

Seasonal Tropical-Extratropical Teleconnections Originating from Tropical Rainfall Modes beyond Canonical ENSO

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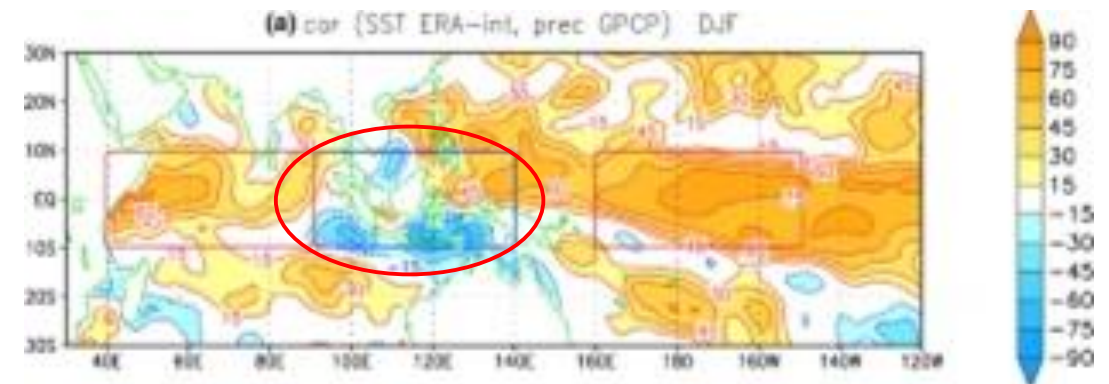
Acknowledgement: Drs. P. Xie, Z-Z Hu, M. Chen, H. Wang

Motivation

Decompose tropical seasonal rainfall into independent modes and then examine the teleconnections from them to the extratropics.

Why rainfall rather than SST?

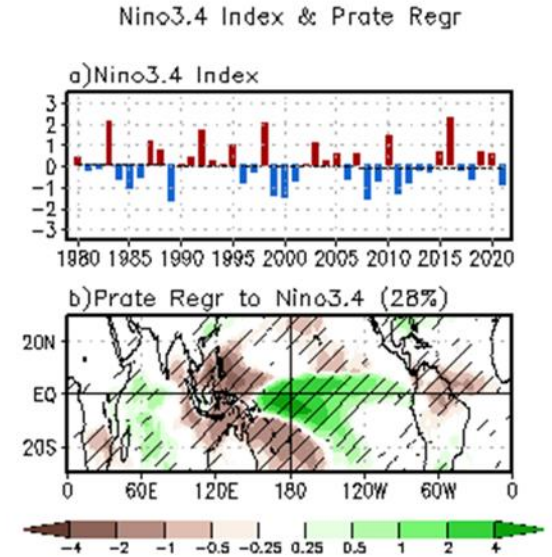
- 1) Rainfall (latent heating) is the direct forcing of the tropical atmosphere;
- 2) SST and rainfall are not well corrected in **some tropical regions** (Chen et al. 2012, Kumar et al. 2013, Moltoni et al. 2015)



(from Moltoni et al.
(2015))

Procedures of the rainfall mode decomposition

- 1) Remove the ENSO related variability from rainfall data, and then apply REOF analyses to the residual
- 2) Regress the time series of the REOF modes to various global fields



