Pacific Marine Environmental Laboratory

Ocean Climate Research

Thermal Modeling and Analysis Project (TMAP)

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Background - 1

TMAP works:

- **To understand the characteristics of air-sea climate patterns that have societal impact and the mechanisms that create them,**
- On strategies to observe them effectively
- **With indices of them to facilitate the delivery of climate services.**

ENSO has been a focus.

Background - 2

Roughly half time (DEH) on national and international global climate observing system planning, coordination and oversight.

- Chaired Ocean Observations Panel for Climate (GOOS/GCOS/WCRP),
- **Led ocean part of GCOS Implementation Plan & its Satellite Supplement (UNFCC, GOOS, GCOS, WCRP, GEO),**
- Chairs CPO/COD Climate Observing System Council,
- **Co-organized Ocean Obs 2009 and GODAE/Oceanview Symposia.**
- GCOS Steering Committee.
- **Active in JCOMM (Mgmt Ctee, Obs Coord. Gp., T.T. Climate Chng. Indices, T.T. Fisheries & climate).**
- Other (see CV)

Background - 3

Some Recent Research Areas:

- Multi-decadal variability*
- **Central Pac. vs Eastern Pac. El Nino events***
- Indices for US ENSO seasonal impacts*
- **Onset of La Nina events**
- ENSO effects on atmospheric CO2 rise

* will show some results

Quality & Performance

24 refereed publications, ‘08-’14

Local, national and international co-authors

Recent ISI citations ~150/yr, H=31

1 PhD. Awarded. M. Carson. U.W. oceanography

Small project. CPO $240k to $210k; *PMEL supports DEH; Dr. Andy Chiodi supported full time as TMAP Co-PI*

Relevance

- **TMAP work addresses the CLIMATE goal of the NOAA and OAR Strategic Plans.**
- Citation statistics and awards suggest ‘preeminent research’ - OAR goal.
- **Ongoing close collaboration with Climate Observations Division of Climate Program Office, including State of the Ocean Climate website.**
- Supports improvement of Seasonal-Interannual Climate Services
- **Engages international partners in plans/activities critical for future of sustained global ocean climate observing system.**

Performance

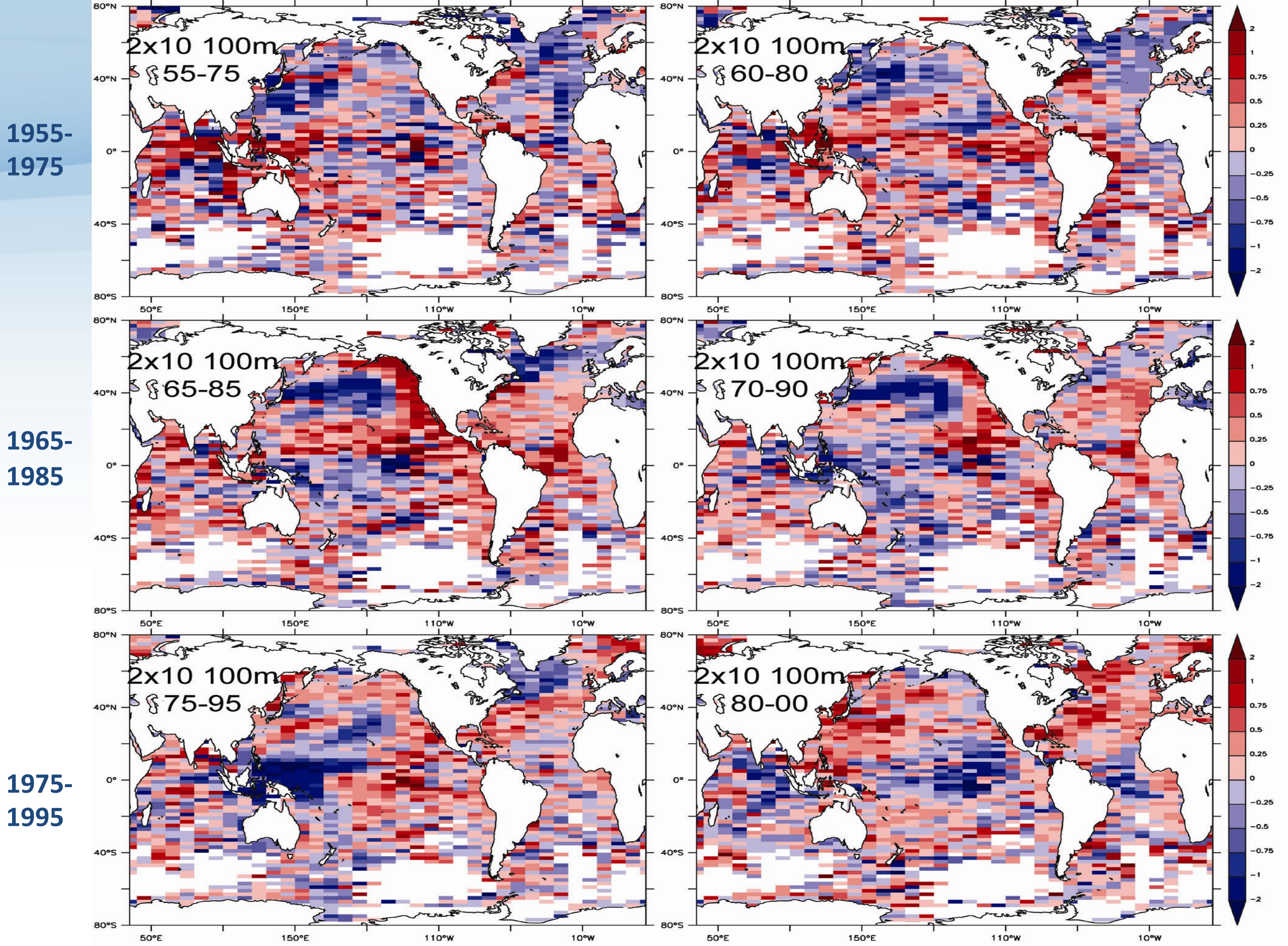
- Let’s look at some research results since the last Lab Review.
- **Start w. two examples of multi-decadal variability.**

