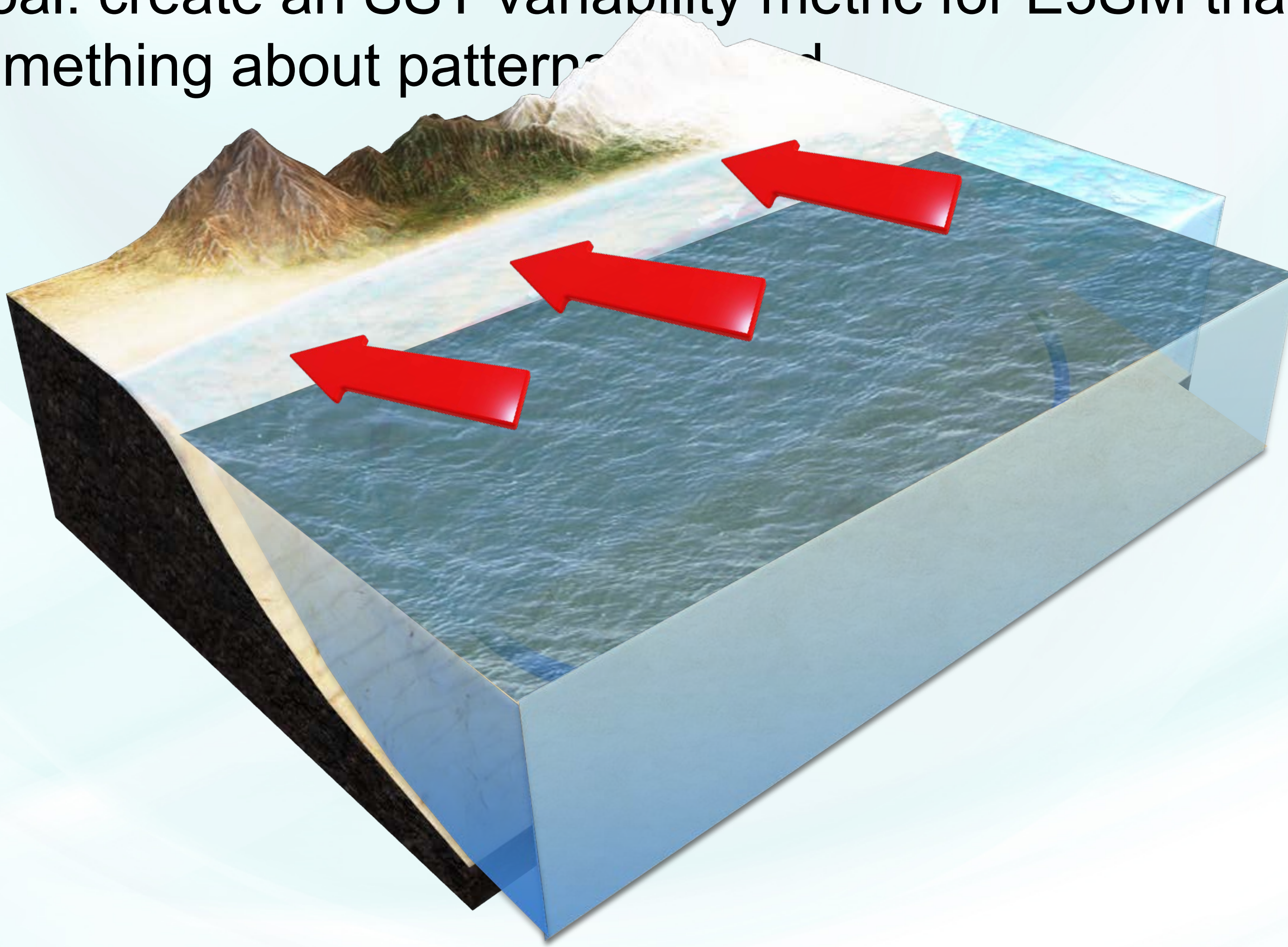
Creation of an SST variability metric for E3SM

LeAnn Conlon, Luke Van Roekel

Can we use sea surface temperature to predict patterns on land in E3SM?

- Goal: create an SST variability metric for E3SM that tells us something about pattern



SST variability

Variability is mostly seasonal

De-seasoned: dominated by ENSO processes

Other important oscillations:

- NAO
- PDO

Sea Surface Temperature Variability: Patterns and Mechanisms

Clara Deser,[1] Michael A. Alexander,[2] Shang-Ping Xie,[3] and Adam S. Phillips[1]

Deser et al. 2010

SCIENTIFIC REPORTS
natureresearch

OPEN Tendencies, variability and persistence of sea surface temperature anomalies

Claire E. Bulgin[1,2], Christopher J. Merchant[1,2] & David Ferreira[1]

Bulgin et al. 2020

ELSEVIER
Weather and Climate Extremes
Volume 21, September 2018, Pages 1-9

Understanding the role of sea surface temperature-forcing for variability in global temperature and precipitation extremes

Andrea J. Dittus [a, b, c], David J. Karoly [a, b], Markus G. Donat [b, d], Sophie C. Lewis [b, e], Lisa V. Alexander [b, d]

Dittus et al. 2018

Open Access | Published: 16 April 2019

Metrics for understanding large-scale controls of multivariate temperature and precipitation variability

John P. O'Brien, Travis A. O'Brien, Christina M. Patricola & S.-Y. Simon Wang

Climate Dynamics 53, 3805–3823(2019) | Cite this article

O'Brien et al. 2019

Ocean/ Land relationships

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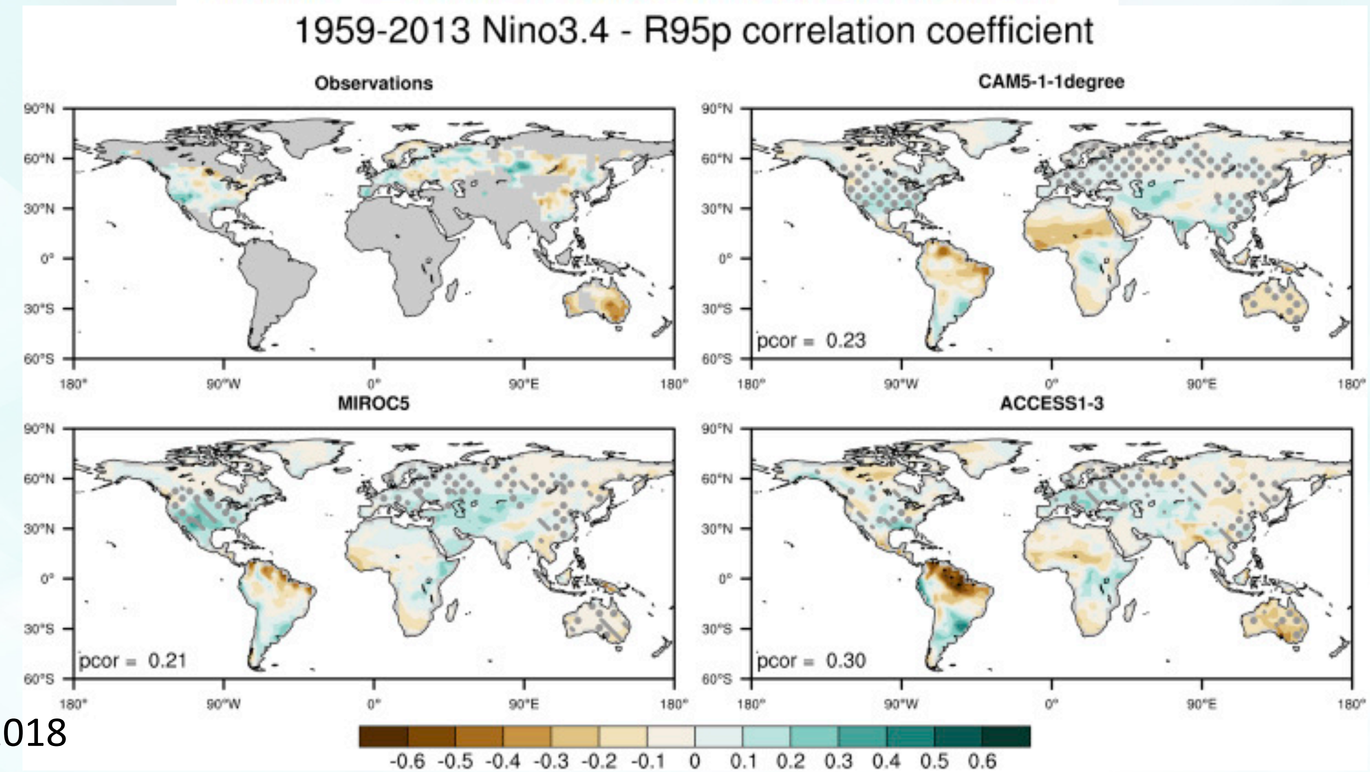

