DATA ASSIMILATION UPGRADES FOR HWRF (with application to HAFS)

Jason Sippel[1] and Henry Winterbottom[2]
05 November 2019

[1]NOAA AOML/HRD
[2]I. M. Systems Group, Inc. (IMSG) and NOAA/NWS NCEP EMC

Outline:

1. Summary of 2019 upgrades

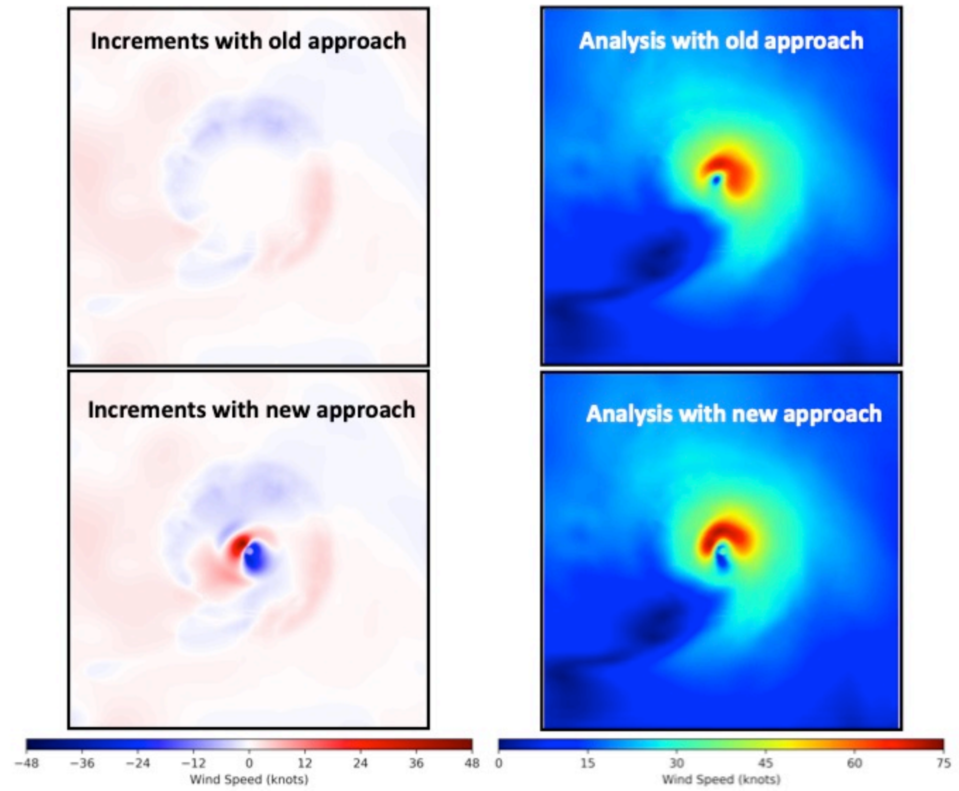
2. Summary of 2020 developments

3. Long-term outlook

4. Conclusions

2019 Upgrades: Inner-core increments

- H219: For *hurricanes*, only the wavenumber 0 and 1 inner-core increments are retained
- Flexibility in specifying which increments to keep (H220)
- Inner-core observations are now more impactful on the TC initial structure and subsequent forecasts
- Forecasts improve



