The Low-Level Jet off the West Coast of Subtropical South America: Structure and Variability

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ABSTRACT

The subtropical anticyclone over the southeast Pacific drives low-level southerly flow along the west coast of South America. In turn, the alongshore flow induces coastal upwelling that supports a wealth of fishery resources. Within this region, satellite data, marine reports, and coastal observations indicate the existence of a southerly coastal jet (i.e., a maximum of wind speed) off central Chile (26°–36°S). The mean features and variability of this southerly jet is documented in this work using 4 yr of satellite-derived sea surface winds, complemented by satellite-derived cloud amount fields and atmospheric reanalysis. Furthermore, analysis of in situ data and model results of a well-defined jet event during October 2000 allows a preliminary description of the jet’s three-dimensional structure and a comparison with the northerly jet off the coast of California.

Southerly jet events off central Chile occur year-round, but they are more frequent during spring–summer (over 60% of the time). The jet is characterized by an elongated maximum of surface wind speed (~10 m s⁻¹) with its axis at about 150 km off the coast and a cross-shore scale of about 500 km. The two Quick Scatterometer (QuikSCAT) fields per day (A.M. and P.M. passes) allow a rough estimate of the amplitude of the diurnal cycle of the surface winds, which appears to be remarkably small in the region of the jet. The jet events are associated with the passage of a midlatitude ridge over the southeast Pacific strengthening the subtropical anticyclone. Upstream and over the jet region the coastal deck of stratocumulus clouds tends to dissipate in contrast to an increase in cloudiness downstream of the jet. In the case study the jet core resides at the top of the marine boundary layer (MBL)/inversion layer. Weak offshore flow prevails above the jet axis, and even weaker onshore flow prevails in the MBL. Consistent with its subtropical location the jet is embedded in a region of large-scale subsidence; nevertheless a mesoscale area of mean upward motion is simulated just downstream of the jet core.

1. Introduction

The subtropical west coast of South America is under the year-round influence of the southeast Pacific anticyclone, resulting in predominantly southerly winds at low levels that turn into SE trades farther offshore and a strong temperature inversion that caps a cool marine boundary layer (MBL). Close to the coast the MBL is well mixed, topped often by a compact deck of stratocumulus (Sc) clouds, and varying in depth from about 300 m at 33°S to about 1000 m at 22°S (Rutllant 1994); farther offshore the MBL deepens and becomes relatively decoupled to the west of 95°W, leading to a broken cloud pattern (Garreaud et al. 2001; Wang et al. 2004). The surface stress exerted by the southerly winds fosters the upwelling of cold, nutrient-rich waters (through Ekman transport and Ekman pumping) and equatorward advection of the latter along the coast (Shaffer et al. 1999; Rutllant and Montecino 2002), supporting a wealth of fishery resources.

Within this region, satellite scatterometer data and marine reports reveal an area of maximum surface wind speed extending a few hundred kilometers off the coast of central Chile (25°–35°S) where average values exceed 8 m s⁻¹ during austral spring and summer (e.g., Halpern et al. 2002; Josey et al. 2002). Furthermore, vertical wind profiles obtained at the coast at 30°S during periods of strong southerly winds reveal a low-level jet (LLJ) structure with strong vertical shear above and below the wind maxima located near the inversion base at about 200 m ASL (Rutllant 1993). Thus, the exis-
tence of a low-level coastal jet off central Chile is suggested by several observations, although its structure and dynamics have not been previously addressed, nor has it been compared with better-documented coastal jets elsewhere, particularly off the California coast (e.g., Bridger et al. 1993; Parish 2000).

