Statistical Optimization of Tropical Cyclone Model Parameters

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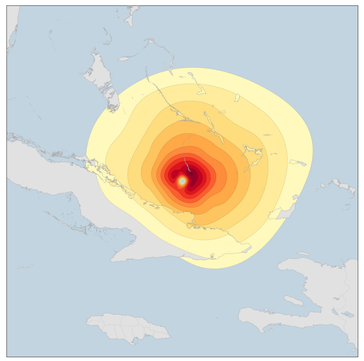
Background

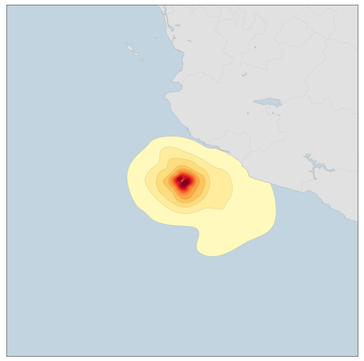
Moody's RMS HWind snapshots are objective analyses of tropical cyclones (TCs). These snapshots, which depict an instantaneous view of a TC's wind field, are composed of standardized wind observations from dozens of data platforms. Such platforms include but are not limited to aerial reconnaissance, remote sensing networks, coastal/oceanic platforms, and inland surface stations. However, when quality or coverage of these observations is insufficient, a parametric wind field model may be employed to produce an estimate of a TC's wind field.

A typical parametric wind field model requires inputs of position, intensity, radius of maximum wind (RMW), and shape parameter(s) that determine the rate at which wind speeds decrease from the RMW. For Hurricane Patricia in 2015, the decay length (X1) may be small, as winds decayed very rapidly with radial distance from RMW. For other TCs such as Hurricane Irma in 2017, X1 may be greater, because winds decreased gradually from RMW.

Hurricane Irma



Hurricane Patricia



Figures 1 and 2: Moody's RMS HWind snapshots of Hurricane Irma and Hurricane Patricia

Objectives

- Improve objectivity of modeled Moody's RMS HWind Snapshots
- Save time for analysts using a wind model. Manually selecting an X1 parameter is often a challenging and time-consuming process.

Methodology

- Download and process operational wind radii data for a given storm from the Automated Tropical Cyclone Forecasting System (ATCF)'s B-Deck dataset using Python.
- Moody's RMS North Atlantic Hurricane parametric wind field model was ran iteratively using various X1 values. With each run, Mean Absolute Percentage Error (MAPE) was computed using the objective ATCF radii and the forecasted parametric model radii.
- After all iterations, three X1s values were selected. Each X1 value was selected to best fit MAPE for R34, R50, and R64 wind radii, respectively.
- Moody's RMS HWind snapshot images were generated for all three X1 values.

Example Figures

Figure 3: Parametric snapshot done by HWind Meteorological Analyst

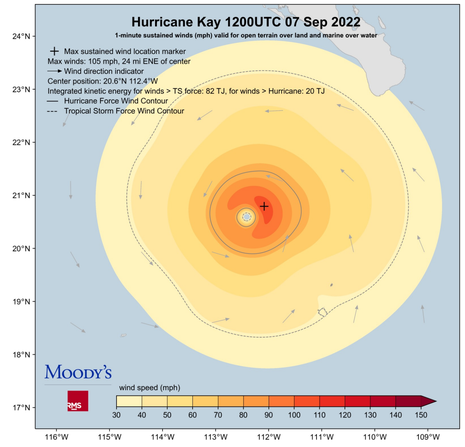


Figure 4: Parametric snapshot, MAPE optimized for R34

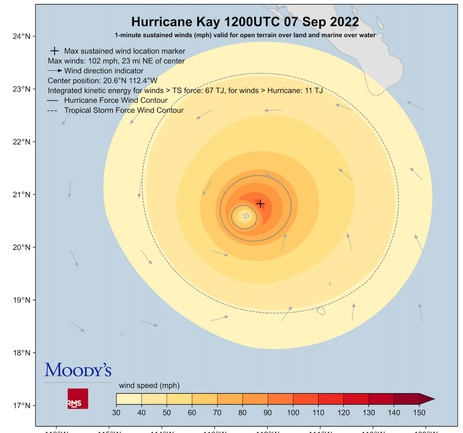
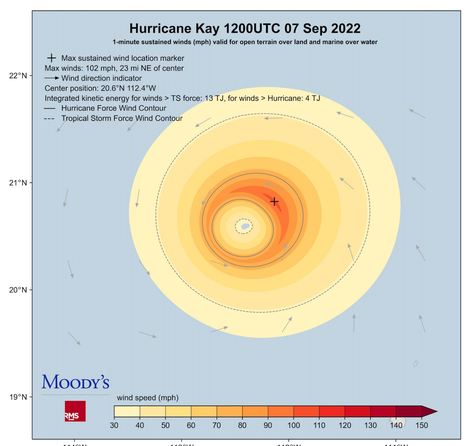


Figure 5: Parametric snapshot, MAPE optimized for R64



Results

- The methodology was effective at producing similar analyses done by an HWind Meteorological Analyst (Fig 3).
- Particularly, the X1 found by optimizing MAPE to fit R34 (Fig 4) was the most realistic of the three X1s. Optimizing for R64 was the least realistic (Fig 5).
- On TCs with highly asymmetric wind fields, the methodology struggled to achieve results comparable with a Meteorological Analyst.
- In future work, MAPE optimization of both decay length and parameters that govern TC asymmetry may prove useful.
- However, optimization of multiple model parameters may be especially challenging. The current methodology can be computationally intensive, and this is expected to increase with additional parameters to optimize.

Conclusions

Optimizing X1 through MAPE is an effective technique in finding a representative decay length in a parametric TC model. In addition to the current objectives, this methodology has other perks:

- Quickly generating an accurate parametric wind field will be very useful for any future research on parametric wind models.
- Once approved for operational use, the methodology will facilitate creation of products that use parametric models for clients.

References

- 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. *AMETSOC*. https://journals.ametsoc.org/view/journals/mwre/134/4/mwr3106.1.xml (Accessed March 16, 2023).

Acknowledgements

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