WSI Tropical MarketFirst

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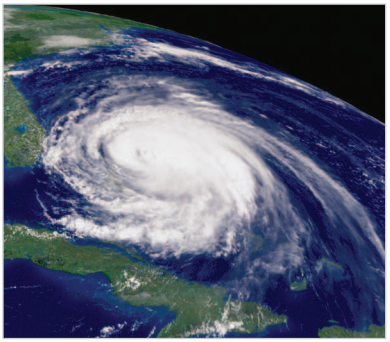

Introduction

WSI Corporation has recently developed WSI Tropical MarketFirst, a product which predicts changes in the forecasts of existing named tropical cyclones for the 1200 UTC run of the Global Forecast System (GFS) model. During the summer and fall, commodity markets are extremely sensitive to each new forecast of an existing tropical system, a forecast of a new system or the dissipation of an existing system. Markets are particularly sensitive to the 1200 UTC run of the GFS model, both due to its widespread availability and to the fact that the run appears during the middle of the trading day. Predictions of changes in the GFS temperature forecasts from run-to-run have proven to be both successful and market-moving (WSI MarketFirst), so expanding the "forecast-of-a-forecast" product suite to encompass tropical activity is a natural progression.

WSI Tropical MarketFirst will predict the 1200 UTC GFS hurricane track forecasts out to 16 days or until the forecasted landfall occurs, along with a "cone of uncertainty" surrounding the forecast track. The product will be made available by 11 AM Eastern Daylight Time, well ahead of the actual 1200 UTC GFS run itself, in order to give clients plenty of time to take market positions based on the prediction.

Methodology

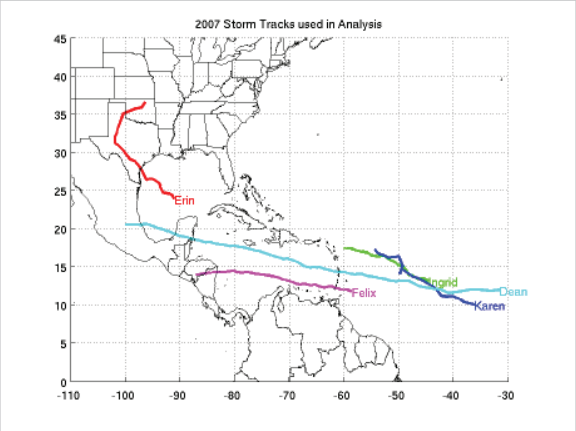

Figure 1. The five 2007 Atlantic basin tropical cyclones chosen for inclusion in the Tropical MarketFirst developmental data set.

The proprietary WSI Tropical MarketFirst technique was developed using data from 12 storms that occurred during 2007 in the Atlantic and West Pacific basins. It is assumed that the combined results from the two basins will apply to either basin, since the general westward movement and mid-latitude re-curvature are common to both sets of storms. In addition, the juxtaposition of data-sparse oceanic regions and data-rich land masses is similar. Since the main area of interest for users of this product will likely be the energy-rich Gulf of Mexico, Atlantic storms which had the potential to affect that area and which had several days of over-water track were chosen (Figure 1). For the West Pacific basin, a number of long-lived Pacific typhoons that made landfall in densely populated areas of Japan, China, and Korea were chosen (Figure 2). Several of these (Krosa, Manyi, Sepat, and Wipha) became super-typhoons during parts of their tracks. Long-lived storms are optimal for this work since – they will provide more forecast times, thus improving the statistical significance of any results.

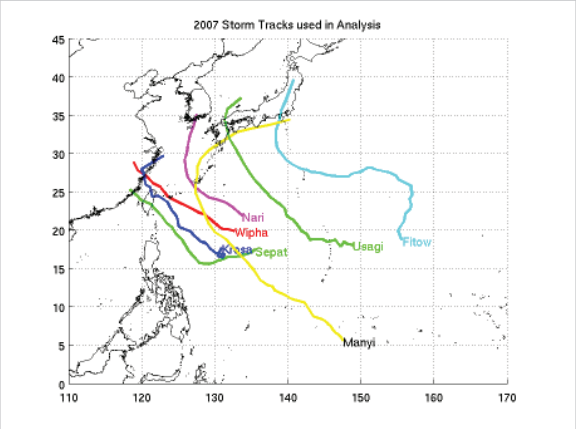

Figure 2. The seven 2007 West Pacific basin tropical cyclones chosen for inclusion in the Tropical MarketFirst developmental data set.

