An OLR perspective on El Niño and La Niña impacts on seasonal weather anomalies

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An Outgoing-Longwave-Radiation (OLR) Perspective on ENSO impacts

Our conclusion:

- ***Most of the statistically significant seasonal weather anomalies in most of the ENSO affected regions result from a handful of events which can be identified by their OLR features (e.g. North America, also globally)***

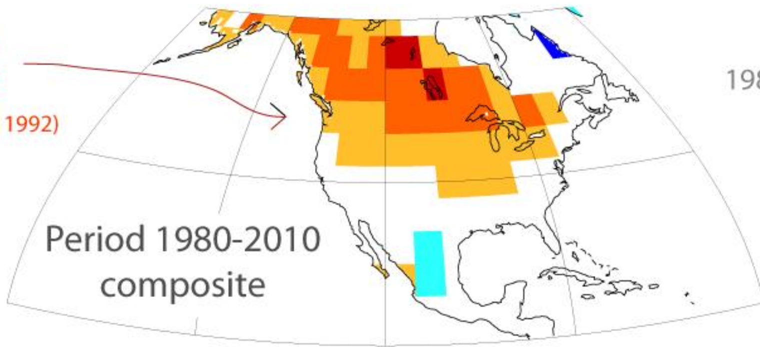
Focus on N. Hemisphere Winter (ENSO Year 0/1), but results also extend to other seasons

ENSO composites are useful to forecasting efforts, but also frustrating.

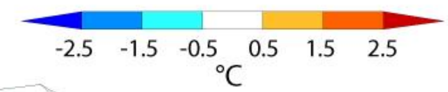
Wintertime (DJF) Temperature Anomaly

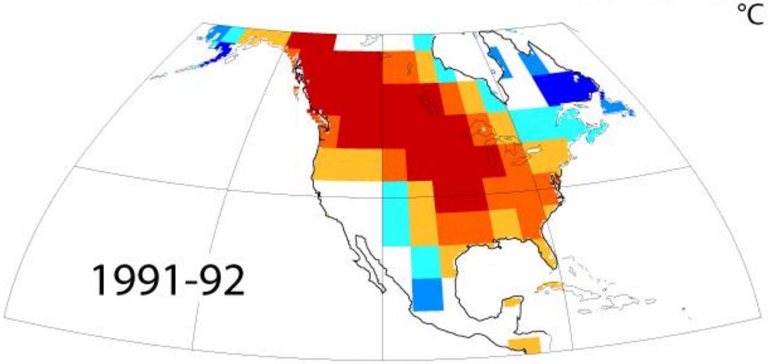
El Niño Average

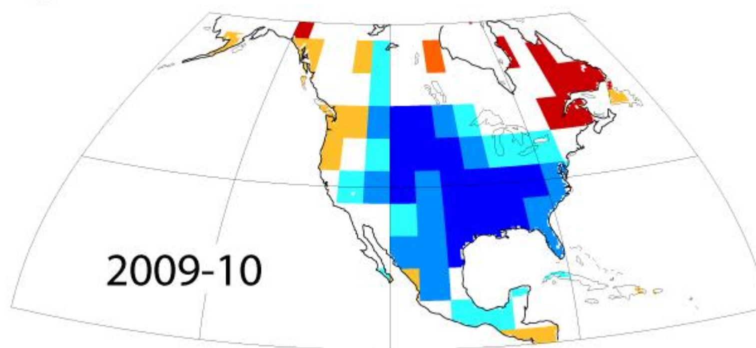
Warm anomaly as expected from classic previous-period composites (Halpert & Ropelewski 1992)



NIÑO3.4 SSTA-based El Nino year list:
1982-83, 1986-87, 1987-88, 1991-92,1994-95, 1997-98, 2002-03, 2004-05, 2006-07, 2009-10







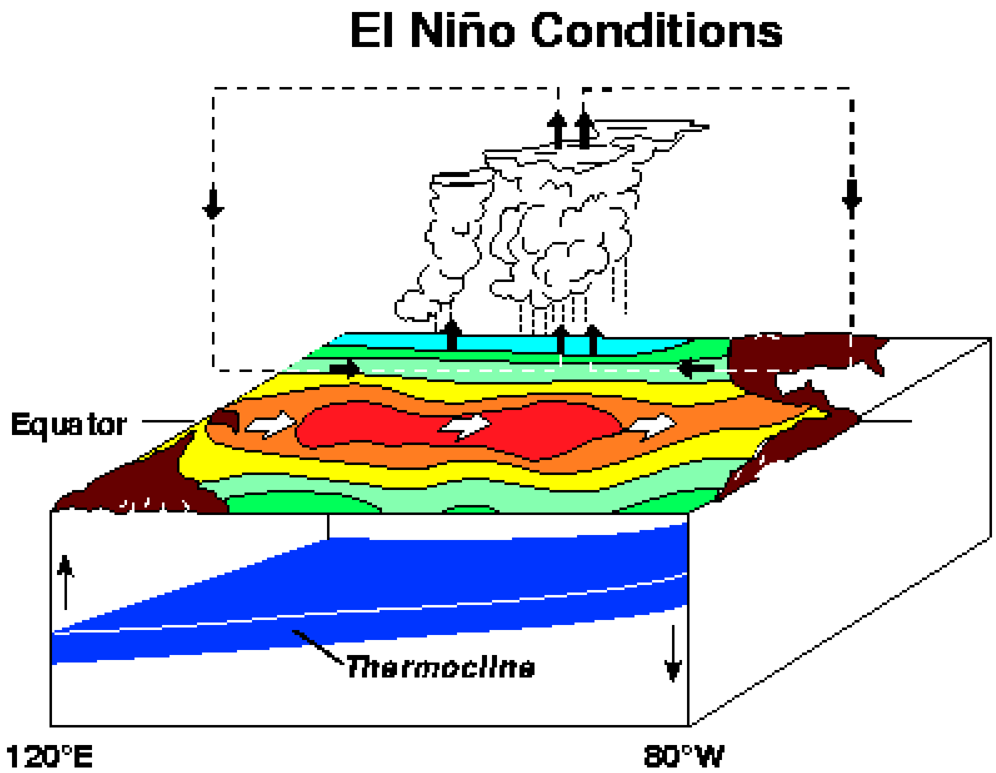
Some of the individual years have anomaly patterns that match the composites...

...and, frustratingly, others do not.

data: CRUTEM3

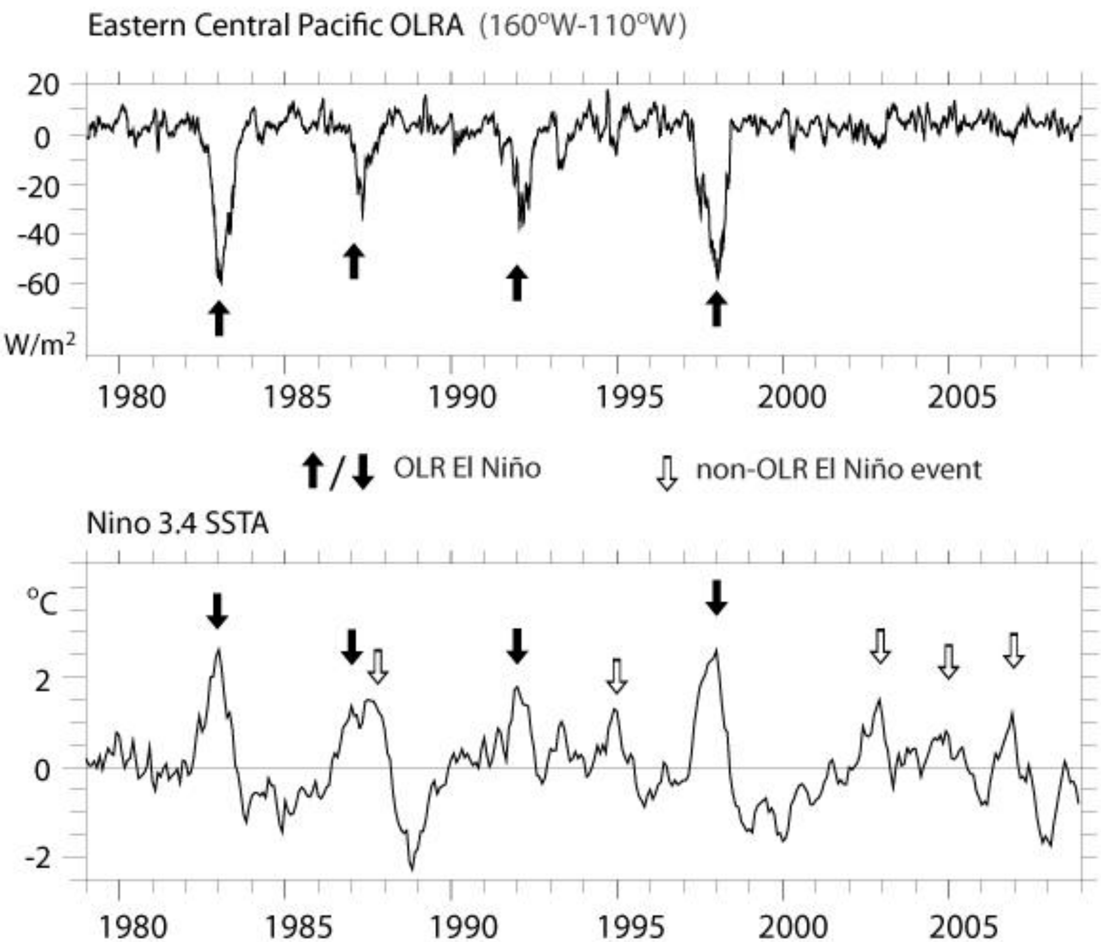
Our initial approach was motivated by the now familiar ENSO cartoons

In the tropics, the arrival of deep atmos. convection conditions is associated with large decreases in OLR.



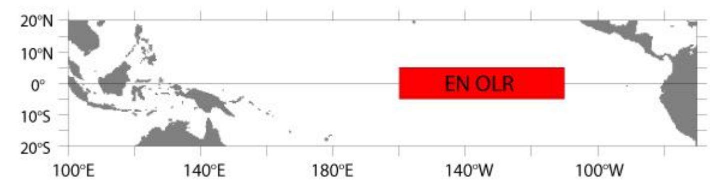
SLP, SST and OLR all provide measures of coupled-system anomalies during ENSO, but **OLR** provides the best look at **atmospheric heating anomalies** which drive atmos. circulation, temp. and precipitation anomalies elsewhere

E. Central Pacific OLR clearly picks out a subset of El Niño years



Only in the 4 large events does the OLR index cross –20 W/m², **and it does so before winter in 3 of 4 cases**.

OLR averaging region



SSTA averaging region

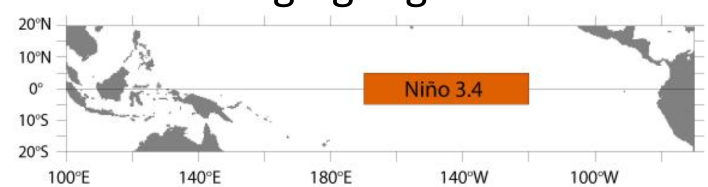
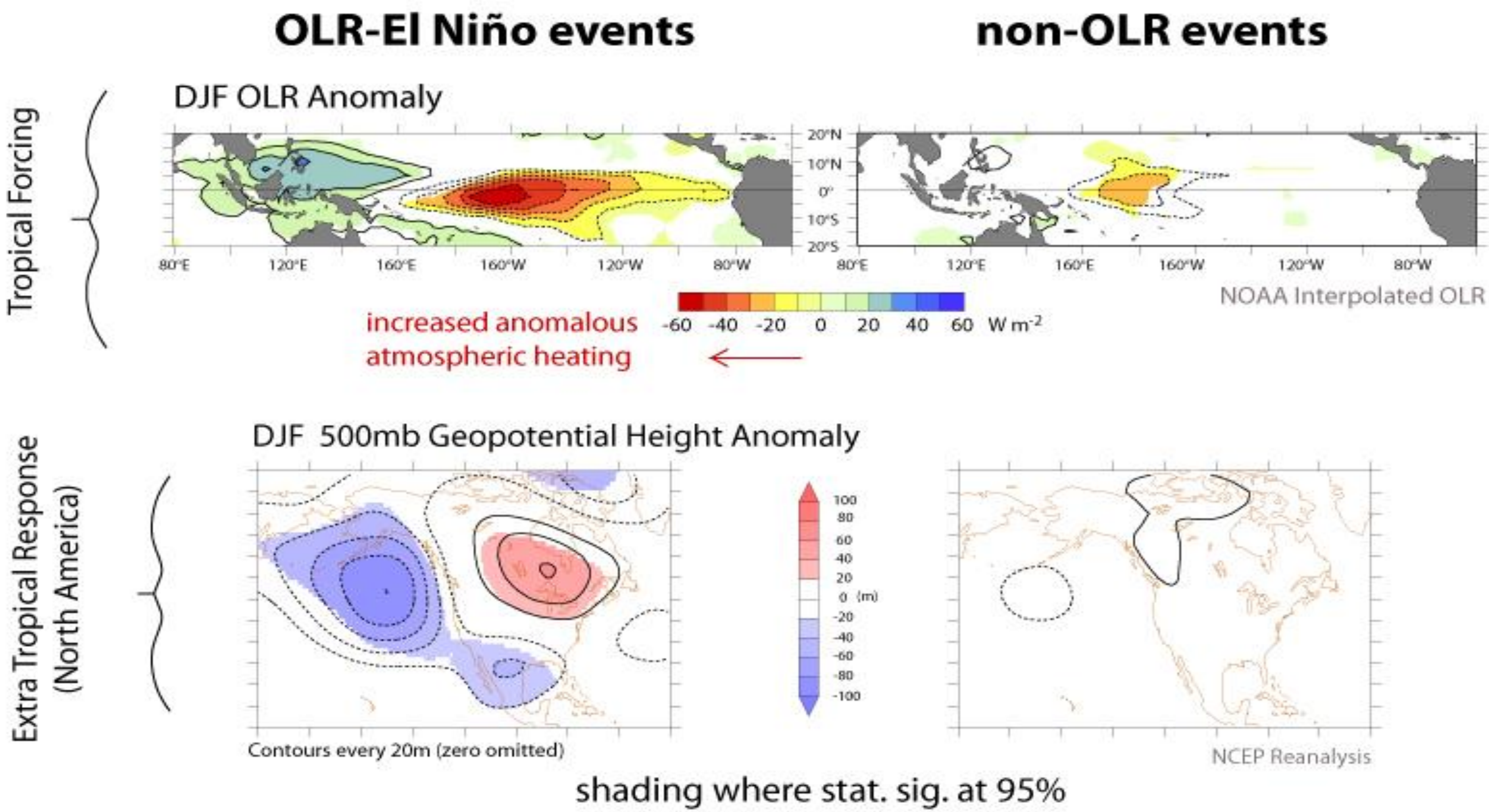


