2018 HFIP Annual Review
PPAV Team Report

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PPAV Team Contributing Organizations

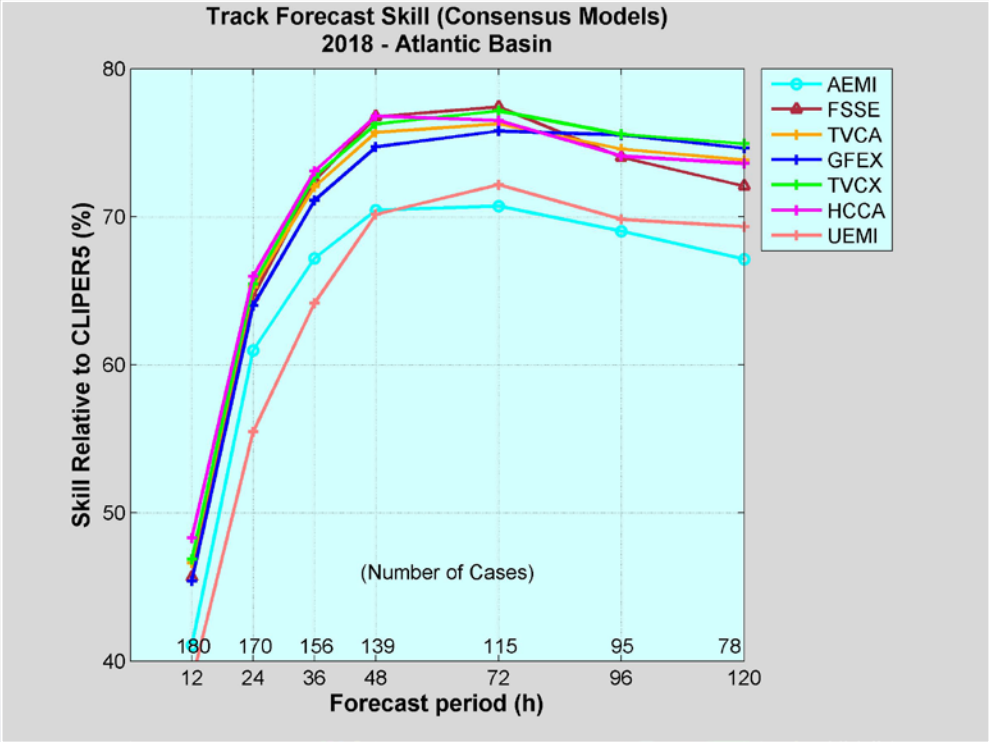
- NHC
- NRL (ATCF)
- AOML/HRD
- NESDIS/CIRA
- DTC
- NCAR/RAL
- ESRL/GSD

PPAV Activities Covered By Other Presentations

- DTC
- Ensembles / RI Tiger Team

NHC Activities: HCCA

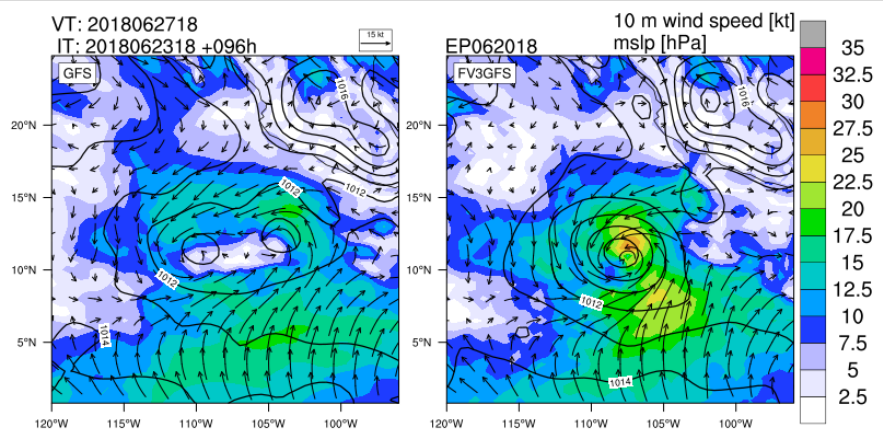
- Code running on WCOSS as part of NHC guidance suite
- Training forecast sets fully automated and updated in real time
- Added CPHC/Central Pacific and WPC backup support
- Evaluated impact of additional models, included HMON for AL intensity
- Updated real-time forecast/verification intranet site-added new diagnostic graphics



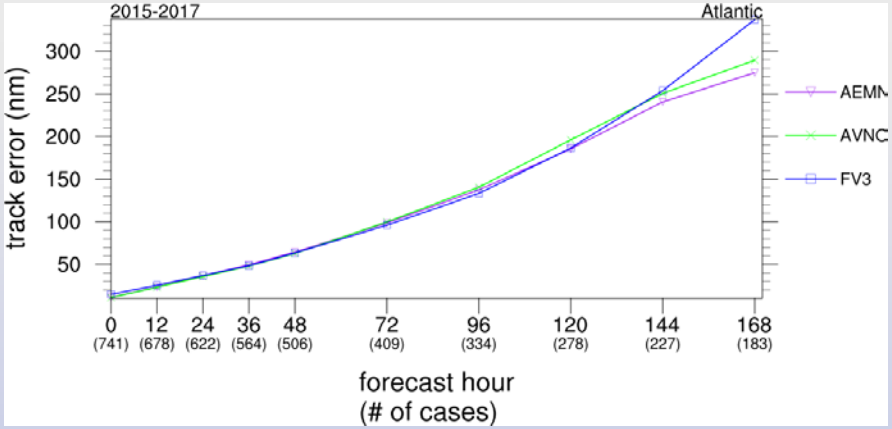
HCCA explicitly referenced in about 1/3 of 2018 Atlantic tropical cyclone discussions (through 10/29)

NHC Activities: Model Evaluation

FV3-GFS

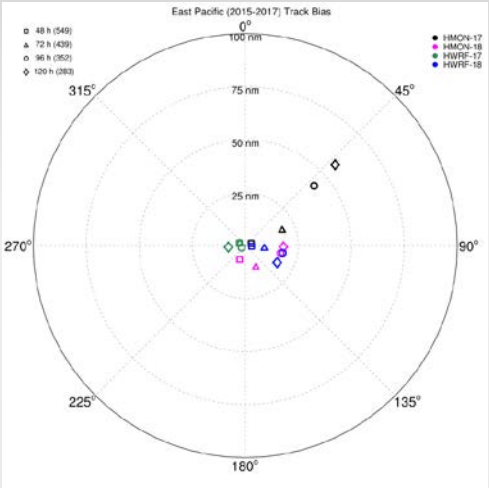


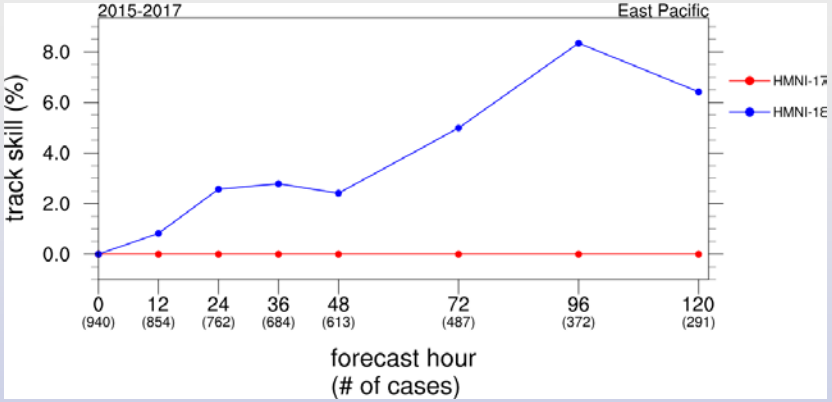
Genesis



Track

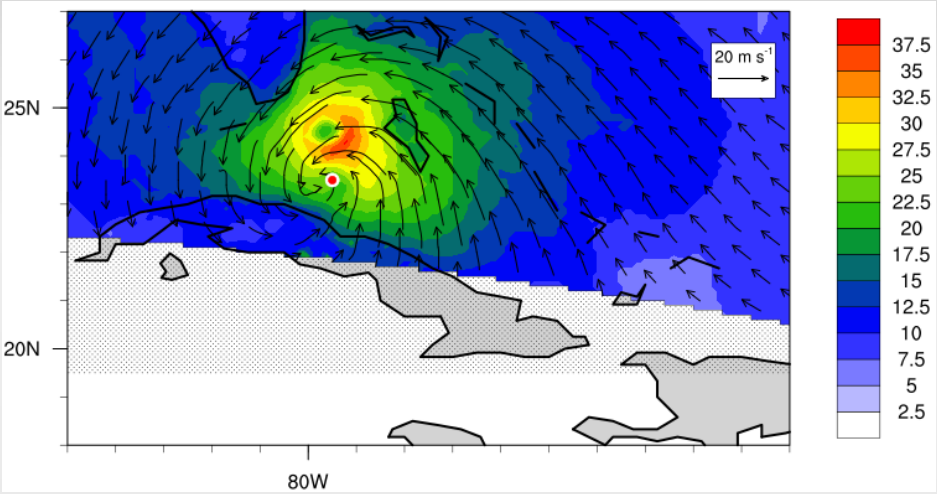
Regional Hurricane Models

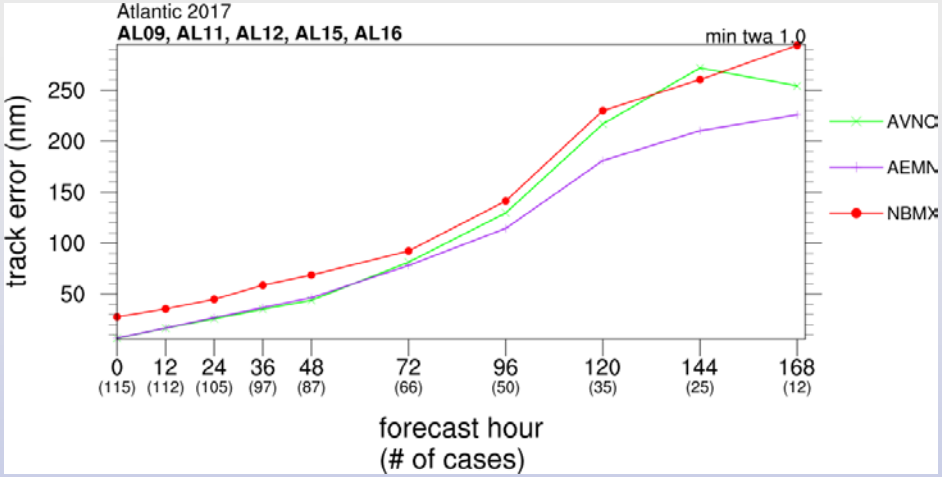




NHC Activities: Model Evaluation

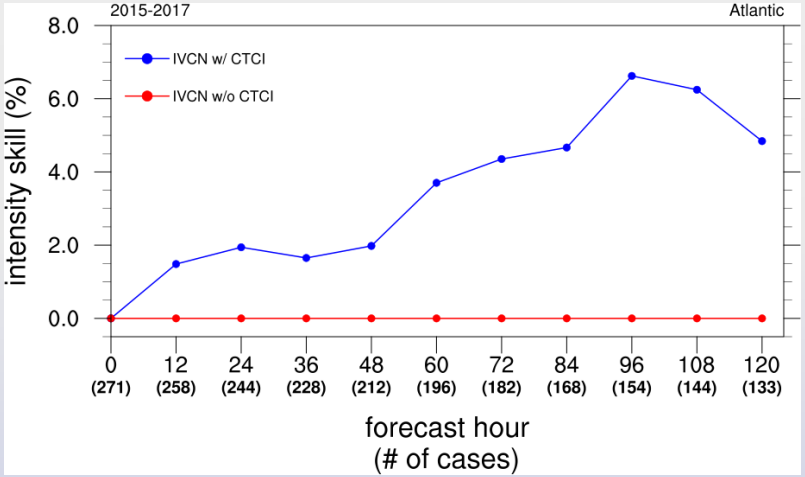
National Blend of Models





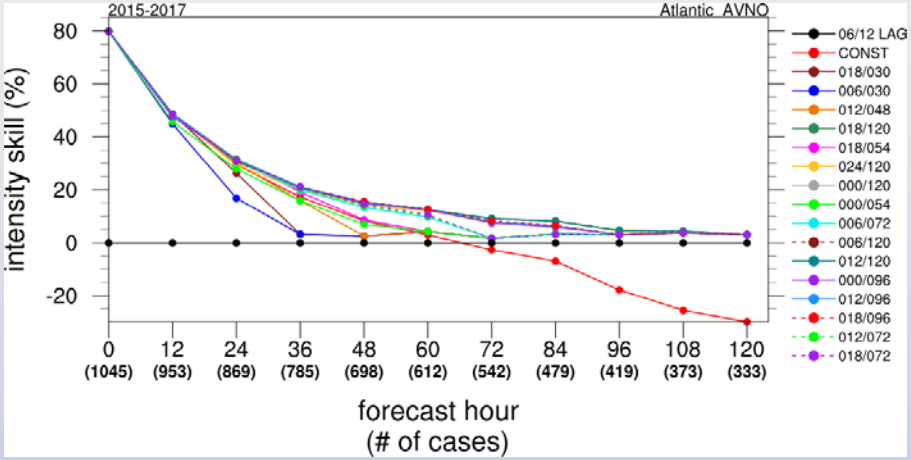
Consensus sensitivity

- Implemented new variable consensus for track and intensity
- Optimized the input models of TVCA/TVCE
- Added HMON to IVCN



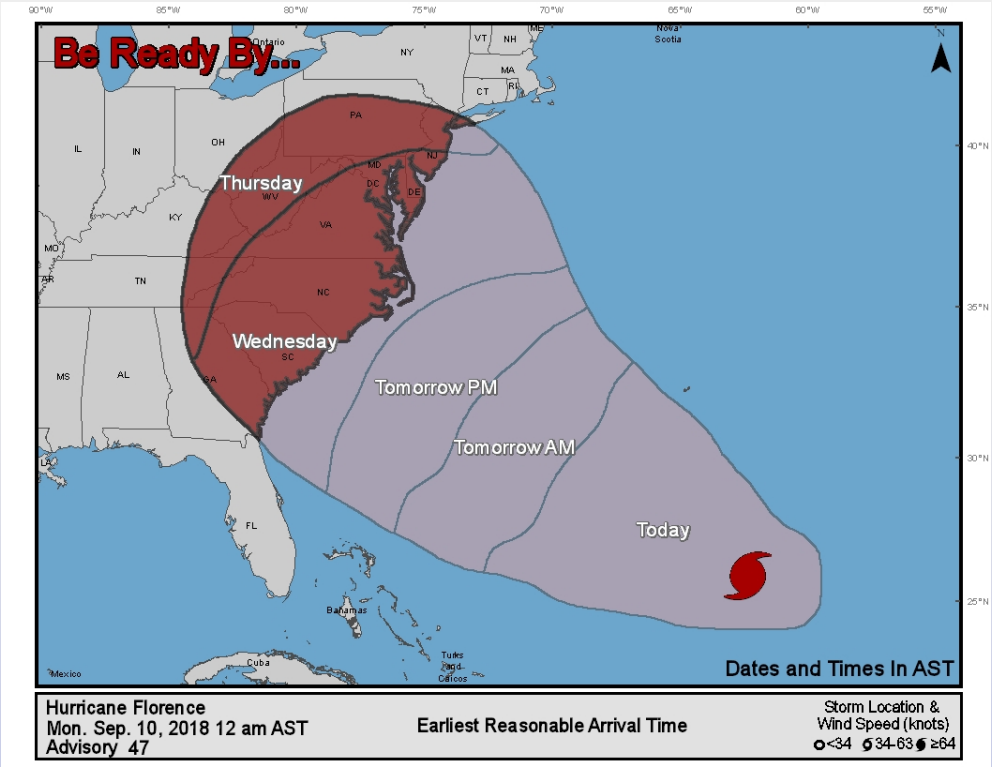
NHC Activities

- Modification to G-IV targeting software to allow for inner and outer circumnavigation loop around the storm
- Evaluation of data denial studies conducted by EMC to determine impact of supplemental radiosondes and G-IV surveillance dropwindsondes on GFS track skill
- Optimization of intensity and wind radii interpolation for AVNO,EMX,HWRF,HMON,CTCX



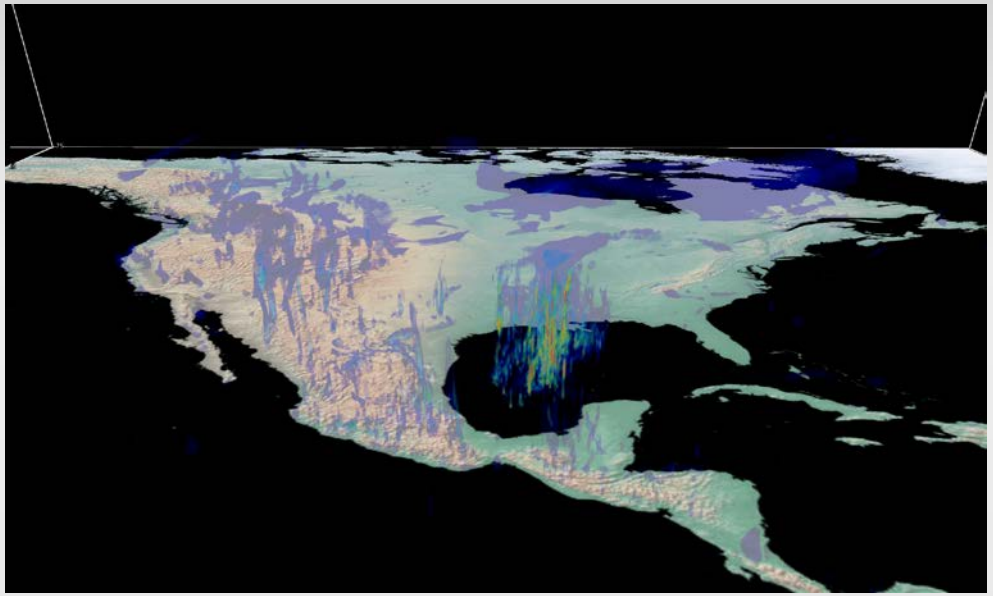
NHC Activities

- "Be Ready By" graphic automated and used for real-time media briefings
- Improved visualization of post-storm surge and other storm impacts
- Time of Arrival operationally implemented



3-D Visualizations for NHC Forecasters

- Forecasters have little time to view details of HWRF and other model fields
- Design 3-D visualizations to provide forecasters with model insight
- Prototype products for
  - Dry air intrusions
  - Trough interactions
  - Shear and vortex response



Absolute vorticity (color contours) from an HWRF forecast for Hurricane Harvey (2017)

