Extreme Precipitation events over South and North America

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Objectives

- Do drought and wet spells have preferred regions to occur?
- What are regional conditions influencing drought?
- What are remote forcing such as SSTAs influencing droughts?
- (We will focus on ENSO and SSTAs in the Atlantic)

Many faces of Drought

- Persistent P deficit – Meteorological drought

  SPI6 < -0.8
- Persistent streamflow deficit- hydrologic drought SRI6 < -0.8
- Persistent soil moisture deficit- Agricultural drought soil moisture % < 20-25%

Observational Data

United States

- Monthly Precipitation (P) over the United States from 1915-2006 (U. of Washington)
- Monthly mean Soil moisture and Runoff from VIC model (1915-2006)

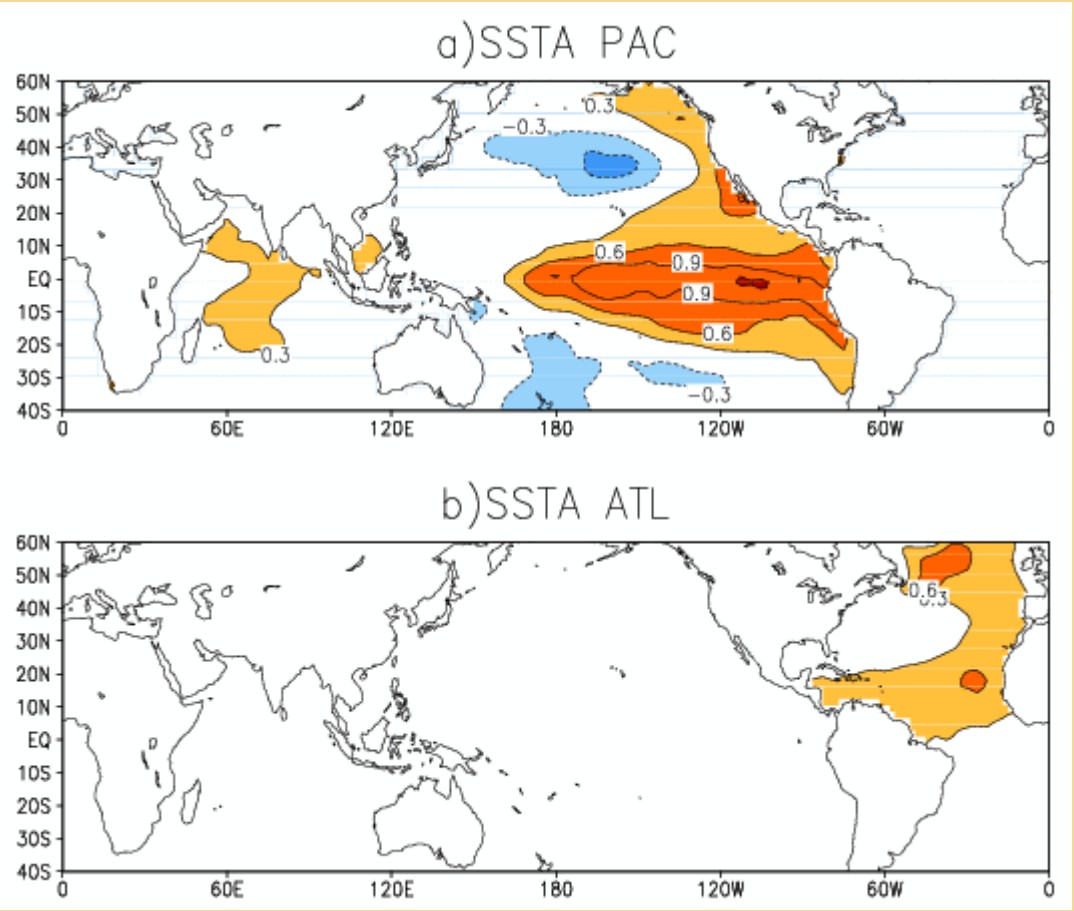
South America

- P (1950-2007) Chen et al.
- PDSI (1948-2003) Dai et al.

Ocean

- SST- reconstructed SSTs 1915-2007 (Smith et al.)

Clivar drought working group experiments



a)Clim
b) Pacific SSTAs: wPna, cPna
c) Atlantic SSTAs:nPwa, nPca,
d) Combined SSTAs: cPca, cPwa, wPca,wPwa

Models:
GFS/NCEP (36-yr),
GFDL
NSIPP(50-yr)
CCM3(US) CCM3.5(SA)

Schubert et al, 2009

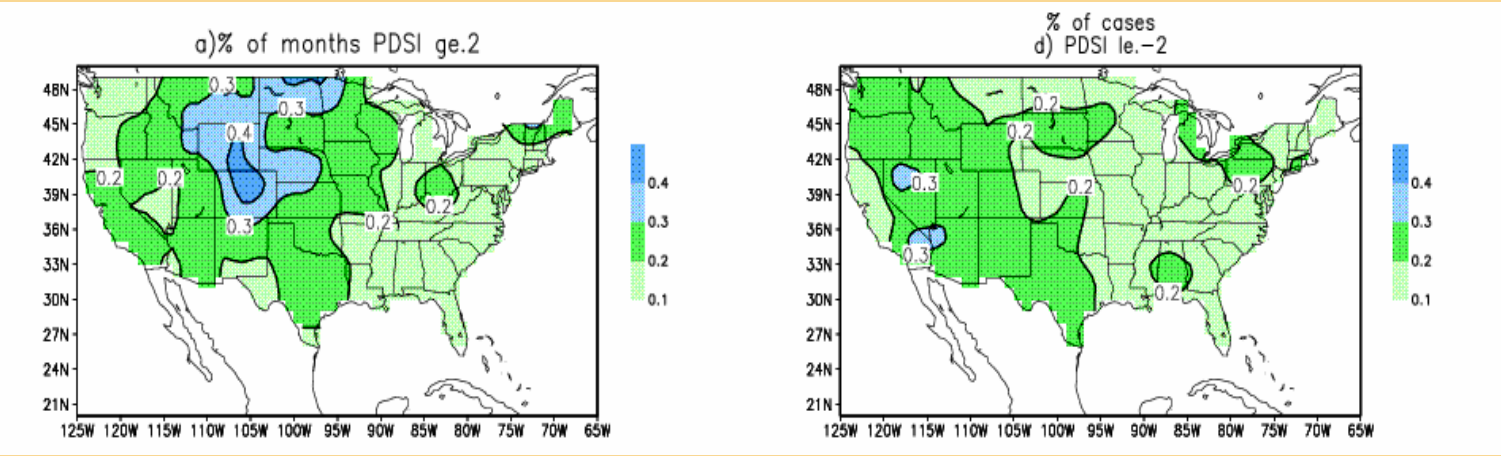
Procedures to analyze model runs

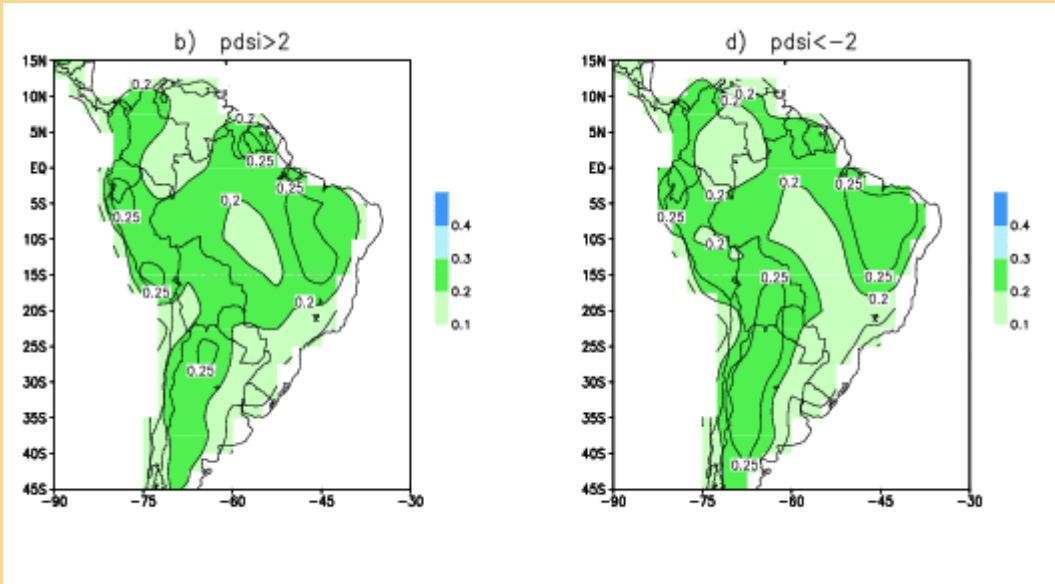
- Pool all monthly mean P together from all 9 experiments
- Calculate 6 month SPI6.
- Count months SPI < -0.8 for each experiment.
- The frequency of drought occurrence

  = the number of month under drought/total months of the experiment.
- The statistical significant test was done using the Monte Carlo method.

