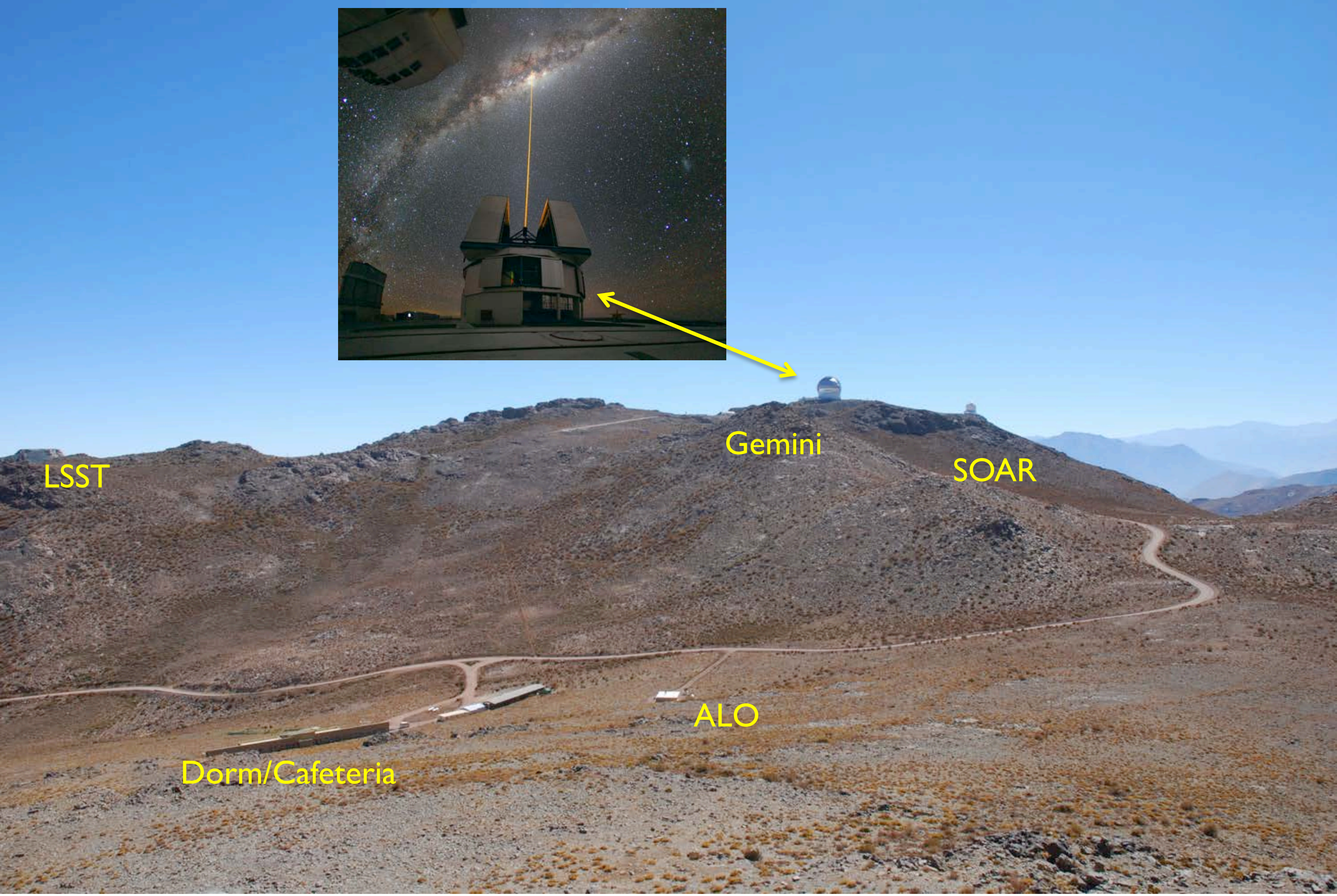
Andes Lidar Observatory 'Highlights-CEDAR 2015'

By Gary Swenson, University of Illinois

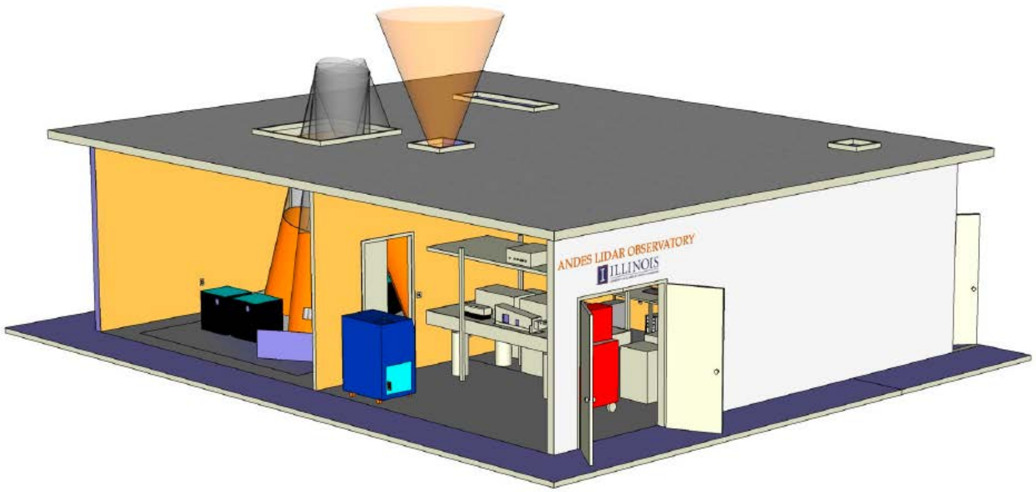
Outline

1. Where is ALO.
2. ALO People.
3. ALO Instrumentation.
4. NEW Performance Summary of Lidar.
5. Wave science – large (PW, TIDES).
6. Wave Science – small (GW, Turbulence).
7. Data Archives.

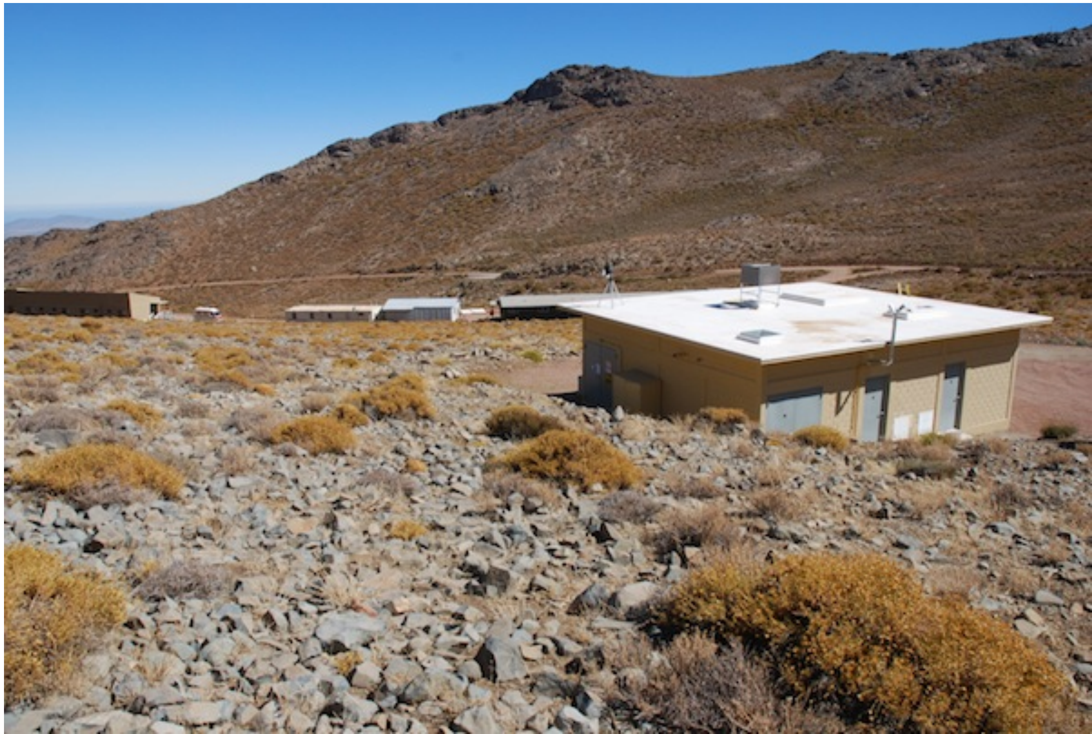
ALO
30° 13' S
70° 43' W
2715 m


Gemini
SOAR
LSST
ALO
Dorm/Cafeteria

University of Illinois, Andes Lidar Observatory



- Facility instrument
  - Lidar (Gary Swenson/Alan Liu, Fabio Vargas)
  - All sky Imager (Alan Liu/Fabio Vargas)
  - Photometer (Tony Mangognia)
  - Temperature Mapper (Mike Taylor, Utah State Univ)
  - Infrared camera (Jim Hecht)
  - Meteor radar (Steve Franke)



ANDES LIDAR OBSERVATORY – Consortium

Consortium of Lidars- Jeff Thayer (UC), Xinzhao Chu (CTC), USU Lidar - Titus Yuan USU , Alomar Lidar -Dave Fritts and Biff Williams (GATS-INC)

AURA (Association of University Research in Astronomy)– Steve Heathcote

ALO

Na wind/temperature lidar - Fabio Vargas, Tony Mangognia, Gary Swenson (U of I) and Alan Liu (ERAU), Chet Gardner (FOUNDER)

OH/OH/GL Imager - Fabio Vargas (UofI) and Alan Liu (ERAU)

Meteor Radar- Steve Franke and Fabio Vargas (U of I)

IR Imager- Jim Hecht and Richard Walterscheid (Aerospace Corporation)

OH Temperature Mapper- Mike Taylor, Dominique Pautet, and Yucheng Chang (USU)

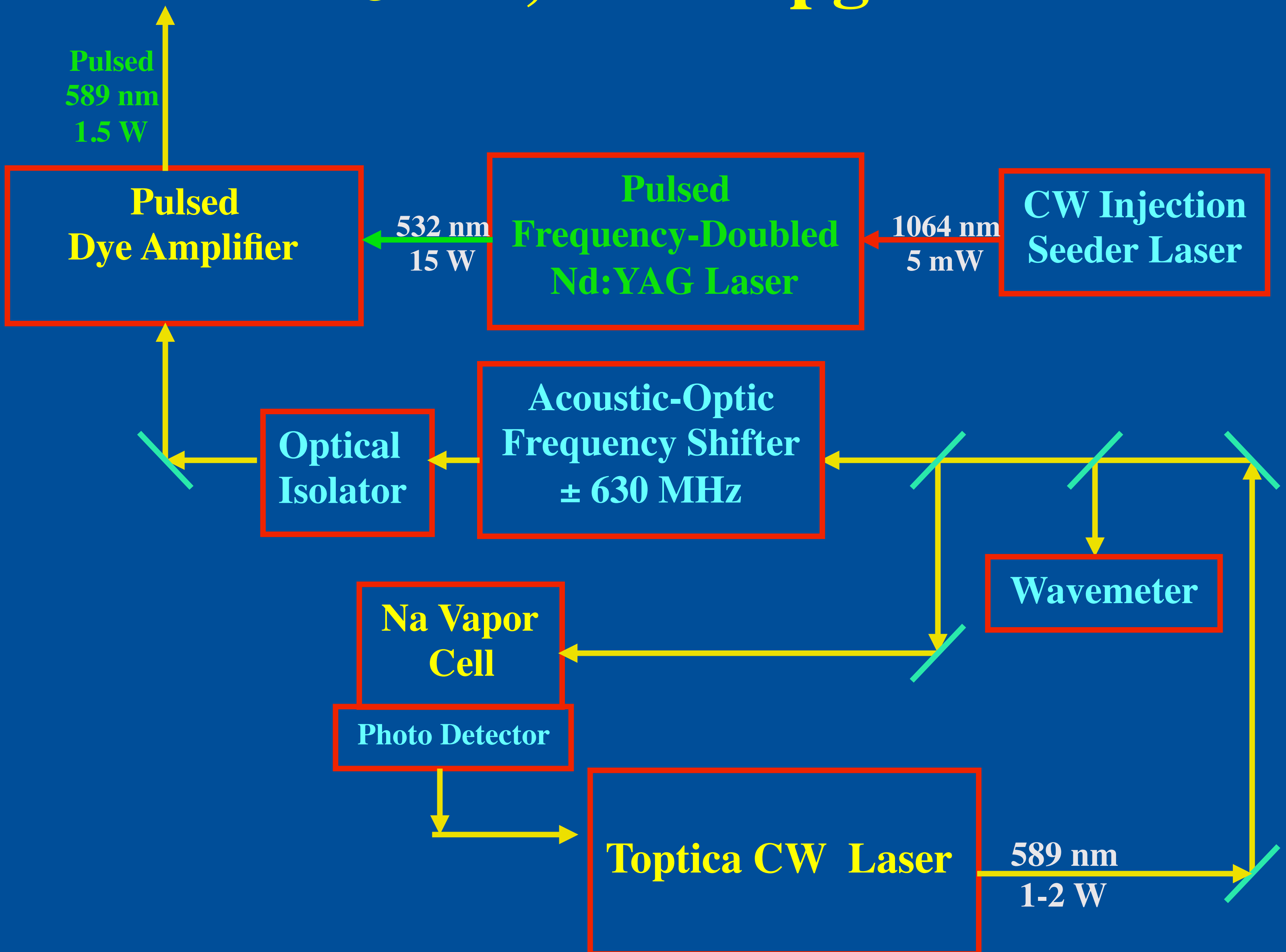
Photometer (3 Channel)- Tony Mangognia and Fabio Vargas (U of I)

Na Wind/ Temperature Lidar

- Alan Liu and Tony Mangognia (GS) are aligning the ALO Na transmitter system (right).

