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ICTP Workshop on Variability in the Western Tropical Pacific
Trieste, 12-16 November 2012

On the summertime temperature variability in southern South America: interannual and interdecadal patterns during the 20th century

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research project: DJF T variability over SSA during the 20th century

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main motivation:

> 1970s *climate shift* over SA – particularly strong in DJF over SSA

specific aims of our research:

> is there a *shifty climate* over SSA?
> (were there other shifts in the 20th century?)

> explore the interannual & interdecadal T variability in DJF, during the whole 20th century over SSA (20CRv2)

> which are the associated dynamical mechanisms / teleconnections?

a conceptual model of the 1970s *climate shift* over South America

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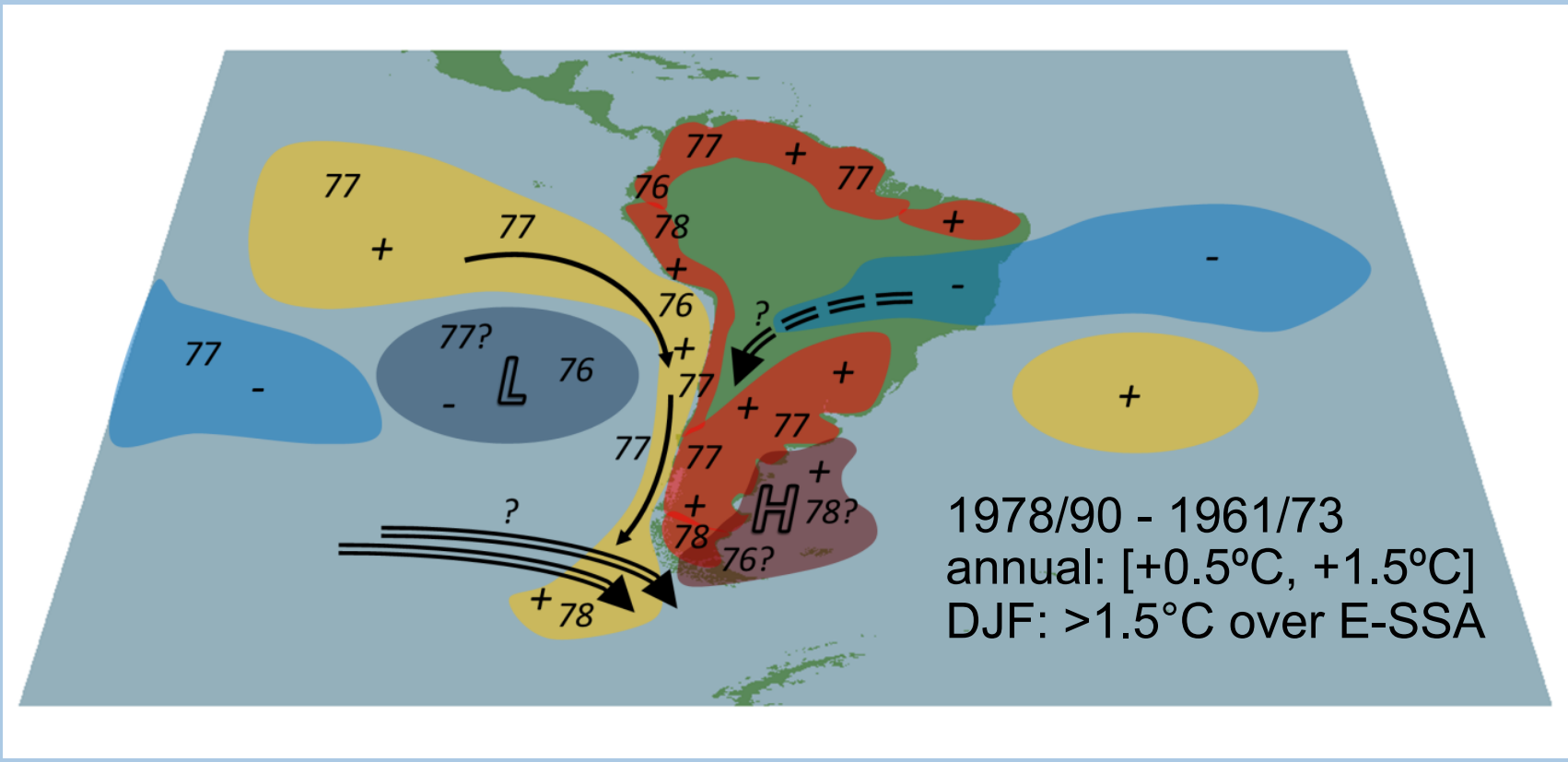
SST, SAT, SLP, P…



> Venezuela, Colombia, Peru, Chile and Argentina/Uruguay

T: regional composites (GHCN)

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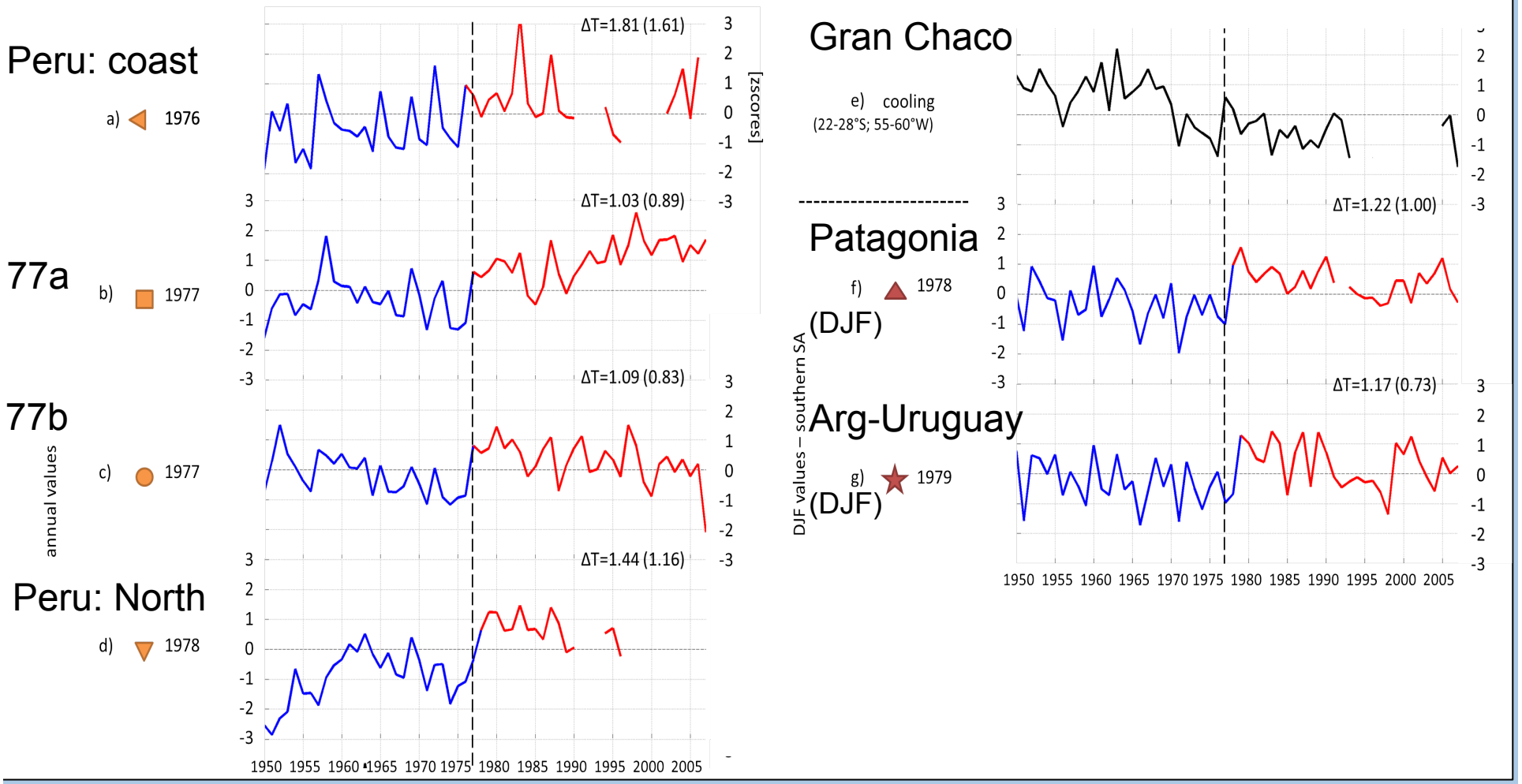

DJF T: 4 N-S composites (GHCN)

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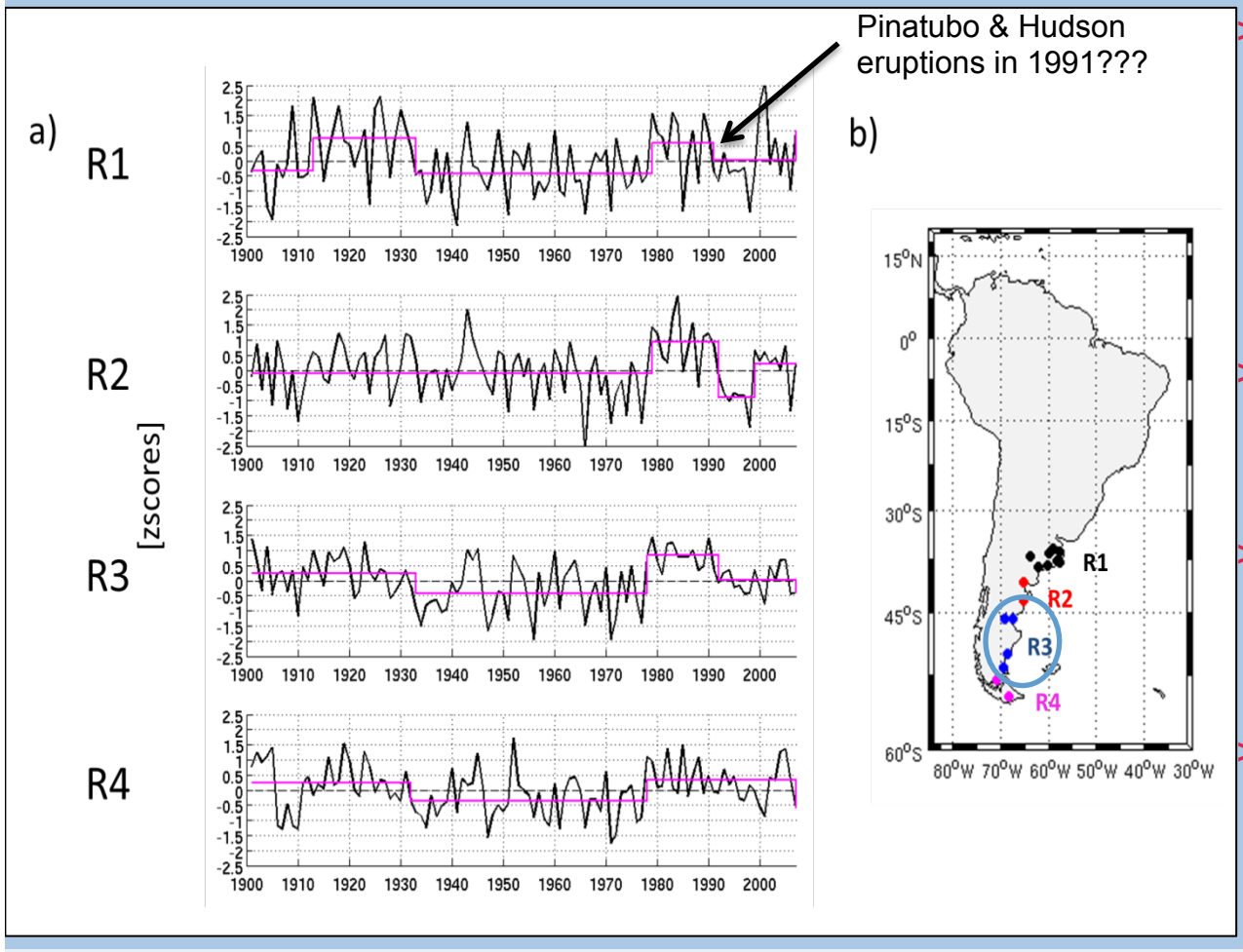