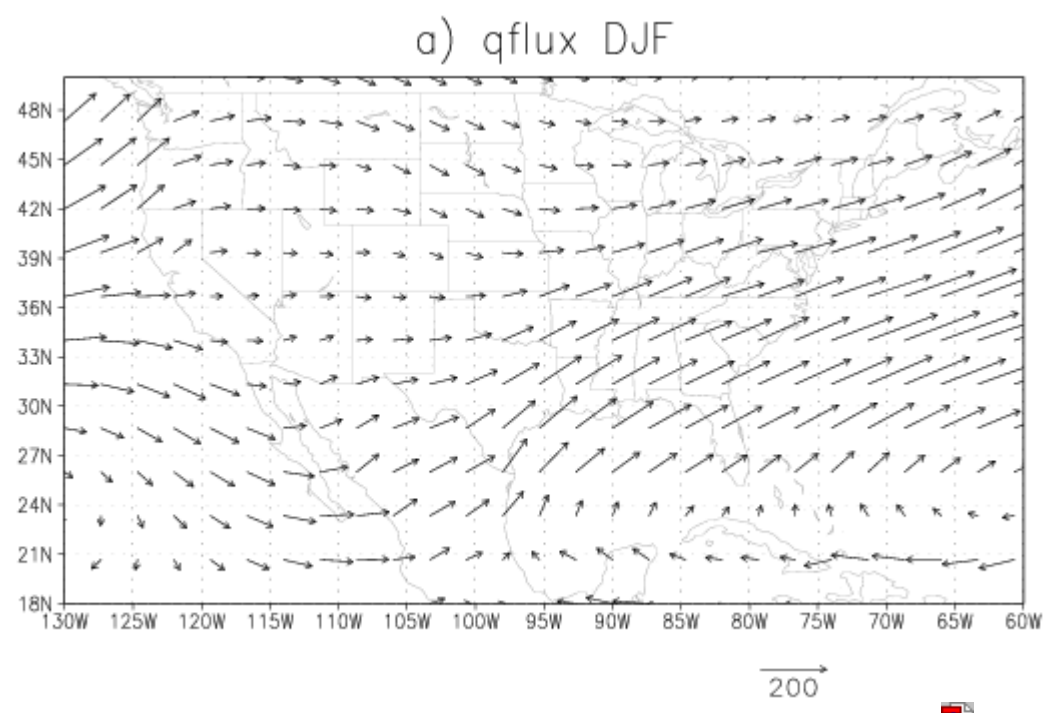
Extreme P events have preferred regions to occur

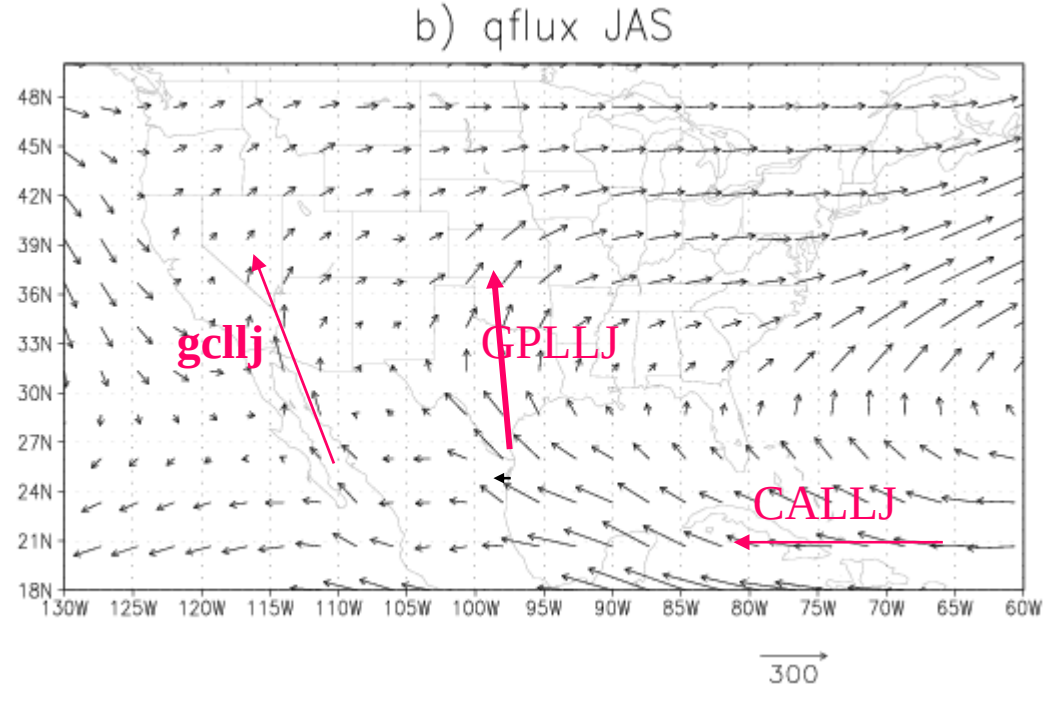
Wet Spells **Droughts** **% of events**





- In midlatitudes, SA and US Both have the west-east contract,
- Contrast is shaper in the United States





Qflux:

Winter:

Southeast : qfluxes from the Gulf of Mexico and Pacific

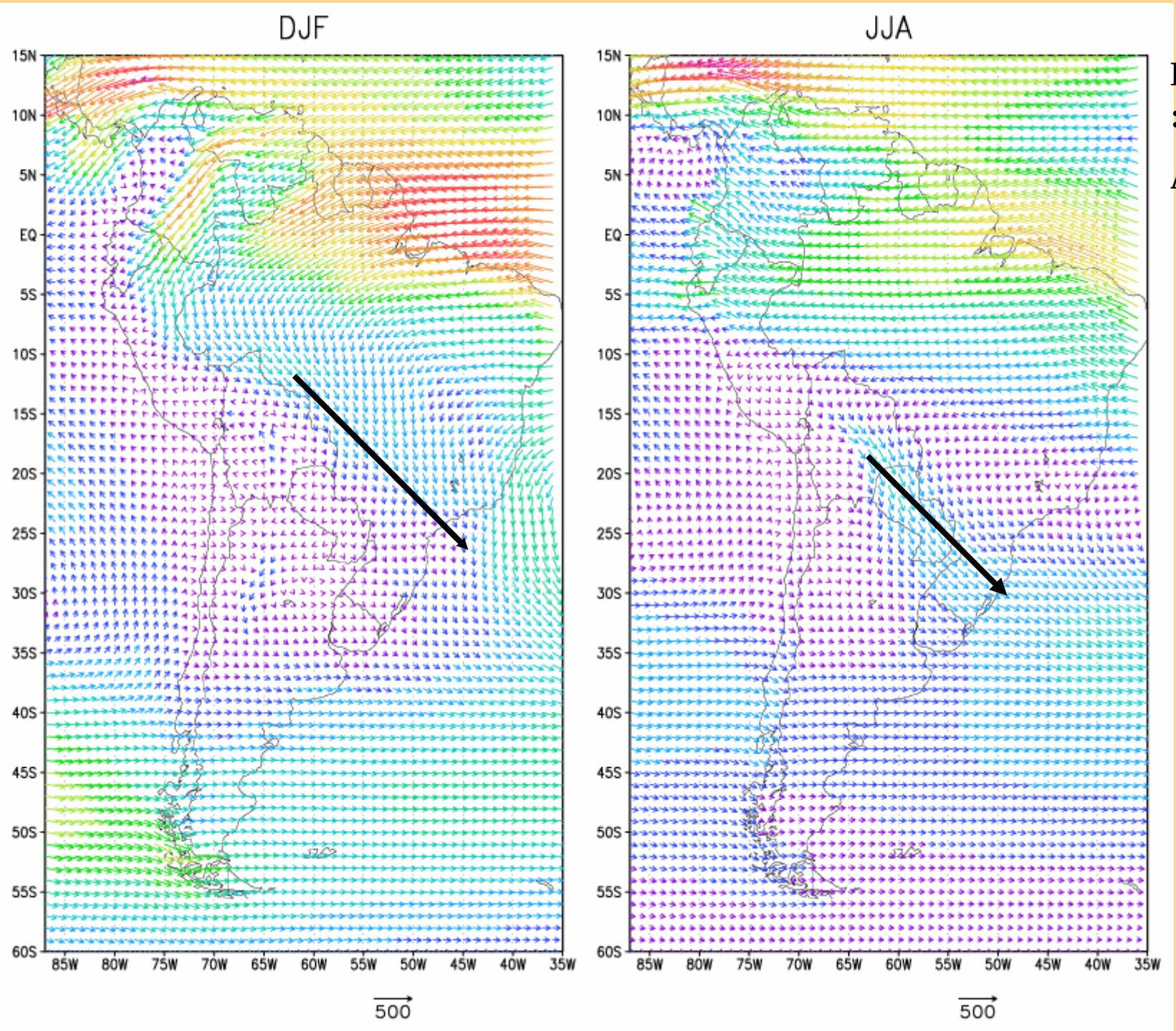
West: from Pacific

Summer:

