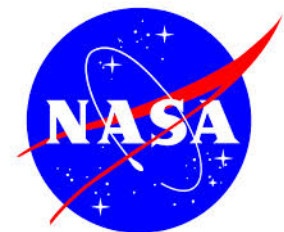


Causes of Extreme Dry Conditions over California during Recent Winters

Hailan Wang^{1 2} and Siegfried Schubert¹
NASA/GMAO¹; SSAI²

September 9, 2014

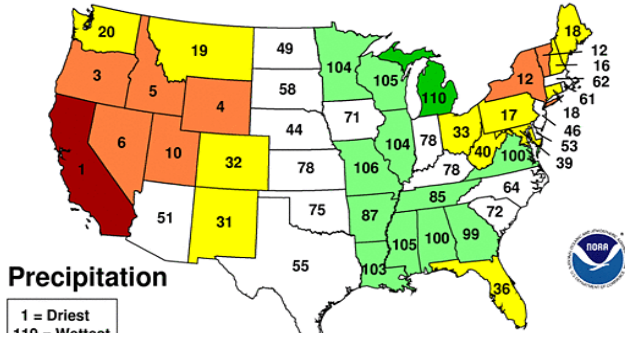


Precip Ranks (1895-present)

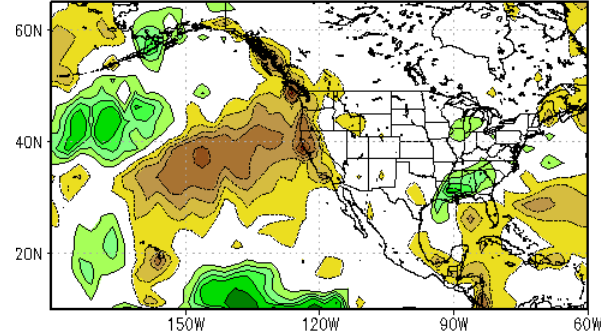
GPCP Precip

January–March 2013 Statewide Ranks

National Climatic Data Center/NESDIS/NOAA



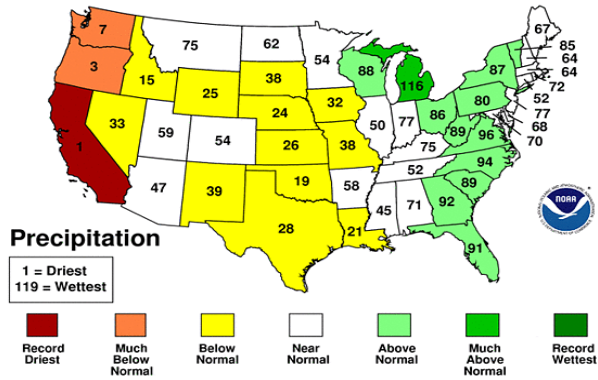
GPCP_precip: DJF2012/13



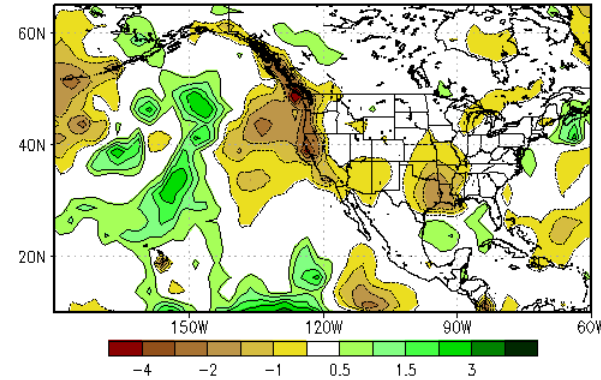
DJF12/13

Nov 2013-Jan 2014 Statewide Ranks

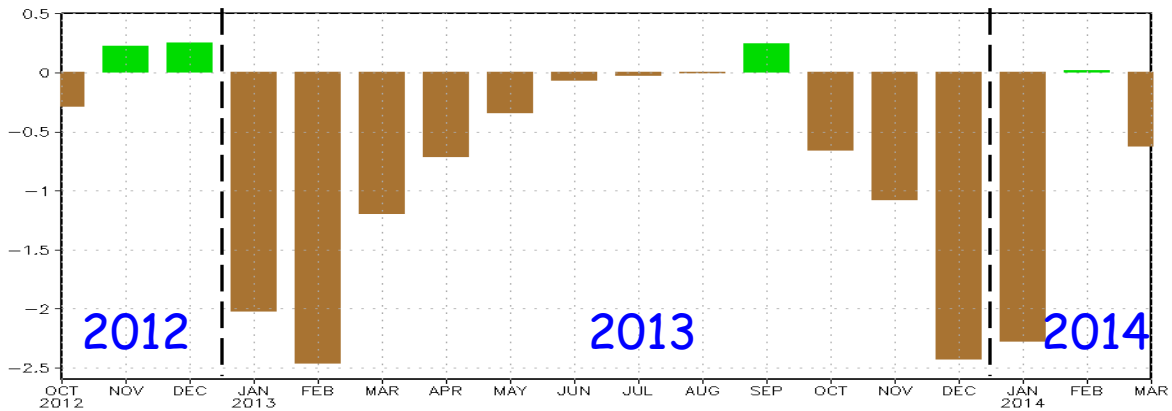
National Climatic Data Center/NESDIS/NOAA



GPCP_precip: DJF2013/14



DJF13/14

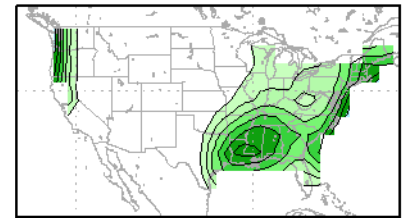


Precip over CA

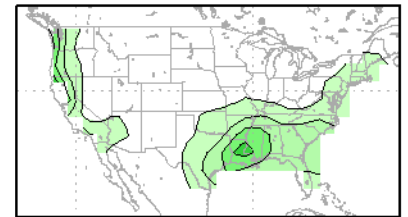
Precip over California

- Comes from extratropical cyclones from the north Pacific under the strong wintertime jet stream
- Precip over California: southwesterlies from north of Hawaii
- Influencing factors
 - ENSO
 - MJO
 - Atmospheric internal variability
 - Variations on decadal and longer time scales
 - PDO
 - Long-term trend

GPCP DJF
Climatology



Standard deviation



Data

- Obs
 - GPCP precip (1979-present)
 - GPCC precip (1901-present)
- MERRA reanalysis
 - 1979-present
- NASA GEOS-5 AMIP Simulations
 - 1 degree
 - 12 members; 1871-present
- Anomalies: from 1980-2010 mean

