ENSO Diversity, Teleconnections and Impacts

Antonietta Capotondi

University of Colorado, CIRES
NOAA Earth System Research Laboratory, PSD

ENSO diversity has been associated with different teleconnections and impact.
How well do we know it?

Focus on US West Coast SST and SSH anomalies

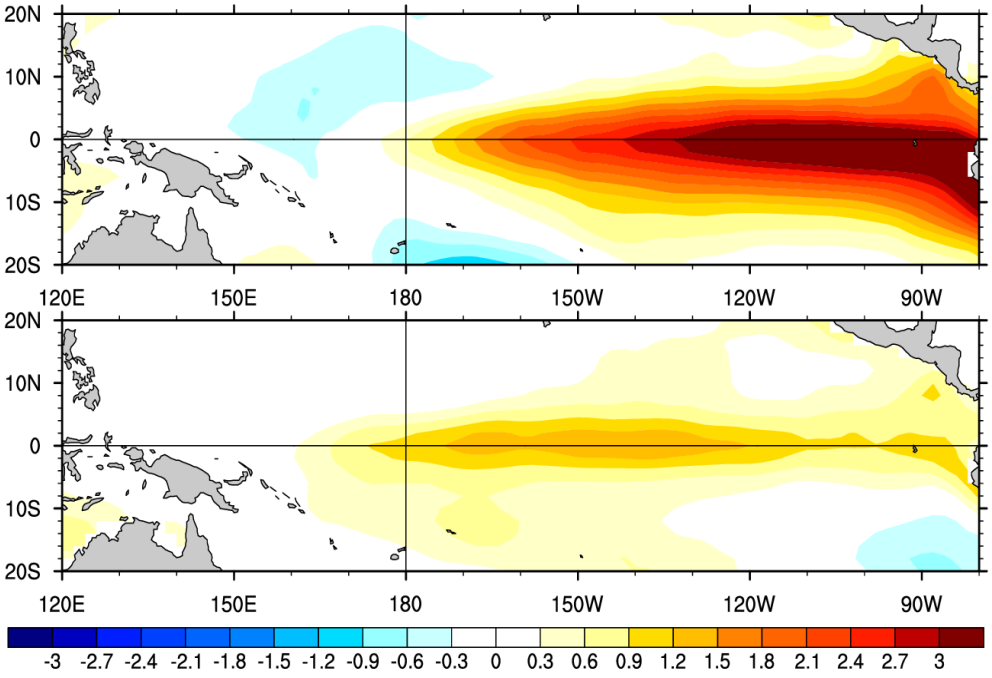
ENSO diversity has been primarily identified with different SST patterns characterized by SST maximum at different longitudes

EP

1997/98

CP

2002/03



NOAA ERSSTv3b

Intense rainfall and floods in the eastern Pacific regions

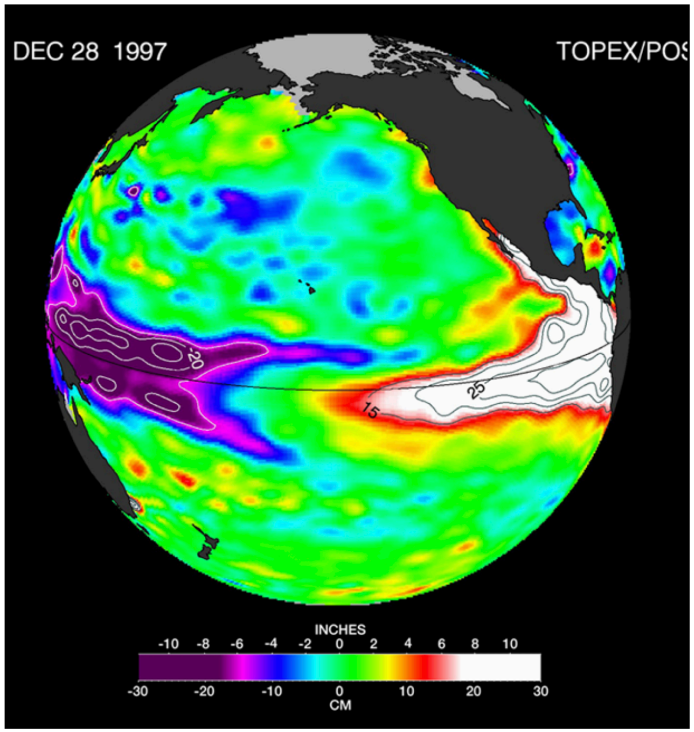
Reduced precipitation over India, northern and eastern Australia

Southern Hemisphere wintertime storm track activity -> Temperature anomalies over Antarctica

ENSO is an important source of predictability for the US West Coast SST and SSH

ENSO influence occurs through oceanic and atmospheric pathways

The Oceanic Pathway --- Remote Influences from the Equatorial Pacific



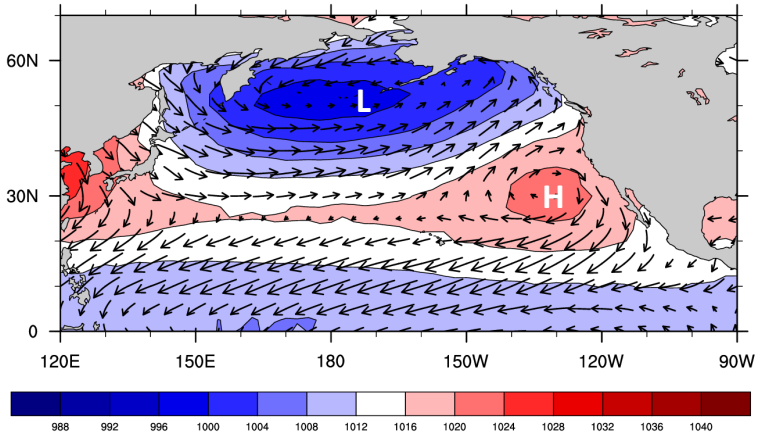
Credit: NASA/JPL-Caltech

Sea Surface Height Anomalies on December 28, 1997 from Topex/Poseidon altimeter

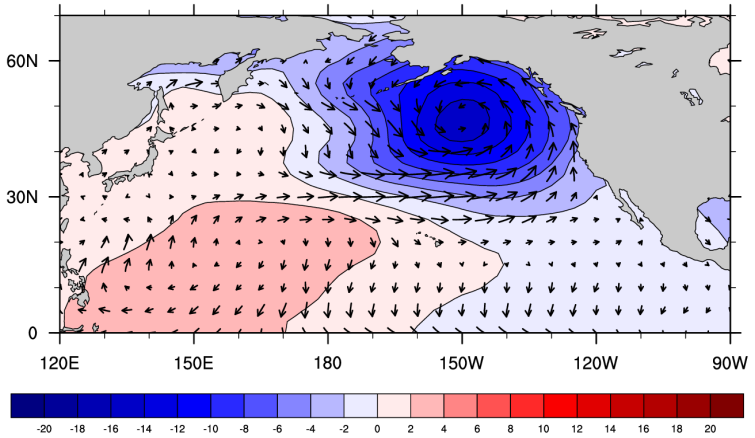
During El Niño events raised sea level (deeper thermocline) in the eastern equatorial Pacific propagates northward along the coast as coastally trapped Kelvin waves.