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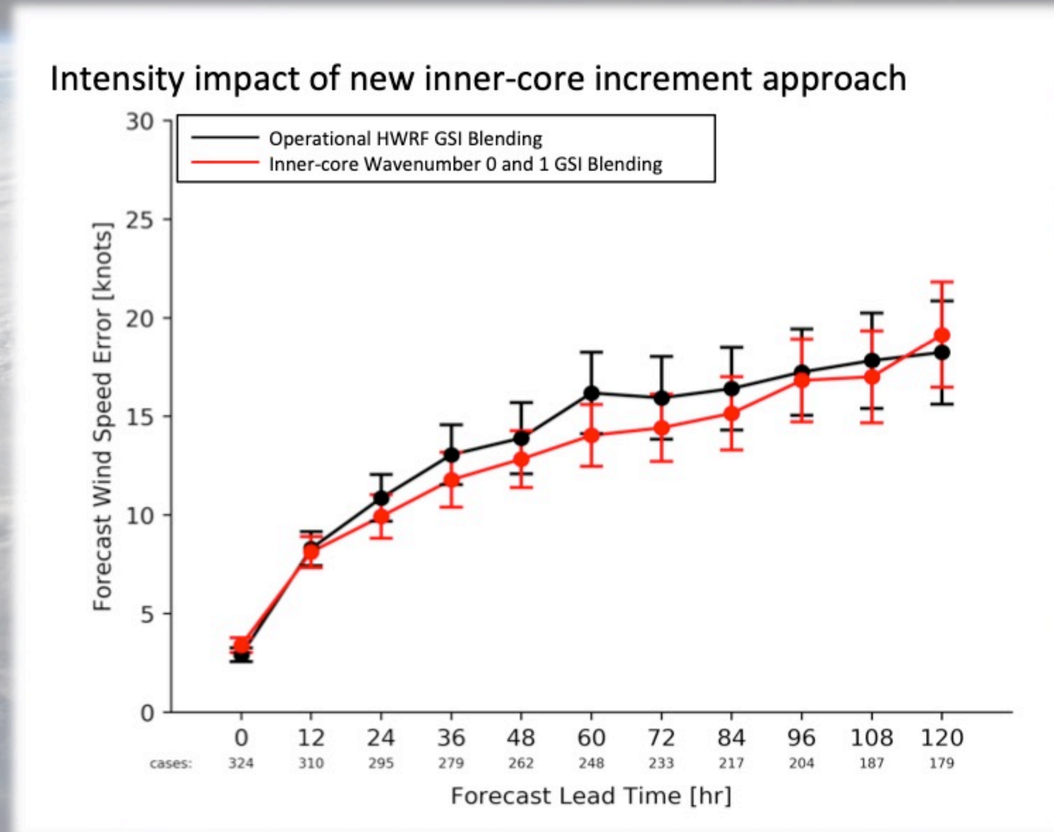
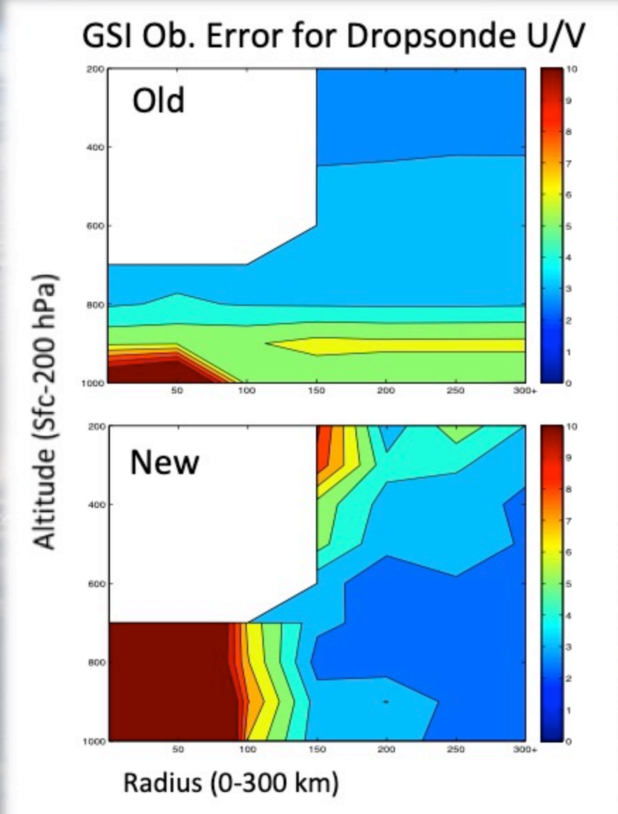


