

# Upsidence wave during VOCALS

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# Upsidence Wave

- 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 offshore 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.

*Note: Local Time: UTC - 5*

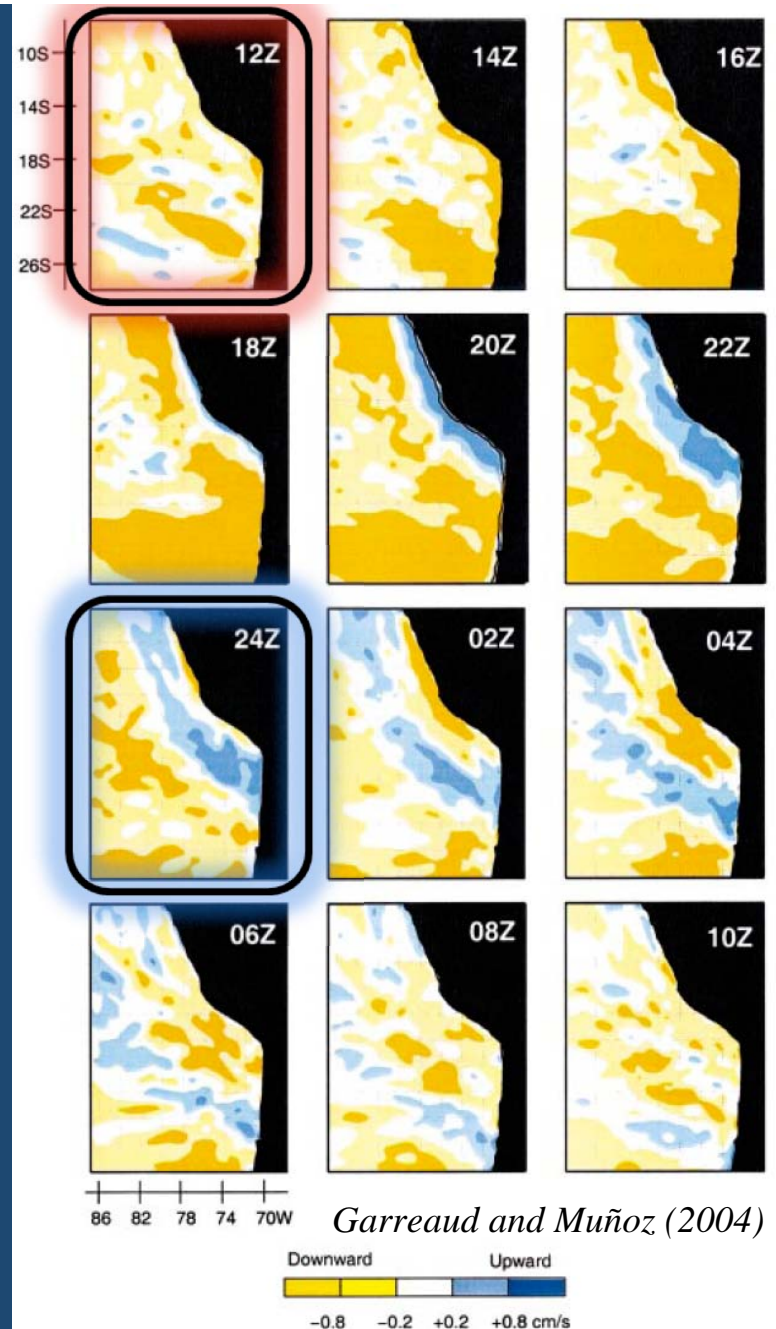
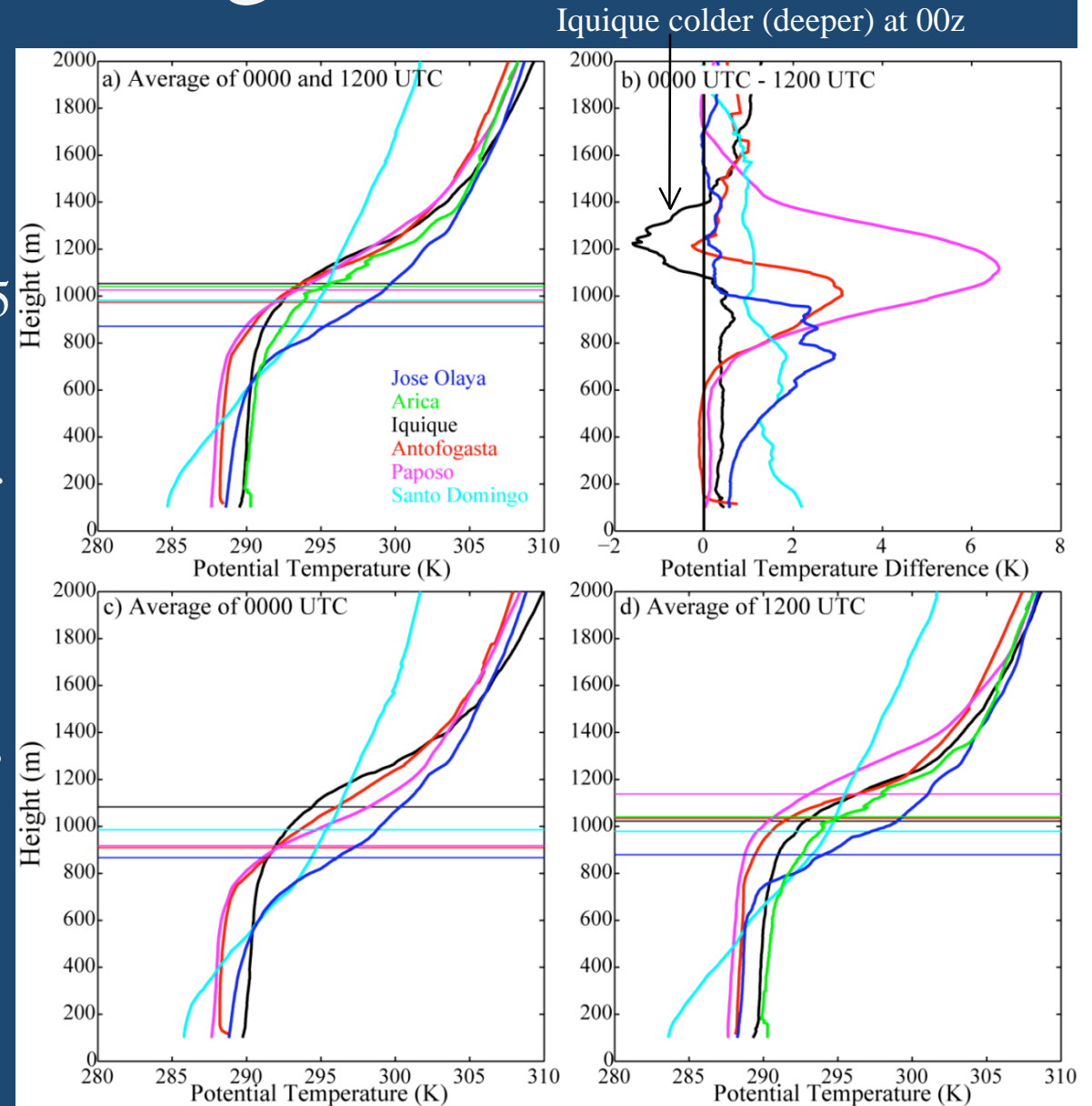