Southeast: from Gulf of Mexico

No flux to the West

From NARR 1979-2006

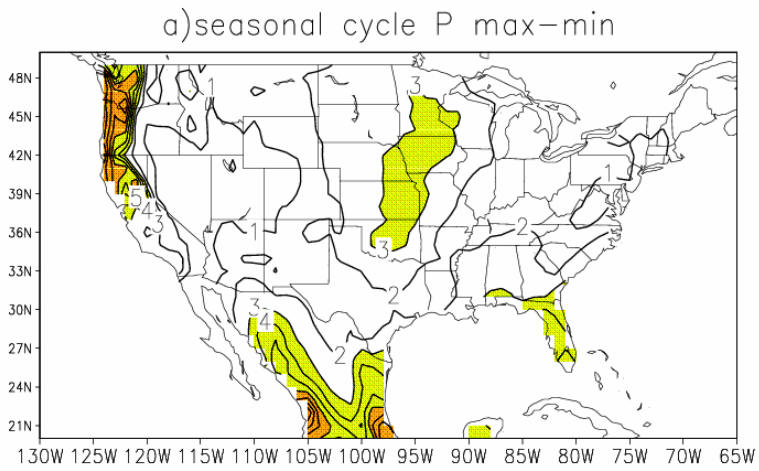


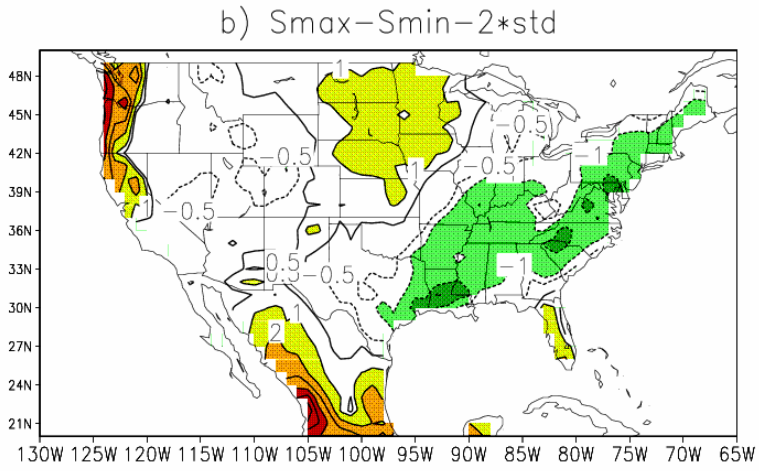
Low level jet :

