Relationship between Decadal Precipitation Anomalies in the western U.S. and Global SSTs: Insights from the IPCC-AR4 models

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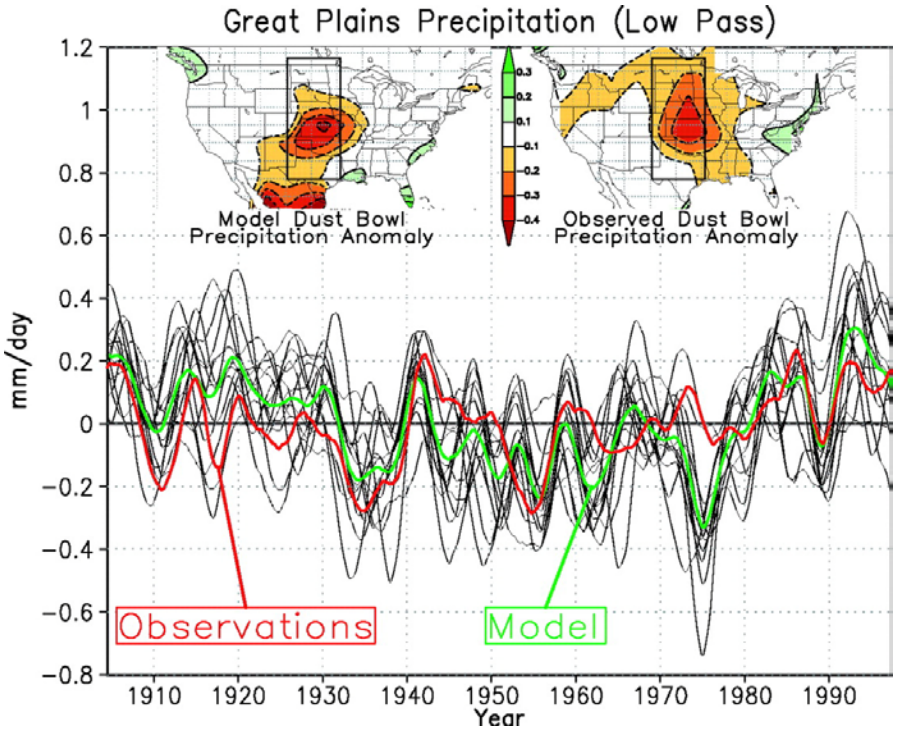
Valuable input from:

Clara Deser, Judith Perlwitz, Martin Hoerling

Motivated by the U.S. CLIVAR Drought in Coupled Models Project (DRICOMP)

The “Dust Bowl”



Schubert et al., Science,2004

Hoerling and Kumar 2003

Seager et al. 2005

Meehl and Hu 2006

CLIVAR Drought WG

Main results from previous studies:

- Ensemble simulations forced with observed SSTs were able to reproduce some of the observed droughts in the western U.S.
- SST anomalies in the tropical Pacific play a major role in forcing precipitation variations.
- Changes in precipitation in the western U.S. are part of a global pattern, and are associated with global-scale changes in atmospheric circulation

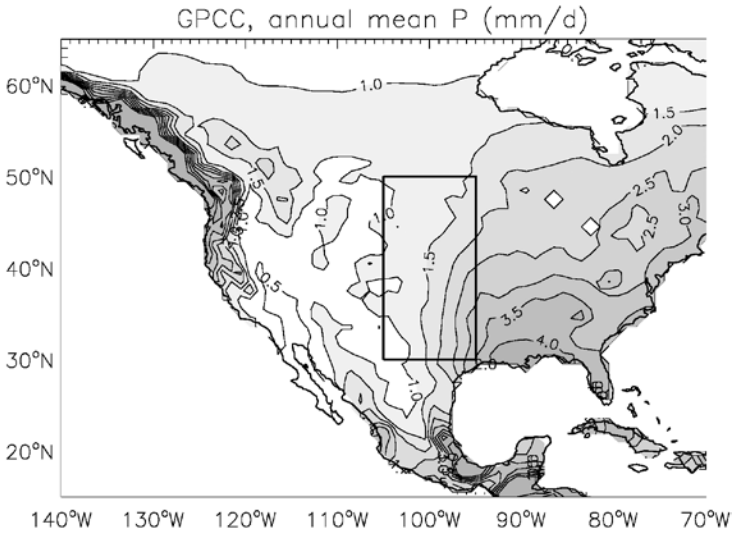
Questions

- Do fully-coupled climate models show a relationship between precipitation and SST similar to what seen in observation and in AMIP simulations?
- How consistent are the results among different models? Are some models more reliable than others?

