Analysis of synoptic conditions during VOCALS-REx

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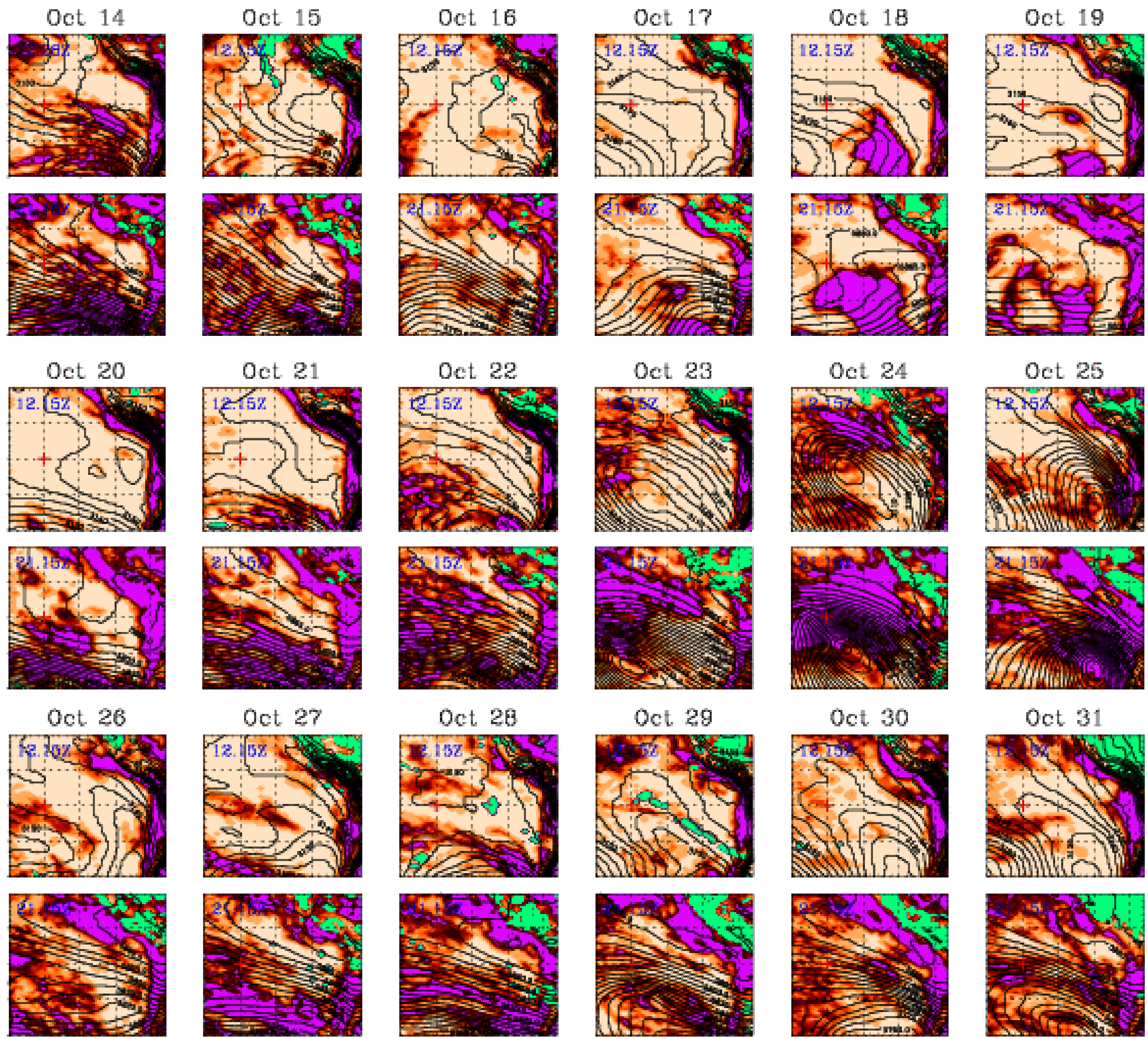
Postage-stamp charts

12.15z GOES low cloud fraction and 00z H700 op. analysis

21.15z GOES low cloud fraction and 00z H500 op. analysis



Day-by-day maps to serve as a reference for the synoptic conditions and the associated cloud field during the campaign.

Other/alternative plots are possible: feedback welcome!

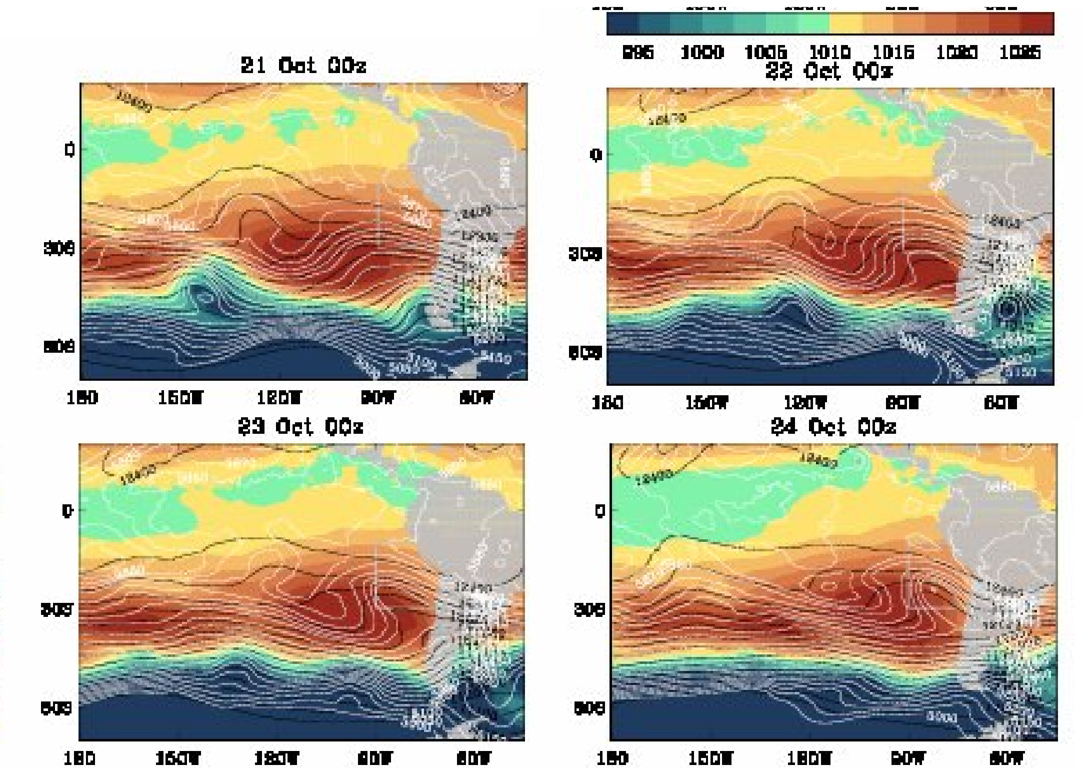
General large-scale conditions and observed regimes

