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An Overview of the El Niño-Southern Oscillation (ENSO) since 2014

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1. The borderline El Niño during the Northern Hemisphere winter 2014-15

Though sea surface temperature (SST) anomalies across a large swath of the central and eastern equatorial Pacific Ocean were above average during October 2014-February 2015, NOAA CPC did not issue an El Niño Advisory, which would have signified the onset of El Niño conditions. The combination of the brief duration of above-average SSTs and a lack of clear atmospheric indicators across the tropical Pacific were the main reasons the winter of 2014-15 was considered a borderline El Niño or ENSO-neutral.

The Niño-3.4 SST index was in excess of +0.5°C during November 2014-January 2015 (based on ERSSTv4 using a 1981-2010 climatology; Fig. 1). In the historical record, a full-blown "El Niño episode" requires ERSST Niño-3.4 SSTs to remain at or in excess of +0.5°C for at least 5 consecutive overlapping seasons (3-month average), a condition not met during this period. In addition, the equatorial Southern Oscillation Index (EQSOI), which measures the difference of sea level pressure between the western and eastern equatorial Pacific, was characterized by small monthly values (between zero and -0.3 standardized units in NCEP CFSR and CDAS) during October-December 2014 (Fig. 2). Global and tropical precipitation anomaly patterns were also largely inconsistent with El Niño during the latter half of 2014 as indicated by small values in the Principal Component (PC-1) time series related to the leading pattern of global precipitation (Fig. 3- top panel). El Niño is typically linked to increased rainfall over the central and eastern equatorial Pacific, but instead, near average rainfall prevailed.

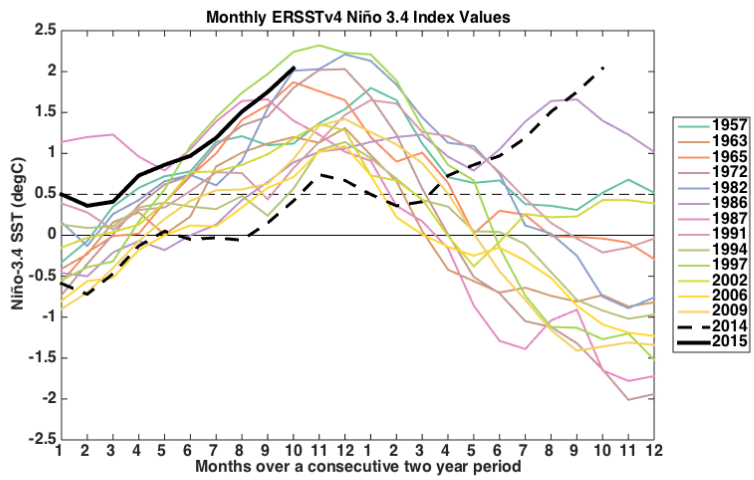

Fig. 1 Monthly Niño-3.4 index values based on the NOAA ERSSTv4 dataset (Huang *et al.* 2015) for previous moderate-to-strong El Niño events dating back to 1950. Values are presented over two years, so the dashed black line shows 2014 (first set of months 1 (Jan) -12 (Dec)) through 2015 (second set of months 1 (Jan) -12 (Dec)). The solid black line shows values only through October 2015.

2. The growth of a strong El Niño through October 2015

An El Niño Advisory was issued in March 2015 due to the increase in several atmospheric indicators and a turnaround in the Niño-3.4 SSTs, which had decreased from January to February 2015 (Fig. 1). The equatorial Southern Oscillation Index (EQSOI) also strengthened to values near -1.0 standard deviations during March (based on NCEP CFSR and CDAS; Fig. 2). Most notably, a strong westerly wind burst emerged and enhanced convection became evident near the International Date Line. This westerly wind burst helped to drive the downwelling phase of an oceanic Kelvin wave eastward, further fueling the growth of El Niño. Also, the oceanic state started off considerably warmer in 2015 compared to early 2014, when models first suggested a possible El Niño.

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El Niño grew at a nearly constant pace through the first three quarters of 2015. By early June, CPC/IRI forecasters favored a strong El Niño event. In August, forecasters indicated the event would be potentially historic, noting that the "consensus unanimously favors a strong El Niño, with peak 3-month SST departures in the Niño 3.4 region potentially near or exceeding +2.0°C" (Aug. 13th ENSO Diagnostics Discussion). By September 2015, the EQSOI was close to -2.0 standard deviations. Also, a prominent west-east dipole of suppressed convection over Indonesia and enhanced convection over the central Pacific had formed (Fig 3-bottom panels). In addition to the tropical Pacific, it was clear that, by July-September 2015, the influence of El Niño extended globally: below-average precipitation was observed over portions of eastern Texas, Central America, the Caribbean, northern South America, India, and some regions of equatorial Africa.

