Forecast of 2019 Atlantic Hurricane Activity

March 27, 2019

Summary

CFAN's late March forecast of 2019 North Atlantic hurricane activity is based on recent ocean-atmosphere anomalies and tendencies that show historical skill as indicators of total hurricanes, accumulated cyclone energy (ACE), and the number of hurricanes making landfalls in the continental U.S. and in the state of Florida. Our current forecasts predict North Atlantic ACE (125) and Hurricanes (7), subject to considerable remaining uncertainties due to conflicting stratospheric and tropospheric indicators in recent months. We more confidently forecast above-normal landfall totals over the U.S. (2), based on more consistent agreement between atmospheric precursors and observed conditions in early 2019.

2000-2018 Obs	Low	Mean	High
N Atlantic ACE	36	**125**	250
N Atl Hurricanes	2	**7.3**	15
FL Landfalls	0	**0.5**	4

2019 Forecasts	Low	Mean	High	Abs Err	N
N Atlantic ACE	65	**126**	170	31	20
N Atl Hurricanes	2.4	**6.2**	10.4	1.5	20
FL Landfalls	0	**1.4**	2.9	0.6	13

Introduction

Indices of North Atlantic hurricane activity display substantial interannual variations (Fig. 1), in addition to prominent multidecadal changes that are positively associated with basin-scale sea surface temperature (SST) changes known as the Atlantic Multidecadal Oscillation (AMO). North Atlantic Accumulated Cyclone Energy (ACE), an integrative metric based on tropical cyclone wind speeds, approximately doubled with an abrupt 1995 shift toward warmer North Atlantic surface conditions. Florida hurricane landfalls display a somewhat different pattern of variability, most notable a prolonged absence of impacts from 2006 to 2015, followed a resumption of activity from 2016 to 2018, when each year experienced a single hurricane impact.