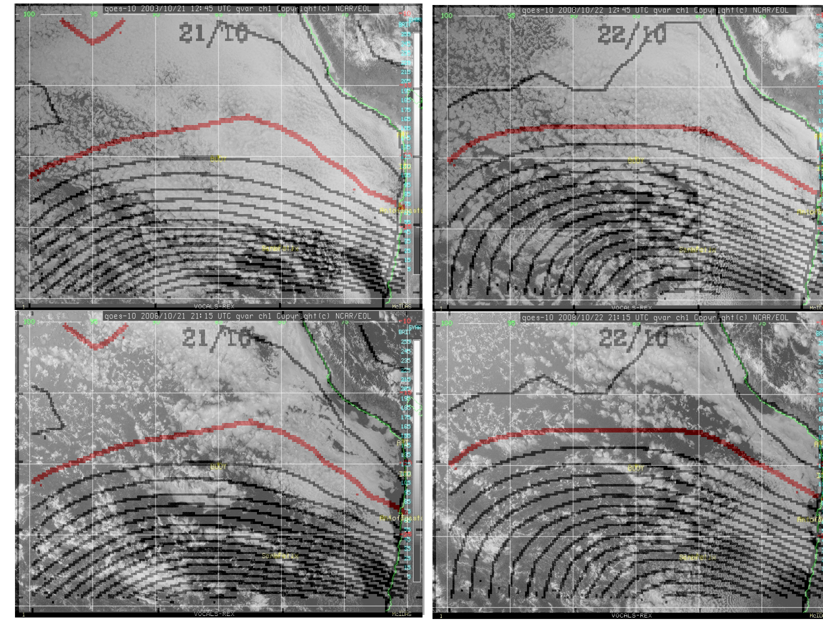
Three different regimes during 15 Oct – 30 Nov:

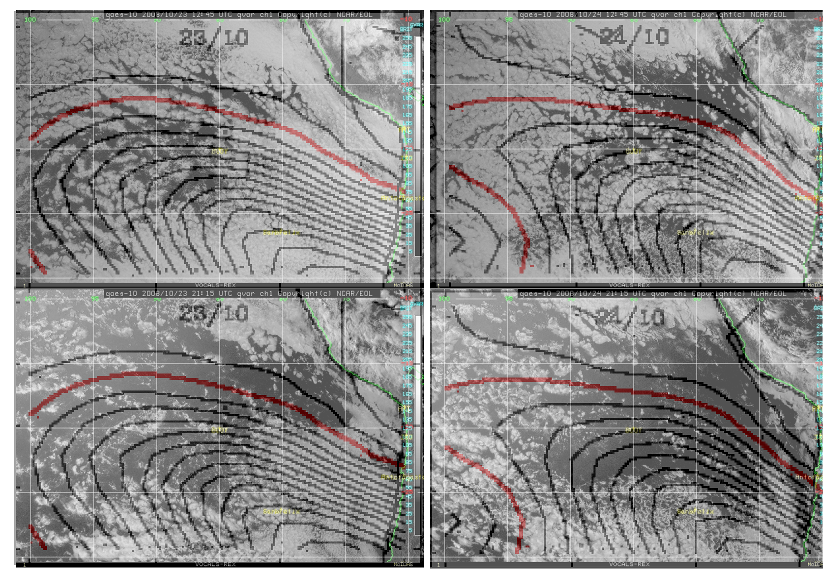
1) 15-31 Oct: strong surface anticyclone, unstable subtropical jet; conditions in the first half of October are similar
2) 3-12 Nov: mid-tropospheric anticyclone, zonal steady jet; terminated by cut-off low 13-16 Nov
3) 17-30 Nov: weak surface anticyclone; steady, strong flow aloft with poleward component

Between these phases conditions are characterised by the evolution and dissipation of synoptically forced, coastal cut-off lows, peaking in 1 Nov and 15 Nov. Other occurrences of CLs are during 22-25 Oct and later during 30/11-2/12. The first is extremely strong, as shown later.

Period1: Oct 15-31







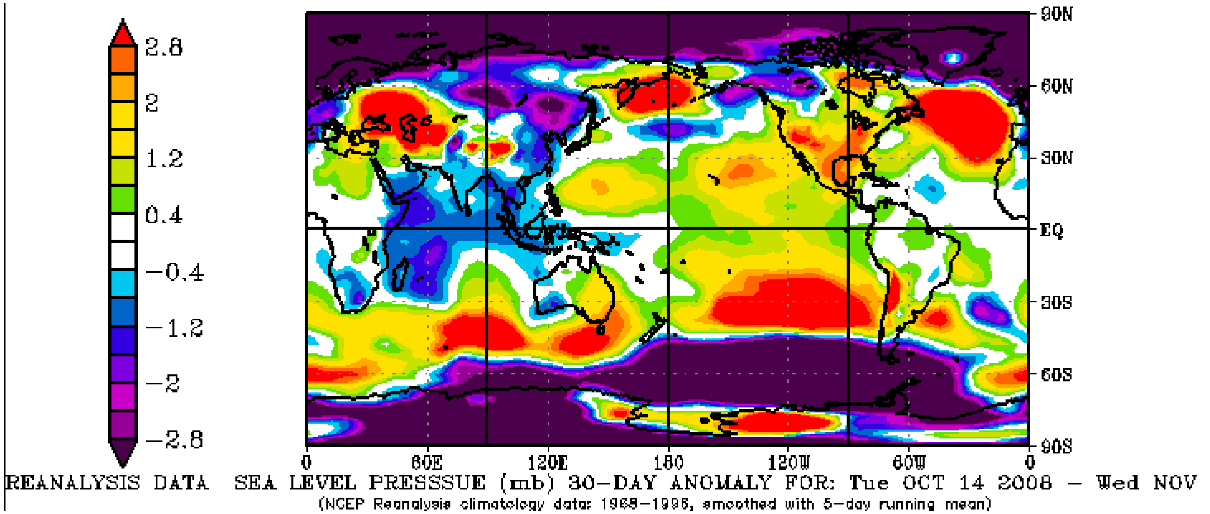
The significant synoptic-scale variability is associated with cyclone waves and baroclinic instability in both the subtropical and the subpolar jet (which are not always distinguishable in this period). Anticyclonic wave-breaking is observed accompanied by large upper-level PV anomalies; on one occasion, Oct 22-25, this directly controls the circulation at 20S.