FIG. 5. Mean vertical velocity at 800 hPa for the Nov 2001 simulation, shown every 2 h using a common shading scale (at bottom). Time is indicated at the top of each panel in UTC (Z).

# Alongshore soundings

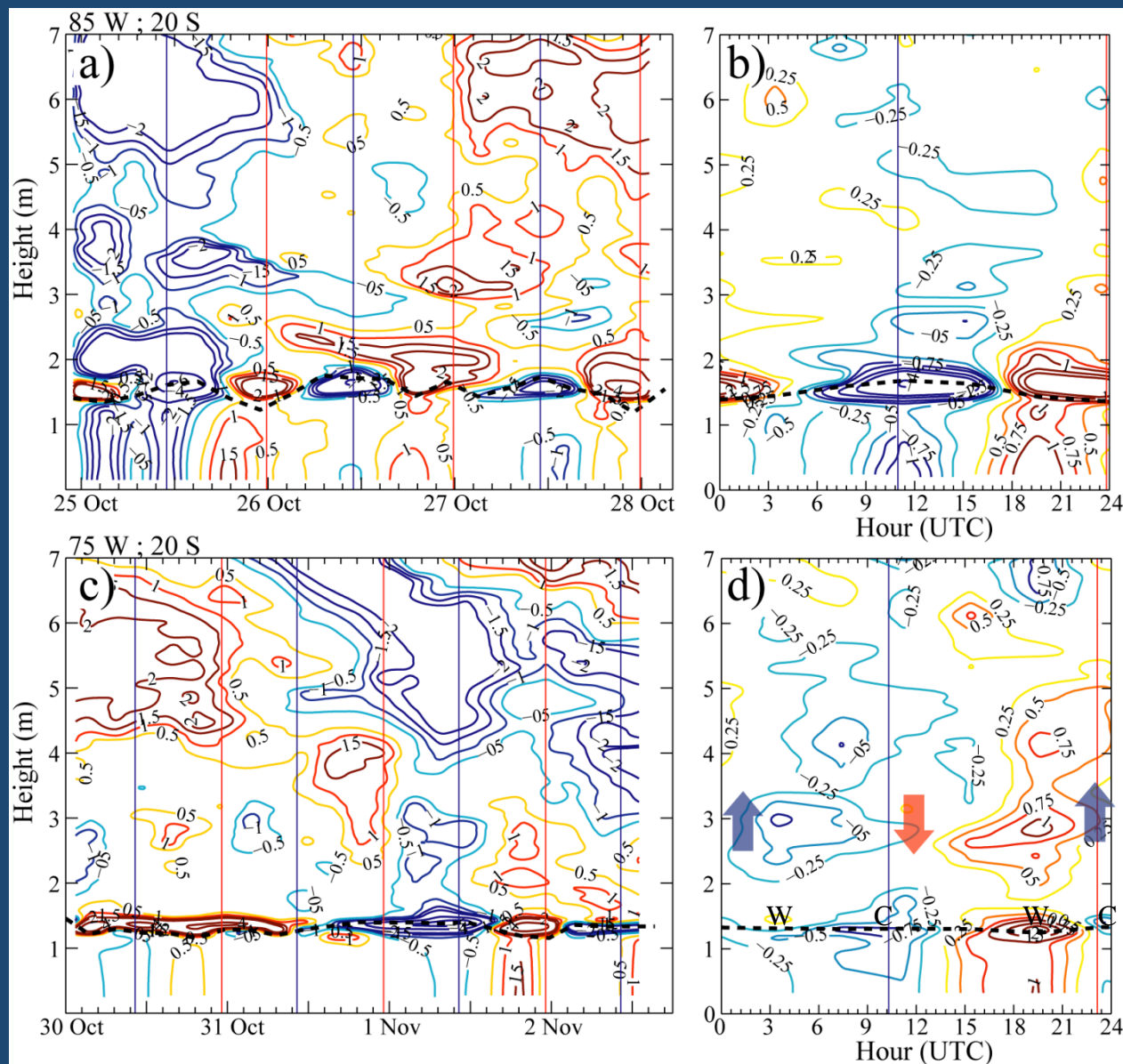
- Since there were slightly different launch times for the stations, 00z and 12z soundings are used for averages from 15 Oct. to 15 Nov.
- Average of all 00z and 12z soundings are quite similar.
- Differences arise when just the 00z and 12z averages are examined.
- Iquique (20°S) is an exception since the MBL is higher during the day than in the morning.
- *From modeling study, 00z is when there is an upsidence wave over Iquique.*



Temperature profiles for the time period from 15 October to 15 November.

