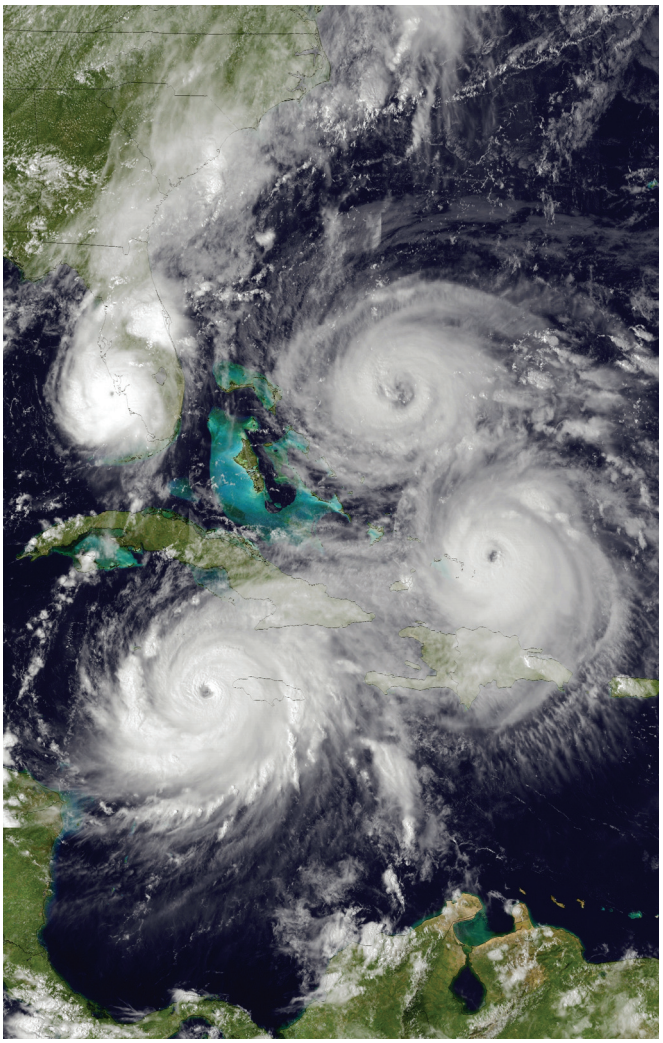
Forecasting lower costs

As the 2005 hurricane season begins, **Mark Saunders**, **Benjamin Lloyd-Hughes** and **Niklaus Hilti** examine the benefits to weather risk management of a recent breakthrough in seasonal US hurricane prediction



Hurricanes Charley, Frances, Ivan and Jeanne approach the US in 2004. Image courtesy of the University of Wisconsin-Madison, Space Science and Engineering Center

Hurricanes are the most expensive natural disasters to strike the US. They are responsible for eight of the nation's 10 most costly catastrophes. Between 1950 and 2004, the annual average bill for damage from hurricanes making landfall on the continental US is estimated at $5.6 billion (at 2004 prices). Last year – one of the worst hurricane seasons on record – four hurricanes struck Florida between mid-August and late September, leaving an estimated damage bill of $45 billion, of which $23 billion was paid out by insurers.

The large year-on-year variability in the number of hurricanes making US landfall (which, since 1950, has ranged from zero to six) means that skilful seasonal forecasts of activity would have sound application in weather risk management. For example, government, public, and emergency planning bodies, and insurers with US interests, would receive advance warning of the likelihood of either high or low hurricane damage during the main hurricane season, which runs from August to October. This would reduce the financial risk and uncertainty associated with the hurricane season.

A recent breakthrough in forecasting, which gives advance warning of the likely severity of the US hurricane season, offers just that – a reduction in uncertainty, with applications across insurance, weather risk management, and catastrophe bond trading and structuring.