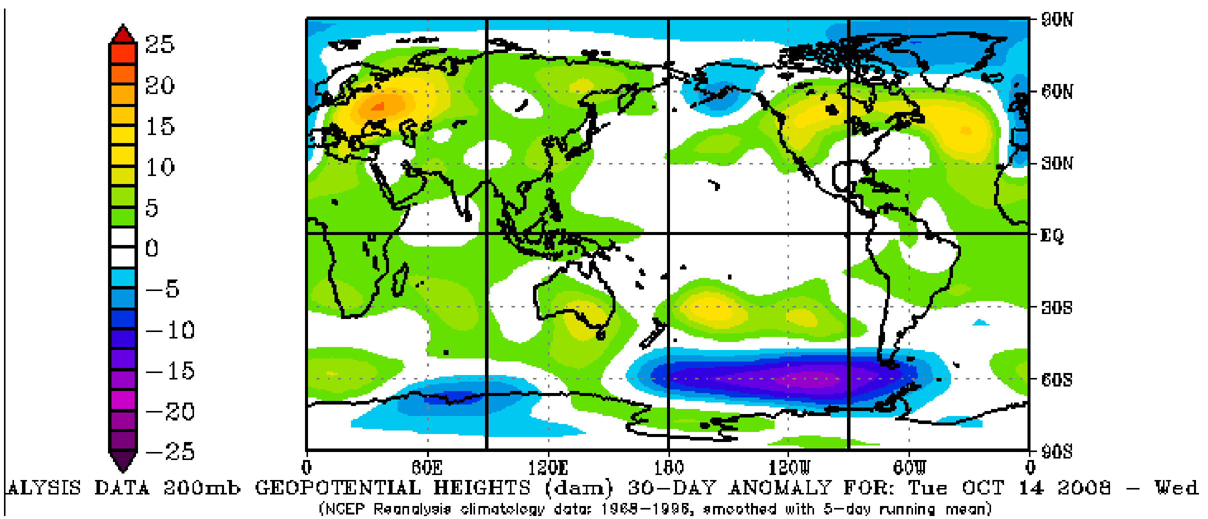
Period 1 teleconnections: the strength of the anticyclone

In October, the surface flow was exceptionally strong.

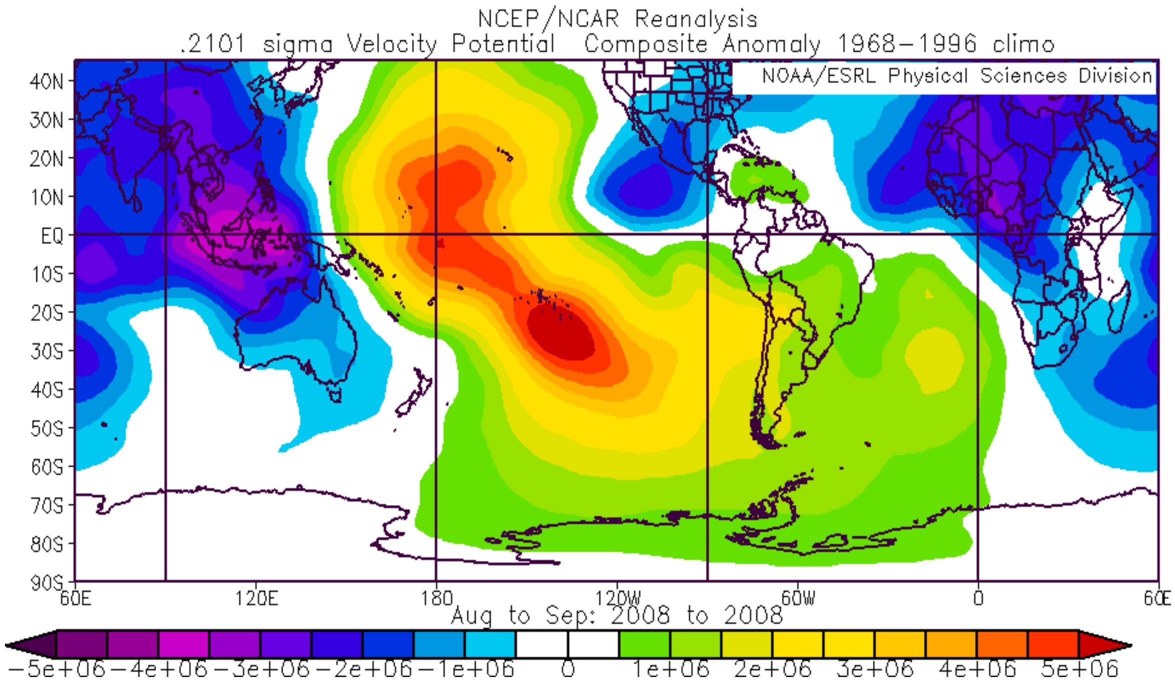
The anomaly was associated with a equivalent barotropic height anomaly, with a zonal-mean dipole signature across the subpolar jet stream.

