

Causes of Extreme Dry Conditions over California during Recent Winters

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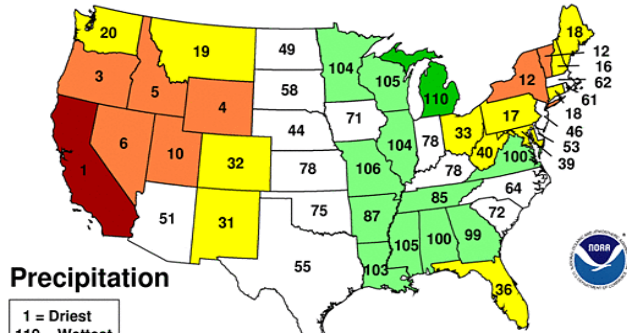
Wang and Schubert 2014: Causes of the Extreme Dry Conditions over California during
Early 2013. BAMS "Explaining Extreme Events from a Climate Perspective"
Seager et al. 2014: Causes and predictability of the 2011 to 2014 California drought.

Precip Ranks

(1895-present)

January–March 2013 Statewide Ranks

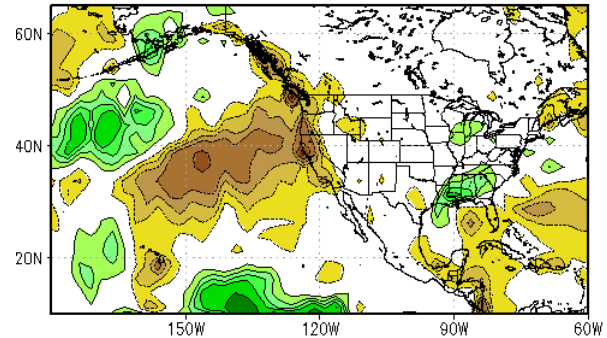
National Climatic Data Center/NESDIS/NOAA



GPCP Precip Anom

(1980-2010)

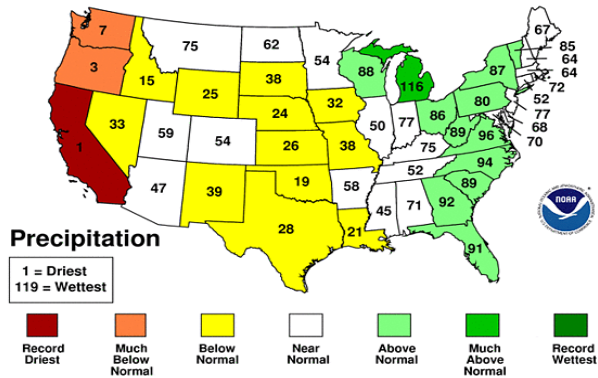
GPCP_precip: DJF2012/13



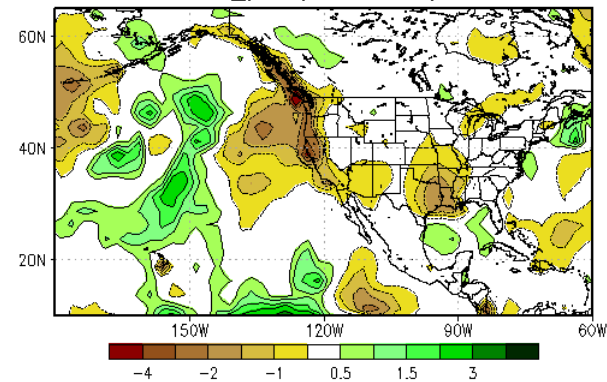
DJF12/13

Nov 2013-Jan 2014 Statewide Ranks

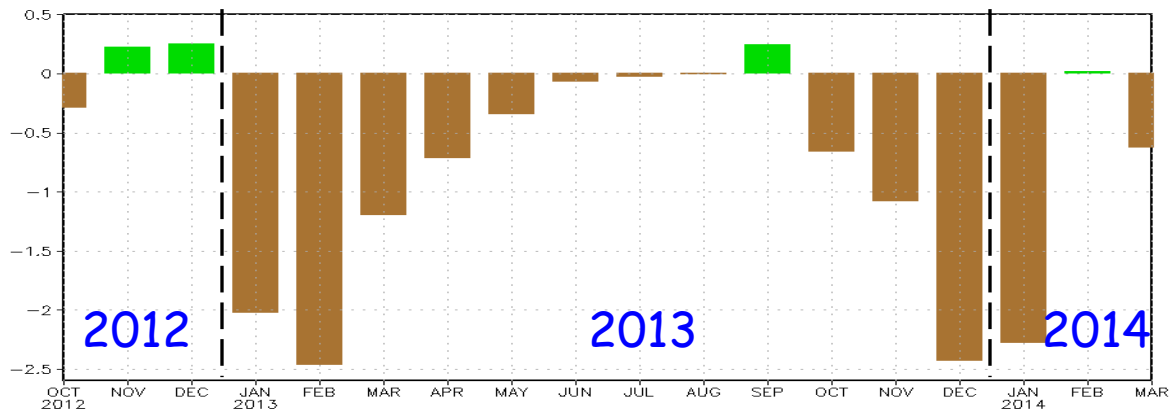
National Climatic Data Center/NESDIS/NOAA