- A high efficiency receiver system pointing EWS was designed and built (left).

Na Wind/Temperature LIDAR-
June, 2014 Upgrade



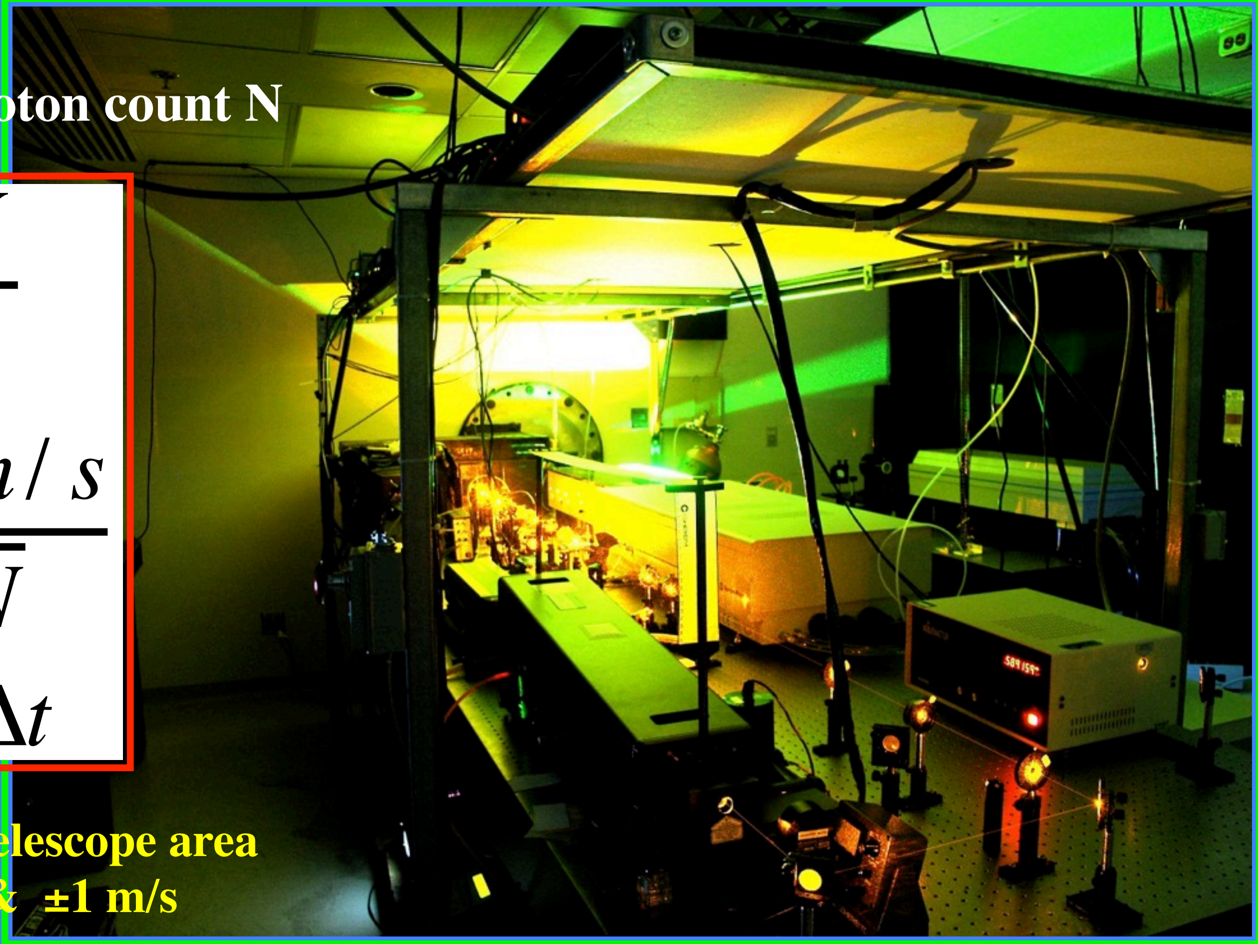
Lidar- Light Detection & Ranging

Accuracy depends on photon count N

$$\Delta T \approx \frac{250K}{\sqrt{N}}$$

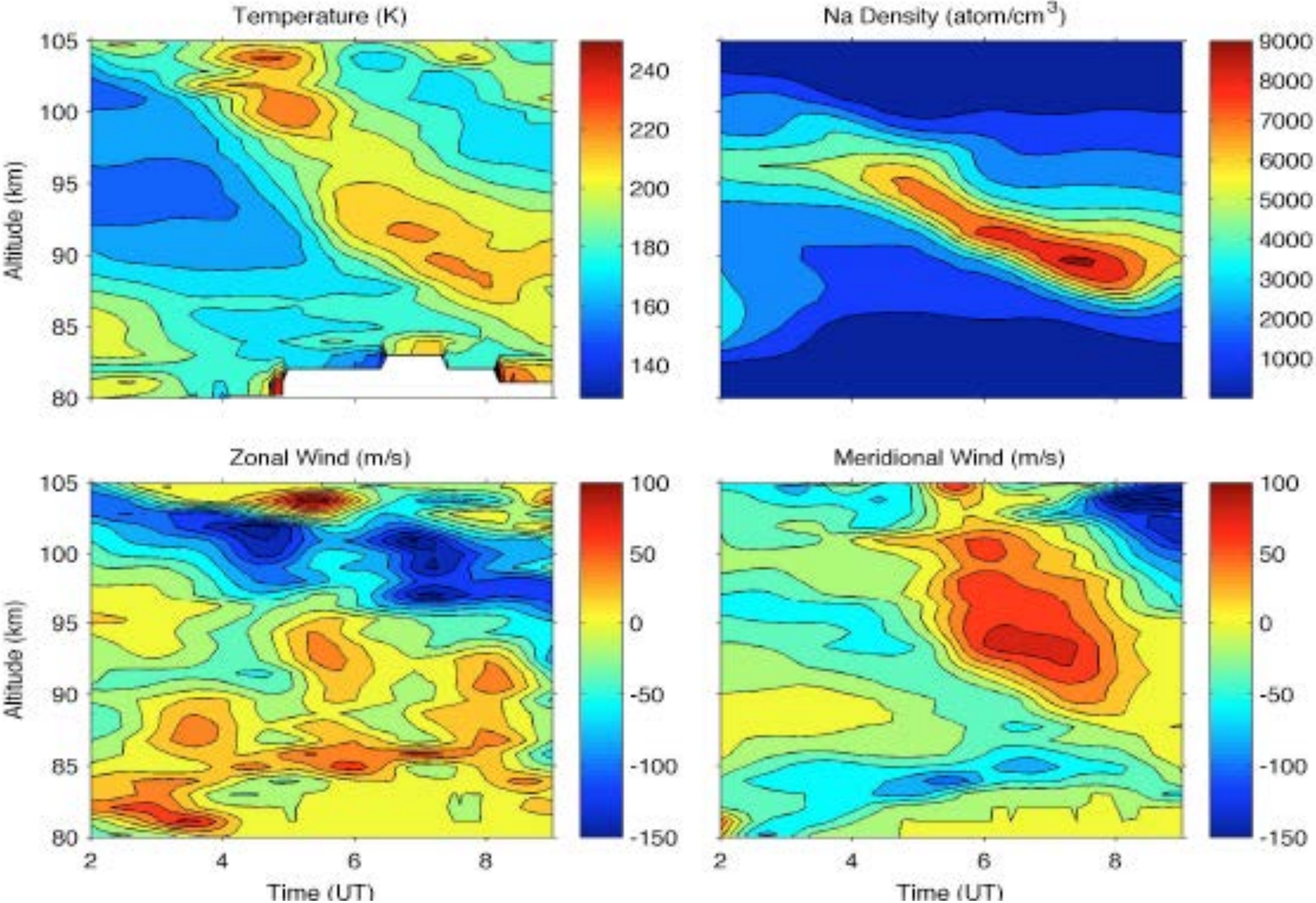
$$\Delta V \approx \frac{200\,m/s}{\sqrt{N}}$$