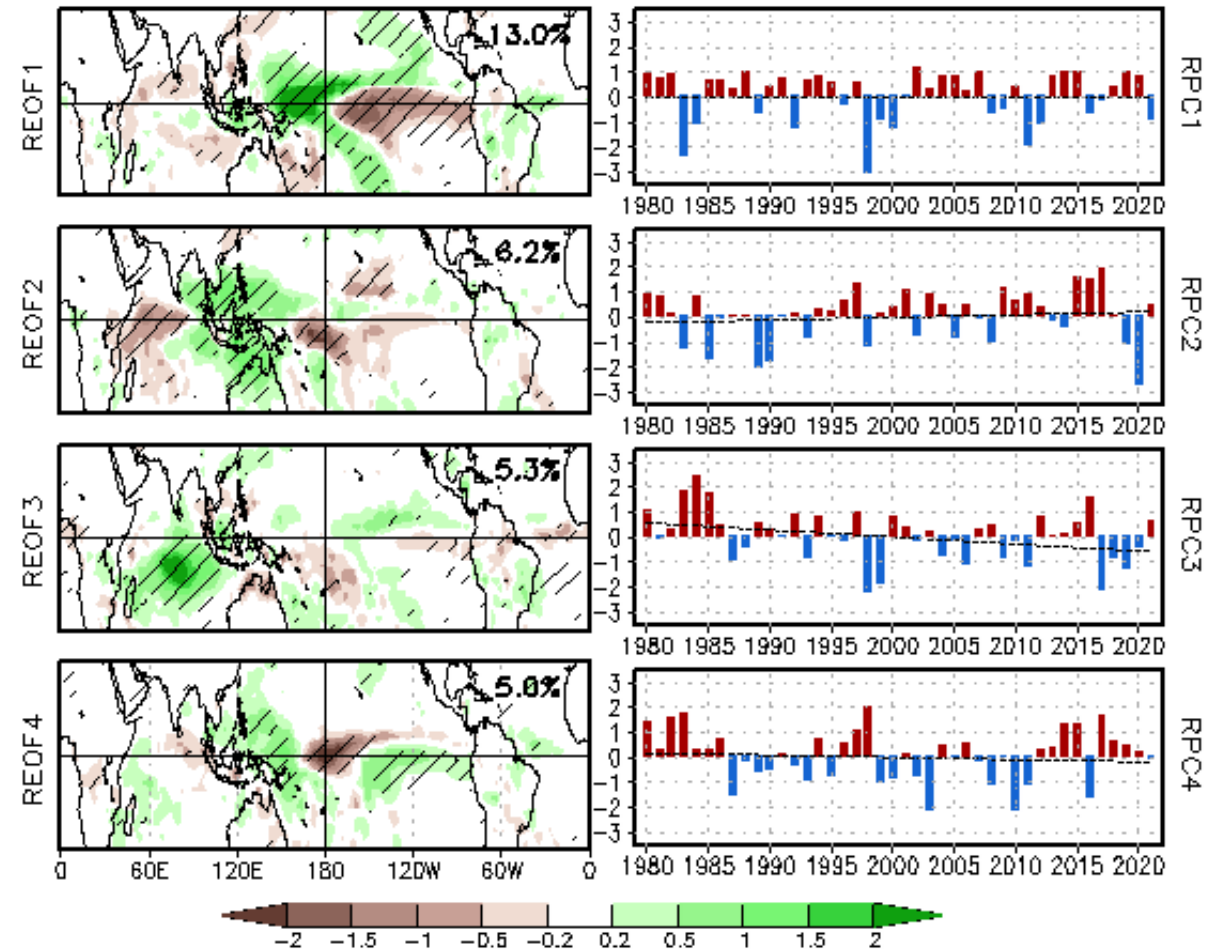
Why take the residual?

EOF (or REOF) analyses to the raw data would cause part of ENSO signal mixed to other modes (Peng et al. 2014)