NRL: ATCF

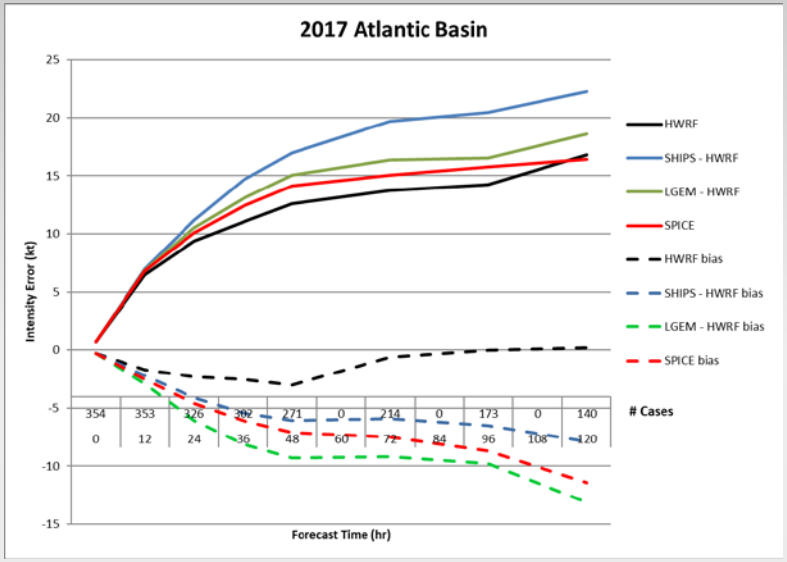
- GUI improvements
- WPC began issuing public advisories for inland depressions in ATCF
- 48 h hurricane-force wind radii forecasts and updated public advisory format

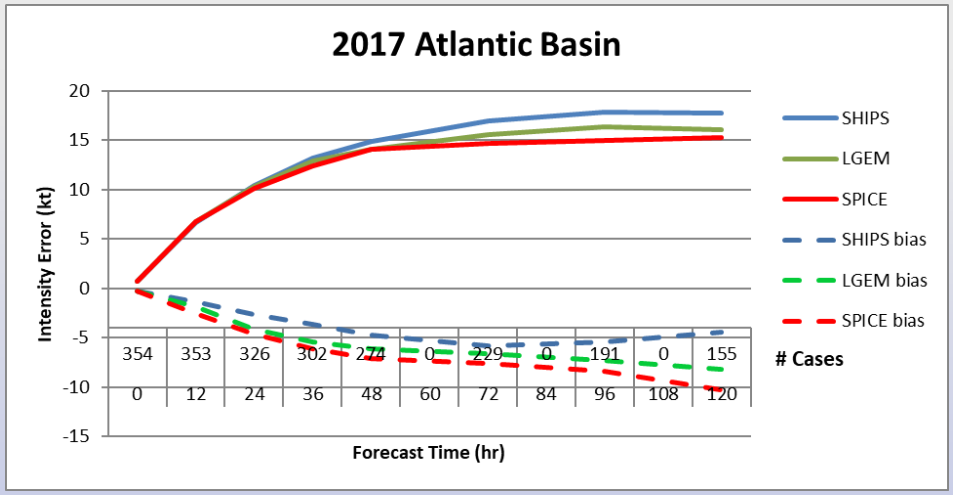
CIRA/NHC: SHIPS/LGEM/RII updates

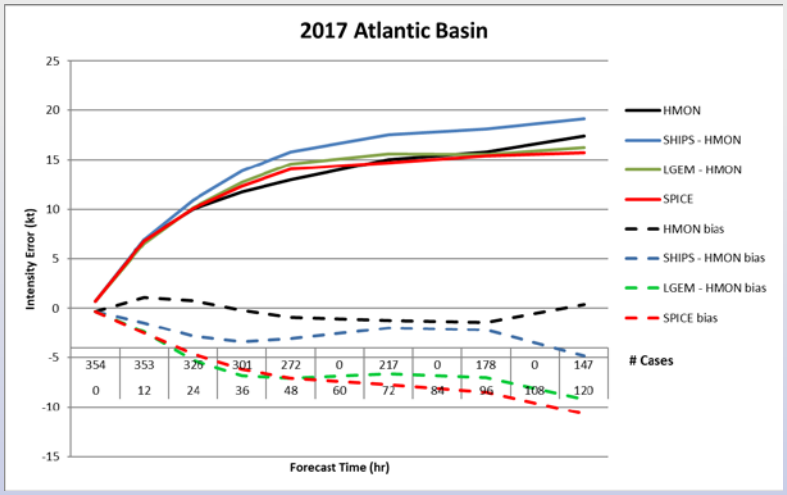
- Added GOES-16 processing for SHIPS/LGEM, METEOSAT currently under development with NHC
- Developmental databases updated for 2018
- Process to run SHIPS from ECMWF fields streamlined and ECMWF SHIPS added to adecks at NHC
- Coordinating with NHC to troubleshoot delivery of e-deck RI guidance; continuing to deliver to NCAR post-processed e-decks from operational RII in the meantime
- Adding forecast of wind radii to SHIPS/LGEM/RII processing to be run semi-operationally at NHC
- New statistical RII model (DTOPS)

CIRA: SPICE

- Examined the replacement of GFDL with HMON in SPICE in 2017
- SHIPS and LGEM run from HWRF fields showed large errors and large negative biases – runs are being investigated for any particular environmental parameters
- Was delivered in demonstration

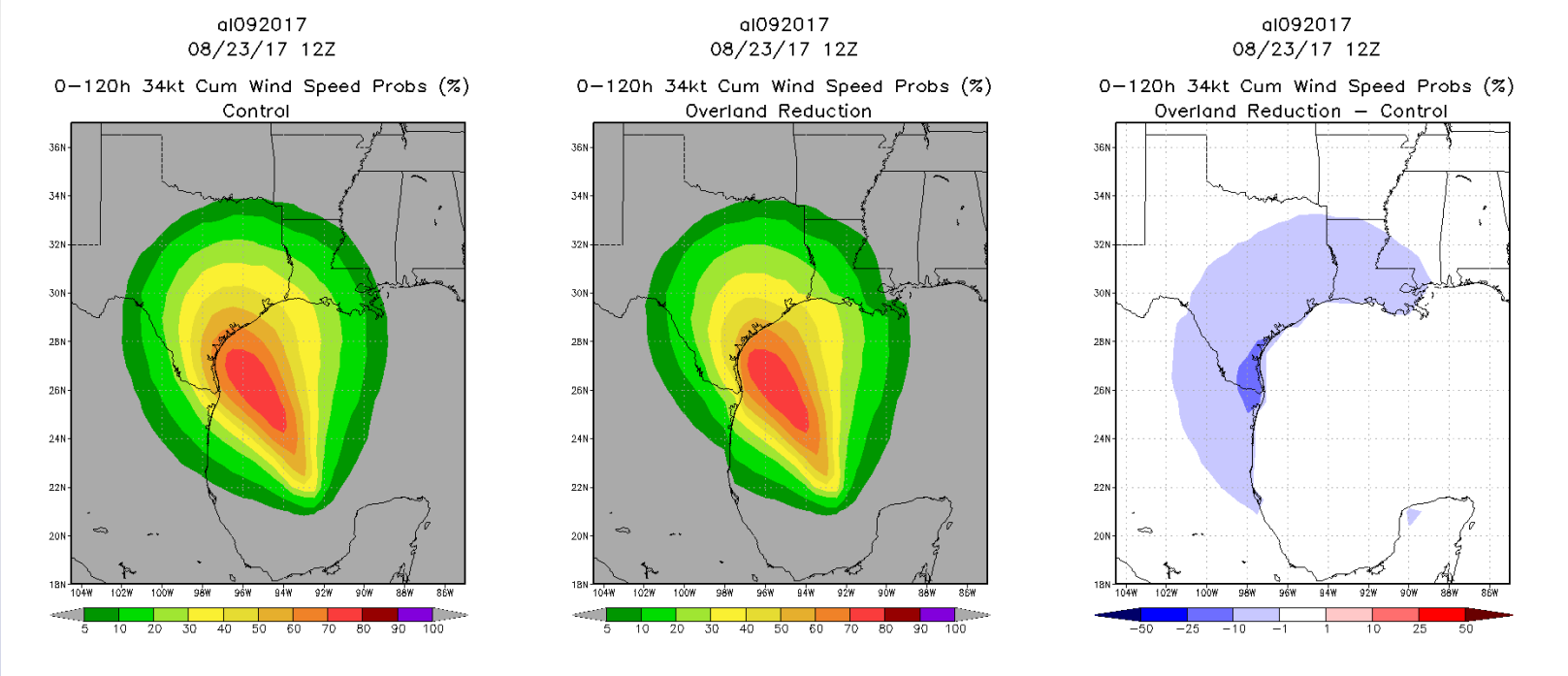




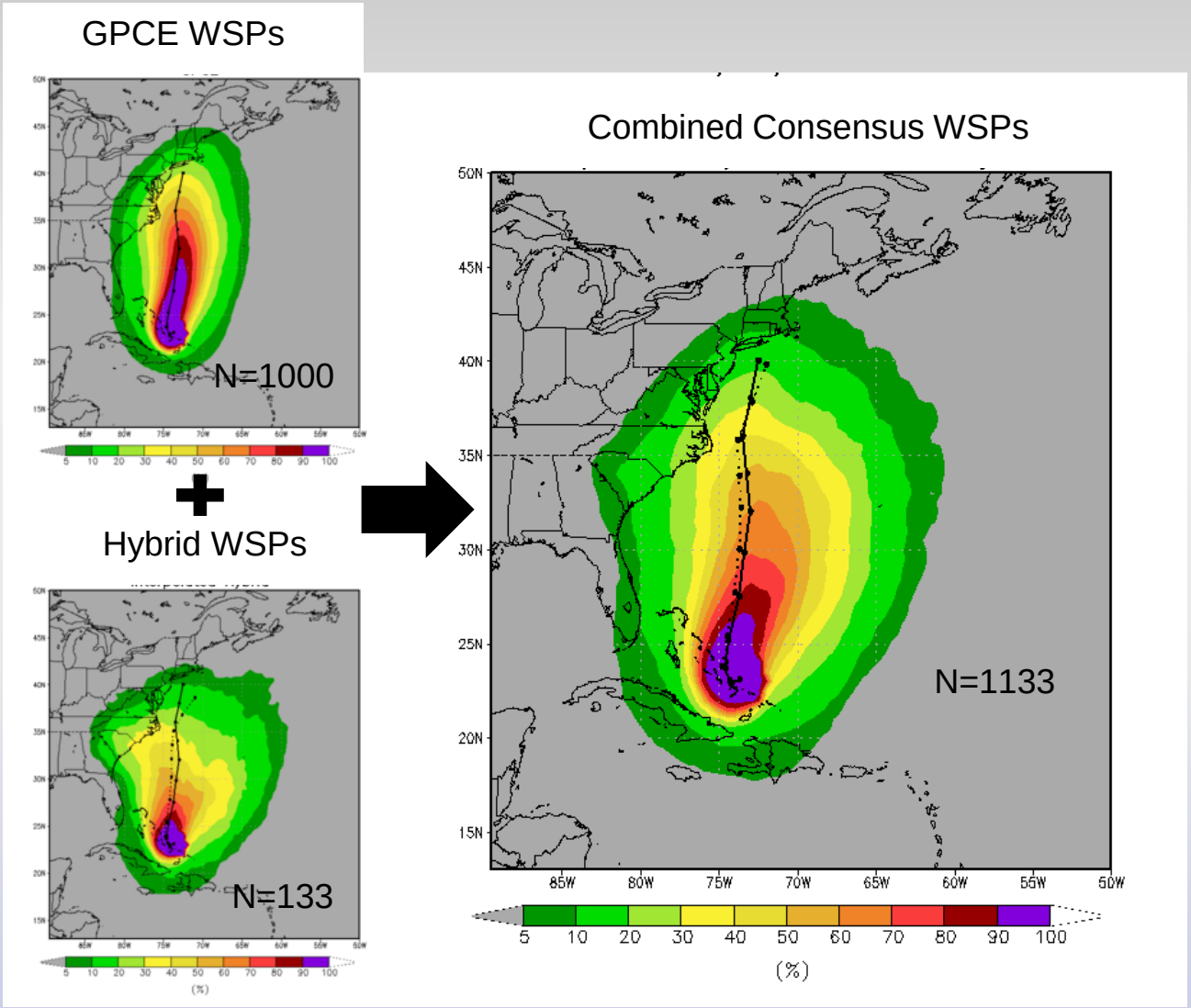


CIRA: Wind Speed Probabilities (WSP)

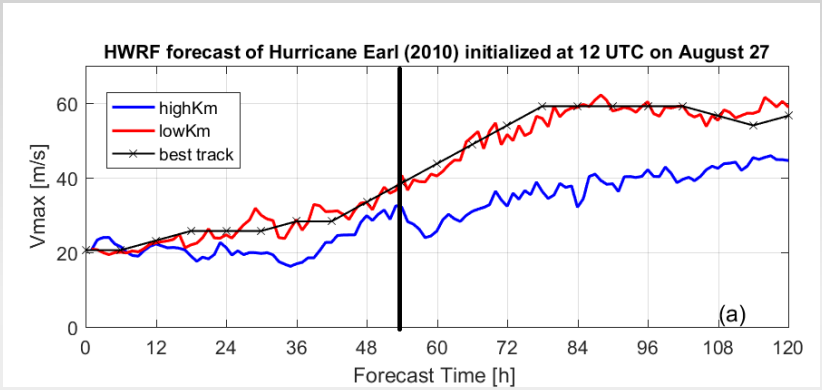
- Inland WSP correction (operational in 2018)
- Inclusion of global model ensemble tracks in WSPs (experimental)

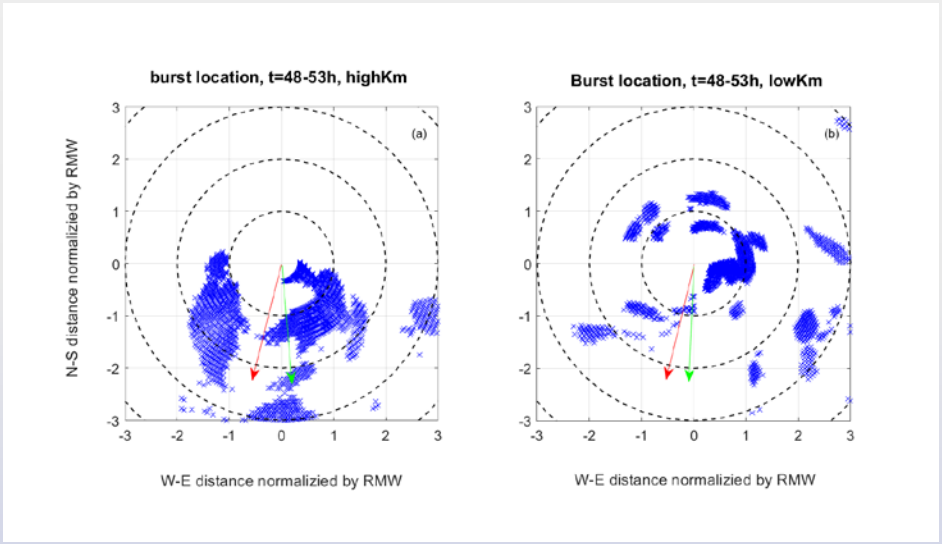


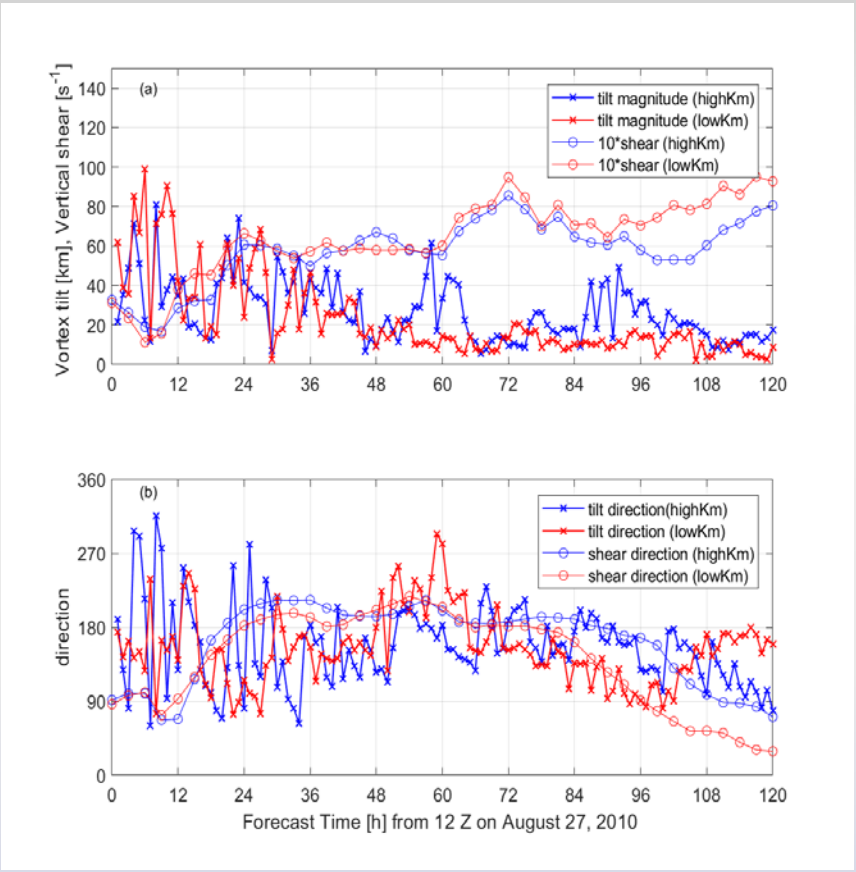
CIRA: Experimental Wind Speed Probabilities (WSP)



HRD Activities: Impact of PBL Physics on HWRF Forecasts of RI Storms in Shear

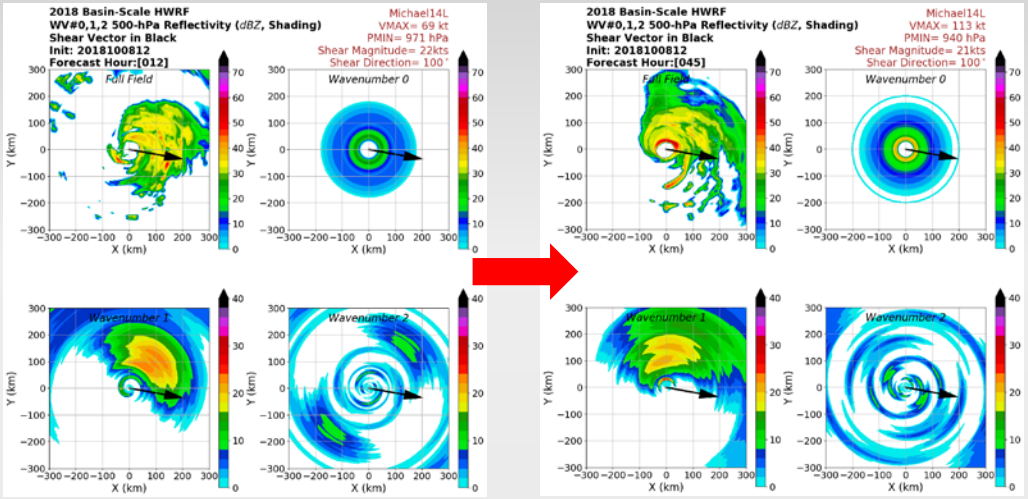






- Vertical eddy diffusivity (Km) in the PBL regulates the vortex-scale (tilt evolution) and convective-scale (bursts) structure, and in turn the rapid intensification (RI) of Hurricane Earl (2010) in HWRF forecasts.

