Science and Technology Infusion Climate Bulletin
NOAA's National Weather Service
41st NOAA Annual Climate Diagnostics and Prediction Workshop
Orono, ME, 3-6 October 2016

2015-16 El Niño Seasonal Weather Impacts from the OLR Event Perspective

A.M. Chiodi and D.E. Harrison

Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, and NOAA/Pacific Marine Environmental Laboratory, Seattle, Washington

1. Introduction

El Niño-Southern Oscillation (ENSO) seasonal temperature and precipitation anomaly associations provide a useful basis for statistical seasonal weather forecasting in the seasons and regions where linkages between the tropical Pacific anomaly state and seasonal weather conditions are sufficiently strong in amplitude and consistent in character from one event to another ("robust"). Robust El Niño seasonal weather associations occur in boreal winter in many affected regions worldwide, when El Niño events reach peak amplitude in the tropical Pacific.

Outgoing-longwave-radiation (OLR) observations provide information about the development of deep atmospheric convection activity in the tropics. Changes in tropical convection patterns, along with the associated atmospheric heating anomalies, are believed to dynamically link the anomaly state of the tropical Pacific with its evident influence on weather conditions elsewhere.

Over the time for which satellite-based OLR information has been available (since 1974), most of the useful El Niño associations have been contributed primarily by the subset of El Niño years that are identifiable by their signature in tropical Pacific OLR (Chiodi and Harrison 2013, 2015; CH13 and CH15). The OLR El Nino index identifies 1982-83, 1986-87, 1991-92 and 1997-98 as "OLR El Niño" years. The U.S. regions with robust OLR El Niño wintertime temperature and precipitation associations were identified in the composite analysis of CH13, based on these four years. CH15 did the same for global (60°S to 60°N) precipitation over land. In both cases, the OLR El Nino composites were found to contain enough statistically significant anomaly (at 90 or 95% confidence) to reach field significance (at 90 or 95% confidence).

In contrast, composites based on the other "non-OLR El Nino years", which have event status based on the common El Niño definitions but not by OLR, yield little statistically significant winter weather anomaly at 90% or 95% confidence. Non-OLR El Niño year winter weather anomaly patterns exhibit a high degree of event-to-event variability, including over the regions where robust associations are found in the OLR El Niño case. The non-OLR El Niño wintertime temperature (U.S.) and precipitation (global and U.S.) composites do not pass field significance tests, even when compromising to the 66% confidence interval (CH13, CH15).

Three of the four previous OLR El Niño events (1982-83, 1991-92, 1997-98) were identifiable from the OLR information (OLR El Niño index) available by the end of fall of ENSO Year 0, in time to be of use to wintertime forecasting efforts, albeit at short lead. Should this type of behavior hold, monitoring tropical Pacific OLR conditions will provide means to usefully strengthen our ability to forecast winter weather in the strongly affected regions. It is not necessary to forecast OLR for this use.

The recent 2015-16 El Niño was identifiable as an OLR-event before winter (Fig. 1). Here we examine the extent to which the winter weather conditions seen in 2015-16 match those seen in the previous event composite (based on 1982-83, 1986-87, 1991-92 and 1997-98), over the strongly affected regions. These include the regions within Africa, South America and North America that were revealed to have robust precipitation associations by the CH15 composite analysis. We examine each of these three cases, but follow CH13 in offering a more detailed look at both wintertime temperature and precipitation associations over the U.S. (contiguous 48 States), rather than examine the entire North American continent. We also discuss the composite wintertime (Dec-Jan-Feb; DJF hereafter) tropical OLR anomaly pattern based on the four previous OLR El Nino events, as well as conditions observed in 2015-16.

Correspondence to: Andrew M. Chiodi, Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, and NOAA/Pacific Marine Environmental Laboratory, Seattle, Washington; E-mail: andy.chiodi@noaa.gov

2. Data and methods

We use gauge-based gridded (1° latitude × 1° longitude) precipitation data from the Global Precipitation Climatology Center (GPCC; Schneider et al. 2015) for information on monthly precipitation anomaly over Africa and South America. GPCC precipitation data is available from http://gpcc.dwd.de. For temperature and precipitation information over the U.S., we use the U.S. Climate Divisional Data set made available by NOAA's National Centers for Environmental Information, at: https://www.ncdc.noaa.gov/monitoring-references/maps/us-climate-divisions.php.