Low-level winds off central Chile also exhibit significant day-to-day changes in magnitude, especially during austral winter and spring. At the coast, there is a tendency for a near-weekly alternation of strong and weak afternoon alongshore winds (Rutllant 1993; Rutllant et al. 2004). This synoptic cycle has been associated with the onset/decay of warm-core coastal depressions under a warm ridge aloft (Garreaud et al. 2002; Garreaud and Rutllant 2003). The synoptic-scale changes in wind also appear tied to changes in the MBL depth and Sc coverage, and all of these changes are highly relevant for coastal meteorology and oceanography. In particular, shallow MBL and Sc clearing episodes tend to occur during periods of strong southerly winds (Garreaud and Rutllant 2003), although the physical basis of such a relationship is unclear. Stronger than normal southerly winds also enhance coastal upwelling and the generation of cold filaments that extends from the region’s major upwelling centers offshore, leading to an overall decrease of coastal SST (Rutllant and Montecino 2002).

In this paper, we use observed data and model results to document the mean structure and variability of the low-level winds off central Chile, with special emphasis on the southerly coastal low-level jet. The paper is structured as follows. Section 2 describes the observations and model results used in this work. The long-term seasonal mean and the diurnal cycle of the surface wind are presented in section 3 using Quick Scatterometer (QuikSCAT) surface wind data. In section 4, the synoptic-scale variability of the wind and its association with changes in the cloud regime is documented using satellite data [QuikSCAT winds and Geostationary Operational Environmental Satellite (GOES) imagery], while reanalysis data are used to characterize the large-scale circulation during periods of strong southerly flow. In section 5 the three-dimensional structure of the coastal jet is described for a case study using a few observed vertical wind profiles and results from a mesoscale model [the fifth-generation Pennsylvania State University–National Center for Atmospheric Research (PSU–NCAR) Mesoscale Model (MM5)] simulation. A summary of our main findings is presented in section 6. The present work is extended in a companion paper (Muñoz and Garreaud 2004, manuscript submitted to Mon. Wea. Rev., hereafter MG) in which the dynamics of the jet is addressed, including the analysis of its momentum, temperature, and turbulent budgets.

2. Data

a. Long-term observations

While the core of the southerly jet off central Chile is presumably a few hundred meters above the sea surface, its time-varying location and spatial extent can be documented using surface wind stress fields derived from satellite-based scatterometer observations. Here we use the sea surface wind components and wind speed ($u_s$, $v_s$, and $w_s$, respectively) derived from version-3 QuikSCAT for the period January 2000–December 2003. All the fields are on a $0.25^\circ \times 0.25^\circ$ latitude–longitude grid derived from the original QuikSCAT swath data available from Remote Sensing Systems (www.ssmi.com). Off the coast of central Chile the ascending and descending passes of the satellite occur at about 1200 and 0000 UTC (8 A.M. and 8 P.M. local time, respectively), covering the region of interest in ~1 h, so we treat these data as snapshots of the surface wind field.

To document the synoptic variability of the Sc deck, we use cloud amount fields derived from GOES-8 data. This dataset is produced by the Cloud and Radiation Research Group at the National Aeronautics and Space Administration (NASA) Langley Research Center, using a split window technique described in Minnis et al. (2001) and Ayers et al. (2002). The data include daily average amounts of total, ice, water, and supercooled liquid water clouds, on a $1^\circ \times 1^\circ$ latitude–longitude regular grid, from 2000 to 2001. To better characterize the low-level Sc deck we use the liquid cloud amount ($C_L$), which is very similar to the total cloud amount field in this subtropical region. The large-scale tropospheric circulation is documented using National Centers for Environmental Prediction (NCEP)–NCAR reanalysis fields, described in detail by Kalnay et al. (1996). Here we use pressure-level fields, with 6-h resolution on a $2.5^\circ \times 2.5^\circ$ latitude–longitude grid.

b. CIMAR-6 observations and simulation

CIMAR-6 was a shipborne expedition aimed at documenting several aspects of the upper ocean and atmosphere off central Chile, organized by the Chilean National Oceanographic Committee. Between 26 September and 13 October 2000, the R/V Vidal Gormaz followed a track from Valparaiso (Chilean coast; 33.5°S, 72°W) to Robinson Crusoe Island (RCI; 34°S, 79°W) to San Félix Island (27°S, 80°W) to Caldera (Chilean coast; 27°S, 72°W). During this period,
Vaisala RS80–15G rawinsondes were launched once daily (1200 UTC) from RCI and twice daily (0000 and 1200 UTC) from the R/V Vidal Gormaz. RCI is a small island (less than 40 km$^2$) about 700 km off the coast, so the vertical profiles obtained there are representative of open-ocean conditions.

