Determining the Error Characteristics of H*Wind

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Introduction

H*Wind is an analytical forecasting and research tool that assimilates tropical cyclone wind observations from multiple data platforms and creates a gridded wind analysis. This product allows forecasters to estimate the maximum wind speed and the extant of damaging winds in a tropical cyclone. Unfortunately, the error sources in H*Wind and their contributions are not well understood, and therefore the final analysis product has an unknown uncertainty. This investigation seeks to determine the error sources involved in an H*Wind analysis and to calculate their impacts on the H*Wind fields.

H*Wind Analyses

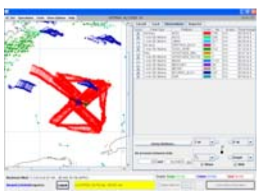

Fig 1: Screenshot of the H*Wind user interface, with observations and the 6-hour storm track plotted.

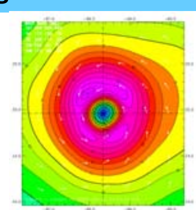

Fig 2: Sample contour plot of an H*Wind analysis.

The process of building an H*Wind analysis can be divided into several steps:

1. **Select a storm and time interval** to perform the analysis on.
2. **Set the storm track.** Most of the track information can be obtained from the H*Wind database, but sometimes interpolations and estimations are needed to get a more detailed track.
3. **Search the H*Wind database for observations.** H*Wind automatically adjusts the observations to a 10 m wind at one-minute marine exposure.
4. **Look over the observations.** Remove any data that is suspect. Also check the data for consistency (e.g. make sure the flight level winds are properly adjusted a 10 m height) and make corrections if necessary.
5. **Perform the analysis.** H*Wind creates the gridded analysis by interpolating and smoothing the data, and by enhancing the wind speeds near the center so they match the peak observed wind speed.
6. **Look over the analysis**. Check for obvious errors, and make sure the maximum analyzed wind speed in an appropriate location. Ensure that the observed wind speeds closely match the analysis.
7. **Make adjustments** to the mesh grid spacing, filter properties, and observation weights if necessary until the analysis is satisfactory.

Methods

Eighty H*Wind analyses were created, each containing data from a six-hour window. Unfortunately, there is insufficient data in any one H*Wind analysis to achieve statistically significant results; therefore, it was necessary to combine data from different storm analyses into a single data set that is large enough to produce significant results. In order to minimize errors resulting from this procedure, the wind speeds were scaled by a model function based on storm parameters. This model function was derived using a neural network.

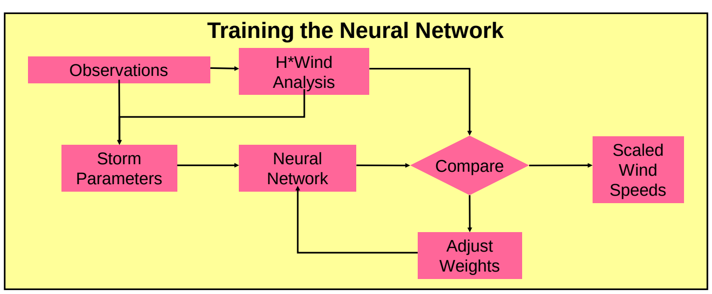

Fig 3: Schematic of the neural network algorithm.

One half of the storm analyses were used to train the neural network, which was used to calculate the scaled wind speeds for the remaining storms. Statistical calculations were then performed on the scaled wind speeds to quantify the errors and biases in the data. In addition, spectral analysis was performed on the H*Wind products to determine the filter wavelength in both radial and tangential directions.

