Application of HWRF ensemble forecasts for prediction and observation targeting

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Overview

- Ensemble forecasts can be used for many purposes beyond obtaining better deterministic forecasts
- One of those applications is determining locations where additional observations might be beneficial to a subsequent forecast
- Could be used to design particular flight tracks around and within TCs where supplemental data could improve forecast

Ensemble Obs. Impact

- Can estimate the impact of an observation using ensemble estimates of forecast metric (J) and observations (HX^b) using:

$$\delta\sigma = -\mathbf{J}(\mathbf{H}\mathbf{X}^b)^{\mathrm{T}}(\mathbf{H}\mathbf{P}^b\mathbf{H}^{\mathrm{T}} + \mathbf{R})^{-1}\mathbf{H}\mathbf{X}^b\mathbf{J}^{\mathrm{T}}$$

Estimated from ensemble forecast data

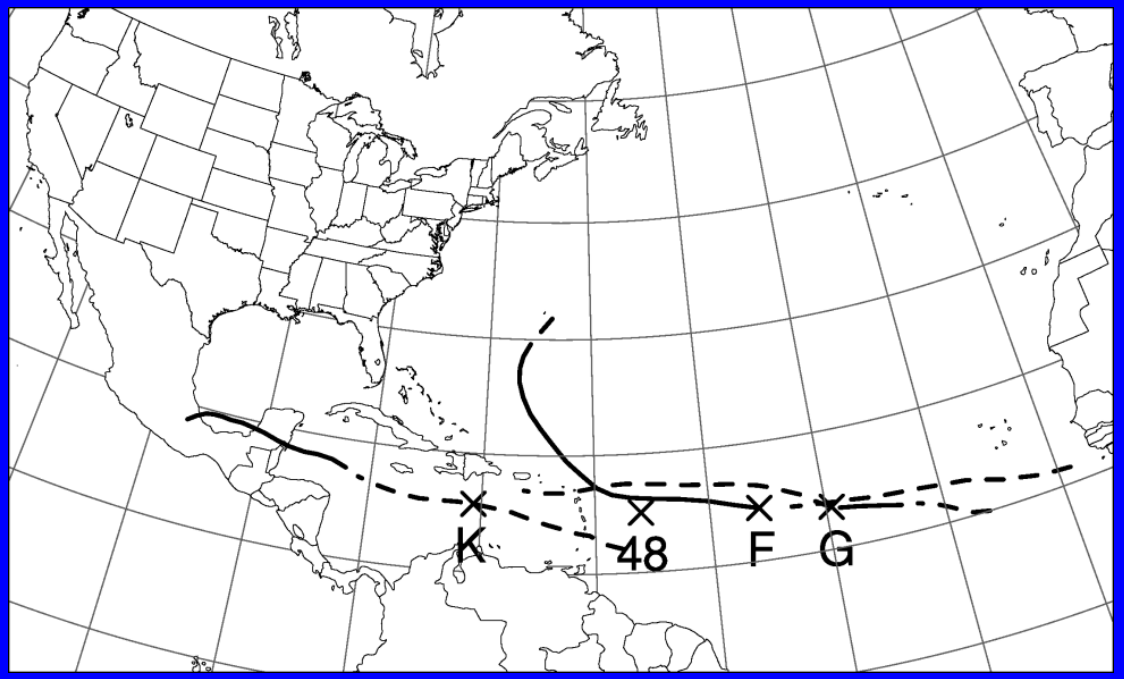
Proportional to sensitivity of forecast metric to model estimate of the observation

Proportional to ratio of uncertainty in model to uncertainty in observation

Ancell and Hakim (2006), Torn and Hakim (2007), Torn (2014)

Ensemble Assimilation Details

- WRF ARW (v3.1), 36 km horizontal resolution, 96 ensemble members, DART assimilation system.
- Observations assimilated each six hours from surface and marine stations (P_{sfc}), rawinsondes, Tri-agency dropsondes (at least 100 km from any TC), ACARS, sat. winds, TC position and minimum SLP, and GPS refractivity starting 1 August
- Cycle observations on 12 km nested domains that follow INVEST + TCs
- Initialize 96 ensemble forecasts each 12 h from analysis ensemble. Nested domain for most interesting INVEST

