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Roles of SST vs. Internal Atmospheric Variability in Winter Extreme Precipitation Along the U.S. West Coast

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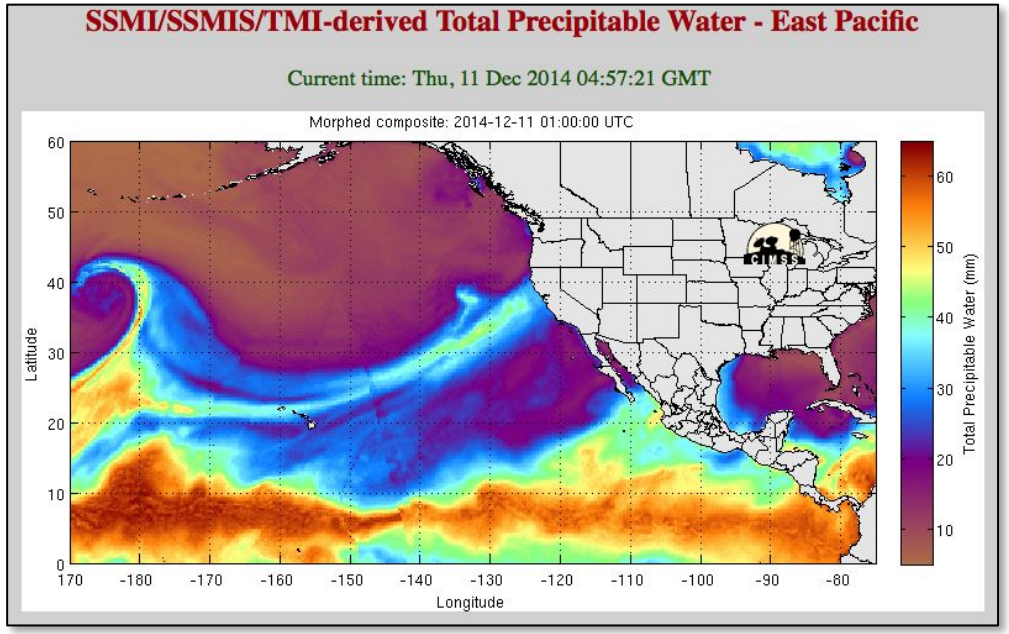
Science question

- Extreme precipitation in the western U.S. has been linked to atmospheric rivers
- Cold season precipitation in the western U.S. has also been linked to ENSO
- To what extent SST forcing contributes to the variance of winter extreme precipitation in North America?



Dominant mode of ARs in the North Pacific

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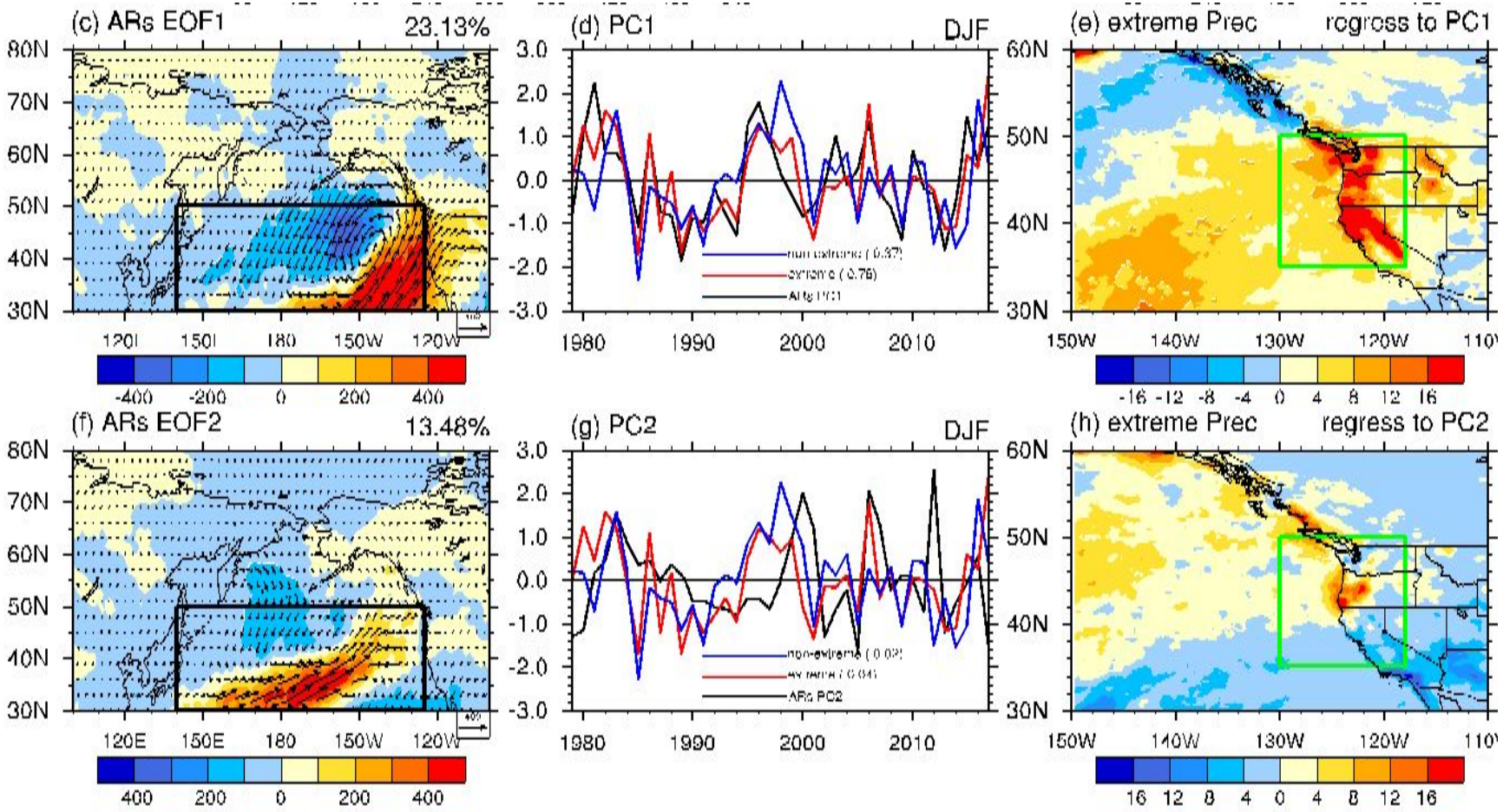
AR defined by 95th percentile of daily IVT in each grid for DJF (1979-2017)