These are the same precipitation and data sets used by CH15 and CH13. The base period used here to calculate the 2015-16 DJF seasonal weather anomalies is 1979-2015. The composites based on the previous four OLR El Niño events are shown here as they were published in CH15 and CH13, based on a 1974-2011 and 1979-2008 base period, respectively. We have confirmed that the composites remain qualitatively equivalent regardless of which of these three base periods is used to calculate anomalies from the mean seasonal cycle.

For up-to-date OLR information we use the NOAA OLR Climate Data Record (CDR), available with just a few days delay at http://olr.umd.edu/.

3. Tropical OLR anomaly

The wintertime (DJF) composite of tropical OLR anomaly based on the four previous El Nino years has a large amplitude and statistically significant (at 95%) negative anomaly (increased convection/atmospheric heating) spanning the eastern two-thirds of the equatorial Pacific Ocean basin (CH15 and Fig. 1). This composite also reveals significant positive OLR anomaly (decreased convection activity) over much of the far western tropical Pacific. The non-OLR composite (CH15; not shown here) has weaker OLR anomalies that reach statistical significance over a much smaller area, including near the Dateline. This difference in OLR behavior suggests that there is a much stronger tropical atmospheric heating anomaly at work in the OLR El Nino years than non-OLR El Niño years.

The 2015-16 DJF tropical OLR anomaly pattern resembles that seen in the OLR El Niño composite. This suggests that a similarly strong tropical atmospheric heating anomaly is at work in 2015-16 as well.

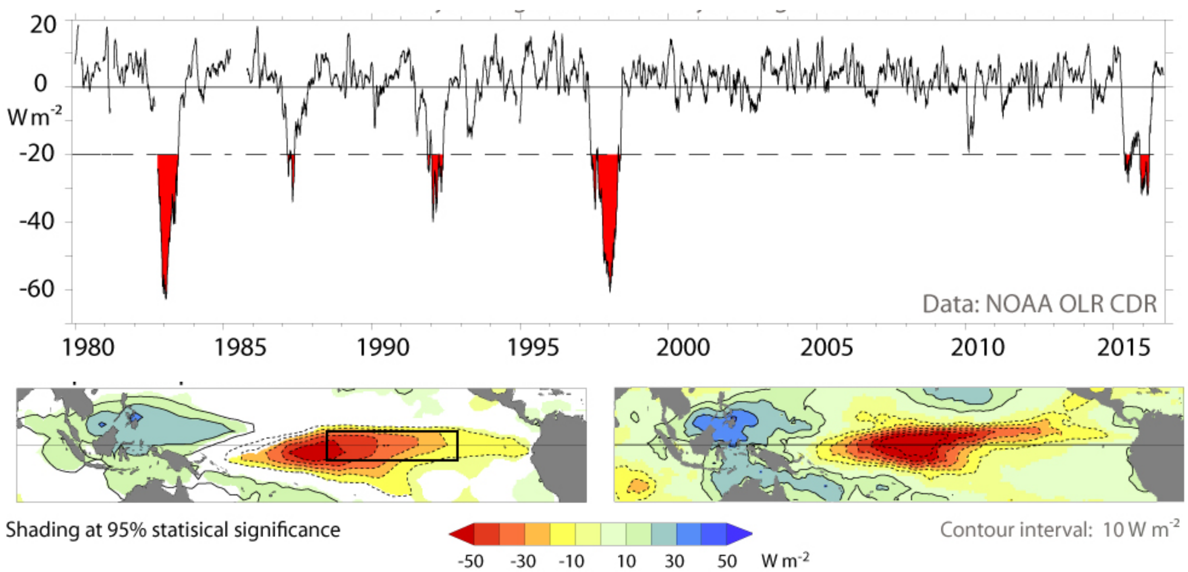

Fig. 1 Upper panel: The OLR El Niño index. The OLR anomaly is monthly mean and area averaged over 160°-110°W and 5°S-5°N. Bottom left: Composite DJF-averaged OLR anomaly based on the previous four OLR El Niño events. The box shows the OLR El Niño index averaging region. Bottom right: OLR anomaly averaged over the DJF period spanning December 2015 through February 2016.

