July Forecast Update for Atlantic, USA and Caribbean Landfalling Hurricanes in 2001

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Forecast Summary

TSR revises its forecasts upward and predicts the 2001 Atlantic hurricane season will be active with basin storm numbers and strikes on the USA and Caribbean Lesser Antilles 20-30% above the 1991-2000 average.

The Tropical Storm Risk (TSR) consortium presents an early July forecast update for Atlantic tropical storm, hurricane and intense hurricane numbers in 2001, and for hurricane strike numbers on the US mainland and on the Caribbean Lesser Antilles. The forecast spans the Atlantic season from 1st June 2001 to 30th November 2001 and is based on data available through the end of June 2001. Our two main predictors are the July-September 2001 forecast trade wind speed over the Caribbean and tropical north Atlantic (a strong proxy for vertical wind shear but more predictable), and the August-September 2001 forecast sea surface temperature(SST) in the tropical north Atlantic. The reason for raising our forecast over that issued last month is that we now anticipate - with the inclusion of June climate data - that both predictors will favour an active season; the forecast tropical north Atlantic SST is expected to be 0.32±0.14 °C warmer than normal and the forecast trade wind speed is expected to be 0.7±0.6 ms^{-1} weaker than normal. Based on rigorous hindcasts 1986-2000, our early July hurricane predictions offer skill improvements over a 10-year rolling prior climatology of 20-30% for basin numbers and 10-20% for landfall strikes.

1a. Atlantic Total Numbers in 2001

		Intense Hurricanes	Hurricanes	Tropical Storms
TSR Forecast (±SD)	2001	3.2(±1.4)	7.7 (±1.6)	12.8 (±2.6)
Average (±SD)	1991-2000	2.7(±1.8)	6.4 (±2.6)	10.8 (±3.6)
Average (±SD)	1971-2000	2.0 (±1.9)	5.6 (±2.7)	9.5 (±3.7)

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 1986-2000		

1b. Total Numbers Forming in the MDR, Caribbean Sea and Gulf of Mexico in 2001

		Intense Hurricanes	Hurricanes	Tropical Storms
TSR Forecast (±SD)	2001	3.0(±1.1)	5.9 (±1.4)	9.7 (±2.8)
Average (±SD)	1991-2000	2.5 (±1.8)	4.6 (±2.9)	7.6 (±4.2)
Average (±SD)	1971-2000	1.7 (±2.0)	3.7 (±3.1)	6.3 (±4.3)

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.

1c. USA Landfalling Numbers in 2001

		Hurricanes	Tropical Storms
TSR Forecast (±SD)	2001	1.9 (±0.9)	3.6 (±1.2)
Average (±SD)	1991-2000	1.3 (±1.2)	3.1 (±1.8)
Average (±SD)	1971-2000	1.3 (±1.1)	2.7 (±1.8)

Key: Landfall Strike Category = Maximim 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 this lead.