- PC1: north-south shift of ARs → north-south dipole of extreme precipitation
- PC2: variations over the main stretch of the ARs located far upstream of North America

Contributions of SST forcing to variances of winter extreme and non-extreme precipitation

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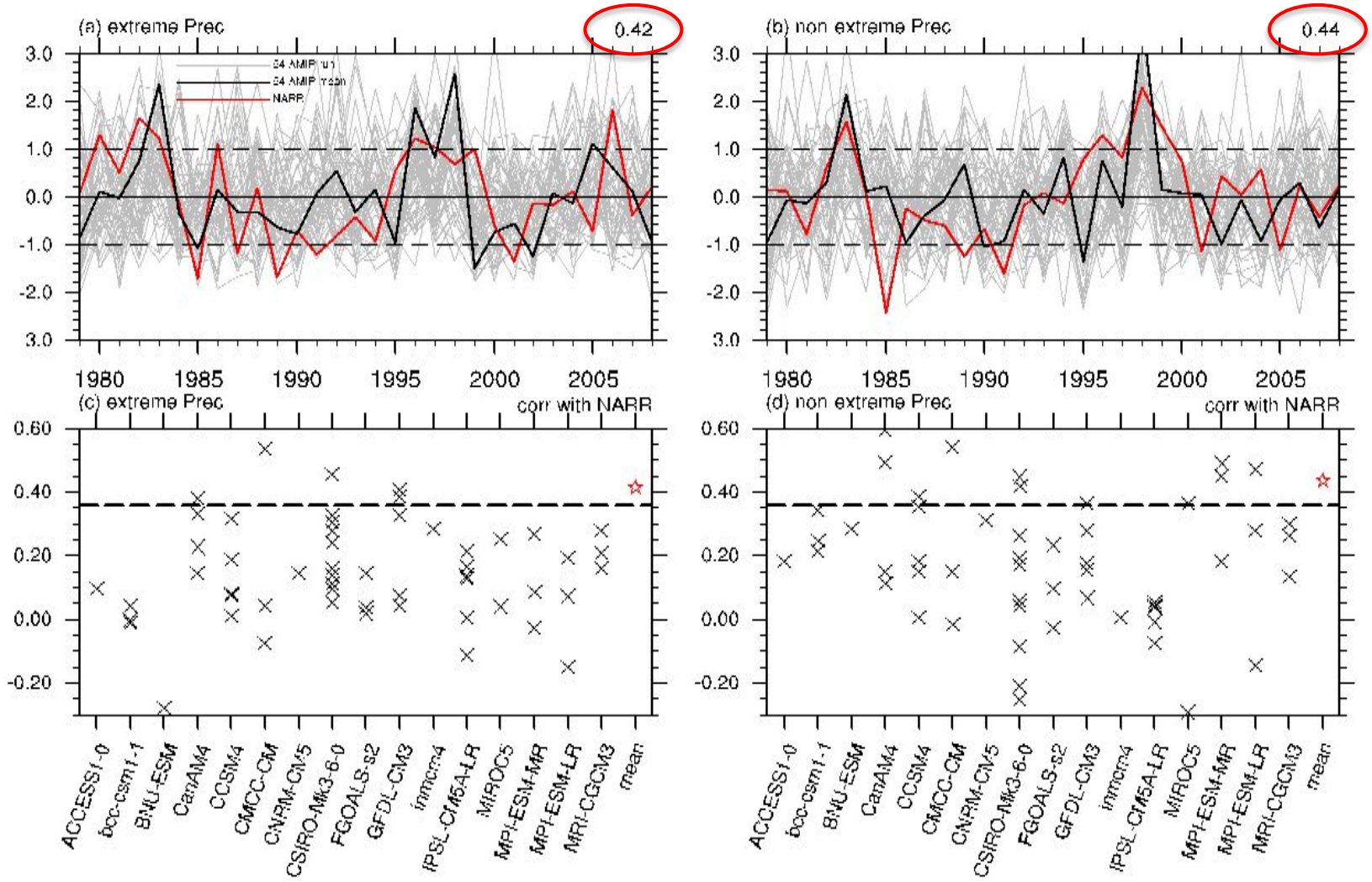
54 AMIP simulations from 16 GCMs



Dashed line: statistically significant at the 95% level of confidence

- SST can regulate precipitation variability along the U.S. west coast
- SST explains about 20% of the variance of winter extreme and non-extreme precipitation
- The residual can be attributed to internal atmospheric variability

Large-scale environment of extreme and non-extreme precipitation under SST forcing