- 4 composites of 19 SAT records, located between 36° and 55°S – detrended & standardized anomalies (1961-1990)
- gaps: linear interpolation from UDel gridded data
- variance adjustment after *Osborn et al.*, 1997
- sequential *Rodionov* t-test to detect shifts

two timescales: Region 3 (R3)

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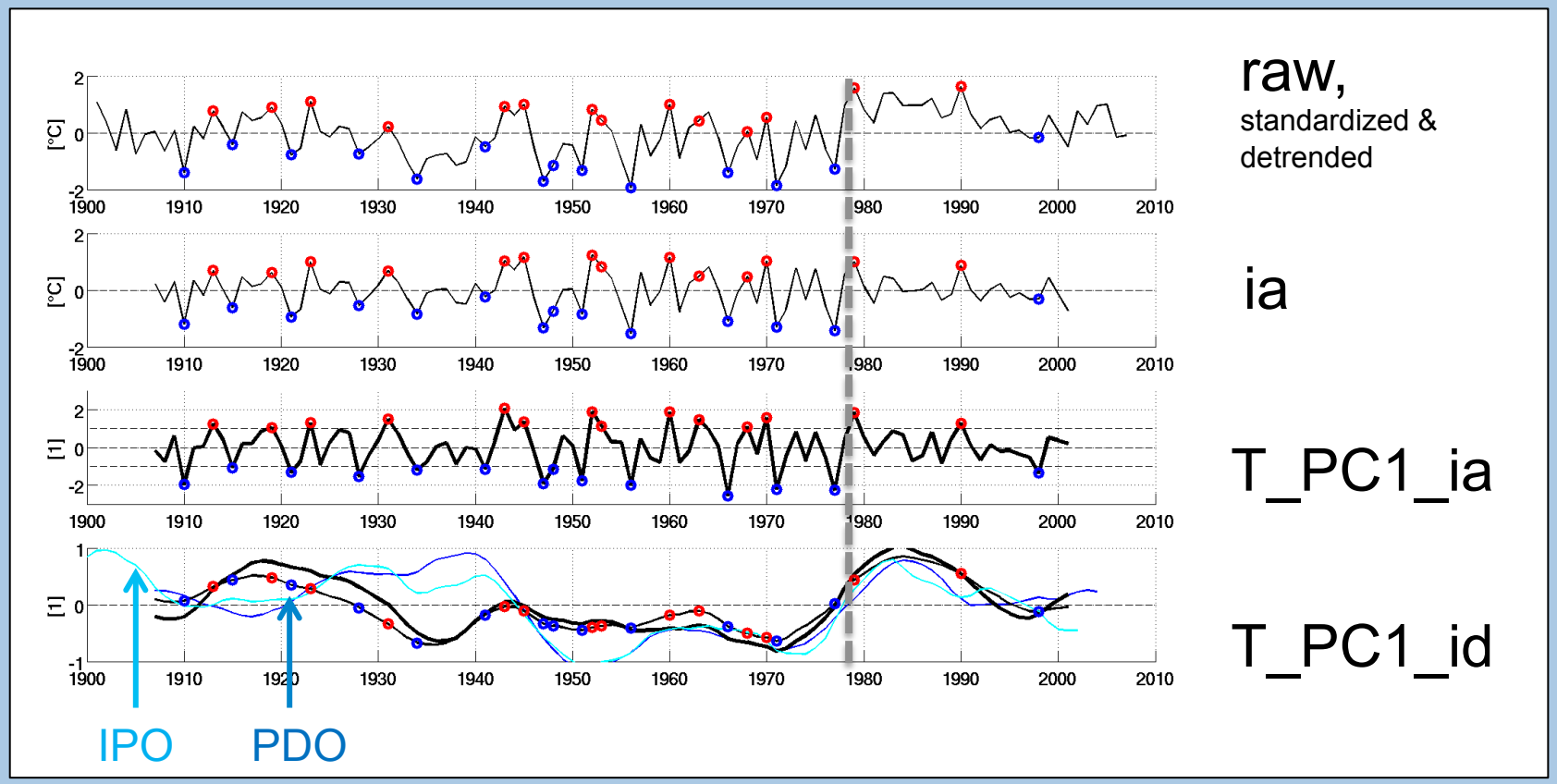

> “filtering” of different timescales by aplying 2x 7-years running mean

→ final length: 1907-2001 (following *Montecinos et al.*, 2003)

lag-correlation: PDO and interdecadal T

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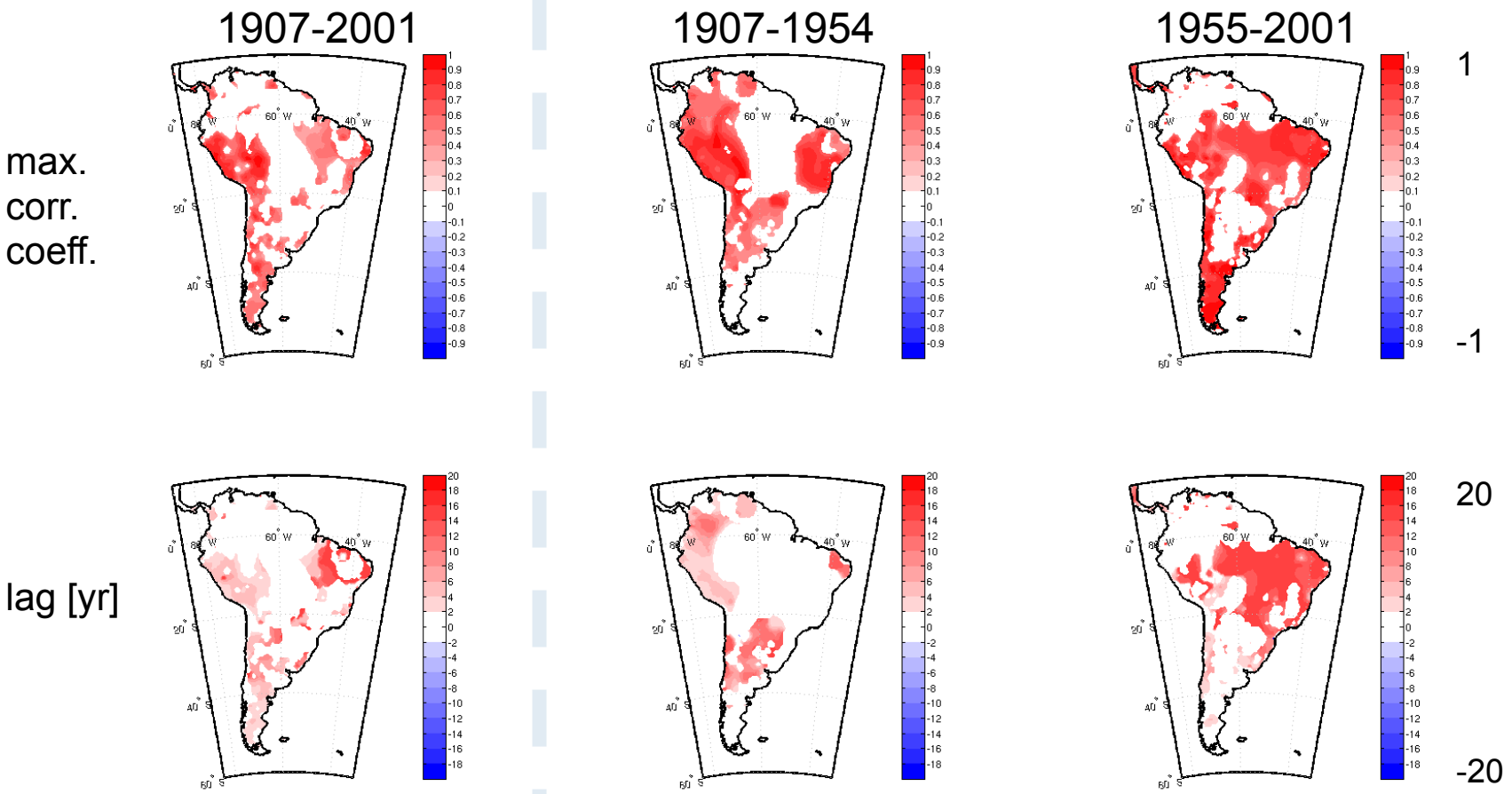

leading variability patterns
(SAT: UDel, SST: ERSSTv3)

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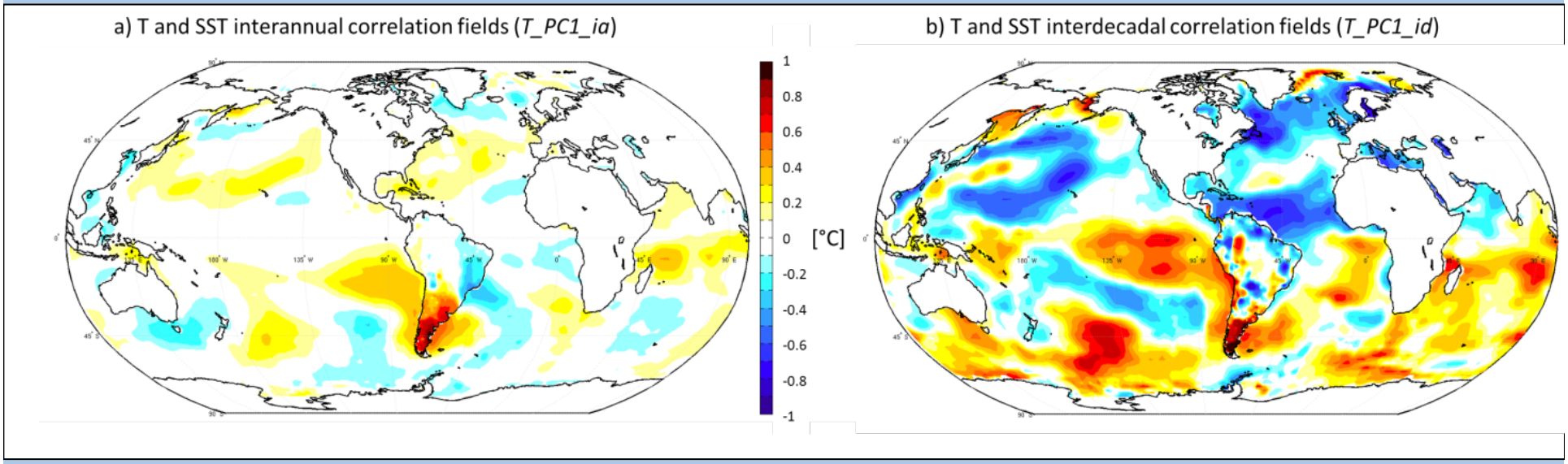

- T_PC1_ia
  - ~60% of original variance
  - spectral peak at ~3.4 years
- T_PC1_id
  - ~80% of original variance
  - spectral peak at ~64 years

selected SA indices: *SSA* SLP (GHCN stations)