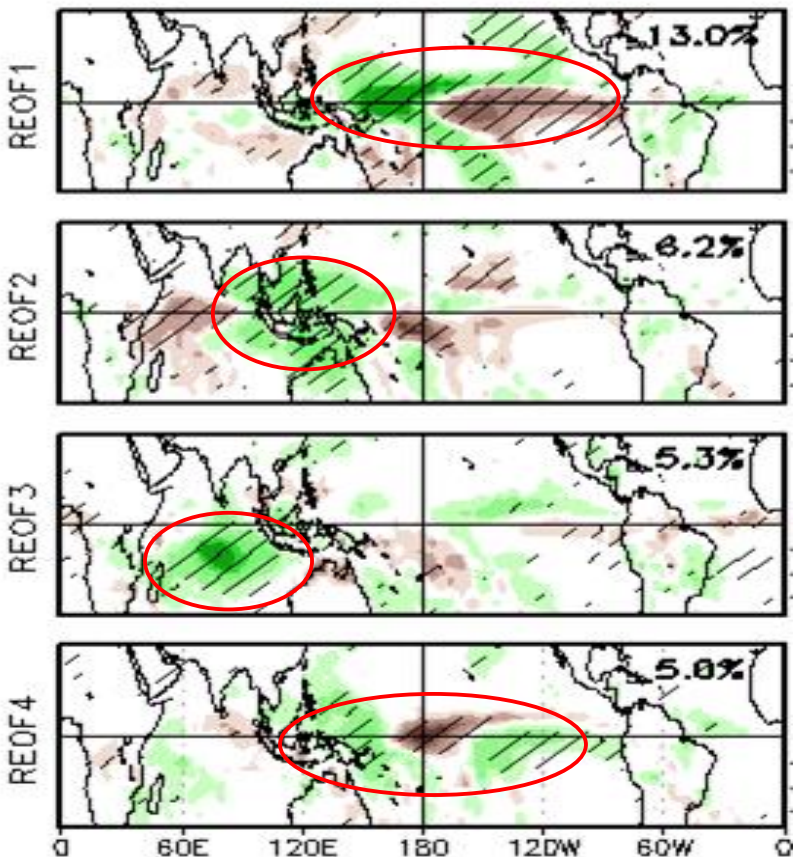
REOF/RPC modes of rainfall residual

1. REOF/RPC 1-4 originate in the tropics (see later analyses);

2. Weak downward trend in mode 3



Rainfall vs SST

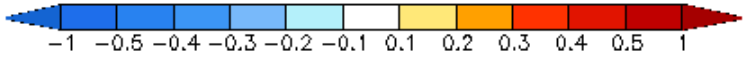
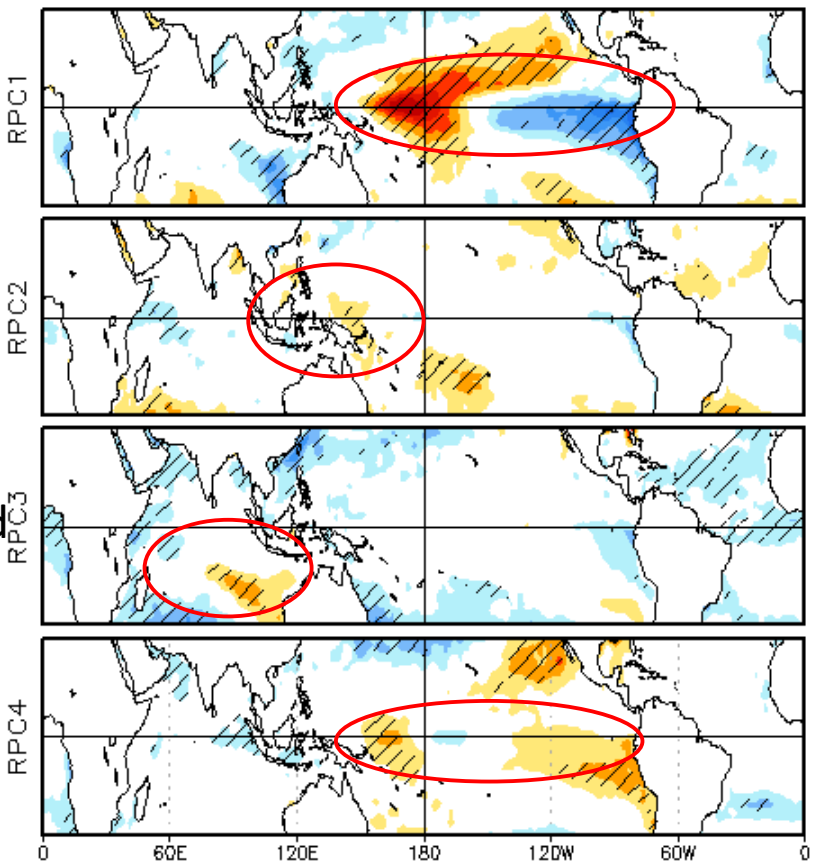


well matched
(El Nino
Modoki)

