

Transitioning Ensemble-based TC Track and Intensity Sensitivity to Operations: Current Status and Future Plans

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Overview

- Resource limitations make it difficult to comprehensively observe the atmosphere
- Sensitivity analysis provides an objective method of identifying potential high-impact observation locations for a given forecast metric
- Current operational TC track targeting methodology is 20+ years old
 - based on steering flow standard deviation, but does not necessarily guarantee that this will impact forecast TC position

Overview

- Other ensemble-based methodologies, such as the ensemble-based sensitivity method, may be better suited because it allows the user to apply TC-related metrics
- First tested for observation targeting in a semi-operational environment during NOAA SHOUT campaign (2015 and 2016)
- Demonstrated with NHC forecasters using ECMWF forecasts during 2017 and 2018

Ensemble Sensitivity

$$\frac{\partial J}{\partial x_{t-\delta t, j} e} \equiv \text{cov}(\mathbf{J}, \delta \mathbf{X}_{t-\delta t, j}) \mathbf{D}_j^{-1} = \frac{\text{cov}(\mathbf{J}, \mathbf{X}_j)}{\text{var}(\mathbf{X}_j)}$$

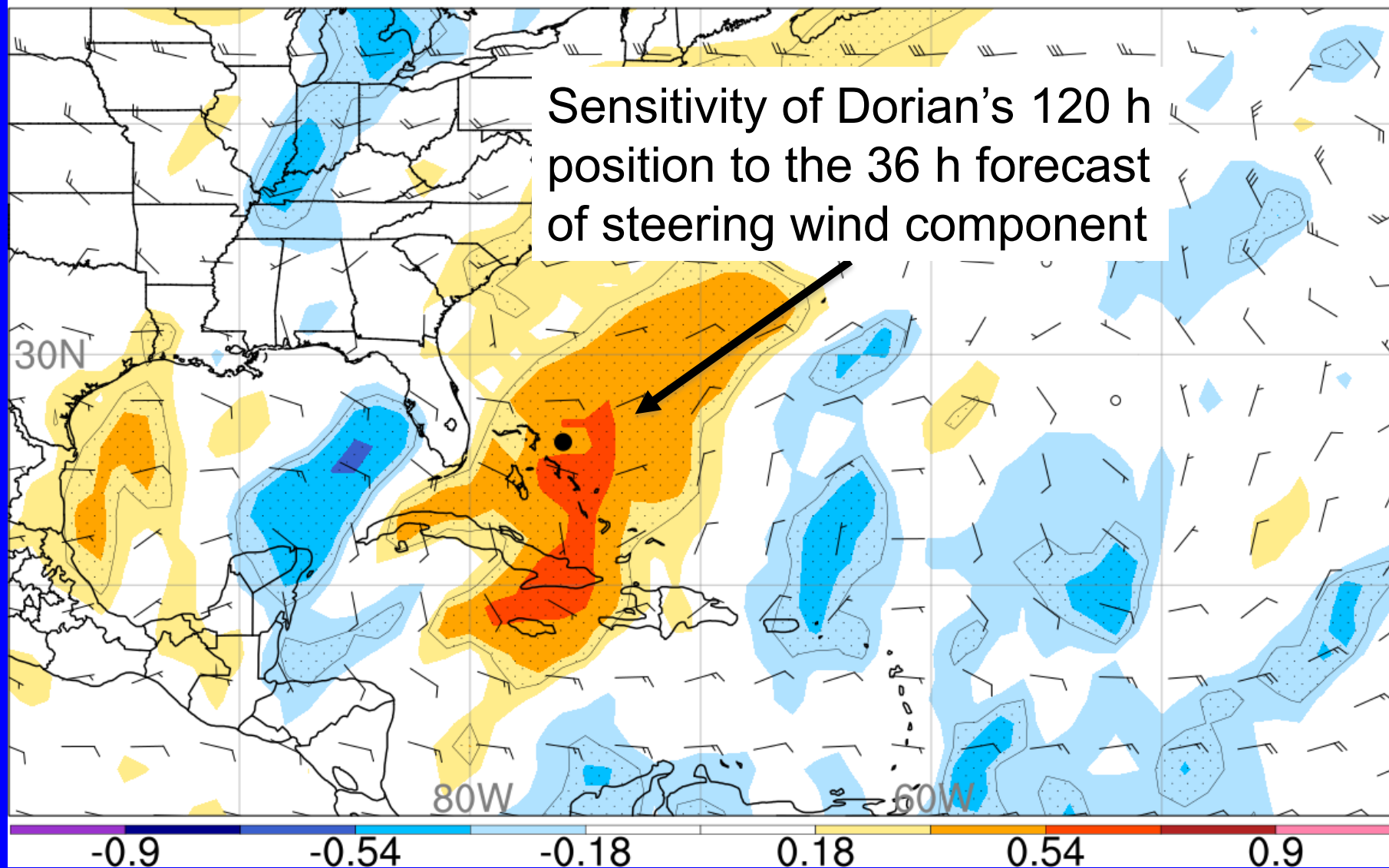
Ancell and Hakim 2007, Torn and Hakim 2008