GPCP_precip: DJF2013/14



DJF13/14

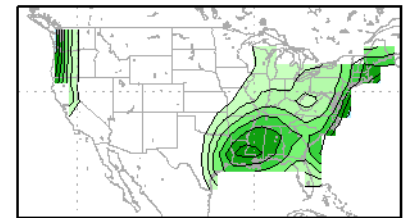


Precip over CA

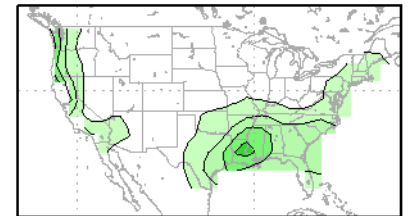
Precip over California

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

GPCP DJF
Climatology



Standard deviation



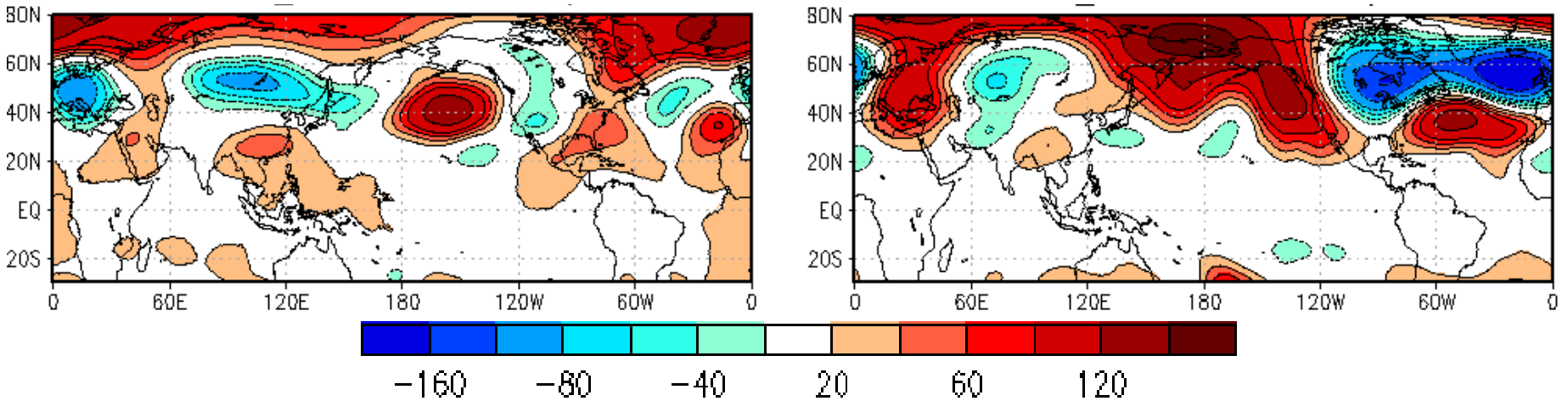
Data

- Obs precip
 - GPCP (1979-present); GPCC (1901-present)
- MERRA reanalysis
 - 1979-present
- NASA GEOS-5 AGCM Simulations
 - 1 degree
 - 12 long-term AMIP simulations (1871-present)
 - Regional SST anomaly experiments
 - Global; TPac; NPac; Ind; Atl
 - Anomaly runs: Sep2012-Mar2014; 30 members each
 - Runs to establish climatology: Sep(-1)-Mar(1) for 1980-2010

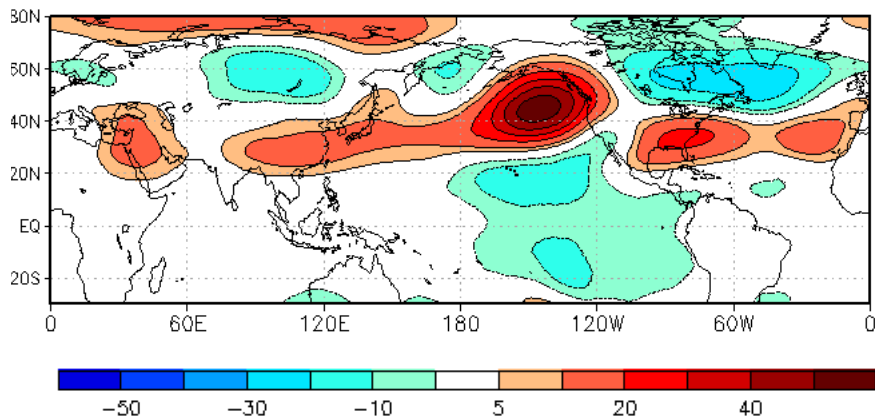
Atmospheric Circulation: H250mb

DJF2012/13

DJF2013/14



Composite anomaly
for dry California winters

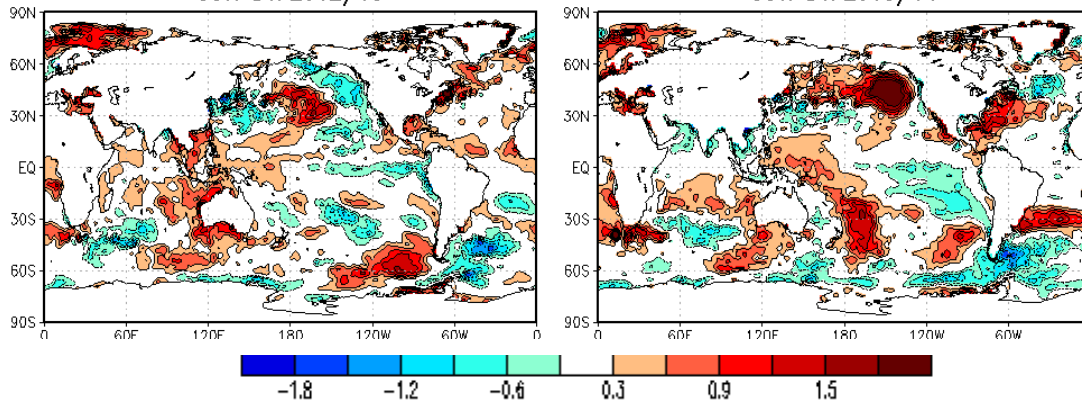


Similar to other dry winters for California, the persistent ridge over NE Pacific prevented north Pacific storms from reaching California during the recent two winters.

GEOS-5 AMIP EnsMean vs. Obs

SST: DJF2012/13

SST: DJF2013/14



MERRA

H250mb

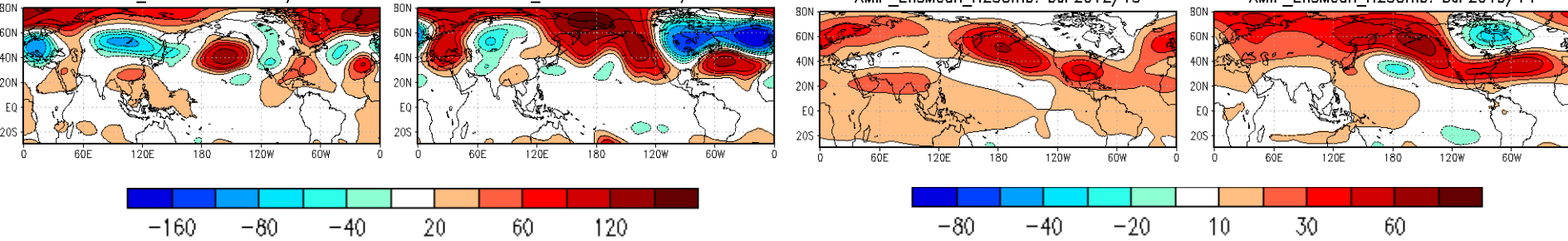
AMIP EnsMean(42)