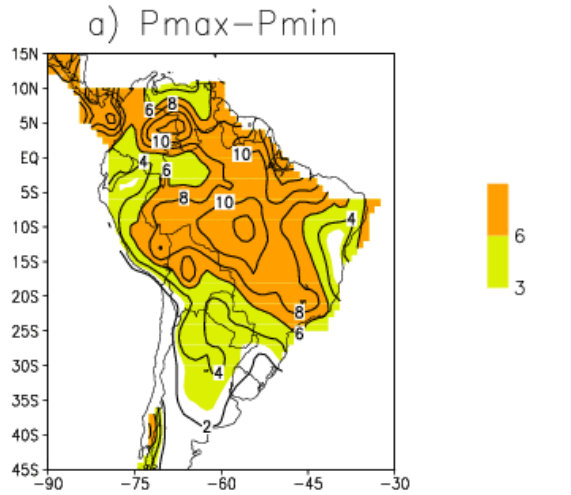
All the time

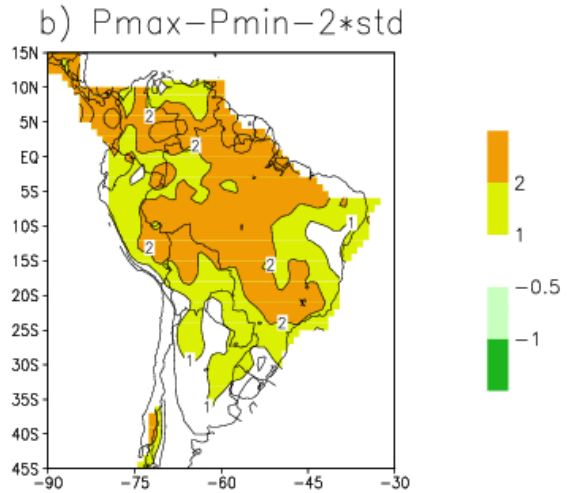
Seasonal cycle

derived from Monthly mean climatology



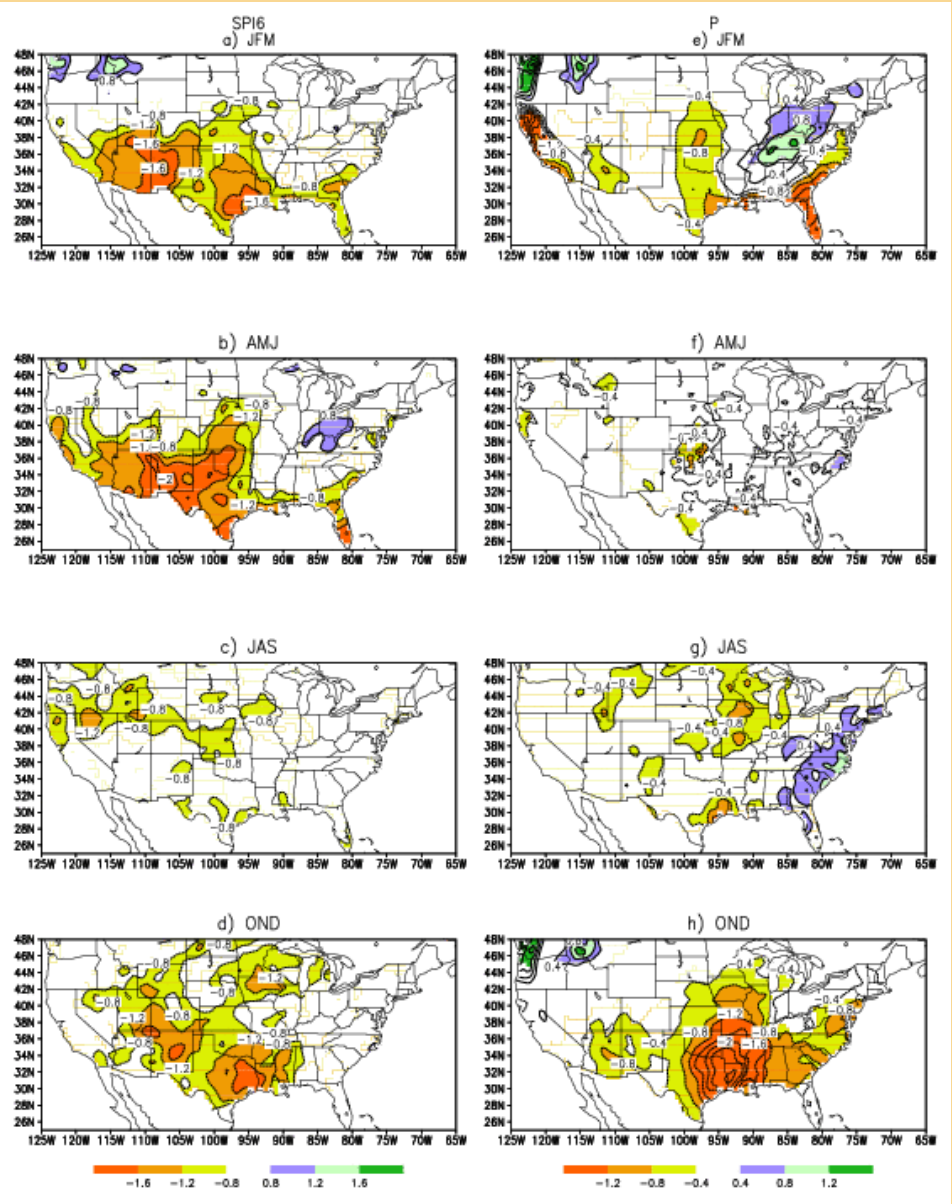






Cold-warm ENSO composites

SPI6 **P**



JFM

AMJ

JAS

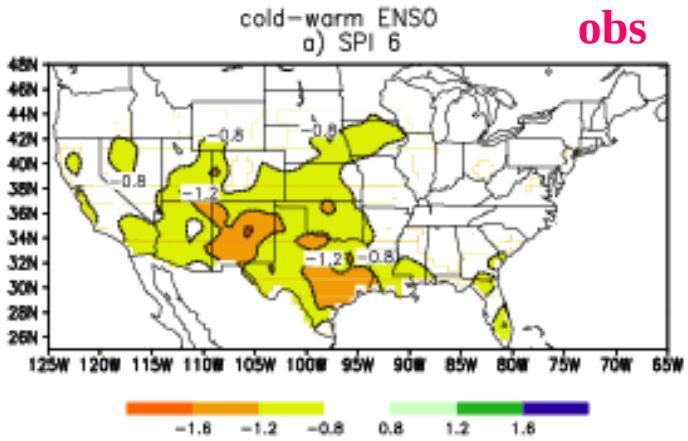
OND

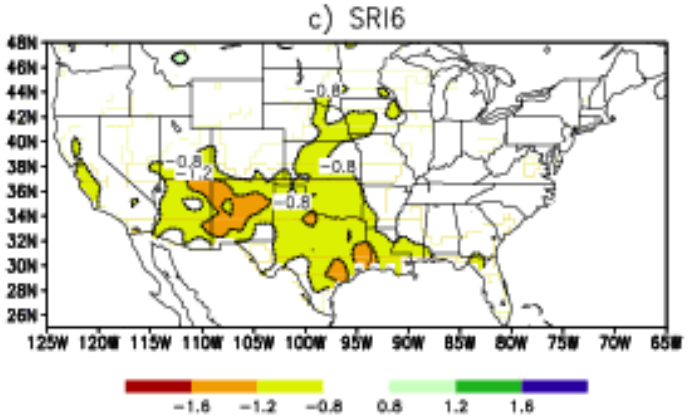
ENSO impact

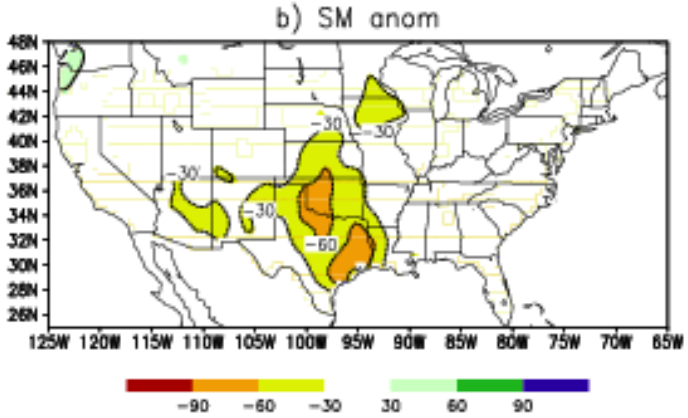
P anom does not imply drought because drought means persistent P anom.

For the East coast, Southeast, cold ENSO may initialize drought but if ENSO persist from winter to summer, then drought will not last because P responses to ENSO are seasonally dependent

For the southern Plains, Colorado basin, Southwest, persist cold ENSO=> persist drought







