July Forecast for North Atlantic Hurricane Activity in 2021

Issued: 6th July 2021

by Professor Mark Saunders and Dr Adam Lea
Dept. of Space and Climate Physics, UCL (University College London), UK

Forecast Summary

TSR maintains its pre-season forecast and predicts North Atlantic hurricane activity in 2021 will be 30-35% above the long-term norm. This outlook is predicated on our expectation that a weak La Niña will develop during autumn 2021.

The TSR (Tropical Storm Risk) early July forecast update for North Atlantic hurricane activity in 2021 anticipates a season with activity that is ~30-35% above the long-term norm and slightly above the 2011-2020 10-year norm. The forecast spans the period from 1st June to 30th November 2021 and employs data through to the end of June 2021. TSR maintains its late-May forecast values despite uncertainty surrounding the values for key environmental fields in August-September-October 2021; notably the state of El Niño Southern Oscillation and the nature of anomalies in tropical North Atlantic sea surface temperature. Our forecast is predicated on the development of a weak La Niña by autumn 2021 and on the development of warmer sea surface temperature anomalies in the tropical North Atlantic and Caribbean Sea by autumn 2021. These factors will both enhance hurricane activity. However, other outcomes are possible. We express the forecast uncertainty in terms of probability of exceedance plots for Accumulated Cyclone Energy (ACE) and for hurricane numbers. At present TSR anticipates there is a 59% likelihood that the North Atlantic hurricane season ACE index in 2021 will be above-average (defined as a value in the upper tercile 1950-2020).

North Atlantic ACE Index and System Numbers in 2021

		ACE Index	Intense Hurricanes	Hurricanes	Tropical Storms
TSR Forecast (±FE)	2021	141	4	9	20
71-yr Climate Norm (±SD)	1950-2020	105	3	6	12
10-yr Climate Norm	2011-2020	123	3	7	17
Forecast Skill at this Lead	2003-2020	22%	29%	25%	22%

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 for the TSR publicly-released seasonal outlooks for the 18-years 2003-2020.

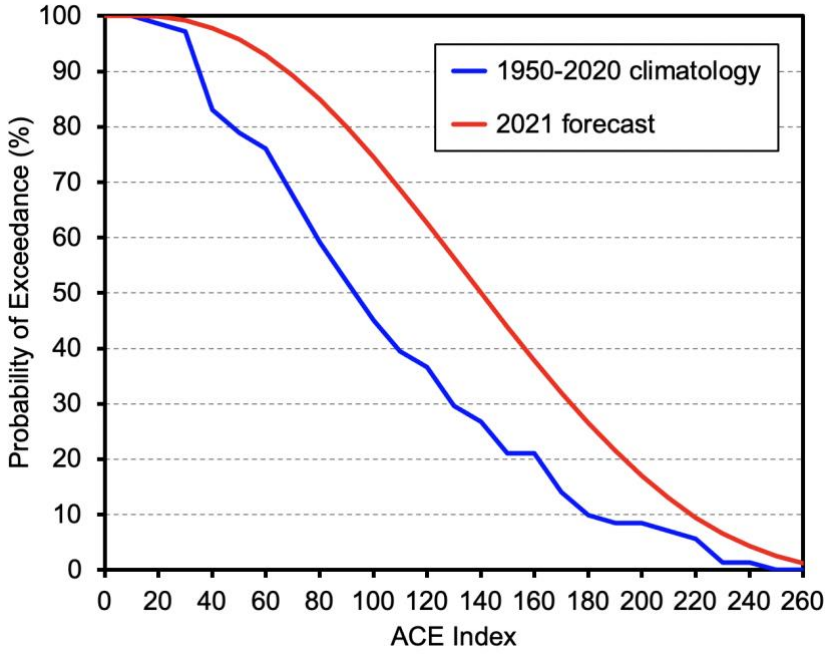
There is a 59% probability that the 2021 North Atlantic hurricane season ACE index will be above-average (defined as an ACE index value in the upper tercile historically (>126)), a 28% likelihood it will be near-normal (defined as an ACE index value in the middle tercile historically (74 to 126)) and a 13% chance it will be below-normal (defined as an ACE index value in the lower tercile historically (<74)).