20 year T(100m) trends

96% of all regions change sign at least once over the 45-year period

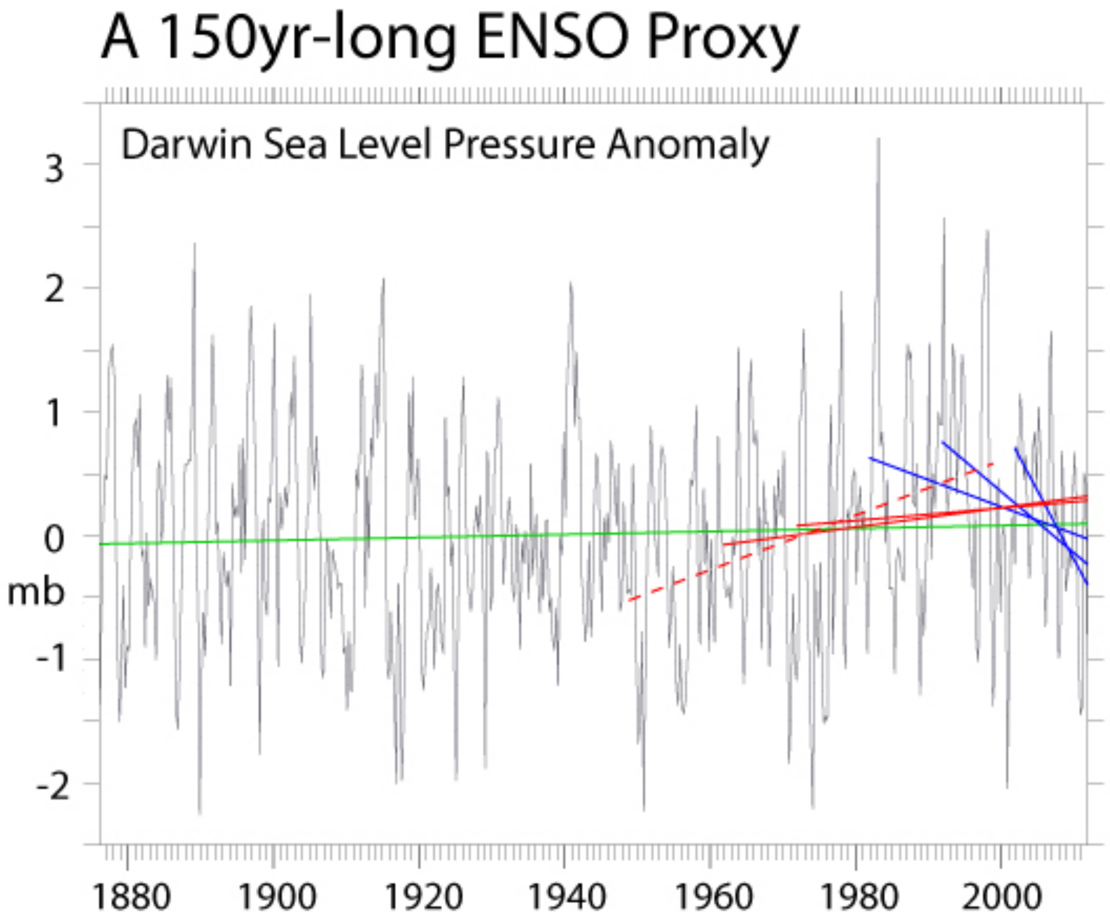
2x10 deg region averages

World Ocean Atlas 2001



Multi-decadal Variability in ENSO

- ENSO has strong low frequency variability, but no 150yr trend.
- **Any random 20-30 year period is unlikely to have similar ENSO characteristics to another.**
- It generally is not ok to extrapolate behavior from one period to the coming period, esp. trends.
- **Implications for e.g., fisheries mgmt., seasonal weather, global change, etc.**



Estimating Trends in ENSO is not a stable process due to multi-decadal variability.

No particular 20 or 30 yr trend is likely to persist over the subsequent 20 or 30 years. No 150yr trend.

ENSO SST anomalies are extensive enough to affect global surface temp. values. Recent 'pause' may be a function of 15yrs w/o major El Nino.