4. El Niño DJF precipitation associations over Africa

Composite DJF precipitation anomaly over Africa based on the 4 previous OLR El Niño events is shown in the upper-right panel of Figure 2, along with the DJF average observed in 2015-16 (upper left panel). Statistically significant (90% level) wet and dry anomalies are seen over some southeastern (*e.g.* Tanzania) and southern (*e.g.* parts of South Africa, Mozambique and Zimbabwe) regions of the continent. Statistically significant dry anomaly is also seen over part of equatorial western Africa.

It is over these affected regions (where the composite is shaded) where we hypothesize that the OLR-perspective on El Niño can be used to strengthen our ability to forecast DJF precipitation during the OLR El Niño events. The 2015-16 DJF precipitation anomaly pattern matches the previous-event composite over these regions (Fig. 2, upper panels); in each case, a coherent dry-to-wet contrast is seen between the southern-to-southeastern part of the continent, and dry anomaly over equatorial western Africa.

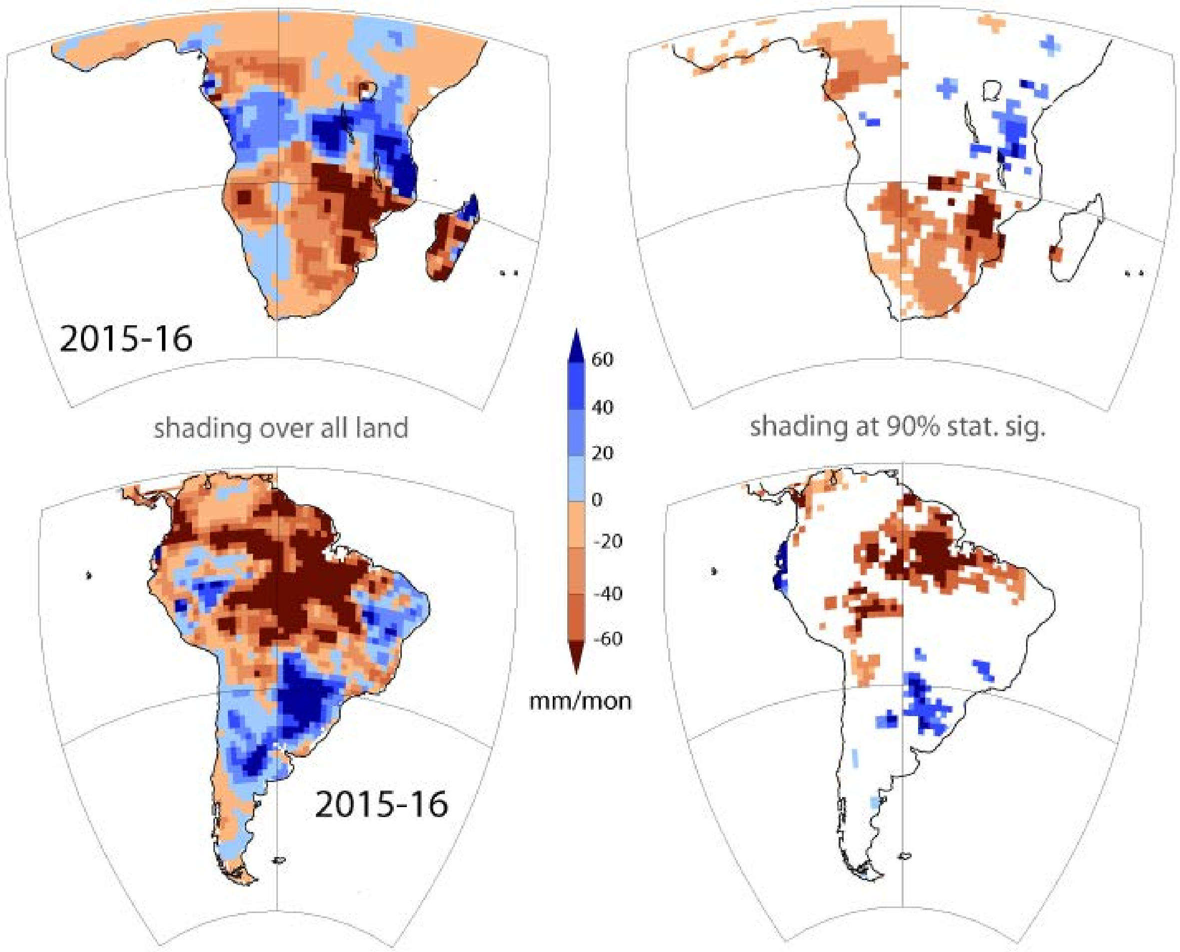

Fig. 2 Left side panels: DJF averaged precipitation anomalies observed during the recent 2015-16 OLR El Niño event. Right panels: Composite DJF precipitation anomalies based on the previous four OLR El Niño events, as described by Chiodi and Harrison (2015).

5. El Niño DJF precipitation associations over South America

The DJF precipitation composite based on the previous four OLR El Niño events reaches statistical significance (at 90%) over much of the Amazon river basin (dry) as well as over a smaller region in Southeastern South America (wet) (Fig. 2, lower panels). Some more localized statistically significant anomaly is also seen along the northwest coast, where dry anomaly is seen over the northwest coast of Columbia and wet anomalies are seen over Equador and Peru.