Cold ENSO=> drought over

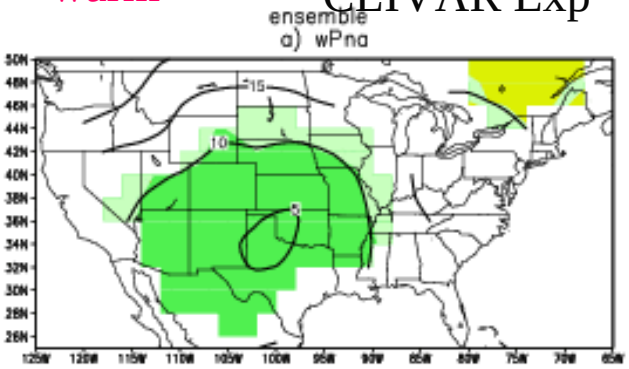
Great Plains

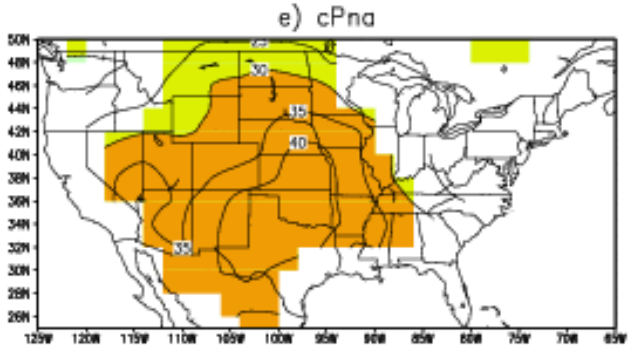
Southwest

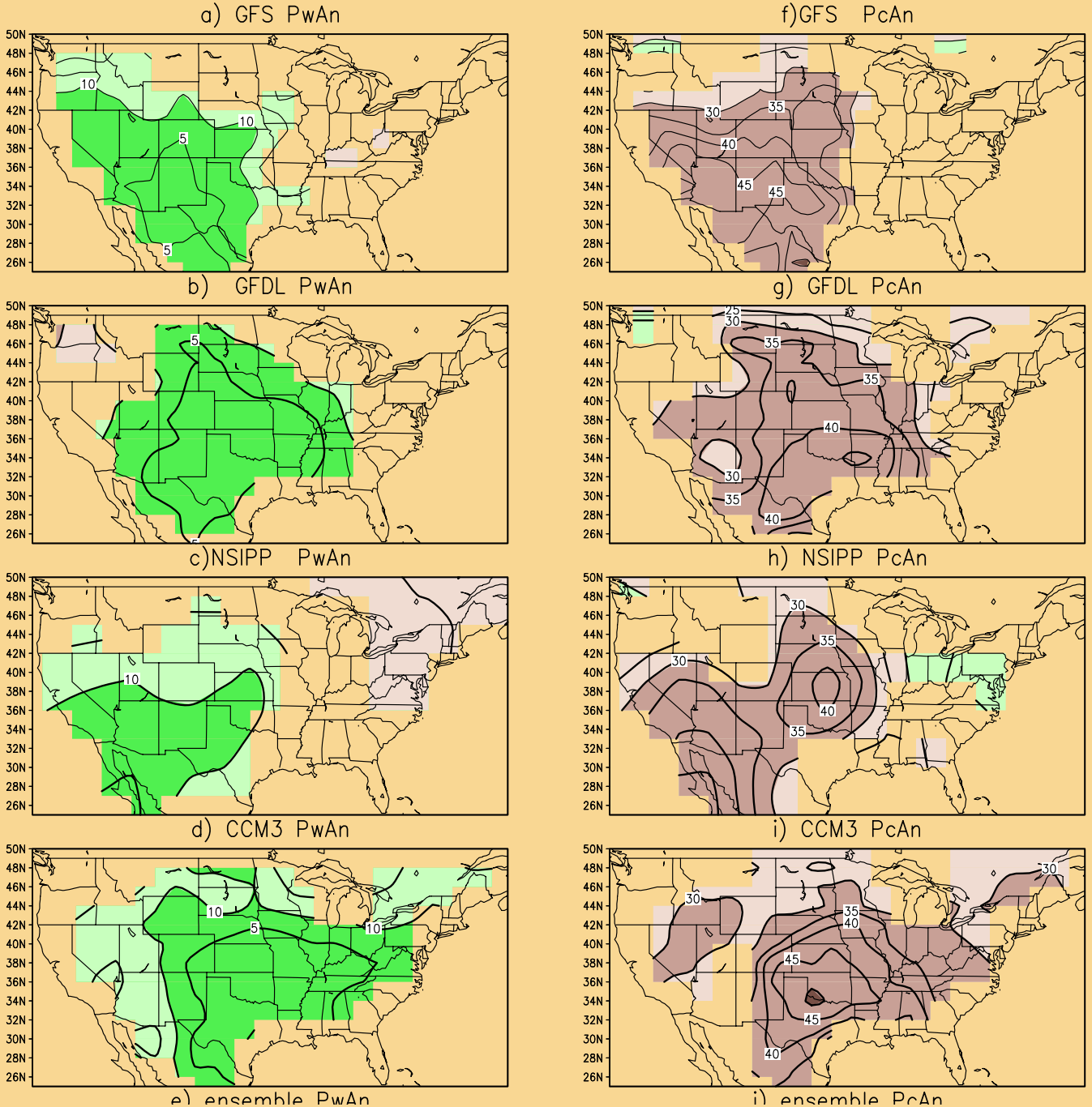
Ensemble Freq of occurrence
CLIVAR Exp

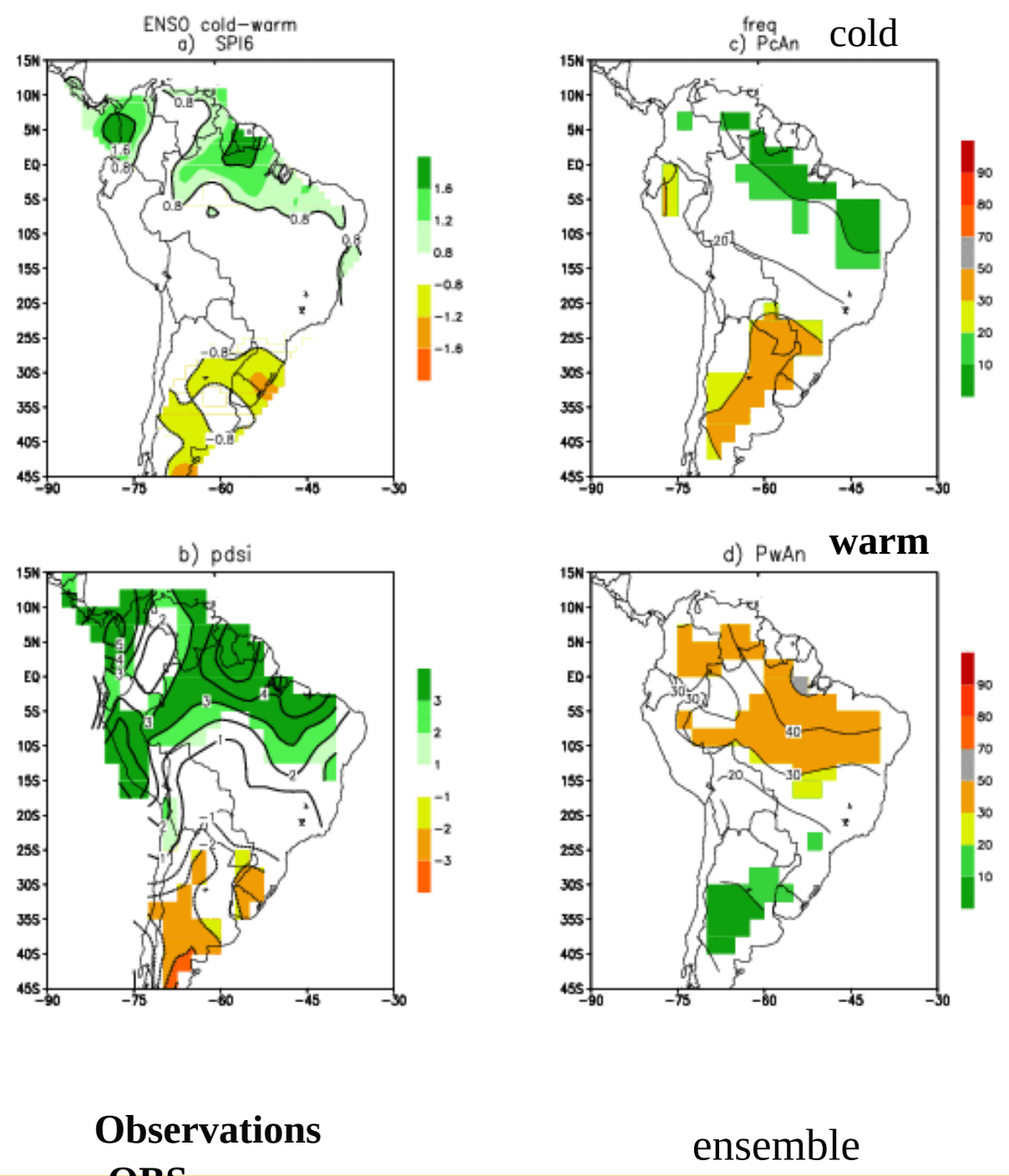
warm

cold






a) GFS PwAn
f)GFS PcAn
b) GFDL PwAn
g) GFDL PcAn
c)NSIPP PwAn
h) NSIPP PcAn
d) CCM3 PwAn
i) CCM3 PcAn
e) ensemble PwAn
i) ensemble PcAn
GFS
GFDL
NSIPP
CCM3



ENSO

Cold=>

More **drought** over Argentina, Southeast South America

Weaker monsoon

Wetness:

Northern South America

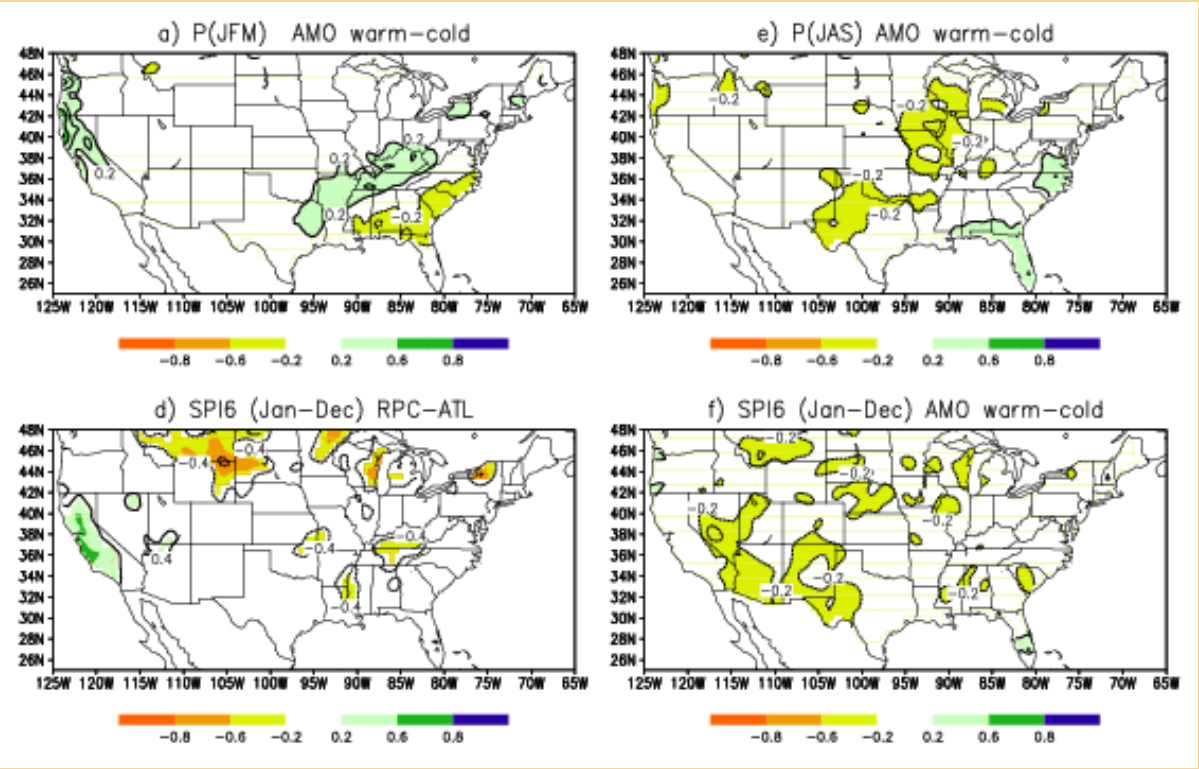
Observations

OBS

ensemble

Atlantic Multi decadal Oscillation

AMO composite warm-cold phase



Decadal influence is small.

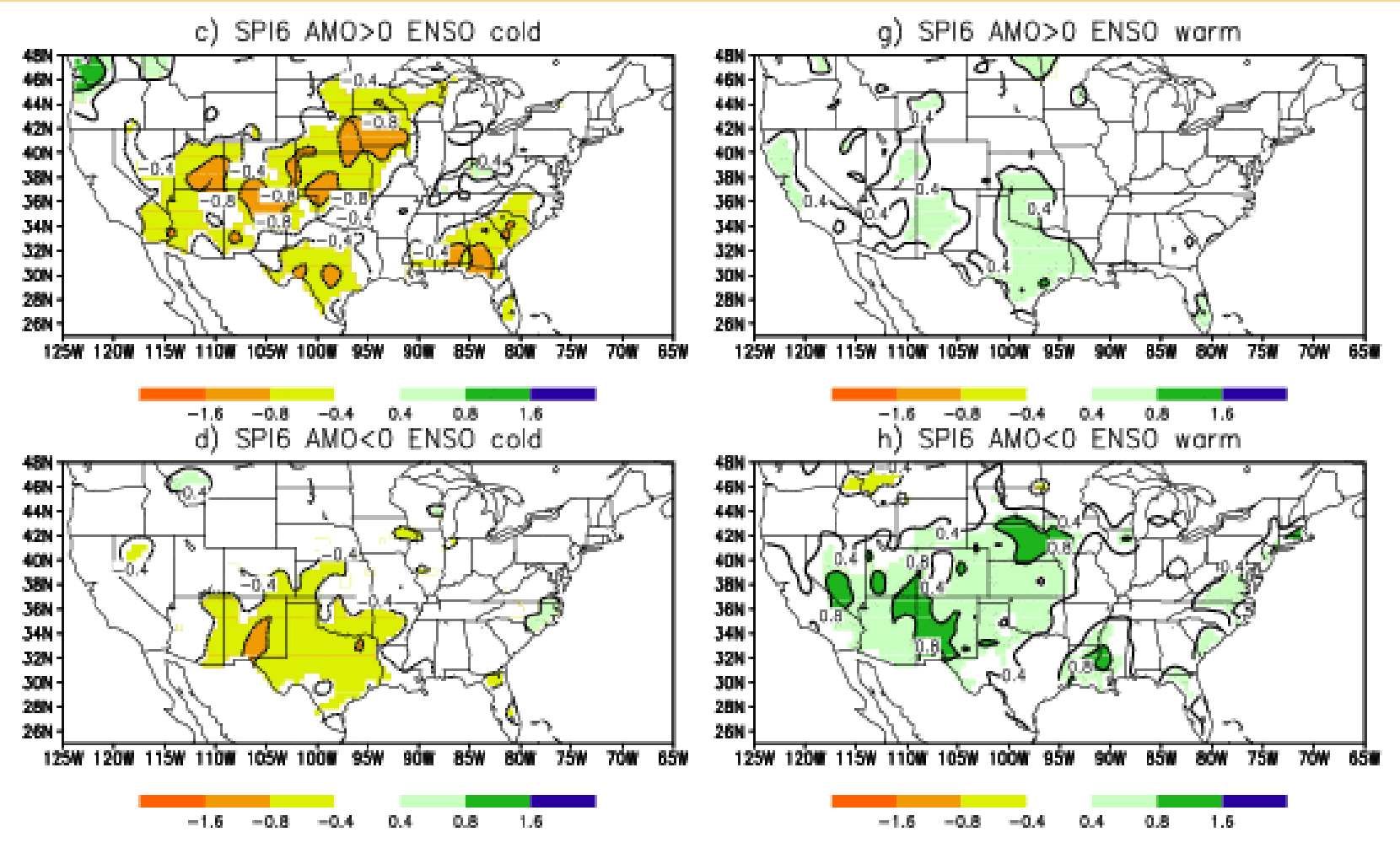
You can filter to get clearer signal, but the percentage of variance is small, so the net influence is small.