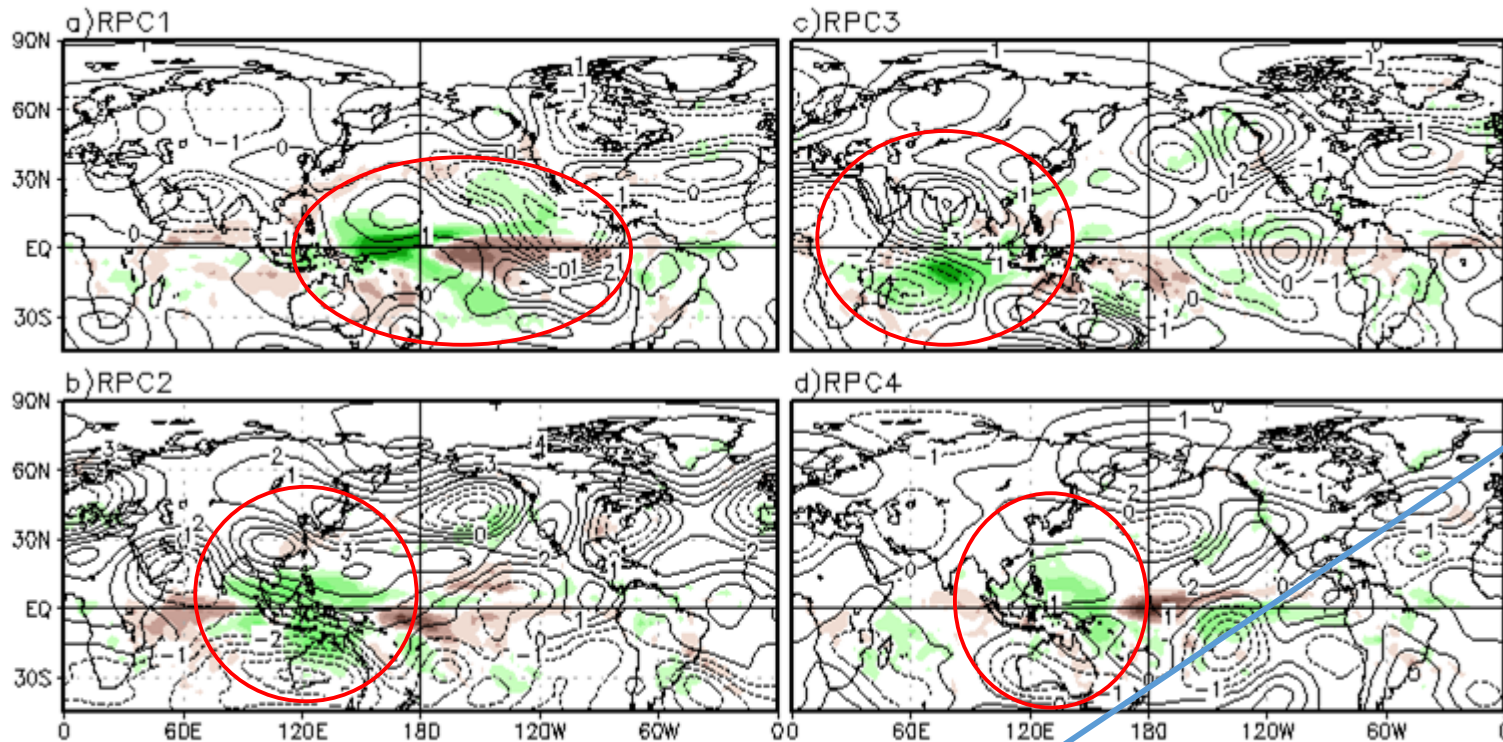
weakly
matched

weakly matched

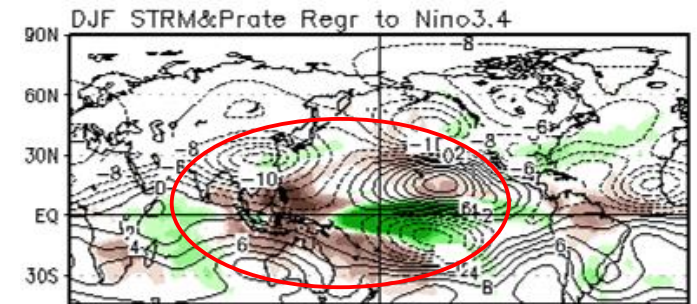
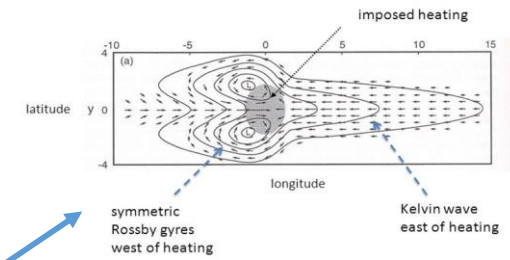
well matched



Forcing-Response relationship check: rainfall vs S200



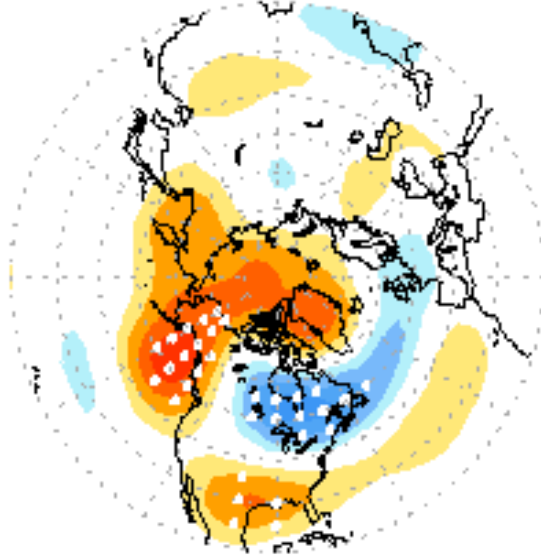
atmosphere response to steady tropical heating (Gill, 1980)



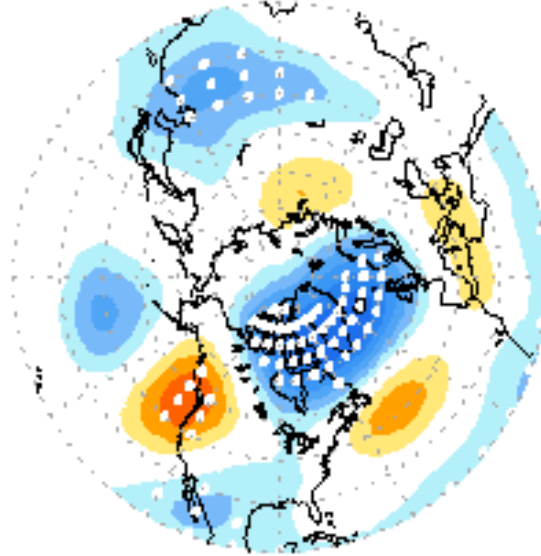
Based on Gill (1980) forcing-response pattern and ENSO pattern, the four S200 patterns are all primarily forced by the corresponding rainfall modes.