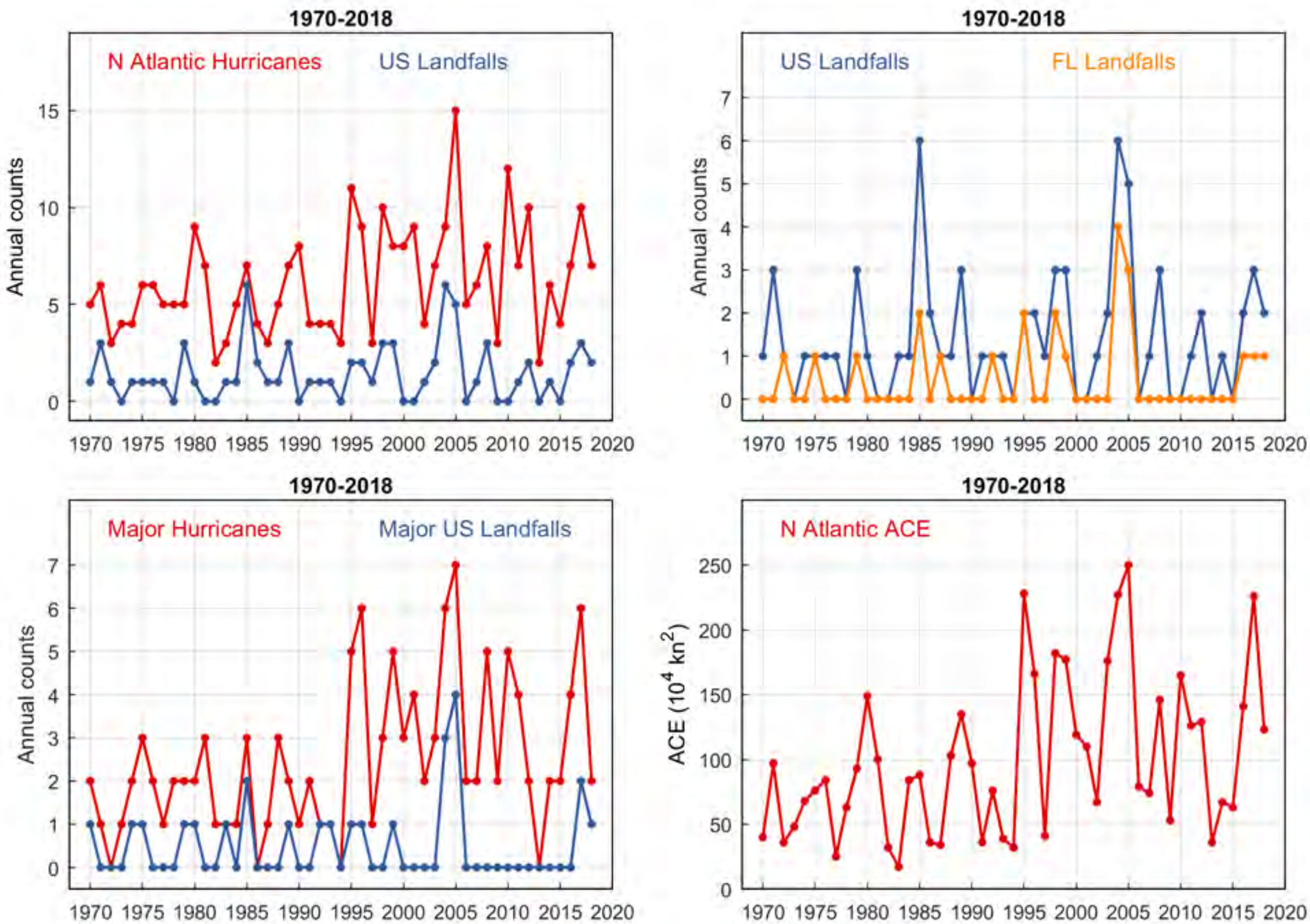

Figure 1. North Atlantic hurricane indices, 1970-2018. Top: North Atlantic hurricane totals (red) and U.S. landfalls (blue). Center: Major hurricanes and U.S. landfalls. Bottom: North Atlantic Accumulated Cyclone Energy (ACE). The ACE index is an integrative measure of storm kinetic energy estimated from squared sums of sustained 6-hourly surface wind speeds during active tropical cyclones. Hurricanes, major hurricanes, and ACE increased abruptly in 1995 with a shift toward higher North Atlantic sea surface temperatures associated with the Atlantic Multidecadal Oscillation.

Seasonal hurricane forecasts issued by government and private agencies are commonly produced in spring and early summer, based largely on current and projected SST anomalies in the tropical North Atlantic and Pacific (i.e. ENSO). During late winter and early spring, however, such predictors display relatively little forecast skill.

CFAN develops seasonal to annual climate forecasts using an innovative data mining approach guided by climate dynamics analysis. CFAN's late-March seasonal forecast for the 2019 Atlantic hurricane season is based on climate conditions and tendencies observed in data from January 1 through March 23, 2019.

The hurricane season typically peaks in the late summer and early fall during the months from August to October. Direct physical indicators of hurricane activity appear robustly in late spring (April-May-June, AMJ). Figure 2 illustrates AMJ correlations of North Atlantic ACE, North Atlantic hurricane frequency and Florida landfall indices with AMJ anomalies of atmospheric sea-level pressure (SLP) and SST. All 3 indices exhibit strong positive relationships (r ~ 0.8) with AMJ SLP over the Arctic, which provides a clear hurricane 'signal' in atmospheric circulation. ACE and Hurricane totals are favored also by negative SLP anomalies over the North Atlantic, which tend to reduce wind speeds and raise SSTs in an Arc-shaped pattern that is characteristic of the AMO and a robust indicator of later hurricane activity (Fig. 2). Florida landfalls, however show a stronger positive response to warm SSTs in the central tropical Pacific.

