ENSO Forecast for 2018

Climate Forecast Applications Network

April 3, 2018

D-R-A-F-T

*** final forecast will be updated 4/6/18 with latest ECMWF forecast ***

Forecast Summary:

CFAN's March 2018 ENSO forecast for a transition to neutral conditions over the summer. The forecast for December 2018 calls for 60% probability of ENSO neutral conditions, with 40% probability of El Nino conditions. Forecasts are guided by the ECMWF seasonal forecast and statistical models using December-February (DJF) atmospheric precursors.

Introduction

CFAN's early season ENSO forecast is motivated by preparing our seasonal forecast for Atlantic hurricane activity. ENSO forecasts made in spring have traditionally had very low skill owing to the ENSO 'spring predictability barrier.'

Currently, an ongoing La Niña event is reflected by a negative sea surface temperature (SST) anomaly (-0.7 °C) in the equatorial east-central Pacific Niño 3.4 region. The present La Niña event, the most recent since 2014, was largely established by fall 2017.

Observers have long noted that cool winter La Niña events often persist or grow into the following winter, in contrast to El Niño events that more frequently undergo rapid spring-summer reversals. From 1980 to 2017, 11 of 14 La Niña winters were repeated by La Niña conditions in the subsequent December. However, reversals have become more frequent in recent years, with all three La Niña to El Niño transitions since 1980 observed in 2006, 2009 and 2014.

CFAN's ENSO forecast analysis is guided by the ECMWF SEAS5 seasonal forecast system and a newly developed statistical forecast scheme based on global climate dynamics analysis.

ENSO forecasts from global models

The IRI/CPC plume of model ENSO predictions from mid-March 2018 is shown in Figure 1. The average for all models is 0.4 for OND and 0.5 for NDJ, with 44% and 48% probabilities, respectively, for El Niño.

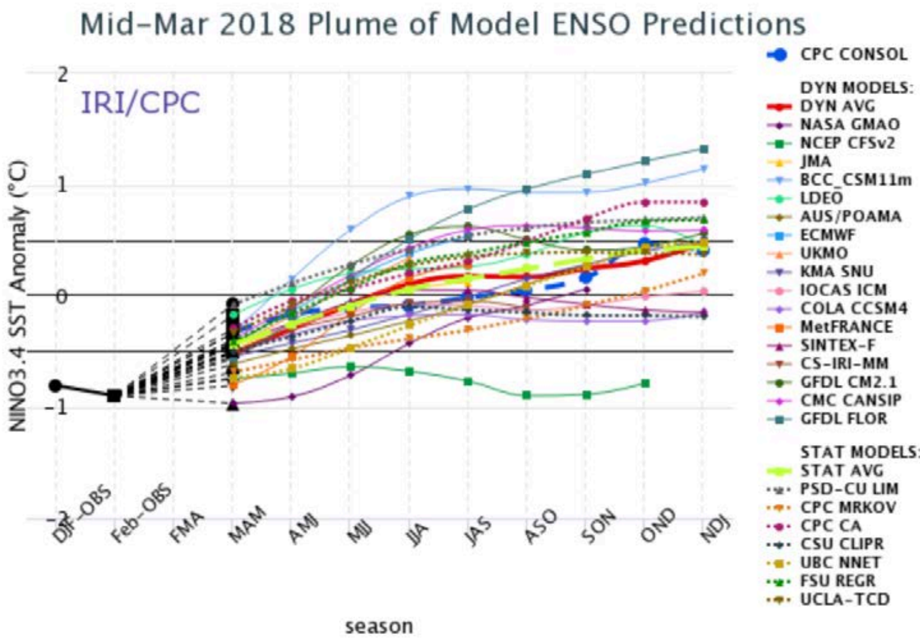

Figure 1. https://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/?enso_tab=enso-sst_table

The latest forecast from NOAA CPC (4/1/18) is shown below, which predicts the highest probability to be neutral values through the end of 2018.

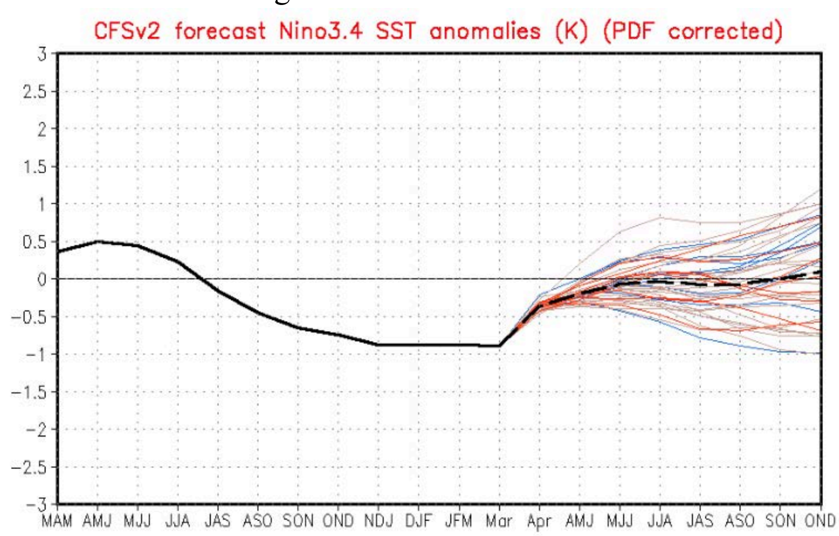

Figure 2. http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/lanina/enso_evolution-status-fcsts-web.pdf

