Extended Range Forecast for North Atlantic Hurricane Activity in 2024

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Forecast Summary

TSR predicts that North Atlantic hurricane activity in 2024 will be very active with activity about 30% above the 1991-2020 30-year norm and around 50% above the long-term 1950-2023 norm. This outlook has large uncertainties.

The TSR (Tropical Storm Risk) extended range forecast for North Atlantic hurricane activity in 2024 anticipates a season with high activity. The forecast spans the period from 1st June to 30th November 2024 and employs data through to the end of November 2023. TSR uses the forecast August-September sea surface temperatures in the Atlantic Main Development Region (10º-20ºN, 60º-20ºW) and the forecast July-September Caribbean trade wind anomaly over the region 7.5º-17.5ºN, 100º-30ºW as predictors. The former is forecast to be warmer than average leading to an enhancement of Atlantic hurricane activity, and the latter is predicted to be weaker than normal due to predicted neat neutral ENSO conditions and above averege sea surface temperatures in the Caribbean Sea. This forecast has high uncertainty due to uncertainty in how warm the Atlantic and Caribbean Sea sea surface temperatures will be in August-September 2024 and by how much this will influence the strength of the Caribbean trade winds. We express the forecast uncertainty in terms of probability of exceedance for Accumulated Cyclone Energy (ACE) and for hurricane numbers.

North Atlantic ACE Index and System Numbers in 2024

		ACE Index	Intense Hurricanes	Hurricanes	Tropical Storms
TSR Forecast	2024	160	4	9	20
74-yr Climate Norm	1950-2023	106	2.6	6.4	12.3
30-yr Climate Norm	1991-2020	122	3.2	7.2	14.4
10-yr Climate Norm	2014-2023	121	3.1	7.1	16.3
Forecast Skill at this Lead	2003-2023	0%	2%	0%	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 for the TSR publicly-released seasonal outlooks for the 21-years 2003-2023.

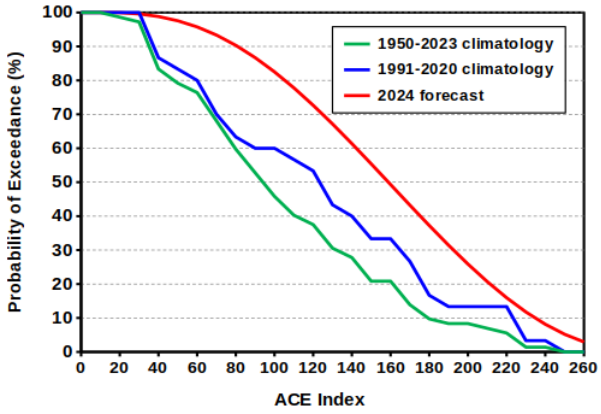
The forecast tercile probabilities (1991-2020 data) for the 2024 North Atlantic hurricane season ACE index are as follows: a 53% probability of being upper tercile (>156)), a 39% likelihood of being middle tercile (75 to 156)) and only an 8% chance of being lower tercile (<75)).

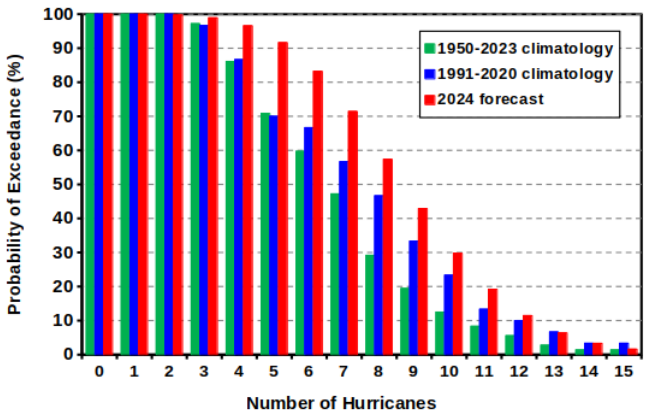
Key: Terciles = Data groupings of equal (33.3%) probability corresponding to the upper, middle and lower one-third of values for the current 30-year climate norm (1991-2020). Upper tercile = ACE value greater than 156. Middle tercile = ACE value between 75 and 156. Lower tercile = ACE value less than 75.

Forecast Probability of Exceedance Plots for the 2024 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 is 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 three sets of PoE data comprising the forecast PoE curve and two climatology PoE curves. 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 2024 and how these chances differ to climatology.





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 2024

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 uses historical data to pool 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 as well as with lead time within the same year. Once the field(s) have been selected separate forecast models are employed to predict the July-September trade wind speed and to predict the August-September SSTs for the upcoming season. 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 modelling 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 by using the Anderson-Darling statistical test.