$$N \propto PA\Delta z\Delta t$$



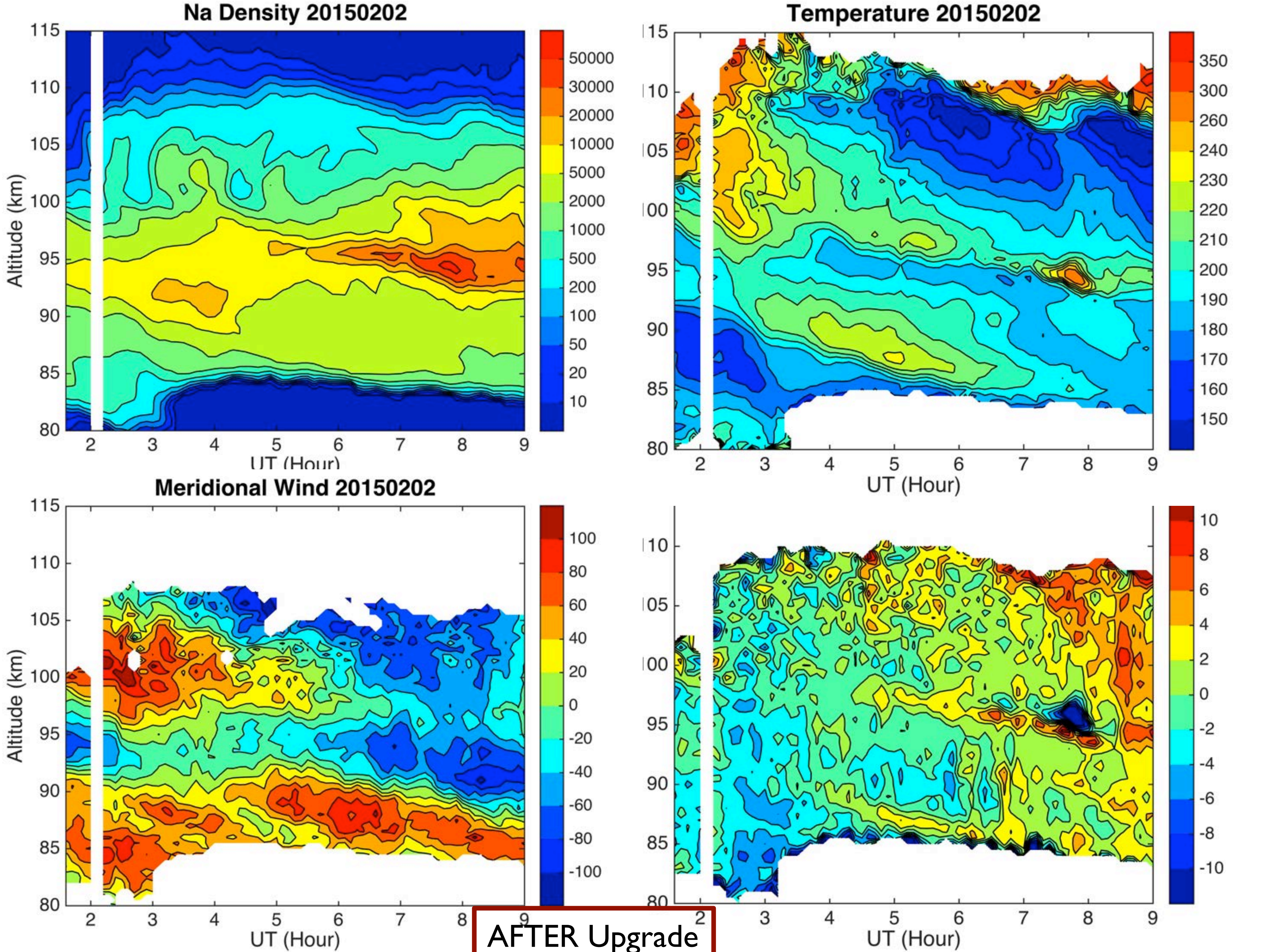
P = laser power   A = telescope area

$N \sim 10^5$ for ±1 K & ±1 m/s

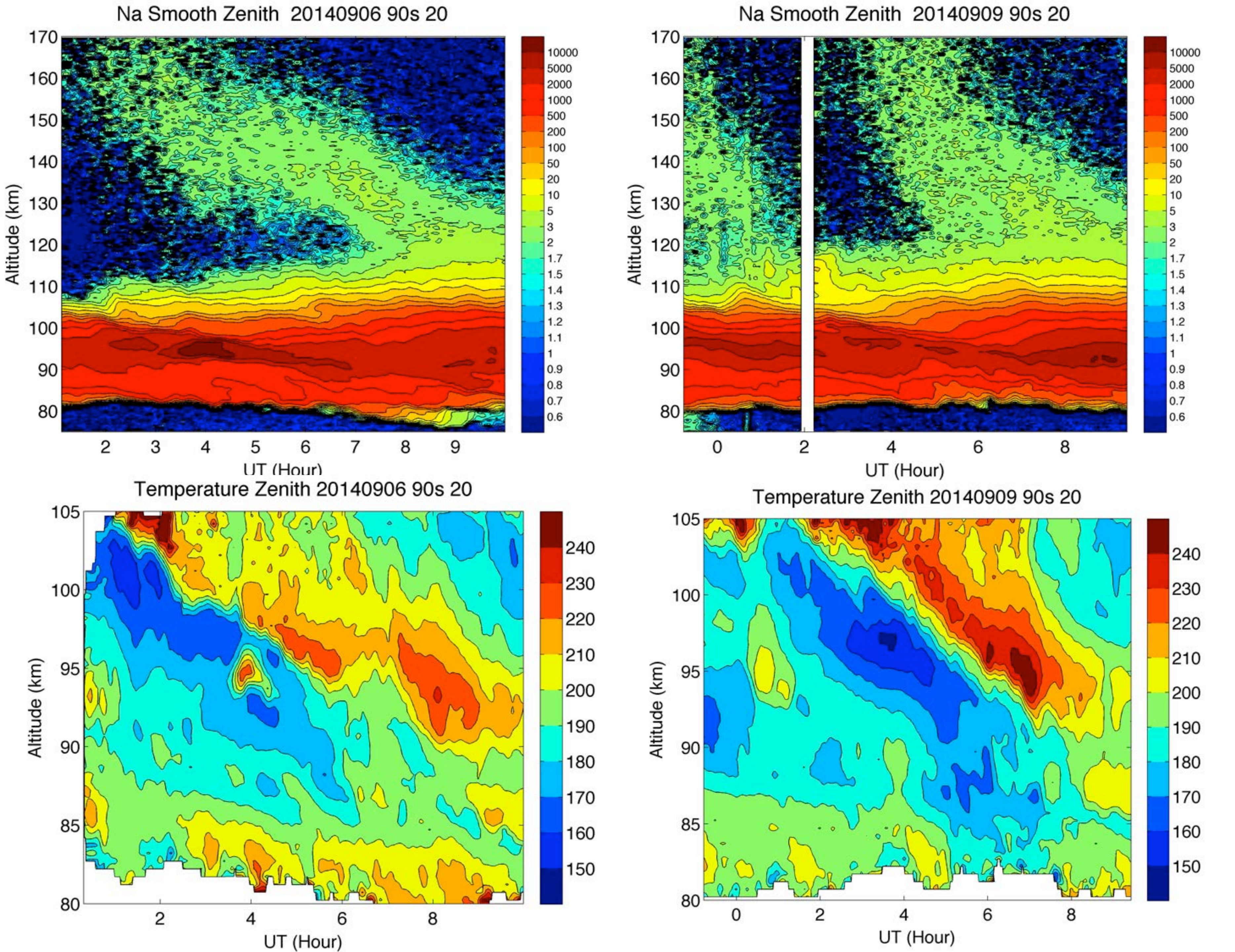


08142010

BEFORE Upgrade

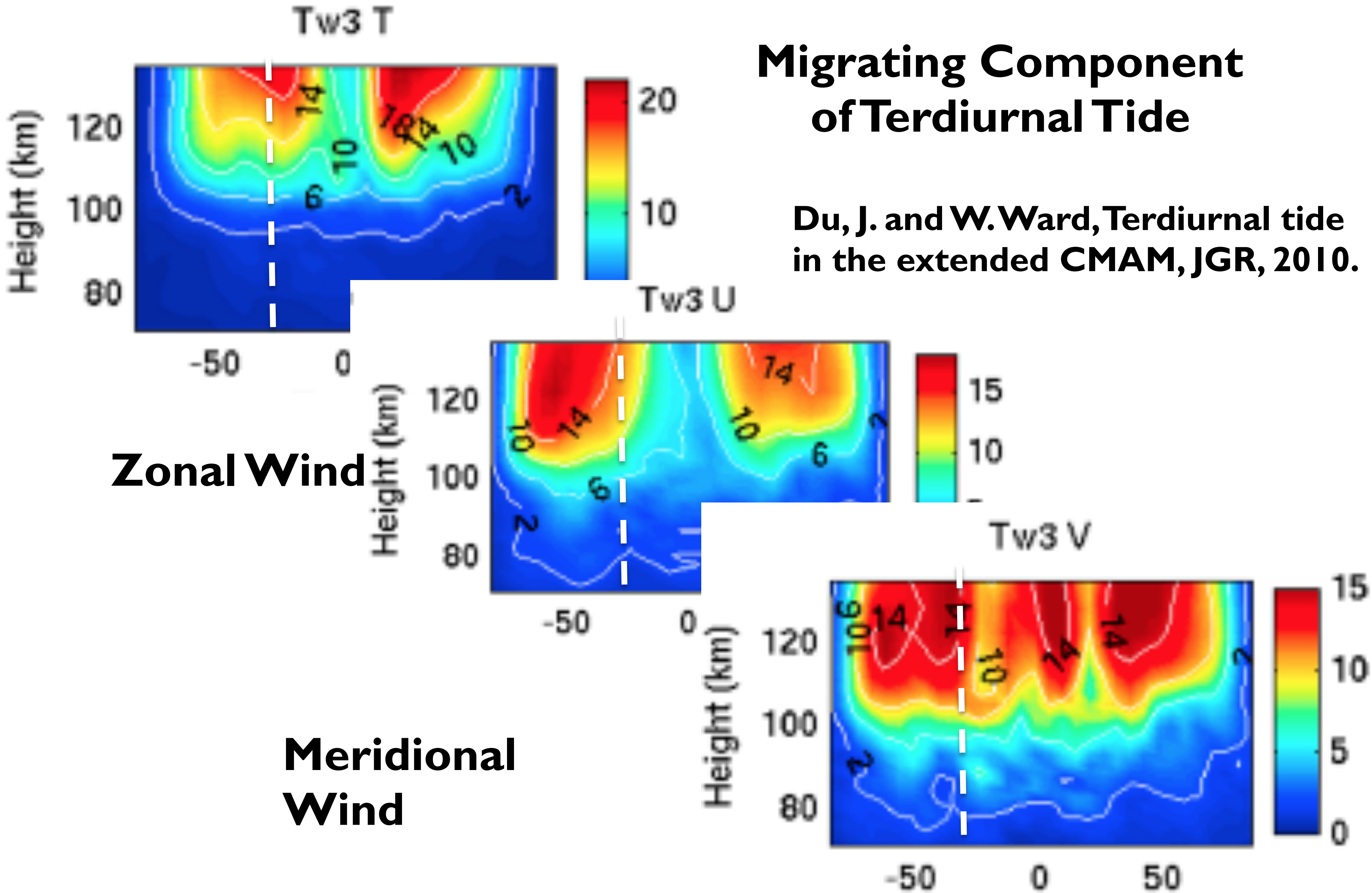


AFTER Upgrade

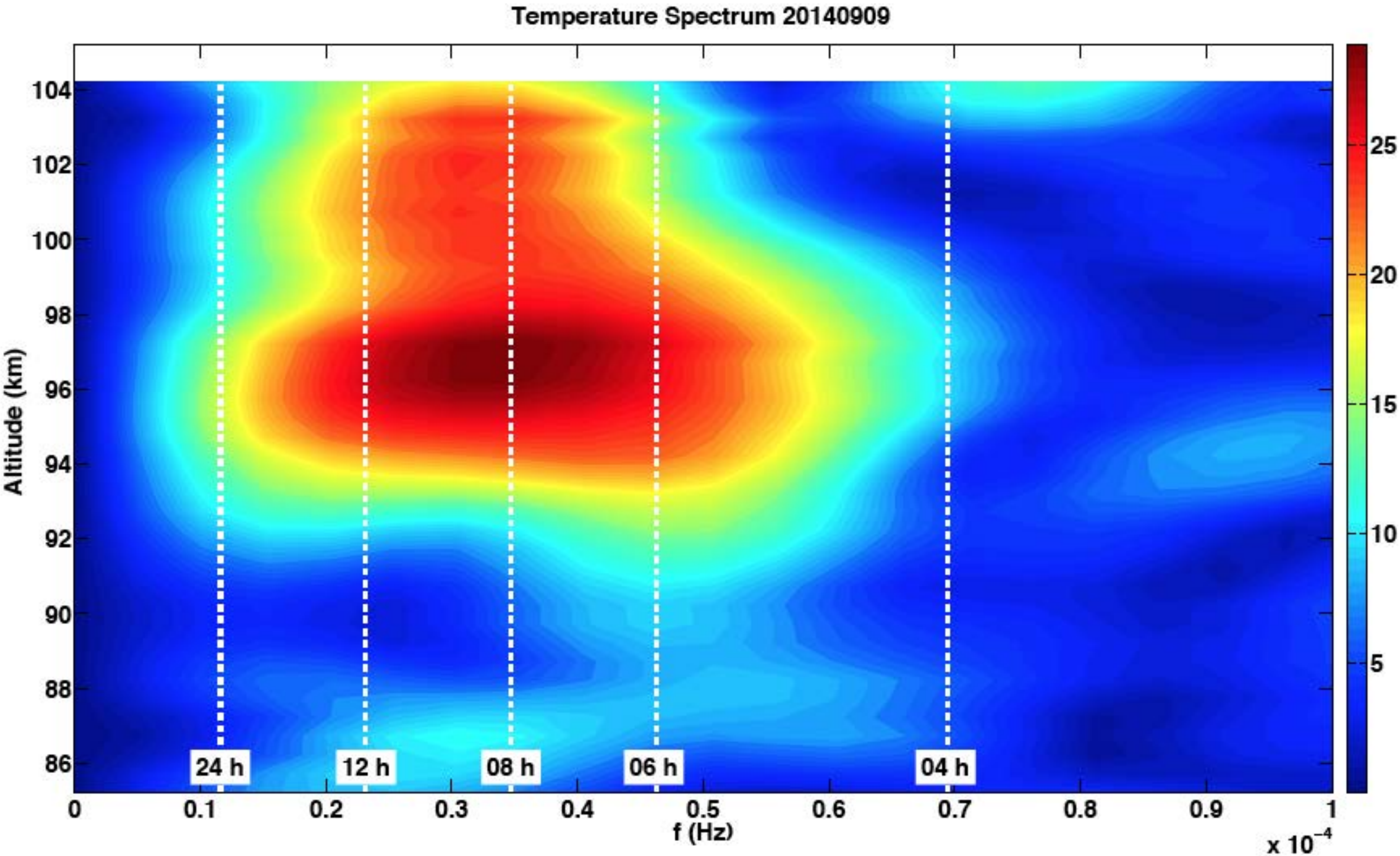

Na Smooth Zenith 20140906 90s 20
Altitude (km)
UT (Hour)
170
160
150
140
130
120
110
100
90
80
2
3
4
5
6
7
8
9
10000
5000
2000
1000
500
200
100
50
20
10
5
3
2
1.7
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
Na Smooth Zenith 20140909 90s 20
Altitude (km)
UT (Hour)
0
2
4
6
8
Temperature Zenith 20140906 90s 20
Altitude (km)
UT (Hour)
105
100
95
90
85
80
240
230
220
210
200
190
180
170
160
150
Temperature Zenith 20140909 90s 20
Altitude (km)
UT (Hour)

