Extended Range Forecast for Atlantic Hurricane Activity in 2002

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Forecast Summary

The 2002 Atlantic hurricane season is anticipated to be active with basin storm numbers and strikes on the USA and Caribbean Lesser Antilles 10% above the 10 year average and 30-40% above the 30 year average.

The Tropical Storm Risk (TSR) consortium presents its first extended range forecast for Atlantic tropical storm, hurricane and intense hurricane numbers in 2002, and for hurricane and tropical storm strike numbers on the USA mainland and on the Caribbean Lesser Antilles. The forecast spans the Atlantic season from 1st June 2002 to 30th November 2002 and is based on data available through the end of October 2001. Our two main predictors are the forecast July-September 2002 trade wind speed over the Caribbean and tropical north Atlantic (a strong proxy for vertical wind shear but more predictable), and the forecast August-September 2002 sea surface temperature (SST) in the tropical north Atlantic. The reason for anticipating another active season in 2002 is our expectation for neutral ENSO conditions combined with warm tropical Atlantic SSTs and weaker than normal trade winds. While forecast skill at this lead is small, we note that our extended range forecast for the 2001 Atlantic hurricane season proved accurate.

1a. Atlantic Total Numbers in 2002

		Intense Hurricanes	Hurricanes	Tropical Storms
TSR Forecast (±SD)	2002	3.0(±1.6)	7.5 (±2.5)	13.0 (±3.6)
10yr Climate Norm (±SD)	1992-2001	2.9 (±1.7)	6.8 (±2.5)	11.4 (±3.5)
30yr Climate Norm (±SD)	1972-2001	2.1 (±1.8)	5.7 (±2.7)	9.5 (±3.6)
Forecast Skill at this Lead	1987-2001	12%	7%	7%

Key: Intense Hurricane = 1 Minute Sustained Wind > 95Kts = Hurricane Category 3 to 5
Hurricane = 1 Minute Sustained Wind > 63Kts = Hurricane Category 1 to 5
Tropical Storm = 1 Minute Sustained Wind > 33Kts
SD = Standard Deviation
Forecast Error = Standard Deviation of Independent Hindcast Errors for 1987-2001
Forecast Skill = Percentage Improvement over Running 10-year Climate Norm Value from Independent Hindcasts 1987-2001 (see §3 for details)

1b. Total Numbers Forming in the MDR, Caribbean Sea and Gulf of Mexico in 2002

		Intense Hurricanes	Hurricanes	Tropical Storms
TSR Forecast (±SD)	2002	3.0(±1.7)	5.8 (±2.7)	9.8 (±4.1)
10yr Climate Norm (±SD)	1992-2001	2.9 (±1.8)	5.1 (±2.8)	8.3 (±4.0)
30yr Climate Norm (±SD)	1972-2001	1.8 (±1.9)	3.8 (±2.9)	6.3 (±4.0)
Forecast Skill at this Lead	1987-2001	13%	8%	5%

The Atlantic hurricane Main Development Region (MDR) is the region 10°N - 20°N, 20°W - 60°W between the Cape Verde Islands and the Caribbean. A storm is defined as having formed within this region if it reached at least tropical depression status while in the area.

1c. USA Landfalling Numbers in 2002

		Hurricanes	Tropical Storms
TSR Forecast (±SD)	2002	1.8 (±1.1)	3.7 (±1.3)
Average (±SD)	1992-2001	1.2 (±1.2)	3.3 (±1.8)
Average (±SD)	1972-2001	1.2 (±1.1)	2.6 (±1.8)
Forecast Skill at this Lead	1987-2001	0%	3%

Key: Landfall Strike Category = Maximum 1 Minute Sustained Wind of Storm Coming Within 30km of Land
USA Mainland = Brownsville (Texas) to Maine

USA landfalling intense hurricanes are not forecast since we have no skill at any lead.

1d. Caribbean Lesser Antilles Landfalling Numbers in 2002

		Intense Hurricanes	Hurricanes	Tropical Storms
TSR Forecast (±SD)	2002	0.4 (±0.4)	0.8 (±0.7)	1.9 (±1.0)
10yr Climate Norm (±SD)	1992-2001	0.3 (±0.4)	0.7 (±0.7)	1.5 (±1.0)
30yr Climate Norm (±SD)	1972-2001	0.2 (±0.5)	0.4 (±0.7)	1.1 (±1.0)
Forecast Skill at this Lead	1987-2001	0%	7%	2%

