ATMOSPHERIC CIRCULATION ANOMALIES AND TELECONNECTIONS ASSOCIATED WITH SUMMER PRECIPITATION IN CENTRAL WEST ARGENTINA

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MOTIVATION

- The Central-West Argentina (CWA, Fig. 1) is a semidesertic region sensitive to climate fluctations. Its highly populated oasis are vulnerable to precipitation variability both in the Andean high mountains and in plains. (Compagnucci et al. 2002).
- CWA precipitation affects noticeably the annual grape production (one of the main economic activity) within the decade (Fig. 2) , which has a great social and economic impact (Agosta and Cavagnaro 2009, Agosta et al., in JAMC, accepted).
- The 1976/77 climate shift affects the tropospheric circulation over southern South America (SA) including CWA (Agosta and Compagnucci 2008).

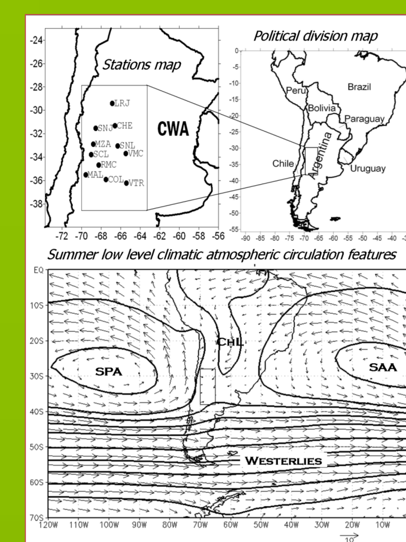


Figure 1: Upper panel: map of location of the meteorological stations within the CWA region (29°-36°S and 65°-70°W). Lower panel: Summer mean lower tropospheric circulation.

South Pacific Anticyclone (SPA), South Atlantic Anticyclone (SAA), Chaco Low (CHL) & Westerlies.

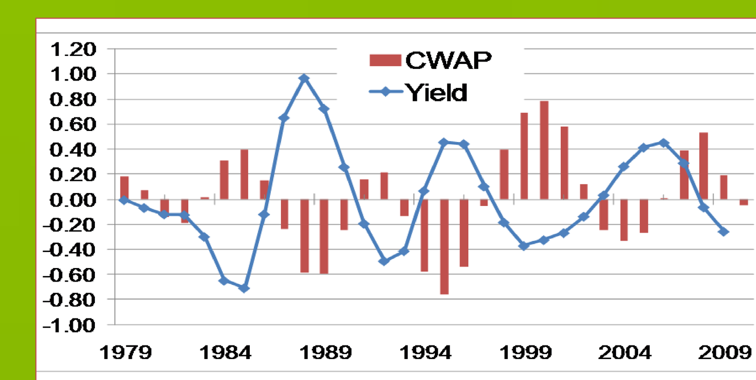


Figure 2: CWA summer standardized precipitation index (CWAP, bars) and regional grape yield index (Yield, line) inverse relationship within the decade. Timeseries are smoothed by a Gaussian 5-term filtering to highlight the low frequency (larger waves or equal to 6 years).

OBJECTIVE

We aim to examine the CWA interannual-to-multi decadal summer (Oct-Mar) precipitation variability and its connection with Southern Hemisphere (SH) seasonal atmospheric teleconnection changes due to the climate shift of the austral summer of 1976/77.

RESULTS

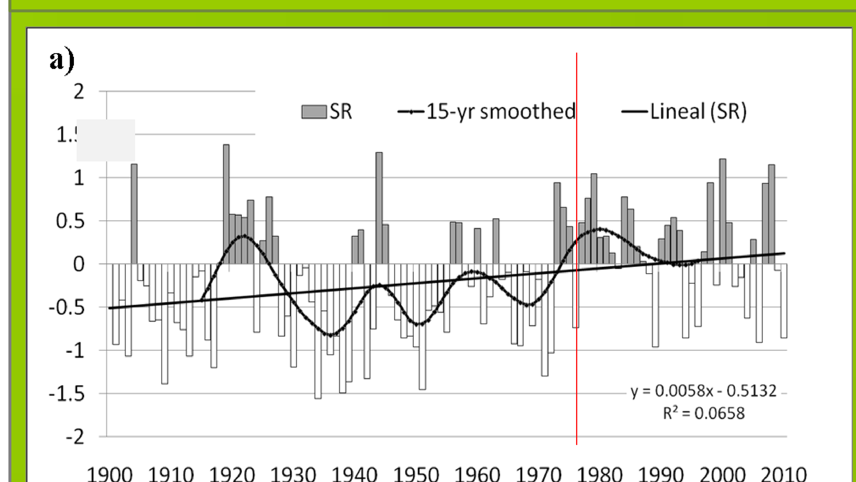


Figure 3
The CWA summer (Oct-Mar) precipitation (SR, similar to CWAP) index timeseries, devised using meteorological station data (vertical bars) from the Argentine Weather Service; the 15-yr smoothed SR-index timeseries (15-yr smoothed), and the linear trend for SR timeseries (Lineal SR).
Linear-trend equation is at the bottom-right corner and the explained variance is R^2. Vertical red line: the 1976/77 summer.