Atmospheric Pathway: Modulation of the Aleutian Low

Mean SLP in Winter (DJF)
NCEP/NCAR Reanalysis,
1960-2017



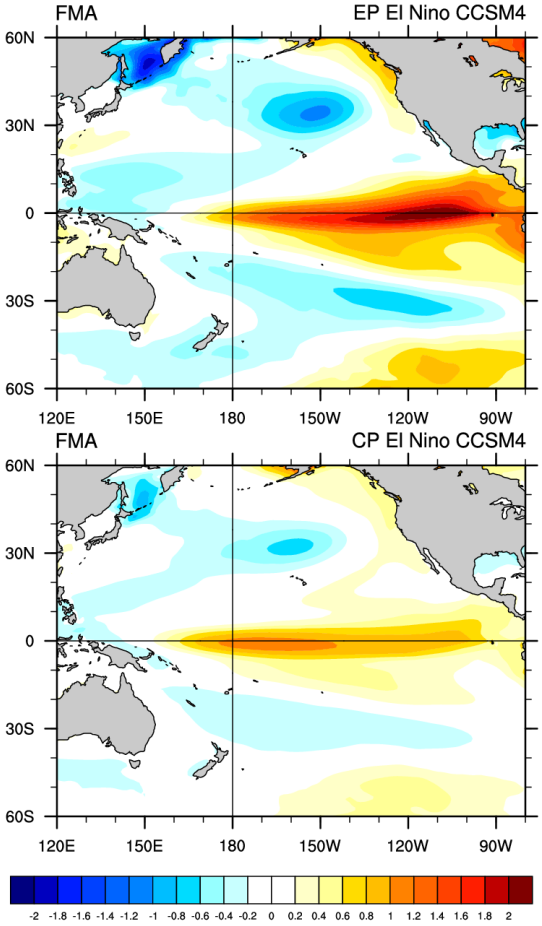
SLP and Wind anomalies
DJF 1982/1983



Composites of SST for EP and CP events identifies with the Niño1+2 and Niño4 indices.

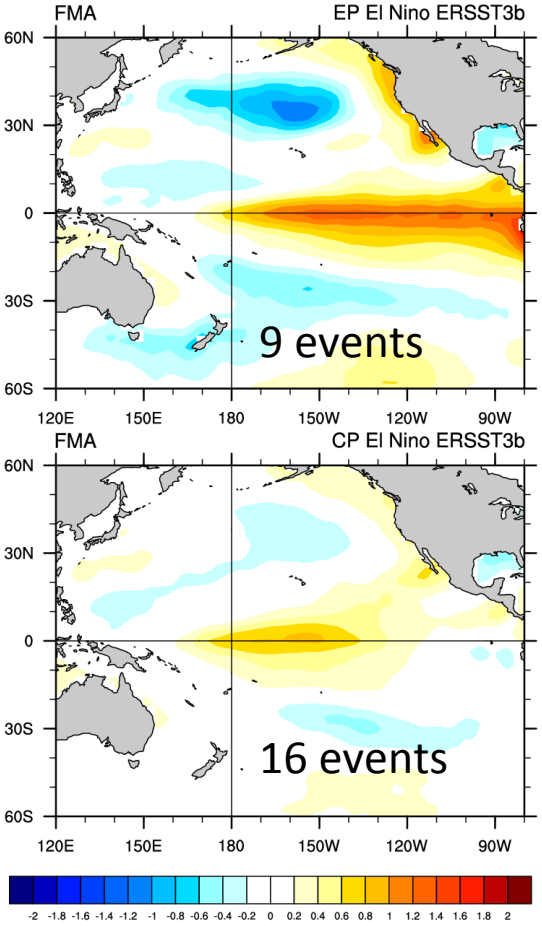
CCSM4 (1300 years)

FMA



ERSST.v3b (1920-2013)

FMA



Response is very similar for EP and CP events but weaker of CP, unclear whether this is due to difference in pattern or amplitude

What are the optimal tropical conditions that maximize SST and SSH along the US West Coast?

Barsugli and Sardeshmukh, 2002: "Global atmospheric sensitivities to tropical SST anomalies throughout the Indo-Pacific basin"

Hoerling and Kumar, 2003: "The perfect ocean for drought"

Shin, Sardeshmukh, and Webb, 2003: "Optimal tropical SST forcing of North American drought"

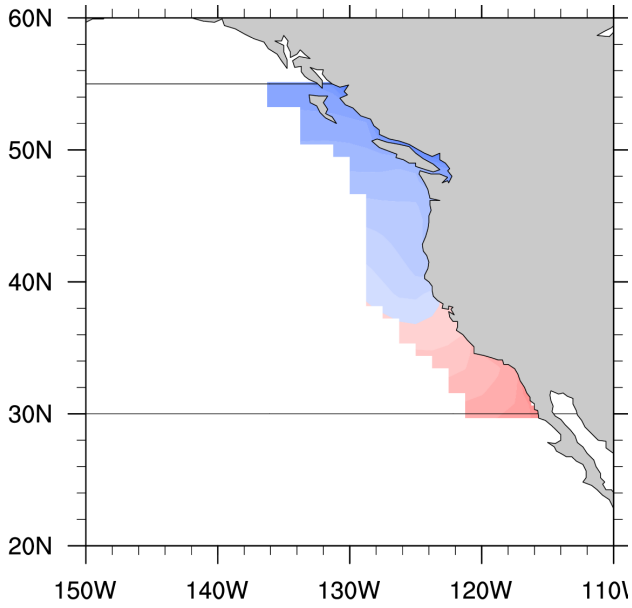
Capotondi and Sardeshmukh, 2015: "Optimal precursors of different types of ENSO events"

What are the optimal tropical conditions that maximize SST and SSH along the US West Coast?