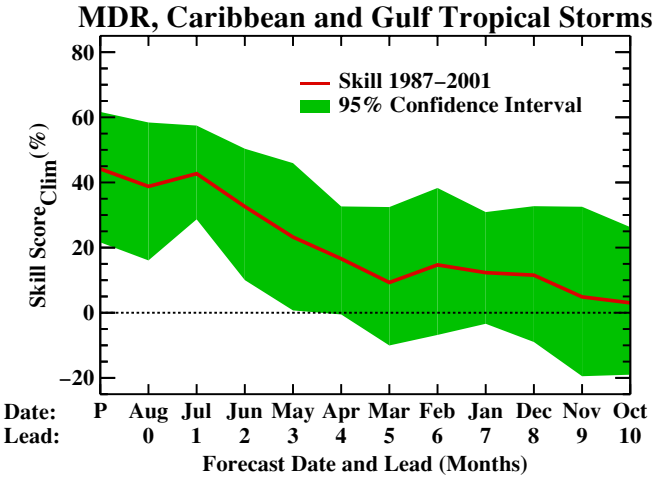
Key: Landfall Strike Category = Maximum 1 Minute Sustained Wind of Storm Coming Within 30km of Land
Lesser Antilles = Island Arc from Anguilla to Trinidad Inclusive

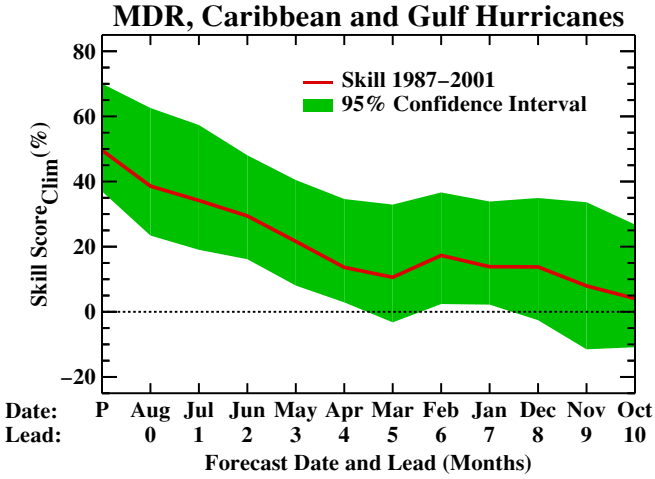
2. TSR Hindcast Skill Versus Lead Time 1987-2001

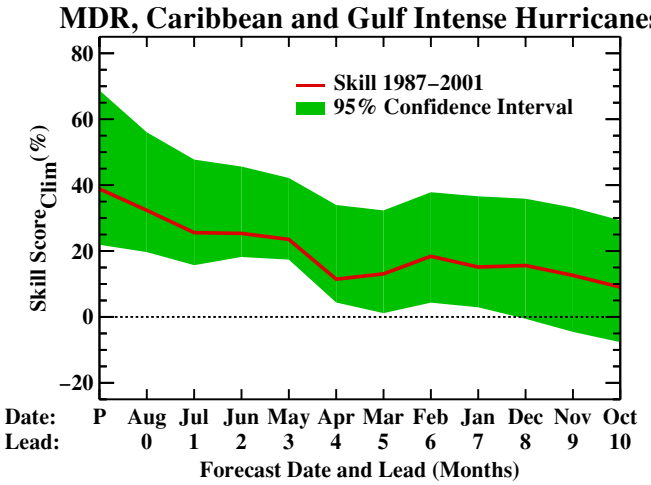
How would the TSR Atlantic forecast model have performed as a function of lead time had it been available in previous years? The figures on the next two pages show the TSR model skill and associated 95% confidence interval at monthly leads out to the previous October. Skill is computed over the last fifteen years 1987 to 2001, and is expressed relative to a rolling 10-year prior climatology (using a running 30-year prior climatology leads generally to higher skills). Full details of the skill score measure and confidence interval calculation are given in §3. 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.

