WAVE ACTIVITY FLUX AND KINETIC ENERGY ANALYSIS APPLIED TO A CUT-OFF LOW EVENT IN SOUTHERN SOUTH AMERICA

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MOTIVATION

Background

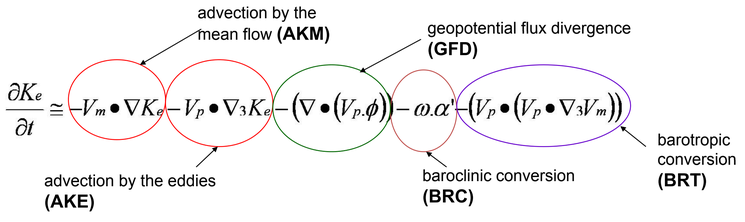
- Cut-off lows (COLs) affect the South American region with a mean frequency of 17 episodes per year and they develop more frequently off the subtropical coast of Chile, in a region between 30º-45ºS and 68º-80ºW. Several COL episodes are associated to significant weather events in the extratropical Andes region and La Plata basin as, heavy rains, hail snowfalls, strong winds.

Objectives

- To further understand the physical processes explaining both the development and stationary characteristics of the COLs that occurred in the vicinity of the west coast of South America, we performed the analysis of the kinetic energy (Ke) equation, during the life cycle of a COL that developed between March 25 and April 2, 2007. We also analyzed the wave activity fluxes, as well as the large-scale circulation conditions during March 2007, to better understand the mean conditions in which the COL was embedded.

DATA AND METHODOLOGY

- Operational analysis from GDAS (Global Data Assimilation System) of the NCEP (National Center of Environmental Prediction) was used, with a horizontal resolution of 1º, 21 pressure levels between 1000 hPa to 100 hPa and a temporal resolution of 6 hours.
- Daily and monthly NCEP-NCAR Reanalysis-2 data from 1979-2010 was used for the study of the large-scale circulation patterns.
- The study period includes the initial and segregation stage of a COL event that occurred from 18 UTC of 24 March 2007 to 00 UTC of 29 March 2007.
- The Ke budget equation used here has been proposed by Orlanski and Katzfey (1991) as follows:

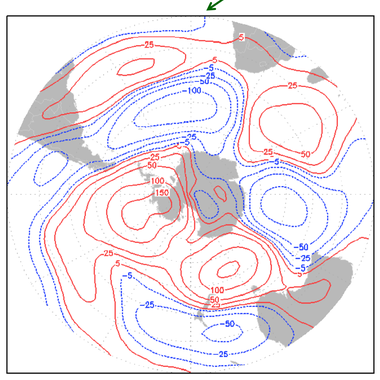


- The ageostrophic geopotential flux which is associated with the convergences and divergences of the geopotential flux was estimated as

$$V_a.\phi = \left(V_p - \frac{\kappa}{f_0} \times \nabla\phi\right).\phi$$

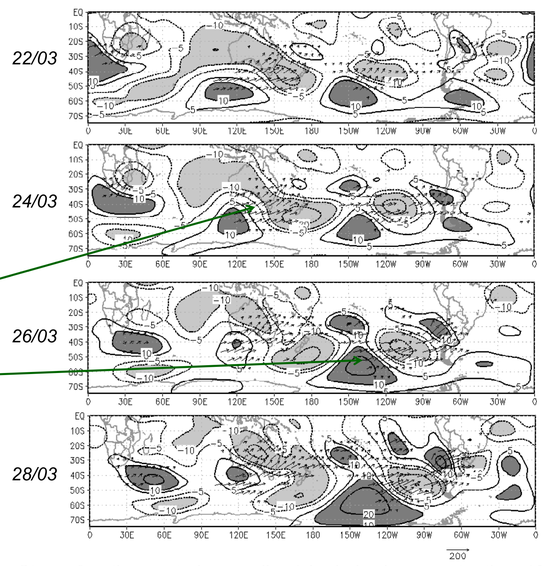
WAVE ACTIVITY PROPAGATION AND STEADY EDDIES

A stationary 3-wave pattern dominates the circulation in the Southern Hemisphere during late summer and upcoming fall of 2007