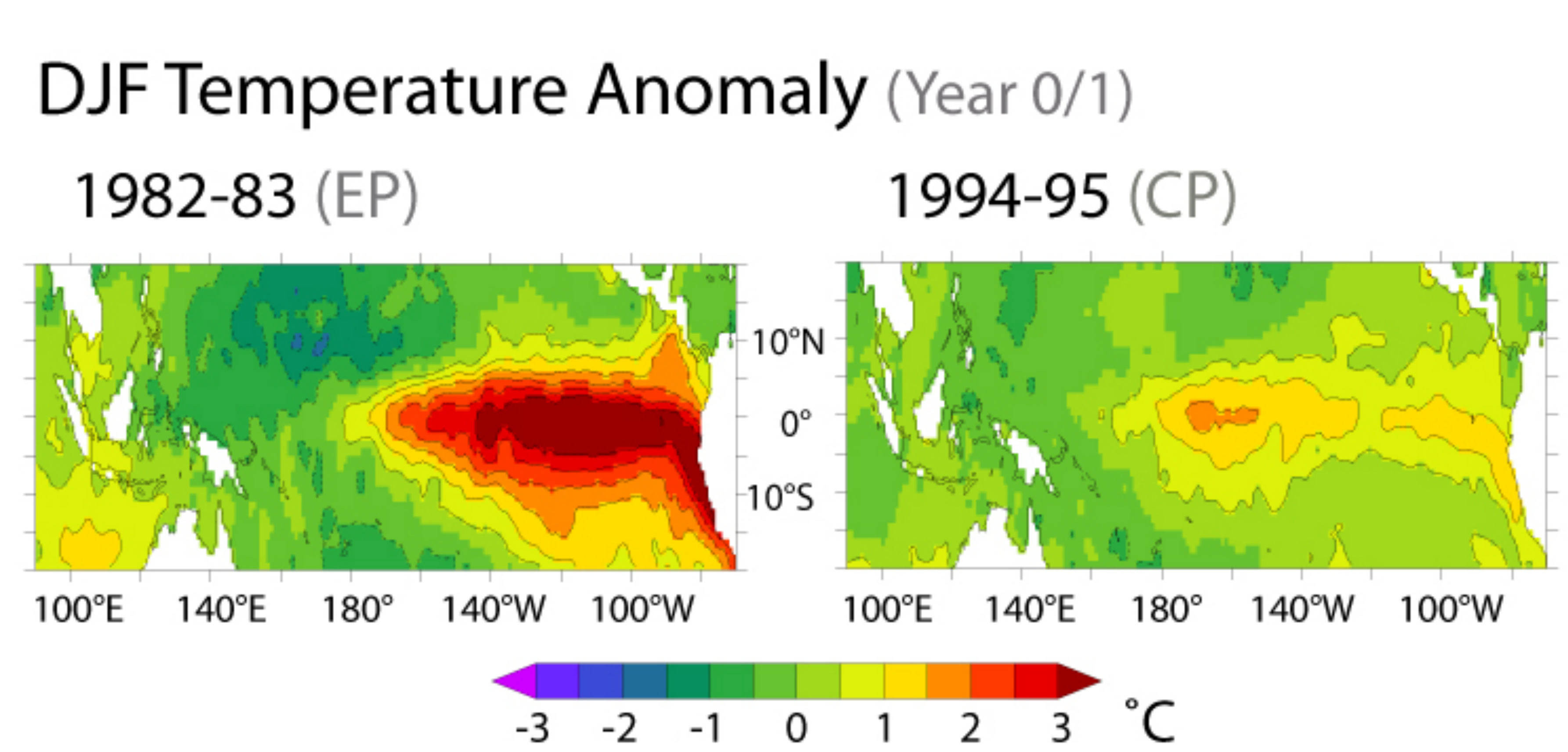
Identifying El Nino and La Nina Events

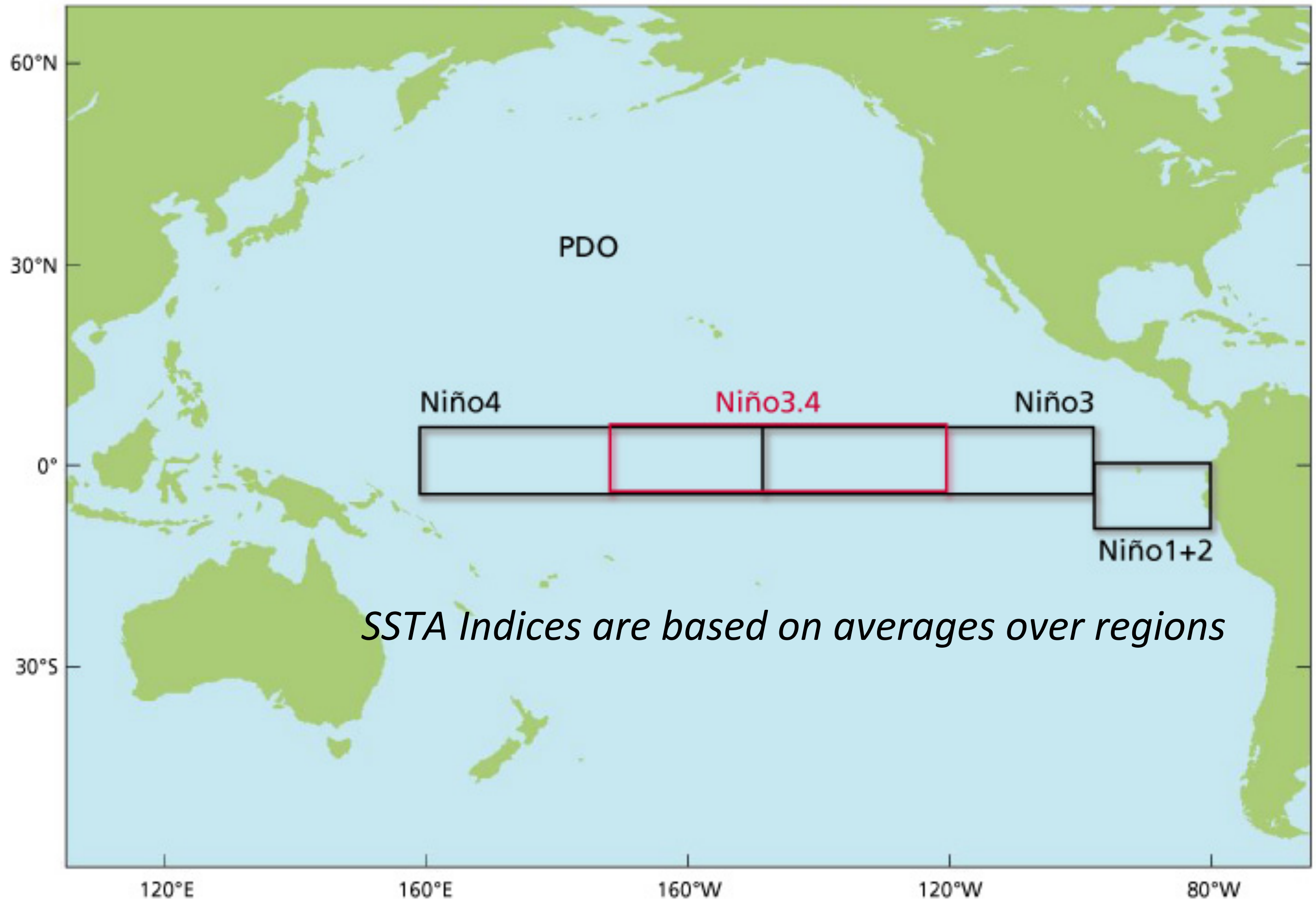
- Nino SSTA indices, SOI, MEI, BEI, and OLR criteria have all been used to define events.
- **Depending upon region and season and impact of interest, different indices will have tighter/different ENSO associations.**
- Will illustrate with one example for North American DJF El Nino weather anomalies
- **Research on best approaches to optimize relationships for each region and each impact is needed and ongoing.**