IPCC models

Pre-industrial control simulations (picntrl)

GFDL-CM2.1 (US)	500 yrs
GFDL-CM2.0 (US)	500 yrs
NCAR-CCSM3 (US)	500 yrs
HadCM3 (UK)	340 yrs
CSIRO (Australia)	380 yrs
CCCMA (Canada)	380 yrs



Great Plains.: 95° -105° W, 30° -50° N

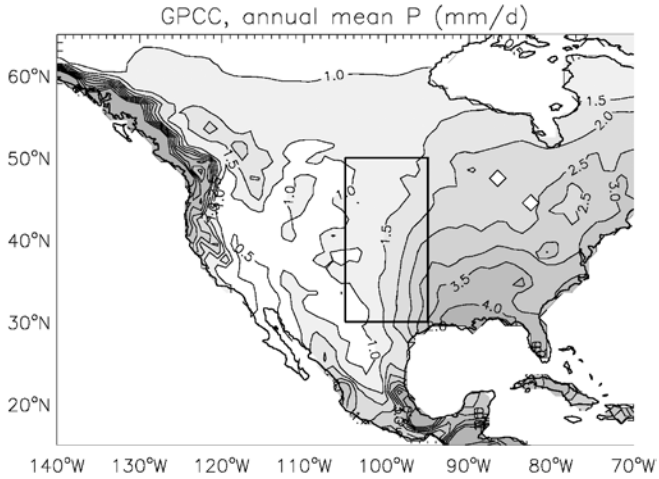
Data (1901-2007):

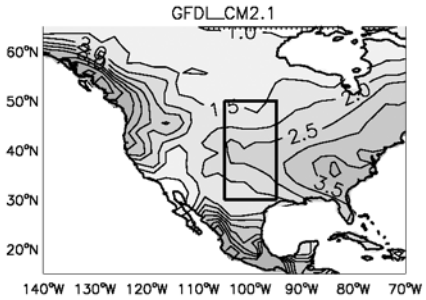
Global Precipitation Climatology Center (GPCC)

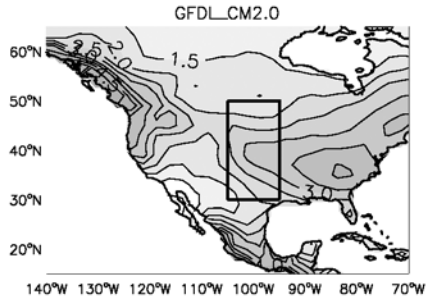
NOAA.ERSST for SST-2007

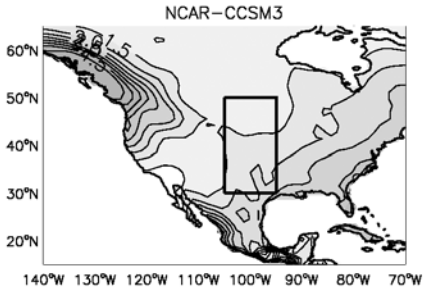
"Decadal" droughts: periods of lower-than-average precipitation lasting >5yrs after 5 yrs running mean

