Atmospheric Variability over the SE Pacific: from the diurnal cycle to climate change

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Outline

- The diurnal cycle of circulation and cloudiness
- The surface wind field (synoptic scale coastal jet)
- Recent trends of temperature and ACC predictions
Key Atmospheric Features over the SEP

- Subtropical High
- Coastal jet
- Andes Mts.
- ITCZ
- SCu deck
- SAM
- Storm Track
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
Mean diurnal cycle of vertical velocity at 800 hPa

Garreaud and Muñoz 2004
**MM5 results. SON simulation.**

- 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)
21ºS, 76ºW, 17 Nov 2001

Diurnal cycle in w and solar radiation

Diurnal cycle in solar radiation only
WMEAN WVAR

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).
MM5 results: w(800hPa).

“Existence” of upsidence wave in “all” seasons suggest is not forced by convection over South America.
Among several interesting features of the sfc. ws field, we focus on the maximum off central Chile and the low-speed area around 18°S. Also notice the wind maximum @ 15°S only present during JJA.
Near-stagnation zone collocated with maximum in CDC
Topographically induced? How deep? Sometime flush?
Model trajectory analysis (in progress)

- $P_0 = 995$ hPa (near surface)
- $P_0 = 950$ hPa (MBL)
- $P_0 = 850$ hPa (Inversion)

-36 hr

+36 hr
Jet-structure in mean field, but how often a jet occurs?

Cluster analysis using ws individual fields:

- Similarity measured by spatial correlation
- Ward method
- Two “best separated” clusters
1-Point correlation map. $V(33S/73W)$ regresed upon

U,V elsewhere (vectors)  U,V elsewhere (vectors)
WS elsewhere (contour)   V elsewhere (contour)
Cloud elsewhere (colors)  SST elsewhere (colors)

Jet events associated with: Stronger anticyclone / Reduced Sc near the coast / Increased Sc off the coast / SST cooling downstream
Further evidence of CJ impacts on ocean

Average kinetic energy from 7 years of altimetry data.

Image courtesy of Oscar Pizarro
MM5 results. October 2000 simulation of a well defined jet event

Garreaud and Muñoz 2005
Muñoz and Garreaud 2005
Simulated (MM5) structure of the coastal jet

Garreaud and Muñoz 2005
Steady-state Dynamics

\[
\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} = \frac{1}{\rho} \frac{\partial p}{\partial x} + f v - \frac{C_d}{H} u |\vec{v}| \]

\[
\frac{\partial v}{\partial t} + u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} = \frac{1}{\rho} \frac{\partial p}{\partial y} + f u - \frac{C_d}{H} v |\vec{v}| \]

Fig. 8. Mean vertical profiles of terms in the budgets of (a) zonal momentum, (b) meridional momentum, (c) liquid water potential temperature, and (d) turbulent kinetic energy, for point at 30.2°S, 72.8°W.
1. Condiciones climatologicas (no-perturbadas)
2. Coastal jet environment
Geographical setting and global context
Regional view (SAT)

Andes East

Andes West

Central Valley

Coast

Ocean

East Andes

West Andes

inland

cost

offshore
Ocean cooling – land warming along north-central Chile. Pattern reverses farther south
Cooling MBL / warming lower free troposphere → increased lower tropospheric stability .... Sc?
How are the models doing?
Not good but no so bad..

20C runs CMIP3 (AR4)
Multimodel mean Regional warming 1970-2000 (SST anomaly). Also shown in contours SLP trend

Global mean: +0.2º/dec

20C runs CMIP3 (AR4)
At interannual time scales, cooling off central Chile associated with spin-up of SEP anticyclone (increased cold advection, upwelling and heat fluxes). The same mechanism appears to operate in last decades to produce trends.
The same mechanism appears to operate in the models during the last decades to produce trends. Thus, observed change is at least partially due to increased GHG (the only common ingredient in GCMs)
Multimodel mean Regional warming A2-BL (future-present). Also shown dSLP

Global mean: +3.3°

The future shows a consistent poleward expansion of the subtropical highs and poleward shift of the storm track. Thus, the same mechanism acting in recent decades appears to operate in the future and cause a regional cooling within a global warming context.
10-m Meridional wind – Outlines of v>6 m/s

Baseline (1960–1990)
B2 (2070–2100)
A2 (2070–2100)
PRECIS Results

2 month extended upwelling season (earlier onset, later demise)

Stronger southerlies