Development of the ground-based radar data assimilation capability within the HWRF hybrid EnVar data assimilation system to improve the land-falling hurricane prediction

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In collaboration with
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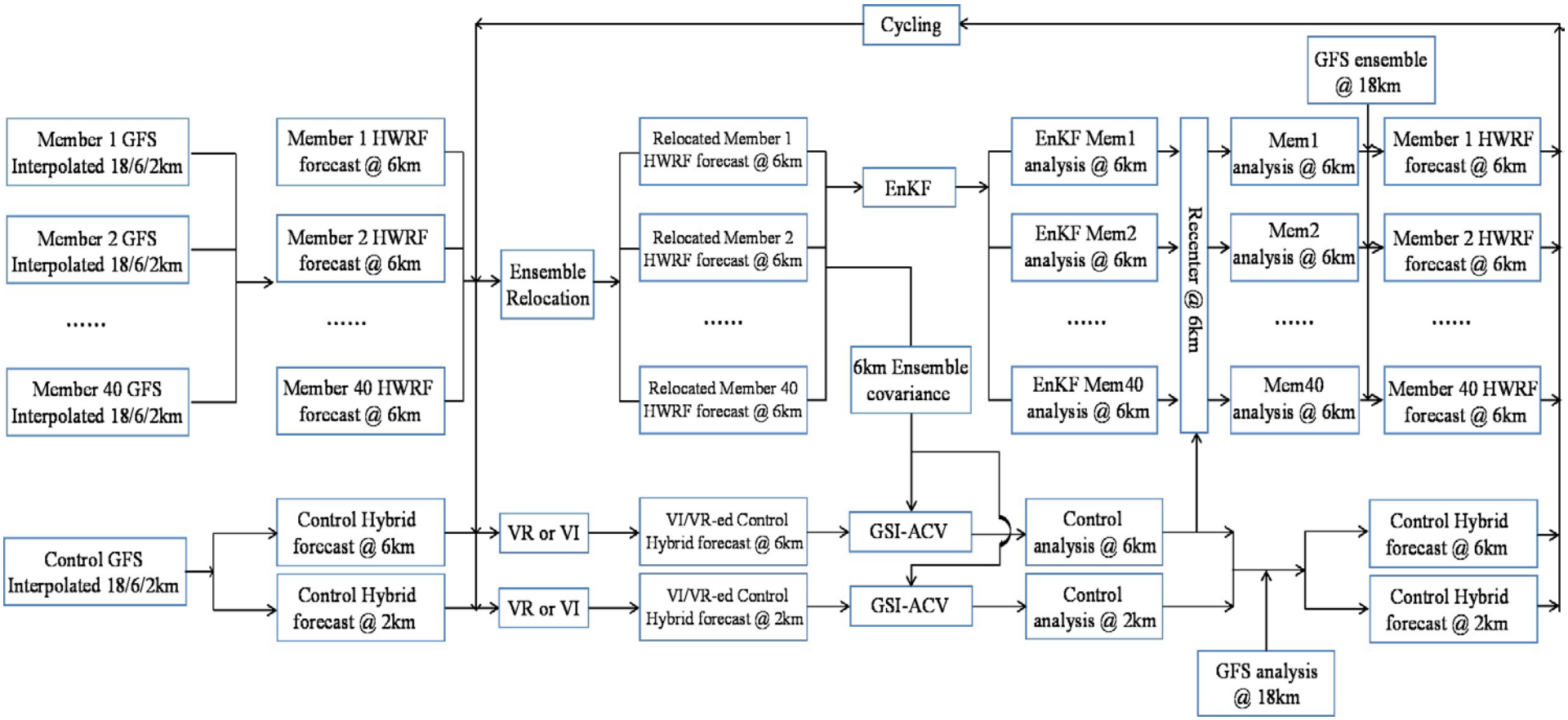
HFIP telecon meeting, Sep. 4, 2019

Issue of Jet access

- International students never got re-access to Jet
- US citizen students still have not get their accounts after 1-year waiting