Figure from Chiodi and Harrison (*J. Climate*, 2013)

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

Much Stronger Wintertime Anomaly Conditions in the OLR-events



Period 1979-2008, as in Chiodi and Harrison (2013)

Much stronger seasonal mean tropical forcing + stronger and more consistent atmos. circulation response in OLR events

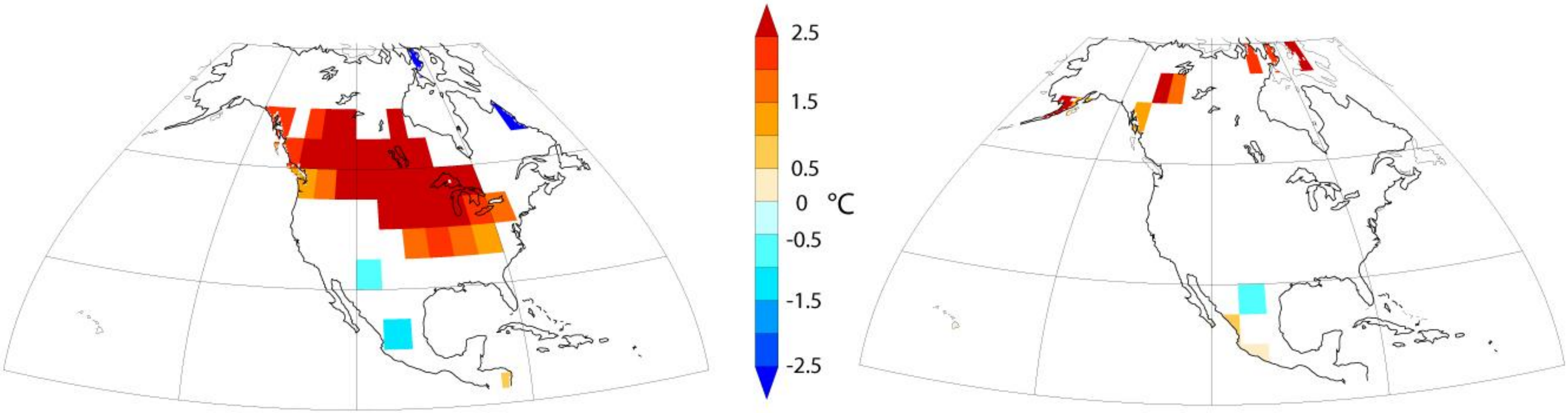
Different types of atmos. anomalies are seen in the other years = composites without much statistical significance

…and for temperature over N. America (e.g.)

DJF Temperature Anomaly Composites

OLR El Niño

Non-OLR El Niño



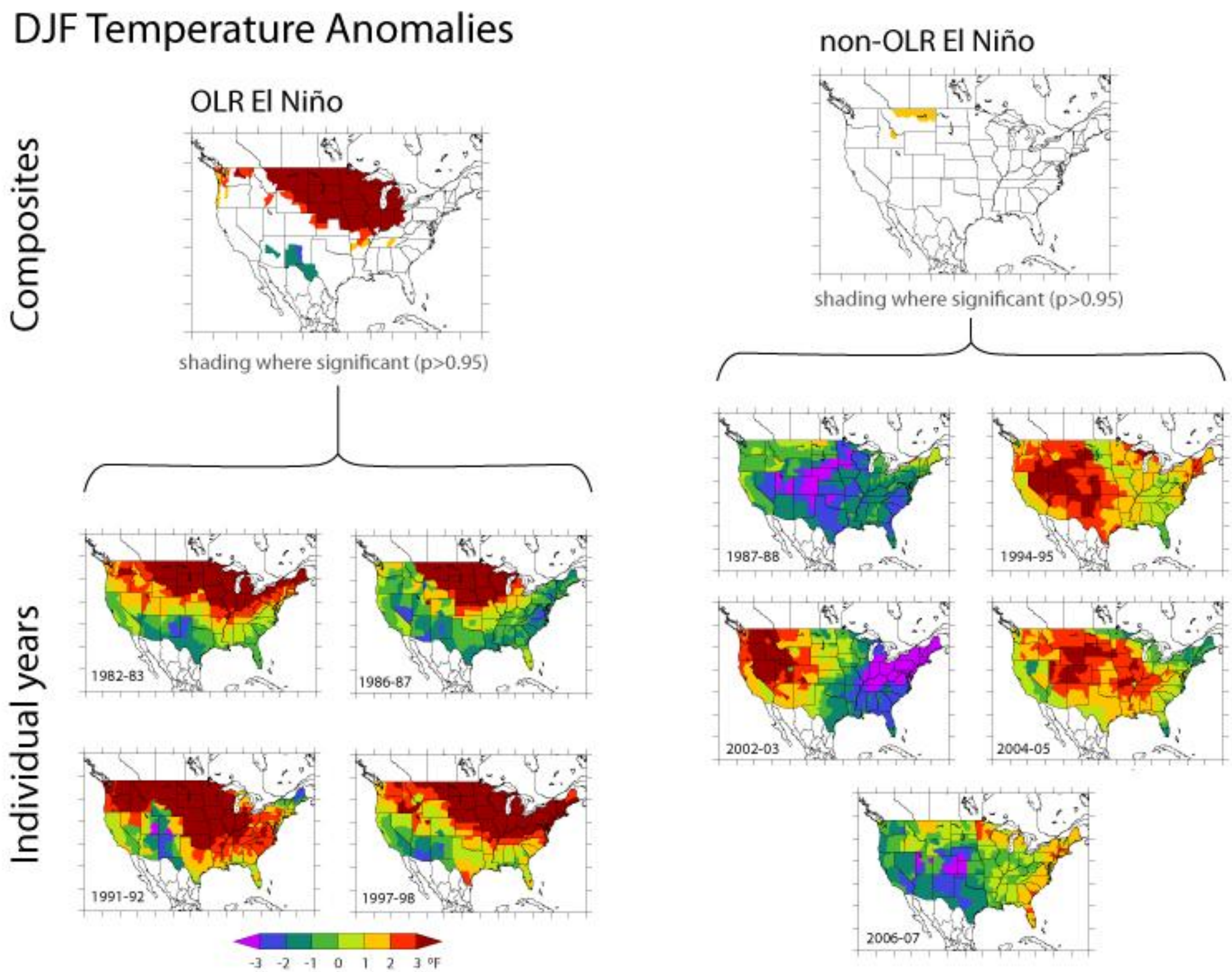
1982-83, 1986-87, 1991-91, 1997-98

masking at 95% local statistical significance
period 1974-2011

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

data: CRU Temp

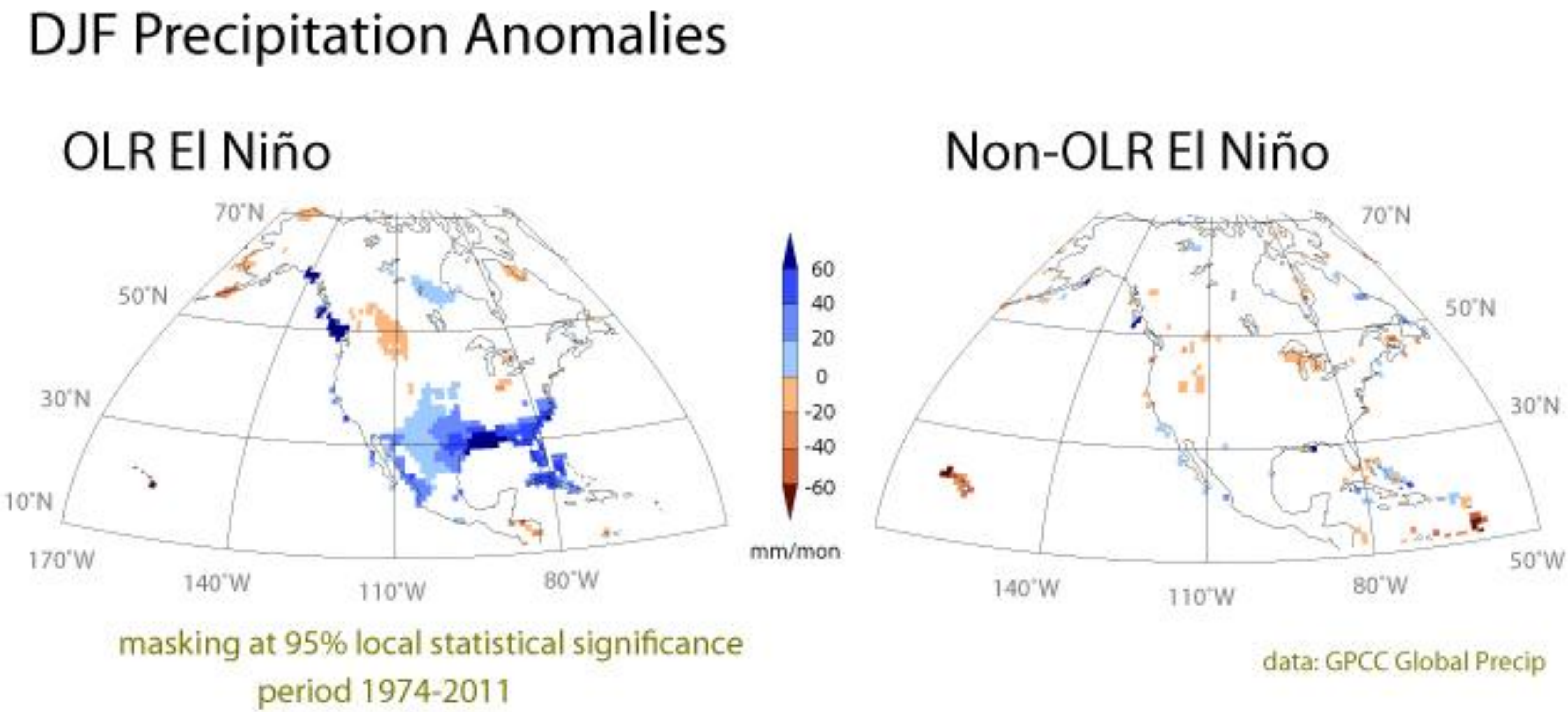
Temp patterns are consistent among the OLR-EN years; different patterns seen in other years



From Chiodi and Harrison (2013)
period 1979-2008

Data: NOAA/NCDC U.S. Climate Division
(relatively good station coverage over U.S.)

Again, except for North America precip.



Highly stat. significant (by amplitude) and consistent anomaly patterns seen in the OLR case = useful to forecasting

The Non-OLR composite anomaly pattern is much less useful to forecasting efforts.

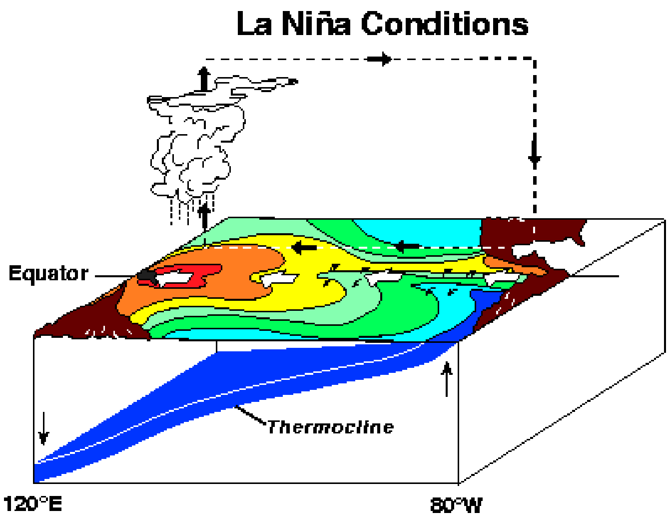
Summary so far: OLR behavior over Tropical Pacific clearly identifies the subset of El Nino years with most of the **useful** *(statistically significant, consistent from year to year)* seasonal weather anomalies, over the time for which satellite-based OLR measurements are available.