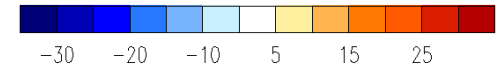
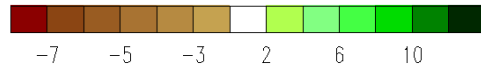
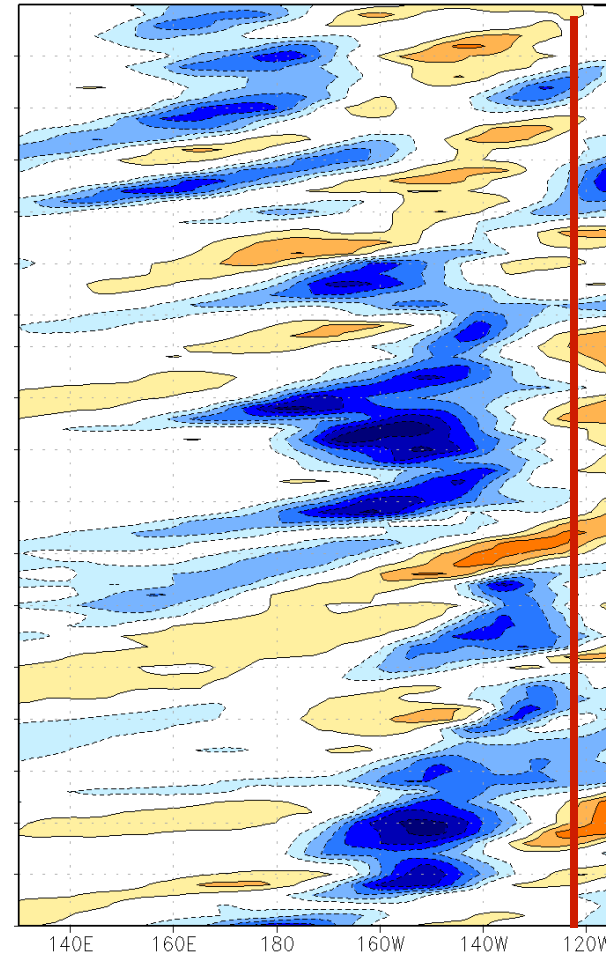
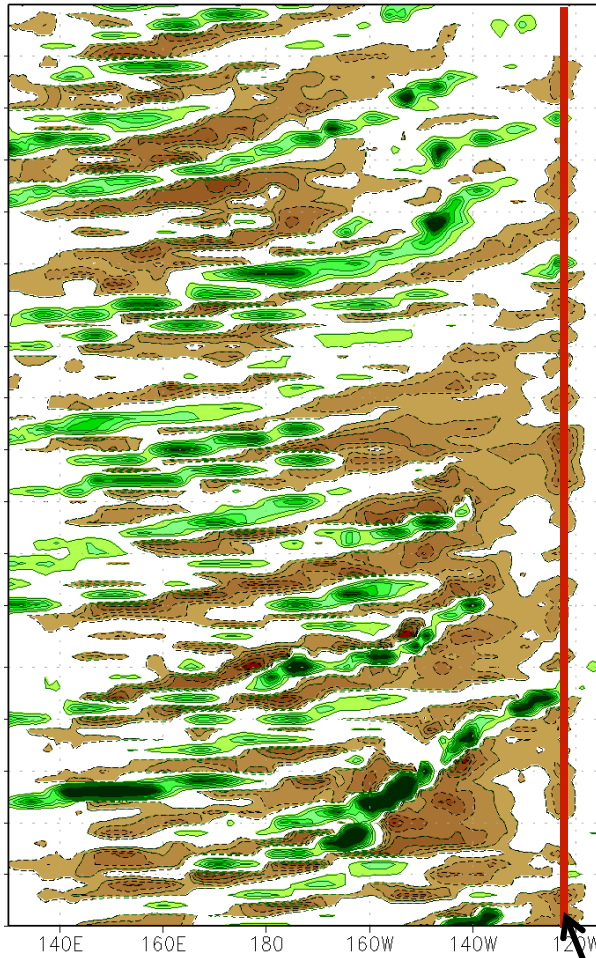
MERRA: Daily Evolution

31Mar
2013

Precip (32N-45N)

U250 (20N-40N)

1Jan
2013



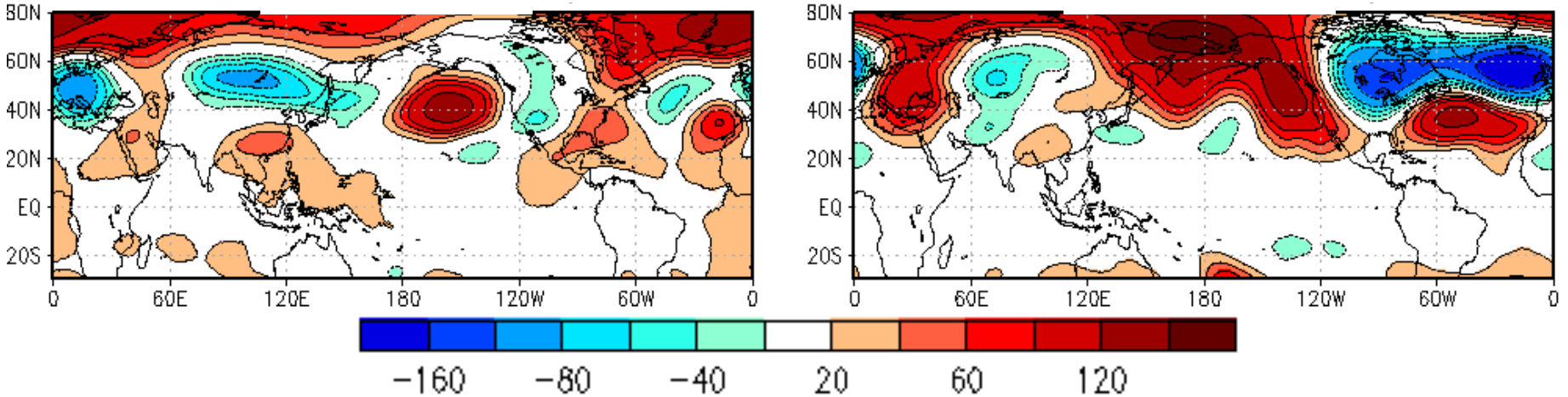
US west
coastline

Considerably less north Pacific storms reached U.S. west coast
Considerably weaker zonal wind over NE Pacific