Corresponding Z200 Patterns

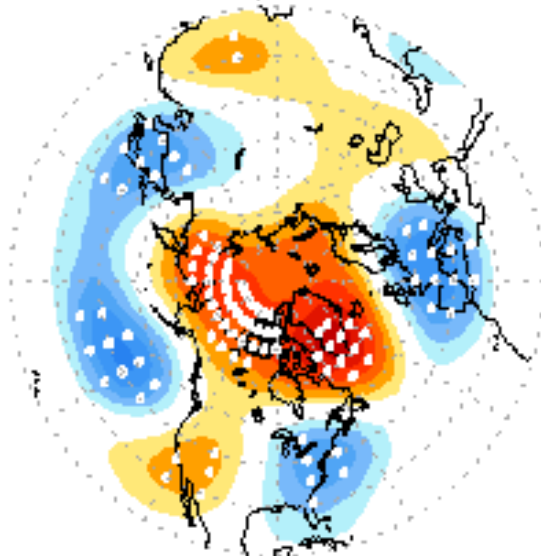
a)RPC1



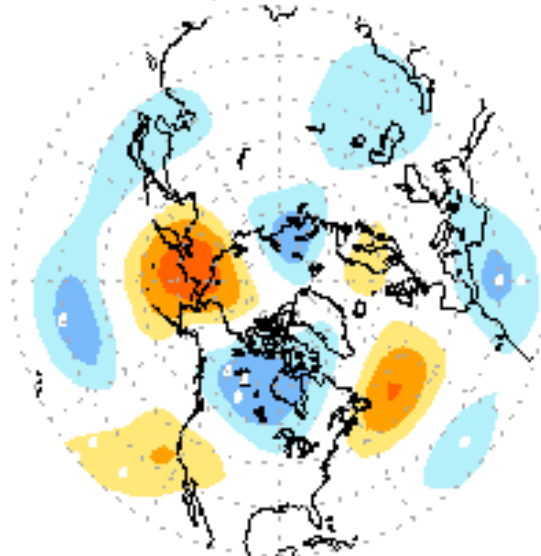
c)RPC3



b)RPC2



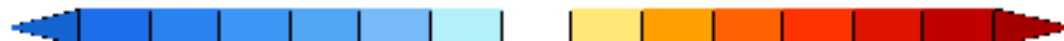
d)RPC4



ENSO



Dotted areas are with 95% significance level