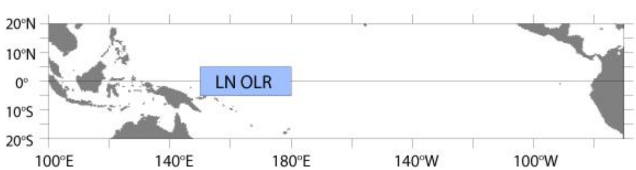
True especially over N. America, but also useful to distinguish OLR and non-OLR El Nino years elsewhere

More on global anomaly patterns later,

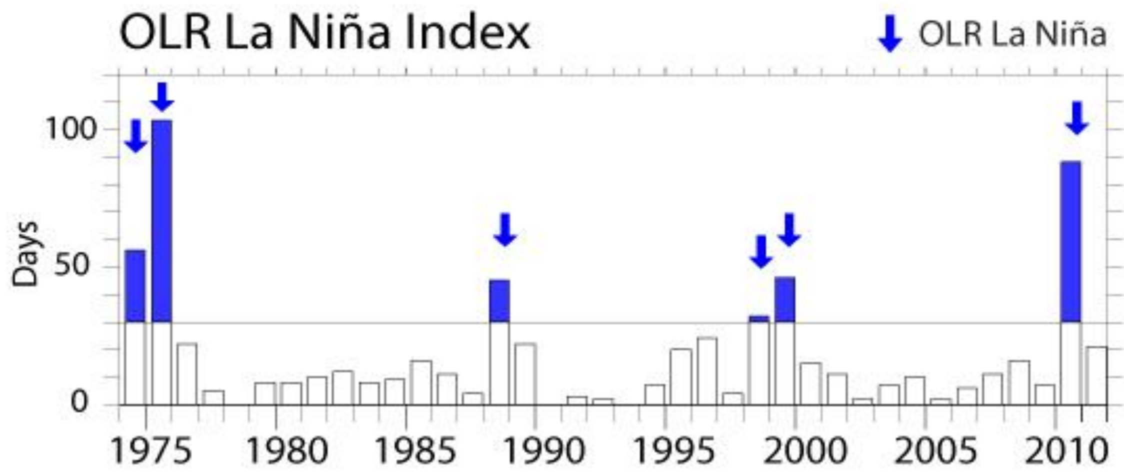
First, what about La Niña?

And now, an OLR index for La Niña

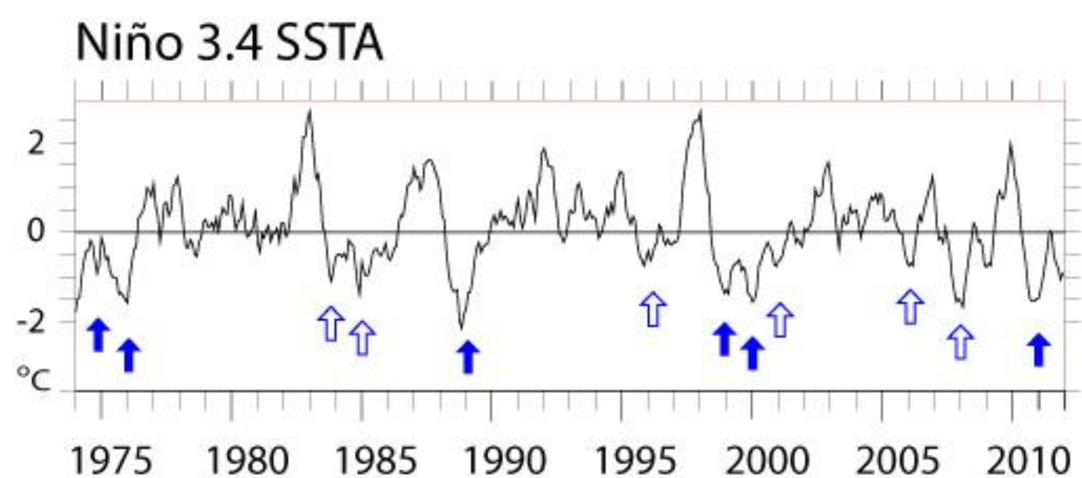




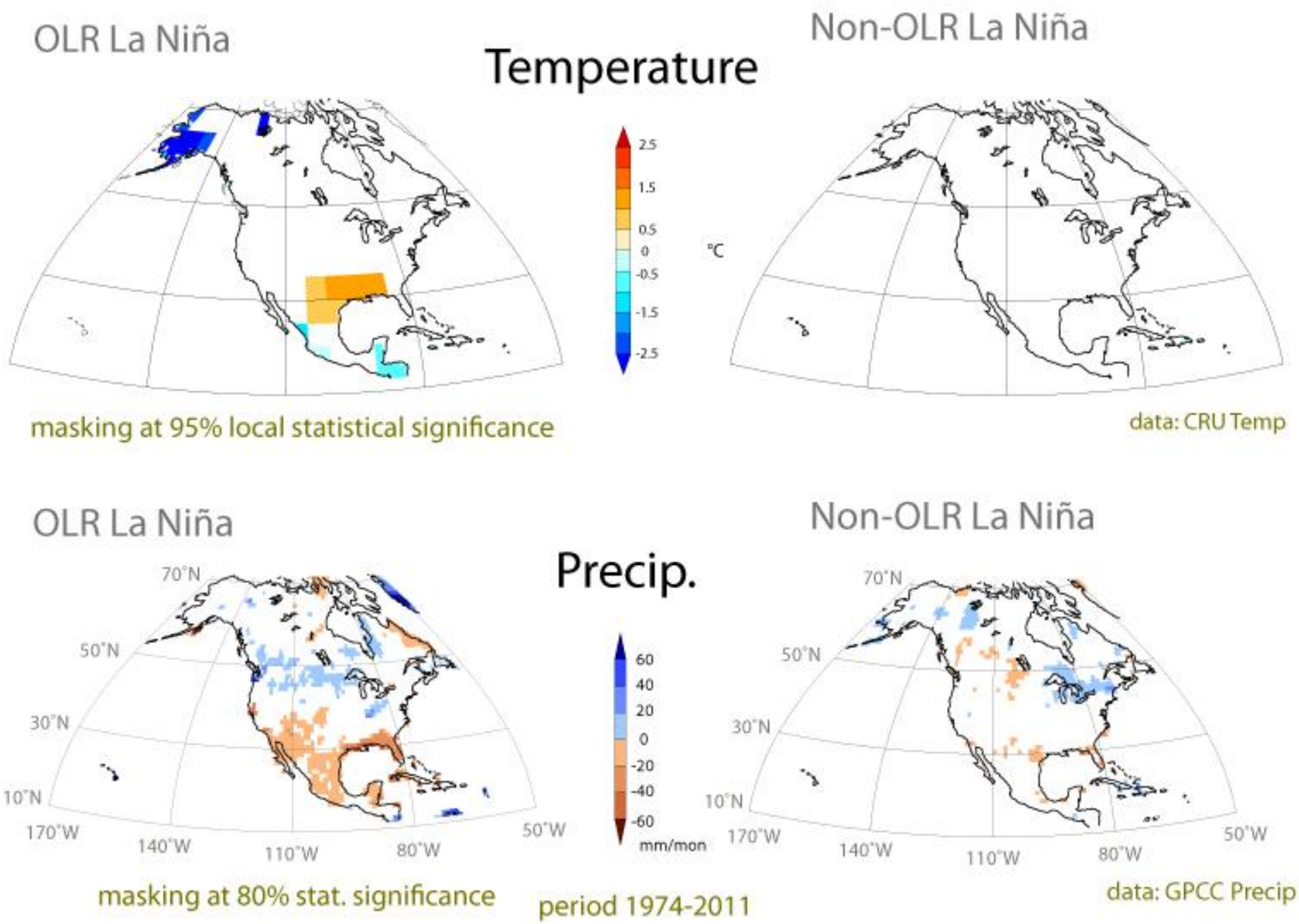
OLR-La Nina Index counts days of clear sky from 1 April to 31 Dec over 150E:180x5S:5N



In only 6 of the last 40 years does the OLR La Nina index exceed 30 days, and it does this before winter in all 6 cases.



La Niña wintertime composite T and P anomalies over N. America,



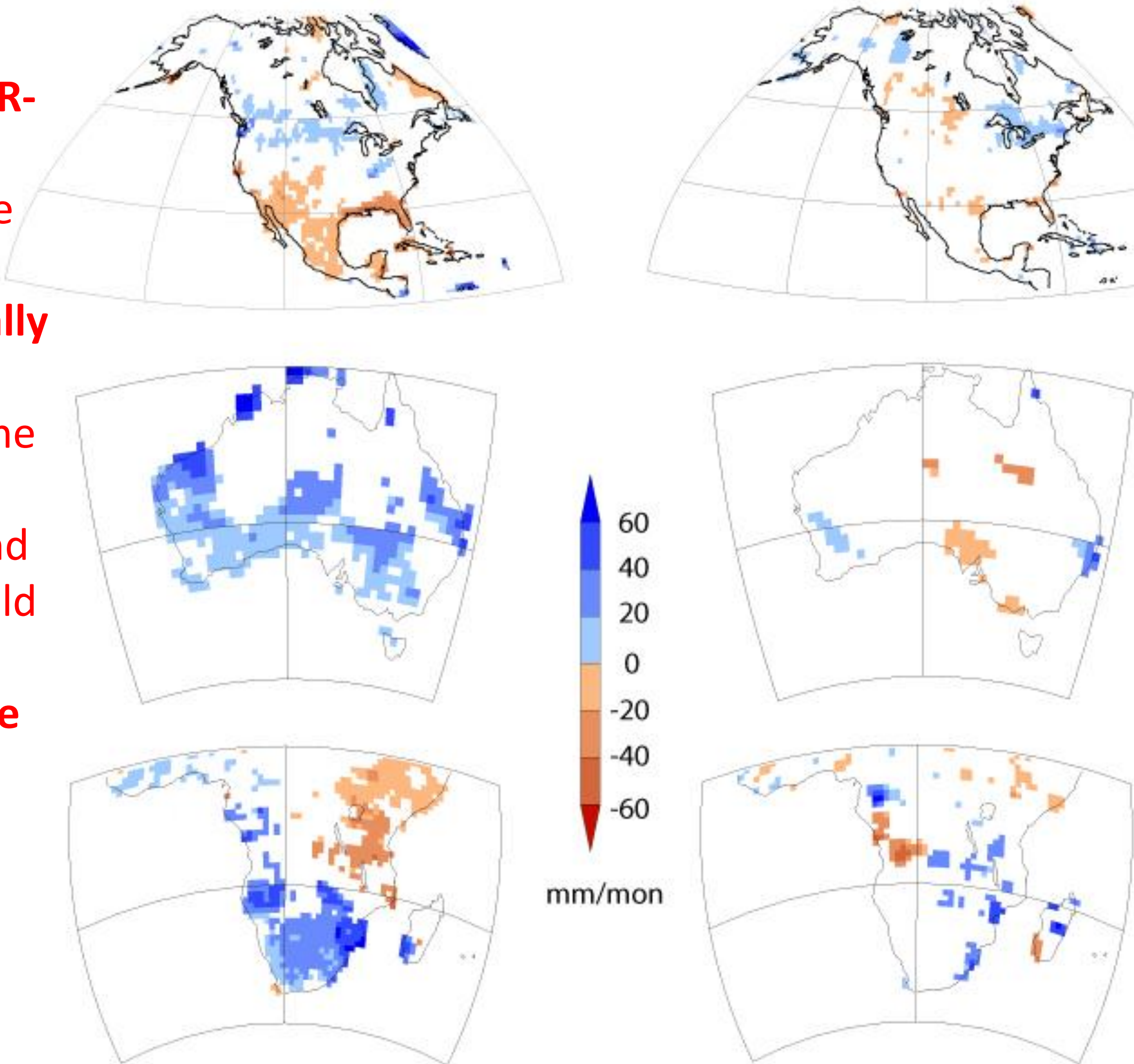
The OLR La Nina index also identifies the subset of years with most of the useful anomalies.

La Niña DJF Precipitation composites, globally (land regions 60°S to 60°N)

OLR La Nina events | Non-OLR La Nina events

(A few example regions shown)

Globally, the **OLR-event** La Nina composites have **much more locally statistically significant anomaly** than the non-OLR composites – and **more than** should be **expected by** effects of **chance alone** (at 90% confidence).



In the **non-OLR** case, the **amounts** of locally significant anomaly **can** easily **be reproduced by** the effects of **chance** alone.