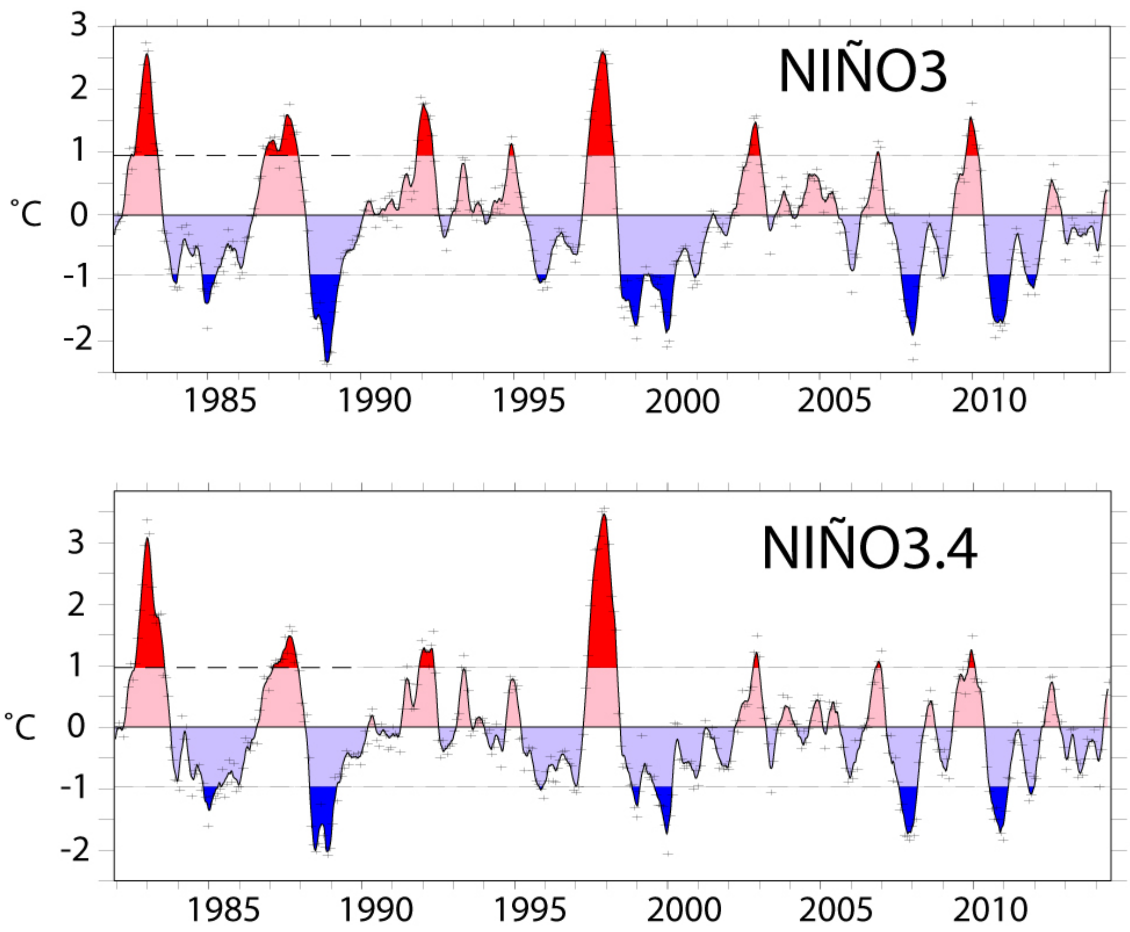
Different Types of El Nino Events

- There are at least two different types of El Nino events, with clearly different US weather impacts.
- **“Eastern Pacific (EP)” events have warming along the equator. from S.Am. coast out through mid-basin and max amplitude in Eastern core of the cold Tongue.**
- “Central Pacific (CP)” events have greatest warming in mid-basin.
- **“CP” events have been more common since ‘97-98 event**
- Some recent SST anomaly plots at peak anomaly illustrate.

Different Types of El Nino Events




60°N
30°N
0°
30°S
120°E
160°E
160°W
120°W
80°W
PDO
Niño4
Niño3.4
Niño3
Niño1+2
SSTA Indices are based on averages over regions



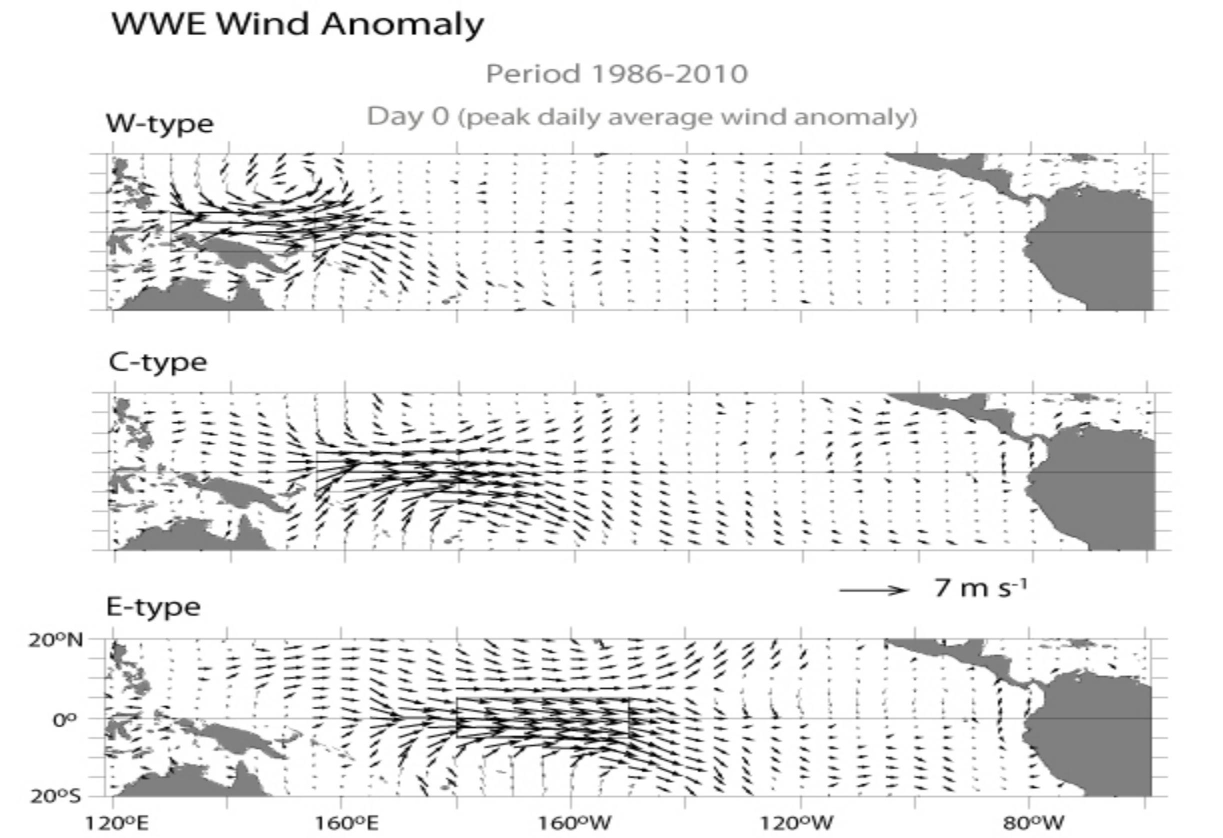
NIÑO3

NIÑO3.4

Note change post 1997: *CP vs EP*

Onset of El Nino Events

- It has been shown that the presence and frequency of Westerly Wind Events is key to the onset of Eastern Pac. El Nino events.
- **We have found that a change in the character of WWEs, since ‘97-98 event can explain appearance of Central Pac. events.**