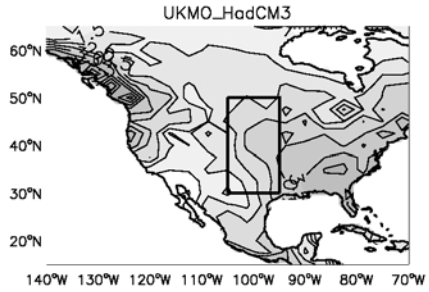
Precipitation climatology

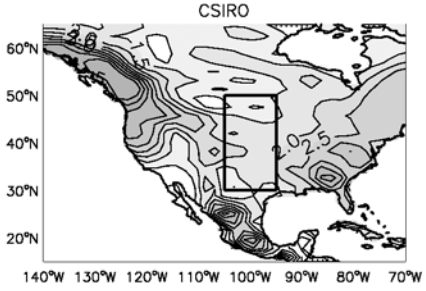


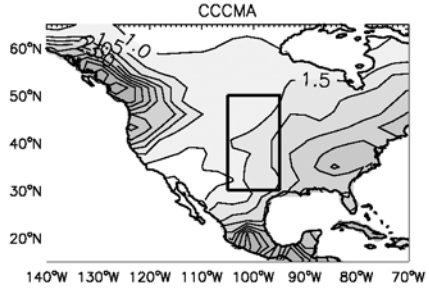




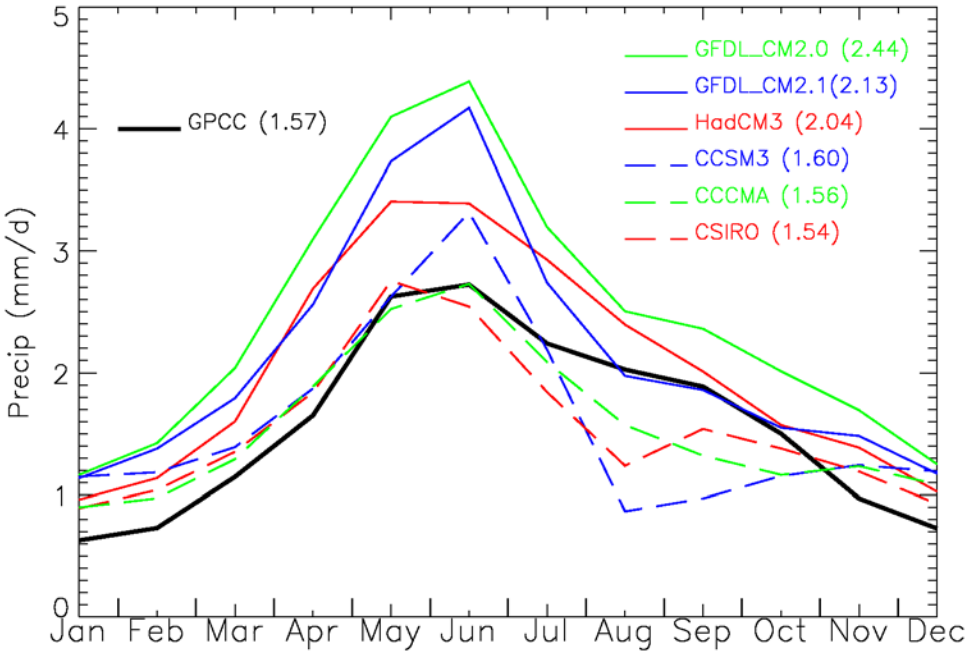






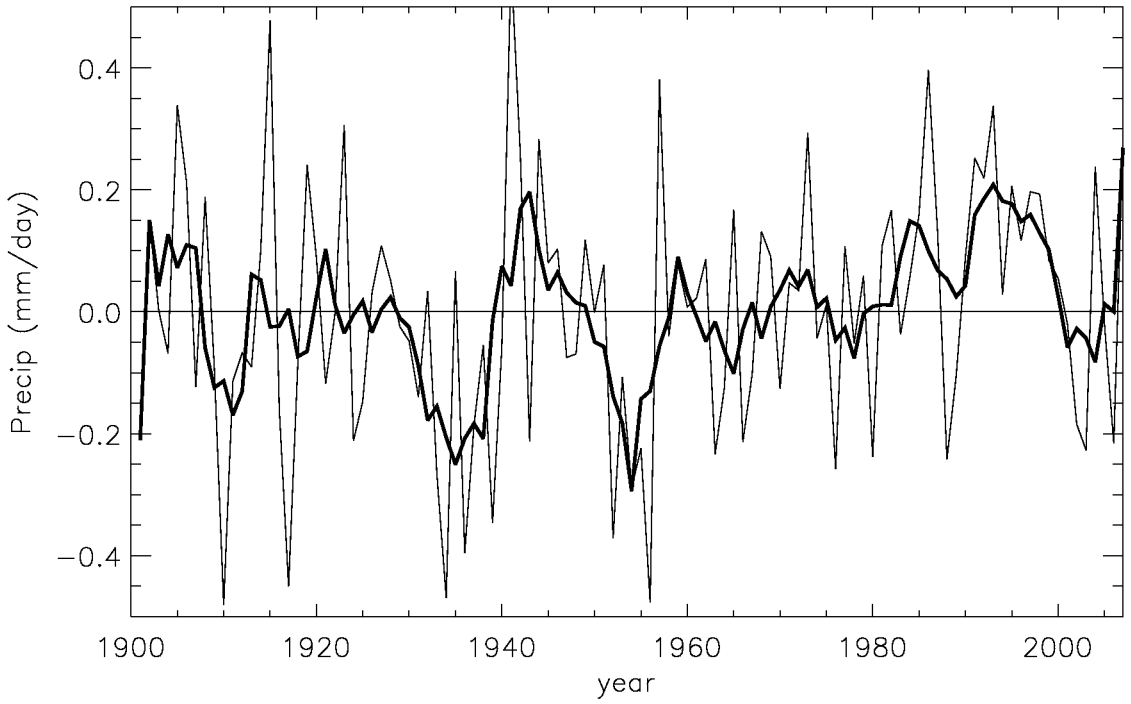


Seasonal cycle of precipitation in the Great Plains region