1d. Caribbean Lesser Antilles Landfalling Numbers in 2001

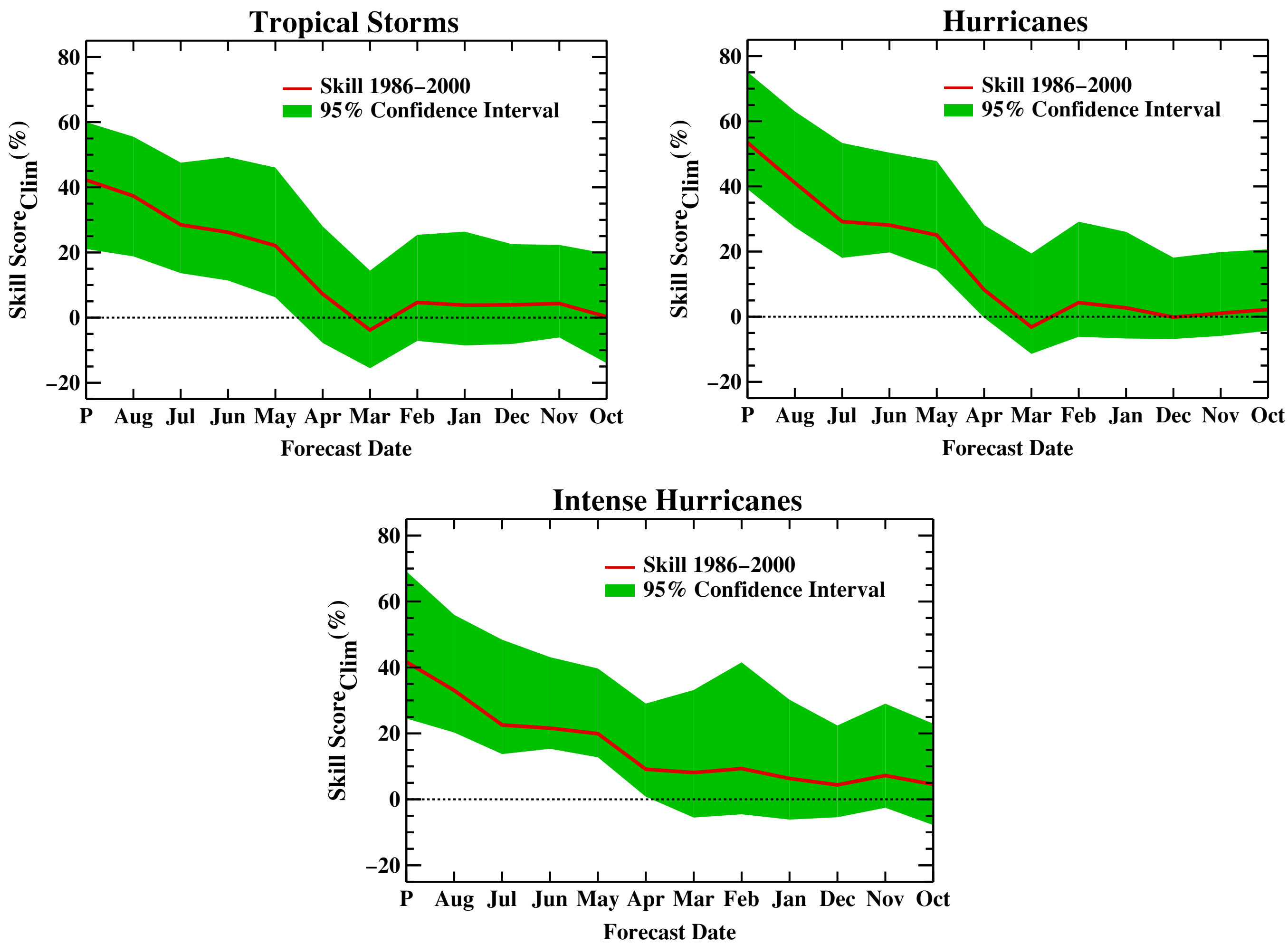
		Intense Hurricanes	Hurricanes	Tropical Storms
TSR Forecast (±SD)	2001	0.4(±0.4)	0.8 (±0.6)	1.9 (±0.9)
Average (±SD)	1991-2000	0.3 (±0.4)	0.7 (±0.7)	1.3 (±1.0)
Average (±SD)	1971-2000	0.2 (±0.5)	0.4 (±0.7)	1.0 (±1.0)

Key: Landfall Strike Category = Maximim 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 1986-2000