Dittus et al. 2018

Ocean/ Land relationships

Implications of North Atlantic Sea Surface Salinity for Summer Precipitation over the U.S. Midwest: Mechanisms and Predictive Value

LAIFANG LI, RAYMOND W. SCHMITT, AND CAROLINE C. UMMENHOFER

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Department of Atmospheric and Oceanic Sciences, and Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder, Boulder, Colorado

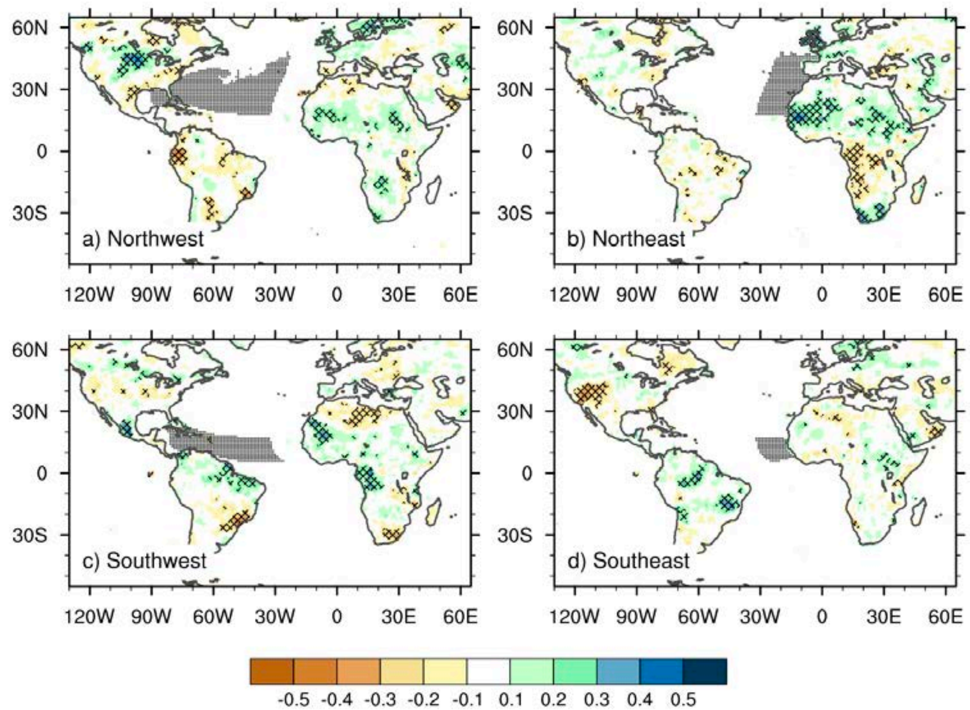
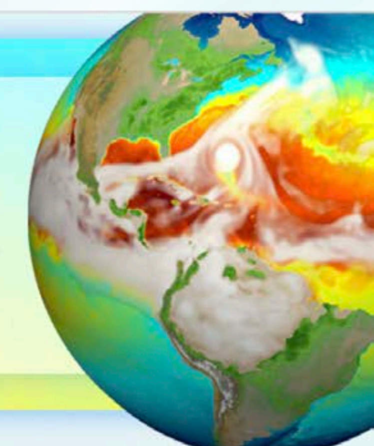


FIG. 3. Correlation between boreal summer (JJA) terrestrial precipitation in the Western Hemisphere (shaded) and springtime North Atlantic SSS indices in the four subdomains of the subtropical basin: (a) NW, (b) NE, (c) SW, and (d) SE. Areas are hatched where the correlation coefficients are significant at the $\alpha = 0.05$ level. The gray-shaded regions in the subtropical North Atlantic are the geographical domains that define the corresponding SSS indices.

Li et al (2016) looked at the relationship between salinity and precipitation

- High SSS over the northwestern subtropical Atlantic coincides with a local increase in moisture. The moisture is then directed toward and converges over the southern United States, which experiences increased precipitation and soil moisture

Approach: do something similar for the U.S. in E3SM using SST



Data Analysis

- Start with low res PI run, SST and precipitation
- Precipitation
  - Standardized precipitation index (SPI)
    - a widely used index to characterize meteorological drought on a range of timescales

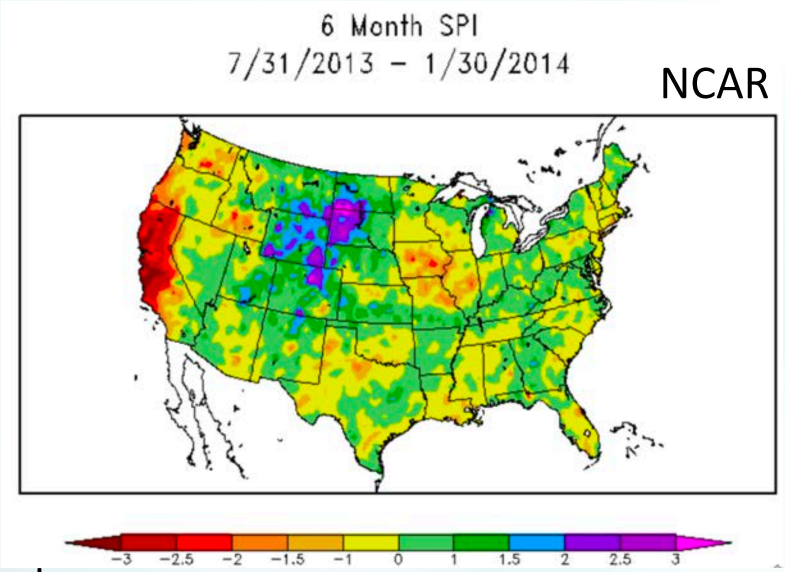
$$SPI = (P - P*)/\sigma P$$

Precipitation

Mean Precipitation

Standard Dev.

