The (dynamically-driven) diurnal cycle in the SEP

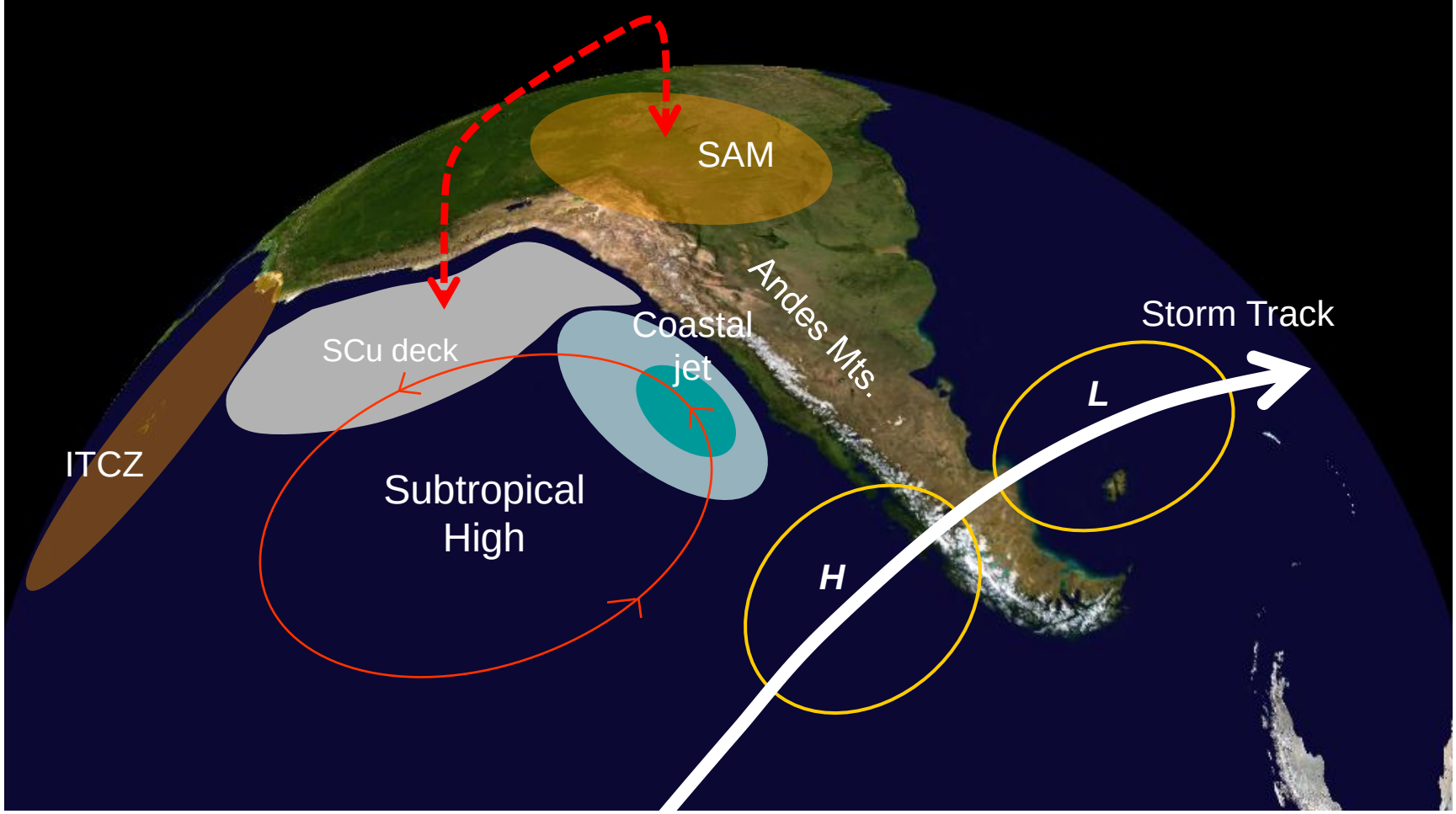
* Does it exist?
* Does it impact clouds?

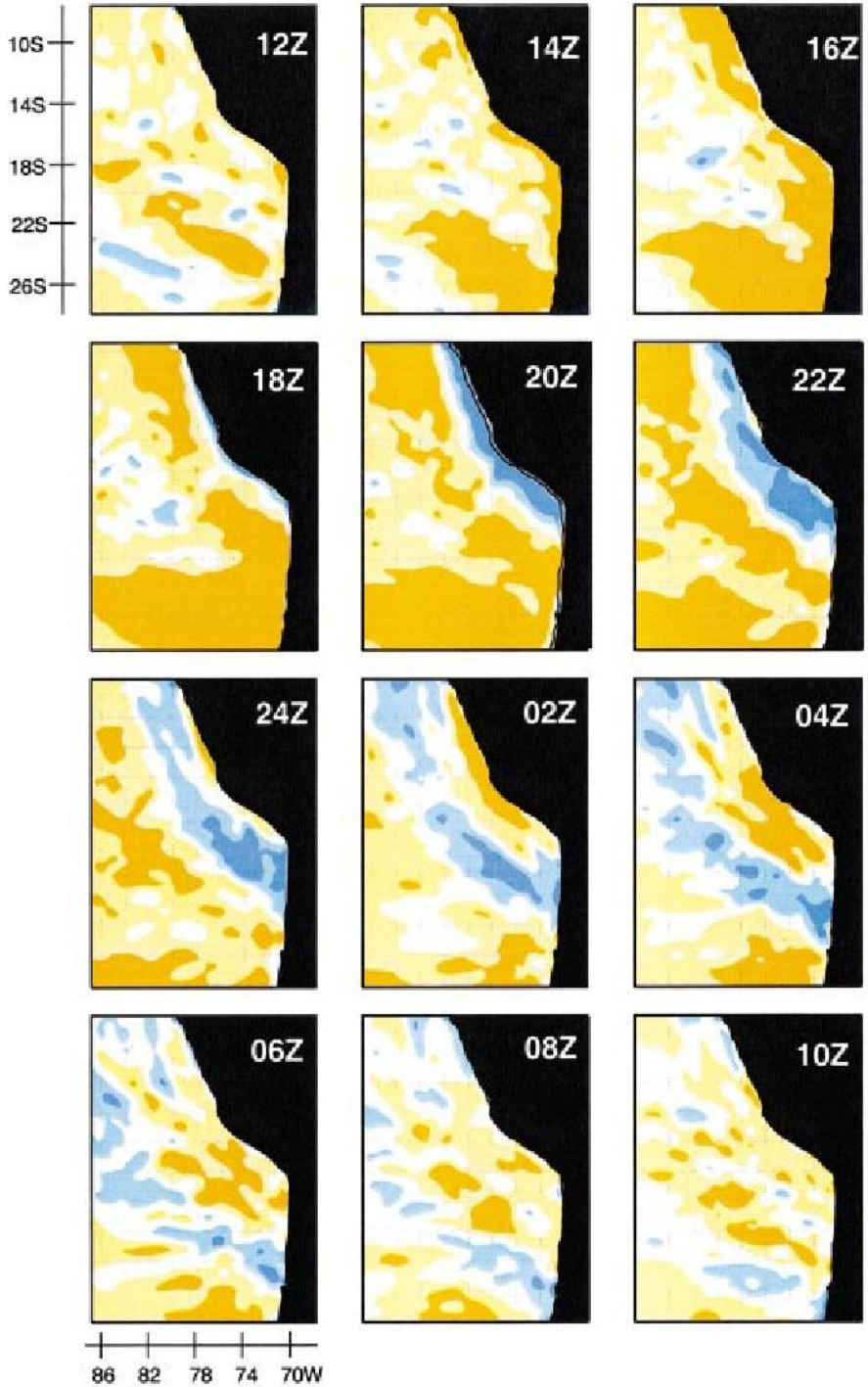
René D. Garreaud, Ricardo Muñoz,
Dave Rahn and José Rutllant

Department of Geophysics
Universidad de Chile

Key atmospheric features over the SEP

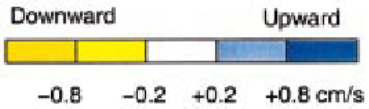
VAMOS: Dynamical link between South American Monsoon and SEP, first suggested by Gandau and Silva-Dias (1998)





