Synoptic-scale transient activity and quasi-stationary waves interactions in association with summer precipitation variability in Central – West Argentina

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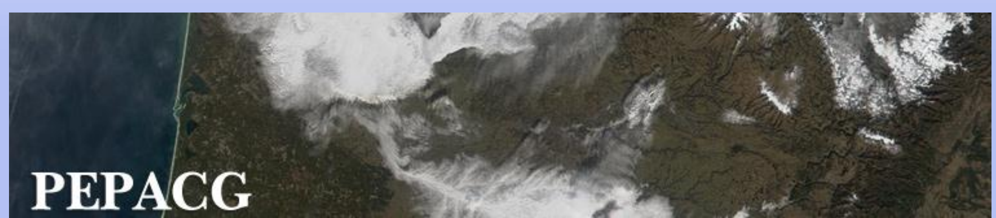


Motivation

- Previous studies highlight the existence of a climate shift in the summer (warm season) precipitation variability in CWA.

  (Agosta et al. 1999, Compagnucci, Agosta and Vargas 2002).

- CWA precipitation affects noticeably the annual grape production within the decade (great social and economic impact).

  (Agosta and Cavagnaro 2009, Agosta et al. 2011, accepted in Journal of Applied Meteorology and Climatology).

- The synoptic-scale tropospheric circulation shows a change over southern South America by 1977, according to changes in the order of the PCs patterns:
  - ✓ Reduced mid-latitude synoptic-scale cyclonic activity.
  - ✓ Increased SAA activity in its western flank

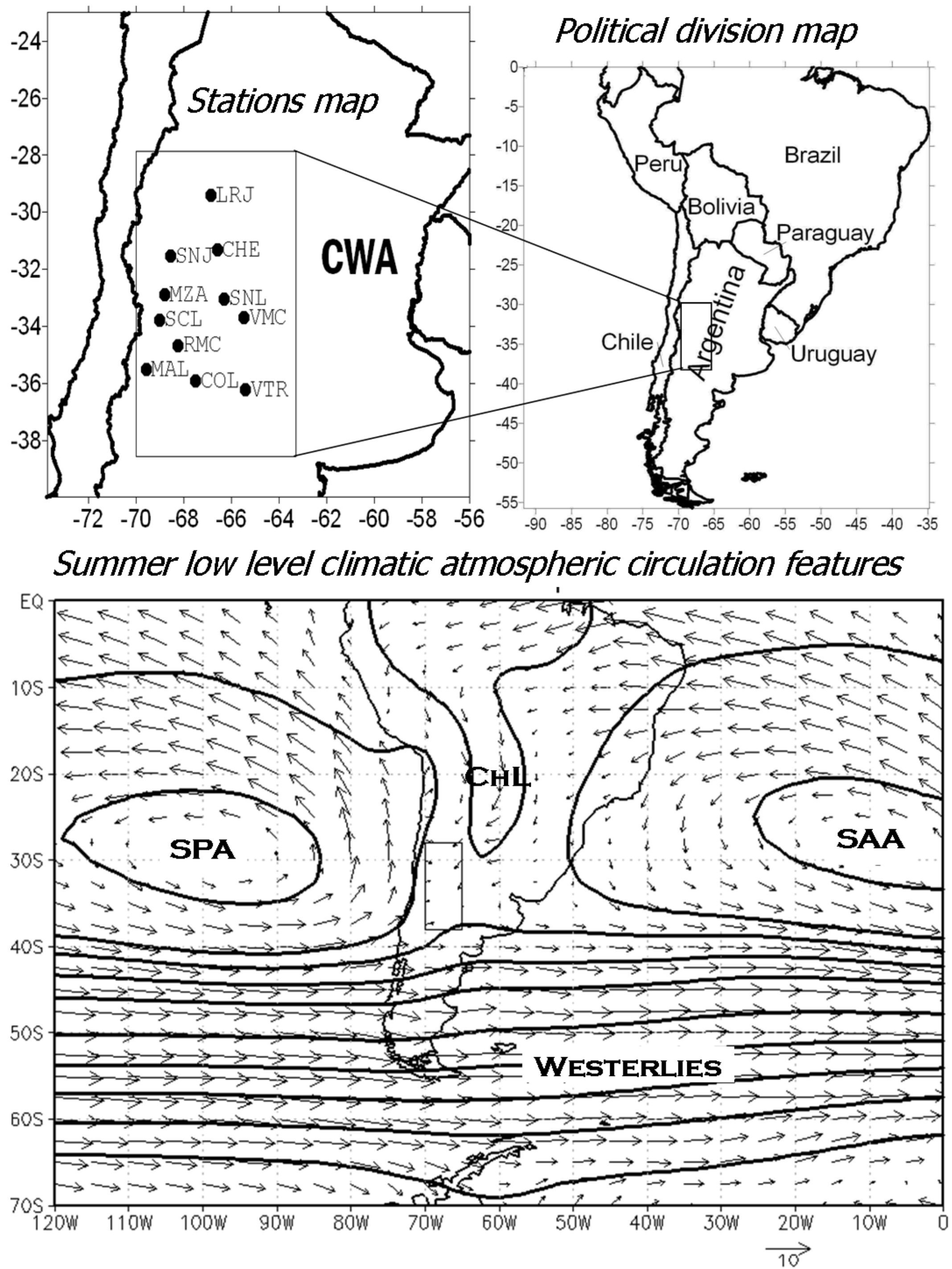
  (Agosta and Compagnucci 2008).

Map of location of the meteorological stations within the Central-West Argentina (CWA) region (29°-36°S and 65°-70°W)

Mean conditions:

- ✓ South Pacific Anticiclone (SPA)
- ✓ South Altantic Anticiclone (SAA)
- ✓ Chaco Low (CHL
- ✓ Weterlies

Andes barrier
Moisture from the Atlantic and Amazonia



Objectives

- To examine the CWA interannual-to-multi decadal summer precipitation variability and its connection with Southern Hemisphere (SH) seasonal atmospheric teleconnection changes due to the climate shift of around 1977.
- To explore the transient activity changes associated with these low-frequencies tropospheric anomalies.

Data

- Monthly precipitation totals from 10 meteorological stations povided by the National Weather Service (1900-2010).
- University of Delaware (0.5°x0.5°) gridded precipitation data (v2) 1901-2008.
- Daily and Monthly (2.5°x2.5°) NCEP/NCAR reanalysis products of atmospheric variables.
- Hadley Center SLP 1 and 2 reconstructions.
- NOAA's (2°x2°) Extended SSTs reconstruccions (v3).