MERRA_H250mb: DJF2012/13

MERRA_H250mb: DJF2013/14

AMIP_EnsMean_H250mb: DJF2012/13

AMIP_EnsMean_H250mb: DJF2013/14



GPCP

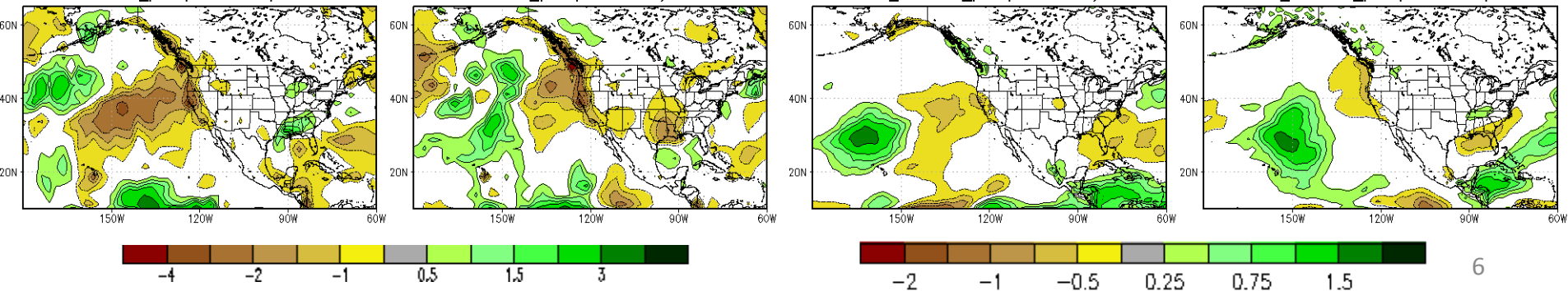
Precip

GPCP_precip: DJF2012/13

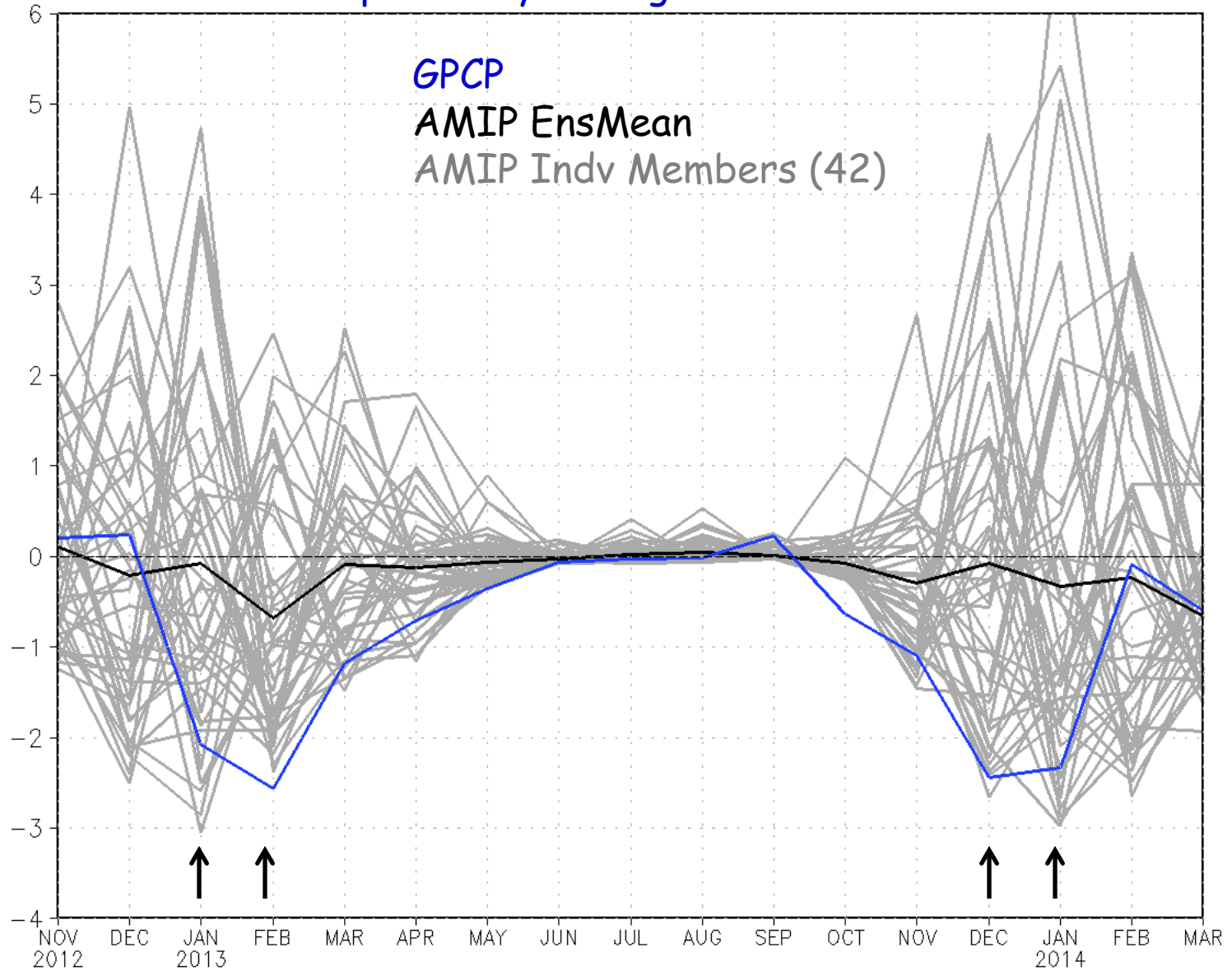
GPCP_precip: DJF2013/14

AMIP_EnsMean_precip: DJF2012/13

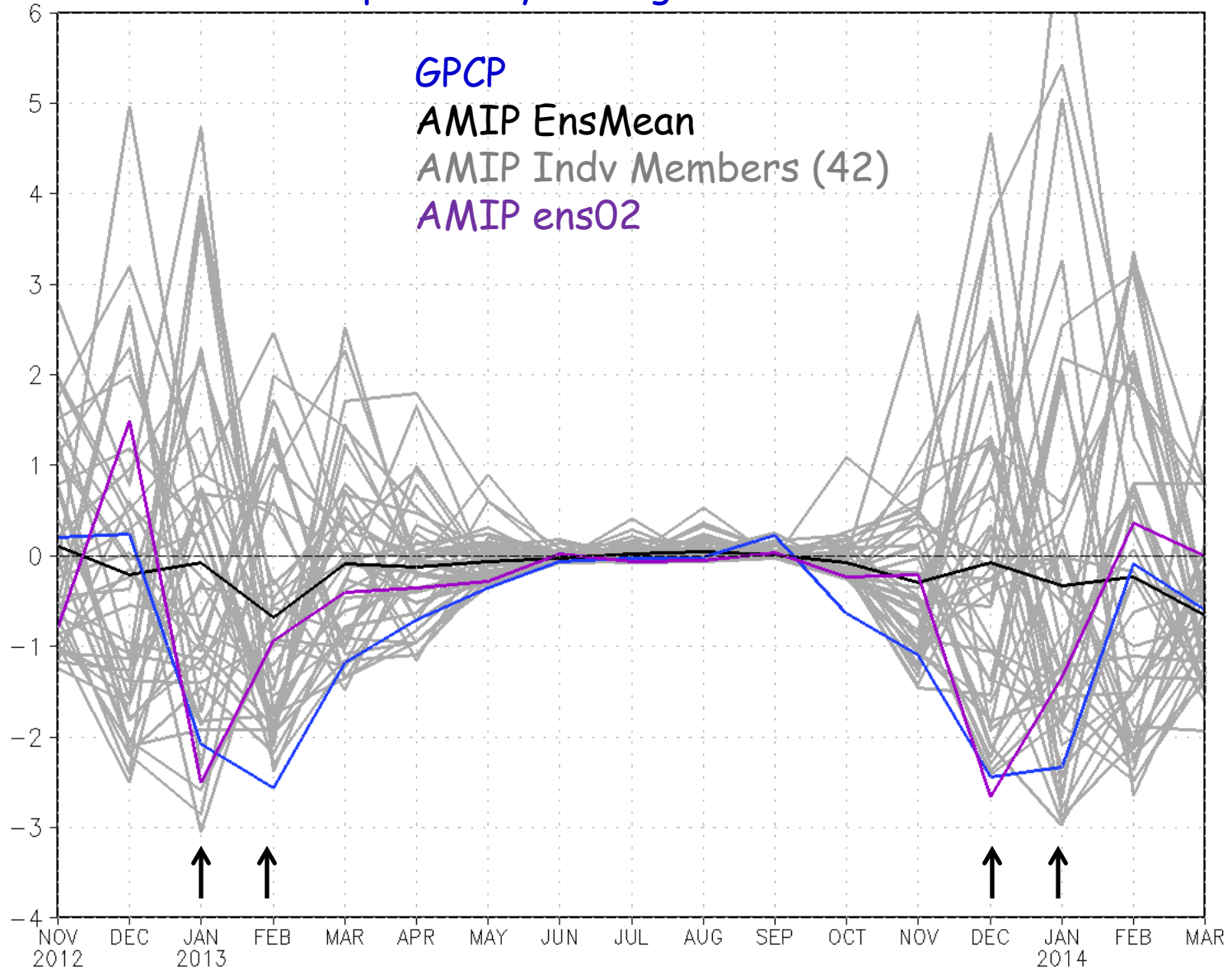
AMIP_EnsMean_precip: DJF2013/14



Precip anomaly averaged over California



Precip anomaly averaged over California



Regional SSTA Experiments