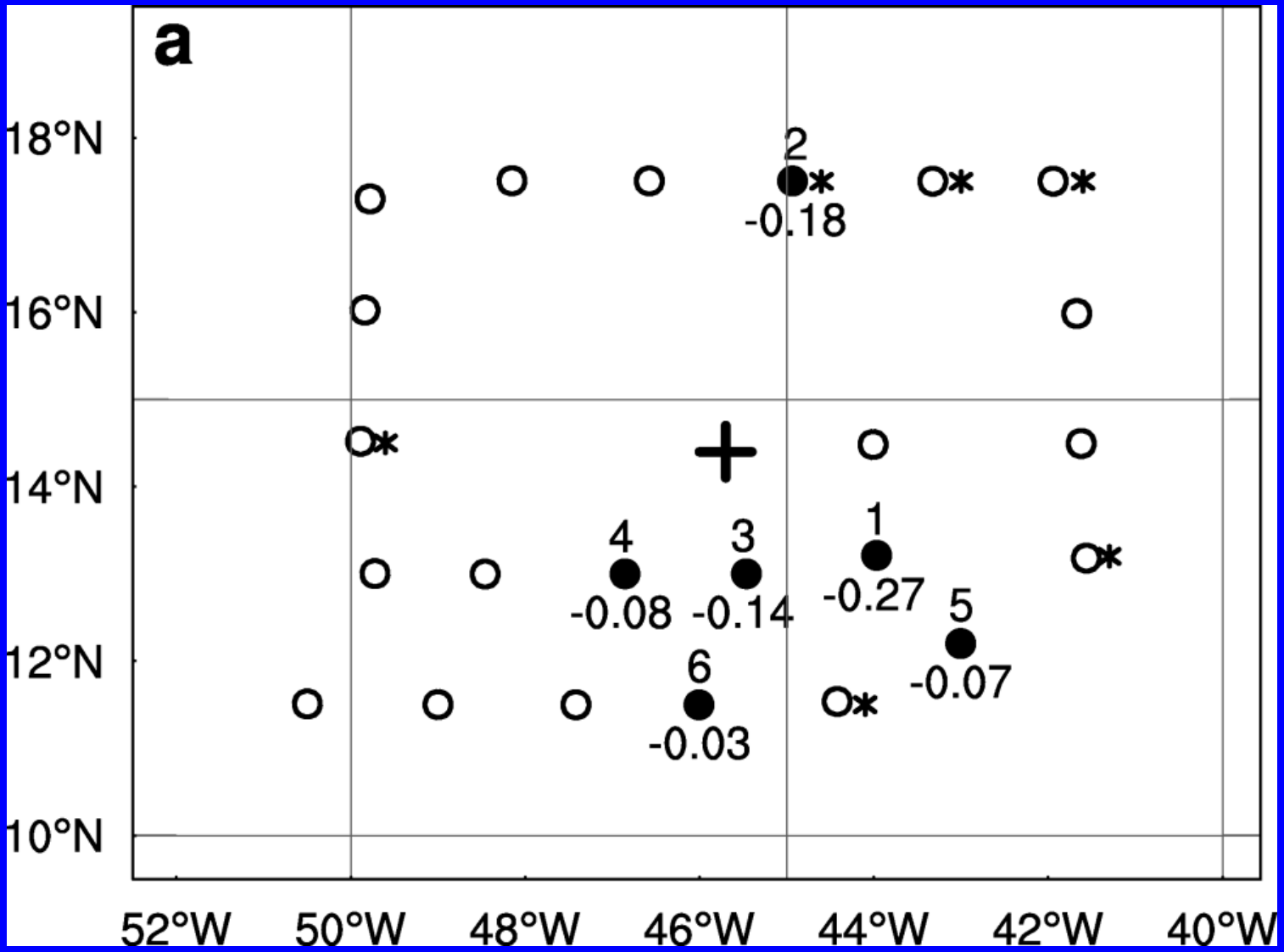


Experiment Description

- Run identical data assimilation experiments, except for number of PREDICT dropsonde profiles:
  - No Dropsonde Data (NoDrop)
  - All Dropsonde Data (AllDrop)
  - Targeted Dropsonde data (TargetDrop)
  - Random set of dropsondes (RandomDrop)
- Measure impact of observations on 48 h 850 hPa circulation associated with TC

Torn (2014, MWR)

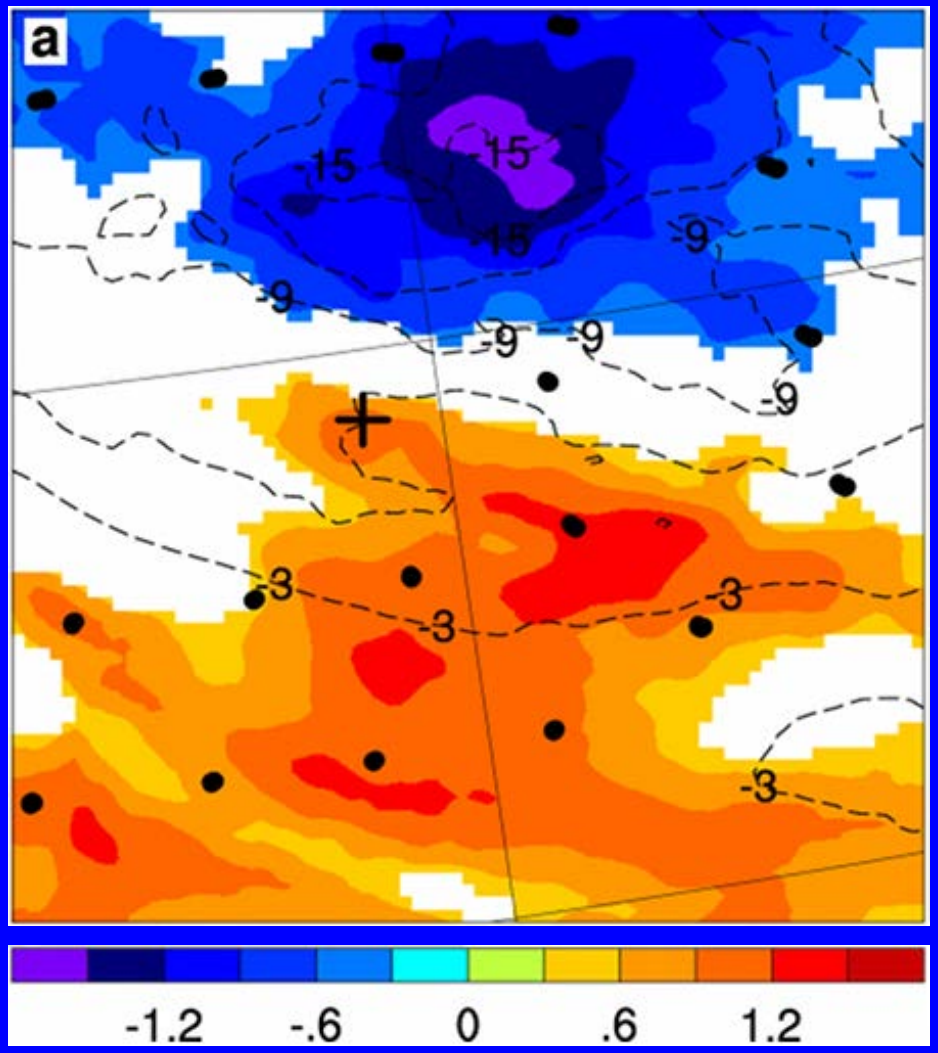
Tropical Storm Fiona



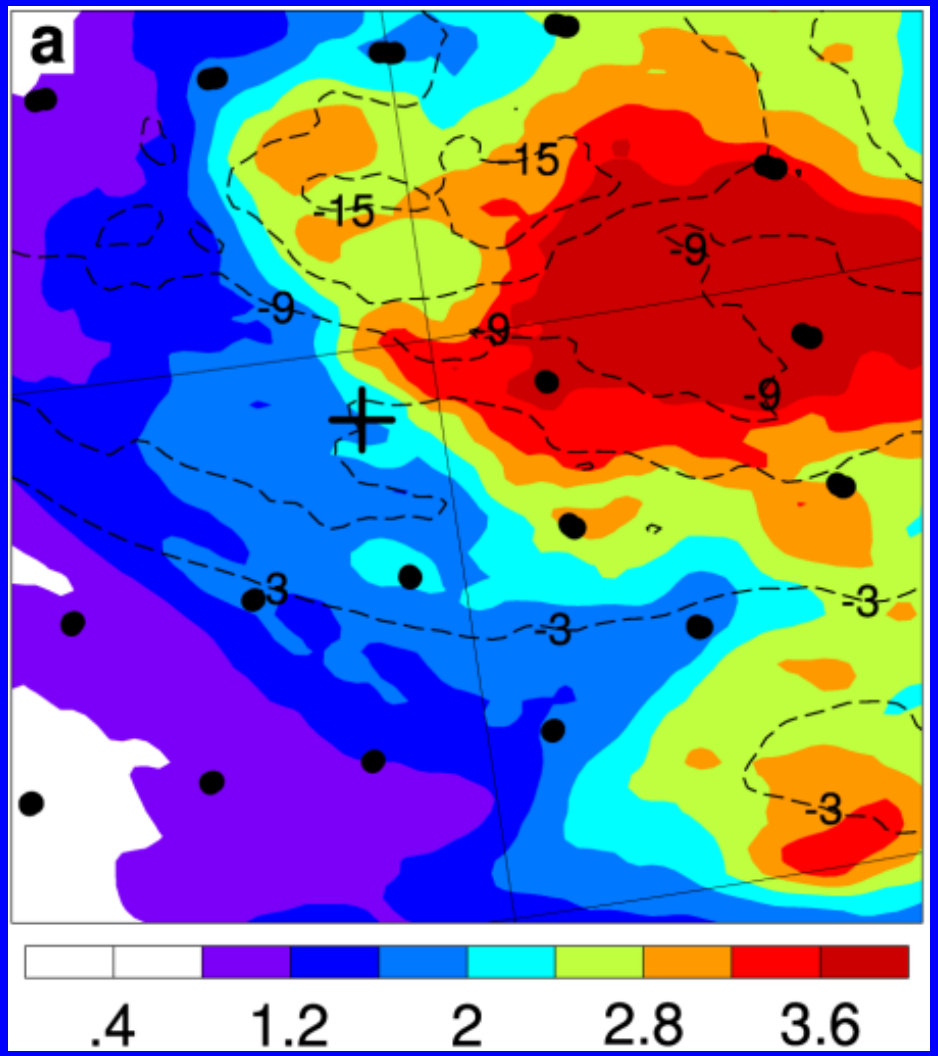
Torn (2014, MWR)