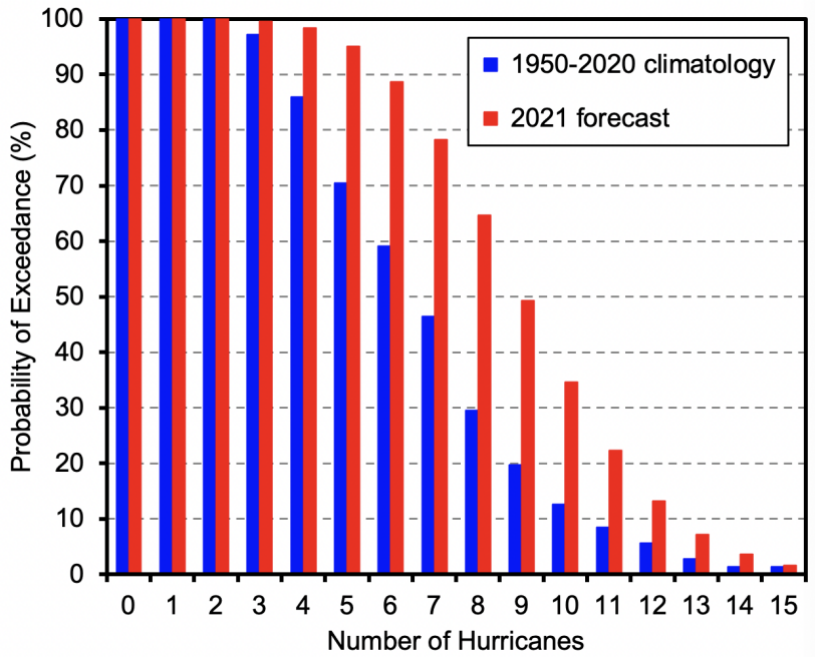
Key: Terciles = Data groupings of equal (33.3%) probability corresponding to the upper, middle and lower one-third of values historically (1950-2020). Upper Tercile = ACE value greater than 126. Middle Tercile = ACE value between 74 and 126. Lower Tercile = ACE value less than 74.

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 for 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 43% 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

MDR, Caribbean Sea and Gulf of Mexico ACE Index & System Numbers in 2021

		ACE Index	Intense Hurricanes	Hurricanes	Tropical Storms
TSR Forecast	2021	120	3	6	12
71-yr Climate Norm	1950-2020	82	2	4	8
10-yr Climate Norm	2011-2020	94	2	5	10
Forecast Skill at this Lead	2003-2020	20%	34%	51%	49%

The Atlantic hurricane Main Development Region (MDR) is the region 10ºN-20ºN, 20ºW-60ºW between the Cape Verde Islands and the Caribbean Lesser Antilles. A storm is defined as having formed within this region if it reached at least tropical depression status while in the area.

There is a 62% probability that the 2020 Atlantic hurricane season ACE index will be above-average (defined as an ACE index value in the upper tercile historically (>96)), a 26% likelihood it will be near-normal (defined as an ACE index value in the middle tercile historically (45 to 96) and a 12% chance it will be below-normal (defined as an ACE index value in the lower tercile historically (<45)). The 71-year period 1950-2020 is used for climatology.

USA Landfalling ACE Index and Numbers in 2021

		ACE Index	Hurricanes	Tropical Storms
TSR Forecast	2021	2.7	2	6
71-yr Climate Norm	1950-2020	2.5	1	3
10-yr Climate Norm	2011-2020	2.6	2	4
Forecast Skill at this Lead	2003-2020	0%	11%	15%

Key: ACE Index = Accumulated Cyclone Energy Index = Sum of the Squares of hourly Maximum Sustained Wind Speeds (in units of knots) for all Systems while they are at least Tropical Storm Strength and over the USA Mainland (reduced by a factor of 6). ACE Unit = $x10^4$ $knots^2$.
Strike Category = Maximum 1 Minute Sustained Wind of Storm Directly Striking Land.
USA Mainland = Brownsville (Texas) to Maine

USA landfalling intense hurricanes are not forecast since we have no skill at any lead.

There is a 45% probability that in 2020 the USA landfalling ACE index will be above average (defined as a USA ACE index value in the upper tercile historically (>2.5)), a 29% likelihood it will be near-normal (defined as a USA ACE index value in the middle tercile historically (1.1 to 2.5)) and a 26% chance it will be below-normal (defined as a USA ACE index value in the lower tercile historically (<1.1)). The 71-year period 1950-2020 is used for climatology.

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.