H250mb

Precip

DJF12/13

DJF13/14

Global

DJF12/13

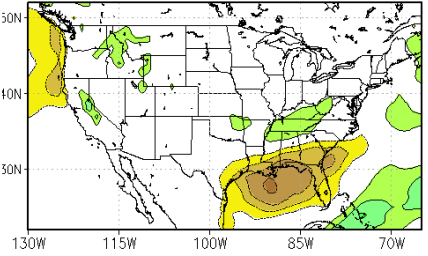
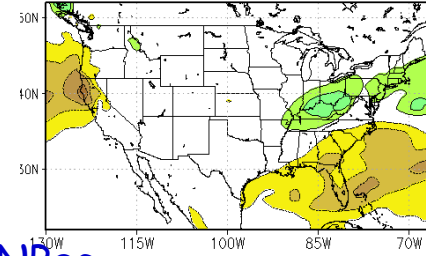
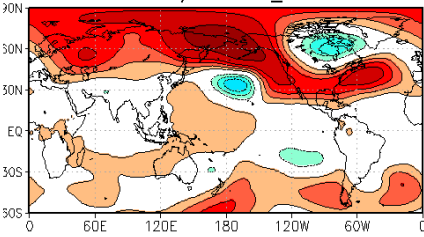
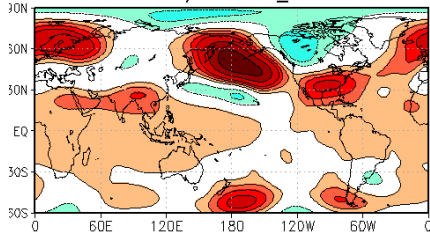
DJF13/14

DJF12/13 Global_SSTA

DJF13/14 Global_SSTA

DJF12/13 Global_SSTA

DJF13/14 Global_SSTA



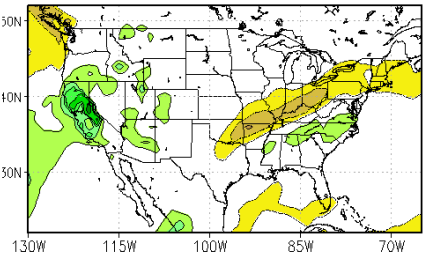
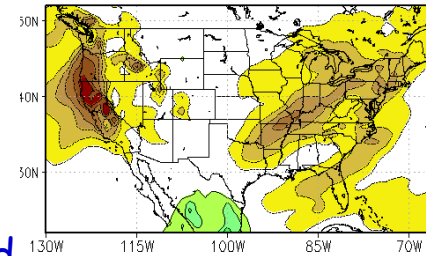
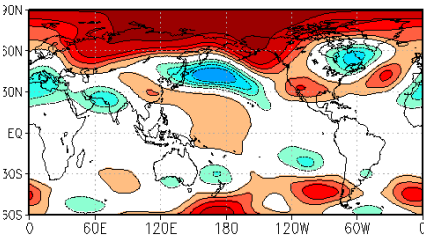
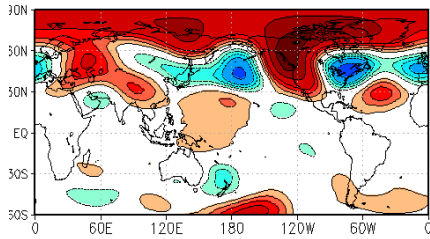
TPac+NPac