# RB soundings

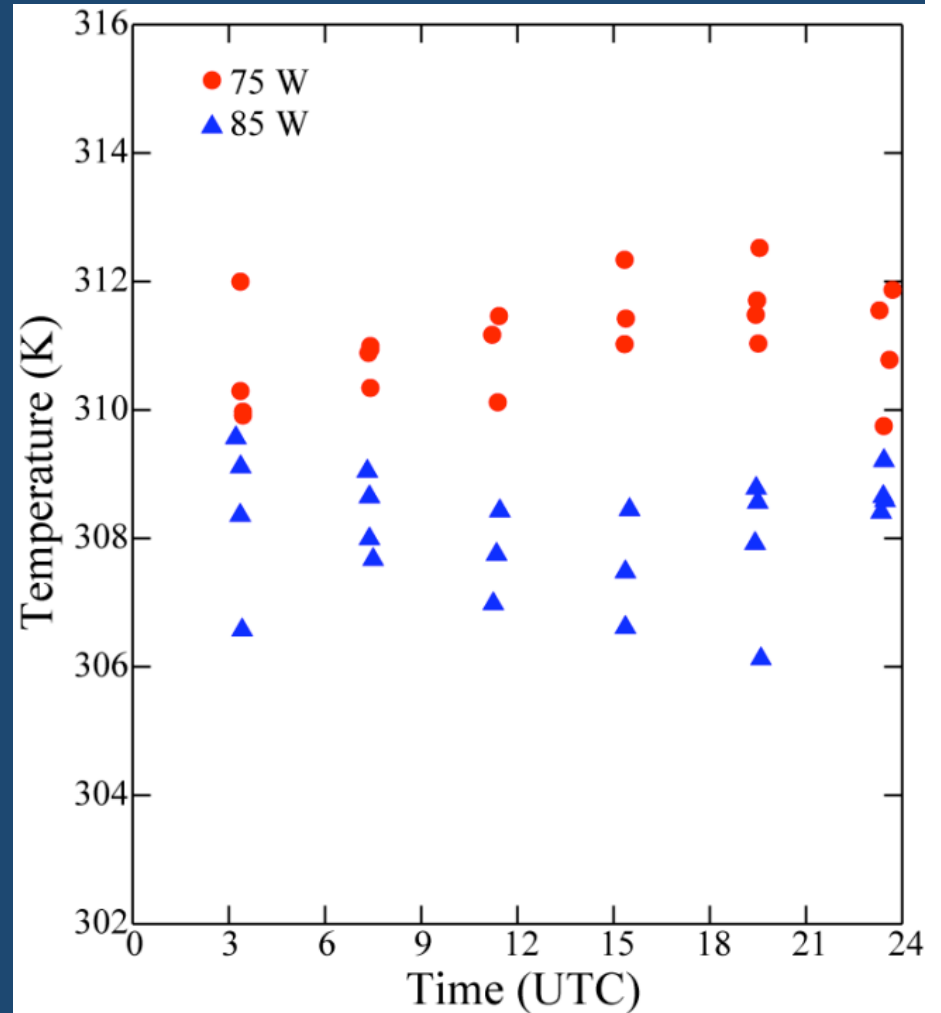
- 20°S, 85°W
  - MBL exhibits typical cloud-topped MBL characteristics, i.e. deepens overnight, thins during the day.
  - Fairly clear changes on the time scale of a day, but not much of a diurnal signal aloft
- 20°S, 75°W
  - MBL is much flatter.
  - Some trend of increasing MBL with time.
  - A clear diurnal signal is seen around 2-3 km.



Potential temperature anomalies from mean taken from Ron Brown soundings along 20°S at 85°W (a, b) and 75°W (c, d) shown as a time series (a and c) and as an average diurnal anomaly (b, d). MBL depth is indicated by bold dashed line. Blue and red vertical lines indicate local sunrise and sunset, respectively.

# RB soundings

- Sounding observations were interpolated to exactly 2.5 km.
- At 2.5 km there is a fairly consistent temperature at each hour of the day.
- A clear diurnal cycle is present at both 75°W and 85°W.
- At 75°W, the highest temperatures are around 2000 UTC.
- At 85°W, the highest temperatures are around 0300 UTC.



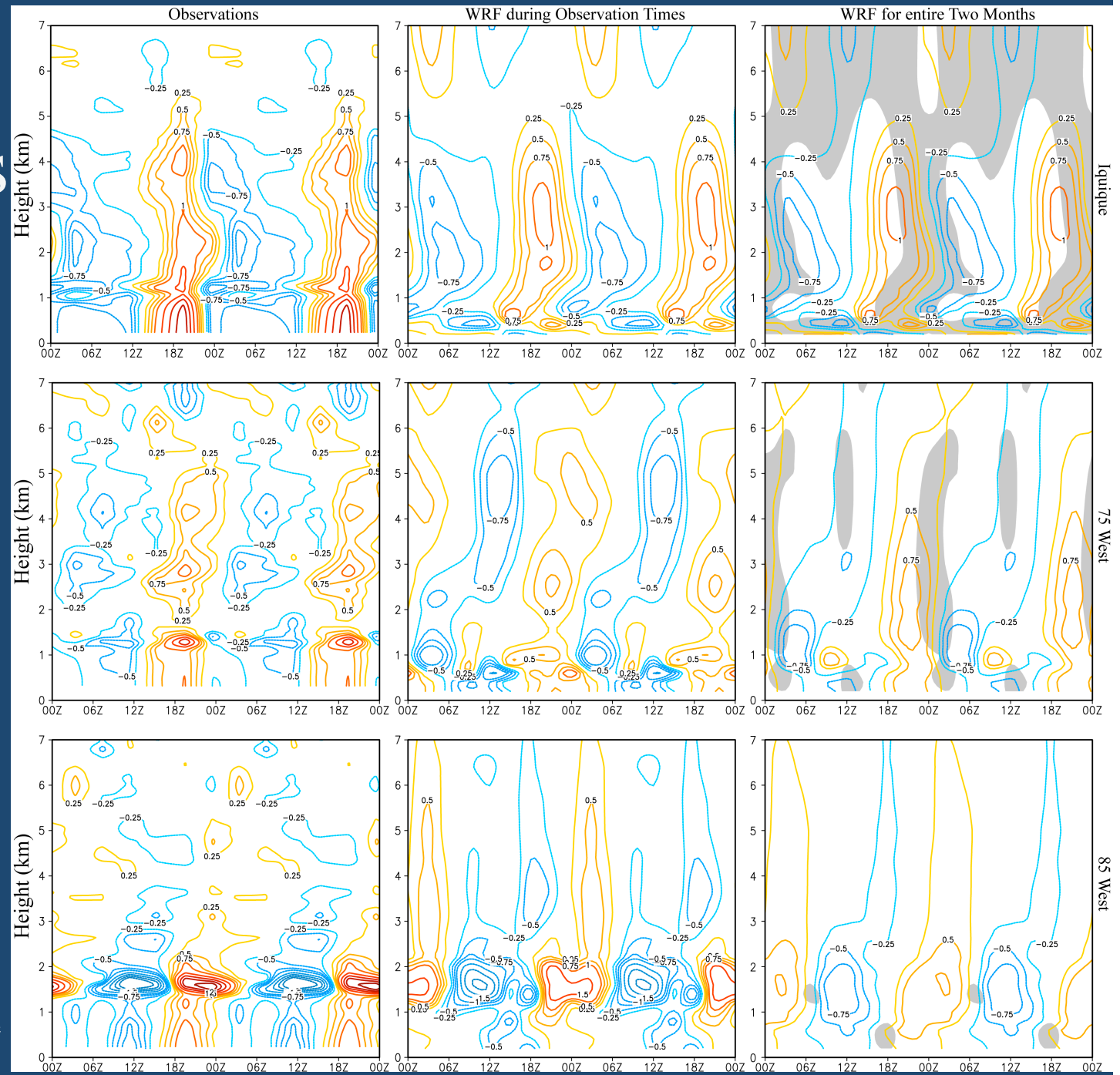
Hourly 2.5-km potential temperature (K) at 20 S; 75 W (red circle) and 20 S; 85 W (blue triangle).