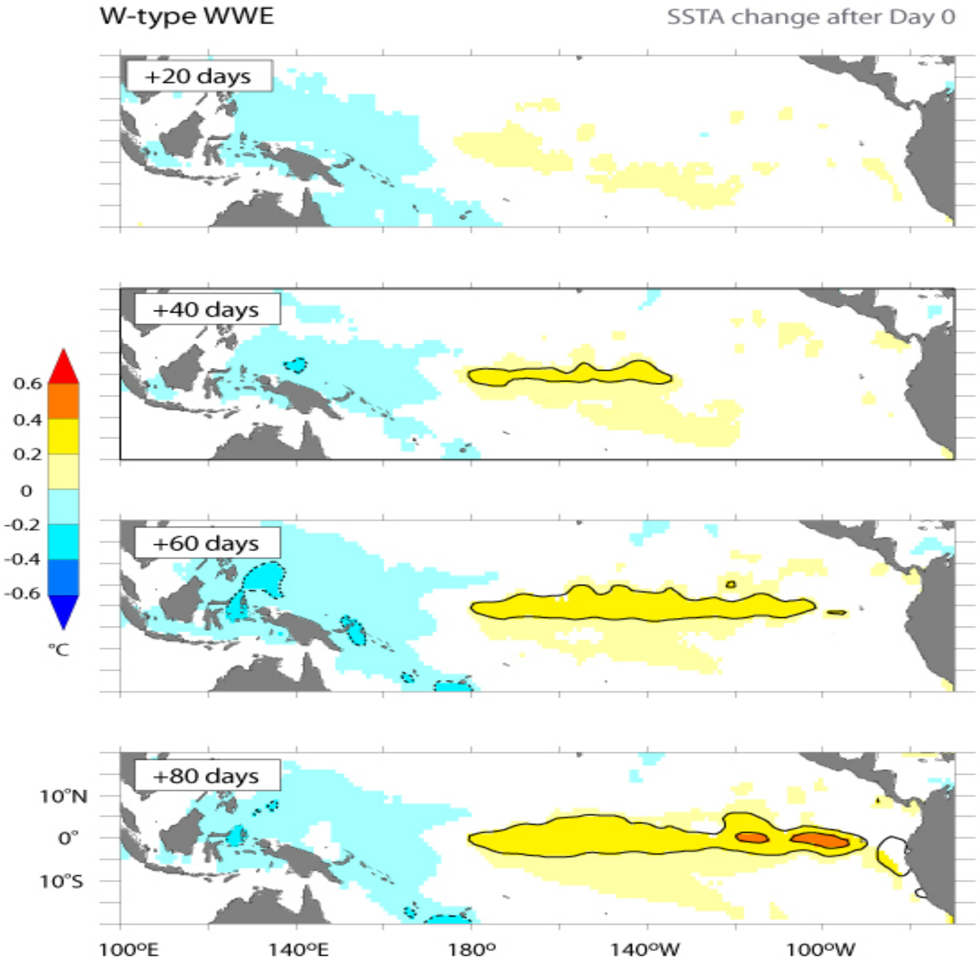
Winds from ECMWF forecasts, RMS ~2m/s vs. TAO

- **WWEs defined based on an objective scheme (Vecchi and Harrison, 1997) which defines "W", "C" and "E" type events based on three equatorial regions.**

- **WWE = any interval of 3 or more consecutive days for which WWE-region average zonal wind anomaly exceeds 2 m/s. Typical max ~7 m/s**

- **"Day 0" is the event-day with maximum zonal wind anomaly**

- **Statistically significant anomalies are seen ~7 days before/after Day 0 in composite**



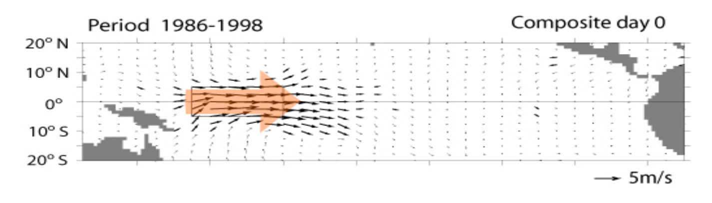
ENSO-neutral conditions, period 1986-2010, shading where statistically significant at 95%

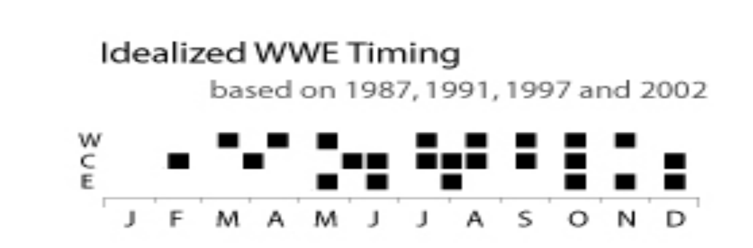
WWEs force waveguide warming.

Statistically significant and coherent EP El Nino type warming occurs following each type of equatorially centered WWE (W, C and E). The warming persists, on average, well into day +80.

Significant warming occurs whether or not there is an MJO. MJO not a factor.