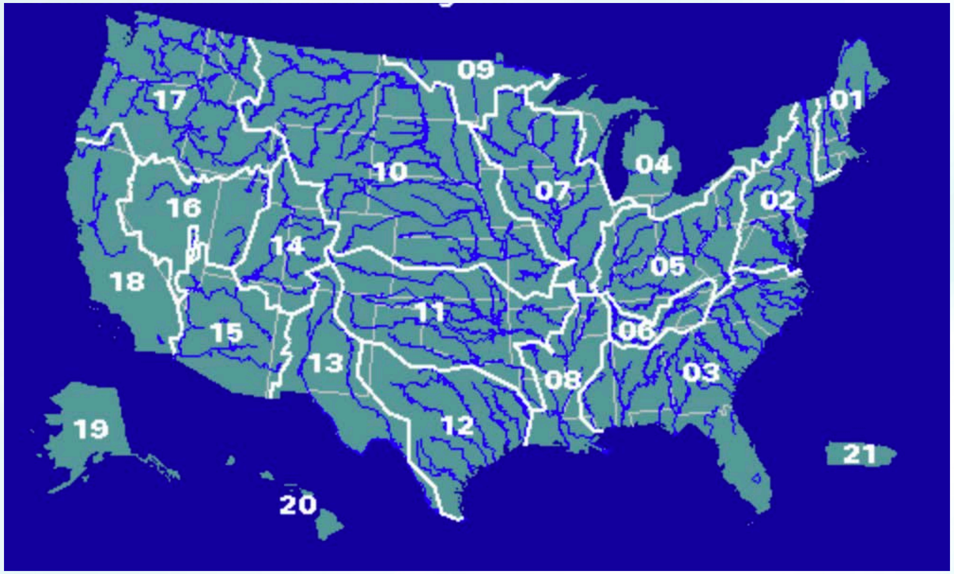
  - Averaged over each HUC02 watershed



NCAR

dry

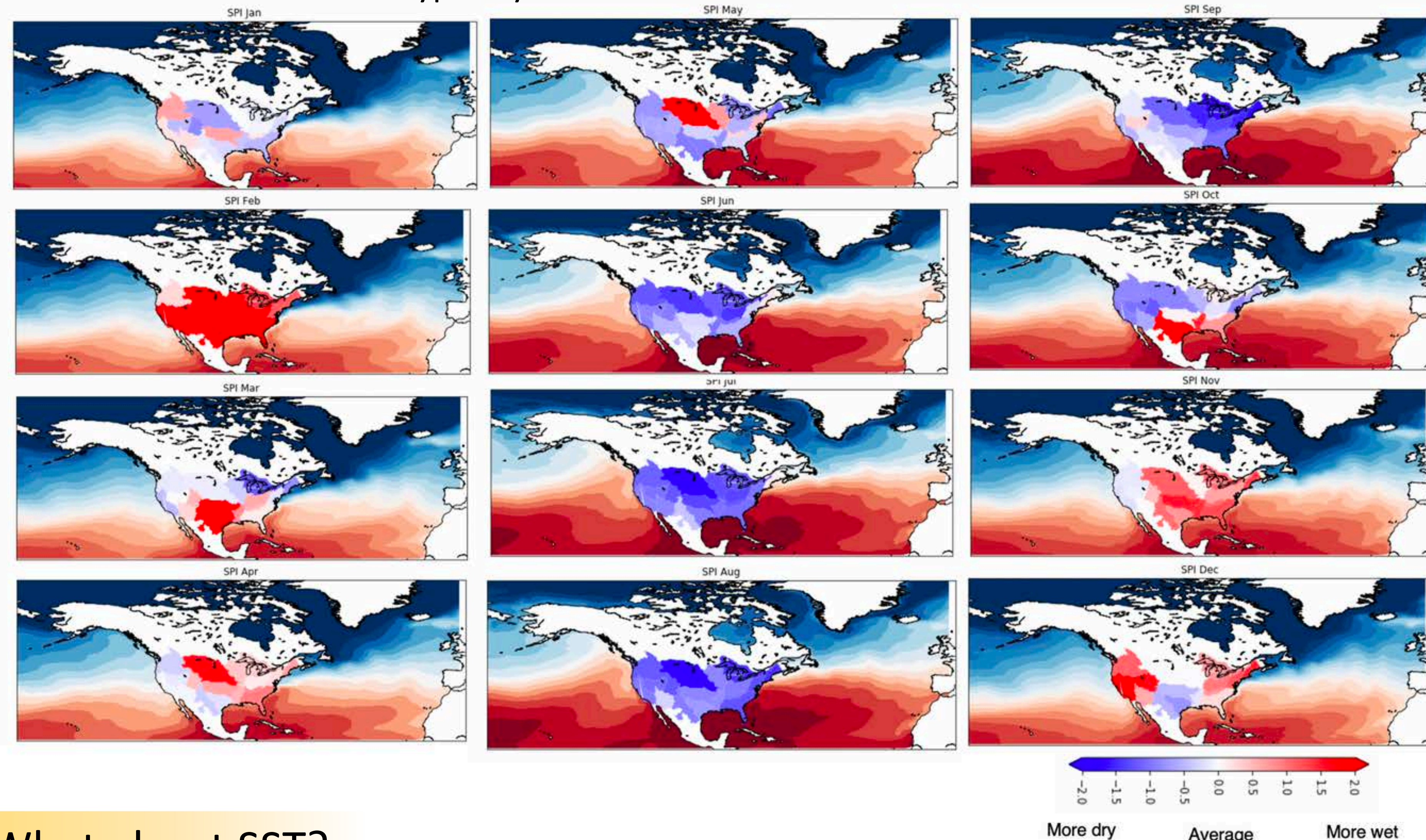
wet



USGS

Standardized Precipitation Index

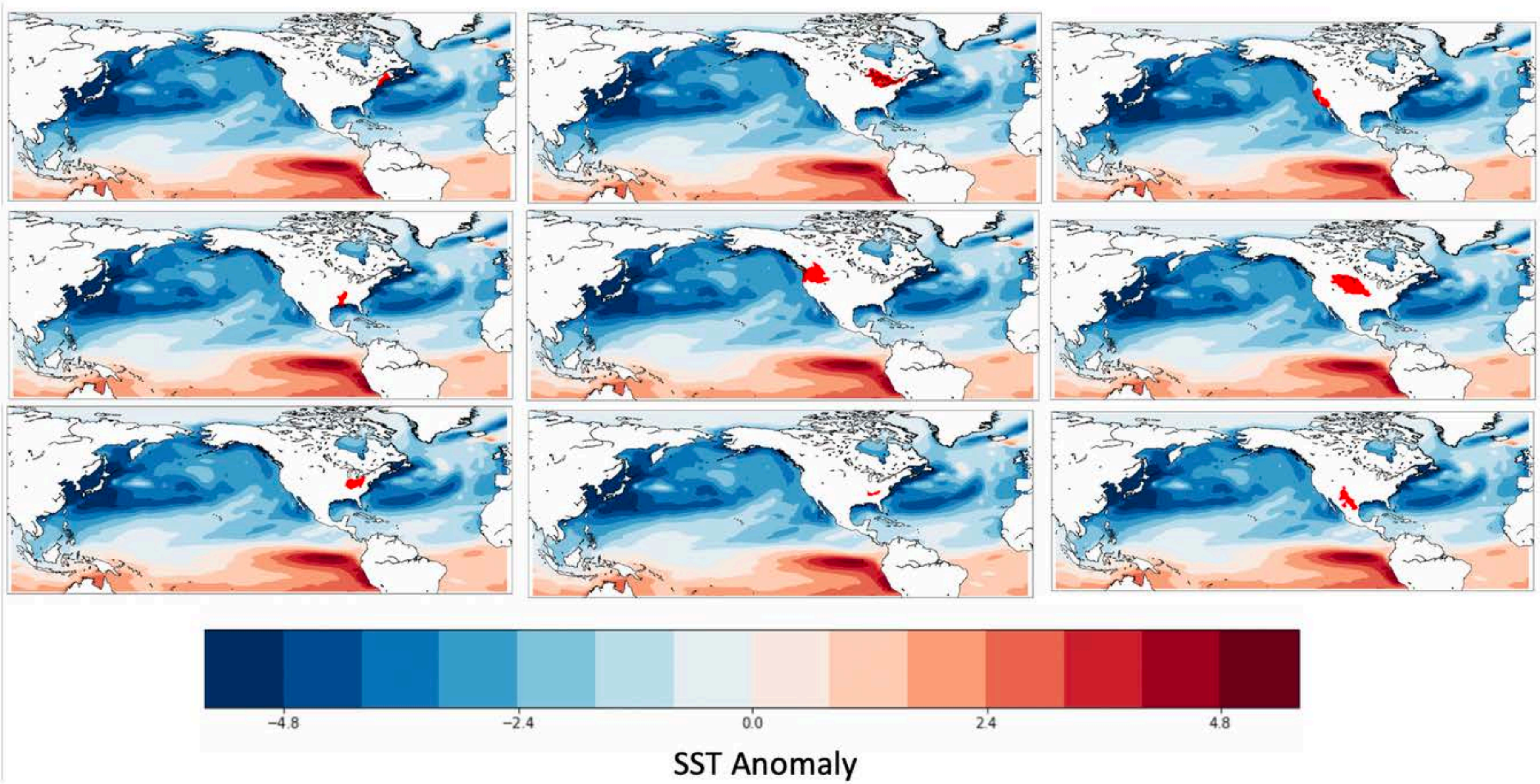
SPI for a typical year for each of the HU02 watersheds



What about SST?