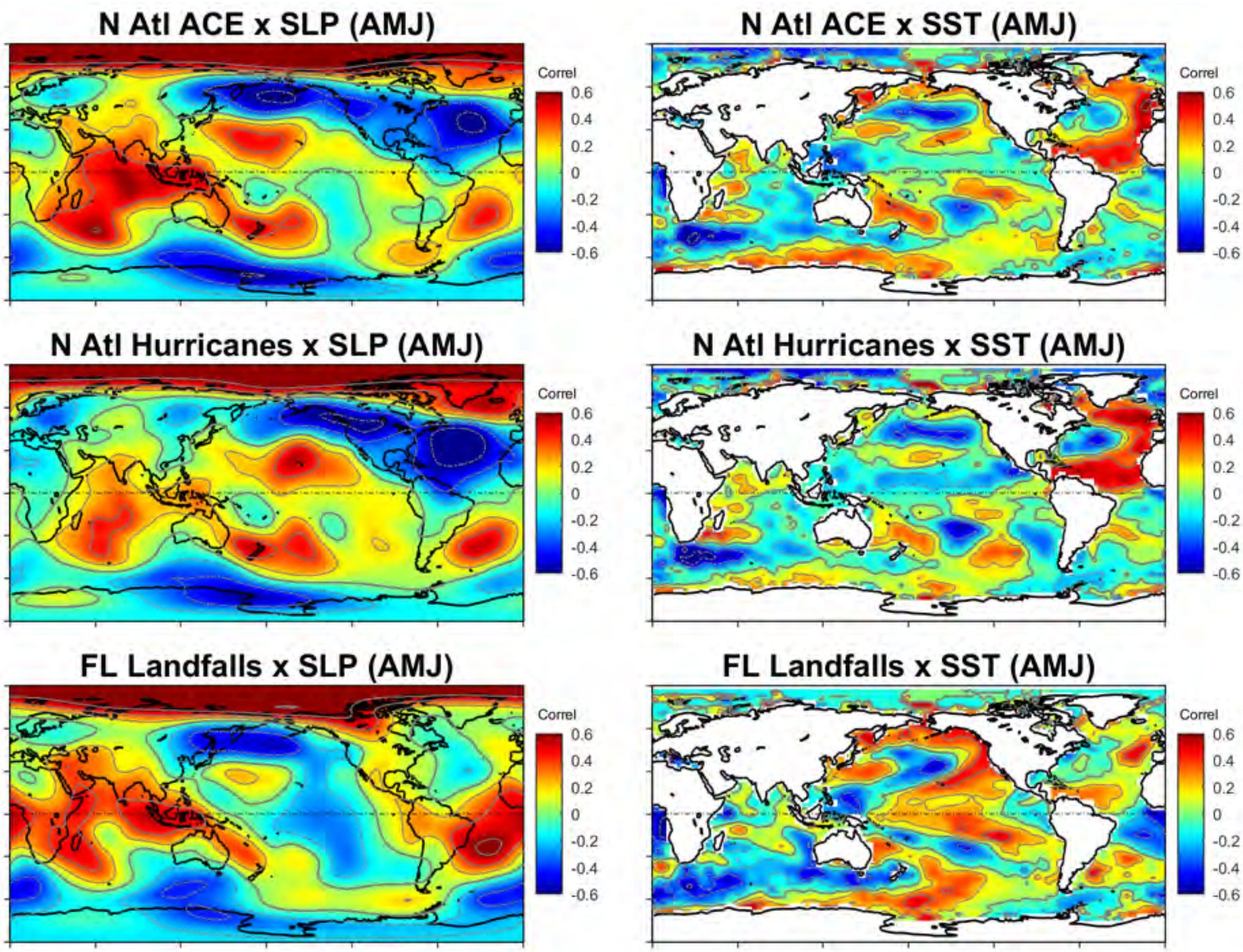

Figure 2. Correlations of late-spring (AMJ) SLP (left) and SST (right) indices of North Atlantic ACE, North Atlantic hurricane frequency and Florida hurricane landfalls (top to bottom).

State of the Pacific and Atlantic Oceans

Expected summer SST conditions in the tropical Pacific were assessed in CFAN's ENSO forecast, issued on March 25. A brief summary is presented here. During fall 2018, warming in the central equatorial Pacific led to a weak El Niño Modoki pattern, which impacted the latter part of the Atlantic hurricane season. A transition toward a weak (conventional) El Niño took place by February 2019 with atmospheric anomalies more consistent with a conventional El Niño pattern. Forecasts of summer SST anomalies are illustrated in Figure. 2. CFAN's ENSO forecast calls for weakening El Niño conditions during spring but a partial regrowth of El Nino Modoki warmth during July-August-September (JAS), overlapping with the early part of the hurricane season. The ENSO forecast for Sept-Oct-Nov 2019 calls for 60% probability of neutral conditions and a 40% probability of weak El Niño conditions. Forecasts suggest largely neutral anomalies of North Atlantic Arc SSTs.

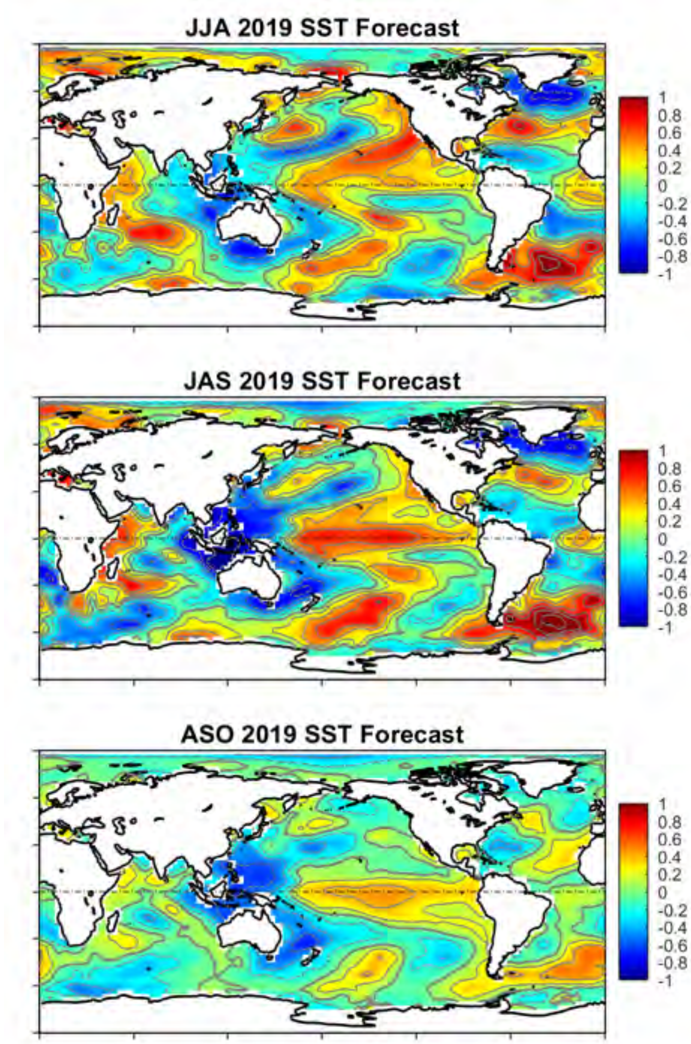

Figure 3. Summer forecasts of seasonal sea surface temperature anomalies, illustrated in local standard deviations.

