

2020-2024 North Atlantic Hurricane Activity Forecasts

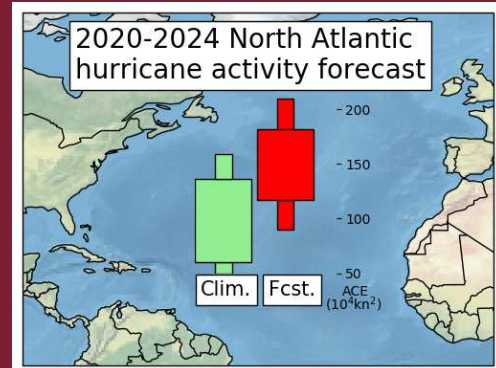
Forecast based on predictions made in November 2019

This document provides forecasts of North Atlantic hurricane activity and US hurricane damage for the period 2020-2024. The headline results are:

- There is a 95% chance of above-average hurricane activity*
- There is a >95% chance of above-average US hurricane damage†

*Hurricane activity (ACE) average defined by mean over the period 1960-2020 ($98 \times 10^4 \text{kn}^2$)

†Damage average defined by median of 5 year total damages over the period 1960-2020 (\$58bn, normalised to 2020)



Hurricane activity forecast

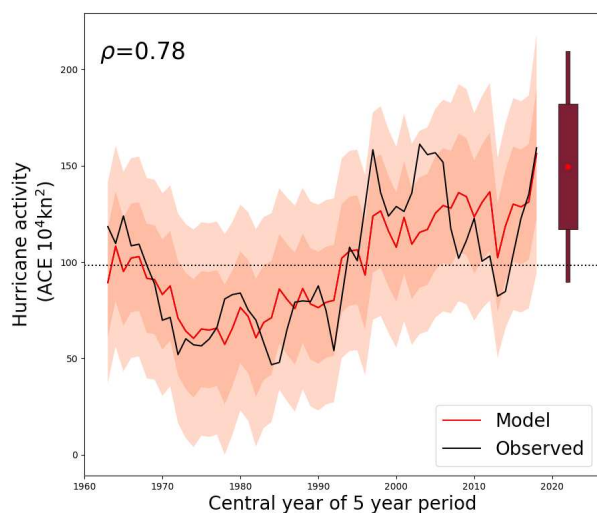


Fig 1: Historical and forecast hurricane activity. Time series of observed (black line) and forecast (red line) 5 year mean hurricane activity (as measured by ACE index). The past forecast 75% and 95% prediction intervals are shown by shading. The 2020-2024 forecast with 75% and 95% prediction intervals is given by the box and whisker plot. The rank correlation coefficient (ρ) is given in the figure. The horizontal dotted line shows the long term average (mean) hurricane activity.

Hurricane activity is measured by the accumulated cyclone energy (ACE), summed over all tropical cyclones in a season. The timeseries of observed and modelled running 5 year mean hurricane activity over the North Atlantic basin is shown in Figure 1. The current forecast predicts a continuation of the current active hurricane phase, with a forecast mean ACE of 150, with 75% and 95% prediction intervals of 117–182 and 90–209 respectively.

US damage forecast

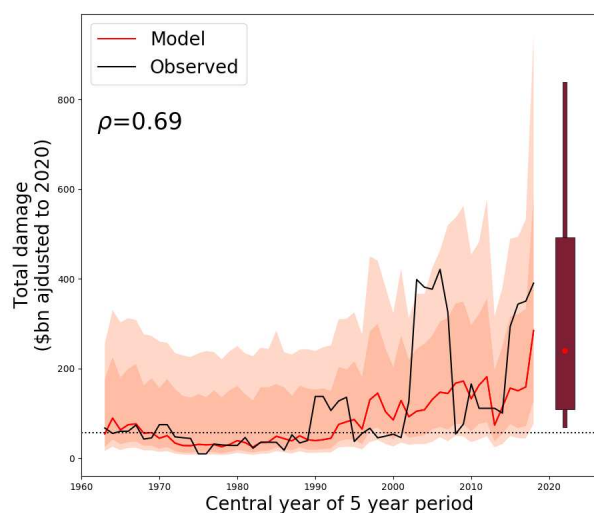


Fig 2: Historical and forecast US hurricane damages. As in Fig 1 but for 5 year running *total* US hurricane damage. The damages have been adjusted to 2020. The horizontal dotted line shows the long term average (median) 5 year total hurricane damage.

