WSI HURRICANE FORECASTING TECHNIQUE

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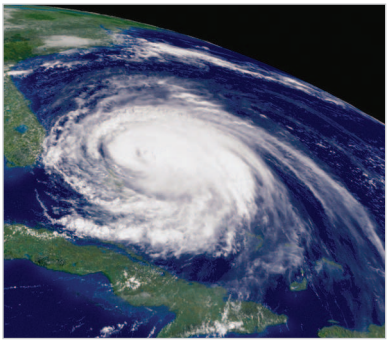

Introduction

WSI Corporation, in collaboration with Guy Carpenter & Company, LLC, has developed a forecasting technique to help assess the risk of losses due to hurricane strikes up to 10 days into the future. State-of-the-art meteorological models are used to predict the track and intensity of hurricanes, as well as providing quantitative measures of the uncertainty of those forecasts, which is especially important at forecast lead times beyond 5 days. The forecast data can be combined with landfall damage models to assess potential insured losses, by taking into account the intensity at landfall and the insured value of property in the expected landfall region. The forecast technique will be initially used for US landfalls only, but it can be easily adapted for use in other regions that are similarly impacted by damaging tropical cyclones.

The unique aspects of the technique include (1) predictive information on tropical cyclones beyond the usual 5 day forecast period, including uncertainty estimates (2) quantitative storm-specific estimates of uncertainty inside of 5 days and (3) incorporation of the entire suite of global medium-range forecasting models. None of these features has been available in the marketplace until the development of this technique.

Track Forecasts

By intelligently combining forecast data from various global meteorological models, the WSI technique provides forecasts for many days beyond what is currently available from the National Hurricane Center (NHC) or other tropical forecasting centers around the world. Because communicating forecast uncertainty to the public is difficult, NHC only disseminates hurricane forecasts out to 5 days. Since NHC and other centers only produce forecasts for the short term, the user is left with little guidance on where a storm may go when it is still far from land. However, although forecast skill does decrease at longer lead times, it is quite common for the models to converge on a storm track forecast well beyond the 5-day period. Further, within 5 days, the NHC forecast "cone" of uncertainty is based solely on historical forecast errors rather than the predictability of the current storm, which can vary significantly from case to case. The WSI technique has been designed to provide forecasts of hurricane tracks, the estimated uncertainty associated with those tracks, and expected losses out to 10 days.

The WSI technique is based on at least 50 possible tracks for each forecast time, and the variance of these tracks is proportional to the forecast uncertainty. Forecast tracks might focus narrowly on a single region, fan out over a large area, or cluster around two likely landfall locations. In cases where the forecasts cluster closely together, users can exploit the relative uncertainty of these long-lead forecasts to establish an optimal market position.

The two examples below illustrate opposite ends of the uncertainty spectrum. Figure 1 shows all of the forecast model realizations for Katrina from the 0000 UTC forecast cycle on 25 August 2005. Note that the range of forecasts spans almost the entire Gulf Coast, much of the East Coast, and a part of the western Atlantic Ocean. The spread of potential model solutions alerts the user of the significant uncertainty of this particular forecast. Decisions should then be made not just on the official mean track forecast, but on the standard deviation of the entire suite of model forecast tracks.

Figure 1. Forecast tracks of all model realizations for Katrina from the 0000 UTC run on 25 August 2005. The colors represent the intensity forecasts as calculated by the statistical intensity algorithm, which is discussed in the next section of the document.

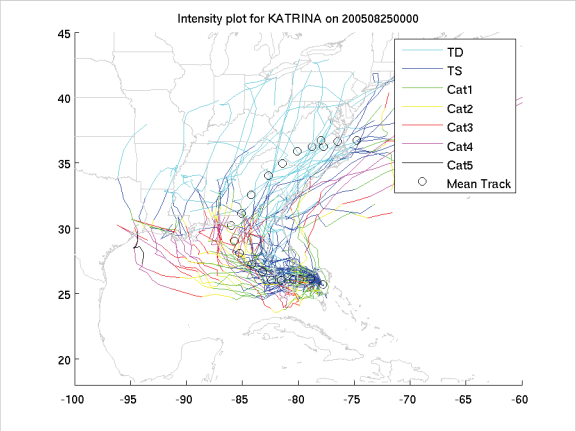

Figure 1.

Figure 2. Forecast tracks of all model realizations for Wilma from the 1200 UTC run on 16 October 2005. The colors represent the intensity forecasts as calculated by the statistical algorithm, which is discussed in the next section of the document.

