**Professor Mark Saunders,** lead scientist at Tropical Storm Risk at the Benfield Hazard Research Centre, University College London, describes the growing success and increasing business relevance of hurricane forecasts.

# The weather forecaster

Hurricanes rank as the United States' most expensive natural disaster. They are responsible for eight of the nation's ten most costly catastrophes. The annual average damage bill from hurricane strikes on the continental US between 1950 and 2004 is estimated at $5.6 billion (at 2004 prices). In 2004 – one of the worst hurricane seasons on record - four hurricanes struck Florida between mid-August and late September (Figure 1) leaving an estimated damage bill of $45 billion ($23 billion insured). Here we show that a recent breakthrough in hurricane forecasting allows damaging hurricane years such as 2004 to be predicted in advance. We also show that the landfall position and intensity of active hurricanes are being predicted with increasing precision. Both these advances offer clear benefits to the re/insurance industry.

What are these benefits? The skilful seasonal forecast of US landfalling hurricane activity would reduce the financial risk and uncertainty associated with the hurricane season. For example, the forecast could guide the retrocessional buying and selling of hurricane catastrophe cover to increase returns and decrease volatility. The increasingly accurate forecasts of hurricane landfall position and intensity offers scope for the skilful real-time probabilistic forecasting of insured loss. Such forecasts would benefit improved claims management, improved shareholder confidence and improved cash flow between insurs and reinsurers.

The strength of hurricane activity striking the United States during the main hurricane season can now be predicted with useful precision thanks to a new model reported in the April 21st 2005 issue of the journal Nature by the Tropical Storm Risk (TSR) venture *(Saunders, M.A. and A.S. Lea, Seasonal prediction of hurricane activity reaching the coast of the United States, Nature, 434, 1005-1008, 2005)*. By using tropospheric height-averaged wind anomalies present over North America and over the east Pacific and North Atlantic oceans during July, seasonal US landfalling hurricane wind energy can be predicted with useful skill. The model gives forecasts from August 1st. Ninety seven percent of all intense (category three to five) hurricane strikes on the US and 87 percent of all hurricane hits on the US occur after this date. The TSR model correctly anticipates whether US hurricane losses are above-median or below-median in 74 percent of the years between 1950 and 2003. It also performed well in "real-time" operation in 2004, predicting US landfalling hurricane wind energy in the upper quartile for this active and damaging season.

**FIGURE 1. COMPOSITE SATELLITE IMAGE SHOWING HURRICANES CHARLEY, FRANCES, IVAN AND JEANNE "APPROACHING" FLORIDA AND US LANDFALL IN AUGUST AND SEPTEMBER 2004. IMAGE IS COURTESY OF THE UNIVERSITY OF WISCONSIN-MADISON, SPACE SCIENCE AND ENGINEERING CENTER.**

The benefit to the reinsurance industry of using the TSR

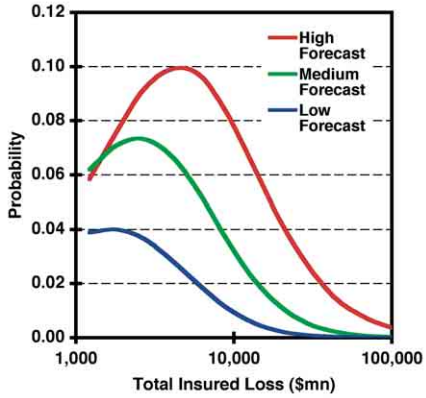


FIGURE 2. US HURRICANE TOTAL INSURED LOSS CONTINGENT ON THE TSR AUGUST 1ST FORECAST.

| Hurricane | Forecast lead time hrs | Error in forecast landfall position (km) | Error in forecast landfall intensity (kts) | Error in forecast landfall time (hrs) |
|---|---|---|---|---|
| Charley | 45 | 4 | -40 | 0 |
| Frances | 45 | 35 | +35 | +16 |
| Ivan | 69 | 16 | 0 | 0 |
| Jeanne | 69 | 11 | -10 | -8 |

Intensity error: - (forecast landfall intensity low)
+ (forecast landfall intensity high)
Timing error: - (forecast landfall time early)
+ (forecast landfall time late)

TABLE 1. PRECISION OF US HURRICANE LANDFALL FORECASTS IN 2004.