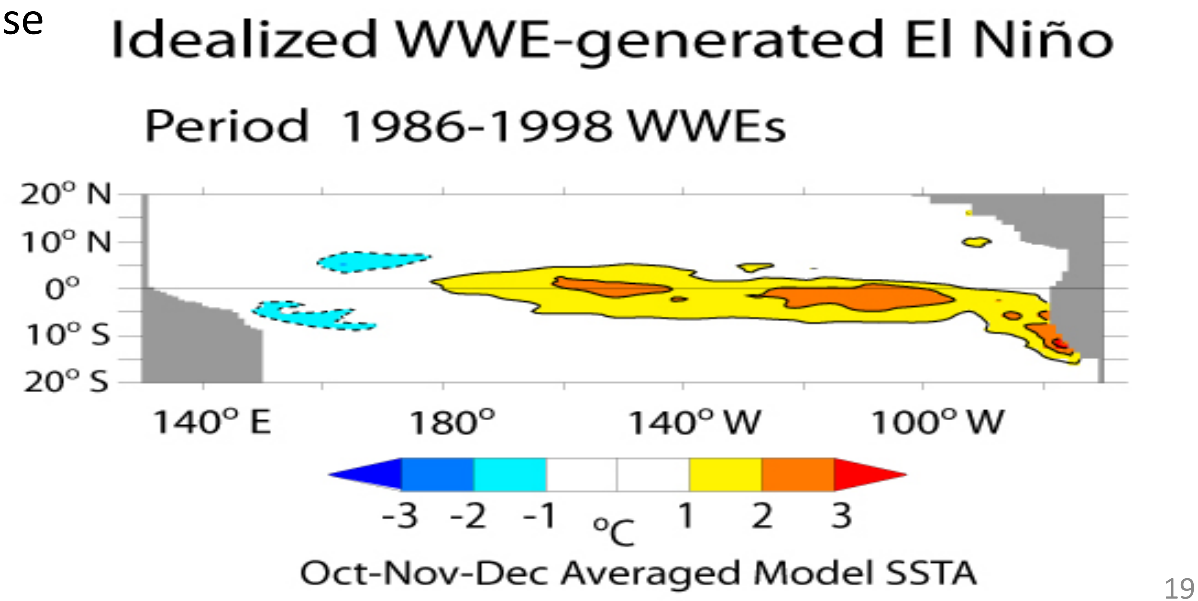
When a series of WWEs, like those just shown, are applied to the model with frequency typical of El Nino years, El Nino-type warming occurs





WWE-region westerlies are the only stat. significant anomalies in this case

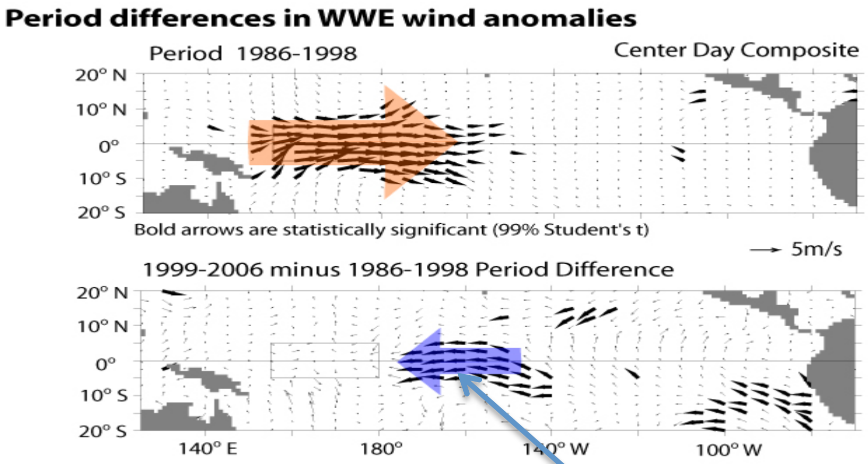
SSTA in ocean model from series of WWEs →

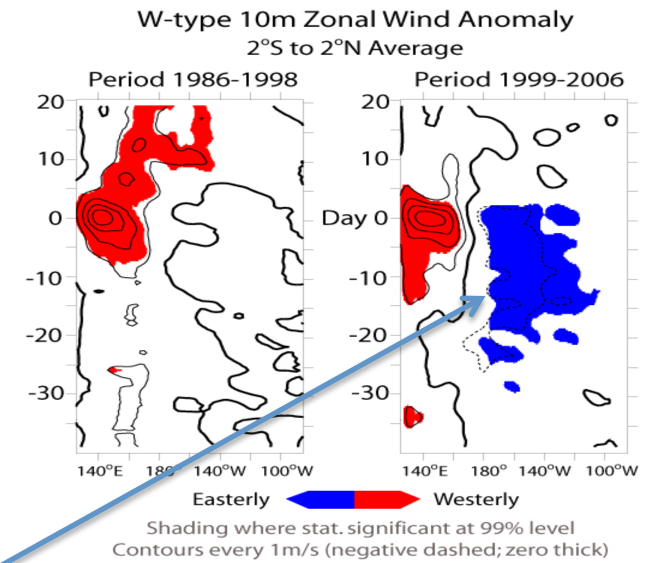


Importance of cold-tongue stress

- The cold-tongue warming effects of WWEs can be neutralized or dominated by local increases in zonal wind stress.
- **This is why some WWEs are not followed by cold-tongue warming.**
- There has been an interesting change in the recent character of many WWEs with consequences on Central Pacific vs Eastern Pacific event evolution.
- **WE REALLY NEED ACCURATE WIND STRESS ACROSS THE WHOLE BASIN!**

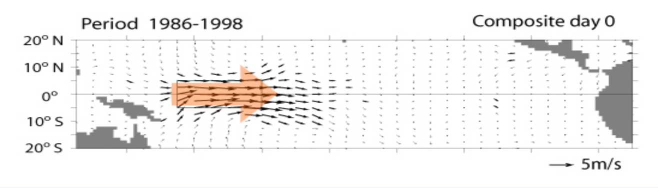
Post-1997-98 WWEs have a cold-tongue easterly element





There has been a significant increase in trade wind easterlies, at the times of WWEs, after the 97/98 event

When WWEs that include the easterly pulse (like the 1999-2006 average) are applied to the model, a Central Pacific El Nino occurs