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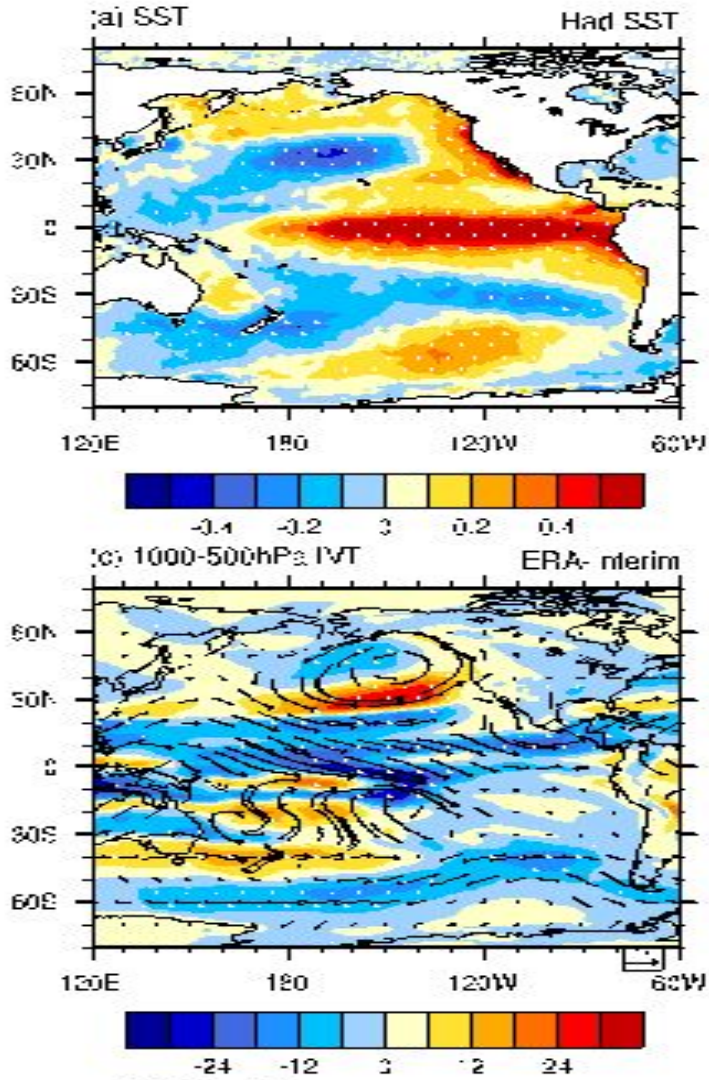
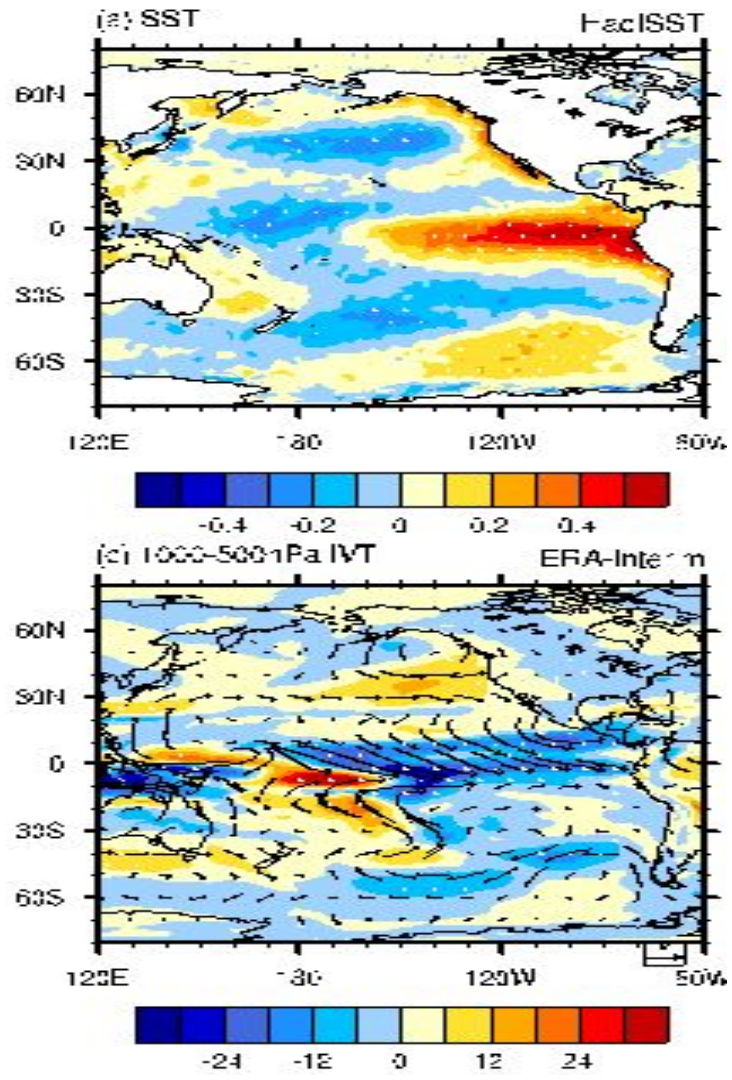
Extreme precipitation



Non-extreme precipitation



- El Niño-like SST pattern: tropical central-to-eastern Pacific vs. far eastern tropical Pacific
- Water vapor transport: advected by the southwesterly flow of the ARs from warm ocean vs. from weaker moisture transport from colder ocean

Large-scale environment of extreme and non-extreme precipitation under SST forcing

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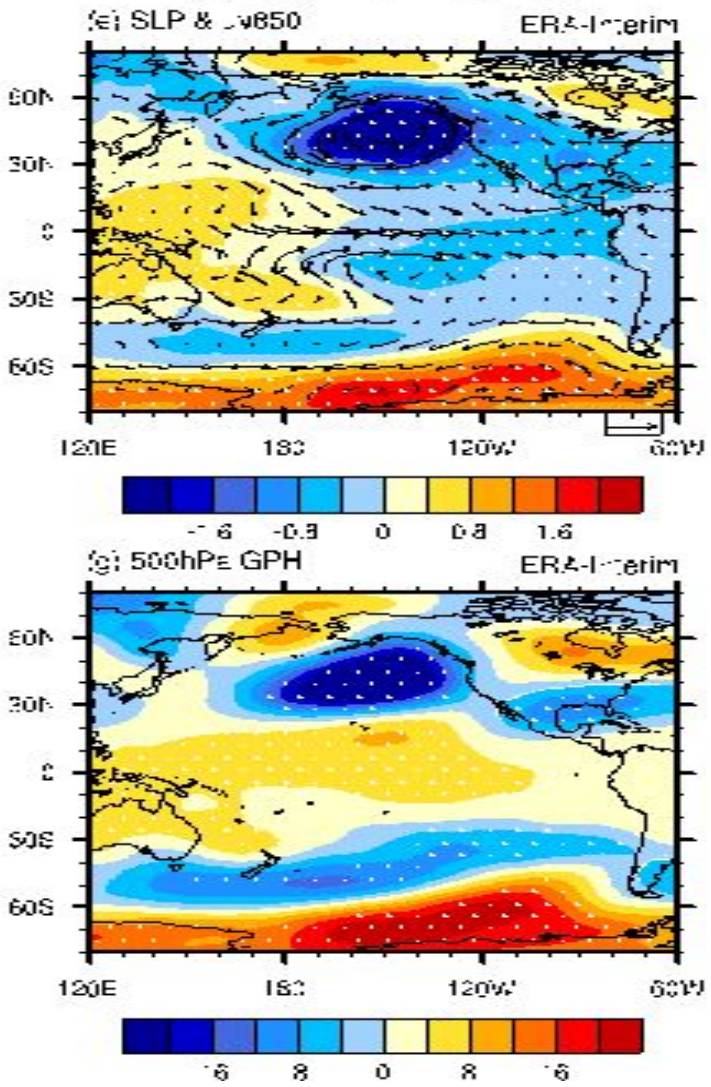
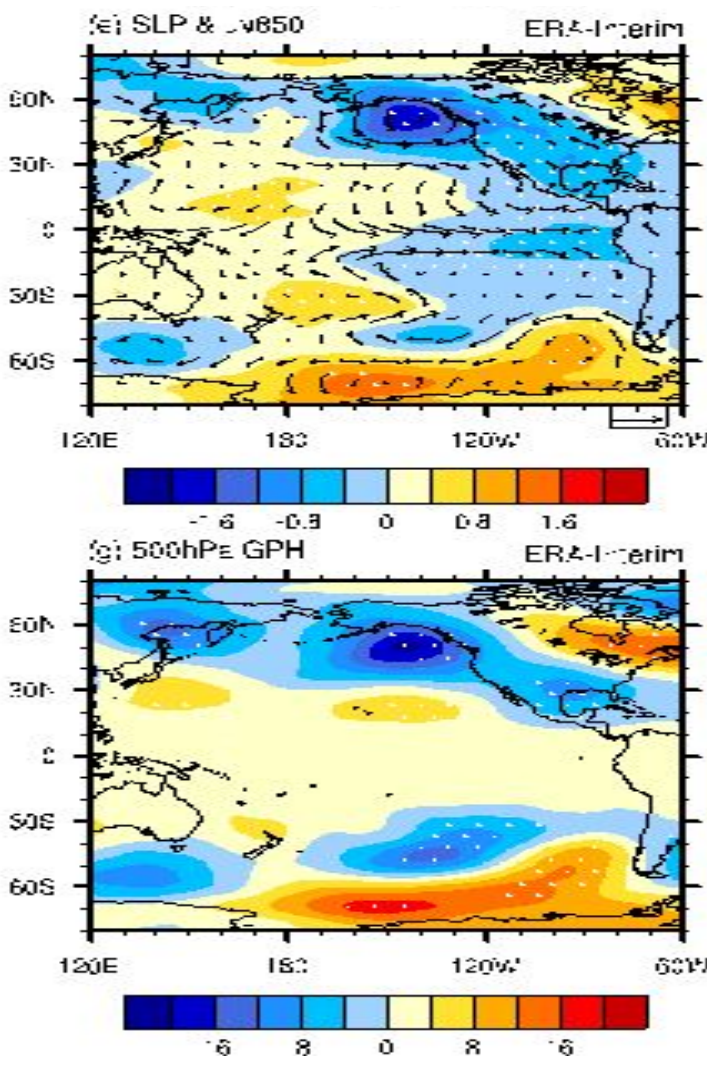
Extreme precipitation