SST anomalies in February 2019 (Fig. 4) show elements of both Modoki and conventional El Niño patterns, featuring concentrated warmth in the central Pacific and a broader expanse of warm equatorial water to the east. North Atlantic SSTs in February display slightly negative anomalies at subpolar and tropical latitudes and weakly positive anomalies over the midlatitudes.

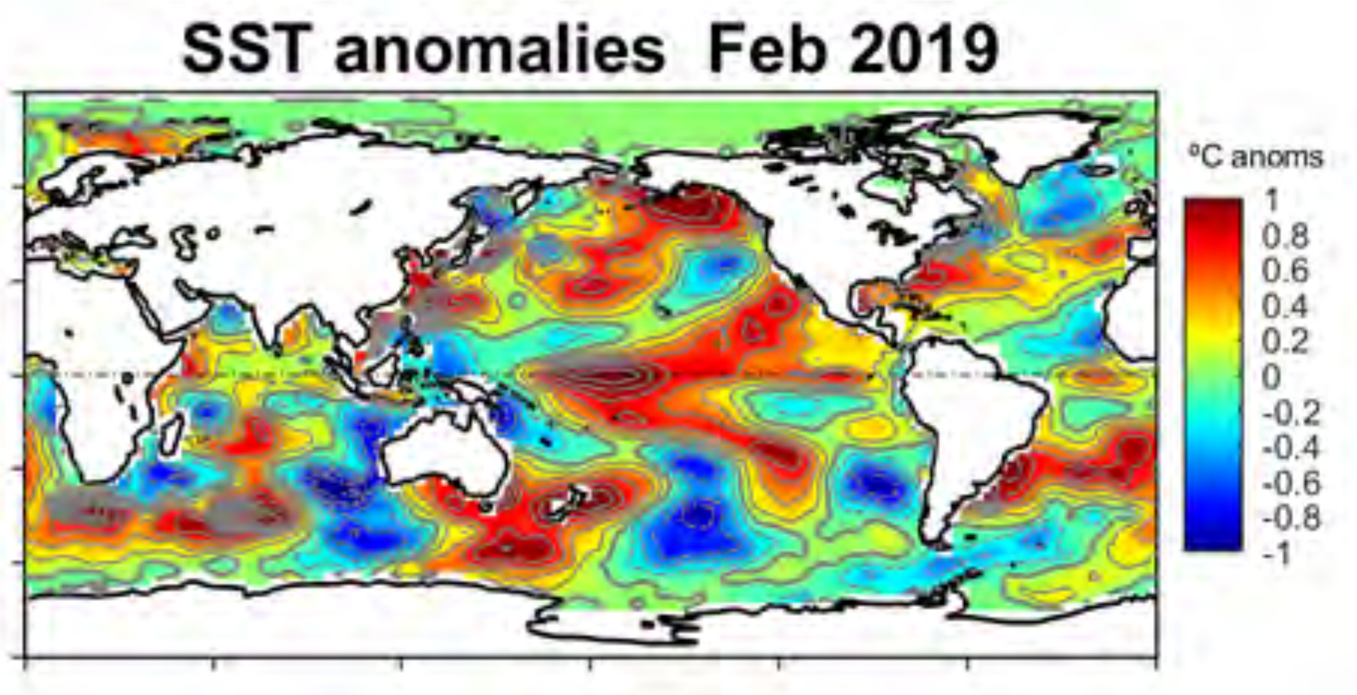

Figure 4. February 2019 sea surface temperature anomalies.

Hurricane Predictors

CFAN's forecast method identifies precursors of Atlantic hurricane activity from seasonal patterns of anomalies and tendencies in globally-gridded sea surface temperatures (SSTs) and numerous dynamical and thermodynamic variables based on NCEP-NCAR Reanalysis data at 17 tropospheric and stratospheric levels. While simple patterns of spring-summer climate anomalies offer direct indications of expected hurricane activity, predictions at longer leads involve interactions of slow seasonal to interannual climate processes, including those related to ENSO and the Quasi-biennial Oscillation (QBO) of equatorial stratospheric winds, which tend to undergo rapid phase transitions during spring.

Potential hurricane predictors were identified through exploratory analysis of correlation patterns between hurricane indices and gridded ocean-atmosphere variables during the period from 2000 to 2018. The correlation time period must be sufficiently long to distinguish real, statistically-significant relationships, but short enough to reflect recent behavior most relevant to current predictions.

