Extended Range Forecast for Atlantic Hurricane Activity in 2021

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Forecast Summary

TSR predicts North Atlantic hurricane activity in 2021 will be above the long-term norm but lower than the hyperactive 2020 hurricane season. However, the uncertainties associated with this outlook are large and the forecast skill at this extended range is historically low.

The TSR (Tropical Storm Risk) extended range forecast for North Atlantic hurricane activity in 2021 anticipates a season with activity ~20% above the long-term norm and close to the 2011-2020 10-year norm level. The forecast spans the period from 1st June to 30th November 2021 and employs data through to the end of November 2020. TSR's main predictor at this extended lead (6 months before the 2021 hurricane season starts) is the forecast July-September trade wind speed over the Caribbean Sea and tropical North Atlantic. This parameter influences cyclonic vorticity (the spinning up of storms) and vertical wind shear in the main hurricane track region. At present TSR anticipates that the July-September 2021 trade wind speed will be slightly weaker than normal – due mainly to our expectation for weak La Niña conditions to occur at this time - and thus will have an enhancing effect on North Atlantic hurricane activity in 2021. The precision of TSR's real-time December outlooks for upcoming North Atlantic hurricane activity between 1980 and 2020 is low.

North Atlantic ACE Index and System Numbers in 2021

		ACE Index	Intense Hurricanes	Hurricanes	Tropical Storms
TSR Forecast (±FE)	2021	127	3	7	16
71yr Climate Norm (±SD)	1950-2020	105	3	6	12
10yr Climate Norm	2011-2020	123	3	7	17
Forecast Skill at this Lead	1980-2020	18%	18%	10%	0%
Forecast Skill at this Lead	2011-2020	29%	38%	12%	0%

Key: ACE Index = Accumulated Cyclone Energy Index = Sum of the squares of 6-hourly maximum sustained wind speeds (in units of knots) for all systems while they are at least tropical storm strength. ACE unit = $x10^4$ $knots^2$.
Intense Hurricane = 1 minute sustained wind > 95 kts = Hurricane category 3 to 5.
Hurricane = 1 minute sustained wind > 63 kts = Hurricane category 1 to 5.
Tropical Storm = 1 minute sustained wind > 33 kts.
Forecast Skill = Percentage improvement in mean square error over running 10-year prior climate norm from cross-validated forecasts with 5-year block-removal for 1980-2020 and for 2011-2020.

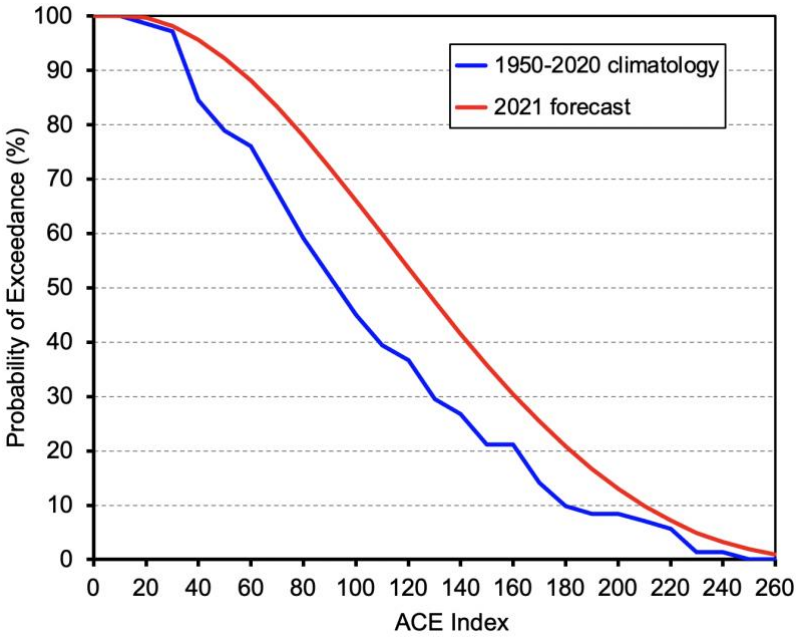
There is a 50% probability that the 2021 North Atlantic hurricane season ACE index will be above-average (defined as an ACE index value in the upper tercile historically (>126)), a 31% likelihood it will be near-normal (defined as an ACE index value in the middle tercile historically (74 to 126)) and a 19% chance it will be below-normal (defined as an ACE index value in the lower tercile historically (<74)).