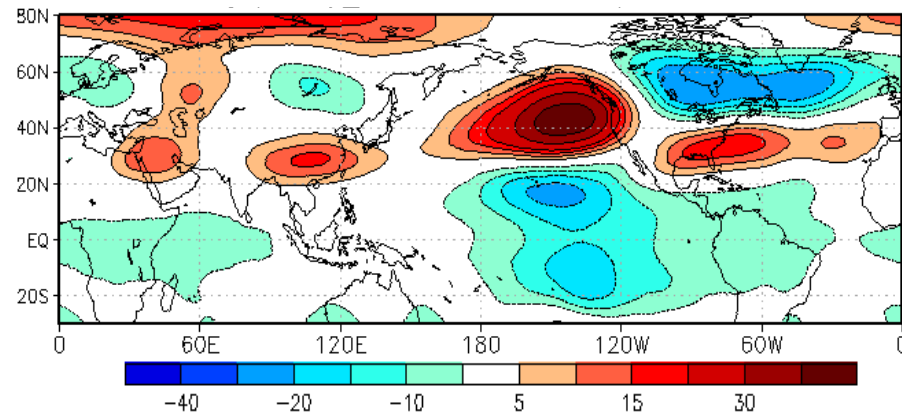
Atmospheric Circulation: H250mb

DJF2012/13

DJF2013/14



Regr against P_California

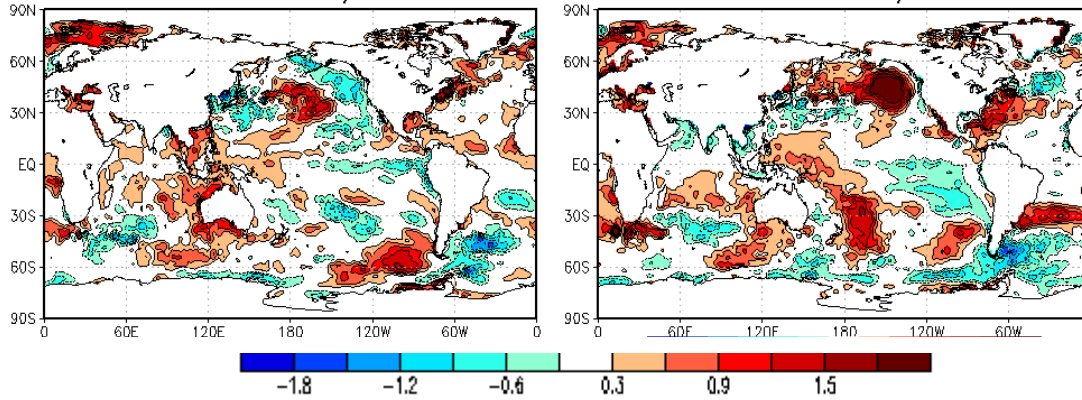


Similar to other dry winters for California, the persistent ridge (40°N) over NE Pacific prevented north Pacific storms from reaching California during the recent two winters.