# Simulated Anomalies

- Simulation by WRF captures main features.
  - Details of WRF in extra slide section.
- Simulation at Iquique and 85°W very good.
- 75°W captures the warming and cooling aloft, but timing for cooling is off. Also MBL height is notably shallower in simulation.
- 4x daily anomalies at the MBL top are present in model as well as during the entire 2 months indicating robust features, even if the timing is off.
- $c \propto \sqrt{H}$ 
  - $2H \rightarrow 1.4c$

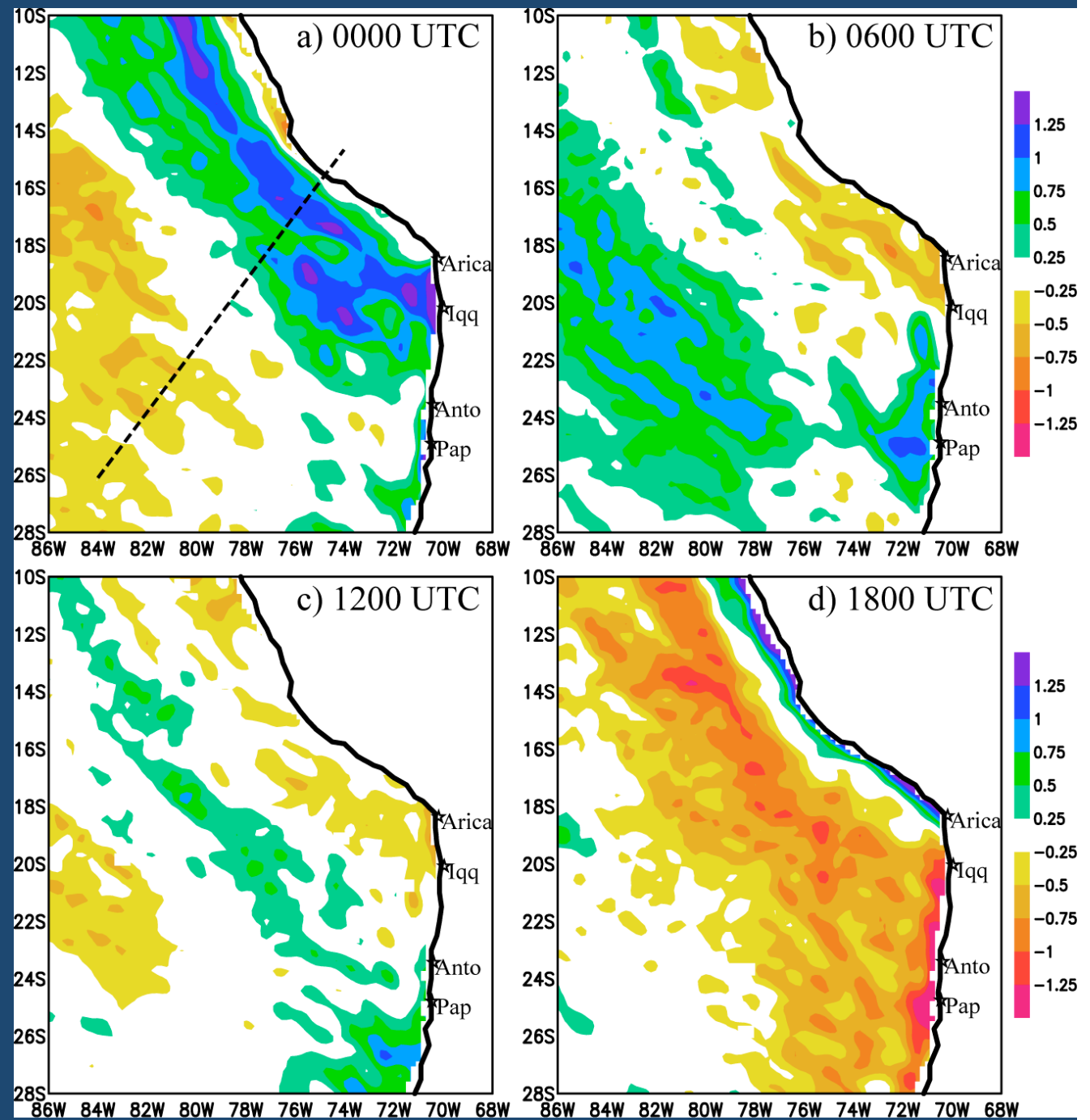
As, previous figure, but shaded Regions indicate upward vertical motion