- Ensemble-based method of computing the sensitivity to model state variables at earlier time
- Above equation is linear regression based on ensemble:
 - Dependent variable is ensemble estimate forecast metric (e.g., position along major axis of variability)
 - Independent variable is ensemble estimate of state variable at a location at an earlier time (e.g., component of steering flow)

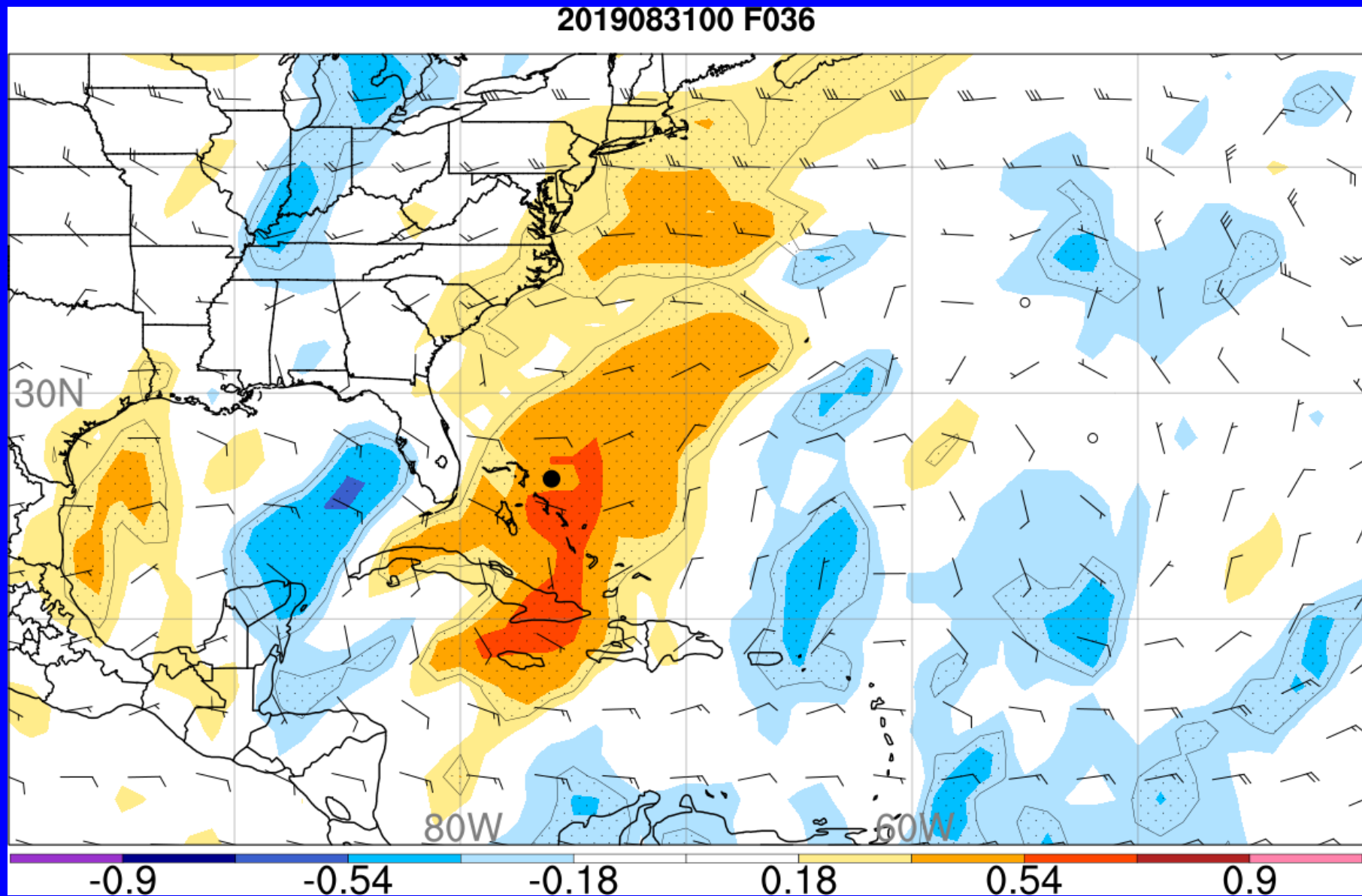
Sensitivity Example

2019083100 F036

Sensitivity of Dorian's 120 h position to the 36 h forecast of steering wind component



Sensitivity Example



Project Objective

- Develop a concise ensemble-based sensitivity product that could be used to identify sensitive regions for TC track forecasts, which could be used to develop aircraft flight tracks and/or identify set of supplemental rawinsondes
 - Test new fields/metrics and figure styles that reduce forecaster analysis time
 - Write single, concise python package
 - Add capability to use sensitivity fields in traveling salesman software