Application to Climate Attribution

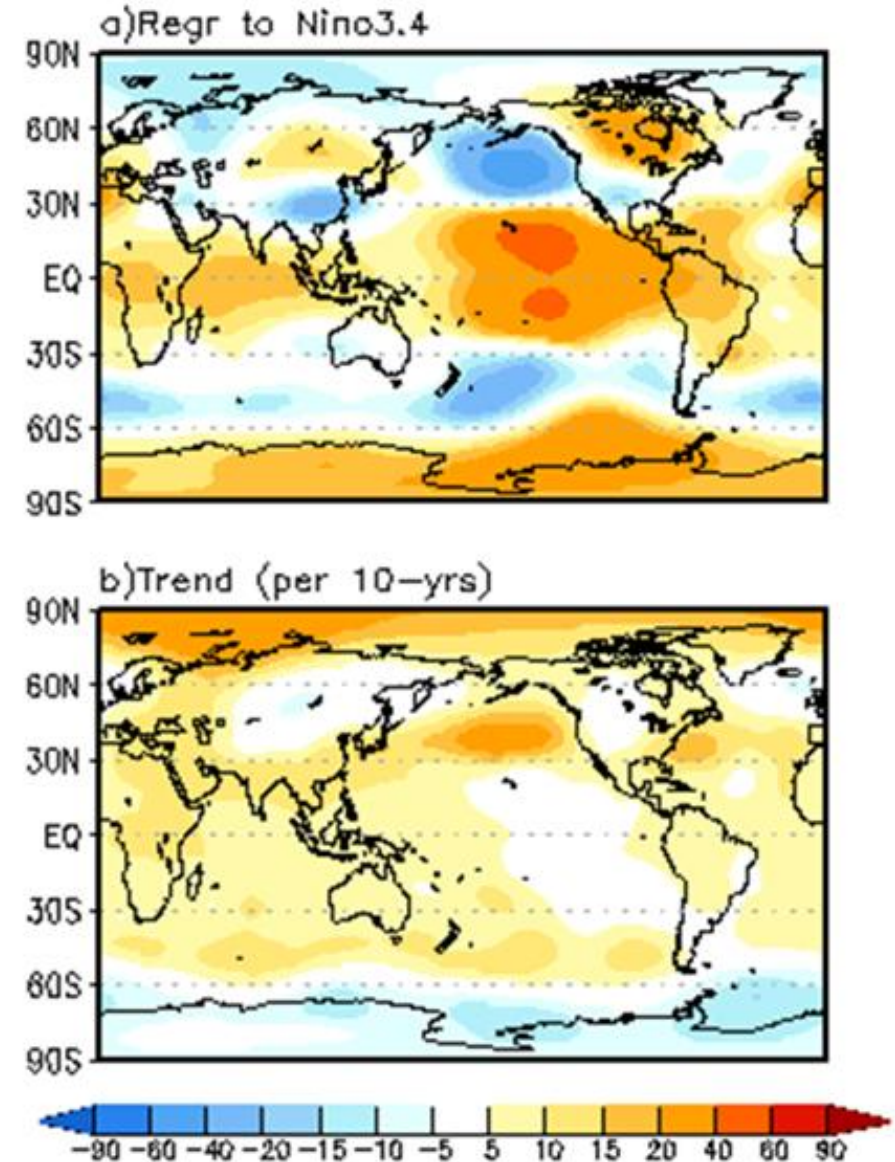
Modes used in attribution analyses:

- 1) ENSO mode
- 2) Residual REOF/RPC 1 to 4
- 3) Linear local trend (interpolated to each year)

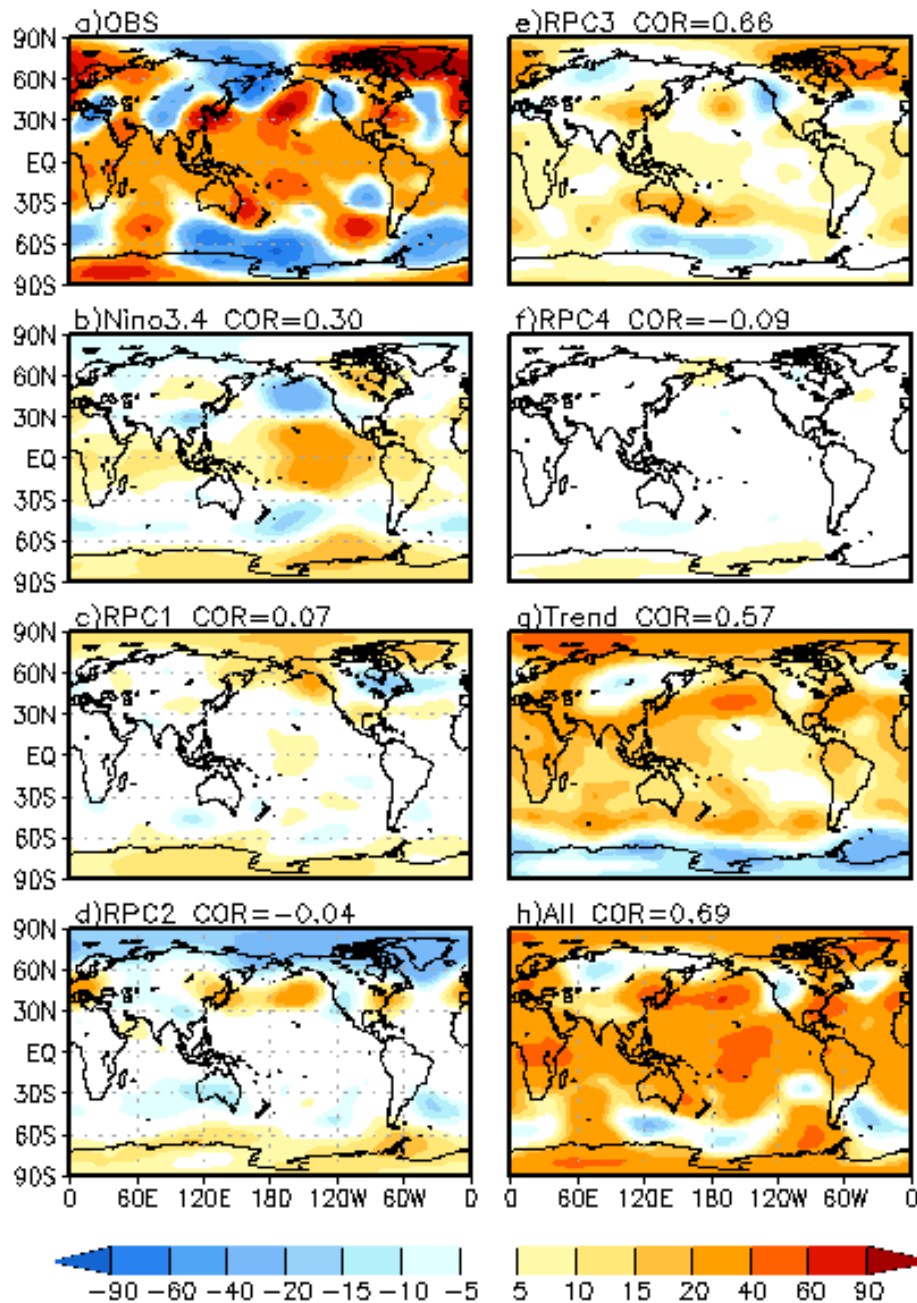
Procedure:

