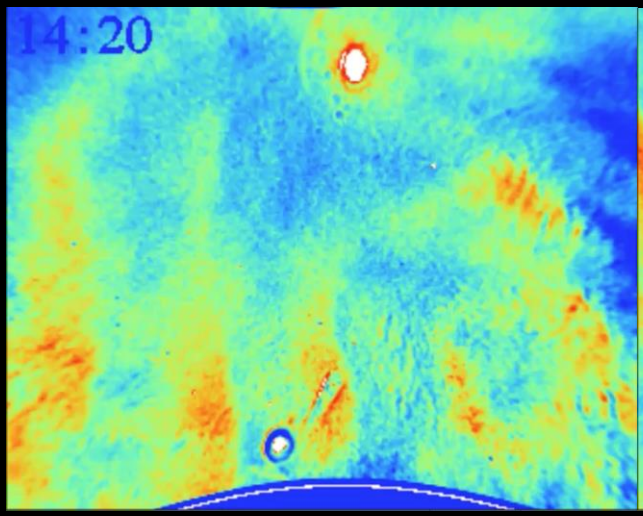
- No mountain waves forecasted due to weak low altitude forcing and large critical layer

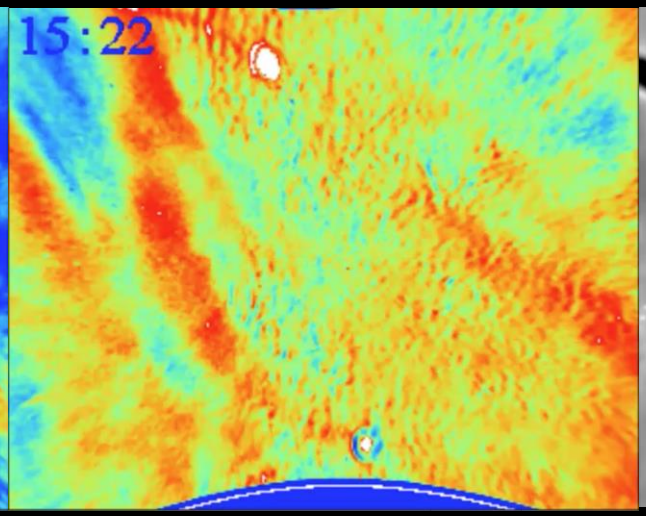
10 hPa




240
Temperature (K)