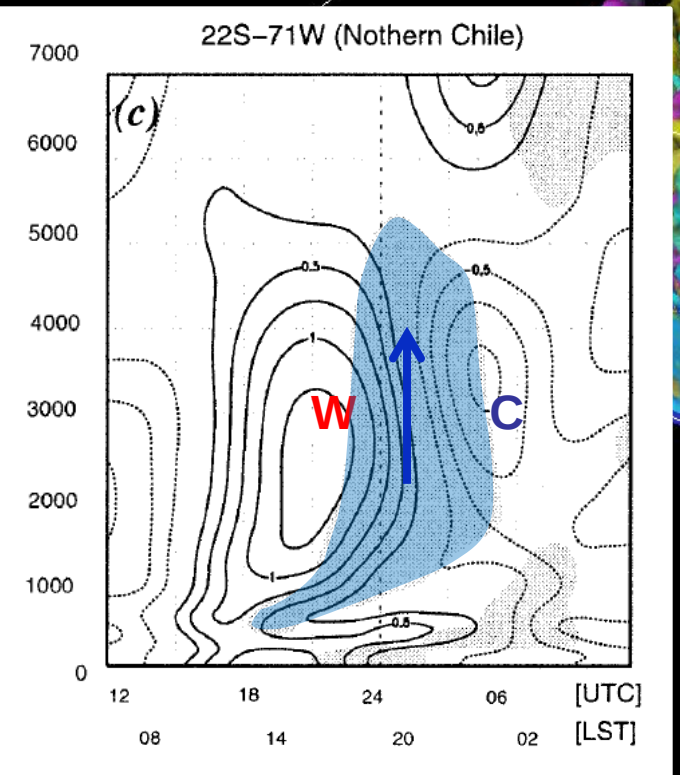
MM5 results SON simulation

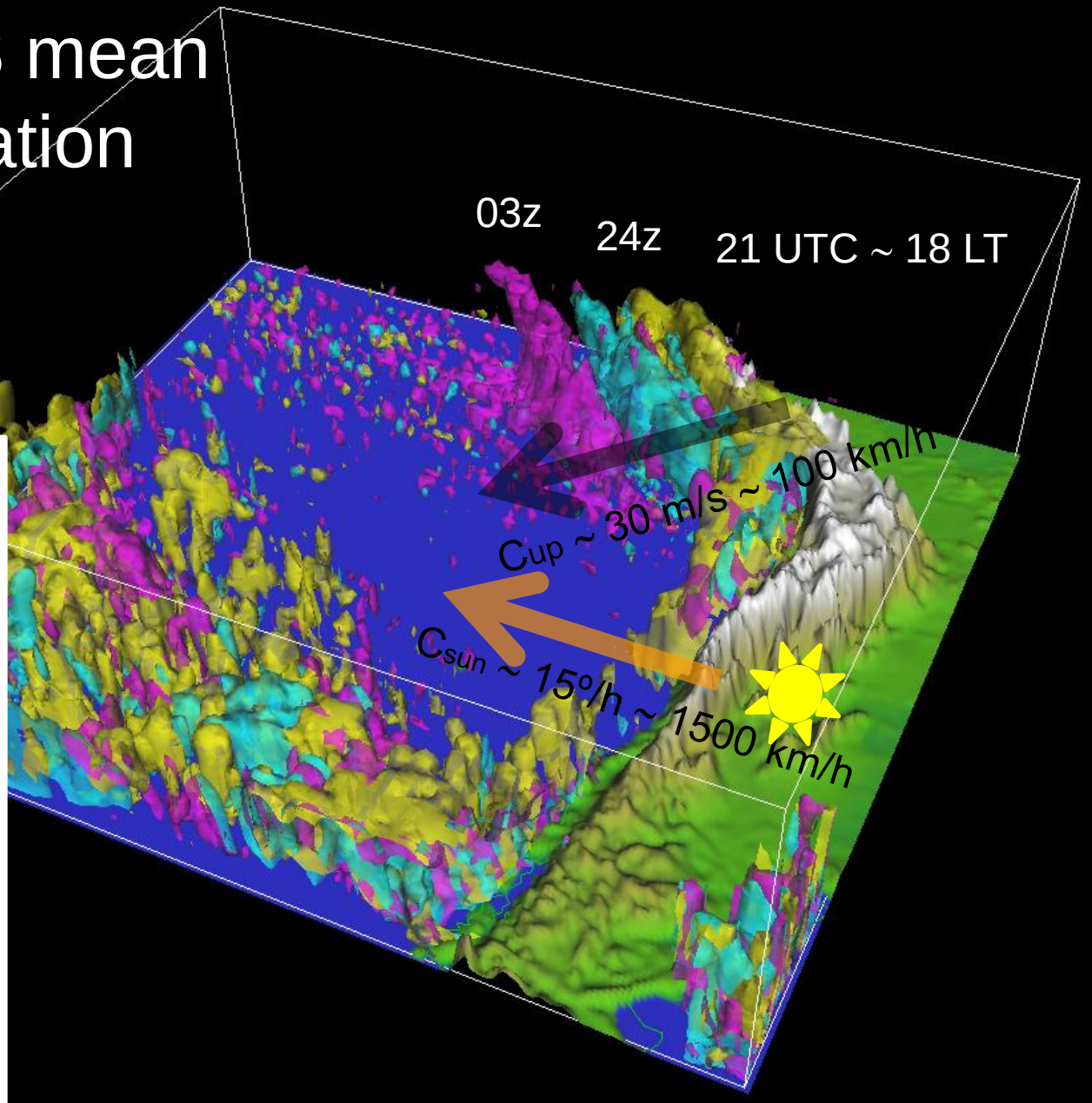
◄ Mean diurnal cycle of vertical velocity at 800 hPa



Garreaud and Muñoz 2004

Isosurface w < -0.1 mm/s
Oct-Nov 2008 mean
WRF Simulation

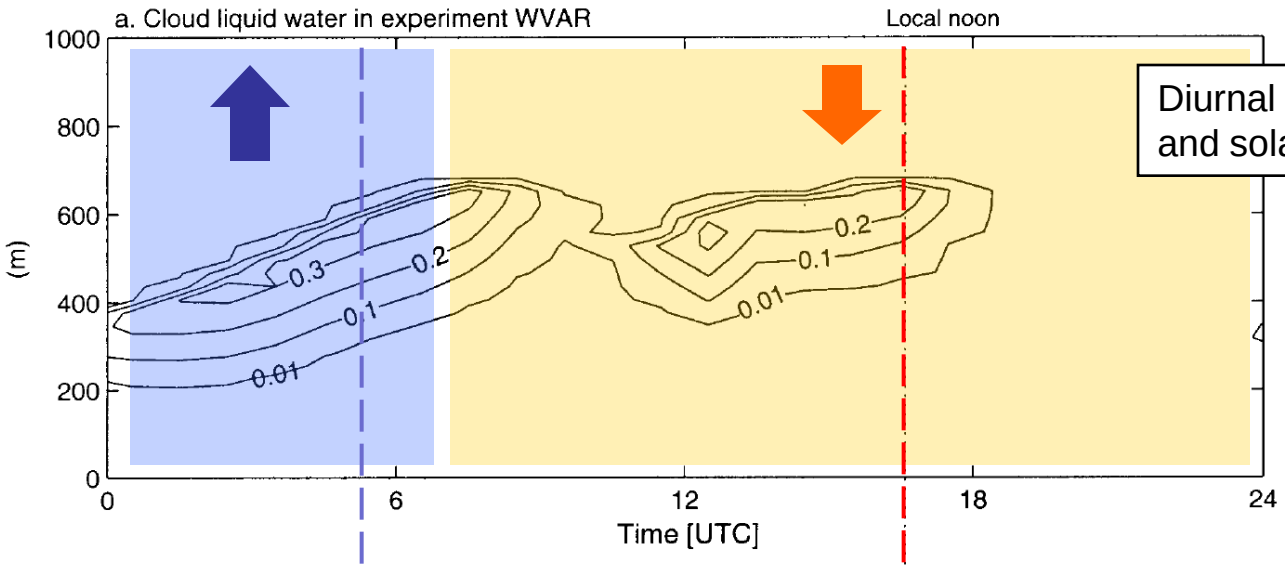




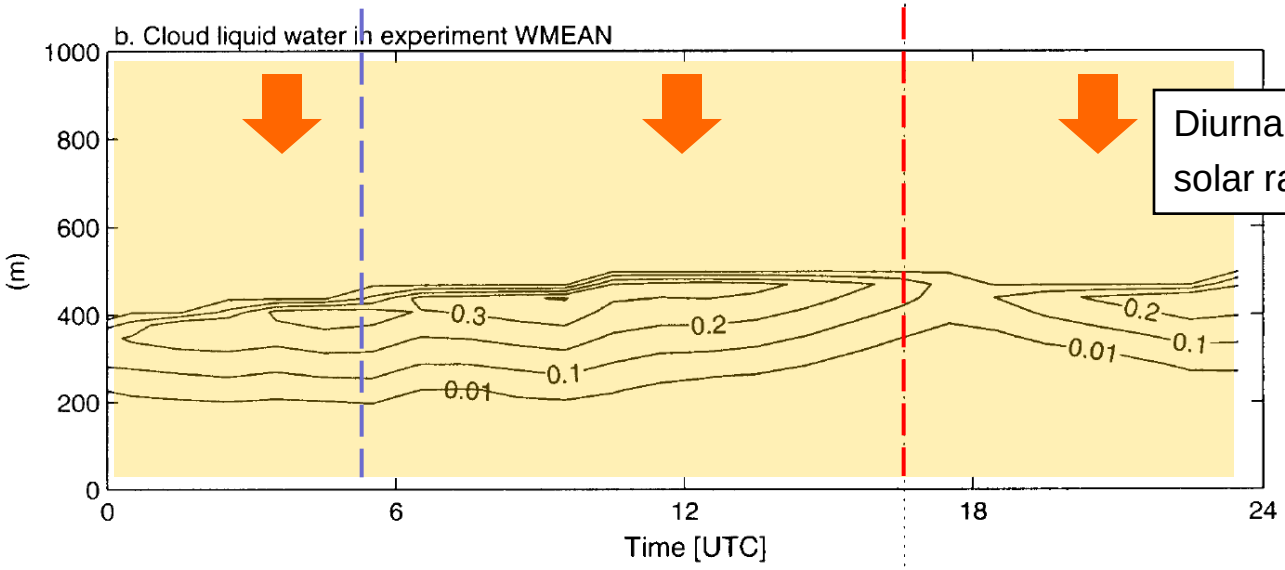
MM5-1D Experiments (no advection)