Masked at 80% local statistical significance (by amplitude)

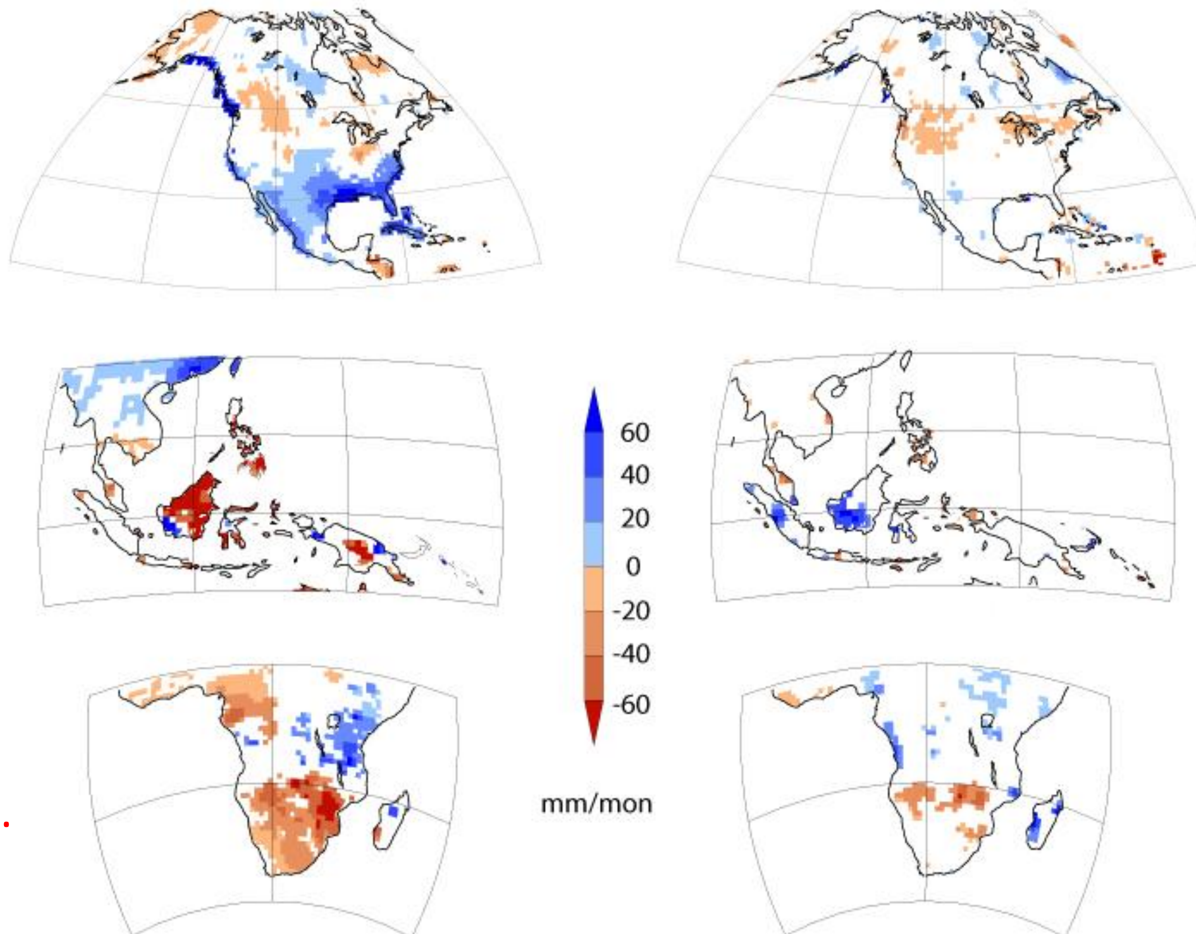
This holds for SON Year 0 also

Same story for El Niño DJF composites: globally, most of the useful anomaly patterns are associated with the handful of OLR events

again, a few regional examples…

OLR events

Non-OLR events



In the **OLR** case, the **amounts** of *locally* statistically significant anomaly are **significant** in an *overall* sense (at 95% confidence).

In the **non-OLR** case, the **amounts** of locally significant anomaly can easily be **reproduced by** the effects of **chance** alone.

Masked at 80% local statistical significance (by amplitude)

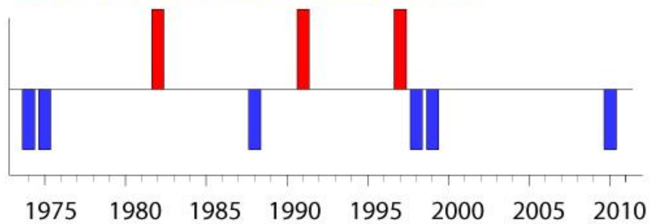
DJF ENSO Year 0/1 shown: *similar results found in MAM Year 1*

A Wintertime (DJF) Global Precipitation Hindcast experiment

First, in:

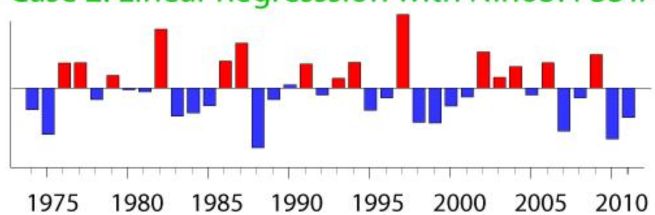
Case 1: We apply OLR composite precipitation only in the 3 (6) El Nino (La Nina) years identified by OLR by the beginning of December Year 0. *Otherwise, the hindcast anomaly = 0.*

Case 1: OLR Event Composites



Case 2: We specify DJF precip. anomaly via linear regression with SON-average NINO3.4 SSTA.

Case 2: Linear Regresssion with Niño3.4 SSTA



Then we examine anomaly correlation coefficients between observed & hindcast precip. This is done globally (60°S to 60°N). **The correlation is computed over all years**, not just those identified by OLR.

RESULTS:

OLR-approach: 27% of land reaches correlation significant at 95%

Linear-Niño34: 16% of land reaches correlation significant at 95%

OLR perspective leads to better hindcast correlation in most locations, even though anomaly is only specified in OLR years!

Conclusions

The OLR perspective leads us to a subset of the years often called “El Niño” and “La Niña”

If our primary interest is in the years that have a reliable seasonal weather anomaly pattern over land, the OLR years are the most important subset

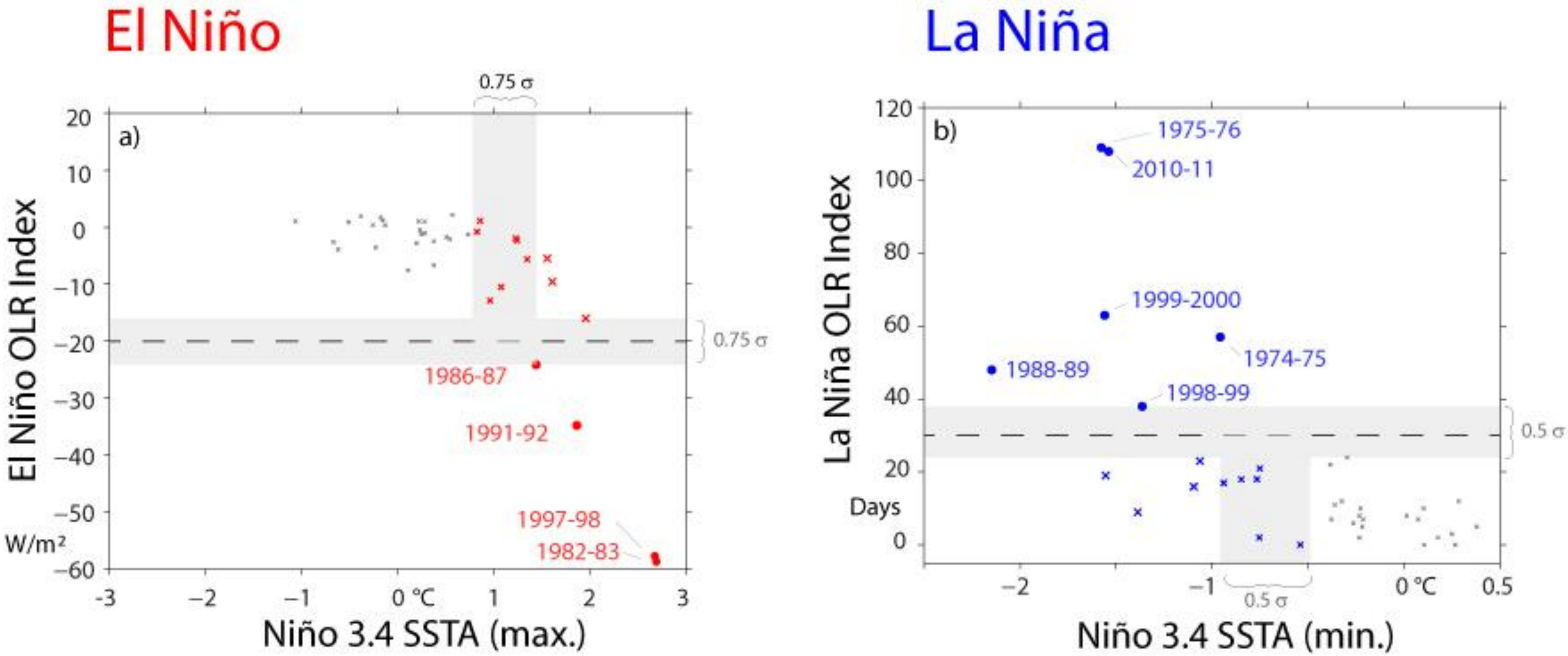
Non-OLR years have few useful associated weather anomalies over most of the globe. A better winter forecast is obtained by ignoring them and using only OLR years.

NIÑO3.4 SSTA cannot reliably identify the OLR events. Understanding better how ENSO SSTA and OLR behavior are related merits attention and both dynamical and statistical modeling work.

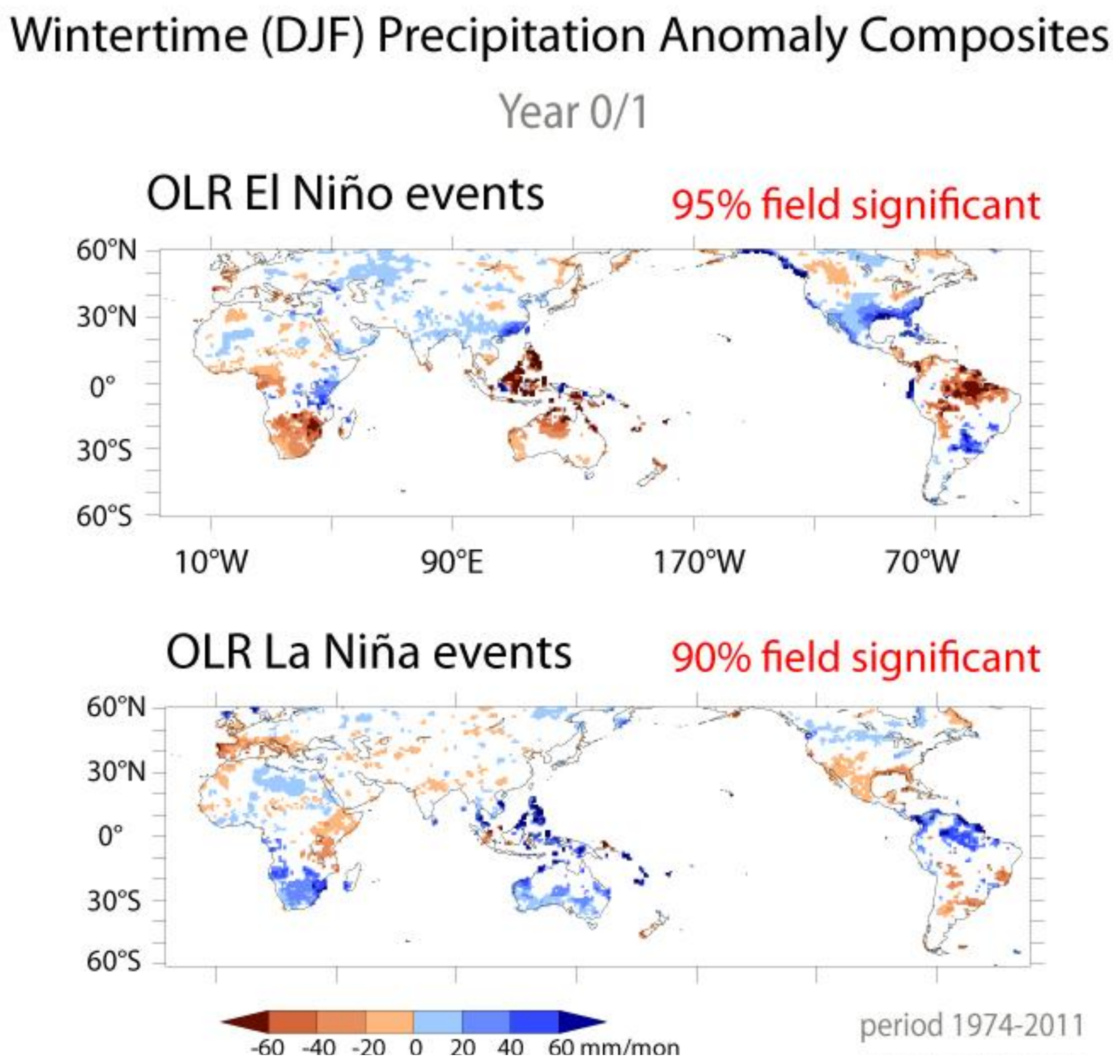
Paying more attention to the OLR behavior of the tropical Pacific, in both models and statistical forecasting efforts, may result in higher-confidence seasonal weather predictions.

End of Talk.
Extra Slides Below.