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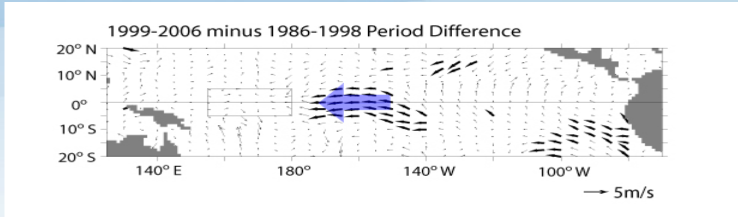
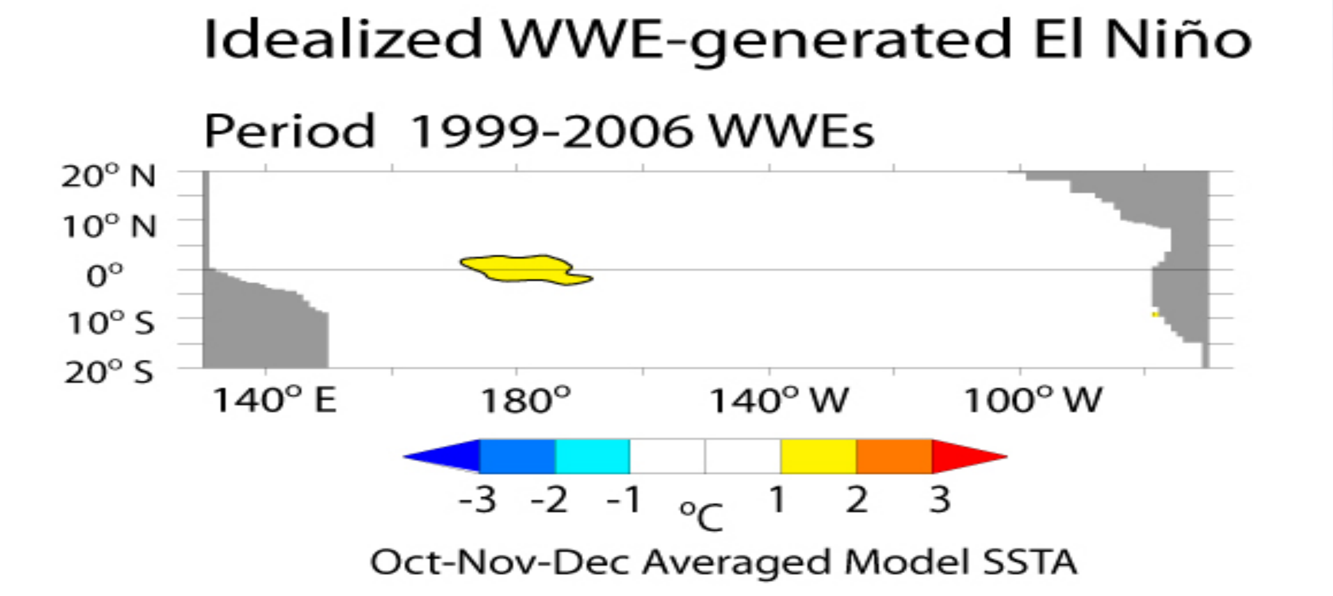


SSTA in ocean model from series of WWEs →



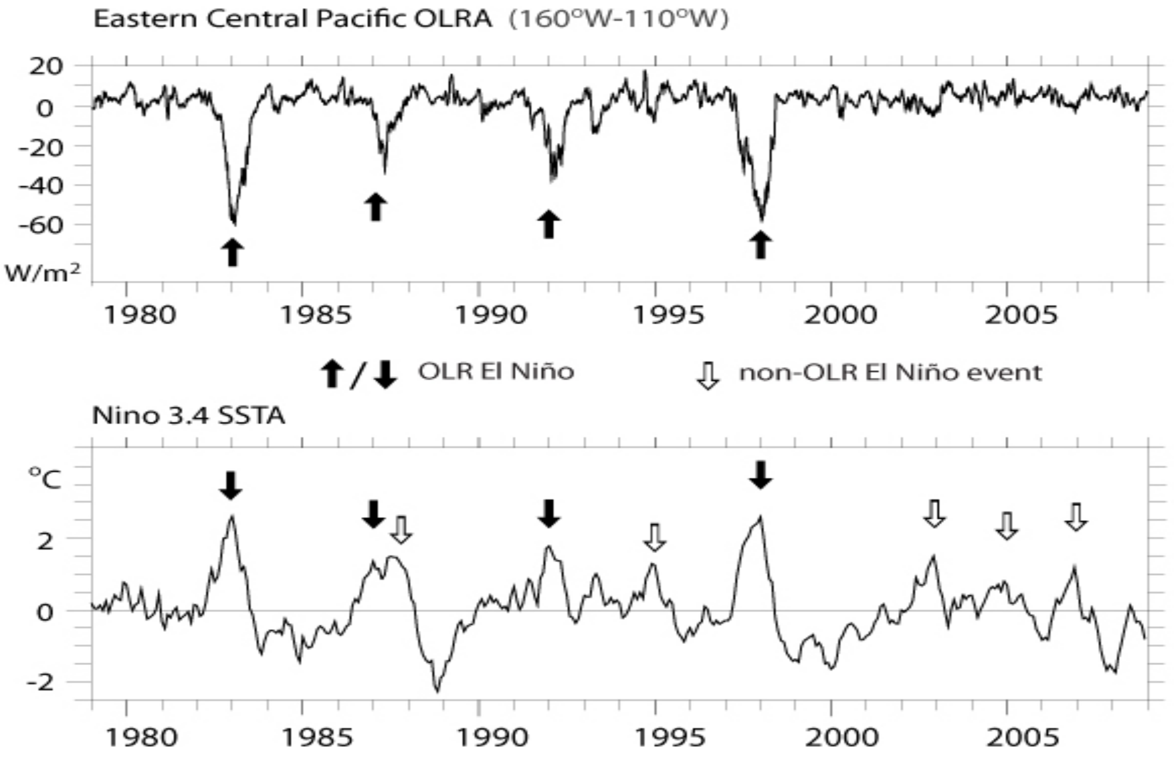
The easterly pulse wipes out the eastern Eq. Pacific warming that would otherwise occur from the WWE region forcing

Model forced with WWE composites from TAO-buoy-based wind stress estimates

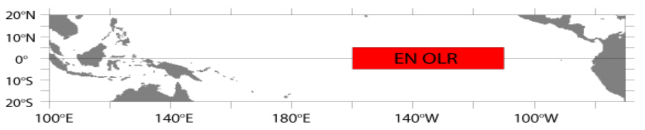
OLR Perspective on El Nino N. Am Seasonal Weather Anomalies

- Since 1975 (when OLR became available), using an OLR index to identify distinctive conditions as OLR-El Nino events leads to fewer events but with much more useful winter weather associations than using NINO3.4 SSTA.
- **The average associations for the non-OLR El Nino years are not robust from event to event and have almost no areas of strong stat. significance. Not explained by amplitude, either**
- Tho' not shown here, the OLR approach also helps in many areas and seasons, globally.

