“Get the **** off the beach, your tan is done!” : A Guide to Hurricane Forecasting

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What is a hurricane?

The title quotes Governor Christie of New Jersey warning people of the imminent arrival of Hurricane Sandy in August, 2012. A hurricane is the most intense form of a tropical cyclone with sustained winds exceeding 120 kilometres per hour (74 mph) that rotate around a strong atmospheric low-pressure system. Hurricanes form in the North Atlantic ocean (typically about 6 per year), and can sometimes make landfall in various inhabited areas of the Caribbean Sea, Mexico and the US. This can lead to significant loss of life, and to some of the world’s greatest economic losses due to natural hazards.

Hurricane Forecasting

The National Hurricane Center (NHC) based at the National Oceanic and Atmospheric Administration (NOAA) in Florida, US issues short-term probability forecasts of tropical cyclone genesis. Probabilities of whether a tropical cyclone will form within 48 hours are provided on a 6-hourly basis throughout the hurricane season from May-November. Hurricanes, however, are not easily predicted, even on short timescales, and confident forecasts can sometimes prove unskillful, as shown in Fig 1…

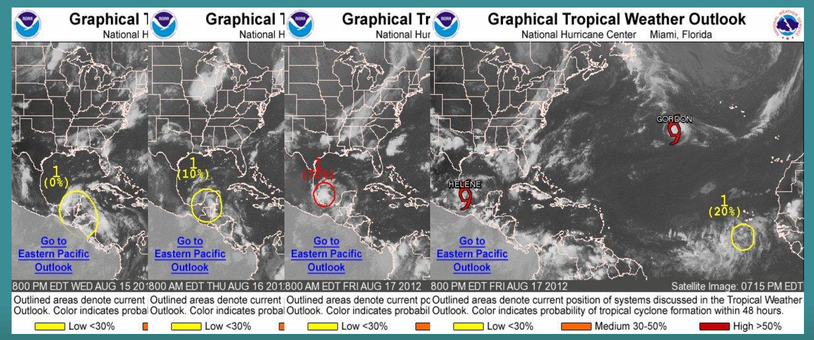

Fig 1. Series of NHC 48-hour forecasts, called “Graphical Tropical Weather Outlooks”, of the likelihood of formation of tropical storm Helene on 15th-17th August 2012. A 0% (actually defined as “near-zero”) probability was assigned yet the storm occurred! (Source: http://www.nhc.noaa.gov)

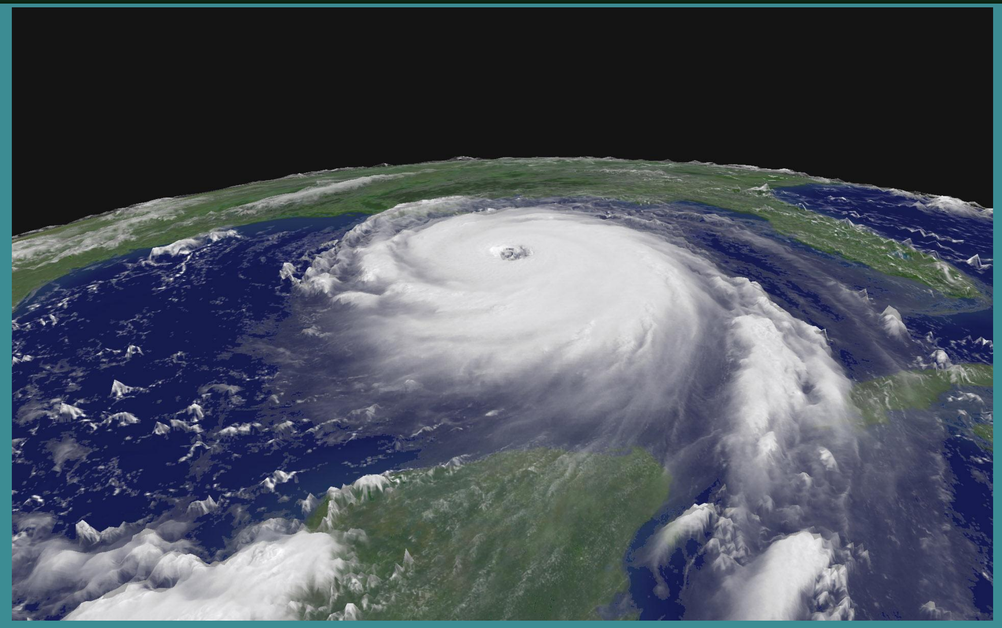

Fig 2. Satellite image of Hurricane Katrina in 2005
(Source: http://www.noaanews.noaa.gov)