2019 Upgrades: Dynamic observation errors

- GSI does not support and adequate range of specified observation errors
- JTTI-supported work developed GSI code to assign more appropriate errors for dropsondes and HDOB
- Results show benefits for intensity
- Neutral track impact



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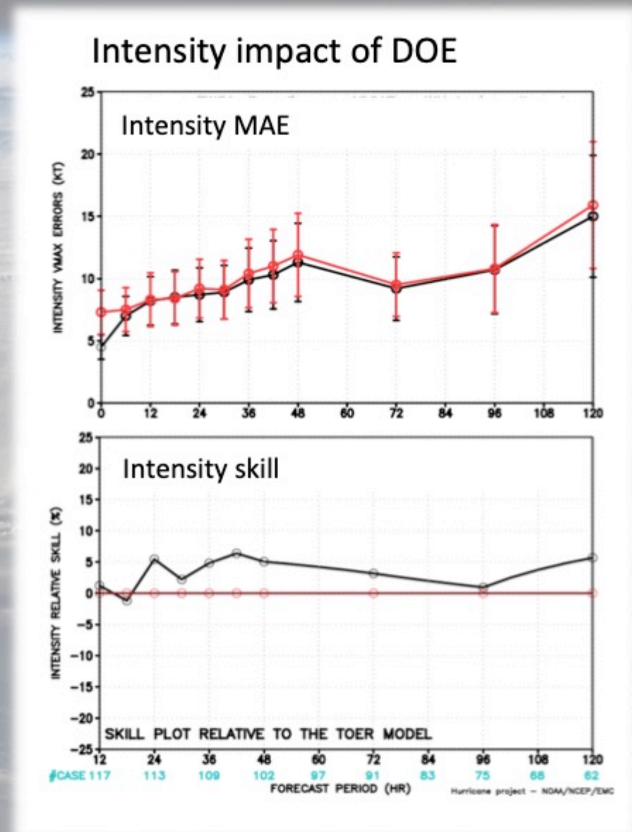

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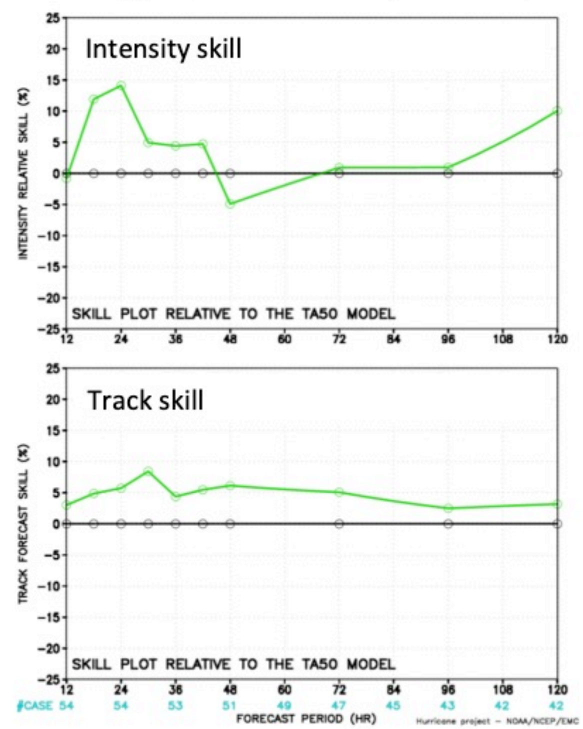
2020 Upgrade Tests: Increment tuning

- 2019: WN0+1 for hurricanes, all increments for TS
- Proposed 2020:
  - All increments below 50 kt
  - WN0+1 for 50-63 kt
  - WN0 for 64 kt +
- Improvements for track and intensity