$\boldsymbol{y}(\tau) = \boldsymbol{H}(\tau)\ \boldsymbol{x}(0)$

$\boldsymbol{y}(\tau)$ target quantity at lag τ
$\boldsymbol{x}$ (0) Tropical Pacific conditions at lag 0
Optimal $\boldsymbol{x}$ is the leading right singular vector of $\boldsymbol{H}$

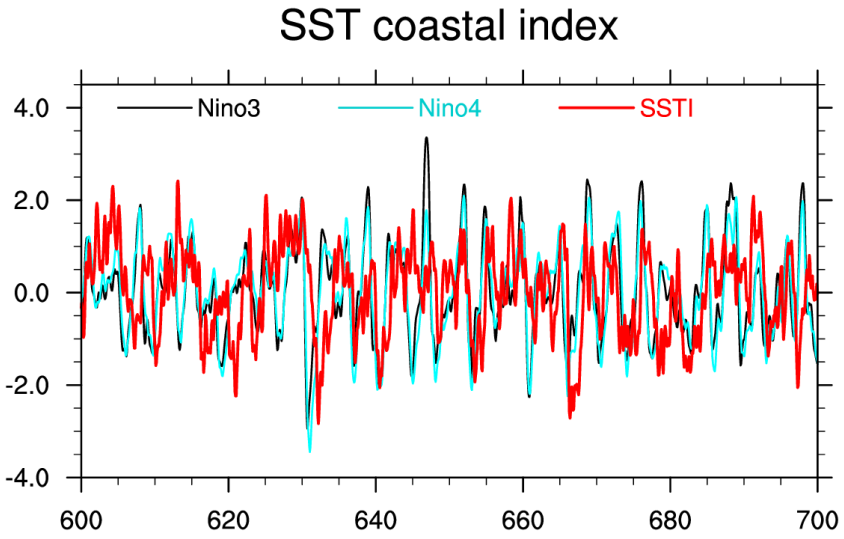
Use output from pre-industrial CCSM4 control simulation (1300 years)

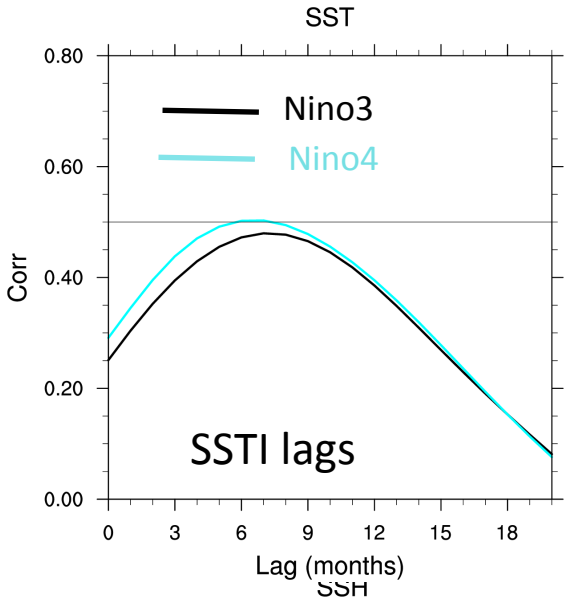


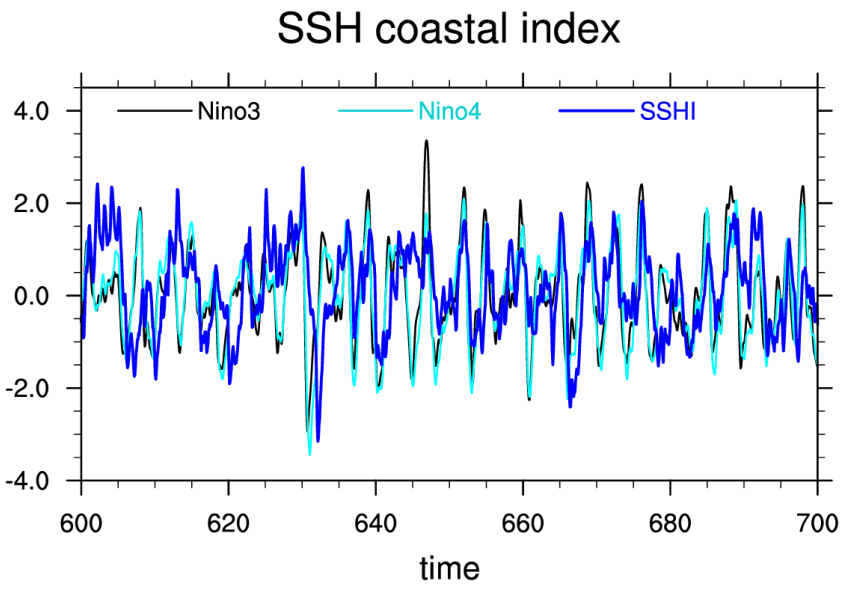
Indices of SST and SSH are determined by averaging the fields in a coastal band extending from 30º to 55ºN

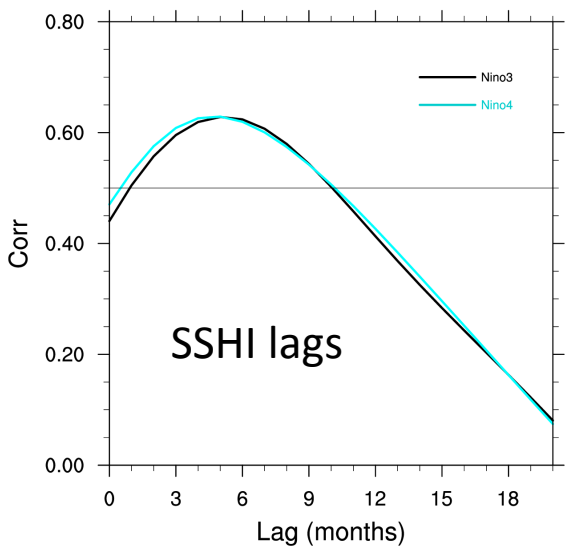
y = coastal index
$\boldsymbol{x}$ = tropical Pacific SSTAs in 25ºS-25ºN

