Forecasting succ

(Re)insurers are hopeful that the success of tracking hurricane *Isabel* could prove beneficial for their risk analysis.

The active 2003 Atlantic hurricane season has already seen two hurricanes strike the US. Hurricane *Claudette* struck Texas on 15 July and hurricane *Isabel* hit North Carolina on 18 September (Figure 1). In addition, damaging hurricanes have struck Bermuda (hurricane *Fabian* on 5 September) and Halifax, Nova Scotia (hurricane *Juan* on 29 September). However, it was *Isabel* which most captured the attention of (re)insurers.

After early estimates placed *Isabel*'s expected insurance loss at $3bn, business professionals throughout the world were glued to their computer screens for several days as the giant storm tracked towards US landfall. Although *Isabel*'s predicted industry loss steadily came down as the storm weakened, eventually making landfall as a weak category 2 hurricane with maximum sustained winds of around 100mph (85 knots), the threat remained high enough for federal government buildings to be shut down in Washington DC, 300 miles from the point of landfall.

By Mark Saunders

A feature of hurricane *Isabel* was the success of its track forecasts. Landfall was predicted correctly at a lead of 72 hours to within 20km and 1 hour. 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 insurers, reinsurers and risk managers. The purpose of this article is to describe how hurricane forecasts are produced, to highlight the remarkable success of the track forecasts for hurricane *Isabel*, and to outline the value of such forecasts to (re)insurers.

Hurricane forecasts

When a tropical cyclone is active, forecasts of the storm position and maximum one-minute sustained winds at leads of 12, 24, 36, 48, 72 and 120 hours are issued every 6 hours by the meteorological agency with warning responsibility for the region of the storm. The agency responsible for the North Atlantic is the US National Hurricane Centre (NHC) in Miami. In making their official track and intensity predictions, NHC forecasters consider and often merge independent predictions made by a number of forecast models produced both in-house and by organisations around the world. Forecast models fall into two main types: 'statistical models' based on a statistical analysis of the past behaviour of storms; and 'dynamical models' which use our knowledge of physics to simulate the motion of the atmosphere knowing its initial state. Dynamical track and intensity models usually outperform their statistical equivalents but take longer (typically about four hours) to run. Hurricane track forecasting is generally better developed than hurricane intensity forecasting.

Hurricane track forecasts have been operational in the North Atlantic for over a decade so an assessment of their performance is straightforward. Annual mean errors in forecast track position have reduced by ~50% since the late 1980s at all lead times out to 120 hours. Mean errors are now ~200km and ~400km at leads of 48 and 96 hours compared to ~400km and ~800km in the 1980s. The three main causes for this reduction are better real-time satellite observations of key parameters such as winds and atmospheric humidity, improved dropsonde measurements from research aircraft, and advances in computer power.

Isabel reached and maintained category 5 (the highest category) hurricane status with peak sustained winds of 140 knots (160 mph) as it tracked to the north of the Caribbean Lesser Antilles between the 11 and 14 September 2003. Forecasts at this time began suggesting landfall on the US east coast.

The official NHC track forecast for *Isabel* out to 72 hours lead issued at 11am EDT on 15 September is shown in Figure 2. This predicted US landfall 50km southwest of Cape Hatteras in North Carolina at noon EDT on 18 September. Actual landfall occurred within 20km of this point almost exactly at noon EDT on 18 September. Predictions at shorter leads also consistently gave this position and time of landfall. This is a remarkable track forecasting success. In contrast, the intensity predictions for Isabel proved somewhat less

Modis Rapid Response Team, NASA Goddard Space Flight Centre.

Figure 1. Hurricane *Isabel* viewed just prior to US landfall in North Carolina at 15:55 UT on 18 September 2003. At this time Isabel was packing one-minute maximum sustained winds of 85 knots (100 mph) with gusts to 105 knots (120 mph).

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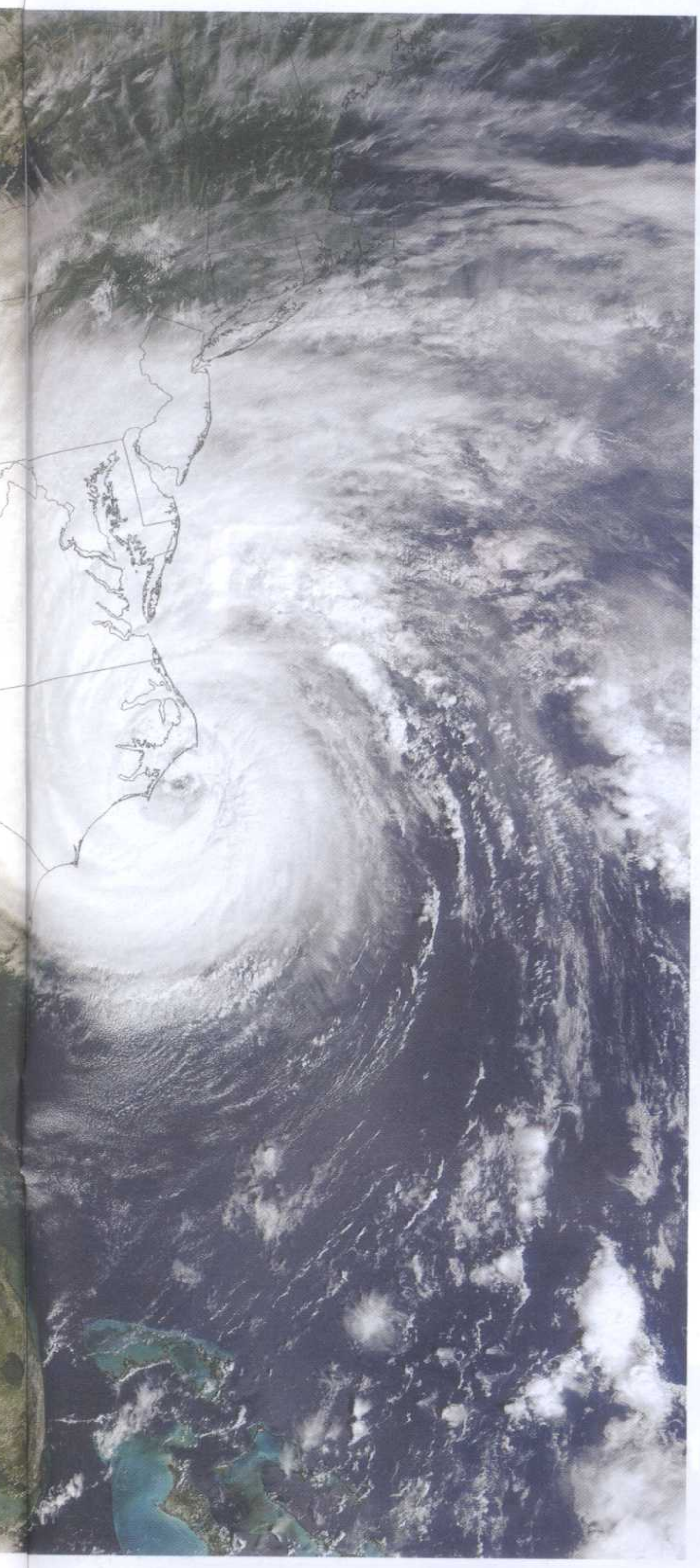

