August Forecast Update for North Atlantic Hurricane Activity in 2019

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Forecast Summary

TSR slightly raises its forecast and anticipates North Atlantic hurricane activity in 2019 will be close to the long-term norm. The sizeable uncertainty associated with this forecast is expressed robustly in terms of probability of exceedance.

The TSR (Tropical Storm Risk) August forecast update for North Atlantic hurricane activity in 2019 calls for a near-norm season. Atlantic basin tropical cyclone activity is forecast to be about 10% below the recent 2009-2018 10-year norm and close to the 1950-2018 long-term norm. The forecast spans the period from 1st June to 30th November 2019 and employs data through to the end of July 2019. The forecast is slightly raised compared to TSR's early July outlook due to the August-September trade wind speed over the Caribbean Sea and tropical North Atlantic now expected to be slightly more favourable for hurricane development. This parameter influences cyclonic vorticity (the spinning up of storms) and vertical wind shear in the main hurricane track region. Probability of exceedance is used to clarify robustly and clearly the uncertainty associated with this outlook. In this way the chance of each hurricane activity outcome occurring is given.

North Atlantic ACE Index and System Numbers in 2019

		ACE Index	Intense Hurricanes	Hurricanes	Tropical Storms
TSR Forecast	2019	100	2	6	13
69yr Climate Norm	1950-2018	104	3	6	11
10yr Climate Norm	2009-2018	114	3	7	14
Forecast Skill at this Lead	1980-2018	47%	41%	50%	50%
Forecast Skill at this Lead	2009-2018	25%	40%	30%	53%

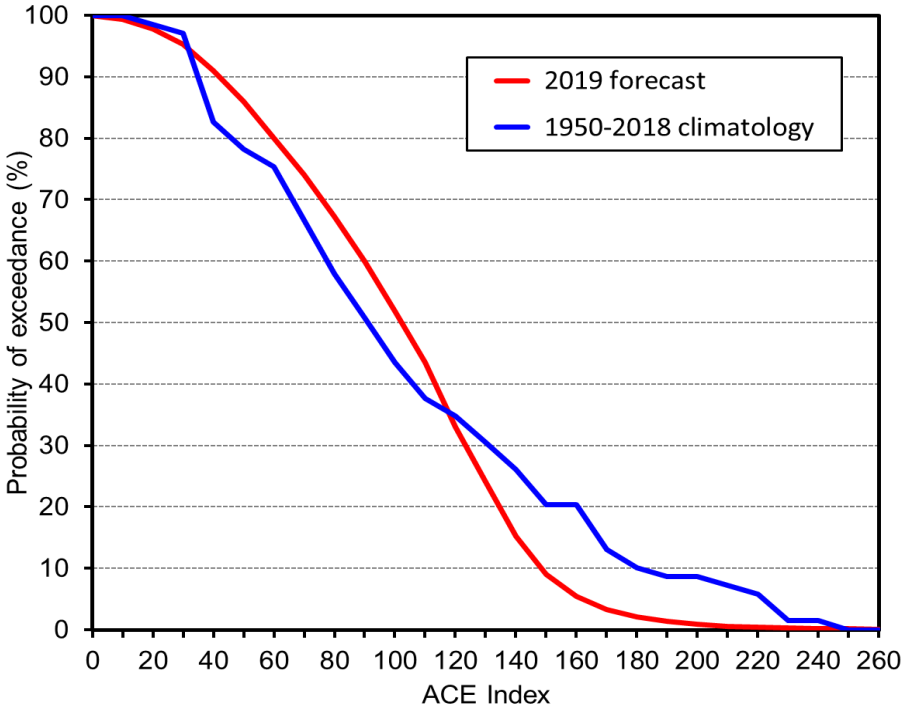
Key: ACE Index = Accumulated Cyclone Energy Index = Sum of the Squares of 6-hourly Maximum Sustained Wind Speeds (in units of knots) for all Systems while they are at least Tropical Storm Strength. ACE Unit = $x10^4$ $knots^2$.
Intense Hurricane = 1 Minute Sustained Wind > 95Kts = Hurricane Category 3 to 5.
Hurricane = 1 Minute Sustained Wind > 63Kts = Hurricane Category 1 to 5.
Tropical Storm = 1 Minute Sustained Winds > 33Kts.
Forecast Skill = Percentage Improvement in Mean Square Error over Running 10-year Prior Climate Norm from Replicated Real Time Forecasts for 1980-2018 and 2009-2018.