Nino3 and Nino4 indices are well correlated with SST and SSH along the coast

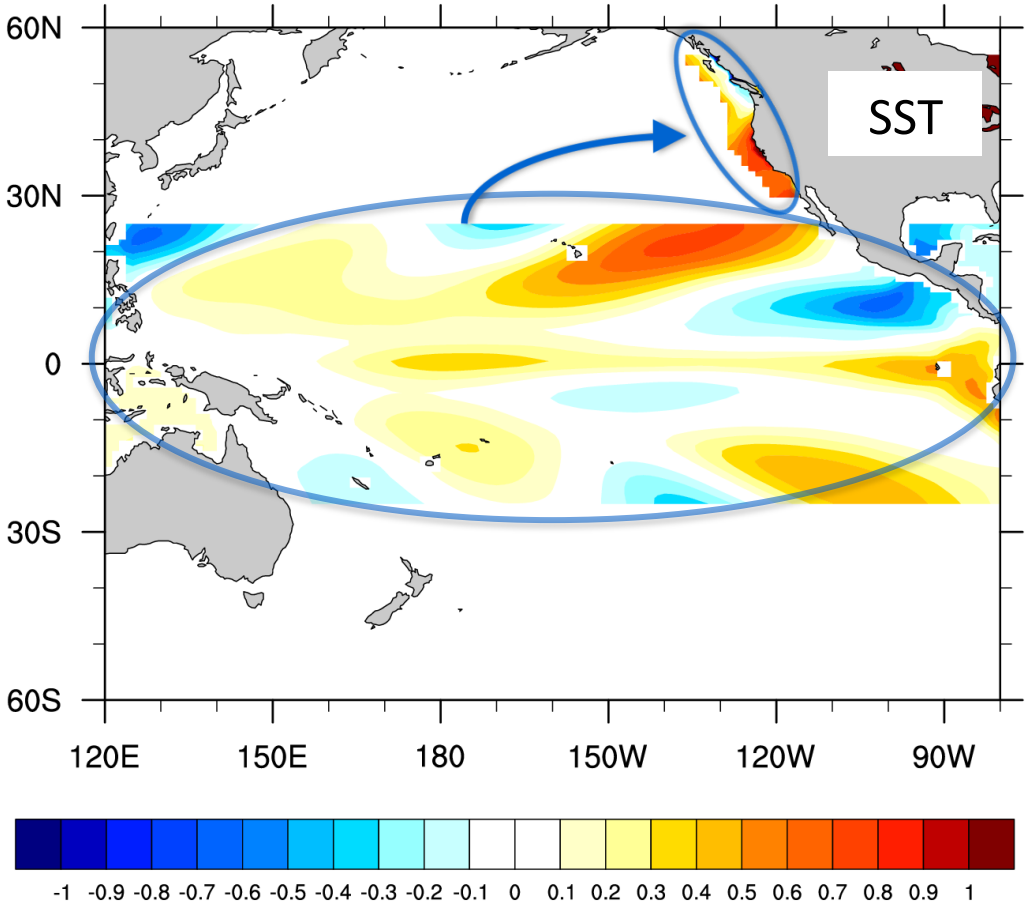








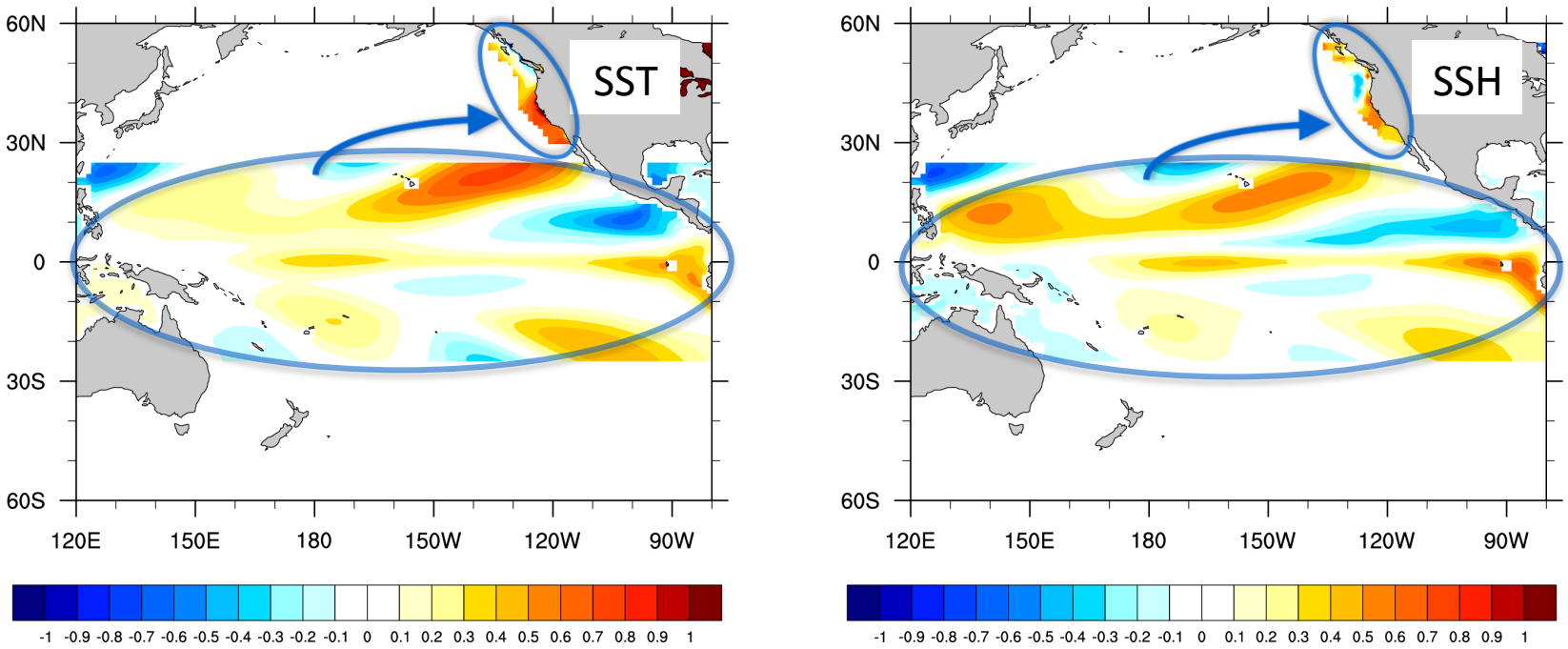
What is the tropical SST pattern that maximizes the SST coastal index at lag τ = 10 months?