The reason why the TSR extended forecast for the 2024 Atlantic hurricane activity calls for ACE-activity above the 1991-2020 climate norm level is our current expectation that warm sea surface temperatures will occur in the Atlantic Main Development Region (MDR) and Caribbean Sea during August-September 2024. Based on the consolidated IRI (International Research Institute for Climate and Society) forecasts, we expect the current ongoing El Niño has peaked in strength and will weaken through winter and spring 2024, with near neutral ENSO conditions anticipated through summer and autumn 2024. Should ENSO be neutral during summer 2024 and the North Atlantic Oscillation (NAO) in April-May-June 2024 is either in its upper or lower tercile, then based on past events/years the NAO may have a sizeable influence on the 2024 Atlantic hurricane activity. Unfortunately there is no skill at predicting the April-May-June 2024 NAO at this ~5 month range.

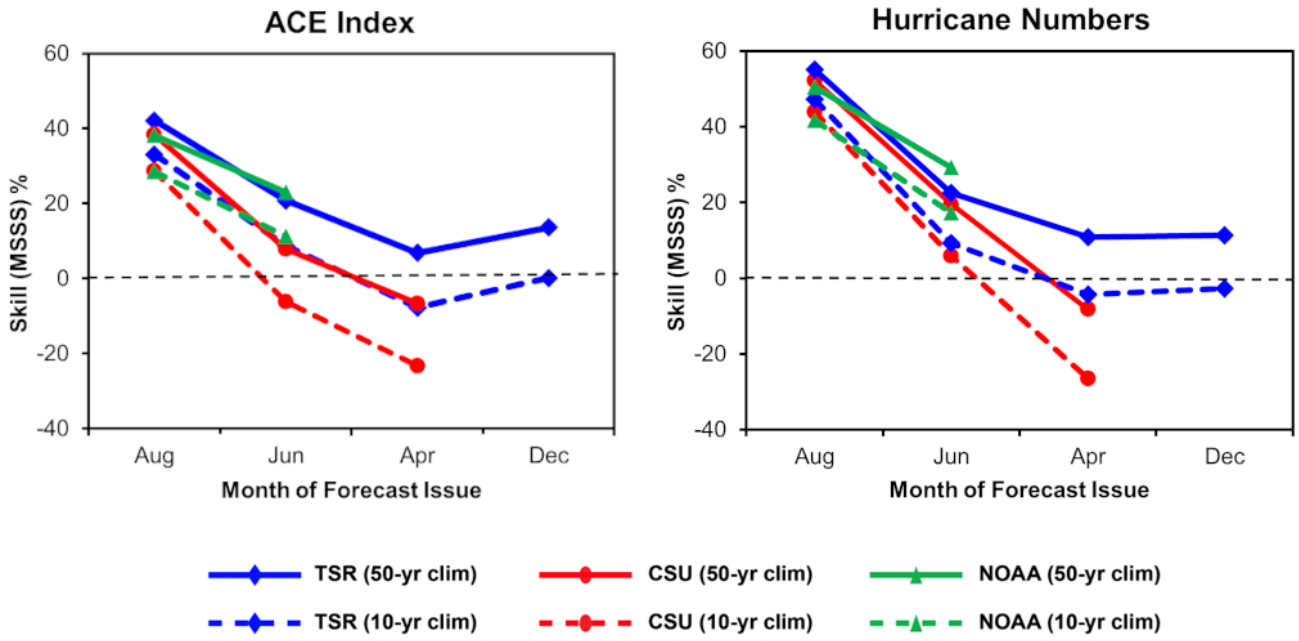
It should be stressed that there are large uncertainties in our extended outlook for North Atlantic hurricane activity in 2024. These uncertainties arise in particular from uncertainties in the influence of the upcoming April-May-June NAO on 2024 hurricane activity, how warm the sea surface temperatures will be in August-Sepetember 2024 and the strength of the trade winds from July-September 2024. The current statistical models used to predict August-September MDR sea surface temperature and July-September Caribbean trade wind speed anomaly has been built using NCEP/NCAR re-analysis data, which we have found tends to have a low bias in sea surface temperature in the Atlantic. An alternative version of the models using ERA5 re-analysis data predicts much warmer sea surface temperatures in the Atlantic and much weaker Caribbean trade winds which results in a prediction for a hyper-active season with an ACE index around 200. In addition, a minority of the IRI forecast models are forecasting Niño 3.4 sea surface temperatures close to weak La Niña conditions, which if verified may provide a further enhancement of Atlantic hurricane activity. Due to the extended lead time we are reluctant to forecast such high activity as would be suggested by some of our analysis; however, we may increase the forecast in our next update in early April.

Precision of Seasonal Hurricane Forecasts 2003-2023 Issued Publicly

The figure on the next page displays the seasonal forecast skill for North Atlantic hurricane activity for the 21-year period between 2003 and 2023. 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 2003-2023. 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 2003-2023.

Further Information and Next Forecast

Further information about the TSR forecasts and their verifications may be obtained from the TSR web site *https://www.tropicalstormrisk.com*. We anticipate that the first TSR forecast update for the 2024 North Atlantic hurricane season will be issued on Monday 8th April 2024.