The latest forecast from ECMWF (initialized March 1) is shown in Figure 3, for Niño3.4 and Niño4 (indicative of Modoki). ECMWF predicts a transition towards El Niño conditions by autumn, with an average September prediction of 0.75^{o}C. There is no evidence of a Modoki (bottom figure, Nino 4).

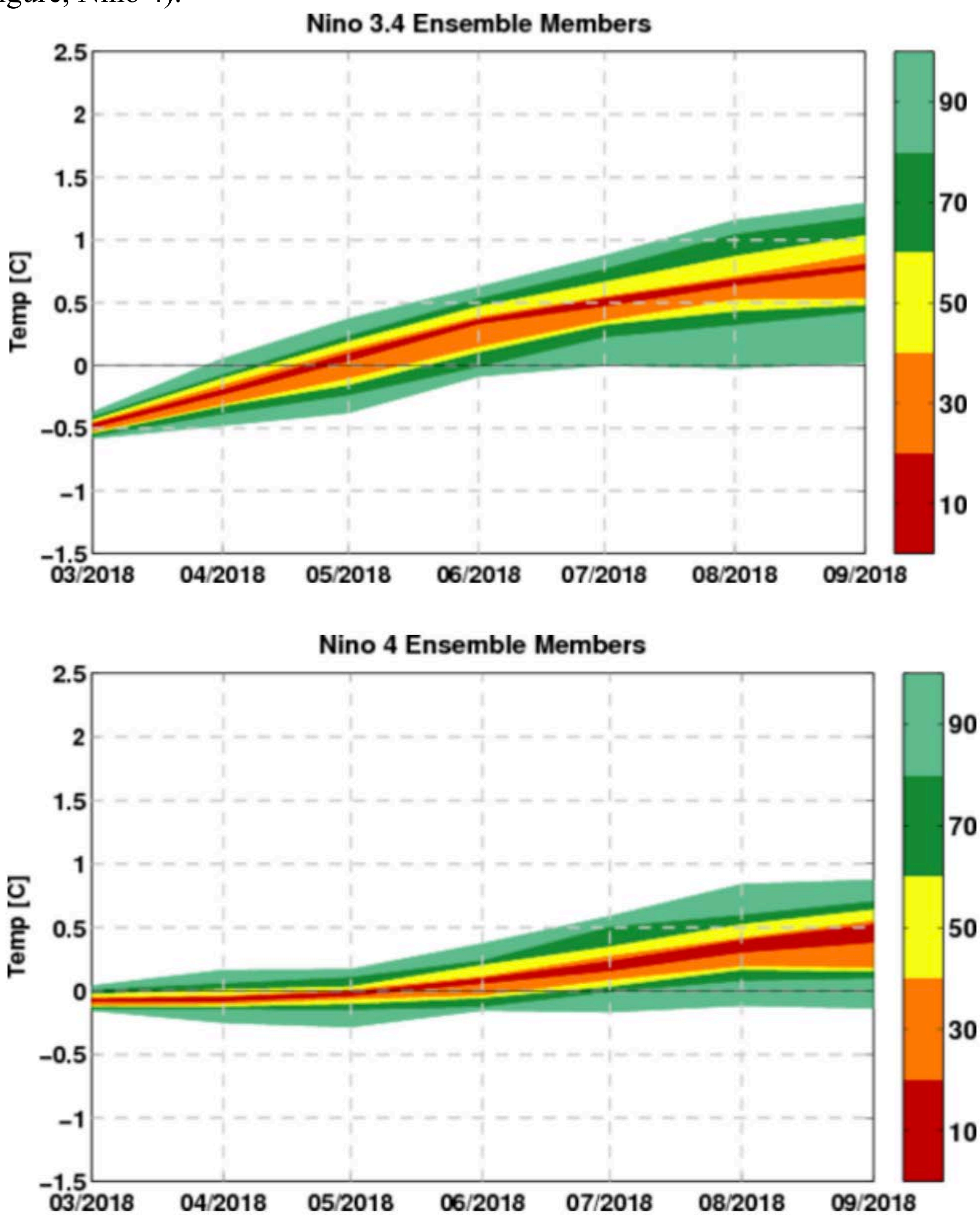

Figure 3: CFAN's analysis of ENSO forecasts from ECMWF SEAS5, initialized 3/1/18. Nino3.4 (top); Nino4 Modoki (bottom).