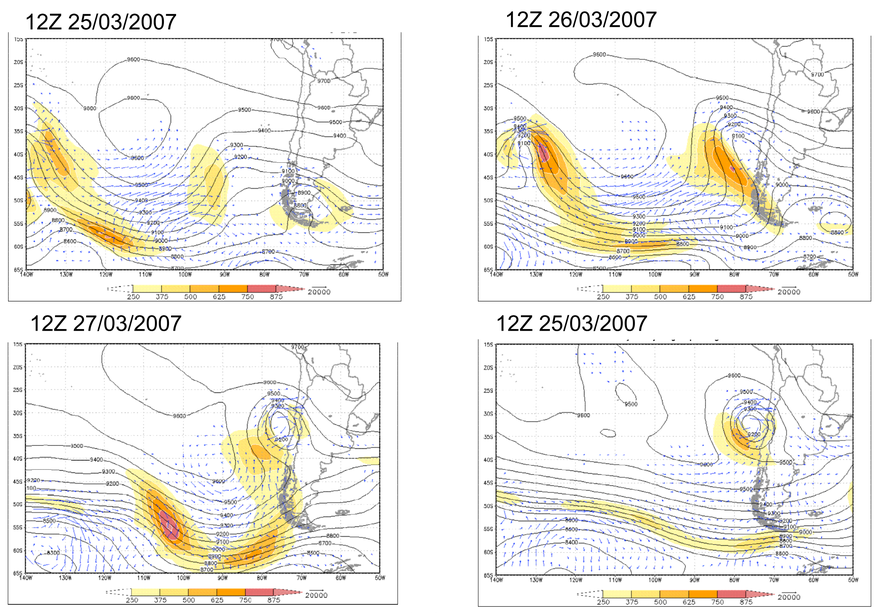
Mean geopotential-height zonal anomaly at 300 hPa (gpm) (averaged between February and March 2007)

Rossby wave propagation is evident from southern Australia, emanating from an amplifying through in the South Pacific towards South America



Streamfunction pentad anomalies (shaded values greater than 10 x 10^6 m^2 s^{-1}) and wave activity fluxes(vectors) at 0.21 sigma level.

EDDY KINETIC ENERGY BUDGET

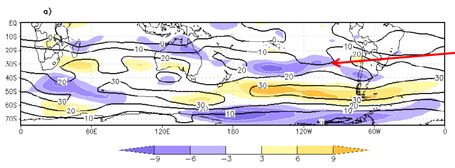


Vertically averaged eddy kinetic energy (shading, $m^2.s^{-2}$), 300-hPa geopotential heights (contour interval 100 gpm), and ageostrophic geopotential height flux vectors ($m^3.s^{-3}$)

Downstream development is observed at the southeastern Pacific from a decaying upper-level trough-ridge system located at the central South Pacific towards the COL

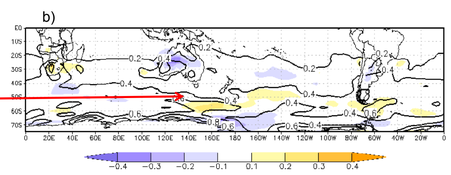
*Along the COL life-cycle, **AKM**, **AKE** and **GFD** dominate the KE budget. **BRT** contribution is always secondary and **BRC** contribution is almost negligible. The exception is the development of the ridge located west of the COL where **BRC** dominates.*

MEAN CIRCULATION AND TRANSIENT ACTIVITY



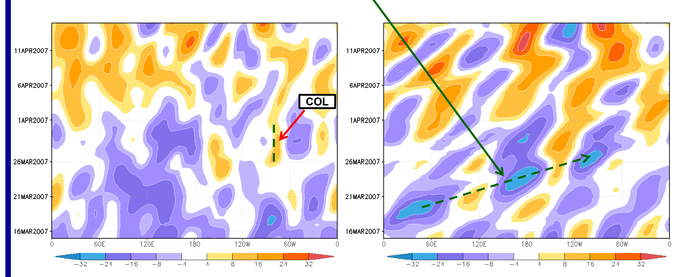
Weak Subtropical Jet conditions over southeastern Pacific Ocean

Intensified mean baroclinicity at middle and high latitudes



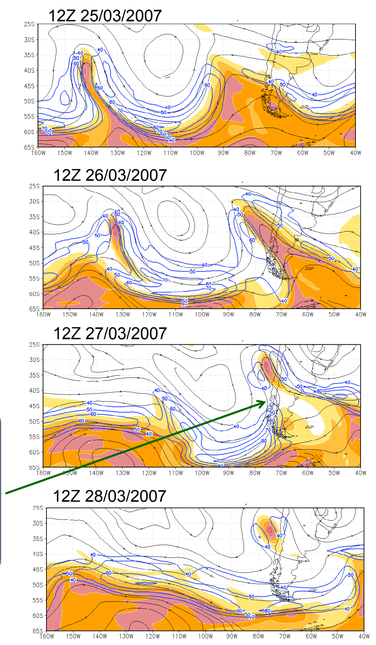
(a) mean zonal wind at 300 hPa from 15 March to 15 April 2007(Contour interval is 10 m.s-1). (b) Eady growth rates computed for the 850–700-hPa layer (Contour interval is 0.2 day^{-1}). Shaded values in both figures are the anomalies with respect to the corresponding climatological means (1979-2010).