In order to track a storm, the storm center is usually defined as the mean sea level pressure minimum. For stronger storms this works well, but for weaker storms the signal can be lost if there is a significant larger-scale pressure gradient (such as at the edge of the Bermuda High). Because of this, we have defined the storm center to be located at the centroid of the triangle defined by the positions of the sea level pressure center, 850 mb geopotential height minimum, and 850 mb vorticity maximum. If one or two of these parameters is missing or ill-defined, the center is defined as

the average of the remaining parameter(s). This provides for a more robust and continuous storm track than using the sea level pressure minimum alone.

Results

a. Case Studies

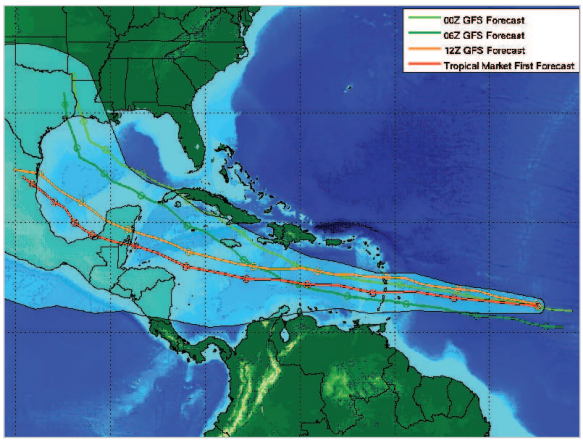

Figure 3. WSI Tropical MarketFirst product from August 15, 2007 for Hurricane Dean. The tracks for the 0000, 0600, and 1200 UTC GFS runs are shown, along with the predicted 1200 UTC GFS run and associated cone of uncertainty.

The WSI Tropical MarketFirst product from August 15, 2007 for Hurricane Dean is shown below in Figure 3. Note that the prediction correctly indicated that the 1200 UTC run would be much farther south than the previous two runs, and away from the market-sensitive regions in the western Gulf of Mexico. However, the uncertainty cone associated with the prediction still indicated a threat to the western Gulf of Mexico, even with the significantly different track prediction (and subsequent verification) of the 1200 UTC run. The uncertainty cone, which is based on the mean track error for each forecast day, provides added value that decision-makers can use to establish optimal market positions for a particular Tropical MarketFirst prediction.

The example in Figure 4, this time from Hurricane Felix, shows that Tropical MarketFirst correctly indicated relatively little change between the 0000 and 1200 UTC GFS runs. The exception is towards the end of the run, where Tropical MarketFirst correctly predicted emergence into the extreme western Gulf, compared to the 0000 UTC run which turned to the west into Mexico.

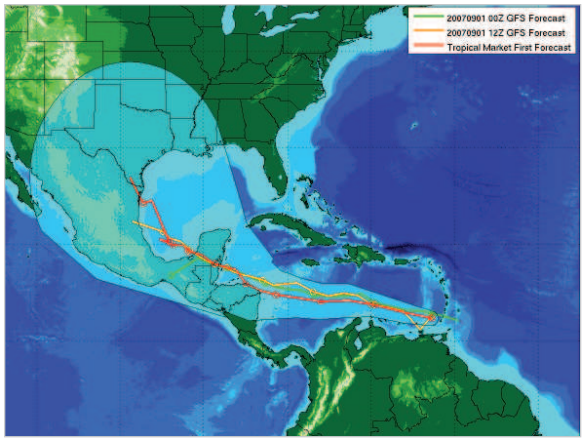

Figure 4. WSI Tropical MarketFirst product from September 1, 2007 for Hurricane Felix. The tracks for the 0000 and 1200 UTC GFS runs are shown, along with the predicted 1200 UTC run and associated cone of uncertainty.