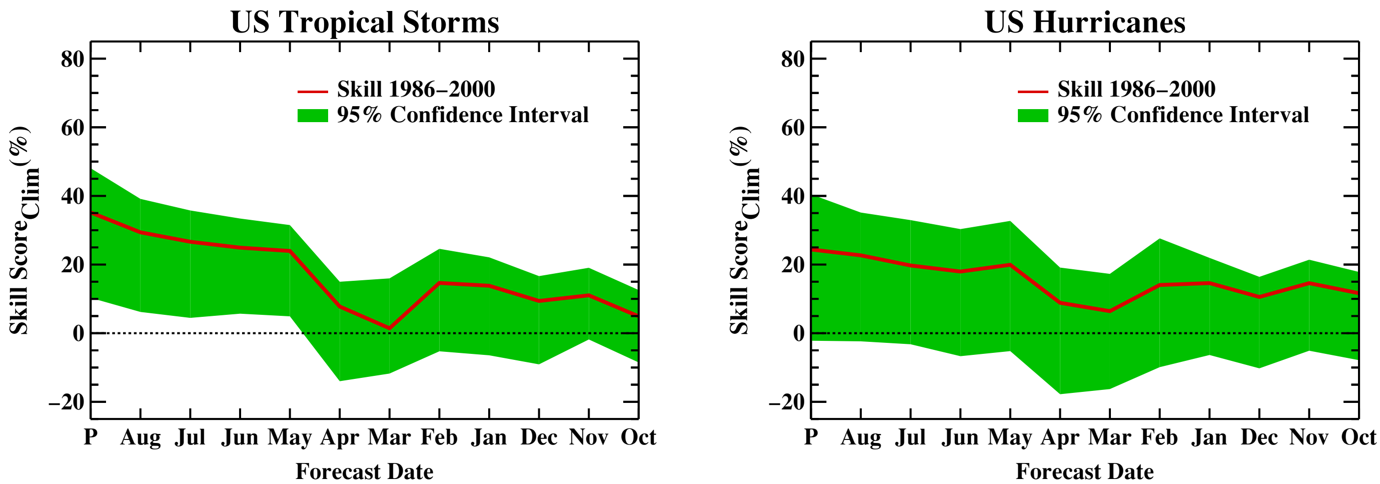
How would the *TSR* Atlantic forecast model have performed as a function of lead time had it been available in previous years? The figures on the next two pages show the *TSR* model skill and associated 95% confidence interval at monthly leads out to 12 months. Skill is computed over the last fifteen years 1986 to 2000, 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



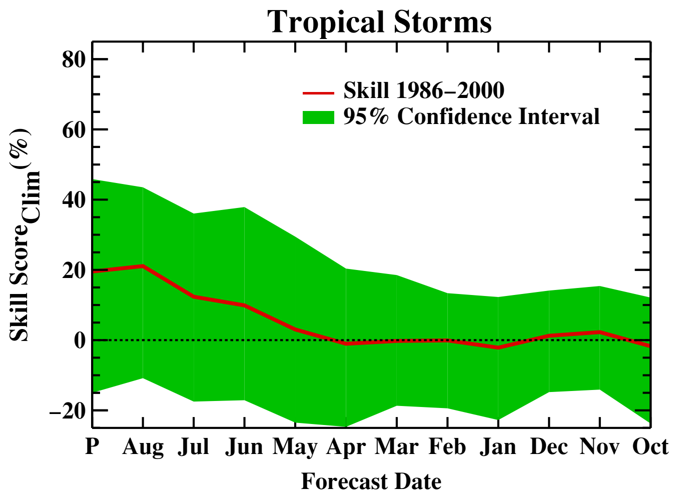
For each strength category the forecast skill rises steadily from the beginning of April. There is no skill, on average, before April. This ‘spring’ predictability barrier is present in both our main predictors.

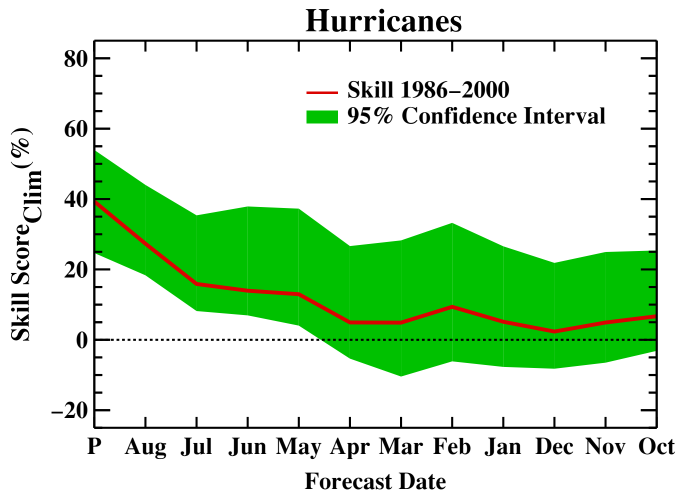
2b. USA Landfalling Storms and Hurricanes



Positive skill is present to 95% confidence for US tropical storm strikes from early May. Weaker and less significant positive skill is present for US hurricane strikes from the end of April.

2c. Caribbean Lesser Antilles Landfalling Storms and Hurricanes





Positive skill is present to 95% confidence for Lesser Antilles hurricane strikes from early May. The model with perfect predictors provide a 40% skill improvement over 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 readily obtained.