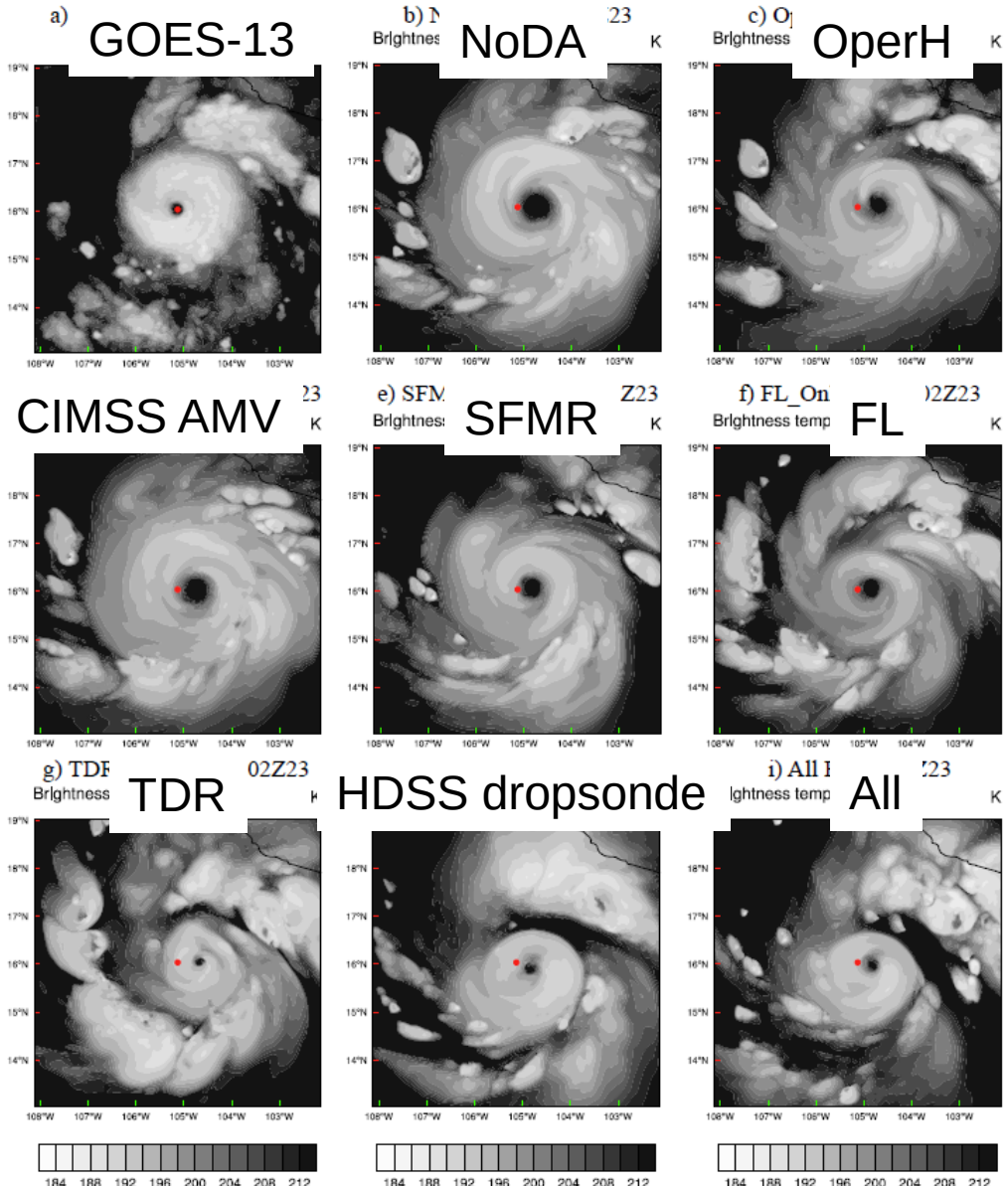
Background and Motivation

Cycled dual resolution HWRF hybrid DA system
Lu* et al, 2016, 2017, MWR



OU MAP students and/or early career scientists *

Background and Motivation



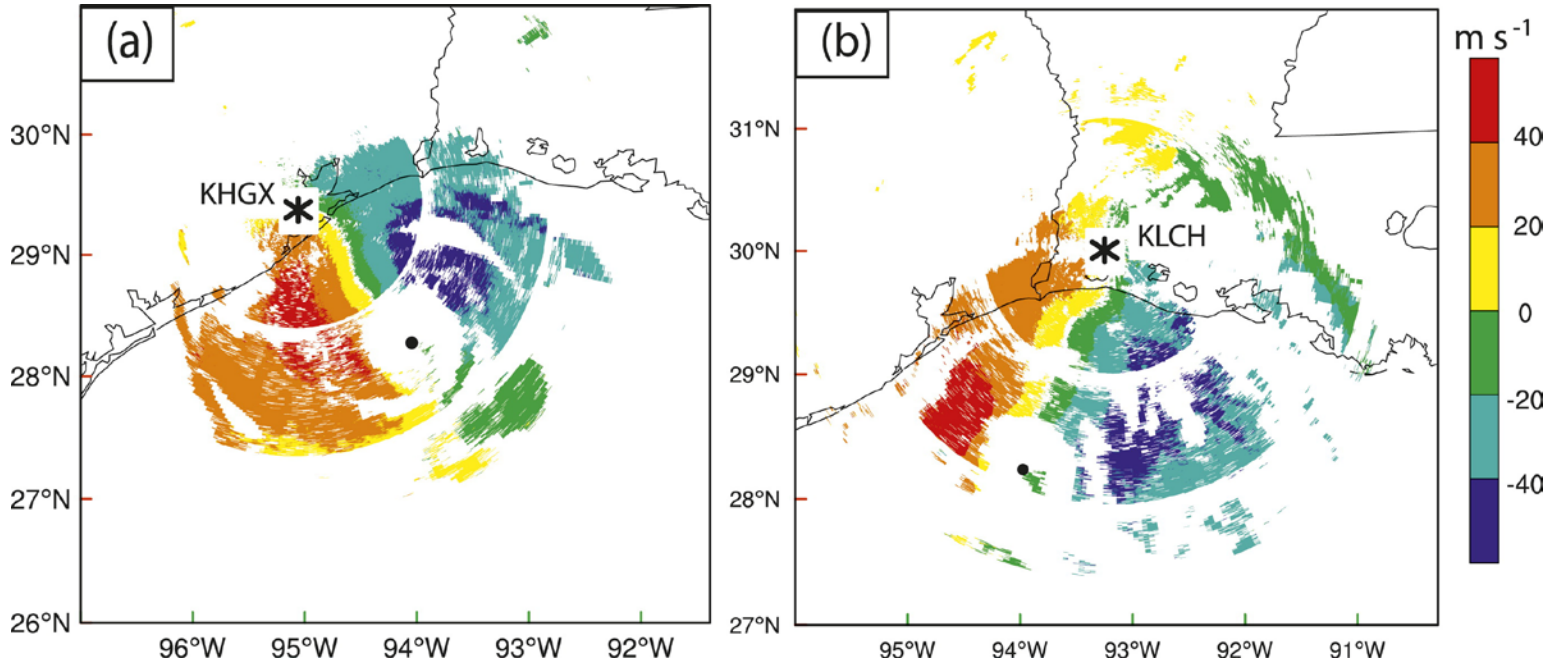
- Variety of observations are assimilated in HWRF hybrid DA (e.g. Lu* and Wang 2019, MWR)