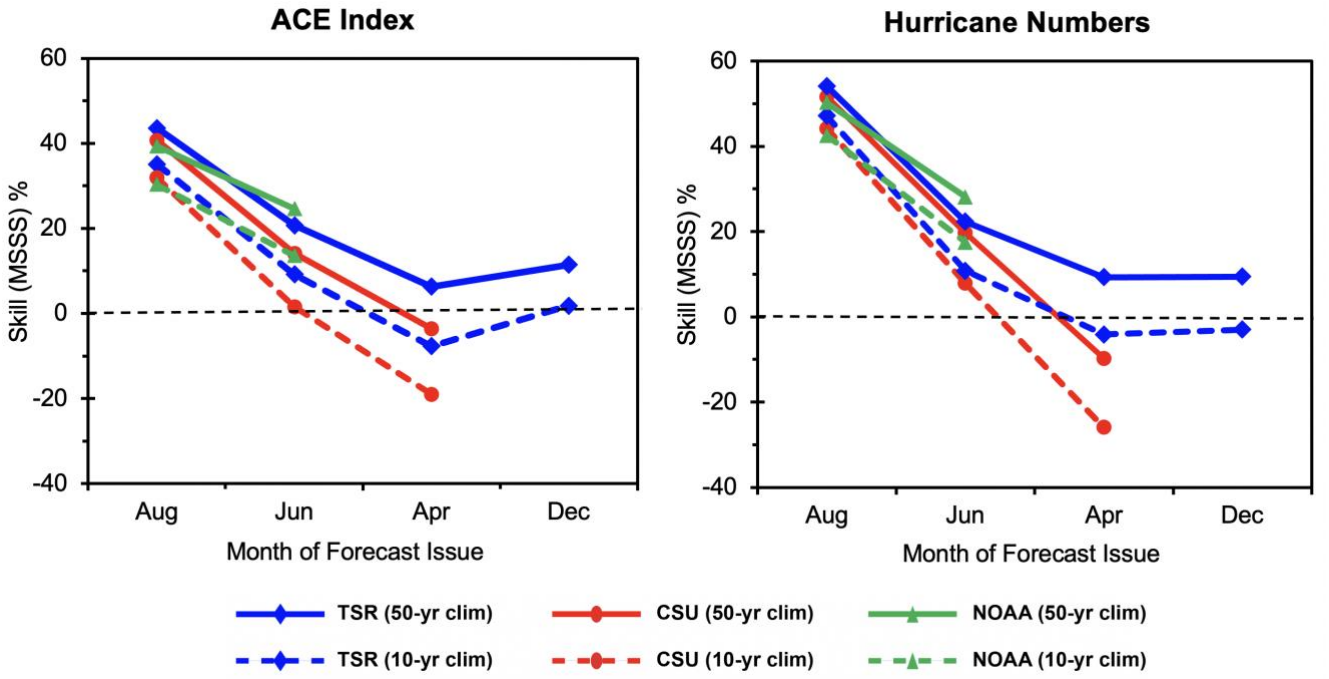
The TSR July forecast update for North Atlantic hurricane activity in 2021 calls for ACE-activity that is ~30-35% above the long-term norm due to two main factors: (1) we anticipate a weak La Niña will develop by autumn 2021; (2) we anticipate tropical North Atlantic SSTs will slowly warm as autumn 2021 approaches. These factors in turn mean that the July-August-September 2021 forecast trade wind at 925mb height over the Caribbean Sea and tropical North Atlantic (region 7.5°N–17.5°N, 30°W–100°W) and the August-September forecast SST for the tropical North Atlantic (region 10°N–20°N, 20°W–60°W) are both enhancing for hurricane activity in 2021. The current forecast for the July-September trade wind is for 0.61±0.59 ms^{-1} weaker than normal (1981-2010 climatology) which is almost identical to its pre-season forecast value of 0.59±0.64 ms^{-1} weaker than normal. The current forecast for the August-September SST is for 0.35±0.25°C warmer than normal (1981-2010 climatology) which is the same as its pre-season forecast value. Weaker than normal trade winds during July-September in the tropical north Atlantic are associated with more cyclonic vorticity and decreased vertical wind shear over the hurricane main development region. This in turn increases hurricane frequency and intensity. However, it should be stressed that uncertainties in the forecast for North Atlantic hurricane activity in 2021 still remain sizeable. These uncertainties surround in particular the strength of La Niña by September-October 2021 and how warm the tropical North Atlantic and Caribbean Sea SSTs will be in August-September-October 2021.

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 final TSR forecast update for the 2021 North Atlantic hurricane season will be issued on Thursday 5th August 2021.

Appendix – Predictions from Previous Months

1. Atlantic ACE Index and System Numbers

Atlantic ACE Index and System Numbers 2021					
		ACE Index	Named Tropical Storms	Hurricanes	Intense Hurricanes
Average Number (1950-2020)		105	12	6	3
Average Number (2011-2020)		123	17	7	3
TSR Forecasts	6 July 2021	141	20	9	4
	27 May 2021	140	18	9	4
	13 April 2021	134	17	8	3
	9 December 2020	127	16	7	3
CSU Forecasts	3 June 2021	150	18	8	4
	8 April 2021	150	17	8	4
NOAA Forecast	20 May 2021	106-184	13-20	6-10	3-5
Met Office Forecast*	20 May 2021	117	14	7	3

***** Refers to activity between 1st June 2021 and 30th November 2021 only.

2. MDR, Caribbean Sea and Gulf of Mexico ACE Index and Numbers

MDR, Caribbean Sea and Gulf of Mexico ACE Index and Numbers 2021					
		ACE Index	Named Tropical Storms	Hurricanes	Intense Hurricanes
Average Number (1950-2020)		82	8	4	2
Average Number (2011-2020)		94	10	5	2
TSR Forecasts	6 July 2021	120	12	6	3
	27 May 2021	116	12	6	3
	13 April 2021	114	11	6	3

3. US ACE Index and Landfalling Numbers

US Landfalling Numbers 2021				
		ACE Index	Named Tropical Storms	Hurricanes
Average Number (1950-2020)		2.5	4	2
Average Number (2011-2020)		2.6	4	2
TSR Forecasts	6 July 2021	2.7	6	2
	27 May 2021	2.8	5	2
	13 April 2021	2.5	4	2