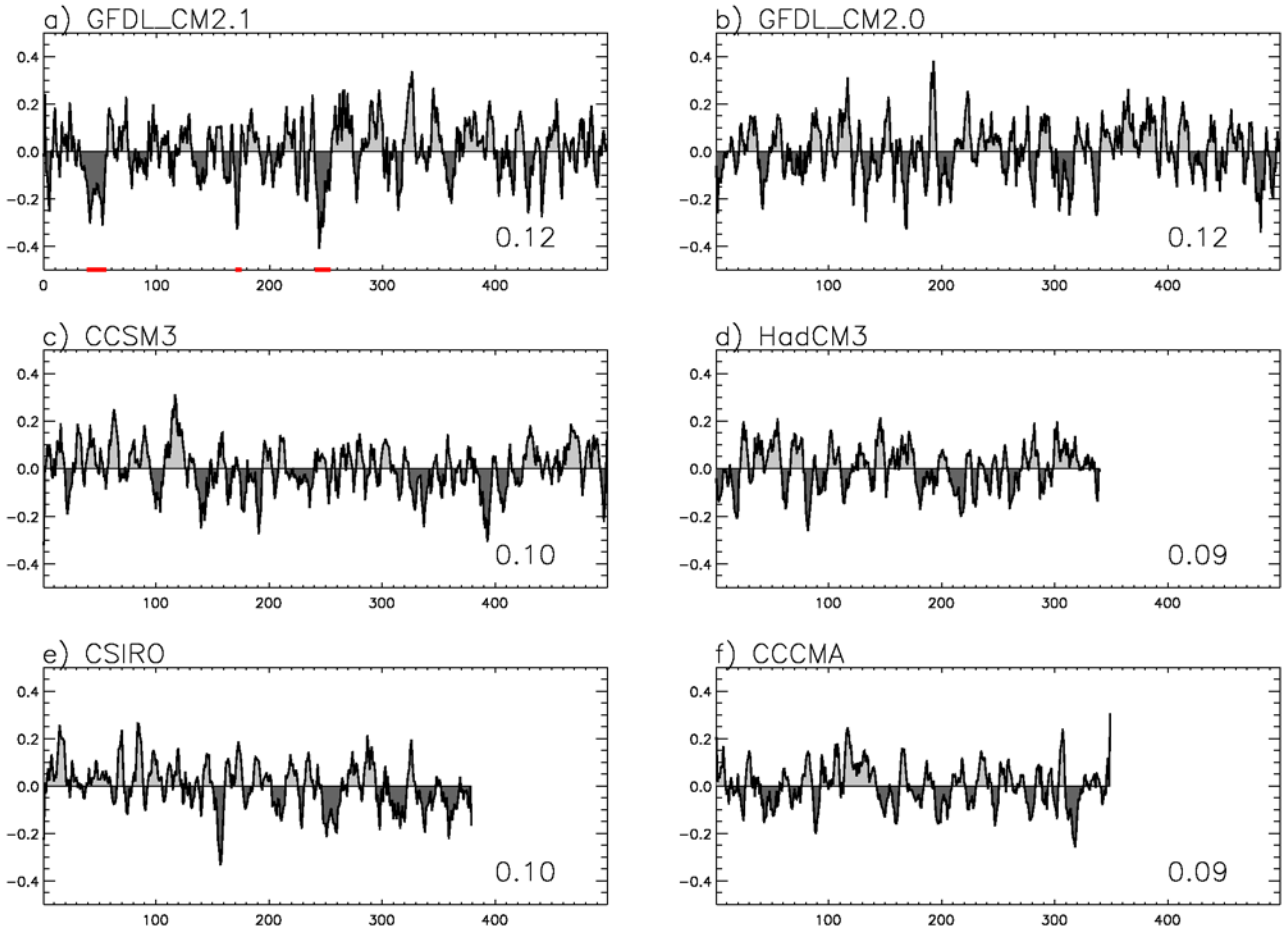
Decadal Precipitation Anomalies (GPCC)

Decadal=5-year running mean



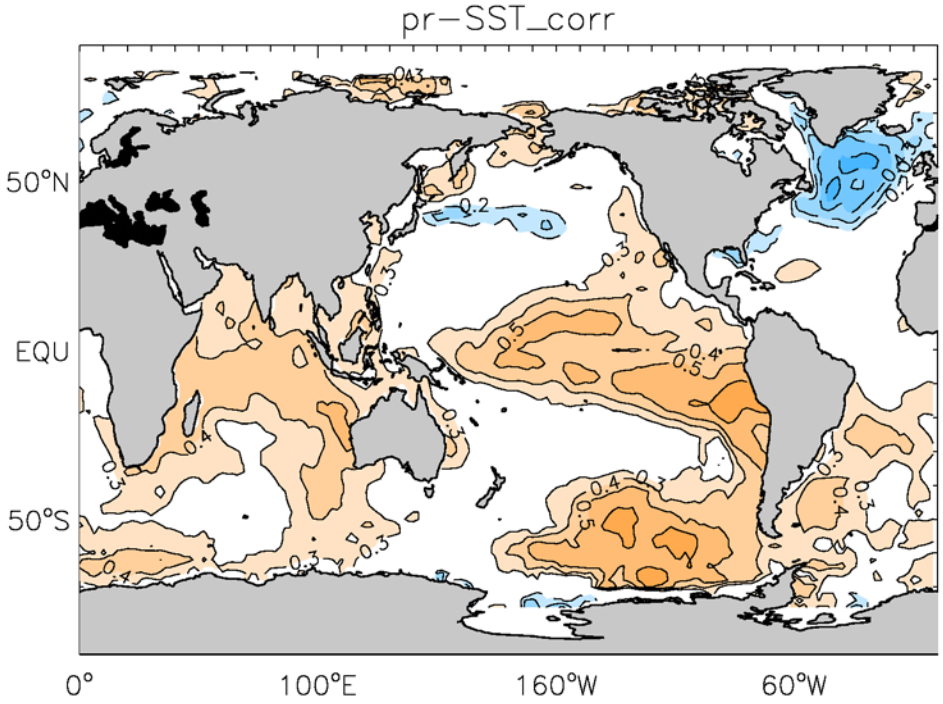
Standard deviation of low-frequency time series 0.11 mm/d

Decadal Precipitation Anomalies (models)