Note: the final forecast report will be updated on 4/6/18 with the ECMWF April ENSO forecast.

CFAN's analysis of the ENSO hindcast skill of the ECMWF SEAS5 shows a correlation coefficient of 0.73 for Niño3.4 forecasts initialized in April for the next seven months (October).

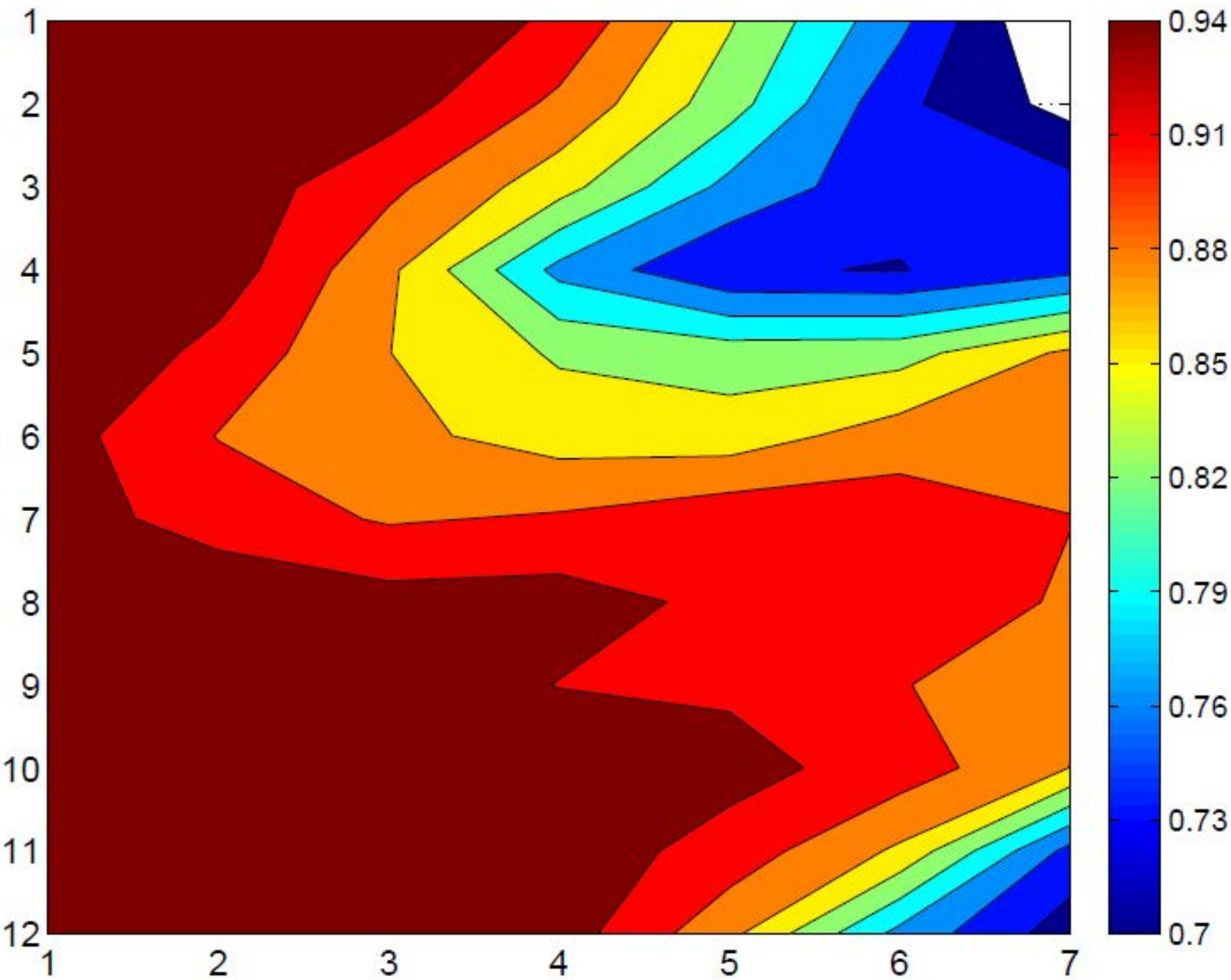

Figure 4: Evaluation of the predictability of the Niño 3.4 index: correlation of observed versus predicted) from ECMWF SEAS5 as a function of initial month and lead-time. From Hirata, Toma and Webster, 2018: Updated quantification of ENSO influence on the U.S. surface climate. https://ams.confex.com/ams/98Annual/webprogram/Paper334884.html

Statistical ENSO forecast model

Figure 5 illustrates the recent ENSO history as depicted by monthly Niño 3.4 anomalies from 1980 to February 2018. Highlighted are the past 14 La Niña Februaries (< -0.5°C), and anomalies in the following Decembers. Since 1980, neutral conditions (-0.5 to +0.5) follow La Niñas about 50% of the time, and La Nina and El Nino about 25% each.