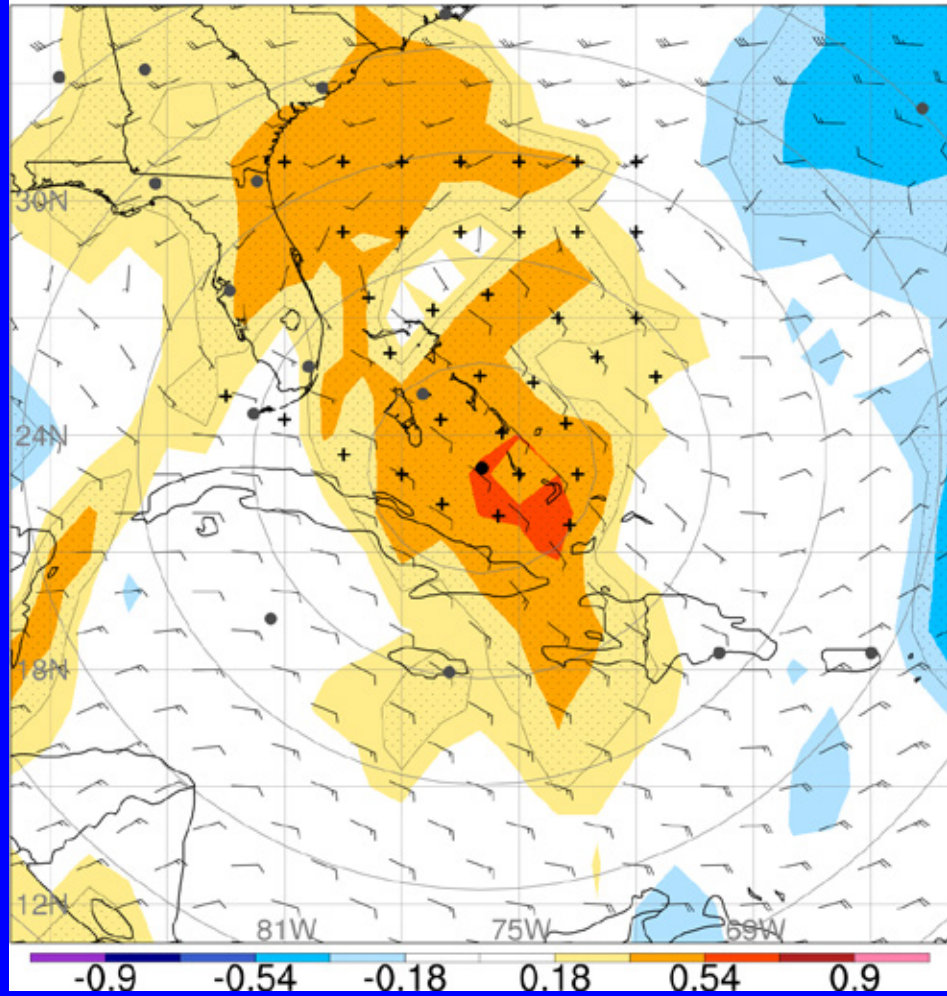
2020 Highlights

- Ran methodology daily on all storms that were present at 0000 UTC
- Provided daily summary of sensitivity output on 25 potential G-IV flights for 7 storms (Isaias, Laura, Marco, Beta, Delta, Zeta, Eta)
- Debut of python-based software package
- Extension to GEFs-based sensitivity
- Incorporation of sensitivity fields in track drawing software and AWIPS II