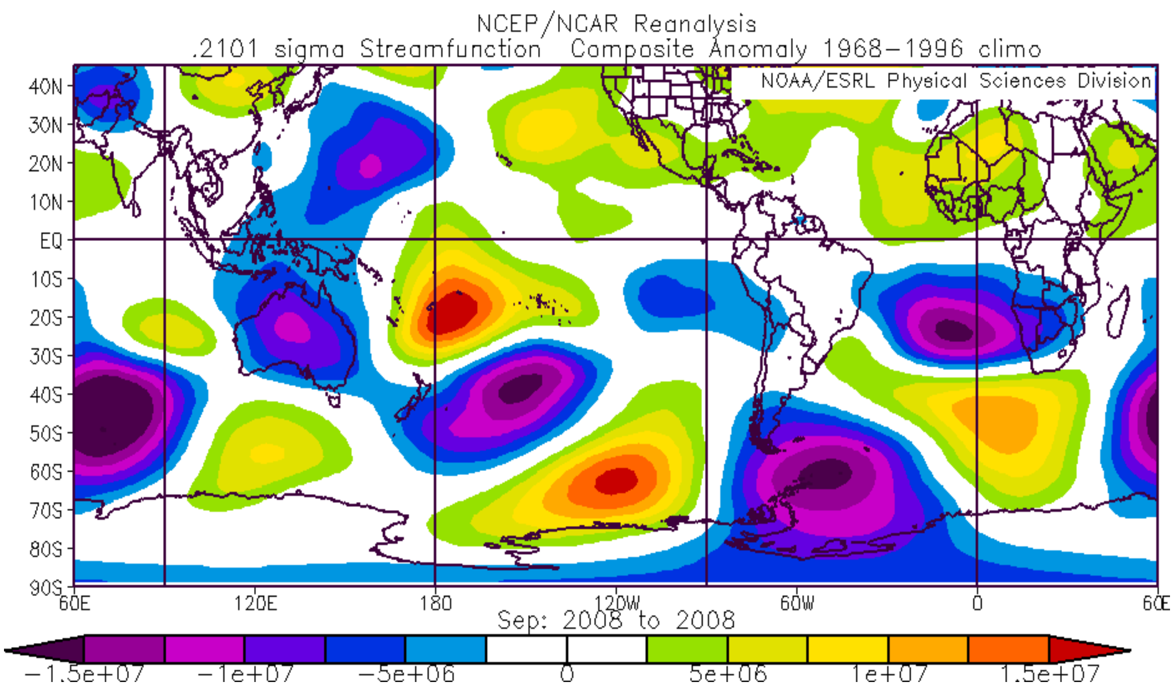
The anomalous meridional distribution of zonal-mean zonal momentum suggests role for eddy transport in setting up and maintaining these conditions