Figure 2 shows the observed 5 year *total* damages over the US due to hurricanes. The losses broadly reflect the hurricane activity in Figure 1, although they are affected by extreme events. The current forecast predicts a median damage of \$240bn (total for 2020-2024, normalised to 2020), with 75% and 95% prediction intervals of \$108bn–\$492bn and \$68bn–\$838bn respectively. Note that there is considerable uncertainty in the upper limits of the damage forecast.

Background Information

The forecasts in this document come from a multi-model ensemble of 4 dynamical (climate) models, with 37 ensemble members in total. Rather than counting individual tropical cyclones, the difference in forecast sea surface temperatures between the main development region (MDR) of hurricanes and the tropics as a whole (MDR-TROP index) is used to predict both hurricane activity (ACE) and US hurricane damage, using an empirical relationship between these measures (see Technical Appendix). The dynamically predicted MDR-TROP index takes both climate change and the current state of the climate into account.

Figures 3 and 4 show the relationship between observed 5 year ACE/damages and the model ensemble mean MDR-TROP from past forecasts. The correlation coefficients (ρ , shown in figures) are both significant at the 95% level. The probabilistic Brier skill scores (BSS, see Technical Appendix) are both greater than zero showing value this forecast is an improvement over the reference forecast (5 year persistence).

The contingency tables (Tables 1 and 2) for forecasting above or below average ACE/damage give a measure of the reliability of the forecasts, and show the corresponding hit and false alarm rates.

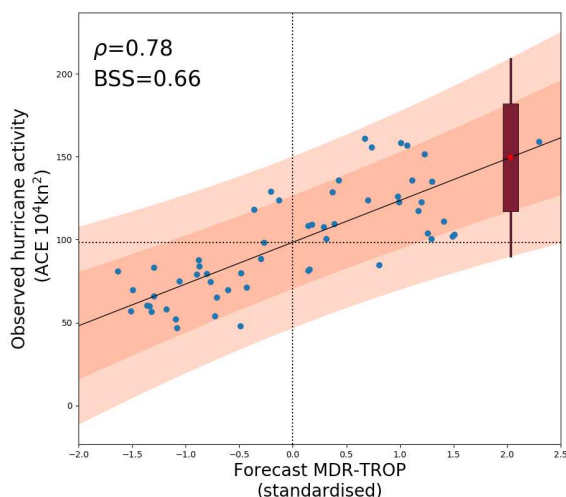


Fig 3: Relationship between observed 5 year mean hurricane activity and forecast MDR-TROP index. Blue dots show past forecasts, while the red dot gives the current forecast. 75% and 95% prediction intervals are shown with shading for past forecasts, and a box and whisker plot for the current forecast. The horizontal dotted line shows the long term average (mean) hurricane activity. The relationship is modelled using linear regression.

Above-average ACE index		Observed	
		Yes	No
Predicted	Yes	25 Hits	3 False alarms
	No	3 Misses	25 Correct rejections
Hit Rate:		90%	
False Alarm Rate:		10%	

Table 1: Contingency tables for forecasting above or below average 5 year mean ACE index.

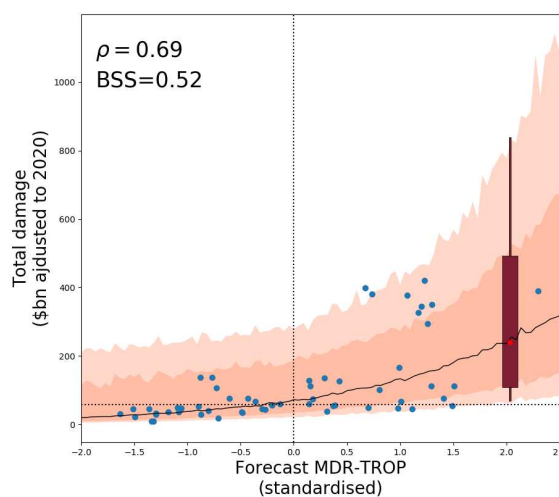


Fig 4: Relationship between observed 5 year total US hurricane damage and forecast MDR-TROP index. Details as in Fig 1. Here the long term average loss marked by the horizontal line is the median (due to the skewed loss distribution). The relationship between US hurricane damage and forecast MDR-TROP takes into account the unpredictable nature of extreme single events such as hurricanes Andrew and Katrina (see Technical Appendix).