b. Aggregate Skill – Directional Correctness

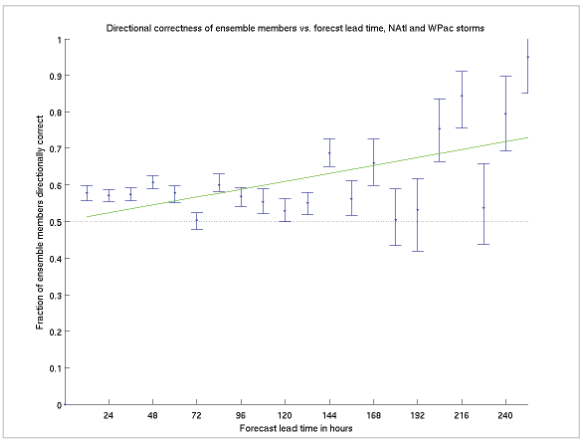

Figure 5. Aggregate directional correctness values for the 12 analyzed storms. The values are denoted by blue dots, with associated error bars (representing the 95% confidence interval) that are dependent upon the sample size. The green line is a best fit of the directional correctness values from days 1-10.

Tropical MarketFirst predictions for all 12 storms were aggregated by forecast hour to determine the skill of the technique. Only those forecast hours prior to landfall were used in the analysis. One particular metric, directional correctness, describes the percentage of times that Tropical MarketFirst correctly predicts the direction of change in the track forecast (left or right of the 0000 UTC GFS forecast). The results in Figure 5 indicate directional correctness values generally between 55-60% through day 5, increasing to 70-75% by day 10. Note that there are very few forecasts beyond day 10, as most of the sampled storms had already made landfall. However, we would expect large directional correctness out to day 16 as well, similar to the skill of the existing MarketFirst temperature product.

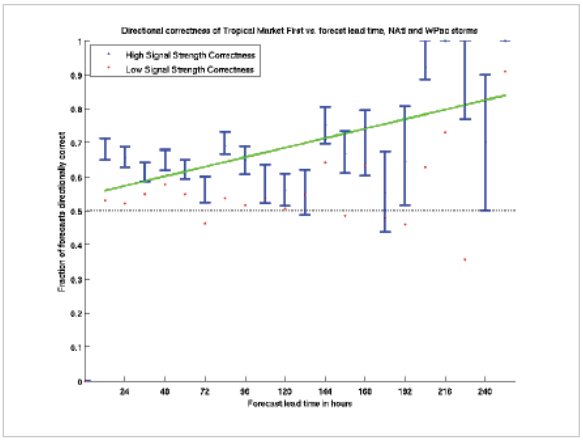

Figure 6. Aggregate directional correctness values for the 12 analyzed storms, partitioned into high and low confidence (signal) cases. High (low) confidence cases are defined as when the deviation between the Tropical MarketFirst track prediction and the 0000 UTC GFS track is larger (smaller) than the mean deviation. The skill of the high confidence cases is denoted by center of the blue error bars (which represent the 95% confidence interval). The green line is a best fit of the directional correctness values for the high confidence cases from days 1-10. The red dots represent the skill of the low confidence cases.

The data sample can be further divided into "high signal" and "low signal" cases, where the signal strength, or confidence, is directly related to the distance between the Tropical MarketFirst track prediction and the 0000 UTC GFS track prediction (Figure 6). Directional correctness values for the high confidence forecasts range from about 60% at day 1 to near 80% by day 10. On the other hand, the skill for the lower confidence cases increases from around 55% at day 1 to 65% at day 10.

The implications of these numbers on the interpretation of the product are fairly straightforward. Tropical MarketFirst is more likely to be directionally correct

when it predicts a track sharply different than the 0000 UTC GFS. If the entire cone of uncertainty lies to the left (or right) of the 0000 UTC GFS track, you have very high confidence that the 1200 UTC GFS track will be to the left (or right) as well. On the other hand, if large portions of the cone are on both sides of the 0000 UTC GFS track, there is significant uncertainty in the 1200 UTC track.

