2A.1 SEASONAL PREDICTION OF ATLANTIC, US AND CARIBBEAN LANDFALLING HURRICANES

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1. INTRODUCTION

Tropical Storm Risk.com (TSR) is a venture which has developed from the UK government-supported TSUNAMI initiative project on seasonal tropical cyclone prediction. The TSR consortium comprises experts on insurance, risk management and seasonal climate forecasting. The TSR industry expertise is drawn from the Benfield Group, the leading independent reinsurance intermediary, Royal & SunAlliance, the global insurance group, and from Crawford & Company, a global provider of risk management services. The TSR scientific grouping brings together climate physicists, meteorologists and statisticians at UCL (University College London) and the Met Office.

The goal of TSR is to produce skilful long-range seasonal hurricane and typhoon predictions. These are designed to benefit a range of business and industry, as well as society and government by reducing the risk, uncertainty and financial volatility inherent to varying active and inactive tropical storm seasons. Substantial inter-annual variability exists in regional tropical cyclone losses. For example, in 1999 and 1997 the US experienced losses of US $8.2 billion and US $0.16 billion (2000 $).

TSR offers seasonal tropical storm forecasts for the Atlantic, NW Pacific and Australian-region basins. In addition, TSR has built in-house seasonal prediction models for various tropical sea surface temperature (SST), ENSO, and atmospheric wind regions. TSR forecasts are available from http://tropicalstormrisk.com

2. METHODOLOGY

Our forecast model is statistical. We model the interannual variability in hurricane numbers using a Gaussian distribution. In selecting predictors we apply correlation significance tests on subsections of the data to ensure predictor persistence and stability. For a predictor to prove stable and acceptable it must pass this test at the 10% level on each data subsection.

Our strategy is to divide the Atlantic basin into three sub-regions: (a) the Atlantic Hurricane Main Development Region MDR (10°N-20°N, 20°W-60°W), (b) the Caribbean Sea and the Gulf of Mexico, and (c) the Extra-Tropical north Atlantic. We can skilfully forecast the seasonal numbers of events forming in (a) and (b) but not in (c). Our basin forecasts comprise the sum of (a) and (b) with climatology used for (c).

We obtain forecasts for landfalling events by 'thinning' the forecasts for total numbers. The total number is multiplied by the historical fraction of the total number that has made landfall. The thinning postulate is unlikely to hold exactly on physical grounds, but is a reasonable approximation in practice.

Forecast skill is assessed by rigorous hindcast testing over the period 1987-2001. We use only prior years to identify the predictors and to calculate the regression relationship for each future year to be forecast - ie the hindcasts are performed in simulated real-time forecast mode. Thus 1987 activity is forecast using 1950-1986 data, 1988 from 1950-1987 data, etc..

3. ATLANTIC HURRICANE PREDICTORS

The TSR model exploits the predictability of tropical SSTs. Anomalous patterns of SST are the primary source of tropical atmosphere forcing at seasonal and interannual timescales. The two main predictors in our model are:

a) July-September forecast 925mb U(east/west)-winds over the Caribbean and tropical north Atlantic region (7.5°N - 17.5°N, 30°W - 100°W). These are forecast from August-September 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 925mb U-winds are a strong proxy for vertical wind shear over this sector but are more predictable. The ENSO SST prediction model comes from an in-house 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.

b) August-September forecast SST for the Atlantic Hurricane Main Development Region MDR (10°N - 20°N, 20°W - 60°W) (Goldenberg and Shapiro, 1996). These SSTs are forecast from the same principal component model as above.

4. SKILL SCORE AND UNCERTAINTY

Several methods are in use to assess the skill of forecast models (eg Wilks, 1995). We employ the percentage improvement in root mean square error over a climatological forecast ($RMSE_{Cl}$). For simplicity we denote this skill measure as 'Skill Score Clim (%)' below. This is a robust and tough skill measure which is immune to the bias problems associated with other skill measures. For climatology we employ the running 10-year period prior to each forecast year. Positive skill indicates the model does better than a climatology forecast, negative skill indicates that it does worse than climatology.

We compute confidence intervals on our forecast skill using the bootstrap method (Efron and Gong,

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1983). This tests the hypothesis that the model forecasts are more skilful than those from climatology to some level of significance. The skill plots below include the 95% two-tailed uncertainty in our forecast skill over a 15-year period.