GEOS-5 AMIP EnsMean vs. Obs

SST: DJF2012/13

SST: DJF2013/14



MERRA

H250mb

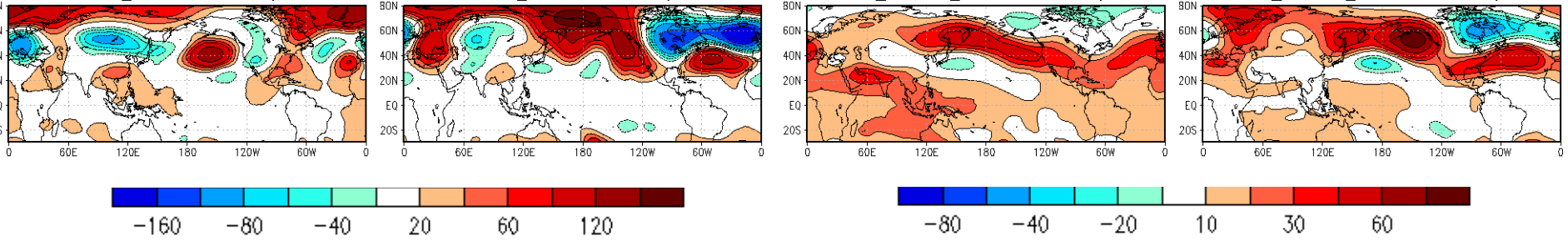
AMIP EnsMean

MERRA_H250mb: DJF2012/13

MERRA_H250mb: DJF2013/14

AMIP_EnsMean_H250mb: DJF2012/13

AMIP_EnsMean_H250mb: DJF2013/14



GPCP

Precip

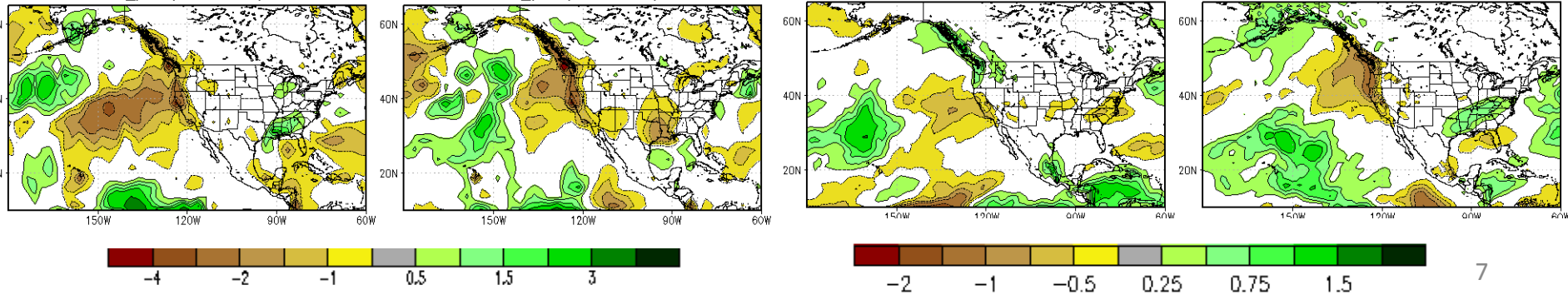
AMIP EnsMean

GPCP_precip: DJF2012/13

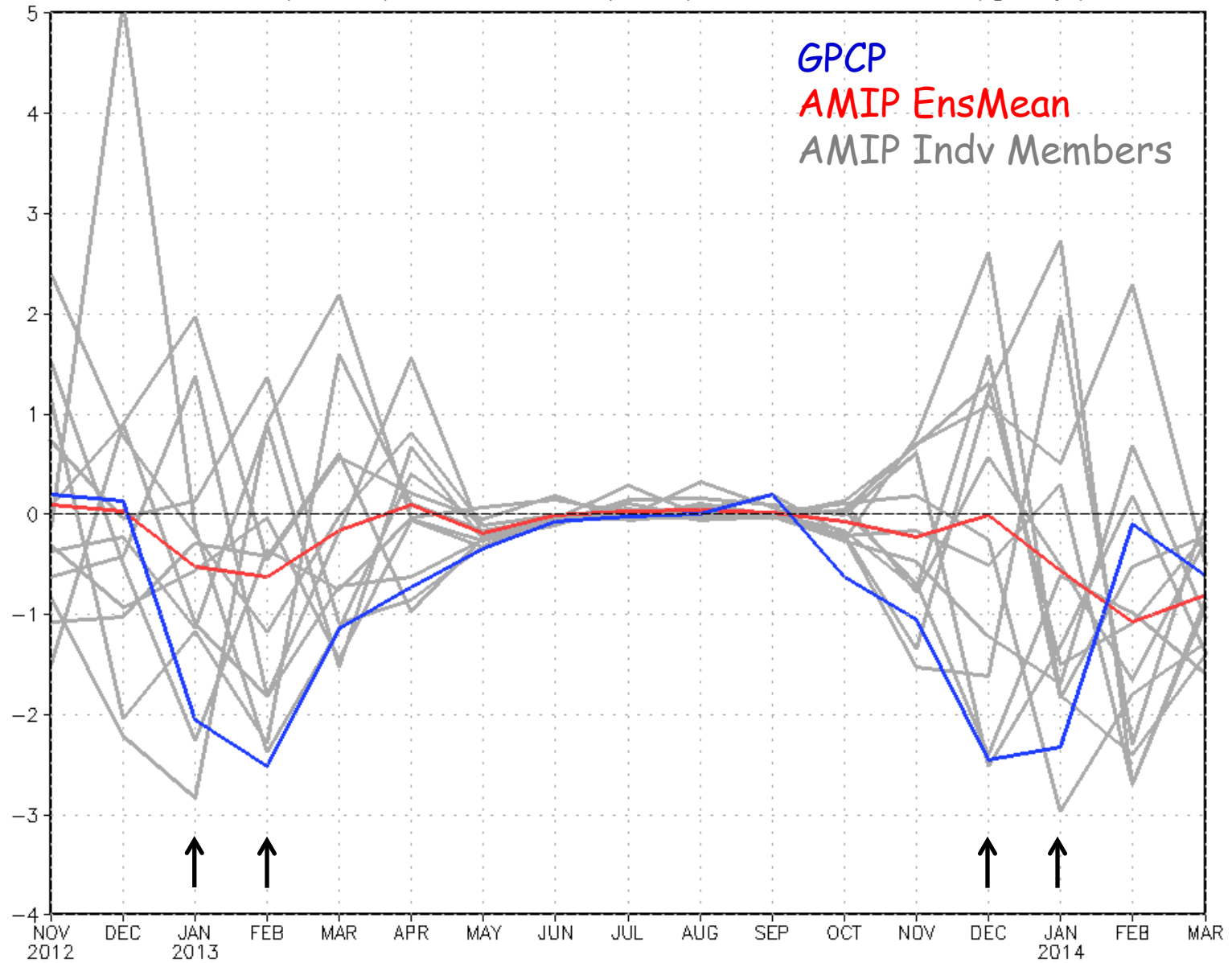
GPCP_precip: DJF2013/14

AMIP_EnsMean_precip: DJF2012/13

AMIP_EnsMean_precip: DJF2013/14



Precip anomaly averaged over California



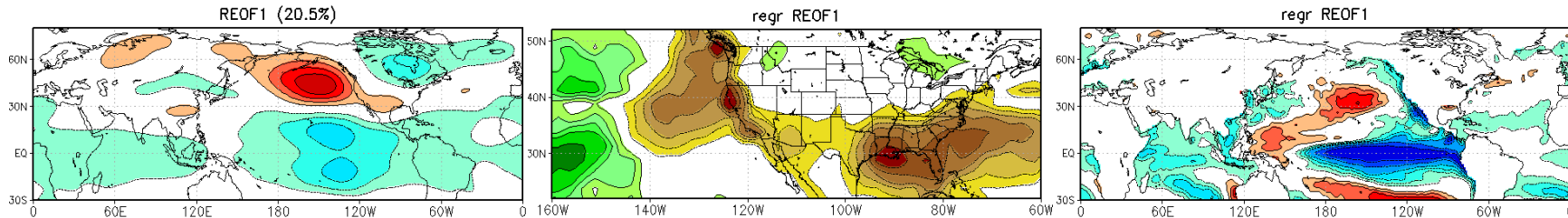
REOFs of MERRA H250mb DJF1979/80-2013/14