AMO warm 1930-1959,1992-2006

AMO cold 1915-1925,1965-1990

AMO influence through ENSO

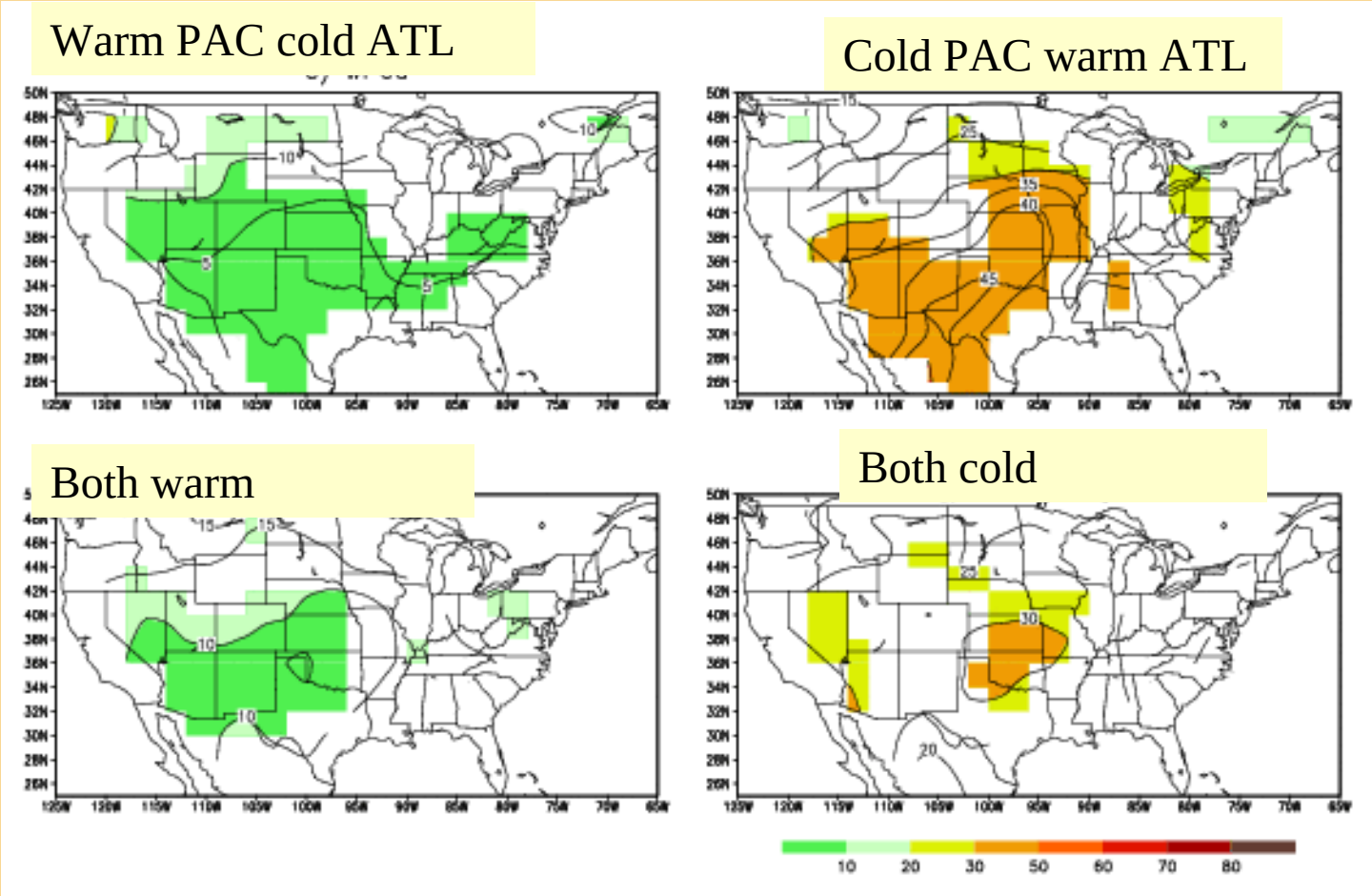
Composite of SPI6 with all seasons together for different phase of the AMO and ENSO



Model experiments

Frequency of drought occurrence

Ensemble (GFS,CCM3, GFDL, NSIPP)



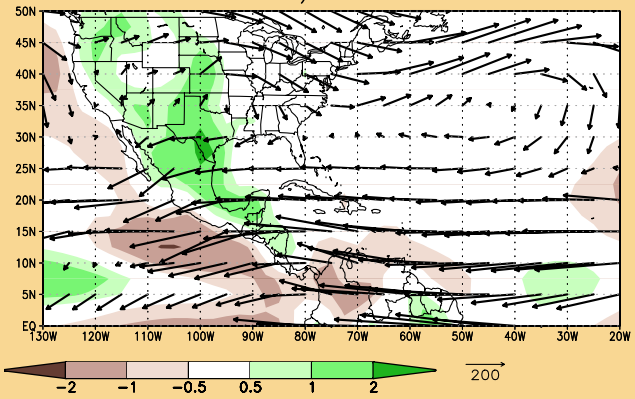
Summary –AMO & ENSO

North America :

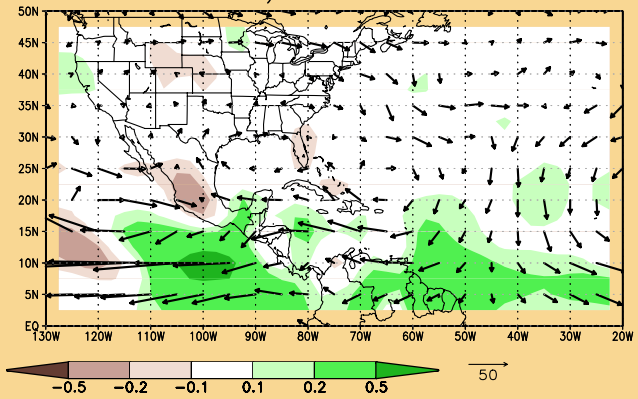
- a) Direct influence of the AMO on drought is small.
- B) The AMO can influence the impact of ENSO on drought. When the Atlantic and Pacific SSTAs are in phase, the net impact is small. When they are out of phase, warm Atlantic SSTAs strengthen the cold ENSO impact on drought,