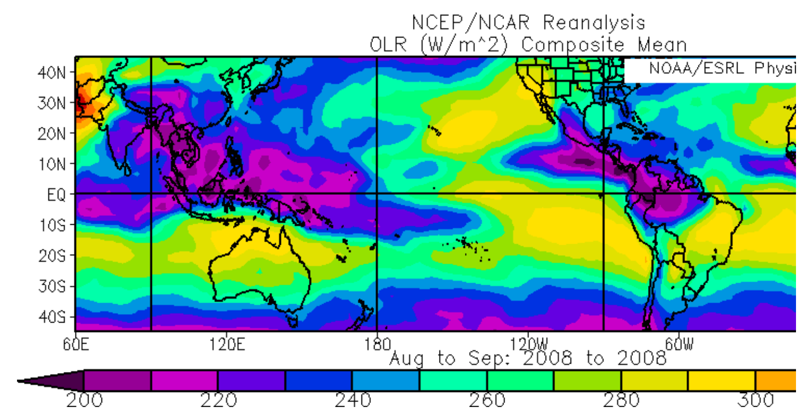


Period 1

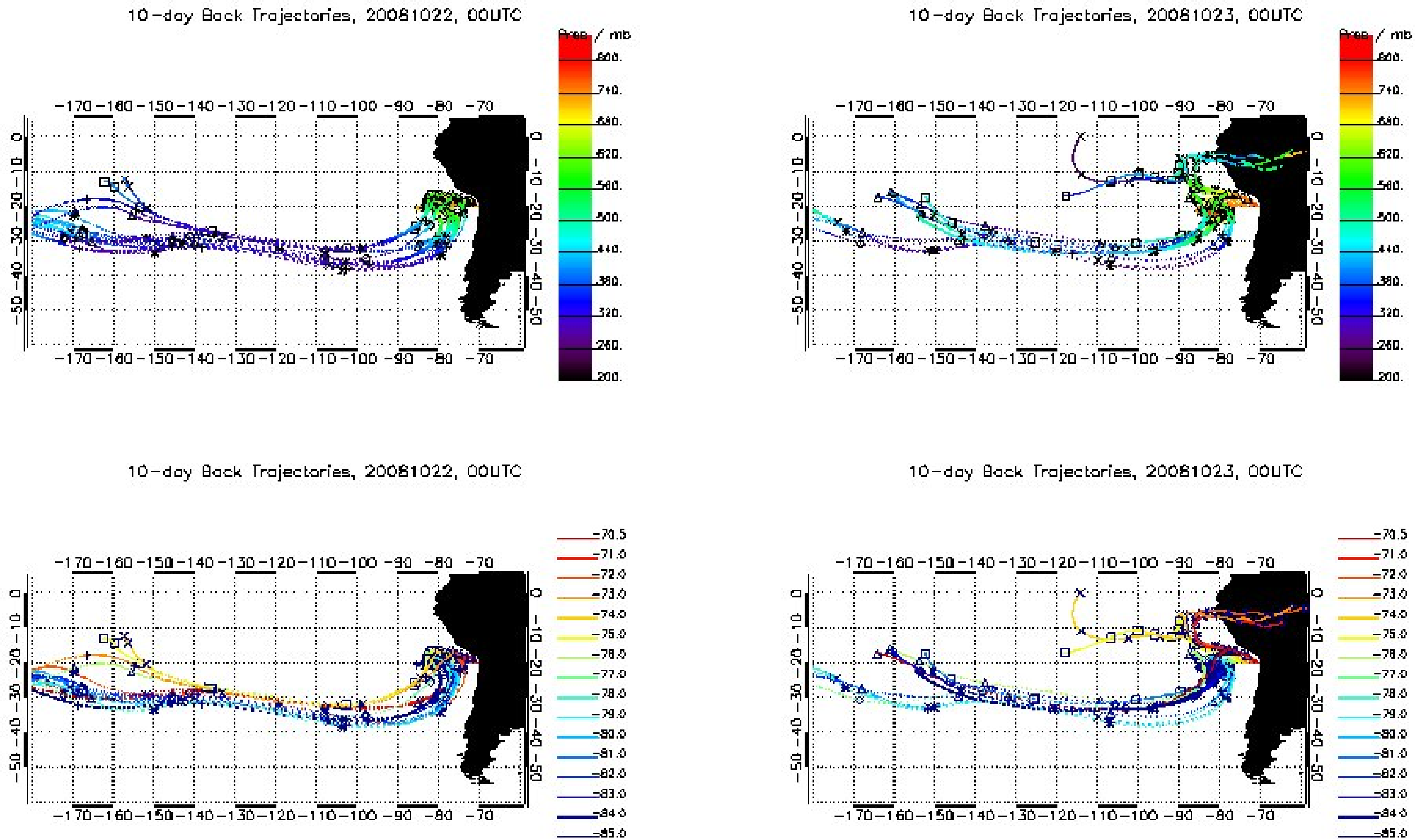




Initially (Aug-Sep) associated with wavetrain from anomalous upper-level divergence in East IO at the end of the SW Monsoon season.

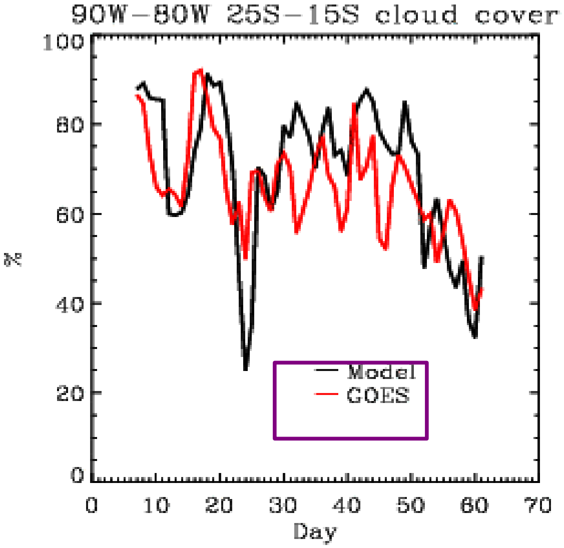


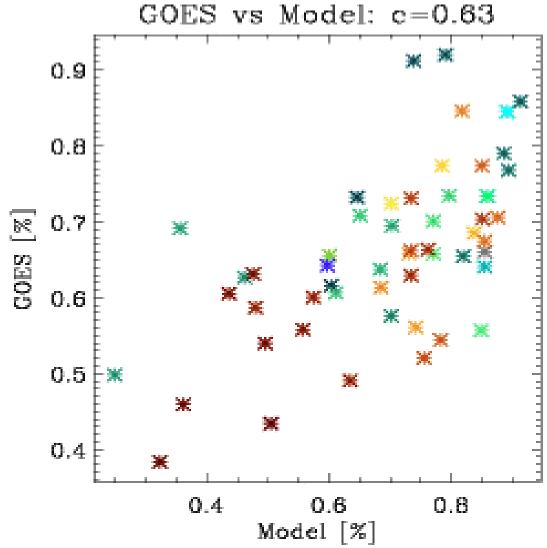
10-day back-trajectories into 20S

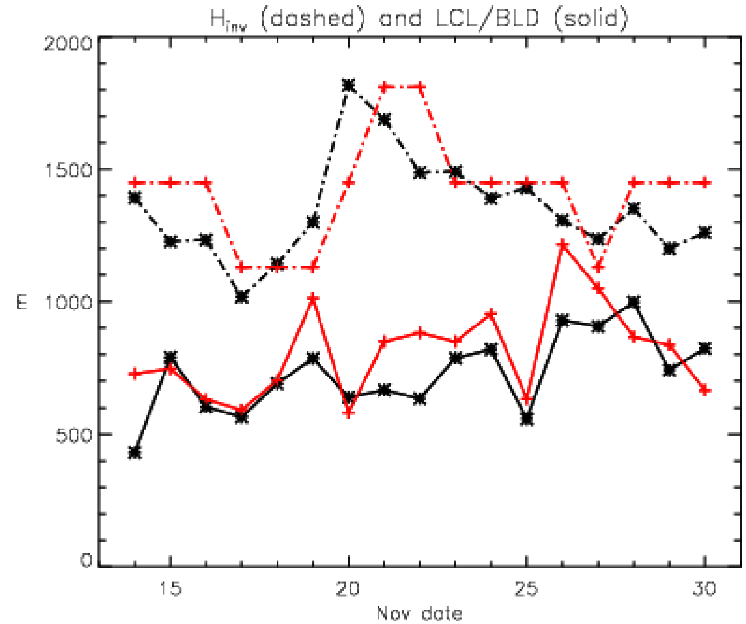


Back trjectories in **Period I** mostly show rapid advection along the jet stream, with very fast descent onto the VOCALS-REx area along the sloping isoentropes of the subpolar front. Between Oct 19 and Oct 25, however, air from the SA anticyclone is entrained in the CL, and advected into the area. This appears to follow from the formation of a mid-level cut-off high moving offshore in the precending days, similar to the longer-lived case that characterises Period II.