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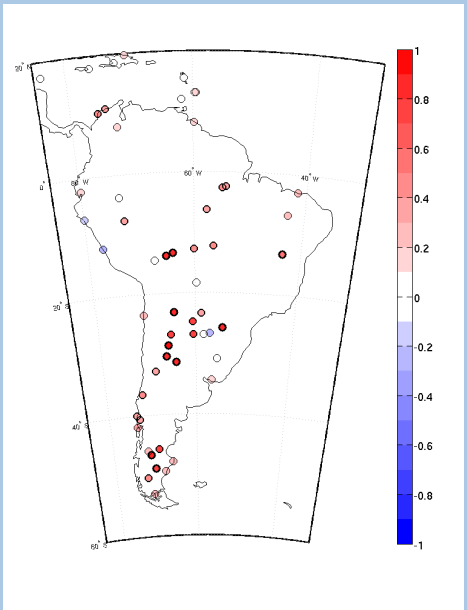
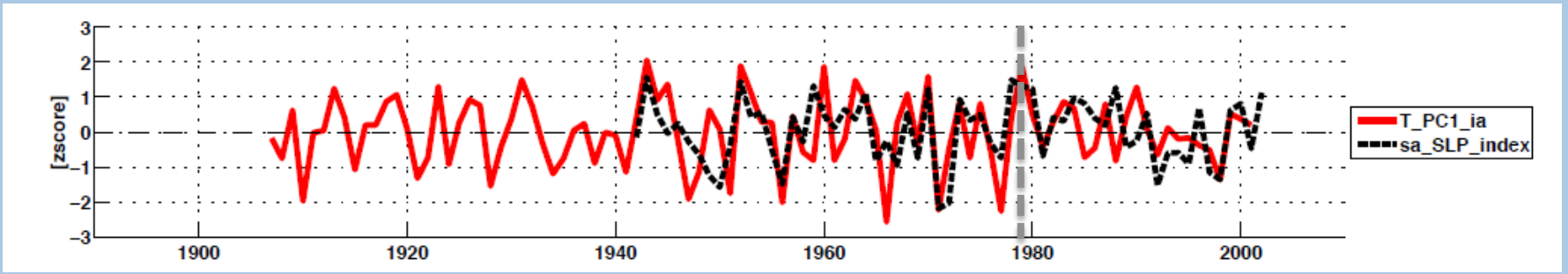


- 57 SLP stations (>80% data for 1961-90)
- *sa_SLP_index* (1942-2002): 10 "representative" (well intercorrelated) stations; variance-corrected
- correlation coefficients with T_PC1_ia:
  1942-2001: 0.53
  1942-1979: 0.59
  1980-2001: 0.32



selected SA indices:
SESA P (UDel)

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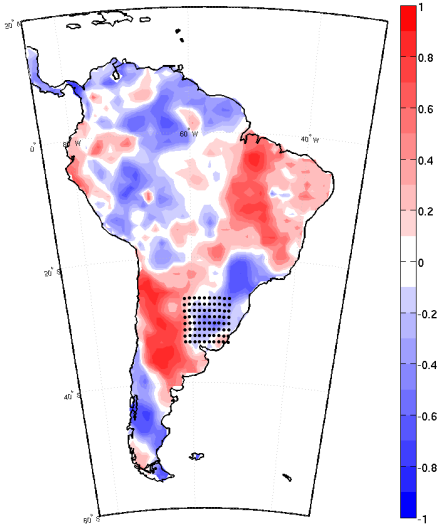
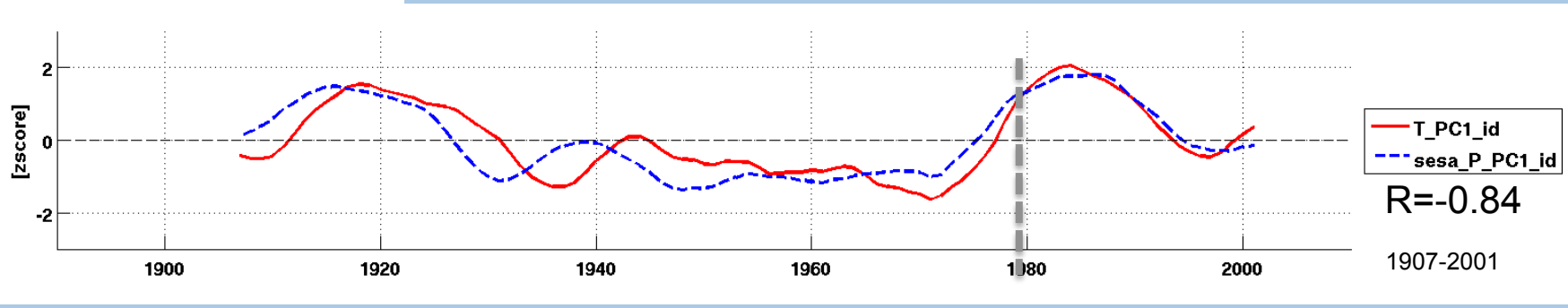


- clear P dipole-like pattern: SACZ-SESA
  — associated to SALLJ variability
- sesa_P_PC1_ia: gridpoints showing anticorrelation ≥ -0.4
- correlation coefficients with T_PC1_ia:
  1942-2001: -0.53
  1942-1979: -0.59
  1980-2001: -0.32



a DJF teleconnection from Oceania: wave train pattern (20CRv2)

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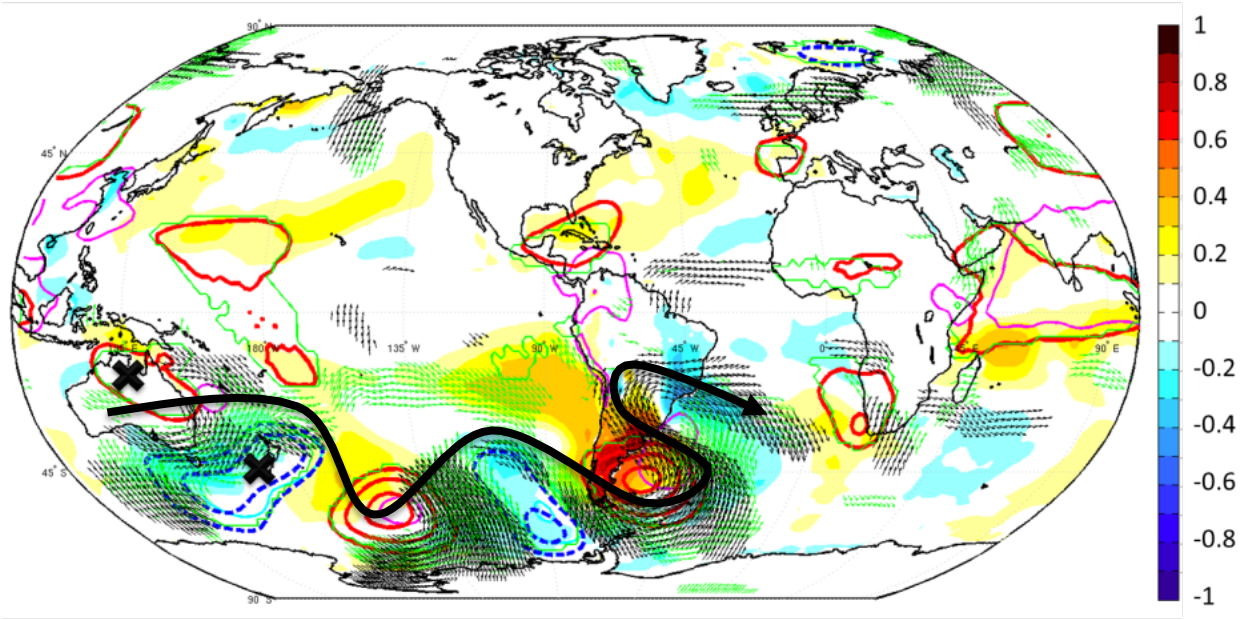
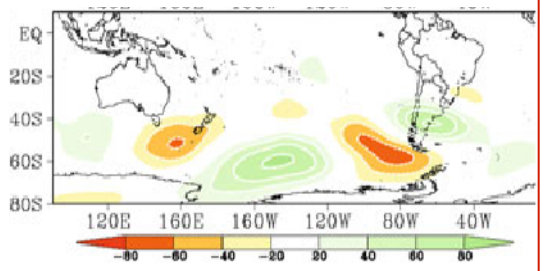


geopotential height @500hPa: positive anomaly

geopotential heigth @500hPa: negative anomaly

wind @200hPa: corr(u&v,T_PC1_ia) >0.2

NNR gph@300hPa anomalies [gpm] – pentads // 1979-2003



Cerne & Vera [2011]

relative cyclone frequency
(RCF: 20CRv2)

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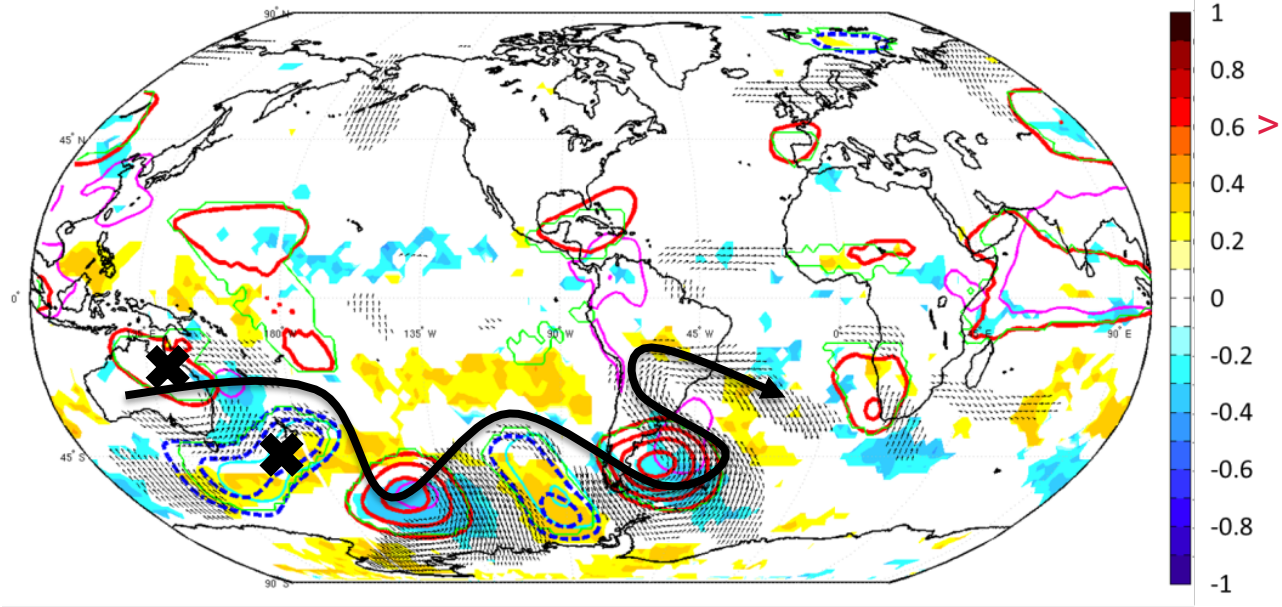

> RCF w.r.t 1872-2008 [*Welker & Martius*, 2012]

> 6-hourly: synoptic signal

selected *instrumental* indices:
(*SSA* T: GHCN, *AUS* P: UDel, *AUS & NZ* SLP: stations)

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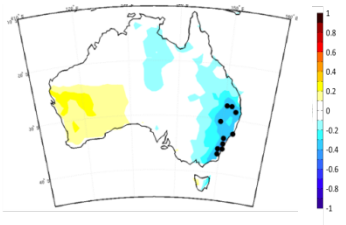
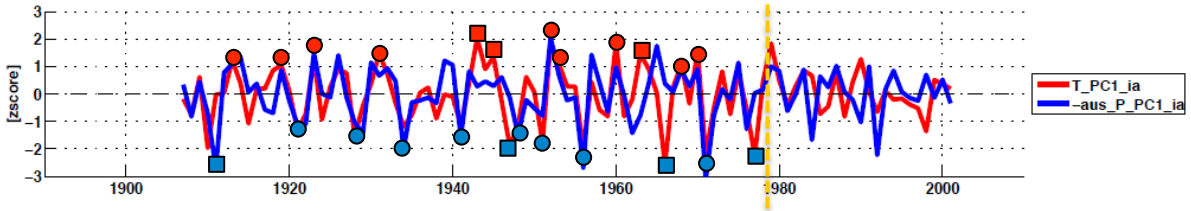


interannual

1979

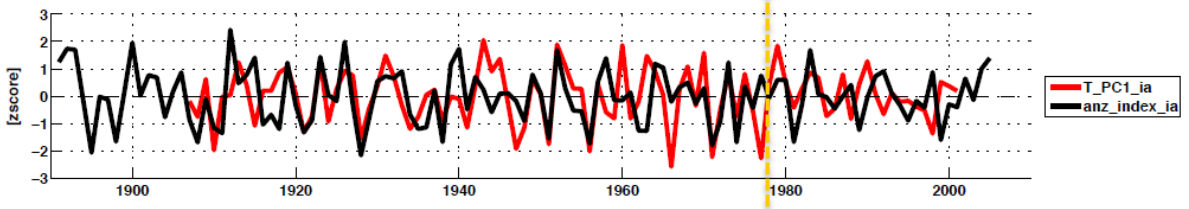
well-correlated warm summer
well-correlated cold summer
bad-correlated warm summer
bad-correlated cold summer

a)



