Seasonal Prediction of Total Wind Energy for Atlantic Hurricane Activity and US landfall

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Introduction

The TSR (Tropical Storm Risk) model, used to provide seasonal forecasts of tropical cyclone numbers for the Atlantic has been modified to forecast the NOAA Accumulated Cyclone Energy (ACE) index, defined as the sum of the squares of 6 hourly wind speeds along all the storm tracks whilst the systems are at least tropical storm strength. For landfalling tropical cyclones, the ACE index is defined as the sum of the squares of the hourly wind speeds for storms that are over land. The motivation for this approach is that the strong and long lived storms contribute most to the ACE index so the magnitude of the ACE index should give a better indication of the overall activity of a season than tropical cyclone numbers.

In this study, we assess the TSR model's cross-validated hindcast skill as a function of monthly lead out to 10 months for the Atlantic for the period 1952 - 2002. A method for predicting US landfalling ACE at lead zero using July wind predictors is also presented for 1950-2002.

Skill and Uncertainty

We employ the percentage improvement in mean square error over a climatological forecast, which is the skill score recommended by the WMO for seasonal forecasts. For climatology we employ a 1952-2002 average. Confidence intervals are computed around this value using the standard bootstrap method (Effron and Gong, 1983) with replacement.

Model Description

The Atlantic basin is split into three regions; the Main Development Region (MDR), 10°N - 20°N, 20°W - 60°W, the Carribean and Gulf (CAGU) region and the Rest region which includes the subtropics. For the MDR and CAGU sea regions, the two predictors used to forecast the ACE index are the forecast July-September trade wind speed over the Caribbean and tropical north Atlantic region (7.5°N - 17.5°N, 30°W - 100°W) and the forecast August-September SST for the MDR. The 925mb trade wind speed is forecast from August-September forecast ENSO and August-September Atlantic/Caribbean forecast SSTs for the regions 5°S - 5°N, 90°W - 160°E, and 7.5°N - 17.5°N, 40°W - 85°W respectively. The ENSO SSTs are predicted from a cross-validated ENSO-CLIPER model (Lloyd-Hughes et al. 2003). The Atlantic/Caribbean SST region is forecast from an in-house statistical principal component model which uses the lagged initial conditions of the leading mode of North Atlantic SST variability. The August-September forecast SST's for the MDR are also forecast from the same principal component model. The total ACE for the Rest region is forecast using a 51-year climatology.

North Atlantic Hurricane ACE Index

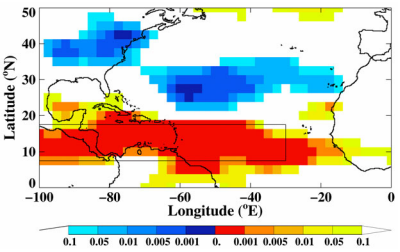

Figure 1. *Correlation pattern significance between July-September 925mb trade wind anomalies and ACE index for the period 1950-2002. Areas coloured are significant at levels of 0.1, 0.05, 0.01, 0.005 and 0.001. The rectangular box indicates the region used for the trade wind predictor.*

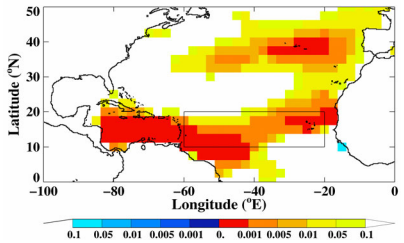

Figure 2. *Correlation pattern significance between August-September North Atlantic SSTs and the ACE index for the period 1950-2002. Areas coloured are significant at levels of 0.1, 0.05, 0.01, 0.005 and 0.001. The rectangular box indicates the Atlantic Main Development Region (MDR).*

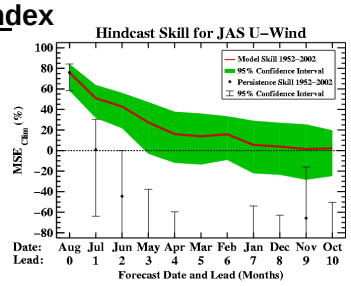

Figure 3. *Cross validated hindcast skill for the period 1952-2002 for the trade wind predictor.*