Interannual OLR and SSTA Peaks

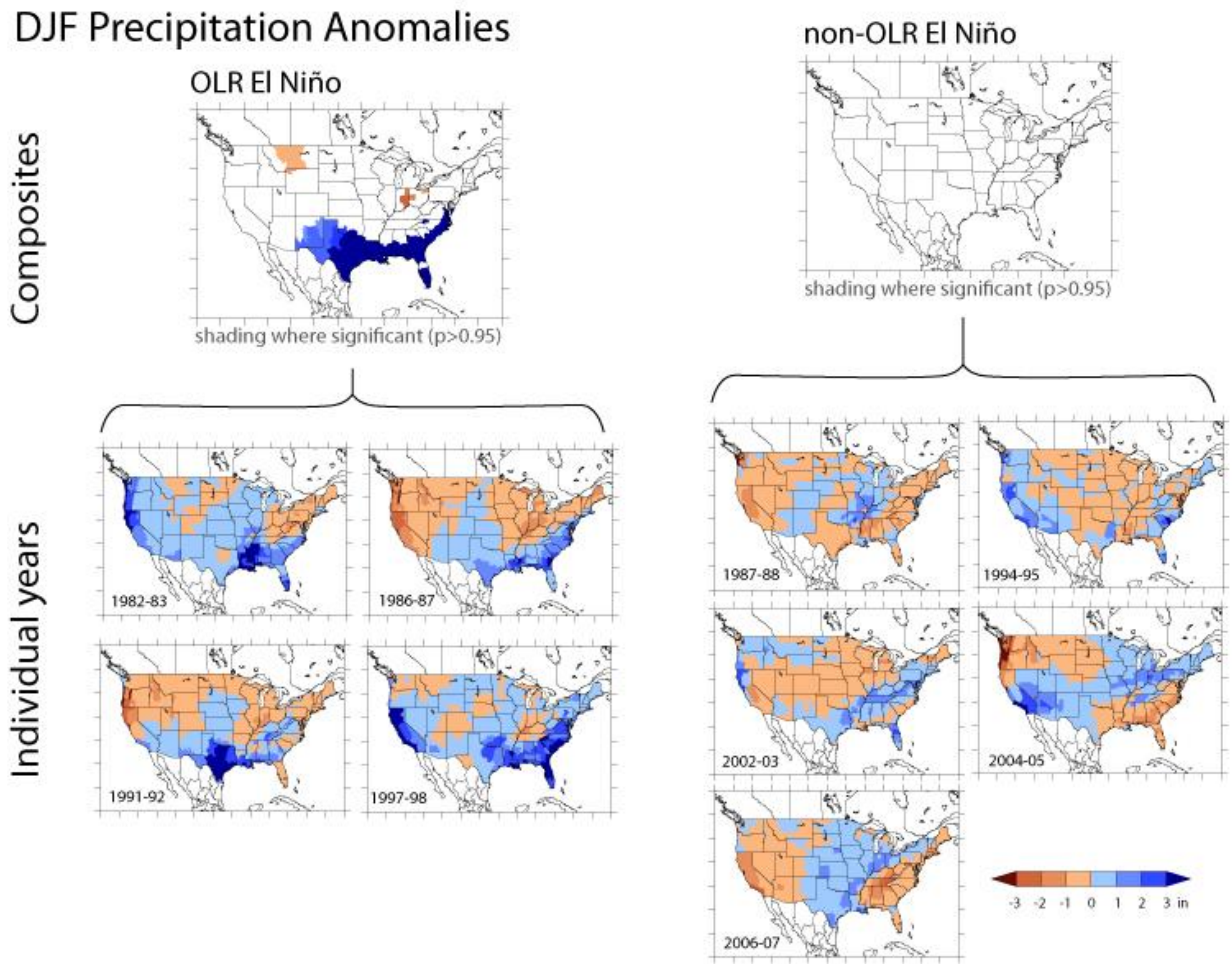


OLR event Precipitation Anomaly



Masking now at 80% local significance, so some shading by chance. Overall, *OLR*-identified *cases exceed the expected effects of chance alone*. ***Non-OLR cases do not.***

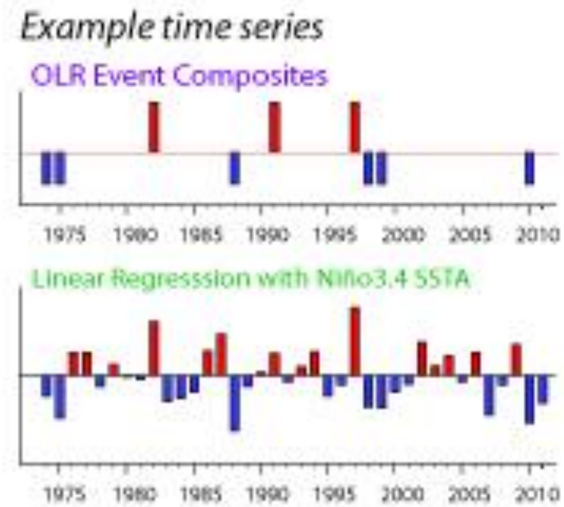
Again, as before, only for seasonal surface precipitation anomaly



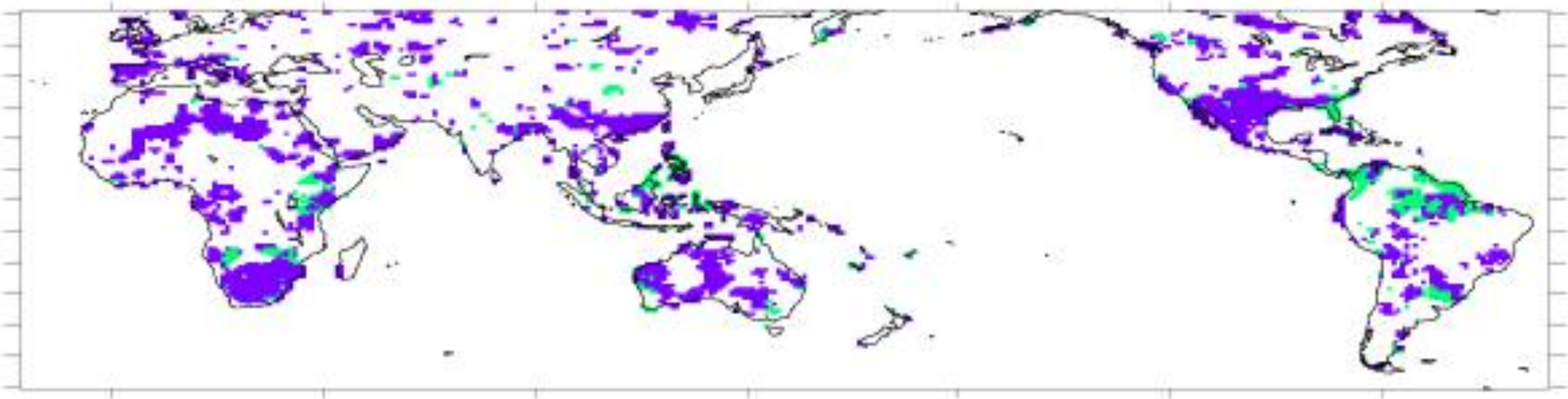
DJF Precipitation Anomaly Hindcasts

Case 1. OLR El Nino (La Nina) precipitation anomaly **composite applied** in the **3** **(6)** years identified by OLR by the beginning of DJF, ***else anomaly = 0***.

Case 2. **Linear regression** with Sep-Oct-Nov averaged **Niño3.4** SSTA.



Anomaly correlation coefficient



Shading where OLR-composite hindcast correlation is statistically significant at the 95% level

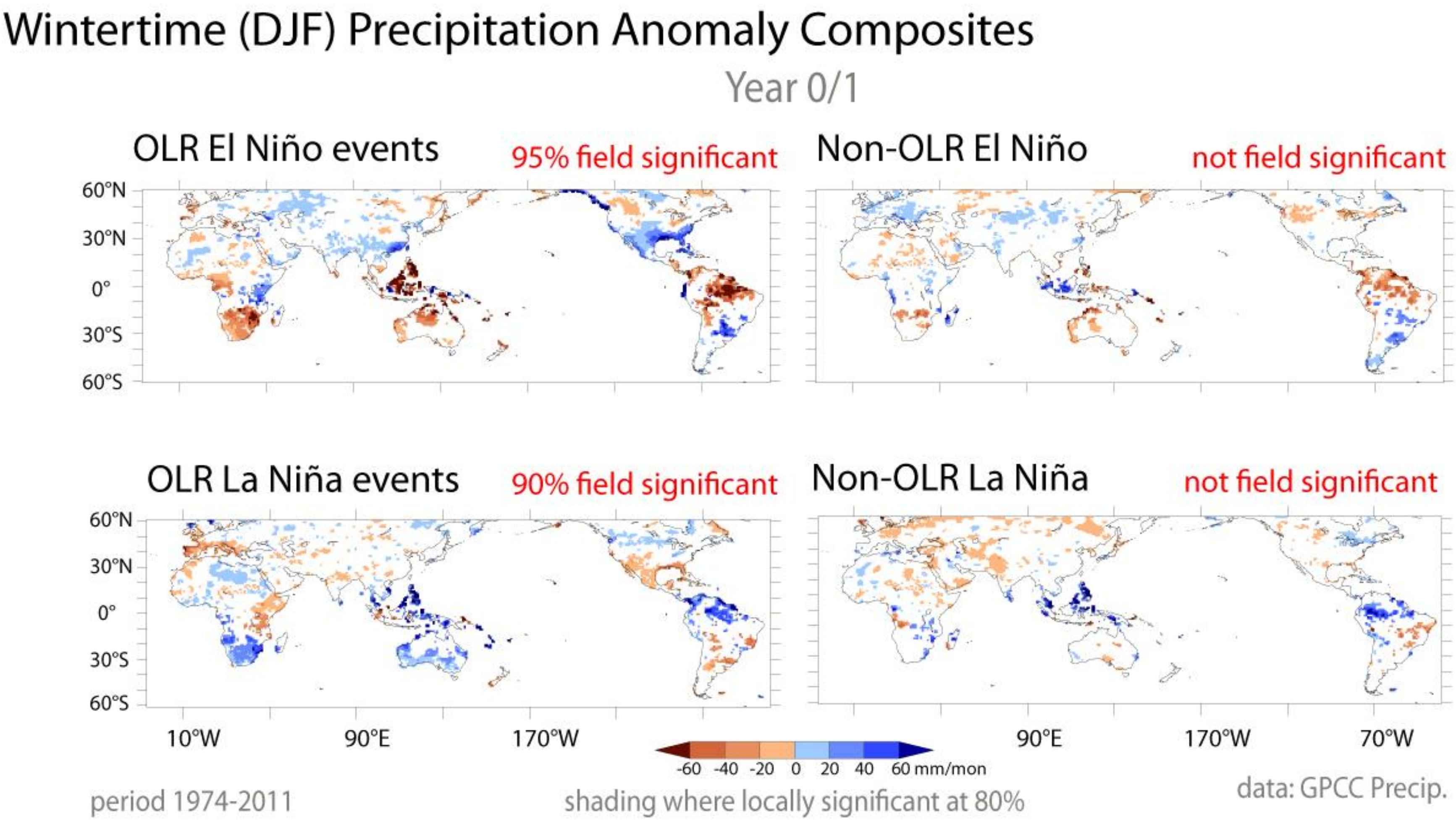
Optimal Correlation { OLR-composite hindcast / Niño3.4 regression

period 1974-2011

precip data: GPCC

OLR perspective leads to better correlation in most locations!

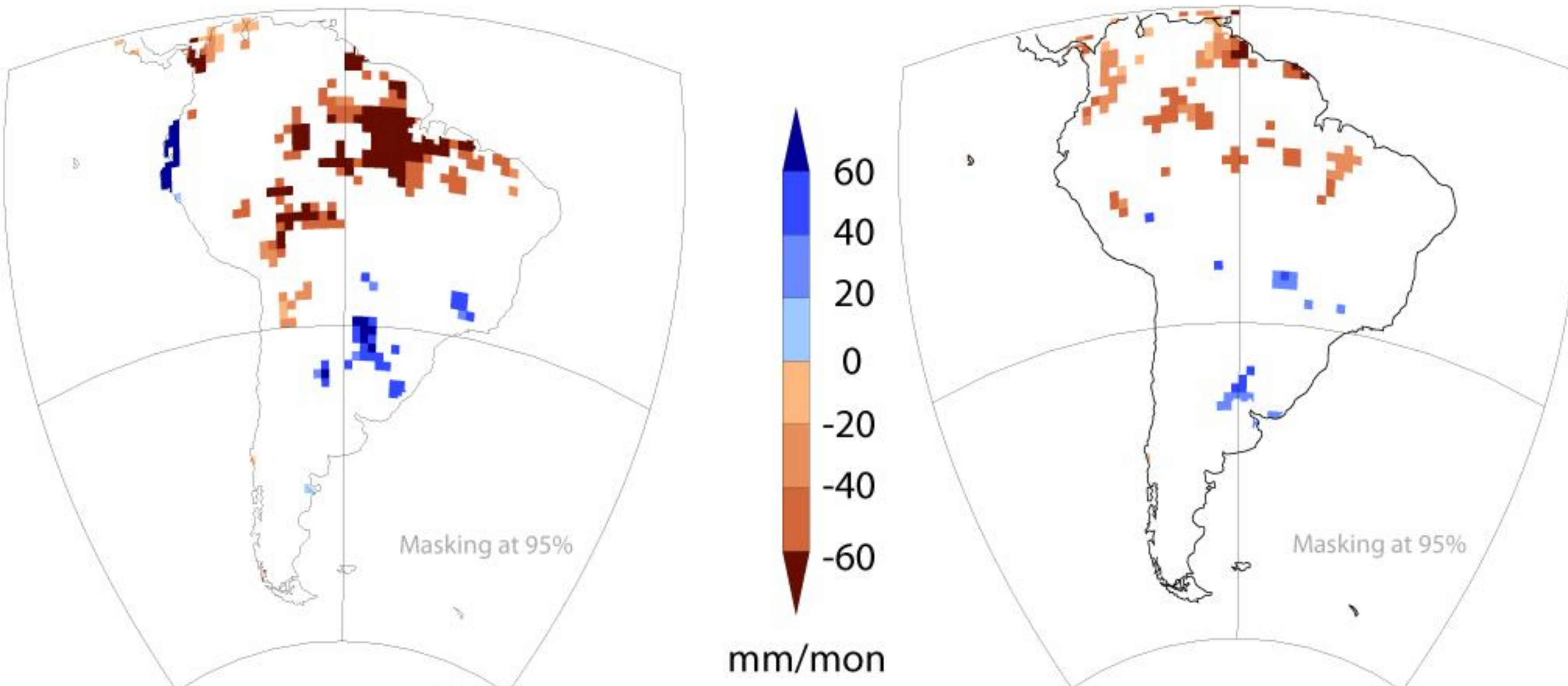
OLR vs Non-OLR Precipitation Anomaly



Masking now at 80% local significance, so some shading by chance. Overall, *OLR*-identified *cases exceed the expected effects of chance alone*. ***Non-OLR cases do not.***