qflux and D(Q) JAS

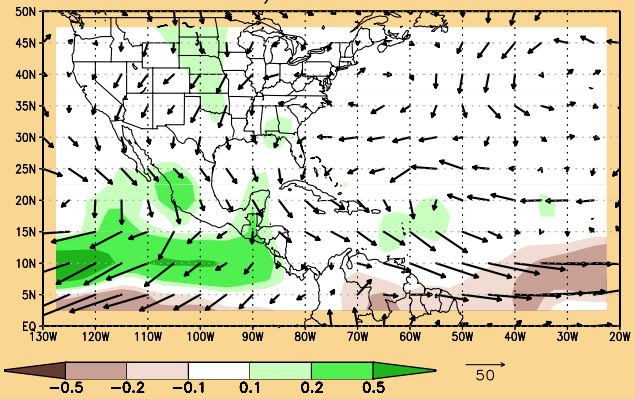
a) clim



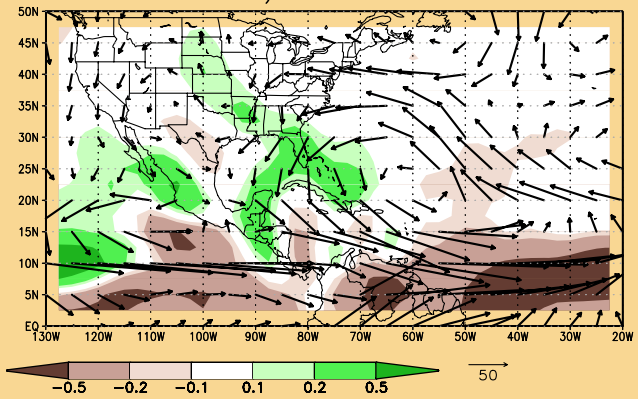
d) PnAc−clim



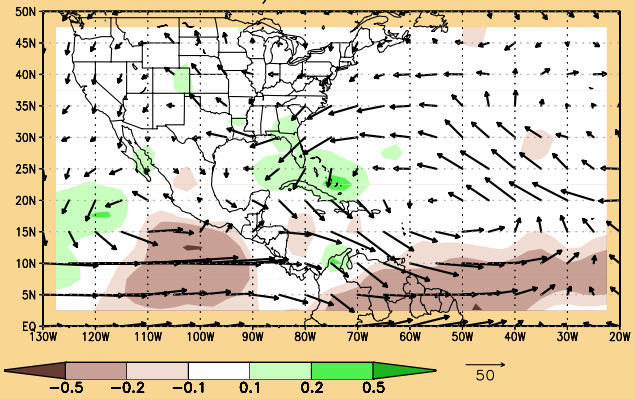
b) PcAn−clim



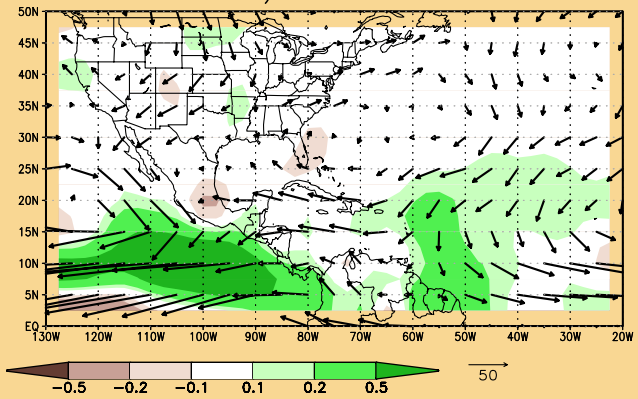
e) PcAw−clim



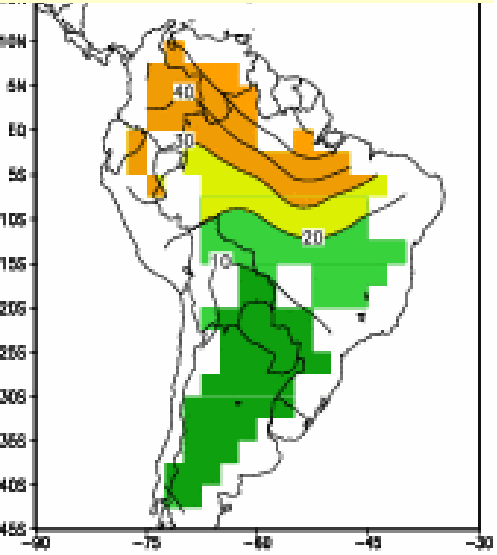
c) PnAw−clim



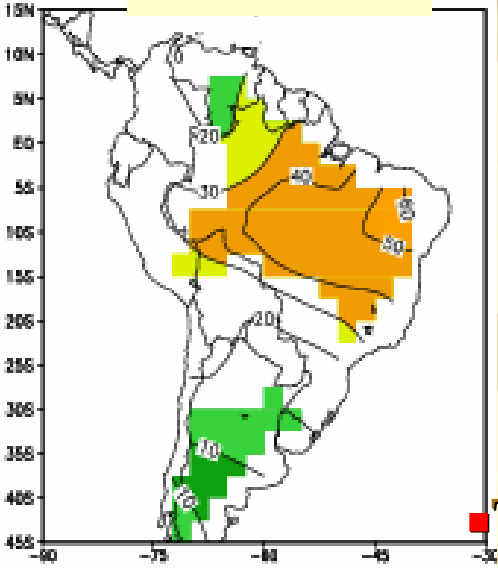
f) PcAc−clim



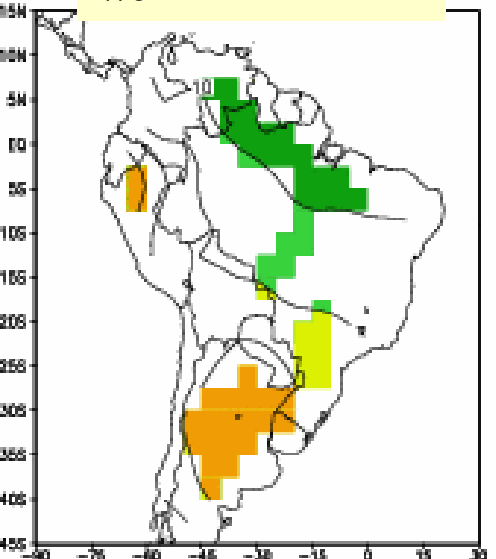
Warm ENSO cold atl



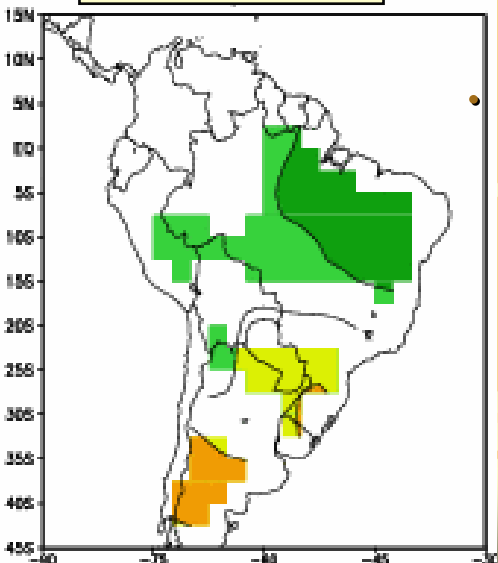
Both warm



Cold ENSO warm ATL



Both Cold



North Atlantic SSTAs modulate the impact of ENSO on drought

The major influence of the atl SSTAs is to modulate the impact of ENSO on drought by shifting the areas of most frequent drought occurrence over northern South America