Methodology

- Precipitation index

$$Y_j(t) = (X_j(t) \cdot 100) / \chi_j$$

$$1 \leq j \leq n$$

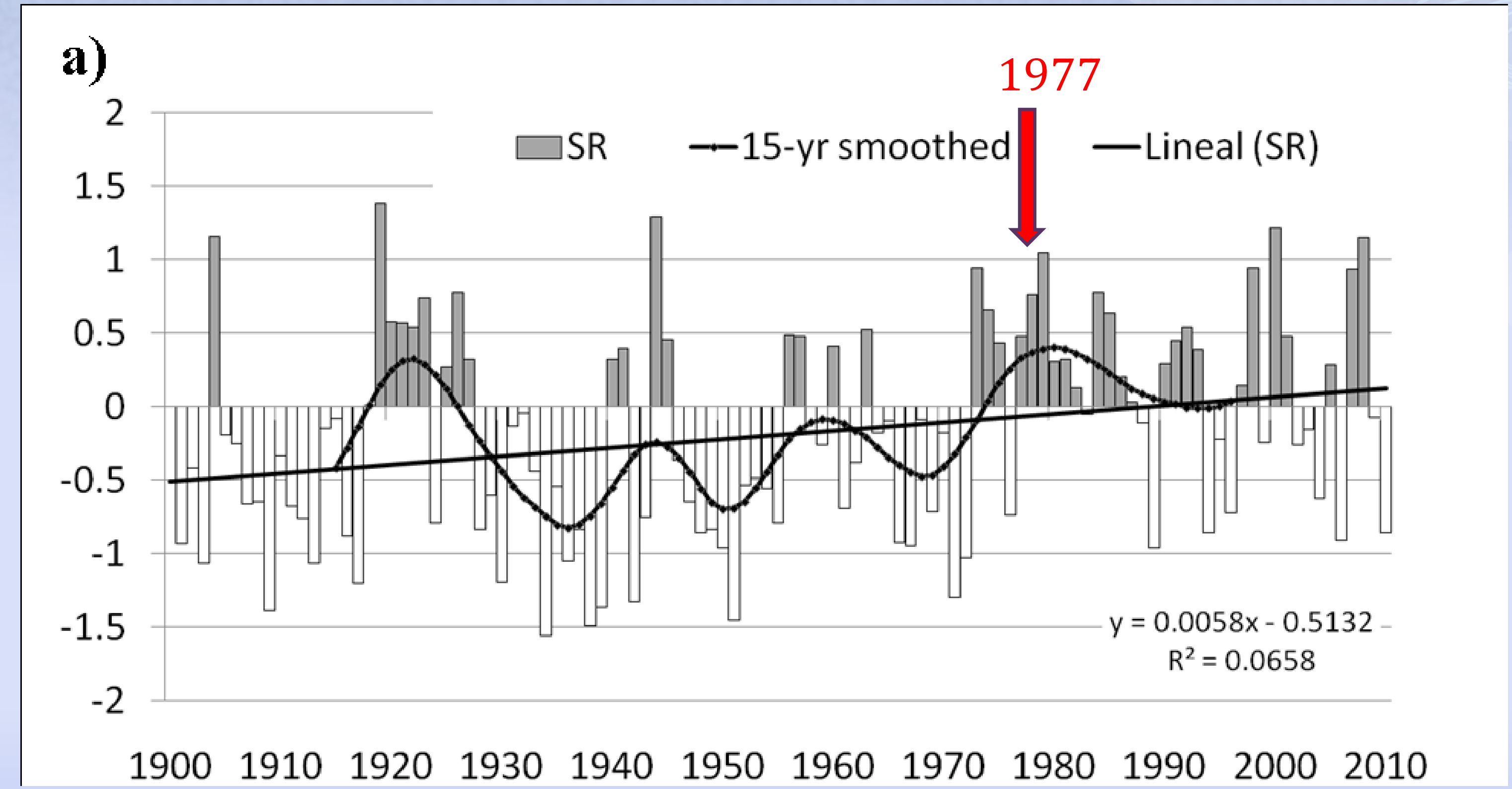
$$P(t) = \sum_{j=1}^{n} Y_j(t) / n$$

- Y_j (t): summer rainfall single series of station *j*, expressed as percentage of its 1961-1990 long run average.
- X_j (t) : station *j*´s summer precipitation in year *t*.
- j. index of stations,
- n: number of meteorological stations