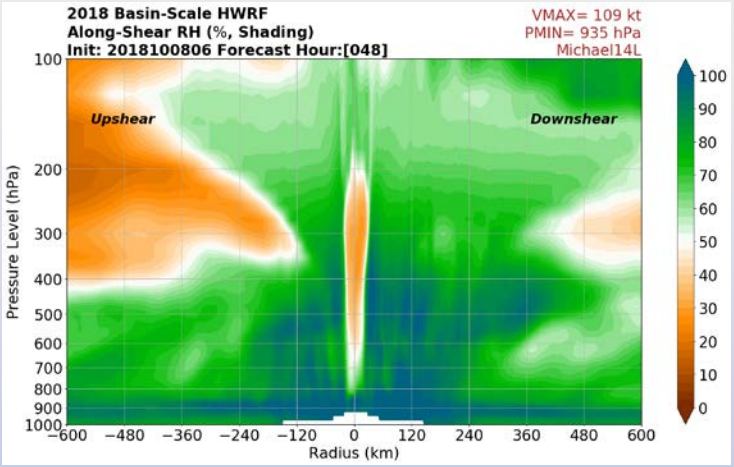
HRD: Polar Cylindrical Analysis for HWRF-B and FV3-GFS



-Analysis and plotting of high-resolution model output in cylindrical coordinates

-These examples show the decomposition of reflectivity into wavenumber 0,1,2

-In this Michael example, Wavenumber-0 (symmetry) grows, wavenumber-1 is more upshear (as convection rotates around), and the storm intensifies



-Other graphics include shear-relative RH, reflectivity

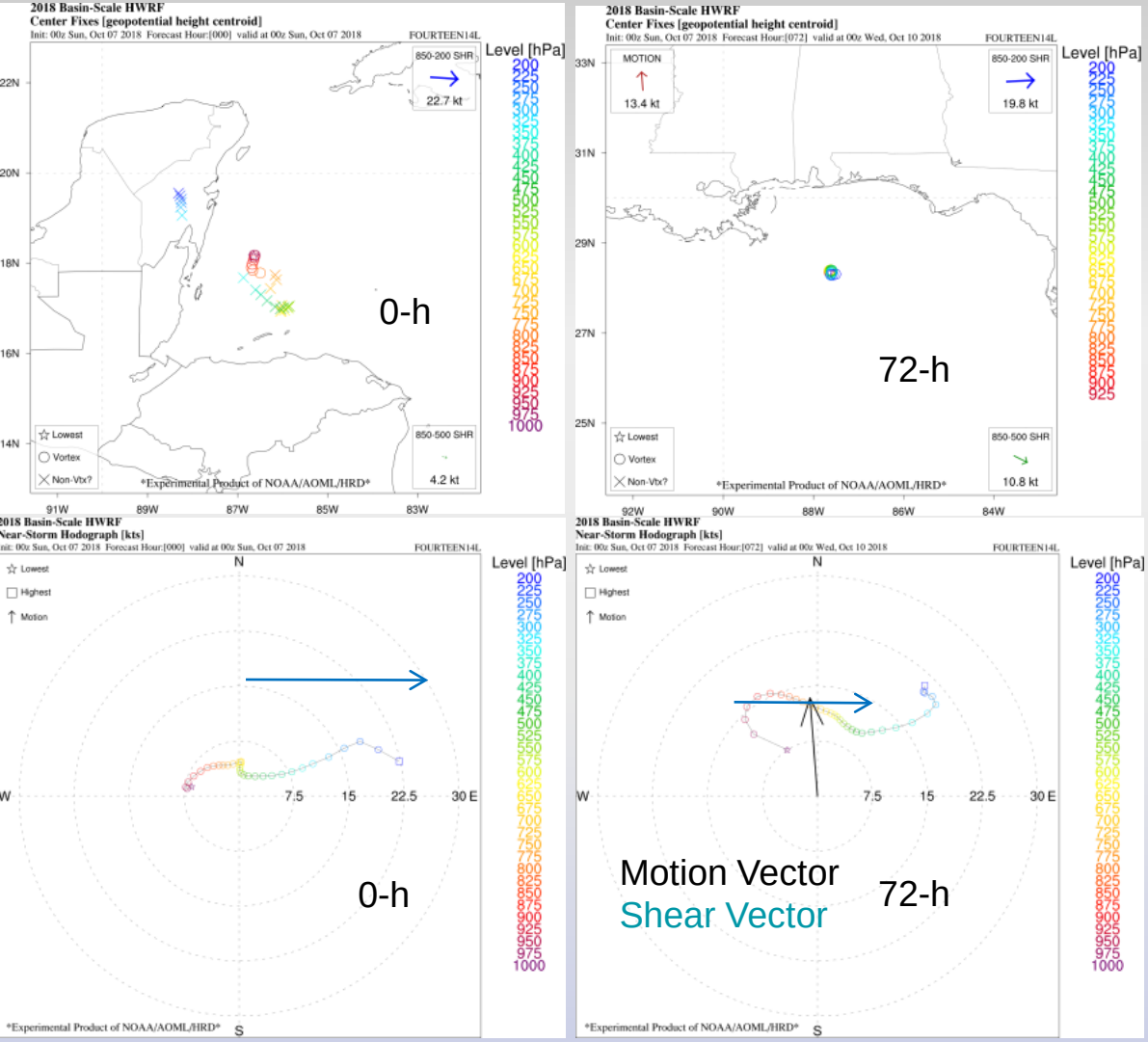
-Along-shear RH for Michael shows how dry air never made it to the core

-Further products available for wind (radial and tangential)

-Vertical structure diagnostics will be added

-Being transitioned to FV3

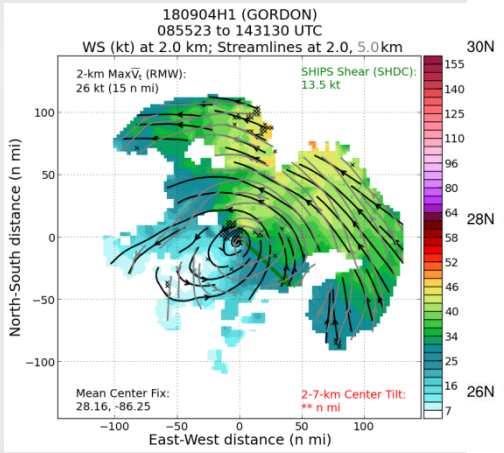
HRD: Vertical Tilt and Near-Storm Hodographs for HWRF-B

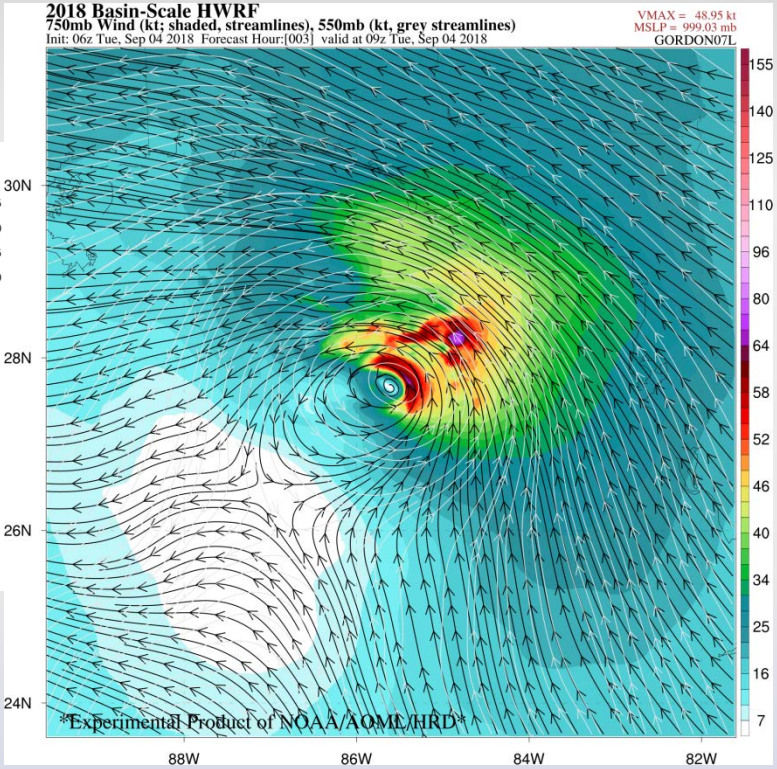


- **Vertical Tilt (top row)** is determined by the geopotential height centroid at each vertical level, starting at the surface center and working upwards in the atmosphere.
- **Near-Storm Hodograph (bottom row)** is determined by the 200-800-km annulus average wind at each vertical level and provides an idea of the steering flow.
- Michael's vortex becomes totally upright by 72-h
- Michael's motion follows 600-700 hPa environmental flow
- Different wind structure for similar SHIPS shear

HRD: TDR-equivalent Products for HWRF-B

Real-Time TDR composite for Tropical Storm Gordon



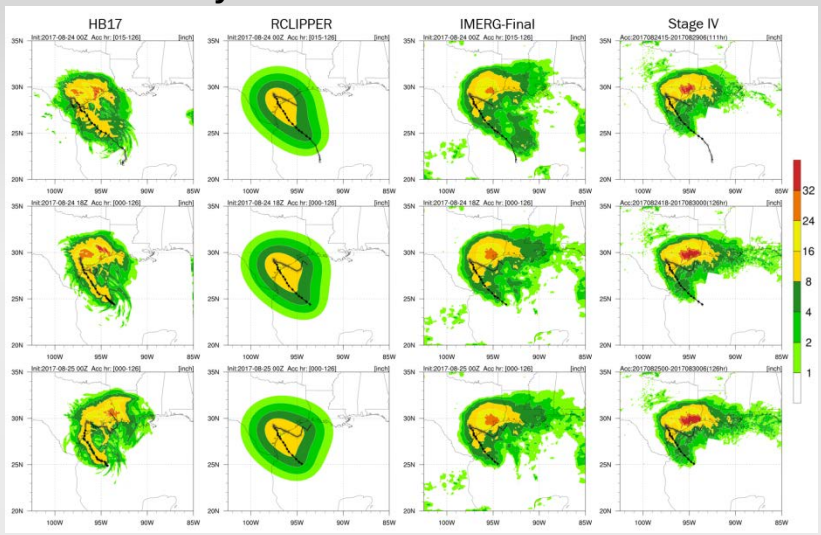


Also available for Reflectivity!

- Evaluate low-level and mid-level winds in the model to those from the observations
- Speed shaded at 750 hPa / 2 km
- Black streamlines = 750 hPa / 2 km
- Grey streamlines = 550 hPa / 5 km
- Similar eastward tilt with height
- HWRF-B overestimated the low-level wind speed near the center
- Far-field wind speeds look realistic

HRD: Precipitation Evaluation for HWRF-B

1. Pattern Analysis

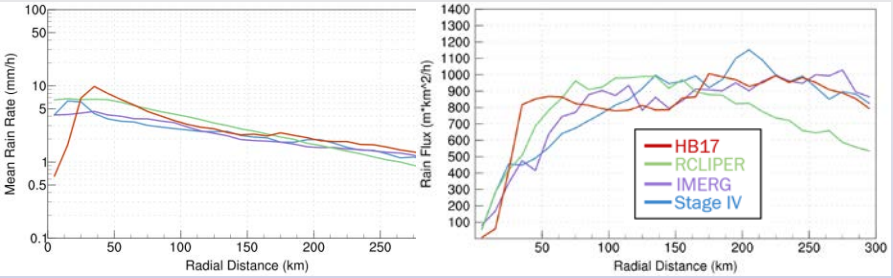


- HWRF-B was capable of generating realistic precipitation patterns and rainfall amounts for Hurricane Harvey.
- HWRF-B overestimated rain rates in the inner core.
- Rain flux takes into account model grid size → better!

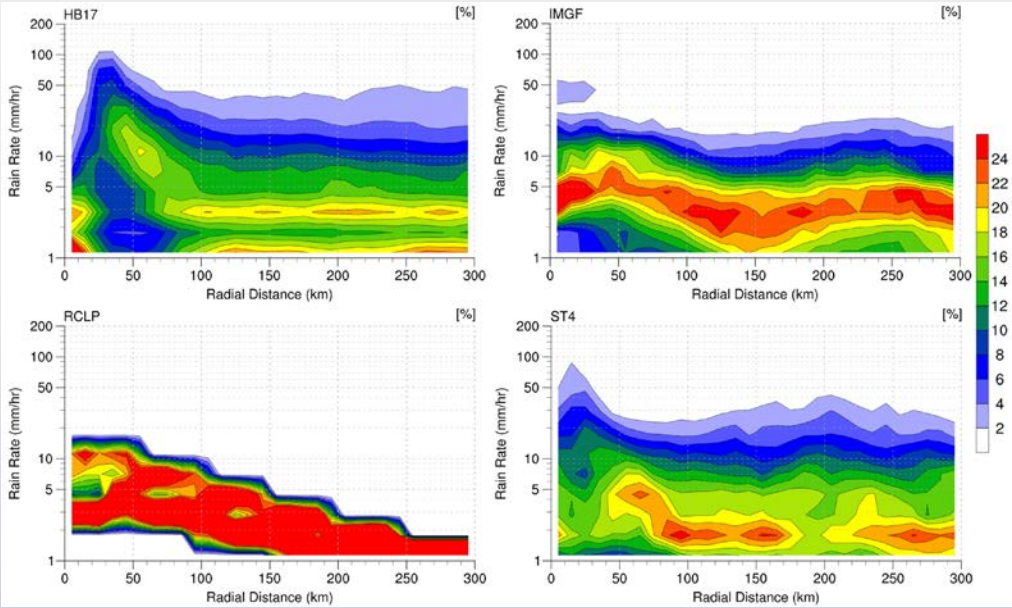
2. Radial Distributions

a. Rain Rate

b. Rain Flux



3. Contour Frequency Radial Distribution (CFRD)



HFIP Website

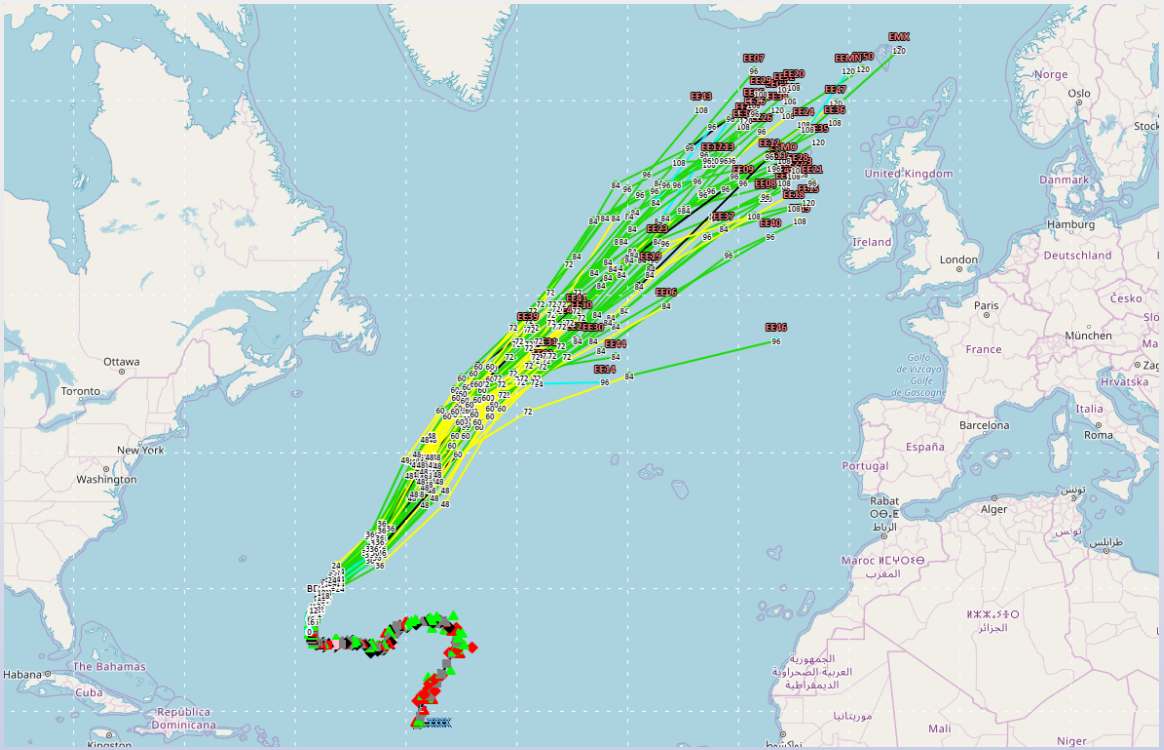
- HFIP products page remains a popular resource in HFIP community and larger community and usage increased in 2018
- Increases visibility and recognition of HFIP
- In 2018 maintained operational model displays, experimental products, graphical model output for evaluation
- Increased participation showcasing results for those granted real-time reservation: HRD, and ESRL's FV3GFS and FIM8
- ‘One-stop’ resource for all known data links related to HFIP via related links
- Products supported in near-real time

HFIP Website

- Products Pages (hfip.org/products)
  - Showcase for experimental models forecasts with operational models for comparison
- Related links Page (hfip.org/related_links)
  - One-stop resource for all known data links related to HFIP
- Google Maps TC Tracks (ruc.noaa.gov/tracks)
  - Interactive maps of TC Tracks
- HFIP.org ~175K pageviews Nov 2017- Oct 2018

NCAR Activities

- Installed visualization software on NHC computers for NHC internal use
- Provided training to forecasters and NHC development staff
- Made updates to software based on NHC feedback
- NHC hopes to use software to assist reanalysis project and improve situational awareness inside building during storm events



Future Plans

- Wind Speed Probabilities
  - Prototype landfall intensity probability product
  - Continued upgrade of NHC Wind Speed Probability model
- Statistical intensity model improvements
  - Adapt to FV3 and GOES-17 for 2019
  - Extend to day 6 and 7
  - Improve rapid intensification indices
  - Ensemble-based statistical models
- New methodology for optimizing use of model trackers
  - Situationally dependent model combinations
  - Error bounds on HCCA
  - Improved representations of model uncertainty (GPCE)