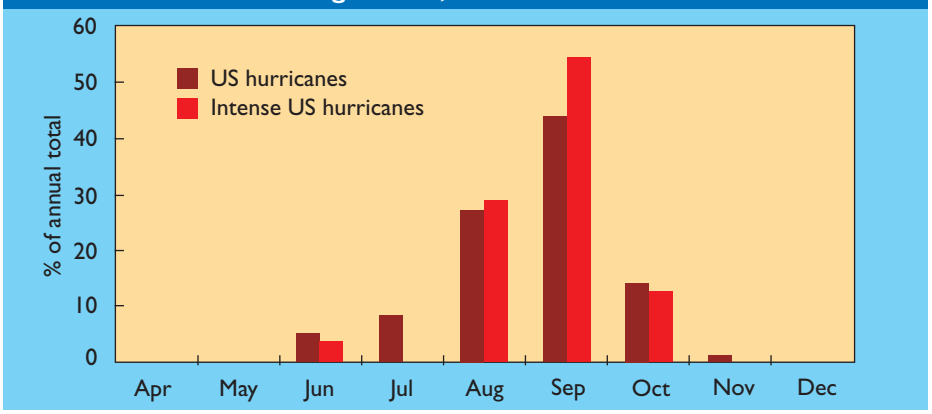
This breakthrough was first reported in a recent issue of the journal *Nature*[1]. The discovery was made by Professor Mark Saunders and Dr Adam Lea from the Tropical Storm Risk (TSR) venture at the UK's Benfield Hazard Research Centre. Without going into details, these scientists developed a new model which uses tropospheric height-averaged wind anomalies present over North America and the east Pacific and North Atlantic oceans during July, to predict seasonal US landfalling hurricane wind energy with useful skill.

The model provides forecasts from 1 August. Ninety-seven percent of all intense (category 3 to 5) hurricane strikes, and 87% of all hurricane hits on the US occur after this date (see Figure 1). The TSR model correctly anticipated whether US hurricane losses were above- or below-median in 74% 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.

So what are the benefits to weather risk management of this forecasting breakthrough? The prime application we consider here is the retrocessional buying and selling of hurricane catastrophe cover within the reinsurance industry. The question we considered was, how much would business returns be improved by revisiting earlier catastrophe retention decisions in the light of this forecast information, available at the start of August?

A product which allows the buying or selling of (re)insurance covers is the Industry

1. Monthly distribution of hurricanes and intense hurricanes striking the US, 1950–2004



1 Saunders, M A and A S Lea, 'Seasonal prediction of hurricane activity reaching the coast of the United States', *Nature*, 434, 1005–08, 2005

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Loss Warranty (ILW). ILWs are financial instruments designed to protect (re)insurers from severe losses due to significant natural disasters. The buyer pays the seller a premium at the inception of the contract and, in return, the buyer can make a claim should a major industry loss occur at or above an agreed trigger level. ILWs provide a transparent and simple example, but standard reinsurance contracts, retrocession or cat bonds could also be considered. We examined two strategies, each contingent upon the TSR early August US hurricane hindcast:

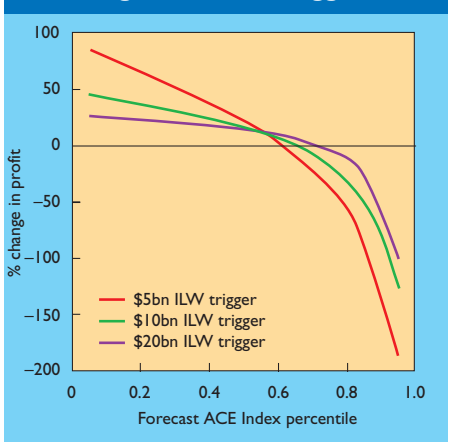
☐ *Forecast Sell* – the strategy of selling an ILW cover to create additional profit.

☐ *Forecast Buy* – the strategy of buying ILW cover to reduce volatility in losses.

These strategies have been tested using a complex model which employs fitted distributions to historical as-if hurricane losses and frequency distributions. We drew 100,000 values from each distribution, and imposed a rank correlation structure consistent with observations. From this synthetic joint distribution, we assessed the business benefits of each strategy. These benefits show little sensitivity to ±10% fluctuations in the purchase/sell price of ILWs.