The optimal SST pattern does not look like a mature ENSO pattern

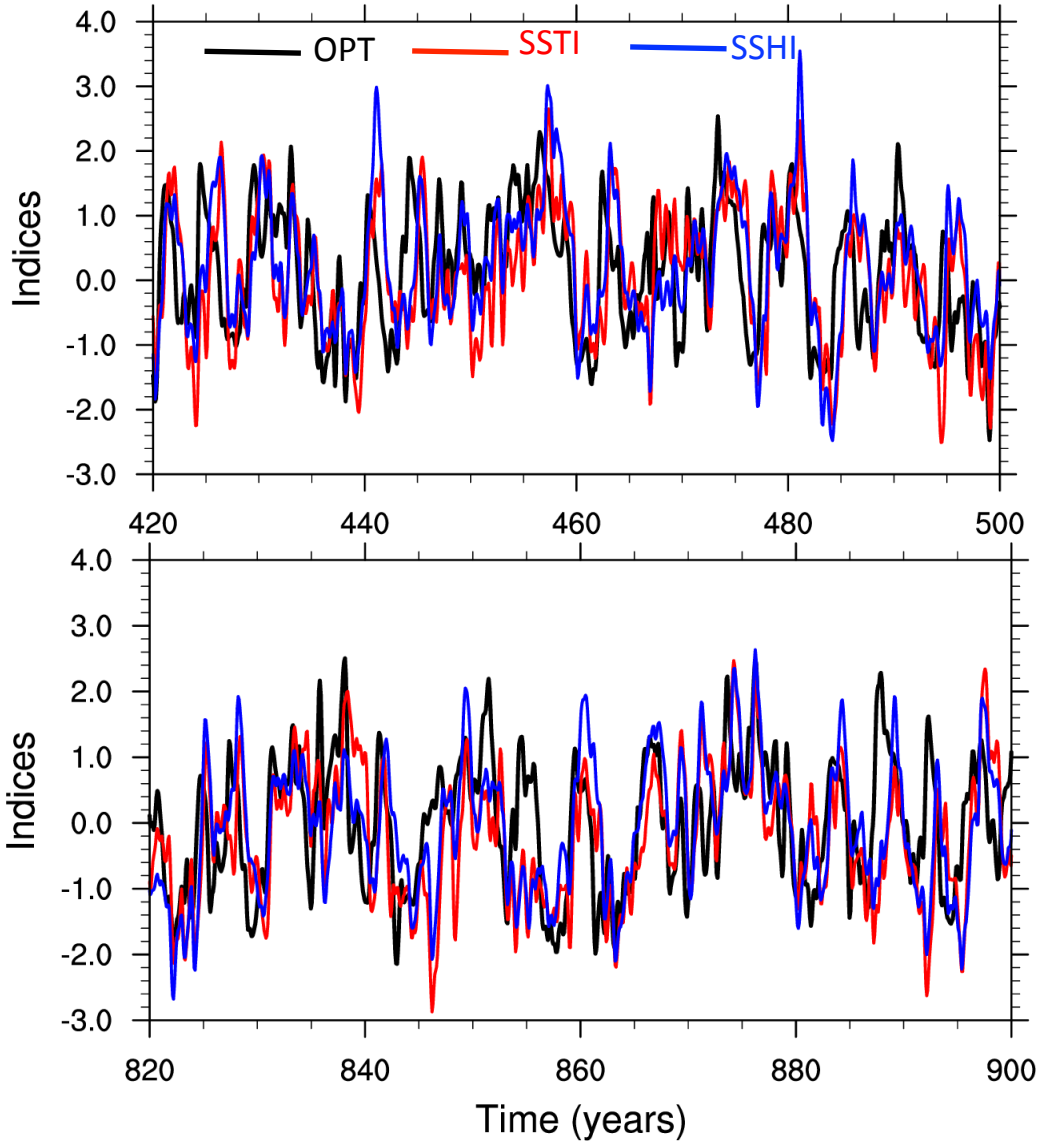
It includes structures similar to some of the ENSO precursors

What is the tropical SST pattern that maximizes the SSH coastal index at lag τ = 10 months?



Optimal tropical SST pattern that maximizes the SSH coastal index is very similar to that for the SST coastal index

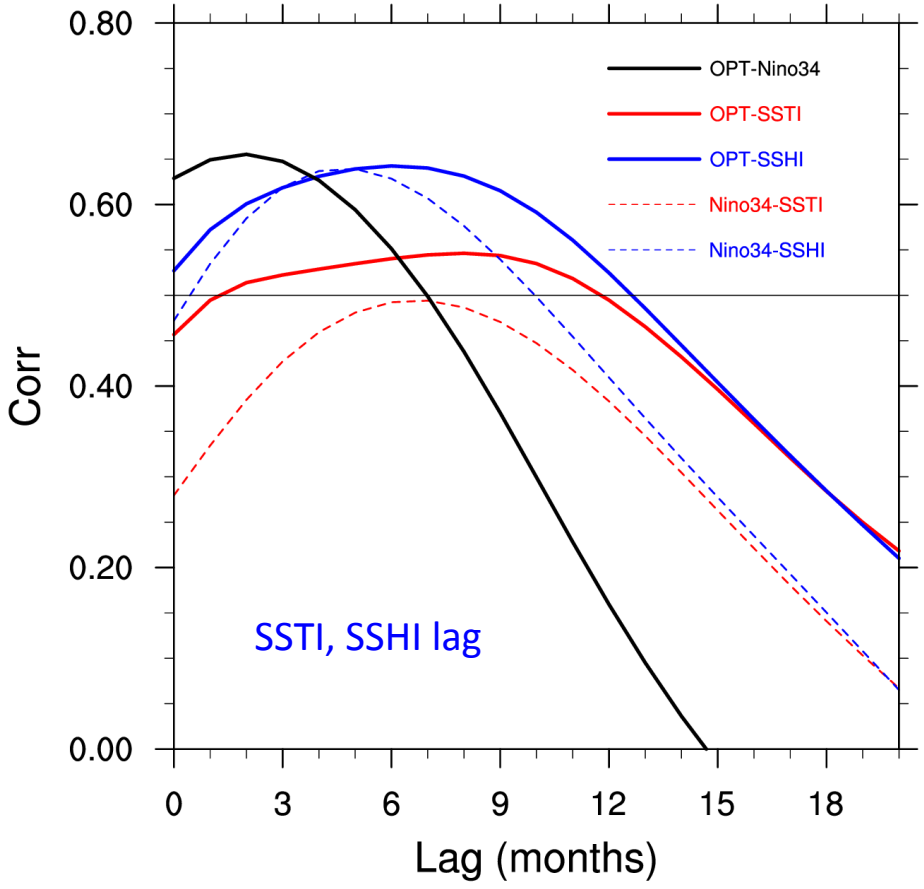
Construct an Optimal Precursor Index (OPT)



There is a good visual correspondence between the optimal index and the coastal indices for SST and SSH

Evidence of decadal modulation

What is the correlation of the Optimal Precursor Index with the coastal indices?