Migrating Component of Terdiurnal Tide

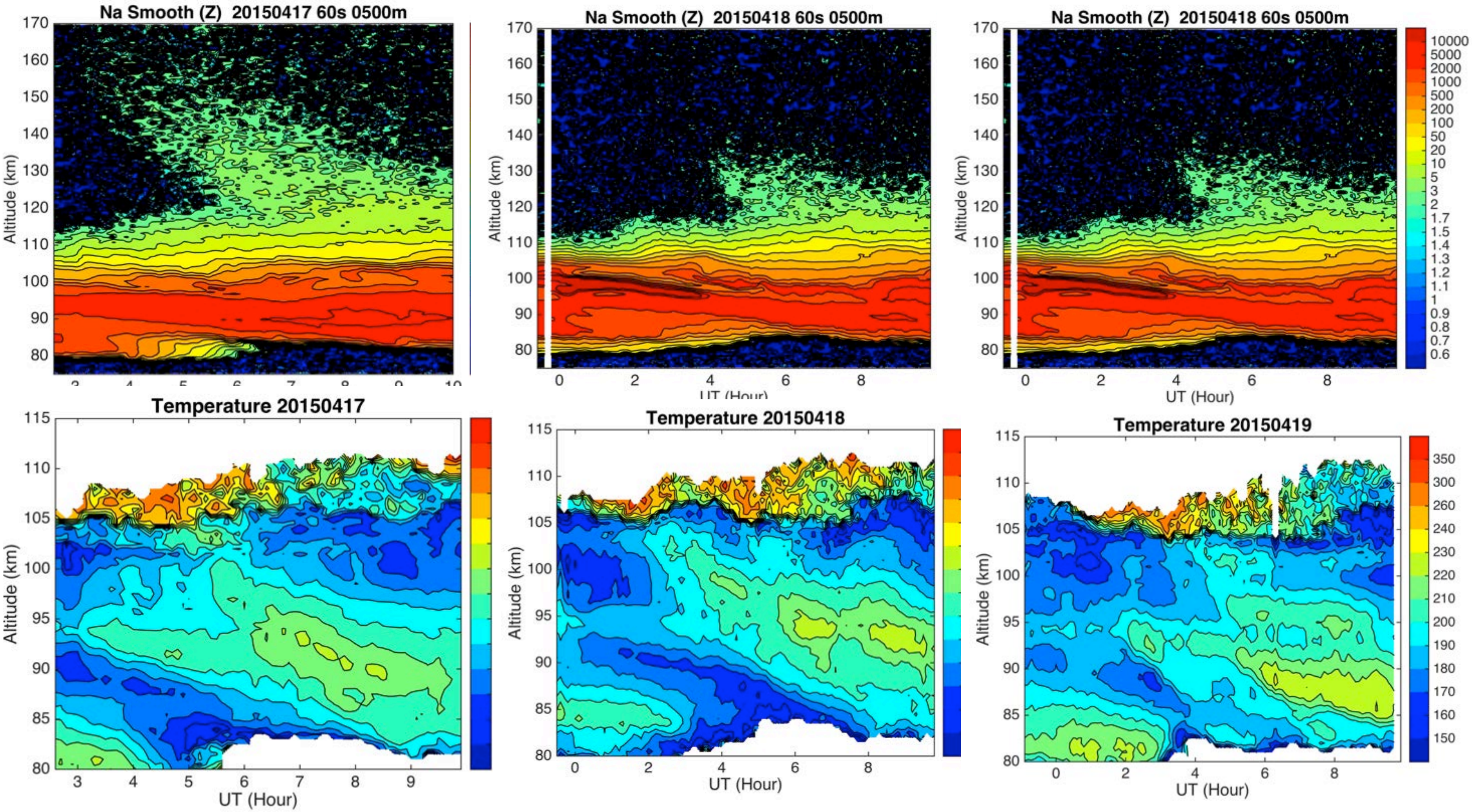
Du, J. and W. Ward, Terdiurnal tide in the extended CMAM, JGR, 2010.

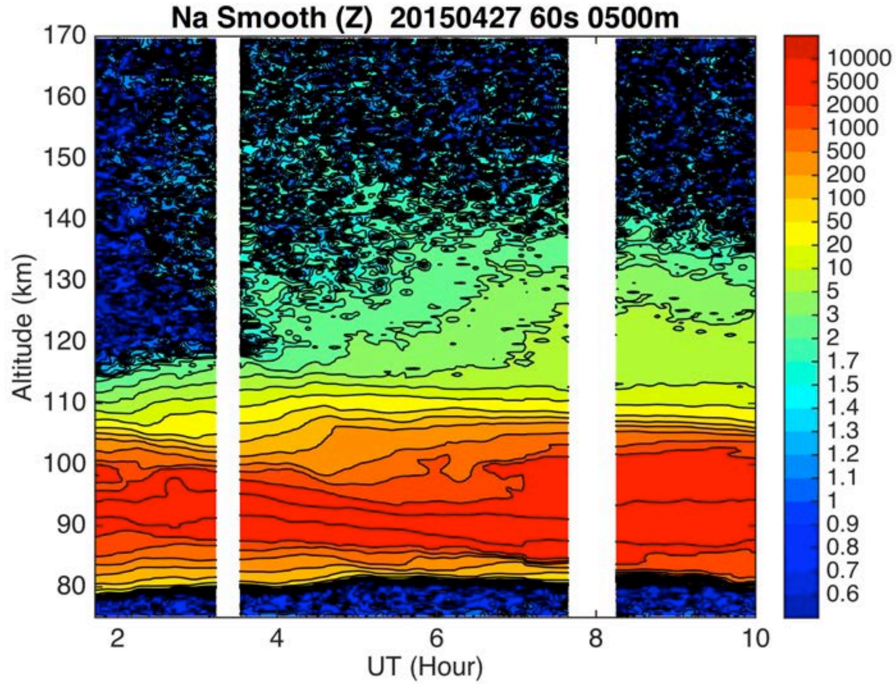


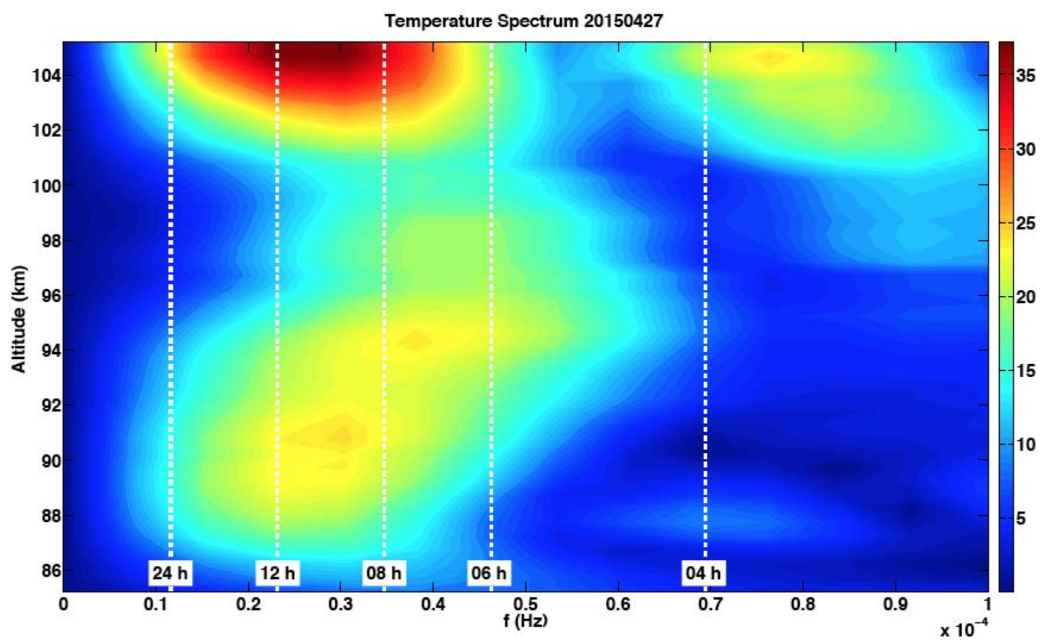
Terdiurnal tide **annual mean amplitude** structures vs altitude and latitude, of migrating component average for T (upper left), U or zonal wind (center) and V or meridional wind (lower right). A vertical dashed (white) line is shown for ALO latitude (30° S).



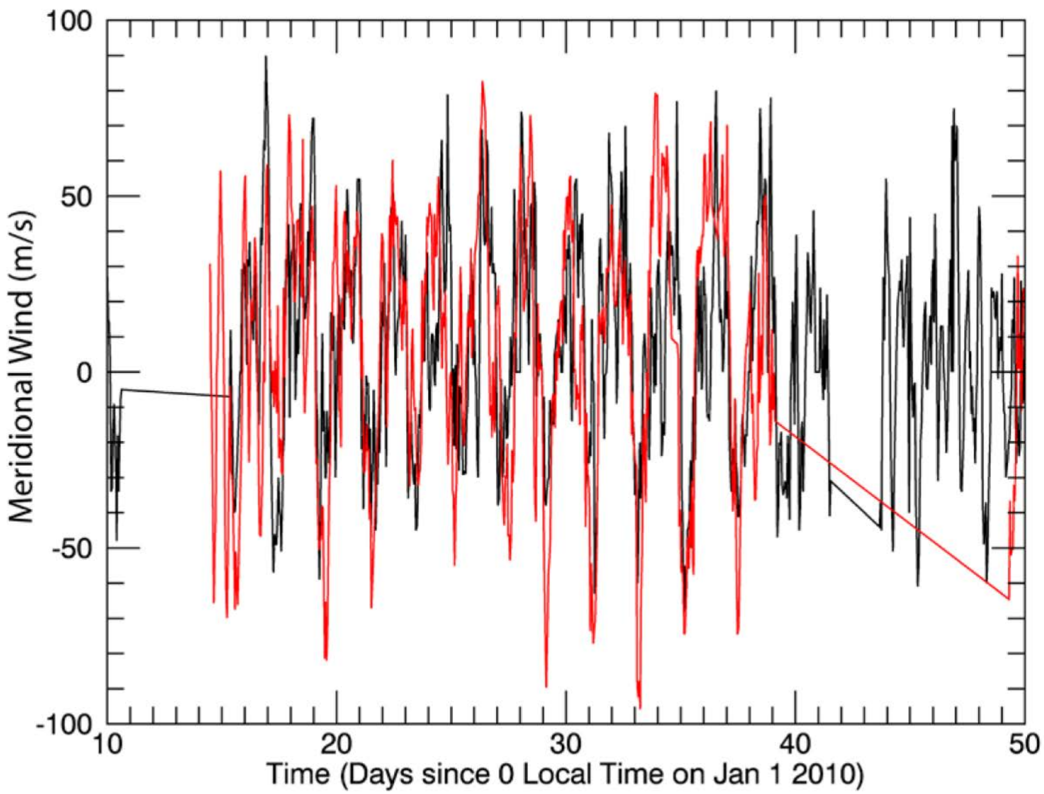
Spectra of temperature altitude versus time for 09/09.