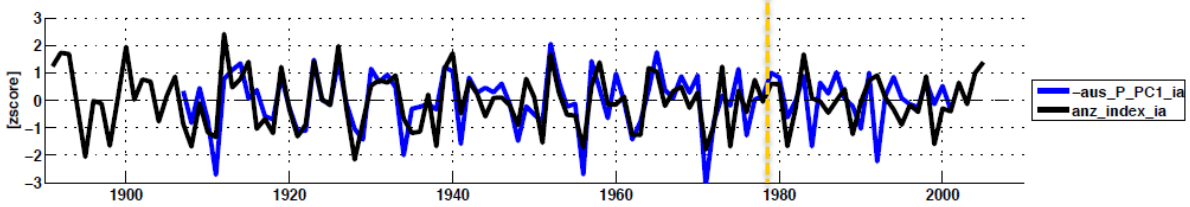
R=0.51 (0.59)
1907-2001 (1907-1979)

b)



R=0.39 (0.45)
1907-2001 (1907-1979)

c)



R=0.65 (0.74)
1907-2001 (1907-1979)

Niño3.4 (EMI) asymmetric pattern on SEQ rainfall during DJF [Cai et al., 2010]

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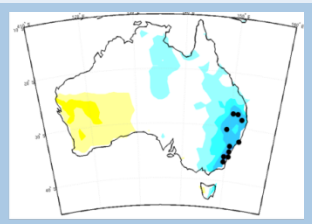


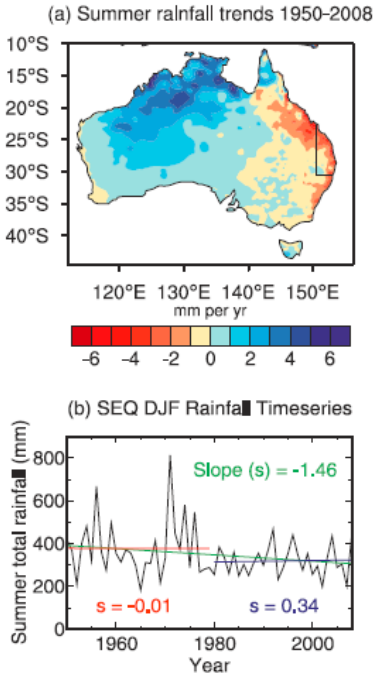
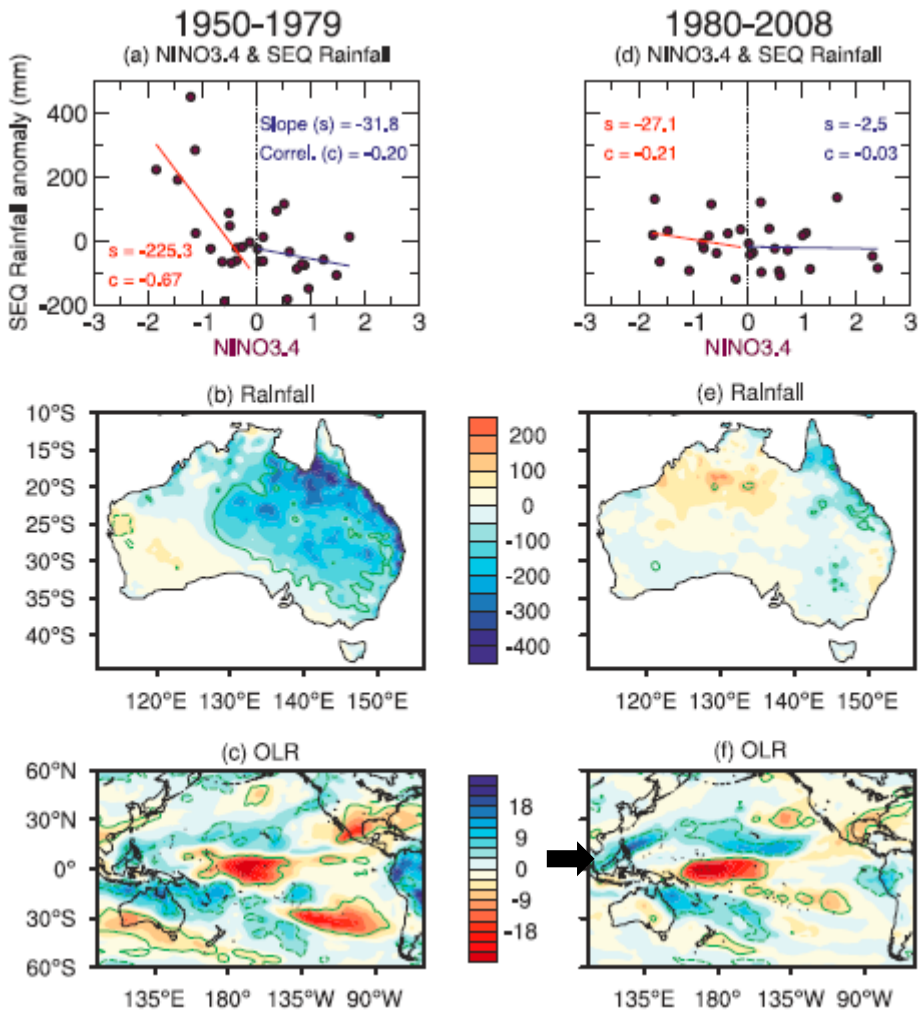
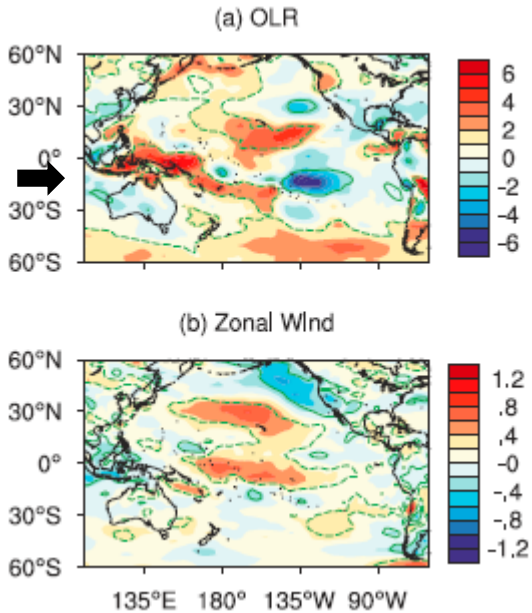


FIG. 1. (a) Australian DJF rainfall trends over the period 1950–2008 (mm year^{-1}). The bordered area indicates the SEQ region. (b) SEQ summer rainfall time series together with trend lines over 1950–79 (red), 1980–2008 (blue), and 1950–2008 (green). The spatial trend pattern and time series are taken from interpolated homogeneous station data, provided by the Australian Bureau of Meteorology (see section 2).



interdecadal modulation
corr with IPO
1948-2007 (NNR)



selected *instrumental* indices:
(*SSA* T: GHCN, *AUS* P: UDel, *AUS & NZ* SLP: stations)

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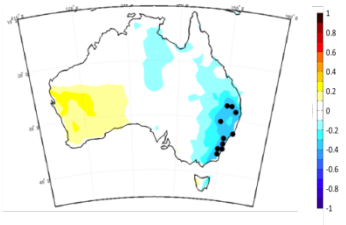
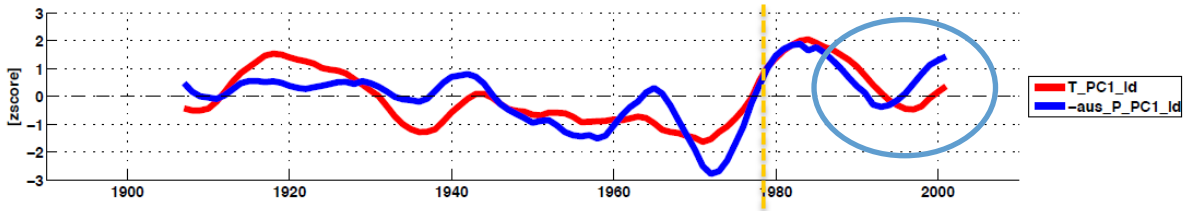


interdecadal

1979

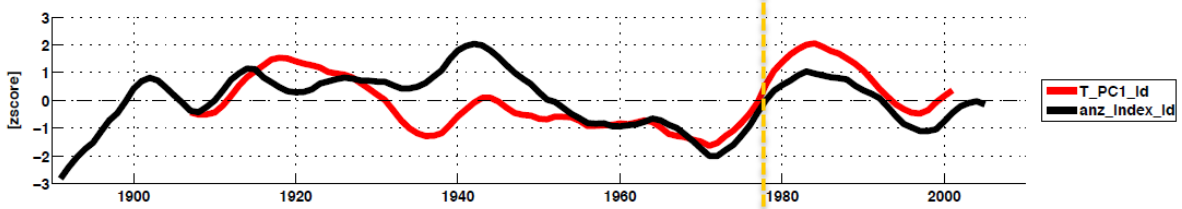
well-correlated warm summer
well-correlated cold summer
bad-correlated warm summer
bad-correlated cold summer

a)



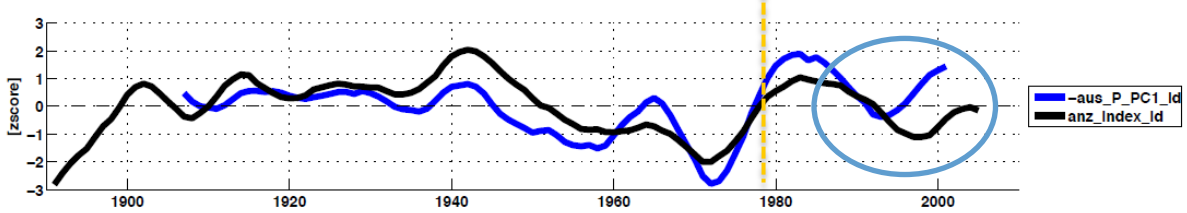
R=0.74 (0.71)
1907-2001 (1907-1979)

b)



R=0.53 (0.53)
1907-2001 (1907-1979)

c)