Impact dependent on location / interference with solar cycle

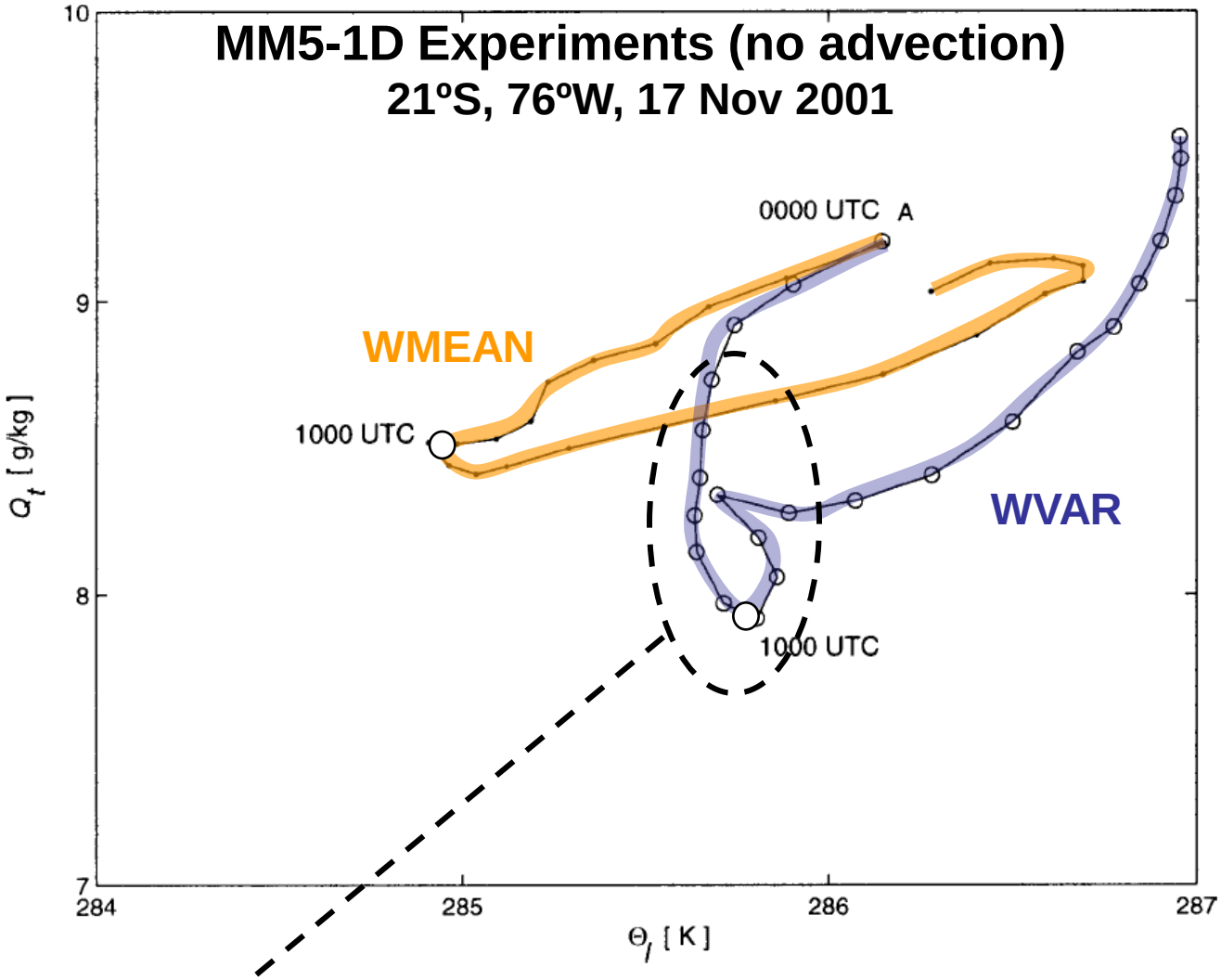
21ºS, 76ºW, 17 Nov 2001



Diurnal cycle in *w* and solar radiation



Diurnal cycle in solar radiation only

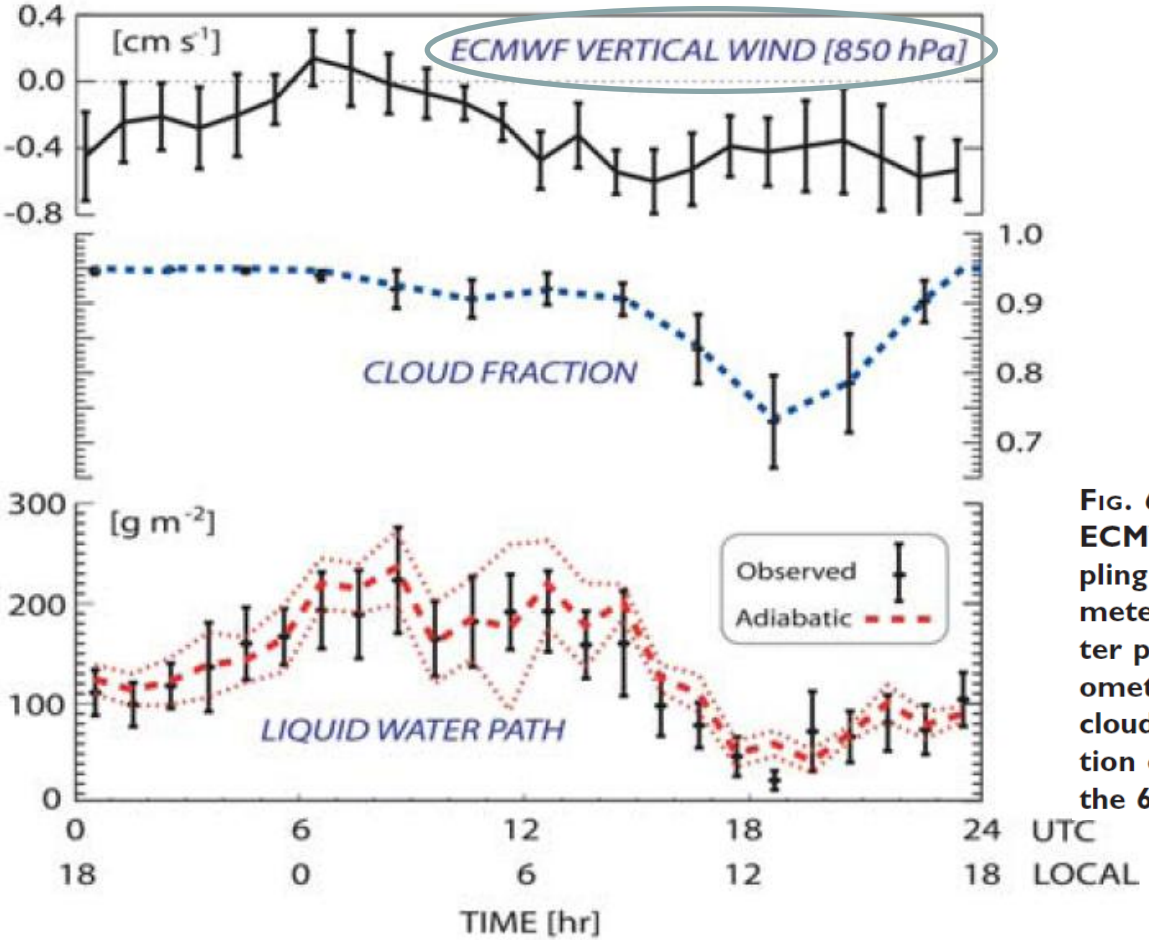


Significant drying (and little cooling) during nighttime hours when upsidence prevails. Larger entrainment at the top of a deeper MBL. (W_{LS} influence the size of the eddied).

THE EPIC 2001 STRATOCUMULUS STUDY

BAMS 2004

BY CHRISTOPHER S. BRETHERTON, TANEIL UTTAL, CHRISTOPHER W. FAIRALL, SANDRA E. YUTER,
ROBERT A. WELLER, DARREL BAUMGARDNER, KIMBERLY COMSTOCK, ROBERT WOOD, AND GRACIELA B. RAGA



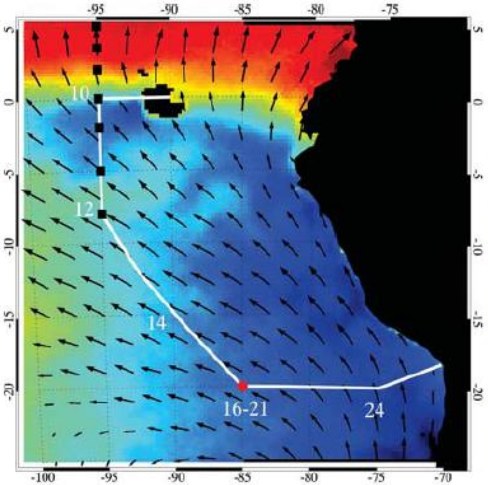
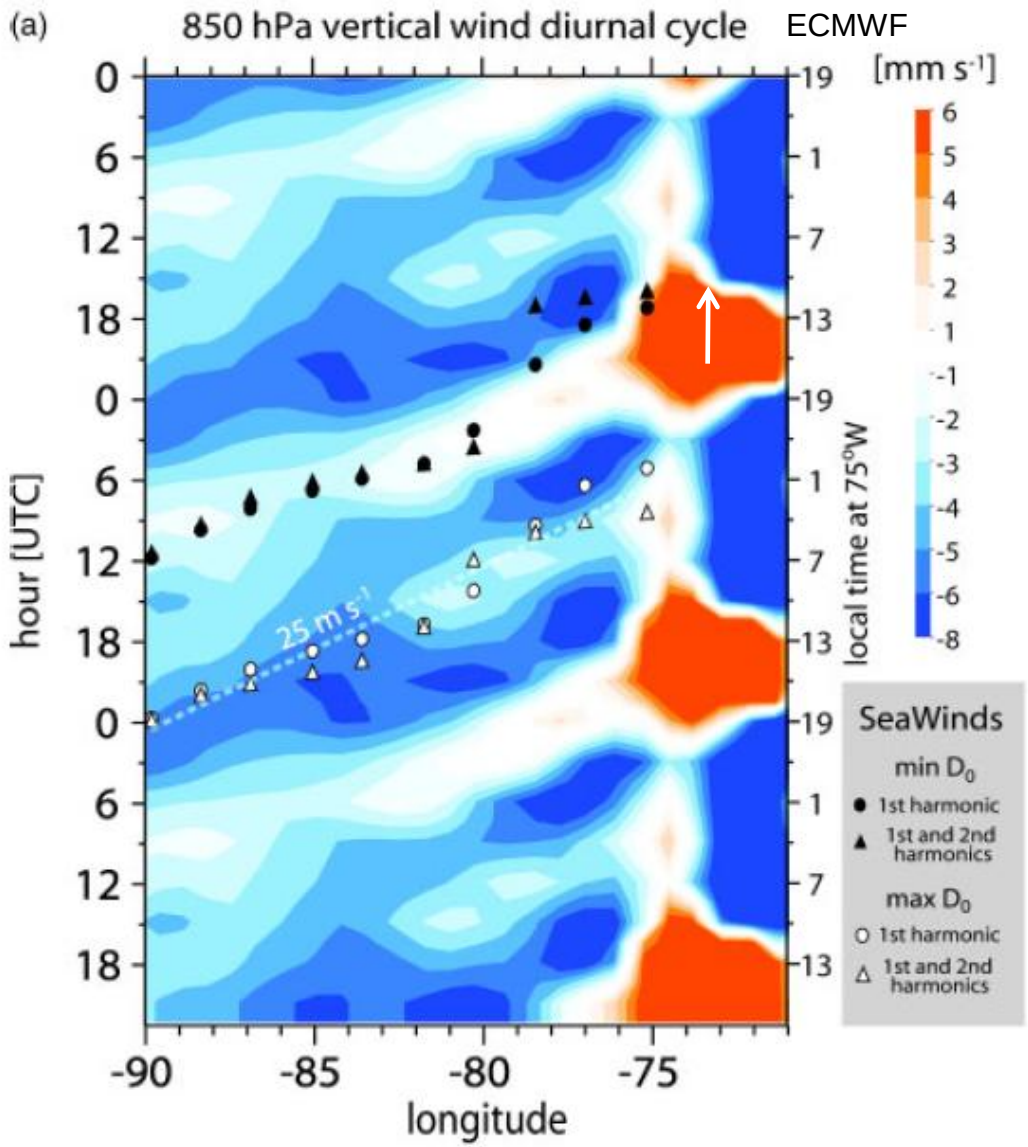


FIG. 6. The buoy-period mean diurnal cycle of (top) ECMWF-predicted vertical velocity from hourly sampling of 12–36-h operational forecasts, (middle) ceilometer-derived cloud fraction, and (bottom) liquid water path derived from the shipboard microwave radiometer, and adiabatic liquid water path derived from cloud thickness. Vertical bars show the standard deviation of hourly average values on individual days from the 6-day hourly mean.

