# Sub-seasonal wind events and El Niño

D.E. Harrison and A.M. Chiodi

contact: andy.chiodi@noaa.gov

JISAO / University of Washington and NOAA / Pacific Marine Environmental Laboratory

## Abstract

It is widely recognized that El Niño events influence global seasonal weather anomalies in many regions and seasons, and that knowledge of ENSO state can provide useful forecasts in regions where the influence is strong and consistent enough from event-to-event. Despite the considerable advances made in the last thirty years of ENSO study, serious challenges still remain in predicting the trajectory of ENSO state (particularly from neutral conditions) and in forecasting the year-to-year weather anomalies seen among the commonly identified El Niño years. The variability of the tropical Pacific in recent years, such as 2012 and 2014, whose early to mid-year anomaly conditions prompted many to forecast the development of El Niño events, highlights the ability of sub-seasonal winds to affect that development. We offer some recent research results on the role that sub-seasonal wind events play in the initiation and growth of different types of ENSO events, with focus on their prolonged effects on the development of sea surface temperature (SST) anomalies in the Pacific oceanic waveguide and the relationship between ENSO anomaly state and seasonal weather anomalies elsewhere.

## Background

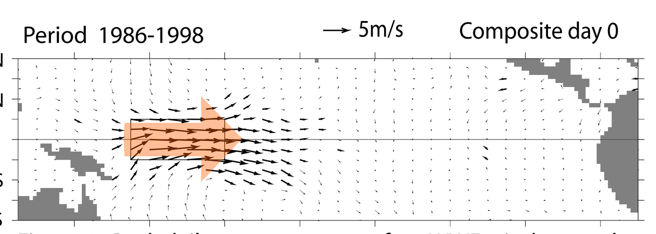


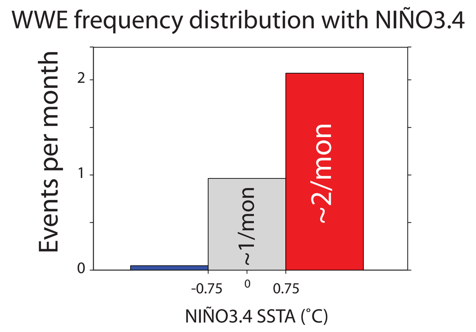

Figure 1. Peak daily average near surface WWE wind anomaly

**Westerly Wind Events** (WWEs) are defined by wind speed anomalies > 3m/s for three or more days over the defining region (W,C or E). "Day 0" is the peak day with amplitudes ~ 7m/s. Stat. sig. anomalies are seen ~ 7 days before and after Day 0 in WWE composites. **Cold-tongue warming of a few tenths of a °C follow single WWEs** that occur in ENSO-neutral conditions, on average.

Importantly, even though the wind events are short-lived, the **warming** they drive **persists 2-3 months** after the WWEs subside.

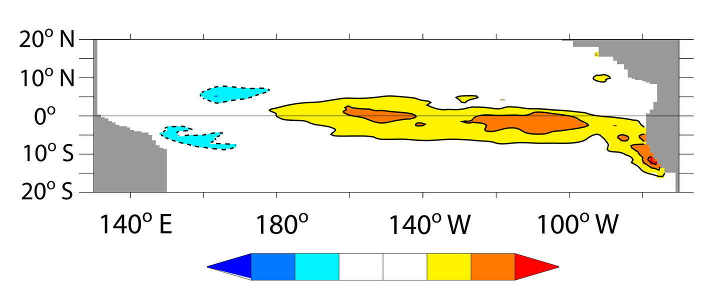
And the **frequency of WWEs increases** as ENSO SSTA (e.g. NINO3.4) warms, providing a positive feedback mechanism for El Nino.

WWE frequency distribution with NIÑO3.4




### Idealized WWE-generated El Niño

Period 1986-1998 WWEs

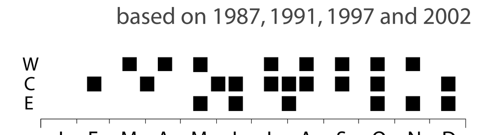


Oct-Nov-Dec Averaged Model SSTA

This means that El Nino years typically experience a series of WWEs. Ocean general circulation model (OGCM) experiments show that such (Fig.1) a series of WWEs is sufficient to drive an El Nino SSTA pattern in the model (Harrison and Chiodi, 2009).

