# Hybrid Statistical-Dynamical Probabilistic Prediction of Hurricane Landfall Winds

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## Introduction

- Motivated by the needs of our clients in the energy and insurance sectors, CFAN has developed a hybrid statistical-dynamical technique to produce forecasts of 2D hurricane landfall winds at high spatial and temporal resolutions.
- The goal of this study is to improve the skill of the wind field forecast by developing a calibration scheme that incorporates hurricane intensity forecasts along with real time observations of hurricane intensity.

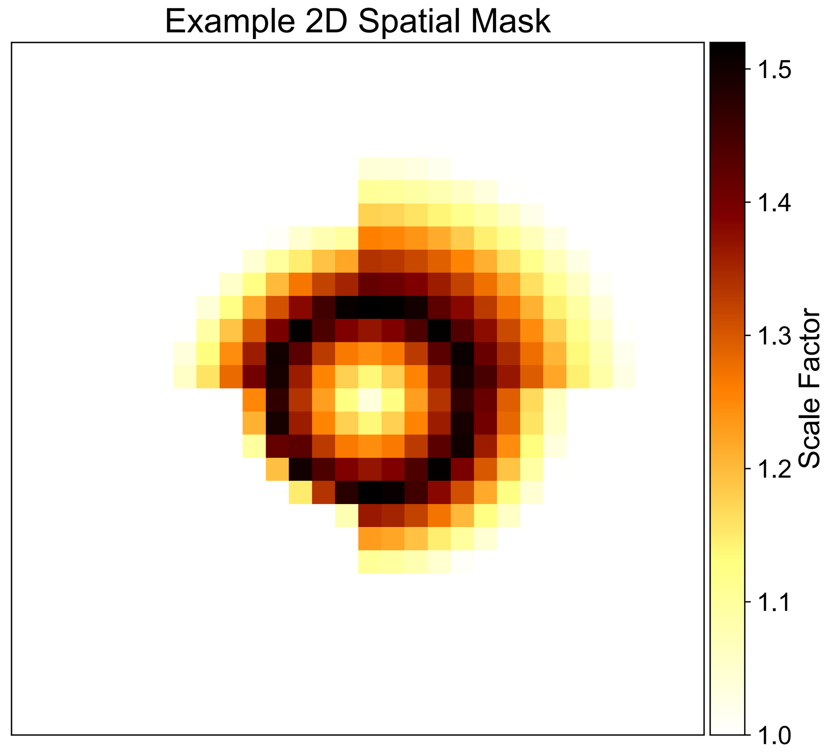
## Background

- CFAN's ECMWF and GEFS based landfall wind forecasts are based upon the raw model winds that are downscaled using a radial wind model (Holland et al. 2010) to 5 km.
- CFAN provides a calibrated intensity forecast for all storms that performs better than the landfall wind field forecasts. The calibrated intensity forecasts are generated by incorporating real time intensity observations and model hindcasts to remove historical biases and distributional errors.
- CFAN's forecast of landfalling winds for several recent landfalling hurricanes – notably Irma and Michael – produced peak winds that were substantially too low.

## Methodology

1. The ECMWF and NCEP forecast tracks and maximum intensity are calibrated using model hindcasts and historical track/maximum intensity information (CFAN Intensity).
2. Using a radial wind model, the coarse-resolution wind-fields are downscaled to 5 km resolution.
3. The resulting 2D wind field is interpolated to a 1-hr resolution and is scaled to the calibrated intensity for each time step.
4. The wind field is scaled horizontally from the center of the storm to the NHC R64 observation to preserve the shape of the storm.
    - This is done by applying a 2D spatial mask that scales the wind field based on the CFAN scale factor (example below).