SST variability

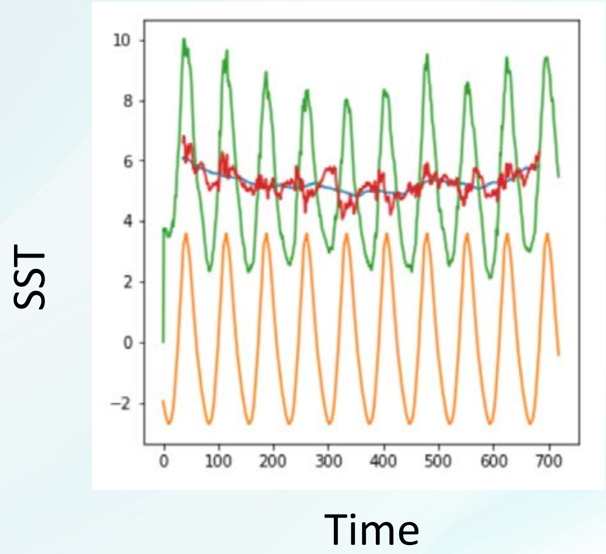
Mean of SST anomalies when precipitation is over the 95% percentile



Data Analysis

- SST (continued)
  - Seasonal cycles give spurious correlations (basically relating a seasonal cycle to itself)
  - Holtz-Winters decomposition avoids this

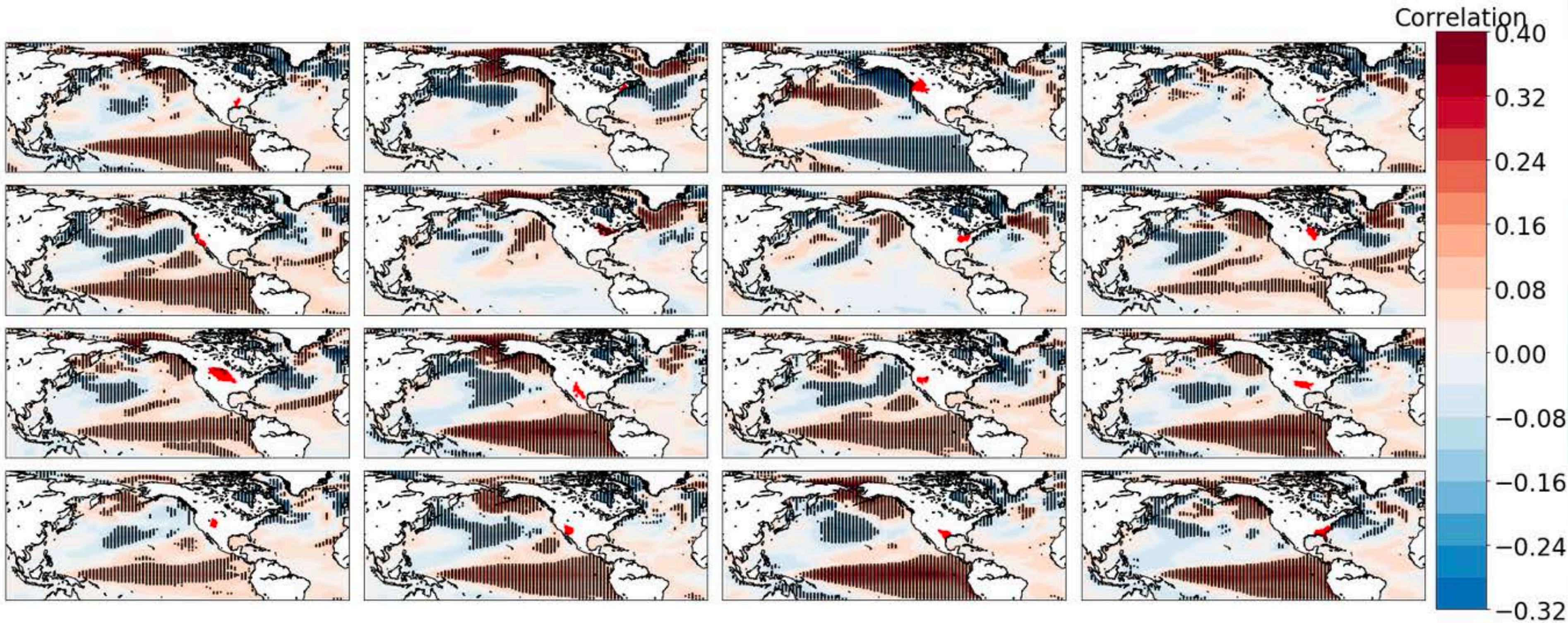
Holt-Winters decomposition on SST: seasonal, trend, residual, raw data



SST/SPI correlations

Correlated SST pointwise over much of the global ocean with SPI in each HUC02 watershed

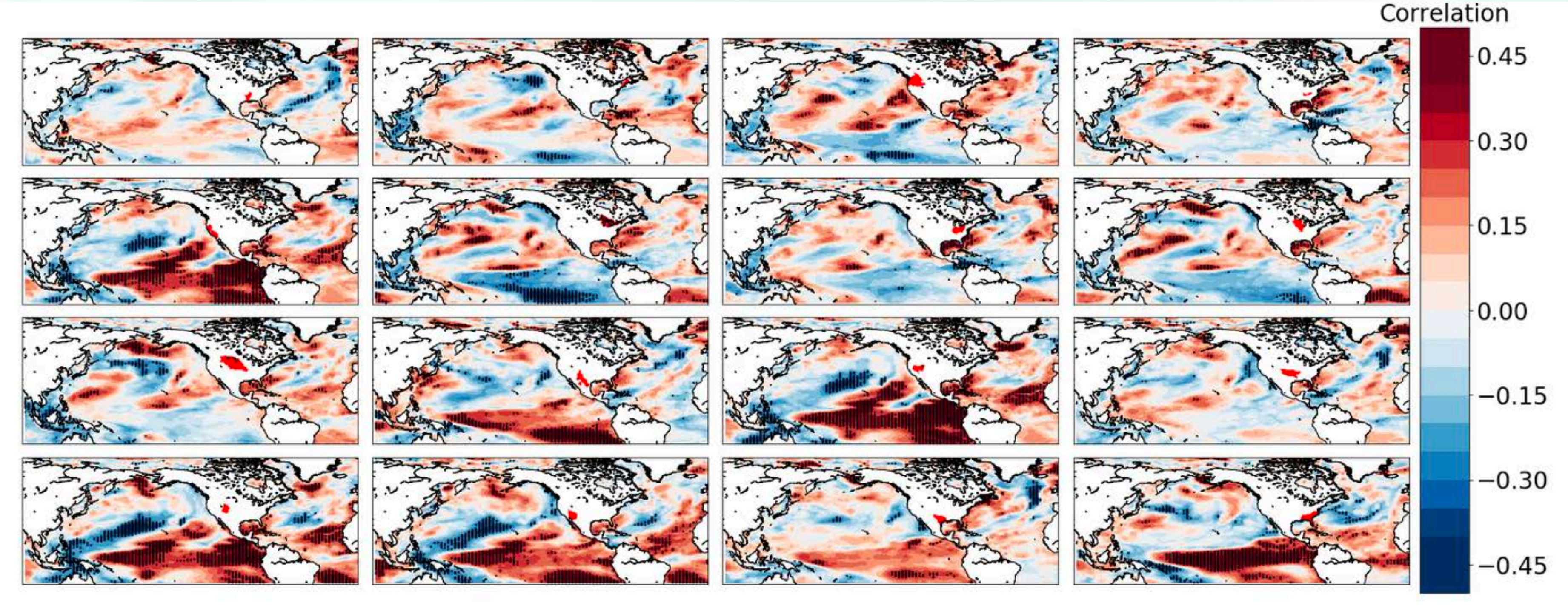
Low resolution, de-seasoned SST (50 years)
Shading indicates significance



A positive correlation indicates that SST increases with SPI (a + SPI indicates more precipitation, a - indicates less). Overall, this means that warmer temperatures along the equator (e.g. an El Nino event) tended to produce significant increases in precipitation in many watersheds; PDO and NAO produce similar results.