Na Smooth (Z) 20150417 60s 0500m
Na Smooth (Z) 20150418 60s 0500m
Na Smooth (Z) 20150418 60s 0500m
Altitude (km)
UT (Hour)
10000
5000
2000
1000
500
200
100
50
20
10
5
3
2
1.7
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
Temperature 20150417
Temperature 20150418
Temperature 20150419
350
300
260
240
230
220
210
200
190
180
170
160
150


Na Smooth (Z) 20150427 60s 0500m
Altitude (km)
UT (Hour)
10000
5000
2000
1000
500
200
100
50
20
10
5
3
2
1.7
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6


Temperature Spectrum 20150427
Altitude (km)
f (Hz)
x 10^{-4}
24 h
12 h
08 h
06 h
04 h

Simultaneous wind observations at 88 km over ALO (Cerro Pachon) and Buckland Park (Adelaide)



Buckland Park (black) and the Andes Lidar Observatory (red)

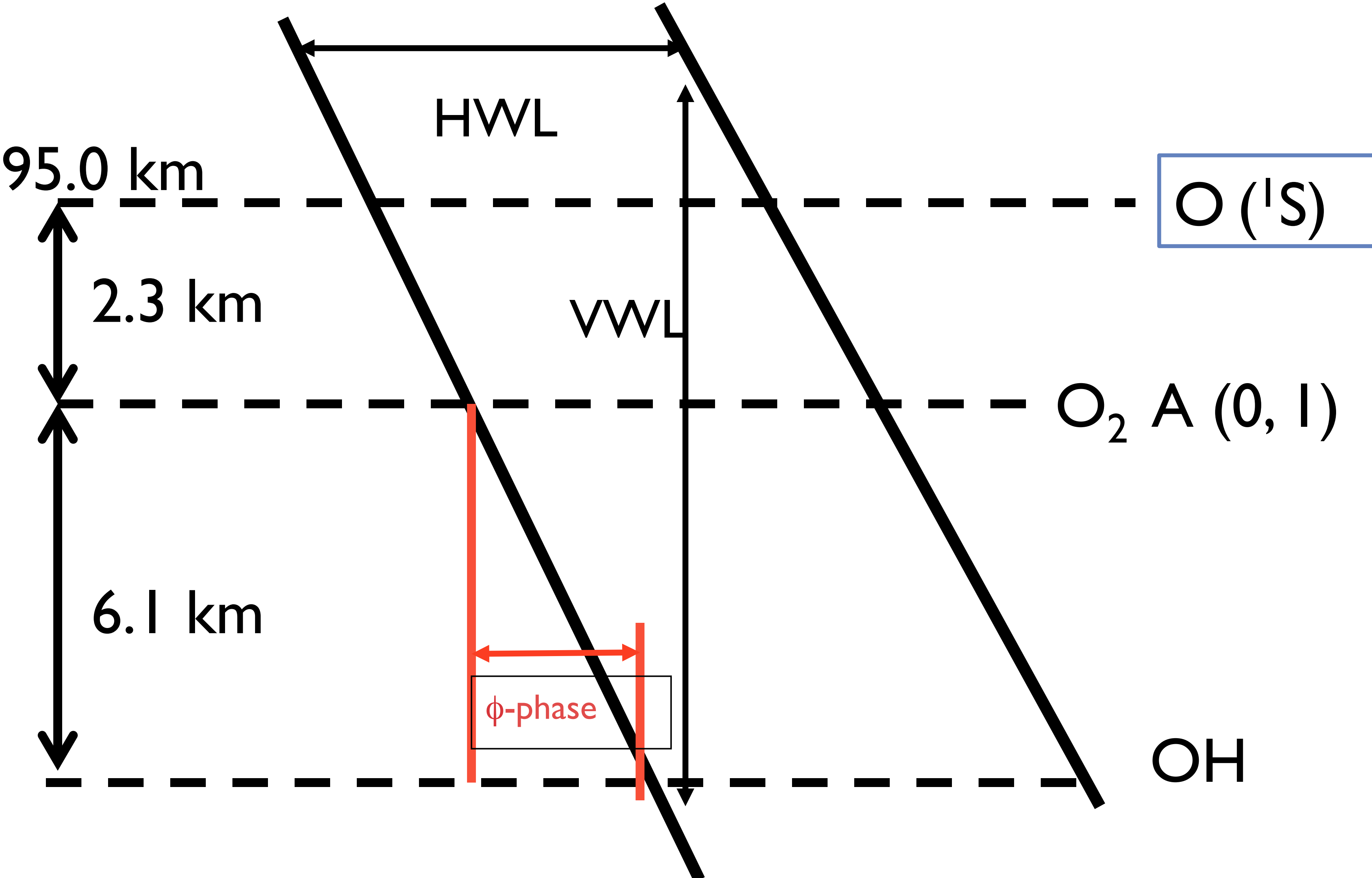
- Plotted versus local time
- The period of the TDW is close to 48 hr and phase locked in local time over successive cycles
- Diurnal tide not evident

Observations of strong acceleration and tidal diminishment when the TDW period is a subharmonic of the diurnal period (48 hr) support the proposal that rapid acceleration is caused by a subharmonic parametric instability

Walterscheid and Hecht

Small Scale Waves/ Structure


All sky imagers, T mapper, and Photometer at ALO



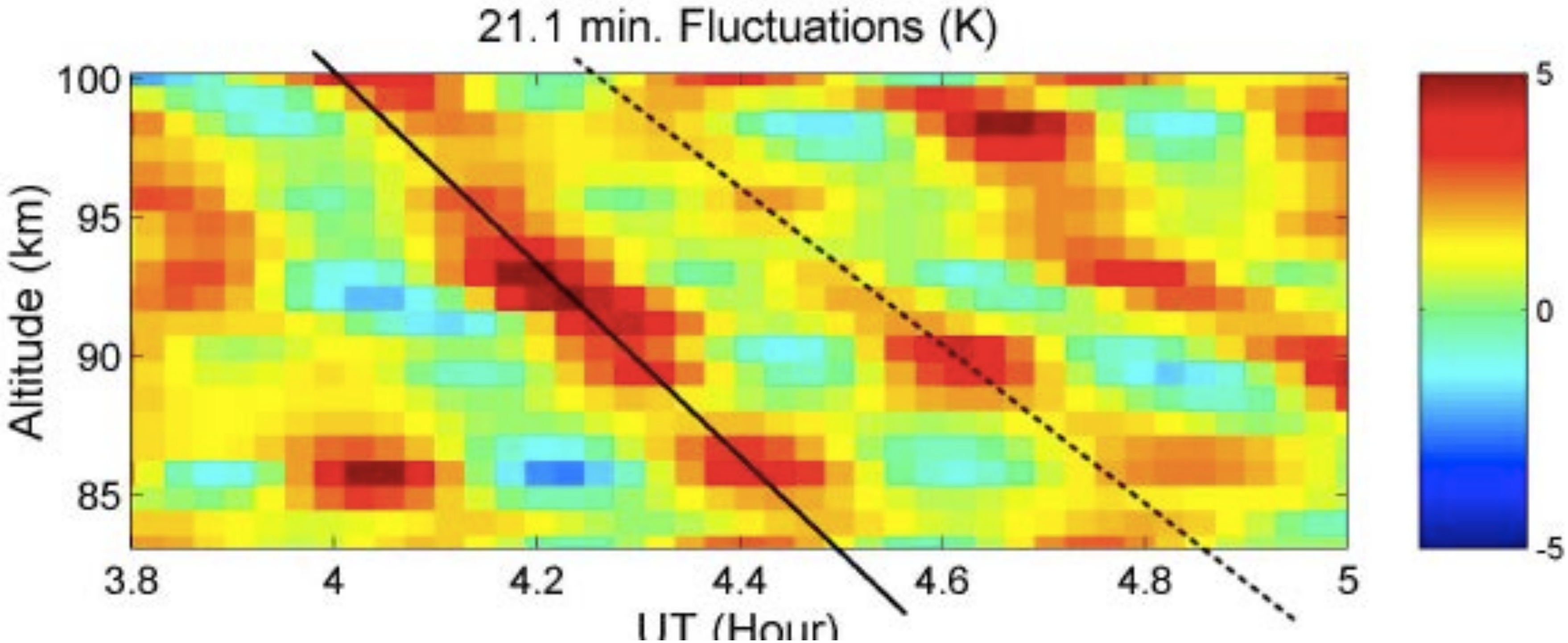
AGW phase fronts and wave phase information versus altitude

Airglow Intensity Modulated by Waves

June 10, 2007 Urbana

Lidar T data filtered for the HF wave observed simultaneously in OH

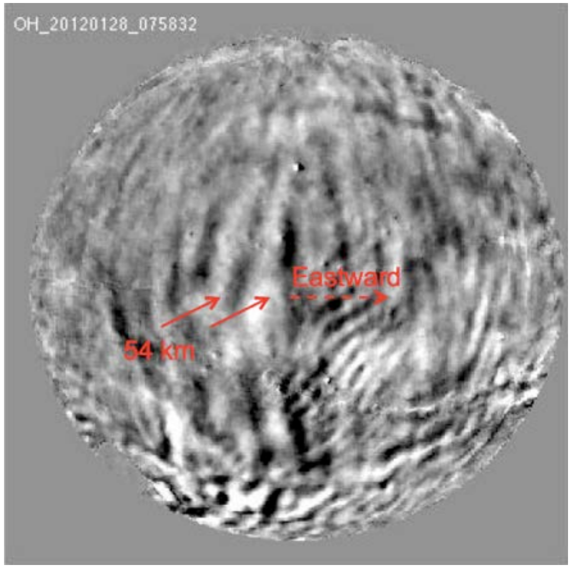
T'/T~1%

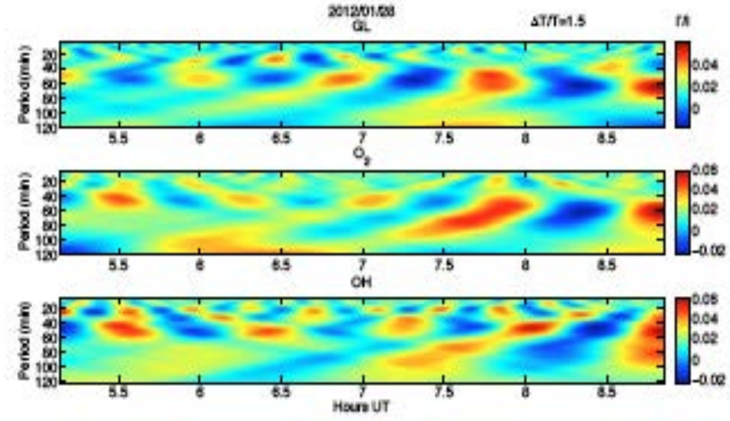


A Gabor filter with the period (21 min) of the GW observed in OH is applied

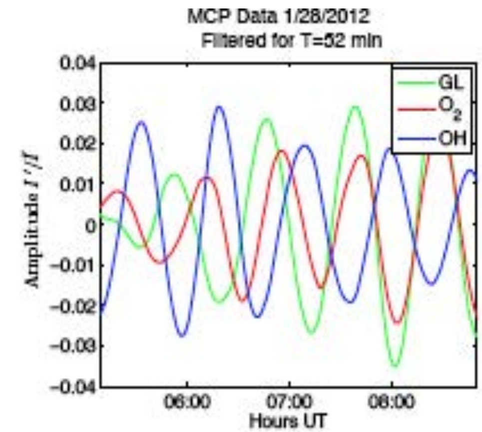
NOTE, the wave is damped (saturated)!

