Hurricane Isabel

Hurricane forecasting for risk reduction

Hurricanes rank historically above earthquakes and floods as the major geophysical cause of property damage in the United States. This article describes how Atlantic hurricane track forecasts are produced, highlights the remarkable success of the landfall forecasts in 2003 and outlines the potential value of such forecasts to risk managers. By Dr Mark Saunders

THE ACTIVE 2003 North Atlantic hurricane season saw three noteable landfalling hurricanes: Fabian, Isabel and Juan. Hurricane Fabian struck Bermuda on 5 September with sustained winds of 115mph (100 knots) or category 3 intensity on the Saffir-Simpson Hurricane Scale. Fabian caused extensive damage (economic loss of US$0.5 billion of which $0.4bn was insured) and is reported to be the worst hurricane to strike Bermuda since 1926.

Hurricane Isabel struck North Carolina on the 18 September as a weak category 2 hurricane with maximum sustained winds of around 100 mph (85 knots). Isabel was a long lived hurricane which had reached category 5 status at sea. Following initial reports which placed its expected insured loss at $3bn, risk managers across the world were glued to their computer screens for several days as the giant storm tracked towards US landfall. Despite weakening as it approached US shores, Isabel still caused considerable damage (economic loss of $5.0bn of which $1.7bn was insured) and led to federal government buildings being shut down in Washington DC, 300 miles from the point of landfall.

Hurricane Juan made landfall near Halifax, the capital of Nova Scotia, as a category 2 hurricane on 29 September. Juan caused extensive damage

in Halifax and across Nova Scotia and Prince Edward Island but precise damage figures are not yet available. Juan was the first hurricane since 1893 to make a direct (eyewall) hit on Halifax.

A feature of all three of these hurricanes was the successful forecasting of the times and locations of their landfalls. 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 70 hours beforehand to within 50 km and one 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 catastrophe risk managers and insurers.

Figure 1. The successful landfall forecast advisories for hurricanes Fabian (top), Isabel (centre) and Juan (bottom; note Juan was still a tropical storm at this time) issued by the US National Weather Service Tropical Prediction Center/National Hurricane Center. These advisories accurately predicted the time and location of each hurricane's strike on land.
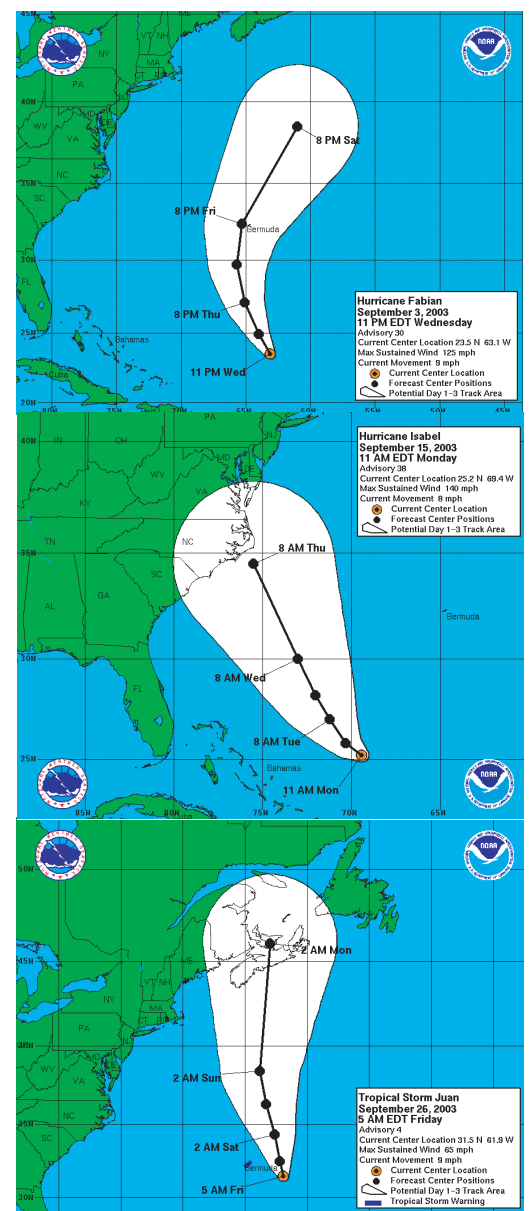
Image: US National Weather Service Tropical Prediction Center / National Hurricane Center.
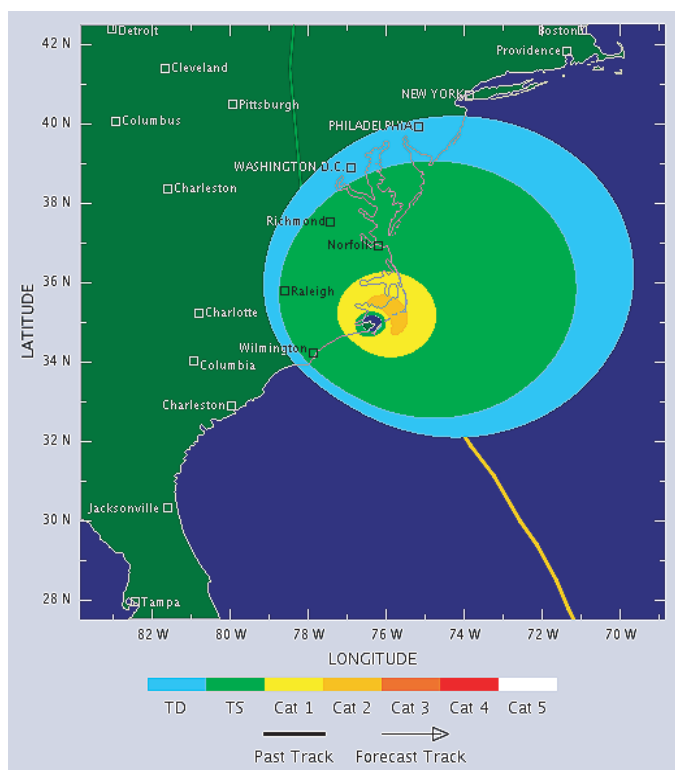
Figure 2. The forecast windfield map for Hurricane Isabel at landfall issued by TSR at 4am EDT on Thursday 18 September, eight hours berfore the storm crosed US shores. Peak sustained winds of hurricane category 2 force (96-110 miles per hour) were forecast to occur to the northeast of the hurricane eye. Hurricane force winds (74 to 95 miles per hour) were anticipated to extend over a distance of ~200km.