# Simulated Results

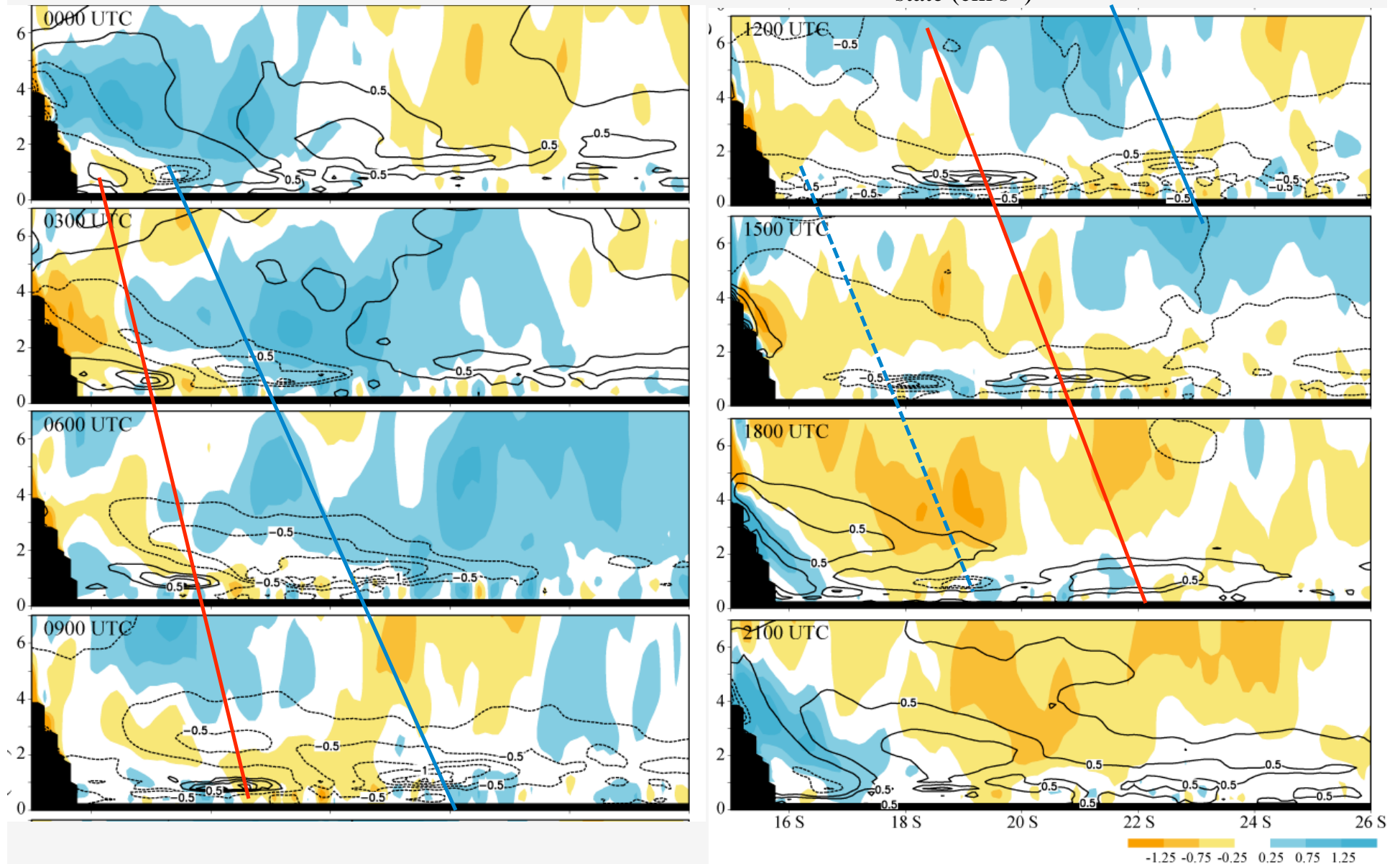
- Upsidence wave as seen in GM04.
  - Upsidence develops in late afternoon.
  - Propagates offshore to the southwest.
- Also a less intense secondary wave is present at 1200 UTC.
  - Associated with the smaller perturbations at MBL top?

*Colors indicate perturbation vertical velocity ( $\text{cm s}^{-1}$ ) at 2.5 km*



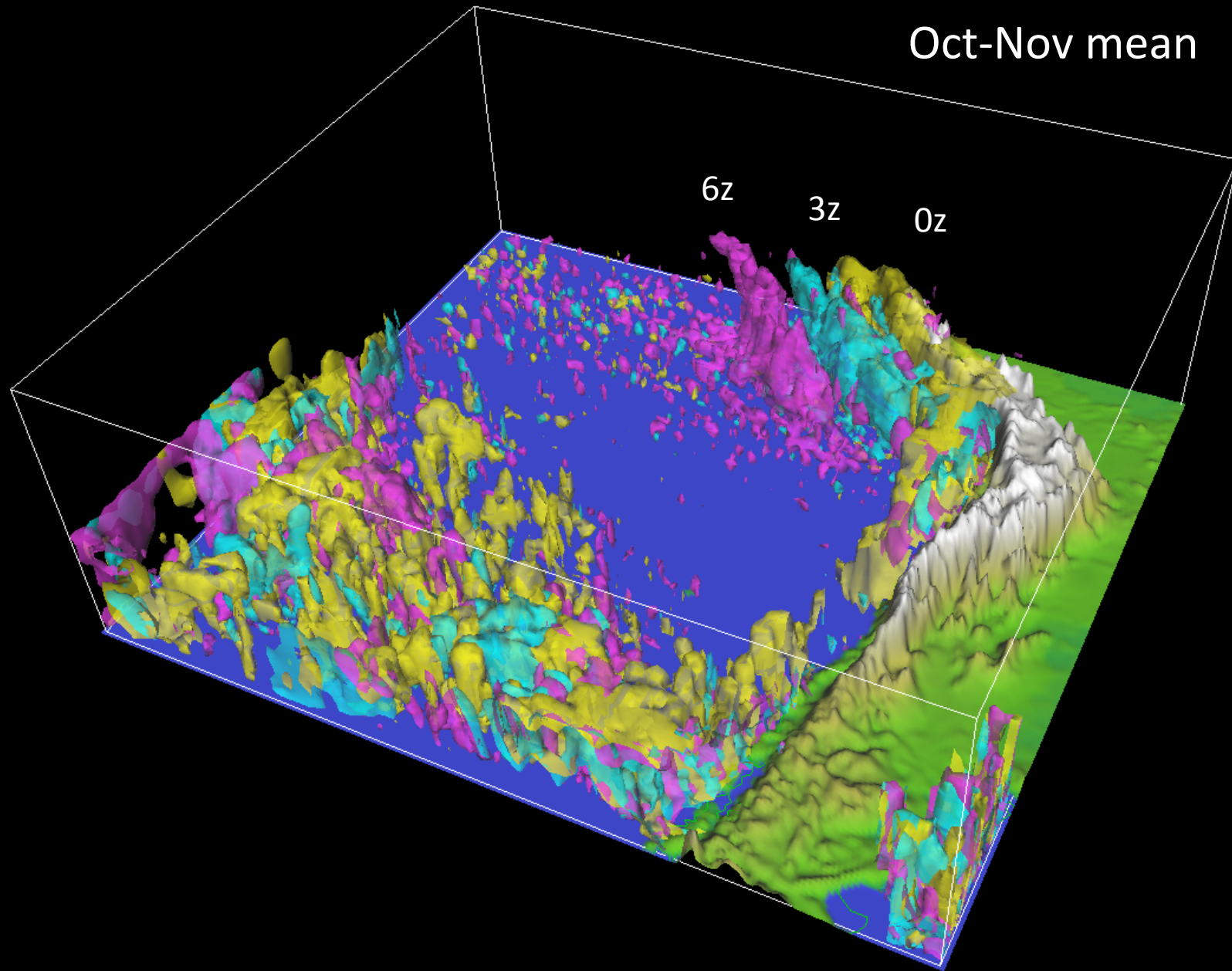
# Model cross sections

Contours indicate temperature perturbations from mean state (K). Color indicates vertical velocity perturbations from mean state ( $\text{cm s}^{-1}$ )