TPac+NPac

TPac+NPac

TPac+NPac

TPac+NPac



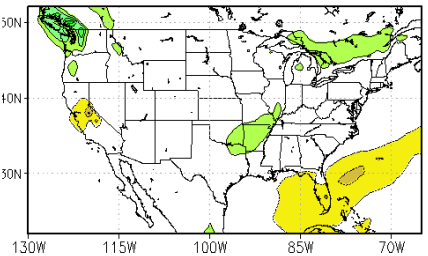
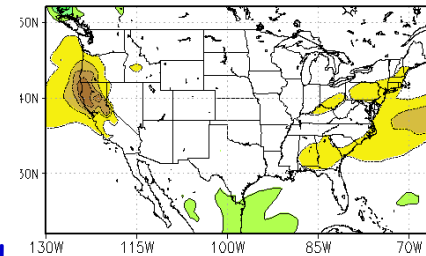
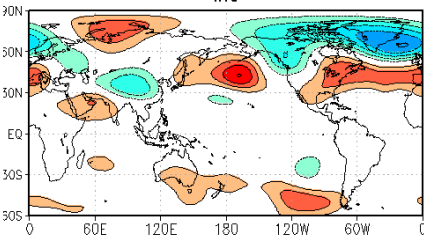
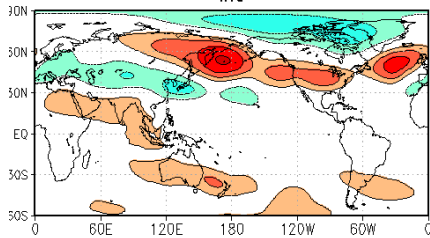
Ind

Ind

Ind

Ind

Ind



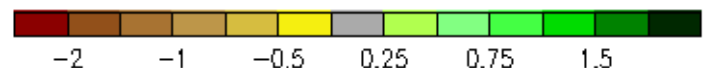
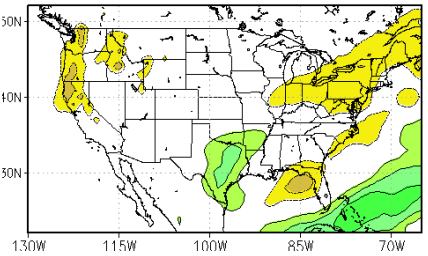
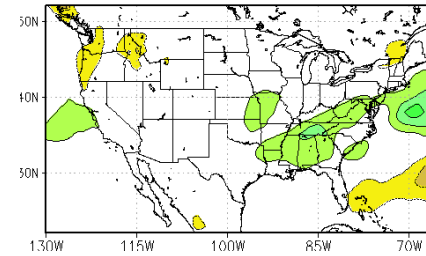
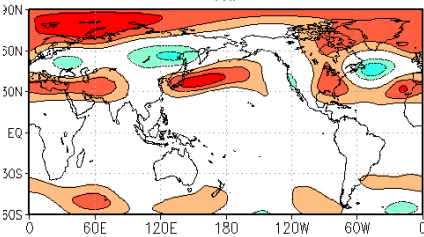
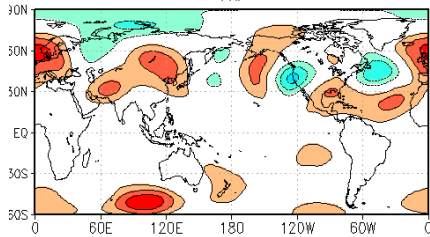
Atl

Atl

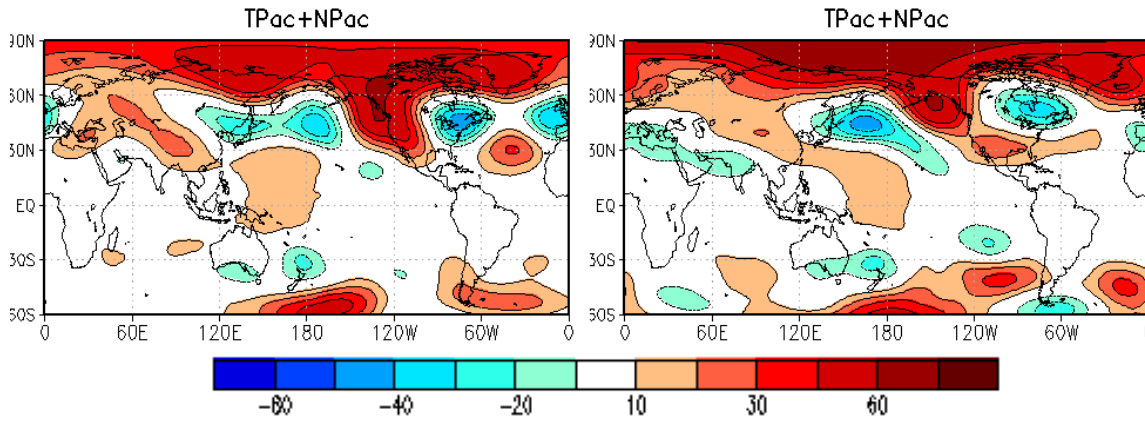
Atl

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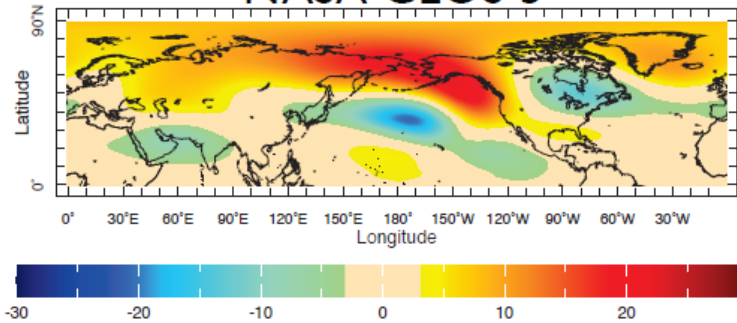
Atl