Hurricane Isaias

0000 UTC
1 August 2020

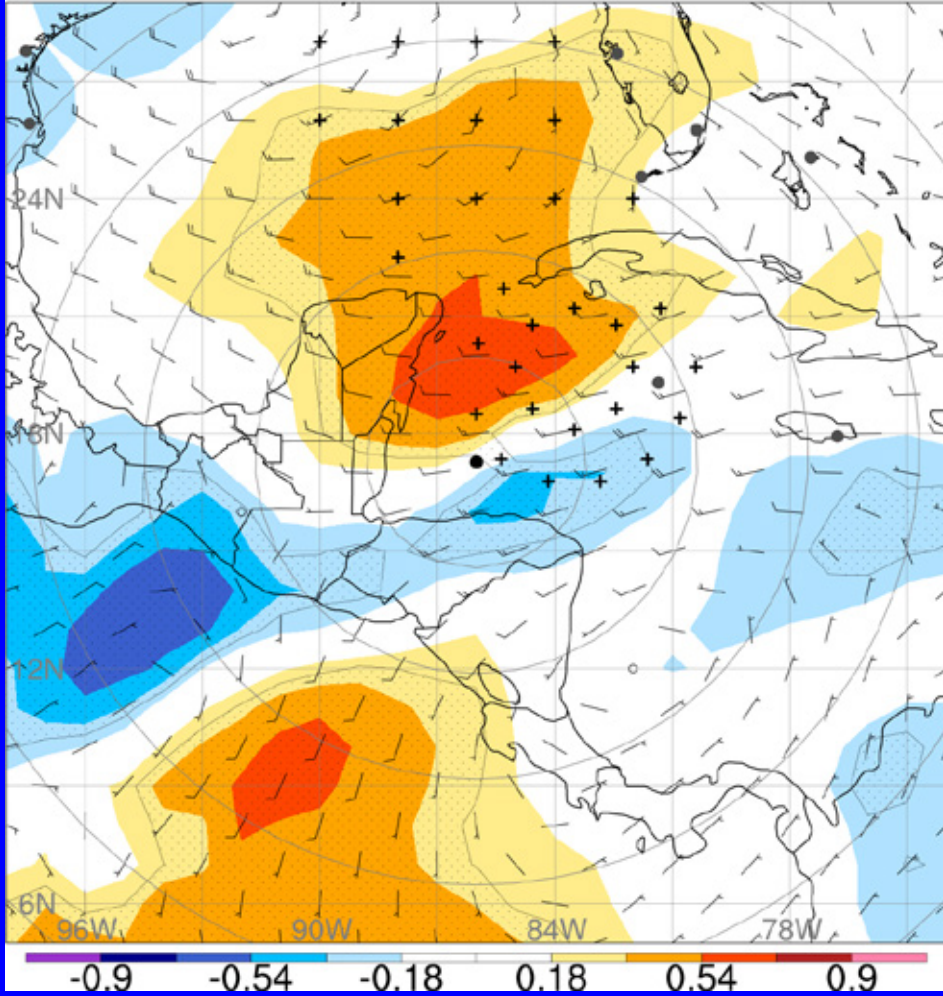
F024 Layer-Average Meridional Wind