185
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
UT Time


13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
UT Time


14:20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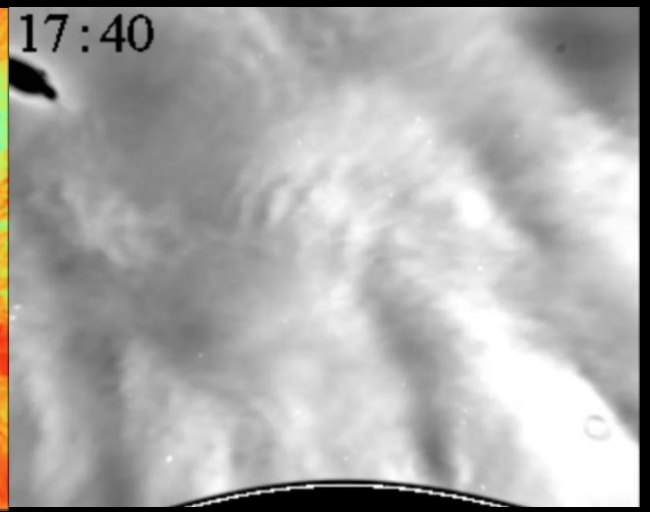
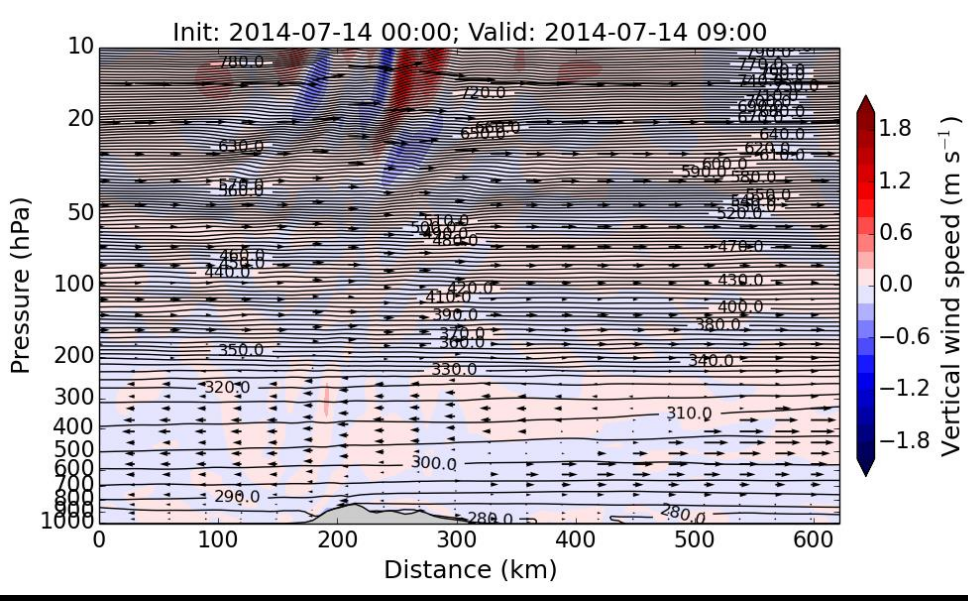
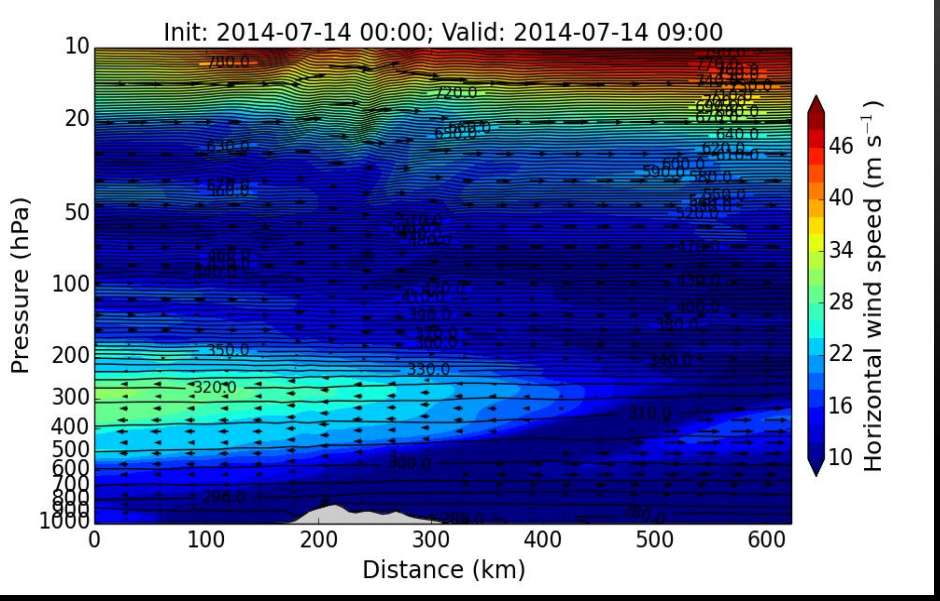
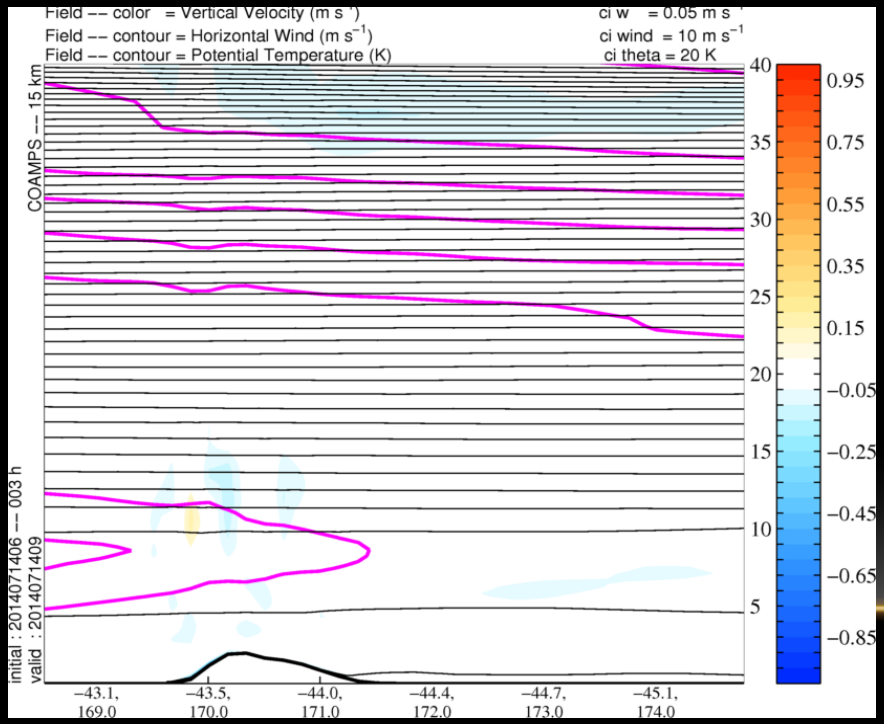
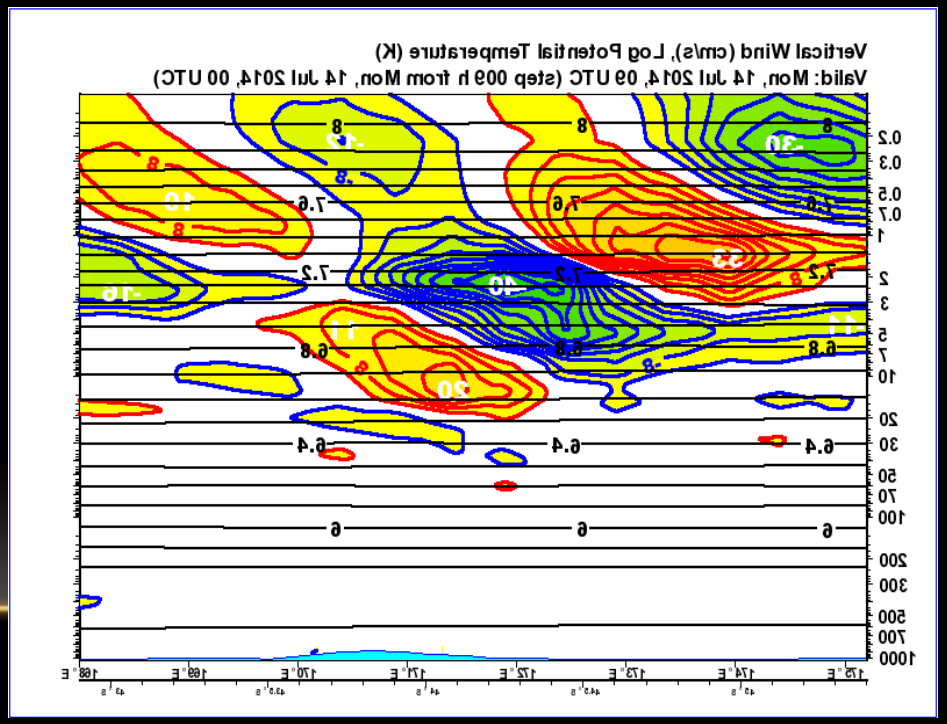

