



April Forecast Update for North Atlantic Hurricane Activity in 2019

Issued: 5th April 2019

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Forecast Summary

TSR maintains its extended range forecast and predicts North Atlantic hurricane activity in 2019 will be slightly below the long-term norm. However, the uncertainties in this outlook are large and the forecast skill from early April is historically low.

The TSR (Tropical Storm Risk) April forecast update for North Atlantic hurricane activity in 2019 anticipates a season with slightly below-normal activity. Based on current and projected climate signals, Atlantic basin tropical cyclone activity is forecast to be about 20% below the 1950-2018 long-term norm and about 30% below the recent 2009-2018 10-year norm. The forecast spans the period from 1st June to 30th November 2019 and employs data through to the end of March 2019. TSR's main predictor 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 trade wind speed in 2019 will be slightly stronger than normal - due mainly to a continuance of weak-to-moderate El Niño conditions - and that this will have a suppressing effect on North Atlantic hurricane activity in 2019. It should be stressed that the precision of hurricane outlooks issued in early April is low and that forecast uncertainties remain large for the 2019 hurricane season. These uncertainties surround in particular the projections for El Niño Southern Oscillation and the North Atlantic Oscillation.

North Atlantic ACE Index and System Numbers in 2019

		ACE Index	Intense Hurricanes	Hurricanes	Tropical Storms
TSR Forecast	2019	81	2	5	12
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	5%	3%	0%	5%
Forecast Skill at this Lead	2009-2018	1%	16%	0%	12%

- 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 = $\times 10^4$ knots².
- 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.

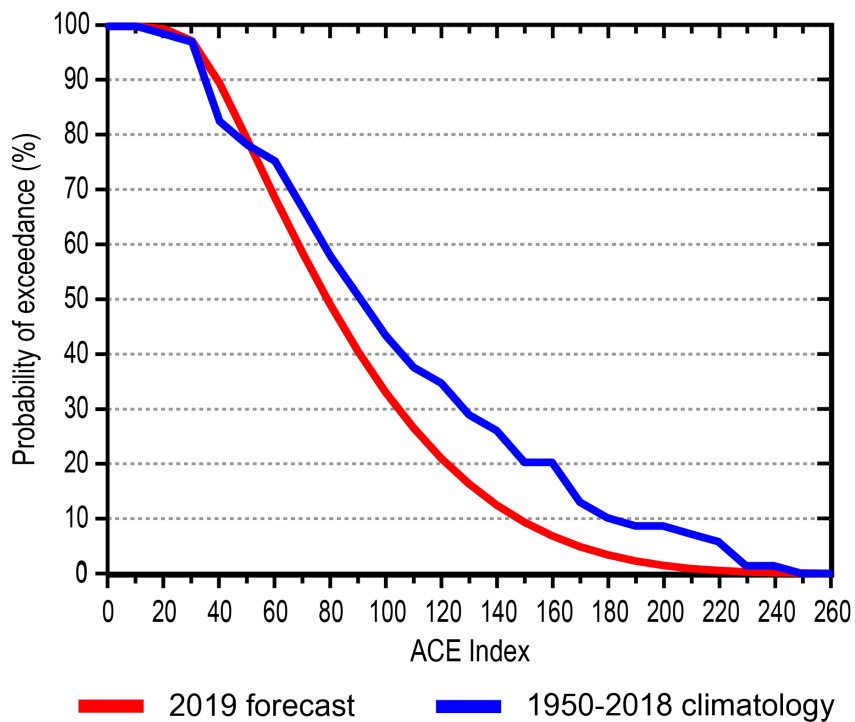
There is a 23% probability that the 2019 Atlantic hurricane season ACE index will be above-average (defined as an ACE index value in the upper tercile historically (>124)), a 34% likelihood it will be near-normal (defined as an ACE index value in the middle tercile historically (72 to 124)) and a 43% 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 (1950-2017).
- 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 April 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	58	1	3	7
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	10%	7%	15%	17%
Forecast Skill at this Lead	2009-2018	11%	25%	18%	31%

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 24% 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 35% likelihood it will be near-normal (defined as an ACE index value in the middle tercile historically (45 to 96)) and a 41% 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	1.3	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	0%	0%	3%
Forecast Skill at this Lead	2009-2018	0%	0%	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 = $\times 10^4$ knots².

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 29% 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 24% 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 47% 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	1.3	0	0	1
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	1%	1%	5%	0%
Forecast Skill at this Lead	2009-2018	0%	1%	2%	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 within the region 10°-18°N, 63°-60°W (reduced by a factor of 6). ACE Unit = $\times 10^4$ knots².