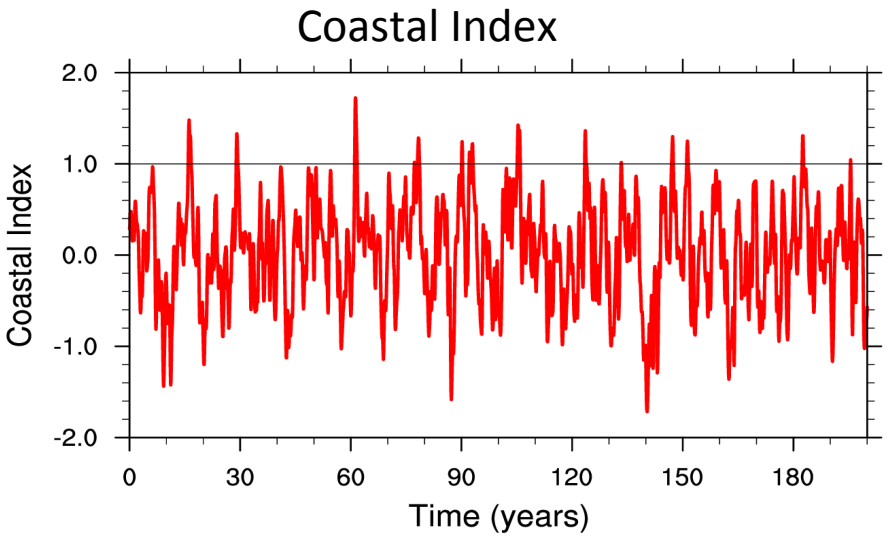


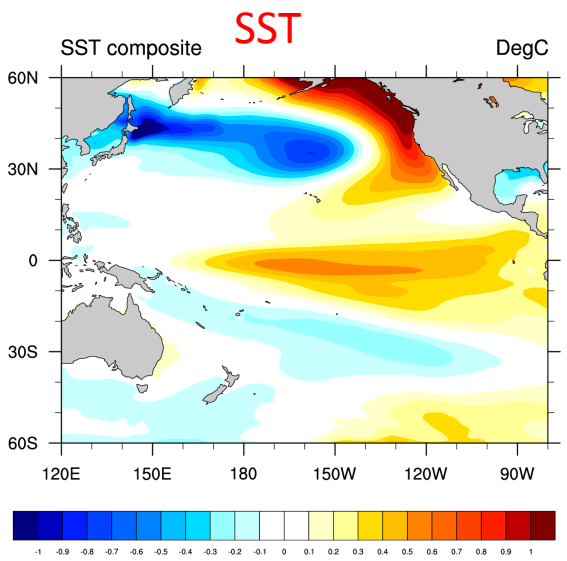
The index OPT associated with the optimal SST pattern has a larger correlation with SSTI and SSHI than the Nino indices at larger lags

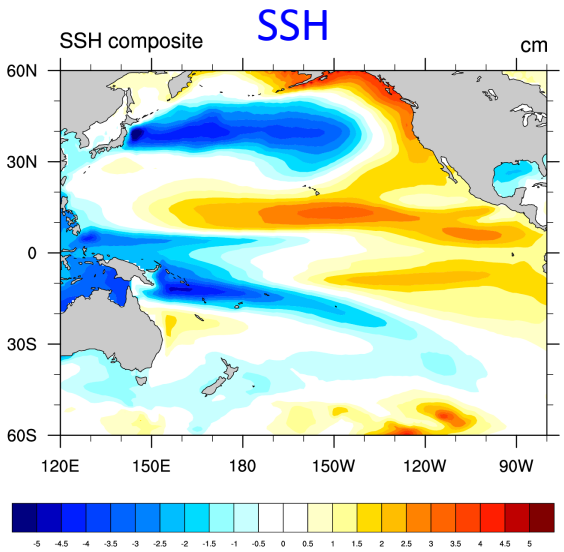
OPT leads the Nino34 index by a few months

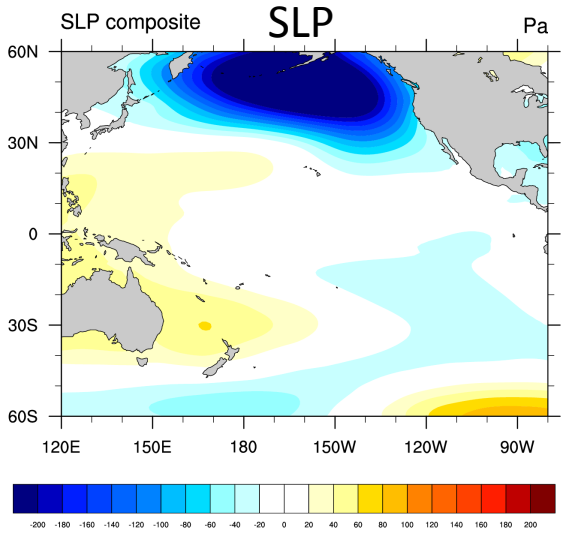
What is the pattern of Pacific SST anomalies associated with max. values of the coastal index?