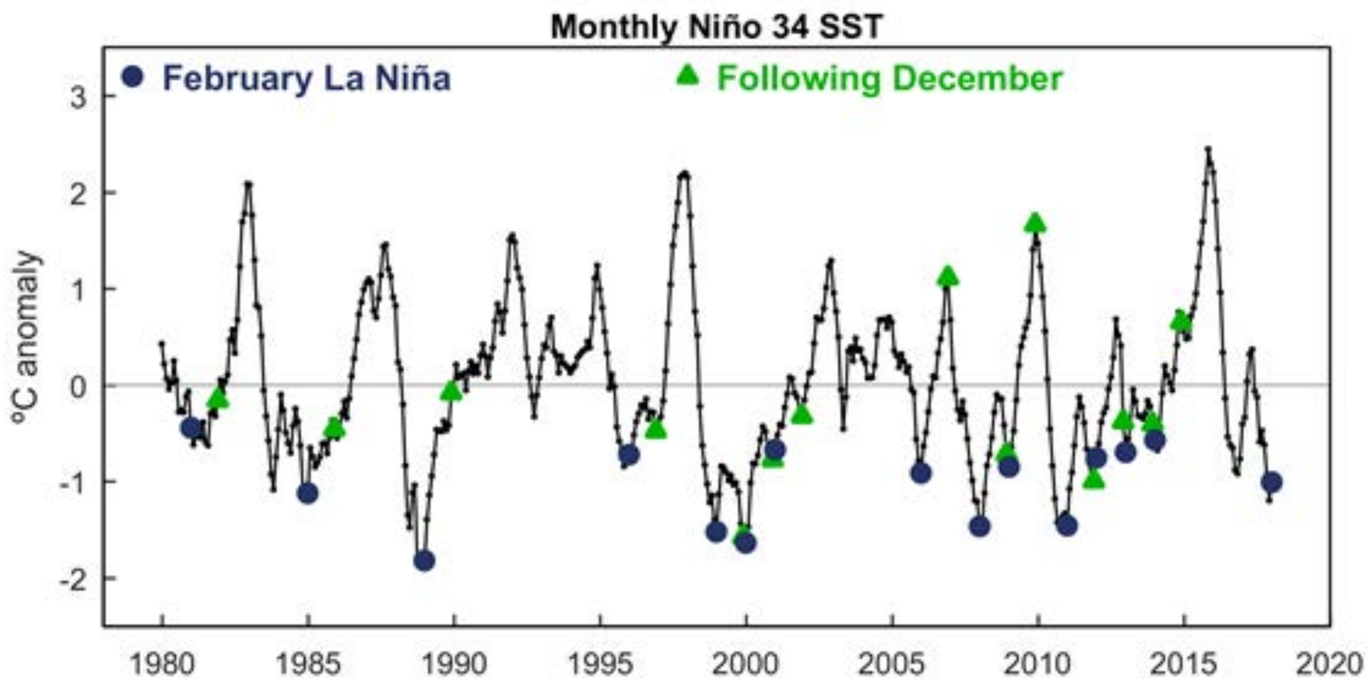

Figure 5. Time series of the monthly Niño 3.4 SST index (5°N-5°S, 170°-120°W), with cool February La Niña anomalies (<-0.5°C) highlighted by blue markers and subsequent December anomalies marked in black.

Fig. 6A illustrates the same data separately for months surrounding each February event, and Fig. 6B shows Niño 3.4 anomalies with respect to February values. From cool initial February conditions, La Niña nearly always moderates in early spring (Fig. 6A), rising from a winter minimum toward a warmer, more neutral ENSO state by April. From April onward, however, a variety of trajectories may develop, leading either to continued warming and transition to El Niño by December, or alternatively, persistence or regrowth of La Niña conditions.