Non-extreme precipitation



- Atmospheric teleconnection: Pacific North American (PNA) with a barotropic cyclonic circulation covering most of North Pacific vs. North Pacific Oscillation (NPO) with a small cyclonic circulation covering eastern North Pacific

Relationship of extreme and non-extreme precipitation with PNA and NPO

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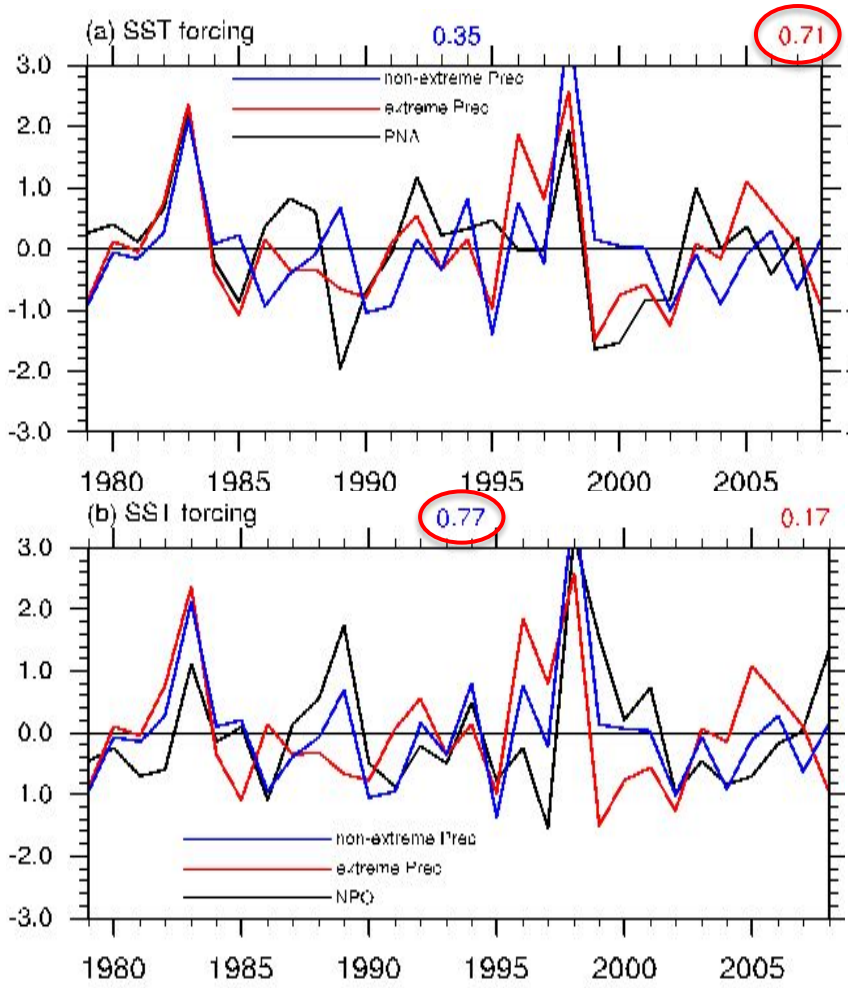
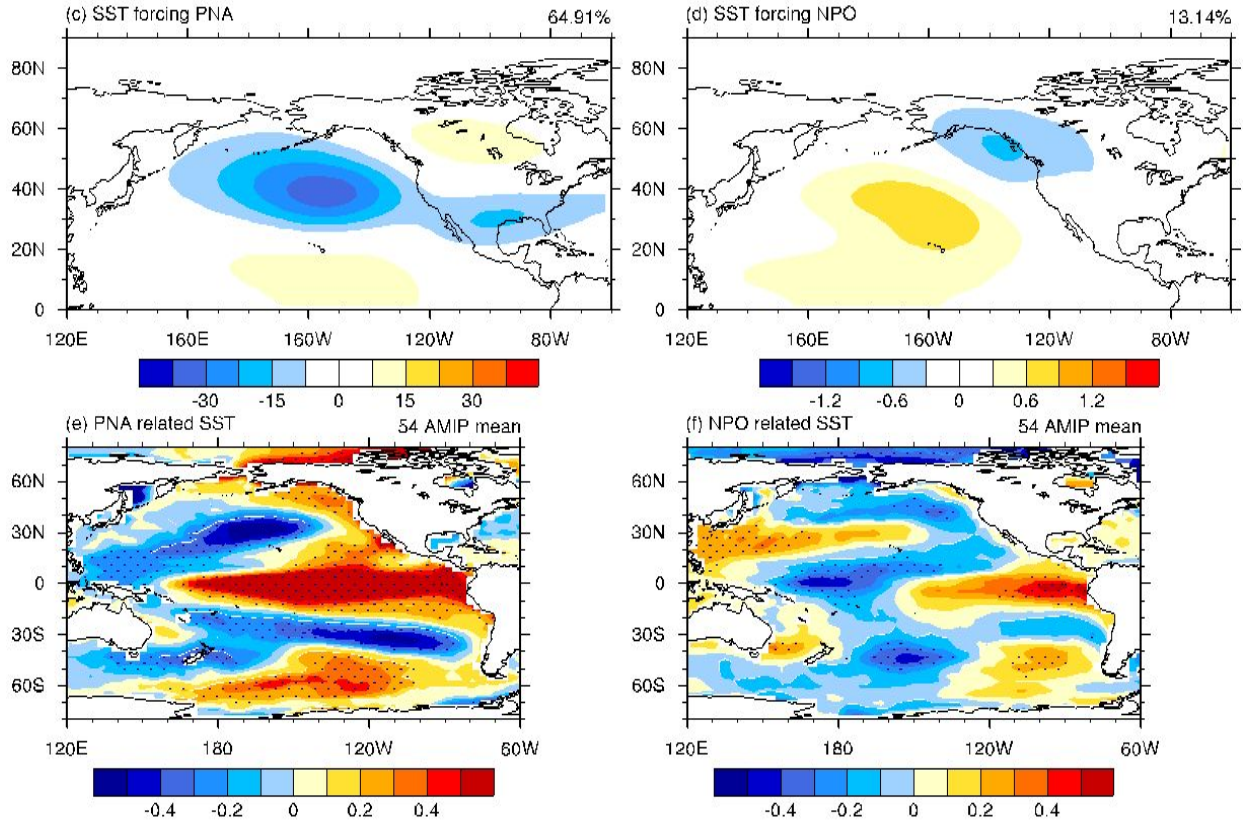
SST-forced extreme precipitation is highly correlated with PNA, while non-extreme precipitation is highly correlated with NPO