There is a 29% probability that the 2019 Atlantic hurricane season ACE index will be above-average (defined as an ACE index value in the upper tercile historically (>124)), a 45% likelihood it will be near-normal (defined as an ACE index value in the middle tercile historically (72 to 124) and a 26% chance it will be below-normal (defined as an ACE index value in the lower tercile historically (<72)). The 69-year period 1950-2018 is used for climatology.

Key: Terciles = Data groupings of equal (33.3%) probability corresponding to the upper, middle and lower one-third of values historically (1950-2018).
Upper Tercile = ACE index value greater than 124.
Middle Tercile = ACE index value between 72 and 124.
Lower Tercile = ACE index value less than 72.

Forecast Probability of Exceedance Plot for the 2019 North Atlantic ACE Index

Probability of exceedance is the preferred method in insurance, finance and other business sectors for quantifying and presenting the uncertainty in natural hazard outcomes. Seasonal hurricane forecasts can have substantial uncertainty but this uncertainty is often unclear due to the manner in which these forecasts are provided. Going forward TSR plans to include in its hurricane outlooks a probability of exceedance (PoE) plot that combines the forecast PoE for the North Atlantic ACE Index and the 1950-2018 climatology PoE for the ACE Index. From this plot one may obtain the forecast likelihood of any ACE value being exceeded and then compare this probability to the climatology likelihood of exceedance. The PoE plot for the TSR August forecast update for the 2019 North Atlantic hurricane season is displayed below.



ACE Index & Numbers Forming in the MDR, Caribbean Sea and Gulf of Mexico in 2019

		ACE Index	Intense Hurricanes	Hurricanes	Tropical Storms
TSR Forecast	2019	77	2	5	9
69yr Climate Norm	1950-2018	81	2	4	8
10-yr Climate norm	2009-2018	90	2	5	10
Forecast Skill at this Lead	1980-2018	45%	43%	62%	66%
Forecast Skill at this Lead	2009-2018	39%	43%	61%	83%

The Atlantic hurricane Main Development Region (MDR) is the region 10°N-20°N, 20°W-60°W 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 33% probability that the 2019 Atlantic hurricane season ACE index will be above-average (defined as an ACE index value in the upper tercile historically (>96)), a 44% likelihood it will be near-normal (defined as an ACE index value in the middle tercile historically (45 to 96) and a 23% chance it will be below-normal (defined as an ACE index value in the lower tercile historically (<45)). The 69-year period 1950-2018 is used for climatology.

USA Landfalling ACE Index and Numbers in 2019

		ACE Index	Hurricanes	Tropical Storms
TSR Forecast	2019	1.6	1	2
69yr Climate Norm	1950-2018	2.4	1	3
10yr Climate Norm	2009-2018	2.0	1	3
Forecast Skill at this Lead	1980-2018	27%	6%	6%
Forecast Skill at this Lead	2009-2018	17%	1%	0%

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 32% probability that in 2019 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 39% chance it will be below-normal (defined as a USA ACE index value in the lower tercile historically (<1.1)). The 69-year period 1950-2018 is used for climatology.

Caribbean Lesser Antilles Landfalling Numbers in 2019

		ACE Index	Intense Hurricanes	Hurricanes	Tropical Storms
TSR Forecast	2019	1.7	0	0	2
68yr Climate Norm	1950-2018	1.5	0	0	1
10yr Climate Norm	2009-2018	2.1	0	1	2
Forecast Skill at this Lead	1980-2018	19%	7%	20%	20%
Forecast Skill at this Lead	2009-2018	6%	1%	10%	4%

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 within the region 10˚-18˚N, 63˚-60˚W (reduced by a factor of 6).
ACE Unit = $x10^4$ $knots^2$.
Strike Category = Maximum 1 Minute Sustained Wind of Storm Directly Striking Land.
Lesser Antilles = Island Arc from Anguilla to Trinidad Inclusive.

Methodology and Key Predictors for 2019

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.

The main factor behind the TSR forecast for a near-average 2019 hurricane season is the anticipated near-average trade wind speed at 925 hPa height over the Caribbean Sea and tropical North Atlantic (7.5–17.5°N, 30–100°W) forecast for July-September 2019. The current forecast for this predictor is 0.04±0.39 ms^{-1} weaker than normal (1980-2018 climatology) which is ~0.6 ms^{-1} weaker than the early July forecast value of 0.58±0.67 ms^{-1} stronger than normal. A near-average July-September trade wind speed translates typically to near-average cyclonic vorticity and near-average vertical wind shear over the hurricane main track region in the North Atlantic. Our expectation for near-average August-September 2019 sea surface temperatures for the eastern and central hurricane main development region (10–20°N, 20–60°W) – a value of 0.19°C warmer than climatology is forecast – further supports our outlook for a near-average 2019 hurricane season. The July-September 2019 trade wind speed is forecast using persistence of the July 2019 trade wind speed.