ALO Highlight

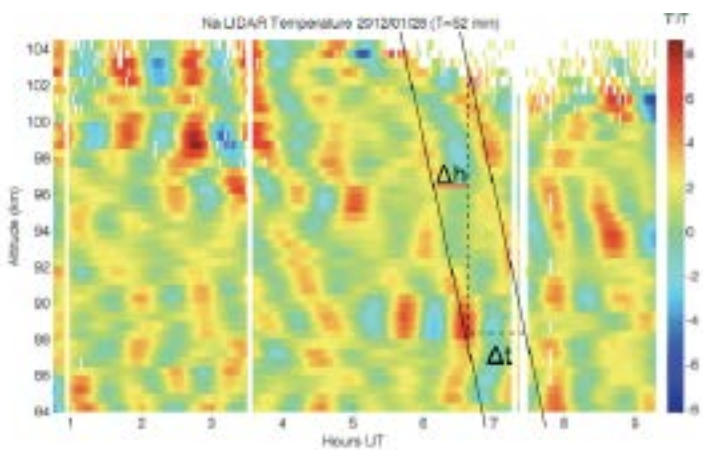


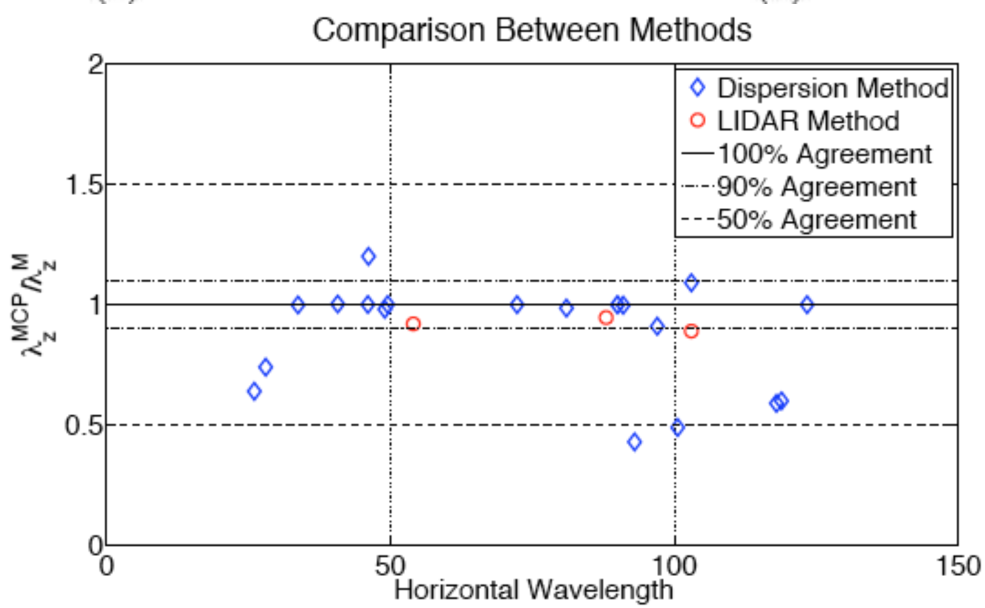


(a)



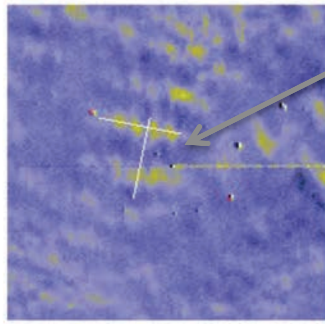
(b)



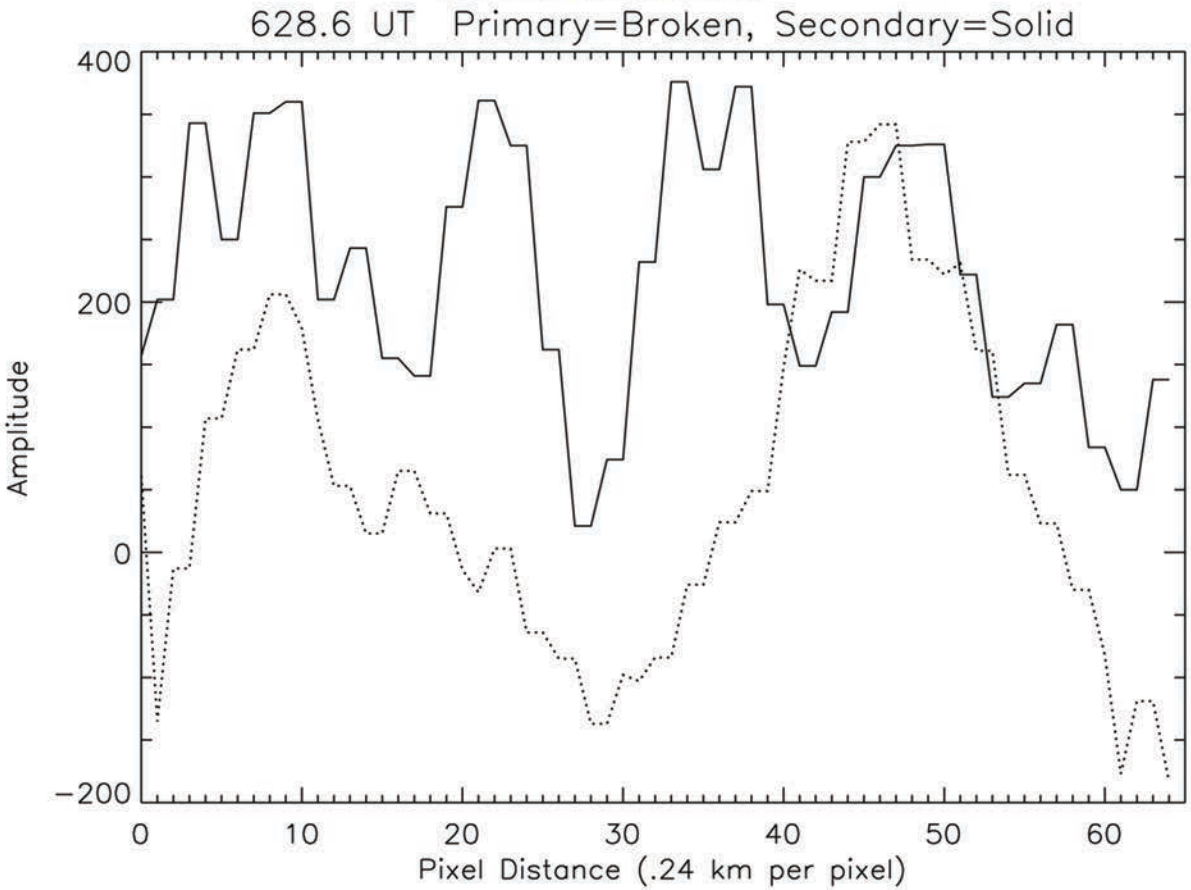


HF AGWs observed with images (UL) and in time histograms of the MCP (UR)have been Used to establish VWL using dispersion relationship, and compared to lidar VWL (LL) in the plot (LR). Mangognia et al., 2015.

Image Showing Primary and Secondary KH Features

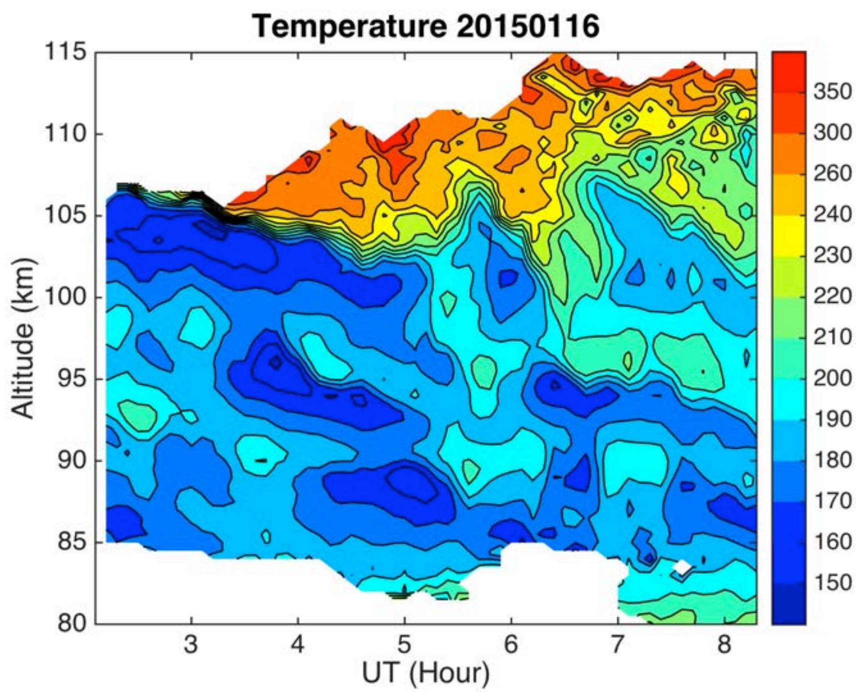


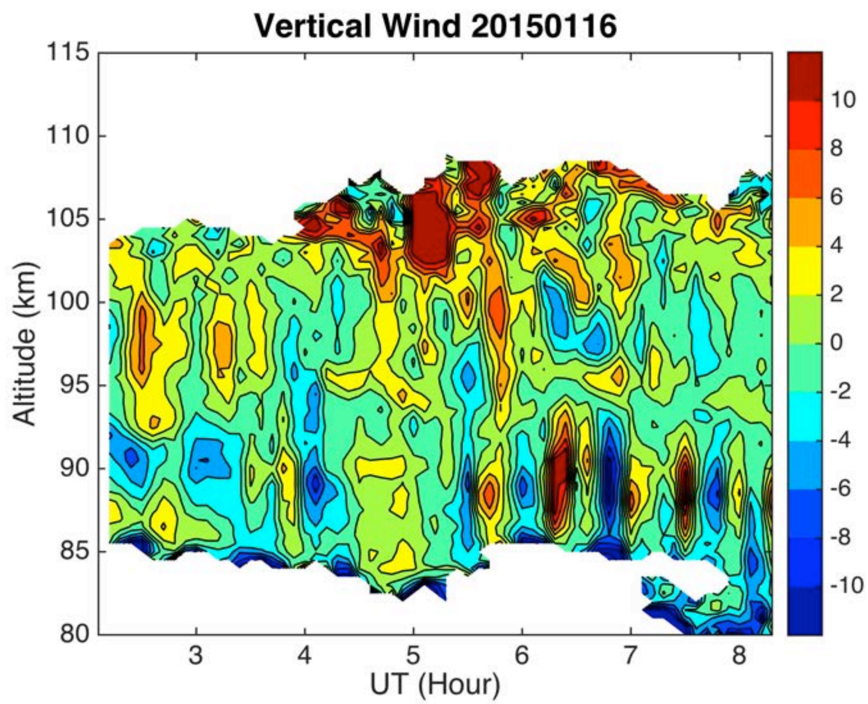
- Primary (P) Kelvin-Helmholtz Phase front
  - Dynamically Unstable
- Secondary (S) Phase fronts are perpendicular
  - Convectively Unstable
  - Form just before Primary breaks down
  - Common at ALO, very rare at Maui