4. Predictors and Key Influences for 2001

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, 40°W - 110°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.
b) August-September forecast SST for the Atlantic Hurricane Main Development Region MDR (10°N - 20°N, 20°W - 60°W).

The forecast SSTs come from an in-house statistical model which utilises initial conditions and trends in global SSTs (Atlantic SST predictions) and from an in-house amended version of the ENSO-CLIPER model (Knaff and Landsea, 1997) for the ENSO SST prediction.

The key factors behind our forecast for an active Atlantic season in 2001 are the anticipated enhancing effect of both predictors, particularly predictor (b). The forecast anomaly (1971-2000 climatology) in predictor (a) is 0.7±0.6 ms^{-1}, which is slightly enhancing for hurricane activity, while the forecast anomaly for predictor (b) is 0.32±0.14 °C which is moderately enhancing for hurricane activity. The 'Skill Score $_{Clim}$ (%)' for predictor (a) is 39% for early July forecasts (23% for early June forecasts), and the 'Skill Score $_{Clim}$ (%)' for predictor (b) is 55% for early July forecasts (35% for early June forecasts). Thus the skill in both forecast predictors rises by nearly 20% between June and July.

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 the Chow parameter stability test, as used in economics, to ensure persistence and stability. This involves running the same regression over subsections of the data to test the hypothesis that the regression parameters obtained for the subsets are not significantly different from those found for the whole regression, against the alternative that one or more are different. This hypothesis must be satisfield at the 5% level for a predictor to prove stable and acceptable.

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 initial approximation.

Forecast skill is assessed by rigorous hindcast testing over the period 1986-2000. 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 1986 activity is forecast using 1950-1985 data, 1987 using 1950-1986 data, etc..

6. Monthly Updated Forecasts

For the 2001 and subsequent Atlantic hurricane seasons, *TSR* offers monthly updated forecasts from early April 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.

TSR's next public forecast for Atlantic, USA and Caribbean Lesser Antilles landfalling hurricane activity will be issued in early August 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 1926-1999 is estimated to be US $ 5.2 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)

TropicalStormRisk.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 leading UK insurance industry experts and scientists at the forefront of seasonal forecasting. The *TSR* insurance expertise is drawn from *Benfield Greig*, a leading independent global reinsurance and risk advisory group, the *Royal and Sun Alliance* insurance company, and from the UK composite and life company *CGNU Group*. The TSR scientific grouping brings together climate physicists, meteorologists and statisticians at *UCL* (University College London) and the *Met. Office*. *TSR* forecasts are available from http://tropicalstormrisk.com.

Acknowledgements

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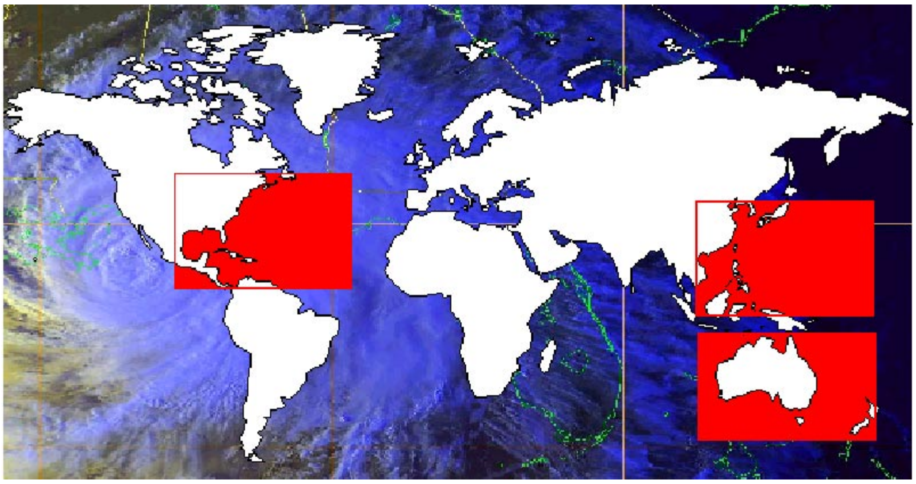

The three tropical cyclone basins under research by the TSR Tropical Storm Risk team.