Plans for FY19

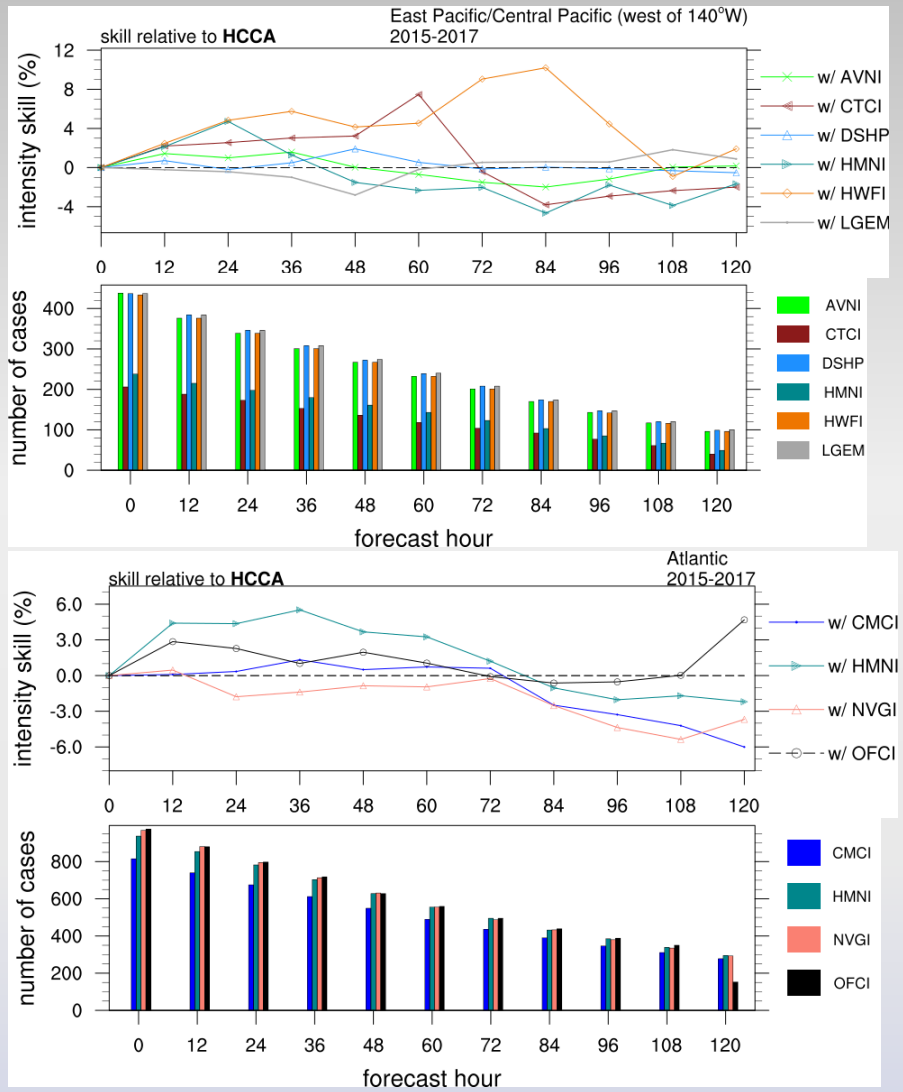
- Continue 3-D model visualization for NHC forecasters
- ATCF enhancements
- Continued evaluation of experimental and operational models
- Improvements to NCAR model display tool
- “Stream 1.5-like” process for experimental forecasts to NHC

EXTRA SLIDES

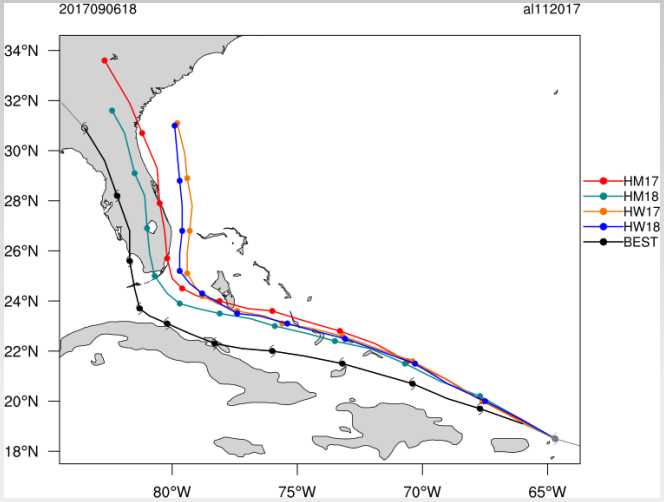
HFIP Corrected Consensus Approach (HCCA)

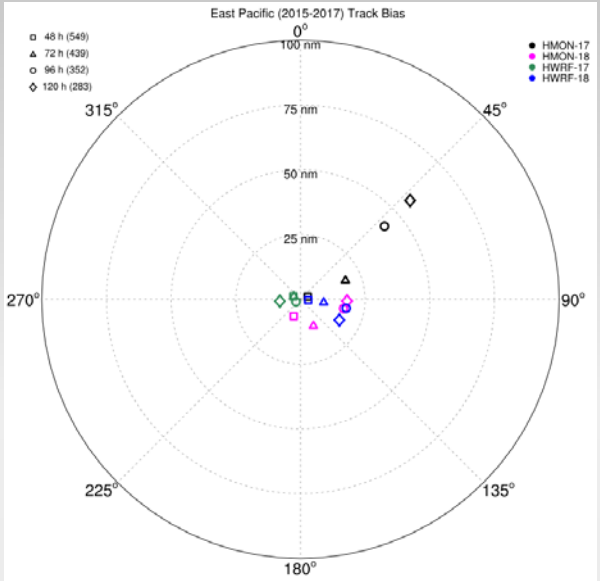
Updates for 2018:

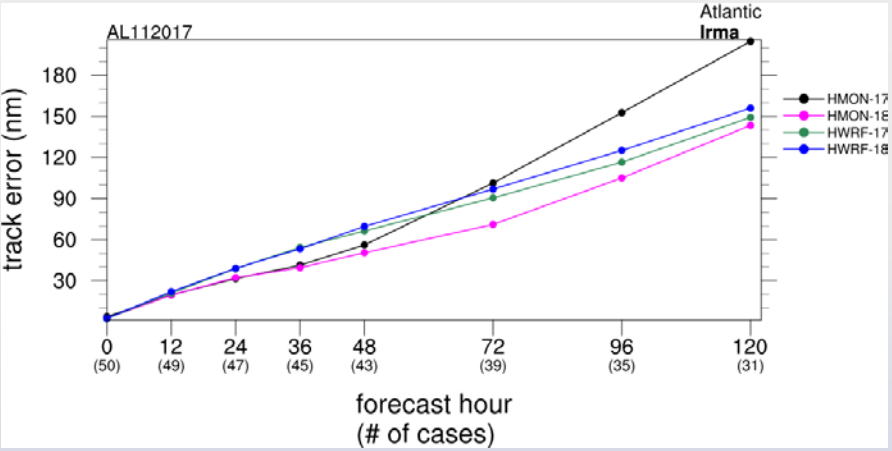
- updated the HCCA code and ported to WCOSS as part of the NHC quasi-production guidance
- training forecast updates are now automated and updated in real-time
- added the capability to forecast for central Pacific systems; conducted sensitivity experiments to determine the optimal input models for central Pacific storms
- evaluated the impact of adding additional input models; included HMON as an input model for AL intensity forecasts
- HCCA is now available to forecasters at CPHC (and WPC during backup situations)
- updated the real-time forecast/verification intranet site; added new forecast diagnostic graphics

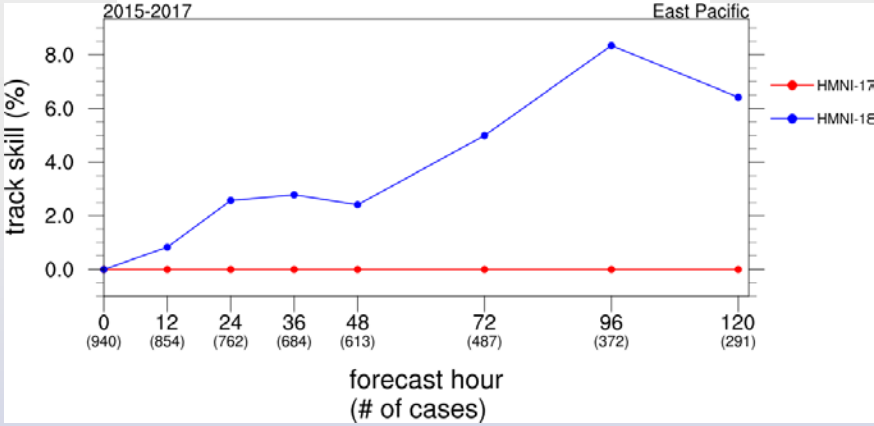


Evaluation of regional hurricane models for tropical cyclone prediction



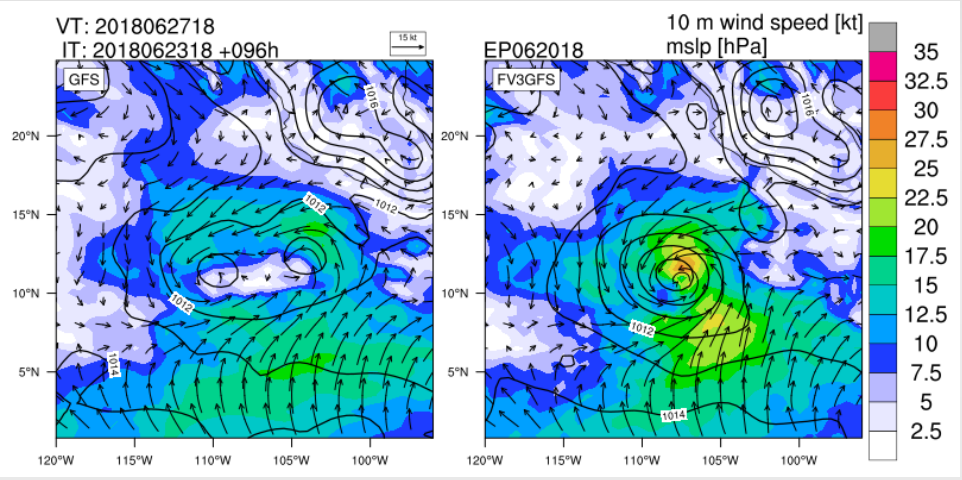




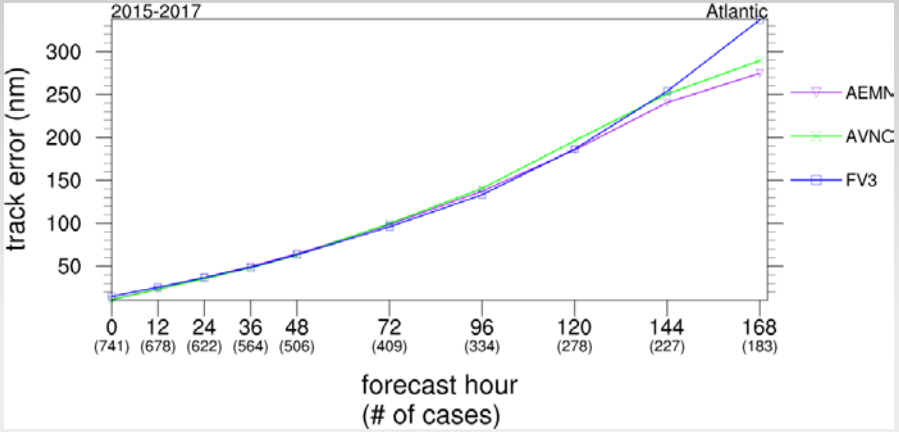


Evaluation of FV3-GFS parallel and retrospective forecasts

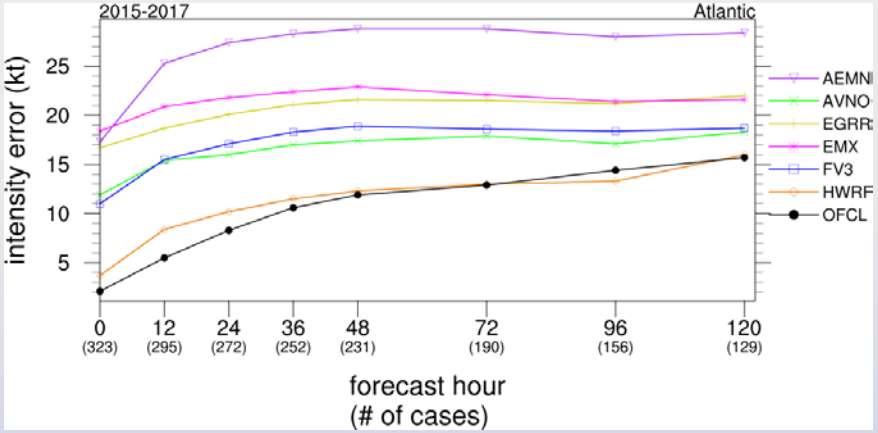
Genesis forecast evaluation



Track verification



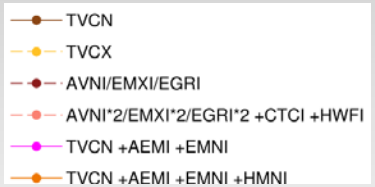
Intensity verification

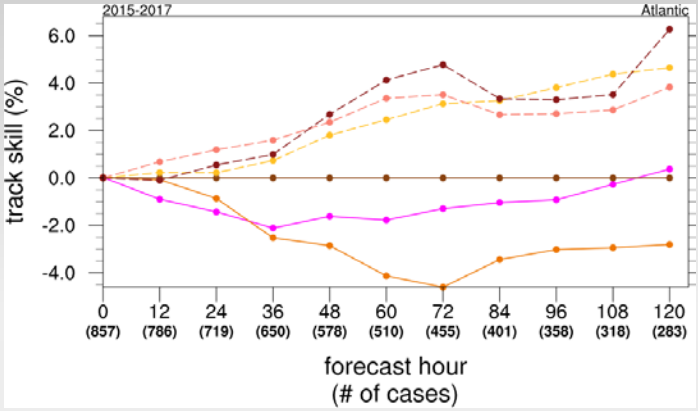


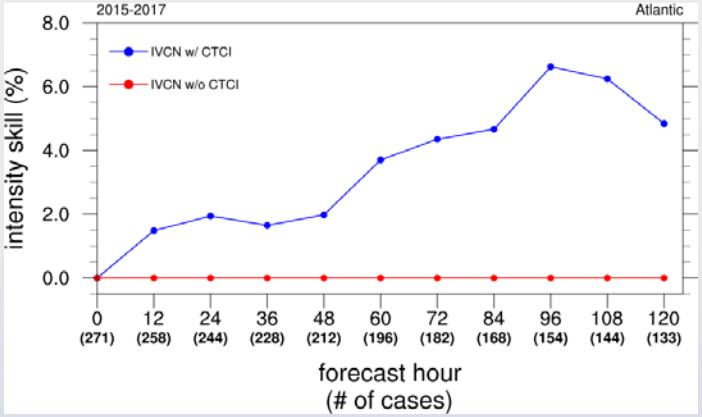
Equally weighted consensus input model sensitivity experiments

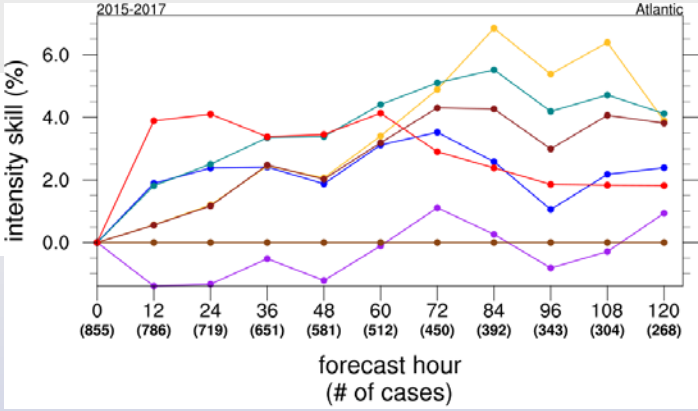
Updates for 2018:

- Implemented a new variables consensus for track (TVDG) and intensity (IVDR)
- optimized the input models of TVCA/TVCE
- added HMON to IVCN