Above-average Loss index		Observed	
		Yes	No
Predicted	Yes	22 Hits	8 False alarms
	No	6 Misses	20 Correct rejections
Hit Rate:		80%	
False Alarm Rate:		30%	

Table 2: Contingency tables for forecasting above or below average 5 year total US hurricane damage.

For further information see Technical Appendix.

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Climate Change

Skillful predictions of multi-year US hurricane damage by decadal prediction systems

EGU2021 NH1.7

Julia Lockwood, Nick Dunstone, Doug Smith, Adam Scaife, Hazel Thornton, Leon Hermanson (Met Office)





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Insurance case study

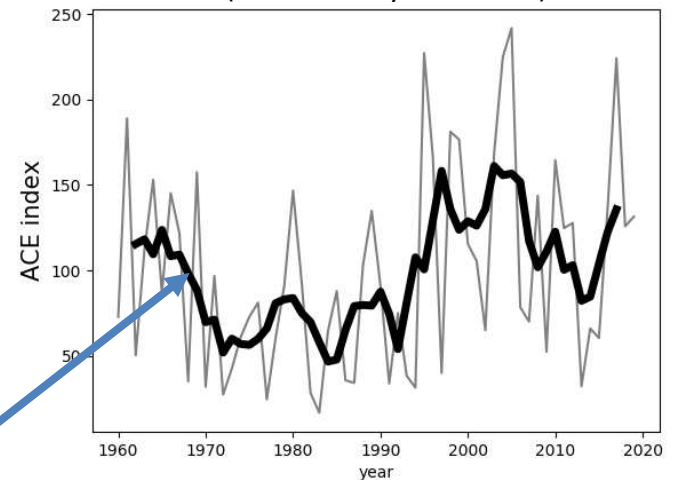
 **Met Office**
Hadley Centre

Willis Research Network
WillisTowersWatson 

- Part of the **C3S Prototype Service for Decadal Climate Predictions project** (see session CL2.5 EGU21-5437)
- Working with Willis Research Network to co-develop decadal (multi-year) hurricane forecasts for insurance

Can multi-year fluctuations be predicted by initialised climate models (decadal prediction systems)?

Observed North Atlantic hurricane activity 1960-2019
(measured by ACE index)



ACE= accumulated cyclone energy (sum of 6 hrly max windspeed² over track for windspeeds >35kn)