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.

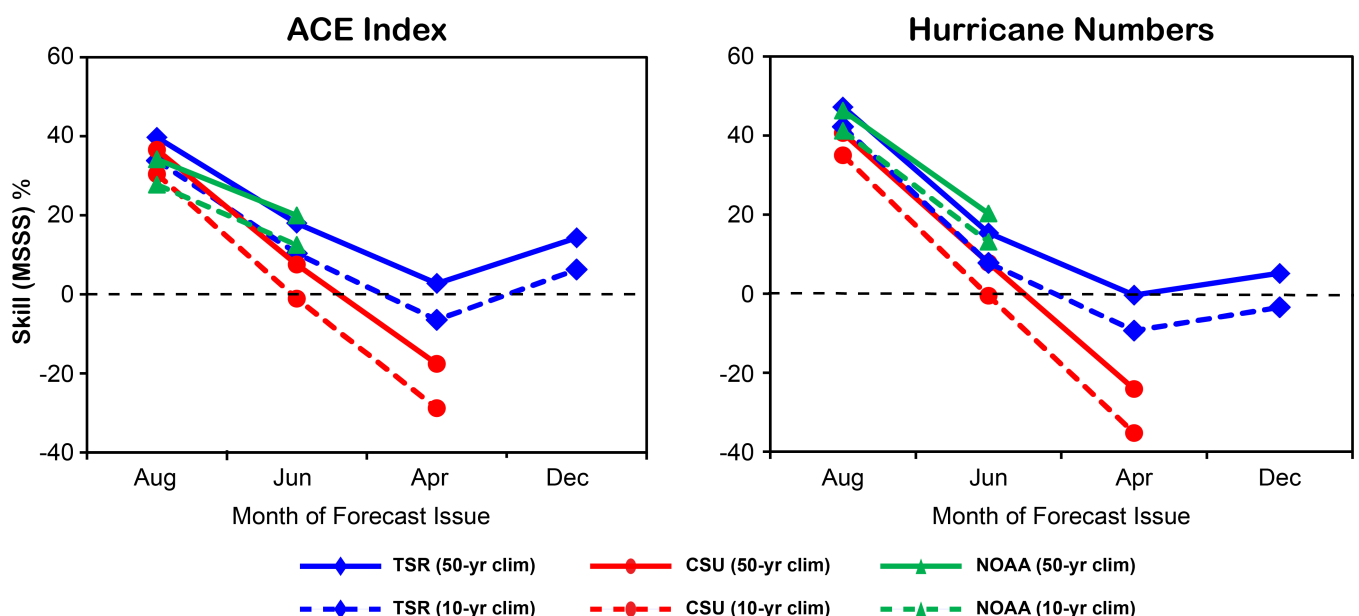
The main factor underpinning the TSR forecast for 2019 hurricane activity being below the long term norm is the anticipated suppressing effect of the July-September 2019 forecast trade wind at 925mb height over the Caribbean Sea and tropical North Atlantic region (7.5°N – 17.5°N, 100°W – 30°W). The current forecast for this predictor is $0.83 \pm 0.88 \text{ ms}^{-1}$ stronger than normal (1980-2018 climatology). This is almost the same as the December forecast value of $0.79 \pm 0.88 \text{ ms}^{-1}$ stronger than normal. Stronger than normal trade winds during July-September are associated with less cyclonic vorticity and increased vertical wind shear over the hurricane main development region. These environmental factors reduce hurricane frequency and intensity. The July-September 2019 trade wind prediction incorporates the current expectations for weak-to-moderate El Niño conditions during July-September 2019 and for slightly cooler than normal tropical North Atlantic SSTs in August-September 2019. The current consensus of dynamical and statistical model ENSO outlooks (https://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/?enso-sst_table) published by the International Research Institute for Climate and Society on the 19th March 2019 is used for the ENSO (El Niño Southern Oscillation) outlook. However, it should be stressed that uncertainties in the forecast July-September 2019 trade wind speed are large due to the large uncertainties in ENSO and in the North Atlantic and Caribbean Sea SSTs at this 4-month lead before the start of the hurricane peak season in August.

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.

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 next TSR forecast update for the 2019 North Atlantic hurricane season will be a pre-season forecast issued on the 30th May 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
CSU Forecast	4 Apr 2019	80	13	5	2
TSR Forecasts	5 Apr 2019	81	12	5	2
	11 Dec 2018	74	11	5	2

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 Forecast	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 Forecast	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 Forecast	5 Apr 2019	1.3	1	0	0