17:40


Init: 2014-07-14 00:00; Valid: 2014-07-14 09:00
Pressure (hPa)
Distance (km)
Vertical wind speed (m s^{-1})
1.8
1.2
0.6
0.0
−0.6
−1.2
−1.8

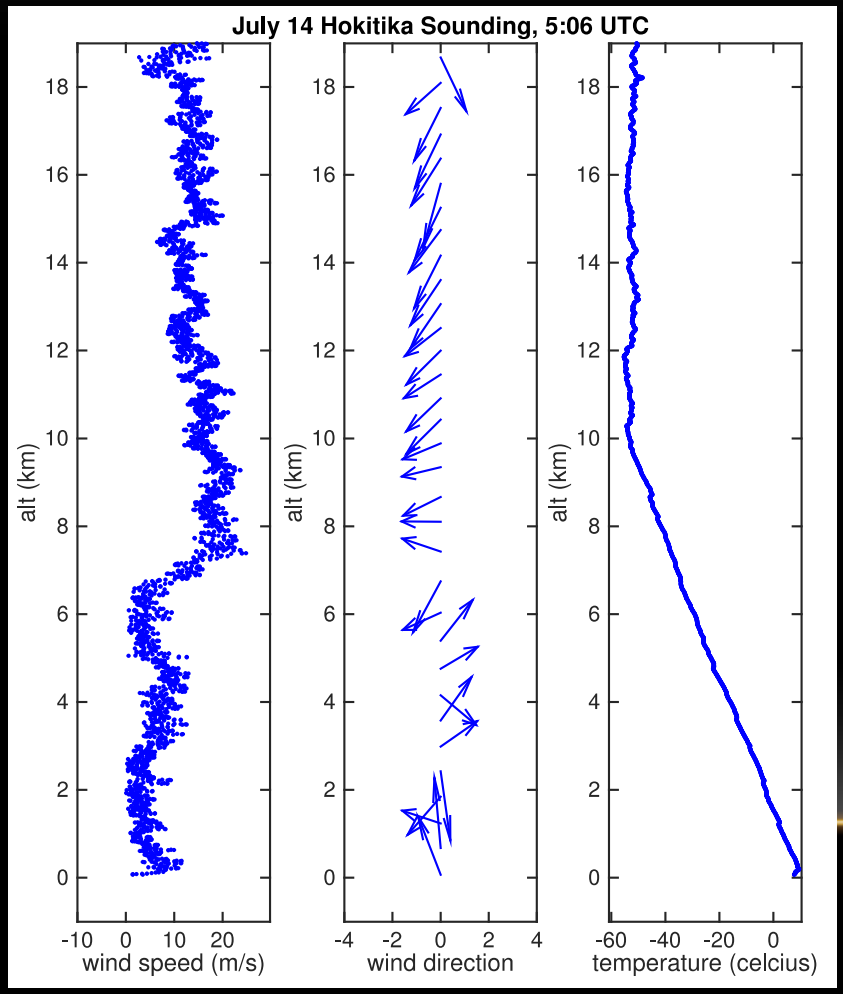

Init: 2014-07-14 00:00; Valid: 2014-07-14 09:00
Pressure (hPa)
Distance (km)
Horizontal wind speed (m s^{-1})
46
40
34
28
22
16
10


Field -- color = Vertical Velocity (m s^{-1})
Field -- contour = Horizontal Wind (m s^{-1})
Field -- contour = Potential Temperature (K)
ci w = 0.05 m s^{-1}
ci wind = 10 m s^{-1}
ci theta = 20 K
COAMPS -- 15 km
initial : 20140714Z06 -- 003 h
valid : 20140714Z09
0.95
0.75
0.55
0.35
0.15
−0.05
−0.25
−0.45
−0.65
−0.85