The August-September large-scale tropical environmental fields used here explain 50-55% of the variance in Atlantic basin hurricane activity between 1950 and 2017. Saunders et al (2017) showed that the August-September 925 hPa trade wind field replicates nearly 50% of the variance in ACE across the 135-year period 1878-2012. Despite this success, there remains ~50% of the variance in long-term Atlantic hurricane activity that is not replicated by current statistical outlook models. This level of unexplained variance means that one must expect sizeable discrepancies to occur at times between the early August forecast and observed levels of hurricane activity.

Forecast Model for US ACE Index and US Landfalling Hurricane Numbers

The TSR early August forecast for the US ACE index and US landfalling hurricane and tropical storm numbers in 2018 is predicted from an ensemble of two models: (1) the July 2017 tropospheric wind anomalies between heights of 925 hPa and 400 hPa over North America, the east Pacific and the North Atlantic (Saunders and Lea, 2005). Wind anomalies in these regions in July are indicative of persistent atmospheric circulation patterns that either favour or hinder evolving hurricanes from reaching US shores during August and September; (2) thinning from the forecast of total Atlantic basin activity.

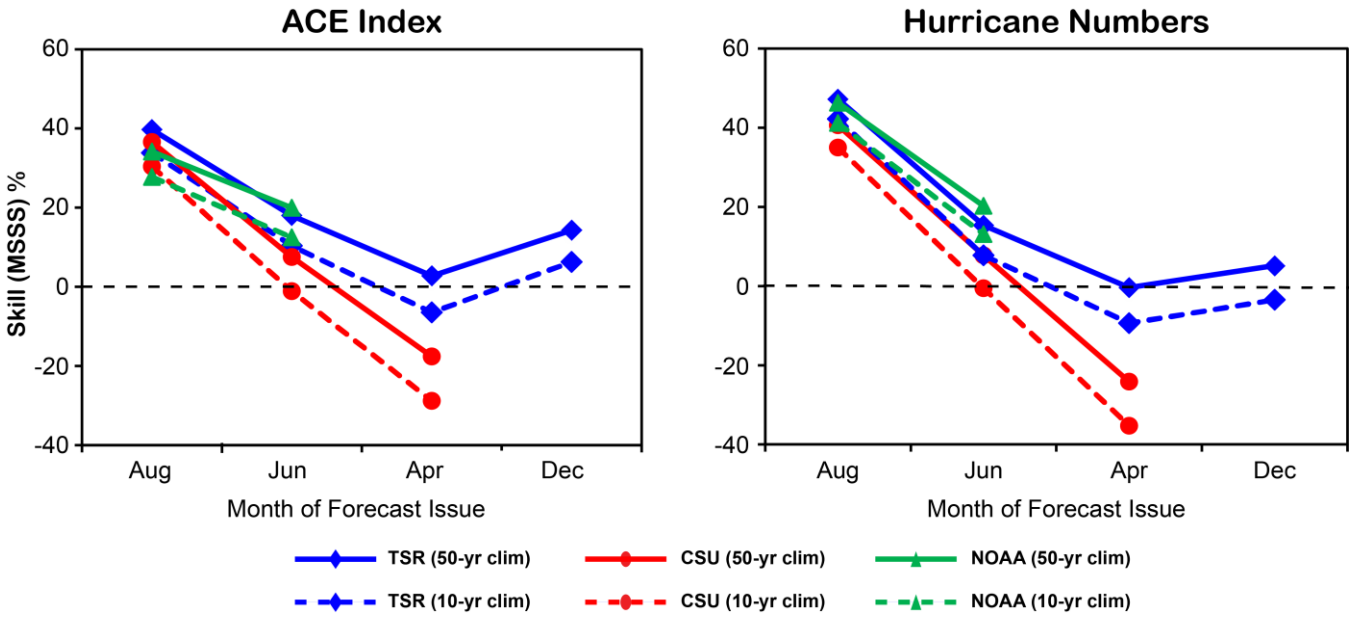
Saunders, M. A. and A. S. Lea, Seasonal prediction of hurricane activity reaching the coast of the United States, *Nature*, 434, 1005-1008, 2005.