To further describe the three-dimensional circulation off central Chile, we simulated most of the CIMAR-6 period using the PSU–NCAR Mesoscale Model [version 3; see Grell et al. (1994) for model details]. The simulation includes two nested domains with horizontal grid spacing ($\Delta x = \Delta y$) of 145 and 45 km. Domain 1 (coarser mesh) covers a significant portion of South America and the eastern Pacific, and domain 2 is centered off central Chile (26°–42°S, 85°–70°W). A total of 56 $\sigma$ levels were used in the vertical, half of them in the lowest 1.5 km where $\Delta z \sim 25$ m. Such a high vertical resolution was needed to properly simulate the MBL depth over open ocean. The model was initialized at 0600 UTC 1 October and continuously integrated for the next 20 days, using time-dependent boundary conditions interpolated to the boundary of domain 1 from the NCEP–NCAR reanalysis grids every 6 h. SST was held constant to its climatological value (Reynolds and Marsico 1993).

The parameterizations used in this simulation are listed in Table 1. Of particular relevance is the representation of the turbulence that controls the development and structure of the MBL. In these model runs we use a 1.5-order turbulence scheme that includes a prognostic equation for turbulence kinetic energy (TKE) and diagnosis of the mixing and dissipation length scales (Shafran et al. 2000).

### 3. Surface wind climatology

In this section we describe the mean features of the sea surface wind field off central Chile. Figure 1 shows the QuikSCAT wind speed and wind vectors averaged over the months November, December, and January (late spring and summer), for a strip along the coast between 19° and 43°S. The main feature in Fig. 1 is an elongated area of maximum wind speeds between 29° and 37°S, with its axis at about 150 km off the coast. The local maximum is located at 34°S, 74°W where the mean speed reaches almost 8.5 m s$^{-1}$, compared to about 6 m s$^{-1}$ in the region outside the closed isolachs. Close to the coast the wind has a rich structure, including several points of local maximum (29°,

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<th>Table 1. Physical parameterizations used in the MM5 for the CIMAR-6 simulations.</th>
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Fig. 1. Mean surface wind speed from QuikSCAT (shaded; scale on the right-hand side in m s$^{-1}$) and wind vectors (arrows; scale at the bottom in m s$^{-1}$) for the period Nov-Jan (2000-04) off the coast of Chile.
30°, and 37°S) probably related to the coastline geometry and coastal topography. The maximum of wind speed occurs in a region of south-southwest winds that are very parallel to the coastline (i.e., alongshore winds). South of ~40°S westerly winds associated with the SH storm track prevail.

The annual cycle of the surface wind speed along the Chilean coast is shown in Fig. 2. For every latitude with QuikSCAT data we have calculated the mean wind speed for the 10 points closest to the coastline, thus producing a wind speed representative of a coastal strip ~275 km wide, and then we have computed the monthly means of these coastal winds. To the north of ~38°S the monthly means of the meridional wind (ws) and the wind speed (ws) are very similar (\( \overline{w_s} = \overline{w_s} \); not shown). The region of maximum speeds (traced by the 7.5 m s\(^{-1}\) isotach) is located between 28° and 32°S during winter and early spring (July to September), expanding as far south as 37°S during summer. The strongest mean ws occurs around December, in agreement with previous surveys (Halpern et al. 2002). The relatively low wind speed during autumn [March–April–May (MAM)] is indicative of weaker or more variable southerly winds in this season. At midlatitudes, the westerlies reach a distinctive maximum during austral winter.