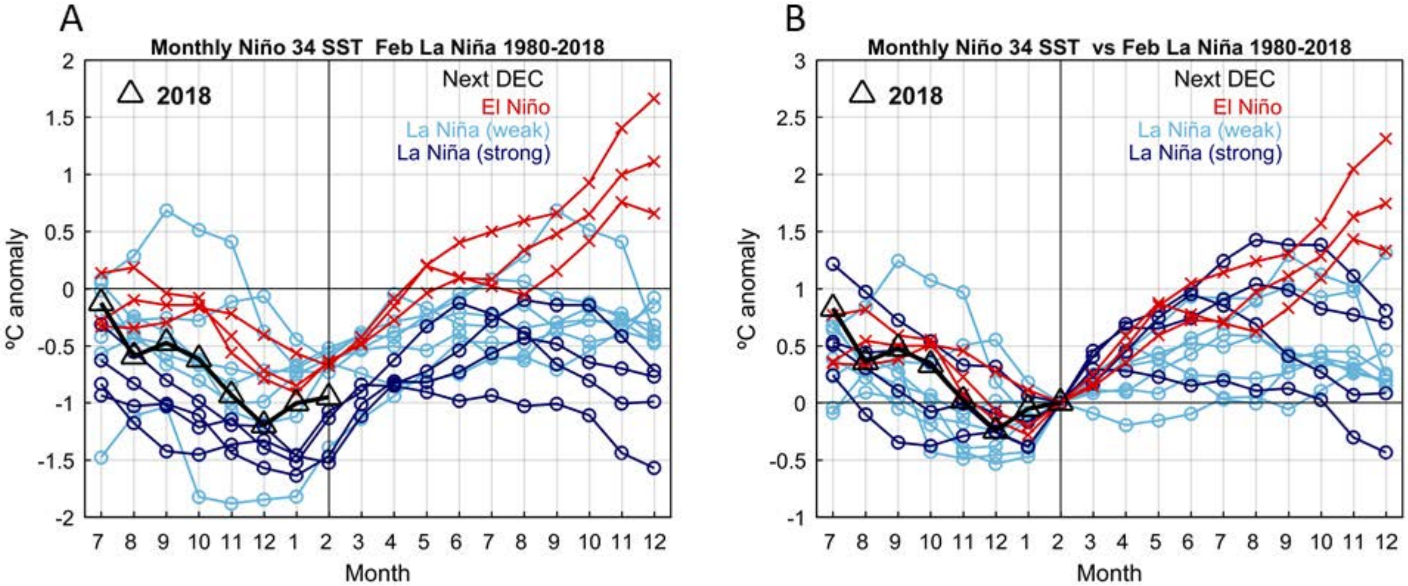

Figure 6. Seasonal Niño 3.4 SST anomalies surrounding February La Niña conditions. A. Time series of monthly anomalies from the prior July through December, plotted separately for each year. Changes culminating in next-December El Niño conditions (>0°C) are plotted in red; weak La Niña conditions (defined here as -0.5 to 0°C) in light blue, and La Niña conditions (< 0.5°C) in dark blue. 2017-18 values are plotted in black triangles through February 2018 (-1.0°C). B. Monthly values relative to February.

Our model for the December 2018 Niño 3.4 forecast was developed by comparing December-February (DJF 2017/18) atmospheric anomalies with patterns in previous La Niña winters that most successfully predict next December Niño 3.4 conditions. Atmospheric data comes from the NCEP-NCAR Reanalysis. Predictor indices are systematically generated from different atmospheric variables over a range of heights, and latitude bands, using different weighting approaches for index construction. The indices are evaluated in leave-one-out mode, and the forecast skill is measured for each. This approach is designed to limit predictors to only those that show historical predictive skill in experiments that emulate the current forecast process.

A subset of three forecast models was selected to produce the overall Niño 3.4 forecast, with additional models used to estimate uncertainties. The most skillful predictors come from Northern Hemisphere DJF zonal (U) wind tendencies in the lower stratosphere, in a pattern that captures weak westerly flow over the Arctic and contrasting strong flow above the subtropical eastern Pacific. Current expression of such conditions in DJF 2017 contribute to expectations of neutral or El Niño conditions by December 2018. Similar indications are given by anomalous DJF convergence in the upper troposphere above Antarctica, as well as patterns of meridional (V) winds in similar areas of the Southern Hemisphere. The skill of these predictors reflect the importance of extratropical forcing of surface wind anomalies and SST responses in the equatorial and off-equatorial Pacific.

Historical forecasts from all three models are compared with observed Niño 3.4 values in Fig. 7. Models are based on data from 1980 through 2017, but show particularly good skill for the 2014 reversal to a weak (+0.6°C) December El Niño, comparable to the magnitude of the event projected for 2018. Individual models produce December 2018 Niño 3.4 estimates of +0.4, +0.5, and +0.9°C, averaging +0.6°C.