Controls on cloud cover

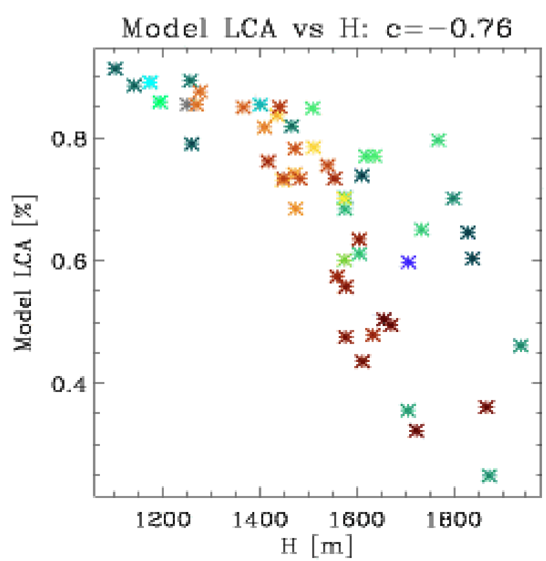


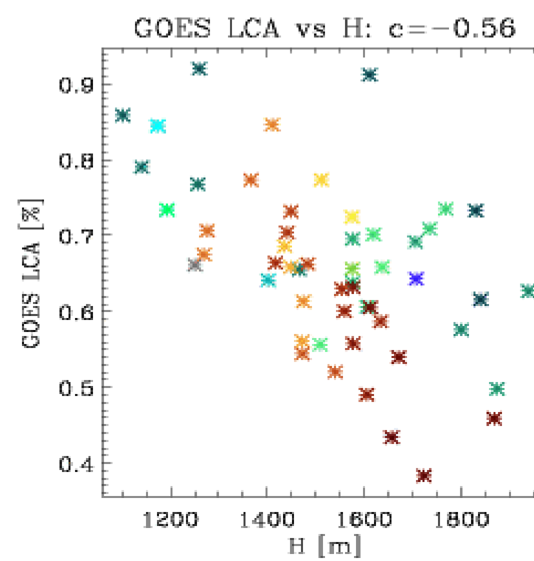




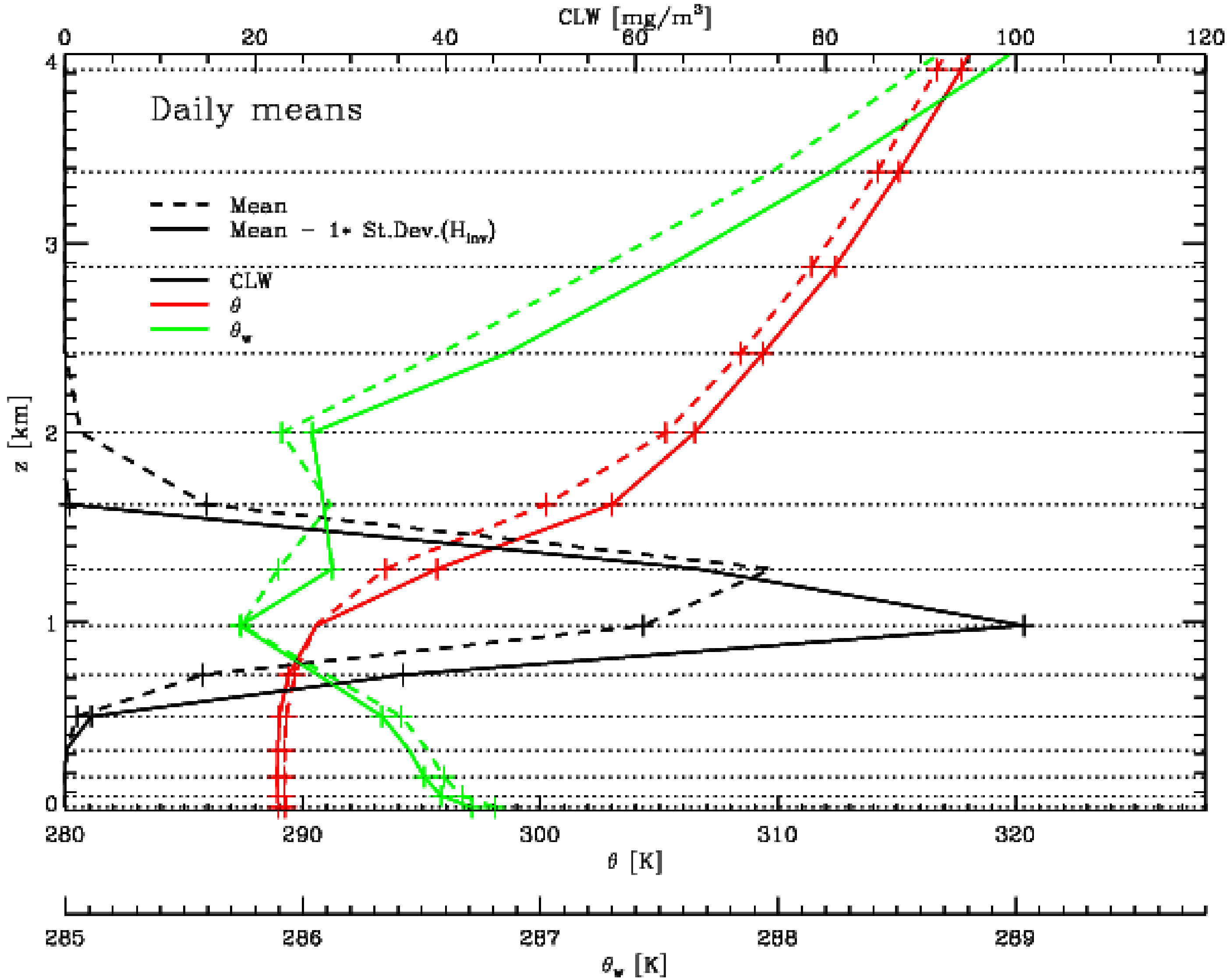
The UKMO operational model gives a useful representation of the observed low cloud over maritime areas.
The simulated inversion height is consistent with soundings.

Strong anticorrelation of cloud with **height of the inversion** [diagnosed as height where d(theta)/dz is maximum]. PBL depth not well correlated.