Tuning impact on track/intensity skill

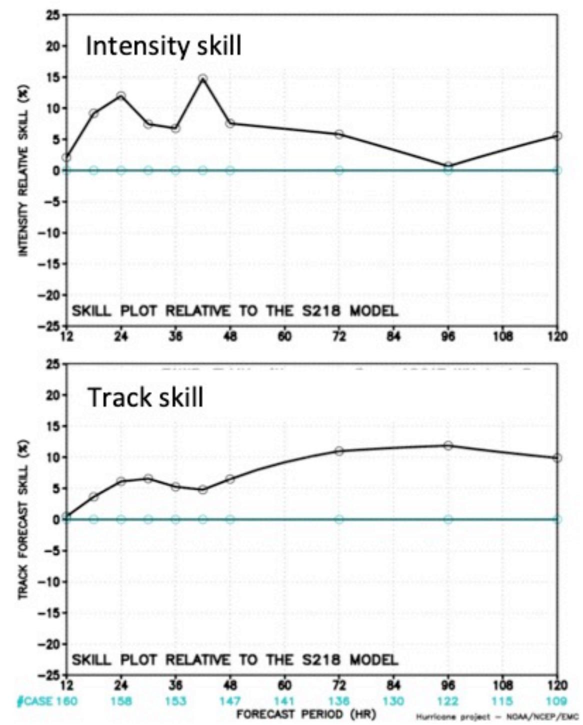


2020 Upgrade Tests: Combined tests

- Tested combined impact of:
  - Increment tuning
  - Adding ASCAT data
  - GSI bug fixes
  - Merge bug fix
  - Other non-DA bug fixes

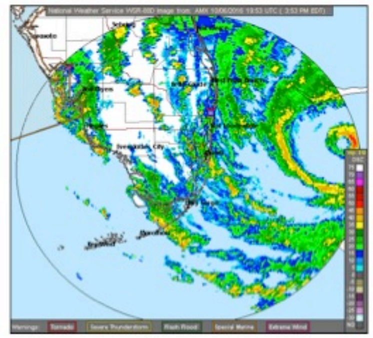
- Large positive impacts for Irma, Maria, Florence, and Michael

Combined impact on track/intensity skill

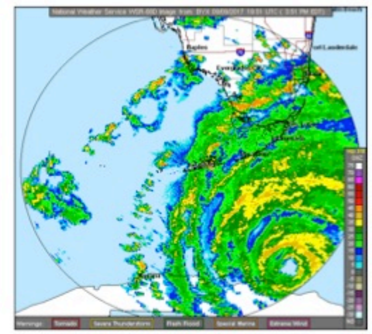


2020 Upgrade Tests: 88-D Vr

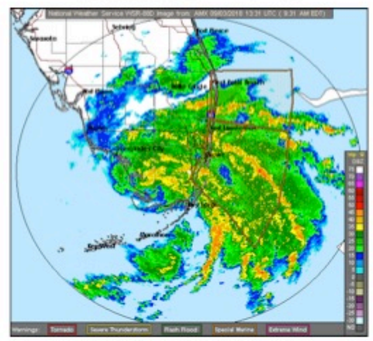
- HWRF currently does not assimilate 88-D data
- Several recent land-falling events (right) may have benefitted from this data
- The impacts from WSR-88D Vr superobs (NAM datastream) being tested
- Neutral to slightly positive results so far (not optimized) for Irma, Michael, Florence