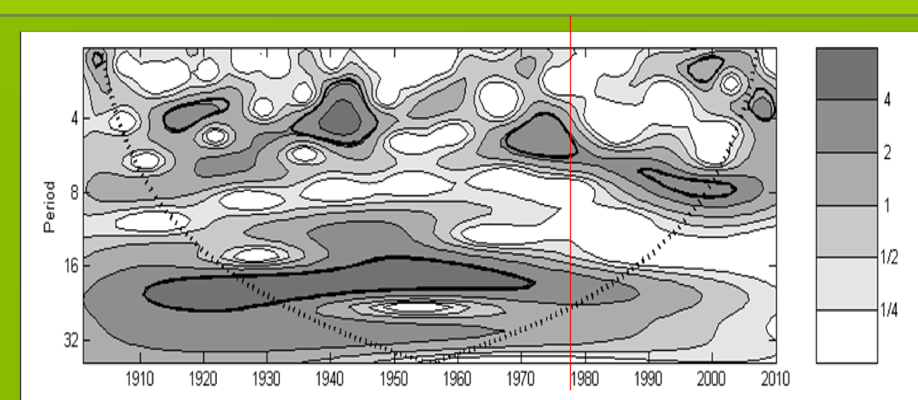


Figure 4
The local wavelet power spectrum of the SR-index for CWA summer precipitation, using the 'Morlet' wavelet. The left axis is the Fourier period (yr). The bottom axis is time (yr). Solid thick contour encloses 95% of confidence for a red-noise process with a lag-1 coefficient of 0.43.

Shaded contours are for graded explained variances at 4=50%, 2=25%, 1=12.5%, ½=6.25% and ¼=3.125%. Dotted line: cone of influence, values between the line and the borders of the graph have important edge effects.

Significant quasi-cycles:
- 16-22 years. => quasi-bidecadal cycle
- 6-8 years => grape-related inverse relationship during the last three decades
- 4-5 years
- Around 2 years.

Main changes
- ✓ The quasi-bidecadal cycle ends in the mid-1970s: alternating periods of wet/dry spells of about 9-yr. duration each from 1910s until 1970s.
- ✓ A prolonged wet spell is observed from 1973 to the early 2000s (more than 30 years)
- ✓ The regional precipitation average increases near 25%.