Wave energy downstream dispersion is observed before COL development



Daily streamfunction anomalies (x 10^6 m^2 s^{-1}) computed from 15 March to 15 April 2007 and averaged between (a) 20º and 40ºS, and (b) 40º to 60ºS.

Anticiclonic Rossby wave breaking is observed at upper levels

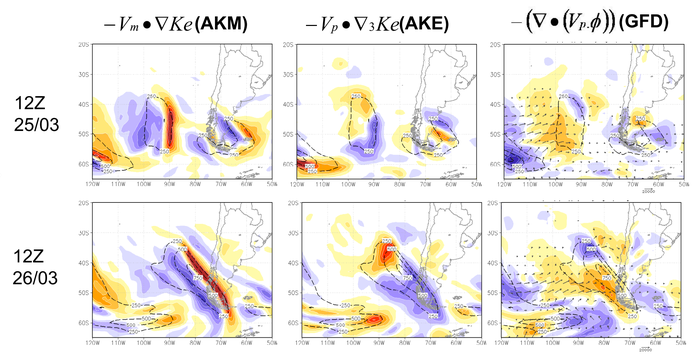


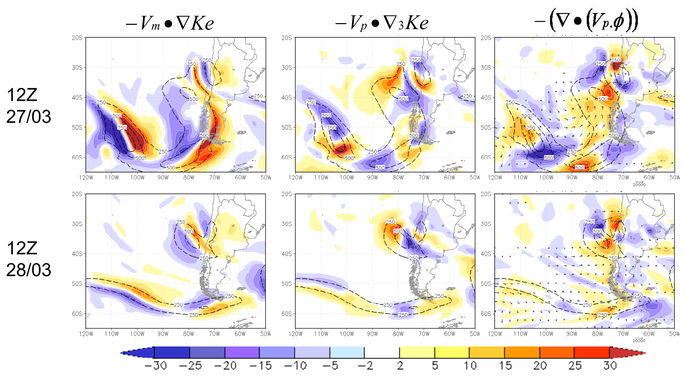
Potential vorticity (shaded, PVU), streamlines (black contours) and maximum wind (blue contours, starting in 40 m s^{-1}) at 330 K level (from ERA interim).

Initial stage:

Displacement of Ke center northeastwards by AKM.

GFD term transfers energy in the SW-NE direction (compensated at some stages by AKE)





Segregation stage:

A balance between the terms is observed at the COL region.

At higher latitudes eastward advection by AKM is important. The GFD term transfers energy from south to north along the west coast of South America maintaining the COL system.

Vertically averaged Ke tendency terms and Ke; a) the advection by the mean flow, b) the advection by the eddies and c) the geopotential flux divergence with the ageostrophic geopotential flux vectors (shaded, $m^2.s^{-3}*10^3$). Black contours represents vertically averaged KE greater than 250 $m^2.s^{-2}$.

CONCLUSIONS:

- The COL event was favored by weak subtropical jet conditions observed at the southeastern Pacific Ocean during that month. In addition, large mean baroclinicity prevailed south of 40º S.
- Stationary 3-wave pattern was evident during that month, which promoted slow propagation of the weather systems at high latitudes, and favored a large-scale wave development at the central South Pacific as depicted by the wave activity fluxes. Moreover, anticyclonic Rossby wave breaking was observed at the southeastern Pacific during the initial stage of the COL.
- The Ke budget analysis shows that the large-scale wave located in the central Pacific played a significant role in the COL development through both advection and energy dispersion processes.
- At the COL initial stage, the AKM term was the dominant process by shifting eastward the Ke packets associated with the COL. The GFD term facilitated the energy transfer from south central Pacific to the northeast.
- During COL segregation stage, a balance between all terms was found at the COL region. At high latitudes, AKM was dominant propagating energy eastward and promoting the shift of the upstream ridge to the southeast, thus contributing to the COL isolation. At those latitudes, GFD contributed to an energy transfer from south to north along the west coast of South America, helping COL maintainance.