Although two QuikSCAT fields per day (A.M. and P.M. passes) are insufficient to fully describe the diurnal cycle of the surface wind, their difference provides a rough estimate of the amplitude of this cycle. Figure 3a shows the average of the P.M. minus A.M. difference of ws for the months November–January. Similar results are found for the other seasons (not shown). The difference maximizes in the northern coastal strip, with mean amplitudes above 2 m s\(^{-1}\), produced mostly by an afternoon increase in the alongshore (southerly) winds. South of 32°S the mean diurnal cycle is strikingly small, with only a very narrow coastal strip showing a weak amplitude of ~0.5 m s\(^{-1}\). Thus, the diurnal cycle at the surface in the climatological region of maximum wind speeds seems very small. In contrast, alongshore winds at coastal stations exhibit a marked diurnal cycle peaking during afternoon (speeds close to or even larger than their offshore counterparts) and with minimum speeds in the night (Rutllant 1993).

Figure 3b shows the standard deviation of the surface wind speed derived from QuikSCAT. The standard deviation is largely associated with submonthly variability, since only P.M. fields were considered and the annual cycle was partially removed by considering only three months of each year (November to January). Over the region of maximum wind speed the standard deviation is maximum, produced mostly by variations of the meridional wind component (\( \sigma_{w_s} \sim 3.5 \) m s\(^{-1}\); \( \sigma_{u_s} \sim 0.5 \) m s\(^{-1}\)). Although much higher than the amplitude of the diurnal cycle (Fig. 3a), the standard deviation is just ~40% of the mean value, indicating that southerly winds off central Chile are quite persistent.
Fig. 3. (a) Average difference of the P.M. minus A.M. surface wind speed fields for the period Nov–Jan from QuikSCAT, (b) Standard deviation of the surface wind speed for the period Nov–Jan (P.M. fields only). Contours every 0.5 m s\(^{-1}\); shading indicates average wind speed in excess of 7.5 m s\(^{-1}\).

To complete our description of the mean fields, Fig. 4 shows the mean and standard deviation of the low cloud amount from September to February. The cloud liquid water amount (\(C_I\)) mean field captures the main features of the Sc climatology (e.g., Minnis and Harrison 1984), including a band of maximum coverage (\(\geq 80\%\)) that is parallel to the coast of southern Peru and a minimum (\(\leq 30\%\)) near the coast of Chile between 30\(^\circ\) and 36\(^\circ\)S where the strong southerly winds prevail. The standard deviation of the \(C_I\) field tends to be out of phase with the mean: it is minimum off the coast of Peru and maximum off the coast of central Chile.

4. Coastal jet events

a. Identification

So far we have documented the existence of a jet structure (i.e., a closed region of maximum \(w_s\)) off central Chile in the seasonal mean fields. To assess the
The recurrence of this structure on a daily basis (i.e., coastal jet events) we performed a cluster analysis based on individual (A.M. or P.M.) $w_s$ fields from November to January (the QuikSCAT wind fields were required to be complete, or near complete, within the region of interest). The similarity between two $w_s$ fields was measured by their spatial correlation coefficient, and a hierarchal clustering technique (Ward’s method) was used to group the data [see Wilks (1995) for method details].

Two “best separated” clusters are suggested from the inspection of the silhouette width diagram (Rousseeuw 1987). The intragroup mean and standard deviation fields are shown in Fig. 5. The members of the first group (63% of the individual fields) are characterized by a southerly jet off central Chile, with little variability among them. Within this “jet group” the maximum wind speeds tend to occur between 32° and 35°S (Fig. 5a). The reverse situation also verifies: when $u_g \sim w_s > 8$ m s$^{-1}$ off central Chile the wind field exhibits a jet structure in this region. The second group includes the remaining 37% of the individual fields, whose average show a broader area of maximum wind speed to the south of 39°S (Fig. 5b). The wind speed maxima in the individual members of this group are mostly associated midlatitude disturbances, and therefore exhibit a larger dispersion in their position and wind direction.