Linear Regression

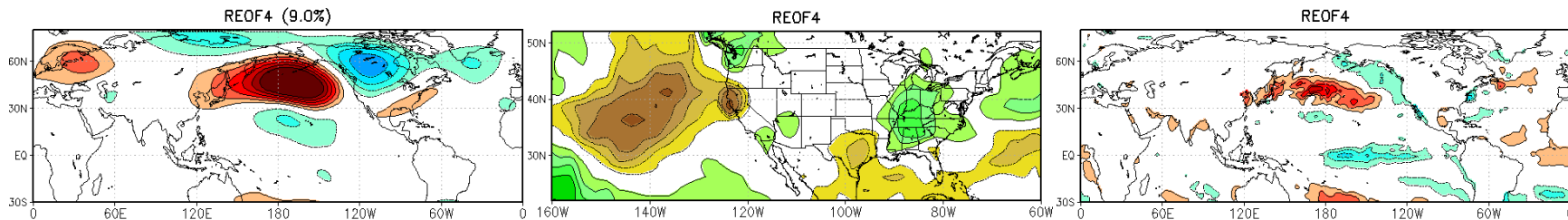
Precip

SST

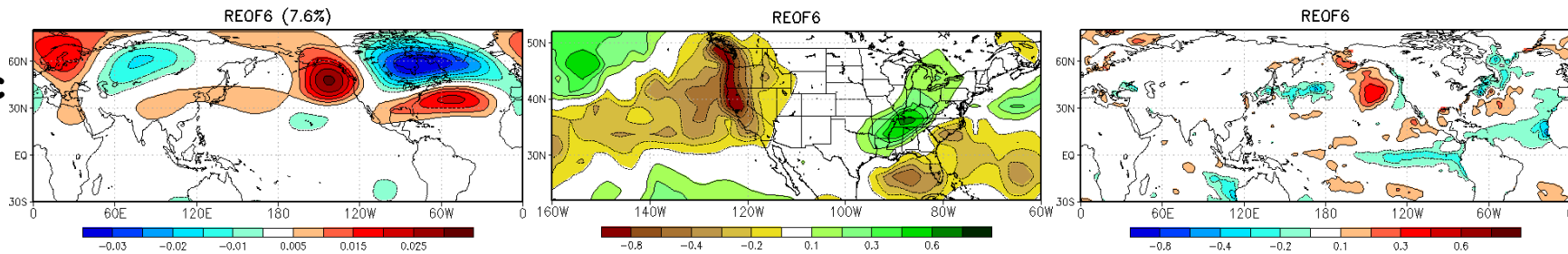
ENSO



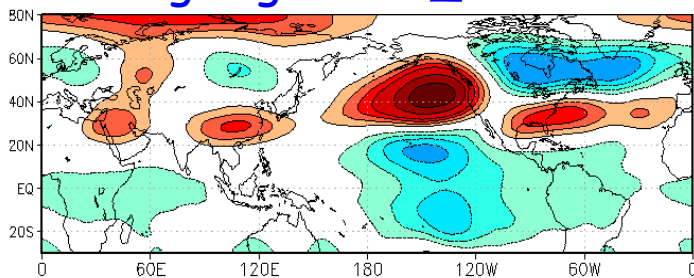
PNA



NE Pac ridge



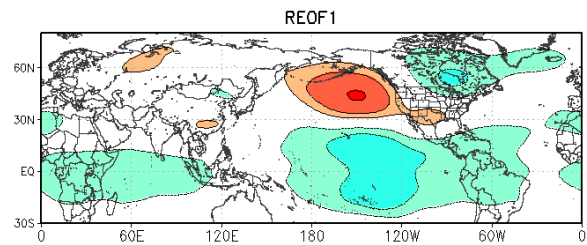
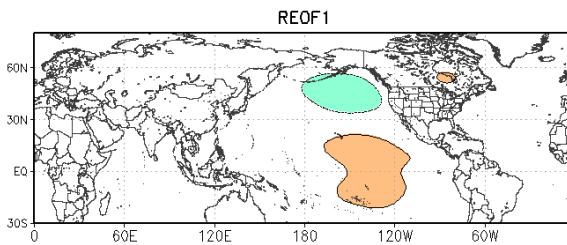
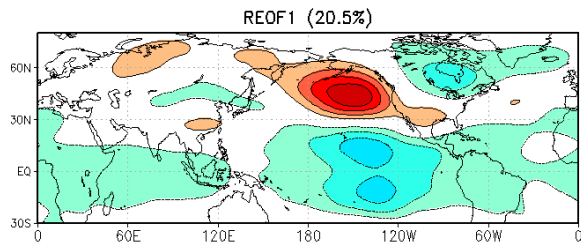
Regr against P_California



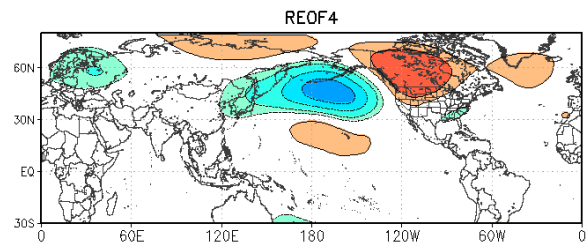
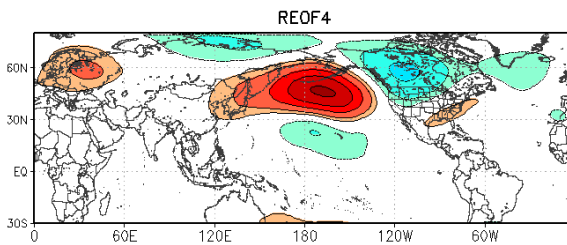
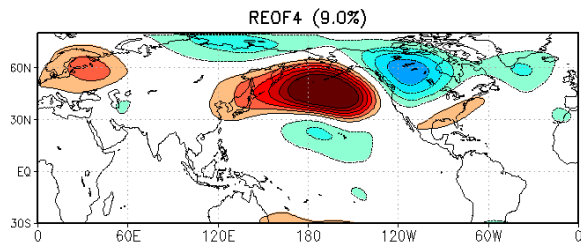
REOFs of MERRA H250mb DJF1979/80-2013/14

Relative contribution to H250mb DJF2012/13 DJF2013/14

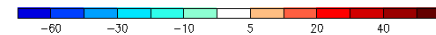
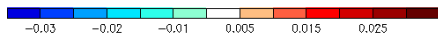
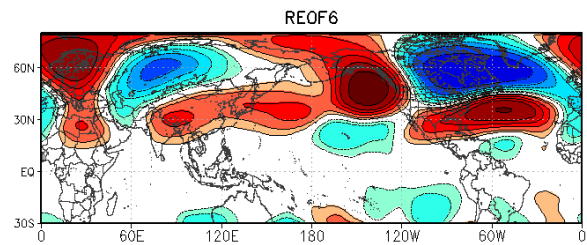
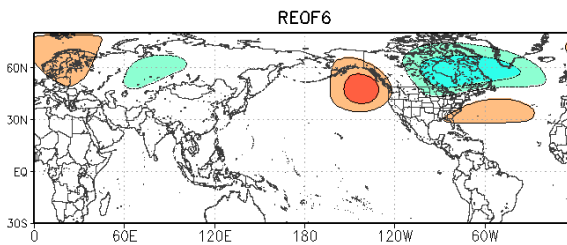
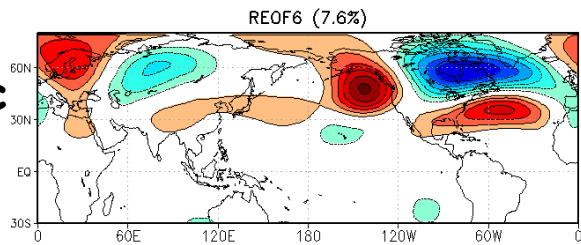
ENSO