The diurnal cycle of surface divergence over the global oceans

QJRMS 2009

R. Wood,[a*] M. Köhler,[b] R. Bennartz[c] and C. O'Dell[c]



Marine boundary layer over the subtropical southeast Pacific during VOCALS-REx – Part 1: Mean structure and diurnal cycle

ACP 2010

D. A. Rahn and R. Garreaud

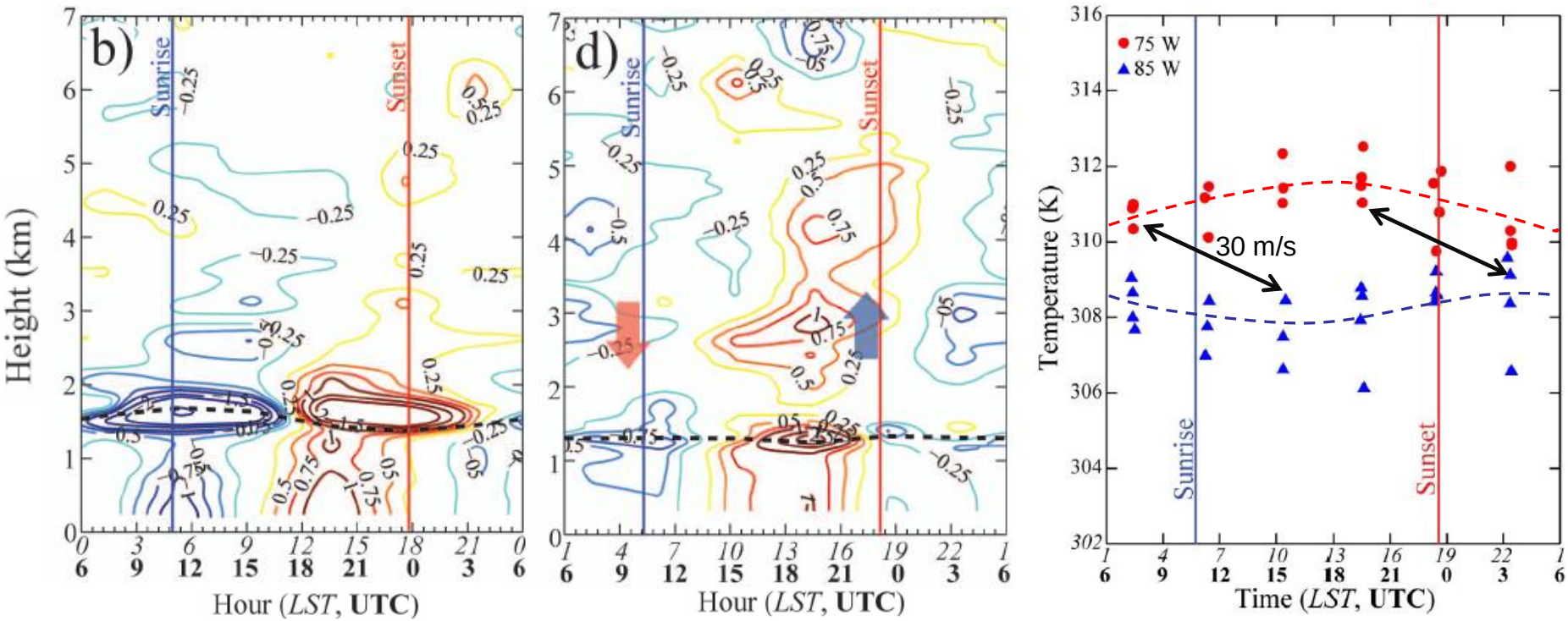
R/B Soundings during VOCALS-REx (add all Stratus Cruises!!!)

θ' hourly departure from 3-day mean

θ at 2.5 km

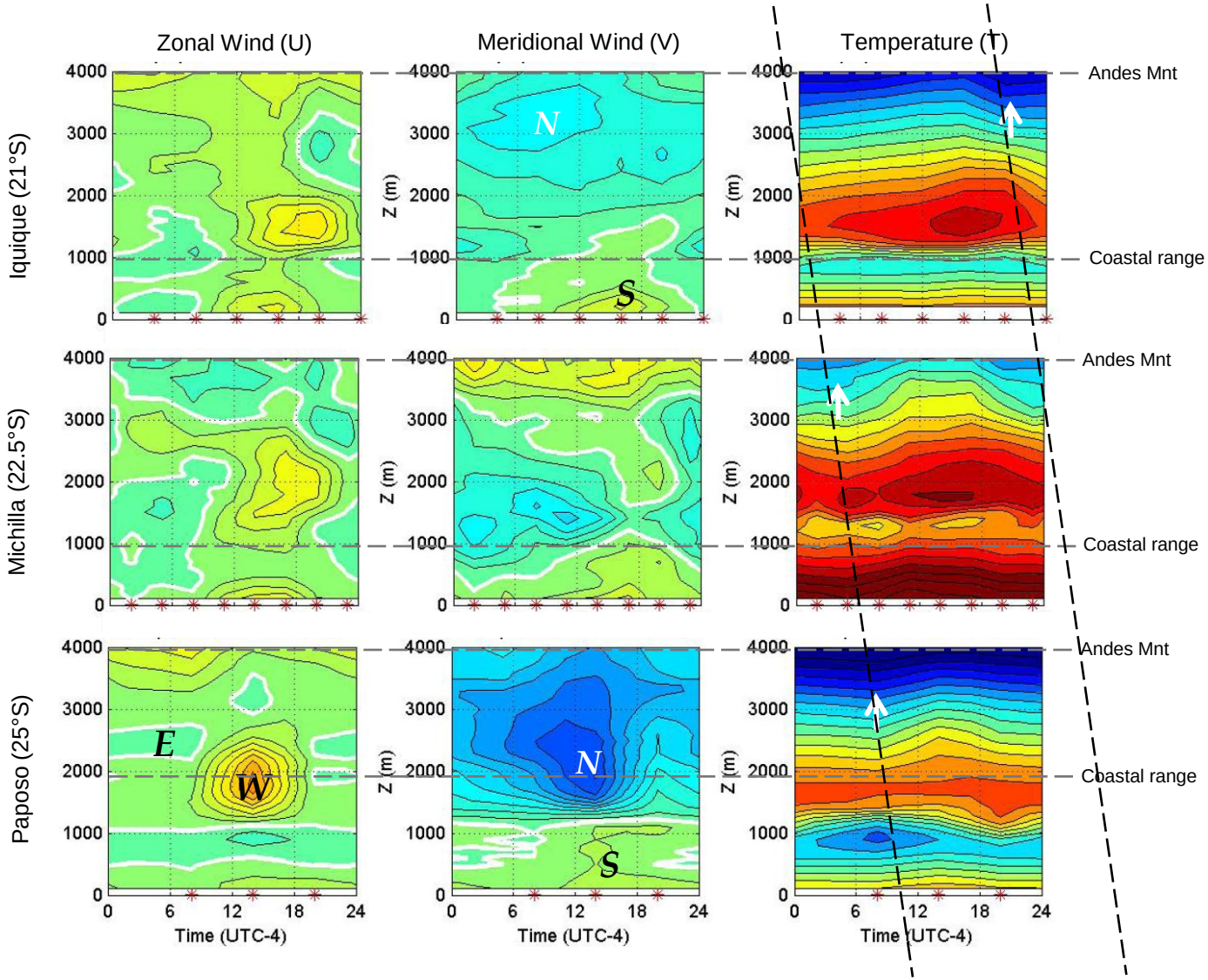
20ºS 85ºW

20ºS 75ºW



Observed coastal diurnal cycles

Paposo & Iquique: VOCAL-REx (Oct-Nov 2008)
Michilla: DICLIMA (January 1998)



Stratocumulus Cloud-Top Height Estimates and Their Climatic Implications

PAQUITA ZUIDEMA AND DAVID PAINEMAL
SIMON DE SZOEKE CHRIS FAIRALL

JClim 2009

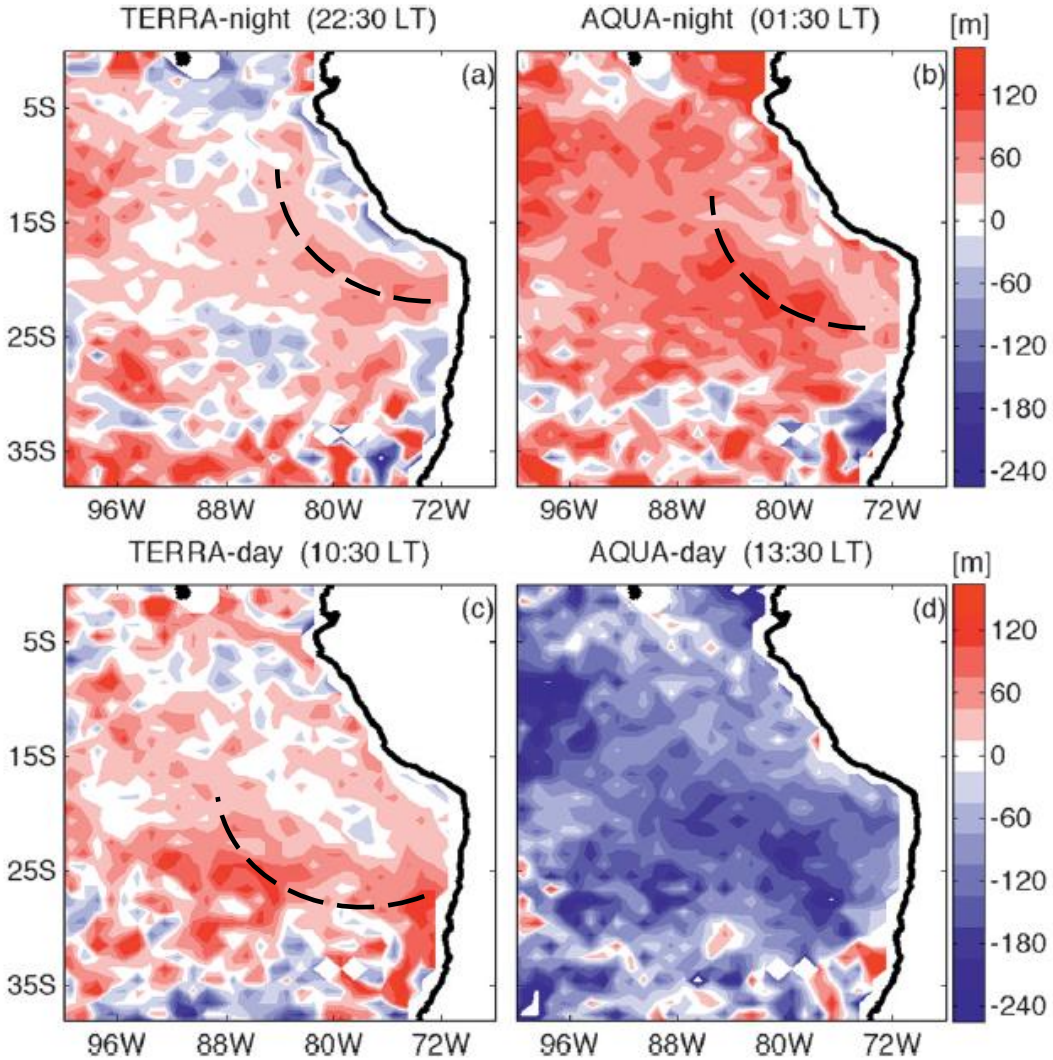
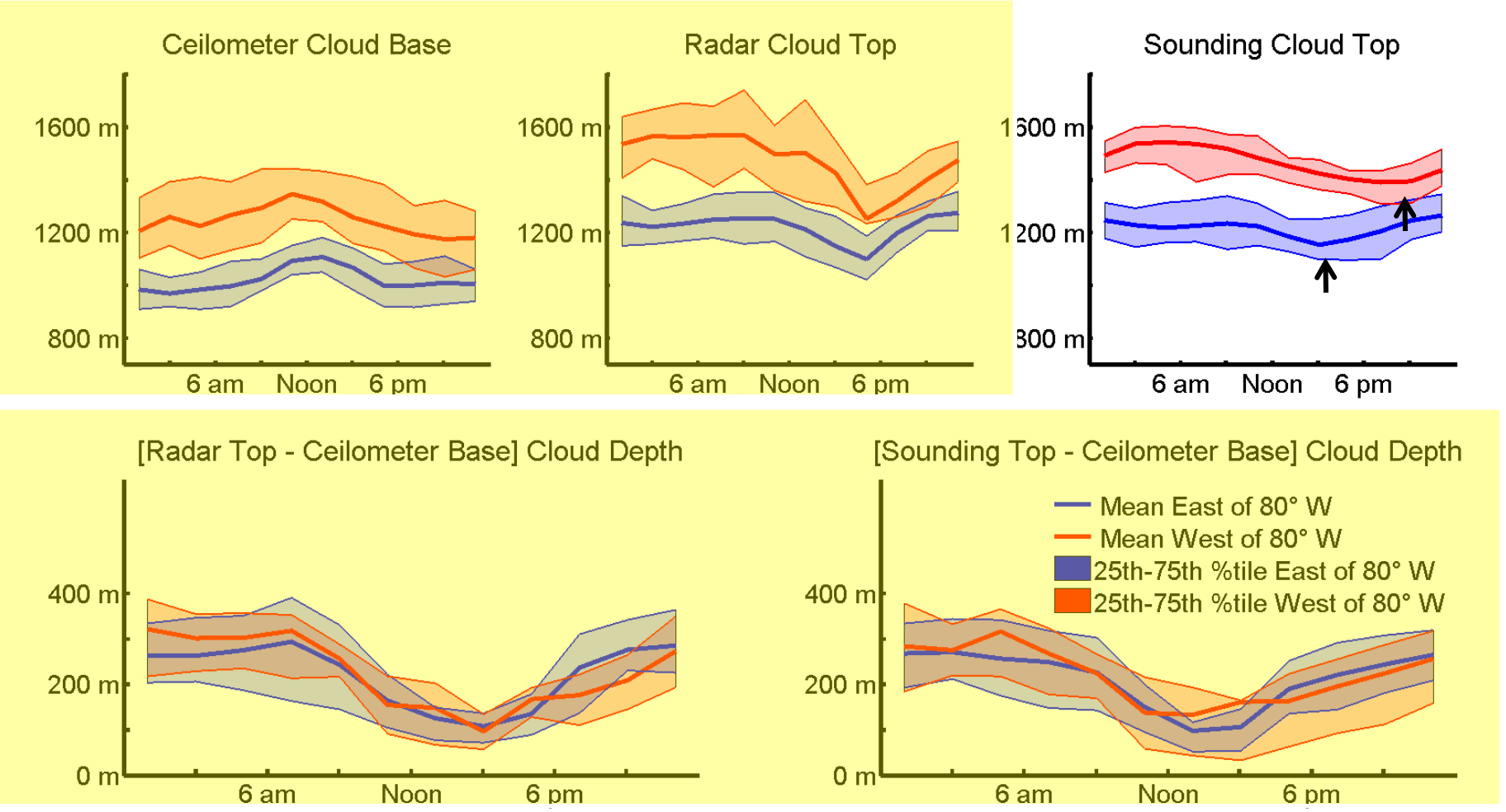