Correlation between GP precipitation and SST

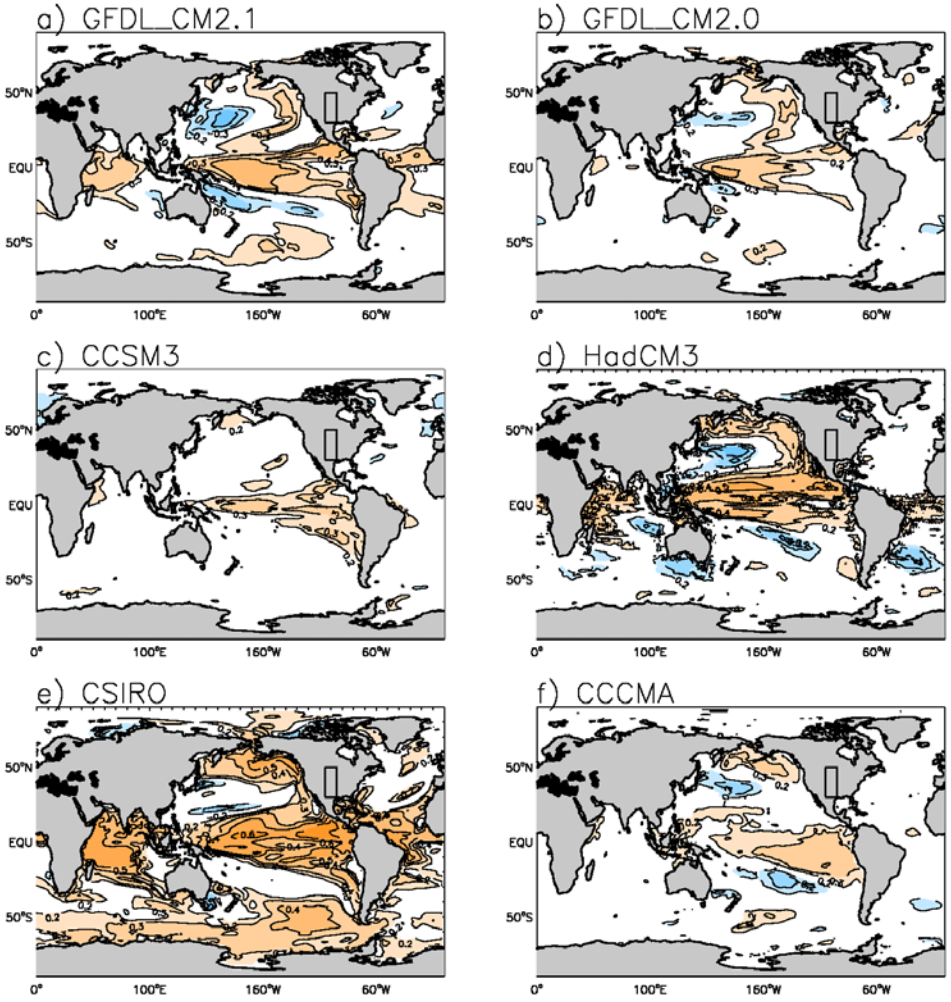
Observations



5-yrs running mean GPCC precipitation & 5-yrs running mean ERSST SST

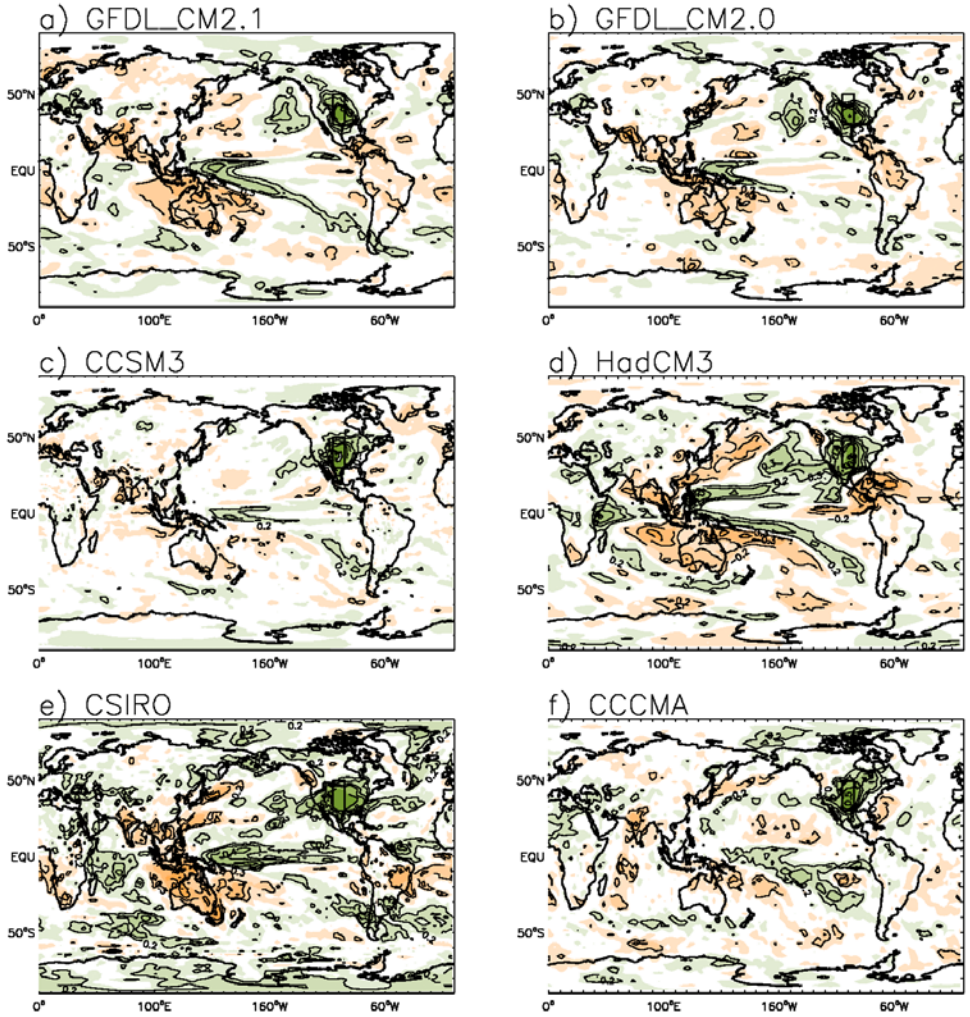
Correlations larger than ~0.45 are statistically significant at the 95% level