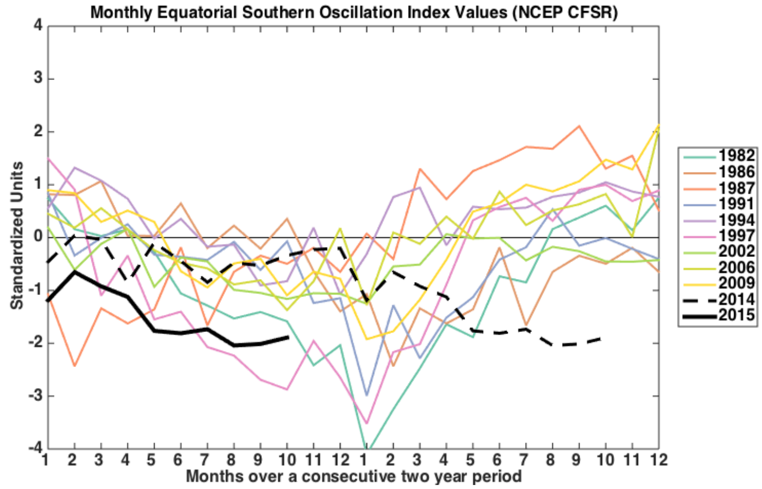

Fig. 2 Monthly Equatorial Southern Oscillation Index values (standardized) based on the NCEP Climate Forecast System Reanalysis (CFSR) for previous moderate-to-strong El Niño events dating back to 1979.