FIG. 10. Same as in Fig. 9, but here cloud-top heights are plotted as the anomaly from the 4-times-daily mean, and cloud fraction is not shown. The panels correspond to (a) *Terra* night, at 2230 LT, (b) *Aqua* night, at 0130 LT, (c) *Terra* day, at 1030 LT, and (d) *Aqua* day, at 1330 LT.

Observations of the Diurnal Cycle of Marine Stratocumulus Clouds and Precipitation

Casey Burleyson[1], Sandra Yuter[1], and Simon de Szoeke[2]



Cloud Liquid Water Path from Satellite-Based Passive Microwave Observations: A New Climatology over the Global Oceans

JCim 2008

CHRISTOPHER W. O'DELL FRANK J. WENTZ RALF BENNARTZ

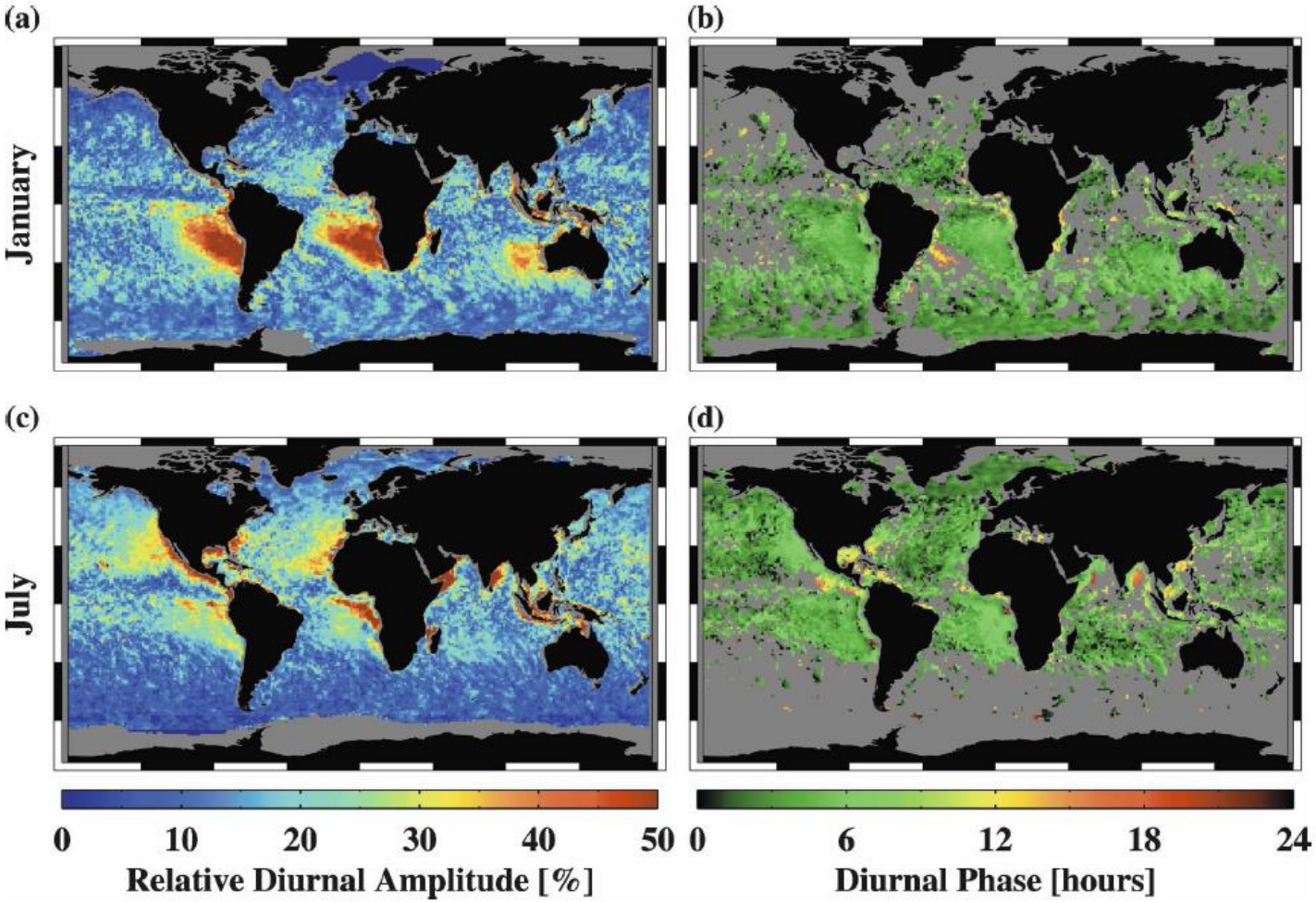


FIG. 10. Relative amplitude and phase of the diurnal cycle in the months of January and July. The diurnal cycle phase is the local time of maximum LWP. Black pixels denote land, while gray pixels denote missing data, from either the presence of sea ice or the close proximity of land; (b), (d) gray pixels also indicate locations without a well-defined diurnal maximum in LWP.

Cloud Liquid Water Path from Satellite-Based Passive Microwave Observations: A New Climatology over the Global Oceans

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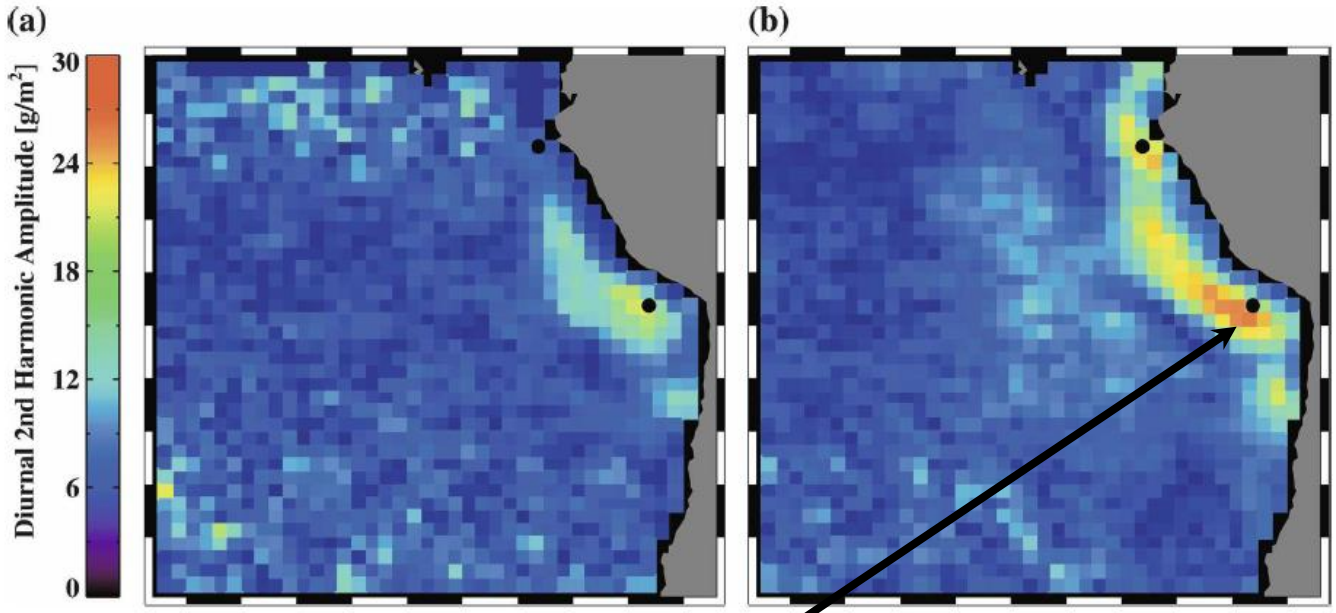
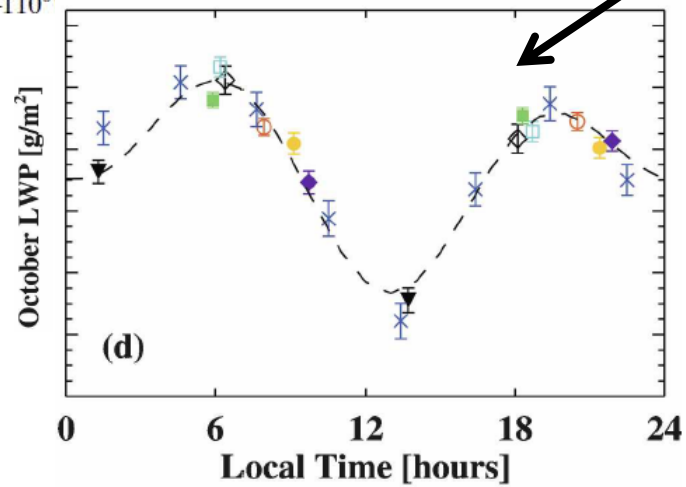


FIG. 11. Map of the amplitude of the second harmonic of the diurnal cycle for a region off the coast of South America for the months of April and October. The plotted region extends from the equator to 40°S, 70°–110°



At this point, dominance of 12-h harmonic due to superposition of 24-h solar cycle and 24-h upsidence wave

From pre-VOCALS and VOCALS-REx data, the *upsidence wave* (propagating offshore from the Southern Peruvian / Northern Chile coast) has an impact in the diurnal cycle of:

* Mid-troposheric θ and *v*	Yes
* Surface divergence	Yes
* Cloud top height	Could be
* Cloud fraction	Could be
* Cloud LWP	???