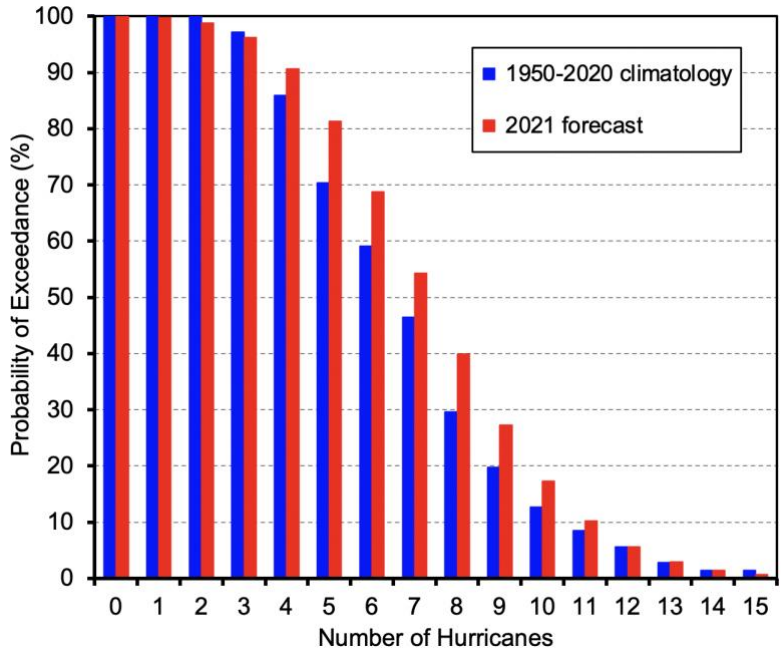
Key: Terciles = Data groupings of equal (33.3%) probability corresponding to the upper, middle and lower one-third of values historically (1950-2020). Upper Tercile = ACE value greater than 126. Middle Tercile = ACE value between 74 and 126. Lower Tercile = ACE value less than 74.

Forecast Probability of Exceedance Plots for the 2021 North Atlantic Hurricane Season

Seasonal outlooks for North Atlantic hurricane activity contribute to the anticipation of risk for insurance companies, other weather-sensitive businesses, and local and national governments. However, the uncertainty associated with such forecasts is often unclear. This reduces their benefit and contributes to the perception of forecast 'busts'. The robust assessment of risk requires a full and clear probabilistic quantification of forecast uncertainty with the forecast issued in terms of probability of exceedance (PoE). In this way the chance of each hurricane number/activity outcome occurring is clear for the benefit of users. Going forward TSR will be including robust forecast probability of exceedance (PoE) information based on the recommendation and methodology described in Saunders et al. (2020).

The plots below display our extended range outlooks for ACE (upper panel) and the number of hurricanes (lower panel) in terms of PoE. Each plot displays two sets of PoE data comprising the forecast PoE curve and the 1950-2020 climatology PoE curve. The forecast PoE curves are computed using the method described in section 3 of Saunders et al. (2020) while the climatology PoE curves are computed directly from observations. The two forecast PoE plots specify the current chance that a given ACE Index and/or hurricane total will be reached in 2021 and how these chances differ to climatology.





There is a 34% likelihood that the 2021 Atlantic hurricane season will be a 'hyperactive' season defined as an ACE ≥ 165% of the median ACE for 1981-2010 (an ACE value of 152.5).

Reference: Saunders, M. A., Klotzbach, P. J., Lea, A. S. R., Schreck, C. J., & Bell, M. M. (2020). Quantifying the probability and causes of the surprisingly active 2018 North Atlantic hurricane season. *Earth and Space Science*, *7*, e2019EA000852. https://doi.org/10.1029/2019EA000852

Methodology and Key Predictor(s) for 2021

The TSR statistical seasonal hurricane forecast model divides the North Atlantic into three regions and employs separate forecast models for each region before summing the regional hurricane forecasts to obtain an overall forecast. For two of these three regions (tropical North Atlantic, and the Caribbean Sea and Gulf of Mexico) the forecast model pools different environmental fields involving August-September sea surface temperatures (SSTs) and July-September trade wind speed to select the environmental field or combination of fields which gives the highest replicated real-time skill for hurricane activity over the prior 10-year period. The nature of this process means that the details of the seasonal forecast model can vary subtly from year-to-year and also with lead time within the same year. Separate forecast models are employed to predict the July-September trade wind speed and to predict the August-September SSTs. Finally bias corrections are employed for each predictand based on the forecast model performance for that predictand over the prior 10 years.

All regressions are performed using normalized data for all variables (predictands and predictors). This ensures that the requirements of linear regression modeling are met; namely that observations are drawn from normal distributions and that regression errors are normally distributed with a mean of zero. In each case the transform distribution is determined using 1950-2019 data. Table S2 in Supporting Information in Saunders et al (2020) lists some of the statistical distributions used to transform particular data sets to a normalized distribution. Normality is assessed using the Anderson-Darling statistical test.