The estimate of uncertainty in the directional movement of the 1200 UTC GFS does not apply, however, to the track error (discussed in the next section). In order words, a Tropical MarketFirst track well to the left or right of the 0000 UTC GFS track should not be expected to have a narrower uncertainty cone than a track similar to the 00Z GFS. In practical terms, a user who sees a Tropical MarketFirst track that re-curves out into the Atlantic, while the 0000 UTC GFS track traverses through the eastern Gulf, can have increased confidence that the 1200 UTC will most likely not move to the left of the 0000 UTC run and into the market-sensitive western Gulf.

c. Aggregate Skill – Mean Track Error

The track errors from the qualifying forecasts of all 12 storms were calculated and aggregated, with the results displayed in Figure 7 below. Track errors increase from about 150 km at day 1 to near 1200 km by day 10. Since we have a very limited number of cases at day 16, the mean track errors are assumed to extrapolate smoothly from the day 1-10 error signal. These mean errors are then used to derive the size of the uncertainty cones (see Figures 3 and 4 for examples).

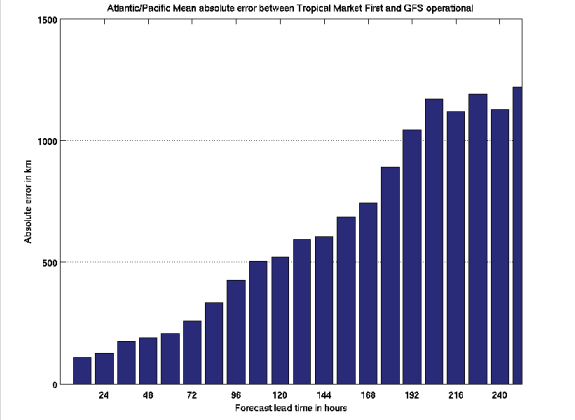

Figure 7.

Figure 7. Mean track errors (in km) for all qualifying forecasts for all 12 storms in the data set.

Conclusion

WSI Tropical MarketFirst has been developed to provide energy traders and risk managers with a skillful prediction of named tropical cyclone tracks produced by the 1200 UTC run of the GFS model, up to two hours before the model output is available to the general public. In particular, Tropical MarketFirst correctly predicts the direction of change in the track (left or right of the 0000 UTC GFS track) 65-70% of the time. These skill values increase with forecast day, ranging from 55% at day 1 to near 75% by day 10. Skill also increases with signal strength, with those Tropical MarketFirst predictions exhibiting significant deviation from the 0000 UTC GFS more likely to be directionally correct than those that are more similar to the 0000 UTC run.

About the Authors

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Todd Crawford, Ph.D., is the director of R&D for the Energy and Risk Services division at WSI. He is also the leader of WSI's subseasonal and seasonal forecasting projects, and regularly issues seasonal forecasts of temperature and precipitation for the US and Europe, along with Atlantic basin tropical activity and US hurricane landfall potential. 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 weather forecasting and thunderstorm initiation. At WSI, Dr. Crawford has developed various automated statistical forecasting techniques for use on seasonal and subseasonal time scales. He has also developed diagnostic techniques for classifying and ranking thunderstorms that are used by both the Media and Energy and Risk divisions at WSI. More recently, he has developed techniques to predict changes in numerical model output for the benefit of WSI's Energy client base, and has developed skillful techniques to predict various aspects of tropical activity, including preseason landfall forecasts and a superensemble technique to produce 10-day forecasts of existing tropical cyclones.

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Meteorologist in WSI's Forecasting Research and Development Group. He received a bachelor's degree in computer science and a master's degree in atmospheric science from MIT, where his graduate research focused on air-sea interactions of intense hurricanes. At WSI, he has concentrated on numerical weather prediction and operational forecasting for aviation clients. He also has several years experience in the financial services industry.

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