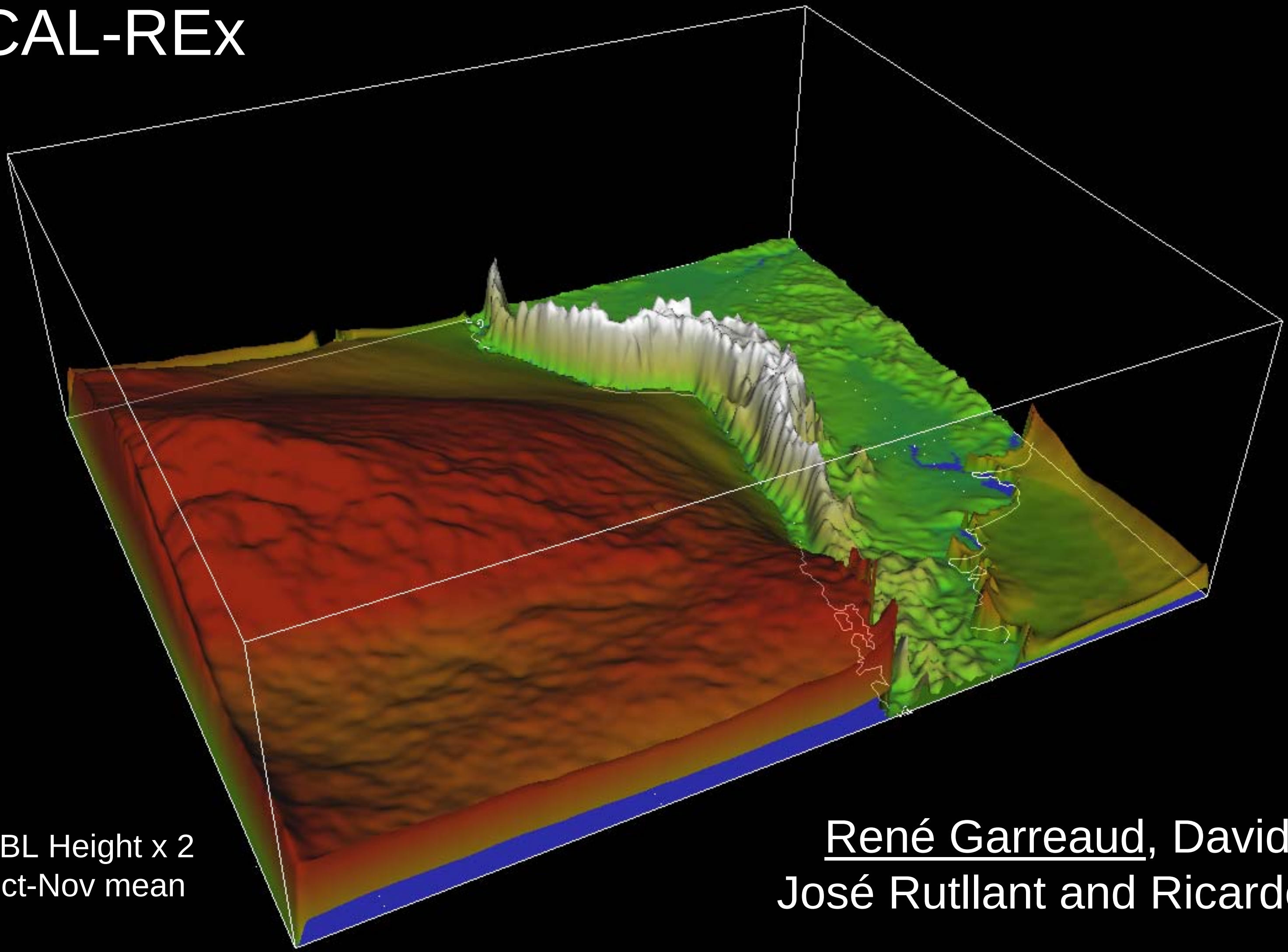
Synoptic Forcing, MBL Variability and Upsidence Wave during VOCAL-REx



Simulated MBL Height x 2
Oct-Nov mean

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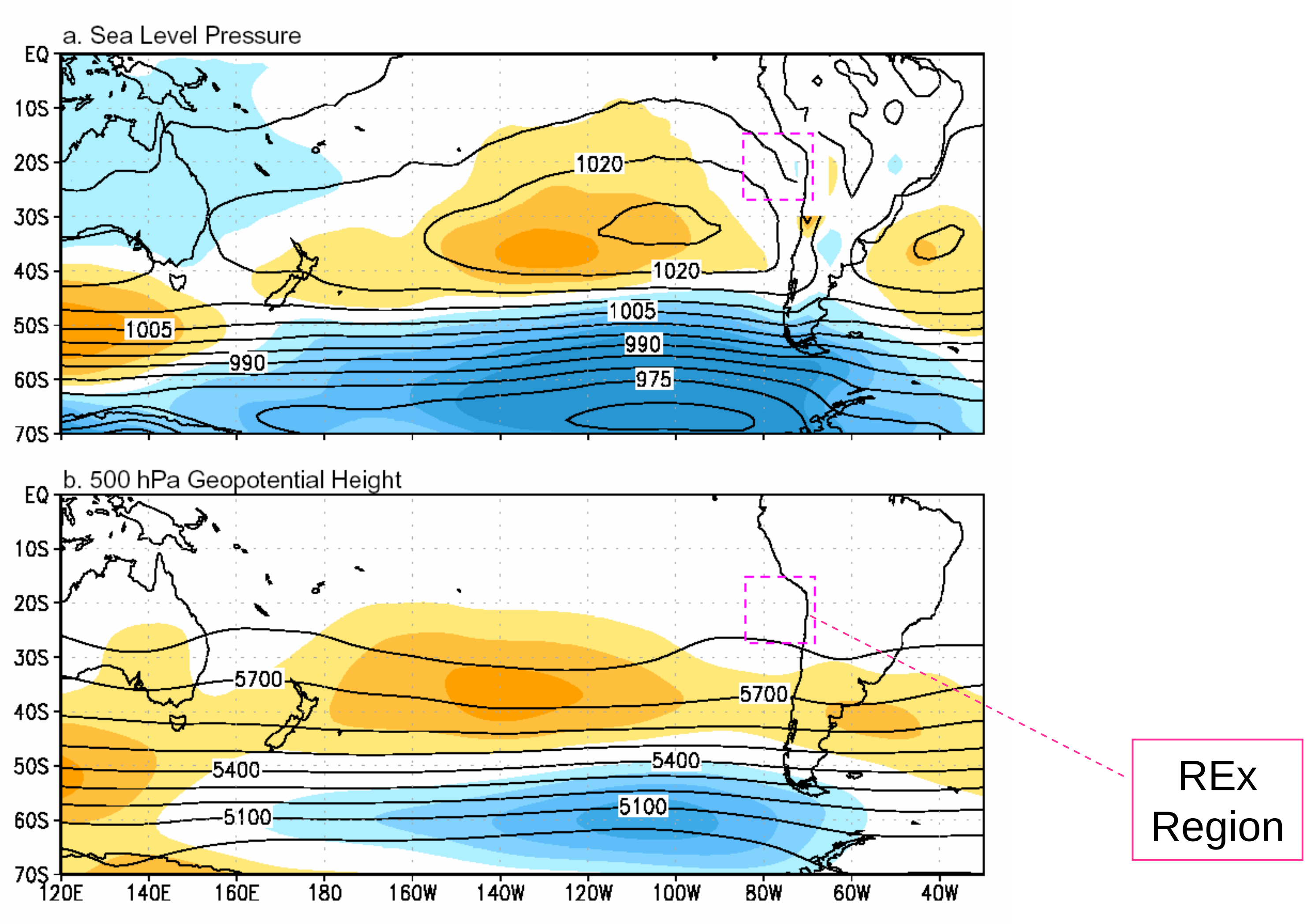
Outline

- VOCALS-REx Summary
- WRF3 VOCALS-REx simulation (better than PREVOCA!)
- Synoptic focing: two periods during REx
- Mean state over the SEP
- MBL Variability: features & forcing
- Diurnal variability (to be continued in D.Rahn’s presentation)

NNR average fields for Oct-Nov 2009



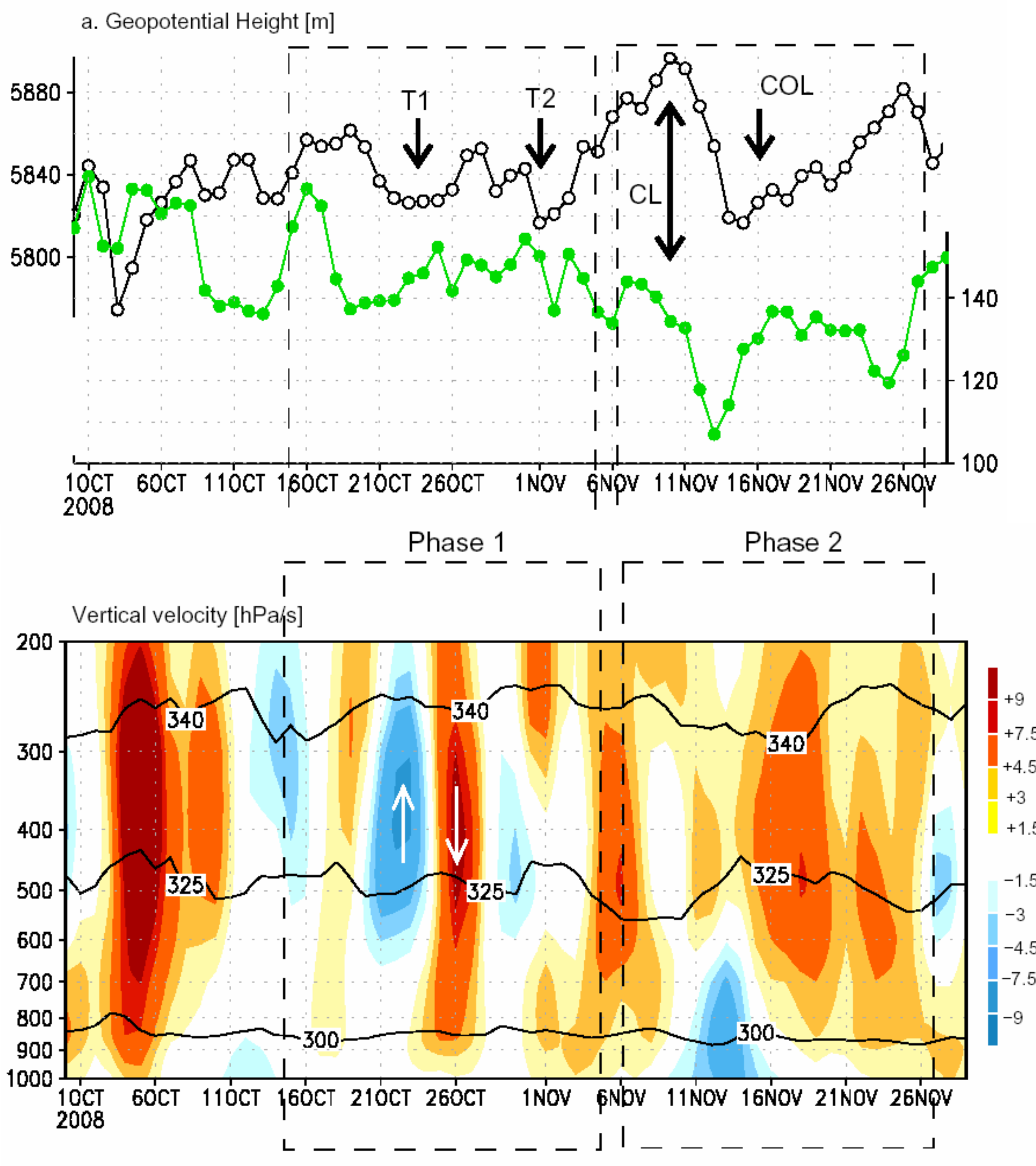
- Near average conditions over REx region
- Higher than average pressure at the core of the SEP anticyclone
- Lower than average pressure at higher latitudes in South Pacific
- Overall La Niña Pattern