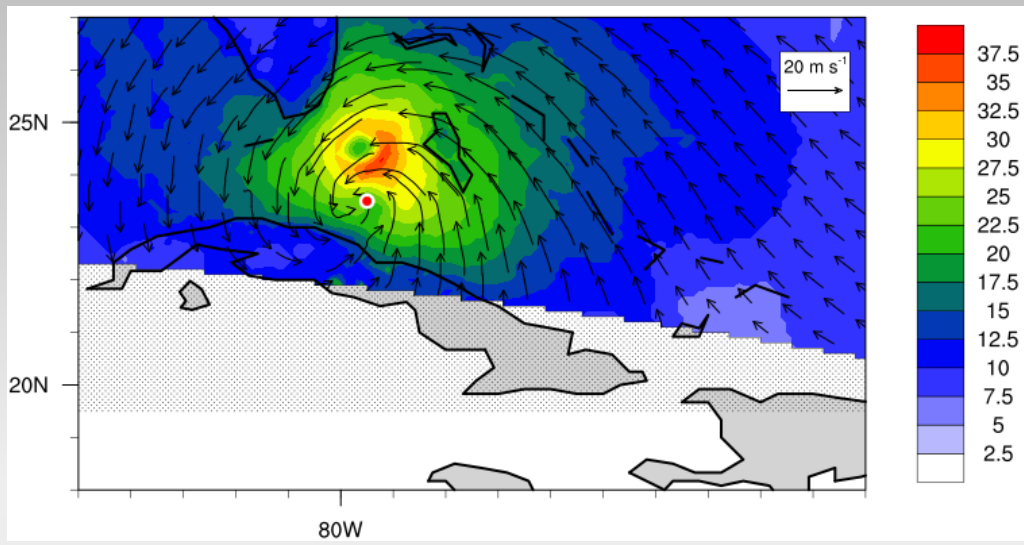


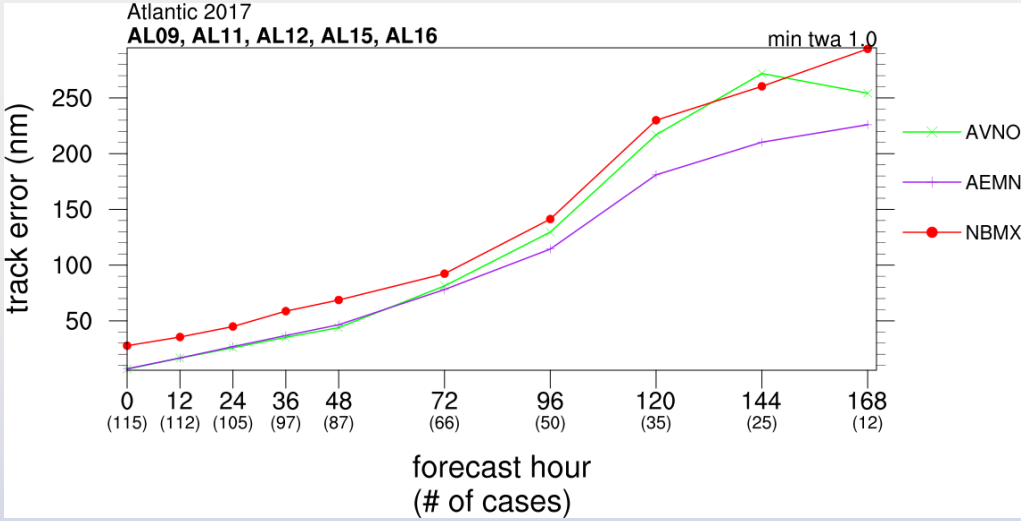




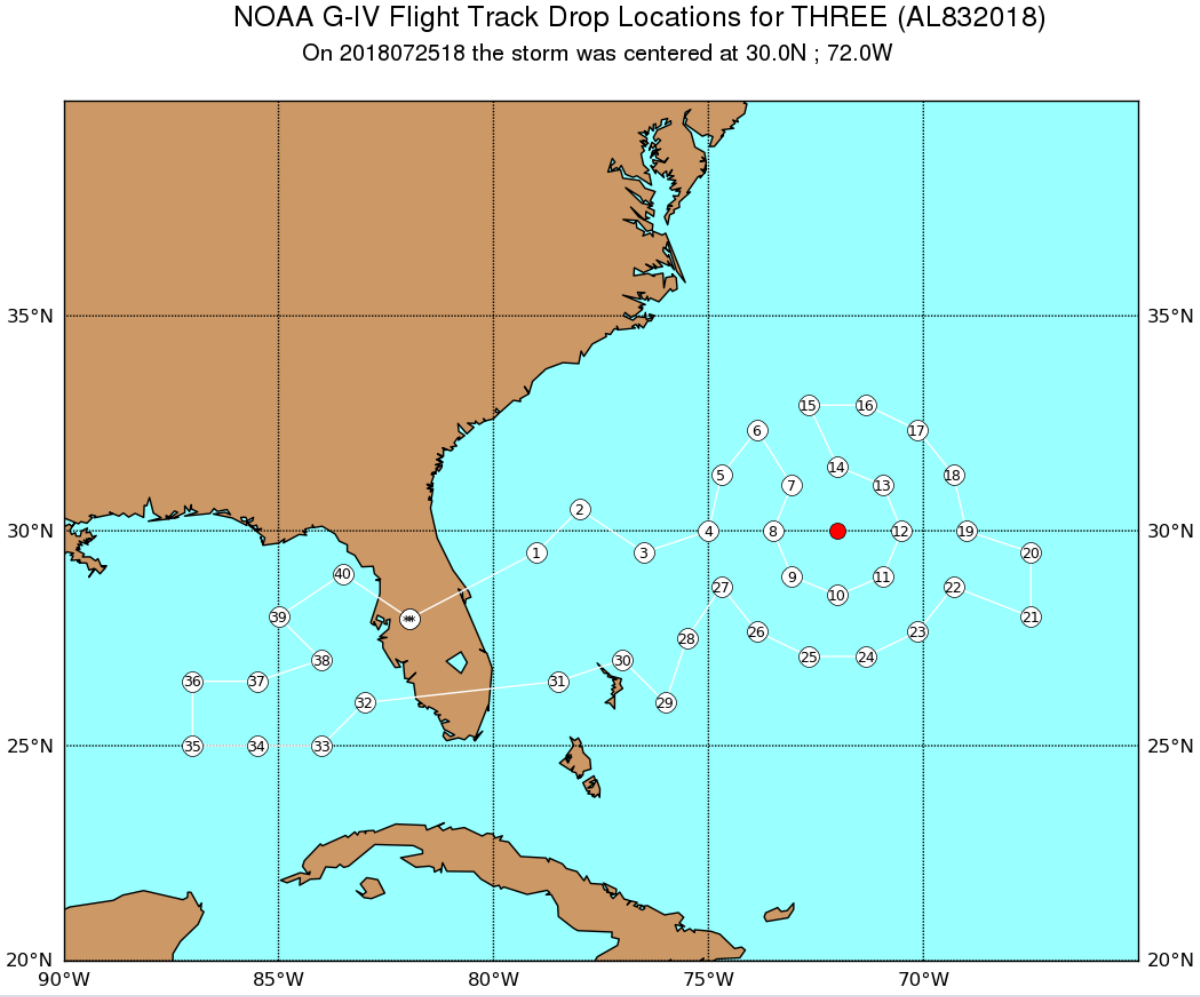


Evaluation of the National Blend of Models (NBM) for tropical cyclone track prediction

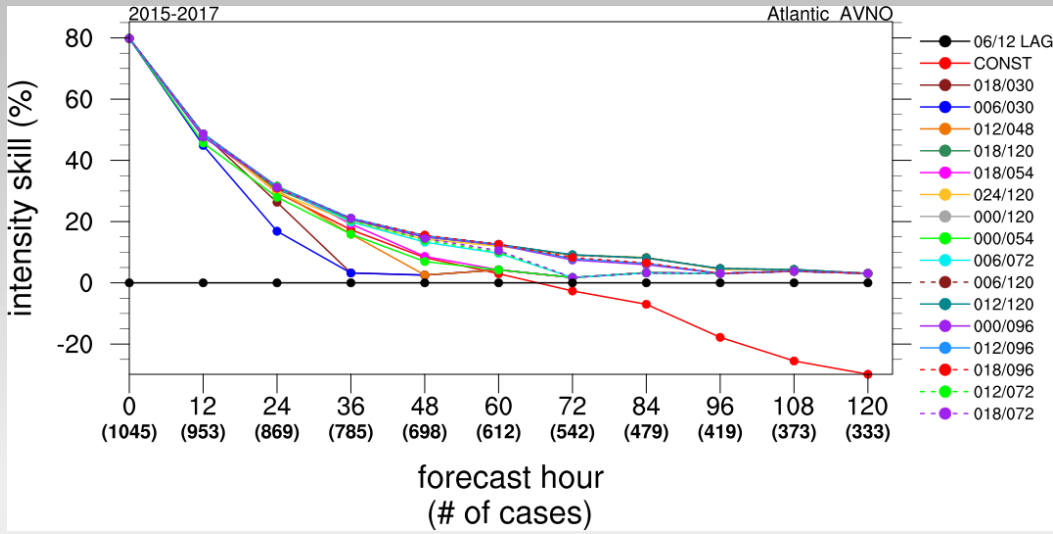


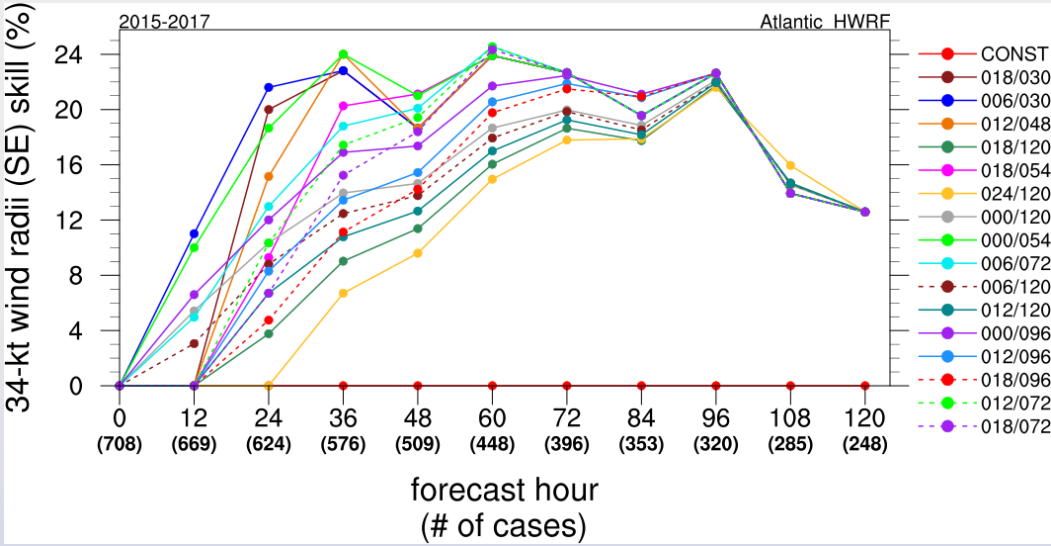


Modification to the G-IV targeting software to allow for an inner (1.5º) and outer (3.0º) circumnavigation loop around the storm

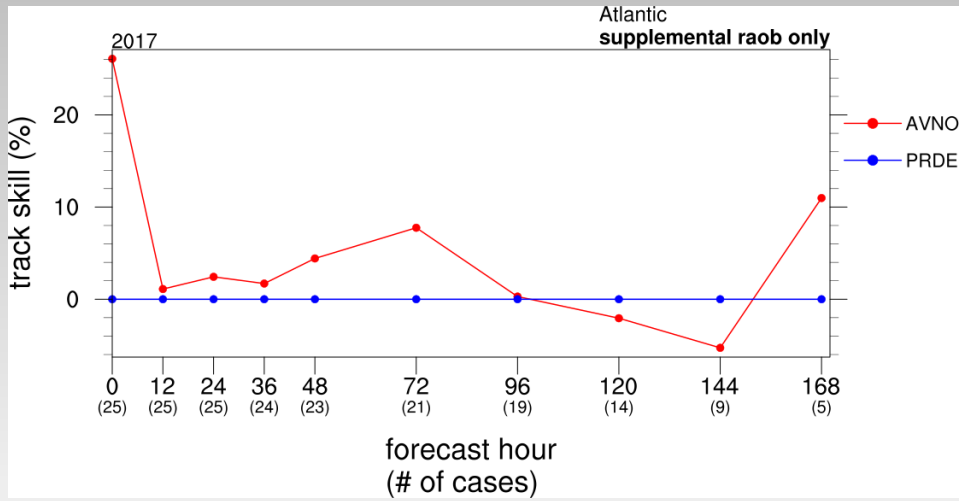


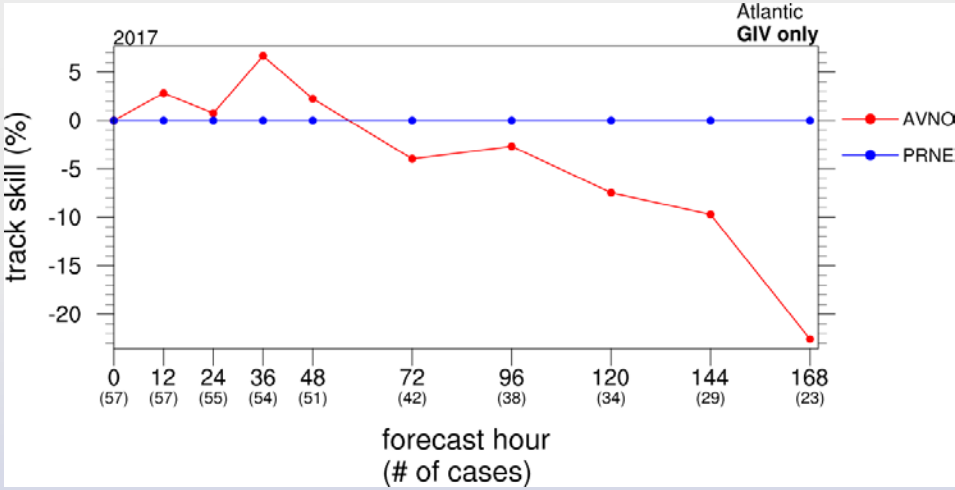
Optimization of intensity and wind radii interpolation for AVNO, EMX, HWRF, HMON, and CTCX





Evaluation of data denial studies (conducted by EMC) to determine how the 06/18 UTC supplemental radiosondes and G-IV surveillance dropwindsondes affect GFS track skill.





CIRA

CIRA UPDATES FOR THE 2018 SEASON FOR WIND SPEED PROBABILITIES AND TO NHC'S OPERATIONAL GUIDANCE SUITE

Andrea Schumacher

Kate Musgrave

HFIP Teleconference – 07/25/2018

INLAND WIND SPEED PROBABILITY CORRECTIONS

Implemented in 2018 NHC WSPs

Updates to improve WSPs over land

WSPs tended to have a high bias over land

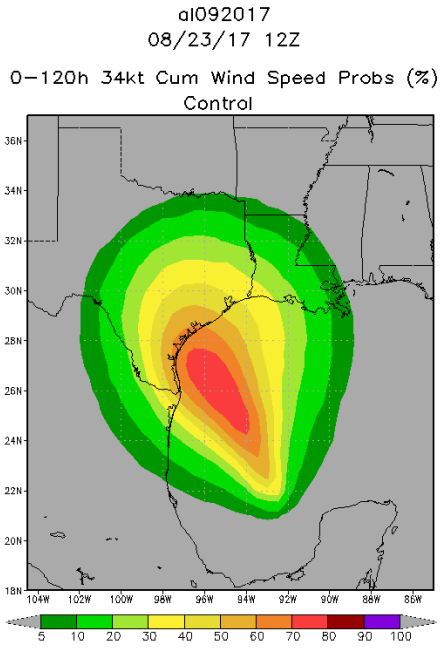
Two updates were made to address this issue

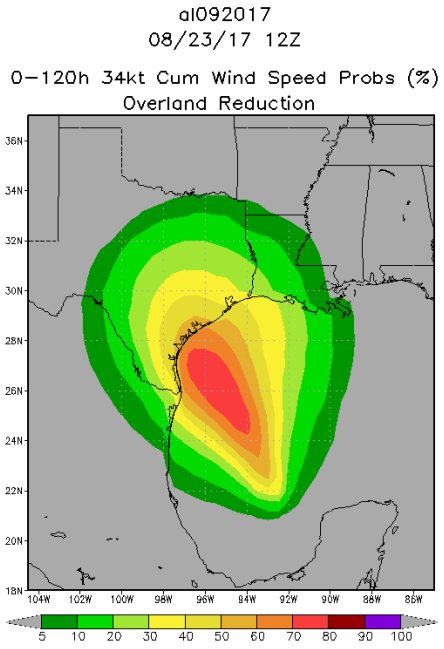
1 – Adapted part of the code that applies a reduction factor to near-surface wind speeds to account for increased friction of land (vs. ocean) to use a smaller time step

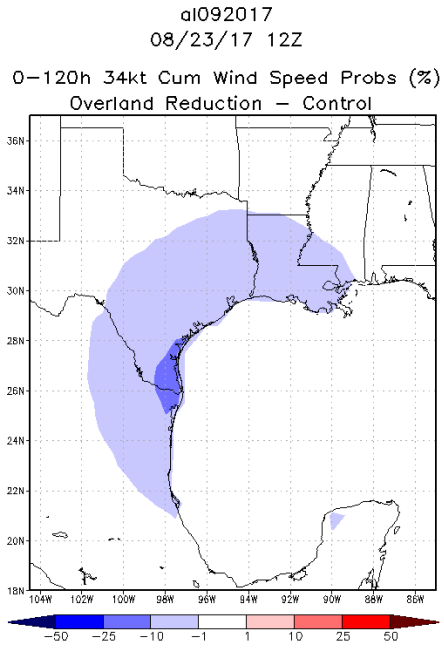
2 –Adapted code to use reduced R34/R50/R64 for overland grid points when TC center is still over water

The result of both of these corrections is reduced, and hence more realistic, wind speed probabilities over land

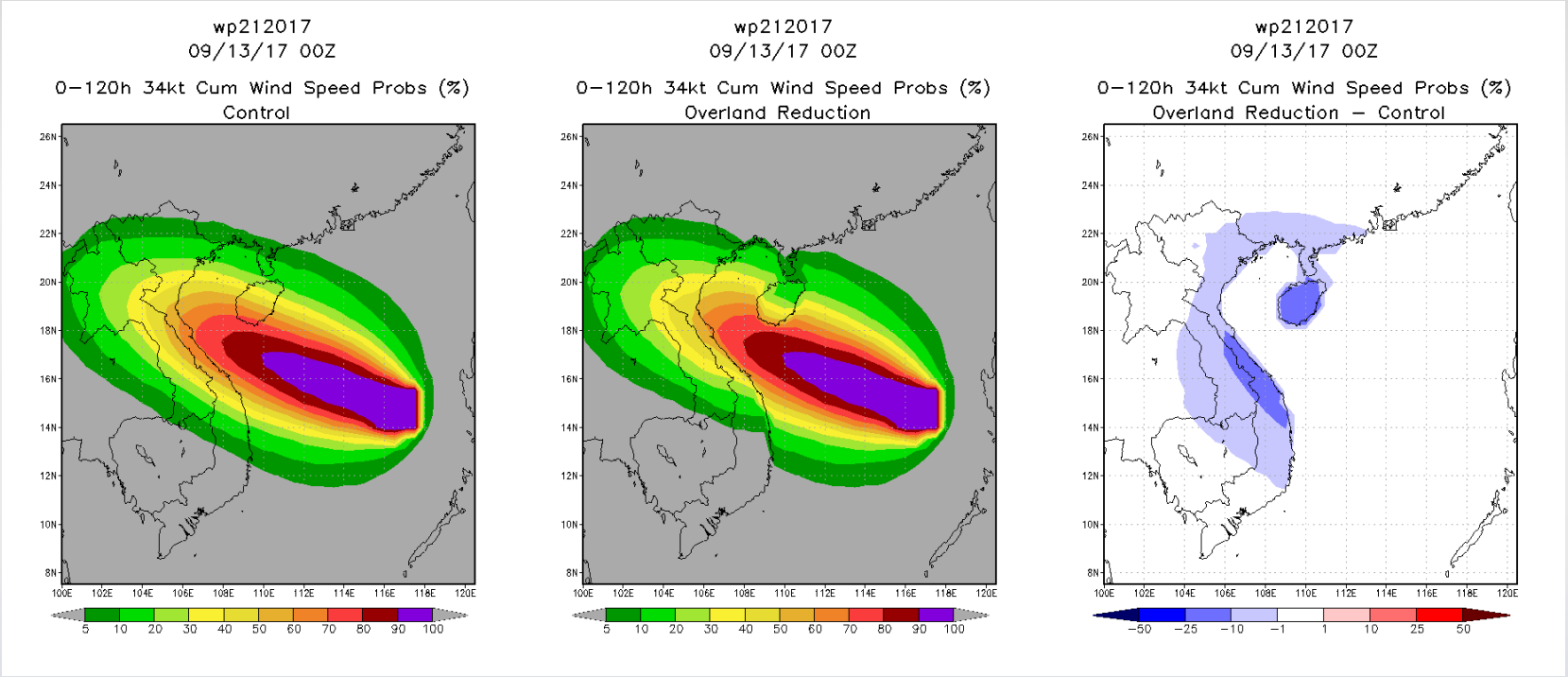
Impact of Inland Correction
Harvey 2017 34-kt WSPs