Correlations between GP precipitation and global SST

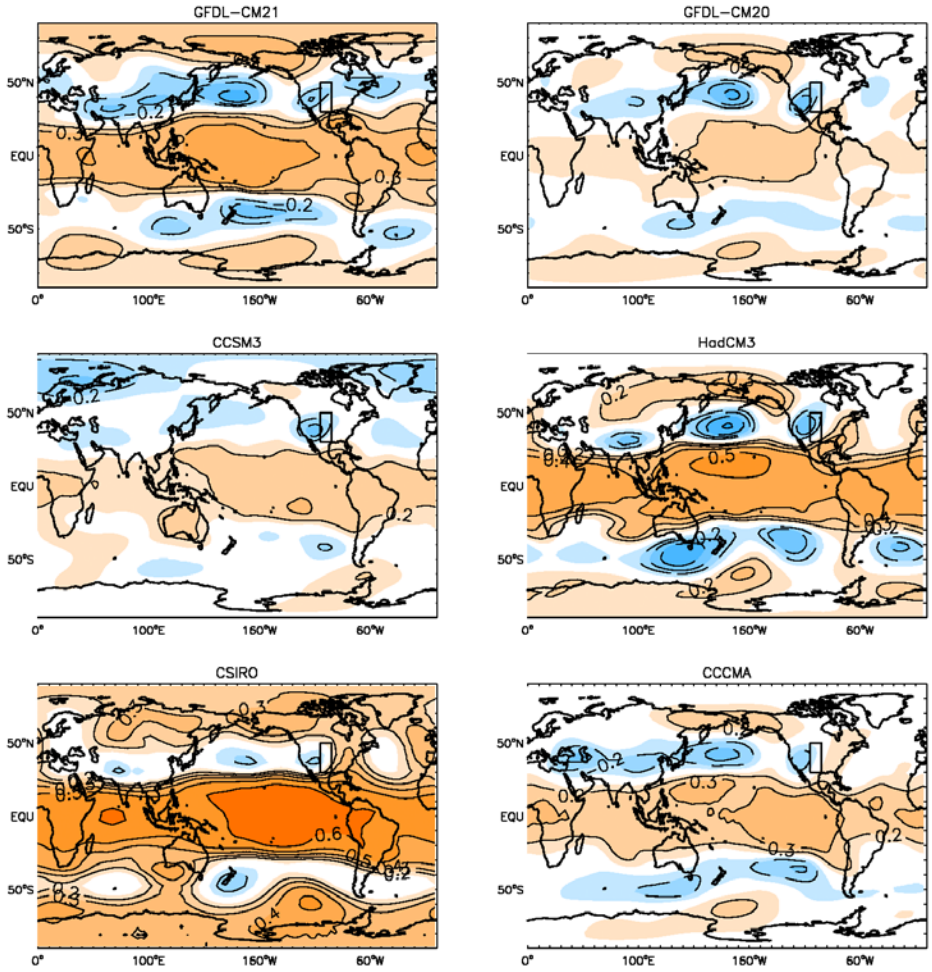


Correlations larger than 0.2-0.25 are statistically significant at the 95% level

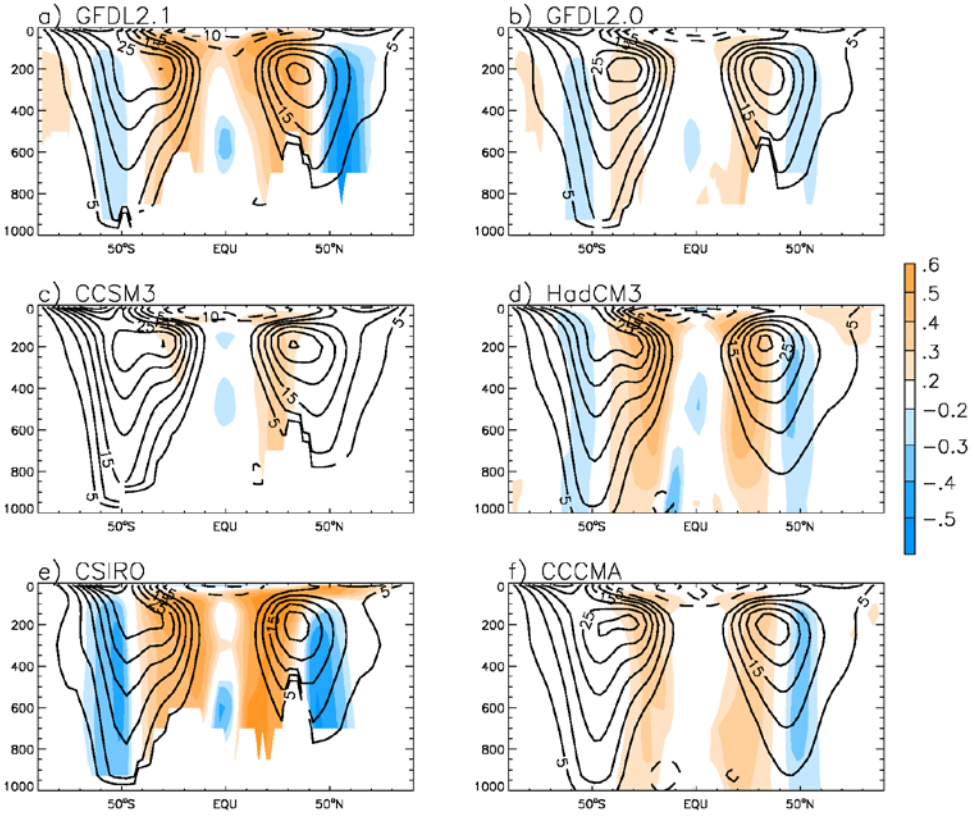
Correlations between GP precipitation and global precipitation



Correlations between GP precipitation and 200 mb geopotential height