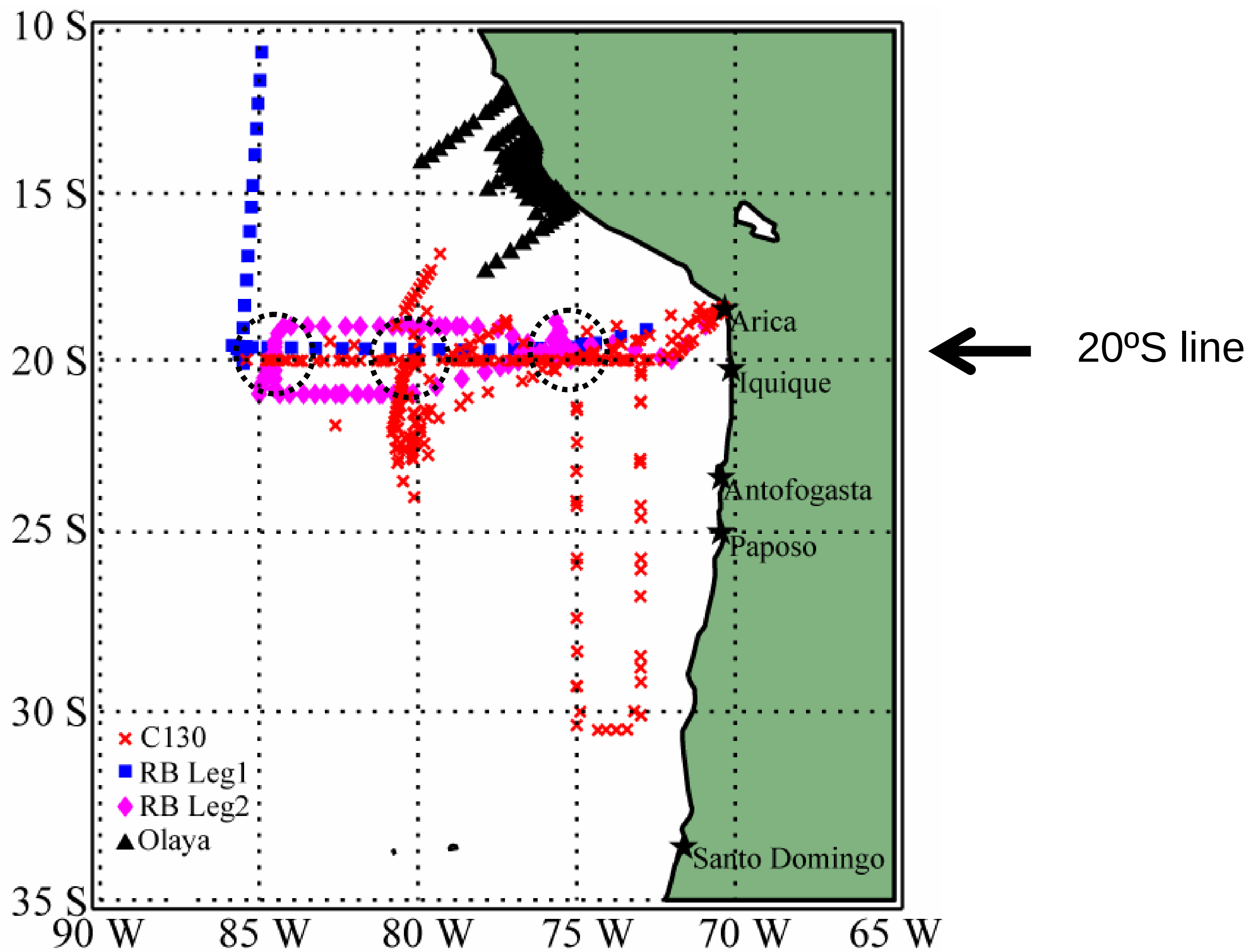
Two mid-level troughs cross the REx Region in October.

The troughs featured strong westerly flow aloft and Northerly flow down to 700 hPa (not shown)

The troughs during Rex Phase 1 altered significantly the vertical velocity field over the SEP…did impact MBL height?

November (Phase 2) was more stable.





Location of vertical profiles from sources including radiosonde launches from land stations, ships (Olaya and Ron Brown), and aircraft (C130 and G1) porpoising through the inversion layer.

WRF3.0 VOCAL-REx Simulation

* 2-month continous run (October and November)

* Output every 3-hr

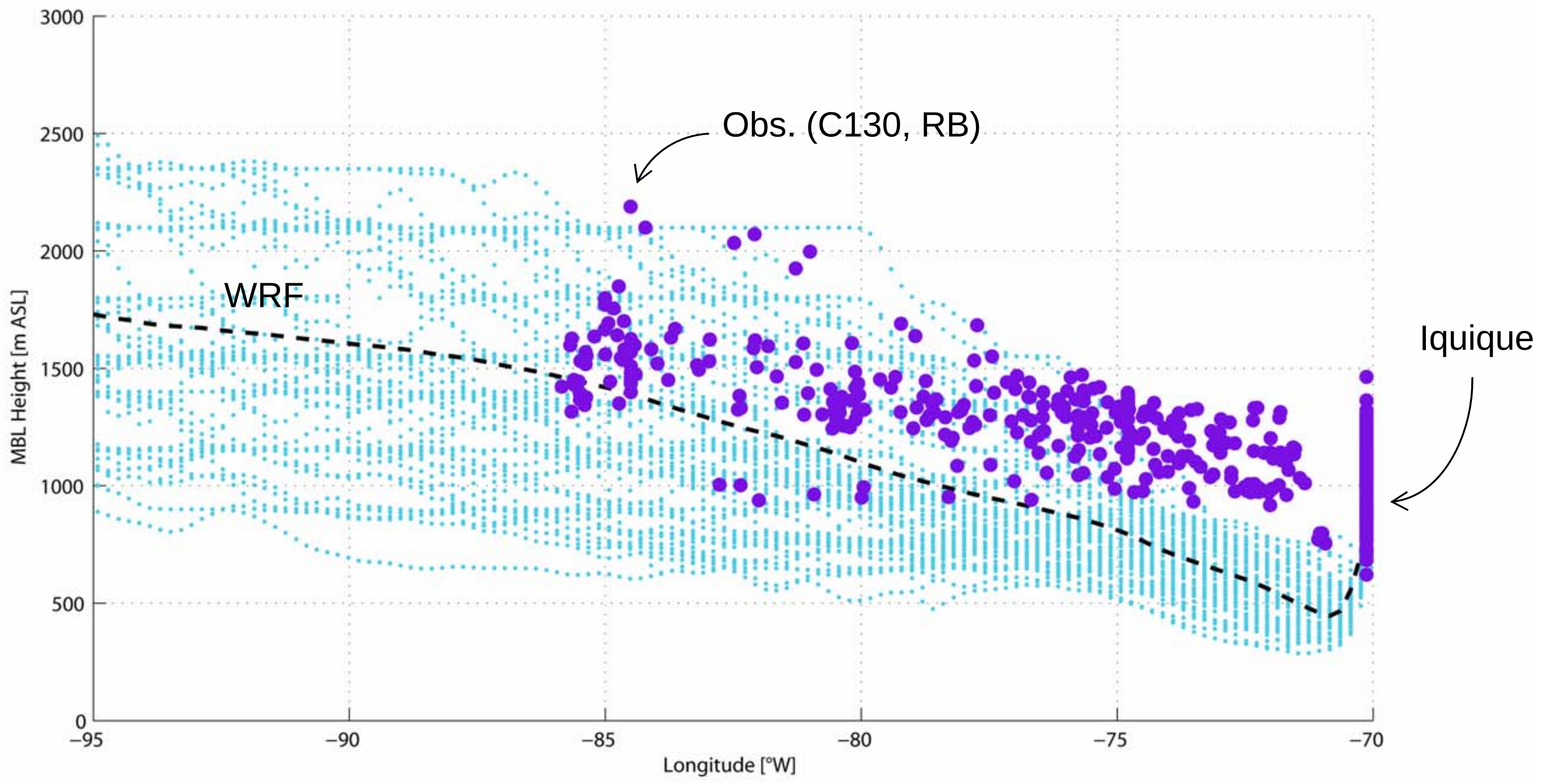
* IC and LBC from NCEP-NCAR Reanalysis

* 280 x 280 grid at 20-km horizontal resolution

* 44 sigma levels with telescoping resolution toward the surface (~10 m near the surface).