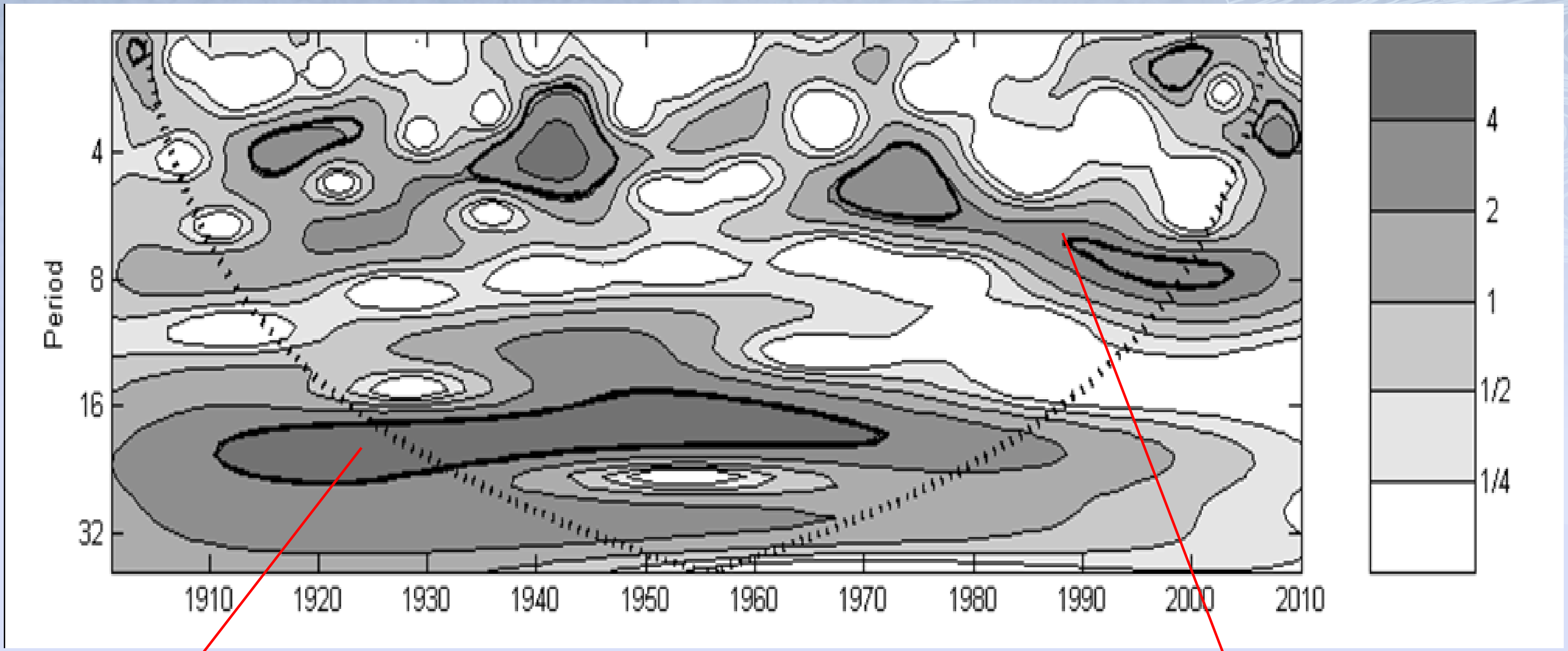
Methodology

- Quartile criterion for the PI to classify wet and dry summers, and to composite cases.
- Wavelet power spectrum of the timeseries (Torrence and Compo 1998)
- Estimation of Plumb (1985)'s quasi-stationary wave activity flux.
- High-pass filtering (2-8 days, as in Inatsu and Hoskings 2004).
- HF transient statistics (i.e. Eddy Kinetic Energy)

Results



- The CWA summer (Oct-Mar) rainfall (SR) index timeseries, devised using meteorological station data (vertical bars); 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



Ca. 18 years

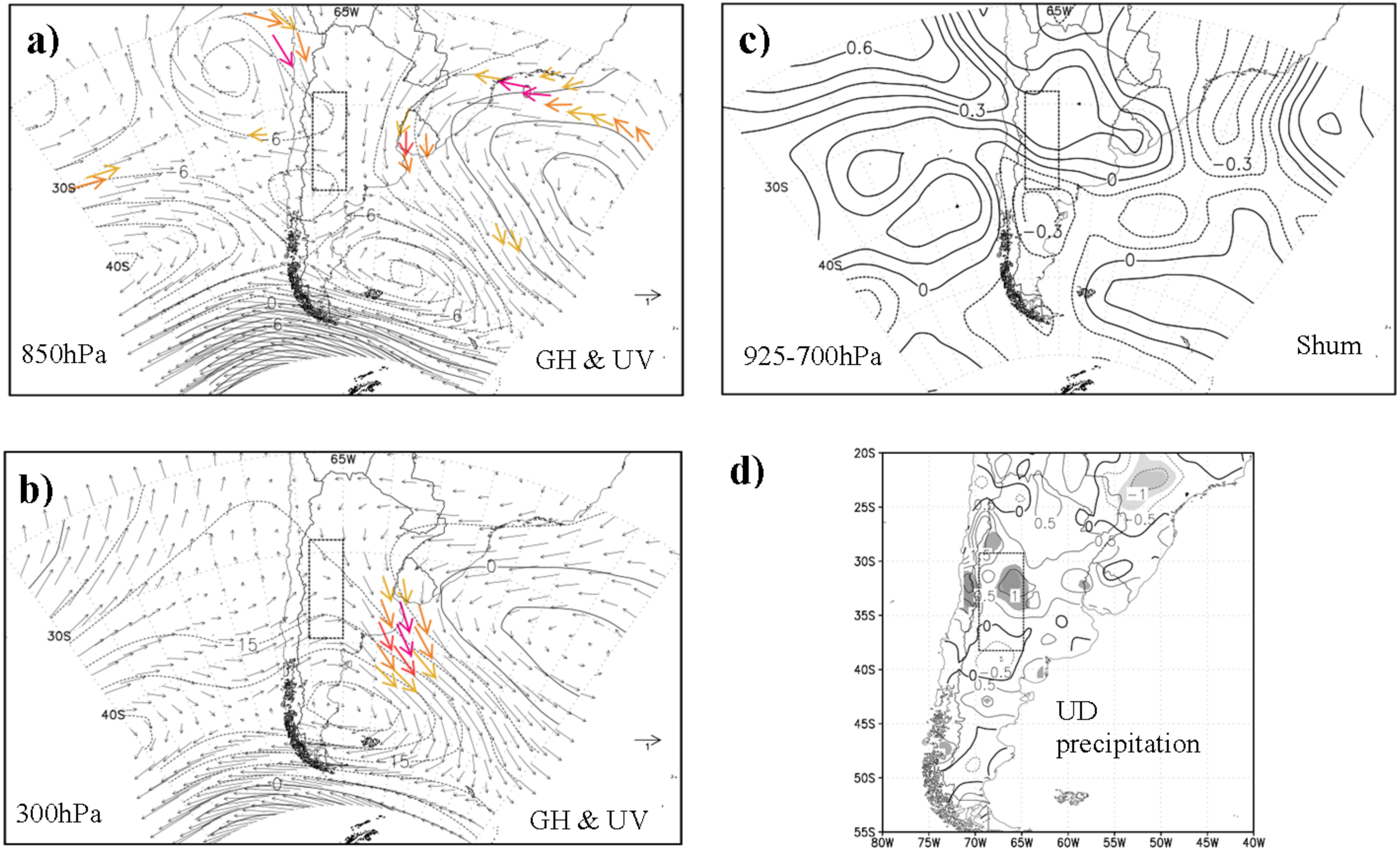
Ca. 6-8 years

- The local wavelet power spectrum of the SR-index for CWA summer rainfalls, 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 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