Thus, the surface wind off central Chile exhibits a southerly coastal jet over 60% of the time during late spring and summer (this number reduces to 45% when

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**Fig. 4.** Mean (shaded; scale at the right side in %) and standard deviation (contours every 5%) of the cloud liquid water amount for the period Sep–Feb (2000/01) derived from GOES-8 data.
Fig. 5. Mean (contours every 1 m s$^{-1}$) and standard deviation (shaded; scale at the right-hand side in m s$^{-1}$) of QuikSCAT surface wind speed calculated on the basis of the members of two groups that results from a cluster analysis (Nov–Jan; see text for details). Also shown are the mean wind vectors (arrows; scale at the bottom) for each group.
Fig. 6. Time–latitude section of the surface meridional wind component (shaded; scale at the right-hand side in m s$^{-1}$) along the coast of Chile for (a) winter 2000 and (b) summer 2000. Dashed lines outline northerly wind ($v_y < 0$). The wind is representative of a coastal strip of ~275 km.
considering wintertime fields). Although the jet is highly recurrent, there is room for high-frequency variability, which is partially illustrated in Fig. 6 (right panel) by a time–latitude diagram of surface meridional wind near the coast during the summer of 2000. Well-defined coastal jet events, signaled by southerlies exceeding 8 m s\(^{-1}\) tend to last a week (ranging from 3 to 15 days), interrupted by shorter periods of weak southerlies or even northerlies that erupt from midlatitudes. In some cases the coastal jet tends to migrate southward in time: maximum winds first appear to the north of 30°S and then expand as far as 45°S. For comparison, Fig. 6 (left panel) shows a similar cross section for wintertime, when there are fewer, weaker southerly coastal jet events and the no-jet periods tend to last longer than in summer.

b. Synoptic-scale patterns

To explore the synoptic-scale covariability of surface winds and low cloud amount, Fig. 7 shows a one-point correlation map of these two fields (data from November to January 2000/01). The map displays the correlation coefficient between daily values of the surface meridional wind at 33°S, 73°W (reference time series) and concurrent values of \( v^*_y \) elsewhere. Since strong meridional winds at 33°S are almost always associated with a southerly coastal jet, the correlation
map reveals the typical features during these events as described below.

First, coastal jet events off central Chile are associated with an enhanced anticyclonic circulation over the southeast Pacific, including stronger than average trades at subtropical latitudes. The center of this anticyclonic gyre suggests also an intensification and poleward displacement of the subtropical high from its climatological center ($27^\circ$S, $80^\circ$W). This latter result is confirmed by regressing the 900- and 500-hPa geopotential fields upon the reference time series of meridional wind. The surface ridging is in turn associated with the passage of a midlatitude ridge aloft over the southeast Pacific (not shown). As shown in MG, the key factor that relates the low-level wind anomalies off central Chile and midlatitude disturbances is the strength of the alongshore meridional pressure gradient.

Low-cloud-amount anomalies exhibit a dipole along the coast, with a decrease in cloudiness upstream and at the region of enhanced southerlies (up to 50%) and a weak increase downstream. The same pattern of reduced cloudiness over the region of enhanced wind is found when varying the latitude of the grid point defining the reference time series along the coast of central Chile (not shown). Such tendency of a “jet under clear skies” emerges by considering surface coastal observations as well. For instance, Fig. 8 shows the scatter diagram between the solar radiation at noon and the meridional wind at 1400 LT for station Lengua de Vaca ($30^\circ$S, $71^\circ$W), where a positive linear association ($r = 0.7$) is evident. Weaker but still significant anomalies of the cloud amount field are also observed far from the coast downstream of the coastal jet. A broad area of increased low-level cloudiness is collocated with the region of enhanced southeasterly trade winds, likely associated with increased cold advection within the MBL and increased subsidence over this region (e.g., Klein 1997).