Tropical Storm Eta

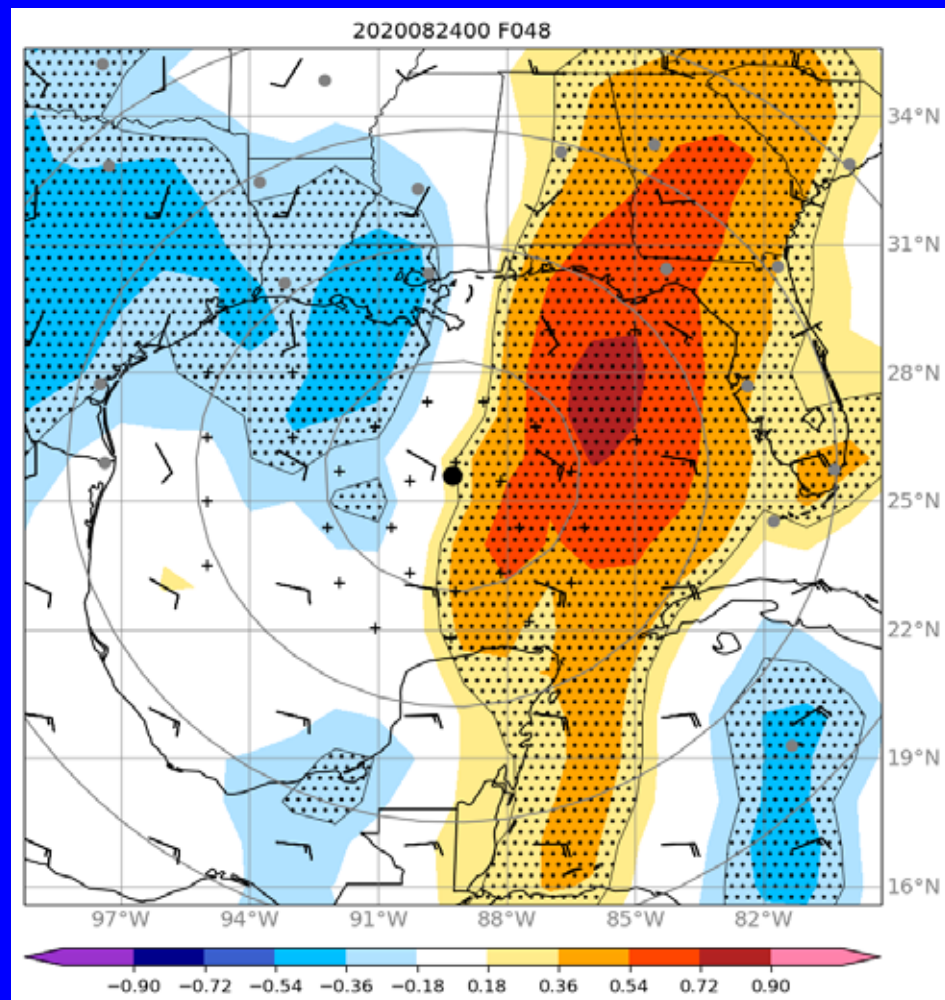
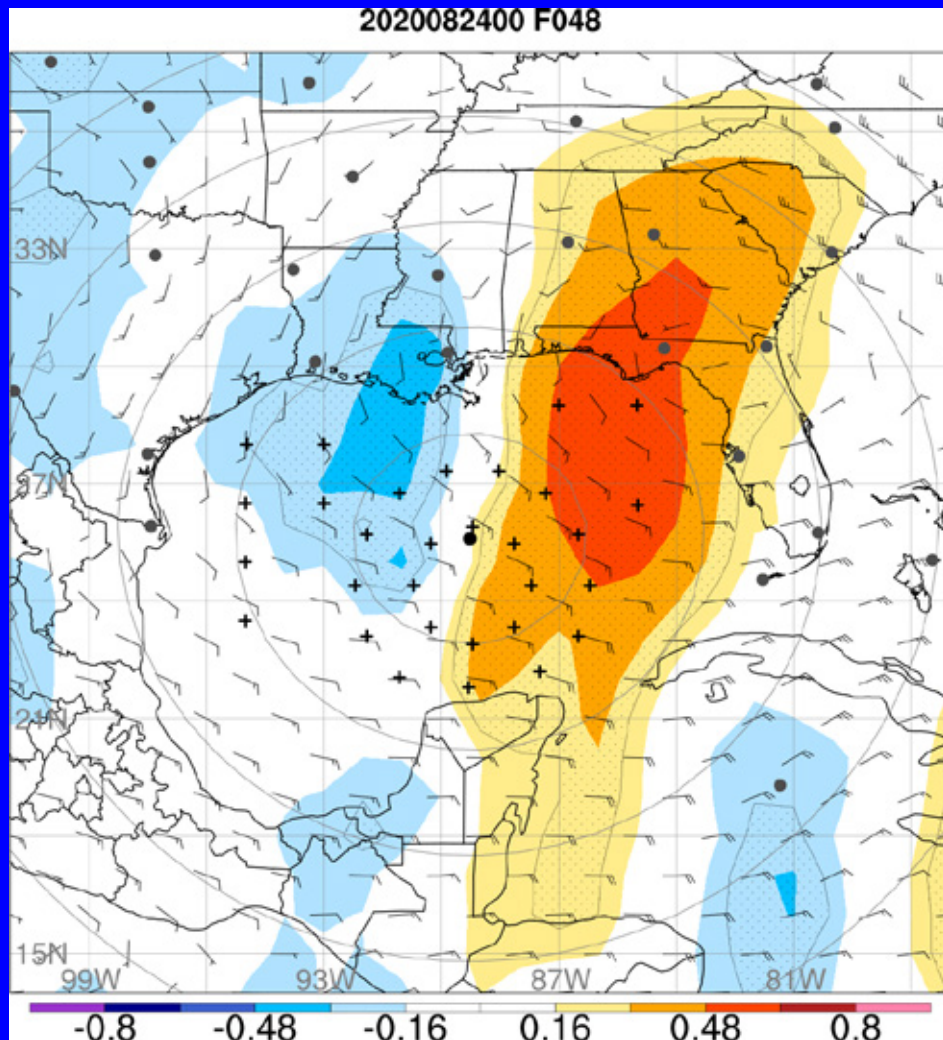
1200 UTC
7 November 2020