Patricia 2015

Background and Motivation

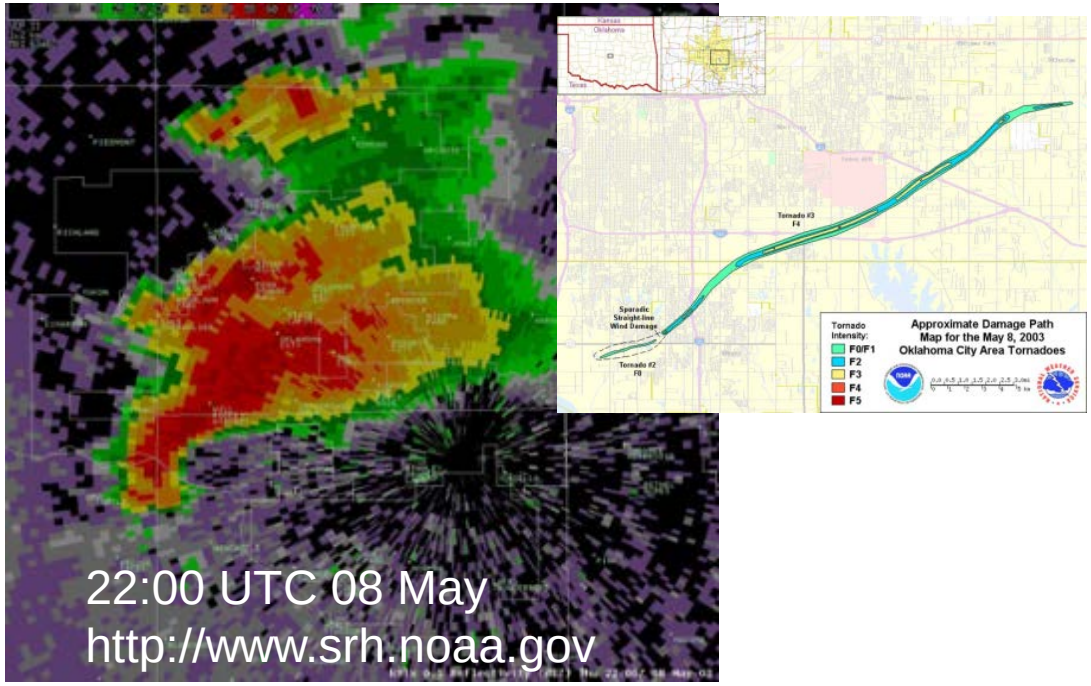
- While TC spends most of their life time over the ocean, extensive damage and economic loss occur while they make landfall
- Ground based radar provides important sampling with high spatial and temporal resolution while TC is near landfall

Li* et al. 2012, MWR

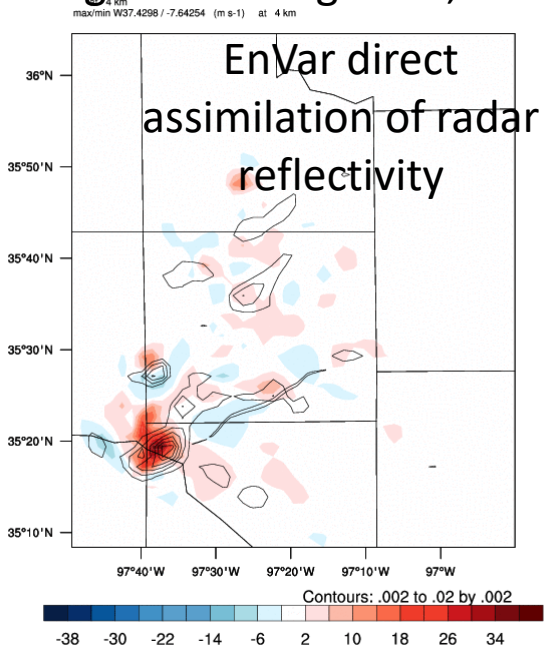


Background and Motivation

- OU MAP lab in collaboration with NOAA EMC, GSD and NSSL has further developed direct ground based radar data assimilation capability in EnVar and EnKF for CONUS convective scale weather prediction under other past supports (Johnson* et al. 2014, MWR, Wang* and Wang 2017, MWR, Duda* et al. 2019 MWR). These capabilities are being used e.g. in NSSL experimental WoF system, HRRRv4/HRRRE, etc.



Wang* and Wang 2017, MWR



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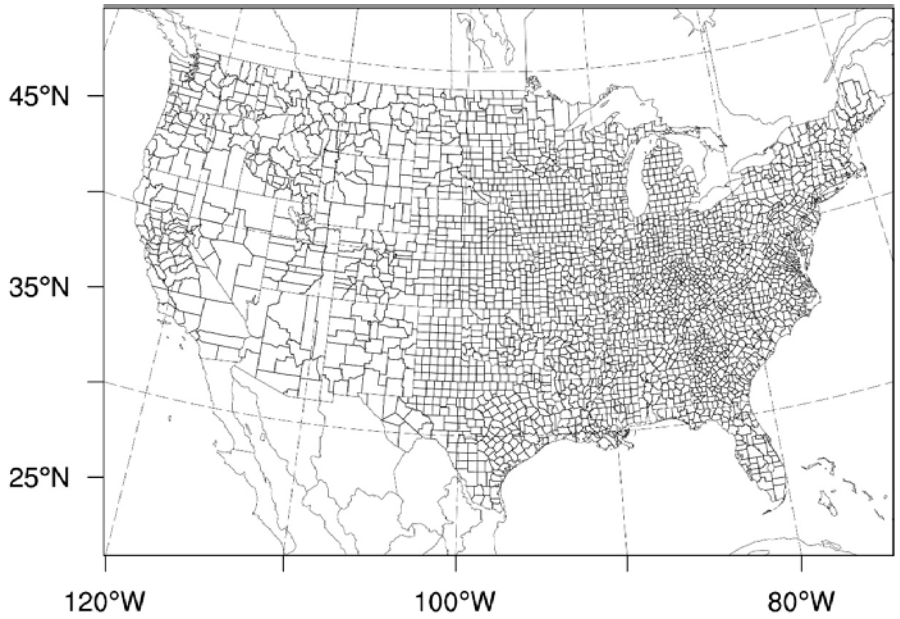
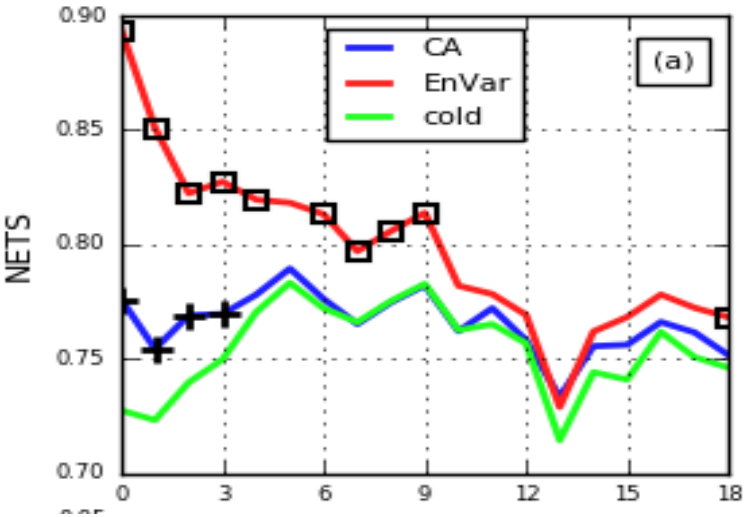