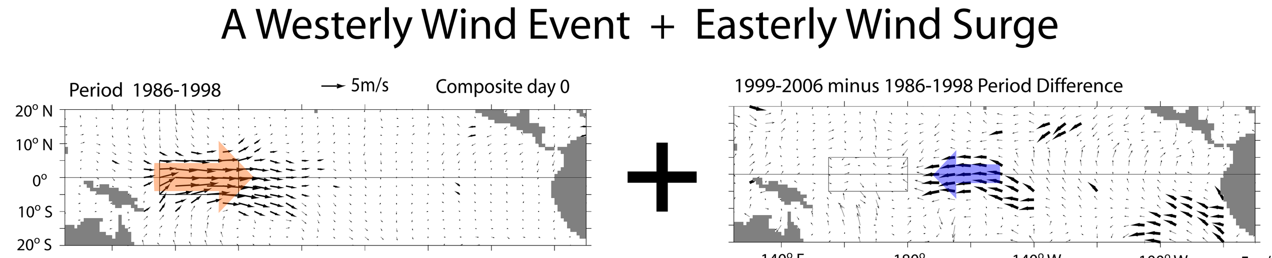
Idealized WWE Timing

based on 1987, 1991, 1997 and 2002



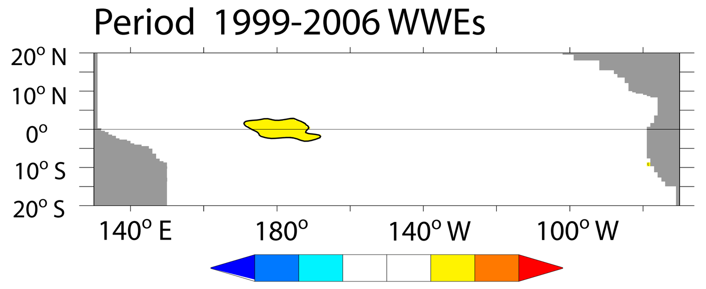

Interestingly, following the large El Nino event of 1997-98, WWEs have had an easterly element over the cold tongue, on average.

A Westerly Wind Event + Easterly Wind Surge




### Idealized WWE-generated El Niño

Period 1999-2006 WWEs



Oct-Nov-Dec Averaged Model SSTA

And when this type of WWE (with easterly pulse) is added in series to the model, a Central-Pacific (CP)-type of El Nino occurs.

References:

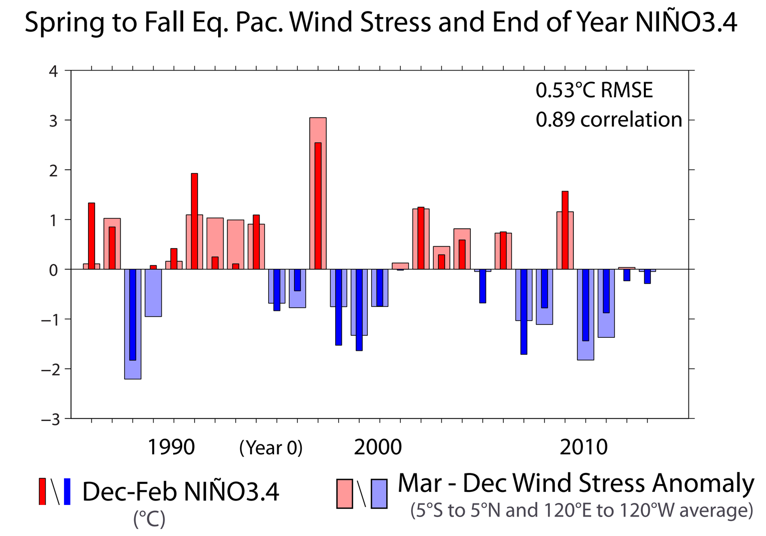
Chiodi, A.M. and D.E. Harrison, 2015: Equatorial Pacific Easterly Wind Surges and the Onset of La Niña Events. J. Climate. doi:10.1175/JCLI-D-14-00227.1, in press.

Chiodi, A.M., and D.E. Harrison, 2013: El Niño impacts on seasonal U.S. atmospheric circulation, temperature and precipitation anomalies: The OLR-event perspective. J. Climate, 26, 822-837. doi: 10.1175/JCLI-D-12-00097.1.