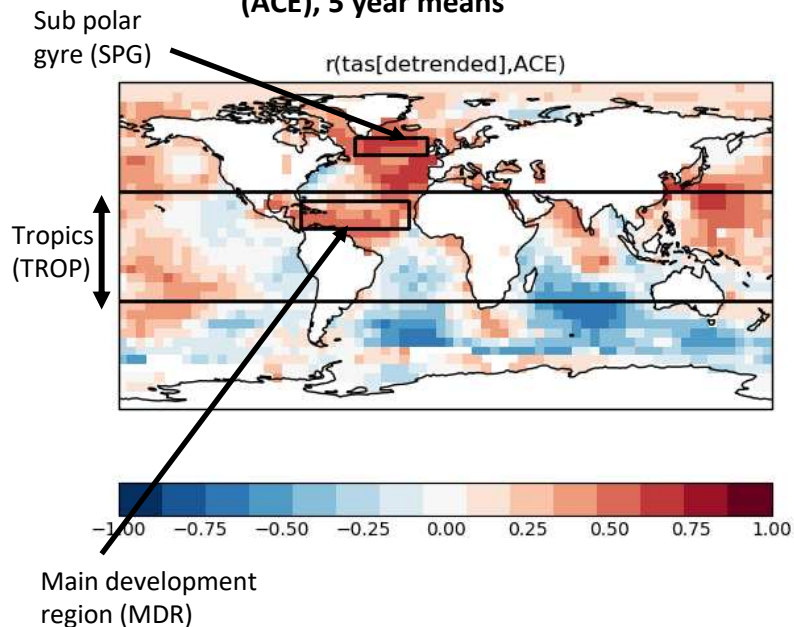


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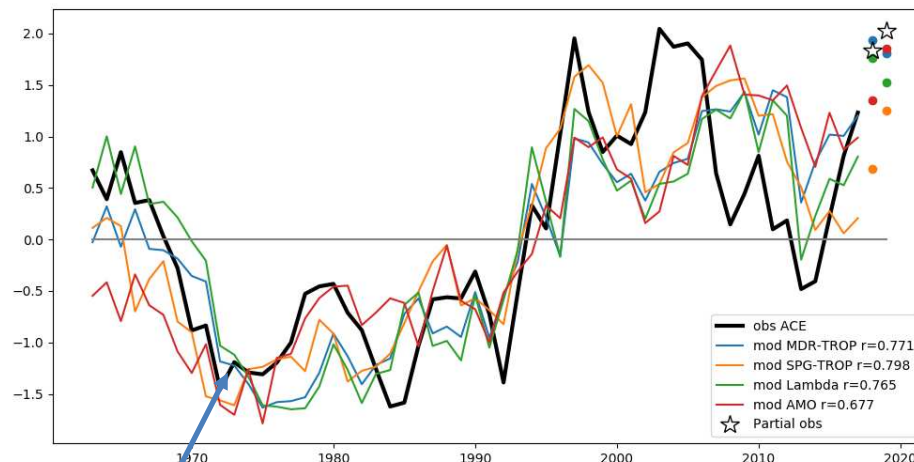
Hurricane proxy indices

- Hurricane proxy indices from initialised climate models (decadal prediction systems) shown to be as skillful as directly tracking hurricanes ([Caron et al 2018](#))
- We investigated the skill of a variety of proxy indices, mostly based on sea surface temperatures.

Correlation between observed temperature
(trend removed) and North Atlantic hurricanes
(ACE), 5 year means



Time series of 5 year mean observed North
Atlantic ACE index and forecast proxy indices
from initialised climate models



Mid year (5 year mean)

Observed ACE (sum of 6 hrly max
windspeed² over track for windspeeds
>35kn)



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MDR-TROP index

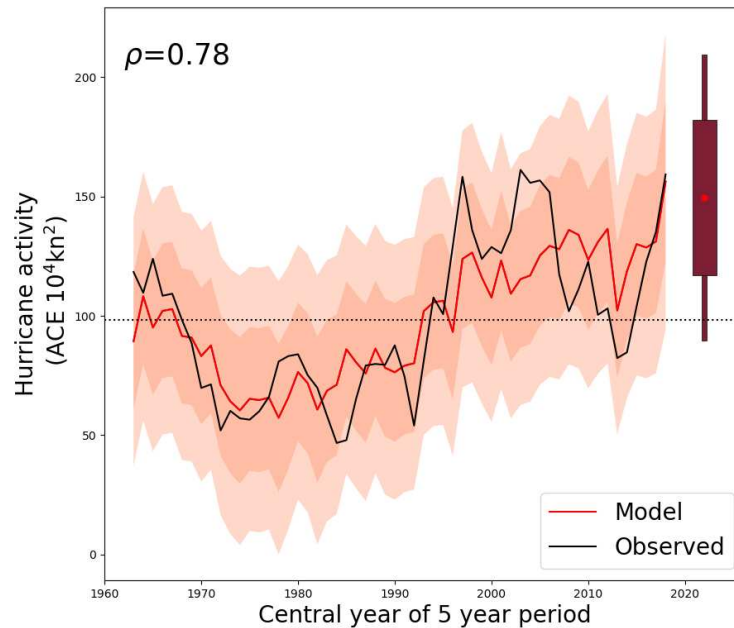
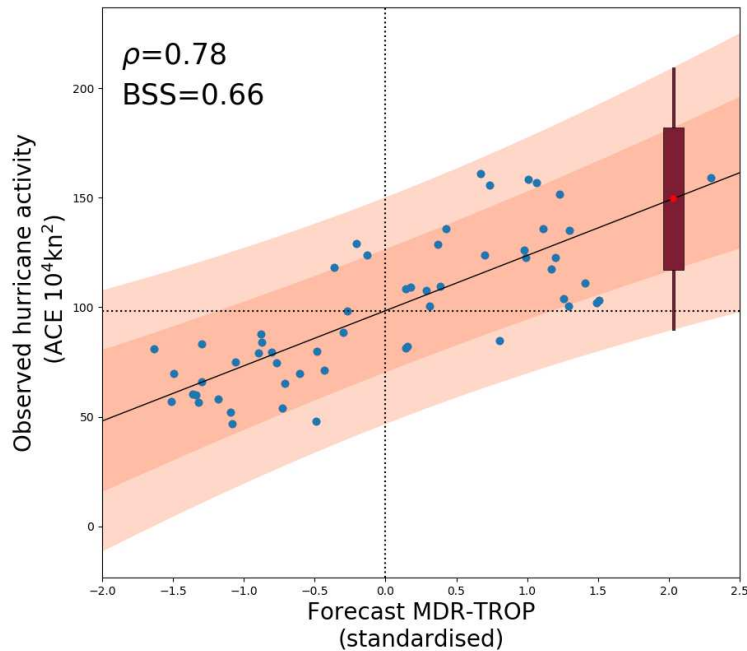
- Index chosen to predict North Atlantic hurricane activity: temperature in main development region – temperature over tropics (oceans only) (**MDR-TROP**)
- “MDR-TROP” calculated from **multi-model ensemble** (DPS4, MPI, CMCC, EC-Earth3; 37 members) of **initialised climate models** (decadal prediction systems)
 - → MDR-TROP prediction includes both external forcing (GHGs, volcanoes, aerosols, etc) and initial state of the climate