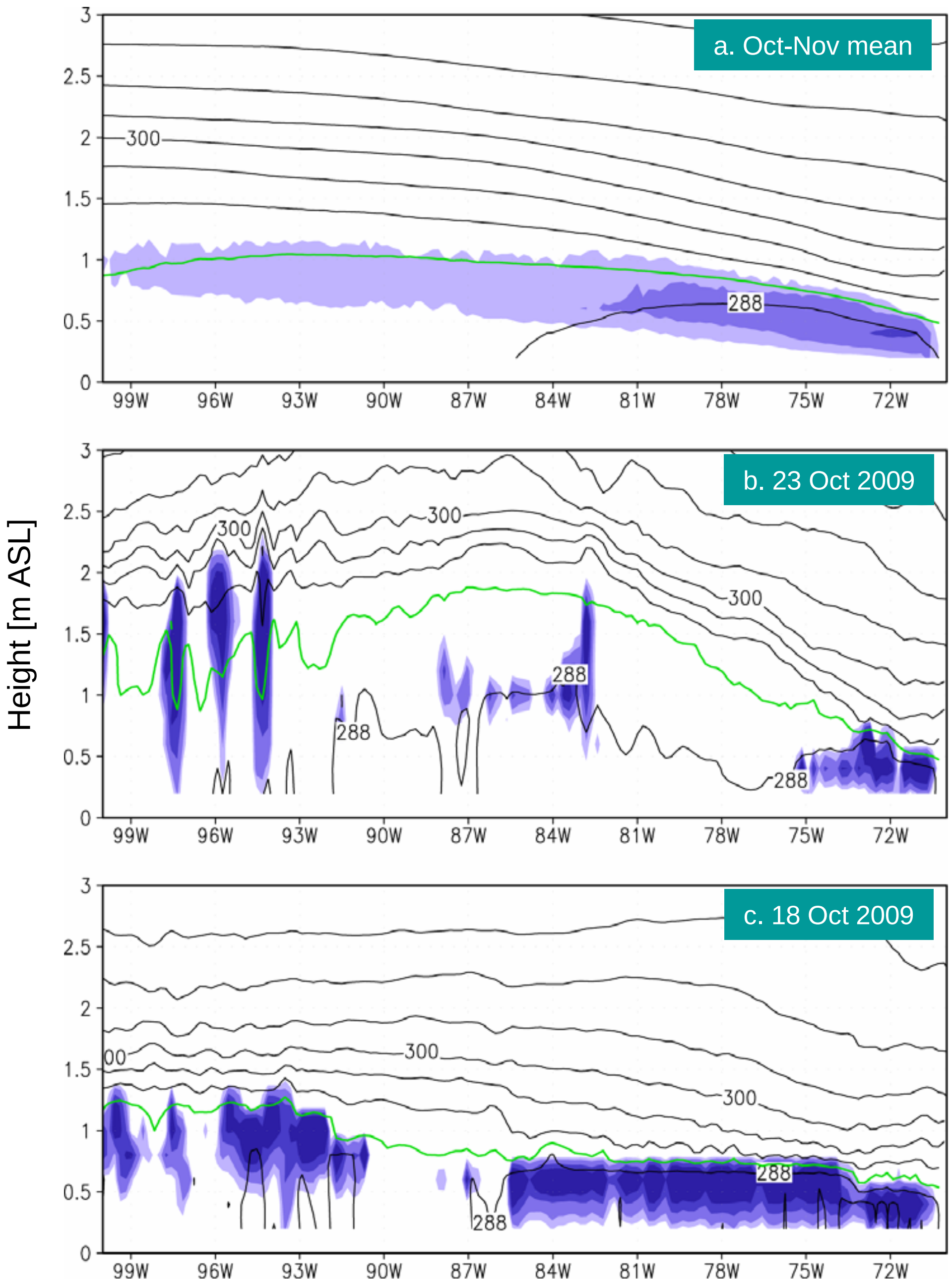
* Some parameters: Thompson microphysics, rrtm and Dudhia radiation, Monin-Obukhov surface scheme, Pleim land-surface model, Mellor-Yamada-Janjic boundary layer, Betts-Miller-Janjic cumulus, second-order turbulence and mixing, and horizontal Smagorinsky first-order closure.

Observed and Simulated (WRF) MBL height at 20°S during VOCALS-REx



Great! *Good* *Bad*

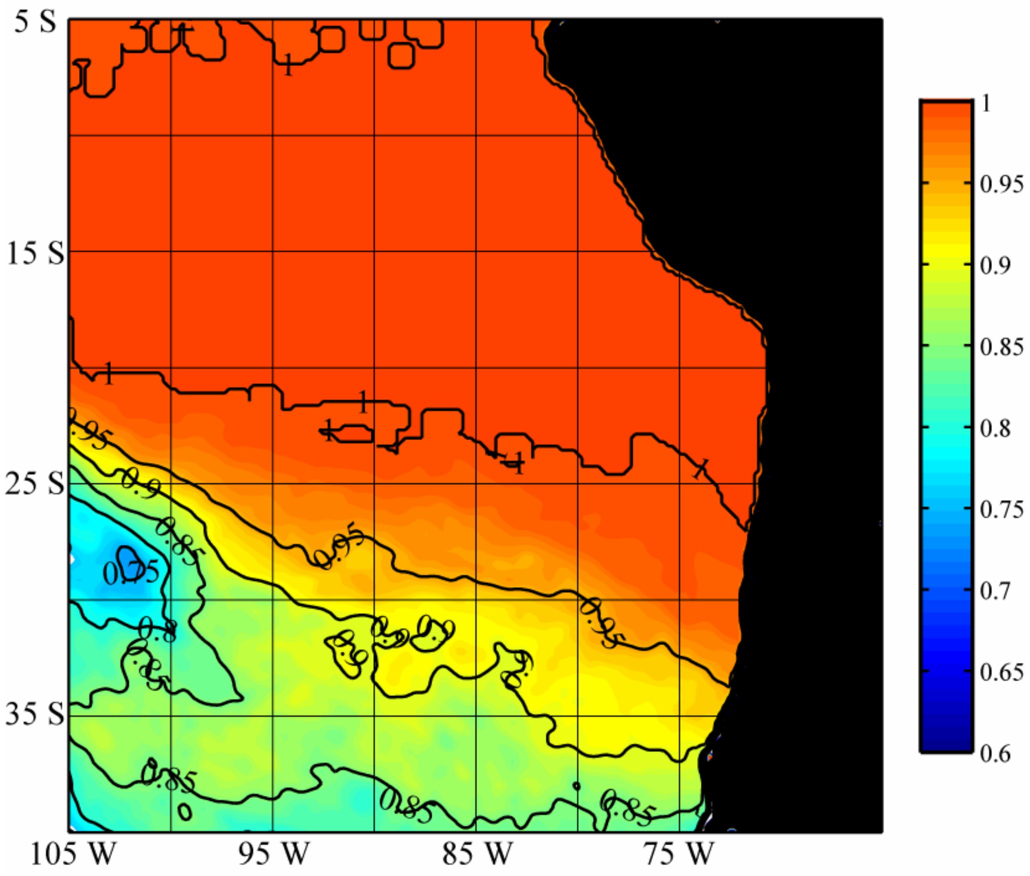
Simulated (WRF) θ and Q_{cld} at 20°S



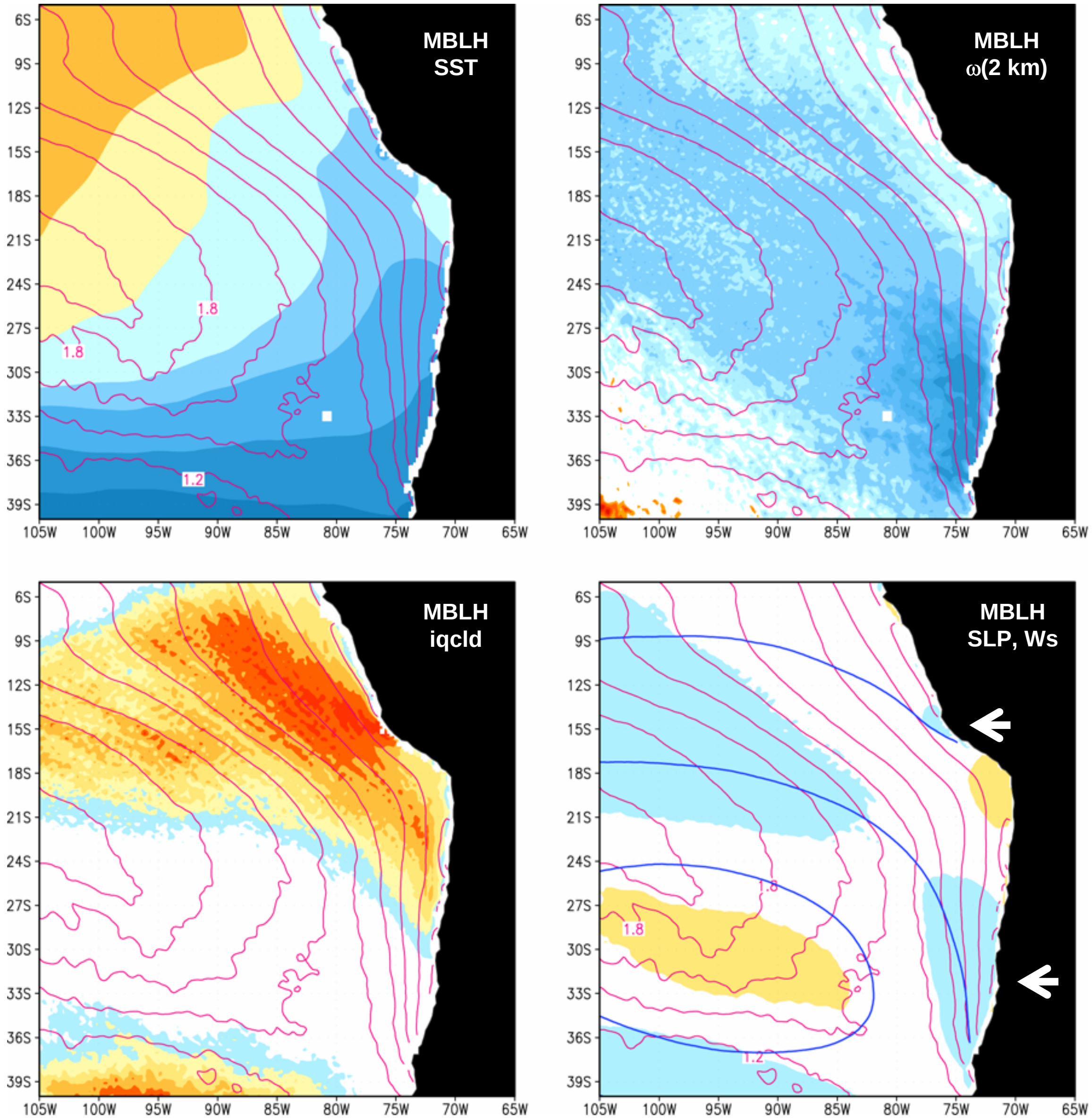
Fraction of MBL frequency in WRF solution over October and November

- MBL Depth found by finding extrema with lowest temperature (throwing out topmost point).
- Check points above, find where temperature is more than 0.5 K, and take the point below as the inversion base.

- North of 25°S a MBL was defined for nearly all times.
- Toward the southwest, MBL is progressively less frequently defined.
- North of 40°S, MBL is present more than 85% of the time.
- Terms are not incorporated when there is no MBL.
- Developing MBL (transition from no MBL to MBL) does have some impact.