Harrison, D.E. and A.M. Chiodi, 2009: Pre- and Post-1997/98 Westerly Wind Events and Equatorial Pacific Cold Tongue Warming. J. Climate, 22, 568-581. doi: 10.1175/2008JCLI2270.1

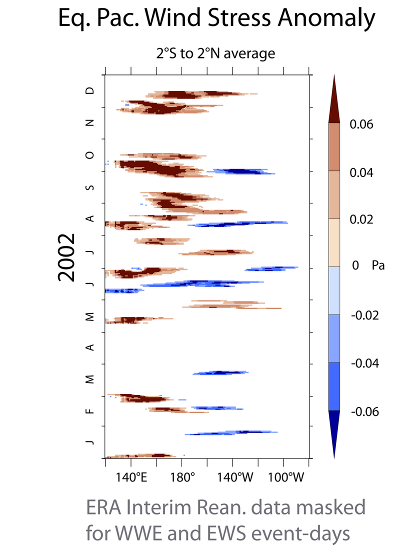
## Zonal Wind Event integrals

Spring to Fall Eq. Pac. Wind Stress and End of Year NIÑO3.4



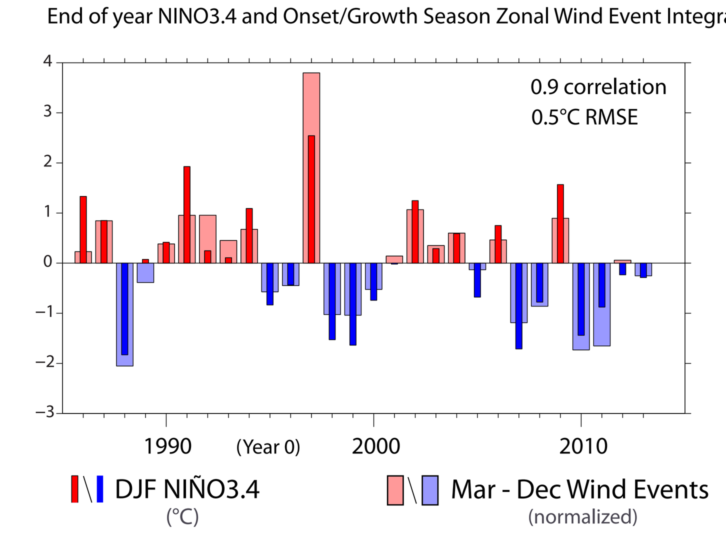

End of year (ENSO peak) Eq. Pacific SSTAs may be controlled by many factors (e.g. sub-surface I.Cs, heat fluxes, momentum fluxes), but we find that much of the story is controlled by the winds, especially the zonal wind component. Integrated Eq. Pac. zonal wind stress anomalies have a close connection to end of year ENSO SSTA (see Fig. on left); a reminder that wind stress anomalies over the Pacific's oceanic waveguide provide a dominant control for end of year NINO3.4 SSTA values.

Eq. Pac. Wind Stress Anomaly



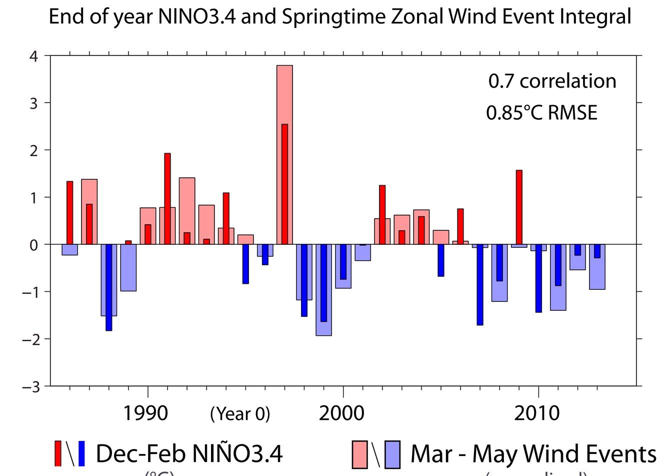

Counting up the time and zonal extent of each year's wind events is able to reproduce the full integral result. The wind event distribution plays a key role in shaping the ENSO-associated wind stress variations.