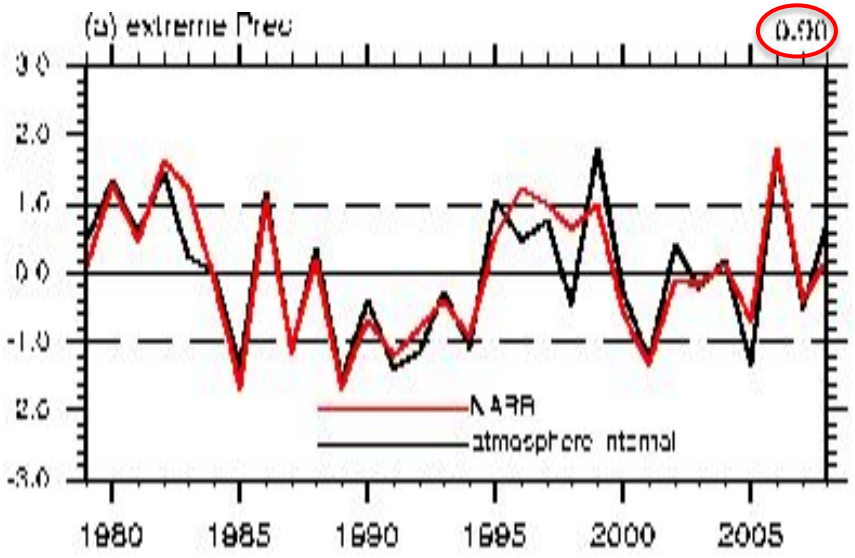
PNA: EOF1 of 500hPa GPH of North Pacific

NPO: EOF2 of SLP of North Pacific



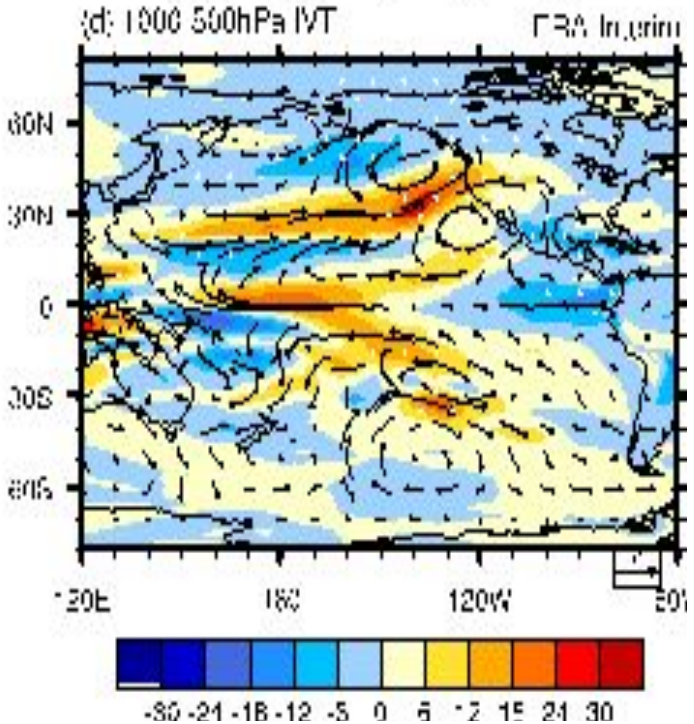
SST forcing based on 54 AMIP runs

Large-scale environment of extreme precipitation associated with internal atmospheric variability

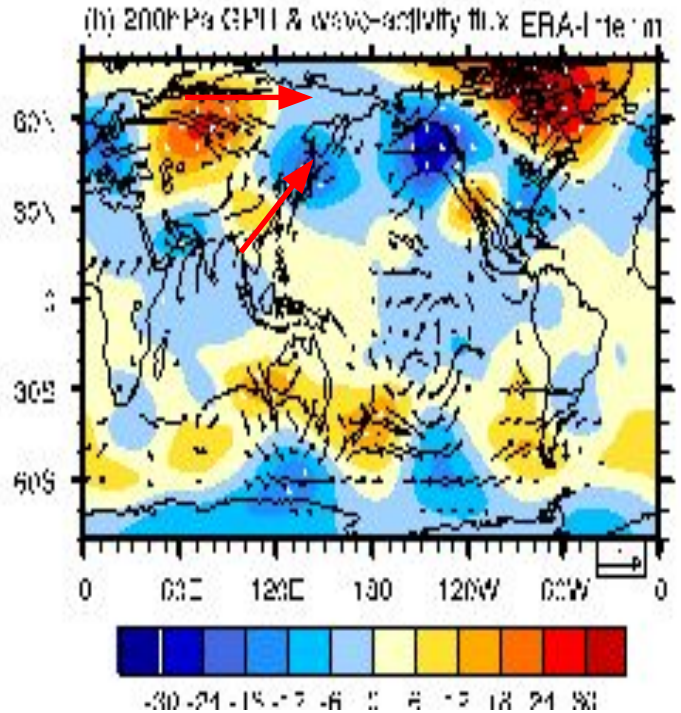


About 80% of variances in winter extreme precipitation can be attributed to internal atmospheric variability.