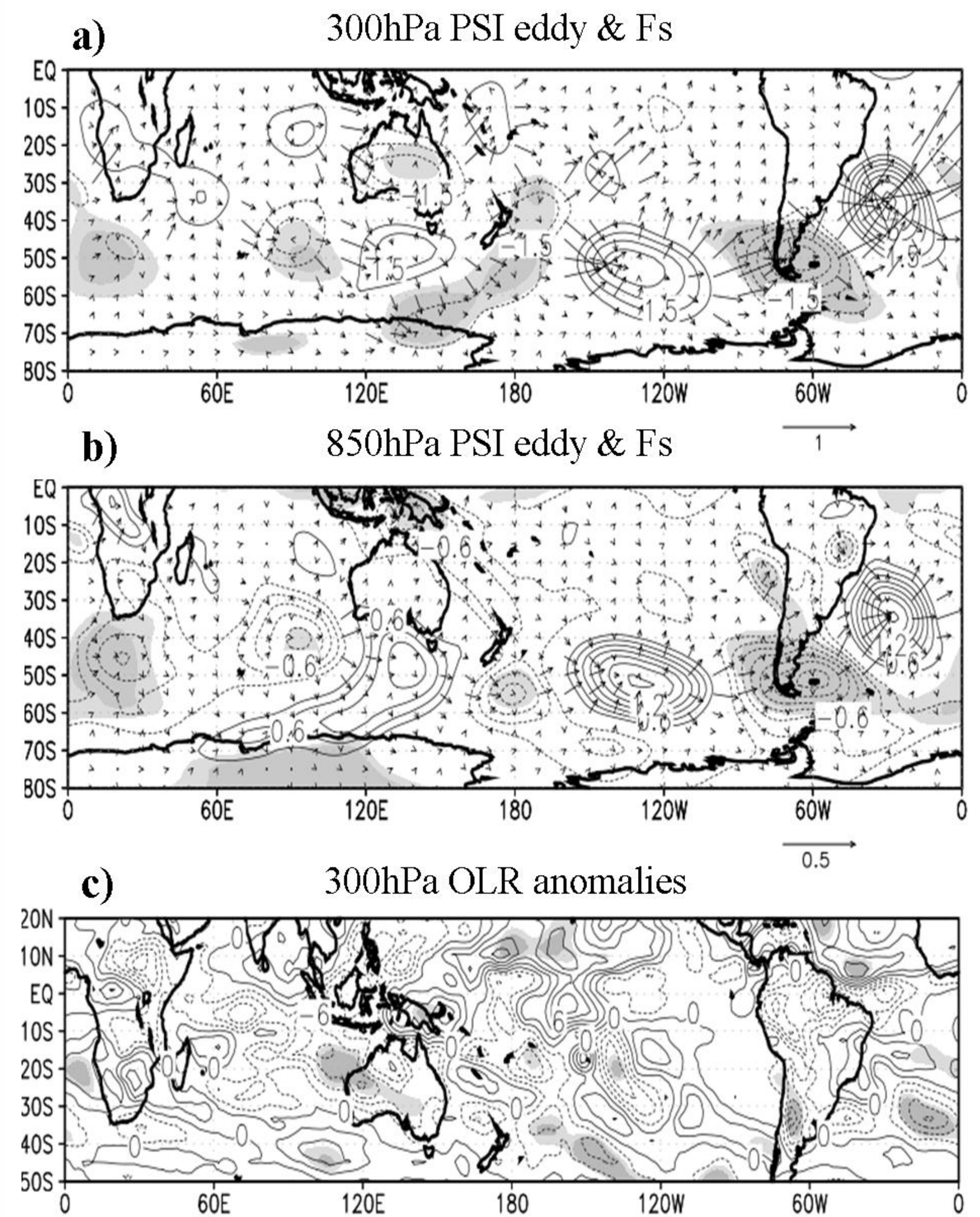
- 16-22 yr. => Quasi-bidecadal
- 6-8 yr. = > grape-yield cycle (inverse relationship)
- 4-5 yr.
- Around 2 yr.