Precip NETS: EnVar direct assimilation of reflectivity vs indirect cloud analysis



Duda* et al. 2019, MWR

Overall objectives

- Leveraging capabilities gained for ground based radar assimilation for continental convective scale weather, the goal of this project is to implement the ground based radar data assimilation capability into HWRF hybrid DA system and evaluate its impact on the prediction of hurricane track, intensity, precipitation, storm structure etc when TCs are near, during and post landfall.

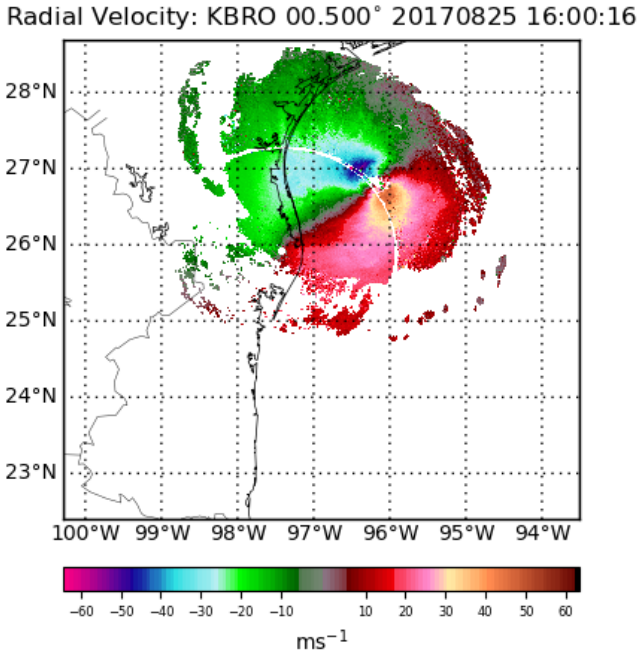
- Note although some capabilities (codes) can be leveraged, TC and continental convective systems are different "beasts". Optimal DA configuration, data pre-processing, etc very likely are different. Therefore each deserves own R&D.

New capabilities developed for Ground-Based Radar Radial Velocity (Vr) data assimilation

- 1) Improve radial velocity operator and its adjoint by including vertical velocity in the operator
- 2) Detailed methods for 1) can be found in Johnson* et al. (2015, MWR) and Wang* and Wang (2017, MWR)
- 3) Develop several options of reading in radial velocity observations
- 4) All these capabilities are interfaced with HWRF

Preprocessing for Ground-based Vr Observation

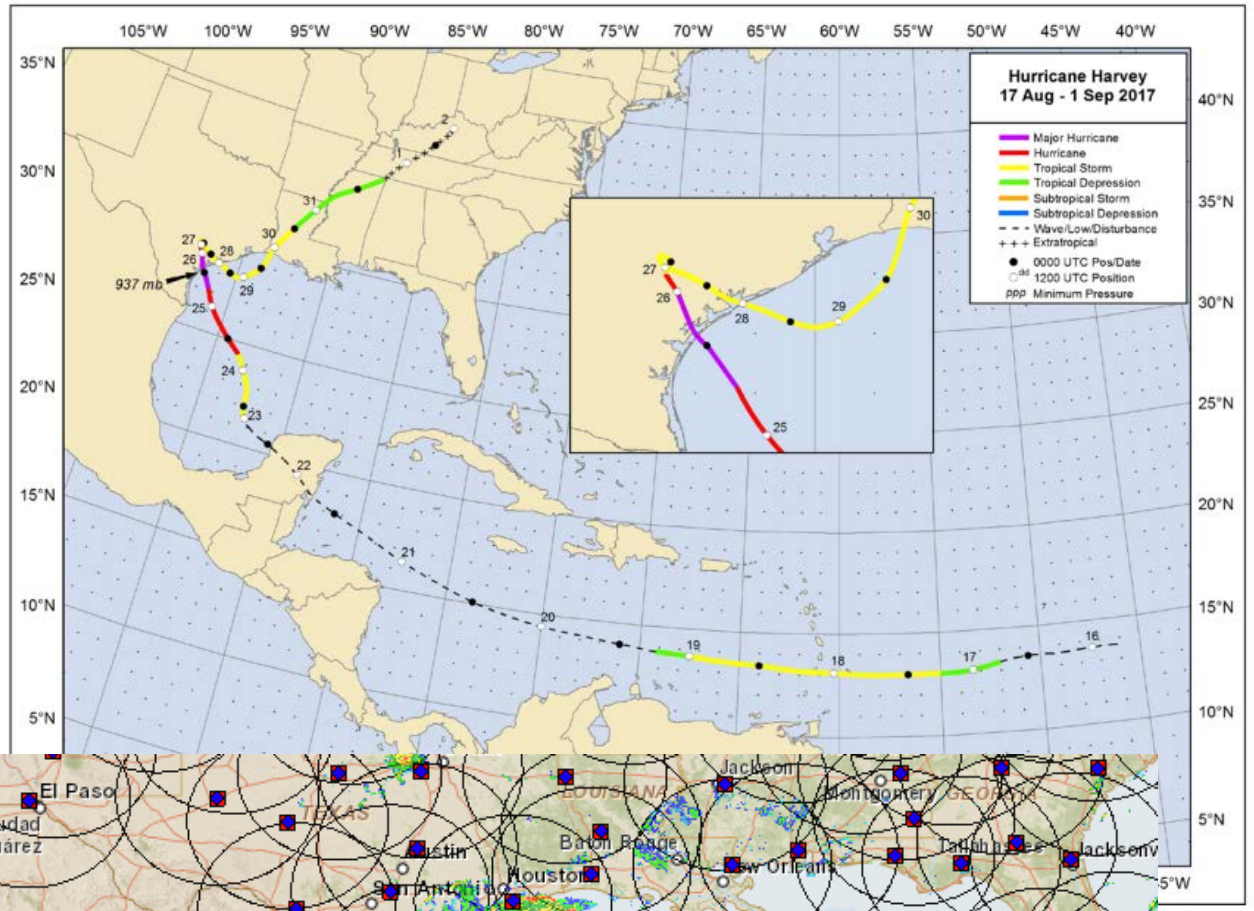
- Plan to leverage the NAM radar data stream and pre-processing (in discussion with EMC and HRD)
- For initial testing of capabilities in slide 9, data obtained from NCDC, QCed & de-aliased using WDSS-II and thinned within GSI