The two larger strongly-affected regions (Amazon Basin and Southeastern South America) exhibit 2015-16 DJF anomaly conditions that rather closely match those seen in the composite based on previous events. The 2015-16 case also matches the composite over the northwestern coast of Columbia, but not over Peru. Although more work is needed to explain the observed precipitation anomalies over Equador and Peru in 2015-16, there is a good overall match between the previous event composite and 2015-16 over South America.

6. El Niño DJF precipitation and temperature associations over the U.S.

The composite U.S. wintertime precipitation anomaly pattern based on the four previous OLR El Niño events reveals coherent and statistically significant (95%) wet anomalies over much of the southeast (Fig. 3, lower right). CH13 showed that each of the four individual event-years exhibited a broad swath of wet anomaly over this region. In 2015-16, DJF-averaged rainfall (Fig. 3, lower left) was substantially heavier than average over much of the southeast, but dryer than normal conditions were unexpectedly seen over Texas.

The OLR El Niño composite U.S. temperature anomaly pattern reveals statistically significant (95%) warm temperatures during DJF over much of the north central U.S (Fig. 3, upper right). The 2015-16 winter temperature anomaly also has >3°F temperature anomaly over this region (Fig. 3, upper left). We have confirmed that the warm anomaly over the north-central U.S. in DJF 2015-16 remains >3°F regardless of whether or not the linear trend in temperature over the study period is removed before the DJF anomaly is calculated. This result is also robust to changing the base period by 5-10 years. The OLR El Nino-associated wintertime warming amplitude over the north central U.S. is large compared to these other sources of variability.