Isosurface  $\omega > 0.1$  Pa/s  
Oct-Nov mean

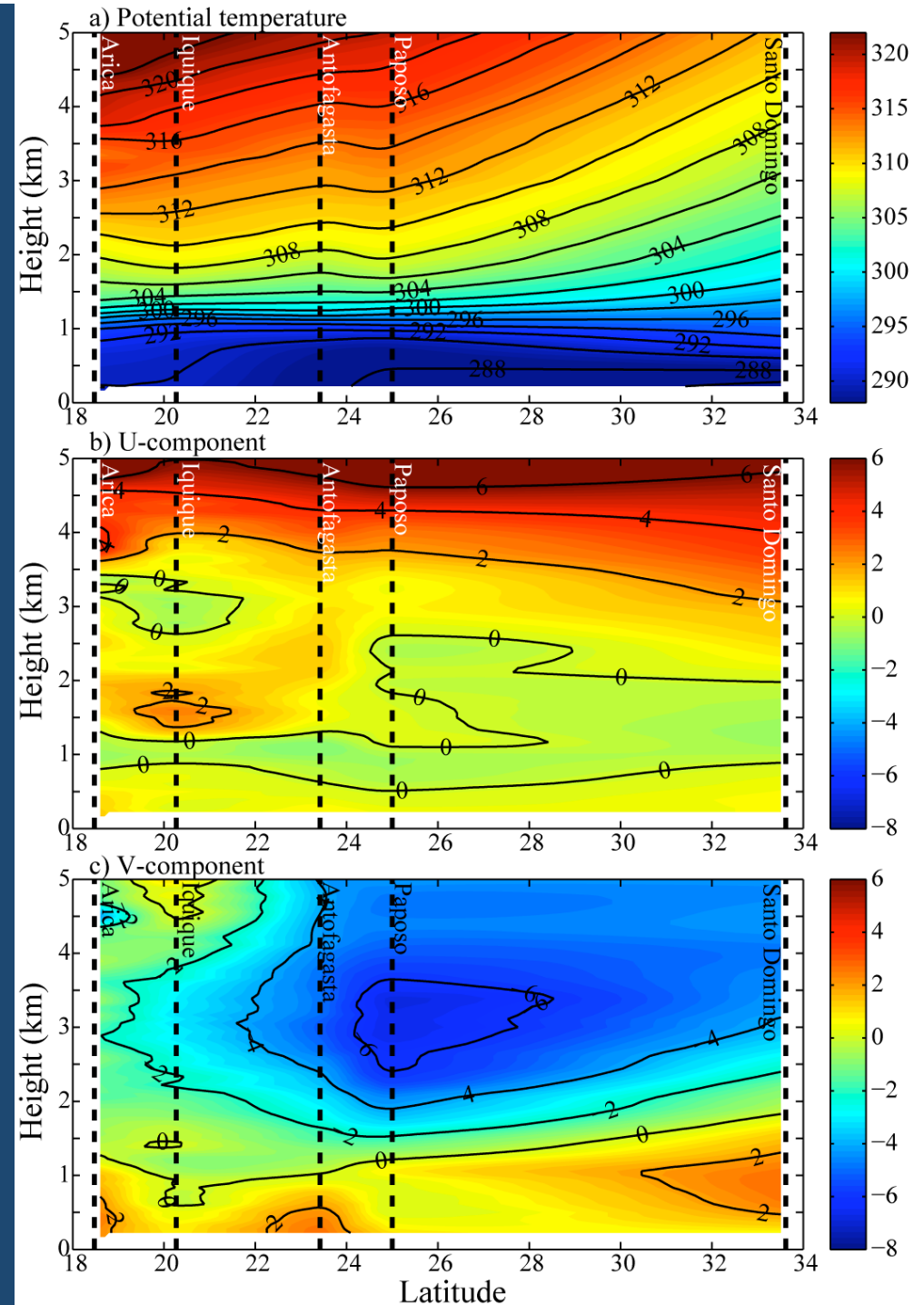


# Summary

- Observations confirm the presence of an upsidence wave simulated previously in GM04.
- Diurnal cycle of MBL is influenced by the upsidence wave.
  - At Iquique the MBL depth responds opposite of the other land stations.
  - At 20°S, 75°W
    - Clear diurnal cycle aloft
    - MBL depth is more or less flat.
  - At 20°S, 85°W
    - Weak diurnal cycle aloft
    - MBL depth acts ‘normally’
- Simulation of this time period shows basically the same features as observations with discrepancies at 20°S, 75°W mainly due to MBL depth issues. (speed of gravity wave at MBL top  $\propto \sqrt{H}$  )
- At the MBL top, there appears to be a less intense, trailing perturbation after the large initial perturbation.
  - Robust features since they are present in the 2-month average as well.