850 hPa Zonal Wind

Sensitivity

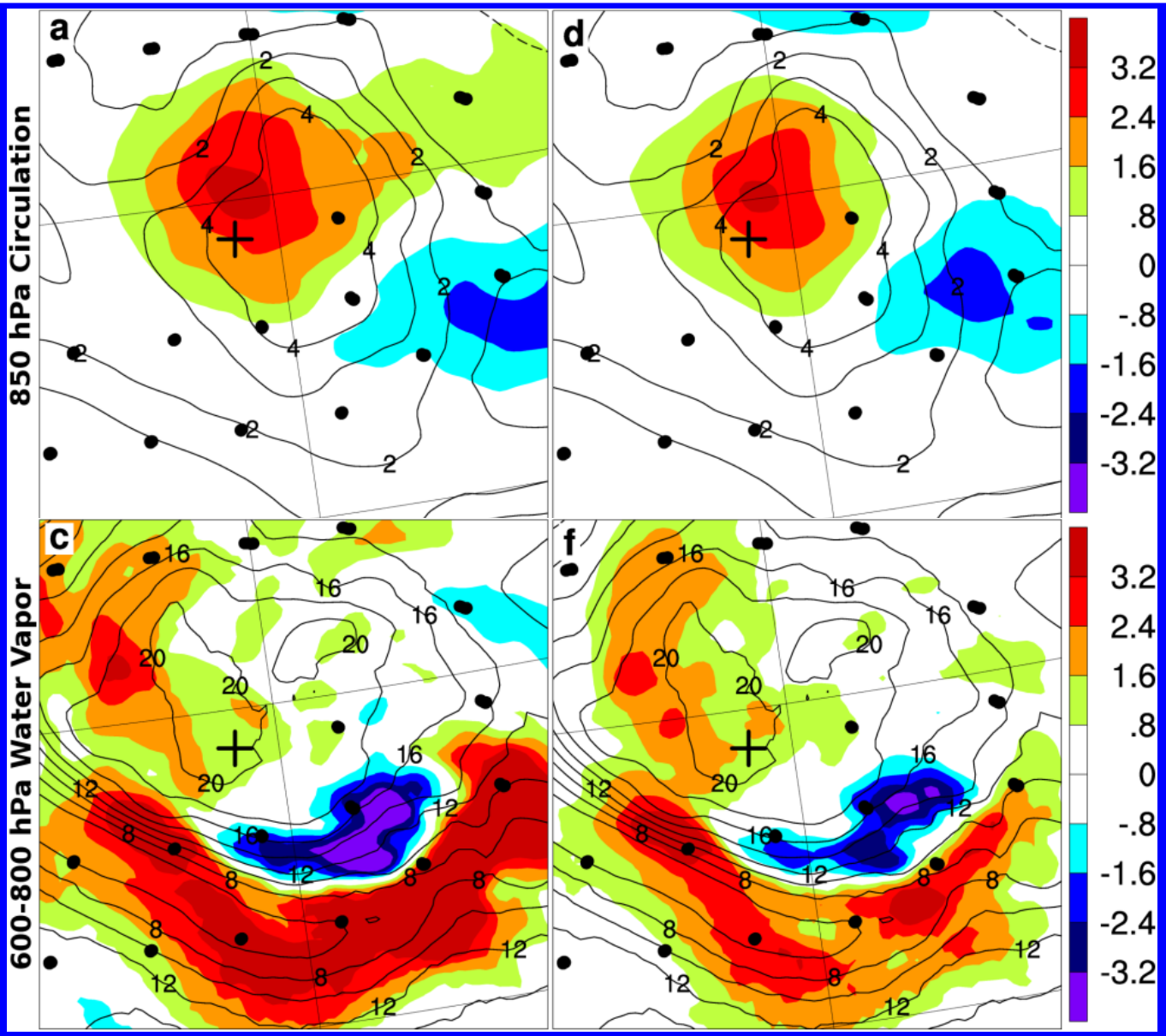


Ensemble Standard Deviation

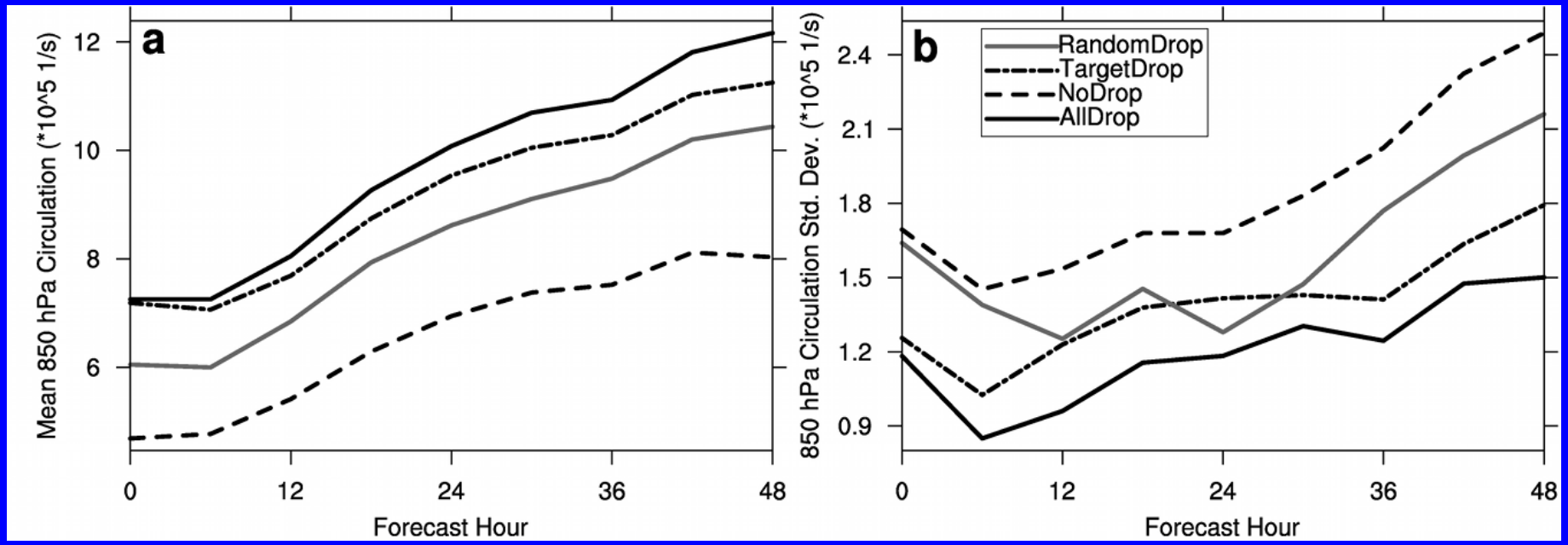


Torn (2014, MWR)