R=0.64 (0.78)
1907-2001 (1907-1979)

well/bad correlated extreme years T_PC1_ia / aus_P_PC1_ia

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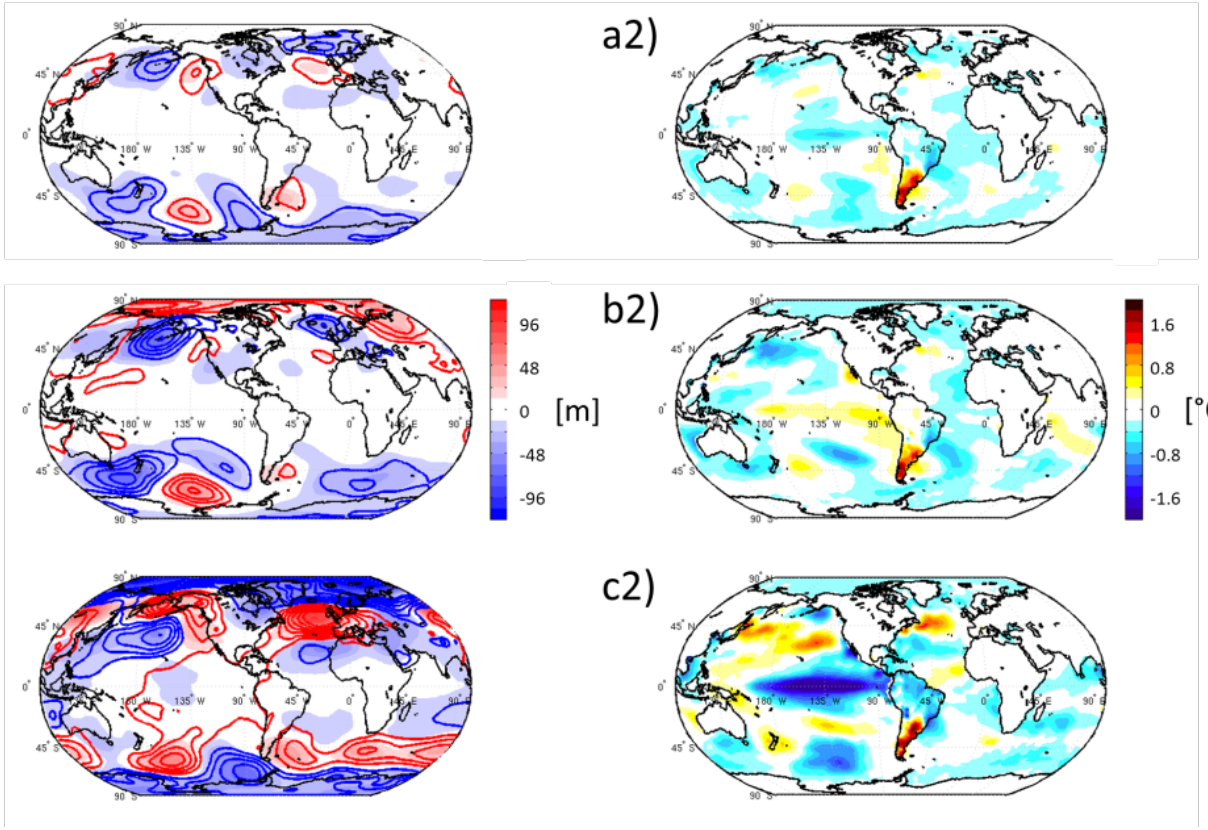
	gph500 & SLP	SAT & SST
all extreme years (28)	a1)	a2)
well-correlated (17)	b1)	b2)
bad-correlated (7)	c1)	c2)



an ENSO signal on the teleconnection?
T_PC1_ia / aus_P_PC1_ia

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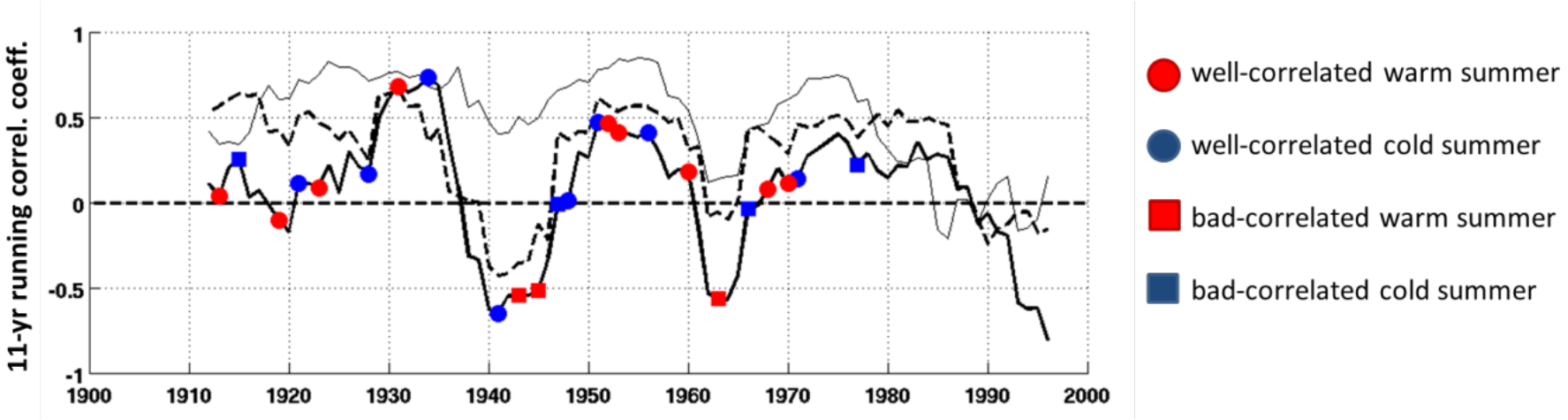
[1]



- 11-yr running correlation coeficients between Niño3.4 and T_PC1_ia / aus_P_PC1_ia
- (decadal fluctuations similar to those shown by Cai et al., 2001)
- 1940-42 El Niño event; 1963 Agung eruption?

conclusions

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- there appears to be a ***shifty climate*** over SSA, but the magnitude of the 1970s shift is unique in the 20th century
- **T_PC1_id**: diverges from PDO during the first half of 20th century
  - warm > cold anomaly transition in early 1930s rather than late 1940s
- **T_PC1_ia**: teleconnection: wave train pattern from Oceania to SSA
  - correlation of SSA T with precipitation in SE Australia
  - imprint of shorter timescales // consistent with *synoptic* fields (RCF) // **MJO?**
  - detectable also in other indices (instrumental SLP records, gridded P)
- ENSO signal seems to play a role in the interannual timescale
- multidecadal climate background modulates the AUS-SSA teleconnection: there is a breakdown around the '70s *climate shift*
  - *related to an eastward shift of the main DJF convection center/Walker circulation over Tropical Pacific since 1980s [Cai et al., 2010] ?*


Thanks for your
attention!

a '*shifty' climate*?

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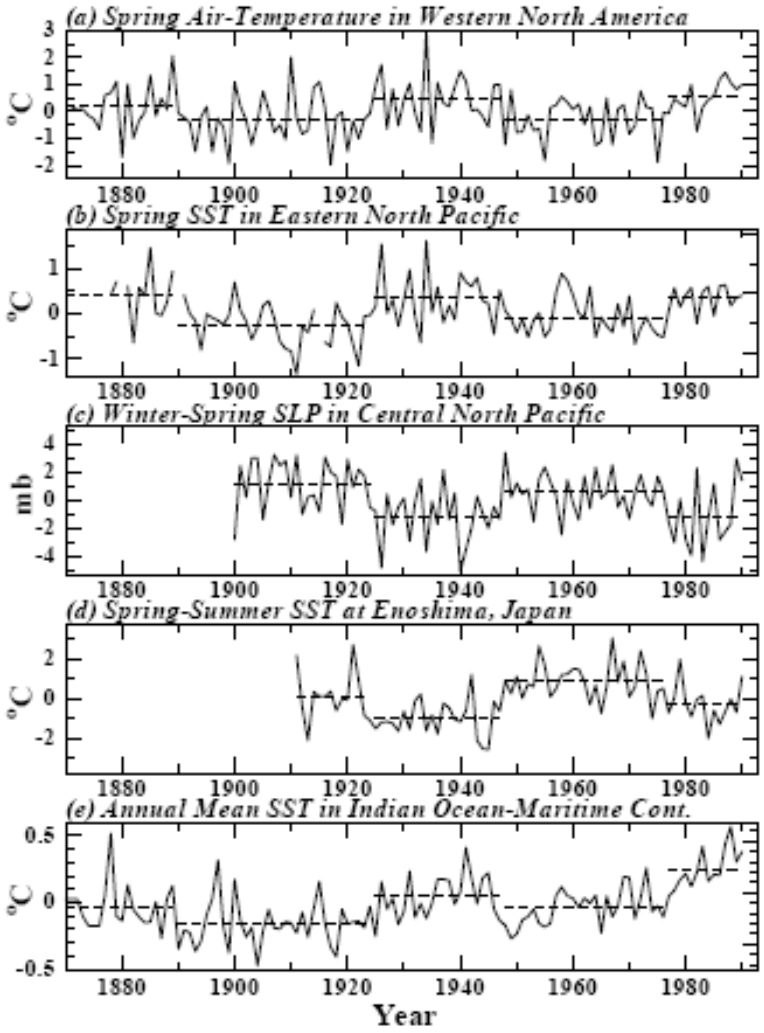

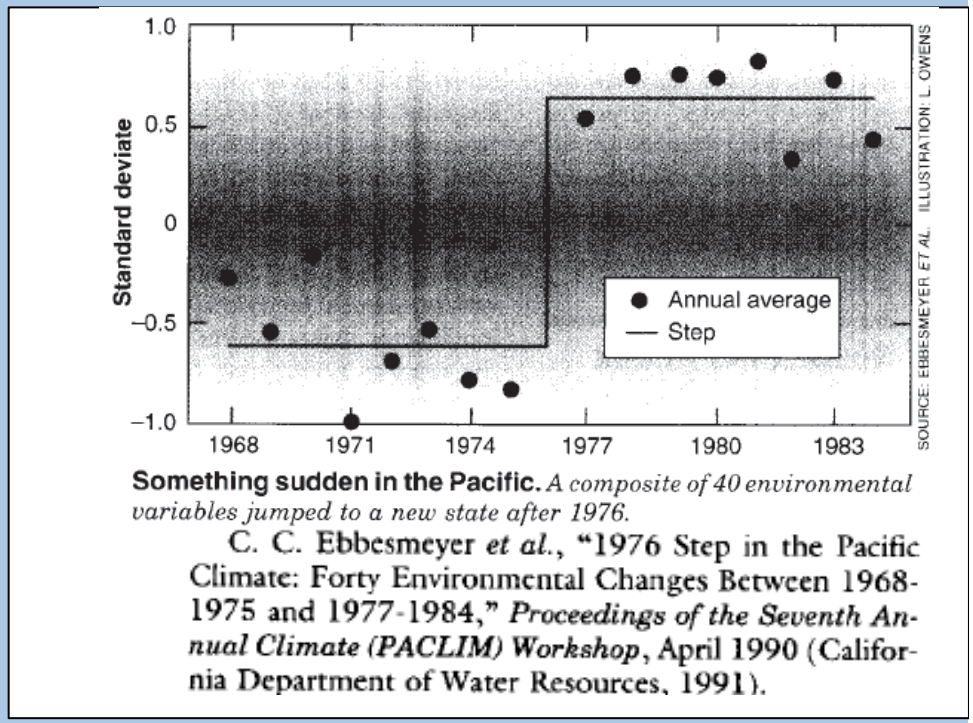

Something sudden in the Pacific. *A composite of 40 environmental variables jumped to a new state after 1976.*

C. C. Ebbesmeyer *et al.*, "1976 Step in the Pacific Climate: Forty Environmental Changes Between 1968-1975 and 1977-1984," *Proceedings of the Seventh Annual Climate (PACLIM) Workshop*, April 1990 (California Department of Water Resources, 1991).

Minobe, S. 1997. A 50-70 Year Climatic Oscillation Over the North Pacific and North America, *Geophys. Res. Lett.*, **24(6)**, 683–686.