DJF Precipitation Anomaly Composites

OLR El Niño | Non-OLR El Niño



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

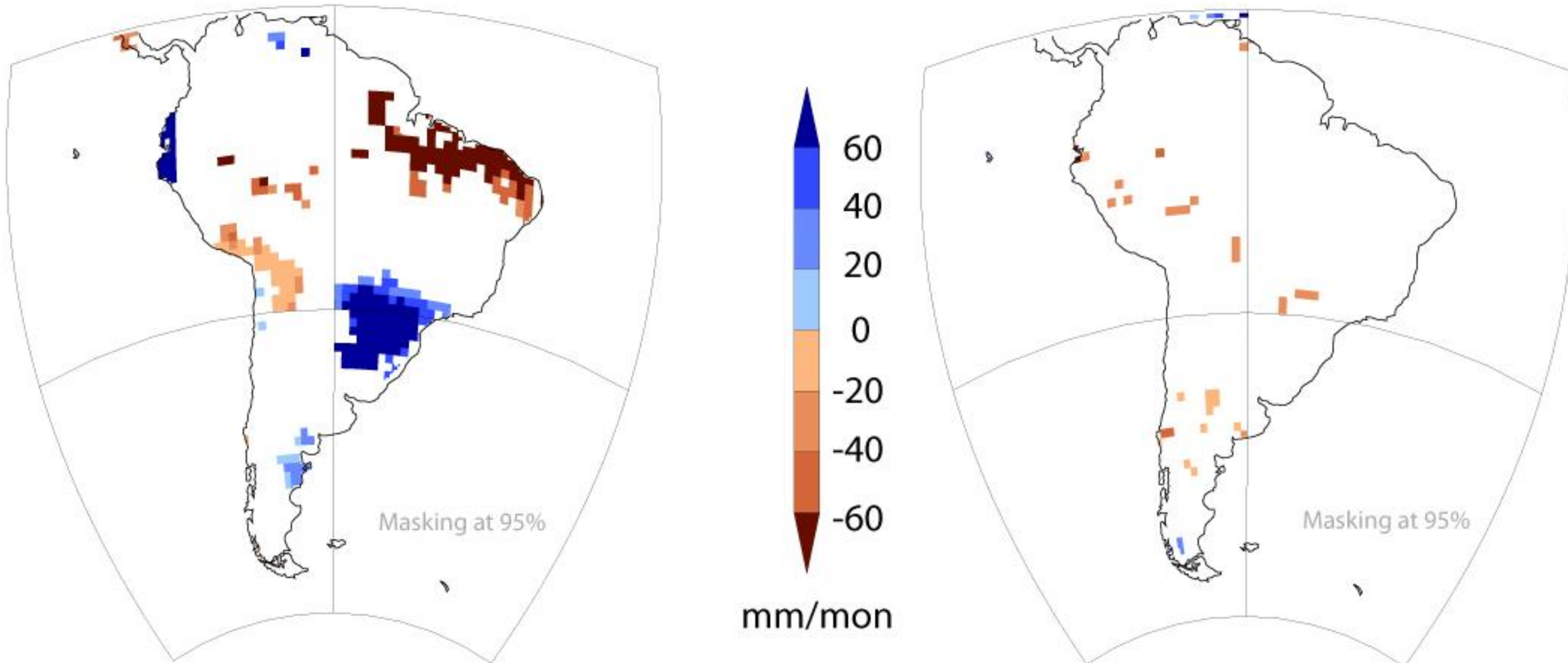
1976-77, 1987-88, 1994-95, 2002-03, 2004-05, 2006-07, 2009-10

data: GPCC Precip

MAM Precipitation Anomaly Composites

OLR El Niño

Non-OLR El Niño



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

data: GPCC Precip

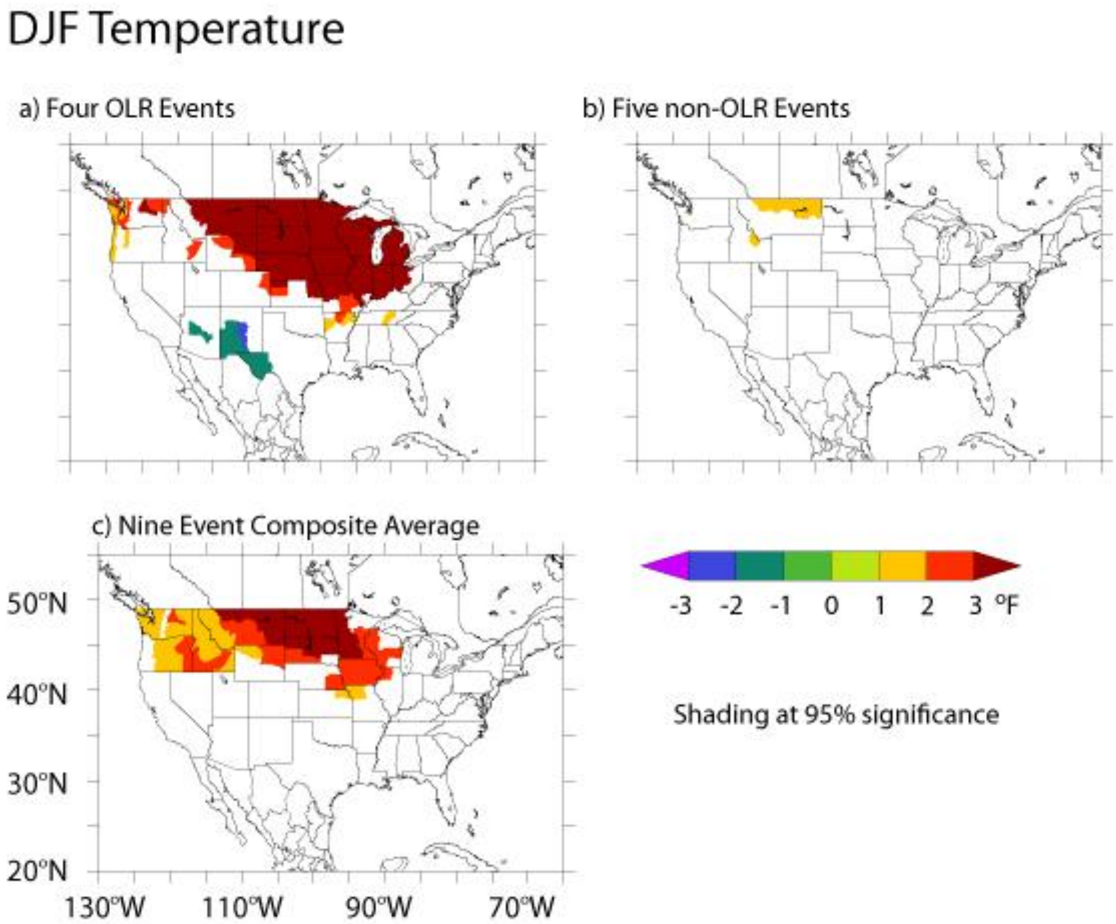
1976-77, 1987-88, 1994-95, 2002-03,
2004-05, 2006-07, 2009-10

USA Winter Surface Temp Anomaly for different subsets of El Nino events.

OLR-El Nino Event Composite

Non-OLR El Nino Event Composite

All-Event Composite



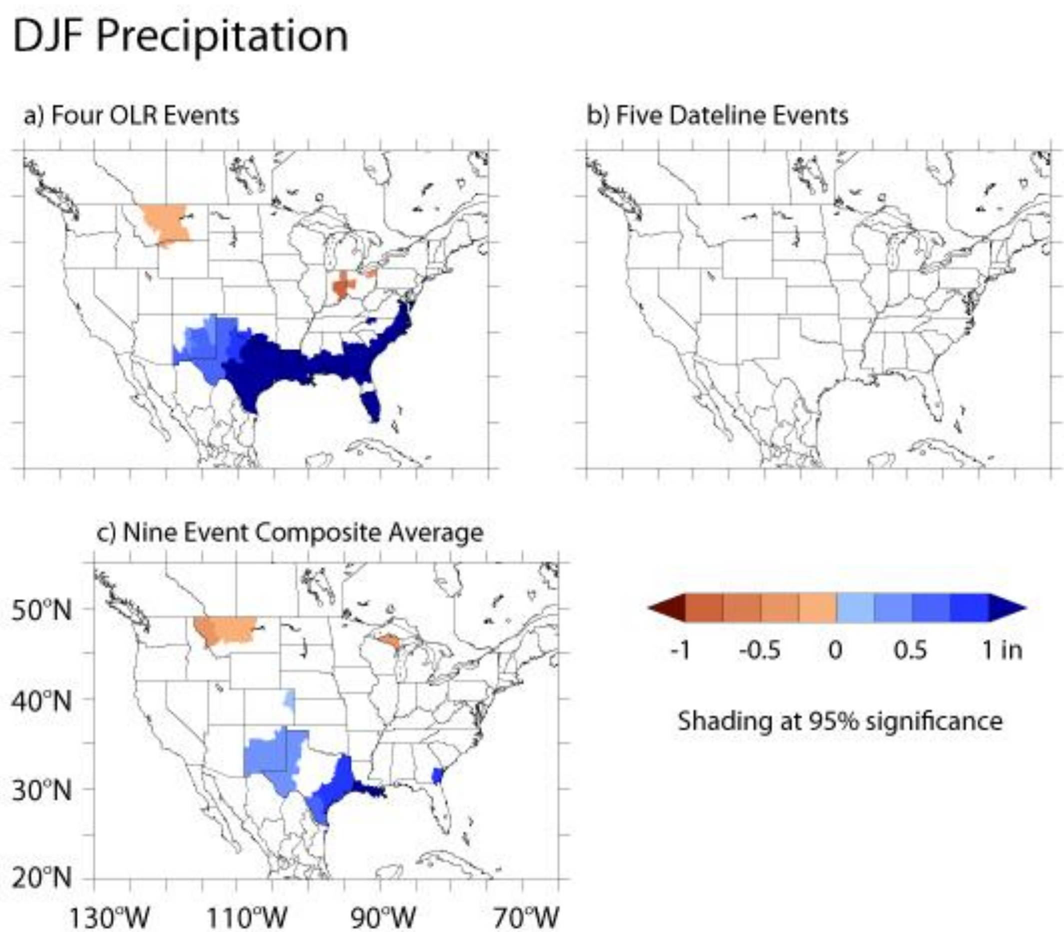
From Chiodi and Harrison (2013). Period 1979-2008.