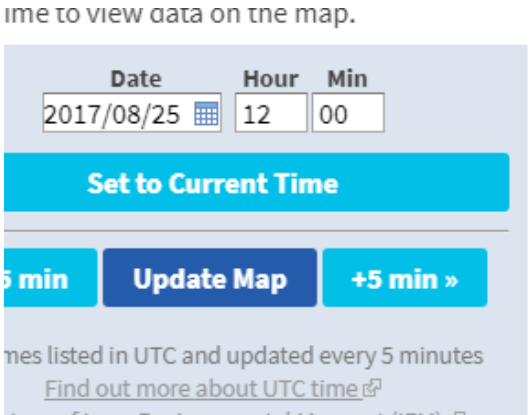


Initial Study with Harvey 2017

2017 Harvey:

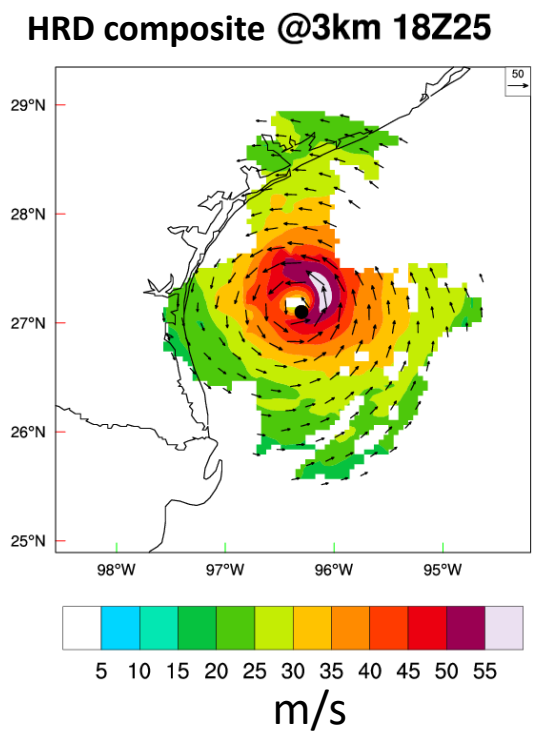
1. High Impact Cat-5 hurricane
2. landfall twice
3. Sampled well by the ground-based radar
4. TDR available at the same time, which provides independent verification