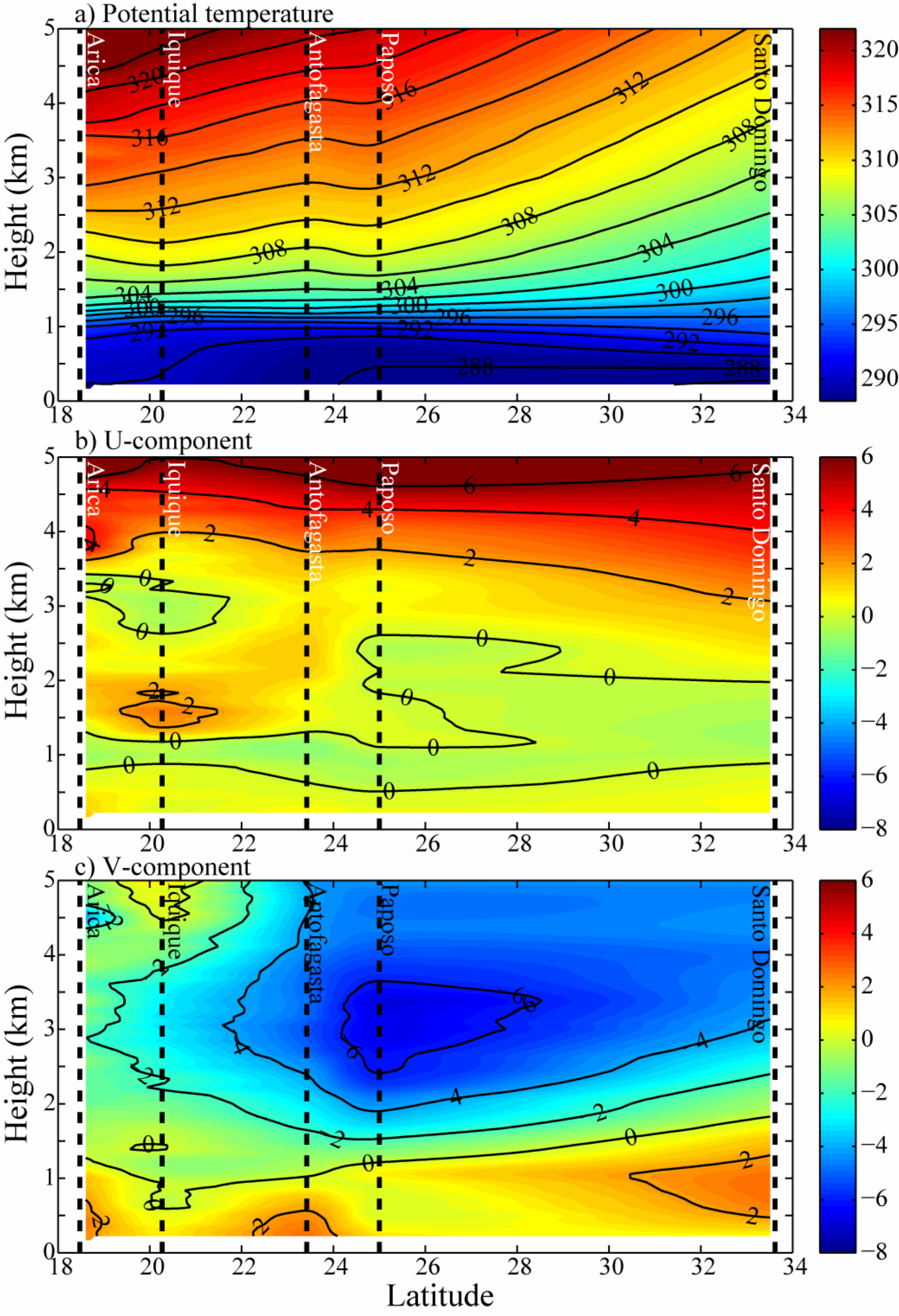


SEP Mean state according to WRF
MBLz loosely related to SST and not related to w

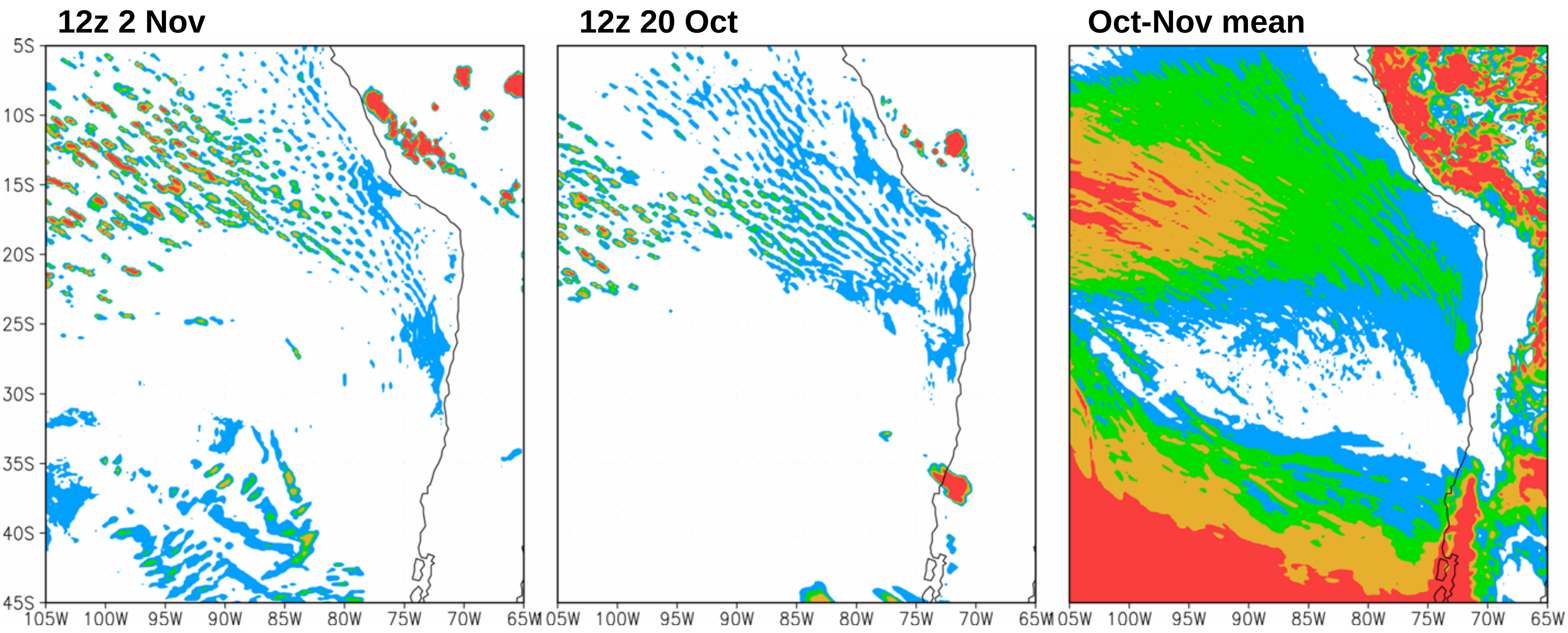


MBLz nearly constant along the coast (in WRF and Obs)

- Average of all 00z and 12z soundings along the coast used.
- Santo Domingo soundings much more variable, leading to diffuse vertical gradient (not concentrated like others).
- Warmer MBL toward the north. Not much change in MBL depth.
- Most of the wind is meridional, wind from north aloft, wind from south within MBL.



Simulated (WRF) drizzle and light rain over the SEP

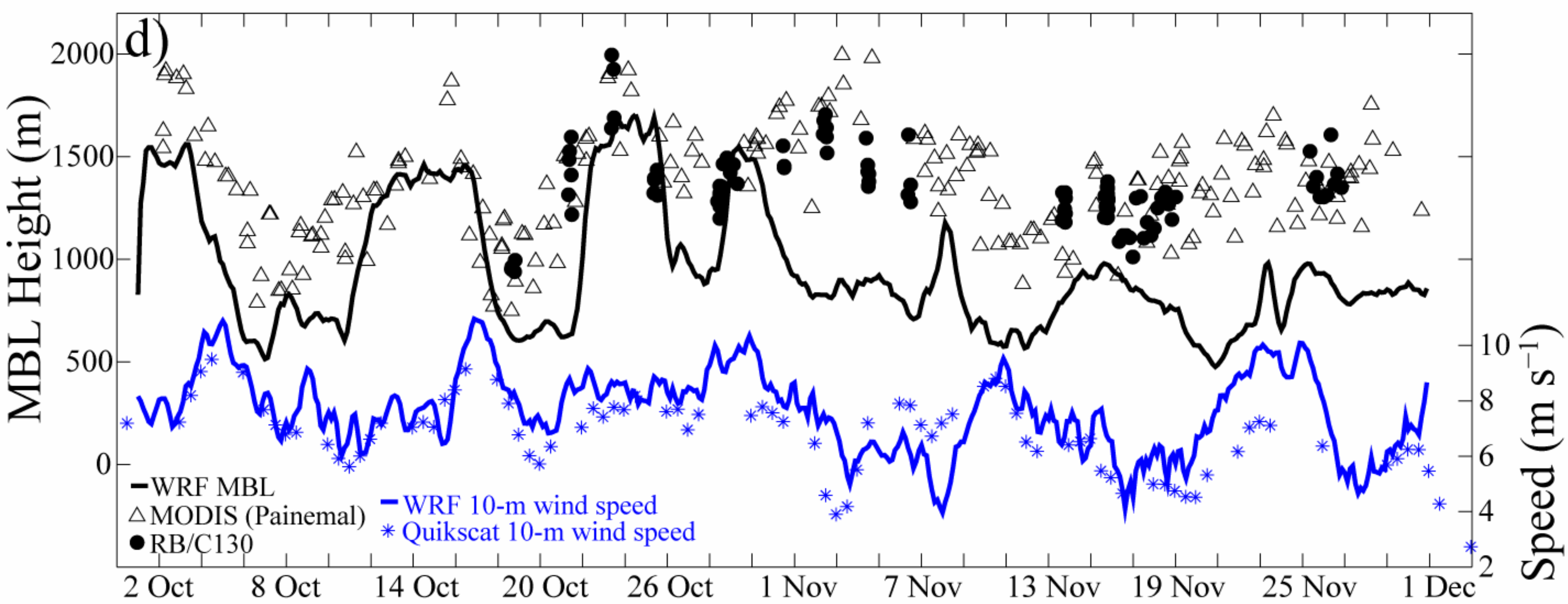


[0.2 0.5 1 mm/3hr]

[0.2 0.5 1 mm/3hr]