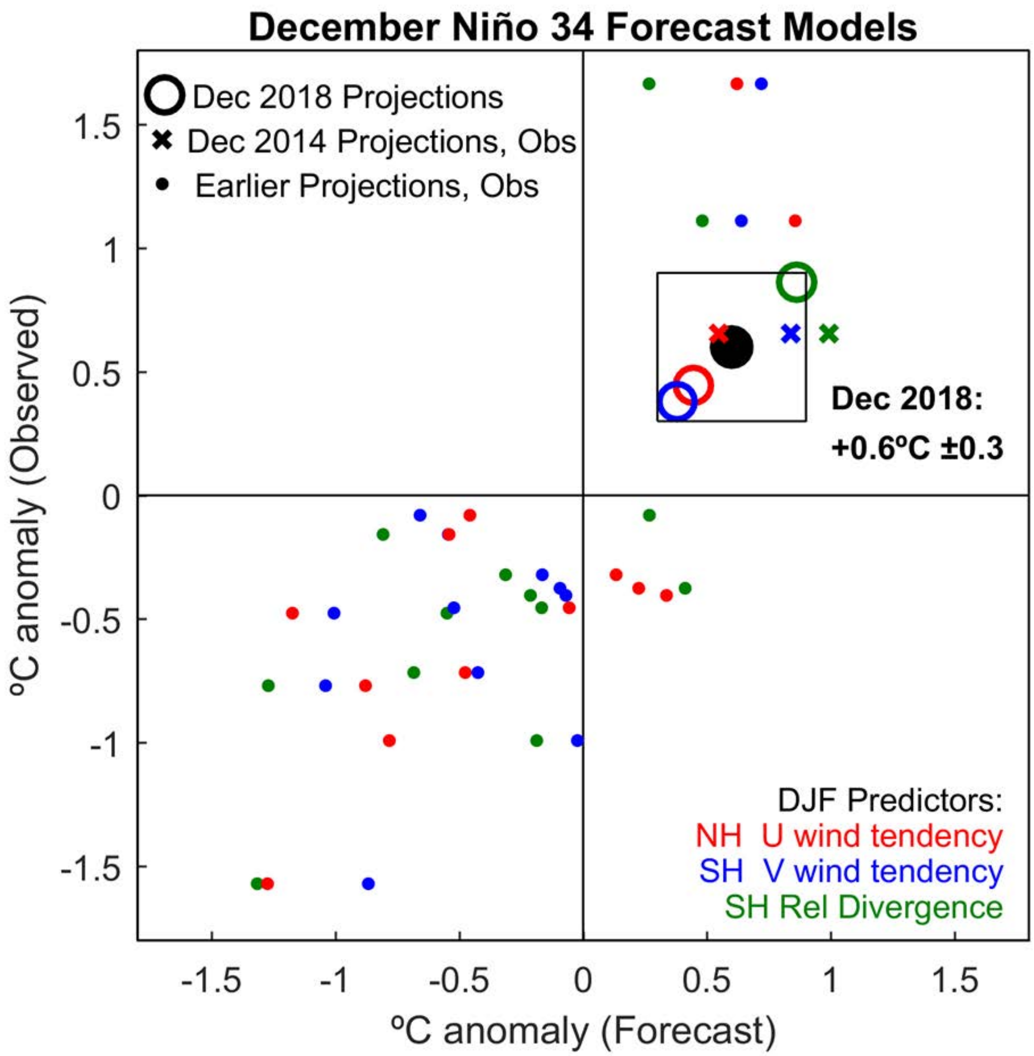

Figure 7. December Niño 3.4 SST projections from three forecast models are based on linear regressions on previous December-February (DJF) atmospheric circulation indices. Points are plotted in relation to December Niño 3.4 forecast values (x-axis) produced from previous DJF atmospheric precursors, and observed December values. Models are based on atmospheric precursors identified in the Arctic/North Pacific (red) and the Antarctic/Southern Hemisphere (green and blue) that show greatest skill in historical forecast experiments (r = 0.7 to 0.8). Individual models correctly estimated the sign of December Niño 3.4 anomalies in 37 of 42 cases (88%). December 2018 Niño 3.4 SST estimates of 0.4, 0.4 and 0.9°C (circles) are based on the recent DJF expression of skillful atmospheric indicators.

Atmosphere-ocean changes during La Niña-to-El Niño transitions are illustrated in composites of sea-level pressure (SLP) and SST anomalies for 2006, 2009 and 2014 (Fig. 8). Initial SST anomalies in February (Fig. 7A) feature La Niña's defining signature pattern of cool water in the east-central equatorial Pacific. High SLP over the eastern tropical Pacific contrasts with low SLP over the Indo-Pacific warm pool, characteristic of an intensified Walker circulation and strong low-level easterly winds that maintain cool La Niña surface conditions in the east.

Composite SST anomalies (Figs. 8D,8E,8G) and SLP (Figs. 8D,8F,8H) reflect developing ocean-atmosphere changes during transitions from February La Niña to December El Niño conditions. Maps reflect anomalies with respect to February values during spring (April-July, AMJ), Summer (July-September, JAS) and fall (September-November, SON) periods. Eastern Pacific surface warming begins in spring, and once established, warm conditions are maintained through December. Throughout much of the calendar year, negative SLP anomalies persist over the North Pacific, while associated cyclonic circulation anomalies tend to weaken off-equatorial North Pacific trade winds, a recognized contributing mechanism to El Niño development. From summer onward, cyclonic North Pacific winds also generate warming the northeast Pacific in conjunction with equatorial SST increases. During spring and summer, transitions to El Niño include coherent SLP anomalies over both polar caps, patterns broadly consistent with the polar atmospheric precursors identified by our forecast models.

Atmospheric precursors of El Niño transitions likely reflect contributions from multiple large-scale mechanisms, rather than a single, continuous process. During each recent transition (2006, 2009, and 2014), a similar two-stage warming pattern (Fig. 9A) is characterized by moderate SST increases in spring (April-May), but minimal changes in a June-September summer window that is followed by final surge of strong warming in October-November. Composite SST changes in spring and fall are also somewhat different in spatial structure. Early warming (Fig. 8B) develops over broad areas of the tropical Pacific from South America to Australia, but more concentrated and intense central Pacific warming is seen in fall.