The Cone of Uncertainty

Probabilistic forecasts are an invaluable tool for decision-makers to make informed plans of action. Not only do they convey how much confidence a forecaster has in their predictions, but they also allow a decision-maker to consider a range of response contingencies. To monitor and improve the quality of a probabilistic forecasting system, forecasting centres regularly evaluate the performance of their forecasts using various statistical measures, and graphical diagnostic tools. Check Fig 3 to see how well a 3-day ahead forecast of the location of Hurricane Katrina’s centre performed in 2005.

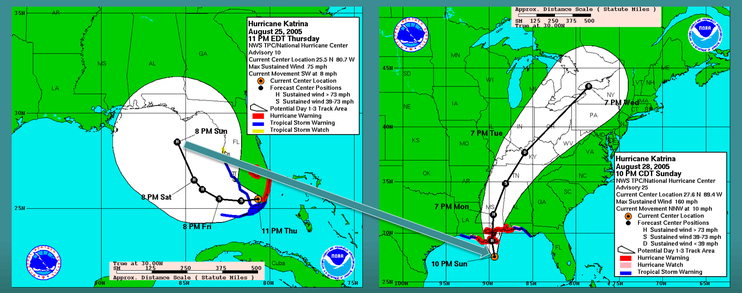

Fig 3. A cone of uncertainty showing how location forecasts of the hurricane’s centre become more uncertain with lead time. In this case, the outcome at 10pm Sunday (right) is almost 5° longitude (roughly 300 miles) away from the predicted location (left), although it almost lies within the forecast's cone of uncertainty. (Source: http://www.nhc.noaa.gov)

How good were the forecasts for the 2012 hurricane season?

Reliability diagrams can be used to compare the forecasts with the corresponding outcomes (either an occurrence or non-occurrence of a tropical cyclone). They consist of a plot of the observed relative frequencies of the event against the forecast probabilities assigned to each outcome. A perfectly reliable forecast system is indicated when all points line up along the diagonal, although some deviation would be expected. *Consistency bars* can be constructed using a resampling technique to quantify the range of fluctuation expected at each probability category. The reliability diagram for the 2012 hurricane season is shown in Fig 4.

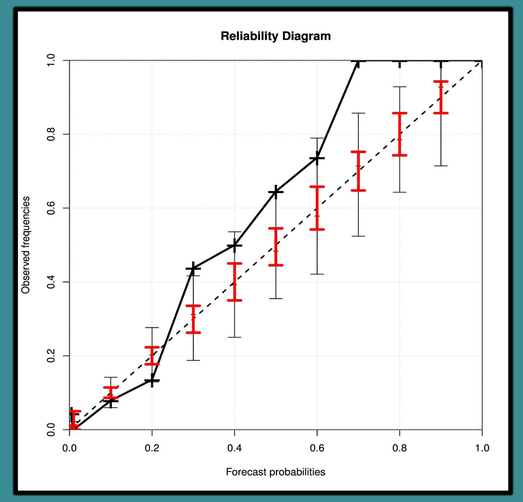

Fig 4. Reliability diagram of NHC forecasts of tropical cyclone formation for the 2012 hurricane season. The observed relative frequency of TC formation is plotted against each forecast probability category (“+” symbols). The black vertical consistency bars indicate the 5-95% quantiles of expected observed relative frequency for reliable forecasts for the actual sample size, and the red vertical bars indicate likewise for a sample size 10 times larger.

Discussion Points:

- **Hurricanes are some of nature’s most destructive events**
- **Probabilistic forecasting is essential for improving predictions, and providing early warning of hurricanes**
- **Reliability diagrams provide a useful tool for monitoring forecast performance**

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