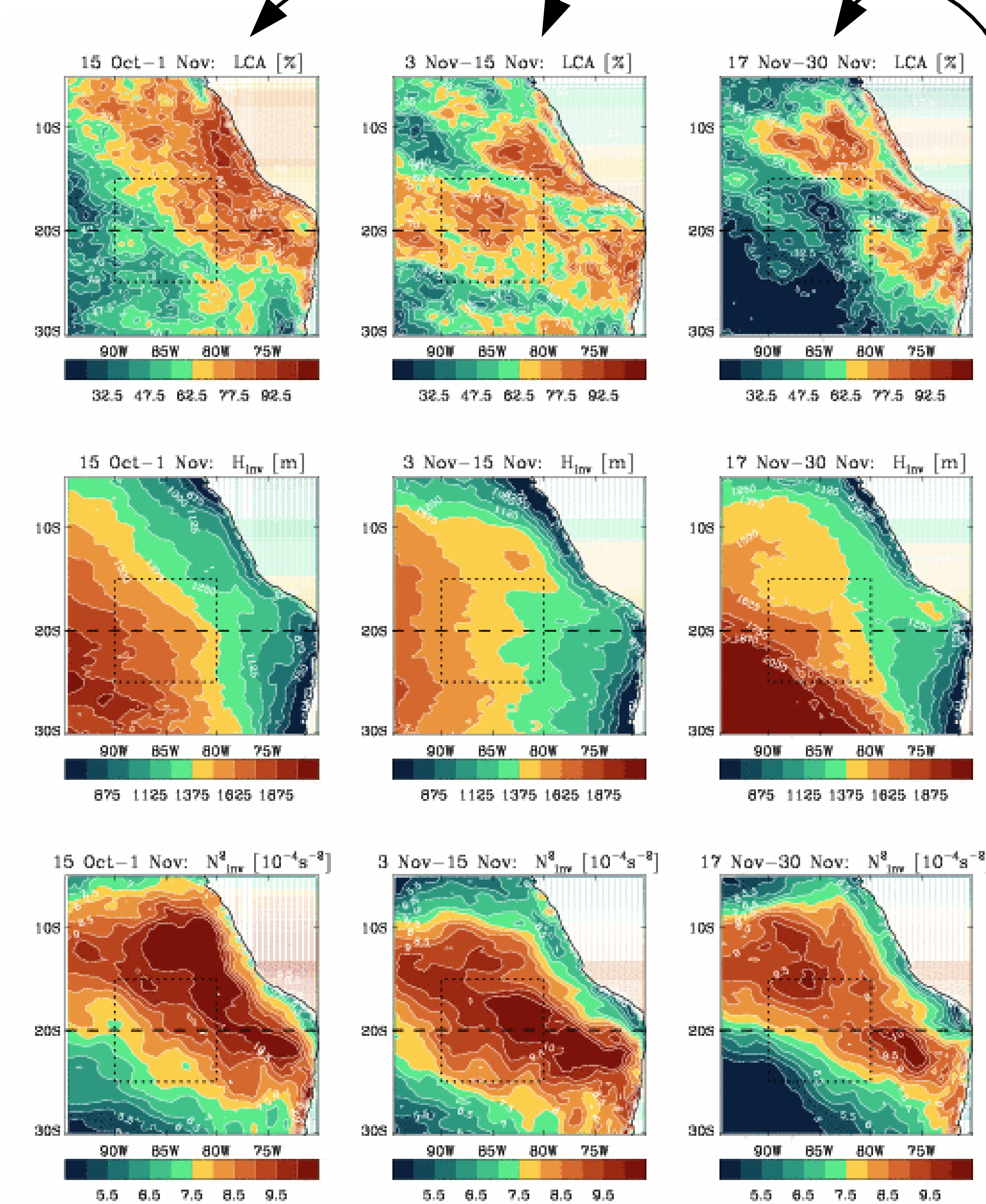




Increased Sc tend to correspond with low, sharp inversion, warm FT and cool PBL

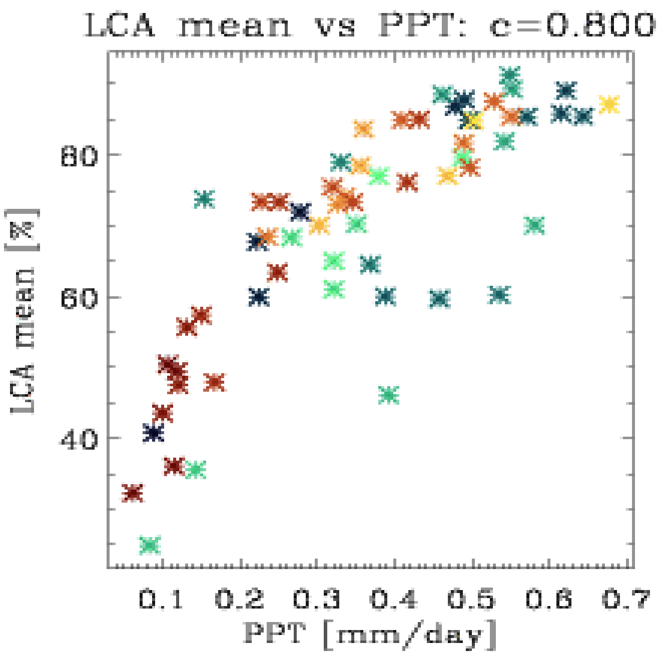


The PBL top characteristics in the three „regimes“



- Period I: high mean cloud cover near the coast, moderate to low in the maritime area (80W-90W, 15S-25S, used as a reference also in subsequent plots). The height, slope and strength of the inversion is moderate.
- Period II: very high cloud cover over maritime area and near the Chilean coast; low, flat, strong inversion.
- Period III: low c.c., and progressively less later. Weak inversion, and high, with large SW-NE gradient.

Model cloud and model precipitation.

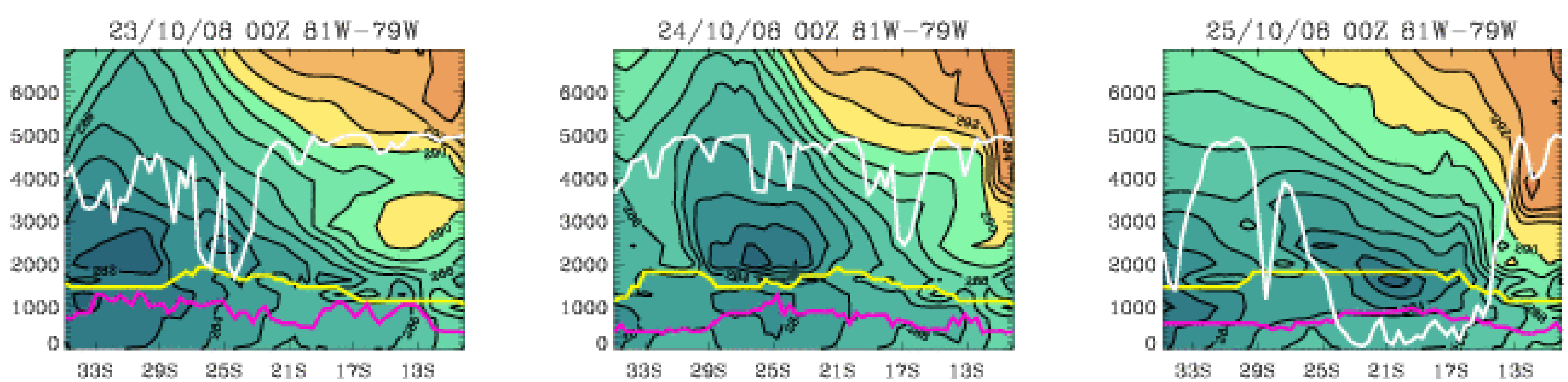


The model does not destroy cloud via drizzle or other cloud microphysical processe.