Impact of Inland Correction
WP21 2017 34-kt WSPs



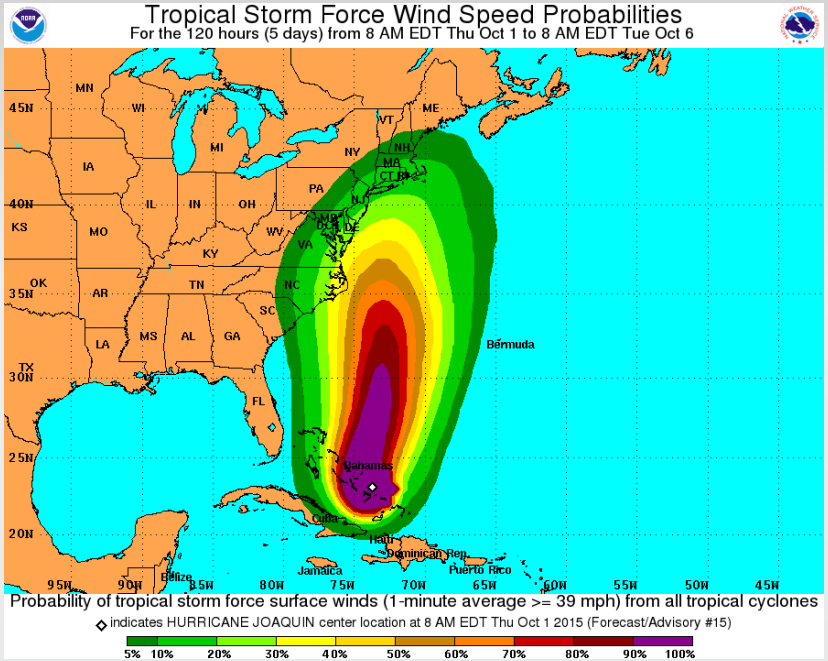
BUD Graphics Archive:
5-day Probability of Tropical-Storm-Force-Winds

Legacy Cone	Cone w/ Wind Field	Wind Speed Probabilities	Arrival Time of TS Winds	Wind Field
3-day no line	3-day no line	34 kt (39mph)	Most Likely	Initial Wind Field
3-day with line	3-day with line	50 kt (58mph)	Most Likely & WSP	Wind History
5-day no line	5-day no line	64 kt (74 mph)	Earliest Reasonable	
5-day with line	5-day with line		Earliest Reasonable & WSP	

Start | - | + | < | > | Rock | Zoom | |< | >| | Save Image

INCORPORATING ENSEMBLE TRACKS INTO THE WIND SPEED PROBABILITIES

Monte Carlo Wind Speed Probability Model

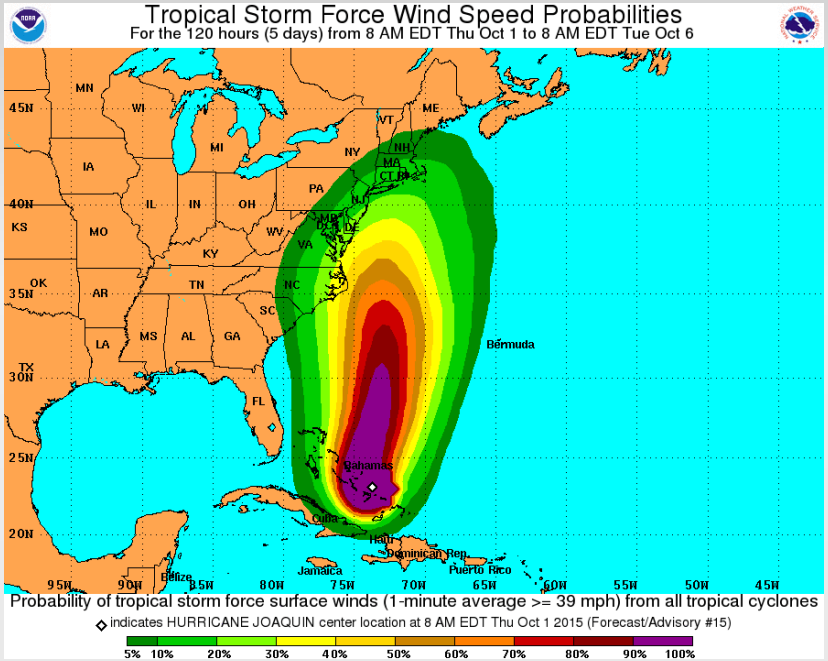


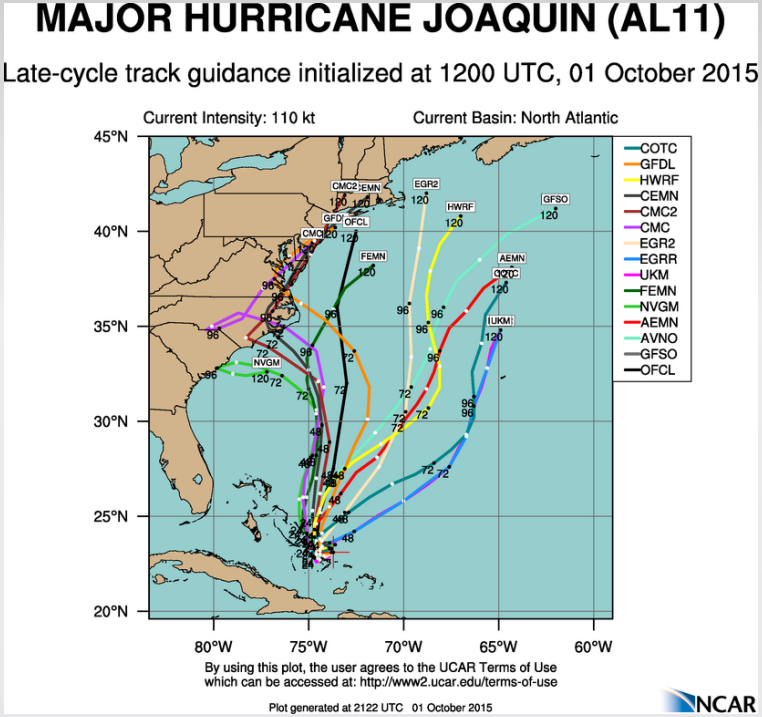
Creates “realizations” based on the official forecast and random sampling of past forecast errors

Provides information about track, intensity, and structure forecast uncertainty in a single set of public products

Represents very little situation-specific uncertainty

Incorporating Situation-Specific Uncertainty – Why?

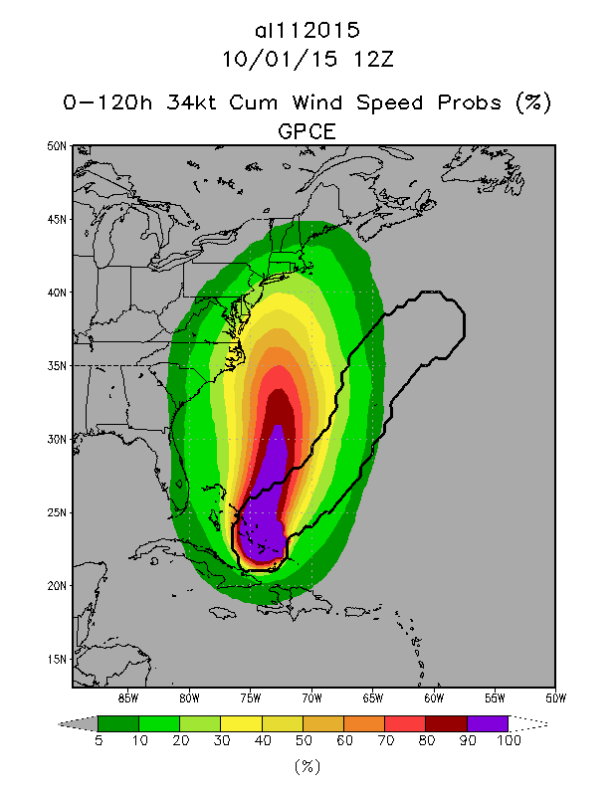


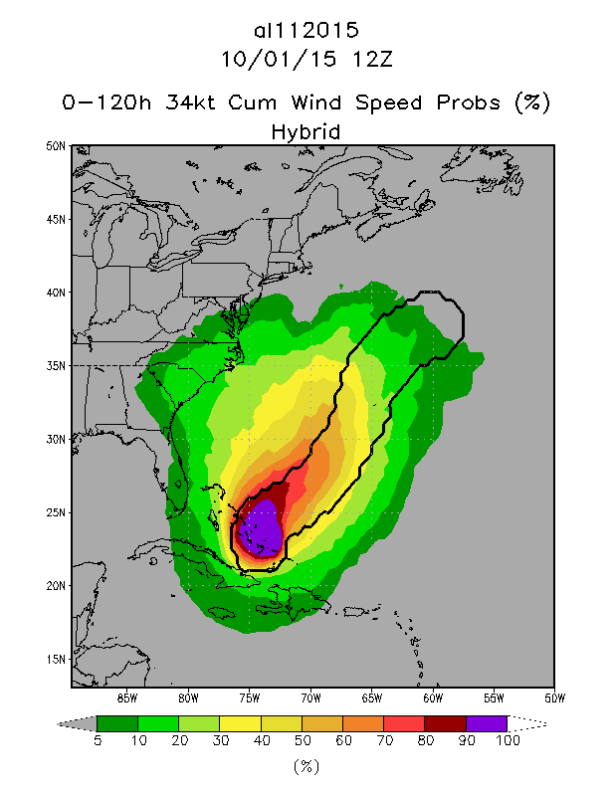


Two plausible track scenarios (landfall SC-VA or NE out to sea)

Since WSPs not a deterministic forecast, they have the potential to represent multiple track scenarios

Past Work – Using Ensemble Tracks to Define Realizations





"Hybrid" methodology - Uses 133 tracks from 5 global model ensemble prediction systems (GFS, ECMWF, FNMOC, UKMET, CMC), intensity and radii estimates use same statistical technique as current WSP model

Issues with Hybrid Methodology

Latency and availability

Many ensembles only available at 0 and 12 Z

Some ensembles have latency up to 10 hours

Forecast Skill

Improved Brier skill scores for specific cases, especially those where model track spread is large

However, slightly degrades Brier skill scores over 4-year sample (2013-2016)

Forecast Consistency

Not necessarily consistent with other NHC forecast products

This is a BIG DEAL in terms of forecast communication

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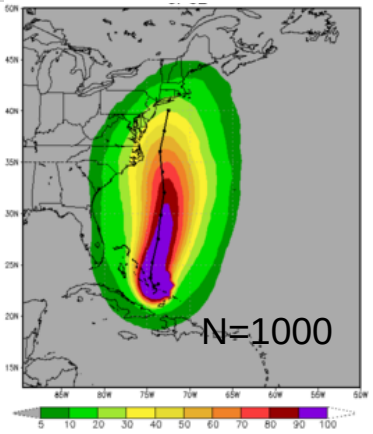
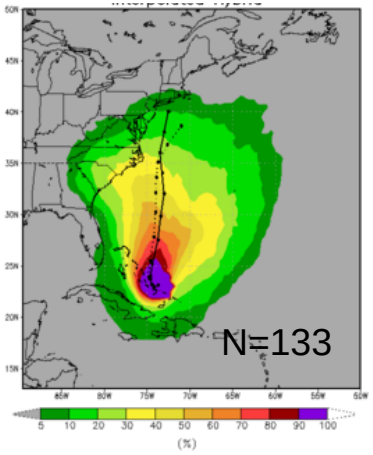
Methodology – Consensus of Ensembles (CoE)

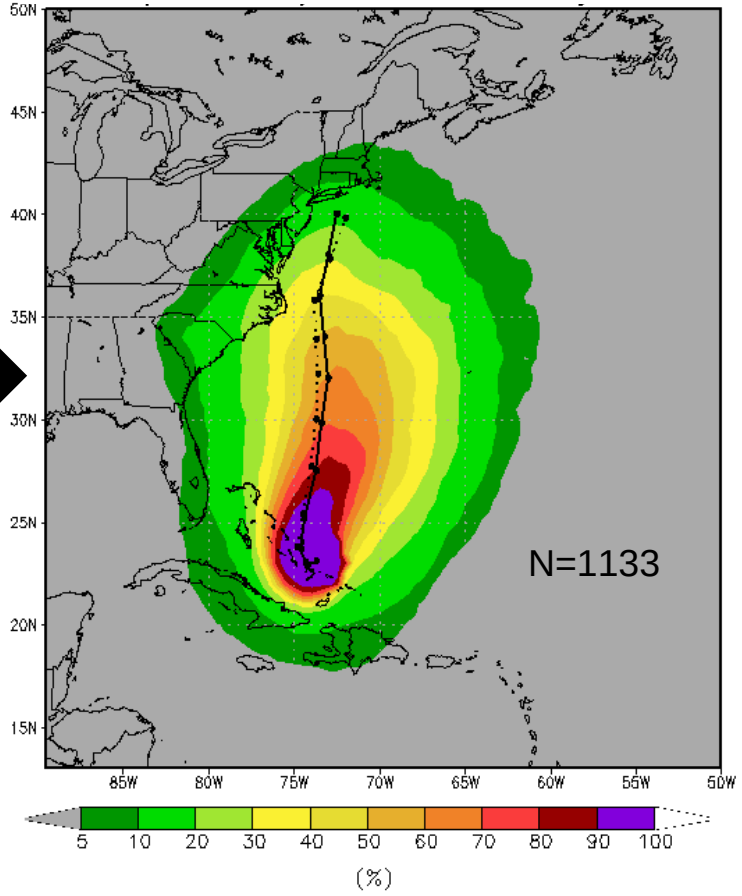
GPCE WSPs



Hybrid WSPs



Combined Consensus WSPs



Verification Metrics (2013-2016)

Brier skill score, $BSS = \frac{BS}{BS_{ref}}$

Answers the question: What is the relative skill of the probabilistic forecast over that of climatology, in terms of predicting whether or not an event occurred?

Range: -∞ to 1, 0 indicates no skill when compared to the reference forecast. **Perfect score:** 1.

Multiplicative Bias, $Bias = \frac{\frac{1}{N}\sum_{N}^{i=1} F_i}{\frac{1}{N}\sum_{N}^{i=1} O_i}$

Answers the question: How does the average forecast magnitude compare to the average observed magnitude?

Range: -∞ to +∞. **Perfect score:** 1.

Optimal Threat Score, $TS = \frac{hits}{hits+misses+false\ alarms}$

Probability threshold used to distinguish prediction of events from non-events varied by 1% from 1% to 100%

Answers the question: How well did the forecast "yes" events correspond to the observed "yes" events?

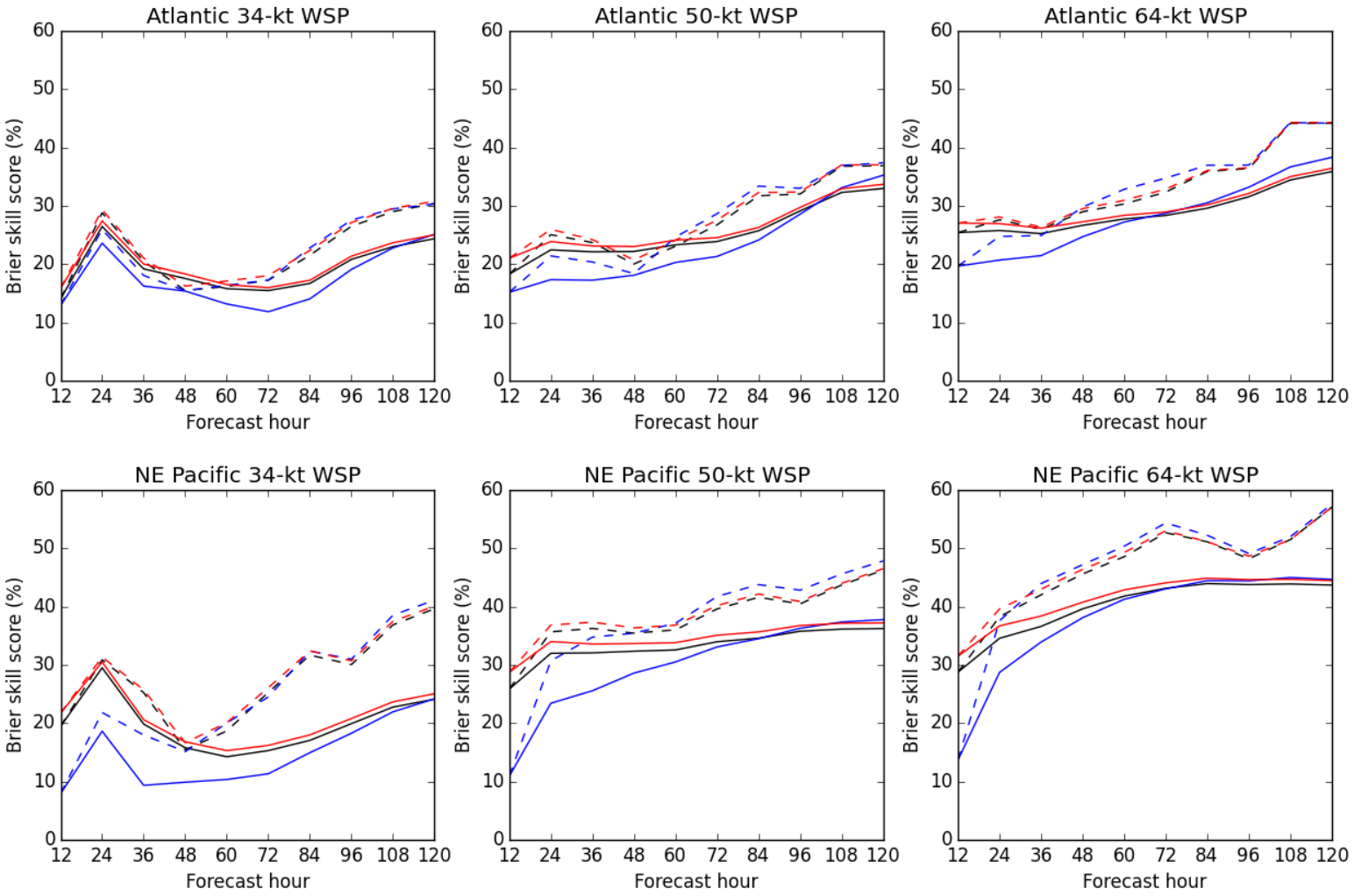
Range: 0 to 1, 0 indicates no skill. **Perfect score:** 1.