Equatorial Pacific warming is typically produced by anomalous westerly winds that reflect weakness in the mean easterly surface flow. In the April-May window of initial spring warming, westerly wind anomalies appear over the central Pacific (Fig. 9C) in conjunction with significant wind anomalies of both signs throughout much of the tropics as well as the Arctic. Fall warming in October-November (Fig. 9D) is similarly traceable to equatorial westerly wind anomalies (Fig. 9E) that extend over much of the tropical and subtropical Pacific and the globe, including both polar regions.

Our current forecast approach, by estimating the December ENSO state, implicitly accounts for all contributing processes during the calendar year.

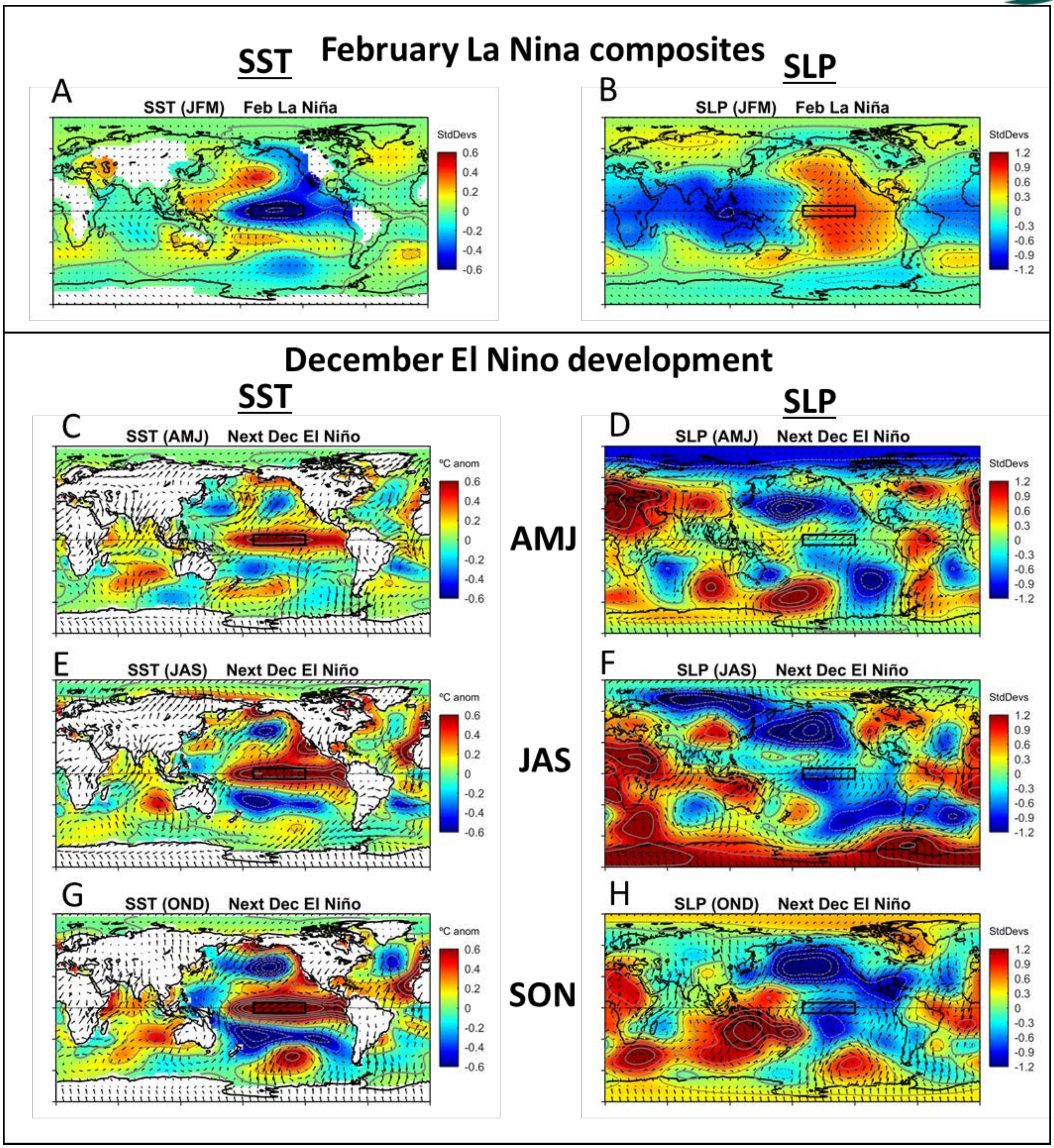

Figure 8. Composite maps of SLP, SST and wind anomalies and changes leading from February La Niña conditions to El Niño in December (2006, 2009, 2014). A. February La Niña SST composite. B. February La Niña SLP composite. C, D. April-June (AMJ) SST and SLP anomalies (differences from February). D,E. July-September (JAS) anomaly differences from February. F,G. October-December (OND) anomaly differences from February. Vectors reflect low-level wind anomalies at 925 hPa.