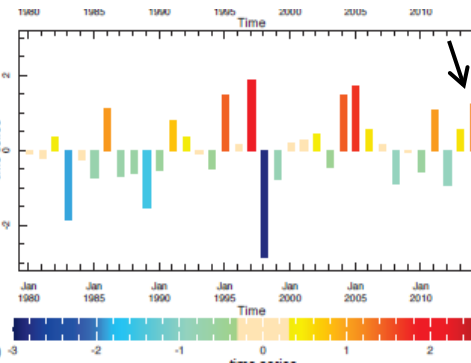
Role of SST



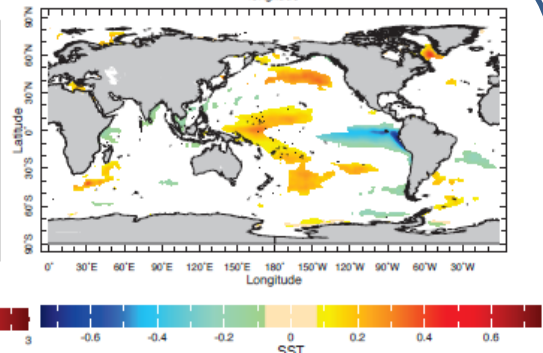
EOF3 of EnsMean H200mb
NASA GEOS-5



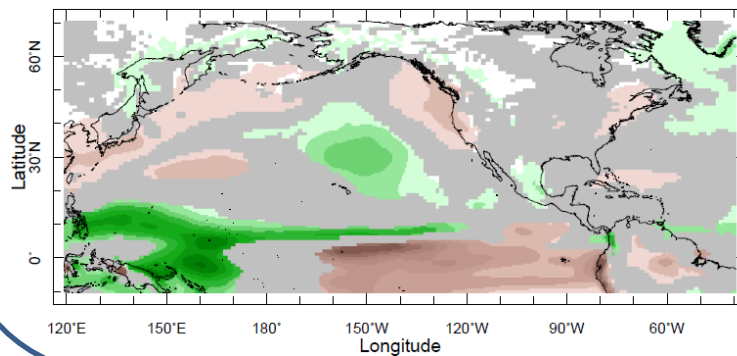
PC3 (6%)



Regr: SST



Regr: Precip
NASA GEOS-5

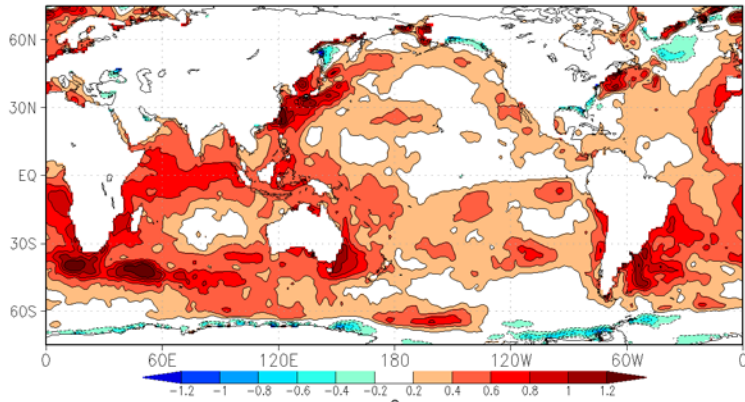


Seager et al (2014)
Zhang, Hoerling et al (2014)

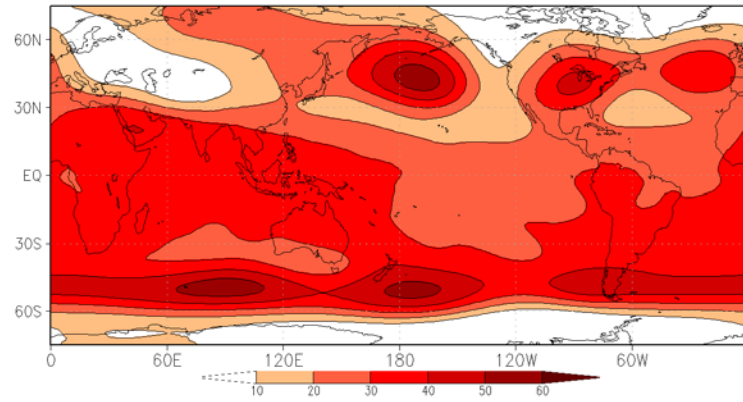
Effect of Long-term Warming Trend

DJF1871-1970 vs. DJF1980-2012

SST



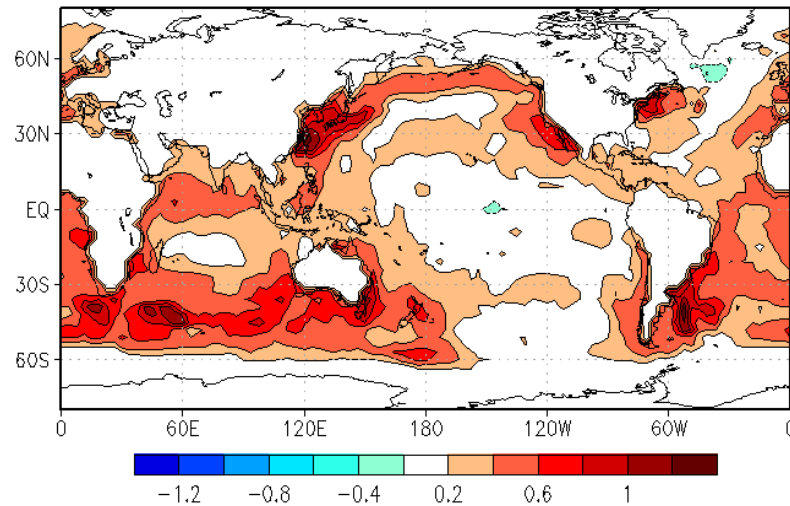
H250mb



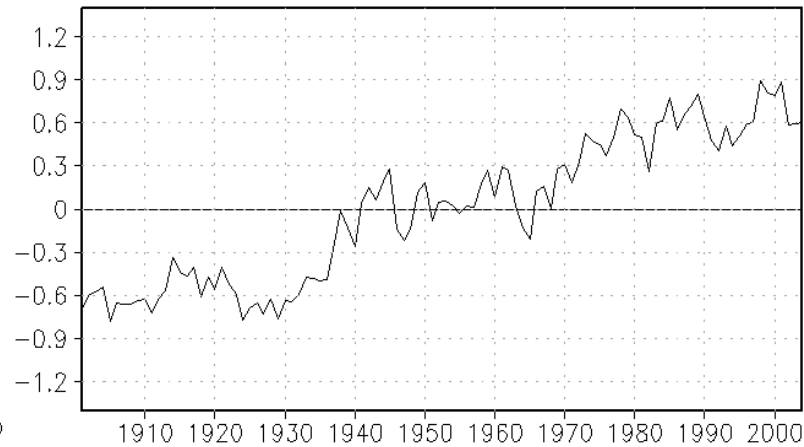
Mean Diff

Leading REOF of annual mean HadISST (1901-2004)