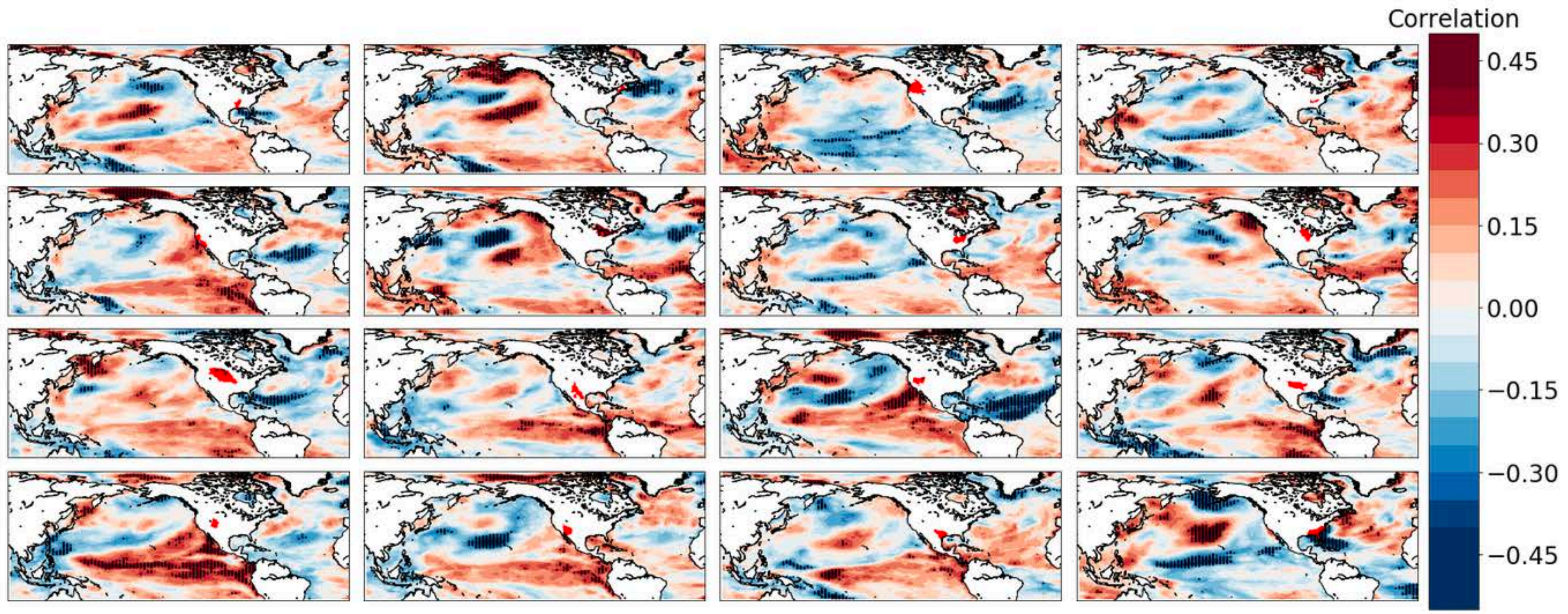
SST/SPI correlations: Seasonal

Low resolution, March only (50 years)
Shading indicates significance

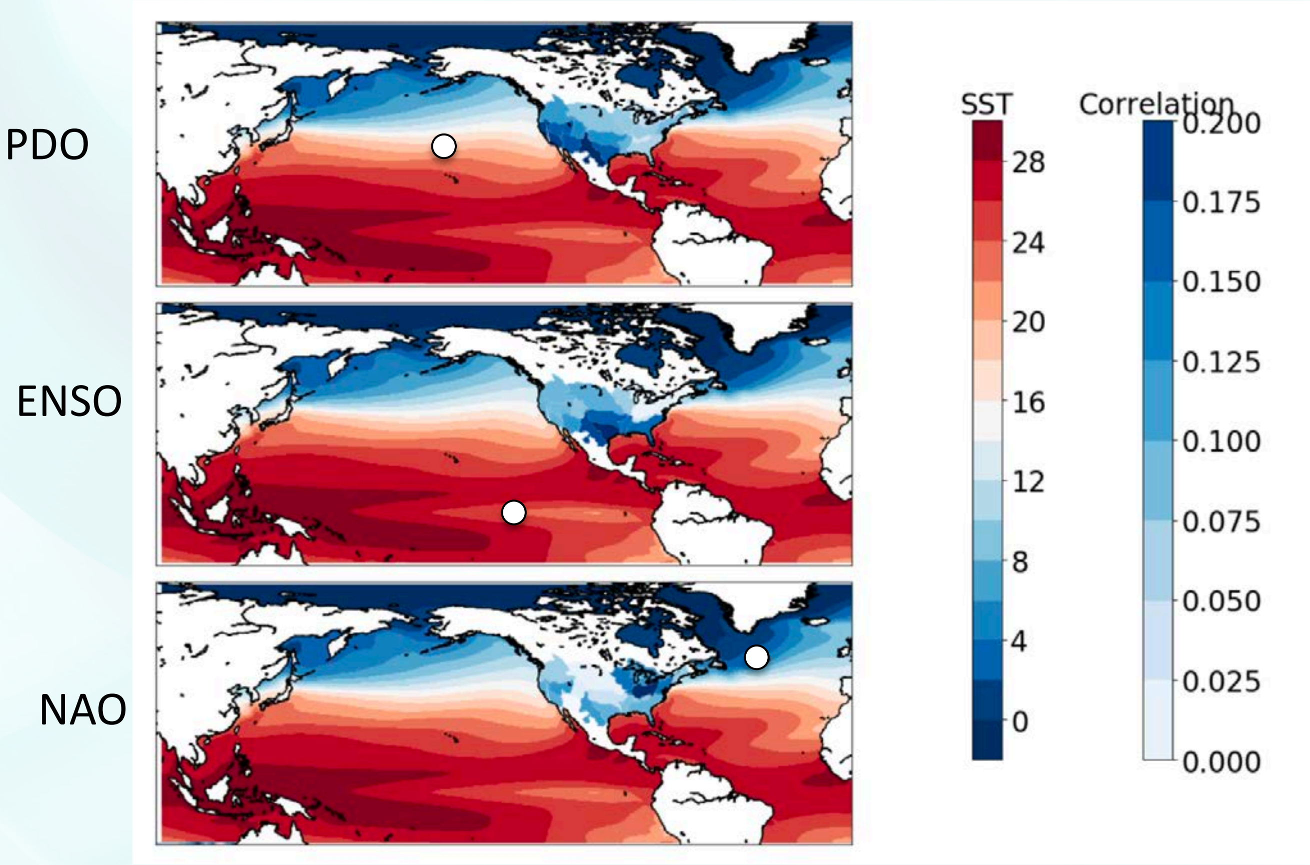


SST/SPI correlations: Seasonal

Low resolution, September only (50 years)
Shading indicates significance



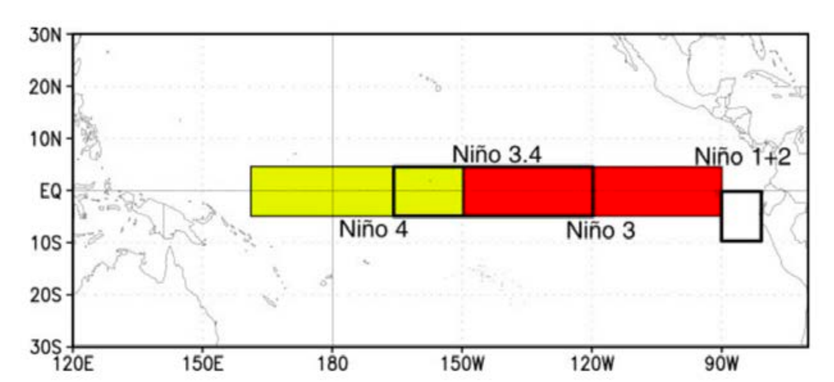
Correlation of timeseries at 3 points, by watershed