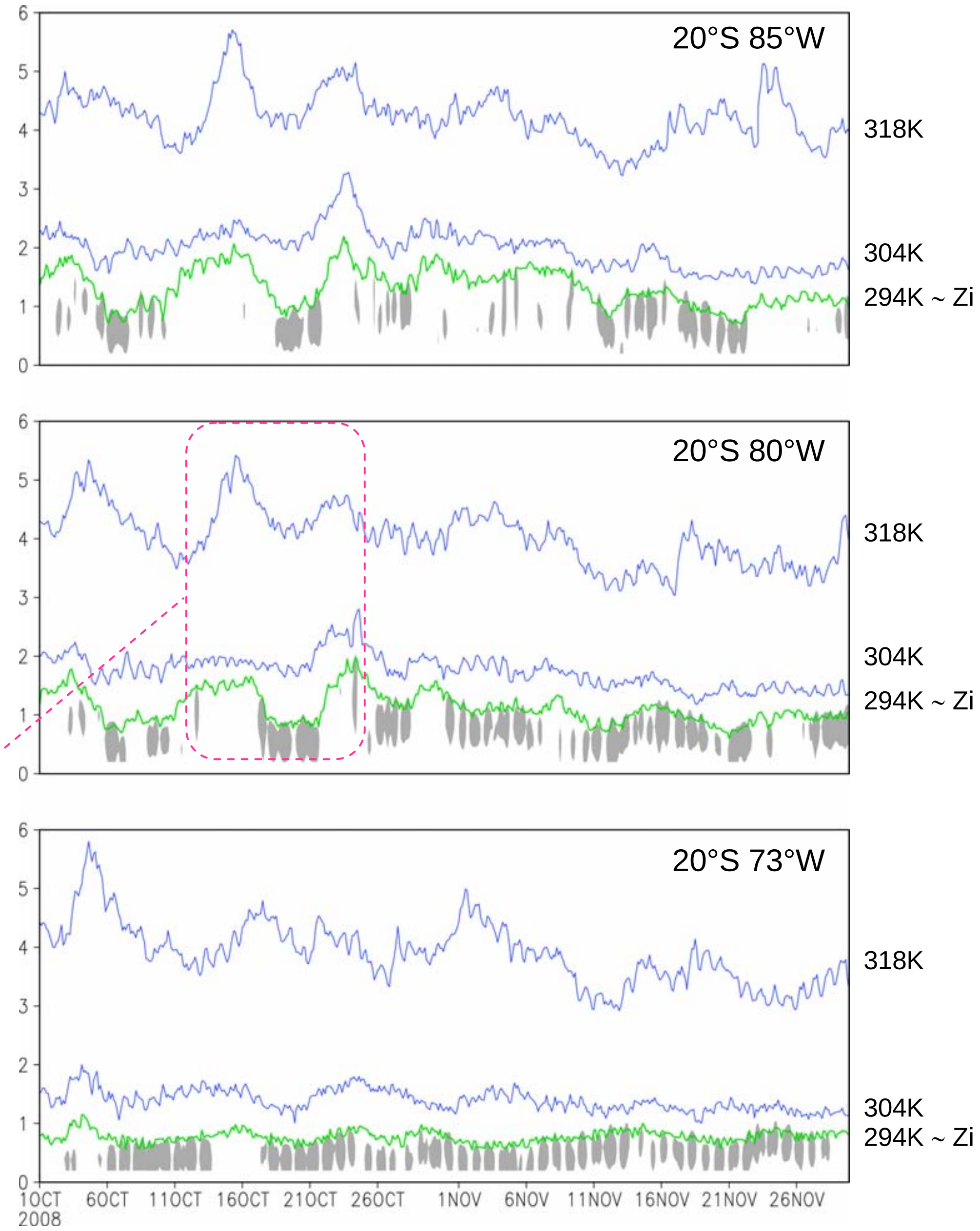
[20 50 100 mm/month]

20ºS - 80ºW

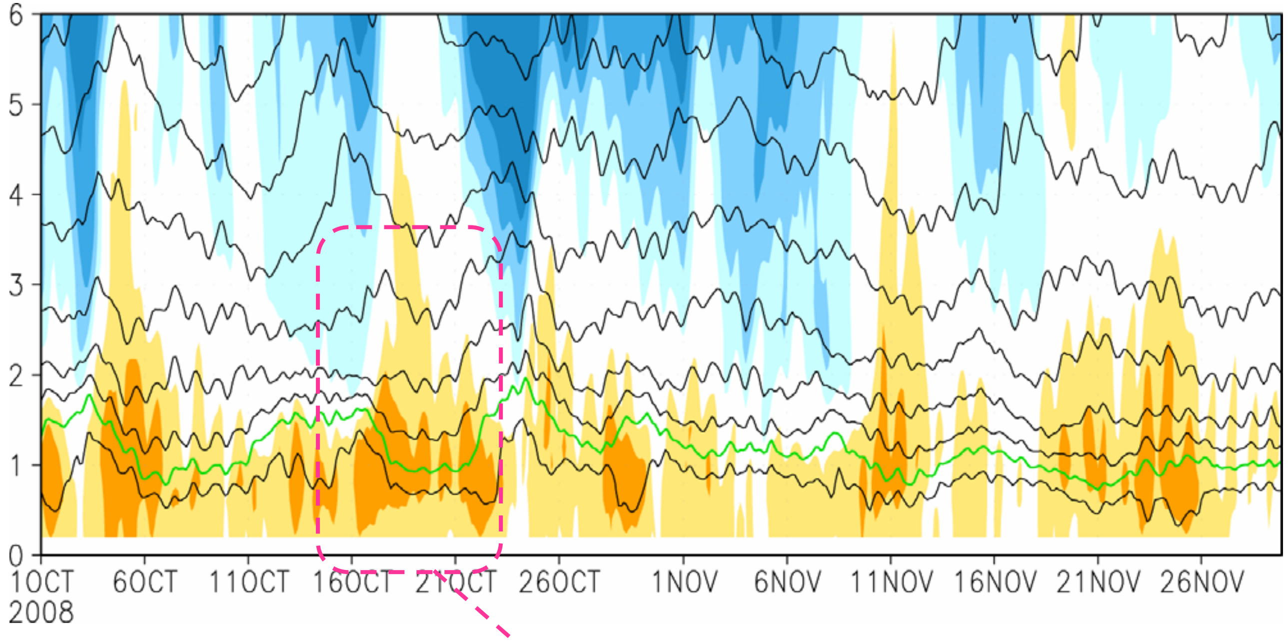


- WRF captures the large MBLz variations well during October, but less so during November.
- Surface wind well simulated during the whole period
- Simulation is typically lower than the observations.

