The (dynamically-driven) diurnal cycle in the SEP

* Does it exist?
* Does it impact clouds?

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VAMOS: Dynamical link between South American Monsoon and SEP, first suggested by Gandau and Silva-Dias (1998)
Mean diurnal cycle of vertical velocity at 800 hPa

MM5 results
SON simulation

Garreaud and Muñoz 2004
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.
Isosurface $w < -0.1 \text{ mm/s}$
Oct-Nov 2008 mean
WRF Simulation

Cup $\sim 30 \text{ m/s} \sim 100 \text{ km/h}$
$C_{\text{sun}} \sim 15^\circ/\text{h} \sim 1500 \text{ km/h}$

03z, 24z, 21 UTC $\sim$ 18 LT
• Significant diurnal cycle in $\theta$ up to 5 km ASL
• Subsidence interrupted by period of upward motion
• Cooling largely produced by vertical advection

Garreaud and Muñoz 2004
MM5-1D Experiments (no advection)
Impact dependent on location / interference with solar cycle
21ºS, 76ºW, 17 Nov 2001

In MM5 we \( w_c \propto Z_{u} \) resulting in more vigorous entrainment of dry air during nighttime…
Drier MBL more susceptible of daytime breakup of SCu

Diurnal cycle in \( w \) and solar radiation

Upward motion promote MBL deepening
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).
Modelling microphysical and meteorological controls on precipitation and cloud cellular structures in Southeast Pacific stratocumulus

H. Wang¹,²*, G. Feingold², R. Wuerf³, and J. Kazil¹,²

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 the corresponding vertical lines indicating median values.
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

R. Wood, M. Köhler, R. Bennartz and C. O’Dell
The diurnal cycle of surface divergence over the global oceans

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(a) 850 hPa vertical wind diurnal cycle

ECMWF

SeaWinds

min $D_0$

1st harmonic

max $D_0$

1st and 2nd harmonics

1st harmonic

1st and 2nd harmonics

25 m s$^{-1}$

local time at 75°W

QJRMS 2009
Marine boundary layer over the subtropical southeast Pacific during VOCALS-REx – Part 1: Mean structure and diurnal cycle

D. A. Rahn and R. Garreaud

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

$\theta'$ hourly departure from 3-day mean

$\theta$ at 2.5 km

$20^\circ$S $85^\circ$W

$20^\circ$S $75^\circ$W

Hour (LST, UTC)

Temperature (K)

30 m/s
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 AND CHRIS FAIRALL

JClm 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 22:30 LT, (b) Aqua night, at 01:30 LT, (c) Terra day, at 10:30 LT, and (d) Aqua day, at 13:30 LT.
Observations of the Diurnal Cycle of Marine Stratocumulus Clouds and Precipitation
Casey Burleyson¹, Sandra Yuter¹, and Simon de Szoeke²
$w_e$ in observations shows a diurnal cycle similar to MM5 simulation, largely due to diurnal cycle in $w_{LS}$.

Fig. 7. Comparison of the diurnal cycle of entrainment as calculated from the $q_r$ budget (solid lines, circular endpoints on error bar), from the $s_i$ 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.
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.
At this point, dominance of 12-h harmonic due to superposition of 24-h solar cycle and 24-h upsidence wave
The diurnal cycle of surface divergence over the global oceans

R. Wood, M. Köhler, R. Bennartz and C. O'Dell

850 hPa vertical wind diurnal cycle

SeaWinds
- min D_o
- 1st harmonic
- 1st and 2nd harmonics
- max D_o
- 1st harmonic
- 1st and 2nd harmonics

LWP Deviation [g/m^2]
A regional real-time forecast of marine boundary layers during VOCALS-REx

S. Wang¹, L. W. O’Neill², Q. Jiang¹, S. P. de Szoeke³, X. Hong¹, H. Jin¹, W. T. Thompson¹, and X. Zheng⁴

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 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.
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-tropospheric $\theta$ and $v$ Yes
* Surface divergence Yes
* Cloud top height Could be
* Cloud fraction Could be
* Cloud LWP ???

Still pending origin of UpW....
Coastal diurnal cycles
Relevant for airmass transport between continent and ocean
Coastal diurnal cycles
Relevant for airmass transport between continent and ocean
Observed coastal diurnal cycles
Paposo & Iquique: VOCAL-REx (Oct-Nov 2008)
Michilla: DICLIMA (January 1998)
Simulated diurnal cycle at Paposo (25°S)
WRF 15 km Simulation (Rhan and Garreaud 2010)