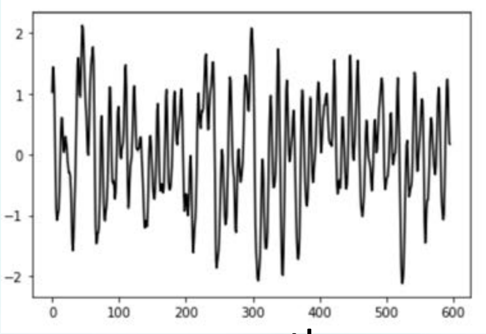
ENSO Comparison with NOAA

Instead of examining precipitation where it looks like ENSO is occurring, we can calculated ENSO itself and see how it relates to precipitation

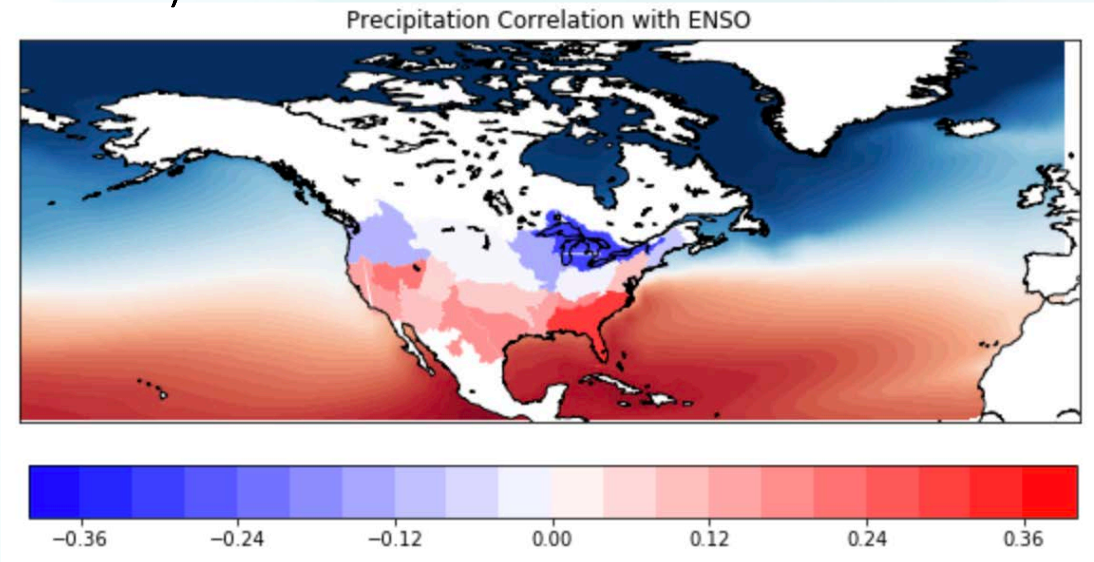
ENSO is calculated based on the NOAA Oceanic Nino Index= surface temperature anomaly for Nino 3.4 (5N to 5S, 170W to 120W)