The benefits of the two strategies are summarised below. Three ILW trigger levels, ($5 billion, $10 billion and $20 billion) are examined. If the total industry loss exceeds the agreed trigger, the buyer is paid the cover (eg, $10 million) that they purchased. The index of forecast US landfalling hurricane activity displayed is the US Accumulated Cyclone Energy (ACE) index. This index reflects the total wind energy of all US landfalling hurricanes and tropical storms each year, and is described in more detail in the *Nature* paper mentioned above.

2. Annual expected change in profitability of ILW sales as a function of the forecast US landfalling hurricane activity index at 1 August and ILW trigger



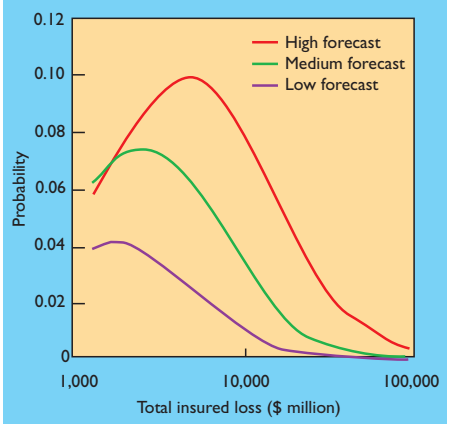
The Forecast Sell strategy is benchmarked against a traditional insurance sales strategy where the same amount of cover ($10 million) is always sold, irrespective of the forecast. The change in profitability from this sale is shown in figure 2, as a function of the forecast US landfalling hurricane activity index percentile and the ILW trigger. Profit is clearly related to the forecast activity index, and thus may be predicted in advance of the main hurricane season.

The largest profits occur in years of low forecast activity. Annual profits for the $5 billion ILW trigger display the largest sensitivity to the activity forecast percentile, with profits in years of low forecast index percentile (0.1 to 0.2) being 70% larger than the mean profit, and profits in years of high activity forecast percentile (0.8 to 0.9) being 100% less than the mean profit (ie, no profit can be expected in years where the forecast index is high). These results lead to the conclusion that an opportunistic capacity allocation, contingent on the seasonal forecast, can lead to up to 70% increased profitability for a reinsurer selling hurricane ILW cover.

The Forecast Buy strategy is benchmarked against a traditional Always Buy strategy where the same amount of cover is always bought irrespective of any forecasts. The reason to buy reinsurance or retrocession is not to make a profit but to reduce the volatility in annual losses. Thus, the Forecast Buy strategy is benchmarked by comparing the premium spent per recovery at constant volatility or risk. The analysis was made with different risk measures such as standard deviation, value-at-risk and expected shortfall (ES). All these measures gave similar results.

Figure 3 illustrates the annual total industry loss as a function of forecast activity index tercile (high, medium and low forecast activity). ES is clearly positively linked to the forecast, having a value for the one in 100-year loss of $20 billion (low forecast), $40 billion (medium forecast) and $100 billion (high forecast). This dependence of ES on the ACE forecast can be exploited so that more ILW cover is bought in high forecast years and less cover in low forecast years. This allows the buyer, over a period of years, to obtain the same reduction in ES as by using the traditional Always Buy strategy, but at a much-reduced premium – typically 30–40%. This reduction is independent of ILW triggers or fluctuations in ILW price.

3. Total insured US hurricane losses contingent on the TSR 1 August forecast



For the damaging 2004 hurricane season, the TSR forecast US ACE index fell in the upper quartile. Thus, the Forecast Buy strategy would have recommended that reinsurers purchase extra protection. Since the $5 billion ILW would have been triggered, reinsurers could have reduced their losses and volatility.

In addition to the property catastrophe (re)insurance applications described above, these innovative results offer other applications in weather risk management. For example, the prices paid for hurricane-linked catastrophe bonds should be influenced by a skilful seasonal US hurricane forecast. This forecast could also reduce the financial risk of industries outside insurance which suffer from losses caused by US hurricanes. Also, hurricane forecasts will create an arbitrage opportunity, should a new hurricane activity index be developed for trading within the capital markets. EF

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