As before, only for seasonal surface precipitation anomaly

For OLR-El Nino Events

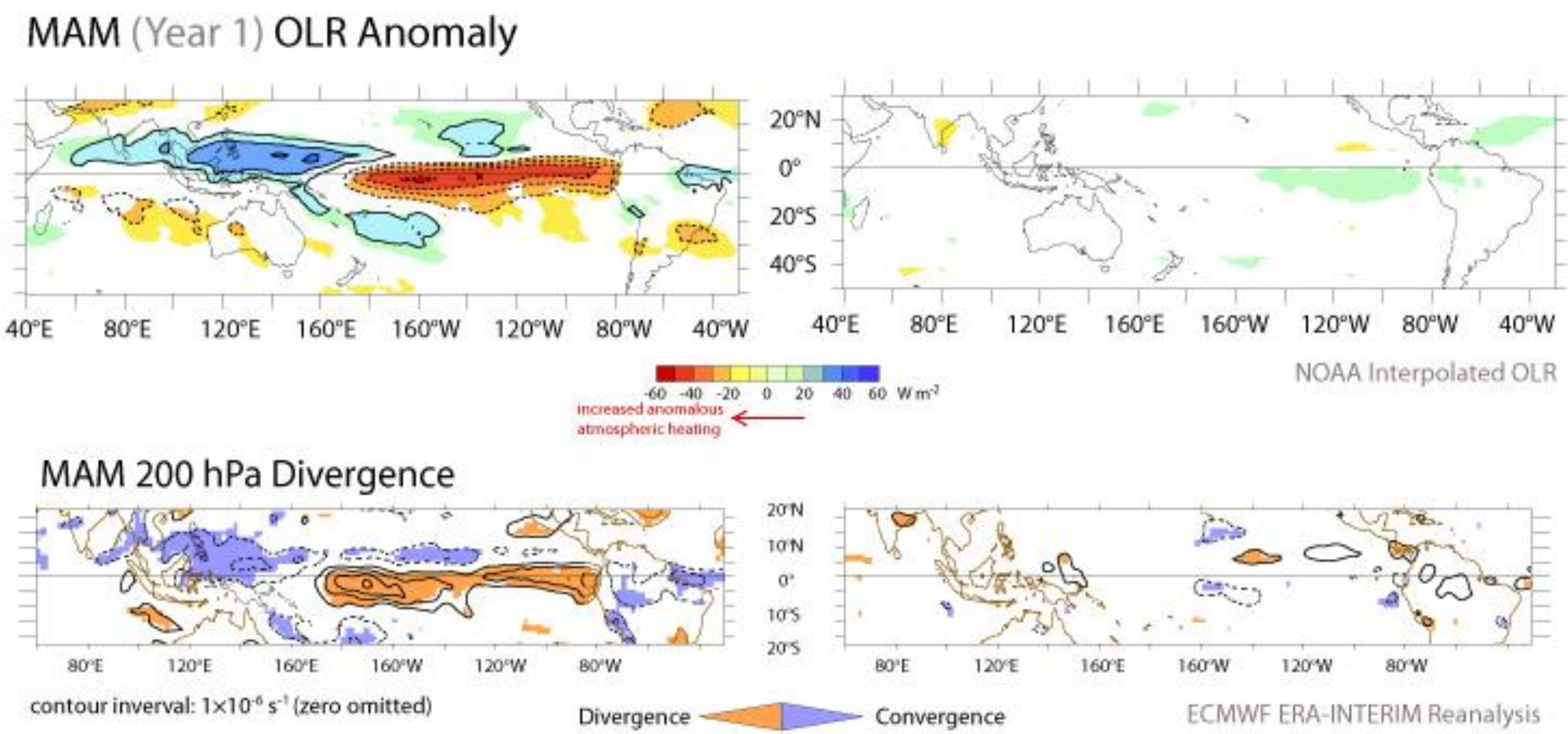
For Non-OLR El Nino Events

Including all El Nino Events



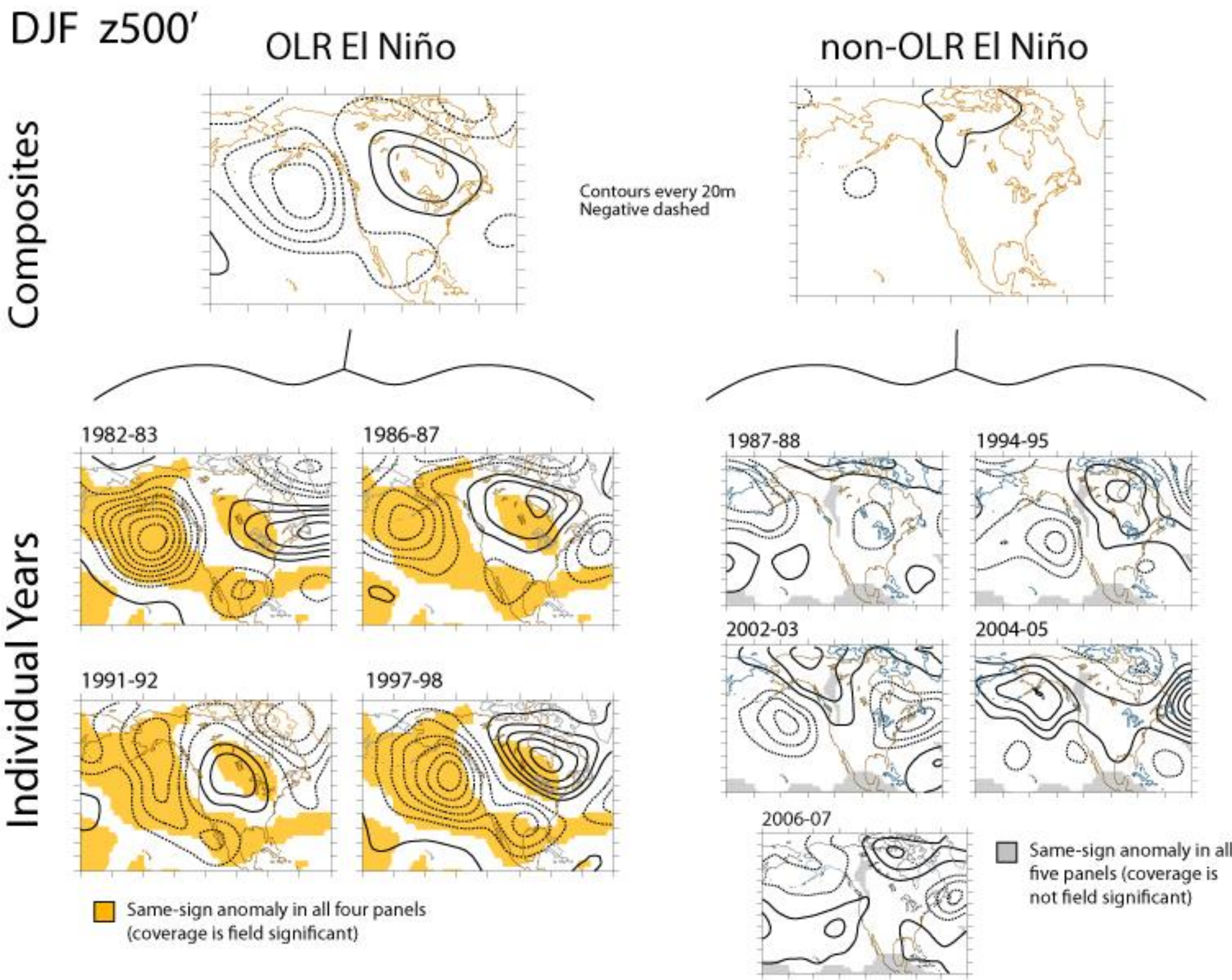
Now for March-April-May,

OLR-El Niño events **non-OLR events**

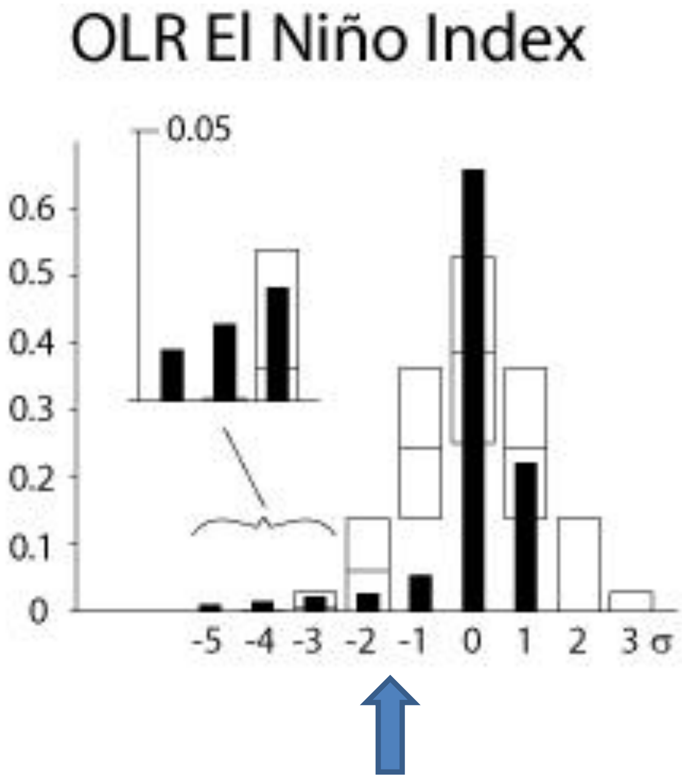


shading where stat. sig. at 95%

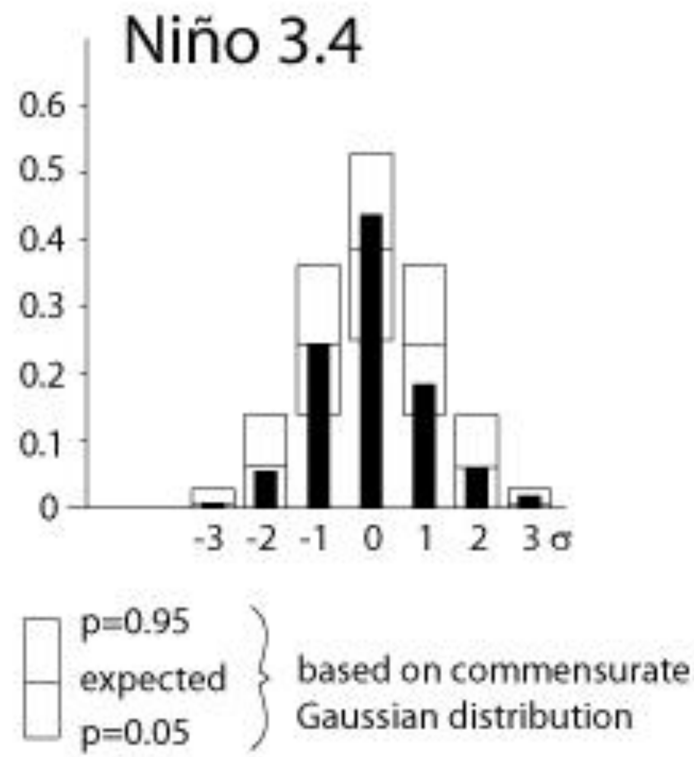
Z500' patterns are similar among the individual OLR years; different otherwise



OLR behavior is more event-like than SSTA, SLP

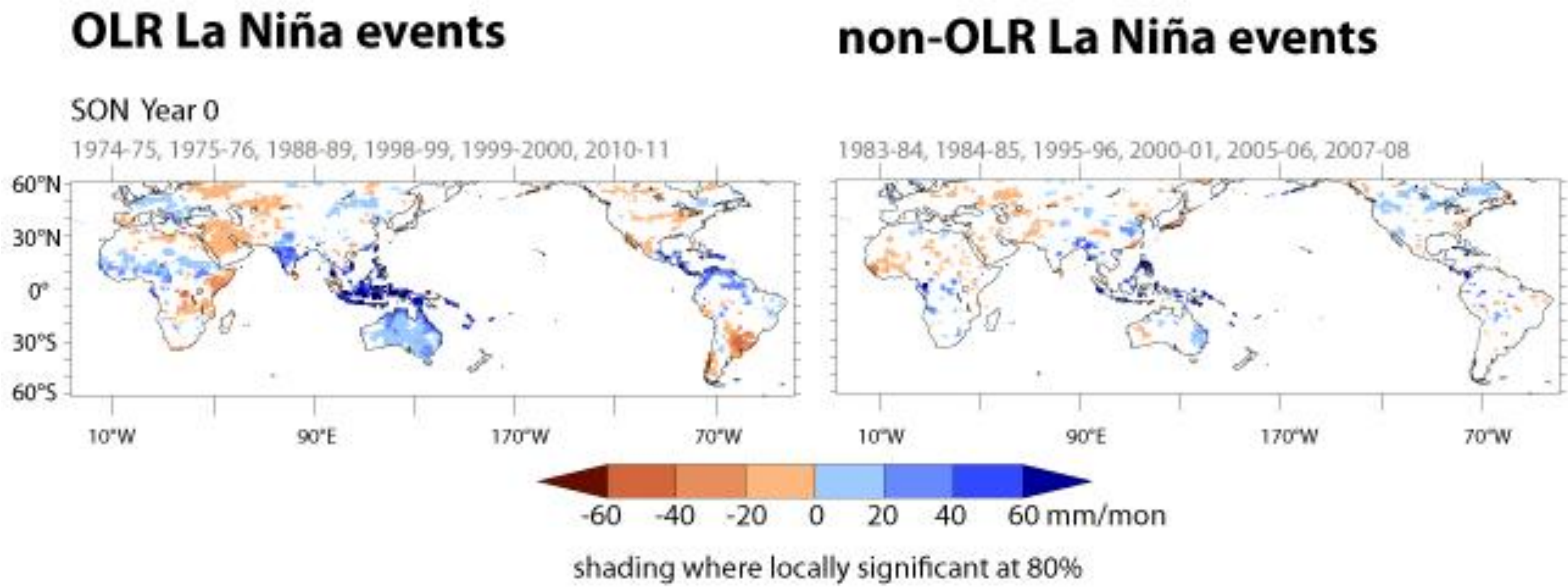


Only in the 4 large events does the index cross the -1.5σ boundary, and it does so before winter in 3 of 4 cases.