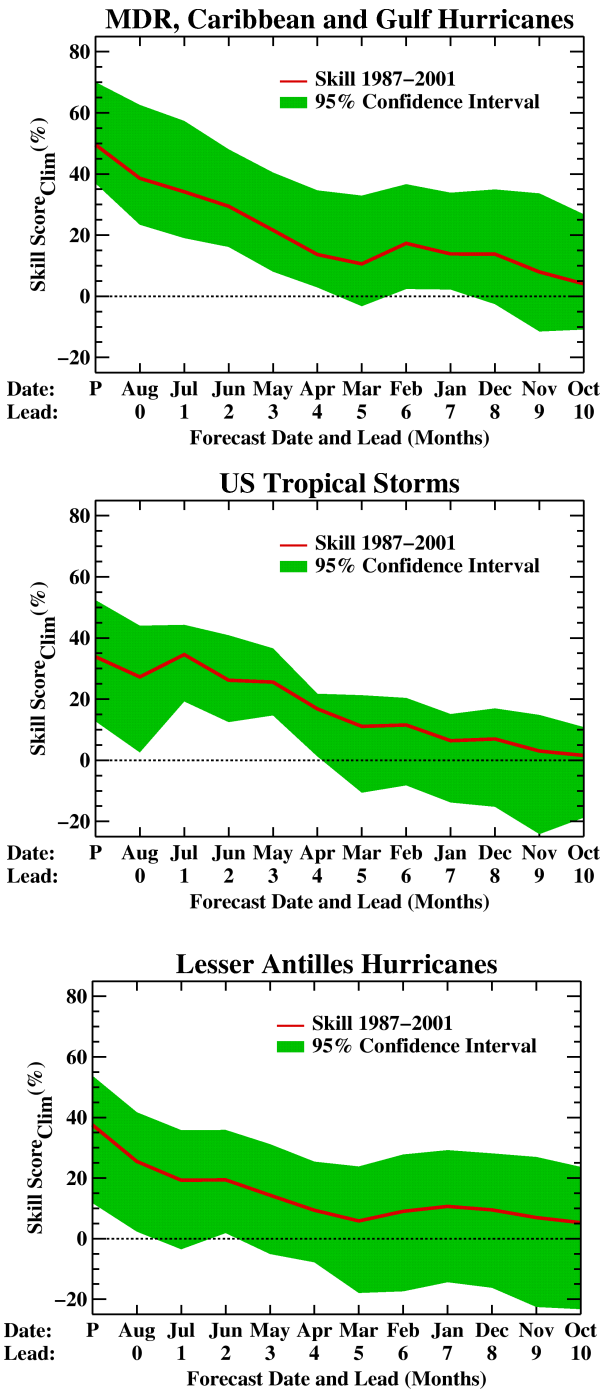

Figure 1. TSR simulated real-time forecast skill 1987-2001 as a function of forecast date and lead month out to the prior October.

5. TSR SIMULATED REAL-TIME FORECAST SKILL 1987-2001

Figure 1 displays the TSR simulated real-time skill 1987-20001 for (a) tropical Atlantic, Caribbean Sea and Gulf of Mexico hurricane numbers, (b) USA landfalling tropical storm numbers, and (c) Caribbean Lesser Antilles hurricane strike numbers. Skill is expressed relative to a rolling 10-year prior climatology (using a running 30-year prior climatology leads generally to higher skills). The 'P' on the skill figures' abscissa denotes the skill with perfect predictors, that is with climate information through to the end of September. The 'Forecast Date' indicates that the forecast is issued on about the 7th of the month in question, thus permitting climate information from the previous month to be assimilated into the model.

For MDR, Caribbean and Gulf hurricane numbers, positive skill to 95% confidence exists out to 7 months lead (the prior January). Forecast skill climbs steadily from early April through to the start of the peak hurricane season at the beginning of August. For US tropical storm strikes, positive skill to 95% confidence exists out to early April, while for Lesser Antilles seasonal landfalling hurricane numbers significant skill exists out to early June.

6. SUMMARY AND FURTHER INFORMATION

TSR has developed innovative statistical forecasts for Atlantic seasonal hurricane activity. These forecasts offer significant skill out to leads of several months. TSR is continuing to expand its services and to further improve the scientific and technical bases of its forecasts. For the 2002 season TSR has introduced monthly updated forecasts for seasonal hurricane activity and landfalling strike numbers. These forecasts together with further information on forecast methodology, simulated real-time forecast skill 1987-2001 as a function of lead time, and on TSR in general, may be obtained from www.tropicalstormrisk.com.

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