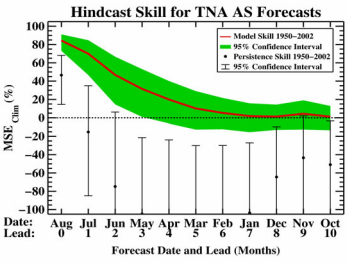

Figure 4. *Cross validated hindcast skill for the period 1950-2002 for the August-September MDR SST predictor.*

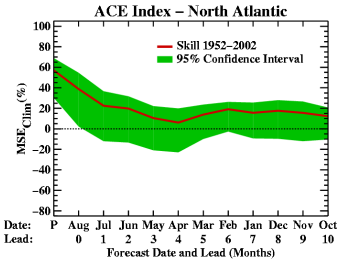

Figure 5. *Cross validated hindcast skill for the period 1952-2002 for the Atlantic total ACE index.*

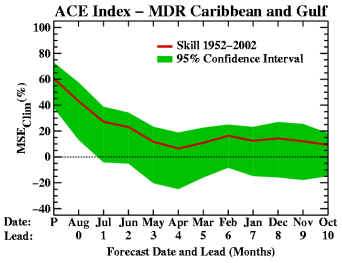

Figure 6. *Cross validated hindcast skill for the period 1952-2002 for storms originating in the Main Development Region, Caribbean Sea and Gulf of Mexico.*

Discussion

Figures 3 to 6 display our cross-validated hindcast skill 1952-2002 for leads out to 10 months. Positive skill to 95% significance is obtained for the July-September trade wind predictor at leads out to 3 months and to leads of 4 months for the Atlantic SST August-September prediction. The total Atlantic ACE index can be forecast with useful skill to 95% confidence from early August. The MDR, Caribbean and Gulf ACE Index can be forecast with useful skill to 95% confidence from early June.

US Landfalling Hurricane ACE Index

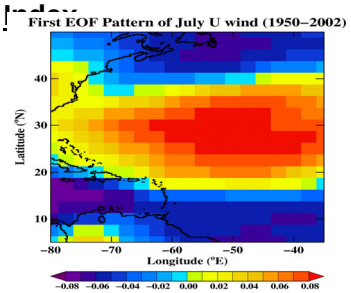

Figure 7. *First principal component of 925 mb U wind anomaly for the period 1950-2002. This has a correlation of 0.45 with the US hurricane landfalling ACE index.*

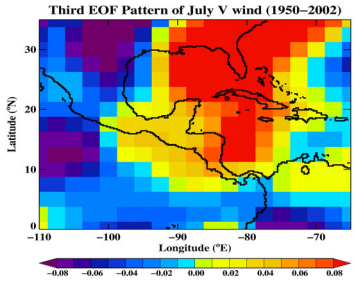

Figure 8. *Third principal component of 925 mb V wind anomaly for the period 1950-2002. This has a correlation of 0.47 with the US hurricane landfalling ACE index.*

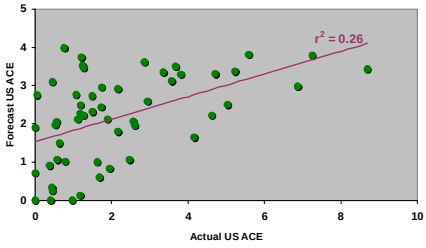

Figure 9. *Scatter plot comparing early August cross validated hindcasts of US landfalling ACE index for the period 1950-2002 and actual US landfalling ACE index. Units are x10⁴ knots².*

Discussion

A method of predicting the US landfalling ACE Index has been devised using the July U and V wind fields in a multi-regression model. Figures 7 and 8 show the two July predictors used in the model. These predictors give a combined correlation of 0.54 with the US landfalling ACE index. The total ACE index is used as a third predictor for years where the early August forecast total ACE index is expected to be significantly above average (>120) or below average (<65). The cross-validated July hindcast skill for the period 1950-2002 obtained from this model is 25%.

Conclusions

1. TropicalStormRisk.com has developed an innovative, rigorous and skilful forecast methodology for the seasonal prediction of total wind energy for tropical cyclone activity in the Atlantic
2. Our model for predicting the landfalling US ACE index at zero lead gives marginal but useful skill.
3. These forecasts will help to reduce risk and uncertainty.

Current TSR forecasts for the Atlantic and US landfalling ACE indices for 2003 can be found at http://tropicalstormrisk.com

Acknowledgements

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