Still pending origin of UpW….

A regional real-time forecast of marine boundary layers during VOCALS-REx

ACP 2010

S. Wang[1], L. W. O'Neill[2], Q. Jiang[1], S. P. de Szoeke[3], X. Hong[1], H. Jin[1], W. T. Thompson[1], and X. Zheng[4]

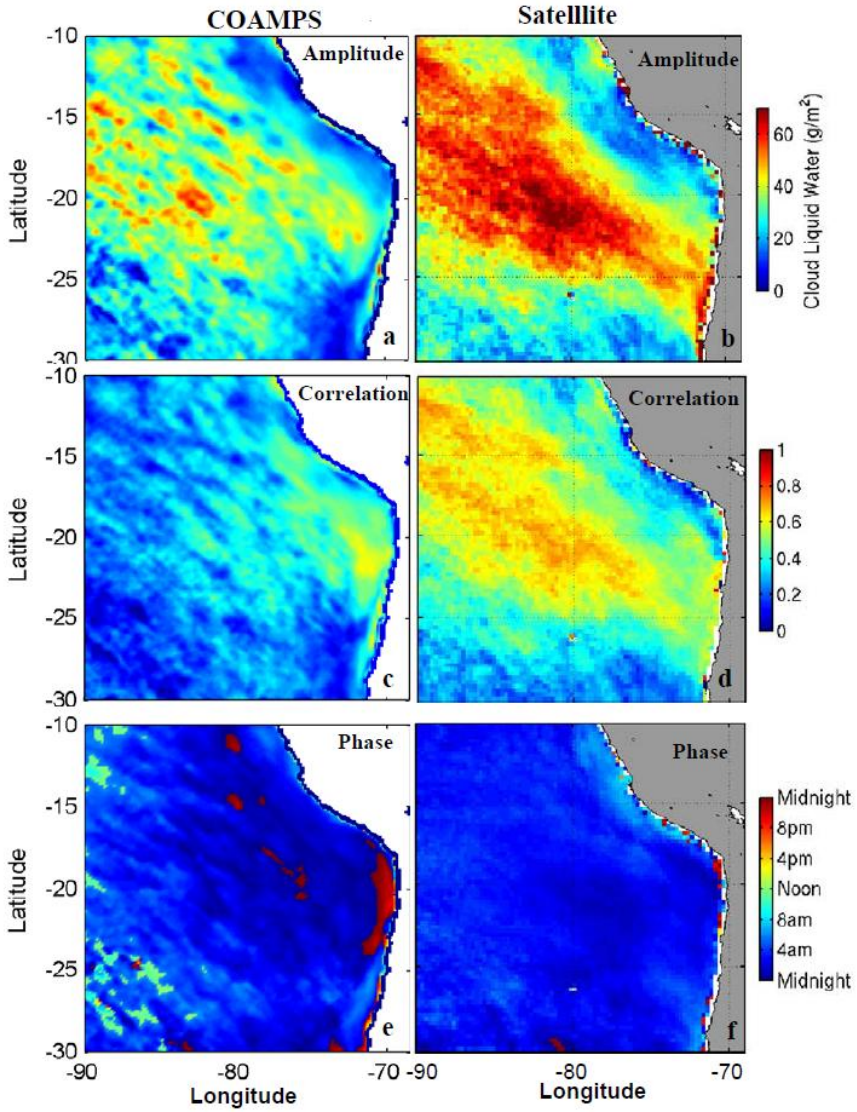


Fig. 4. Comparison of the harmonic analysis of LWP between the COAMPS forecasts (left column) and the satellite data (right column). **(a)** Predicted diurnal amplitude; **(b)** satellite diurnal amplitude; **(c)** correlation with the predicted harmonic diurnal function; **(d)** correlation with the satellite diurnal function; **(e)** local hours of the LWP maximum in the model; and **(f)** local hours of the LWP maximum in the satellite data.

Mixed-Layer Budget Analysis of the Diurnal Cycle of Entrainment in Southeast Pacific Stratocumulus

JAS 2005

PETER CALDWELL, CHRISTOPHER S. BRETHERTON, AND ROBERT WOOD

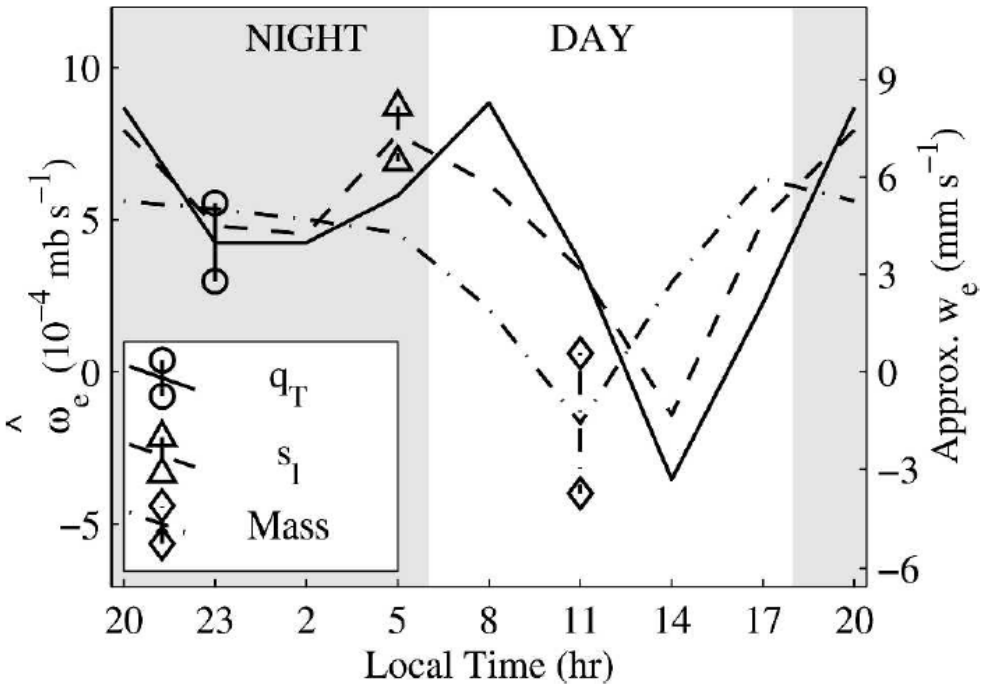
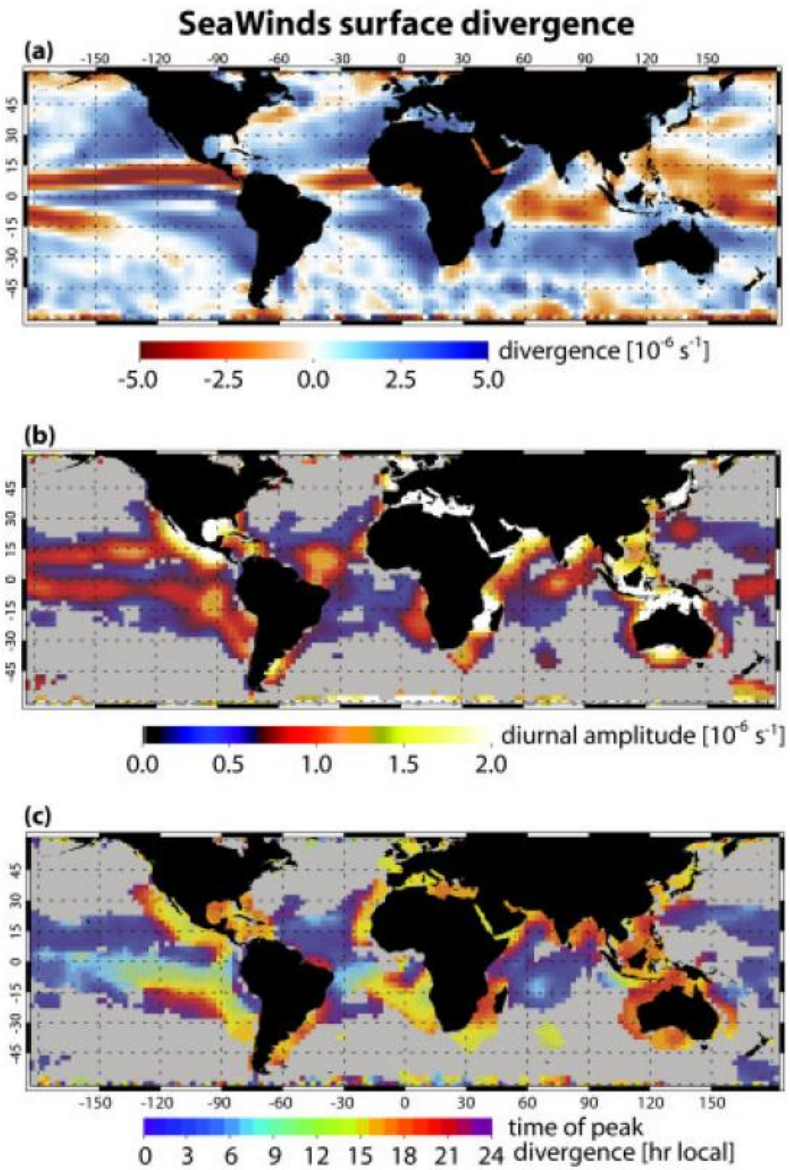


FIG. 7. Comparison of the diurnal cycle of entrainment as calculate d from the q_t budget (solid lines, circular endpoints on error bar), from the s_l budget (dashed lines, triangular endpoint), and from the subsidence method (dot–dashed lines, diamond endpoint). Error bars represent one standard deviation limits on the mean associated with sample variability over the 6 days. Only one error bar is presented for each method because the error is assumed identical for each time of day.