Analysis Increments



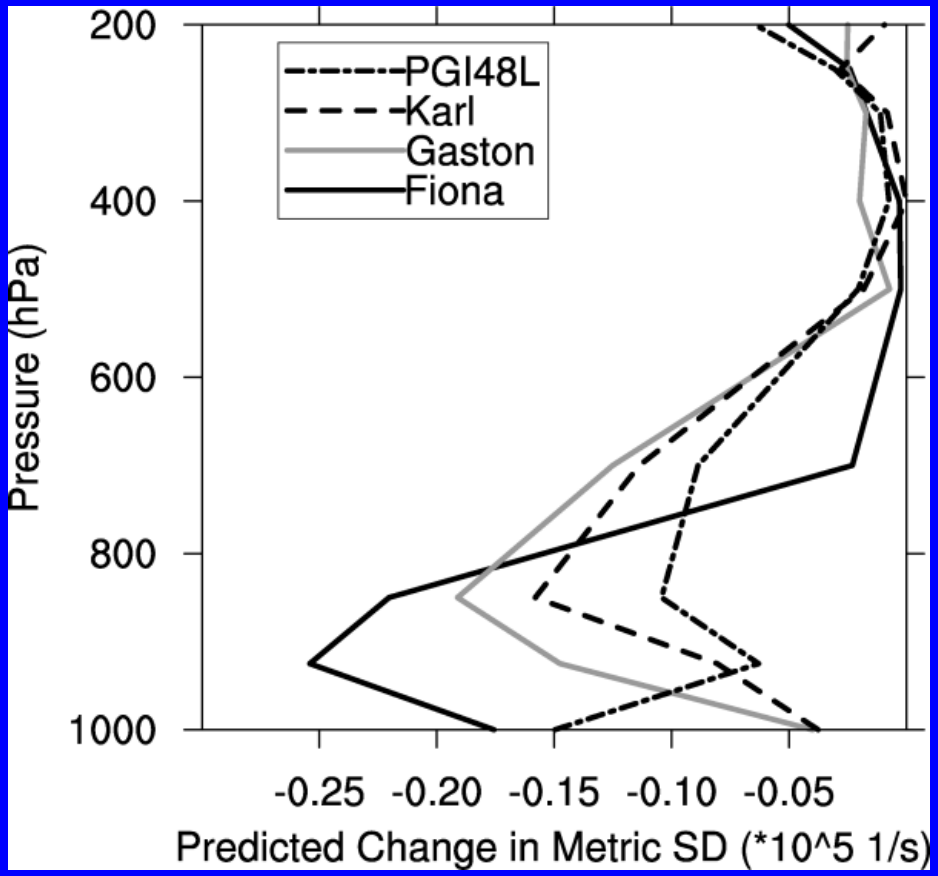
Forecast Results



Torn (2014, MWR)

- Dropsondes reduce intensity later in forecast
- Target set has nearly same impact as assimilating all
- Same result obtained for three other cases during PREDICT

Observation Impacts

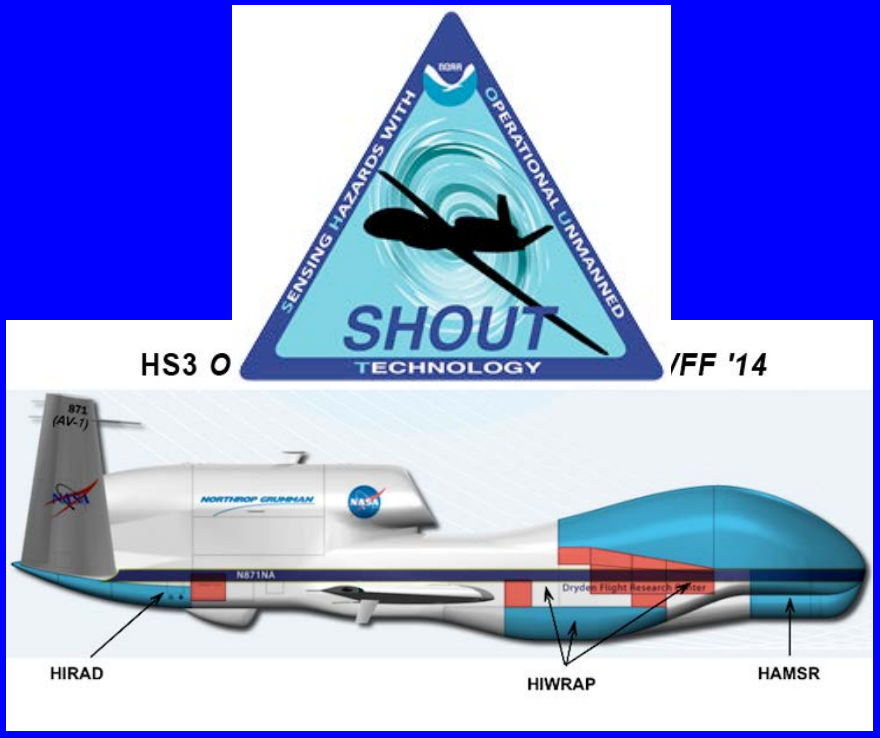


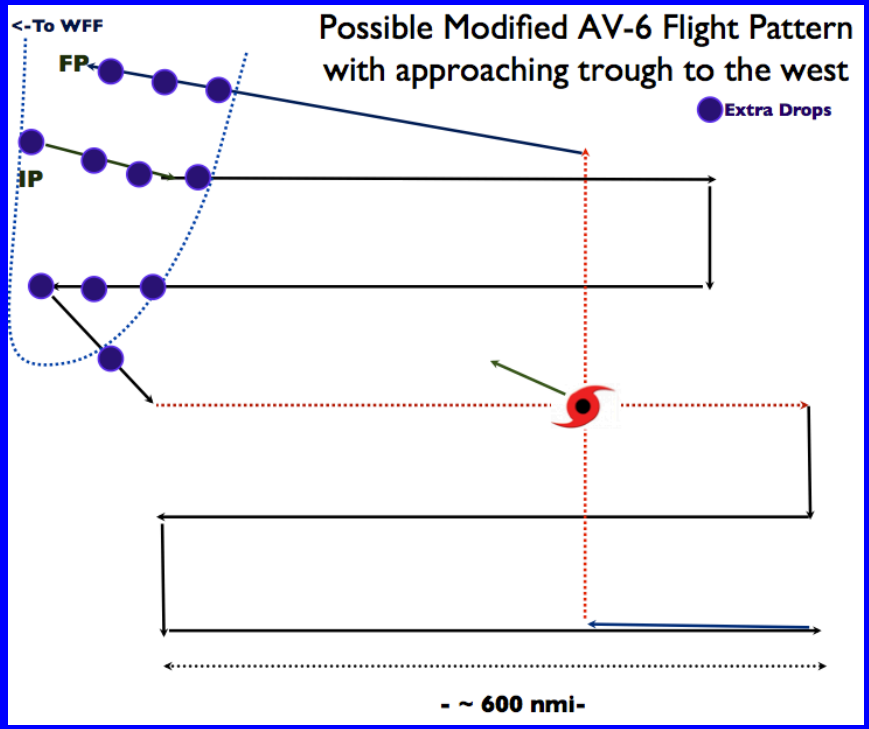
Torn (2014, MWR)