Hurricane track forecasts

When a tropical cyclone is active, the meteorological agency with warning responsibility for the region of the storm issues forecasts of the storm position and maximum one-minute sustained windspeed at leads of 12, 24, 36, 48, 72 and 120 hours every six hours. The agency responsible for the North Atlantic is the US National Hurricane Center (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 an analysis of the past behaviour of storms and "dynamical models" which use our knowledge of physics to simulate the motion of the atmosphere from 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 that 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 about 50% since the late 1980s at all lead times out to 120 hours. Mean errors are now about 200km and about 400km at leads of 48 and 96 hours compared to around 400km and 800km in the 1980s. The three main reasons for this reduction are better real-time satellite observations of key parameters such as winds and atmospheric humidity, improved measurements of pressure, temperature, humidity and winds aloft from research aircraft, and advances in computer power.

Forecasts

Fabian was a powerful Atlantic hurricane that maintained category 3 or 4 intensity for a week. between the 30 August and 6 September 2003. The first NHC advisory to indicate a direct strike on Bermuda was issued at 11pm eastern daylight time (EDT) on Wednesday 3 September (Figure 1). Bermuda landfall was predicted for 8pm on Friday 5 September with storm maximum sustained winds of 105 knots. This forecast proved accurate with Fabian's eyewall passing over Bermuda at 4pm EDT on this day with peak sustained winds of 100 knots.

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 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 on 15 September is shown in Figure 1. This predicted US landfall 50km southwest of Cape Hatteras in North Carolina at noon on Thursday 18 September. Actual landfall occurred within 20km of this point almost exactly at noon on the 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 accurate. The intensity at landfall expected at 11am on the 15 September was 110 knots (125 mph), compared to the actual value of around 85 knots (100 mph).

Juan formed southeast of Bermuda late on the 24 September. The first NHC advisory to indicate a strike on Nova Scotia was issued at 5am on Friday 26 September 2003. Landfall was forecast for 50km east of Halifax at midnight on Sunday 28 September with maximum sustained winds of 60 knots. This forecast proved accurate except that Juan's intensity at landfall was underestimated. Actual landfall occurred at Halifax within one hour of the predicted time with peak sustained winds of 85 knots (100 mph). Juan's intensification as it approached landfall appears to have been a result of its passage over unusual-

ly warm waters southeast of Nova Scotia.

Early post-event analyses suggest that a reason for the great success of the Fabian, Juan and especially Isabel landfall forecasts was the extra data available from dropsondes (recording instruments released by surveillance aircraft) from the hurricane programme of the National Oceanic and Atmospheric Administration (NOAA). 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 was anticipated properly at the longer leads.

How risk managers use forecasts

Accurate forecasts of a hurricane's landfall position and strength may be used to generate spatial windfields for the storm at and after landfall. By combining these forecast windfields with proprietory vulnerability models, catastrophe risk modelling companies can provide near real-time forecasts of potential insurance loss on a county by county basis. Figure 2 shows an example of a spatial windfield produced in real-time by the UK's Tropical Storm Risk (TSR) forecasting venture. It displays Isabel's forecast windfield at landfall made eight hours before the storm crossed US shores.

Enterprising business professionals can use this information and anticipated loss estimates to organise claims response units, optimise capital and even trade catastrophe bonds. However, confidence in the accuracy of the forecast windfields and forecast losses needs building before risk managers and insurers will routinely employ such information in business decisions.

Are the successful hurricane landfall forecasts in 2003 unique or do they 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, satellites provide better real-time monitoring of tropical environmental conditions and computer models improve. Track intensity forecasts will also improve with further research. Thus, forecasting successes such as in 2003 will become more common, thereby reducing risk and uncertainty and offering increased comfort to catastrophe risk managers. ■

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