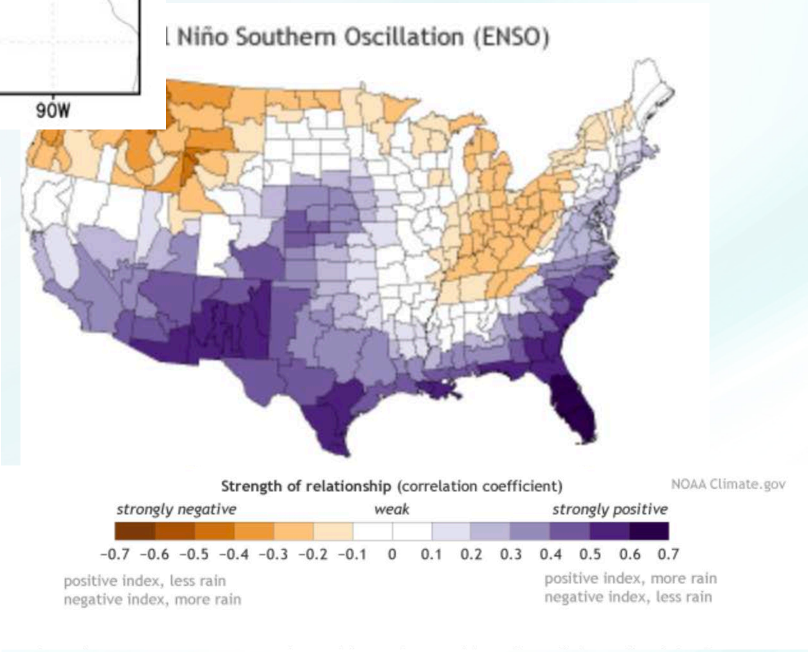


ENSO index

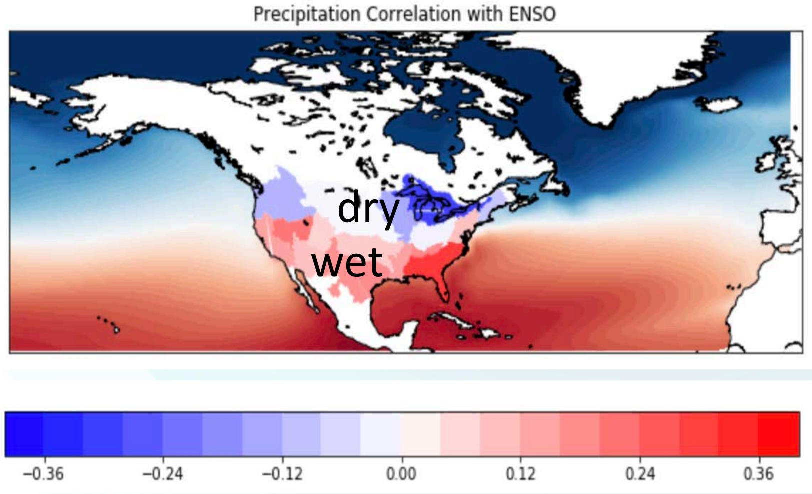


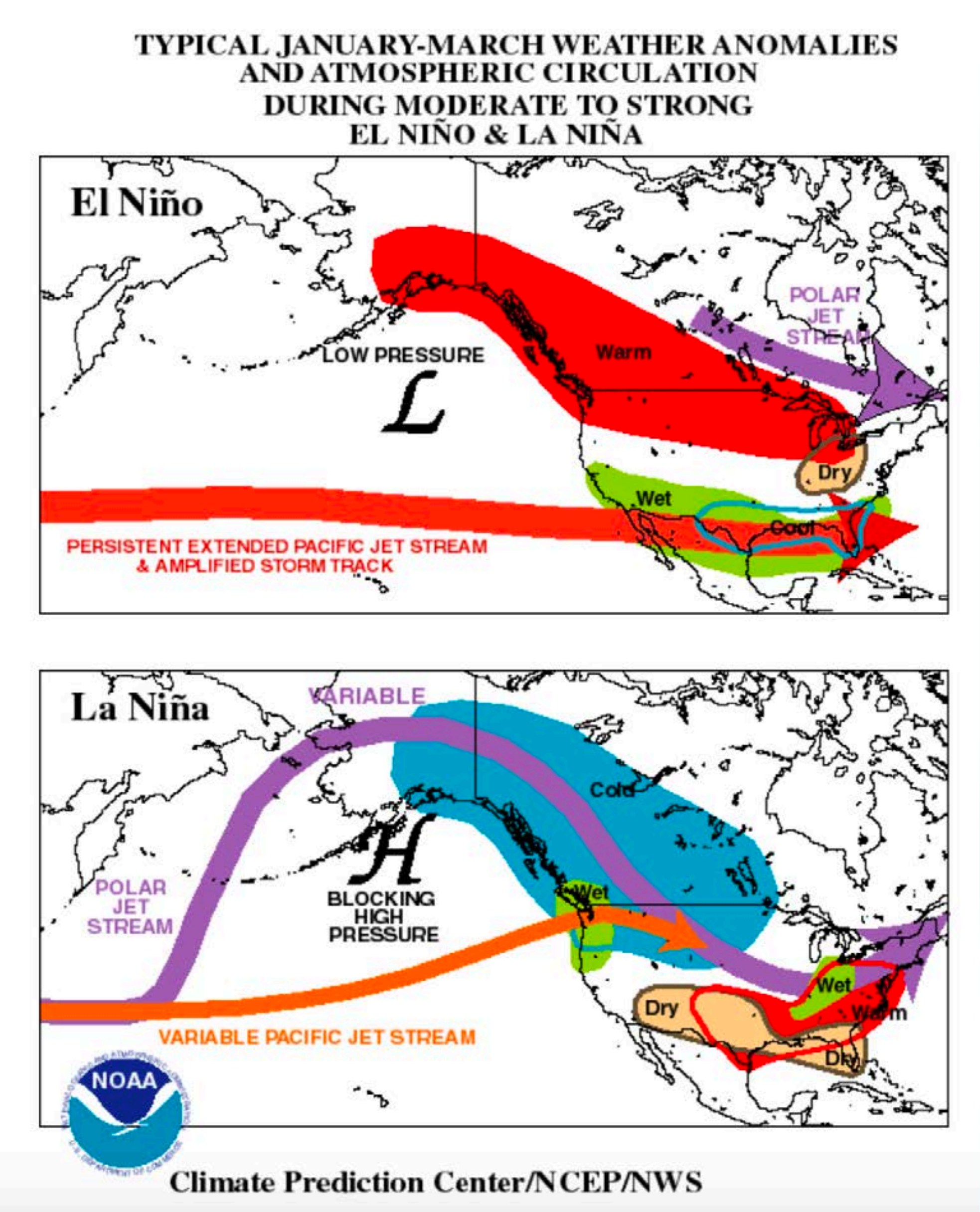
month





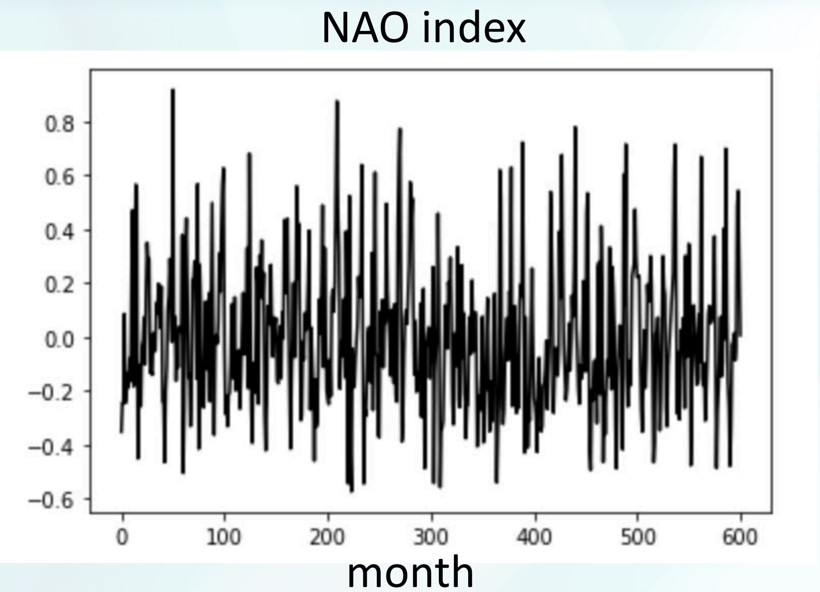
ENSO

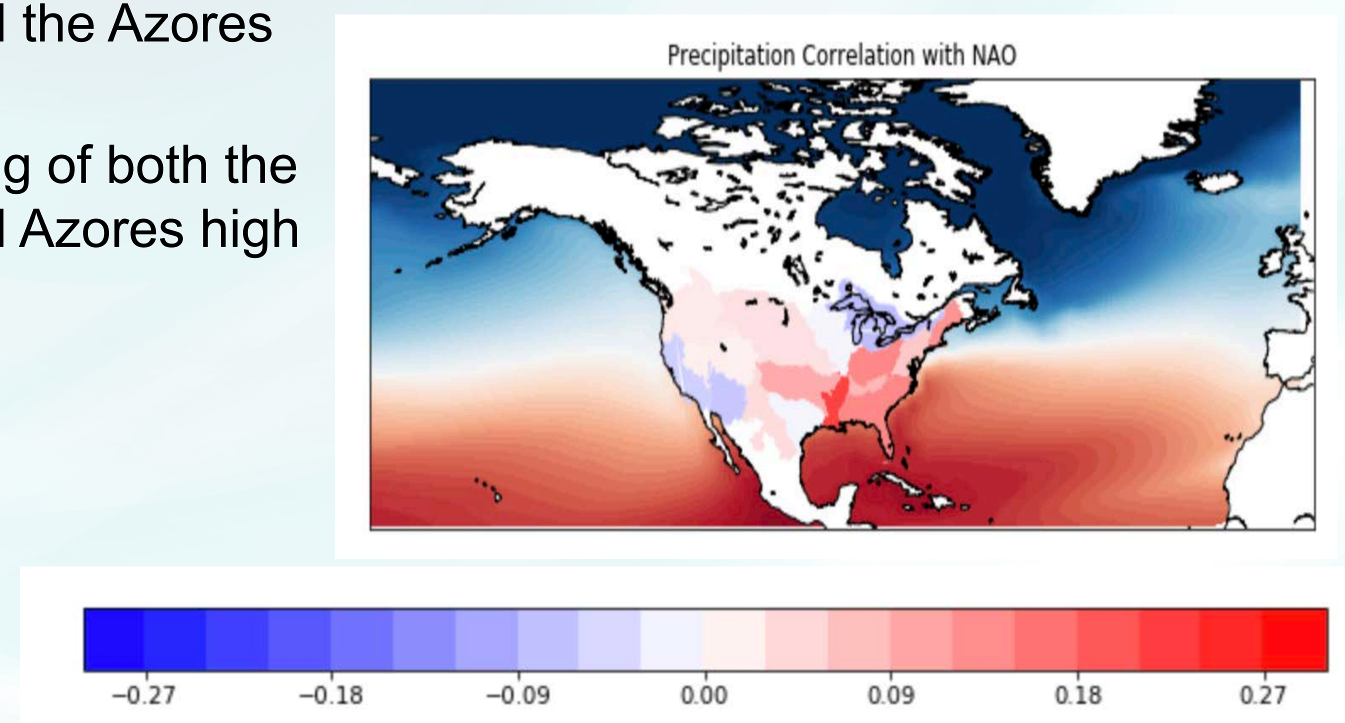

Precipitation Correlation with ENSO
dry
wet
−0.36
−0.24
−0.12
0.00
0.12
0.24
0.36