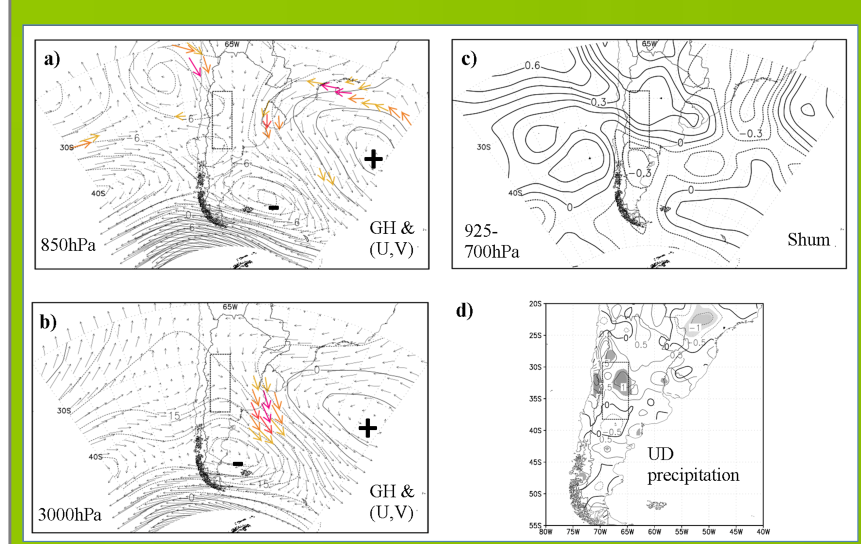
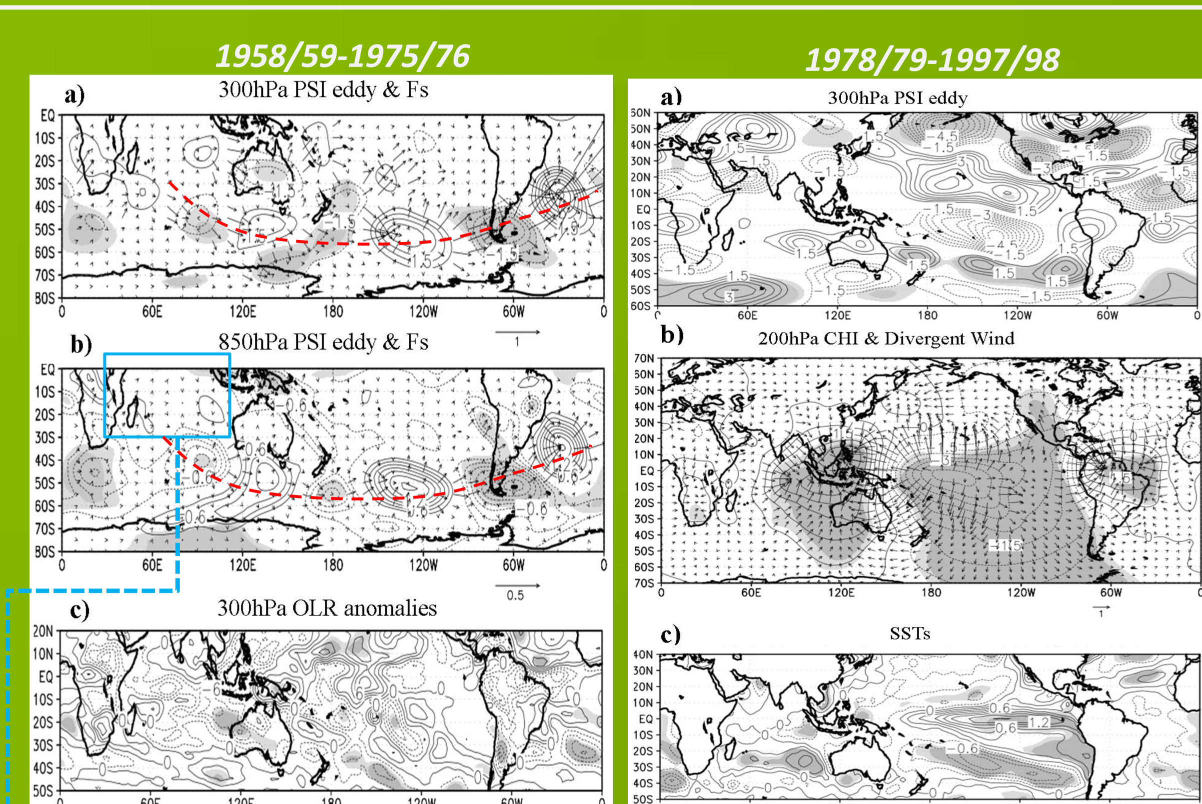
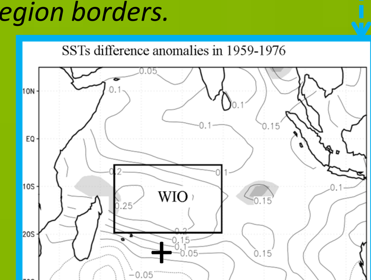


Figure 5
Composite difference anomalies (composites made by quartile criterion of the SR-index distribution) between CWA wet summers after 1977 and before 1977 for geopotential height (GH, mgp) and vector wind (UV, m/s) at 850 hPa (panel a) and at 300hPa (panel b); for the 925-700hPa integrated specific humidity (Shum, g/kg, panel c), data from NCEP-NCAR reanalysis I; and for the University of Delaware (UD) 0.5° gridded precipitation (in standard deviation units, panel d).
Highlighted vectors are significant over the 90% confidence level. Shaded areas in panel (d) are significant at the 90% (lighter grey) and 95% (grey) confidence levels. The rectangle roughly represents the CWA region borders.

- ✓ Wet summers after the summer of 1976/77, when compared with those before it, are linked to positive GH anomalies in the western flank of the SAA and negative GH anomalies in mid-latitudes (the inverse is observed for dry summers).





Positive values in WIO region are associated with QSW propagation toward SA (Chan et al. 2008).