End of year NINO3.4 and Onset/Growth Season Zonal Wind Event Integral



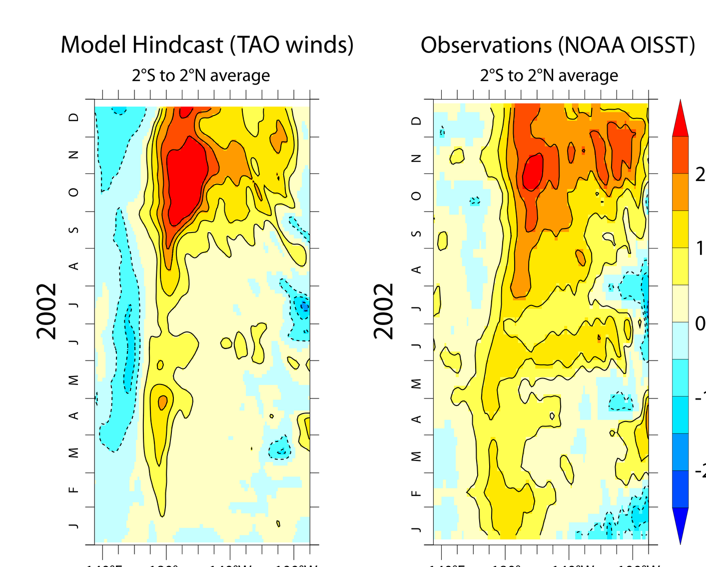

To get the wind event integral in this case, in each year we sum the red (WWE) and subtract the blue (EWS) shaded regions.

End of year NINO3.4 and Springtime Zonal Wind Event Integral




What are the forecasting implications of this? The frequency dependence of WWEs and EWSs (see Chiodi and Harrison, 2015) on ENSO SSTA provides a positive feedback for El Nino and La Nina, respectively. We repeat the wind event integral just over the springtime, still targeting end of year NINO3.4. The result confirms forecasting skill at this lag (similar to more sophisticated models) but yields a RMSE (0.85°C) that is close to the standard deviation of NINO3.4 itself, which still leaves much of the story untold.

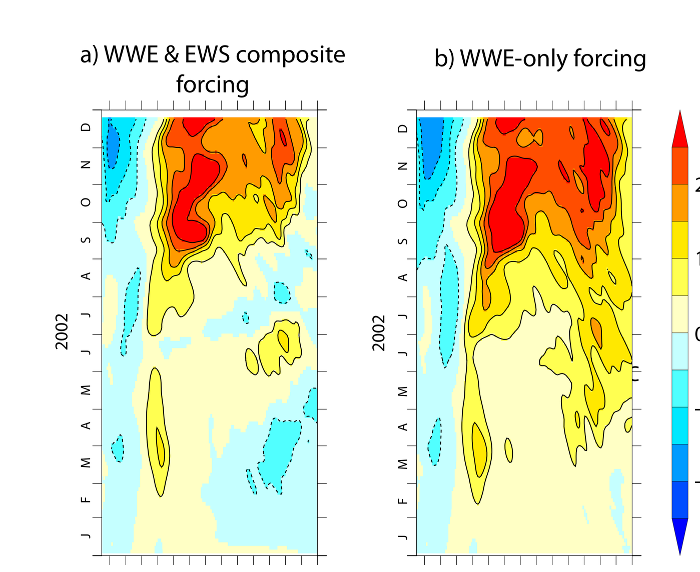
## El Nino Hindcasts




We find that the detailed development of El Nino SSTA can be diagnosed with accurate knowledge of zonal winds across the Eq. Pacific waveguide. The example on the left shows how well the 2002 El Nino can be hindcast in an OGCM forced by just TAO/TRITON buoy-measured wind stress anomalies.

In the experiment (a), to the right, we first reconstruct the zonal wind stress field by applying WWE and EWS composites at their observed times/locations. Forcing from just the 16 WWEs and 8 EWSs is able to reproduce a qualitatively correct CP El Nino SSTA development.

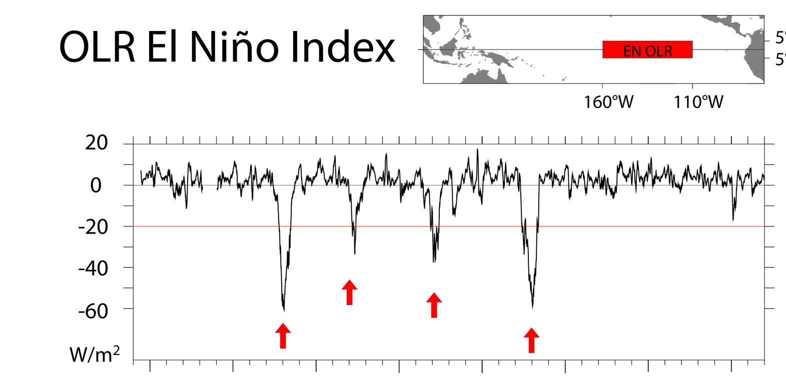
In experiment (b), we omit the EWSs. When this is done an EP-type El Nino occurs.