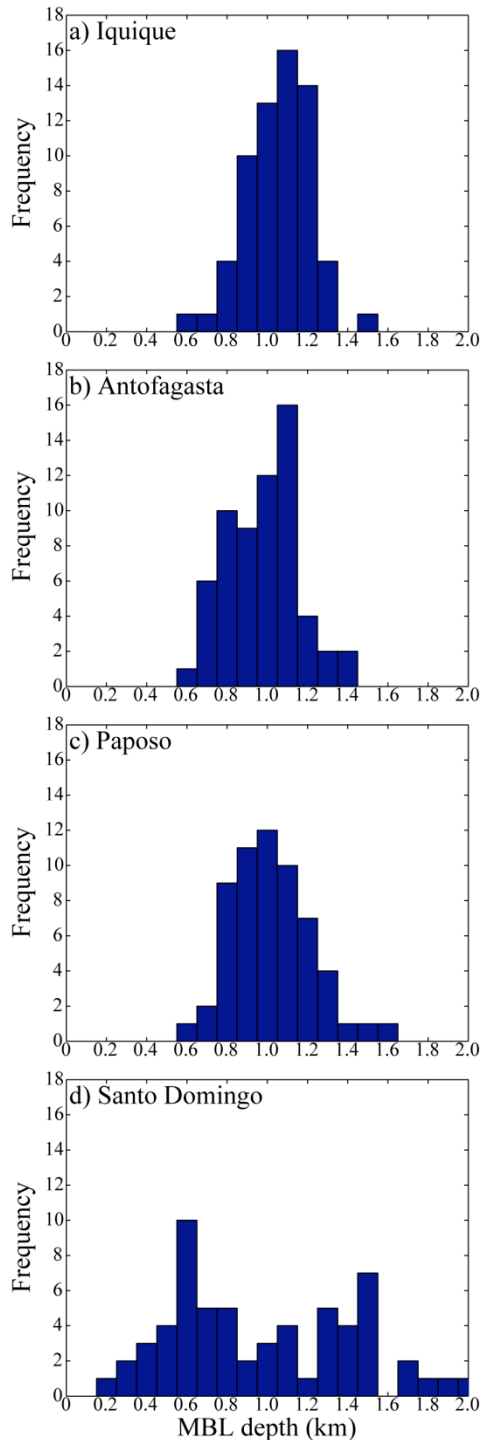
# Alongshore cross section

- 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.



# Distribution of MBL depth

- Data from all 00z and 12z soundings during the period 15 October to 15 November 2008.
- Iquique, Antofagasta, and Paposo are normally distributed with averages and standard deviation fairly similar.
- Santo Domingo contains a large spread in the distribution due to the highly variable MBL.

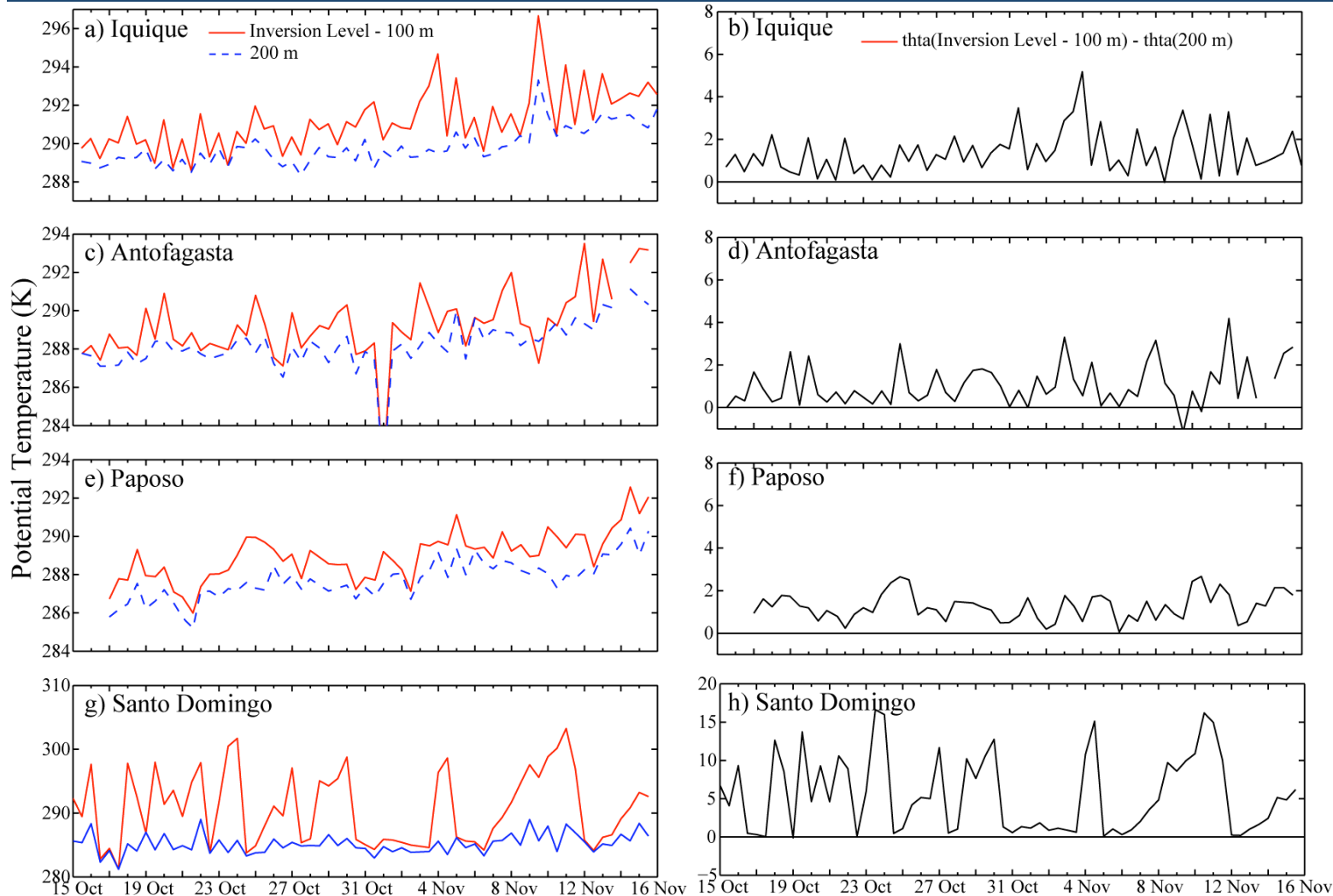


	0000 UTC	1200 UTC	12 - 00	Mean 00 and 12	All
Jose Olaya	867	880	13	873	860
Arica	-	1041	-	-	1027
Iquique	1083	1023	-60	1053	1038
Antofagasta	909	1034	125	972	971
Paposo	918	1138	220	1028	1066
Santo Domingo	986	979	-7	982	982