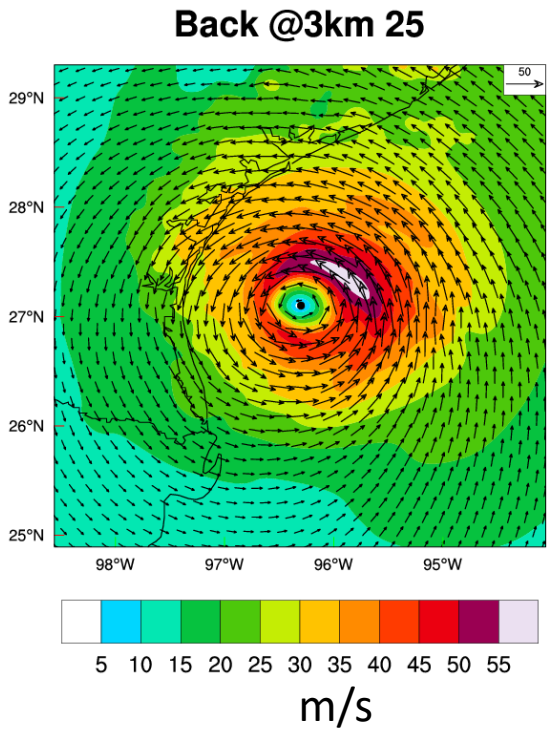


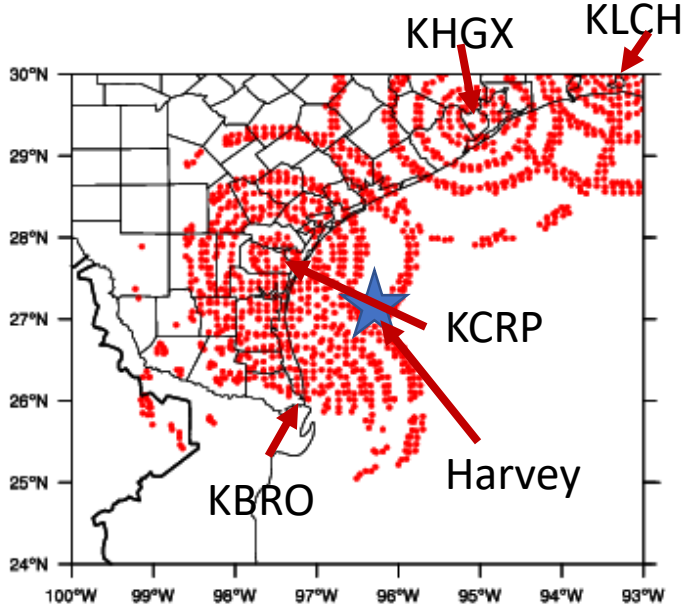


Initial Experiments

-- Harvey Pre-landfall at 201708251800 UTC



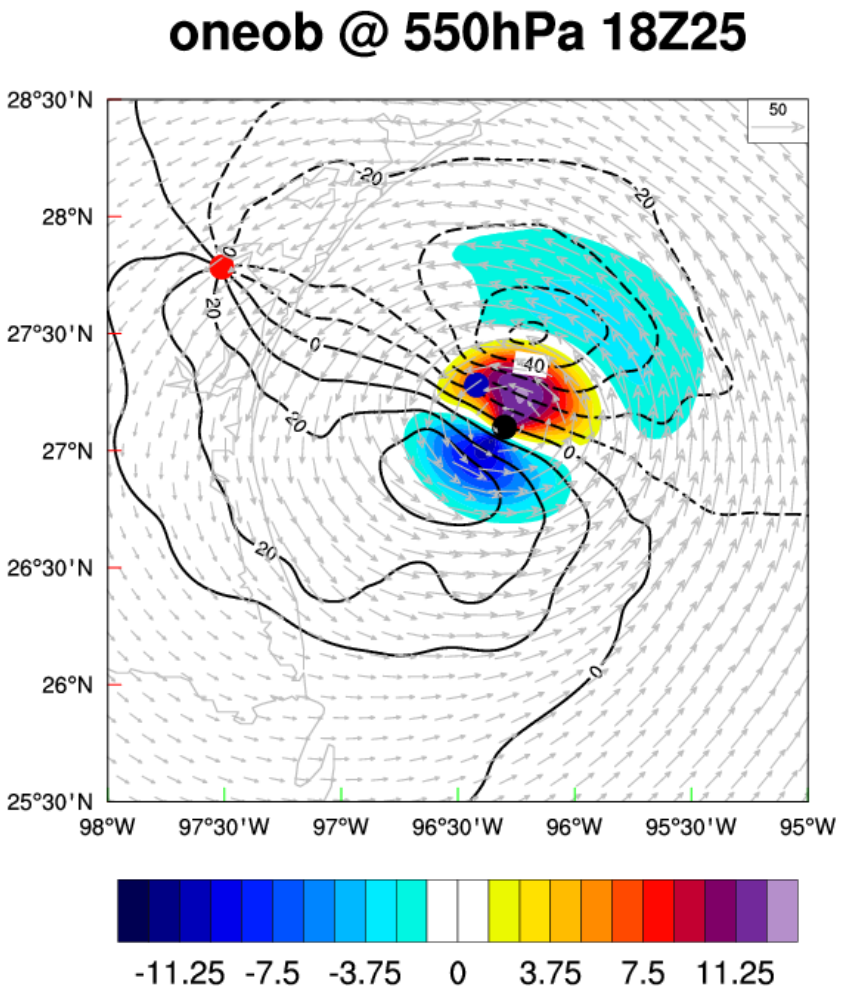




KBRO: Brownsville
KCRP: Corpus Christi
KHGX: Dickinson
KLCH: Lake Charles

- The 6-hour background forecast initialized from the GFS analysis is too large and the maximum wind is located more toward the NE compared to the TDR radar composite.