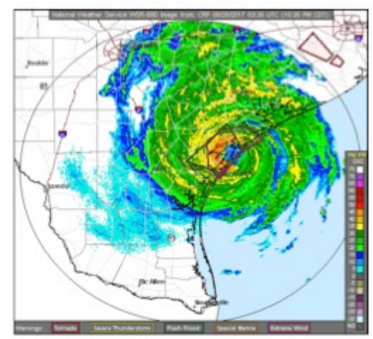
Matthew - 2016



Irma - 2017



Gordon - 2018



Harvey - 2017

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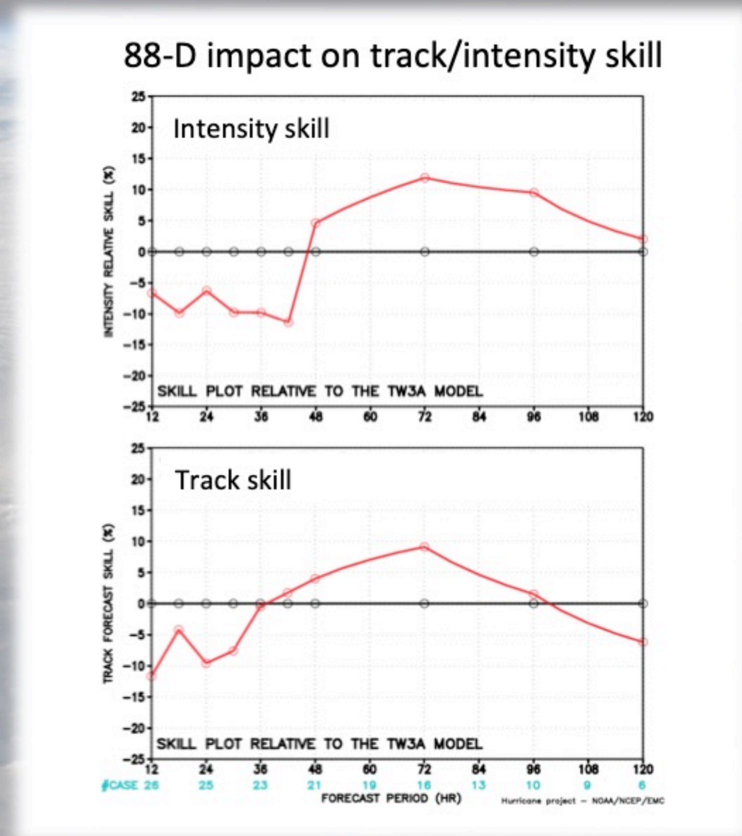
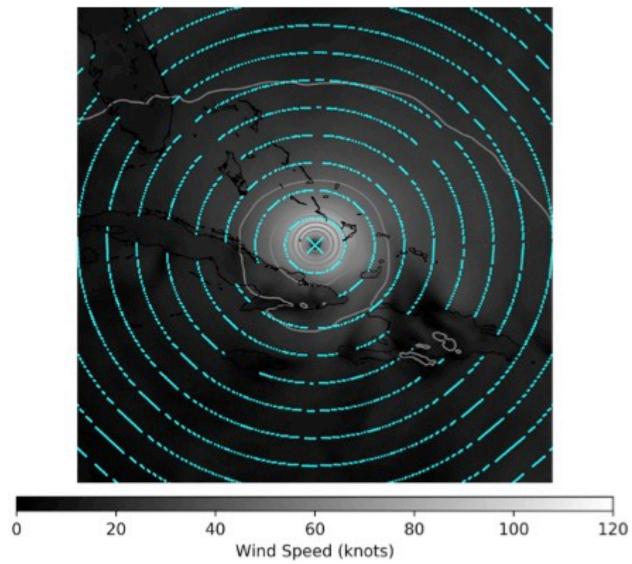


2020 Upgrade Tests: Vortex relocation

- Problems with current vortex relocation and modification package:
  - Large adjustments during first 12h
  - Large bias in inner-core wind radii
- Possible alternatives:
  - Modifications to existing VR/VM package
  - GSI-based relocation