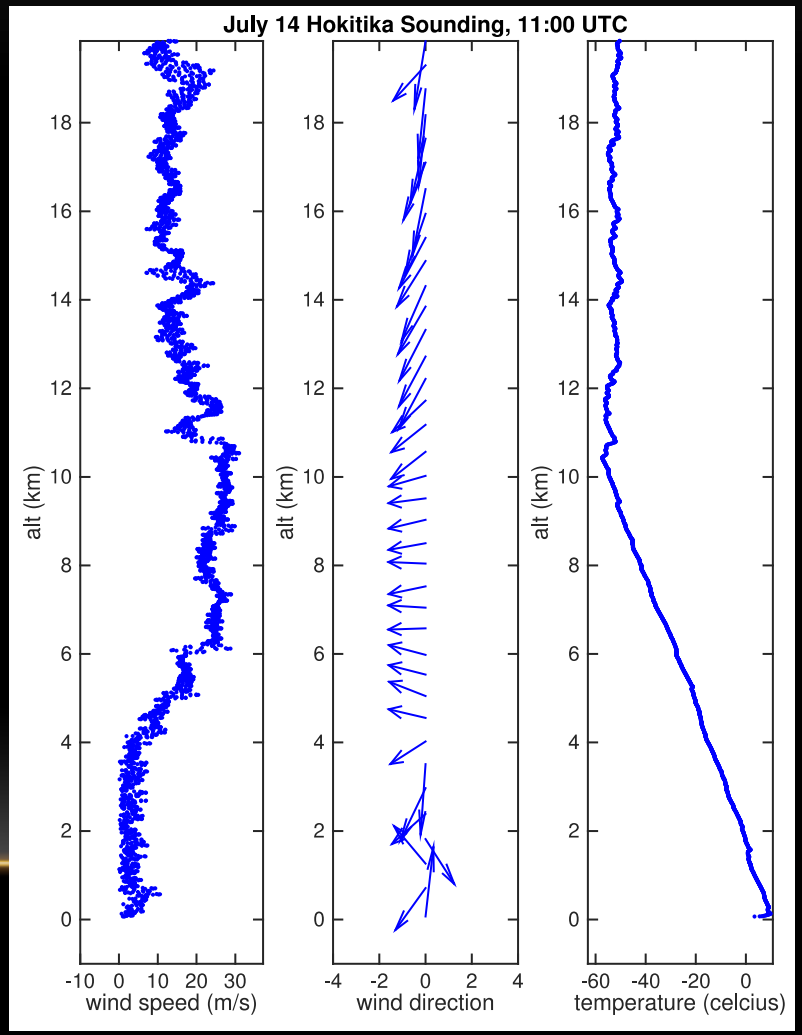

Vertical Wind (cm\s), Log Potential Temperature (K)
Valid: Mon, 14 Jul 2014, 09 UTC (step 009 h from Mon, 14 Jul 2014, 00 UTC)

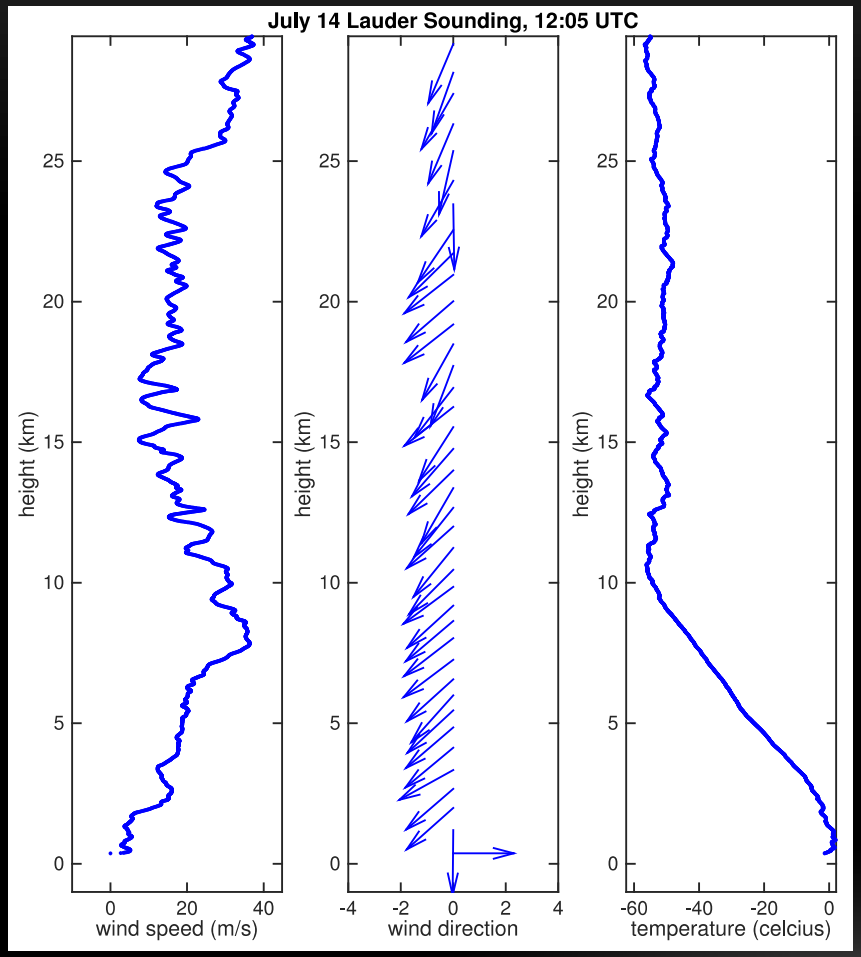
Wind profiles from the soundings display oscillatory behavior indicative of wave propagation from 10-20 km where models predict no activity