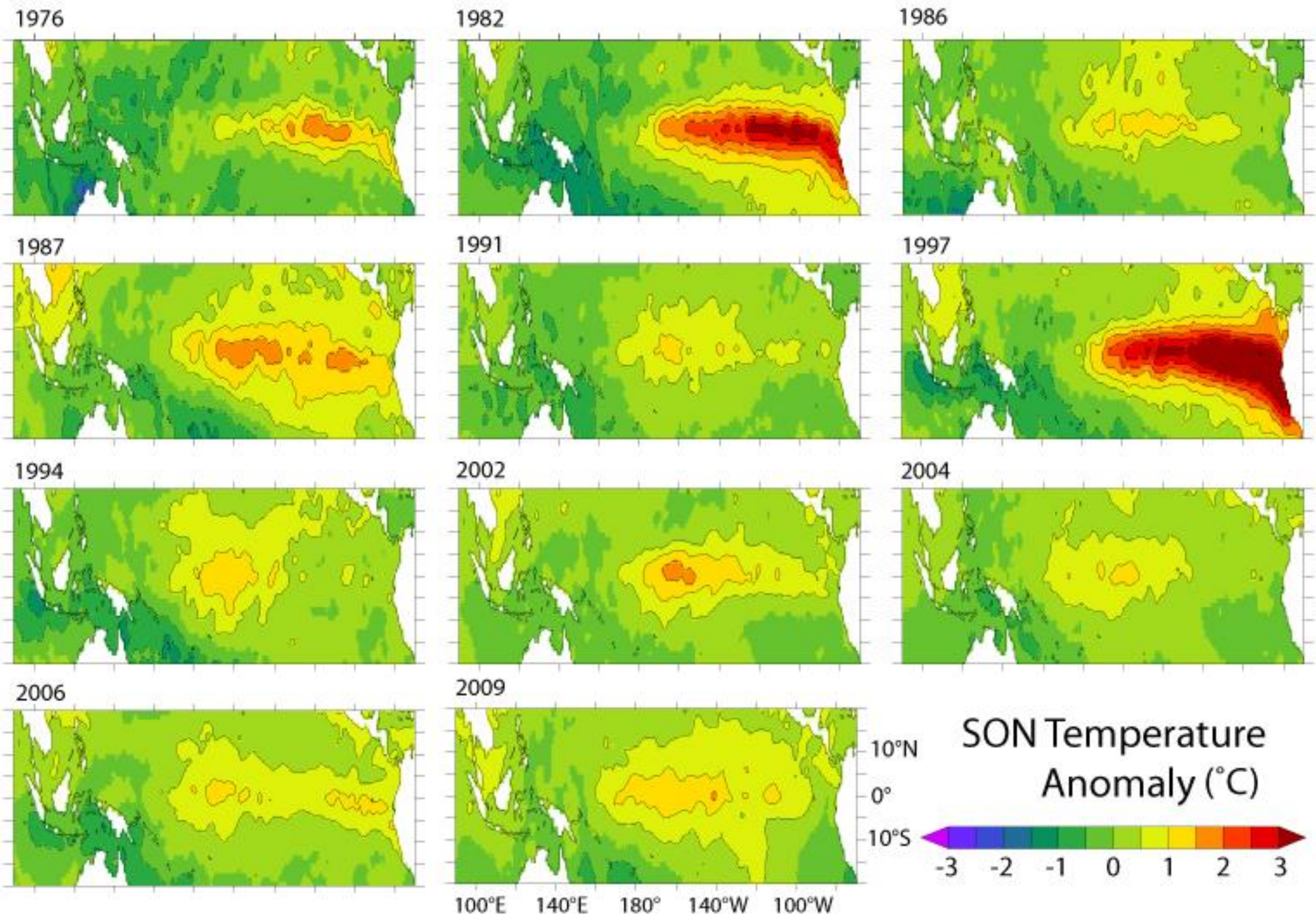


See Chiodi and Harrison (2010)

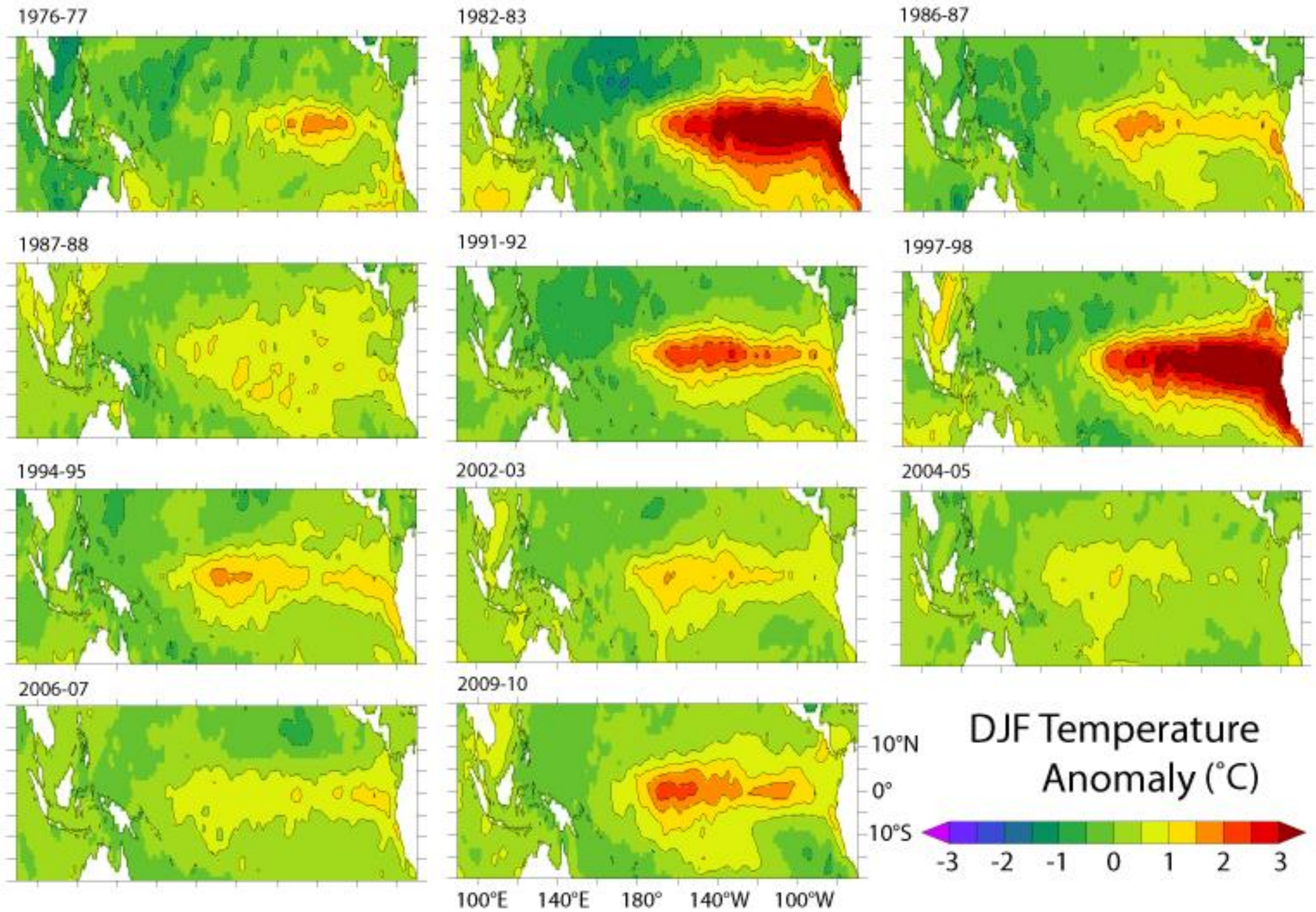
La Nina Seasonal Precipitation Anom.

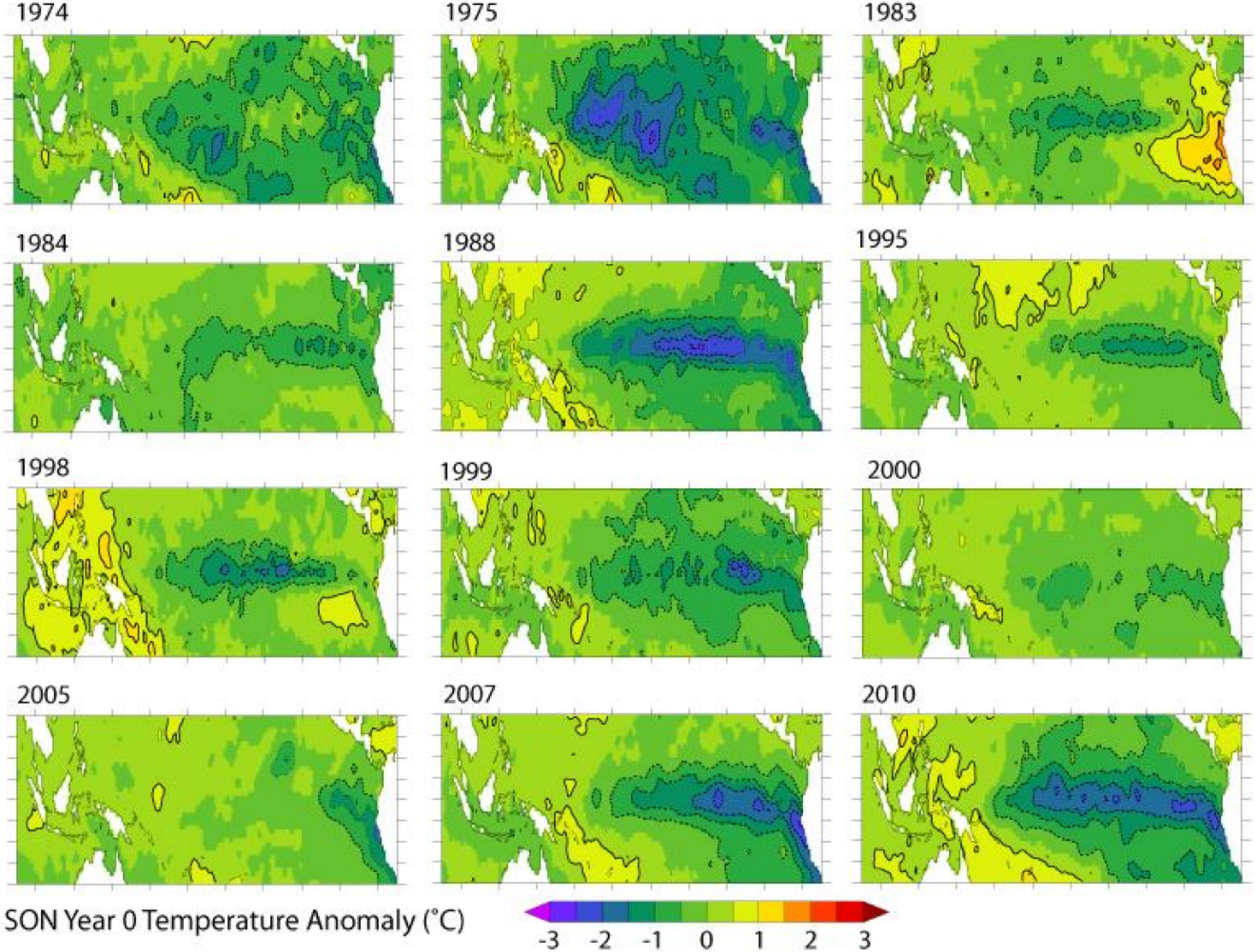


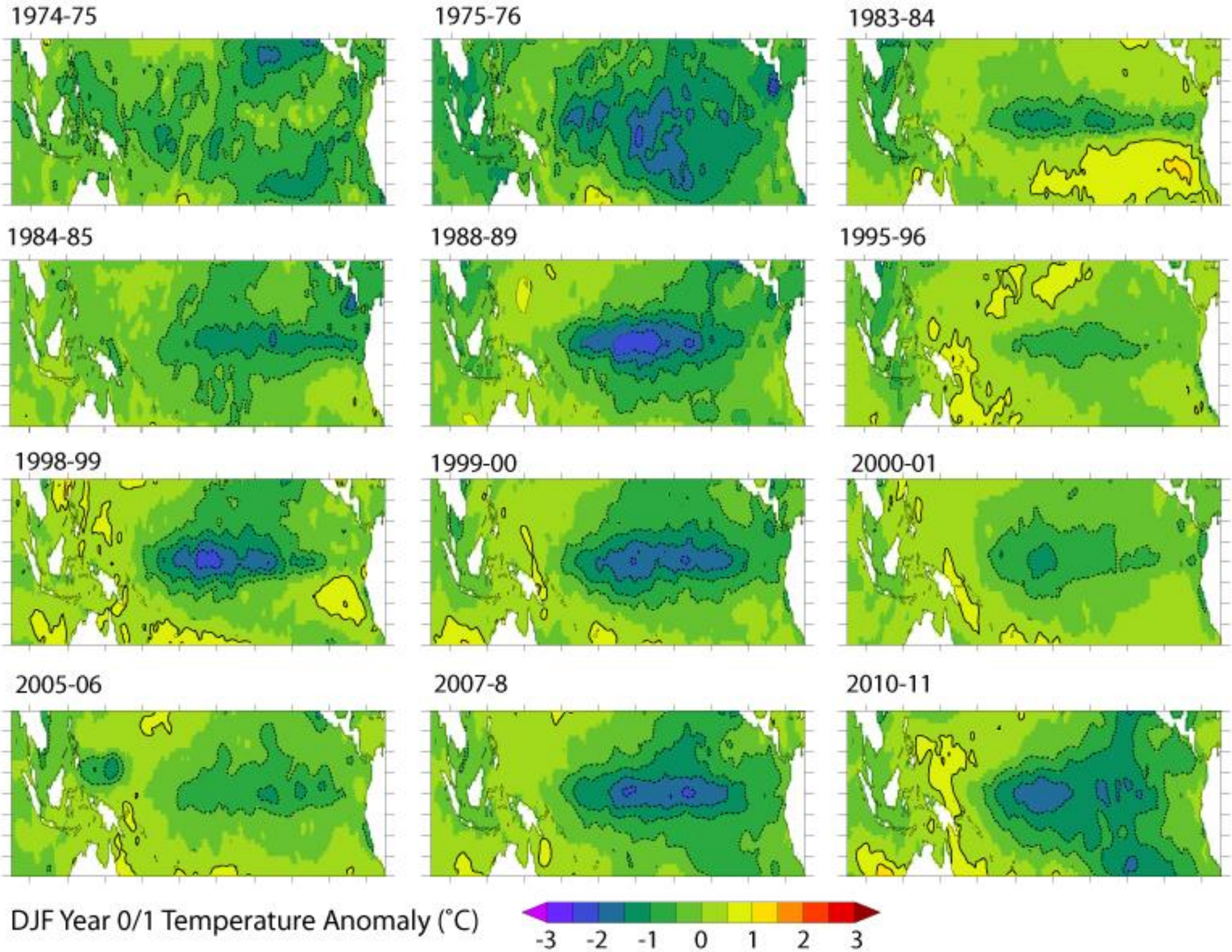
El Nino Seasonal SSTA patterns



El Nino Seasonal SSTA patterns




1974
1975
1983
1984
1988
1995
1998
1999
2000
2005
2007
2010
SON Year 0 Temperature Anomaly (°C)
-3
-2
-1
0
1
2
3



DJF Year 0/1 Temperature Anomaly (°C)