SST composites at coastal index maxima



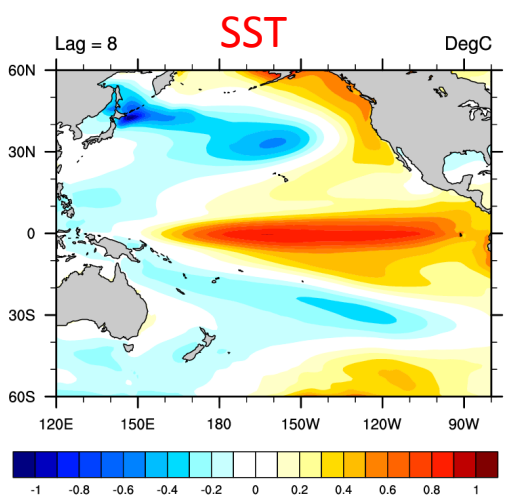


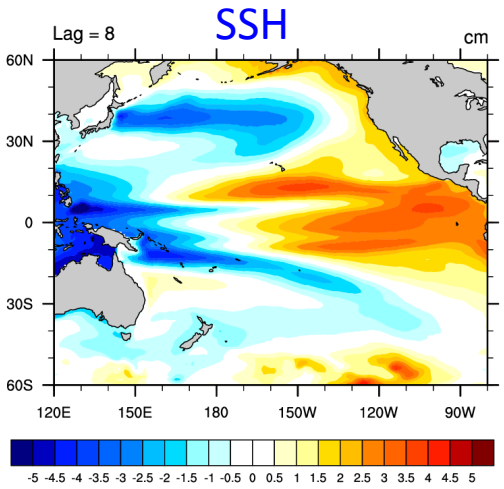


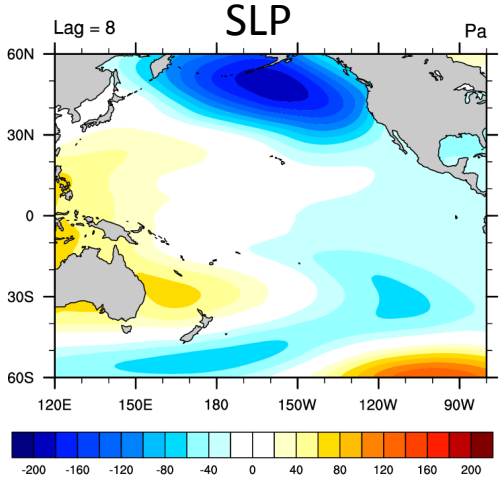


Can the optimal SST pattern be viewed as a precursor for the basin-wide conditions? YES

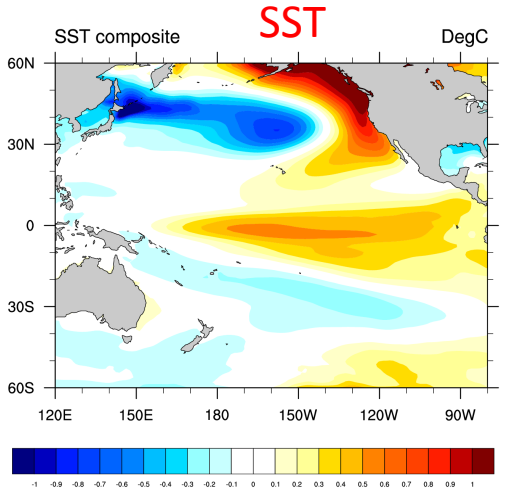
Consider composite conditions 8 months after peaks of optimal precursor index