After-1977 wet composite minus before-1977 wet composite



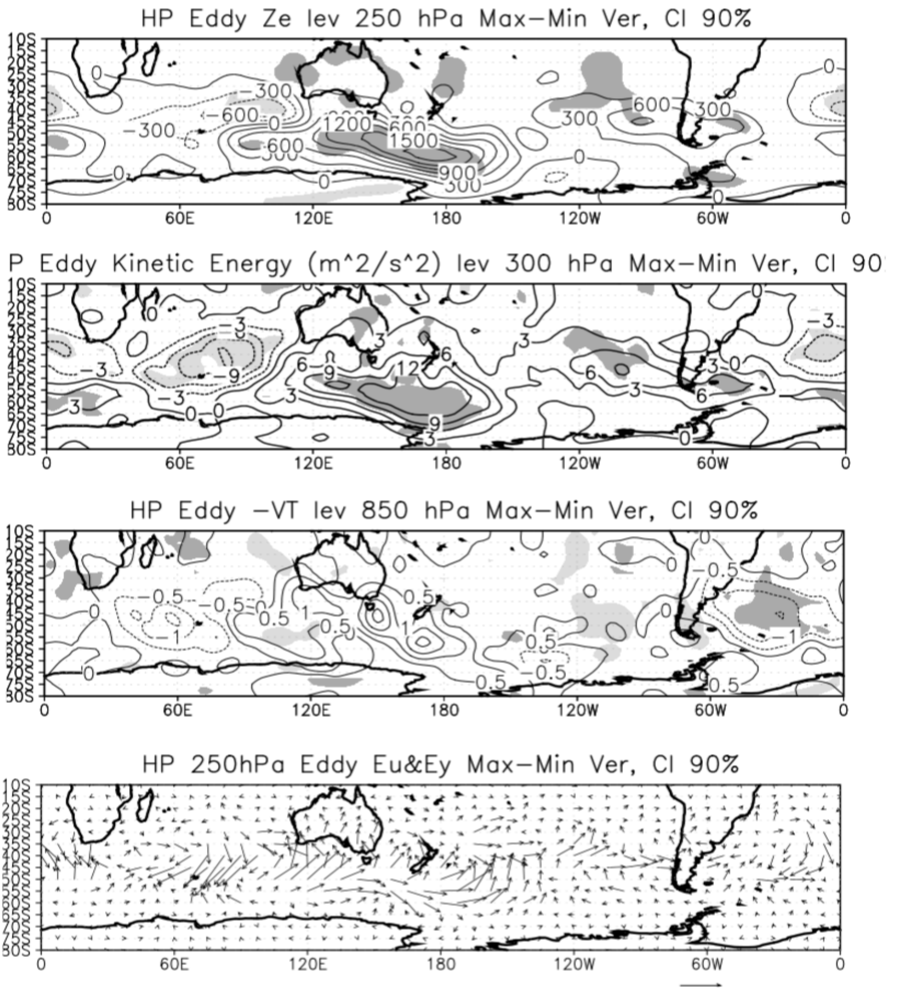
Composites before 1977

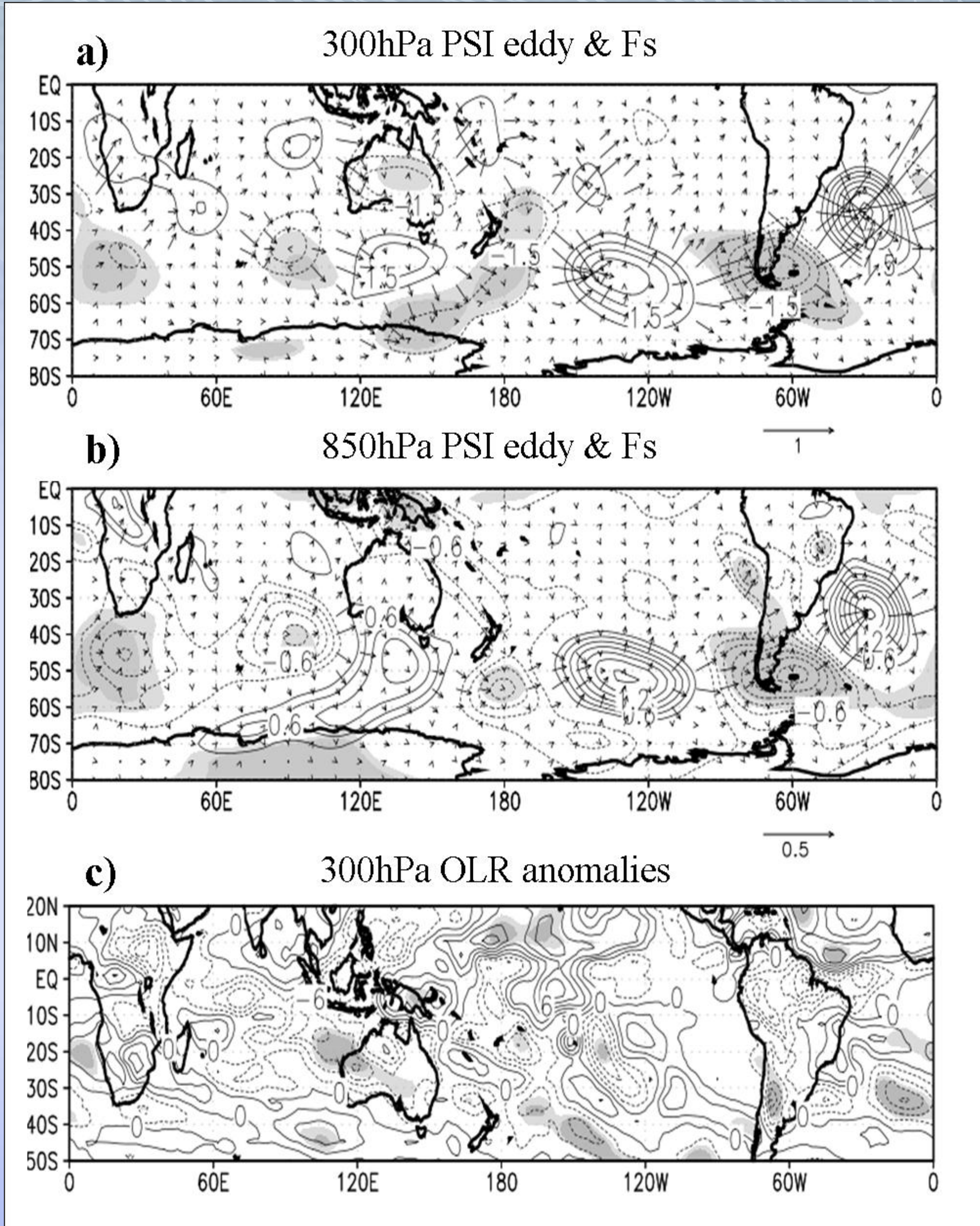
- ✓ QSWs propagations from tropical southern Indian and Pacific oceans.



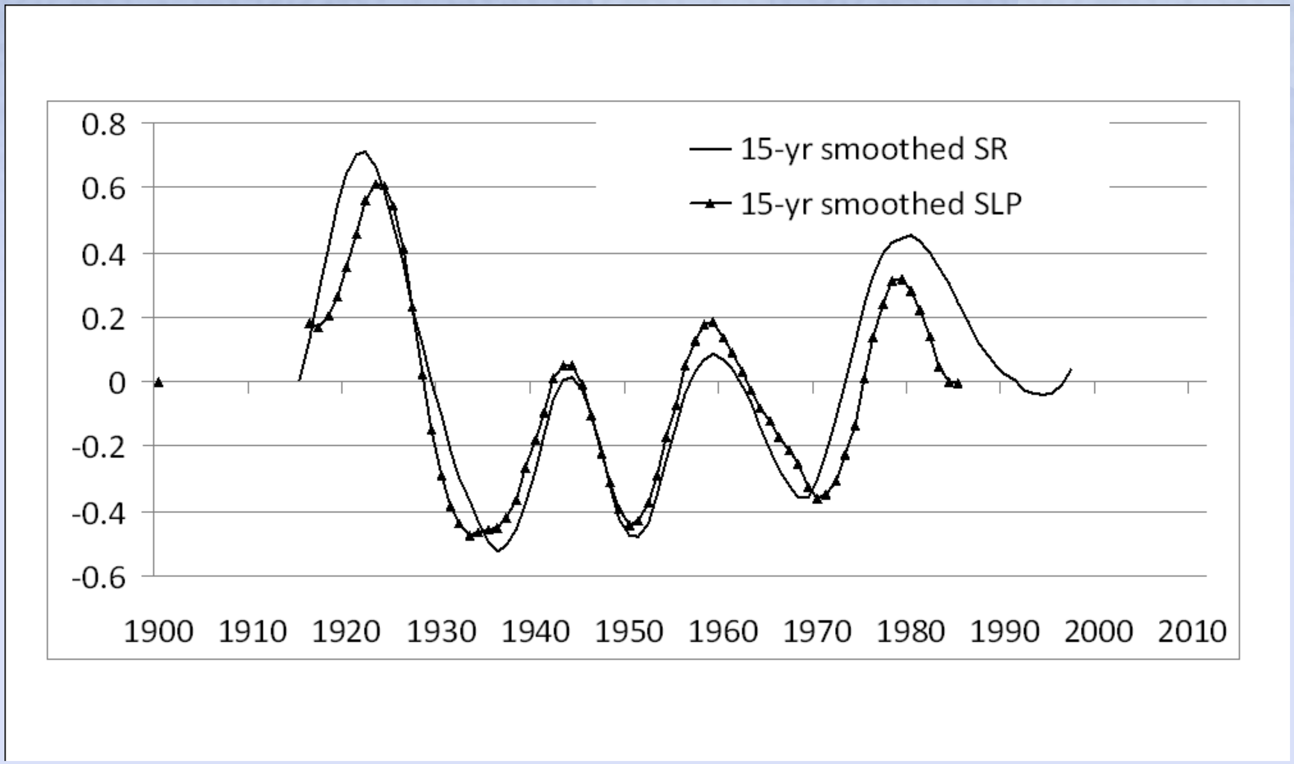
Anomalous streamfunction (PSI, in 10e-6 m^2/s) eddy and the corresponding horizontal Plumb's stationary wave-activity flux (Fs, vector, in m^2/s^2) at 300hPa (panel a) and 850 hPa (panel b); 300 hPa OLR wet-minus-dry composite anomalies (panel c).