REOF1 27.2%



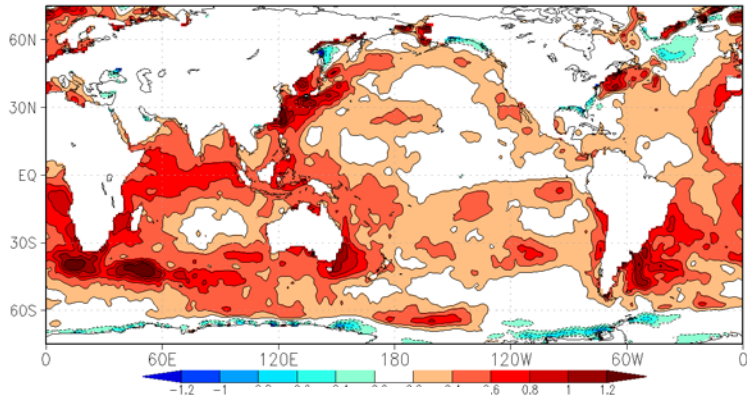
PC1



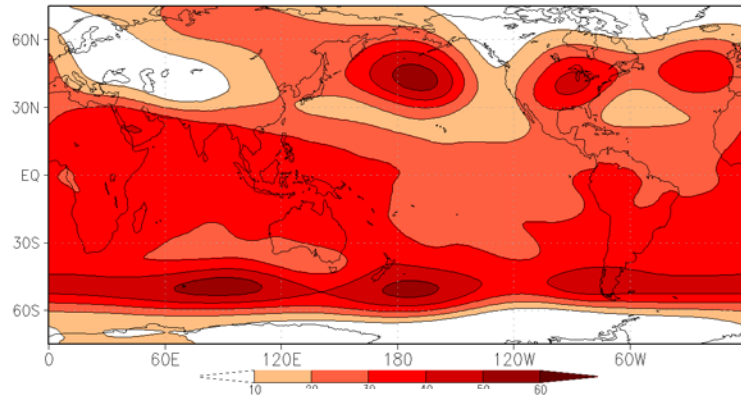
Effect of Long-term Warming Trend

DJF1871-1970 vs. DJF1980-2012

SST

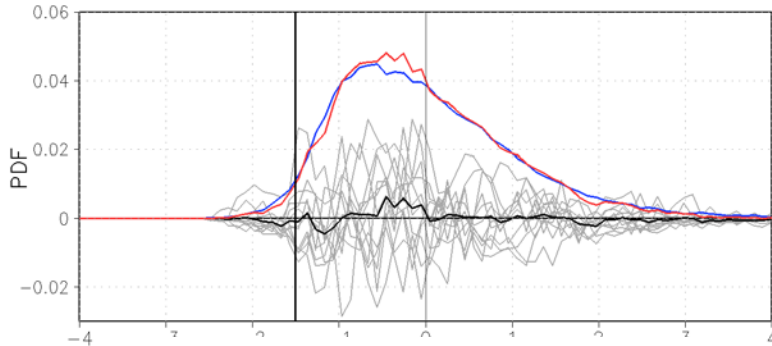


H250mb

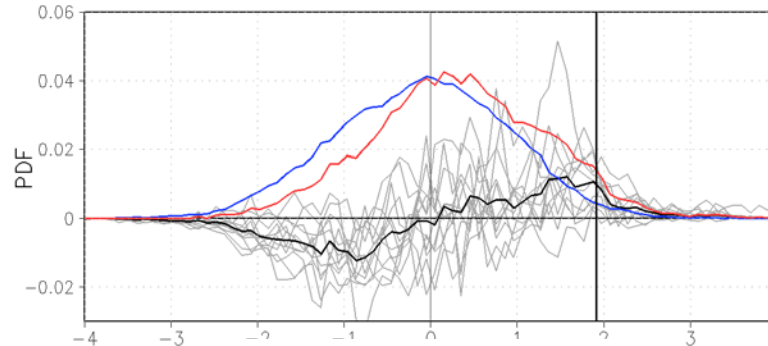


Mean Diff

Precip_CA

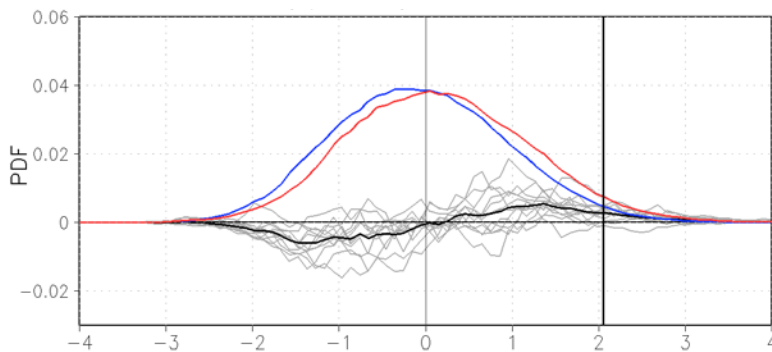


T2M_CA

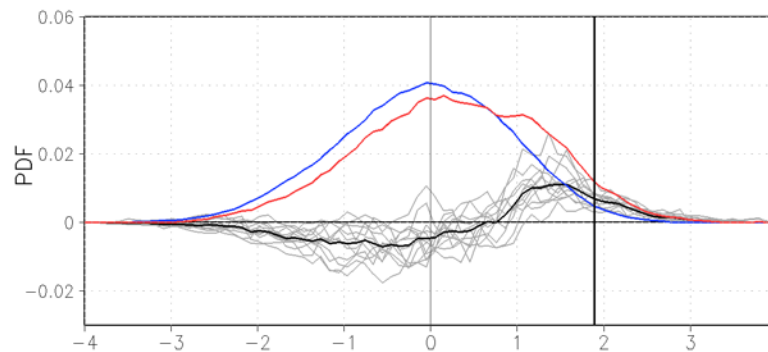


PDF
change

Precipitable Water (NE_Pac)