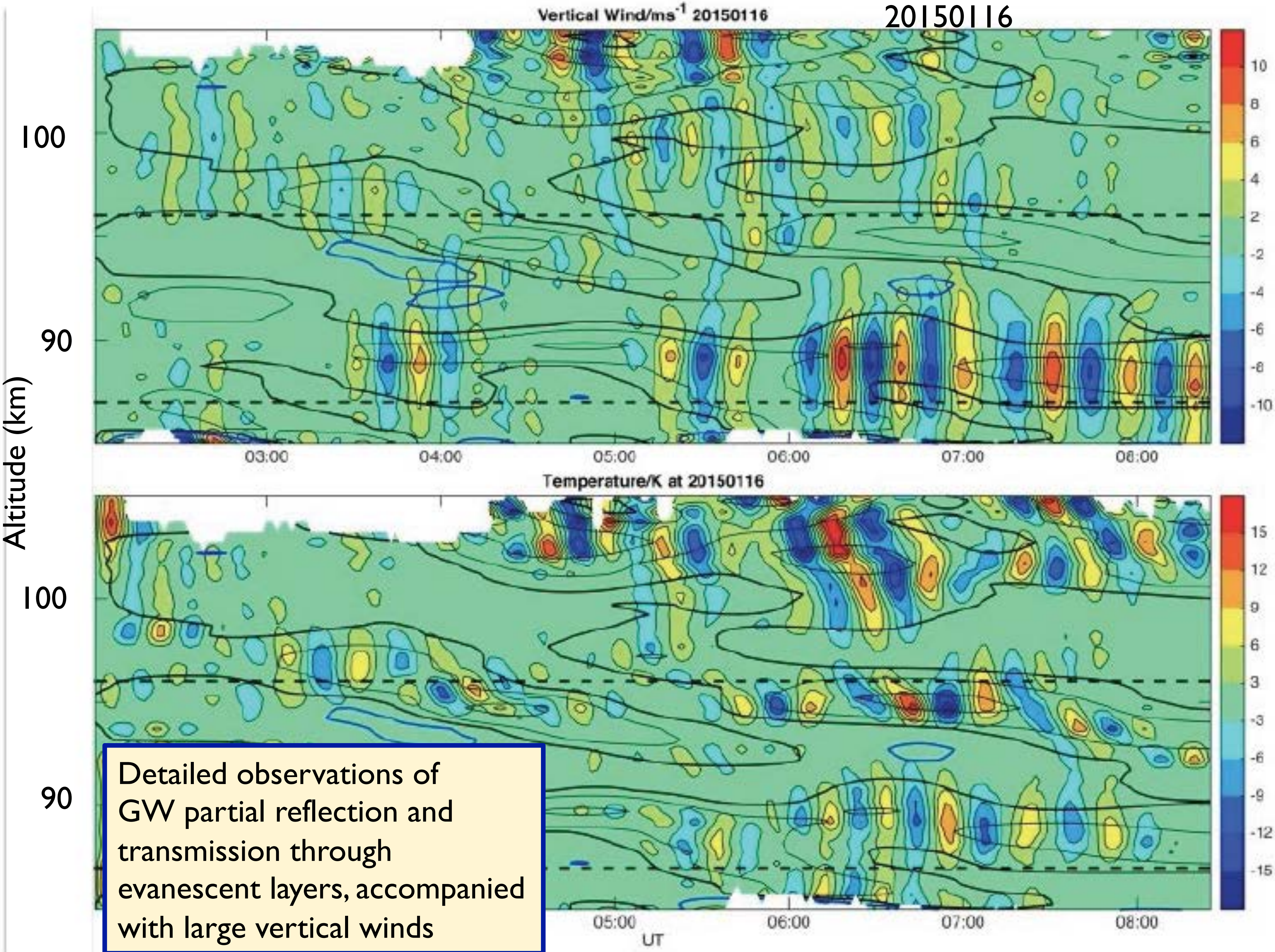


- P/S wavelength ratio about 3
- Close to Classical Models
  - Peltier
  - Fritts

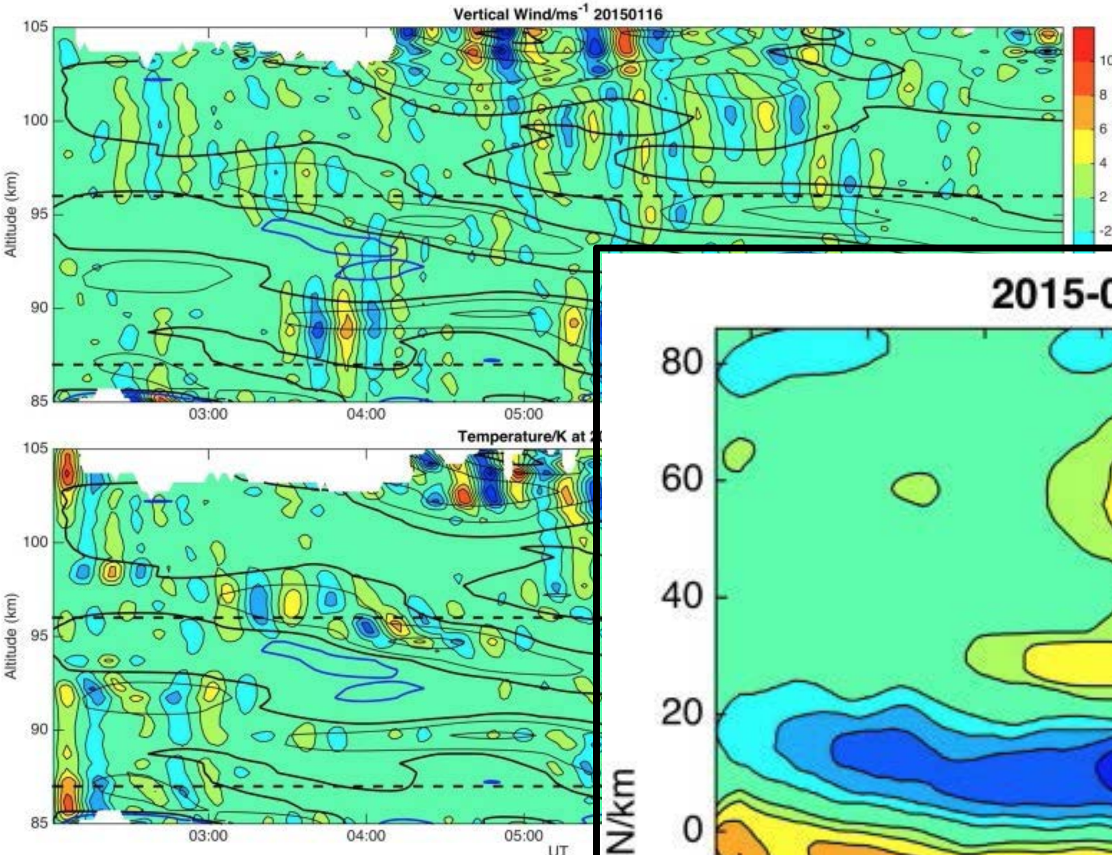
Hecht

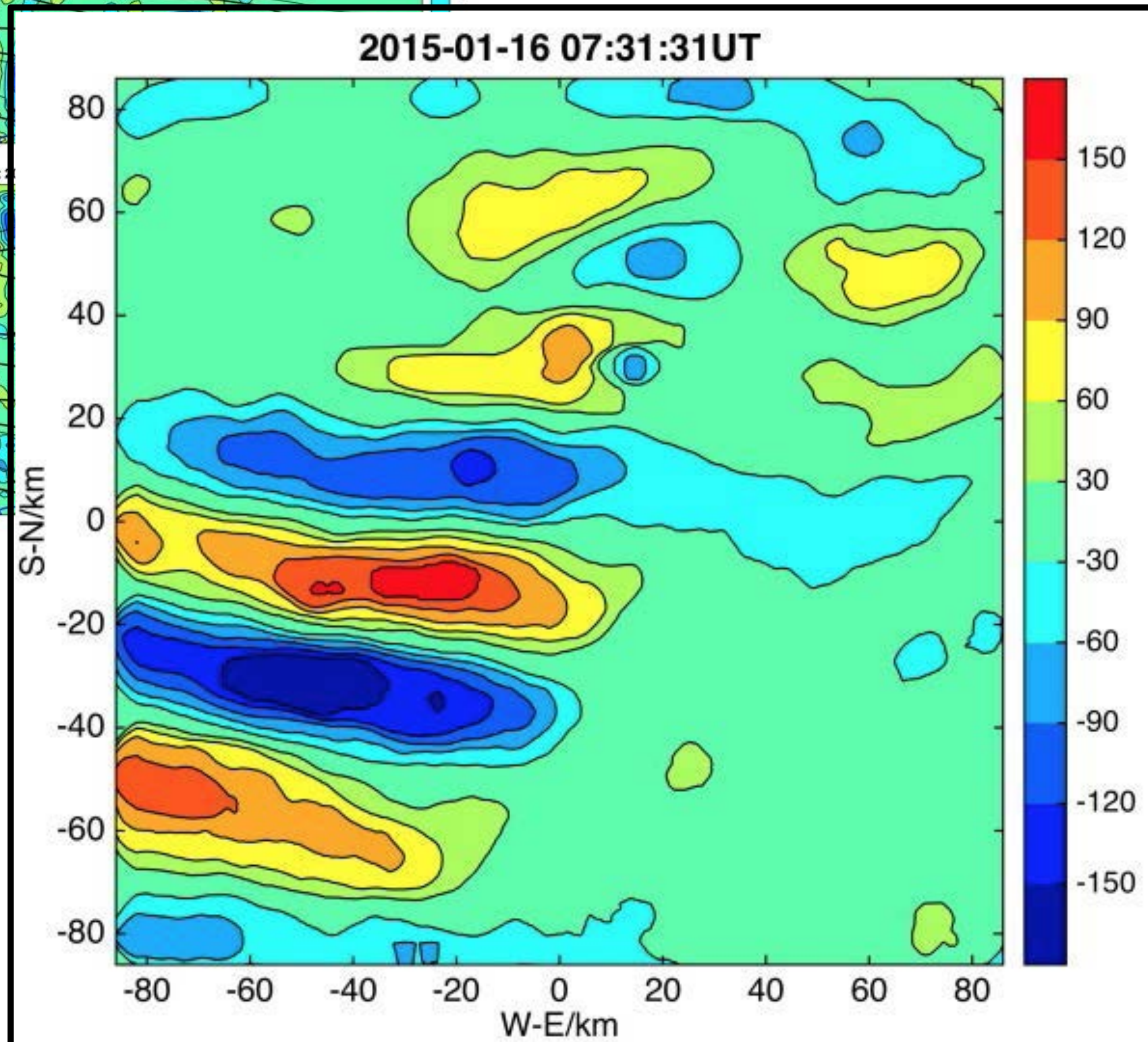

Temperature 20150116
Altitude (km)
UT (Hour)
115
110
105
100
95
90
85
80
3
4
5
6
7
8
350
300
260
240
230
220
210
200
190
180
170
160
150


Vertical Wind 20150116
Altitude (km)
UT (Hour)
115
110
105
100
95
90
85
80
3
4
5
6
7
8
10
8
6
4
2
0
-2
-4
-6
-8
-10

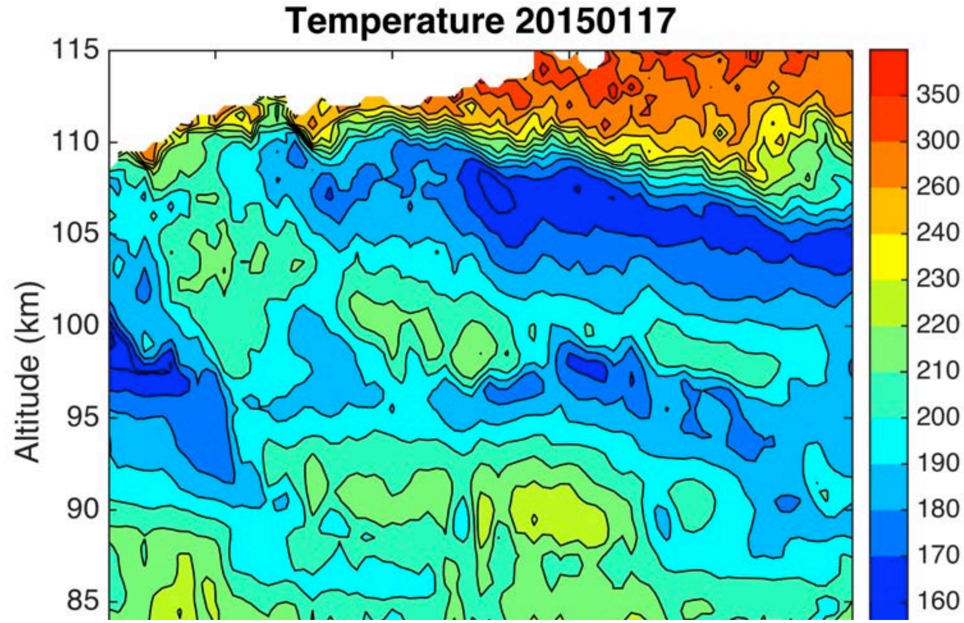


Detailed observations of GW partial reflection and transmission through evanescent layers, accompanied with large vertical winds