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Original Code

Python-based Code



Hurricane Laura forecast initialized 0000 UTC 24 August 2020, valid 48 h later

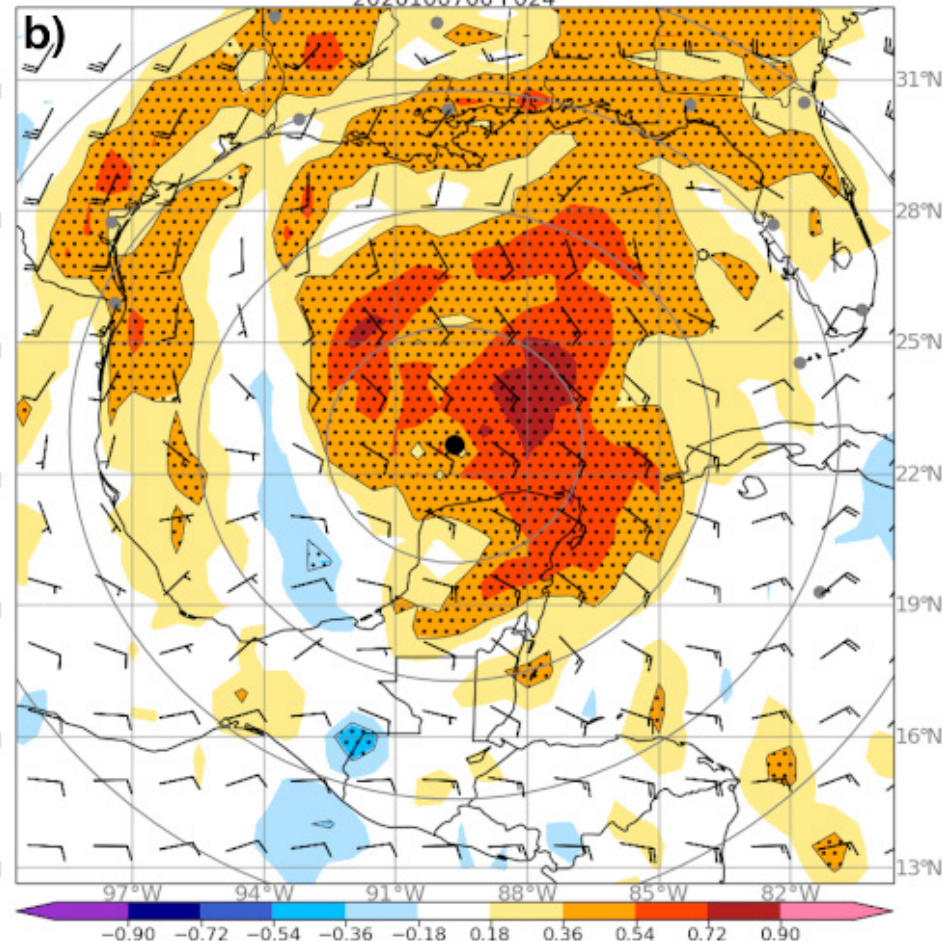
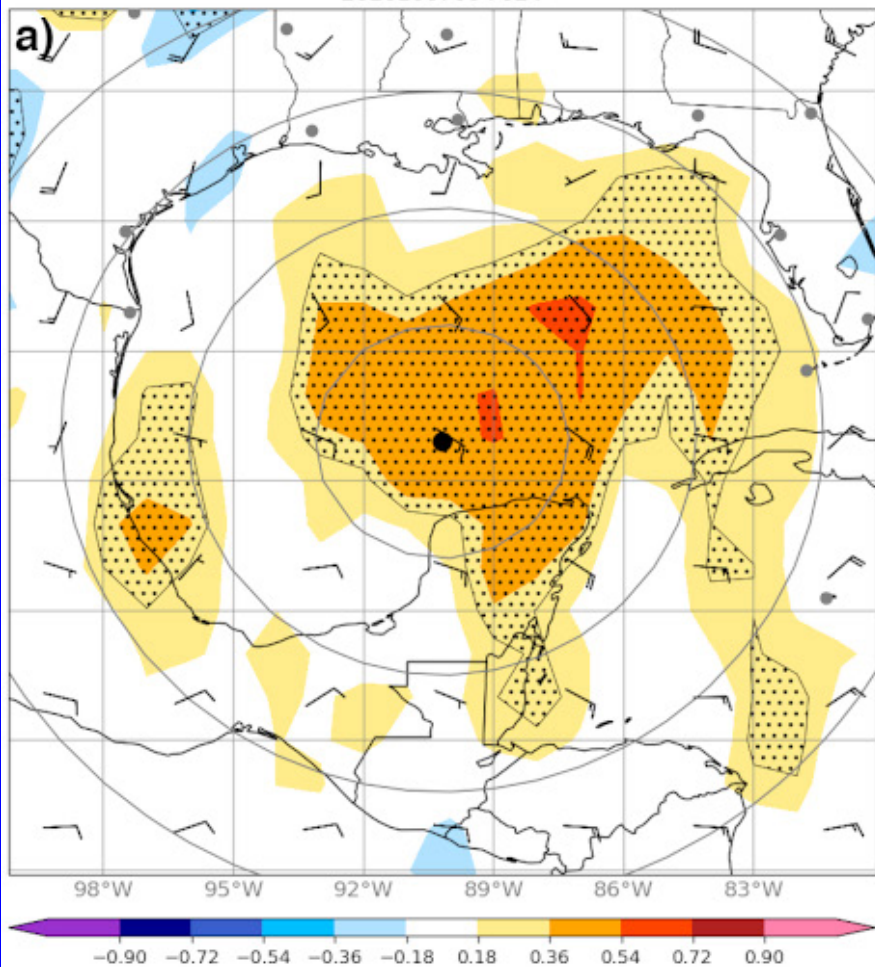
Sensitivity Comparison