2a. MDR, Caribbean and Gulf of Mexico Basin Numbers 1987-2001

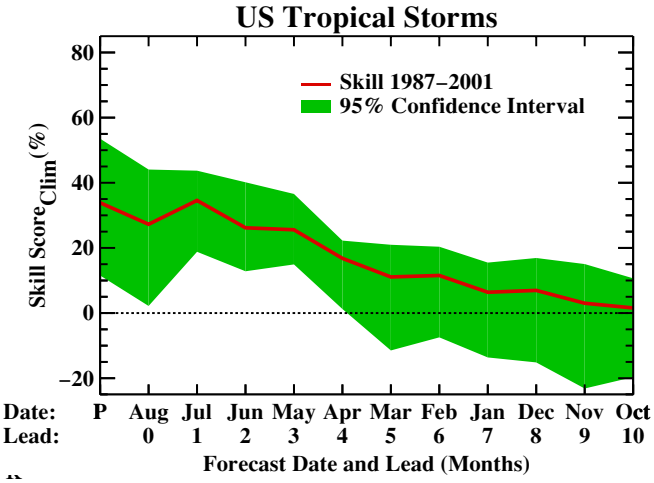


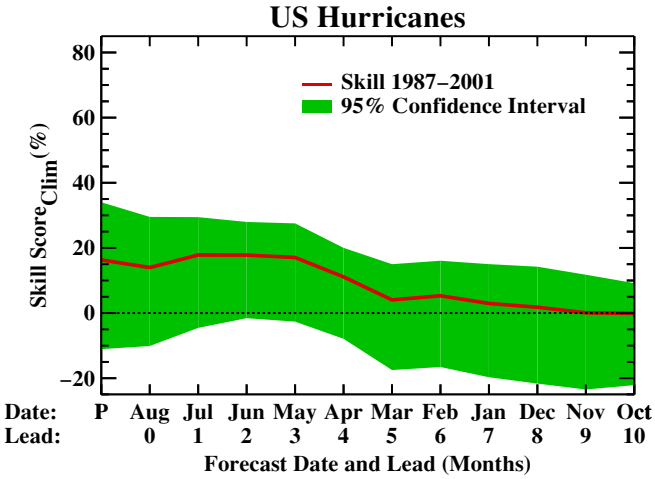




For each strength category the forecast skill rises steadily from the prior October through to August, the main hurricane season start. Highest skills are seen after passage through the 'spring predictability barrier' in March-April.

2b. USA Landfalling Storms and Hurricanes 1987-2001

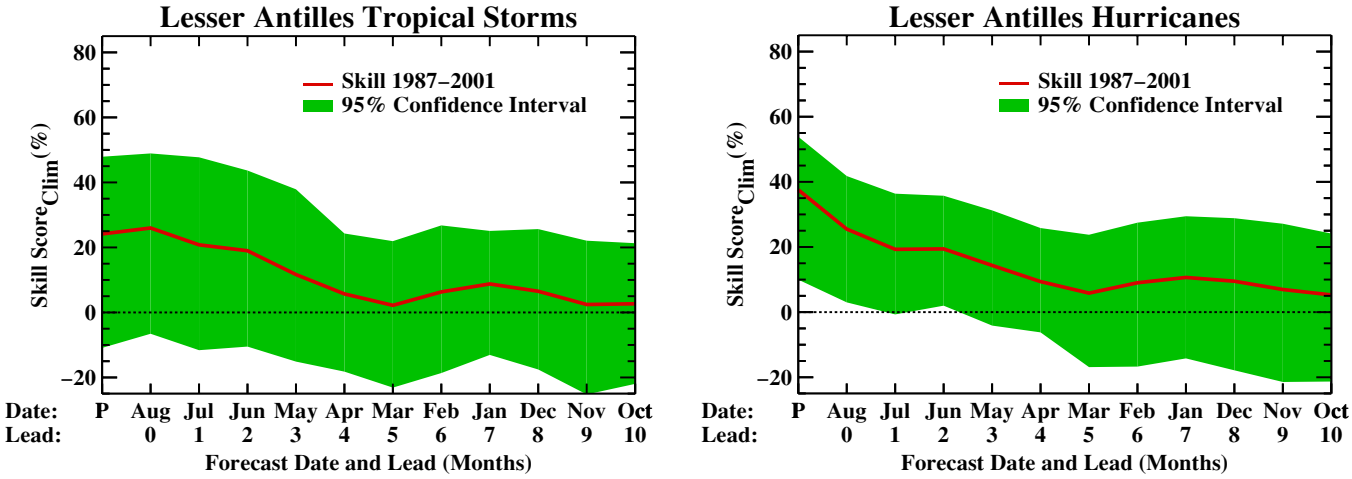




Skill is present to 95% confidence for US tropical storm strikes from early April. Weaker and less

significant positive skill is present for US hurricane strikes from the early May.

2c. Caribbean Lesser Antilles Landfalling Storms and Hurricanes 1987-2001



Positive skill is present to 95% confidence for Lesser Antilles hurricane strikes from early June. The model with perfect predictors provides nearly a 40% skill improvement over the prior 10-year climatology.