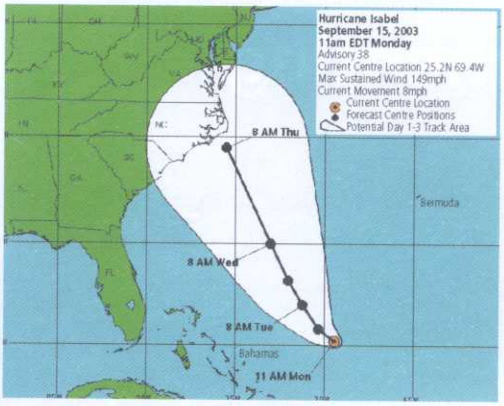

Figure 2. The forecast advisory for hurricane *Isabel* issued by the US National Weather Service Tropical Prediction Centre/National Hurricane Centre at 11am EDT on Monday 15 September 2003. US landfall was predicted for 50km southwest of Cape Hatteras at noon EDT on Thursday 18 September. Actual landfall occurred within 20km of this point at the exact time predicted three days earlier.

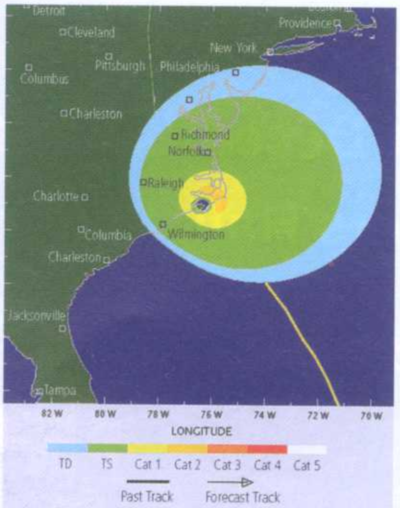

Figure 3. The forecast windfield map for hurricane *Isabel* at landfall issued by TSR Tropical Storm Risk at 4am EDT on 18 September eight hours prior to the storm crossing US shores. Peak sustained winds of hurricane category 2 force (96-110 miles per hour) were forecast to occur to the northeast of the hurricane eye. Hurricane force winds (74 to 95 miles per hour) were anticipated to extend over a distance of ~200km. Image courtesy of TSR.

accurate. The intensity at landfall anticipated at 11am EDT on 15 September was 110 knots (125 mph) compared to the actual value of around 85 knots (100 mph).

Early post-event analyses suggest that a reason for the great success of the *Isabel* track forecasts was the extra data available from dropsondes released by surveillance aircraft from the National Oceanic and Atmospheric Administration hurricane program. Forecasts which contained these data outperformed those which did not by 25% at 48 hours lead and by 40% at 72 hours lead. The decline in *Isabel*'s intensity from 15 September appears to be due to an increase in environmental vertical wind shear and a decrease in the storm's forward speed. Slow-moving storms stir more cold water to the surface resulting in storm weakening. Neither of these suppressing factors were anticipated properly at the longer leads.

By computing the storm's spatial windfield at and after landfall risk modelling companies can provide — through the use of proprietory vulnerability models — near real-time estimates of insurance losses on a county-by-county basis. Figure 3 shows an example of a free-to-use spatial windfield produced in real-time by the Tropical Storm Risk (TSR) forecasting venture. It shows *Isabel*'s forecast windfield at landfall made eight hours prior to the storm crossing US shores. Enterprising business professionals can use this information and anticipated loss estimates to optimise capital, organise claims response units and even trade catastrophe bonds. However, since the accuracy of the loss estimates depends largely on the skill of the original storm track and intensity forecasts, confidence in the quality of the latter needs building before insurance and reinsurance executives will routinely employ such loss estimates in business decisions.

Thus is the track forecasting success for *Isabel* a one-off or does it indicate a trend towards more accurate forecasts? The answer is certainly the latter. The track positional errors for hurricanes (and indeed for tropical storms worldwide) have not reached predictability limits and will continue to improve as computers become more powerful, as satellites provide better real-time monitoring of tropical environmental conditions, and as computer models improve. Track intensity forecasts will also improve with further research. Thus successes such as *Isabel* will become increasingly common thereby improving risk awareness and opening up opportunities for business based on the real-time forecasting of loss.

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