Example 2D Spatial Mask

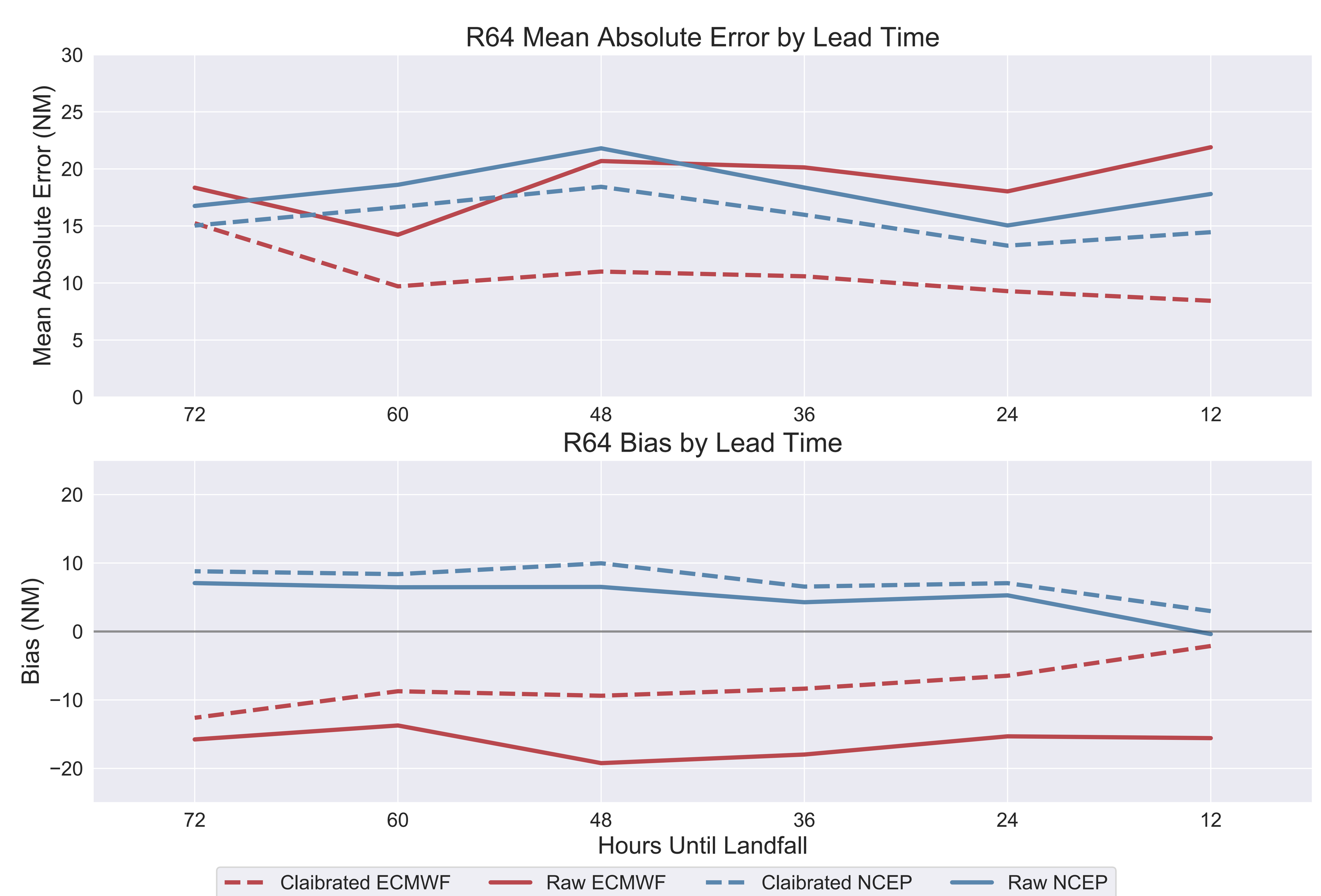



## Error Evaluation

- Error statistics of intensity mean absolute error (MAE) and intensity bias are used to evaluate the performance of the calibration technique
- Evaluation was performed for 5 landfalling hurricanes (Hermine, Irma, Nate, Florence, and Michael) for all forecasts within 72 hours of landfall