MBLz variations not always coupled with changes aloft



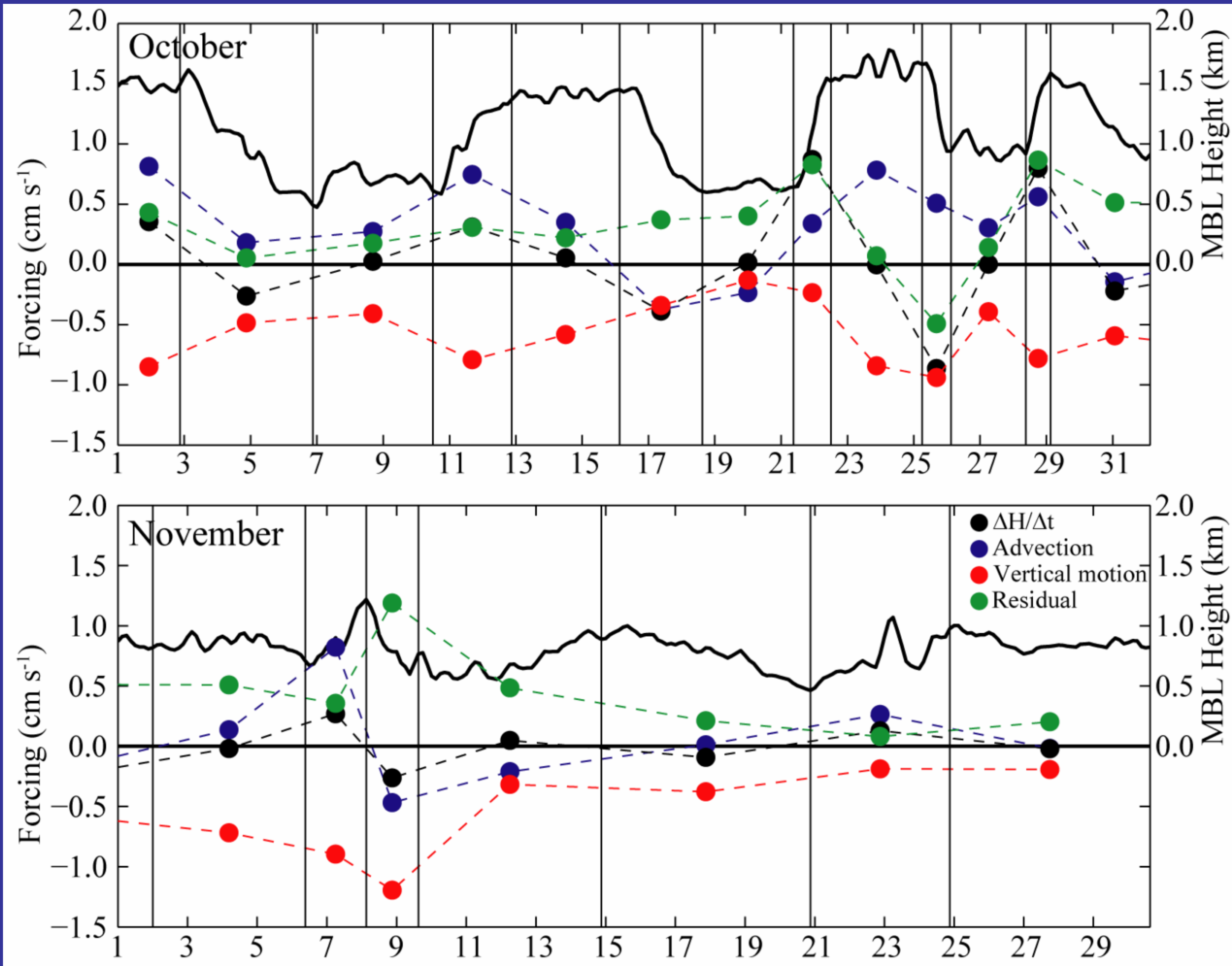
20ºS - 80ºW

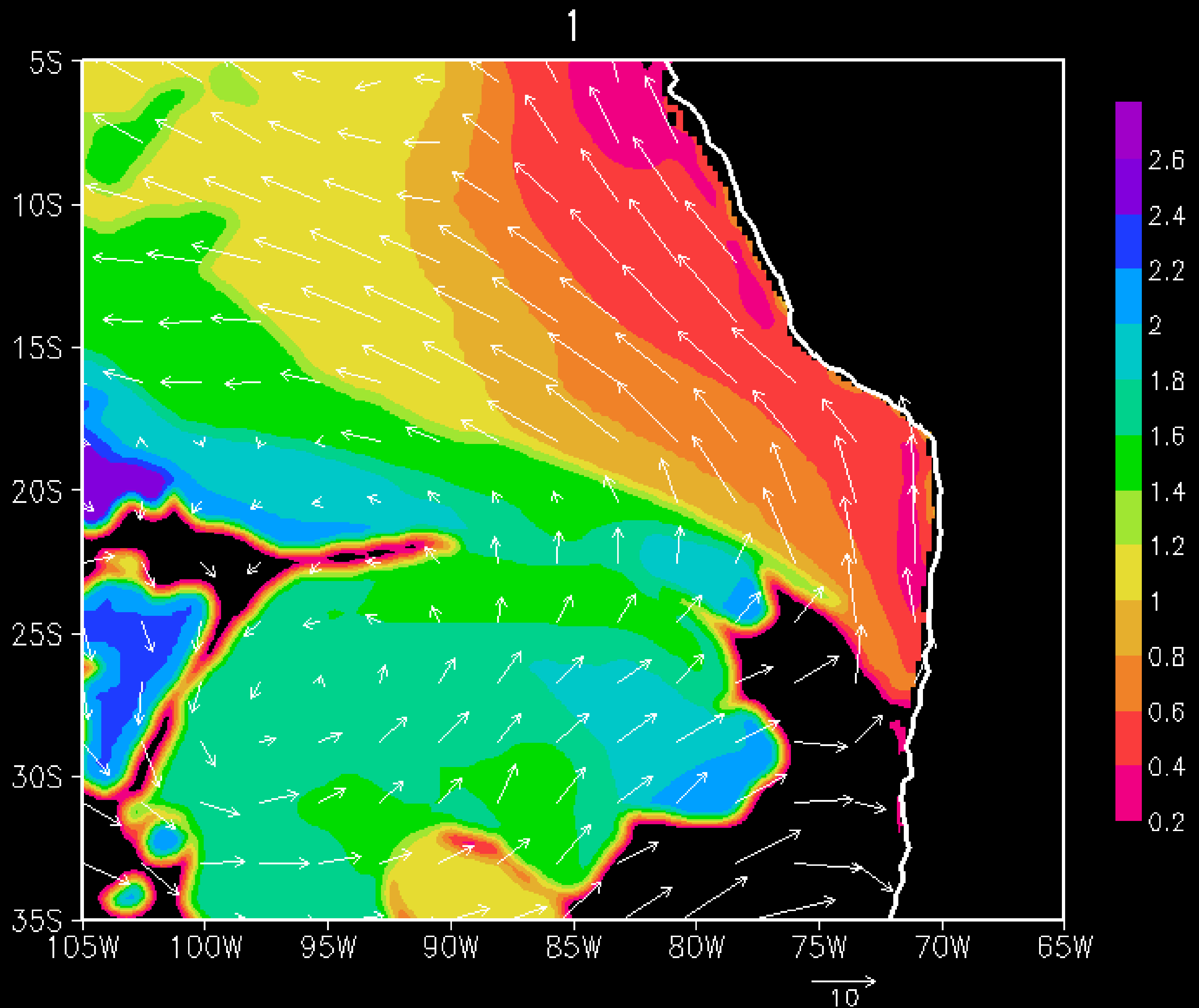


MBLz variations coupled with easterly wind events

Time series at 20°S, 80°W

- As seen previously, October is much more variable than November.
- Subsidence and Residual are on average the largest, opposing terms
- Advection and dH/dt are more variable and appear to be related.




1
5S
10S
15S
20S
25S
30S
35S
105W
100W
95W
90W
85W
80W
75W
70W
65W
10
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2

Summary I

- Comparison with MBL observations demonstrates
  - WRF captures the large variations fairly well in October, but not so well in November.
  - MBL heights in WRF are lower than observed.

- While the vertical velocity and residual tend to be the dominant opposing terms, variability of MBL depth appears to be tied closely to the variability in advection.

- Synoptic influence from the mid-latitudes can be translated into the subtropical region.

- What are the effects on the cloud field?

Upsidence Wave

(Rahn's Presentation)

- Garreaud and Muñoz (2004, GM04)
  - A robust diurnal cycle of vertical motion between 1-5 km in the subtropical southeast Pacific (SSEP).
  - The band of upward motion initiates at the coast in the late afternoon/early evening and propagates to the southwest.
  - At 0000 UTC a band of upward motion extends along the coast Peru and over Iquique.
  - At 1200 UTC there is a band of downward motion offshore between 22°S and 26°S.