1. For a particular season t , examine contribution from each mode: $f_n(t)P_n(x,y)$, ($n=1 \rightarrow 6$);
2. Add them together and then compare with anomalies in OBS;
3. If tropical modes and trend **can't** explain the anomalies, the anomalies can be attributed to the natural variability of the extratropics

DJF Z200 Patterns: ENSO and Trend



Reconstruction of Z200 for 2018/19 DJF



DJF 2018/2019

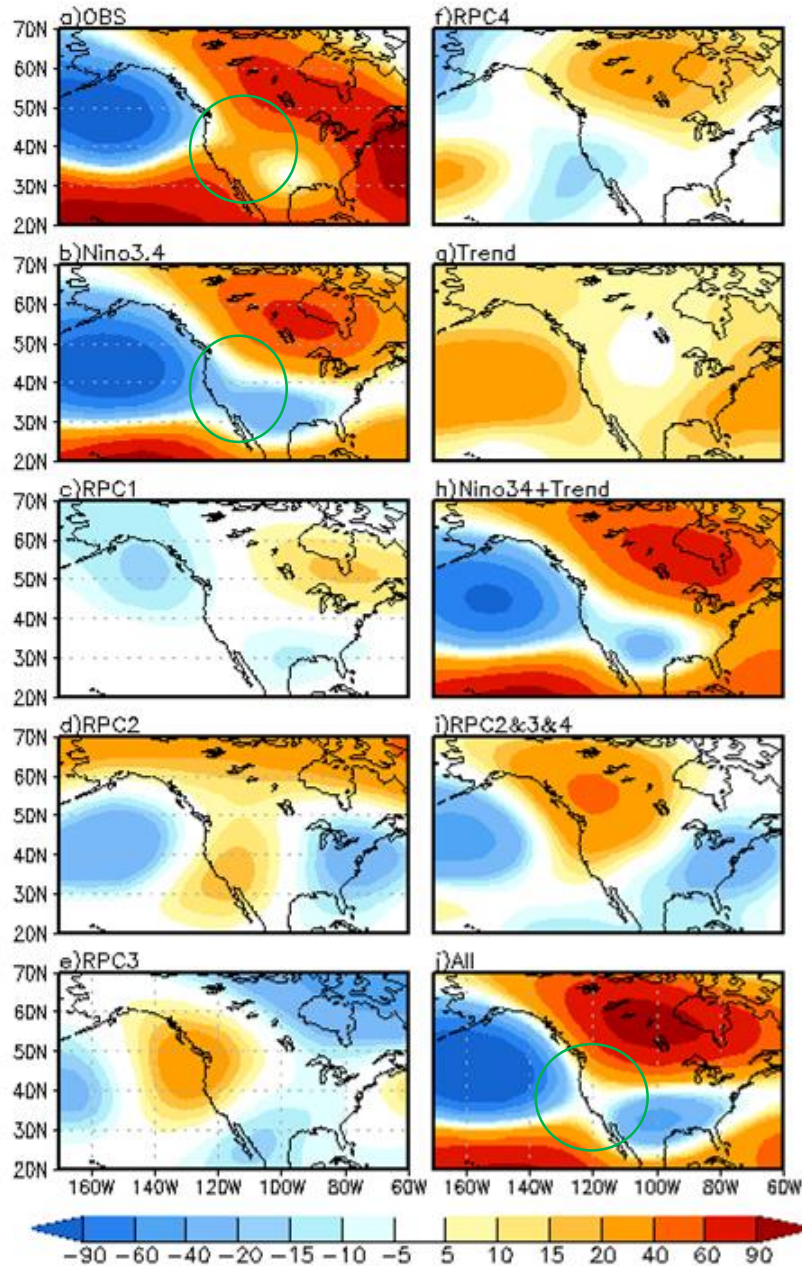
COR: global pattern correlation with OBS