Eastern Central Pacific OLR and El Niño



Monthly OLR Anomaly. 160°W:110°W and 5°S-5°N



NINO3.4 SSTA

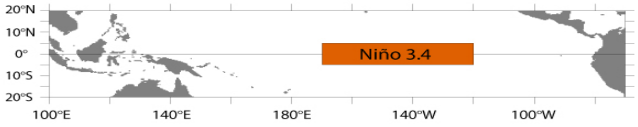


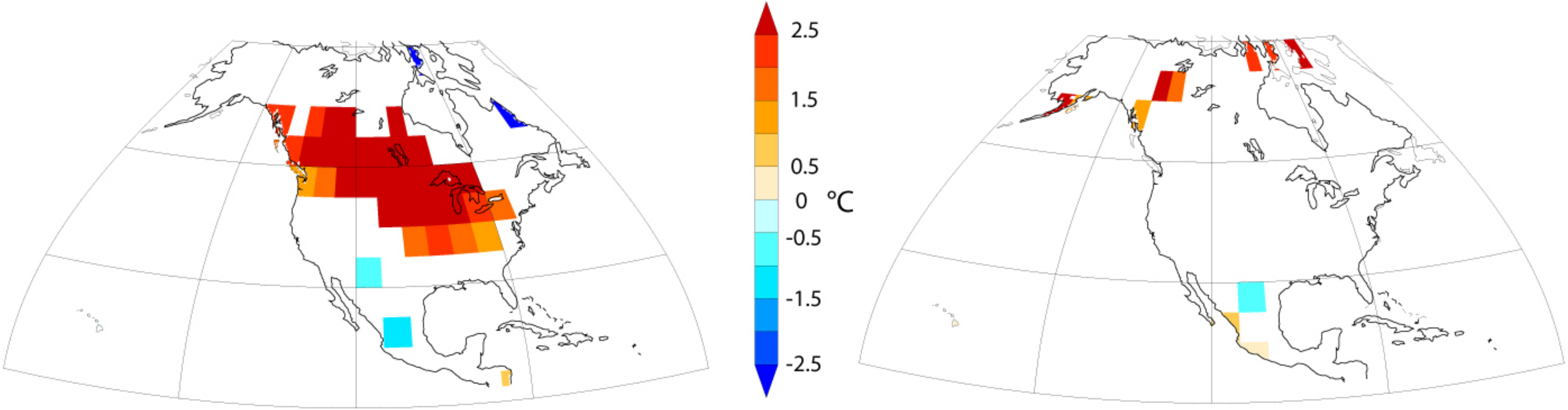
Figure from Chiodi and Harrison (*J. Climate*, 2013)

OLR from NOAA Interpolated data set (Liebmann and Smith, 1996)

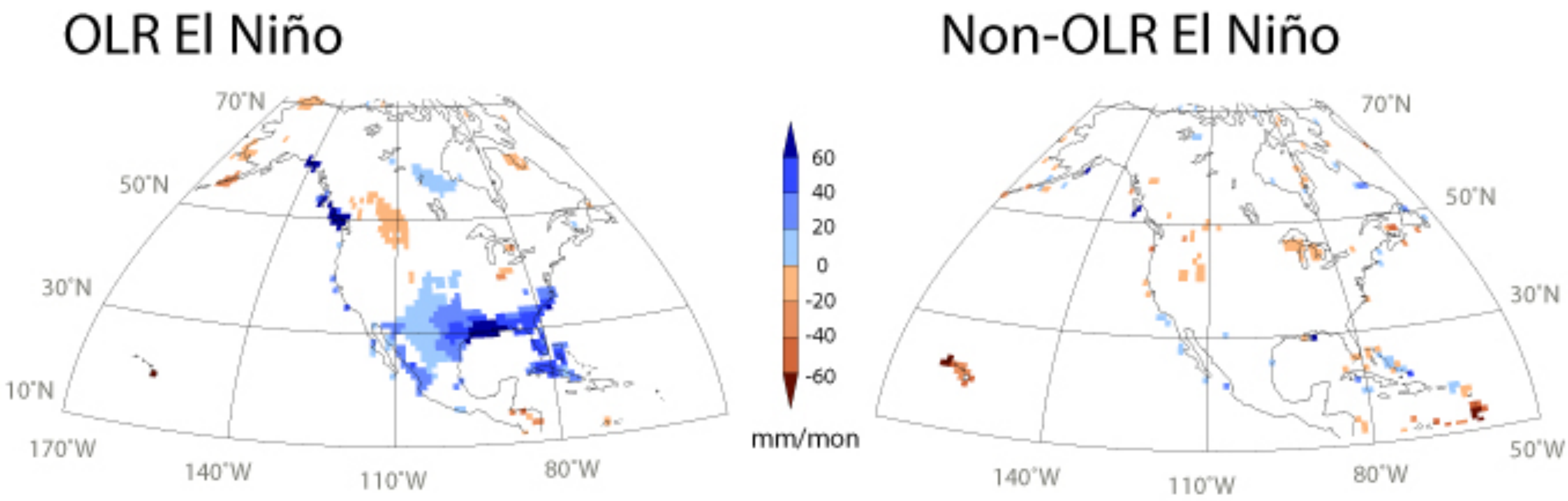
Dec-Jan-Feb Temperature Anomaly

OLR El Niño

Non-OLR El Niño



Dec-Jan-Feb Precipitation Anomaly



La Nina

- There is a similar utility to looking at an OLR index for La Nina events.
- **There is also an "Easterly Wind Surge" aspect to the onset of La Nina events, that connects the surface winds and OLR behavior.**
- We needed the daily TAO historical wind data to sort this out.
- **Andy has a poster on some of our La Nina results.**

Future Directions

TMAP projects are selected opportunistically.

- Next GCOS Status Report, Implementation Plan
- **Ocean subsurface climate indices of societal use.**
- Onset and termination of La Nina events.
- **Amplitude of El Nino and La Nina events.**
- Improved statistical forecasting of ENSO events.
- **Connections w. Tropical fisheries mgmt.**

Thank You