Composite anomalies correspond to the period 1959-1976. Shaded areas are significant at the 90% (lighter grey) and 95% (grey) confidence levels.

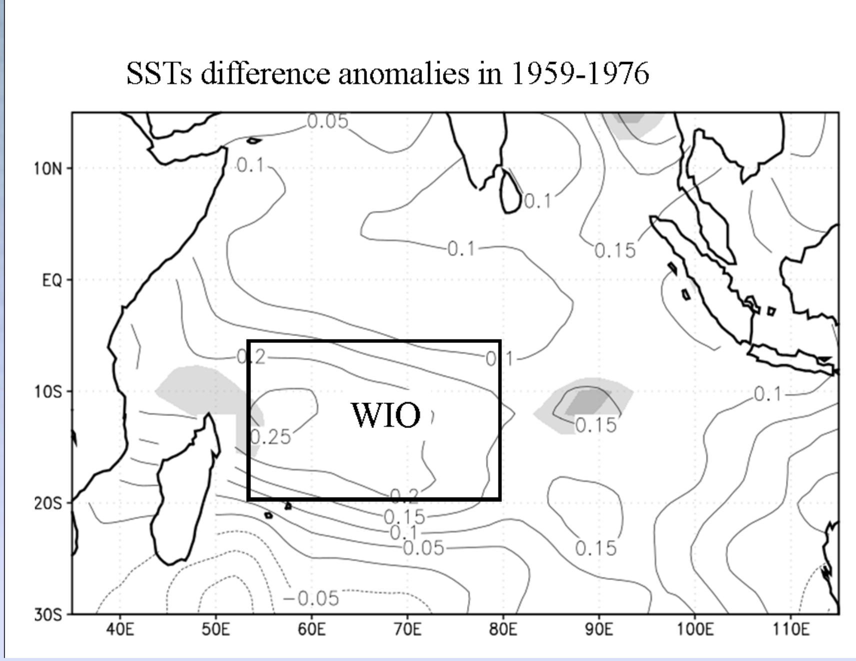




2-8 days (high frequency) transient waves activity is anomalously enhanced/decresead => they are contributing to reinforce QSWs propagation via vorticity and heat perturbed fluxes convergence into the mean flow



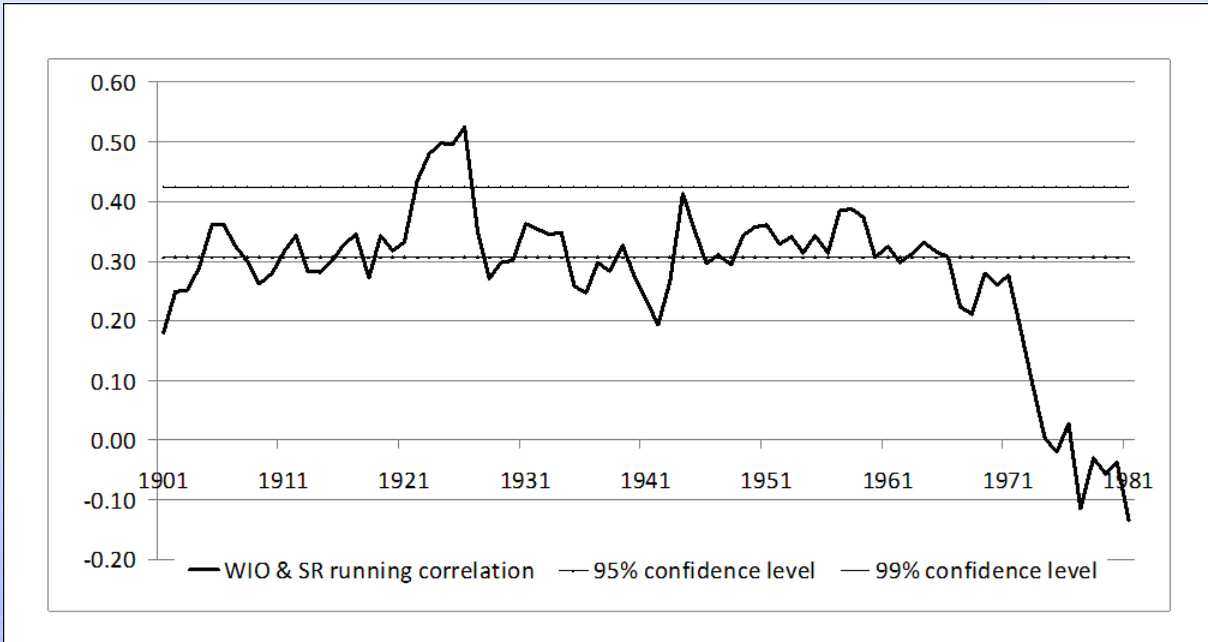
- Both SLP (at about 50°S and 55°W, close to the Malvinas/Fakland Is.) and the CWA precipitation smoothed timeseries show their interdecadal coherence.