There is continuous, weak drizzle, proportional to CLW.

Cloud-top entrainment appears to be important. The inversion is often potentially unstable to mixing with the cloud layer ($d\theta_w/dz<0$).

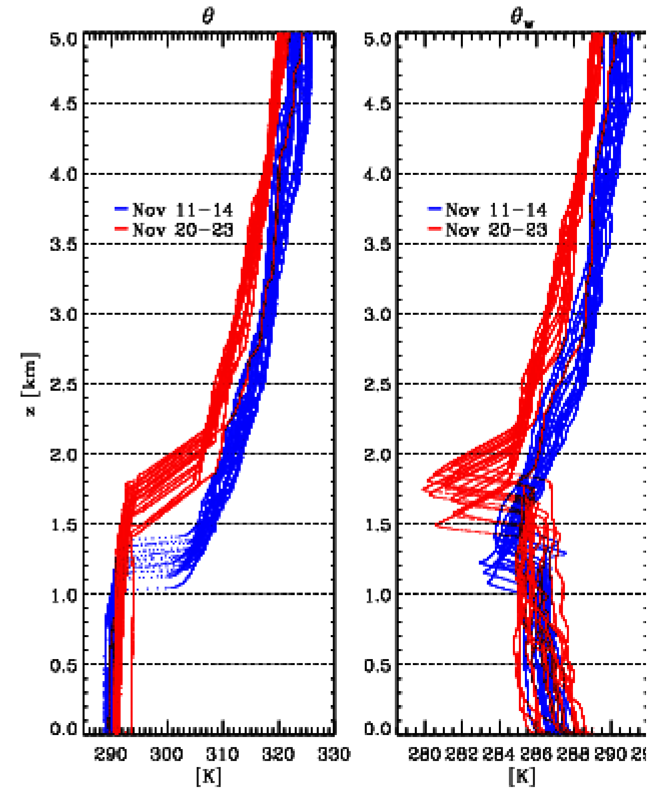
This maintains entrainment in balance with FT subsidence, but sudden dynamic lofting of the inversion can cause the cloud layer to decouple, cut off its PBL moisture supply, and be mixed away. Oct 23-25 exemplifies this.

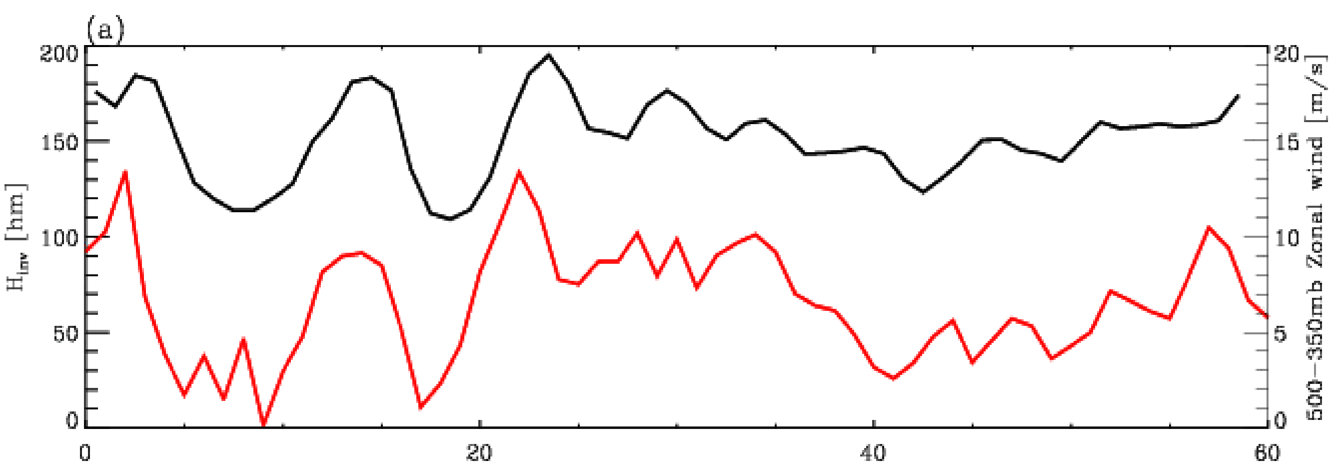


Synoptic controls on inversion height

There appears to be a preferred location of the inversion:

- The FT has a T profile close to moist-adiabatic
- The PBL is nearly dry-adiabatic
- For entrainment to be effective, $\Delta\theta_w<0$ is required across the inversion
- If $\Delta\theta_w>0$ (absolute stability), entrainment tends to be reduced and the inversion tends to sink
- $\Delta\theta_w$ large and negative will cause large mixing rates, and favour PBL deepening
- The point $\Delta\theta_w=0$ sinks as the FT warms, or the PBL cools (adiabatic displacements in the vertical have the opposite effect)





Both cool FT and warm PBL favour a high inversion and low cloud cover; but FT changes appear more important than the PBL. Strong correlation with FT heights

Summary

- The synoptic and large-scale flow during VOCALS-REx has been documented from operational reanalysis data
- At least three different types of general conditions were encountered which were associated with different properties of the low-level cloud field
- Even without a representation of cloud microphysics and aerosol processes, UKMO operational forecasts capture the regional changes in cloud cover
- These are associated with synoptic-scale forcing, much of it from the variability of the jet streams, and display large-scale teleconnections
- This association may be understood in terms of the local physics associated with cloud-top entrainment and the constrains arising from mass- and energy conservation