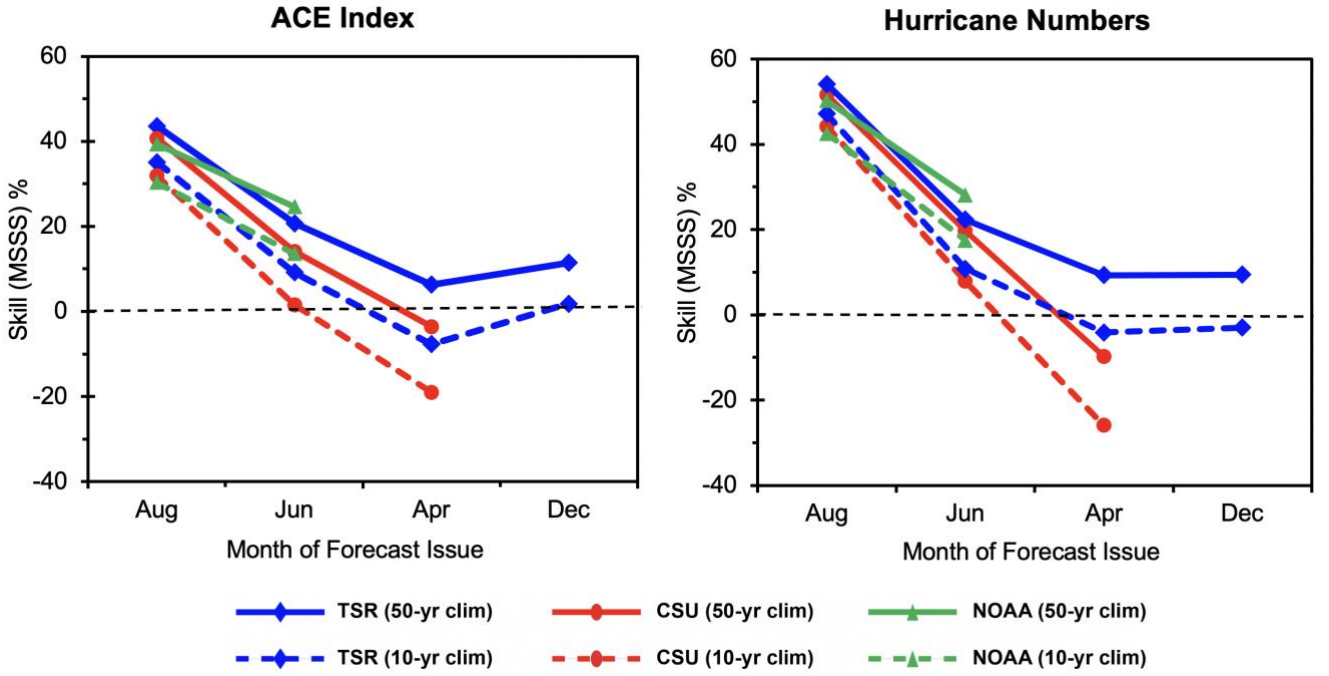
The reason why the TSR extended forecast for the 2021 Atlantic hurricane activity calls for ACE-activity ~20% above the long-term norm is our current expectation for weak La Niña conditions to occur during July-August-September 2021. We consider that this is the more likely scenario at present due to the strength of the current La Niña event and the historical tendency for the summer following a strong La Niña event to also exhibit La Niña conditions (albeit less strong than in the previous year). Based on this ENSO outlook and the expectation for North Atlantic SSTs during July-September 2021 to be slightly warmer than normal, we forecast the July-September 2021 trade wind speed at 925mb height over the Caribbean Sea and tropical North Atlantic region (7.5°N-17.5°N, 100°W-30°W) to be 0.49±0.80 ms^{-1} weaker than normal (1981-2010 climatology). A weaker than normal trade wind speed favours enhanced hurricane activity. However, it should be stressed that uncertainties in the forecast July-September 2021 trade wind speed are large due to the large uncertainties in the forecast ENSO and in the forecast North Atlantic and Caribbean Sea SSTs at this extended 6-month range.

Precision of Seasonal Hurricane Forecasts 2003-2020 Issued in Real-Time

The figure on the next page displays the seasonal forecast skill for North Atlantic hurricane activity for the 18-year period between 2003 and 2020. This skill assessment uses the seasonal forecast values that were issued publicly in real-time by the three forecast centres TSR, CSU (Colorado State University) and NOAA (National Oceanic and Atmospheric Administration). Skill is displayed as a function of lead time for two measures of seasonal hurricane activity: the ACE index and basin hurricane numbers.

The Mean Square Skill Score (MSSS) is used to define the forecast skill. MSSS is the percentage improvement in mean square error over a climatology forecast. Positive skill indicates that the model performs better than climatology, while a negative skill indicates that it performs worse than climatology. Two different climatologies are used: a fixed 50-year (1951-2000) climatology and a running prior 10-year climate norm.

It should be noted that NOAA does not issue seasonal hurricane outlooks before late May and that CSU stopped providing quantitative extended-range hurricane outlooks from the prior December after 2011. It is clear there is little skill in forecasting the upcoming ACE and numbers of hurricanes from the previous December for the period 2003-2020. Skill starts to climb after April as the hurricane season approaches with moderate-to-good skill levels being achieved, on average, by early August.



Although there are mostly only small differences in skill between the three forecast centres, the TSR model has been either the near-equal best or the best performing statistical seasonal forecast model at all lead times for the period 2003-2020.

Further Information and Next Forecast

Further information about TSR forecasts and verifications may be obtained from the TSR web site *http://www.tropicalstormrisk.com*. The first TSR forecast update for the 2021 North Atlantic hurricane season will be issued on Friday 9th April 2021.