PNA



NE Pac ridge



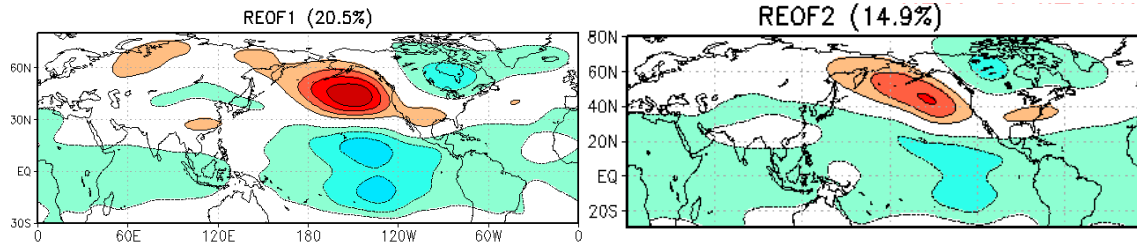
REOF Analysis of DJF H250mb

MERRA
1979/80-2012/13 detrended

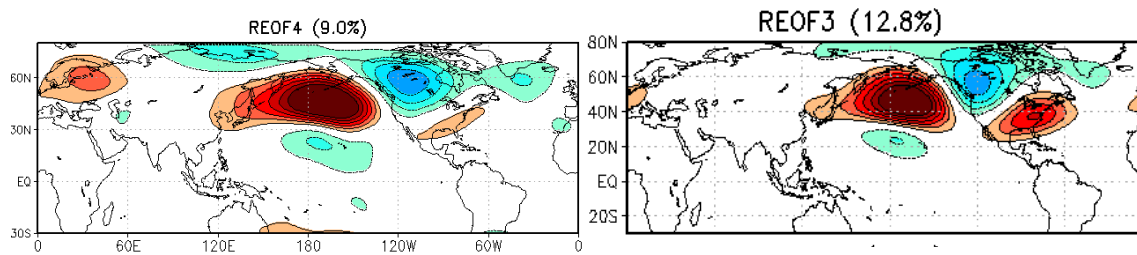
12AMIPs
1871-1975

ClimSST
99 years

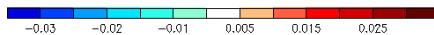
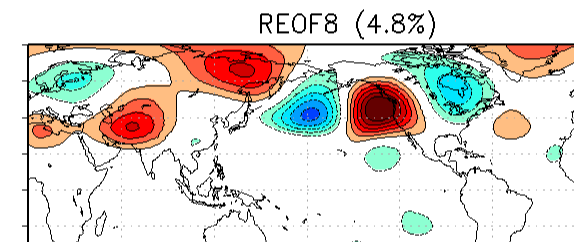
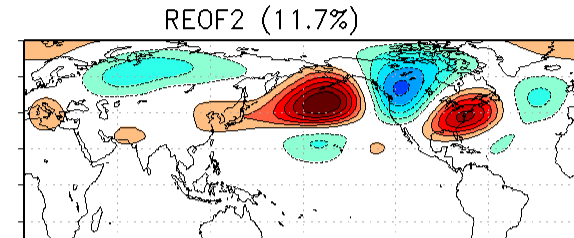
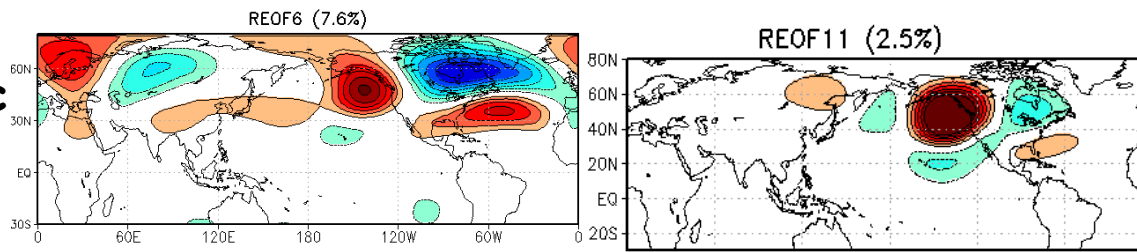
ENSO



PNA



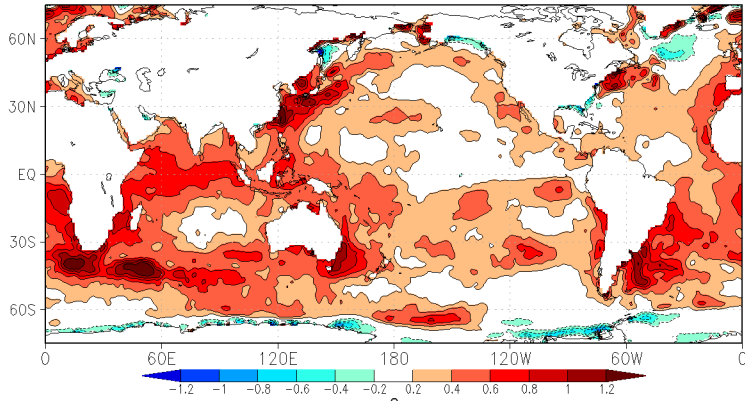
NE Pac ridge



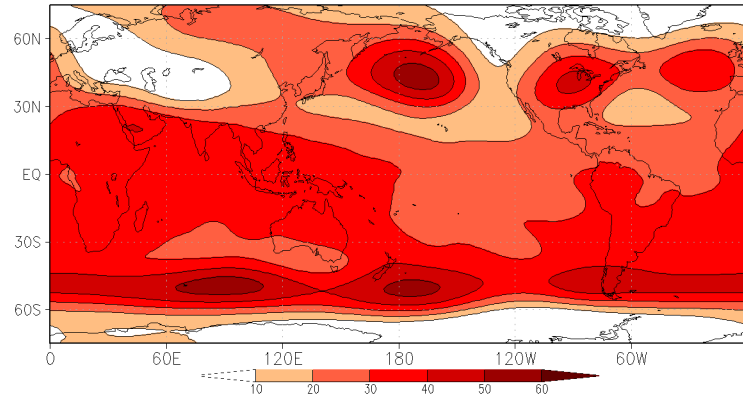
- 1) PNA pattern in ClimSST similarly seen in other AGCMs (e.g. Lau 1981; Straus and Shukla 2002)
- 2) ENSO (external); PNA, NE Pacific ridge pattern (may be to a large extent internal, modulated by SST)