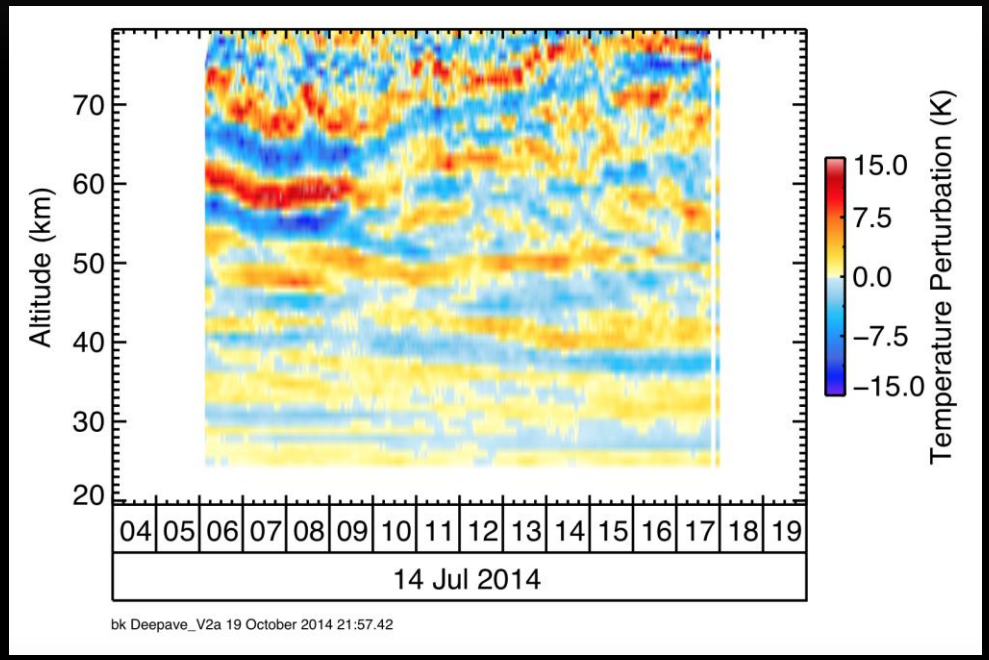
- This provides further indication that small amplitude waves may be able to propagate through low velocity “critical” layer



- However, the wave source remains ambiguous due to near-zero velocities from 0-5km




July 14 Lauder Sounding, 12:05 UTC
height (km)
wind speed (m/s)
wind direction
temperature (celcius)


Altitude (km)
14 Jul 2014
Temperature Perturbation (K)
15.0
7.5
0.0
−7.5
−15.0
bk Deepave_V2a 19 October 2014 21:57.42

LIKELY CAUSE?

- Undetermined – model and sounding data show no indications of vertical wave propagation at mountain level, though velocity perturbations are apparent in the soundings starting at 8 km altitudes
- However, it's worth noting that the soundings pick up small-amplitude propagation where the models predict no wave activity.
- If the wave source is orographic, then wave propagation must occur in such a way that the low altitude velocity perturbations are not resolved by the models or the soundings.
- If the wave source is nonorographic, then the cause for their cross-mountain orientation and long periods with zero phase speed remains unclear.

SUMMARY

- Low forcing conditions at mountain level can still result in high altitude wave propagation if horizontal wind speeds are low and have a continuous, positive vertical gradient.
- Orographic waves initialized under weak forcing conditions may be able to propagate through low-velocity critical layers.
- Further investigation is needed to verify the source of these seemingly-orographic waves and characterize their propagation dynamics below 50 hPa.


QUESTIONS?