The Precision of Seasonal Hurricane Forecasts 2003-2018

The figure below displays the seasonal forecast skill for North Atlantic hurricane activity for the 16-year period between 2003 and 2018. This assessment uses the seasonal forecast values issued publicly in real-time by the three forecast centres TSR, NOAA (National Oceanic and Atmospheric Administration) and CSU (Colorado State University). Skill is assessed as a function of lead time for two measures of seasonal hurricane activity: ACE and basin hurricane numbers.

Forecast precision is provided using the Mean Square Skill Score (MSSS) which 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 April for the period 2003-2018. Skill starts to climb as the hurricane season approaches with moderate-to-good skill levels being achieved, on average, by early August.



TSR has been either the best performing or the near equal-best performing statistical seasonal forecast model at all lead times for the period 2003-2018.

Additional information about the accuracy of the TSR seasonal outlooks and of the long-term validity of the TSR seasonal model may be obtained from these two publications:

1. Klotzbach, P. J., M. A. Saunders, G. D. Bell and E. S. Blake (2017), North Atlantic seasonal hurricane prediction: underlying science and an evaluation of statistical models, in *Climate Extremes: Patterns and Mechanisms*, Geophys. Monogr. Ser., vol 226, edited by S-Y. Wang et al., pp. 315-328, American Geophysical Union, John Wiley & Sons. doi/10.1002/9781119068020.ch19/pdf (Please see section 19.2.5 – pages 323-325).

2. Saunders, M. A., P. J. Klotzbach and A. S. R. Lea (2017), Replicating annual North Atlantic hurricane activity 1878-2012 from environmental variables, *J. Geophys. Res. Atmos.*, *122*, 6284-6297, doi:10.1002/2017JD026492.

Further Information and Next Forecast

Further information about TSR forecasts and verifications may be obtained from the TSR web site *http://www.tropicalstormrisk.com*. This is the final TSR forecast update for the 2019 North Atlantic hurricane season. TSR will issue its extended range outlook for the 2020 North Atlantic hurricane season in early December 2019.

Appendix – Predictions from Previous Months

1. Atlantic ACE Index and System Numbers

Atlantic ACE Index and System Numbers 2019					
		ACE Index	Named Tropical Storms	Hurricanes	Intense Hurricanes
Average Number (1950-2018)		104	11	6	3
Average Number (2009-2018)		114	14	7	3
TSR Forecasts	6 Aug 2019	100	13	6	2
	4 July 2019	89	12	6	2
	30 May 2019	88	12	6	2
	5 Apr 2019	81	12	5	2
	11 Dec 2018	74	11	5	2
CSU Forecasts	5 Aug 2019	105	14	7	2
	4 June 2019	99	13	6	2
	4 Apr 2019	80	13	5	2
NOAA Forecast	23 May 2019	65-140	9-15	4-8	2-4

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

MDR, Caribbean Sea and Gulf of Mexico ACE Index and Numbers 2019					
		ACE Index	Named Tropical Storms	Hurricanes	Intense Hurricanes
Average Number (1950-2018)		81	8	4	2
Average Number (2009-2018)		90	10	5	2
TSR Forecasts	6 Aug 2019	77	9	5	2
	4 July 2019	65	8	4	2
	30 May 2019	65	8	4	2
	5 Apr 2019	58	7	3	1

3. US ACE Index and Landfalling Numbers

US Landfalling Numbers 2019				
		ACE Index	Named Tropical Storms	Hurricanes
Average Number (1950-2018)		2.4	3	1
Average Number (2009-2018)		2.0	3	1
TSR Forecasts	6 Aug 2019	1.6	2	1
	4 July 2019	1.5	2	1
	30 May 2019	1.5	2	1
	5 Apr 2019	1.3	2	1

4. Lesser Antilles ACE Index and Landfalling Numbers

Lesser Antilles Landfalling Numbers 2019					
		ACE Index	Named Tropical Storms	Hurricanes	Intense Hurricanes
Average Number (1950-2018)		1.5	1	0	0
Average Number (2009-2018)		2.1	2	1	0
TSR Forecasts	6 Aug 2019	1.7	2	0	0
	4 July 2019	1.5	2	0	0
	30 May 2019	1.5	2	0	0
	5 Apr 2019	1.3	1	0	0