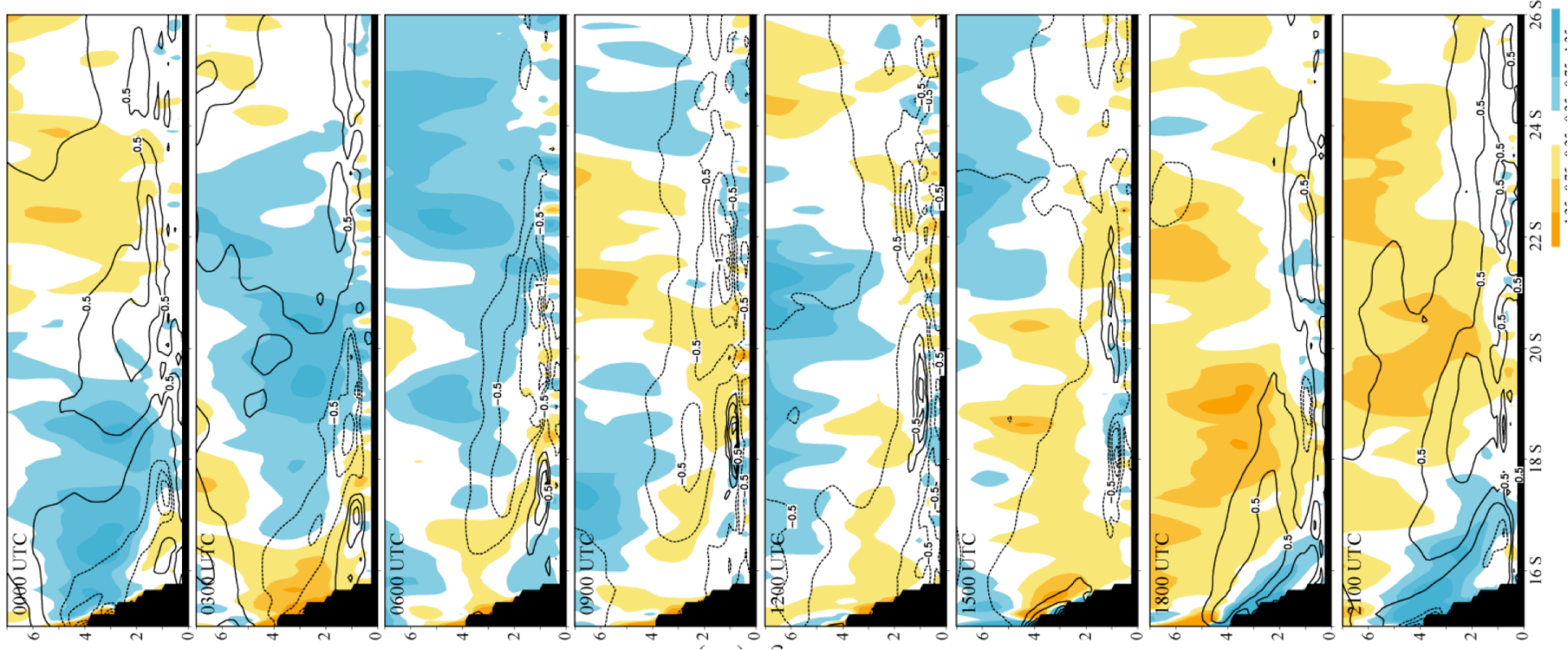
# Measure of stability within the MBL

- All 00z and 12z soundings from 15 October to 15 November.
- Potential temperature near the top and bottom of the MBL



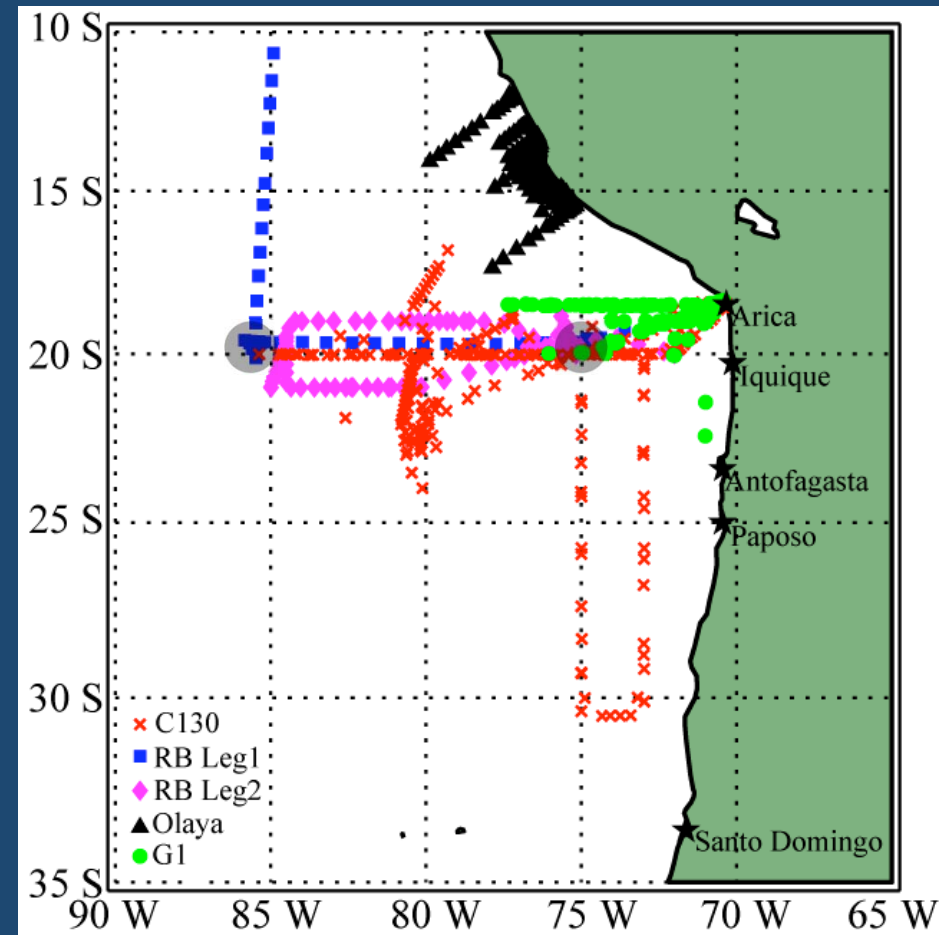
# WRF details

- Initialized from GFS 1 degree reanalysis
- 2-month run over October and November 2008
- Output every 3-hours
- 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 (Janjic) surface scheme
  - Pleim land-surface model
  - Mellor-Yamada-Janjic boundary layer
  - Betts-Miller-Janjic cumulus
  - Second-order turbulence and mixing
  - Horizontal Smagorinsky first-order closure eddy coefficient.



# Observational Evidence

- Observations from VOCALS can be used to directly observe features of an upsidence wave for the first time.
- Coastal soundings from land stations.
  - Not always consistent with launch time, but all include a 0000 UTC and 1200 UTC launch.
- Ron Brown has two stationary periods (~3 days) offshore along 20°S at 75°W and 85°W.
- C130 and G1 detect MBL depth leaving and arriving at Arica.
- Included some data from Olaya soundings taken 5-17 October with the exception of the long transects.



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.