The coastal jet off central Chile: Climatology, dynamics and relationship with cloud/SST

René Garreaud, Ricardo Muñoz, J. Rutllant

Departamento de Geofísica
Universidad de Chile

(*) www.dgf.uchile.cl/rene
Key atmospheric features over the SEP

- Climatology: NCEP-NCAR, QSCAT
- SST/Cloud: QSCAT, SSMI, GOES
- Structure / dynamics: MM5 simulation
- Conclusions
Surface wind climatology (u,v,ws): QSCAT 2000-2003 / 0.25°
Annual cycle of \( w_{sfc} \) along 74°W: QSCAT 2000-2003

Fig. 2. Monthly means of the surface wind speed along the coast of Chile from QuikSCAT. The wind speed is representative of a coastal strip of \( \sim 275 \) km. Contours every 1 m s\(^{-1}\); shading indicates wind speed in excess of 7.5 m s\(^{-1}\). The annual cycle is repeated twice.
LTM annual mean SLP and Surface Wind Speed

(NCEP-NCAR Reanalysis)
Surface wind variability (SONDJF): QSCAT 2000-2003

Max. $\sigma$, but $\sigma$/mean = 0.4

Min. PM-AM
QSCAT also reveals some meso-scale details
Mean WS: PM - SONDJF

![Map and Scatter Plot](image)
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
• V > 8 m/s off central Chile almost always associated with a southerly jet (dark shaded)

• Jet events typically a week long (3-15 days)

• More frequent, stronger and longer in summer.
1-Point correlation map. $V(33S/73W)$ regressed upon

Jet events associated with: Stronger anticyclone / Reduced Sc near the coast / Increased Sc off the coast / Sea surface cooling at and downstream the jet
Jet under clear skies evident in coastal data as well
Further evidence of CJ impacts on ocean

Average kinetic energy from 7 years of altimetry data.

Image courtesy of Oscar Pizarro
Further evidence of CJ impacts on ocean

Monthly composite of Chlorophyll (March 202).

Evidence of maximum in eddy activity and filaments between 30-40°S (10-17°S also).

Image courtesy of Ted Strub.
Three-dimensional structure from an MM5 simulation during CIMAR-6 period
Simulated (MM5) structure of the coastal jet

\[ V > 18 \text{ m/s} \]
WHOI Stratus-2004 Cruise

a. Sounding-height section of potential temperature (every 3K) and wind speed (9,12 m/s)

Day (December)

Height [m a.s.l.]

3000
2400
1800
1200
600
0

21.58 87.3W NW-SE 26.95 72.2W N-S
21.58 87.3W NW-SE 26.95 72.2W N-S
21.58 87.3W NW-SE 26.95 72.2W N-S
21.58 87.3W NW-SE 26.95 72.2W N-S

WS > 15 m/s

b. Individual soundings (T: Solid blue, Td: dashed blue, wind speed: red)
Steady-state Dynamics

\[
\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} = \frac{1}{\rho} \frac{\partial p}{\partial x} + fv - \frac{C_d}{H} u |\vec{v}| \quad \text{and} \quad \frac{\partial v}{\partial t} + u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} = -\frac{1}{\rho} \frac{\partial p}{\partial y} + fu - \frac{C_d}{H} v |\vec{v}|.
\]

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.
Steady-state dynamic

\[- \frac{1}{\rho} \frac{\partial p}{\partial y} = \frac{C_d}{H} \nu^2\]

seems to hold for day-to-day changes
Thus, day-to-day changes in the meridional pressure gradient (alongshore) explain more than 70% of the changes in meridional wind over the Jet region.

Meridional pressure gradient is in turn modulated by the passage of mid-latitude disturbances.

Indirect effect on zonal (cross-shore) pressure gradient.

Local $R^2 : v_{sfc} - d\Phi_{900}/dy$
Conclusions

• The southerly jet has a cross-shore scale of about 500 km. The jet core reside at the top of the MBL / inversion layer and just downstream of a region of strong meridional thermal gradient.

• Weak (but very relevant) offshore flow prevails above the jet axis and even weaker onshore flow prevails in the MBL (blocking effect of the coastal range).

• Coastal jet events (few days / several per month) associated with enhanced anticyclone. Strong, coastal parallel surface winds lead to broad area of sea surface cooling. Time-scale not addressed.

• The jet is embedded in a region of LS subsidence; nevertheless a mesoscale area of mean upward motion is observed downstream of the jet core → Cloud pattern

• Model results also allows us to study the momentum and thermodynamic balance that explains the jet.

[Garreaud and Muñoz 2005, Muñoz and Garreaud, 2005]