Figure 6: ***Left panel:*** Anomalous streamfunction (PSI, 10e-6 m²/s) eddy and the corresponding horizontal Plumb's stationary wave-activity flux (Fs, m²/s²) at 300hPa (a) and 850 hPa (b). Wet-minus-dry composite anomalies for OLR (watt/m², c). Period 1958/59-1975/76.
Right panel: Anomalous 300 hPa PSI eddy (panel a). Wet-minus-dry composite difference anomalies for 200hPa velocity potential (CHI, 10-6 m²/s), divergent wind vectors (m/s, b), and for global SSTs (°C, c). Period 1978/79-1997/98 (similar to 1978/79-2009/10). *Shaded areas are significant at the 90% (lighter grey) and 95% (grey) confidence levels.*

- ✓ Before 1977, CWA precipitation is linked to equivalent barotropic quasi-stationary wave (QSW) propagation from the tropical southern Indian and South Pacific towards SA.
- ✓ After 1977, CWA precipitation is linked to eastern equatorial Pacific SST warming and poleward anomalies related with ENSO-like conditions.

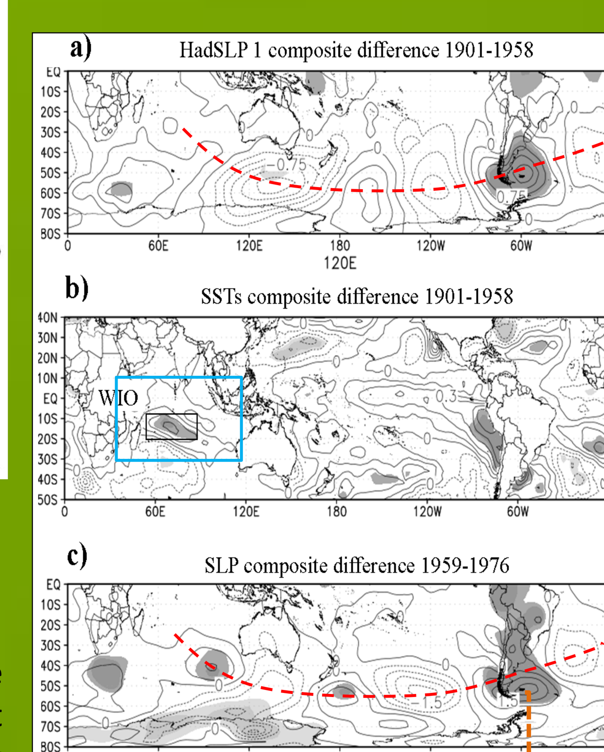


Figure 7
Wet-minus-dry summer composite difference for HadSLP1 data (a), SSTs in the period 1901-1958 (b), and for NCEP/NCAR SLP in 1959-1976. *Shaded areas indicate significant anomalies at the 90% (lighter grey) and 95% (grey) confidence levels.*

- ✓ Even much further back from reanalysis era, from the beginning of the 20th century, the southern tropical Western Indian Ocean area (WIO) appears to be related with CWA precipitation via Rossby wave propagation.

The 15-yr smoothed SR index timeseries and the 15-yr smoothed MF SLP timeseries (the MF SLP is the HadSLP1 data averaged on 45°-55°S and 60°-55°W over the southwestern South Atlantic, near the Malvinas/Falkland (MF) Islands).

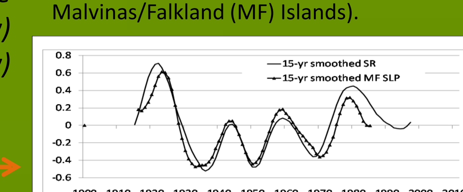


Figure 8
Upper: The 30-yr running correlation between the SSTs WIO index and the CWA summer rainfall (SR) index.
Lower: Idem but for an El Niño (EN) index and SR.
The 95% and 99% confidence levels according to the one-tail Pearson's coefficient correlation's test with (n-2) degree of freedom.

- ✓ WIO and CWA precipitation show stationary relationship until the early 1970s.
- ✓ The El Niño ad CWA precipitation are unrelated.

CONCLUDING REMARKS

- The summer precipitation in CWA shows significant quasi-cycles with periods about 2, 4-5, 6-8 and 16-22 years.
- A prolonged wet spell is observed from 1973 onwards, leading to an increase about 25% in regional average due to the climate shift of 1976/77. The precipitation variability is unrelated with ENSO at interannual scale.
- From the early 20th century until the mid-1970s the precipitation variability is associated with QSWs propagation from the WIO regions and the South Pacific toward mid-latitude SA. The QSWs generate vertical motion and moisture anomalies at middle-to-subtropical latitudes east of the Andes responsible for the CWA precipitation anomalies (not shown).
- After 1976/77 the precipitation variability is associated with equatorial symmetric circulation anomalies linked to El Niño-like warmer conditions. This generate changes in the subtropical jet over SA (not shown).
- Positive (negative) moisture anomalies in CWA after 1976/77 are consistent with those observed in subtropical Argentina, north of 40°S, in association with inflation (deflation) of the western flank of the SAA.
- The quasi-bidecadal cycle is present in the SA mid-latitude tropospheric circulation.

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