A cyclonic circulation enhances the IVT by ARs



A wave packet over the mid-to-high latitudes resemble the circumglobal teleconnection (Branstator 2002)



Possible triggering of circumglobal teleconnection

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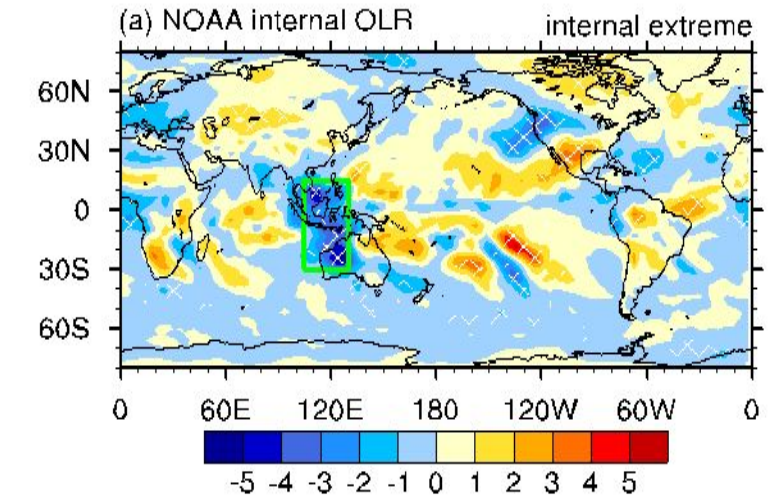
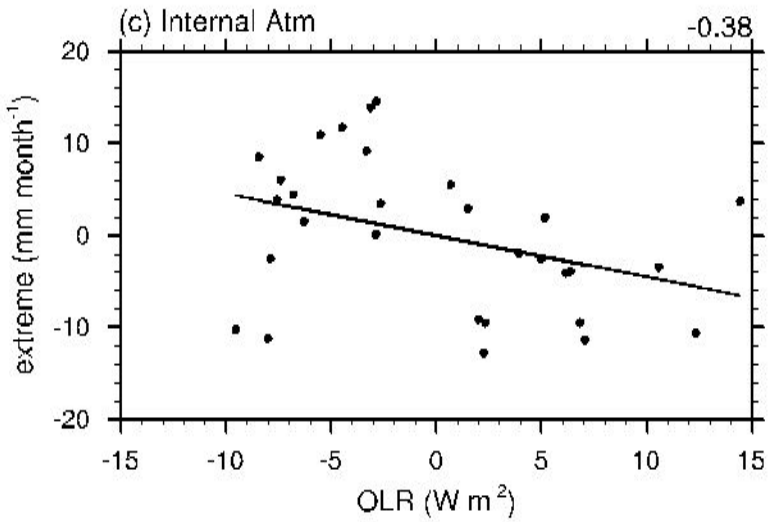
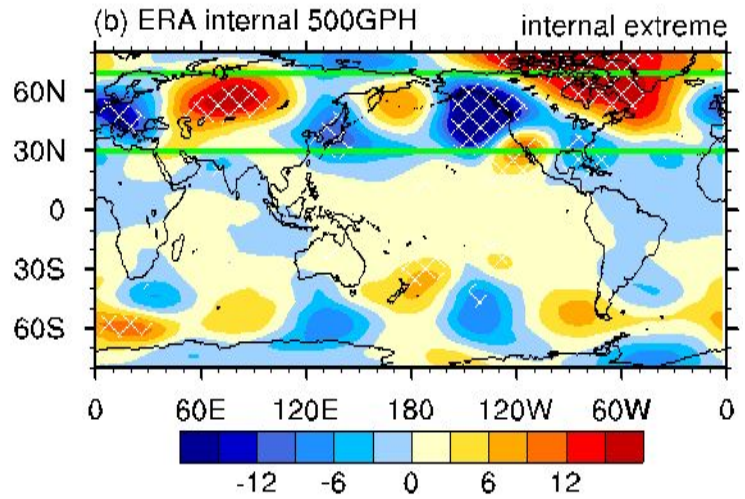
Regression of OLR onto extreme precipitation