Global correlation maps were calculated for each gridded physical variable and vertical level for anomalies and tendencies integrated over 1- to 3-month periods from January to March. Annual time series representing the strongest regional to global-scale correlation patterns were retained as potential hurricane predictors. Candidate predictor indices were then tested for historical forecast skill using 'leave-one-out' experiments that forecast each year's hurricane anomaly using only information available from other years.

Forecast model

Winter hurricane precursor patterns showing sufficient and greatest forecast skill were used to calculate hurricane anomaly estimates for 2019, based on recent winter 2019 expression of atmospheric anomalies with respect to the correlation pattern. Ensembles of up to 20 hurricane index estimates were produced from different atmosphere-ocean variables and vertical levels. In Figure 5, each gray line corresponds to a single forecast model developed from one atmospheric variable at one vertical level, and the solid blue lines reflect the overall annual forecast values based on the ensemble means. Forecast model results are shown in Table 1 and Figure 5. In Table 1, forecast uncertainty is reflected in the range of model predictions, and the mean absolute error (MAE) in leave-one-out tests.

Discussion

Ensembles of current 2019 hurricane forecasts (Fig. 5) display large spreads and bimodal distributions, seen particularly in estimates of North Atlantic hurricane totals (Fig. 5, top right). High hurricane totals are indicated by recent near-surface atmospheric anomalies, consistent with our earlier Fall forecasts. Examples in Fig. 6 show recent anomalies of lower-tropospheric 850 hPa zonal (u) winds and SLP that match those consistently preceding high North Atlantic hurricane totals, leading to predictions of 10 events. However, Figure 7 illustrates recent patterns of stratospheric vertical velocities (100 hPa omega) and 10 hPa zonal winds that suggest just 4 North Atlantic hurricanes in 2019.