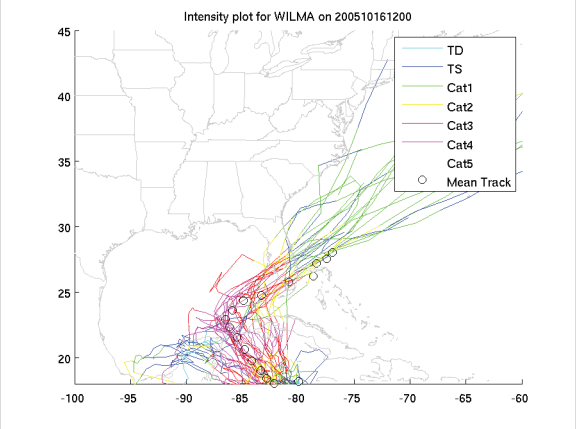

Figure 2.

Figure 3. WSI track forecasts from Katrina, issued at 12-hourly intervals from August 24-29, 2005. Each forecast track is labeled with the date (e.g., 0825) and initialization time (e.g., 00Z or 0000 UTC) of the forecast. The observed track is denoted by a solid black line with open circles.

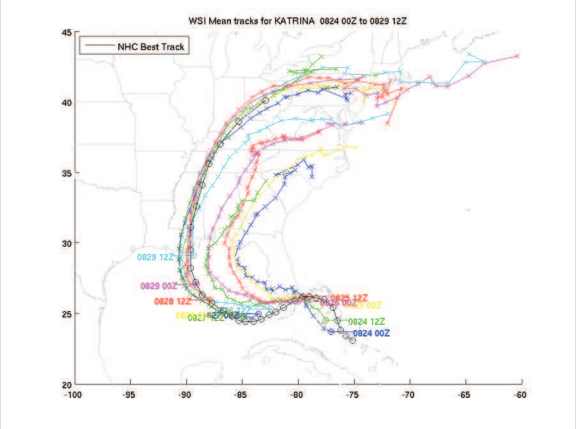

Figure 3.

On the other hand, the forecast track for Wilma was relatively clear as far out as 8 days from landfall in Florida. Figure 2 shows this graphically, as a majority of the suite of model solutions had narrowed to a southern Florida landfall by 16 October (landfall was 24 October).

The difference in predictability of the two storms can be further illustrated in a time series of mean forecast tracks. Figure 3 shows that the forecast for Katrina was not very clear until 1200 UTC on 26 August, when the WSI forecast "locked in" on the New Orleans area, just 3 days ahead of landfall.

Figure 4 on the other hand, suggests that the eventual southern Florida landfall of Wilma was correctly forecasted 8 days ahead of landfall, well beyond the typical 5-day forecast window provided by other products. Only the WSI technique would have been able to provide this important information to potential users.

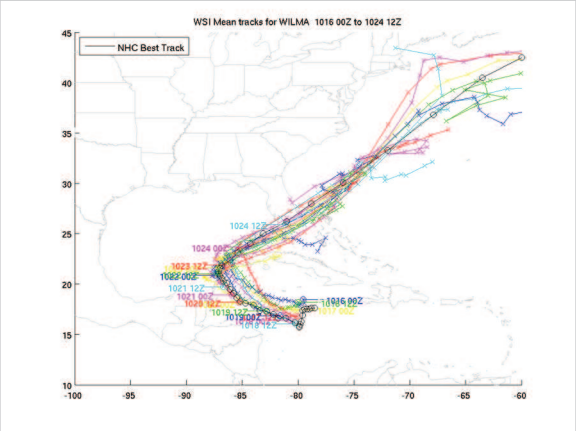

Figure 4. WSI track forecasts from Wilma, issued at 12-hourly intervals from October 16-24, 2005. Each forecast track is labeled with the date (e.g., 1017) and initialization time (e.g., 00Z or 0000 UTC) of the forecast. The observed track is denoted by a solid black line with open circles.

Even within 5 days, the WSI technique provides significant value relative to NHC forecasts. NHC forecasts are also issued with uncertainty estimates (cones), but this information is not storm-specific, and is instead based on mean historical forecast errors. This technique results in identical cone sizes for all storms and all forecasts, regardless of the complexity of any particular track forecast. The WSI technique incorporates uncertainty estimates that are driven by the actual meteorological conditions at the time of the forecast – an important edge in cases where models are converging on a single track many days in the future.