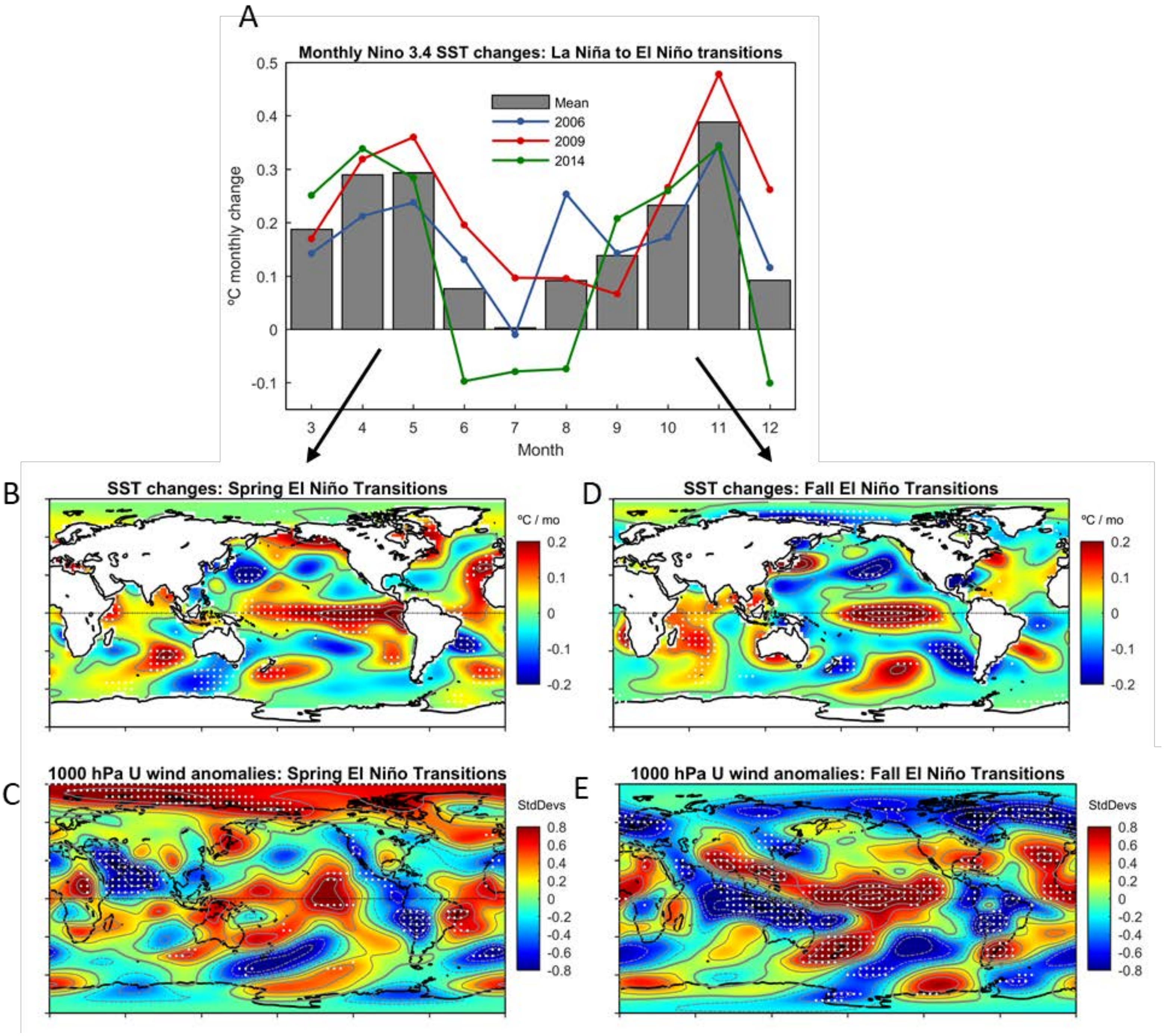

Figure 9. Seasonal ocean-atmosphere changes during La Niña-to-El Niño transitions in 2006, 2009 and 2014. A. Monthly changes in Niño 3.4 SST. B. Composite SST changes during April-May of all three years. White hatching reflects statistically significant ($p < 0.05$) anomalies, based on observations from both months and all three years. C. Composite April-May anomalies of 1000 hPa (near-surface) April-May zonal winds. Red shading (westerly anomalies) in the tropical Pacific reflect weak easterly flow conducive to observed eastern Pacific warming and growth of El Niño. D. Composite October-November SST changes. E. Composite October-November zonal winds.

Forecast summary

CFAN's near-term prediction of ENSO is for a transition to neutral conditions over summer.

Our extended-range statistical model predicts an average value of Nino3.4 0.6°C for December 2018. The forecast probabilities are:

El Nino	> 0.5	40%
Neutral +	0 to +0.5	46%
Neutral -	-.05 to 0	13%
La Nina	< -0.5	0%