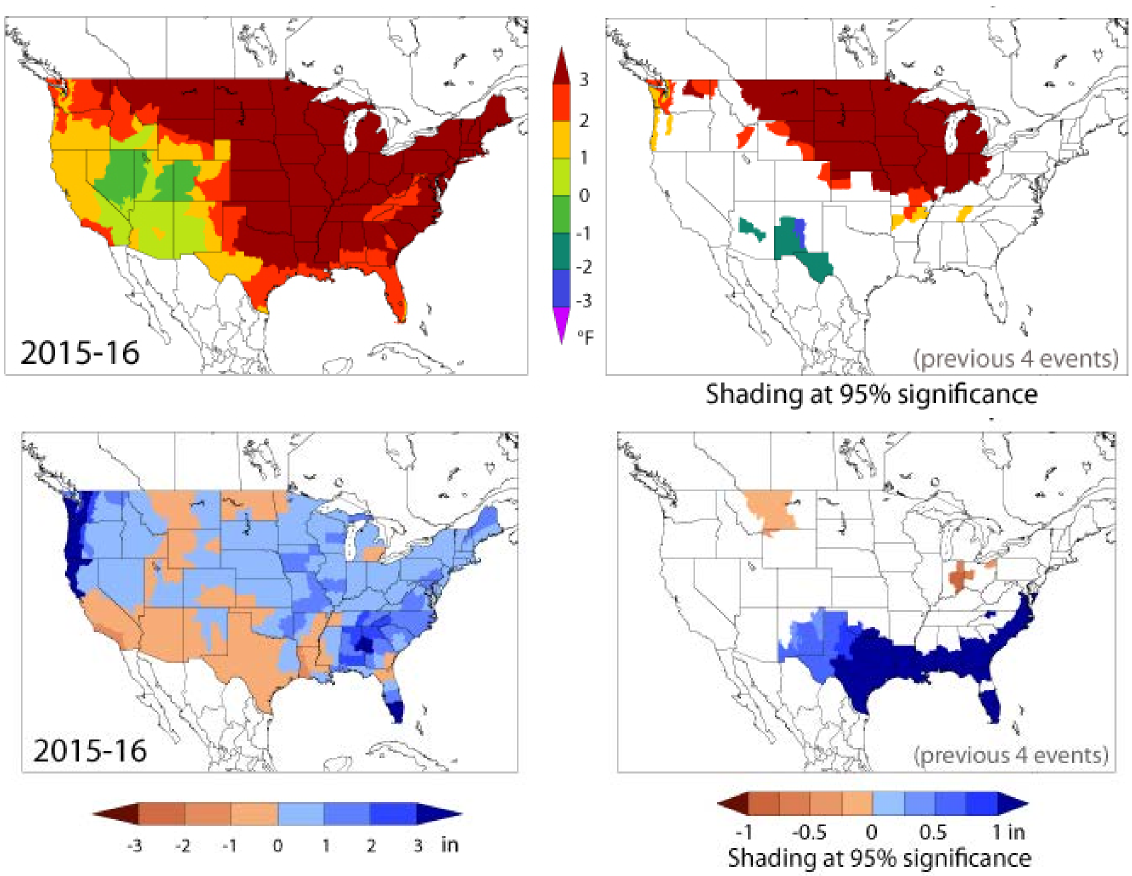

Fig. 3 DJF-averaged temperature (upper) and precipitation anomaly (lower) over the U.S. for the composite based on the previous four OLR El Niño events (right) and the 2015-16 event (left).

7. Summary

We have shown previously that most of the useful El Niño-winter weather anomaly associations worldwide have been contributed by the subset of El Niño years that are distinct based on tropical Pacific OLR. We have now experienced five such OLR El Nino years over the time for which satellite-based OLR information is available, with 2015-16 being the fifth. As was the case in most of the previous events, 2015-16 was distinguished by the OLR El Niño index before winter. We have previously hypothesized that this situation provides opportunity to strengthen our ability to forecast wintertime weather conditions over the regions where robust associations have been revealed by the prior events. Obviously, this requires that the associations remain consistent in future events. We have examined the extent to which the 2015-16 DJF weather anomalies are consistent with the previous-4-event composite over the regions where robust associations have been revealed by the composite.

The wintertime weather anomaly observed over the north central U.S. in 2015-16 well matches that seen in the composite of previous events in that a coherent patch of substantially (> 3°F) warm anomaly is seen in both cases. The observed 2015-16 DJF precipitation anomaly conditions also have the same character as those in the composite over about 75% of the regions previously identified as having robust associations (Peru and Texas being the exceptions). This basic agreement supports our hypothesis that the OLR-perspective on El Niño seasonal weather associations offers strengthened ability to make event-year winter weather forecasts in the robustly-affected regions.

Acknowledgements. This publication is partially funded by the Joint Institute for the Study of the Atmosphere and Ocean (JISAO) under National Oceanic and Atmospheric Administration (NOAA) Cooperative Agreement NA10OAR4320148, and by support from the Climate Observations Division of the NOAA Climate Program Office (FundRef number 100007298) as well as from NOAA's Pacific Marine Environmental Laboratory.

REFERENCES

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*, **23**, 822-837. doi: 10.1175/JCLI-D-12-00097.1

Chiodi, A.M., and D.E. Harrison, 2015: Global seasonal precipitation anomalies robustly associated with El Niño and La Niña events - An OLR perspective. *J. Climate* , **28**, 6133-6159. doi: 10.1175/JCLI-D-14-00387.1

Schneider, U., M. Ziese, A. Becker, A. Meyer-Christoffer, P. Finger, 2015: Global Precipitation Analysis Products of the GPCC. Global Precipitation Climatology Centre, 14 pp. ftp://ftp-anon.dwd.de/pub/data/gpcc/PDF/GPCC_intro_products_2008.pdf