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ACE skill

- Use linear regression of observed 5-year-mean North Atlantic hurricane activity (ACE) onto forecast “MDR-TROP” to make ACE prediction for coming 5 years
- Correlation skill = **0.78** (significant at 95%)
- Beats 5 year persistence skill (=0.45)





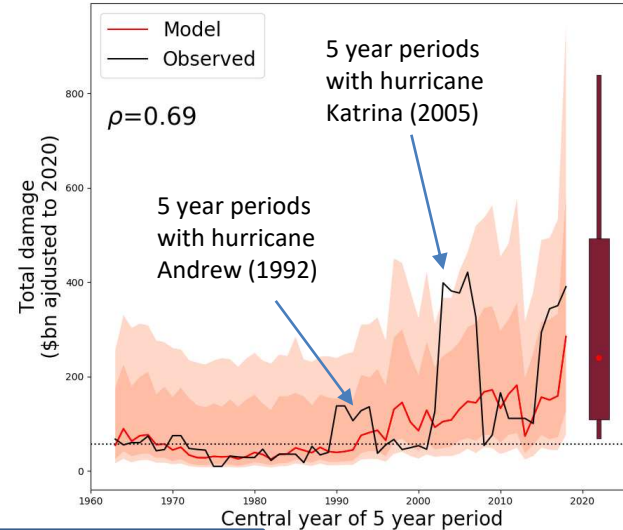
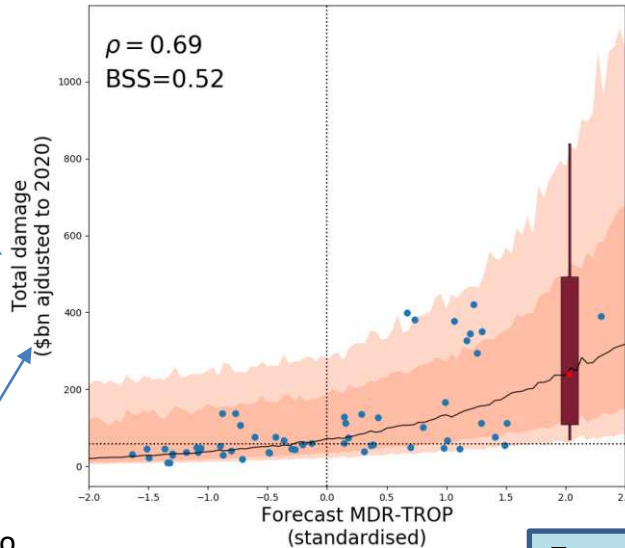
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US hurricane damage/insured loss

- “MDR-TROP” index also has high correlation with 5-year-total US hurricane insured losses and damages (=insured+non-insured losses), but relationship is non-linear.

Total damages shown here, compiled from [Annual Summaries of North Atlantic Storms](#) (National Hurricane Center) and [NOAA NCEI U.S. Billion-Dollar Weather and Climate Disasters \(2021\)](#)

Damages are adjusted to 2020, taking into account inflation, changes in population and wealth ([Pielke & Landsea 1998](#))



Correlation skill of damage forecasts
 $\rho = 0.69$

Loss/damage time series is strongly affected by extreme single events (hurricanes Andrew and Katrina), difficult to model with standard statistical distributions.

To make loss/damage prediction, perform linear regression of observed $\log(\text{damage})$ onto forecast MDR-TROP, *after removing the losses from the outliers (Andrew and Katrina)*



Then assume that events such as Andrew and Katrina are **unpredictable** and independent of MDR-TROP -> can occur randomly in any given 5 year period (gives more realistic prediction intervals)



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Forecasts

- Forecast made for 2020-2024 (models initialised in 2019)
- Forecast for 2021-2025 (2020 initialisation) available soon!