SST

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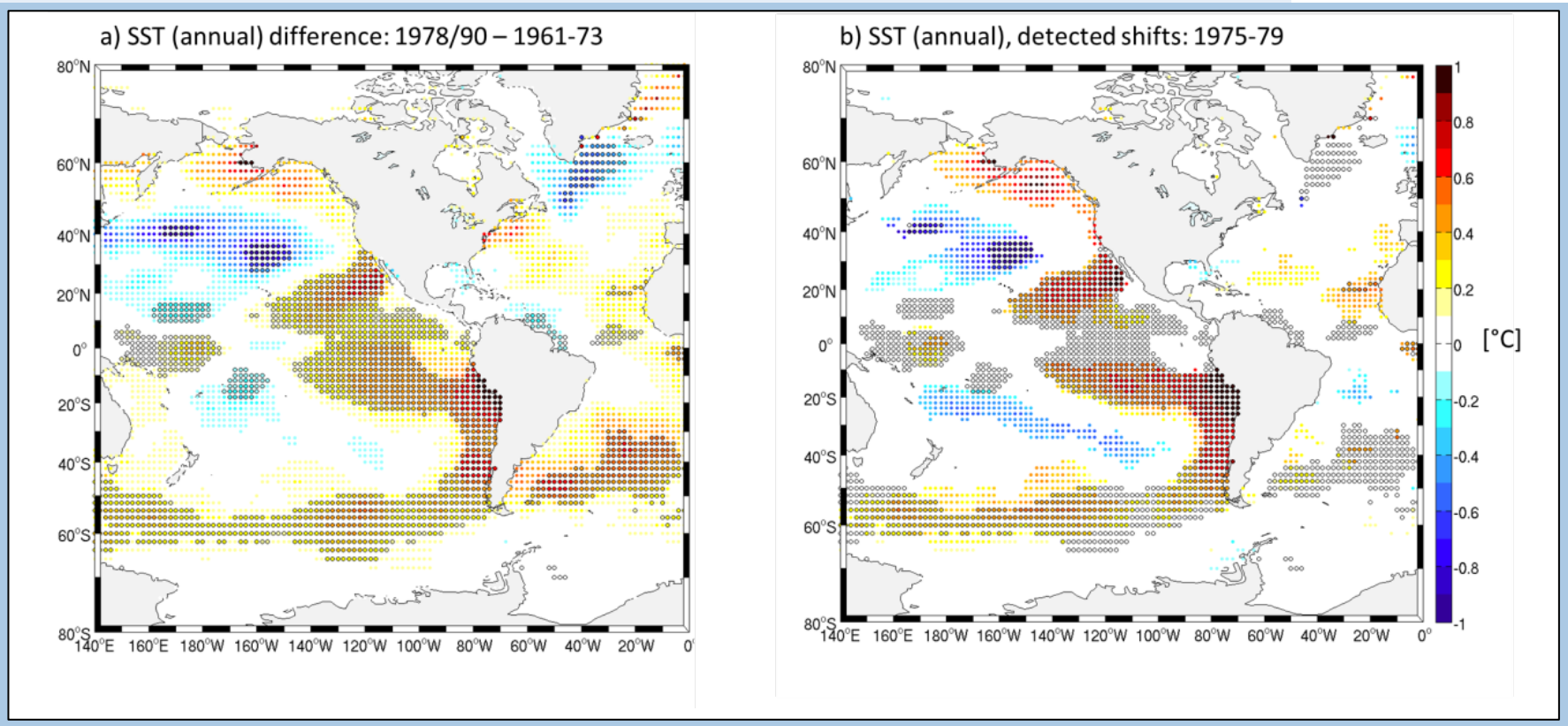

> test de Rodionov, t de Student secuencial, p=90%, L=10 años, entre 1975/79

$$dif = \bar{x}_{nvo} - \bar{x}_{ant} = t\sqrt{2\bar{s}_l^2 / l} \qquad RSI = \frac{1}{l\bar{s}_l}\sum_{t_{nvo}}^{m}\left(x_i - \bar{x}_{crit}\right), \quad m = t_{nvo}, t_{nvo}+1, \ldots, t_{nvo}+l-1$$

T over South America

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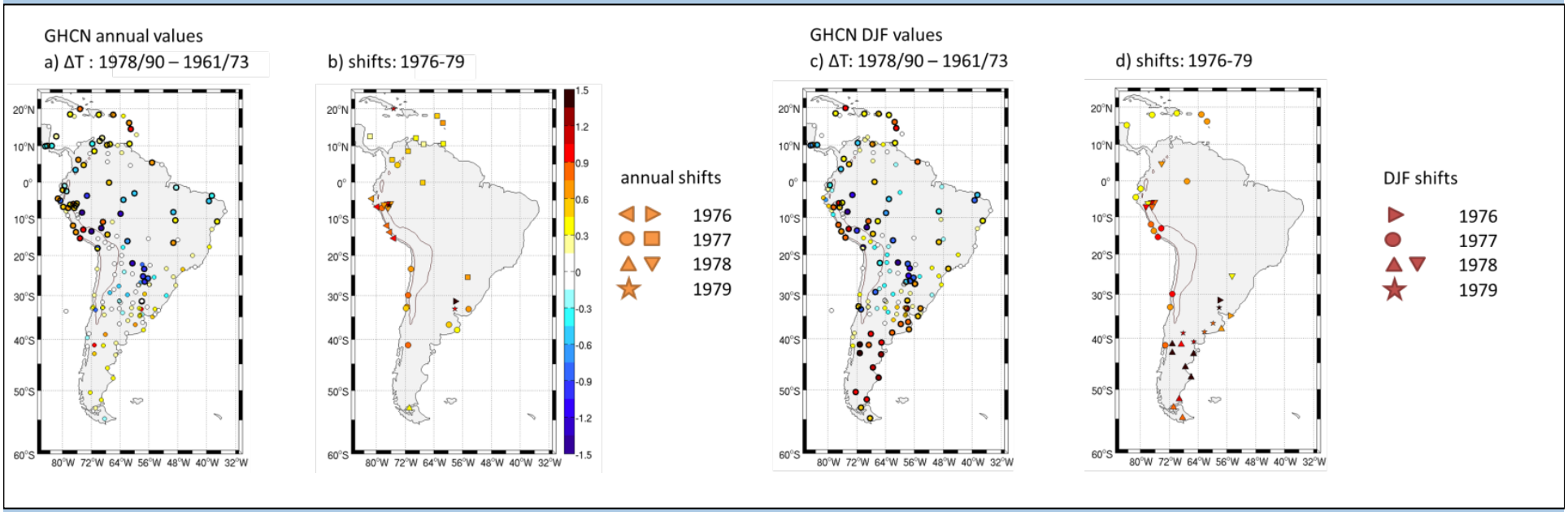

- annual ΔT: SST influence
- mostly due to a summer (DJF) signal
- > regional composites

SLP: SE Subtropical Anticyclone & Southern Tip of SA (NNR & ERA-40)

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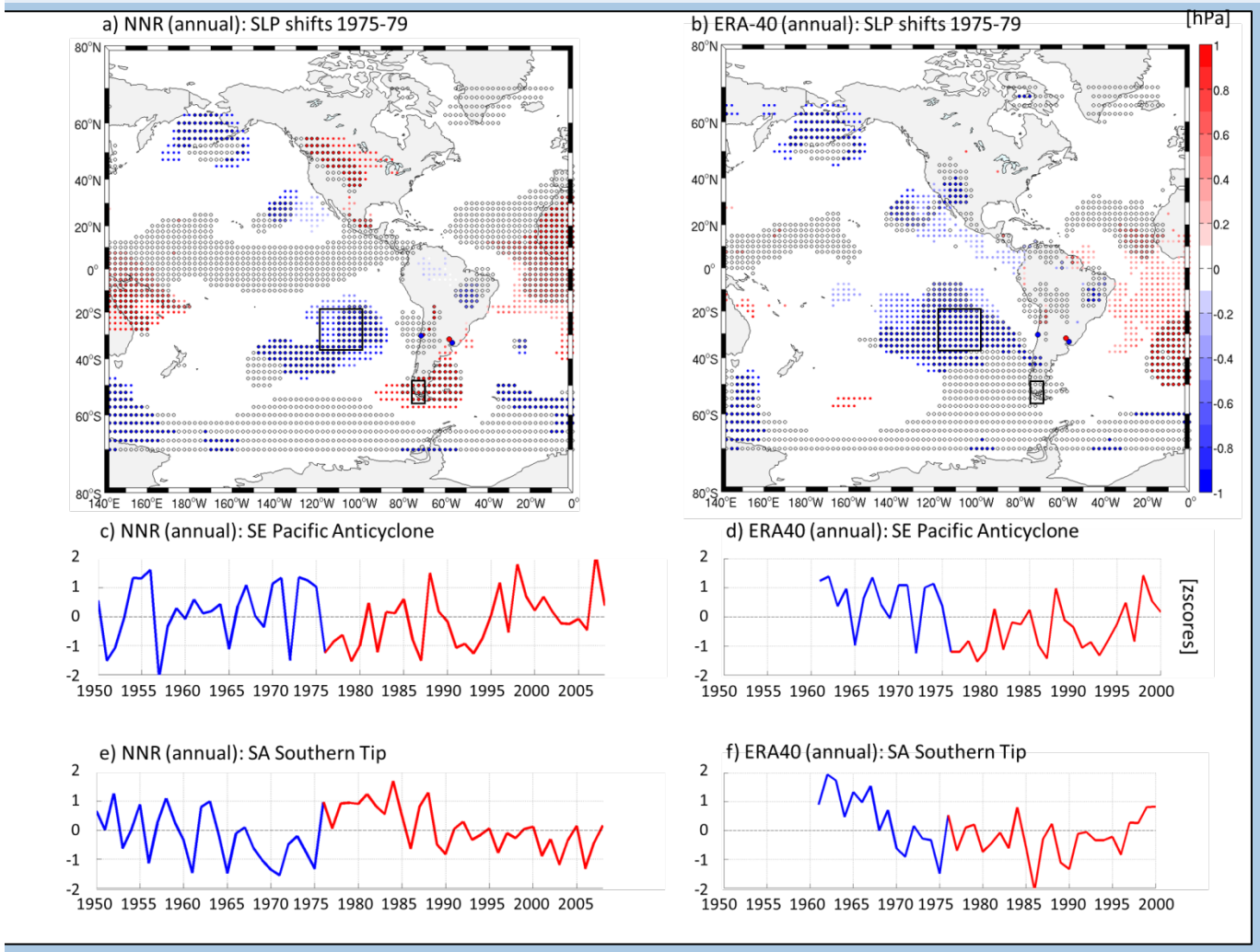

- disminución (salto ↓) de la intensidad del Anticiclón del PSE en 1975/76

→ menor surgencia costera

→ menor advección fría

- anomalía de circulación anticiclónica en el extremo austral de SA

→ consistencia con tendencia positiva de AAOI, más marcada en DJF [*Marshall*, 2003]

precipitation (Udel)