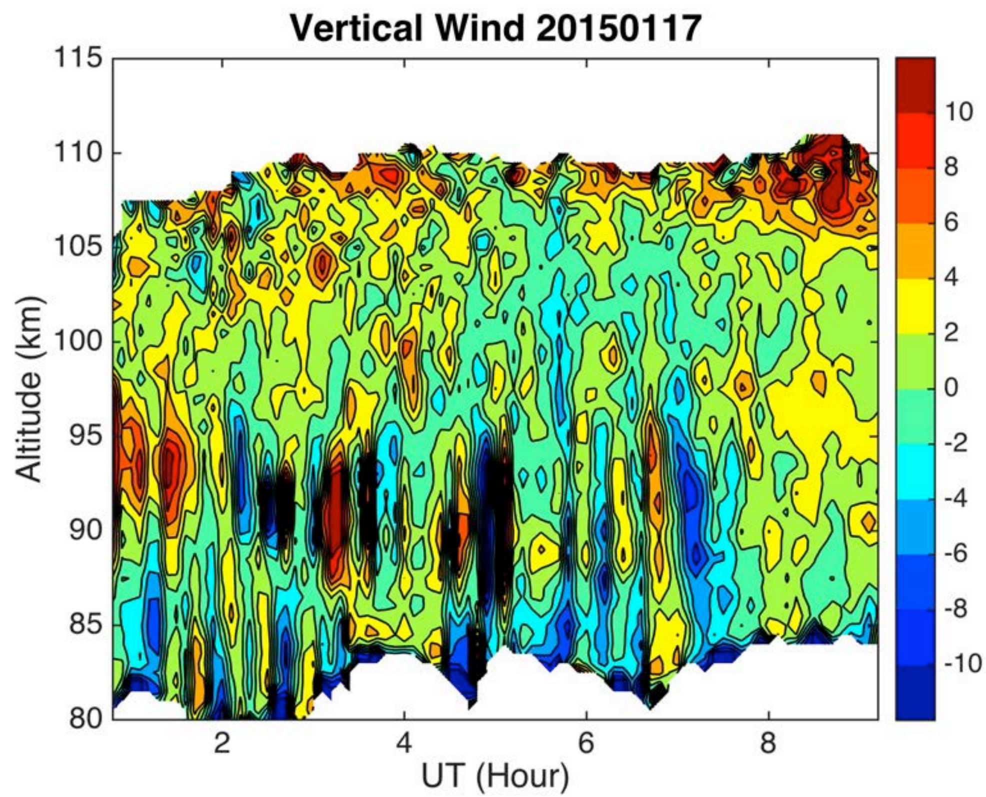




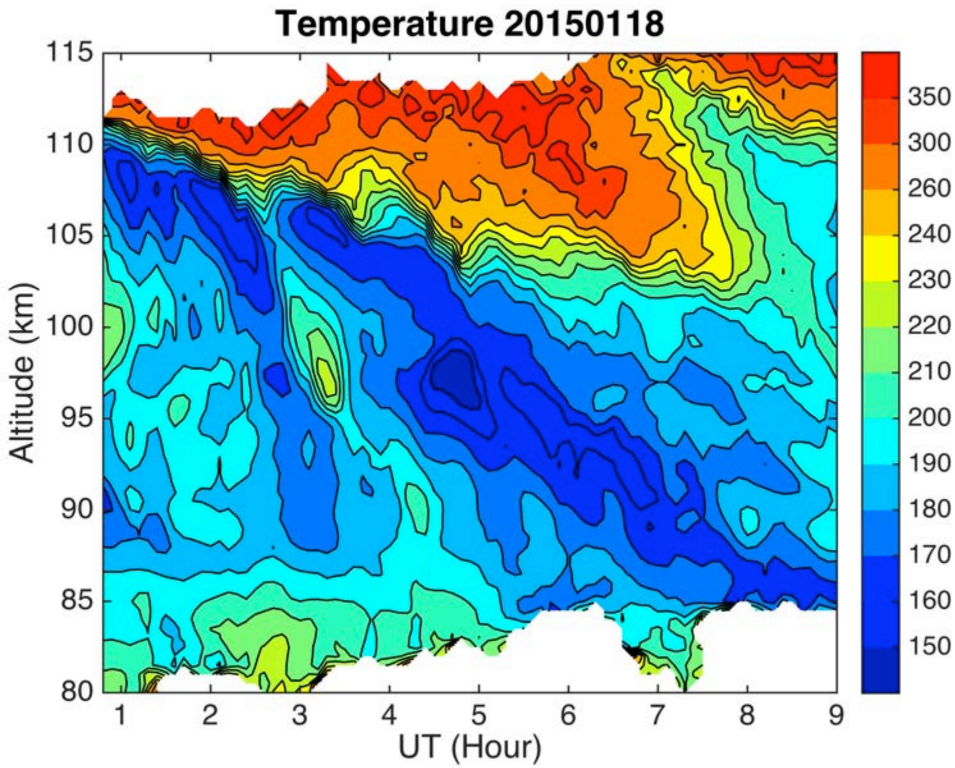
Colocated imager showing southward propagating wave structure.



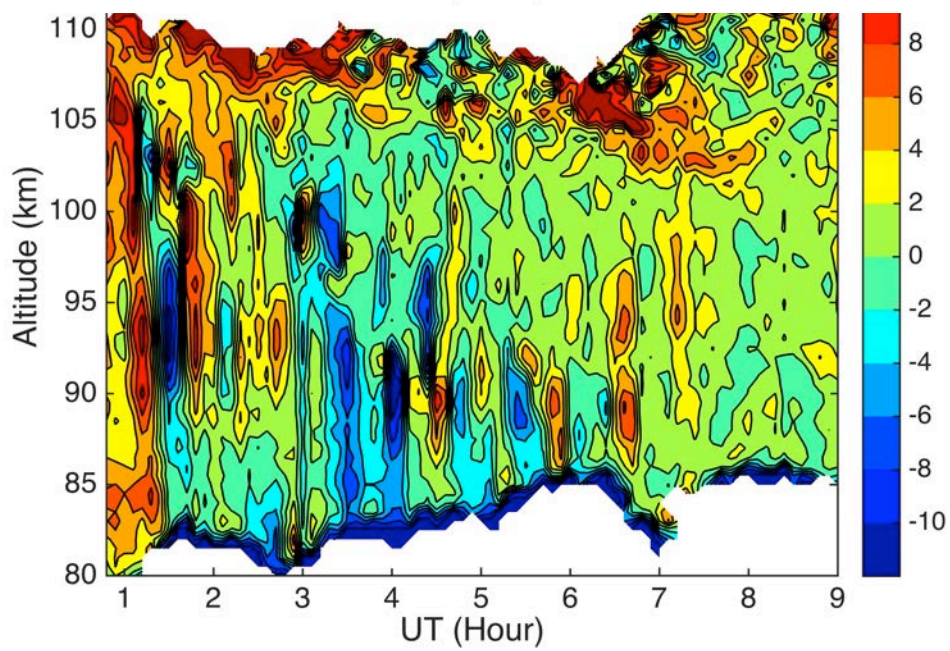
Temperature 20150117
Altitude (km)
115
110
105
100
95
90
85
350
300
260
240
230
220
210
200
190
180
170
160



Vertical Wind 20150117
Altitude (km)
115
110
105
100
95
90
85
80
2
4
6
8
UT (Hour)
10
8
6
4
2
0
-2
-4
-6
-8
-10

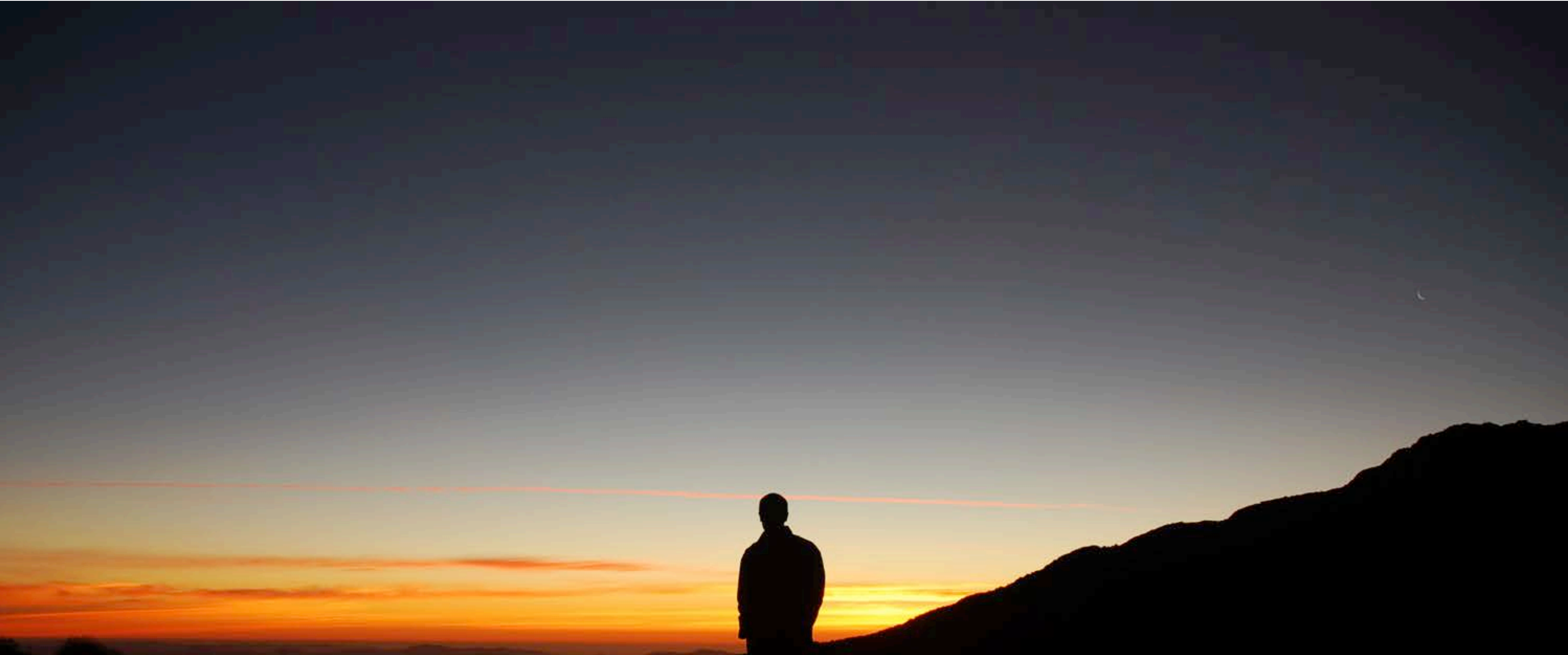


Temperature 20150118
Altitude (km)
UT (Hour)
115
110
105
100
95
90
85
80
1
2
3
4
5
6
7
8
9
350
300
260
240
230
220
210
200
190
180
170
160
150



Altitude (km)
UT (Hour)
110
105
100
95
90
85
80
1
2
3
4
5
6
7
8
9
8
6
4
2
0
-2
-4
-6
-8
-10

In Summary, the ALO is an observatory well
Equipped to perform geophysical measurements
For the dynamic and chemical processes ongoing
In the upper Mesosphere and lower thermosphere.



A tribute to Tony Mangognia, Phd 2015

- -designed and built beam steering
- -designed and build receiver sensors
- -operated many campaigns
- -painstakingly contributed to UPS installation
- -a major contributer to ALO software
- -wrote the satellite avoidance software
- -designed, built, and managed the multi-channel photometer