The diurnal cycle of surface divergence over the global oceans

QJRMS 2009

R. Wood,[a*] M. Köhler,[b] R. Bennartz[c] and C. O'Dell[c]



Modelling microphysical and meteorological controls on precipitation and cloud cellular structures in Southeast Pacific stratocumulus

H. Wang[1,2,*], G. Feingold[2], R. Wood[3], and J. Kazil[1,2]

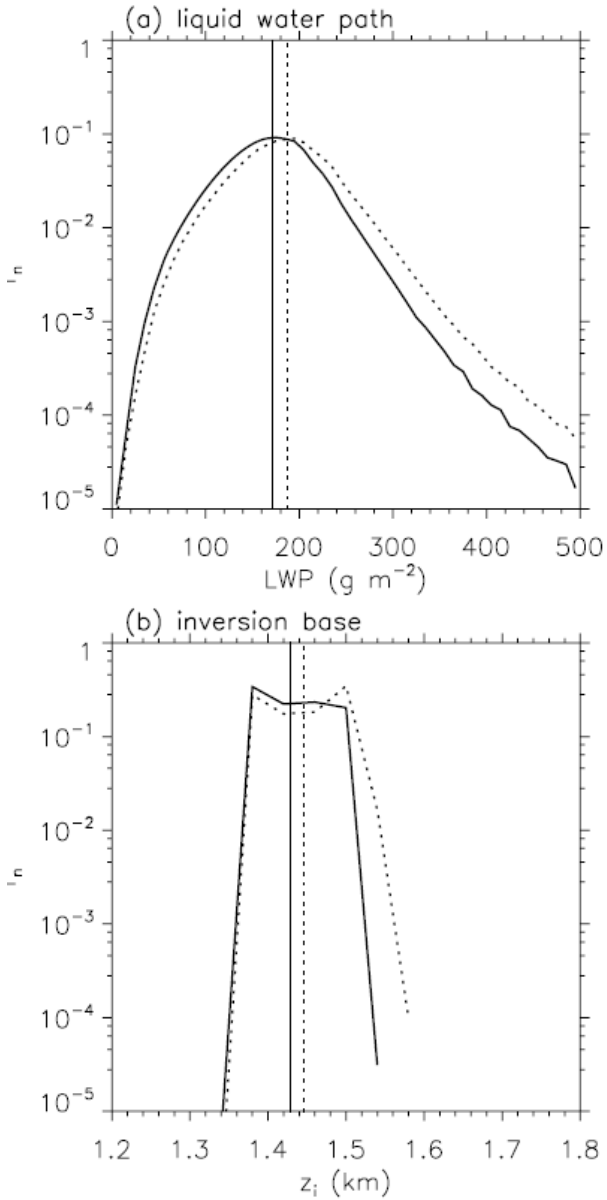
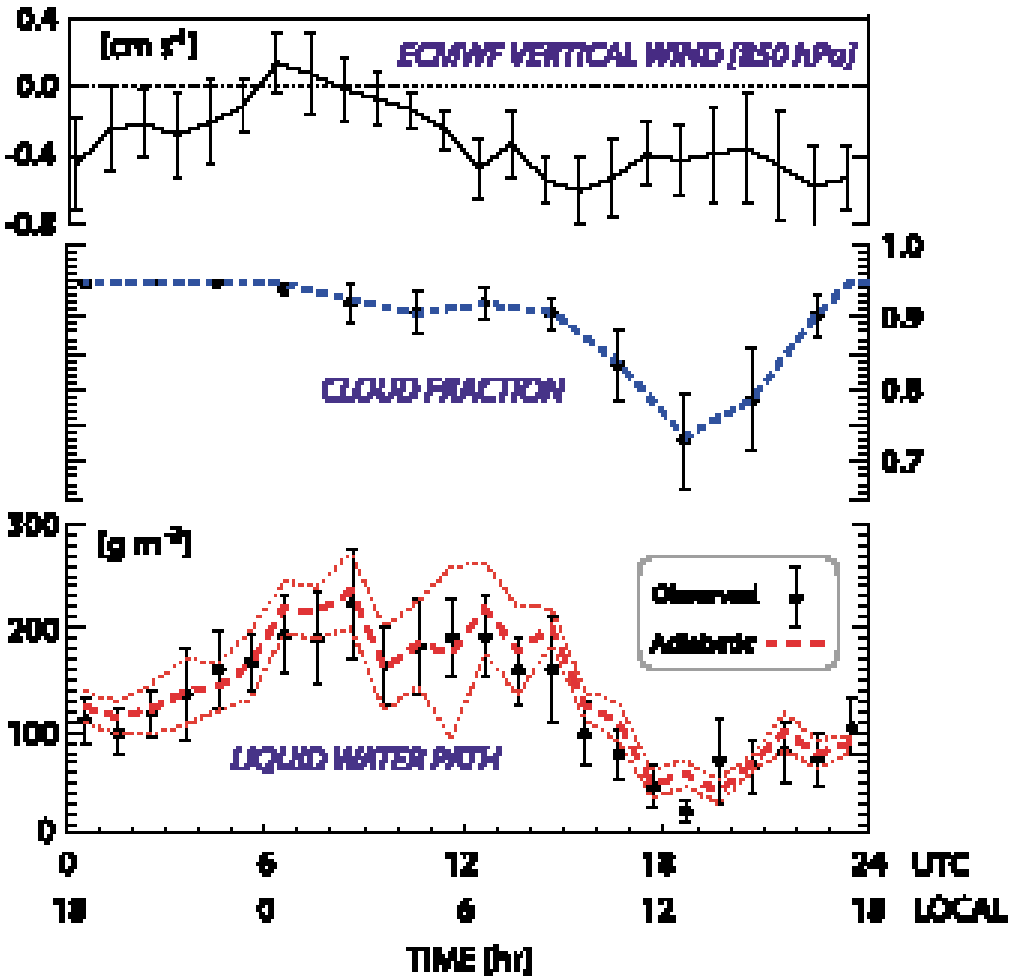


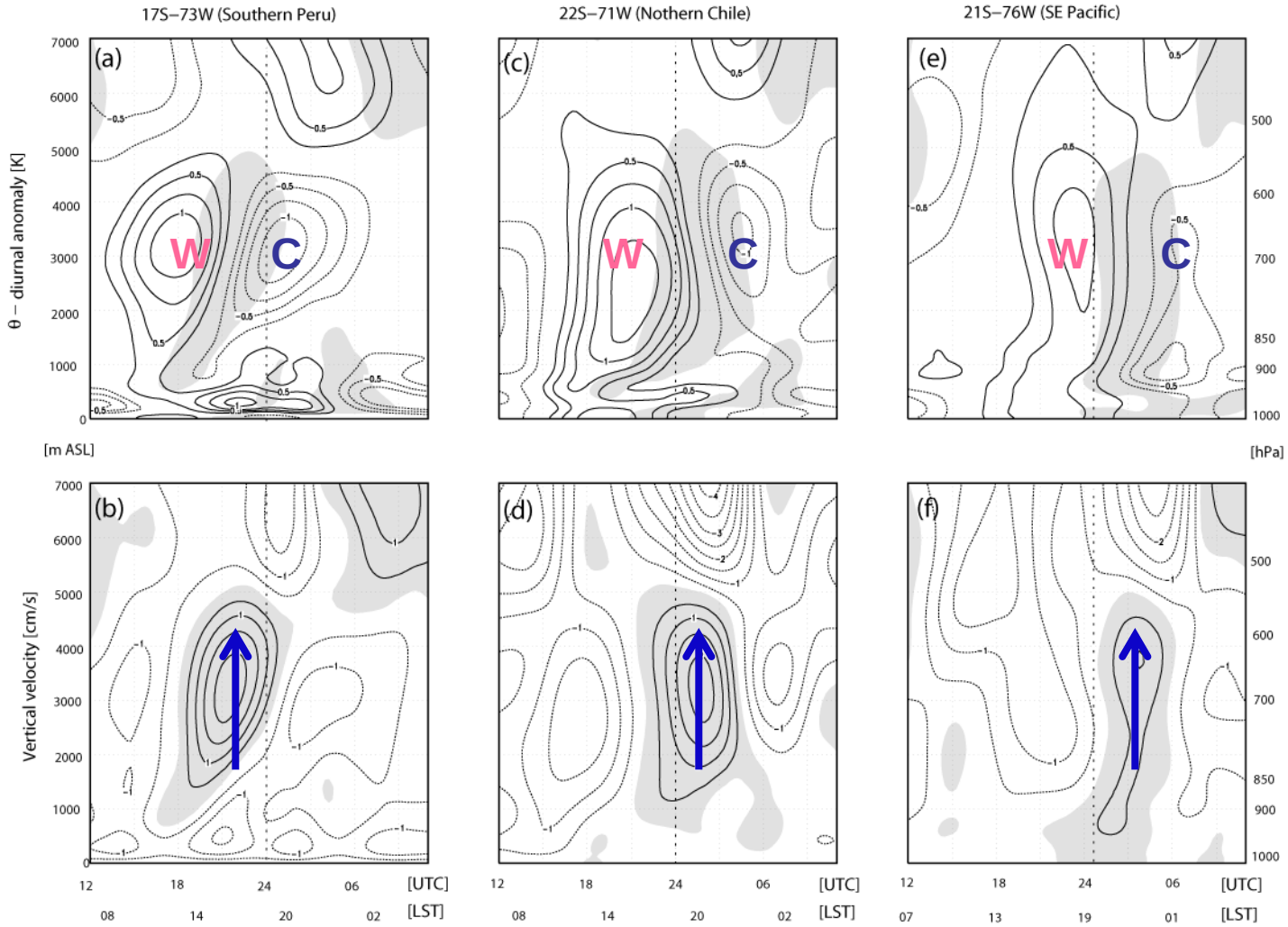
Fig. 9. Normalized frequency distributions of **(a)** liquid water path, **(b)** inversion base height over 8 h for experiments CTRL (solid lines) and UPSW (dotted lines) with the0 corresponding vertical lines indicating median values.

A distinctive feature of this Sc deck is its particularly pronounced diurnal cycle in cloud amount (Minnis and Harrison 1984; Rozendaal et al. 1995) and LWP (Bretherton et al. 2003; Wood et al. 2002), that is highly relevant to the quantification of the true impact of Sc on climate (Bergman and Salby 1997).



Bretherton et al. 1999

MM5 results. SON simulation.