5. Three-dimensional structure

In contrast to satellite-based surface wind observations, there are no long records of vertical profiles off the coast of central Chile. Nevertheless, a well-defined coastal jet was observed during the last half of CIMAR-6 (5–13 October 2000; see Figs. 9a and 9c), which allows a preliminary description of the jet’s three-dimensional structure.

Of particular relevance are the observations taken during the last transect followed by the R/V *Vidal Gormaz* at ~27°S between 9 and 12 October 2000, shown in the upper panels of Fig. 10. The transect was generally 300 km to the north of the maximum meridional winds for this period except in the last sounding shown (0000 UTC 12 October), when the jet had moved north and the ship was ~250 km off the coast. In this last observed profile the vertical structure of the coastal jet is quite clear. The MBL is here about 500 m deep and is capped by a ~8 K temperature inversion. The wind speed increases from about 10 m s$^{-1}$ at the surface to 16 m s$^{-1}$ at the top of the MBL to more than 20 m s$^{-1}$ at the top of the inversion layer, decreasing farther up. A jet core within the inversion layer and uniform wind speeds in MBL are also observed in the second profile from the coast (~500 km offshore). Farther west the low-level jet structure tends to vanish.

Model surface wind speed averaged during this event compares very well with the observations (cf. Figs. 9a and 9b), especially in capturing the position and magnitude of the maximum near the coast at 30°S. The model also reproduces well the MBL depth at RCI (open-ocean conditions), where it varies between 500 and 1500 m ASL (not shown). Furthermore, the lower panels in Fig. 10 show the modeled vertical profiles at the same points/times sampled by the R/V *Vidal Gormaz*. The depth of the MBL decreases steadily to the east, although at a larger rate than in the observations. Thus, the modeled MBL near the coast reaches only ~300 m, capped by a temperature inversion weaker than observed. In spite of this, the modeled wind profile still shows the development of a coastal jet with a similar structure than the observations.
Fig. 9. (a) Observed (QuikSCAT data) surface wind speed averaged between 5 and 13 Oct 2000 (all available QuikSCAT fields were used, including some with incomplete coverage of this region). Filled circles indicate positions of the R/V Vidal Gormaz every 12 h during the period 9–12 Oct 2000. (b) As in (a) but for the simulated (MM5) surface wind speed. Dashed lines indicate the cross sections used in Figs. 11 and 12. In (a) and (b) the contour interval is 1 m s$^{-1}$. (c) Time series of QuikSCAT (filled circles) and simulated (solid line) surface wind speed at 30.1°S, 73.2°W during the CIMAR-6 period (1–20 Oct 2000).
Very steady conditions in the position and intensity of the jet were found in the period 9–11 October (Fig. 9c). In the following we take averages of the model results for this 3-day period (all days, all hours) to further describe the structure of the coastal jet. Figure 11 shows a meridional cross section of several variables taken along a line passing through the jet axis (73°W, ~100 km off the coast). The core of the jet (e.g., $v > 18$ m s$^{-1}$; shaded in this and subsequent figures) extends from 31° to 29°S and at ~400 m ASL, within the temperature inversion capping the MBL. In this range of latitude the inversion base height roughly coincides with the mean altitude of a near-continuous coastal range. The jet axis is centered in a region of maximum vertical stability, just to the north of a region of marked meridional temperature gradient. The mean zonal flow is weak and offshore above the jet and even weaker and onshore within the MBL. Subsidence prevails over most of this subtropical region, except for an area of positive mean vertical velocity downstream of the jet core. Figure 11d shows a slight dip in the simulated inversion base at the jet location that is consistent with the observed pattern of cloudiness along the coast: clear conditions upstream and at the jet location, and cloudy

Fig. 10. (top) Vertical profiles of temperature (thin line; °C), dewpoint temperature (dashed line; °C), and wind speed (thick line; m s$^{-1}$) from radiosondes launched from the R/V Vidal Gormaz during the period 9–12 Oct 2000 (date and time of the radiosonde indicated at the top of each panel). All the locations were at ~27°S when the ship was moving toward the Chilean coast (see Fig. 9 for locations). (bottom) As in top panels, but for corresponding model (MM5) results.
conditions downstream. This inversion height undula-
tion is probably related with the descent–ascent pattern
shown in Fig. 11d, an aspect that we investigate in MG.