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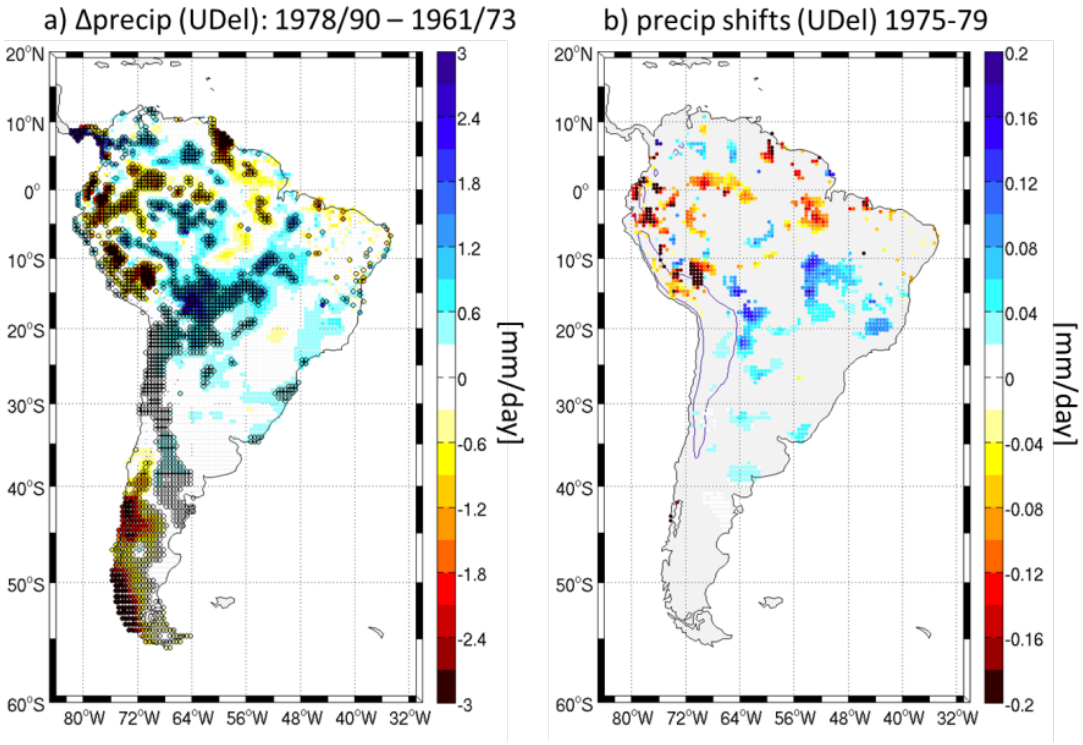
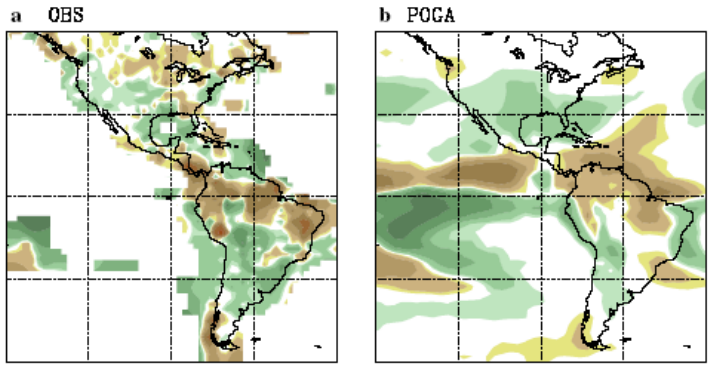
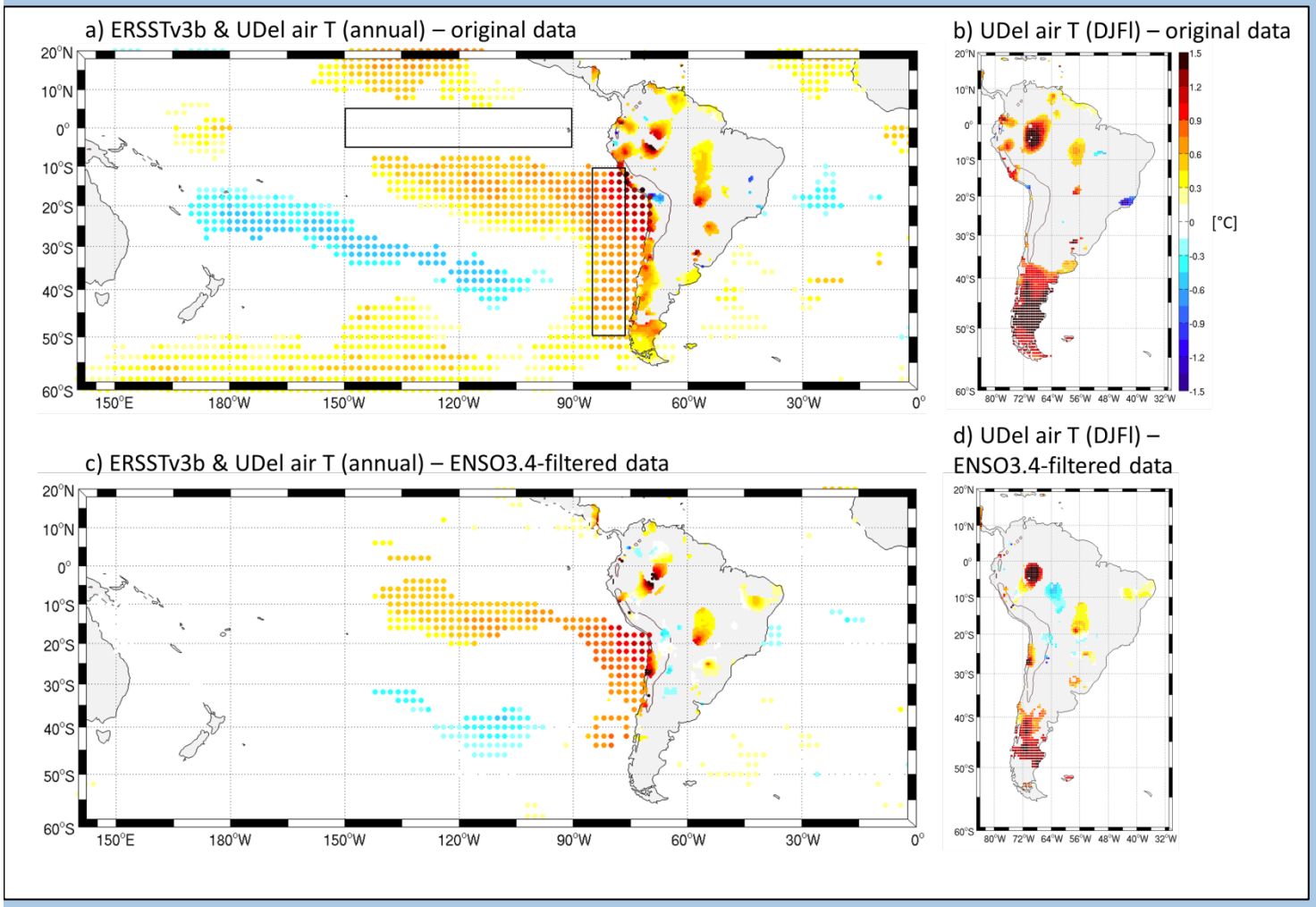




[Huang et al., 2005]

Fig. 2 The "post- minus pre-1976" difference in Jan–May precipitation for **a** observation based on CAMS data set. **b** The 16-member ensemble average from the POGA-ML experiments. **c** The 48-member ensemble average from the GOGA runs. **d** Thirty-year average of the difference between a pair of the SCYC runs. Units are in mm/day with *color scales* indicated at the bottom. White areas are with insufficient data or with very weak signals (within ±0.1 mm/day). All panels in Figs. 2, 3, 4, 5, 6 and 7, except Fig. 2a, are gently smoothed with a T31 filter (truncation at total wavenumber 31). The Domain shown is 150°W–30°W and 60°S–60°N

T shift & ENSO



- simple linear regression over Niño3.4
- DJF shift can't be solely adscribed to a higher frequency of warm ENSO events after mid-70s
- other factors

T_PC1_ia
SLP / rr

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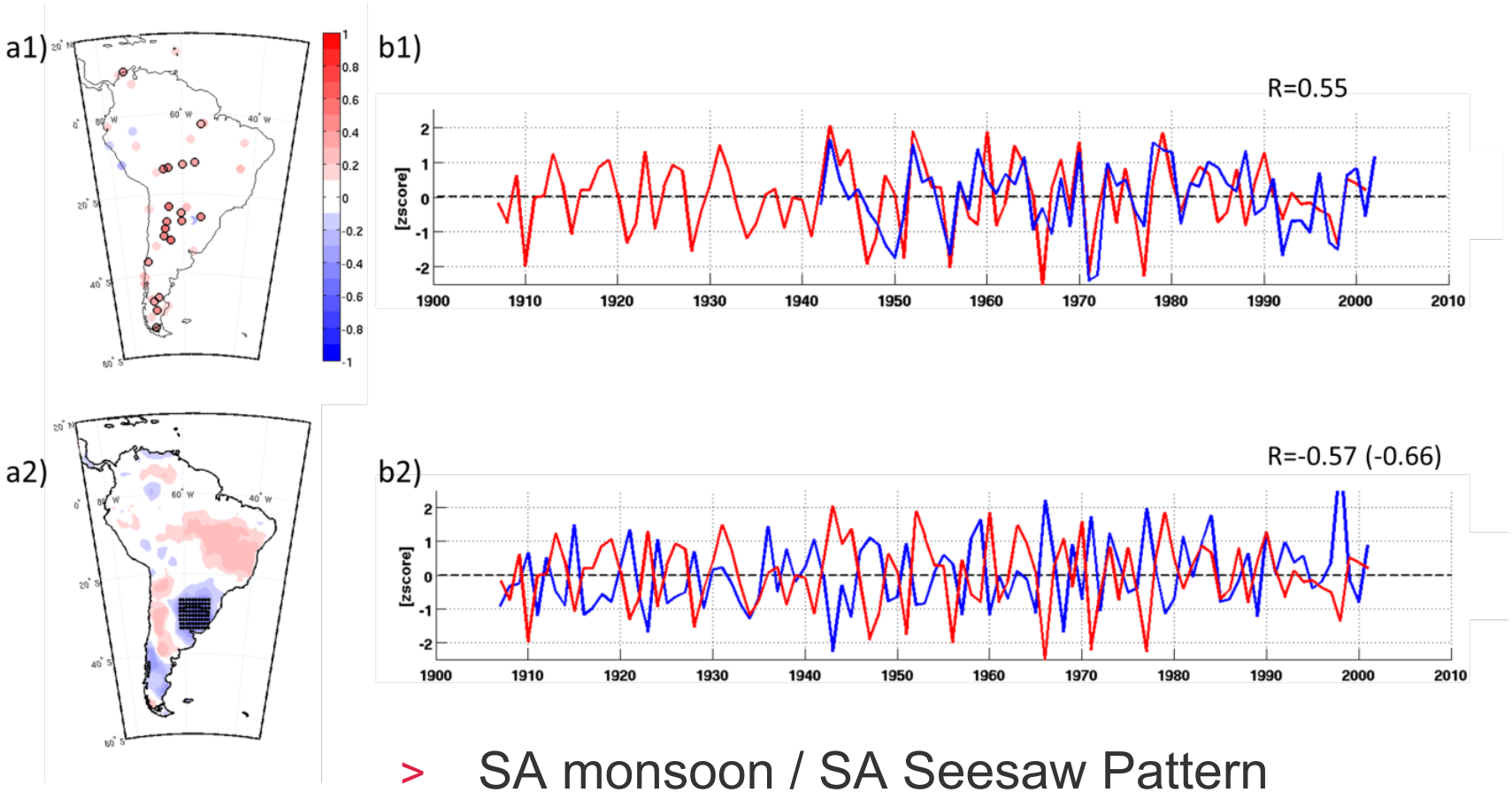

> SA monsoon / SA Seesaw Pattern

T_PC1_ia: correlation with SLP / rr

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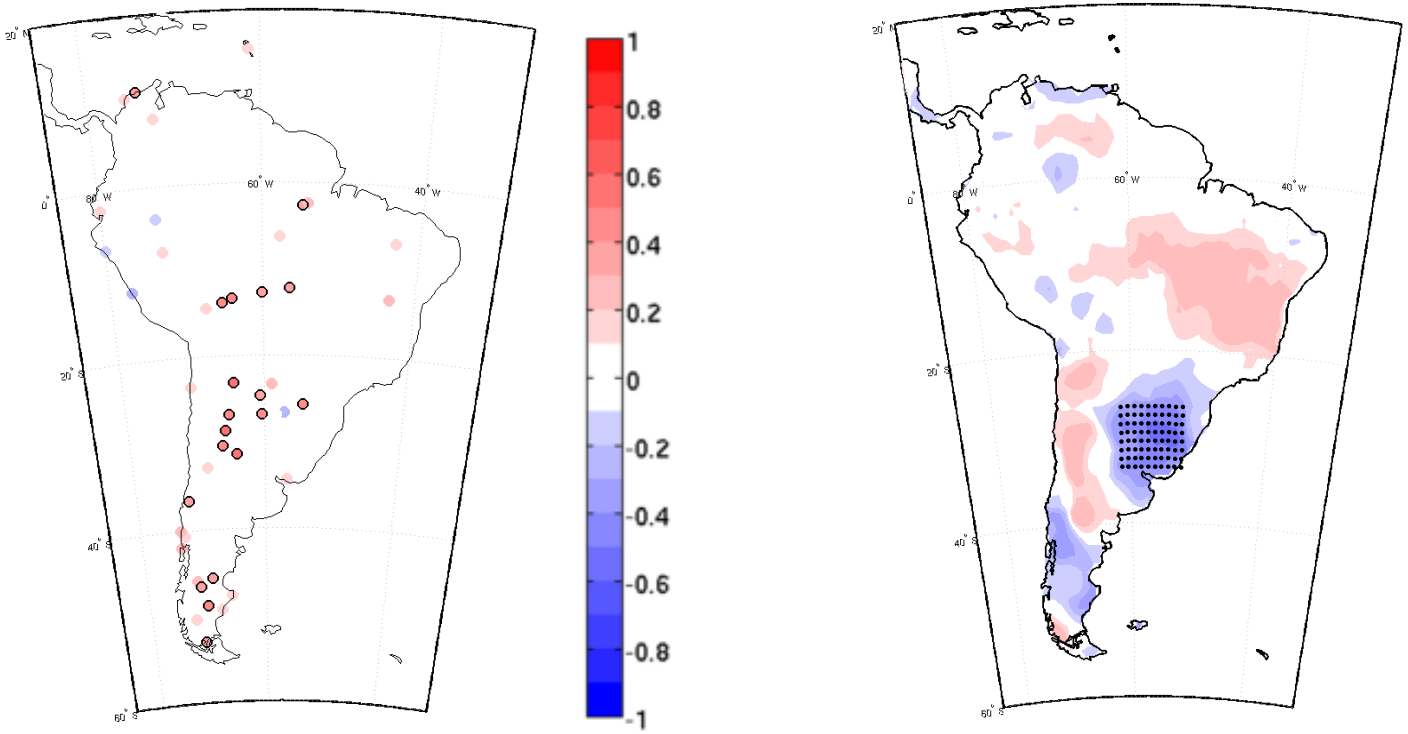

