Seasonal Prediction of Total Wind Energy for Tropical Storm Activity in the Atlantic and Northwest Pacific

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Introduction

The TSR model, previously used to provide seasonal forecasts of tropical cyclone numbers for the Atlantic and North West Pacific, has been modified to forecast the NOAA Accumulated Cyclone Energy (ACE) index, defined as the sum of the squares of the 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 strongest and most 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 models true independent forecast skill as a function of monthly lead out to 10 months for the Atlantic and North West Pacific total ACE index, and the Atlantic US landfalling ACE index for the period 1987 - 2002.

Skill and Uncertainty

We employ the percentage improvement in mean square error over a climatological forecast, which is the recommended skill score used by the WMO. For climatology we employ a running 15 year period prior to each forecast year. 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 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 an inhouse amended version of the ENSO-CLIPER model (Knaff and Landsea, 1997). 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 prior 10-year rolling climatology.

For the North West Pacific, the predictor used is the forecast August-September Niño 4 SST. We only use prior years to calculate the regression relationship for each future year to be forecast i.e. the forecasts are performed in simulated real time forecast mode. Landfalling US ACE Index is calculated by thinning from the forecast Atlantic total ACE Index using a climatological thinning factor.

North Atlantic ACE Index

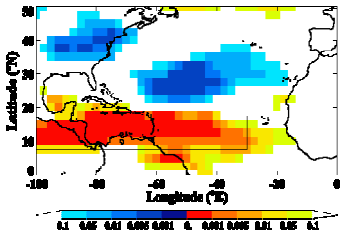

Figure 1. *Correlation pattern significance between July-September 925mb trade wind anomalies and ACE index for the period 1950-2002. Areas coloured are significant at levels of 0.1, 0.05, 0.01, 0.005 and 0.001. The rectangular box indicates the region used for the trade wind predictor.*

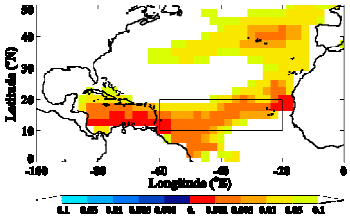

Figure 2. *Correlation pattern significance between August-September SSTs and ACE index for the period 1950-2002. Areas coloured are significant at levels of 0.1, 0.05, 0.01, 0.005 and 0.001. The rectangular box indicates the Atlantic Main Development Region (MDR).*

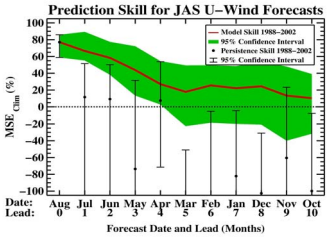

Figure 3. *Simulated real time forecast skill for the period 1988-2002 for the trade wind predictor.*

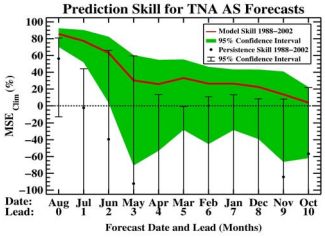

Figure 5. *Simulated real time forecast skill for the period 1988-2002 for the August-September MDR SST predictor.*

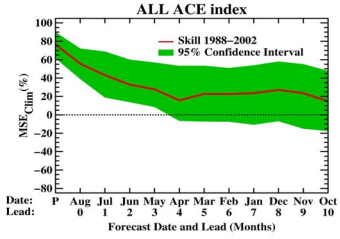

Figure 4. *Simulated real time forecast skill for the period 1988-2002 for the Atlantic total ACE index.*

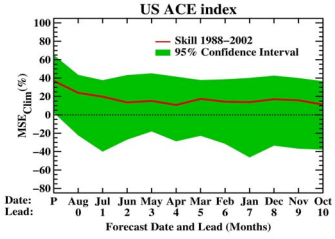

Figure 6. *Simulated real time forecast skill for the period 1988-2002 for the US landfalling ACE index.*

Discussion

Figures 3 to 6 display our simulated real time forecast skill 1988-2002 for leads out to 10 months. Positive skill to 95% significance is obtained for the July-September trade wind predictor up to lead 4 and lead 2 for the Atlantic SST August-September forecasts. The total Atlantic ACE index can be forecast with useful skill from about April onwards. The plateau of skill at longer leads is due to an incorrect forecast of the Caribbean U wind at lead 4, which was correct at lead 5, for two years. If these years were removed, the skill for both the Caribbean U wind and the Atlantic total ACE index would decay to zero at long leads. The US landfalling ACE forecast shows positive skill to 95% significance for perfect predictors.

Northwest Pacific ACE Index

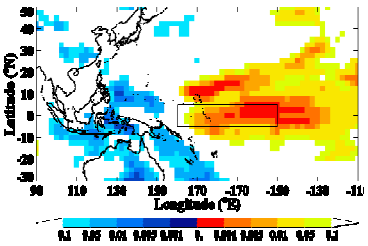

Figure 7. *Correlation pattern significance between August-September SST and total NWP ACE index for the period 1970-2002. Areas coloured are significant at levels at 0.1, 0.05, 0.01, 0.005 and 0.001. The rectangular box indicates the Niño 4 region.*

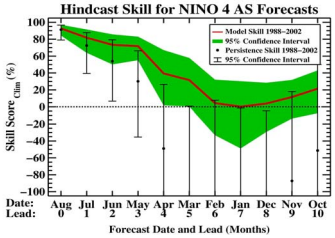

Figure 8. *Simulated real time forecast skill for the period 1988-2002 for the Niño 4 SST region.*

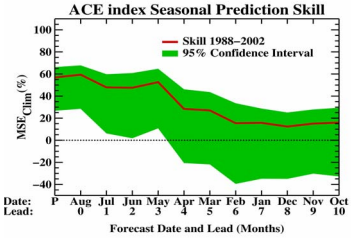

Figure 9. *Simulated real time forecast skill for the period 1988-2002 for the northwest Pacific ACE index.*

Discussion

Figures 8 and 9 display our simulated real time forecast skill 1988-2002 for leads out to 10 months. The AS Niño 4 SST shows predictability from March onwards. Positive skill for the NWP ACE index to 95% significance is obtained only from May onwards.

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 and Northwest Pacific.
2. Skill to 95% confidence exists from:
   a) Early May for the Atlantic ACE Index.
   b) Early April for the Northwest Pacific ACE Index.
3. These forecasts will help to reduce risk and uncertainty.

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

Acknowledgements

We thank David Simmons (Benfield Group), Dr Paul Rockett (Benfield Group), Alan Fowler (Royal & SunAlliance), Jonathan Clark (Crawford & Company) and Karen Dutton (Met Office) for industrial liaison. We acknowledge meteorological input from Dr Mike Davey (Met Office) and web site management by Frank Roberts (UCL).