- Significant diurnal cycle in θ up to 5 km ASL
- Subsidence interrupted by period of upward motion
- Cooling largely produced by vertical advection

Garreaud and Muñoz 2004

The diurnal cycle of surface divergence over the global oceans

QJRMS 2009

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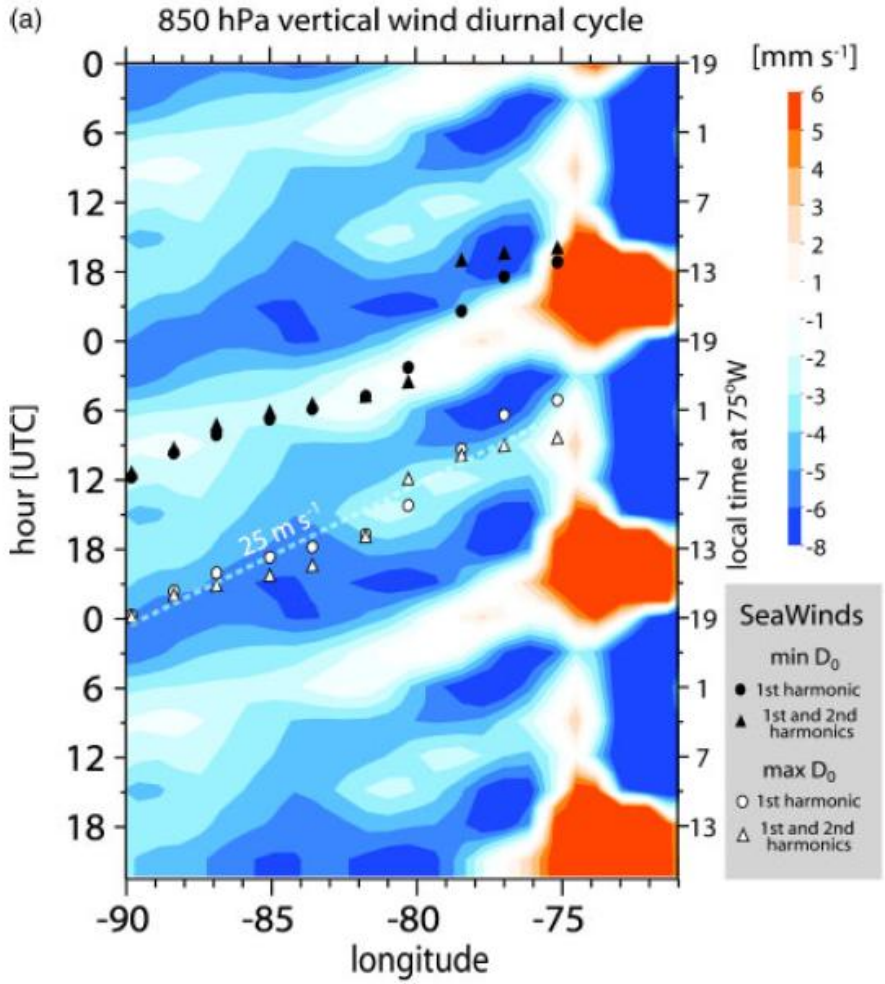
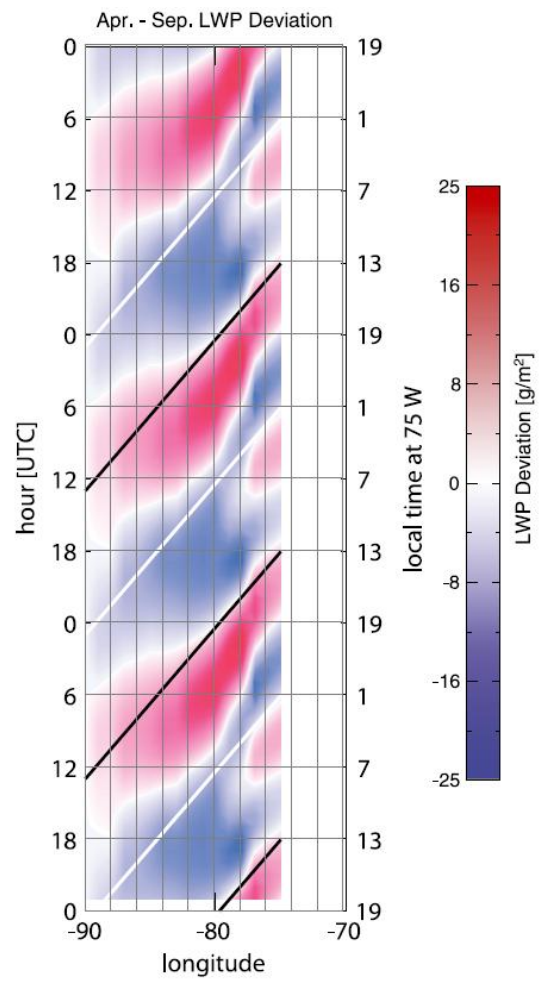




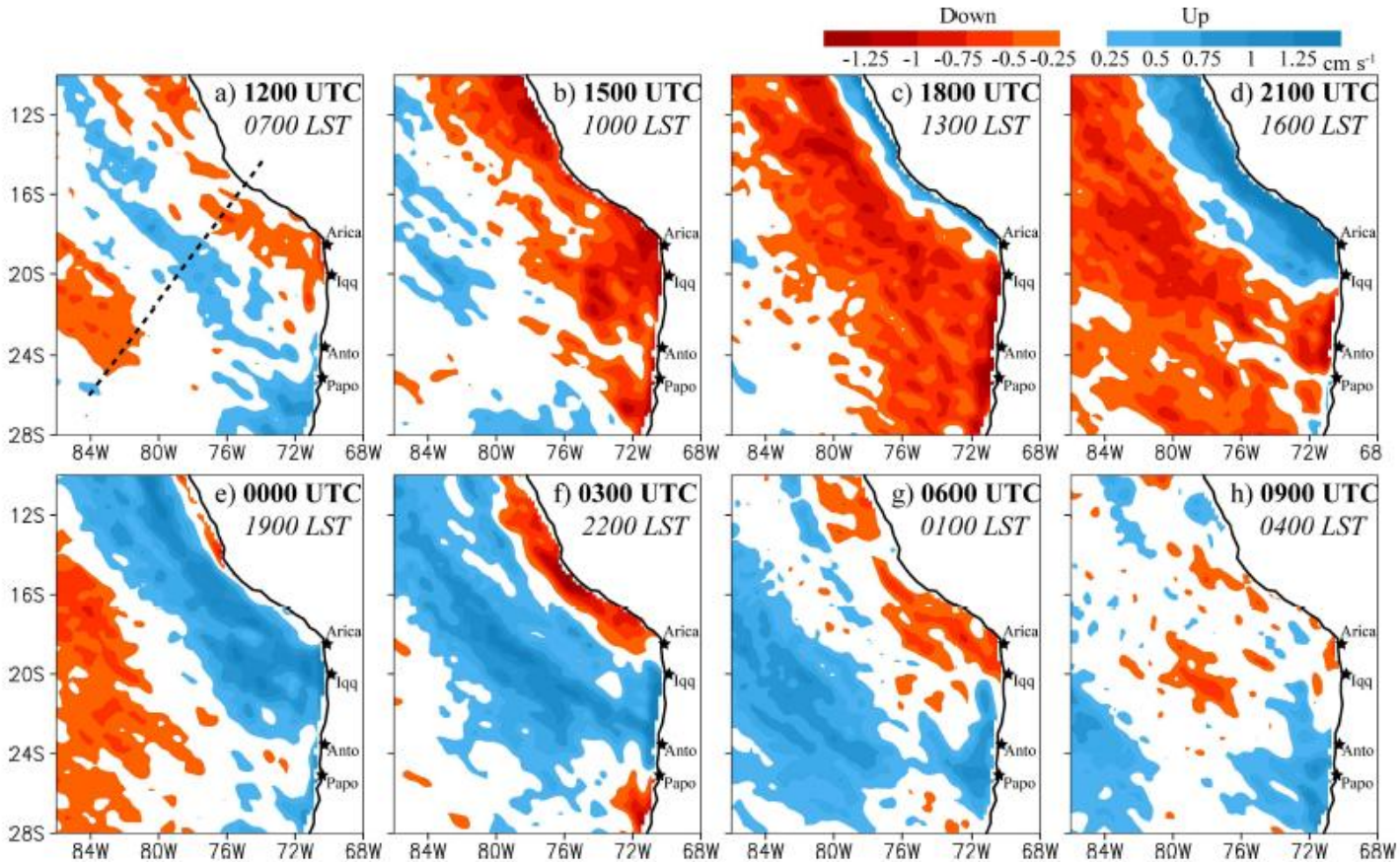
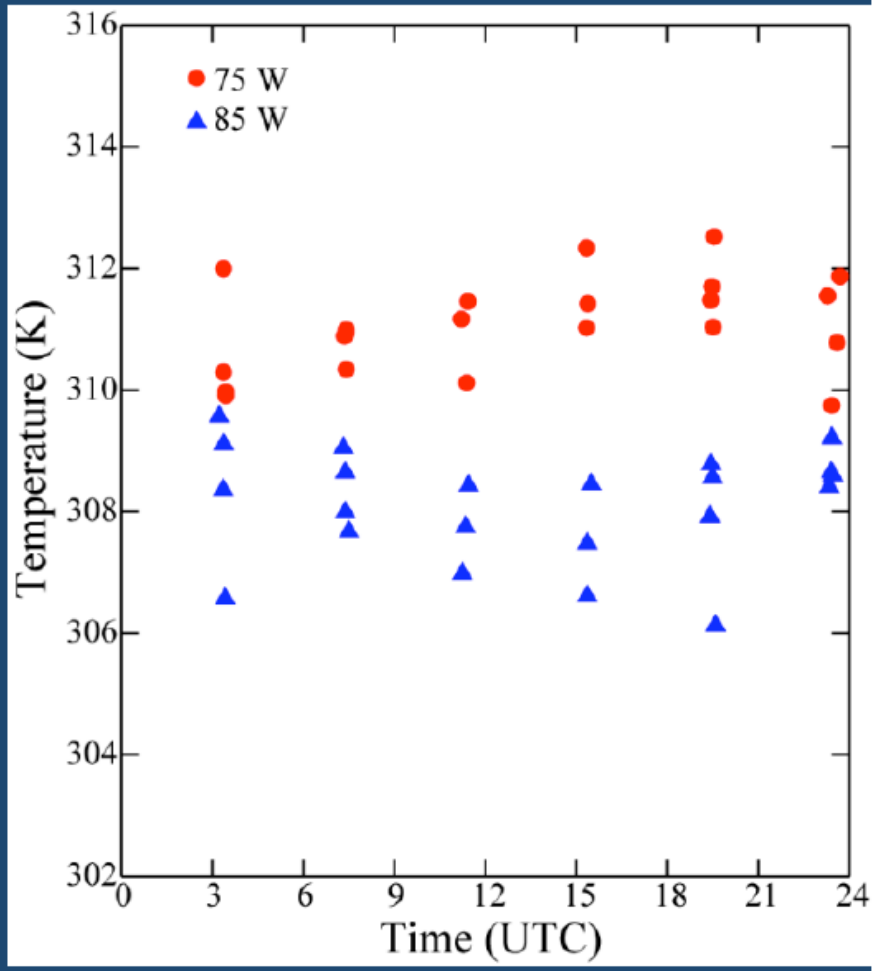


Fig. 9. WRF-simulated 2-month mean diurnal vertical velocity anomalies (cm s^{-1}) at 2.5 km every 3 hours. Red (blue) indicates downward (upward) motion. Dashed line in **(a)** depicts location of subsequent cross section. Also shown is the location of the coastal sounding stations during VOCALS-REx.

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).

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