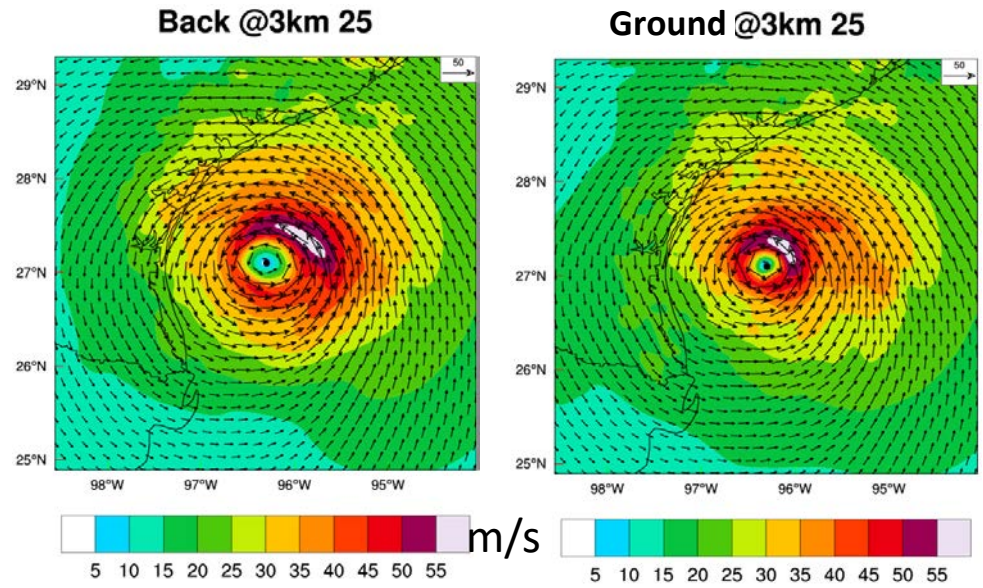
Single observation test

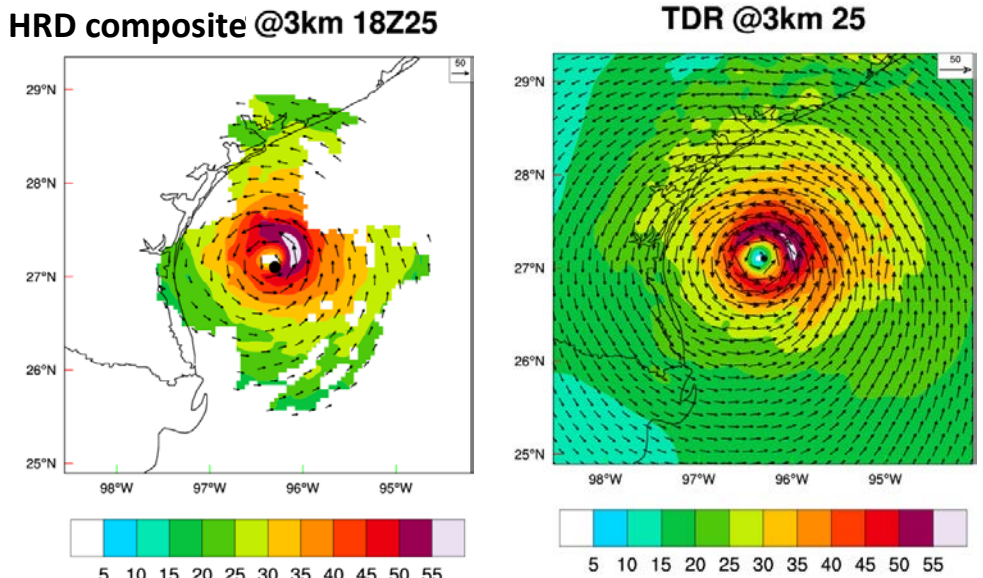


- One ob test suggests reasonable increment: correcting the location and tightening the storm
- Including W in the operator led to more correction. More impact is expected when TC moves closer to the radar coverage.

Horizontal wind analysis at 3km

201708251800 UTC

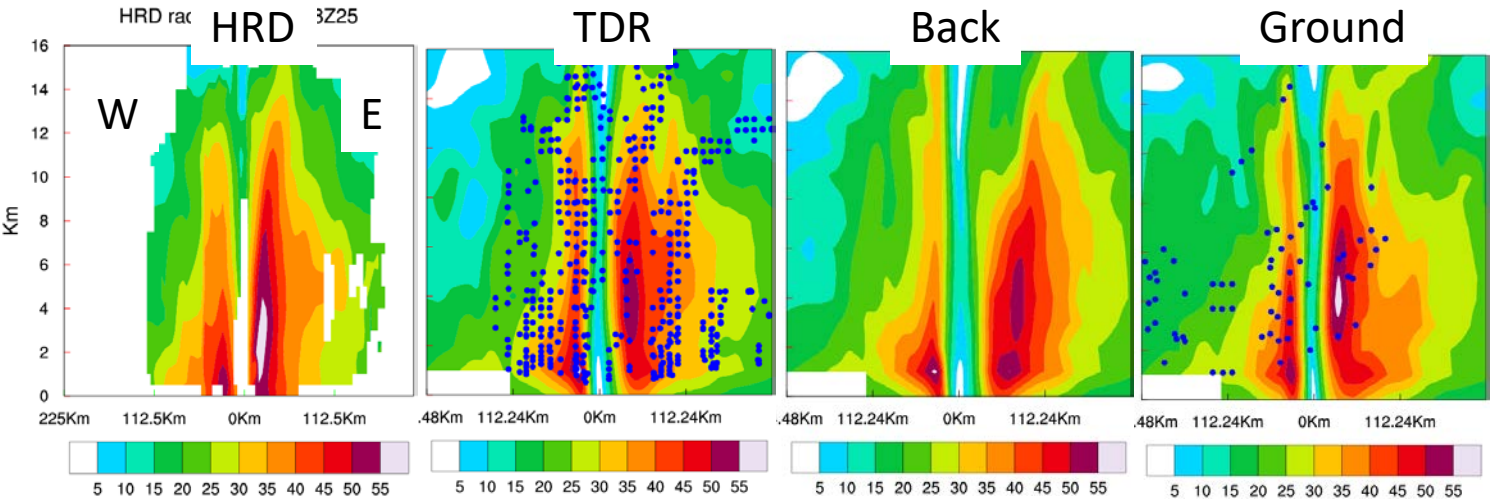




- Assimilating the ground-based radar radial wind observations clearly reduced the storm size and corrects the maximum wind morphology.
- Although only 5-min worth of data were assimilated, the analysis after assimilating the ground-based radar observations resembles the HRD TDR wind composite