- According to Chen et al. (2008), WIO region is associated with Rossby waves propagation that may influence precipitation in South America

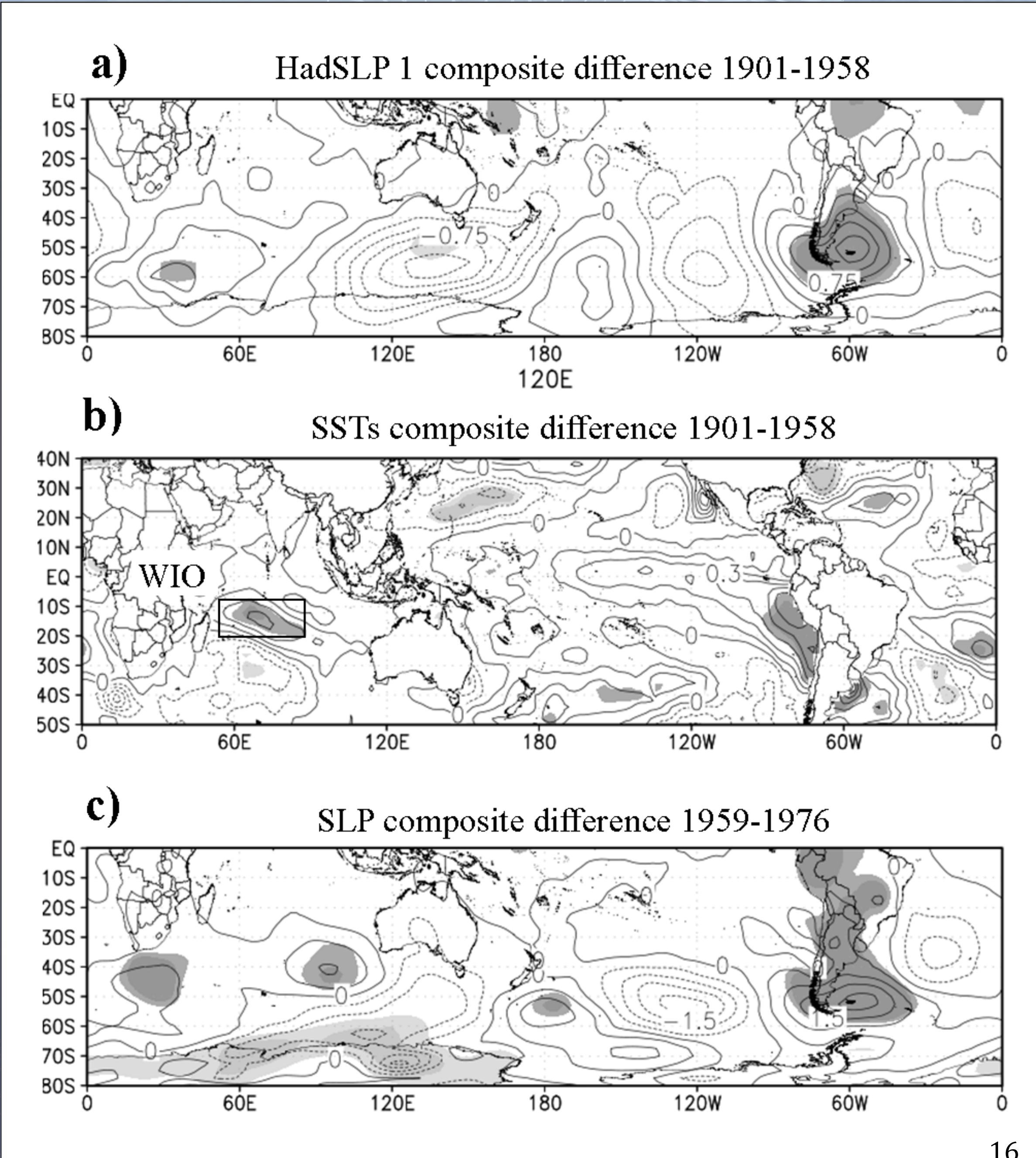
- Stationary relationship during several decades, suggesting a possible low-frequency interaction between the WIO and the CWA rainfall all over the past century.

- After the early 1970s correlations values fall close to zero, hence the WIO and CWA summer rainfalls lose their association.



1901-1958 Composites

- The positive signal over the WIO region is insentified
- SLP composites shows similar QSWs anomalies