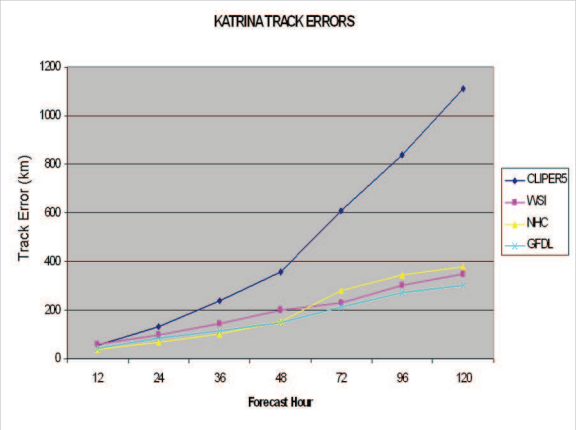

Figure 5. Mean forecast track errors during Katrina for WSI, NHC, and the CLIPER5 and GFDL models as a function of forecast hour

While the primary advantages of the WSI technique are increased forecast lead time and more detailed estimates of uncertainty, the mean track forecasts also appear to do quite well at shorter lead times as well. Figure 5 shows the average track error forecasts for the WSI, NHC, and GFDL (Geophysical Fluid Dynamics Laboratory) model forecasts during Katrina, along with the forecasts from the "no-skill" baseline CLIPER5 statistical model. The WSI forecasts have similar skill to both the NHC and GFDL forecasts, and are much more skillful than the CLIPER5 forecasts. Further, neither the NHC nor the GFDL forecasts provides storm-specific uncertainty estimates at even these shorter lead times, so a user of these products may be unaware that a particular forecast is fraught with more or less uncertainty than usual.

Intensity Forecasts

In addition to the track, accurate intensity (wind speed) forecasts are crucial to predicting the magnitude of insured losses at storm landfall. Landfall intensity forecasts for each track are created using a statistical model whose inputs include the important parameters that influence storm strength: ocean temperature, passage over land, atmospheric wind shear, and other atmospheric factors.

Similar to the track forecasts, the spread between the various intensity forecasts will provide valuable information, since the various realizations will define the envelope of possibilities, rather than just providing an average value.

Figure 6 below shows the time series of landfall intensity forecasts for Katrina, starting with the 5-day forecasts made on 24 August. Note that the errors in the mean landfall intensity forecasts never exceed 30 knots, even out to 5 days. These numbers compare quite favorably to both the NHC and the SHIFOR5 forecasts, both of which had average intensity forecast errors greater than 30 knots beyond 72 hours during Katrina (from page 28 of http://www.nhc.noaa.gov/verification/pdfs/Verification_2005.pdf). Note that the uncertainty estimates, as depicted in this figure by the difference between the 20th and 80th percentile of all model realizations, also convey useful information. In this case, there was significant uncertainty in the expected landfall intensity on 24-25 August, before the modeling system converged quite rapidly on the 26th.

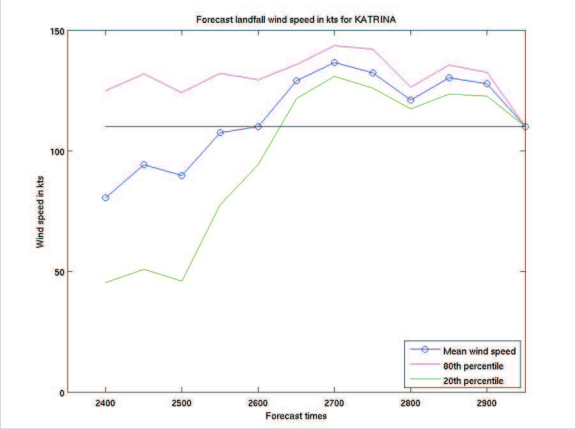

Figure 6.

Figure 6. Time series of the forecasted landfall wind speed for Katrina forecasts. The forecast times on the x-axis are of the format 'ddhh', starting with the 0000 UTC 24 August forecast. The mean wind speed (using all 50 model realizations) is given in blue, while the 20th and 80th percentile wind speeds are given in green and magenta, respectively. The observed landfall wind speed is given by the black solid line (110 kts)

Conclusion

A new hurricane forecasting technique has been developed by WSI, in collaboration with Guy Carpenter & Company, LLC, to address an important need in the marketplace. By incorporating forecast information from multiple global atmospheric models, the technique conveys a richer set of information than what is available from the NHC or any individual hurricane model. The technique can be used to extend the forecast domain from 5 to 10 days, enabling users to establish market positions for a given storm days ahead of those relying on NHC information alone. Also, the forecasts are combined with quantitative estimates of uncertainty so that users can act with a richer view of the relative probabilities of storm landfall location and intensity.

About the Authors

Todd M. Crawford, Ph.D. Lead Seasonal Forecaster and a Principal Scientist in WSI's Forecasting Research And Development Group. He is the leader of WSI's seasonal forecasting project in the Forecast Research and Development group. He received a bachelor's degree in meteorology from the University of Wisconsin, and master's and doctorate degrees in meteorology from the University of Oklahoma. Before joining WSI, Dr. Crawford was a scientist at the National Severe Storms Laboratory where he pursued research interests in the fields of mesoscale weather forecasting, mesoscale dynamics, diagnostic modeling, and thunderstorm initiation. At WSI, Dr. Crawford has developed various automated statistical forecasting techniques for use on seasonal, subseasonal, and medium-range time scales.

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About WSI Corporation

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