Reliability

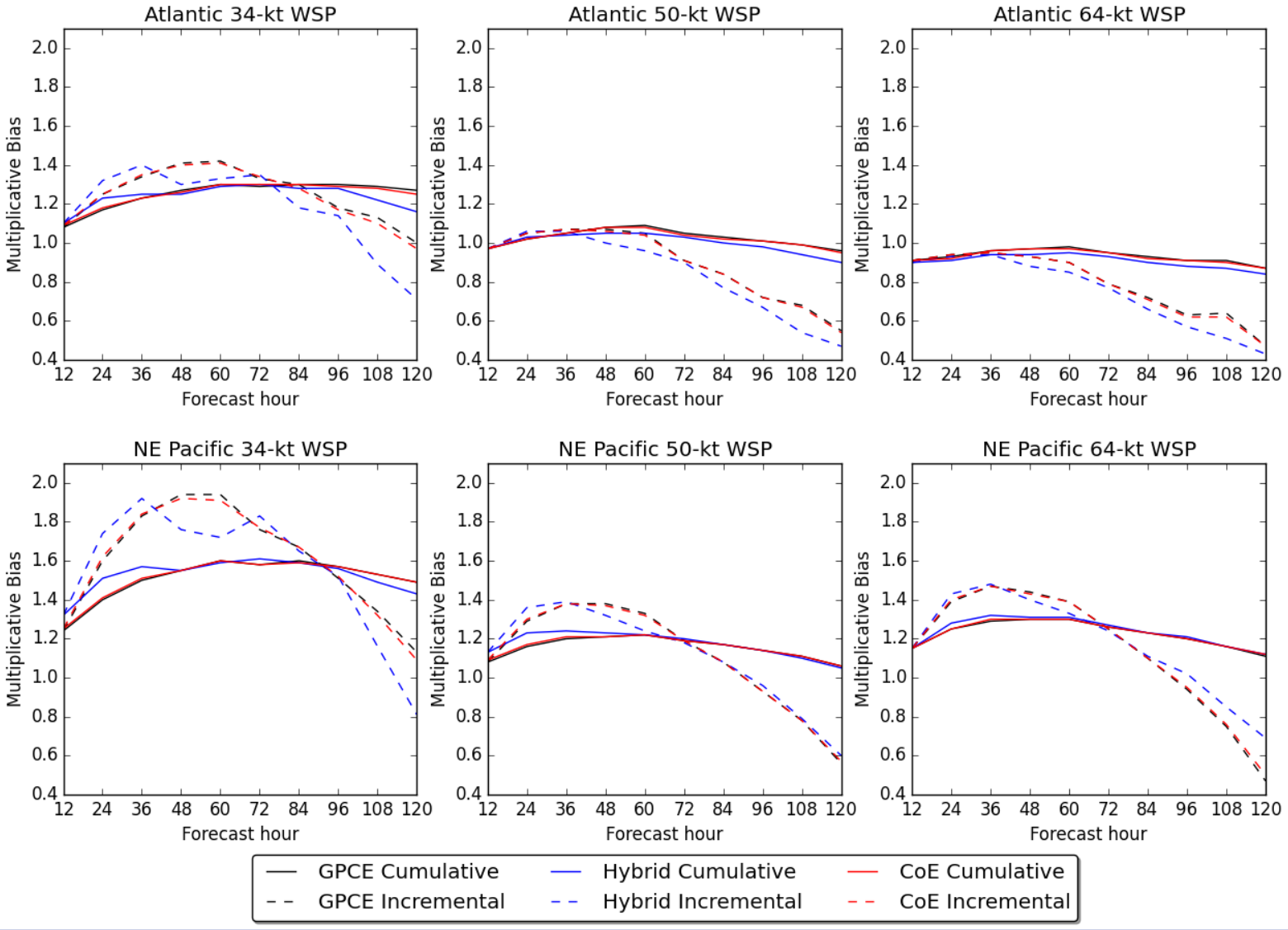
Answers the question: How well do the predicted probabilities of an event correspond to their observed frequencies?

Reference: http://www.cawcr.gov.au/projects/verification/

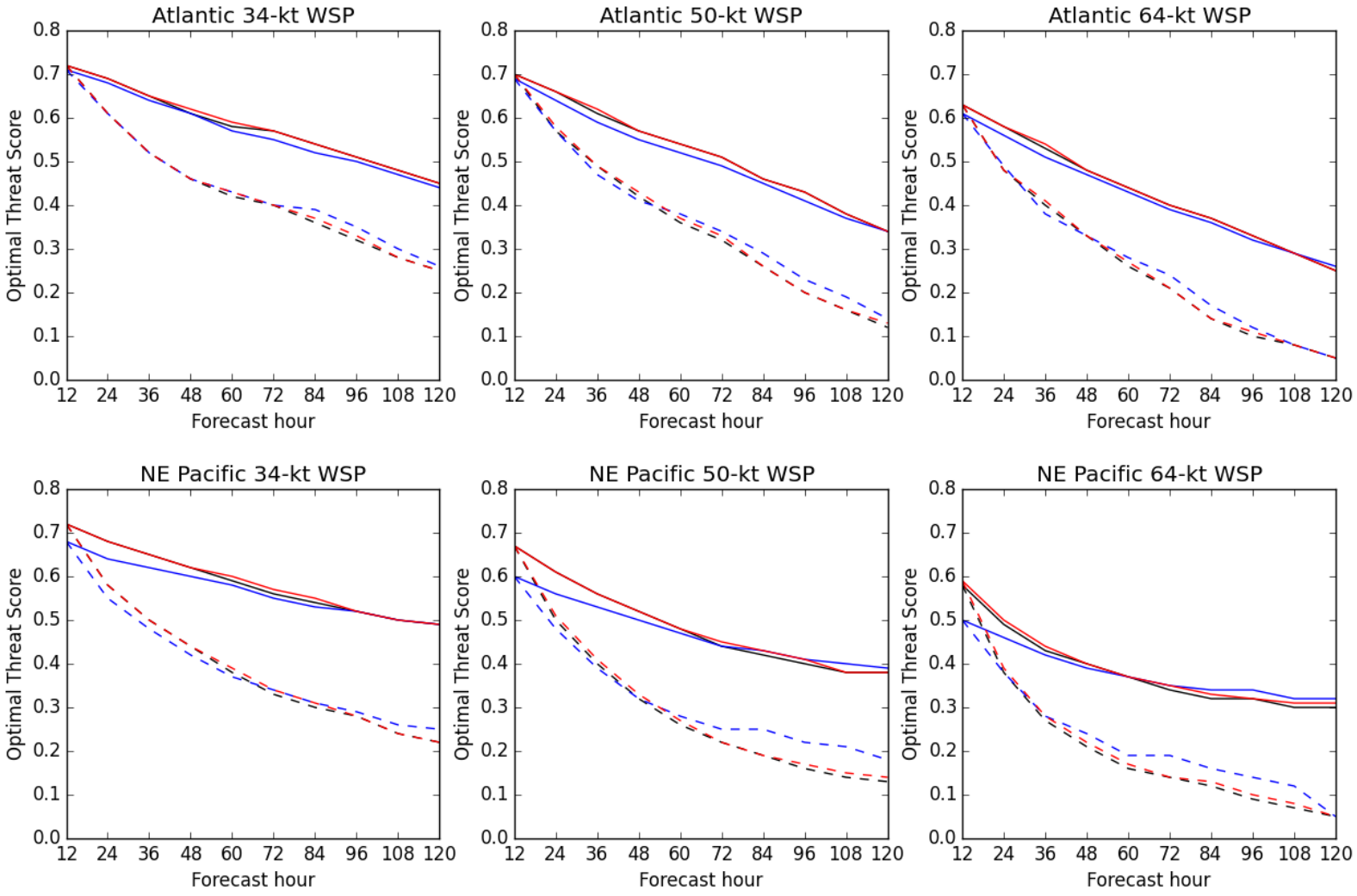
Brier Skill Scores (x100)



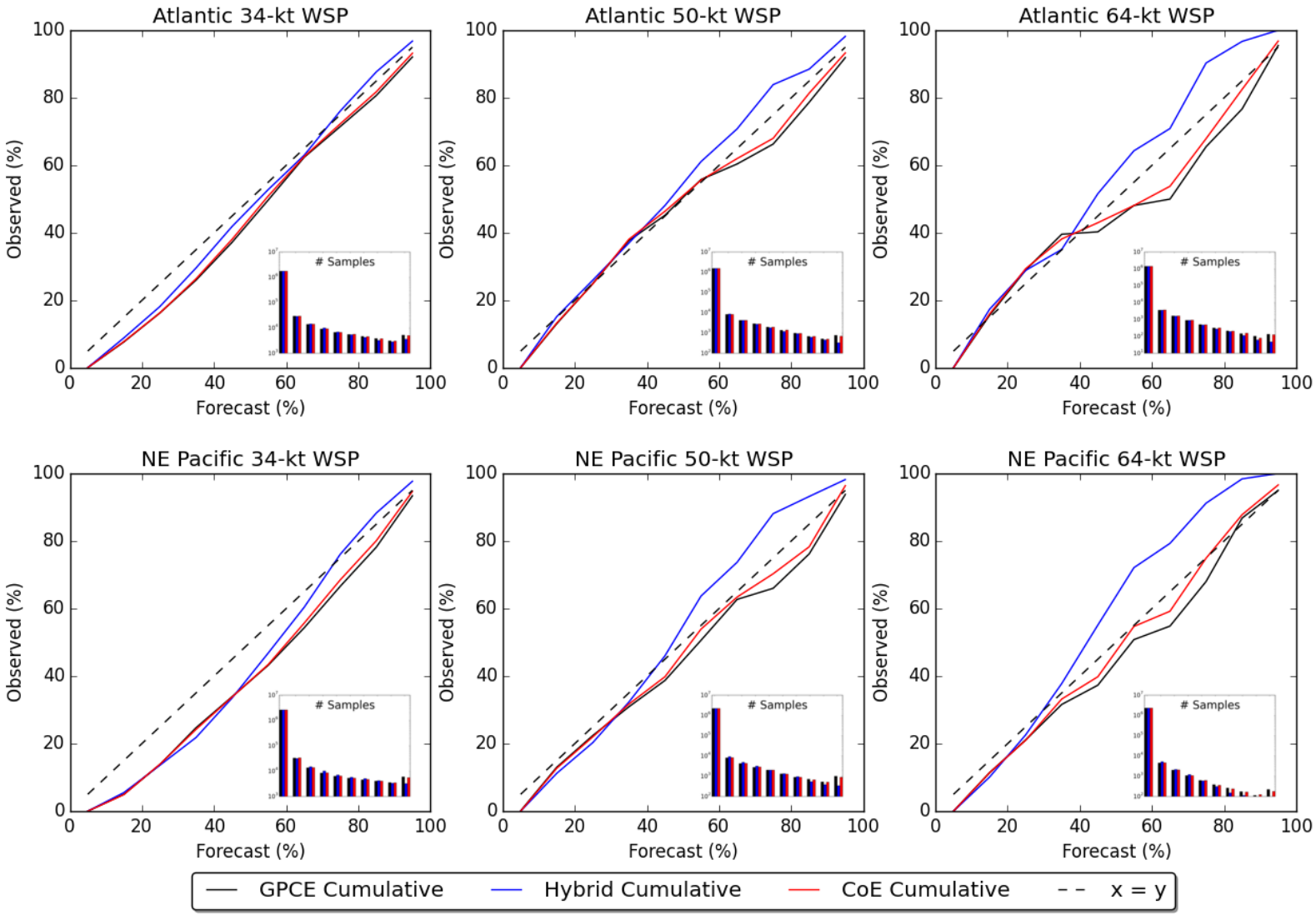
Multiplicative Bias



Optimal Threat Score



Reliability (0-120h Cumulative)



Ensemble Weighting

CoE approach gives each member equal weighting

Statistical members, 1000/1133 = 88%

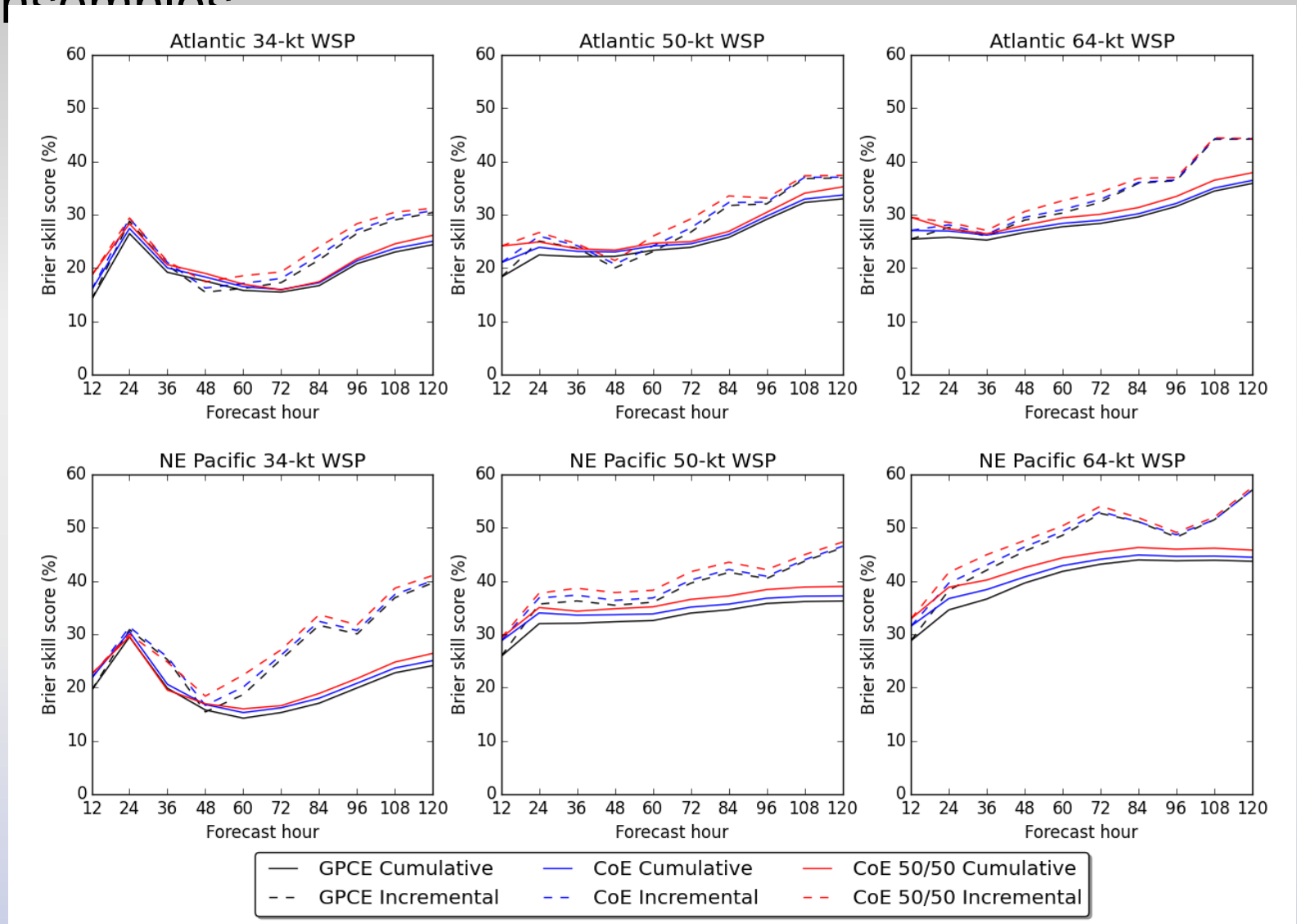
Dynamical members, 133/1133 = 12%

Another approach would be to choose weightings for each group of ensembles (i.e., statistical vs. dynamical)

Tested statistical/dynamical weightings of 25%/75%, 50%/50%, and 75%/25%

Only showing results for 50%/50% here

BSS – Equal weighting of dynamical & statistical ensembles

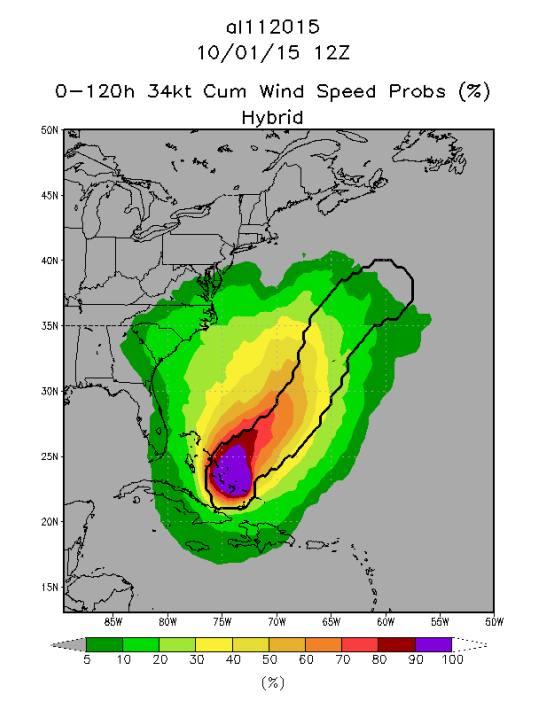


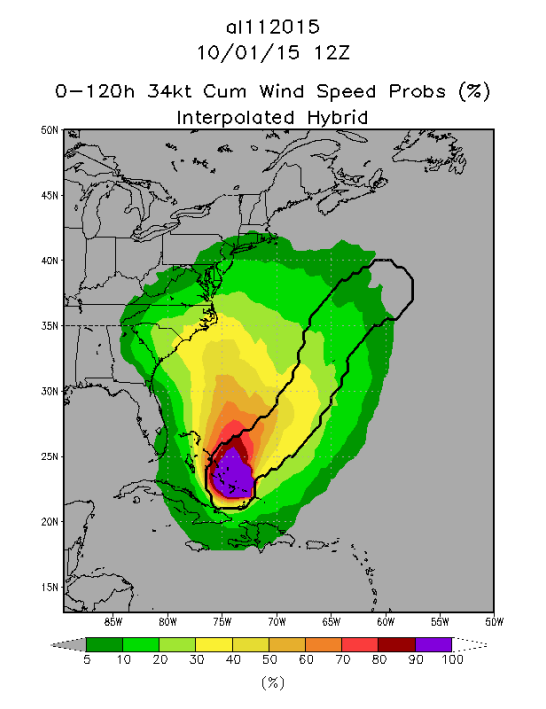
Global Model EPS Latency

CoE methodology does not address the issue of ensemble latency

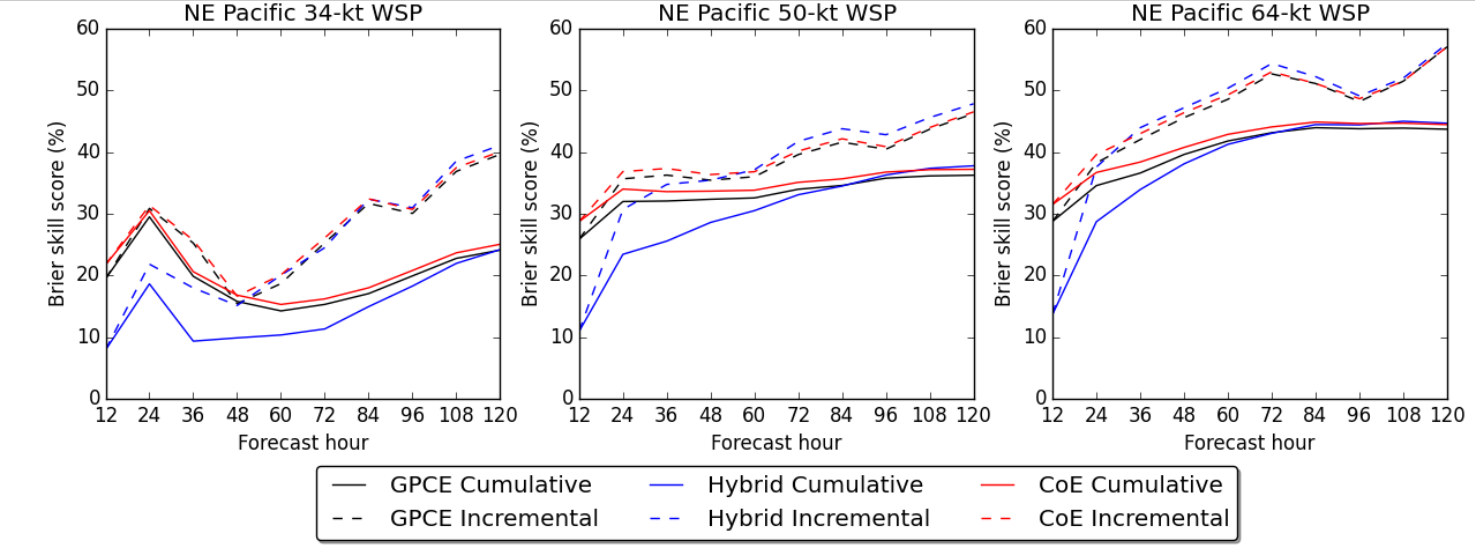
Some ensembles aren't available until 10+ hours after synoptic time