Results

The data was binned by radius and observation type, and the mean and standard deviation of the scaled wind speed was calculated for each bin. The relative biases of each data type can be inferred from a plot of the means, shown below:

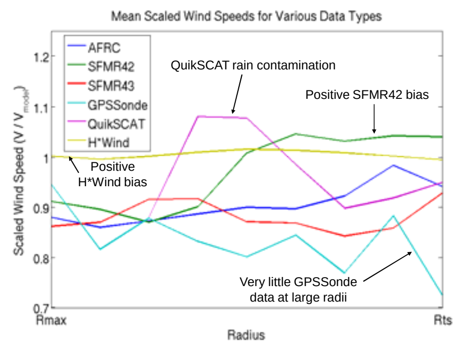

Fig 4: Mean value of observed wind speed divided by the wind speed model function for five data types and the H*Wind analysis as a function of radius. A large spread in the scaled wind speed between two or more data types signifies a large relative bias between them. Rmax and Rts refer to the radius of maximum wind and the tropical storm force wind radius, respectively.

The standard deviation for a given data type and bin represents the effects of the following errors:

- Random data errors
- Spatial variations within a data bin
- Temporal variations in the six-hour analysis window
- Errors in the scaling technique

The sum of these errors generally ranged from 10-15%, of which 2-3% was artificially created by the scaling technique.

The results of the spectral analysis are shown below.

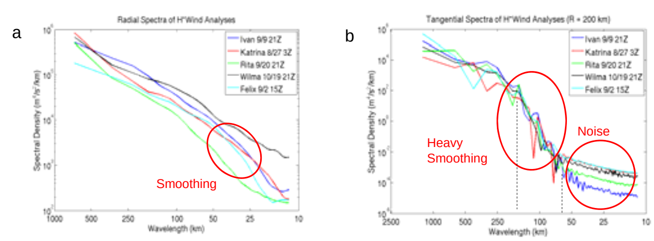

Fig 5: Spectra of five H*Wind analyses in the radial (a) and tangential (b) directions. Smoothing is present at wavelengths where the spectral density decreases sharply, and noise is present at wavelengths where the slope of the spectral density is horizontal.

Conclusions

Sources of error in H*Wind can be divided into two basic groups: Observation errors and analysis errors. Observation errors included random errors, spatial and temporal variations, and relative biases between different observation platforms. The sum of these errors was found to be on the order of 10-15%, with higher errors present in data types that had large biases.

The H*Wind analyses generally introduced a positive bias near the storm center; it is hypothesized that this bias results from the enhancement scheme near the eyewall that ensures the analysis resolves the highest observed wind speed. The H*Wind could not resolve small-scale variability away from the eyewall, limiting the ability of H*Wind to resolve small scale features such as outer rain bands. Users of H*Wind in both operational and research fields must consider these characteristics, as well as the spatial and temporal scales, in order to quantify the uncertainties associated with the product.

References

Brennan, M.J., C. C. Hennon, and R.D. Knabb, 2009: The operational use of QuikSCAT ocean surface vector winds at the National Hurricane Center. *Wea. & Forecasting,* **24,** 621-645.

Kent, E.C., P.K. Taylor, and P.G. Challenor, 1998: A comparison of ship- and scatterometer-derived wind speed data in open ocean and coastal areas. *Int. J. Rem. Sens.,* **19,** 3361-3381.

Powell, M.D., S. H. Houston, and T. A. Reinhold, 1996: Hurricane Andrew's landfall in South Florida. Part I: Standardizing measurements for documentation of surface wind fields. *Wea. & Forecasting,* **11,** 304-328.

Powell, M.D. and S. H. Houston, 1996: Hurricane Andrew's landfall in South Florida. Part II: Surface wind fields and potential real-time applications. *Wea. & Forecasting,* **11,** 329-349.

Powell, M.D. et al., 1998: The HRD real-time hurricane wind analysis system. *J. Wind Eng. Ind. Aerodyn.,* **77 & 78,** 53-64.

Willoughby, H.E., R.W.R. Darling, and M.E. Rahn, 2006: Parametric representation of the primary hurricane vortex. Part II: A new family of sectionally continuous profiles. *Mon. Wea. Rev.,* **134,** 1102-1120.