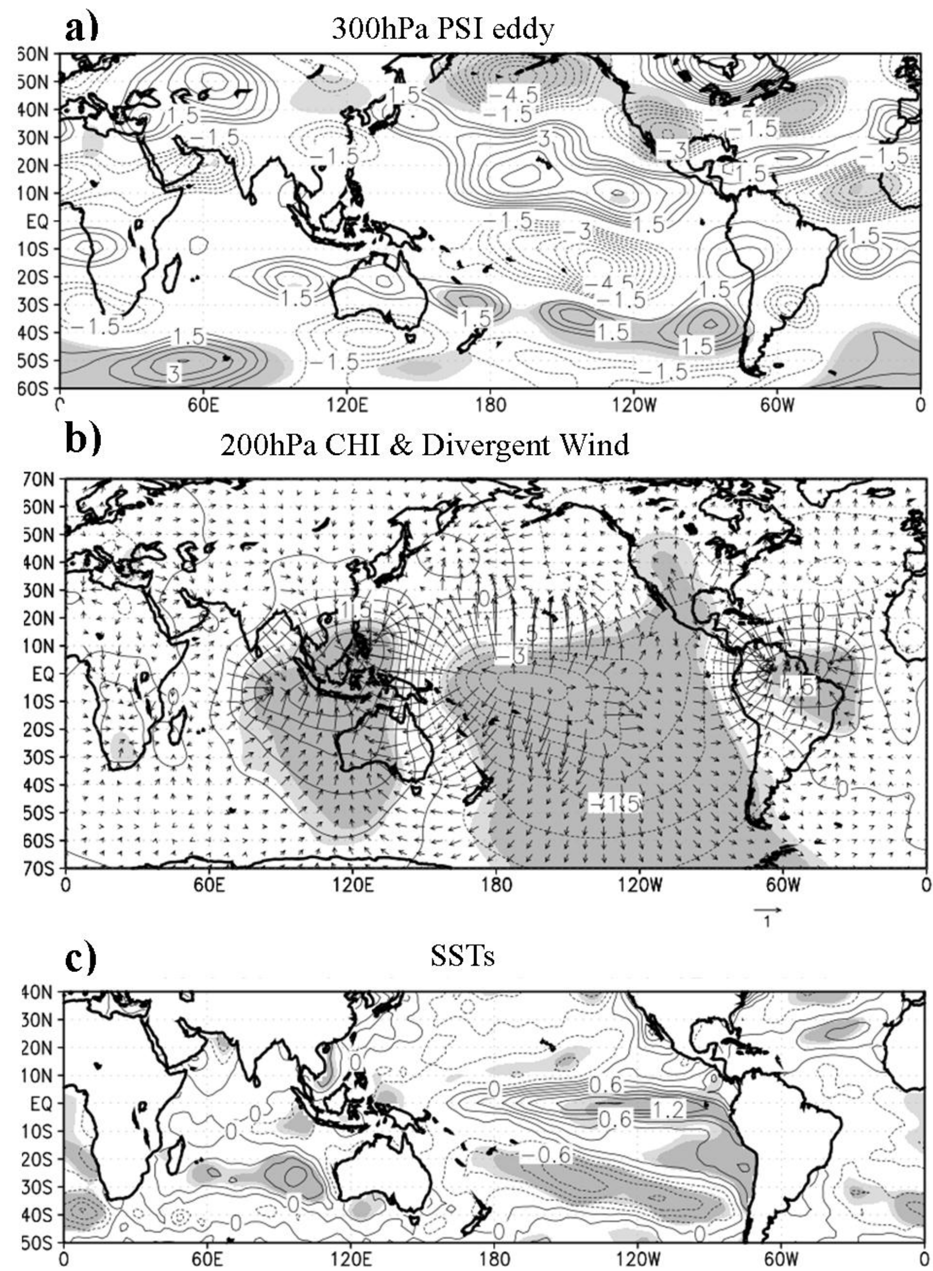


After 1977 composites

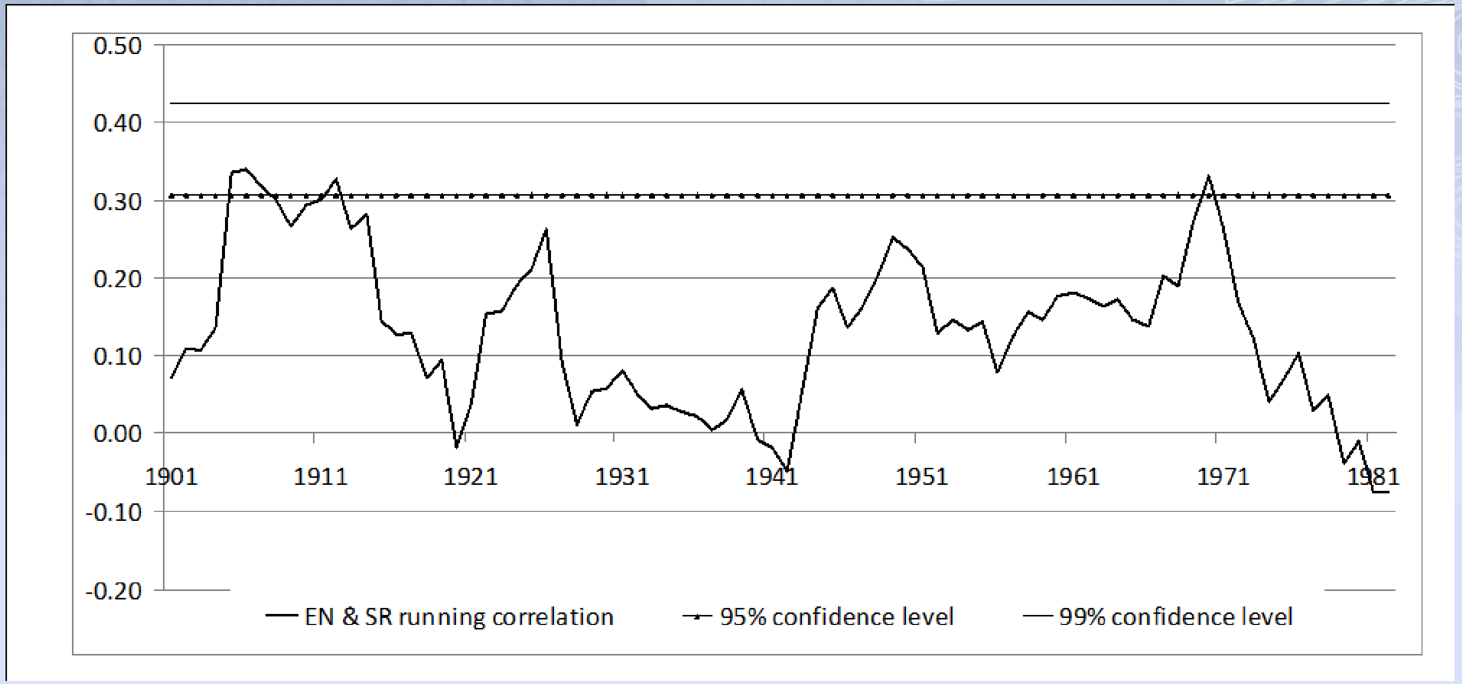
- ✓ Symmetric anomalies around the equator line.
- ✓ El Niño-like conditions

Anomalous streamfunction (PSI in $10e^{-6}\,m^2/s$) eddy at 300hPa (panel a). Wet-minus-dry composite difference anomalies for 200hPa velocity potential (CHI in $10^{-6}\,m^2/s$) and divergent wind vectors (in m/s. Both in panel b), and for global SSTs (panel c).

Composites and anomalies correspond to the period 1979-1998. Shaded areas are significant at the 90% (lighter grey) and 95% (grey) confidence levels



Wet-dry composite difference in the period 1978-1998



The CWA precipitation and ENSO are unrelated at inter-annual scales.

Summary

- 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 to the early 2000s.
- From the early 20th century until the mid-1970s the precipitation variability is associated with barotropic quasi-stationary waves (QSWs) propagation from the tropical southern Indian Ocean (WIO) and the South Pacific.
- This generates vertical motion and moisture anomalies at middle-to-subtropical latitudes east of the Andes over southern South America
- It could be also linked to another mid-latitude source along the stormtracks, to the east of New Zealand.
- After 1976/77 the precipitation variability is associated with equatorial symmetric circulation anomalies linked to El Niño-Southern Oscillation (ENSO)-like warmer conditions.
- Positive moisture anomalies are consistently observed at lower latitudes in association with inflation of the western flank of the South Atlantic anticyclone.
- Out of this the precipitation variability is unrelated with ENSO.

Future works will be

- To determine how QSWs modulate HF transient activities and their feedbacks at interdecadal decades.

- To analyse the nature of the quasi-bidecadal oscillations present in both SH mid-latitude tropsopheric circulation and SSTs.

MANY THANKS FOR YOUR ATTENTION!

A part of these results are appearing in :

Agosta, E.A. and R.H. Compagnucci (in press): Central West Argentina Summer Precipitation Variability and Atmospheric Teleconnections, Journal of Climate.

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