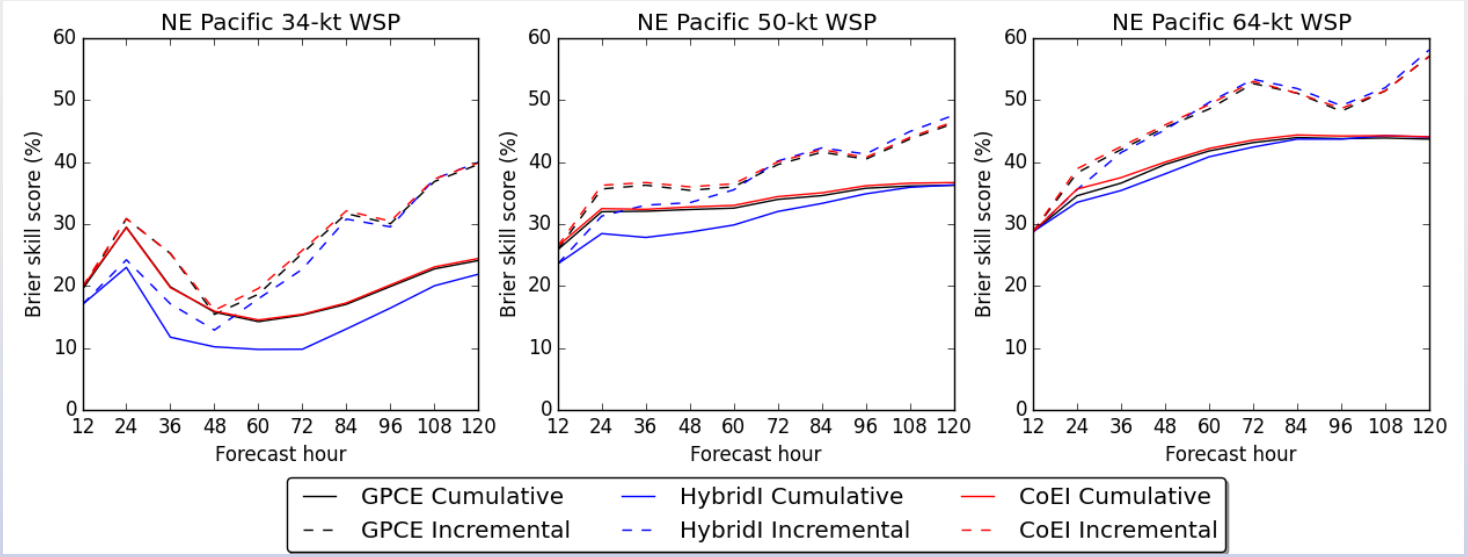
Potential solution: interpolate ensembles from 12-hours prior (using methodology similar to that used to generate AVNI)



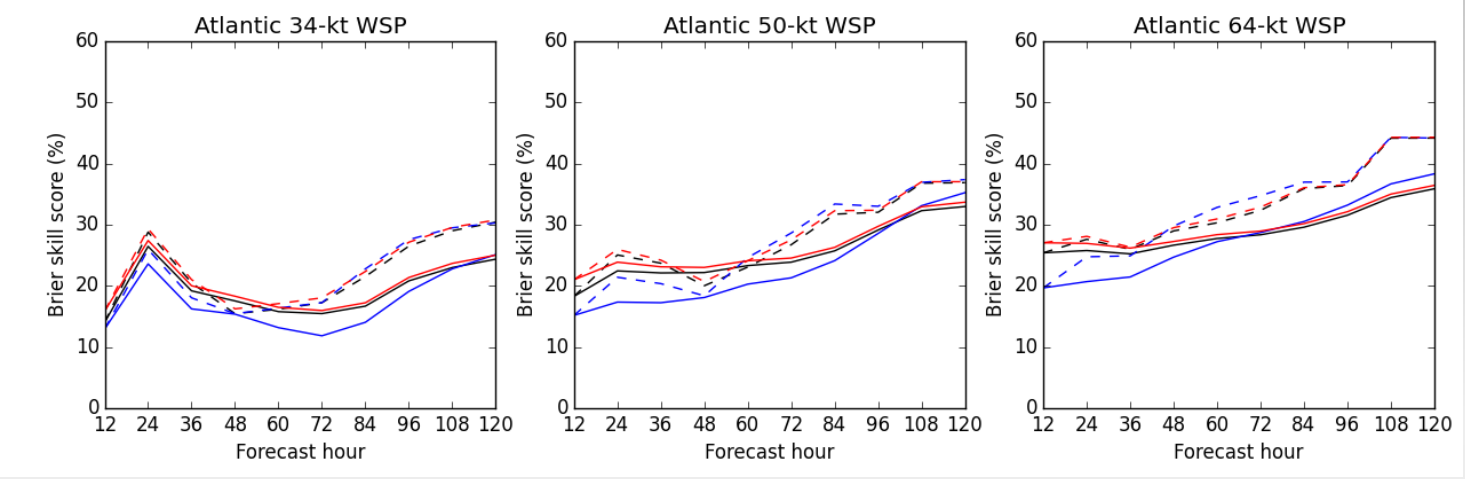


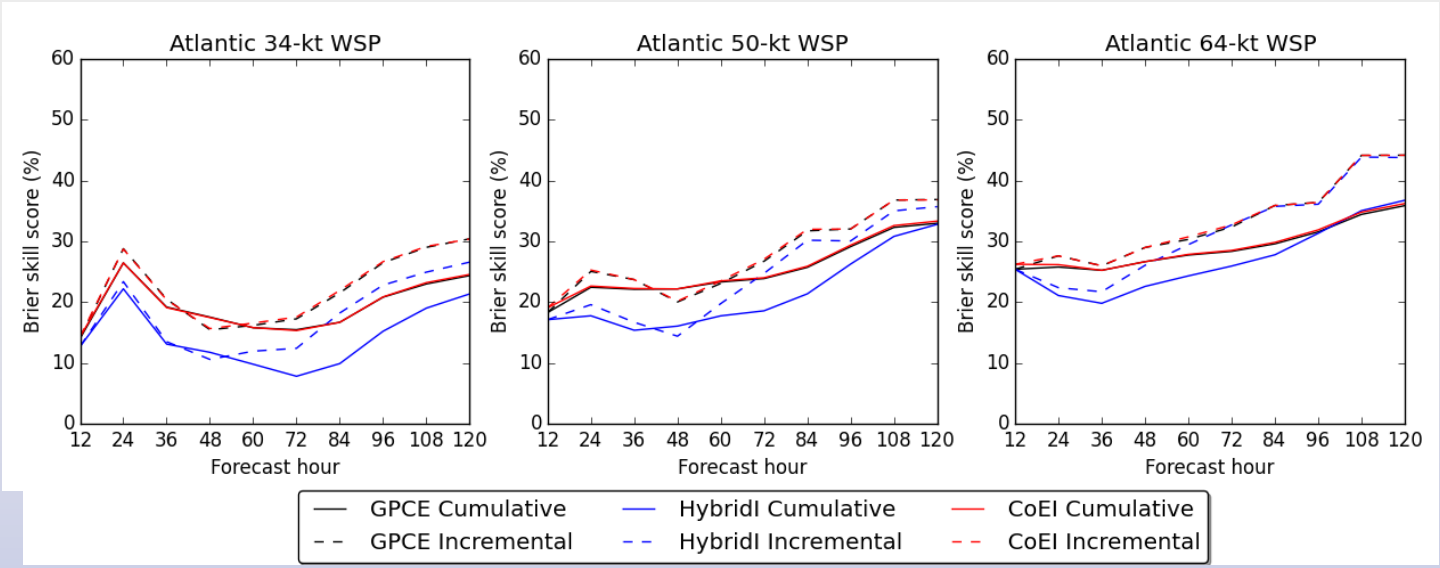
BSS – Interpolated (NE Pacific)





BSS – Interpolated (Atlantic)





Hybrid/CoE WSP Summary

Consensus of ensembles approach, where dynamical and statistical realizations are combined into a single consensus, improved forecast skill in both the Atlantic and NE Pacific by most verification metrics examined

CoE approach generates WSPs that are relatively consistent with NHC official track and intensity forecasts

Weighting of dynamical vs. statistical members of the CoE can be optimized to improve forecast skill. However, the less the statistical members are weighted, the higher the potential for forecast inconsistencies

Latency is still an issue. Using 12-hour interpolated ensembles provides far less improvement in forecast skill, degrading skill in some cases. More work needed.

NHC'S OPERATIONAL GUIDANCE SUITE

SHIPS/LGEM/RII updates

GOES-16 ingest incorporated into the SHIPS/LGEM processing

Meteosat ingest currently being developed in cooperation with NHC

SHIPS developmental databases updated to train 2018 version

Process to run SHIPS from ECMWF fields streamlined

Coordinating with NHC to trouble-shoot delivery of e-deck RI guidance; in the meantime CIRA continues delivery to NCAR of post-processed e-decks from operational RII

Adding the forecast of wind radii to SHIPS/LGEM/RII processing, to be run semi-operationally at NHC

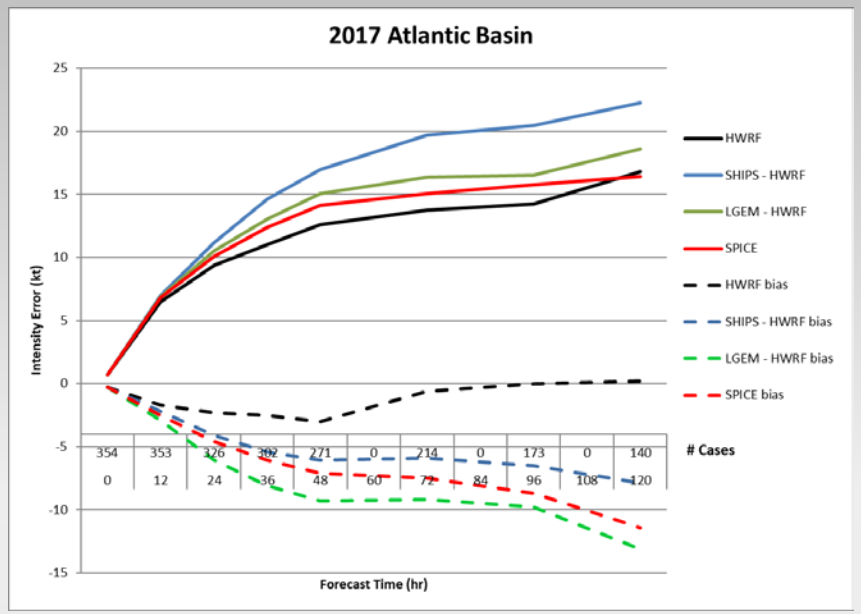
Ec ships

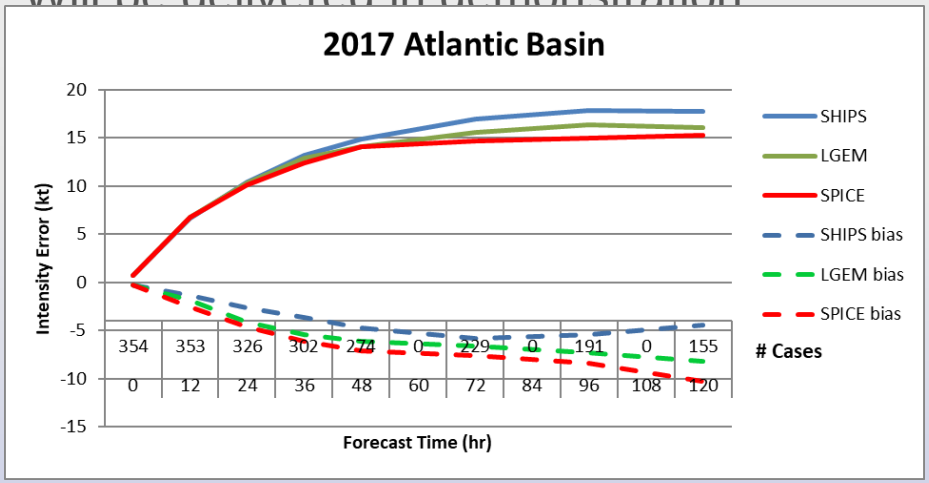
SPICE

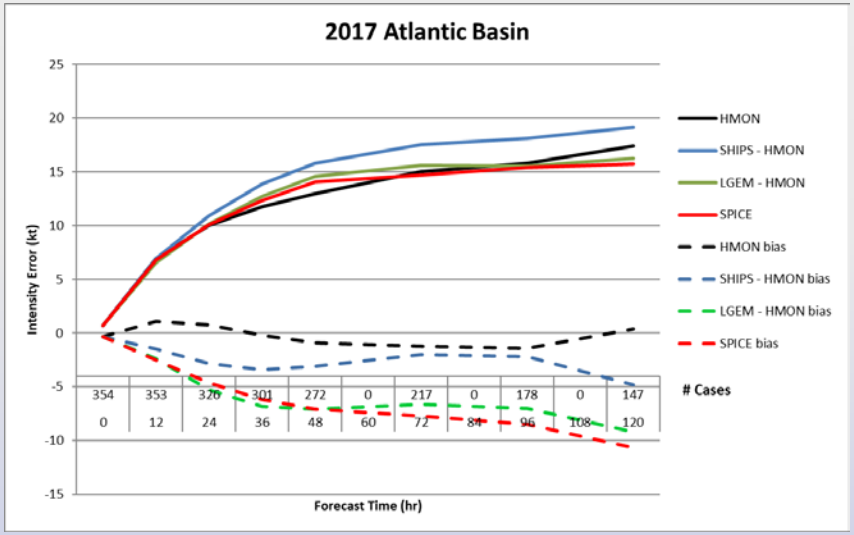
Examined the replacement of GFDL with HMON in SPICE in 2017

SHIPS and LGEM run from HWRF fields showed large errors and large negative biases – runs are being investigated for any particular environmental parameters

Will be delivered in demonstration

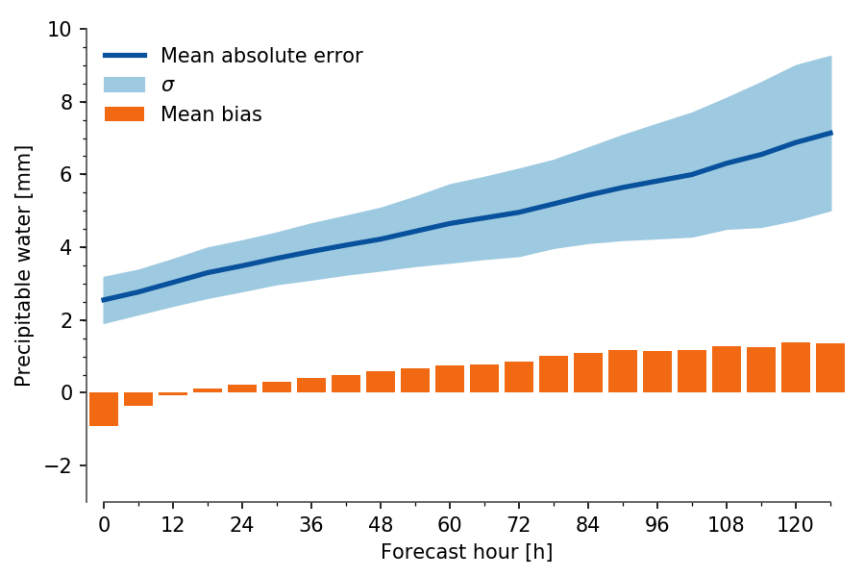






TPW - Mean absolute error & bias

2017 Atlantic HWRF

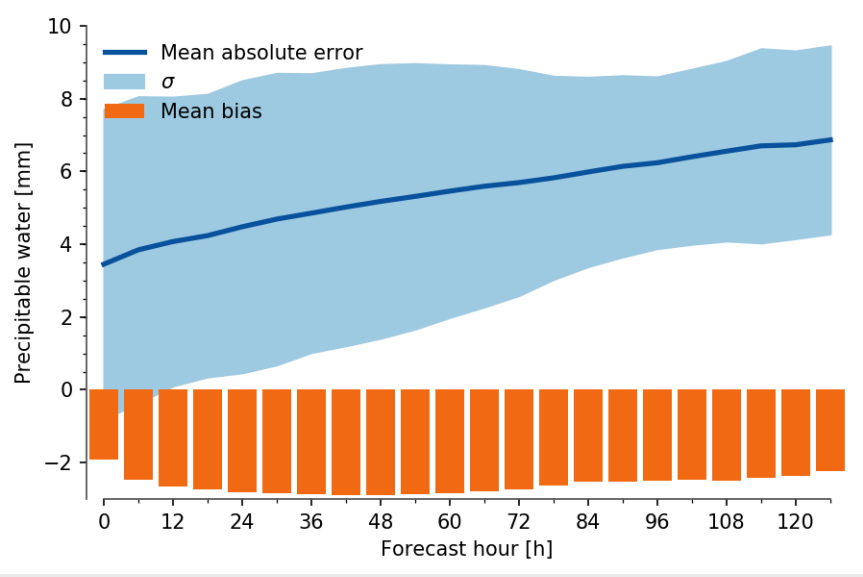


HWRF starts out with a slight dry bias (this behavior is different than 2015-2016 seasons)

As convection develops in the model, a moist bias develops

The moist bias grows through out the model simulation

2017 Atlantic HMON



Less constancy in the moisture errors, which is exemplified by large spread

Dry bias stabilizes within the first 24 hours of the simulation

The role of inner-core and boundary layer dynamics on tropical cyclone structure and intensification
– Chris Slocum; Advisers: Wayne Schubert & Mark DeMaria

Explore applicability of wave-vortex theory to tropical cyclones, which provides an alternative balance to gradient balance

Analytically solve for vortex potential vorticity development in response to diabatic heating distribution in this framework

Examine the impact of Burgers' equation and shock dynamics on boundary layer evolution in response to various gradient profiles in axisymmetric and line-symmetric frameworks