H250mb (NE_Pac)

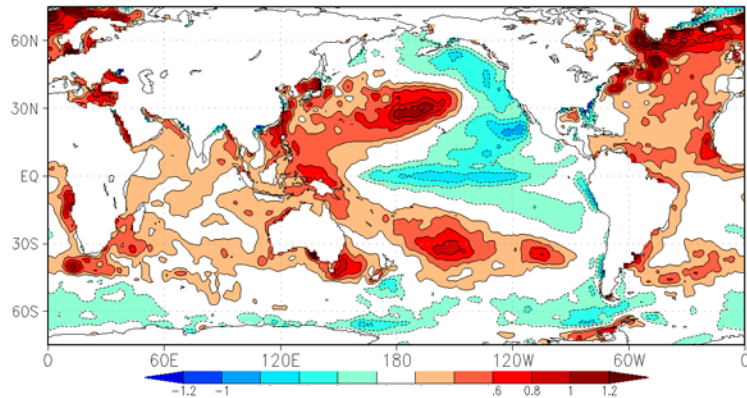


1980-2012
1871-1970
(1980-2012)minus
(1871-1970)

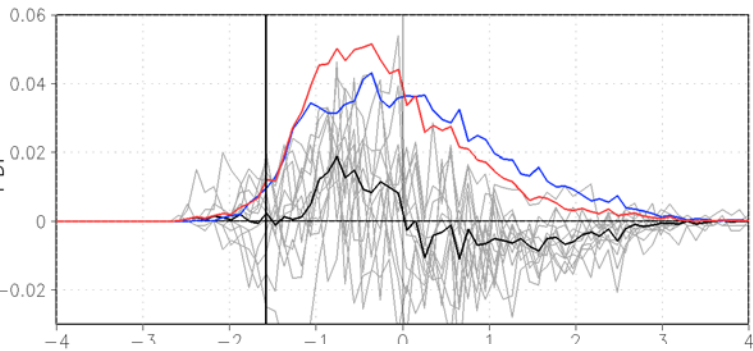
Recent Climate Change

DJF1979-1996 vs. DJF1998-2012

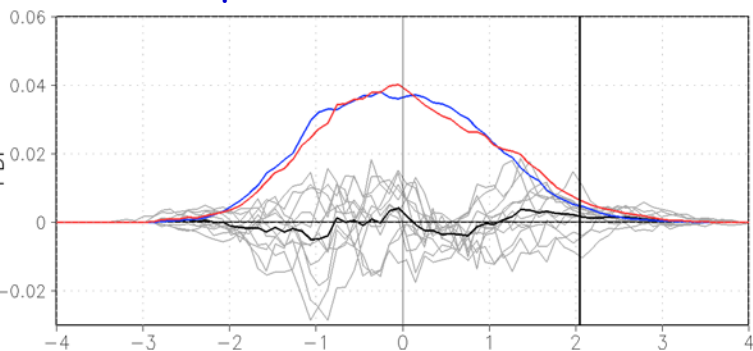
SST



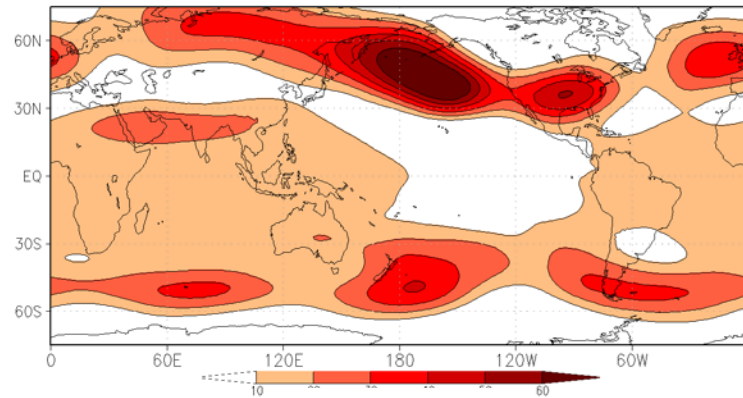
Precip_CA



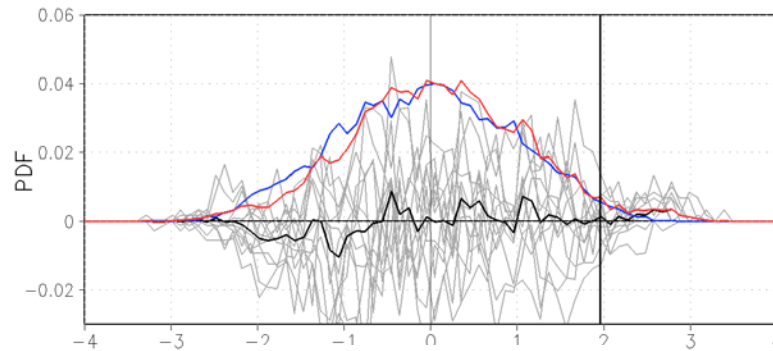
Precipitable Water (NE_Pac)



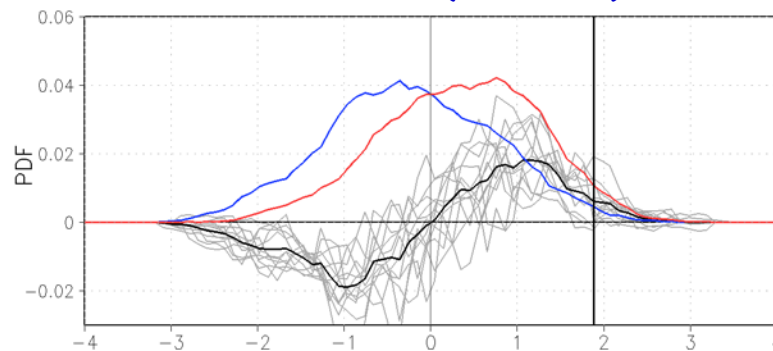
H250mb



T2M_CA



H250mb (NE_Pac)



Mean Diff

PDF
change

1998-2012
1979-1996
(1998-2012)minus
(1979-1996)

Conclusions

- Immediate cause:
 - Ridge over northeast Pacific prevented north Pacific storms from reaching California
- Underlying causes:
 - SST produced a predilection for California drought, with atmospheric internal variability explaining the extreme magnitude, particularly for the dry event during early 2013
- Climate change
 - Long-term warming trend 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.