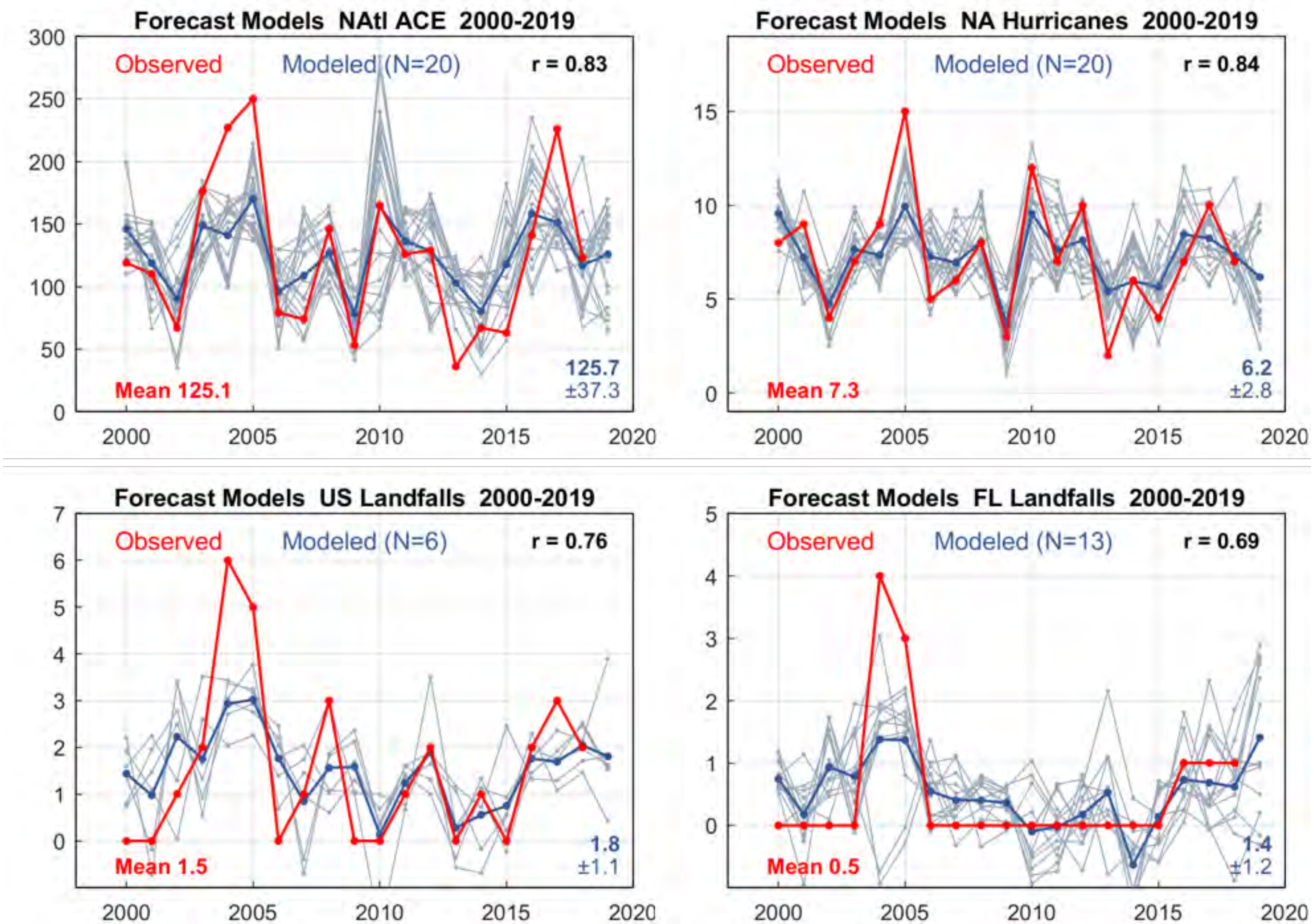

Figure 5. Model hindcast hurricane estimates (blue) and observed historical metrics (red). Fine gray lines depict individual model estimates and blue lines reflect model means. A. North Atlantic ACE. B. North Atlantic hurricane totals. C. US hurricane landfalls. D. Florida hurricane landfalls. Values in the lower right of each panel reflect the expected 2019 index value based on the mean of individual model estimates and the ±1 standard deviation spread. Lower left values display index means over the 2000-2018 period.

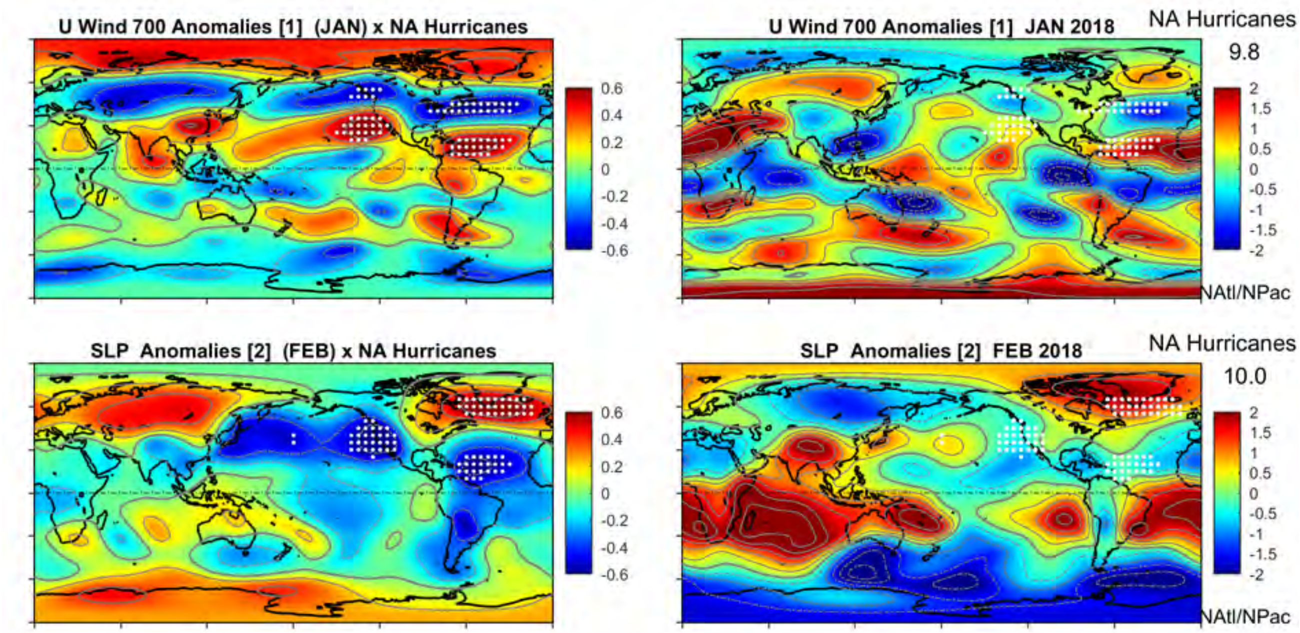

Figure 6. Lower tropospheric/Near-surface winter atmospheric correlations with NATL Hurricanes (left) and actual winter 2019 anomalies (right). Near-surface conditions over the NH suggest a high number (10) of hurricanes in 2019, relative to the 2000-2018 average (7). Hatching reflects areas of most consistent hurricane precursors.