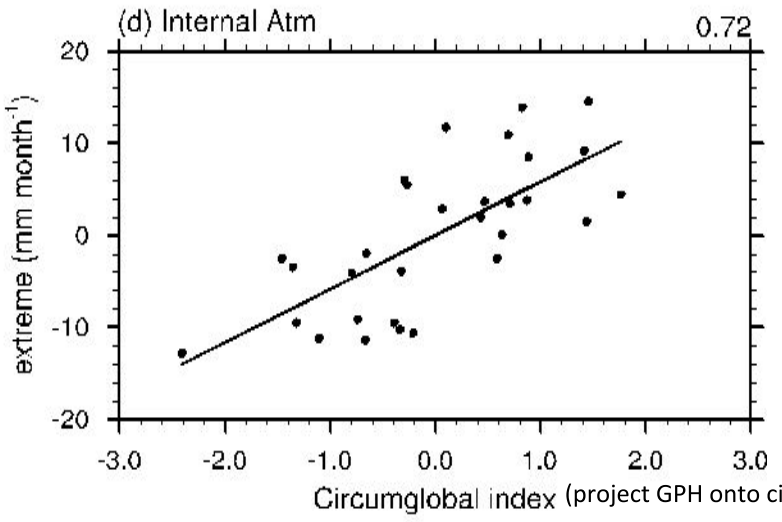
Tropical signal





Mid-to-high latitude signal





Regression of GPH500 onto extreme precipitation

OLR vs. circumglobal: -0.47

Possible drivers of the anomalous winter of 2016-17

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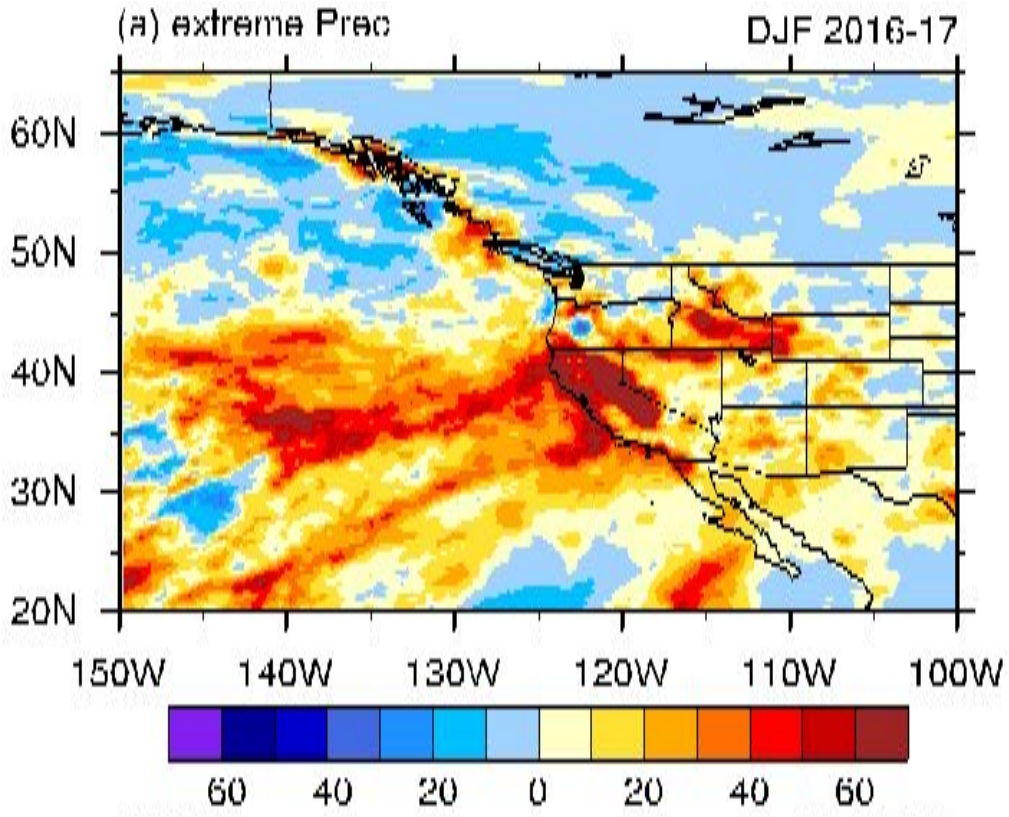
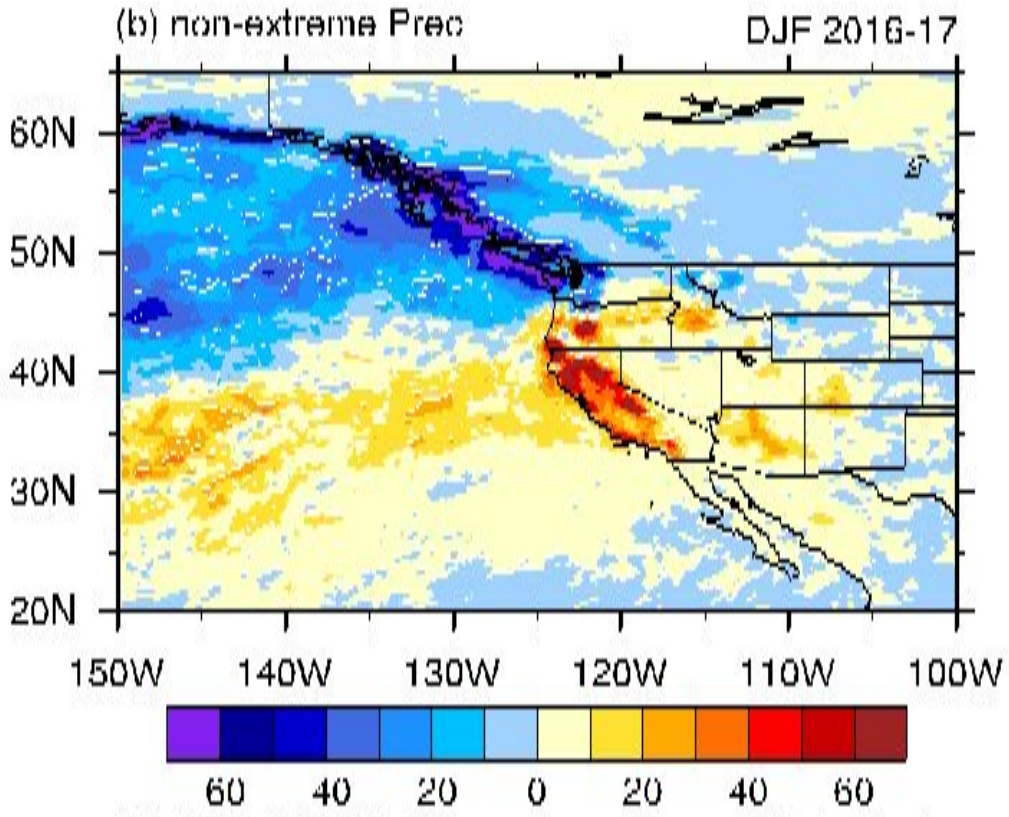
Record extreme precipitation in the winter of 2016-17 over California