Major contributions are from
REOF/RPC3 (COR=0.66),
trend (COR=0.67)
ENSO (COR=0.30)

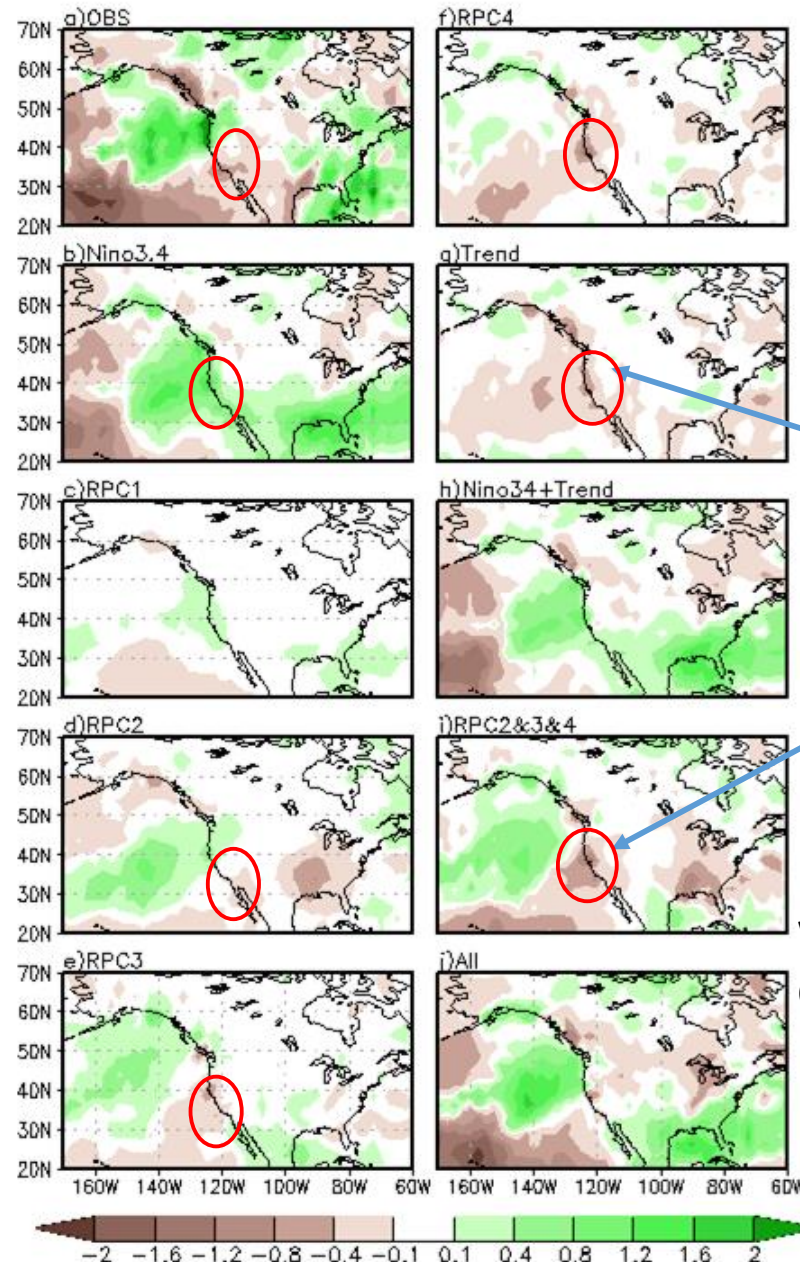
← All added
(COR=0.69)

California precipitation deficit in DJF 2015/16

Reconstruction of Z200 for 2015/16 DJF



Reconstruction of Prate for 2015/16 DJF



REOF/RPC 2,3,4 & local trend contributed most

It appears multiple tropical rainfall modes were associated with the California Precip deficit, why models didn't capture them?

Summary

1. Seasonal tropical rainfall modes beyond ENSO are obtained by applying REOF analysis to the data with canonical ENSO signal linearly removed, and the associated tropical-extratropical teleconnection patterns are identified with a regression procedure;
2. The four leading rainfall modes originate in the tropics because the corresponding rainfall-atmospheric circulation patterns well match the typical forcing-response pattern;
3. The time series of the rainfall modes and the associated teleconnection patterns, together with ENSO teleconnection and local trend, are applicable to climate attribution analysis.
4. The attribution analysis methodology can separate tropically forced and long-term trend related variability from the extratropical natural variability. In perspective, it is also applicable to the analysis of seasonal predictions and model validation.