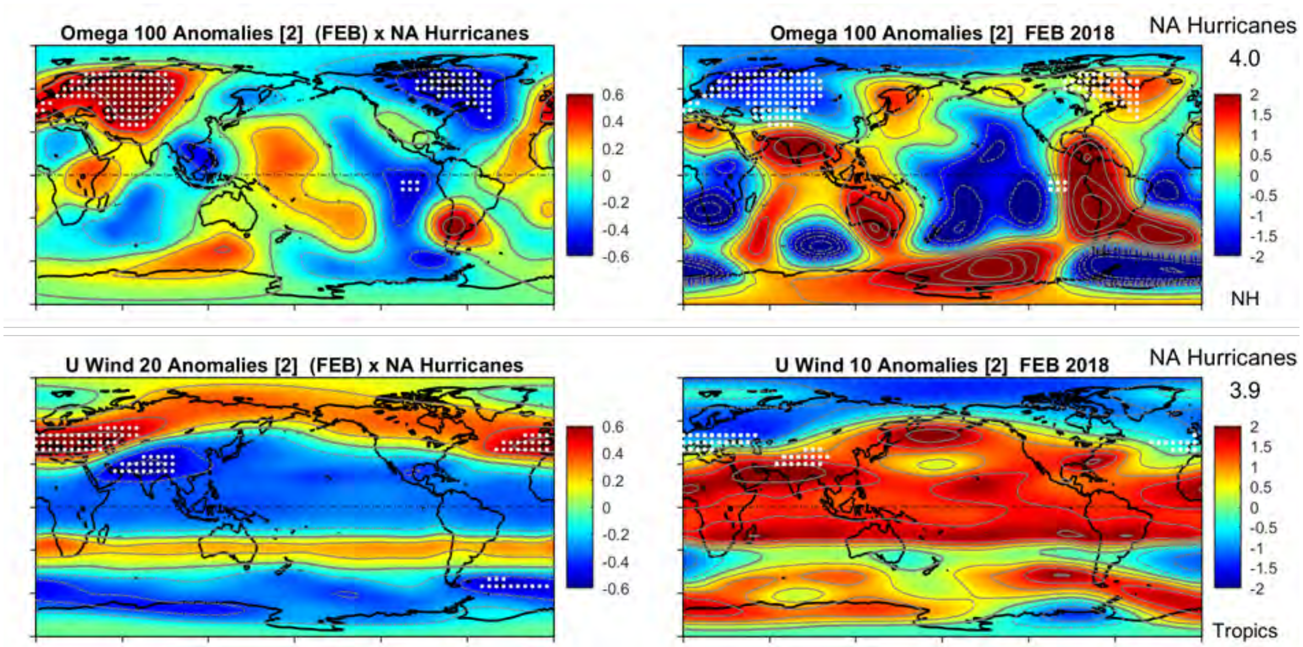

Figure 7. Stratospheric winter atmospheric correlations with N Atlantic Hurricanes (left) and actual winter 2019 anomalies (right). Stratospheric conditions over the NH suggest a low number (4) of hurricanes in 2019, relative to the 2000-2018 average (7). Hatching reflects areas of most consistent hurricane precursors which contribute to forecast indices.

Strong hurricane activity is indicated by near-surface wind and SLP patterns related to the negative phase of the North Atlantic Oscillation (NAO), characterized by anomalous high pressure over Greenland and low pressure over the North Atlantic, a pattern that tends to raise North Atlantic Arc SSTs and favor tropical convection in summer. Stratospheric circulation anomalies, however, feature an upper low over Greenland and the Arctic that is conducive to opposite (NAO+) SLP anomalies at the surface that tend to cool the North Atlantic sea surface and reduce hurricane activity.

Figure 8 illustrates expected spring (AMJ 2019) SLP anomaly pattterns, based on relationships with Fall hurricane predictors (prevalent in NH meridional winds), as well as those developed from Winter (January-March) surface and stratospheric data, both also dominated by high-latitude NH circulation and pressure anomalies. Fall conditions and Winter surface conditions (Fig. 8, left panels) both lead to expectations of high Arctic SLP in spring 2019 within a NAO- pattern that is consistent with strong hurricane activity later in summer.

Winter stratospheric anomalies, however, suggest low Arctic SLP in spring and NAO+ conditions that tend to cool the North Atlantic sea surface and reduce hurricane activity. Averages of surface and stratospheric predictor time series (Fig. 8 lower right) highlights the strong divergence of 2019 estimates from the surface and stratosphere. Past examples of conflicting surface and stratospheric indicators (e.g. 2010, 2014) fail to indicate clearly which influence is more likely to prevail in 2019. Overall ensemble means of the model forecasts suggest near-average (ACE) for the active period since 1995.