3. Skill Score and Uncertainty

Several methods are in use to assess the skill of forecast models (eg Wilks, 1995; von Storch and Zwiers, 1999). 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 $_{Clim}$ (%)' in the above figures. We consider this is a robust skill measure which is immune to the bias problems associated with the Percentage of Variance Explained and Percentage Agreement Coefficient 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, 1979; also see Efron and Gong, 1983). This tests the hypothesis that the model forecasts are more skilful than those from climatology to some level of significance. We apply the bootstrap by randomly selecting (with replacement) 15 actual values together with their associated predicted and climatology forecast values to provide a fresh set of hindcasts for which the $RMSE_{cl}$ skill measure can be calculated. This process is repeated many times (2,000 in this case) and the results histogrammed to give the required skill score. Provided that the original data are independent (in distribution and in order), the distribution of these recalculated values maps the uncertainty in the forecast skill about the original value over a 15-year period. 95% two-tailed confidence intervals for this uncertainty are then obtained.

4. Predictors and Key Influences for 2002

Our model exploits the predictability of tropical sea surface temperatures (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). These SSTs are also forecast from the same principal component model.

The key factors behind our forecast for an active Atlantic season in 2002 are the anticipated enhancing effect of both predictors. The forecast anomaly (1971-2000 climatology) in predictor (a) is 0.63±0.85 ms^{-1}, which is enhancing for hurricane activity, and the forecast anomaly for predictor (b) is 0.27±0.29 °C which is also enhancing for hurricane activity. The 'Skill Score $_{Clim}$ (%)' for predictor (a) at this lead is 12%, and for predictor (b) it is 8%.

5. Forecast 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 in identifying the predictors and in calculating the regression relationship for each future year to be forecast - ie the hindcasts are performed in strict 'forecast' mode. Thus 1987 activity is forecast using 1950-1986 data, 1988 using 1950-1987 data, etc..

6. Monthly Updated Forecasts

For the 2002 Atlantic hurricane season, TSR will be offering monthly updated forecasts through to early August for each basin and landfalling strength category listed in §1. The figures on pages 3 and 4 show the TSR forecast skill and uncertainty as a function of lead month. Please contact Dr Mark Saunders (mas@mssl.ucl.ac.uk) if you are interested in this service. A summary and forecast verification for the 2001 Atlantic season will be issued in December 2001.

7. Potential Benefits

Hurricanes rank above earthquakes and floods as the United States' costliest natural disaster. The annual damage bill in the continental US from hurricane landfalls 1926-2000 is estimated to be US $ 5.1 billion (2000 $). Substantial interannual variability exists in these losses - witness 1999 and 1997 with bills of US $ 8.0 billion and just US $ 0.15 billion respectively. Skilful long-range forecasts of seasonal US and Caribbean hurricane strike numbers would benefit society, business and government by reducing - through the available lead-time - the risk and uncertainty inherent to varying active and inactive storm seasons.

8. Tropical Storm Risk.com (TSR)

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 UK insurance industry experts and leading scientists on seasonal 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 Offic*e. TSR forecasts are available from http://tropicalstormrisk.com.

Acknowledgements

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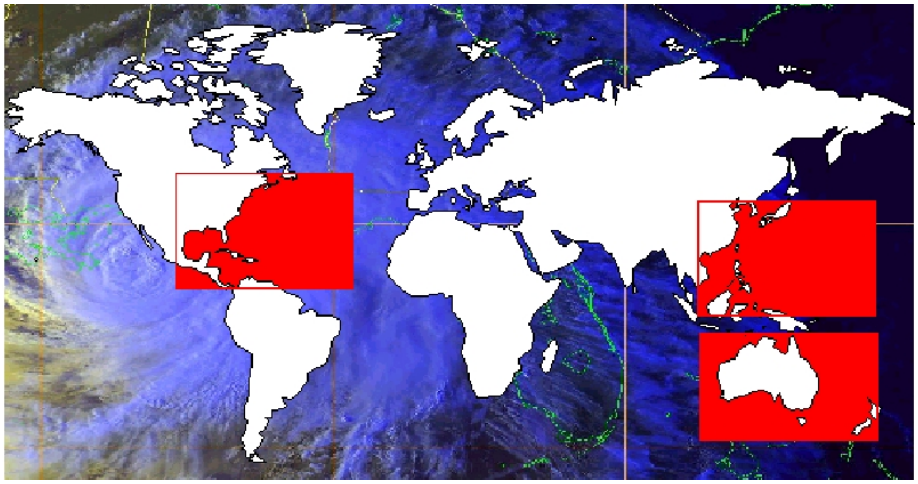

The three tropical cyclone basins under research by the TSR Tropical Storm Risk team.