Example sampling data points in proposed GSI relocation strategy

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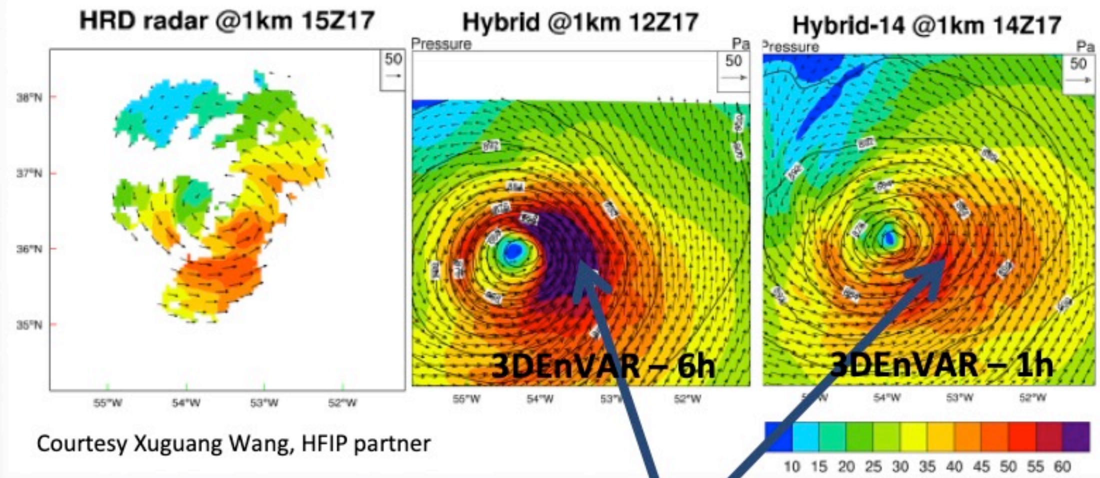
Long term: Improving inner-core covariance

- Current 6-hour window with 3D-EnVAR susceptible to imbalance
- DTC has workflow with flexible (e.g., 1-3 h) HWRF cycling intervals, which could improve forecasts
- Alternatively, 4D-EnVAR could also improve balance

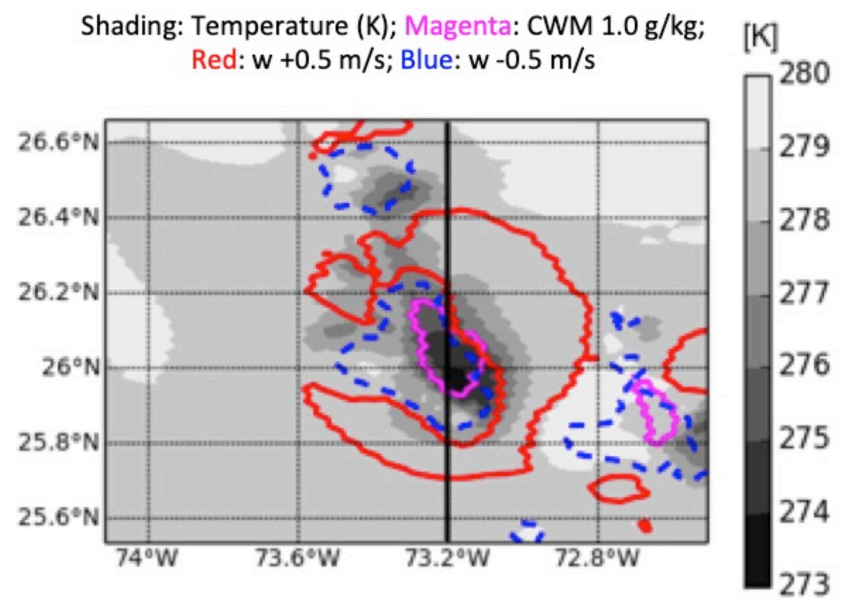


Courtesy Xuguang Wang, HFIP partner

High-frequency full cycling alleviates imbalance.

Long term: Cycling whole model state

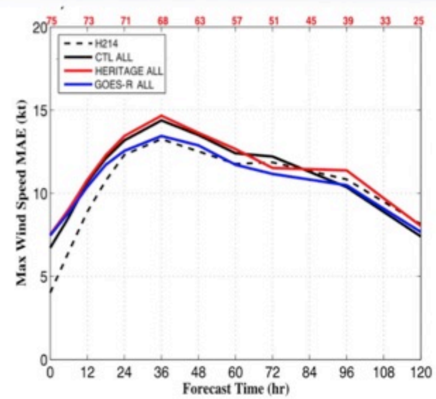
- The operational HWRF does not cycle condensate or vertical motion
- Studies have demonstrated an unphysical evolution of the TC if these are mishandled
- This also allows more effective satellite and radar data assimilation
- HFIP-funded partners are working on this