> SA monsoon / SA Seesaw Pattern

a DJF teleconnection from Oceania: wave train pattern

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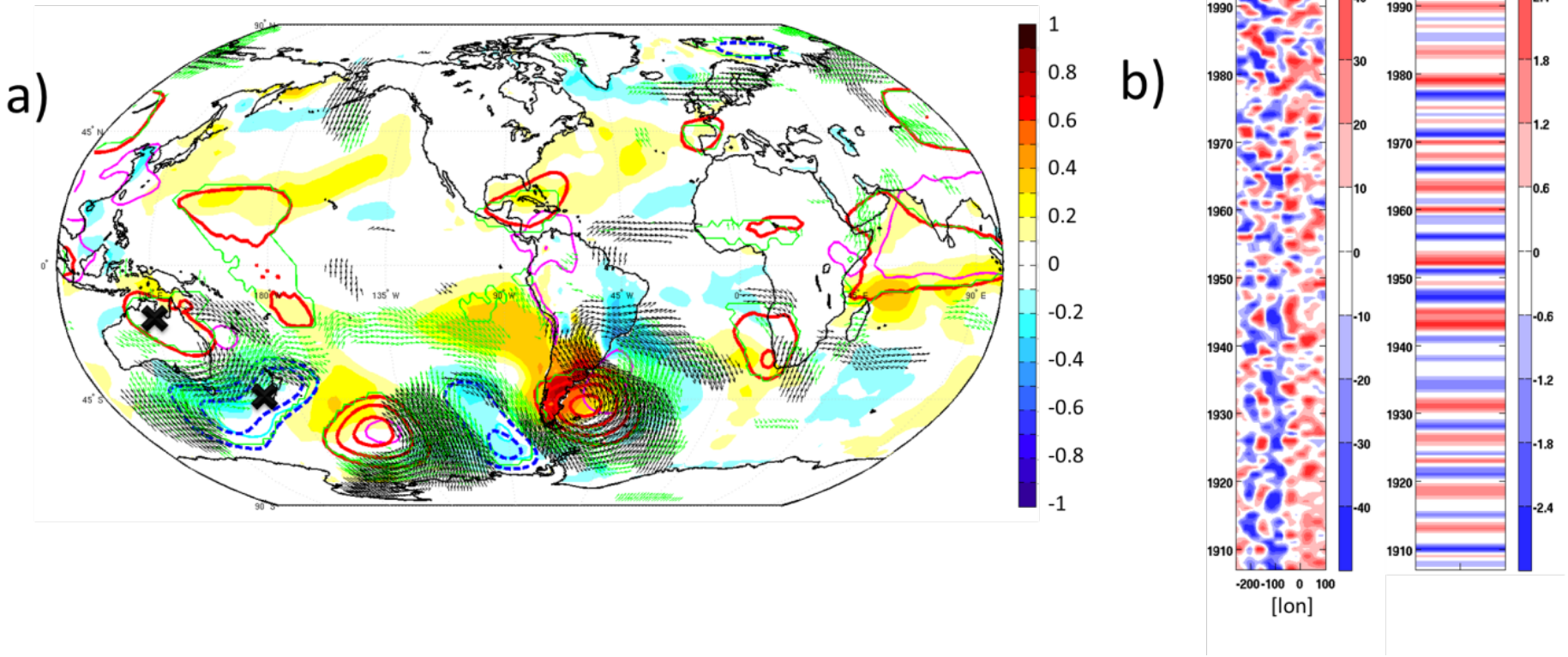

Australian precipitation as signal

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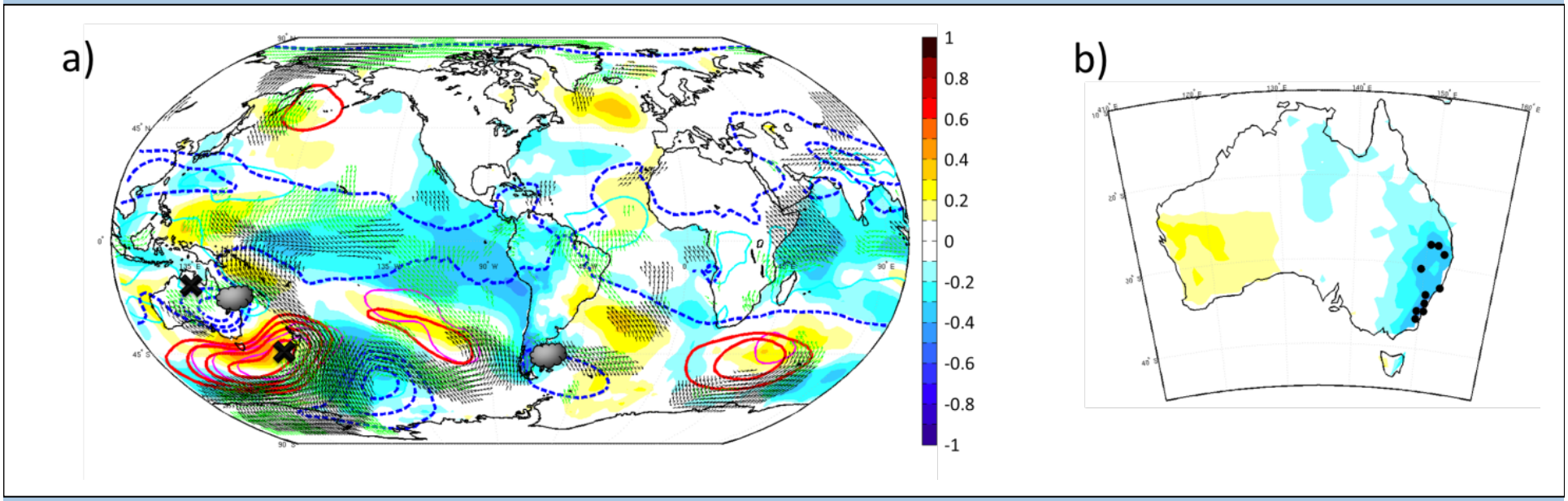

- deflected wave train over Southern Pacific
- Australia-New Zealand SLP dipole

selected *instrumental* indices:
(SSA T: GHCN, AUS rr: UDel, SLP: stations)

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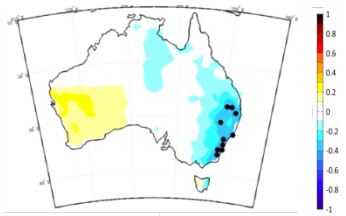

well-correlated warm summer
well-correlated cold summer
bad-correlated warm summer
bad-correlated cold summer

a) [zscore]
T_Patagonia_PC1.ia
-RR_Australia_PC1.ia
R=0.50 (0.59)
1907-2001 (1907-1979)

b)
-RR_Australia_PC1.ia
mjc_index
R=0.60 (0.68)
1907-2001 (1907-1979)

c)
T_Patagonia_PC1.ia
mjc_index
R=0.38 (0.42)
1907-2001 (1907-1979)

an ENSO signal on the teleconnection?
T_PC1_ia / aus_rr_PC1_ia

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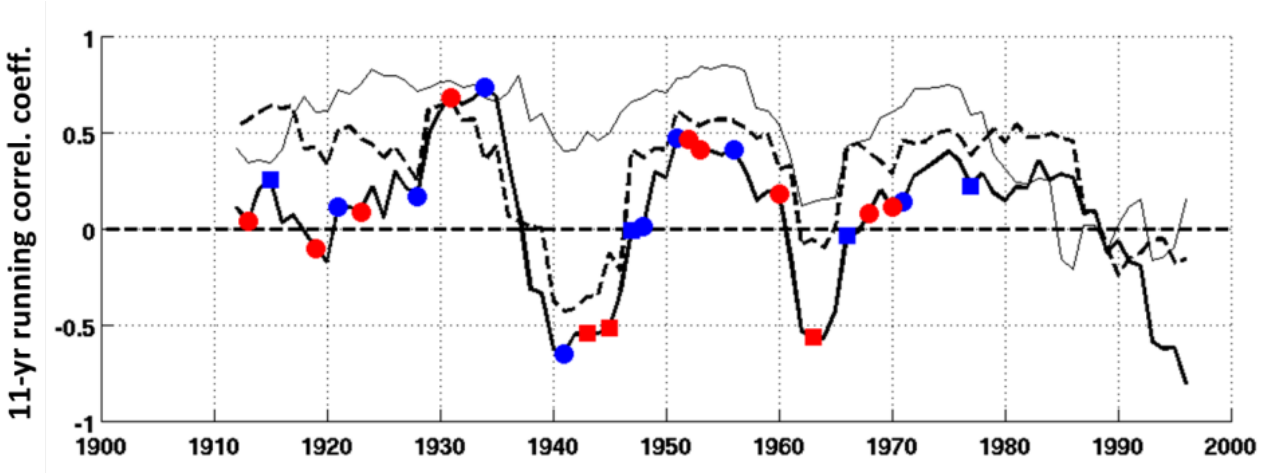
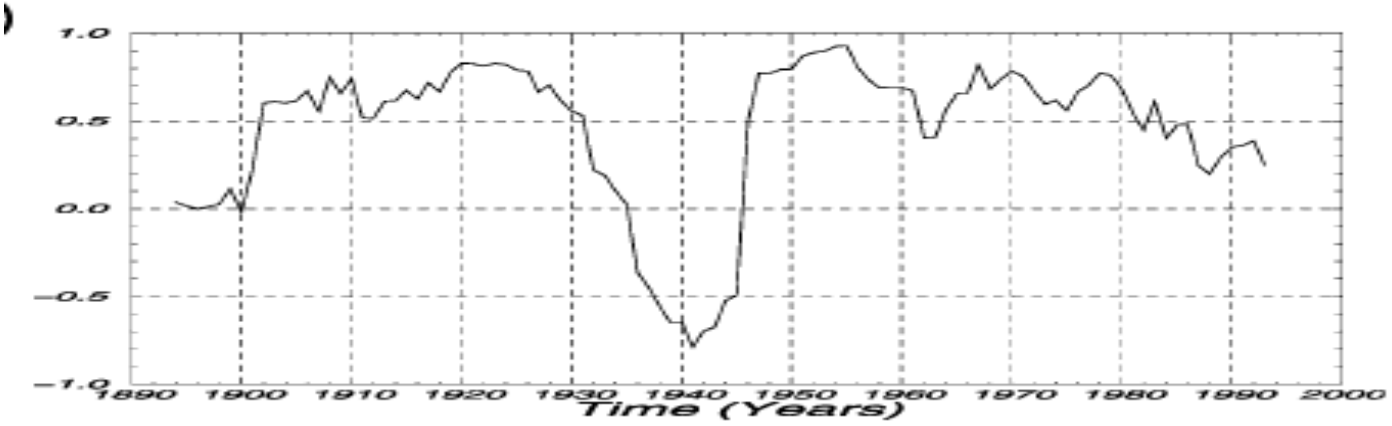
[1]





Cai et al. [2001]