Mean zonal cross sections of the temperature and
wind at 29.8°S are shown in Fig. 12. A low-level maxi-
mum in $v$ extends from the coast all the way to the
western boundary of the model domain (79°W). Nev-
ertheless, the region with strong vertical shear is cen-
tered at 73°W and has a cross-coast scale of $\sim$400 km.
The sloping of the MBL and the increase of the vertical

![Figure 11](image.png)

**Fig. 11.** Model-derived meridional section along 72.7°W (see Fig. 9) of several variables averaged for the period 9–11 Oct 2000: (a) meridional wind (contoured every 2 m s$^{-1}$); (b) zonal wind (contoured every 1 m s$^{-1}$); (c) potential temperature (contoured every 1 K); (d) vertical wind (contoured every 3 mm s$^{-1}$; negative values in dashed lines). In all panels, shading indicates meridional wind in excess of 18 m s$^{-1}$ (jet core).
stability toward the coast are evident in these figures, and the maximum thermal gradient is above the MBL.

6. Concluding remarks

On the basis of four years of QuikSCAT data we have documented several aspects of the surface winds off the coast of subtropical South America (central Chile), including the existence of a very recurrent southerly (equatorward) jet with its axis \(~150\) km off the coast. The region corresponds to the eastern flank of the low-level anticyclonic circulation over the southeast Pacific and is bounded by a prominent topography: a coastal range that in many places rises above 1000 m

Fig. 12. Same as in Fig. 11, but along 29.8°S.
and the Andes Cordillera, which rise to more than 4000 m within 300 km from the coastline.

A closed region of maximum wind speed ($w_s \approx 8$ m s$^{-1}$) off central Chile was found in the winter, spring, and summer seasonal means, reaching a maximum extent and most poleward position ($30^\circ$–$37^\circ$S) from November to February. Over this region, the amplitude of the mean diurnal cycle in surface wind (estimated as the difference between P.M. and A.M. fields) is strikingly small, with only a very narrow coastal strip showing a weak amplitude of $\sim$1 m s$^{-1}$. In contrast, the standard deviation of $w_s$ maximizes over the climatological jet region, although its ratio to the mean value is less than 0.4.

Applying a cluster technique to daily $w_s$ fields we found that a southerly jet occurs over 60% (45%) of the time during late spring and summer (winter). Well-defined jet events tend to last a week, interrupted by shorter periods of weak southerlies or even northerlies. The jet events are associated with the passage of a midlatitude ridge over the southeast Pacific/southern South America strengthening the subtropical anticyclone (especially its southern flank). The physical link between the synoptic-scale variability of the subtropical jet and the extratropical forcing is addressed in MG. Clear skies tend to occur in the region collocated with and upstream of the jet core, while increased cloudiness tends to occur in the region downstream of the jet along the coast and farther offshore.

Analysis of in situ data and model results for a well-defined jet event during October 2000 allows a preliminary description of the jet’s three-dimensional structure. The jet core resides at the top of the MBL/inversion layer and just downstream of a region of marked meridional thermal gradient. Weak offshore flow prevails above the jet axis, and even weaker onshore flow prevails in the MBL. The southerly jet has a cross-shore width of $\sim$500 km, sloping toward the coast at the MBL top. Thus, the structure and intensity of the southerly jet off central Chile are similar to the northernly jet off the coast of California (e.g., Bridger et al. 1993; Parish 2000). Consistent with its location along the subtropical west coast of South America, the jet is embedded in a region of large-scale subsidence; nevertheless a mesoscale area of mean upward motion is observed just downstream of the jet core.

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