Initialization Time	Zonal Wind	Meridional Wind	Temperature	Specific Humidity
1200 UTC 30 August	-0.57	-0.10	-0.09	-0.0002
1800 UTC 2 September	-0.21	-0.17	-0.21	-0.0008
1200 UTC 12 September	-0.08	-0.27	-0.10	-0.008
1800 UTC 30 September	-0.22	-0.23	-0.07	-0.03

SHOUT Application

- Recently completed SHOUT field project provided first opportunity to apply this method in real-time
- Focus was on benefit from dropsonde data

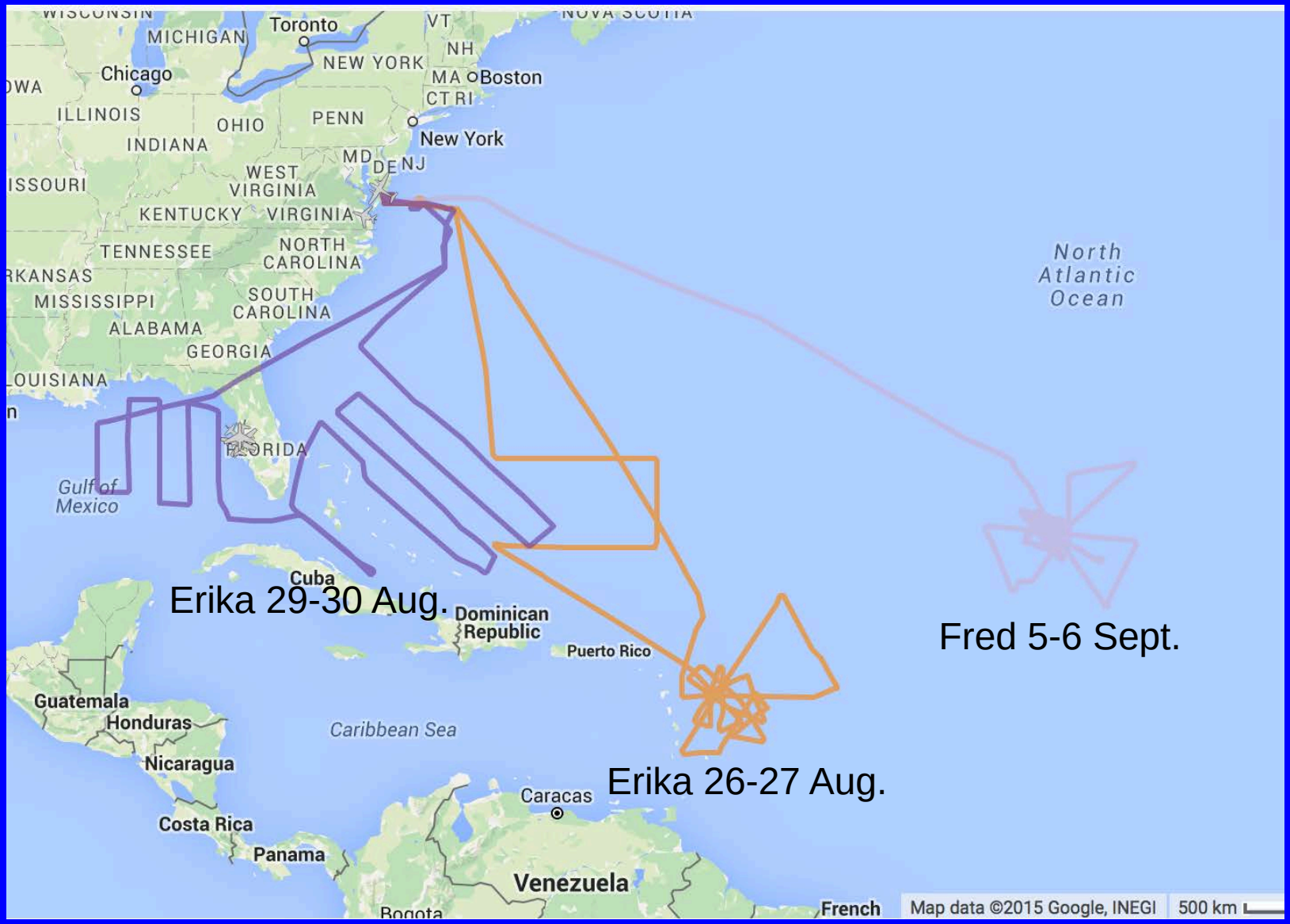


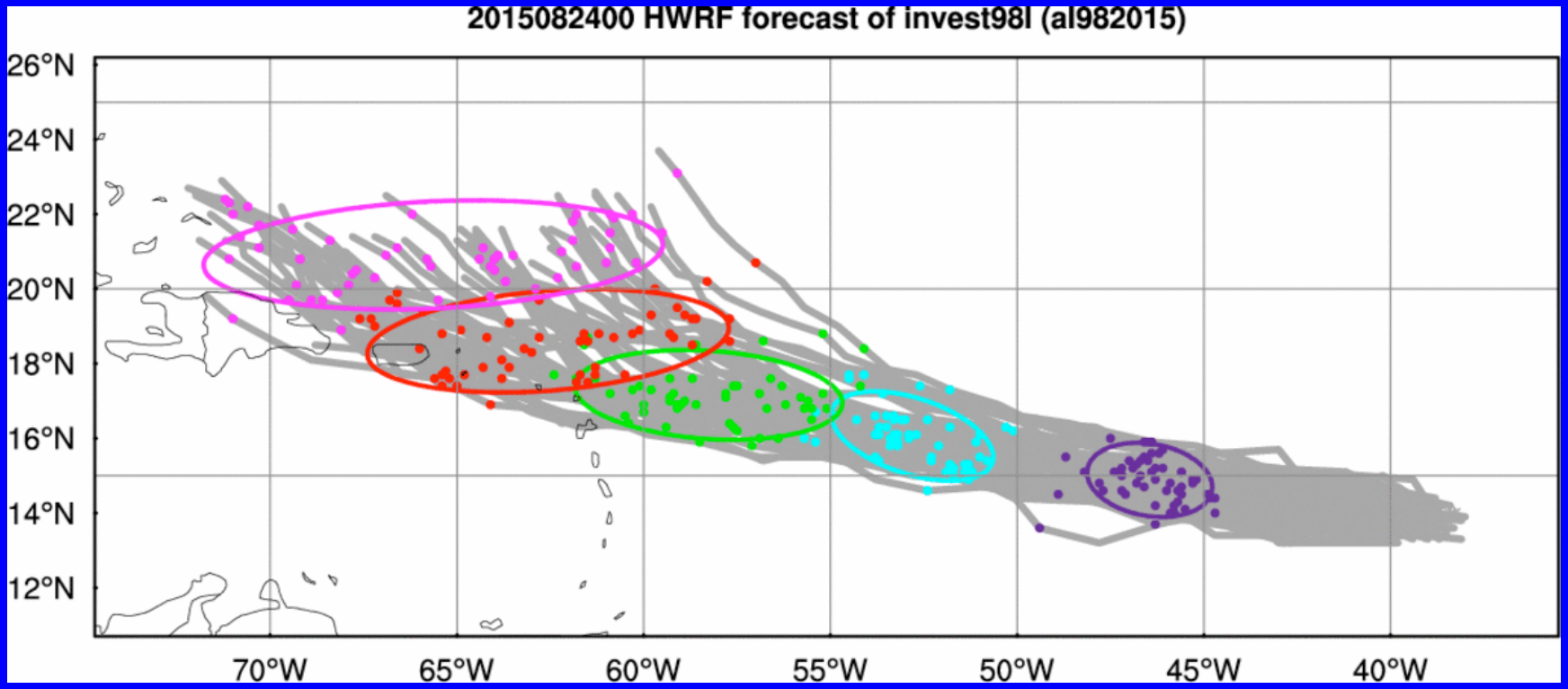


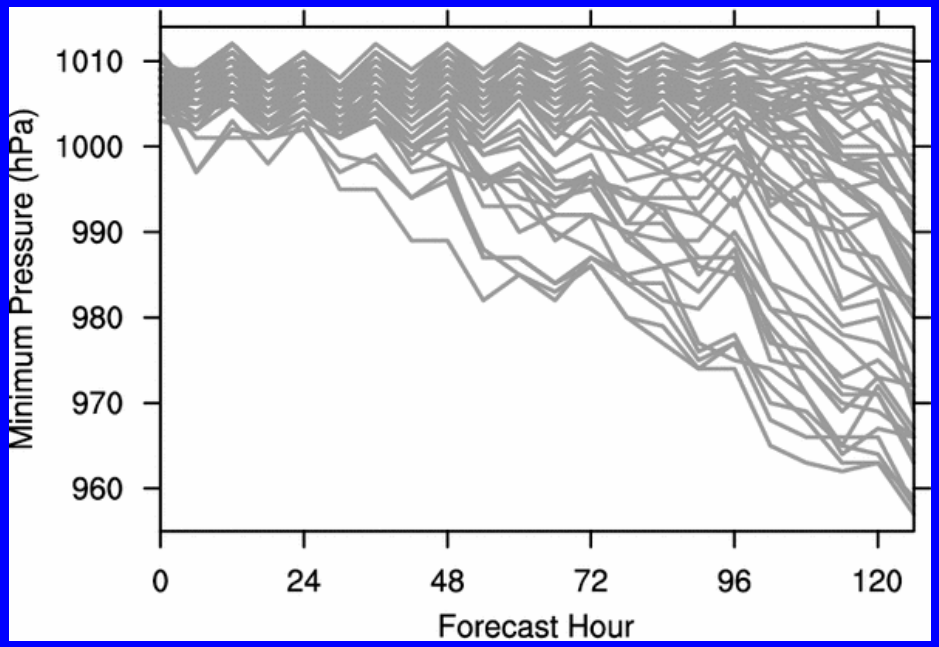