ECMWF

GEFS

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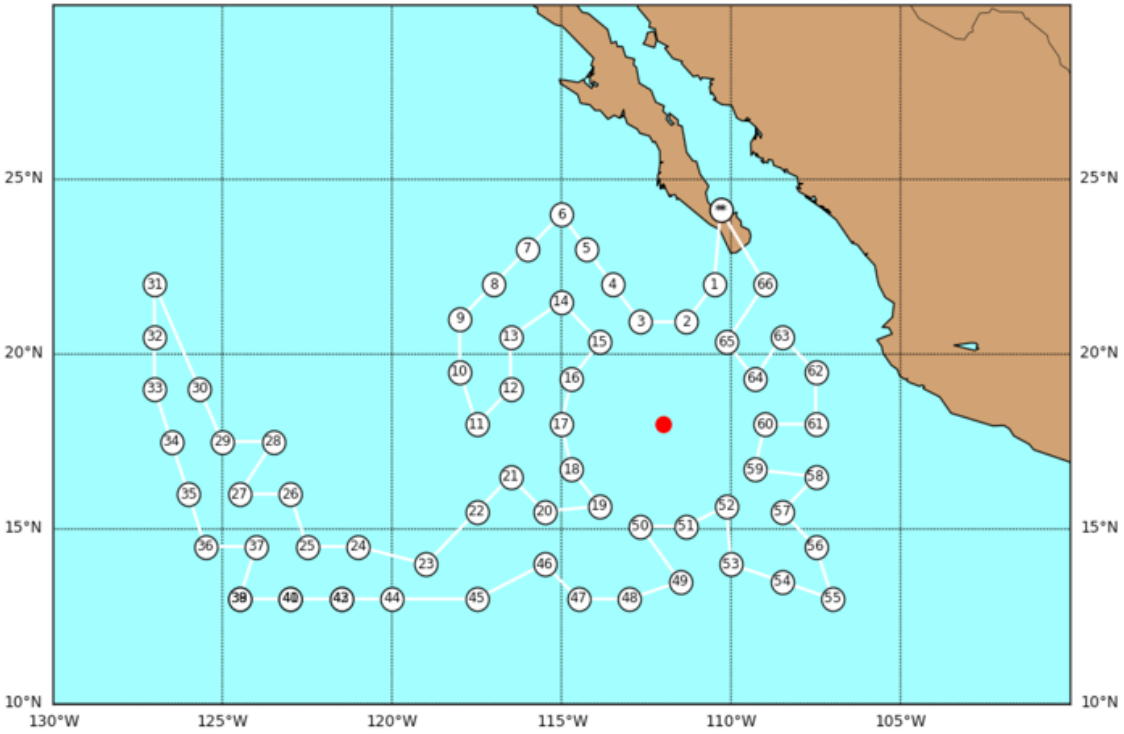
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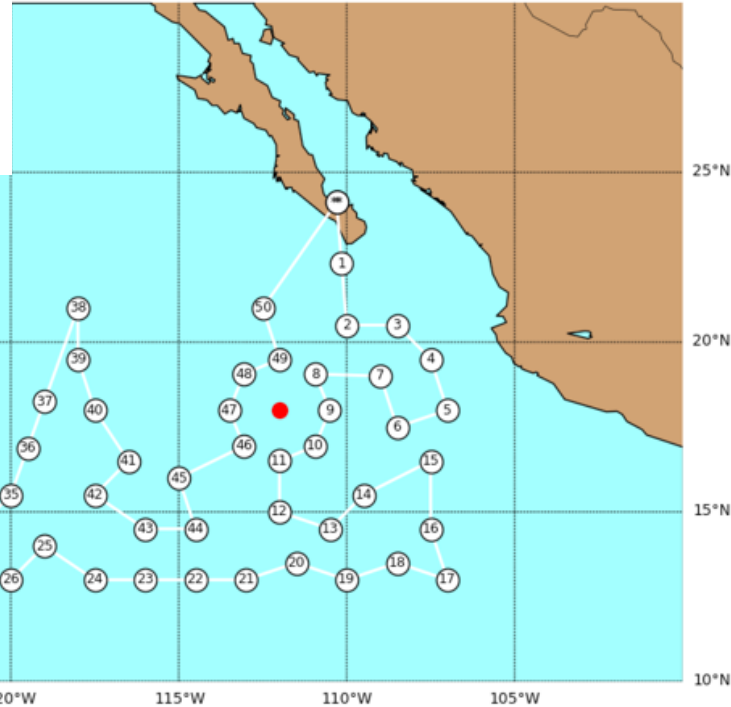
Hurricane Delta forecast initialized 0000 UTC 7 October valid 24 h later

NOAA G-IV Flight Track Drop Locations for TESTGEFS (EP052020)
On 2020070812 the storm was centered at 18 N; -112.00 W