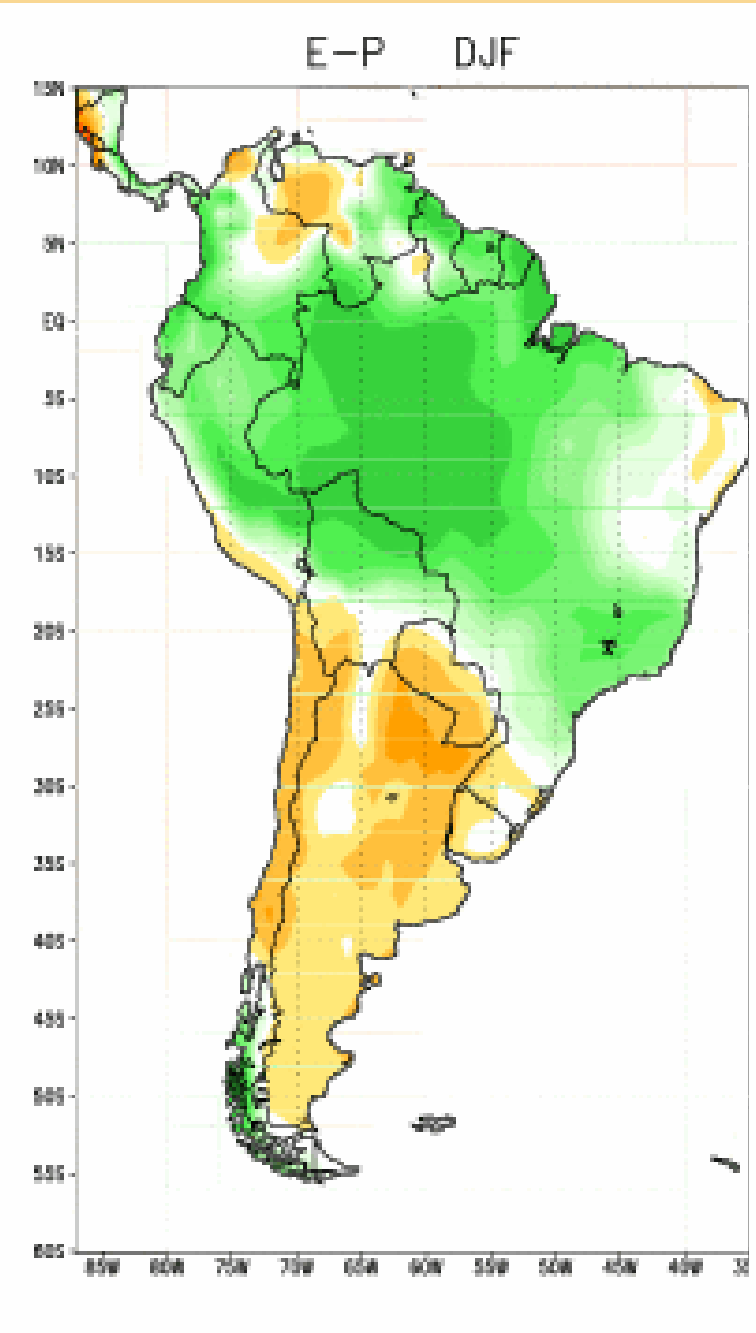
Conclusions

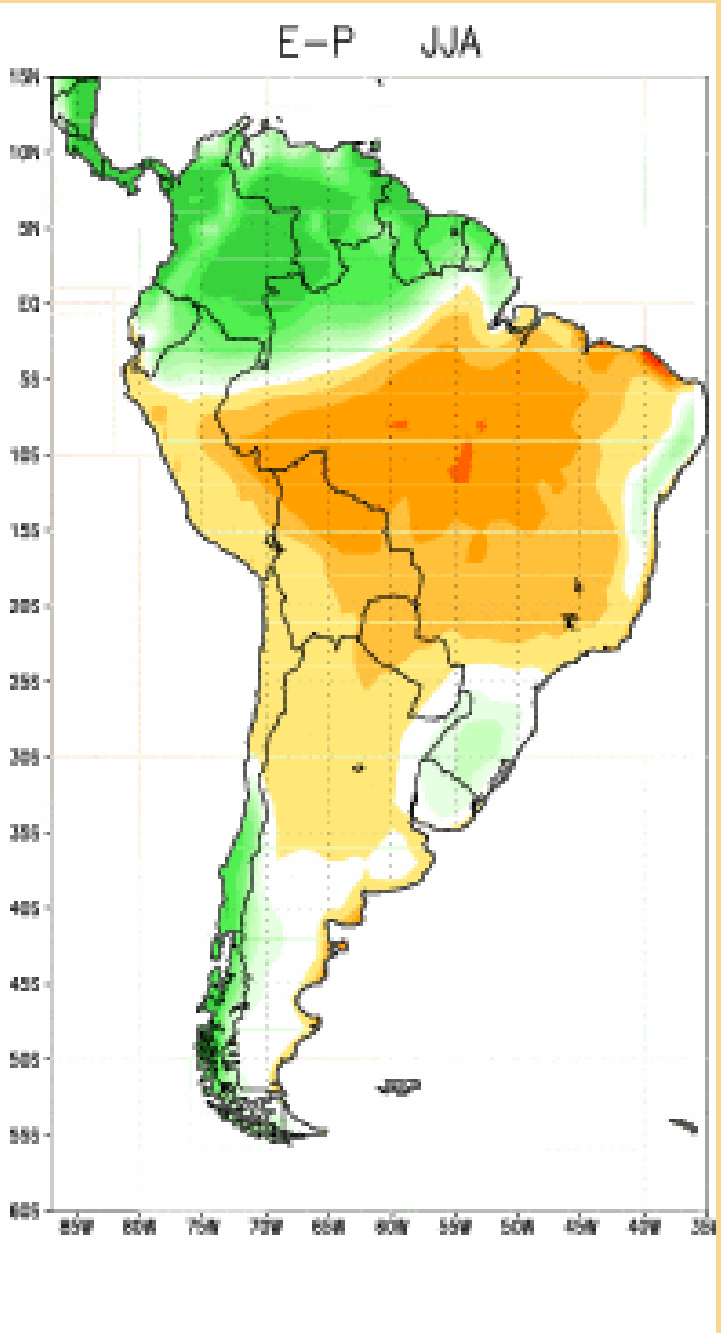
- Drought and wet spells for both South America and the United States have preferred regions to occur. The moisture transport plays an important role.
- ENSO has strong influence on drought:

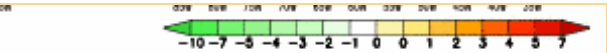
A) United States cold ENSO is in favor of drought over the Great Plains, Southwest

B) South America: cold ENSO in favor of wet spells over north South America and drought over southeast South America, Argentina and weaker monsoon

- The impact of the Atlantic SSTAs is indirect. They modulate the influence of ENSO on drought.







AMAZON:

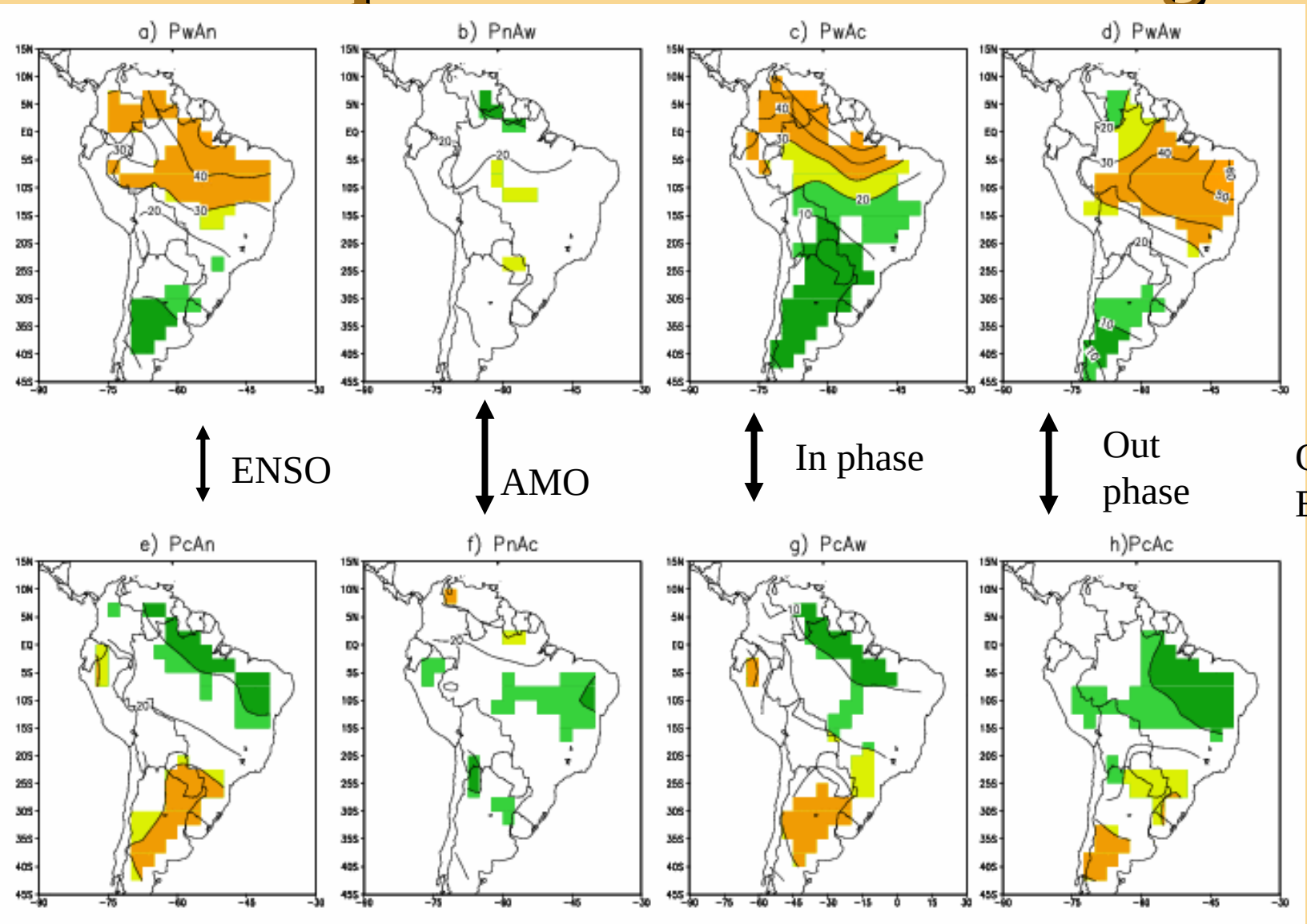
DJF:

Moisture sink

JJA

Moisture source

North Atlantic SSTAs modulate the impact of ENSO on drought



South America

- The impact of ENSO on drought over South America is regionally and seasonally dependent.
- Drought is more likely to occur over Southeast South America and Argentina during cold (warm) ENSO events and wetness (dryness) is in favored over northern Brazil.
- The direct influence of the tropical North Atlantic (NTA) SSTAs on drought is limited over Brazil including the Amazon with warm SSTAs in favor of drought.
- The major influence of the NTA SSTAs is to modulate the impact of ENSO on drought by shifting the areas of most frequent drought occurrence over northern South America. During cold ENSO, warm North Atlantic SSTAs is in favor drought over northwestern South America and cold NTA SSTAs favor drought over northeast brazil.