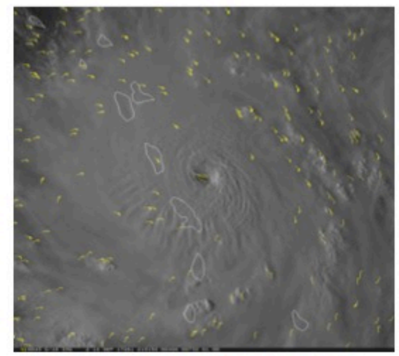
Wu et al., [2017]: When condensate is initialized without vertical motion, evaporation cooling and precipitation settling cause unphysical adjustments.

Long term: Atmospheric Motion Vectors

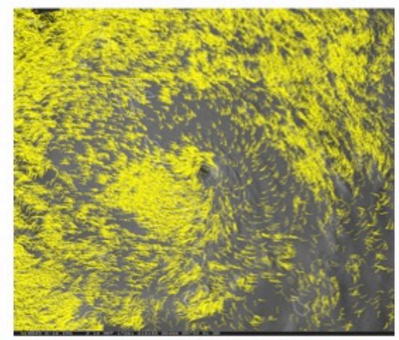
- NESDIS AMV processing is currently geared toward the global model
- Recent studies have shown that mesoscale AMV assimilation improves HWRF forecasts
- *Velden et al.*, are working with NESDIS for operational mesoscale-AMV processing
- Other HFIP-funded research ongoing to assimilate GOES-R SWIR, CAWV, and VIS AMV observations



Maximum wind-speed forecast errors when assimilating mesoscale (blue) and currently processed (red) AMVs processing for TCs Gonzalo, Edouard, and Sandy [*Velden et al.*, 2017].



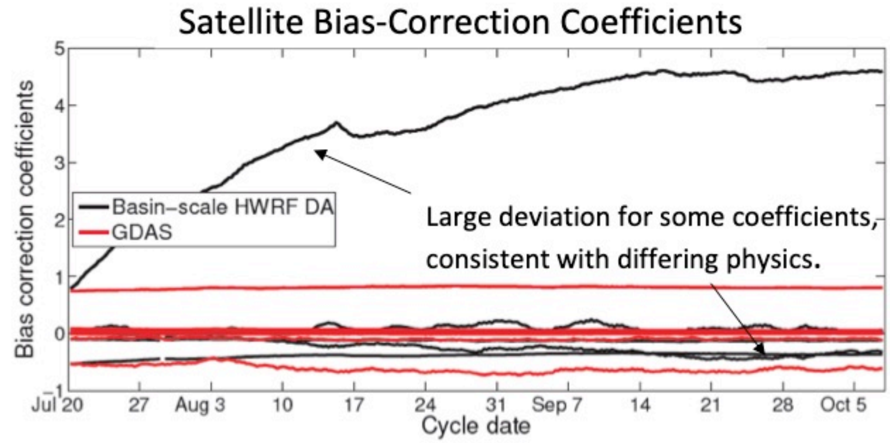
Maria – Operational AMVs



Maria – Enhanced AMVs

Long term: Satellite Radiances

- HWRF makes deficient use of satellite radiances (both cloudy and clear)
- Transition to basin-scale HWRF would allow us to generate our own BC coefficients
- Cycling of model state would allow us to use cloudy-radiance data



Satellite bias correction coefficients computed using a cycled large, static domain in HWRF vs. GDAS bias correction coefficients during the 2017 NATL and EPAC hurricane seasons.

Conclusions:

- The HWRF/HAFS data assimilation system is rapidly advancing and contributing to lower forecast errors
- Potentially major changes in the near future as we add new observation types and improve upon existing methods
- HFIP is improving and expediting research to operations
- Some advances (HWRF satellite bias-correction, frequent cycling, etc.) will require significant computational resources
- Ongoing development is mindful of HAFS and methodologies will be transferred to FV3-based HAFS as needed