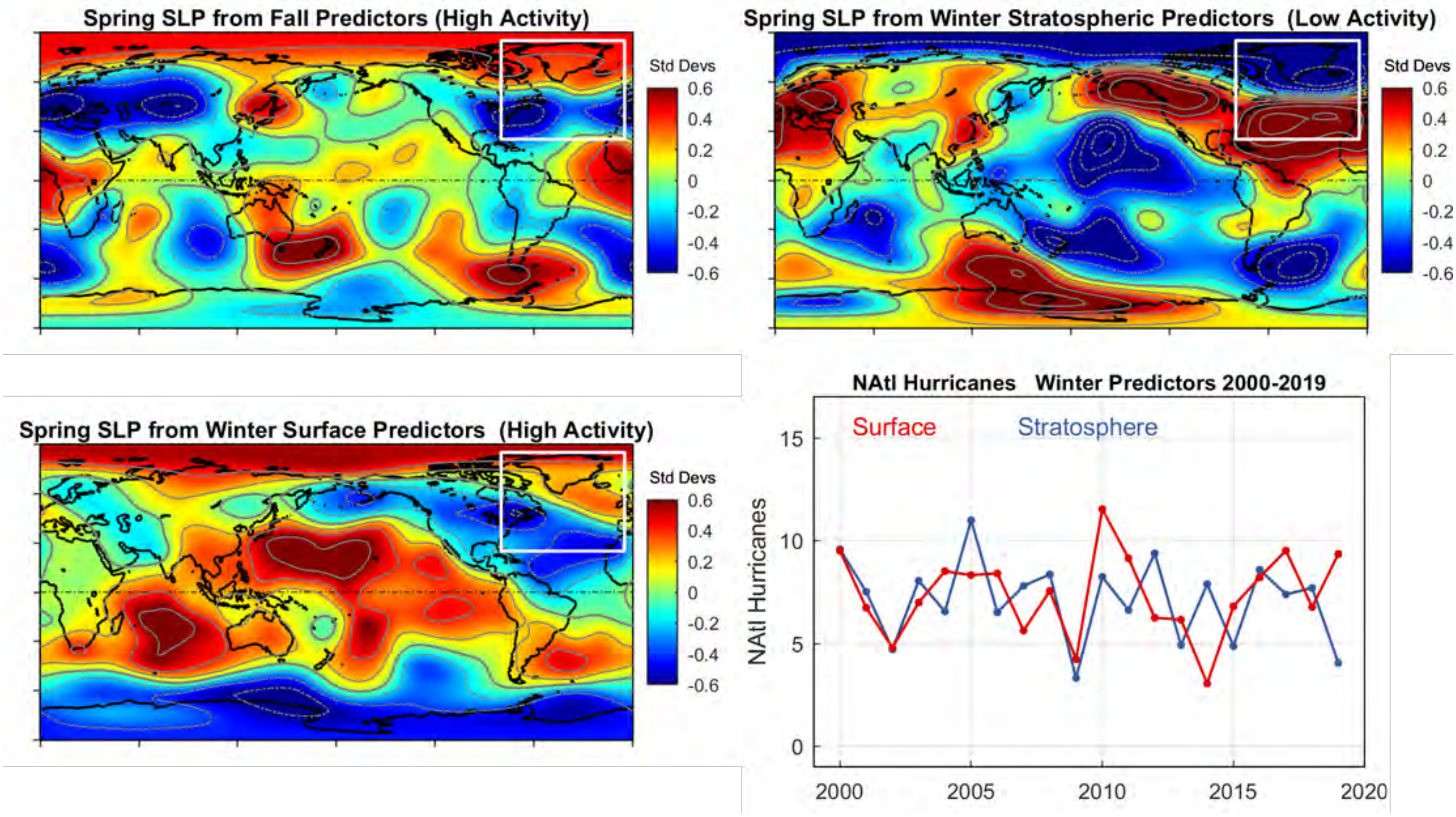

Figure 8. Spring (AMJ 2019) SLP forecasts, based on regression relationships with averaged predictors of North Atlantic Hurricanes. Top left: SLP forecast based on hurricane predictors from our Fall 2018 forecast. Bottom left: SLP forecast based on winter predictors from near-surface levels. Top right: SLP forecast based on winter hurricane predictors from stratospheric levels. Bottom left: Comparisons of hurricane forecasts based on surface and stratospheric predictors. Note the large divergence of final 2019 values. Fall predictors and Winter surface predictors suggest a NAO- pattern of spring SLP anomalies (box), which systematically precedes strong hurricane activity. Winter stratospheric predictors suggest the opposite NAO+ pattern of spring SLP, which precedes low summer hurricane activity.

Further information about CFAN's forecasts

Further information about CFAN's tropical forecast products – TropiCast – can be found at https://www.cfanclimate.net/products-tropical-cyclones.

CFAN's long-range seasonal forecast is available only to subscribers.

About CFAN

Climate Forecast Applications Network (CFAN) develops innovative forecast tools that give longer and more accurate warnings of extreme weather events, so clients can better prepare and recover. CFAN's staff applies the latest research to a wide range of customer challenges, helping businesses and government around the world. Our advanced prediction tools provide clients with the confidence to make complex and difficult decisions about weather risks.

CFAN was founded in 2006 by Judith Curry and Peter Webster and launched under the Enterprise Innovation Institute's VentureLab program at Georgia Tech. Its research has been assisted by grants from NOAA, the Department of Energy and the Department of Defense.

Contact Information

Dr. James Johnstone, Senior Scientist
jajstone@gmail.com

Dr. Judith Curry, President
curry.judith@cfanclimate.com
(404) 803-2012