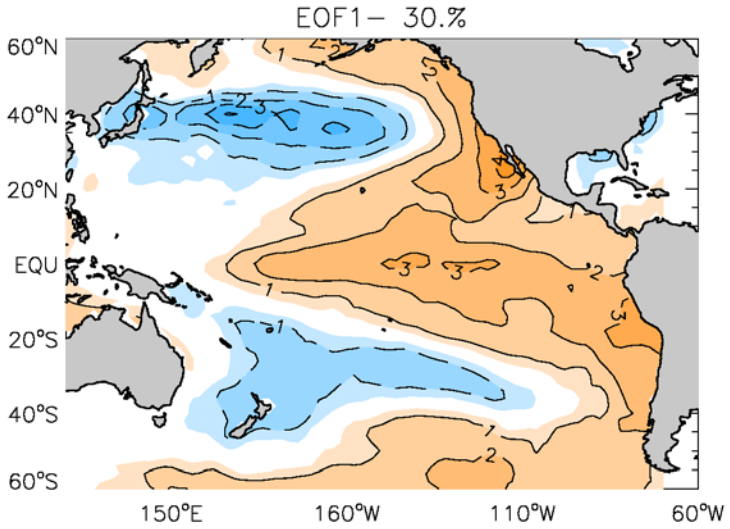
Correlation between GP precipitation and zonal mean zonal wind

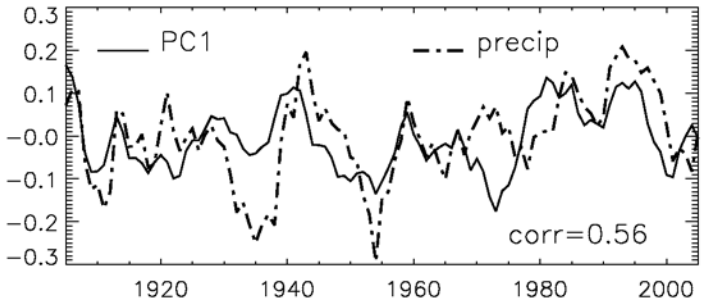


Contours: mean zonal wind

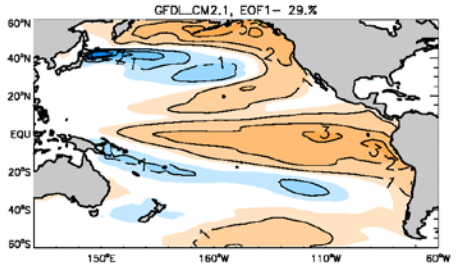
Shading: correlations

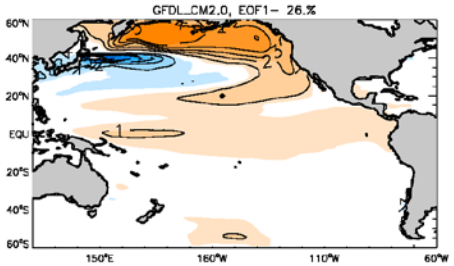
Are the Pacific SST anomalies related to the Interdecadal Pacific Oscillation (IPO)?