DJF1871-1970 vs. DJF1980-2012

SST



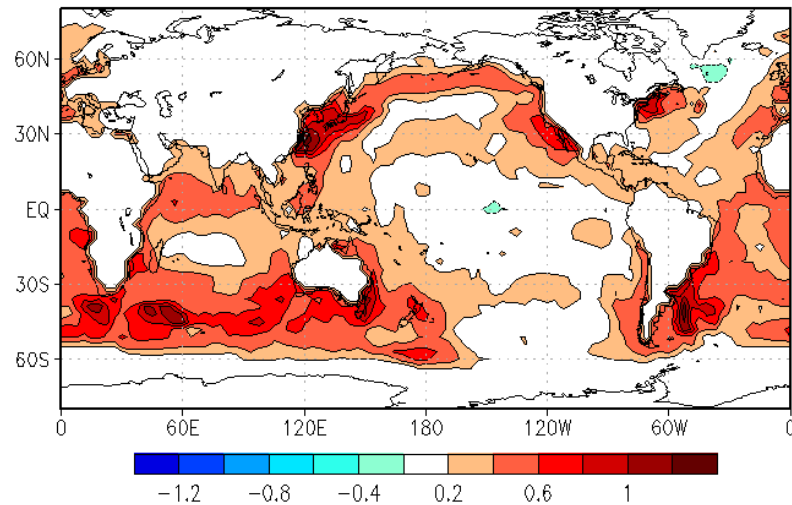
H250mb



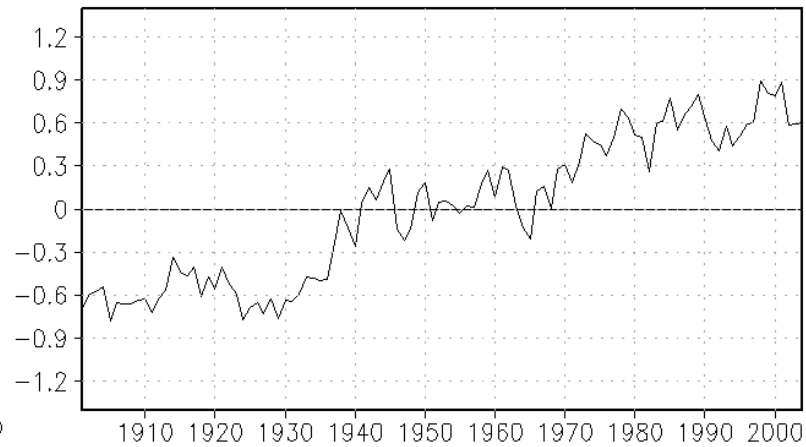
Mean Diff

Long-term warming trend mode
Leading REOF of annual mean HadISST (1901-2004)