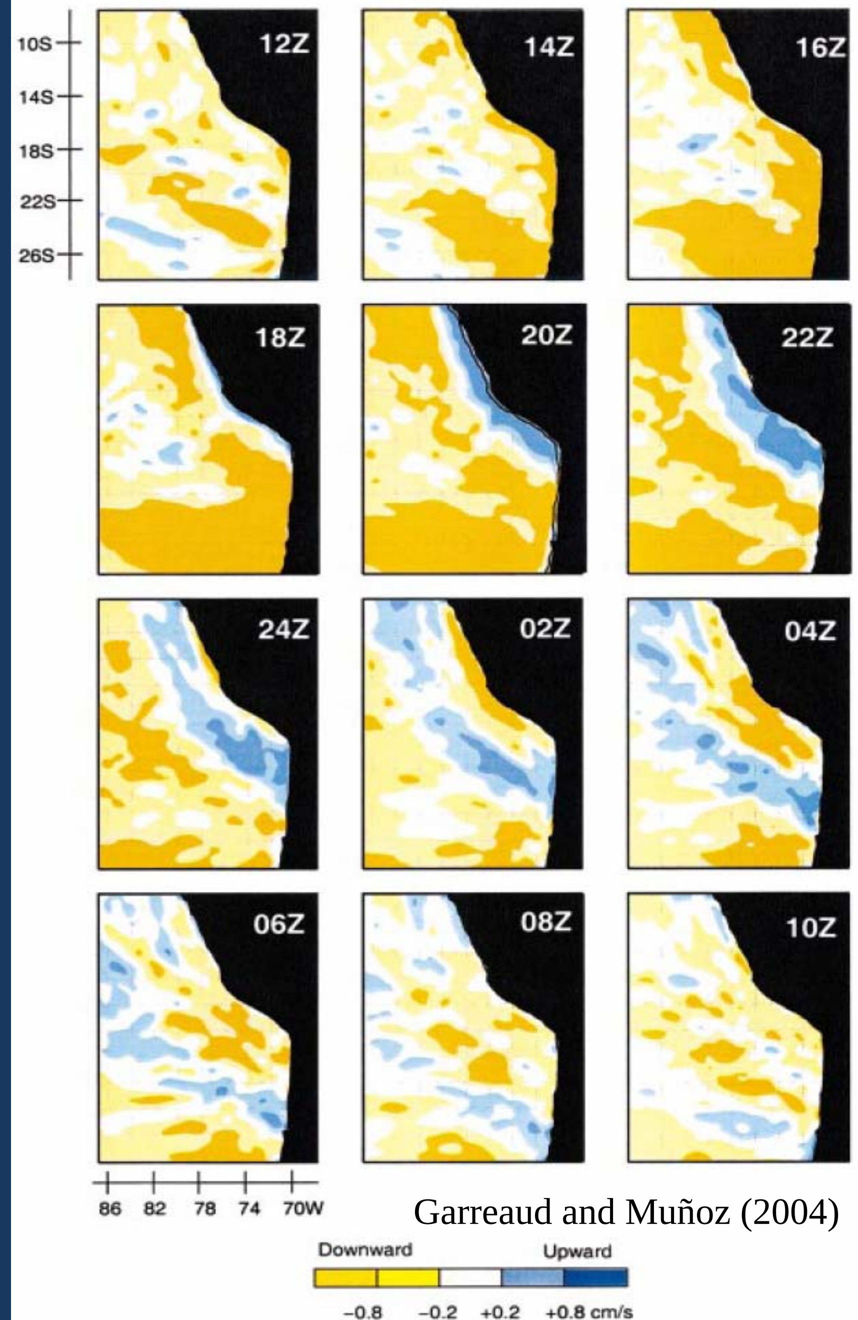
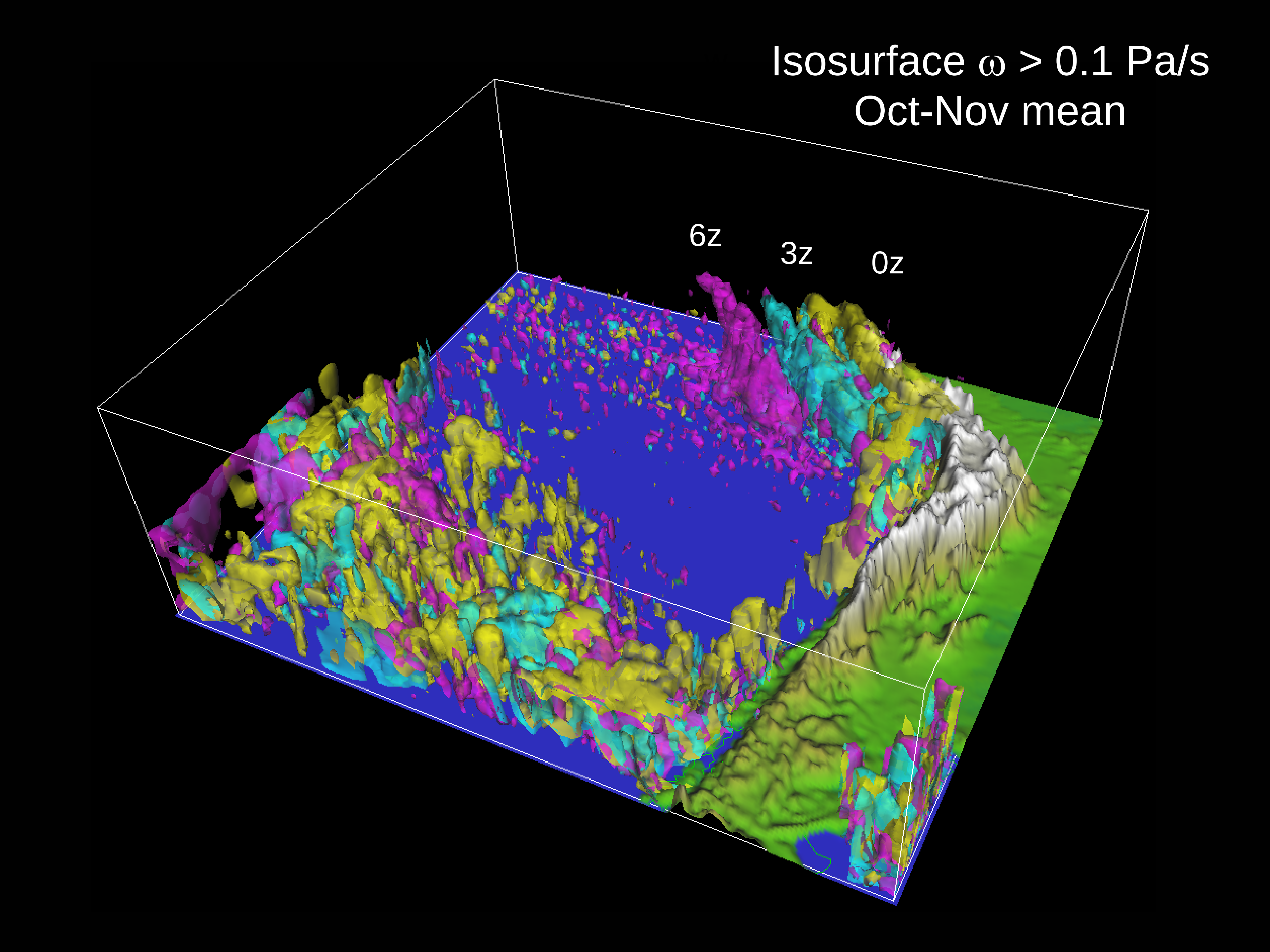
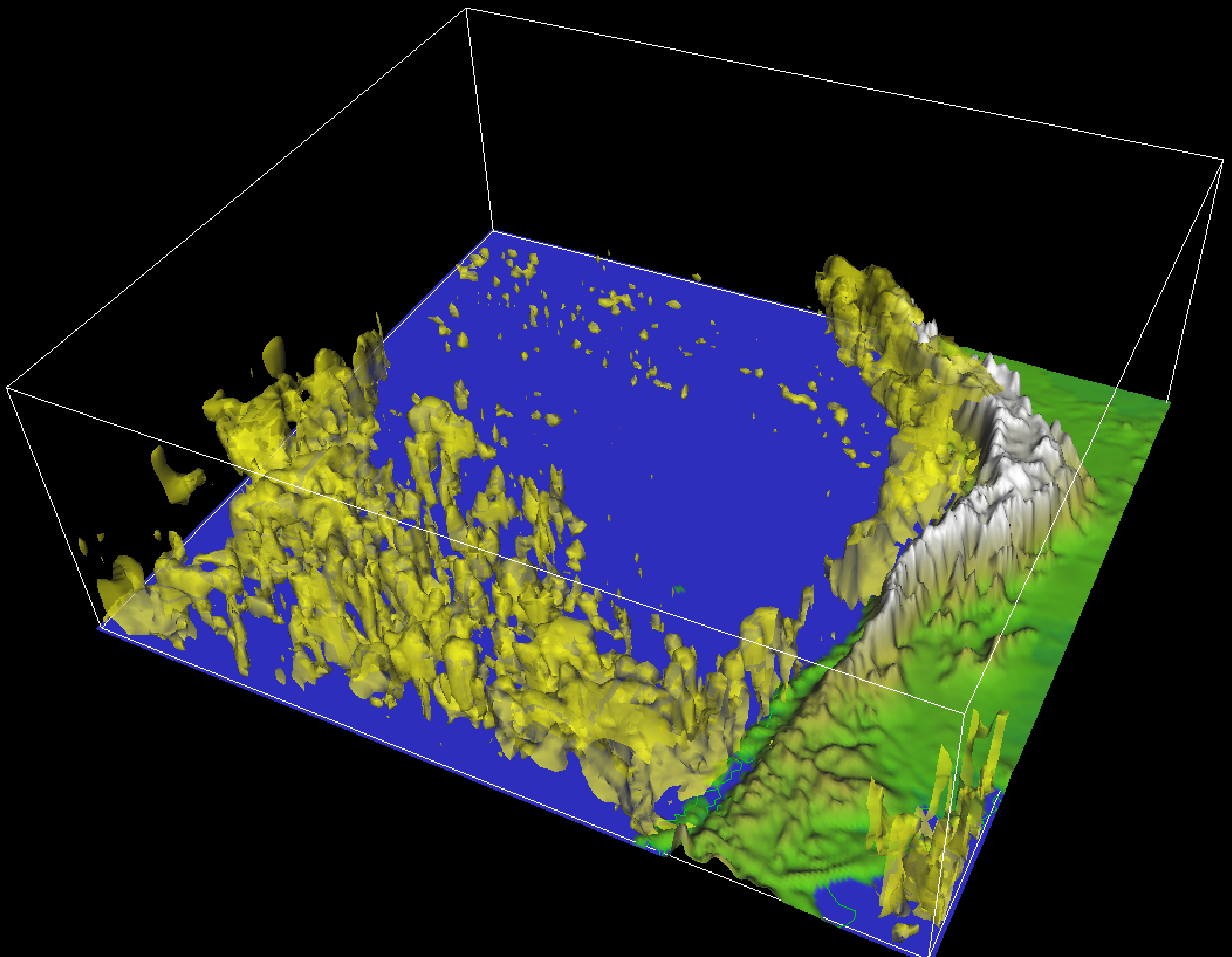
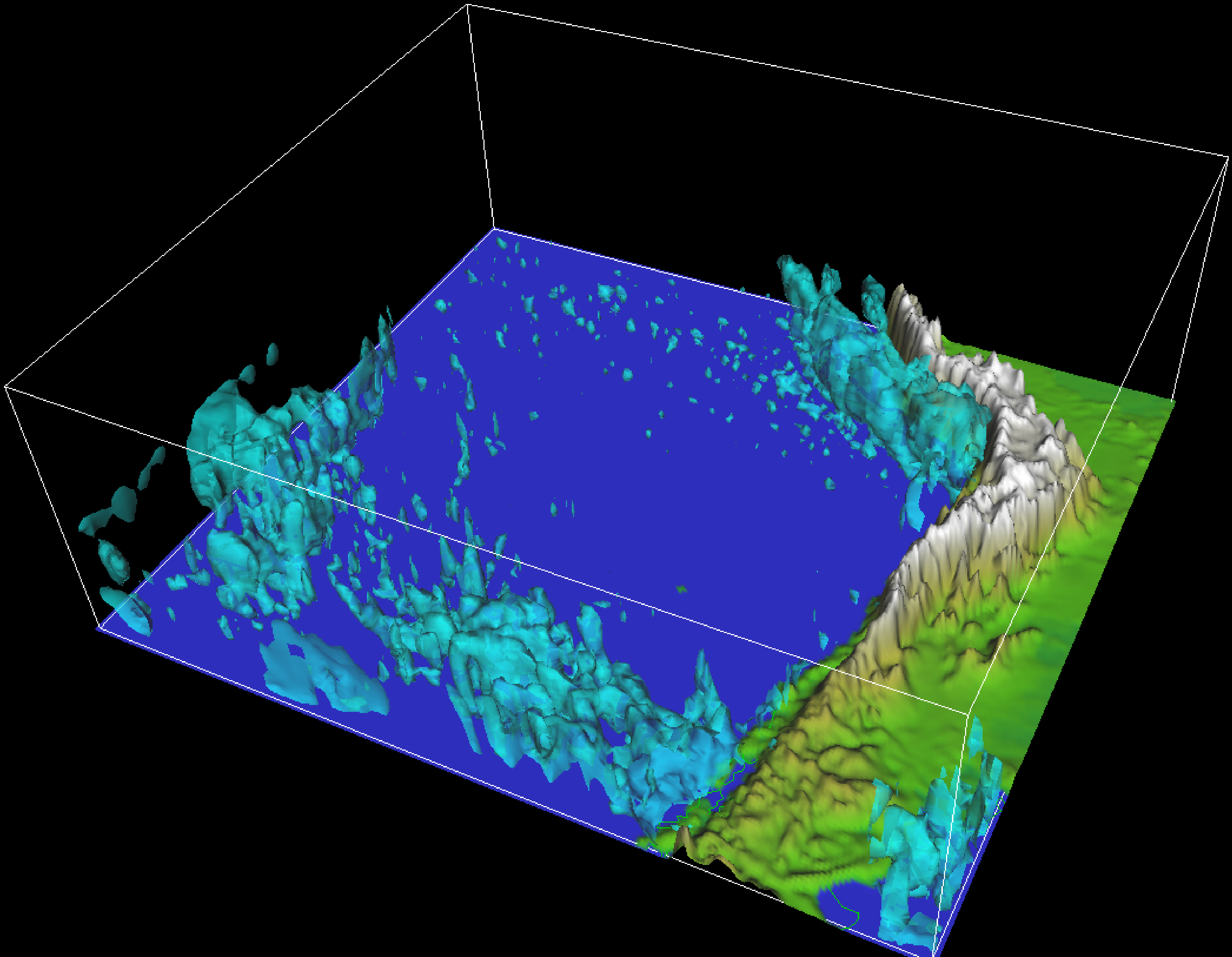
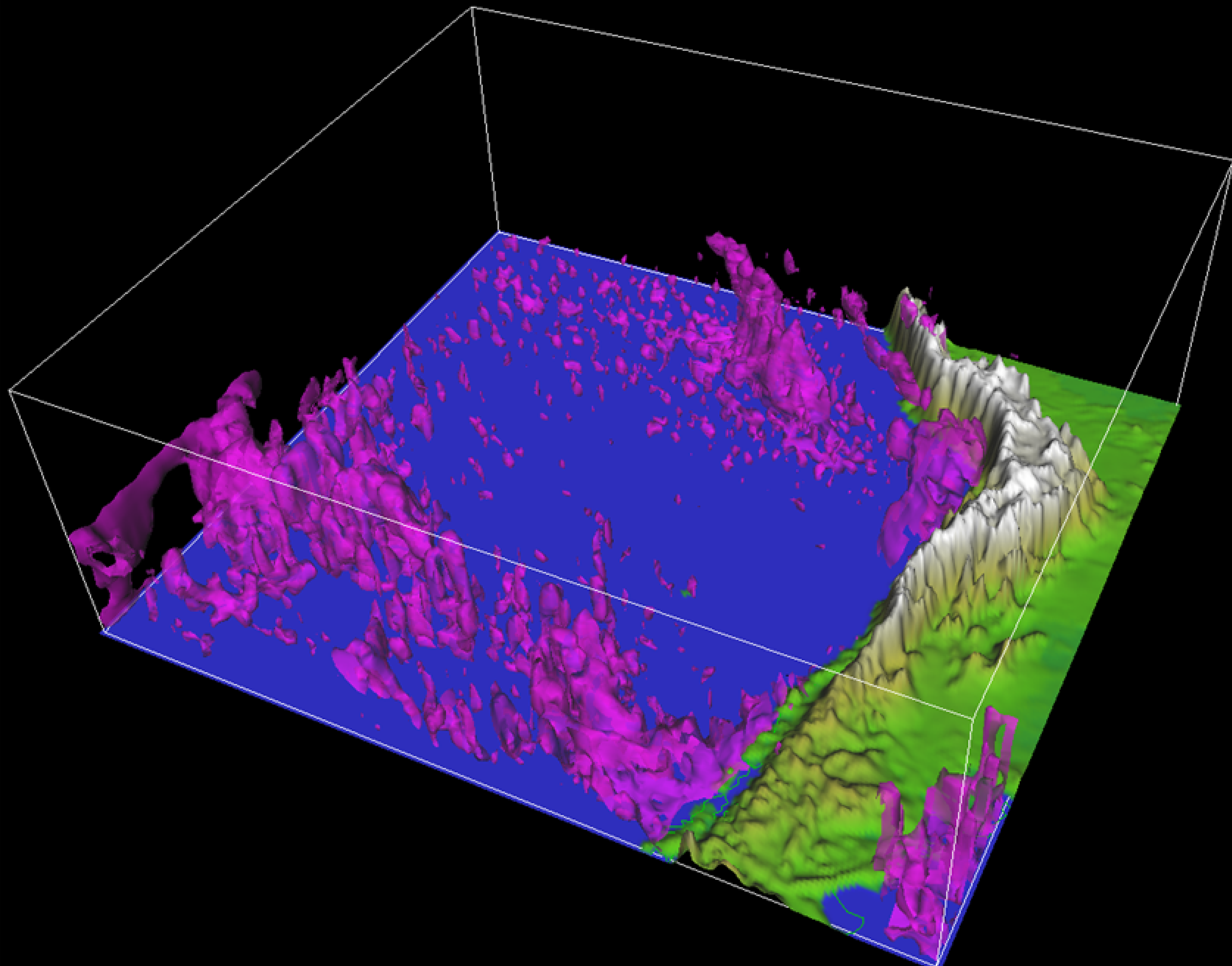