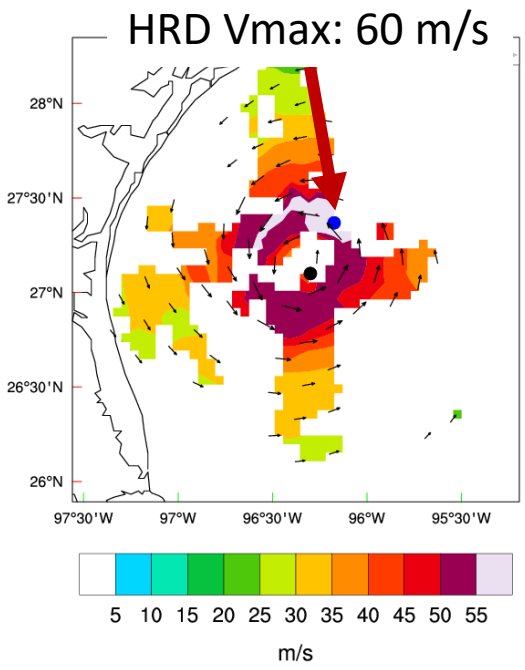
West-East cross-section analysis

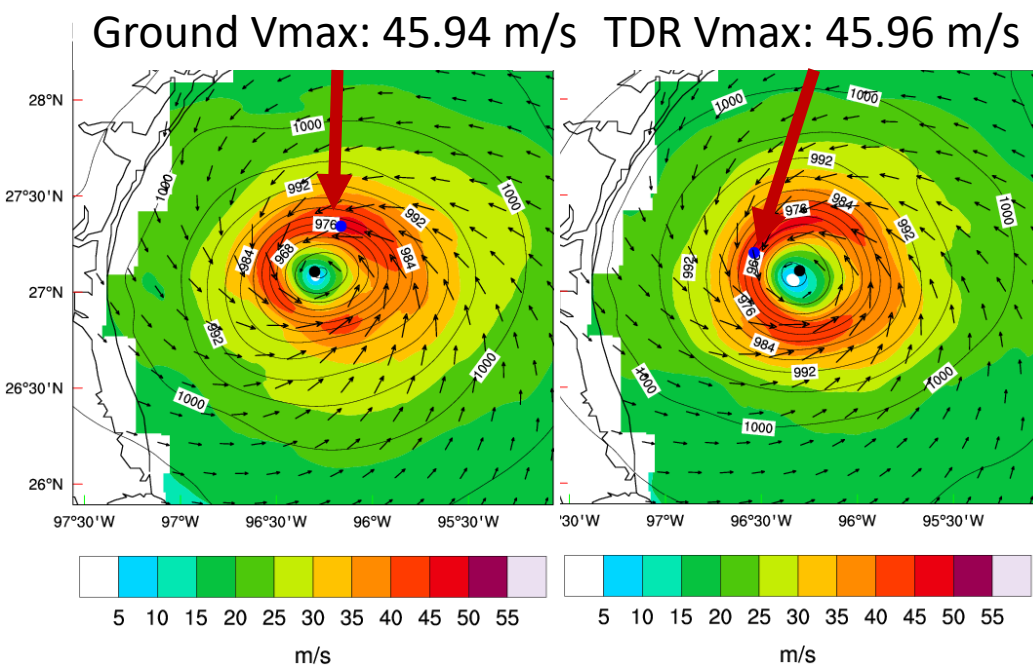
201708251800 UTC



- Assimilating the ground-based radar radial wind observations reduces the size of the storm
- Max wind in the east branch captured well by the assimilating ground based radar which is consistent with the correction of the maximum wind location in early slide.

Horizontal surface wind analysis
(201708251800 UTC)

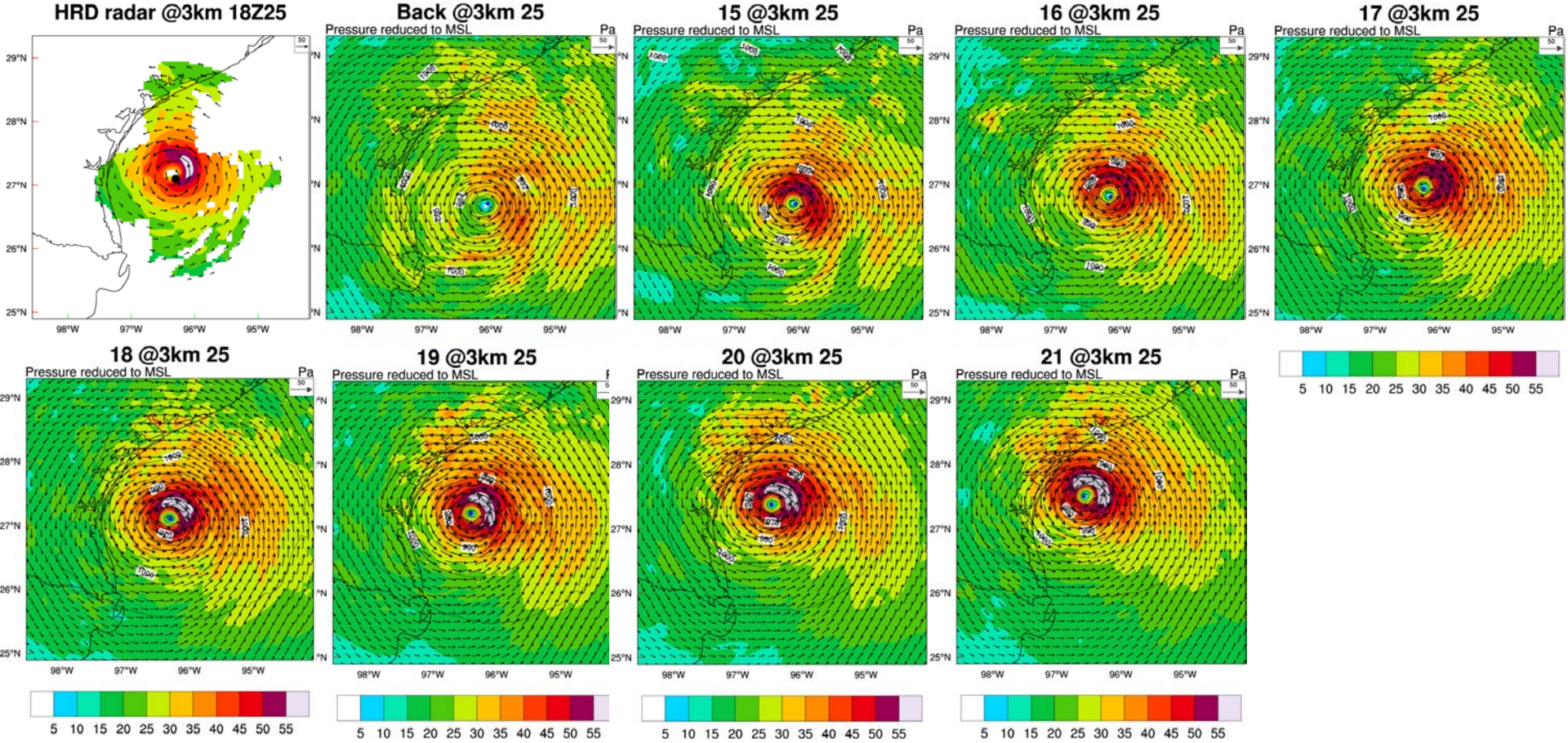




- Vmax still too weak after ground based radar DA likely due to HWRF bias.
- The size of the storm and the location of Vmax are corrected compared to without assimilation

Initial Cycling DA Results

-- Hourly Cycling DA of ground-based radar observations



Hourly Cycling DA helps improve the size and intensity in the analysis

Ongoing and future work

- Further test new capabilities developed
- Systematic cycling experiments with Harvey and other case (s) (e.g. Michael) to determine optimal ground based radar DA configuration (Jet access issue needs to be resolved very soon)
- Leverage EMC and HRD experience on operational ground based radar data pre-processing and interface that with HWRF for additional testing (collaboration with EMC and HRD)
- Discuss with EMC and HRD on plans to transition to operational HWRF
- Further R&D on assimilating ground based radar reflectivity on TC analysis and prediction

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