TYPICAL JANUARY-MARCH WEATHER ANOMALIES
AND ATMOSPHERIC CIRCULATION
DURING MODERATE TO STRONG
EL NIÑO & LA NIÑA
El Niño
LOW PRESSURE
L
Warm
POLAR JET STREAM
Dry
Wet
Cool
PERSISTENT EXTENDED PACIFIC JET STREAM
& AMPLIFIED STORM TRACK
La Niña
VARIABLE
Cold
H
BLOCKING HIGH PRESSURE
POLAR JET STREAM
Wet
Dry
Wet
Warm
Dry
VARIABLE PACIFIC JET STREAM
NOAA
Climate Prediction Center/NCEP/NWS

NAO

- NAO can be calculated as the normalized sea level pressure difference between Reykjavik and Lisbon
  - + NAO=strengthening of the Icelandic low and the Azores high
  - -NAO= weakening of both the Icelandic low and Azores high





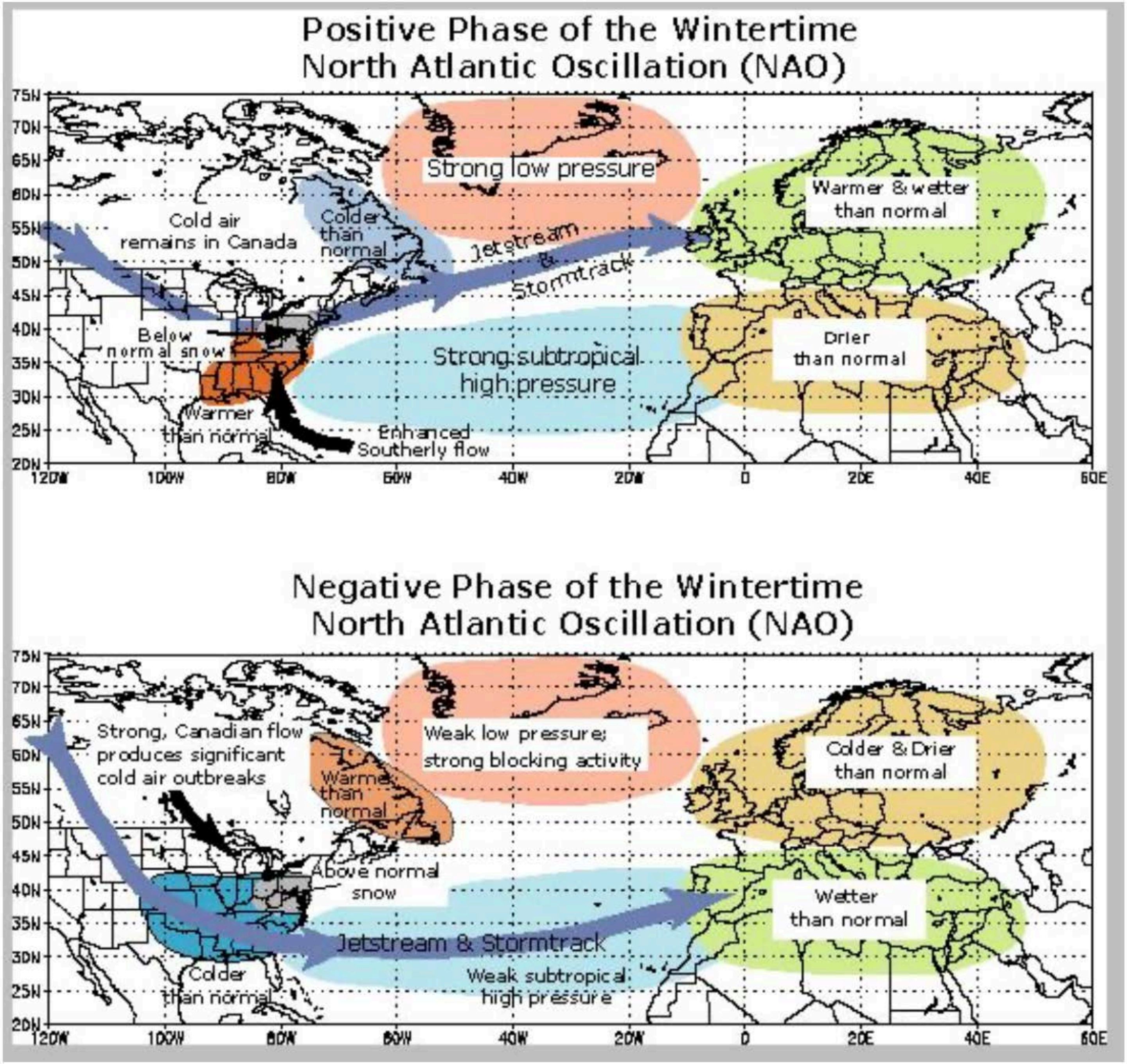
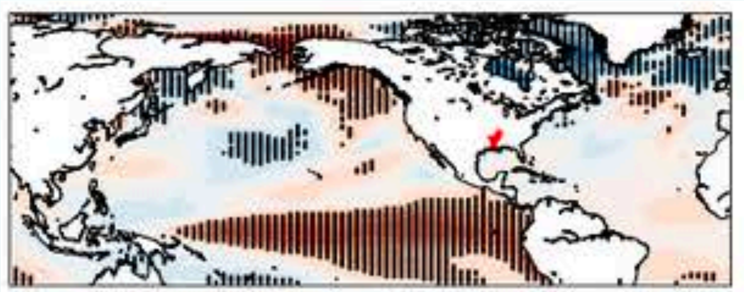


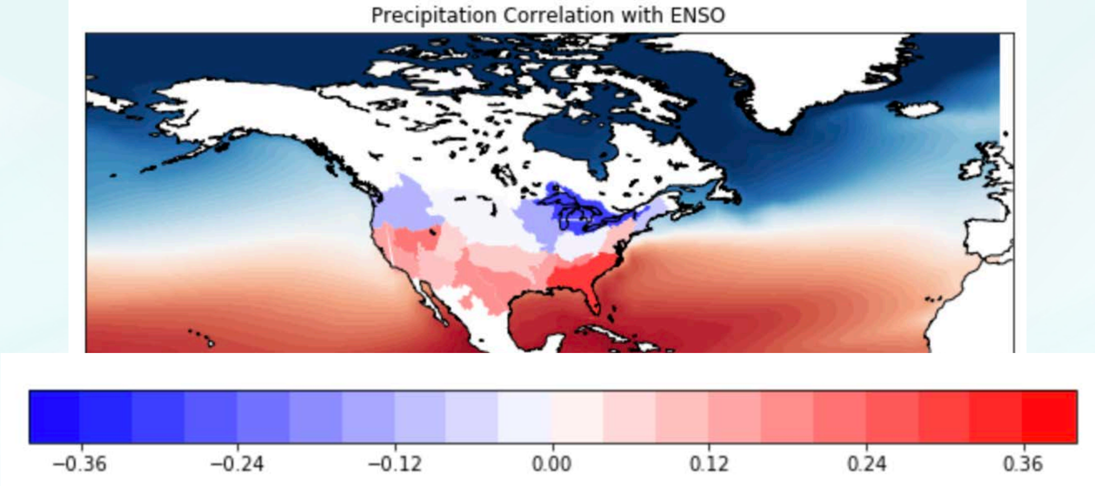
Figure B. Phases of the North Atlantic Oscillation. (Image from NCEI).

Summary

- We can now pinpoint specific locations where SST affects drought/wetness across the U.S. in E3SM



- Most watersheds across the U.S. are influenced primarily by variability in decadal oscillations, especially ENSO and NAO



- NAO and ENSO affect precipitation patterns as expected across the U.S.

In progress

- Projection, high resolution run correlations
- Chlorophyll
- Other ideas?