## Intensity Error

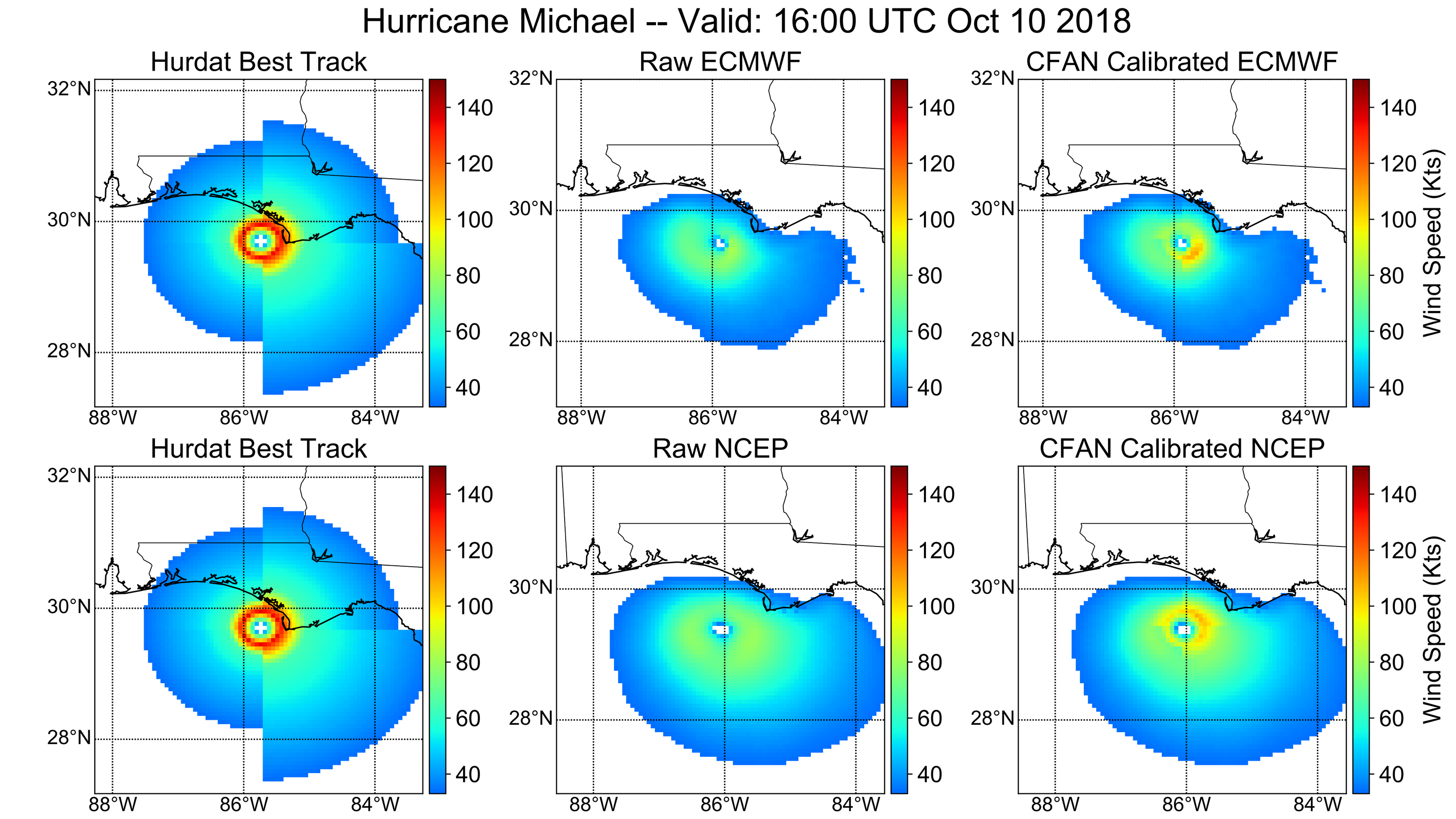

## R64 Error

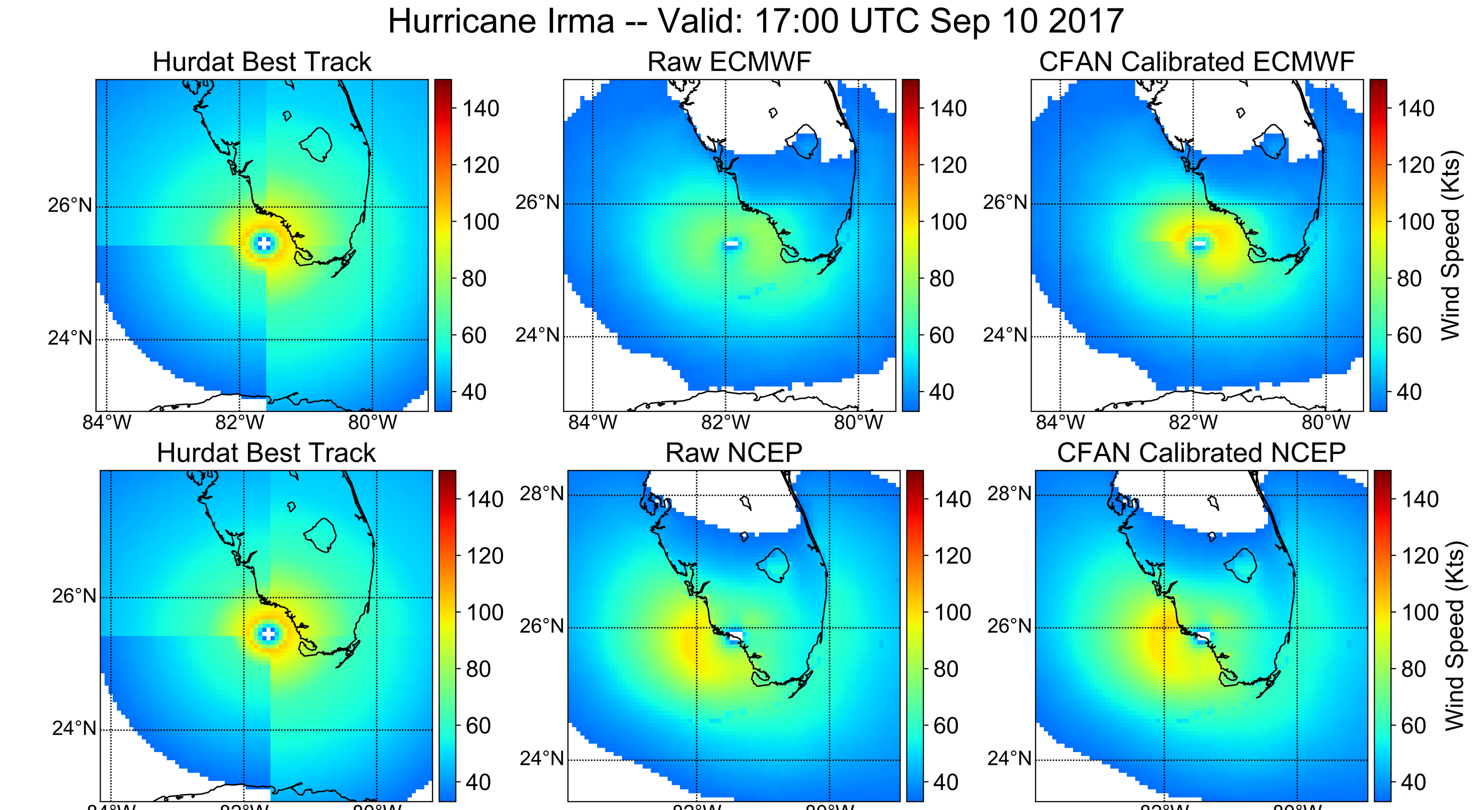



- ECMWF and NCEP intensity error is reduced for all lead times
- ECMWF intensity bias shifts from completely negative to mostly positive
- ECMWF and NCEP R64 error is reduced for all lead times

## Hurricane Wind Field Forecast

- The following images show a forecast of the 2D wind field for Hurricane Michael (2018) and Hurricane Irma (2017) 2 hours before landfall




- Substantial improvement relative to the observed winds is seen from the calibration of the 2D wind field relative to the uncalibrated wind fields for both Michael and Irma.
- The largest improvement occurs with ECMWF forecast with a smaller (but still significant) improvement for the NCEP forecast.

## Conclusions

- Using statistical and dynamical information we were able to improve the intensity error at all lead times from 0-72 hours
- Using NHC R64 observations to control the extent of the wind field that the calibration is applied to helps reduce wind field R64 errors closer to landfall while also retaining the shape of the forecasted wind field

## References

Holland, G.J., J.I. Belanger, A. Fritz, 2010: A revised model for radial profiles of hurricane winds. *Mon. Wea. Rev.*, **138**, 4393-4401.