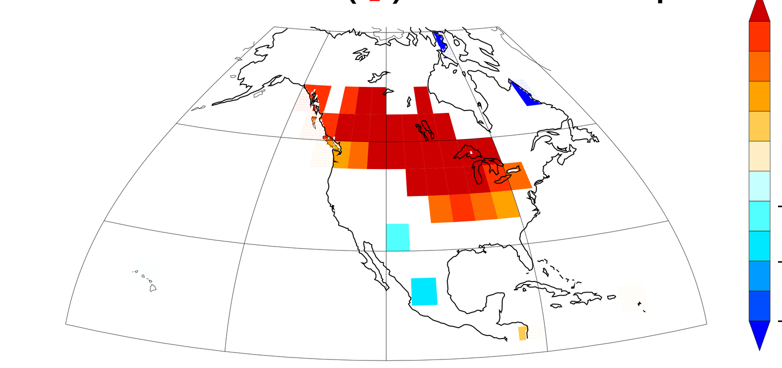

## El Nino impacts on seasonal weather anomalies

Many ways have been used (e.g. SST, SLP, OLR, multivariate indices) to characterize the anomaly state of the tropical Pacific. NINO3.4 SSTA indices are the most commonly used, but there is large event to event variability in the associated weather anomalies. We show that an OLR (outgoing-longwave-radiation) index identifies a subset of years with consistent seasonal weather anomalies. Interestingly, there is little consistent seasonal weather behavior in the remaining non-OLR events

OLR El Niño Index



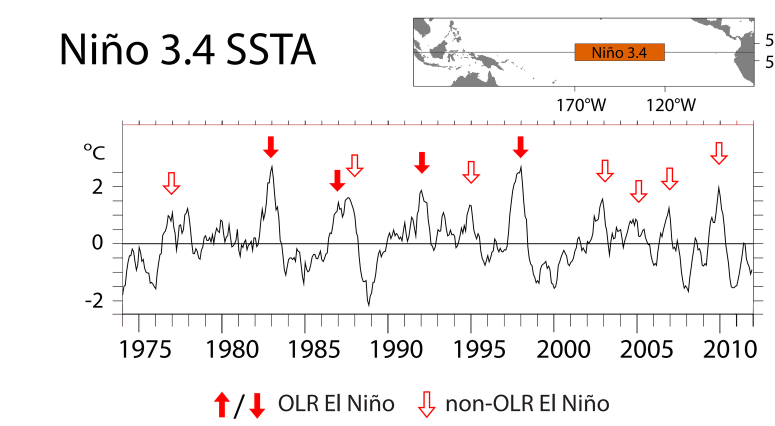
OLR El Niño (↑) Winter Temp.



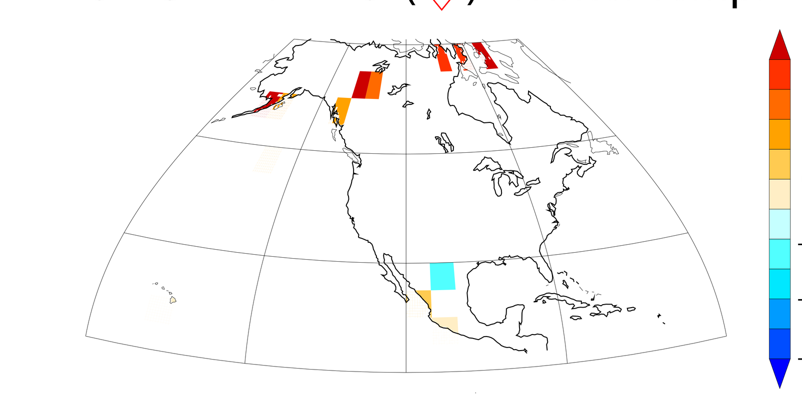
1982-83, 1986-87, 1991-91, 1997-98

Deep-atmospheric convection reaches the eastern central Pacific in only a handful of El Nino years. The OLR El Nino years have the expected seasonal weather anomalies, the others do not!

Niño 3.4 SSTA




Non-OLR El Niño (⇩) Winter Temp.