SHOUT Setup

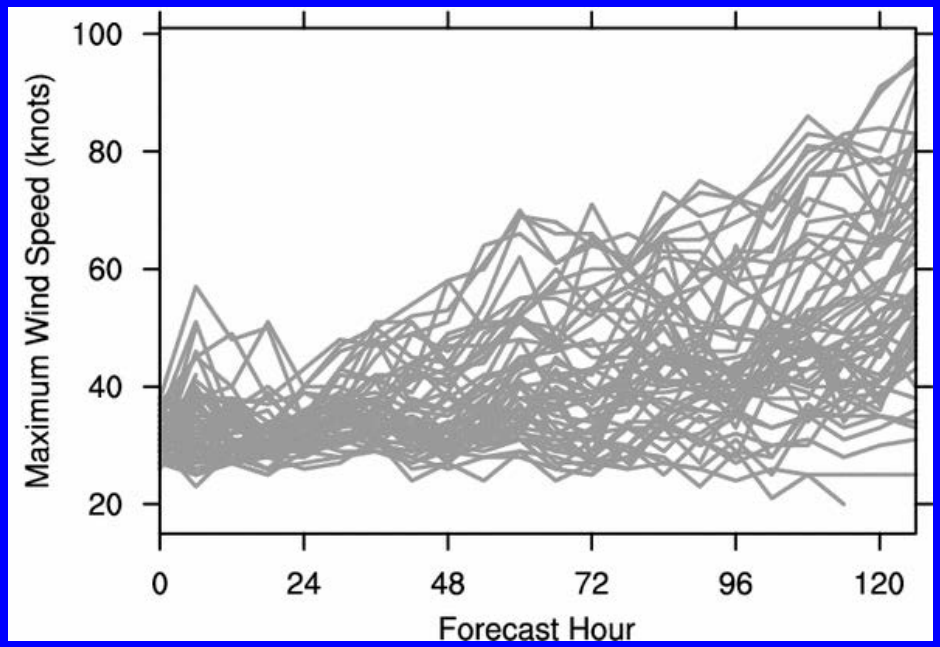
- Identify storm of interest
- Generate 80 member HWRF ensemble forecast initialized 0000 UTC
  - Same setup as operational HWRF EPS, except:
  - IC perturbations taken from GFS hybrid DA
  - Forecasts run in 20 member blocks every 6 h (1-20 at 0600 UTC, 21-40 at 1200 UTC, etc.)
  - Once forecast is finished, compute reduction in ?? h position and intensity forecasts to assimilating hypothetical dropsonde u, v, t, RH data at regular grid in storm-centered framework