August 1st forecast to revisit earlier US hurricane catastrophe retention decisions is evident from Figure 2. This diagram plots the probability of annual total insured loss conditional on the TSR forecast. The chances of a significant loss are clearly much higher in those years with a high forecast. It is also evident from Figure 2 that if extra reinsurance cover were purchased in high forecast years volatility or risk would be reduced. One measure of volatility is the Expected Shortfall (ES) – the average loss than can be expected every, say, 100 years. For the 1 in 100 year loss, ES has values of $20 billion (low forecast), $40 billion (medium forecast) and $100 billion (high forecast). This dependence of ES on the forecast landfalling hurricane activity means that over a period of years a buyer of retrocessional reinsurance cover who finesses the amount of cover bought based upon the forecast can obtain the same reduction in ES as someone who was following a traditional Always Buy strategy but at a much reduced premium. Modelling suggests that saving in premium could be as high as 30-40 percent. This reduction is independent of fluctuations in either the cover price or cover trigger.

For the damaging 2004 hurricane season the TSR forecast US landfalling hurricane activity index fell in the upper quartile. Thus TSR would have recommended that reinsurers purchase extra protection. By following this forecast guidance reinsurers could have reduced their volatility and losses in 2004.

Accurate hurricane track and intensity forecasts have been used traditionally to issue evacuation warnings and to save lives. However, increasingly they are also being employed as an important financial risk tool for catastrophe risk managers and re/insurers. The 2004 hurricane season followed 2003 by showing remarkable accuracy in predicting at leads of two or three days the locations and times of landfall of all the major hurricanes to reach US shores. In 2003 hurricane Fabian's direct hit on Bermuda was predicted correctly at a lead of 45 hours to within 20 km and four hours. Hurricane Isabel's US landfall was forecast correctly at a lead of 72 hours to within 20 km and one hour. Hurricane Juan's strike on Nova Scotia was predicted correctly at a lead of 70 hours to within 50 km and one hour. Table 1 displays the precision of the US landfall forecasts for hurricanes Charley, Frances, Ivan and Jeanne made at lead times of either 45 or 69 hours. These forecasts were issued by the US National Hurricane Centre. The precision is impressive. The average errors in the forecast landfall position, forecast landfall intensity and forecast landfall time for the four hurricanes are just 19 km, -4 kts and +2 hours respectively.

Accurate forecasts of a hurricane's landfall position and strength as in Table 1 may be used to generate maps giving the forecast probability that hurricane-strength winds will affect a given location (eg. cresta zone, city or grid square) at a lead time out to five days. This new risk product is being offered for the 2005 hurricane season by the US National Hurricane Centre (www.nhc.noaa.gov) and by the TSR venture (www.tropicalstormrisk.com). Additionally TSR is providing the product for all global tropical cyclones. The grid size being used by TSR is 0.2° by 0.2° (22km by 22km). Forecasts will be updated every six hours. This product will allow re/insurers to receive real-time information on the likelihood of potential loss for their portfolios. This information can be used to organise claims response units, optimise capital and even trade catastrophe bonds.

In summary, the success and business relevance of hurricane forecasts is steadily increasing. Re/insurers and others could have reduced their losses in 2004 by acting upon the TSR forecast for seasonal US landfalling activity. Confidence in the accuracy of forecasts still needs building before insurers and reinsurers will employ them routinely in business decisions. As the 2005 main hurricane season approaches we believe that the TSR forecast advances should - if acted upon - benefit risk decision-making.

*Seasonal prediction of hurricane activity reaching the coast of the United States*, by Dr Mark A. Saunders and Dr Adam S. Lea, appears in the April 21st issue of the journal Nature. The paper may be accessed from www.nature.com.