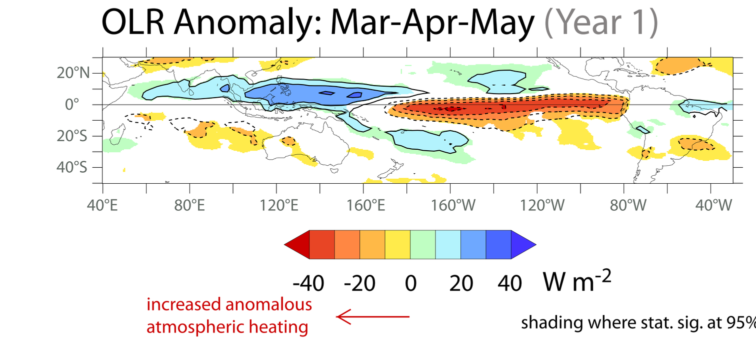


1976-77, 1987-88, 1994-95, 2002-03, 2004-05, 2006-07, 2009-10

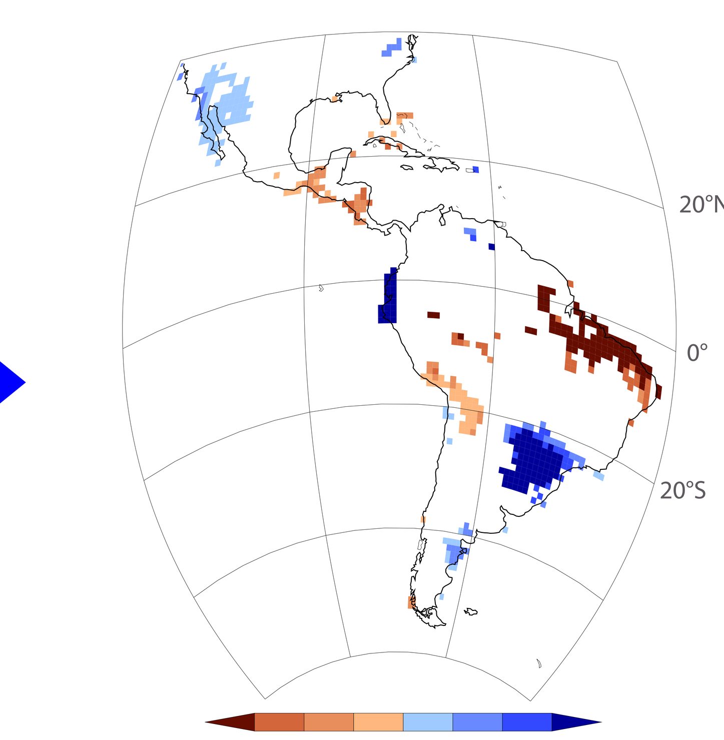
### OLR El Niño (↑)

Strong, stat. significant OLR anomalies are seen across the Eq. Pacific in the OLR El Nino years. This signifies a dramatic change in the distribution of tropical Pacific atmos. heating = strong influence on weather elsewhere.

OLR Anomaly: Mar-Apr-May (Year 1)



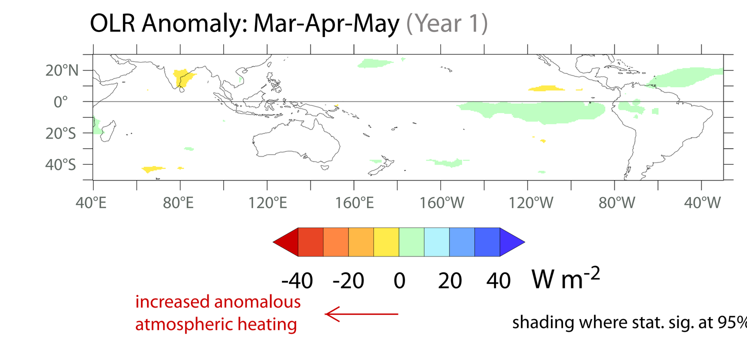

OLR El Nino Precipitation Anomaly Mar-Apr-May (Year 1)



### Non-OLR El Niño (⇩)

Different OLR anomaly conditions, and not nearly as much statistically significant precipitation anomaly is seen in the non-OLR El Nino composites

OLR Anomaly: Mar-Apr-May (Year 1)




non-OLR El Nino Precipitation Anomaly Mar-Apr-May (Year 1)