SHOUT Missions



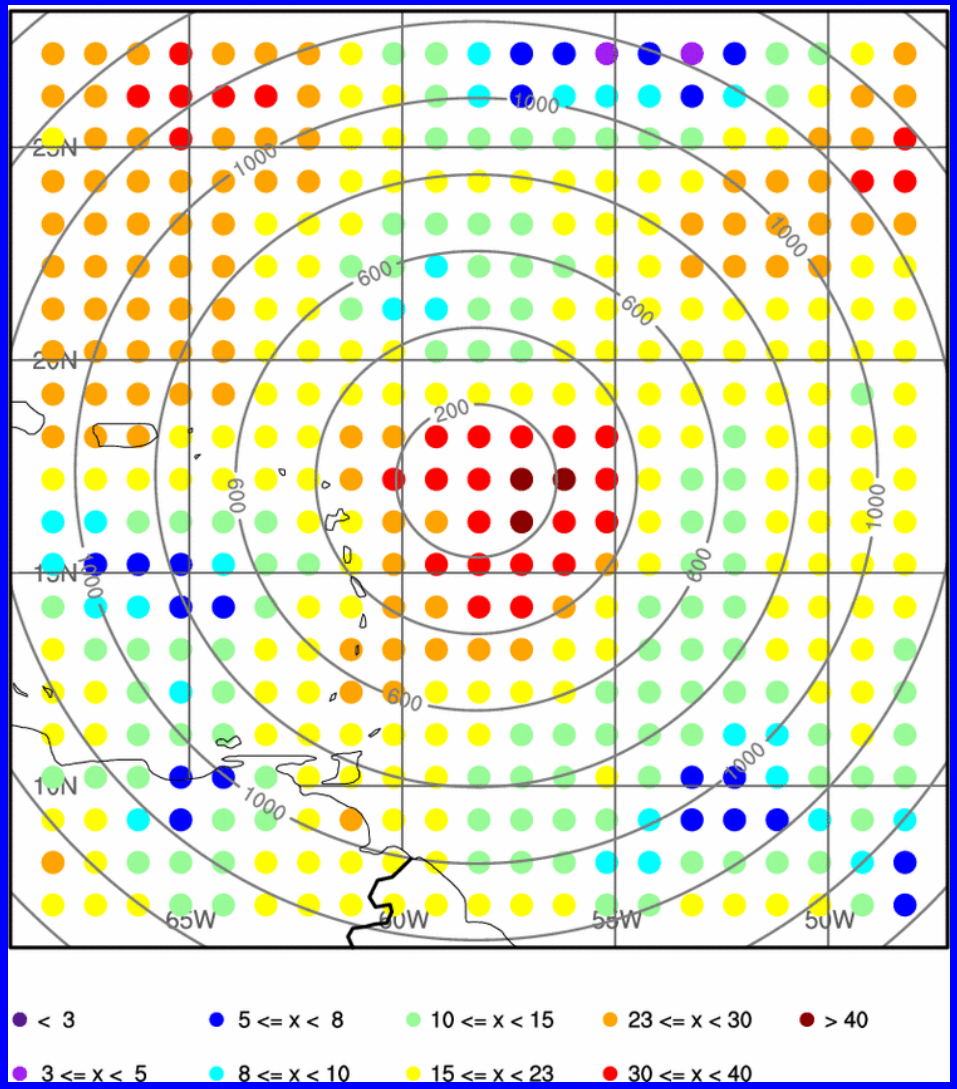

2015082400 HWRF forecast of invest98l (al982015)
26°N
24°N
22°N
20°N
18°N
16°N
14°N
12°N
70°W
65°W
60°W
55°W
50°W
45°W
40°W