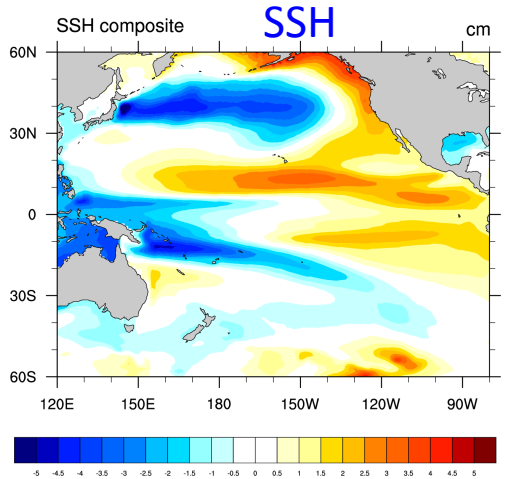


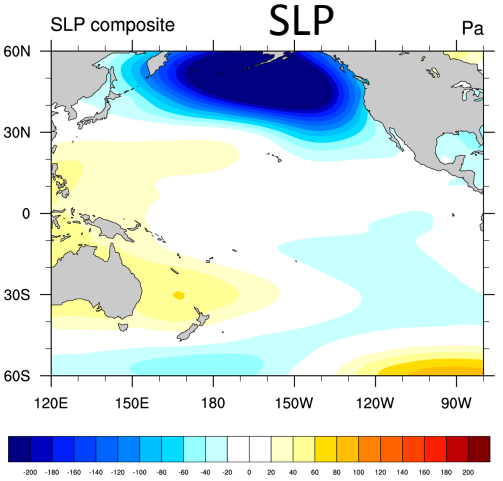


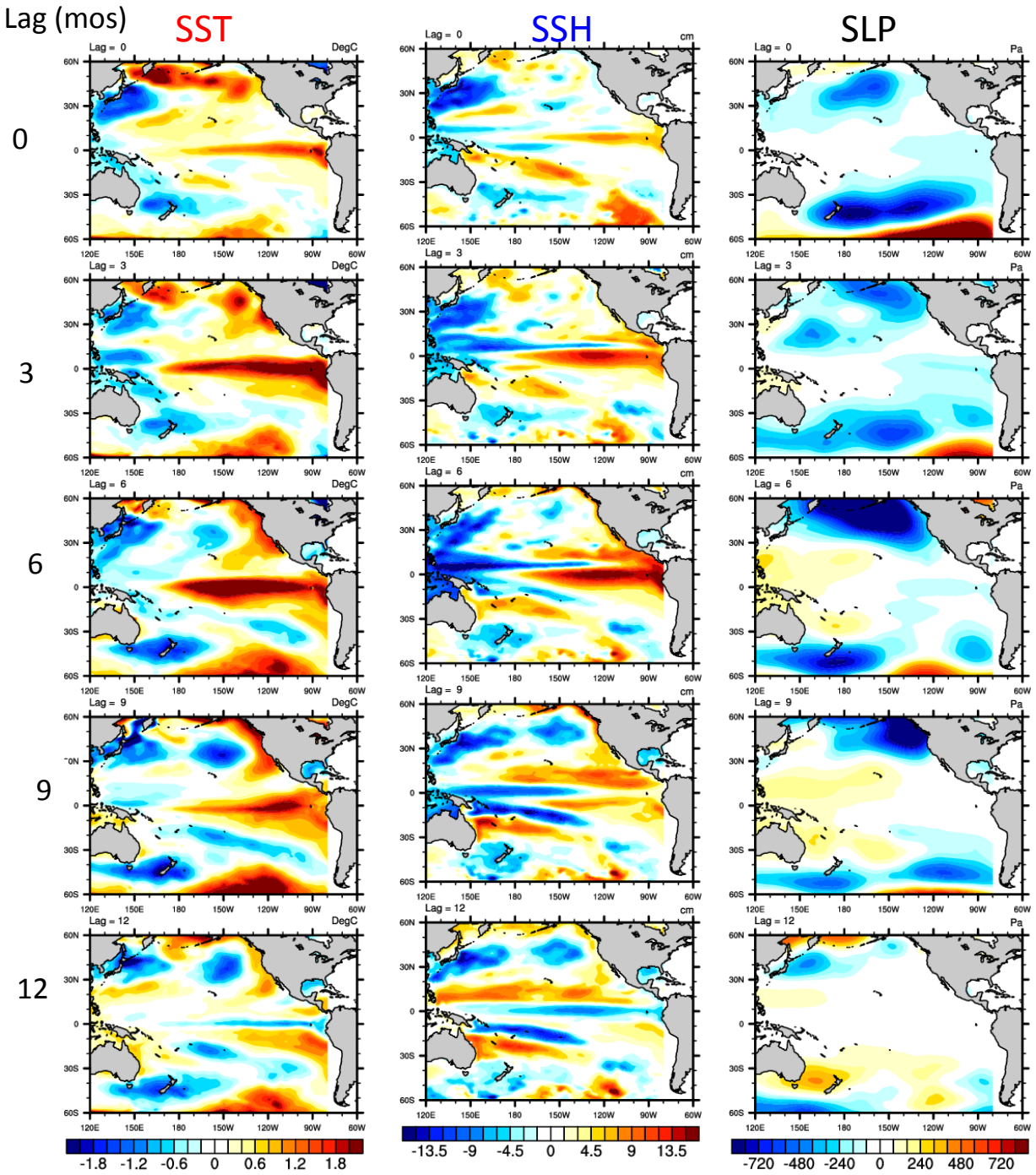


Tropical Pacific composites at coastal index maxima









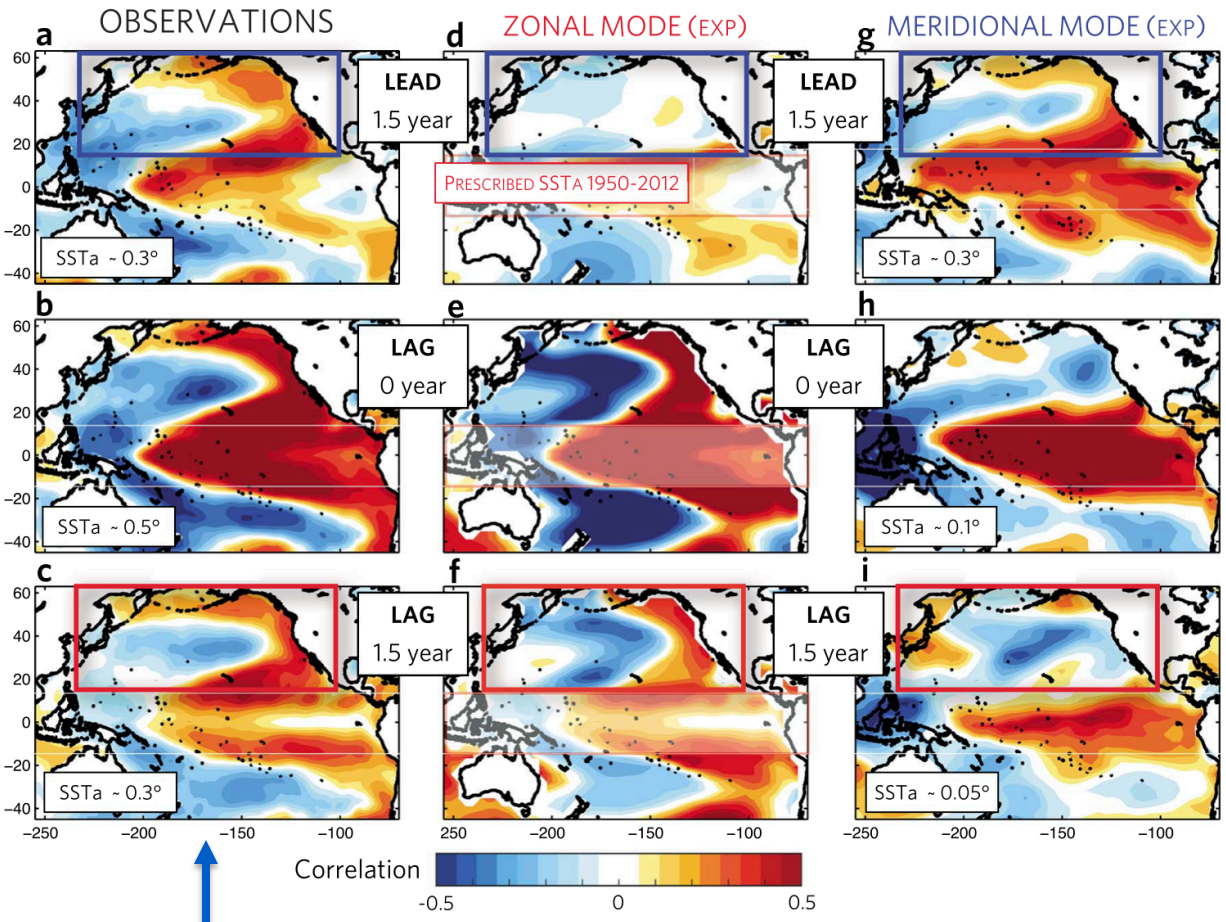
Case study

Evolution of SST, SSH, and SLP fields starting at model year 1034 (Lag 0), when Optimal Precursor Index is maximum

Anomalous large SST and SSH conditions in the coastal region occur throughout the whole evolution of the ENSO event, from the growing to decaying phase

Meridional Modes play a key role in Pacific decadal variability

(Di Lorenzo et al. 2015)



Correlation between leading PC of low-pass filter SSTAs (timescales > 8 years) and SSTAs over the entire basin

Conclusions

1. The tropical SST patterns that SST and SLA along the US West are more sensitive to do not necessarily coincide with a mature ENSO pattern.
2. ENSO precursors (North Pacific Meridional Mode) appear to play an important role in both promoting ENSO growth and influencing US West Coast anomalies.
3. ENSO is a complex phenomenon that cannot be characterized by one index. Its entire pattern evolution needs to be considered.
4. Decadal variability can be expected to influence the US West Coast and modulate ENSO impacts (e.g. Di Lorenzo et al. 2015)