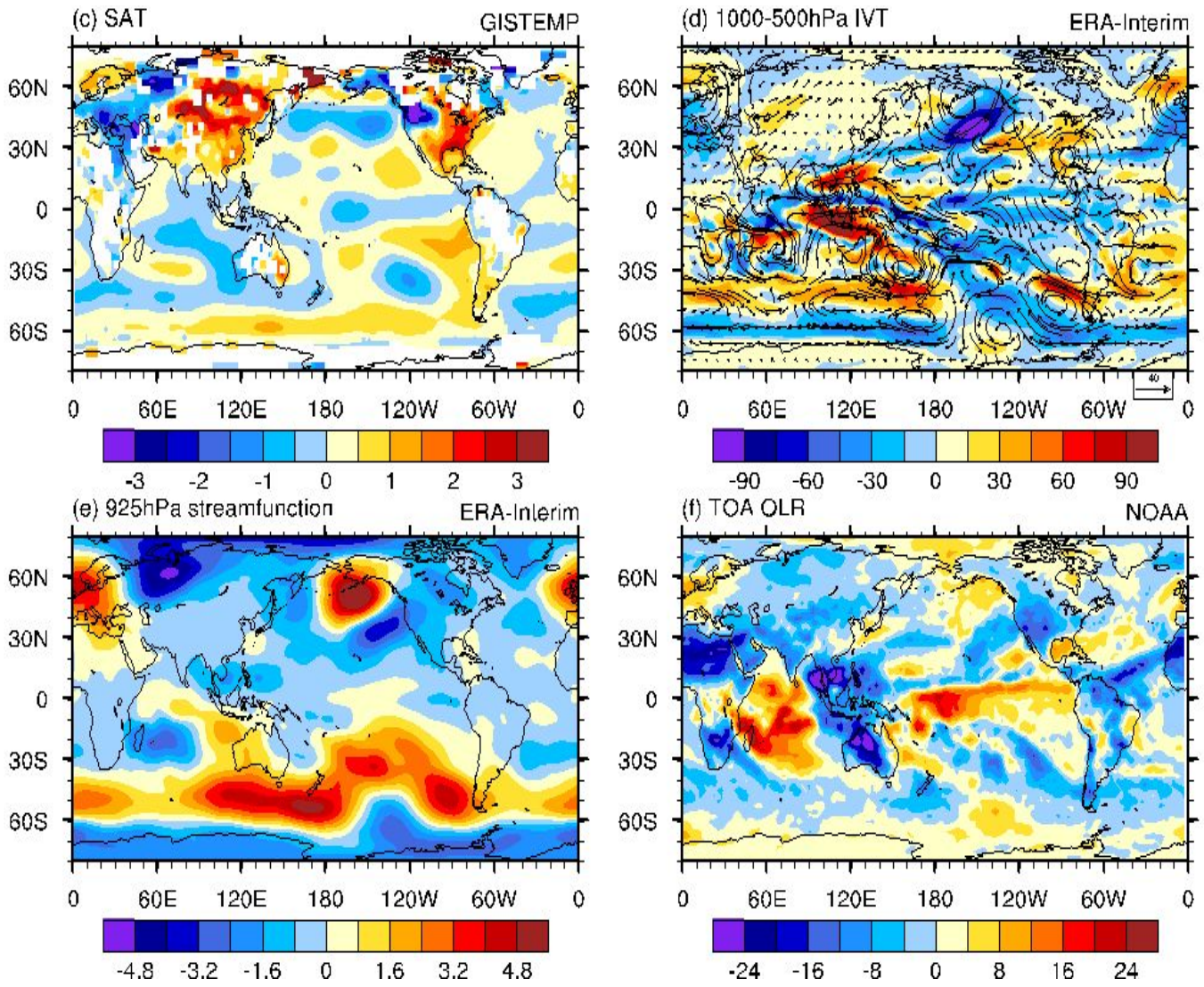
2.5 STD



0.36 STD

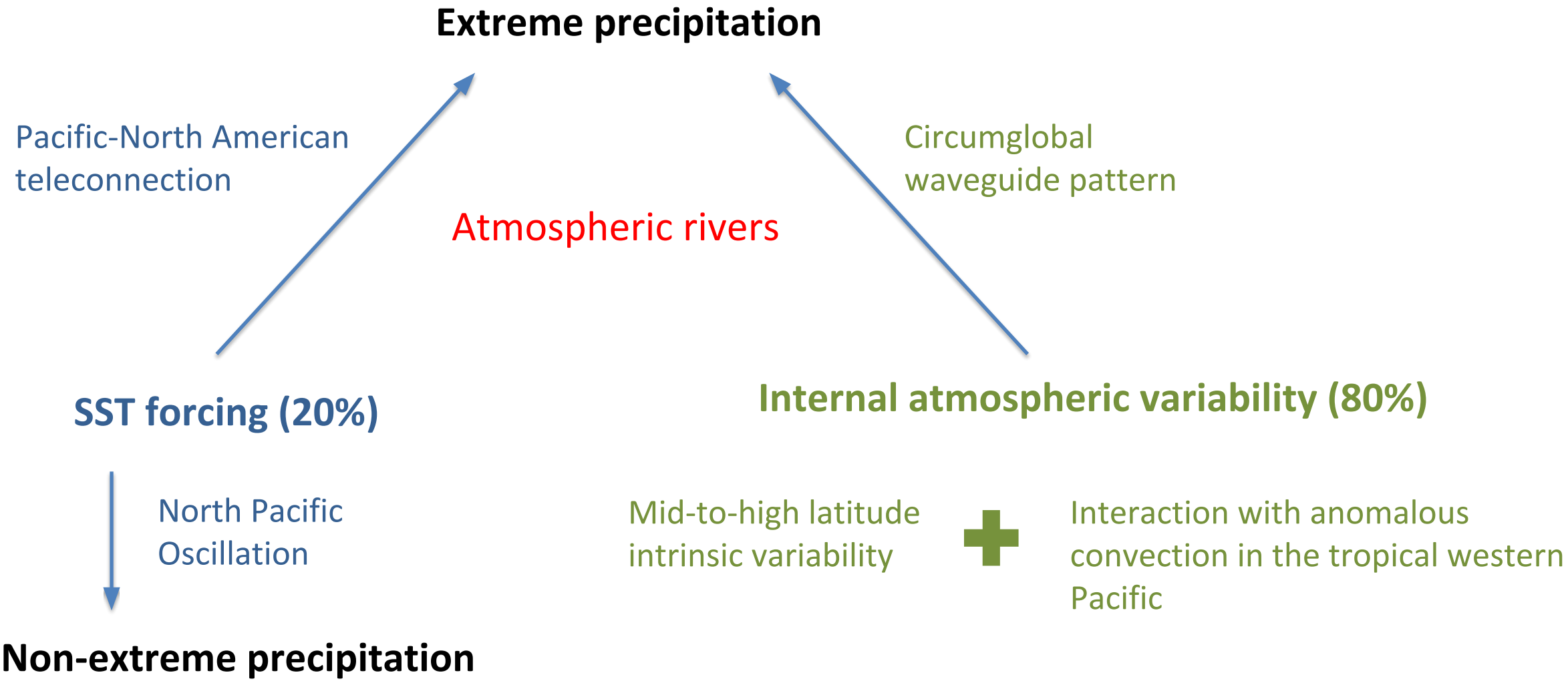


Possible drivers of the anomalous winter of 2016-17



- Not an El Niño event
- A circumglobal wave train is evident in the mid-to-high latitudes over North Pacific with more ARs making landfall in CA
- Enhanced convection over the Maritime Continent appears to serve as the wave source

Summary


Extreme precipitation
Pacific-North American teleconnection
Atmospheric rivers
Circumglobal waveguide pattern
SST forcing (20%)
Internal atmospheric variability (80%)
North Pacific Oscillation
Mid-to-high latitude intrinsic variability
Interaction with anomalous convection in the tropical western Pacific
Non-extreme precipitation