Minimum Pressure (hPa)
1010
1000
990
980
970
960
0
24
48
72
96
120
Forecast Hour

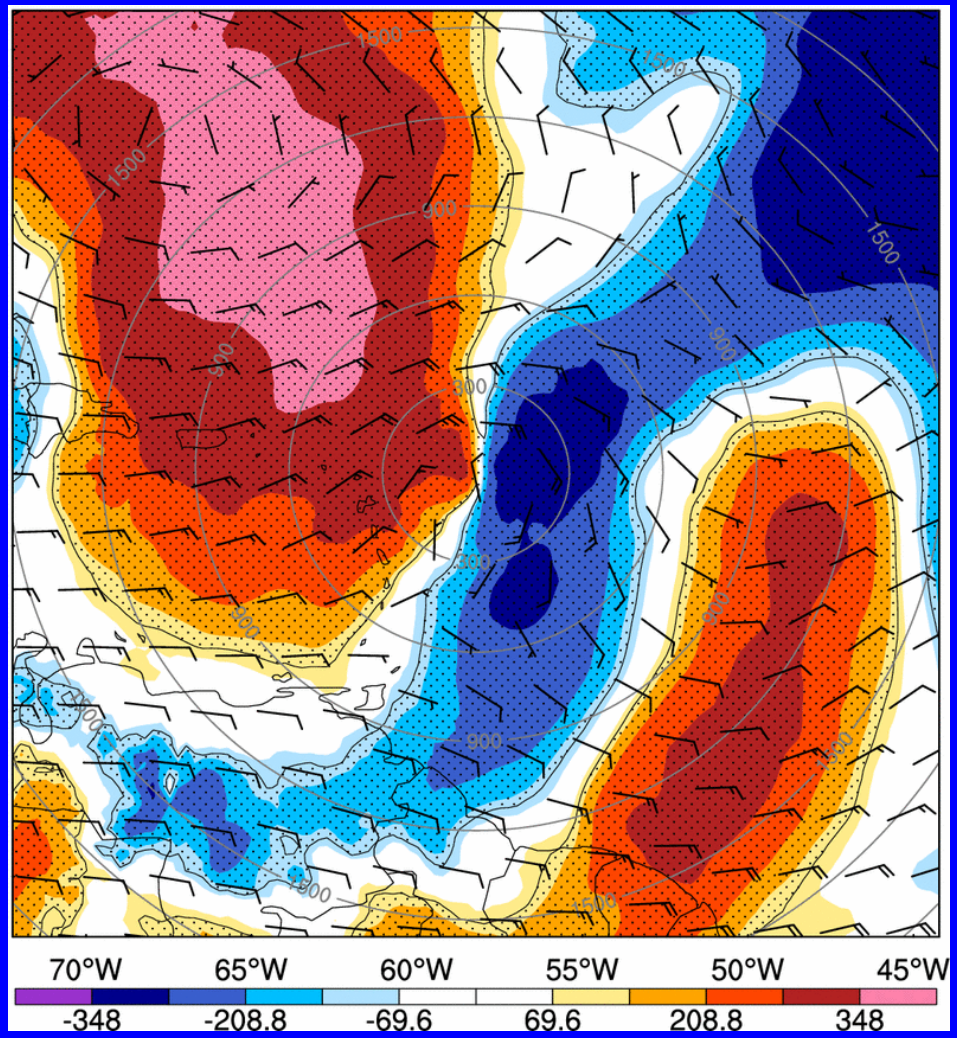

Maximum Wind Speed (knots)
100
80
60
40
20
0
24
48
72
96
120
Forecast Hour

00 UTC 29 Aug. Position

Dropsonde Variance Reduction



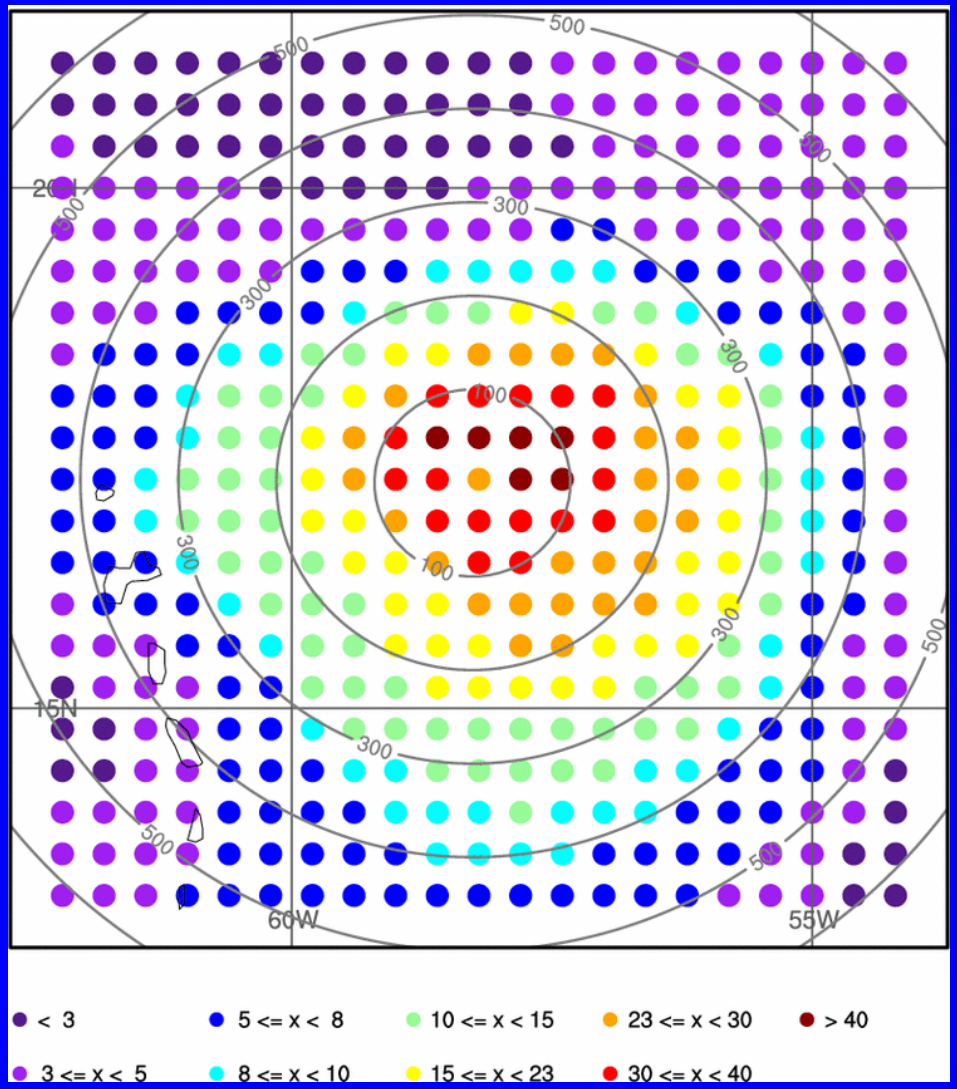
DL Meridional Wind Sensitivity



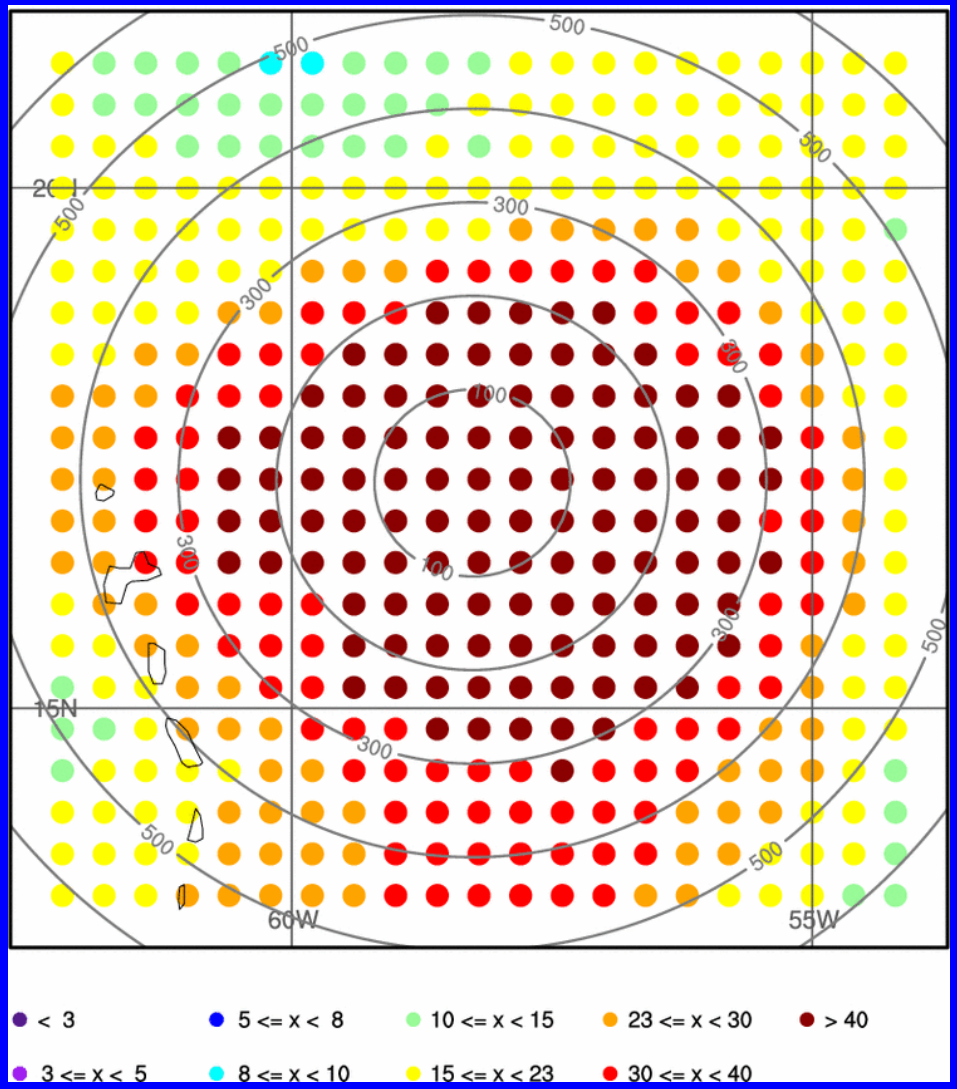
Valid 00 UTC 27 August

00 UTC 29 Aug. Intensity

Minimum SLP



10 m Kinetic Energy within 200 km



Summary

- Ensemble-based observation impacts are cheap to compute given the existence of an ensemble of sufficient size
- Method is flexible; many different TC-related metrics can be employed
- Assimilation of reduced number of targeted dropwindsondes provided comparable impact as all data
- Method provided useful guidance during SHOUT, cases very limited
- Future work will employ similar tests as Torn (2014) with 2015 cases of interest

Torn, R. D., 2014: The impact of targeted dropwindsonde observations on tropical cyclone intensity forecasts of four weak systems during PREDICT. *Mon. Wea. Rev.*, **142**, 2860–2878.

http://www.NEEDAURL