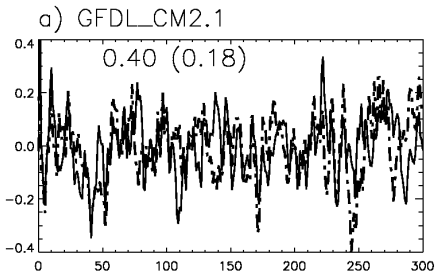


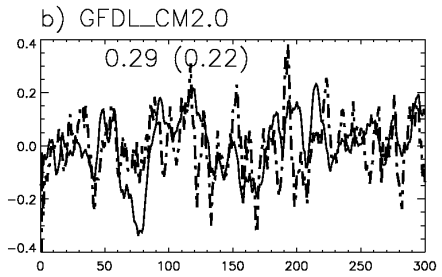


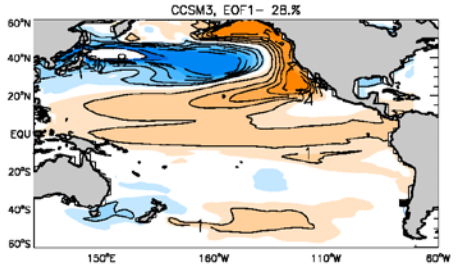
Are the Pacific SST anomalies related to the Interdecadal Pacific Oscillation (IPO)?

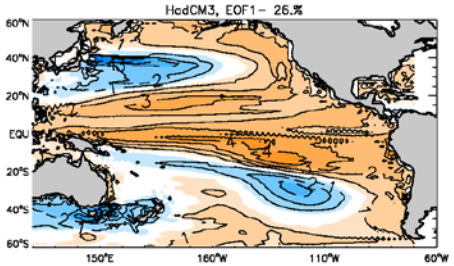


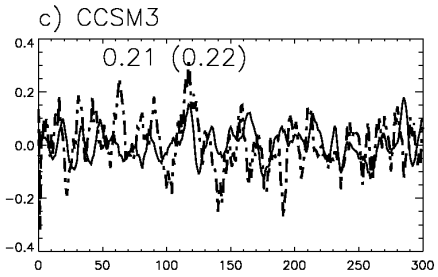


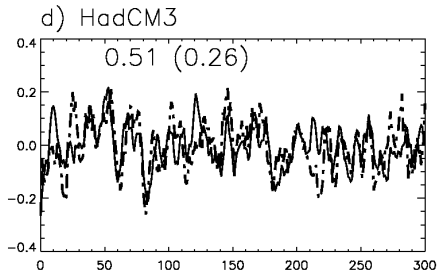


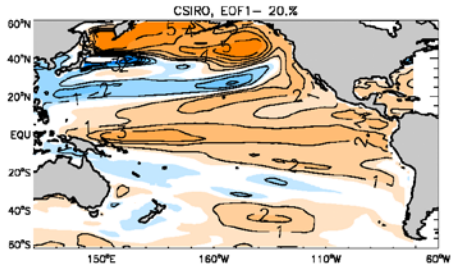


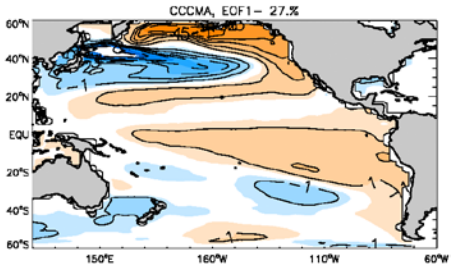


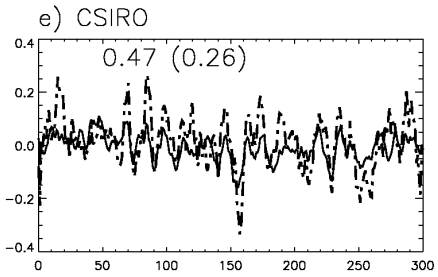


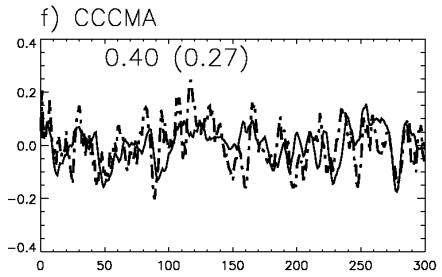












Conclusions

- All the models consistently show the central role of the tropical Pacific SSTs in controlling Great Plains precipitation at decadal timescales

- Models also show that low-frequency precipitation anomalies in the Great Plains region occur in connection with global scale anomalies, confirming results from AMIP simulations and paleoclimate records.

- In most models there is a statistically significant relationship between decadal precipitation anomalies in the GP region, and the leading mode of Pacific decadal SST variations

Future work

- Examine future climate scenarios, including trend and natural variations
- Examine Pacific decadal variability to understand how predictable precipitation variations may be.