Original Method

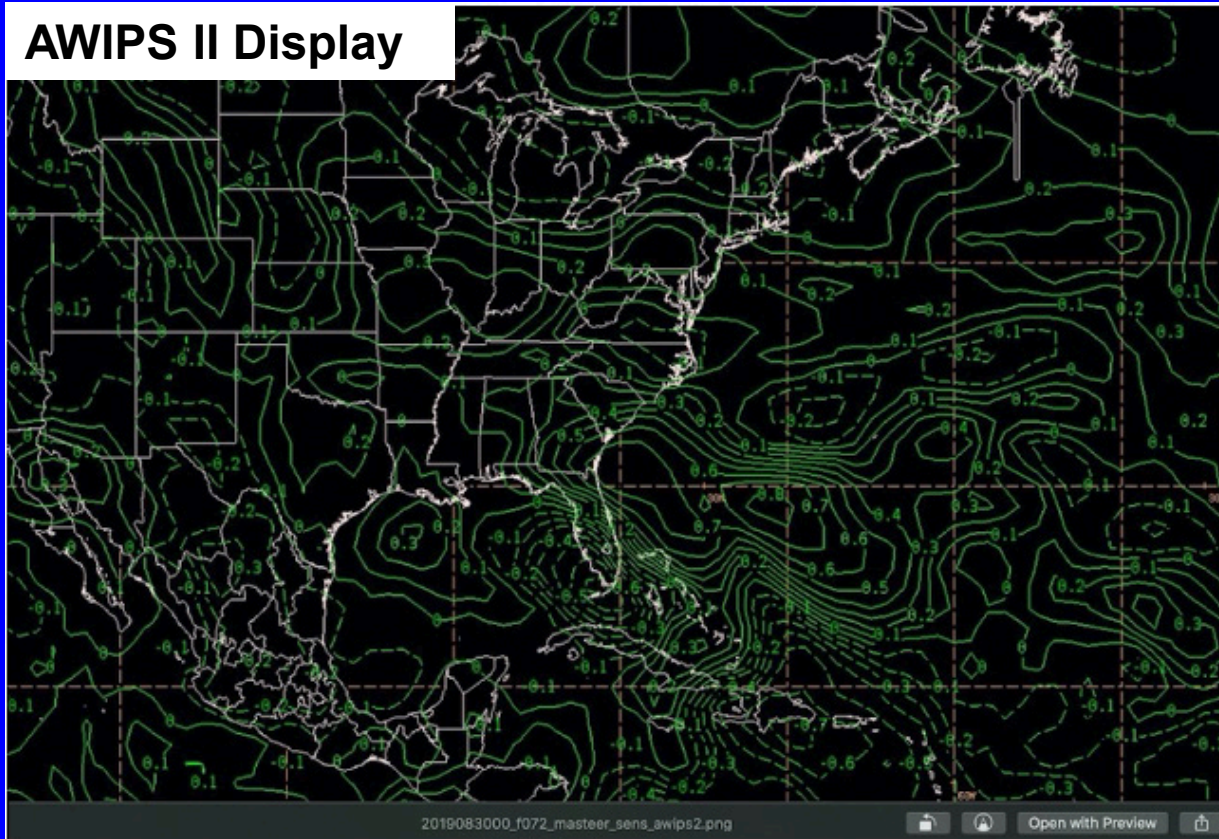


Track Drop Locations for TEST (EP052020)
The storm was centered at 18 N; -112.00 W



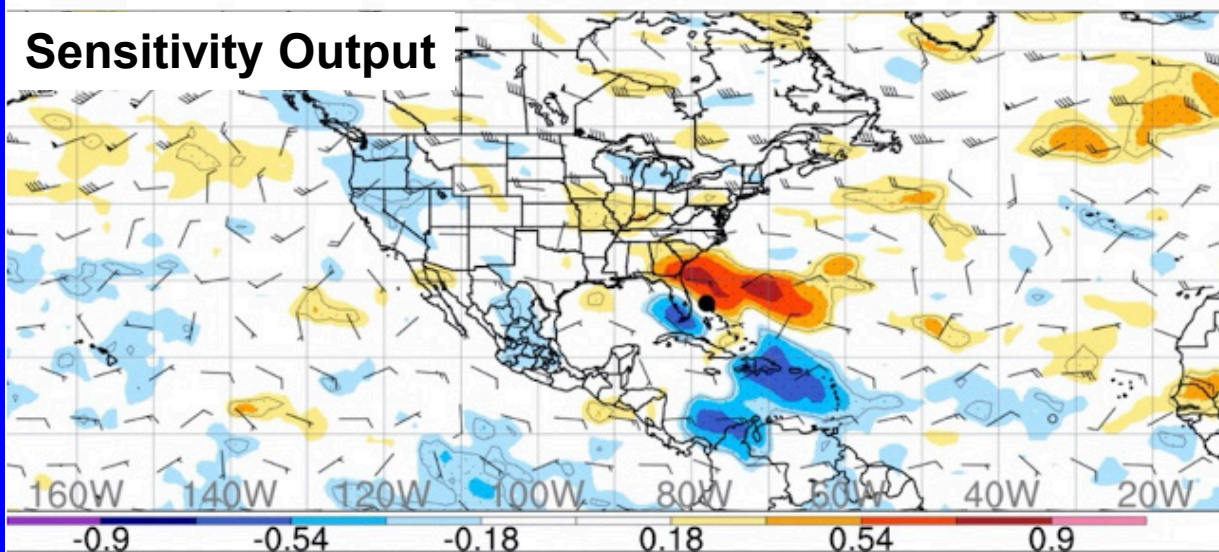
Sensitivity-Based

AWIPS II Display



2019083000 F072

Sensitivity Output



Future Plans

- Run python-based software on NHC computing system in parallel to UAlbany
- Work with JHT facilitator to finish flight software and AWIPS II adaptation
- Develop training module on how to use sensitivity output
- Further analysis of particularly sensitive cases (i.e., Hurricane Marco)
- Test applying technique to other metrics (i.e., intensity, wind field, rainfall)