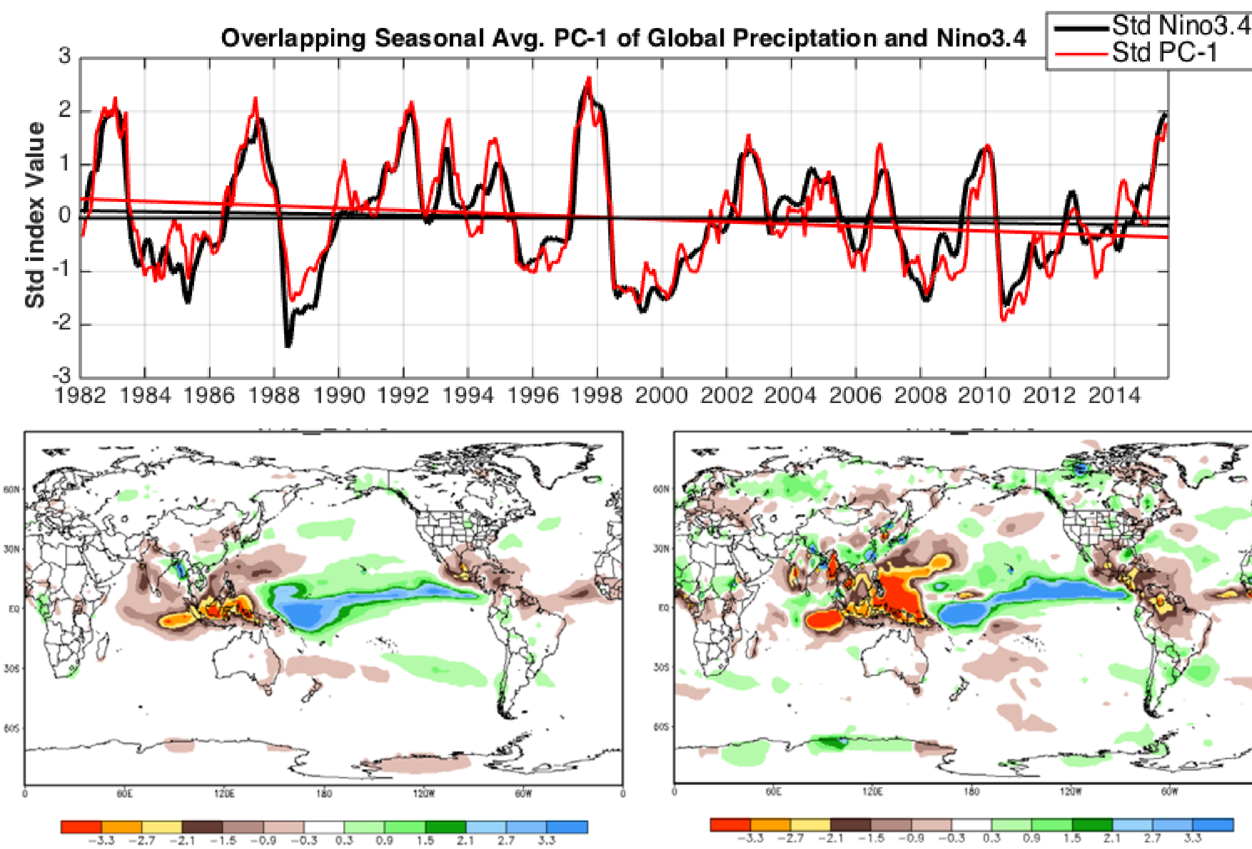

Fig. 3 (top panel) Standardized monthly Niño-3.4 index values (black line) and the leading Principal Component of global precipitation (red line) from January 1982 through September 2015. (left bottom panel) The reconstruction of July-September (JAS) precipitation anomalies based on the JAS 2015 PC-1 value. (right bottom panel) The observed July-September 2015 precipitation anomalies. Data based on the Climate Anomaly Monitoring System (CAMS) and OLR Precipitation Index (OPI; Janowiak and Xie 1999).

3. North American Multi-Model Ensemble (NMME) Niño-3.4 SST forecasts through October 2015

NOAA CPC first issued an El Niño Watch in March 2014 stating there was roughly a 50% chance of El Niño developing during the Northern Hemisphere summer or fall. This outlook was based largely on multi-model forecasts of the Niño-3.4 SST index. One tool is the North American Multi-Model Ensemble (NMME), a suite of state-of-the-art general circulation models updated once monthly, which favored El Niño to develop in 2014. Fig. 4 displays the Niño-3.4 SST forecasts based on ensemble averages of each of the NMME models (listed in the legend) that were run, or initialized, from January 2014 through October 2015. The colored lines only show the model forecasts initialized in October 2015, while the grey lines show the forecasts made prior to October 2015. The thick black line is the observed Niño-3.4 SST index based on the high resolution, daily OISST dataset (Banzon *et al.*, 2014).

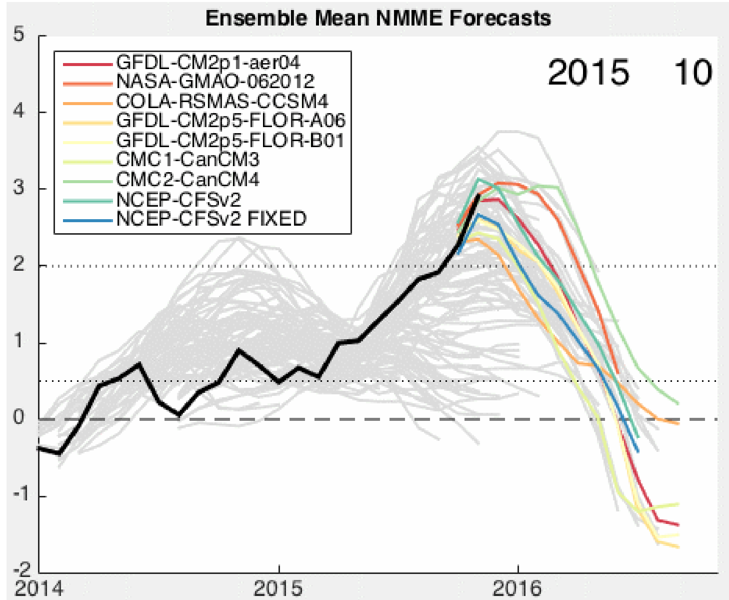

Fig. 4 North American Multi-Model Ensemble (NMME) forecasts of the Niño-3.4 SST index for runs made from January 2014 through October 2015. The colored lines only show the model forecasts initialized in October 2015, while the grey lines show the forecasts made prior to October 2015. The thick black line is the observed Niño-3.4 SST index based on the high resolution, daily OISST dataset. See Kirtman *et al.* (2014) for more details on the NMME.

From Fig. 4 it is clear that NMME forecasts of the Niño-3.4 SST index were too warm for target forecasts in 2014. Most ensemble averages (grey lines) were greater than the observations (black line). Some ensemble mean forecasts of Niño-3.4 were at or in excess of 2°C for the latter half of 2014, which is an indicator of a strong El Niño. While some warming was observed during the last half of 2014, SSTs only barely reached minimal El Niño thresholds (see Section 1).

In contrast, the NMME forecasts performed considerably better during 2015. By the time an El Niño Advisory was issued in March 2015, most NMME models suggested at least a moderate-to-strong El Niño. Two models, the NCEP CFSv2 and the COLA-RSMAS CCSM4, were hinting at an El Niño during 2015 as far back as runs made in November 2014. There was a slight positive bias in the NMME plume for target forecasts in summer 2015, but largely the observations (black line) were clearly within the spread of the NMME forecasts through most of 2015.

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