REOF1 27.2%

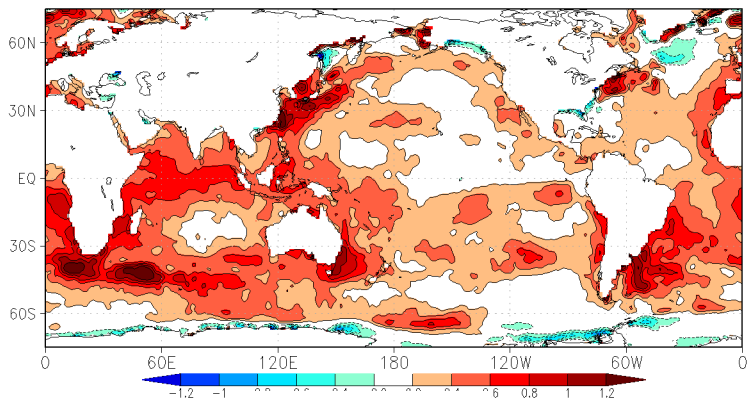


PC1

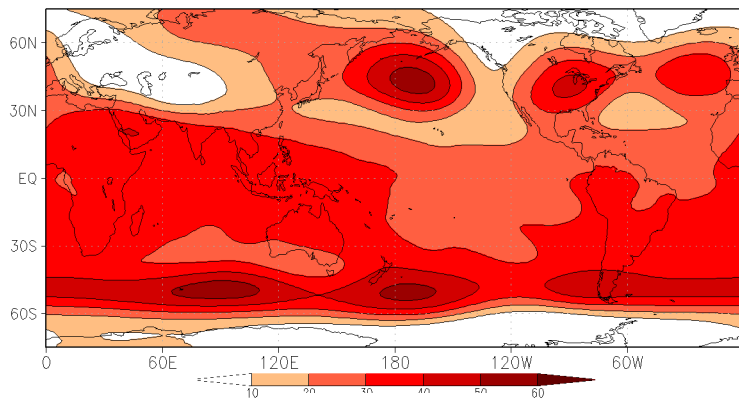


DJF1871-1970 vs. DJF1980-2012

SST

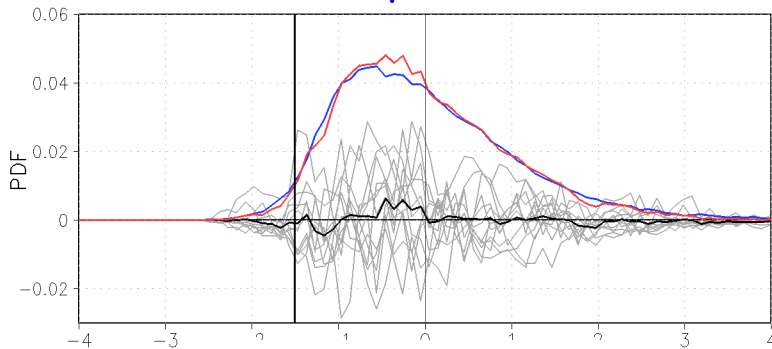


H250mb

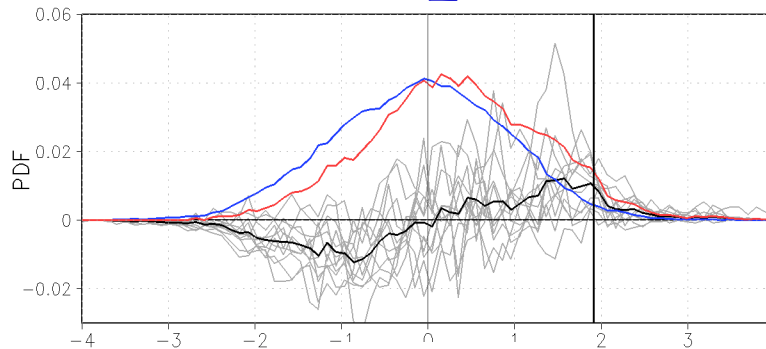


Mean Diff

Precip_CA

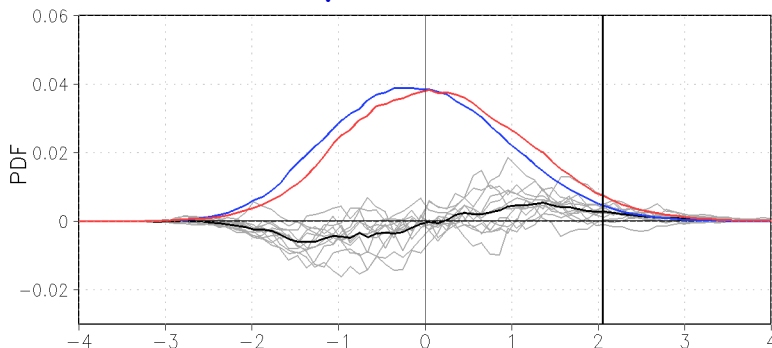


T2M_CA

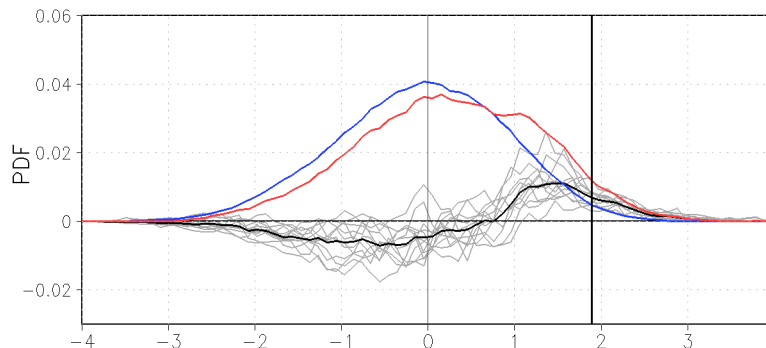


PDF
change

Precipitable Water



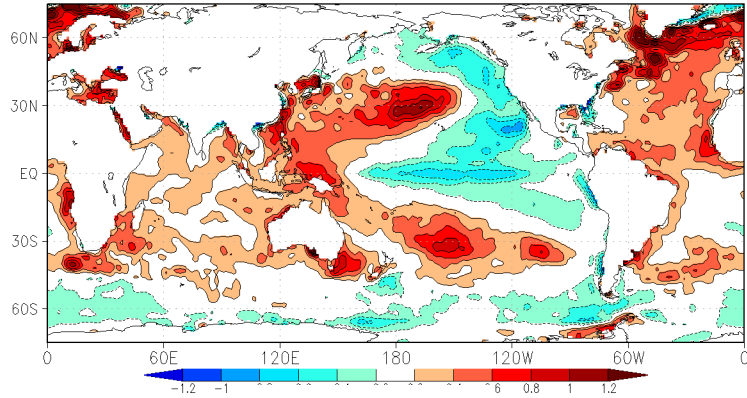
H250mb



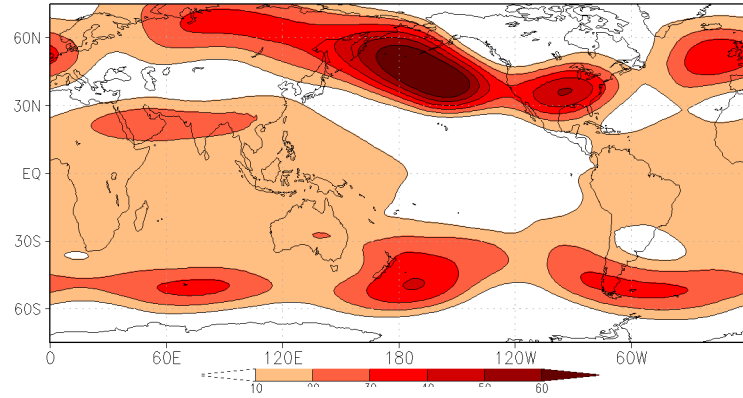
1871-1970
1980-2012
1980-2012
Minus
1871-1970

DJF1979-1996 vs. DJF1998-2012

SST

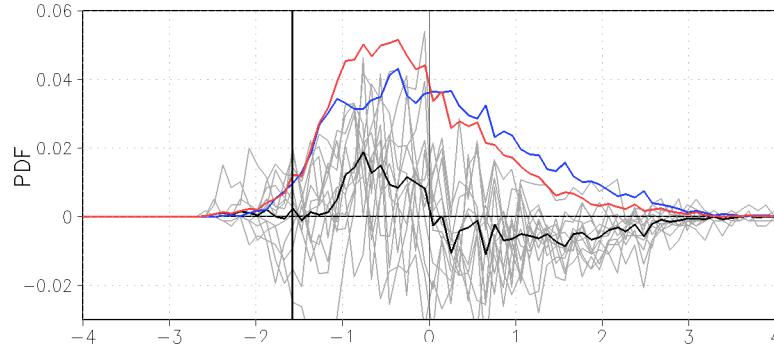


H250mb

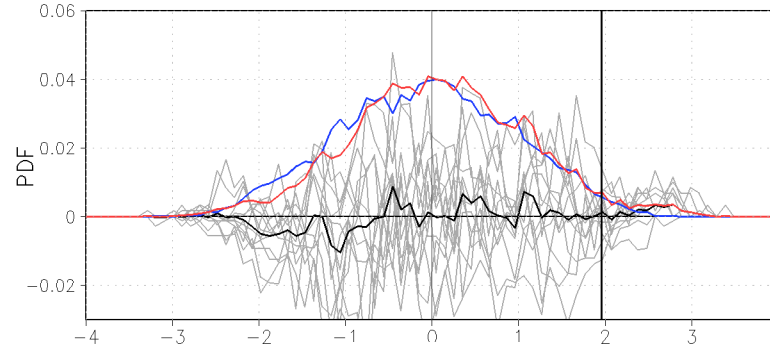


Mean Diff

Precip_CA

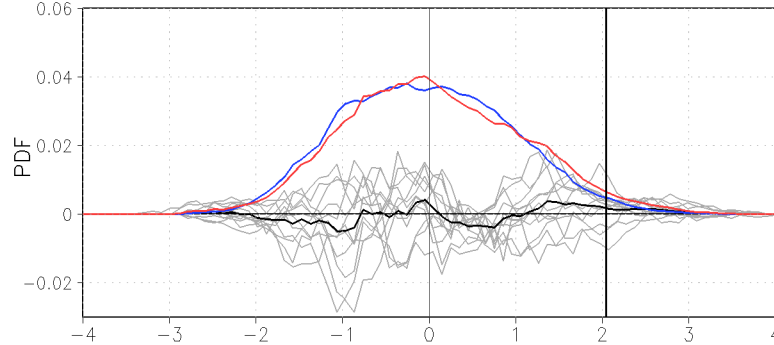


T2M_CA

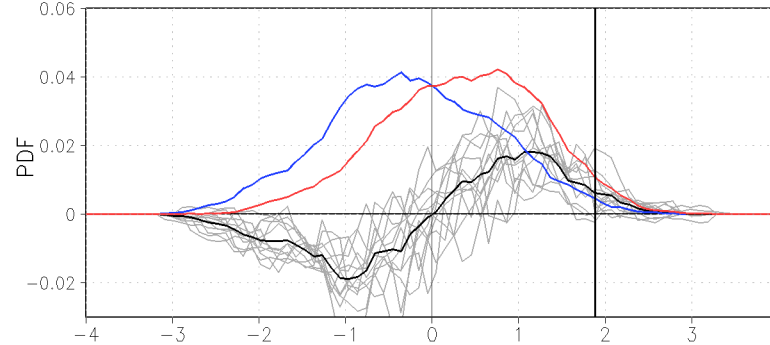


PDF change

Precipitable Water



H250mb



1871-1970
1980-2012
1980-2012
Minus
1871-1970

Conclusions

- Immediate cause:
 - Ridge over northeast Pacific prevented north Pacific storms from reaching California
- Underlying causes:
 - SSTA produced a predilection for California drought, with atmospheric internal variability explaining the extreme magnitude, particularly for the dry event during early 2013
- Climate change
 - The long-term warming trend since late 19th Century appears to make no appreciable contribution because of the counteraction between its dynamical and thermodynamic effects.
 - PDO phase change during recent decades enhances occurrence of dry events over California.