FIG. 5. Mean vertical velocity at 800 hPa for the Nov 2001 simulation, shown every 2 h using a common shading scale (at bottom). Time is indicated at the top of each panel in UTC (Z).


Isosurface ω > 0.1 Pa/s
Oct-Nov mean
6z
3z
0z



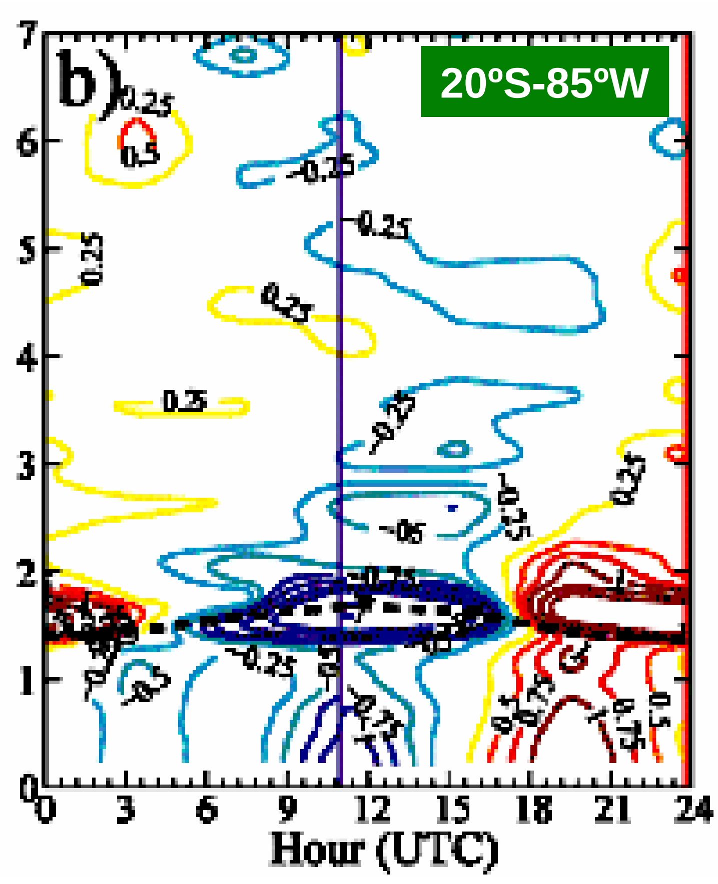


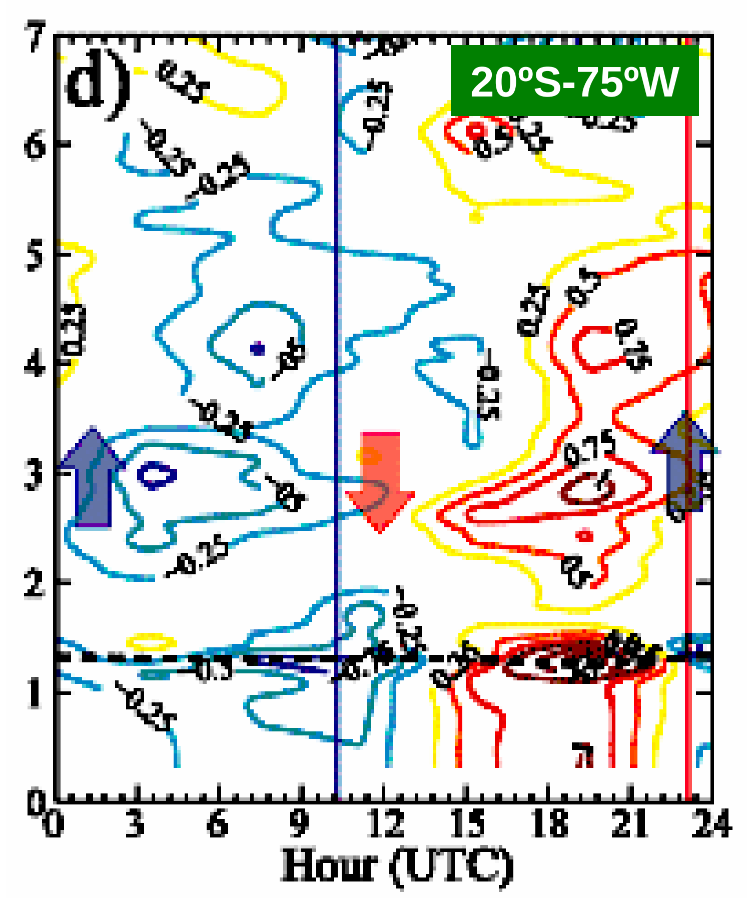


Ron Brown diurnal cycle temperature anomalies

1ºK diurnal amplitude aloft due to upsidence wave

What about clouds?



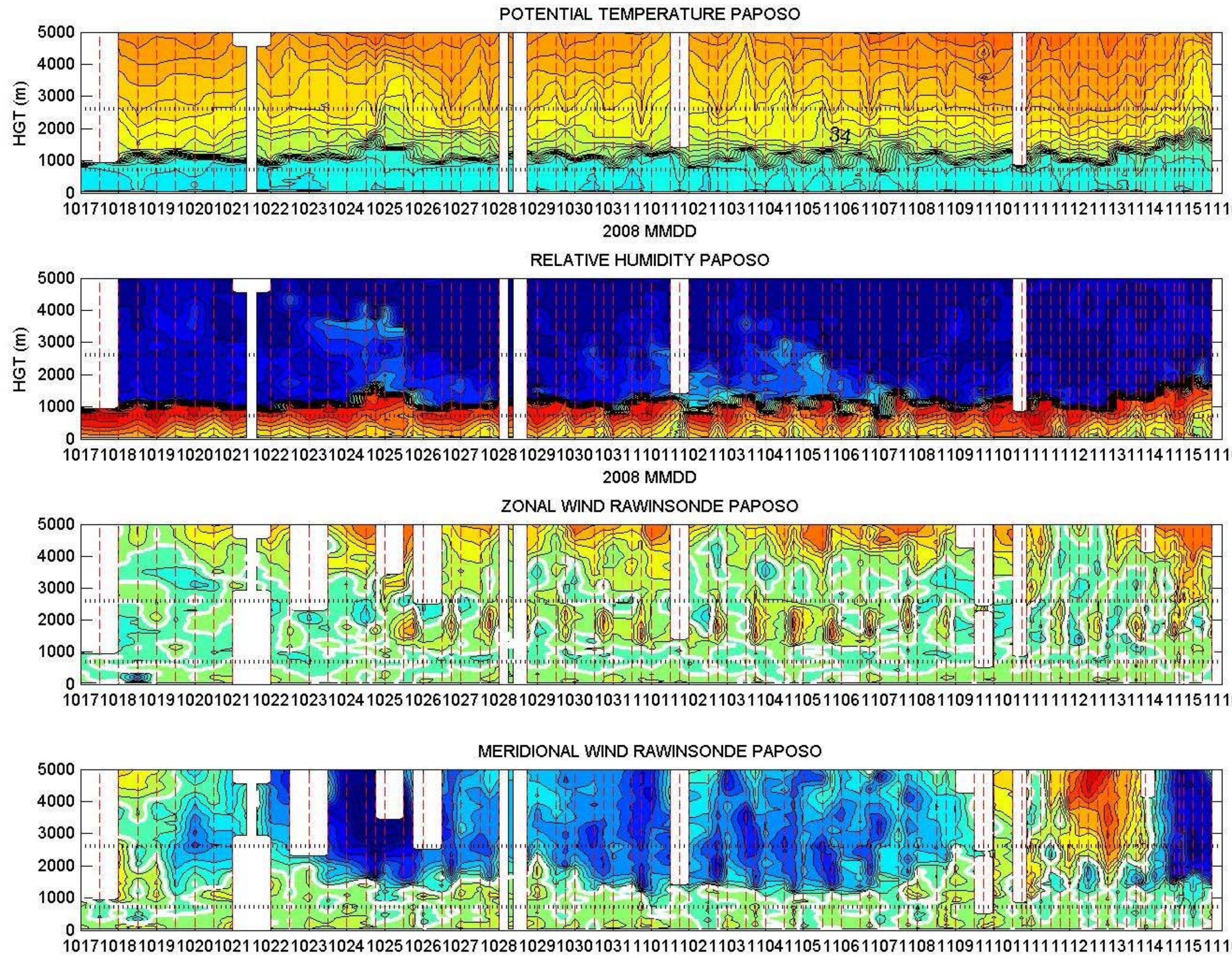


- MBL exhibits typical cloud-toped MBL characteristics, i.e. deepens overnight, thins during the day.
- Not much of a diurnal signal aloft

MBL is much flatter.

A clear diurnal signal around 2-3 km.

Coastal Observations at Paposo
Little day-to-day changes, great diurnal variability



Coastal Observations at Paposo
Little day-to-day changes, great diurnal variability
Note the “elevated” sea-breeze circulation (above 1 km)