The Development of Next NCEP GEFS

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Outline

- **Introduction**
- **Experiment and Verification**
  - — Conventional verification metrics
  - — Precipitation
  - — Tropical cyclone
  - — MJO and week3&4
- **Summary**
- **GEFS v13**

PROD-GEFS (v11) .vs. FV3-GEFS (v12)

	PROD-GEFS	**FV3-GEFS**
Member size	21 members	**31 members**
Model	GSM, **Semi-Lagrangian**	**FV3**
MP	ZHAO-CARR MP	**GFDL MP**
Resolution	TL574L64 (~33km) (d1-8) +TL382 (~50km) (d9-16)	**C384L64 (~25km) (d1-16/35)**
SST forcing	Climatology relaxation	**NSST + 2-tiered SST**
Model uncertainty	Stochastic STTP	**Stochastic physics suite (SPPT + SKEB+*SHUM*)**
Initial uncertainty	GSM-GFS EnKF 06 fcst	**FV3-GFS EnKF 06h fcst**

Major Changes of GEFS in the next version (V12, Q2FY20)

- Changing the dynamical core from the global spectral model (GSM) to GFDL FV3.
- Switching from Stochastic Total Tendency Perturbation (STTP) to a suite of two/three “stochastic physics” methods.
- Similar physics package except changing Zhao-Carr MP to GFDL MP
- **Extending 16-day forecast to 35-day forecast**

GEFS v12 for next implementation

(FV3-GEFS v1.0)

- Q3FY18: Start to produce 20 years (1999-2018) reanalysis
- Q4FY18: Start to produce 30 years (1989-2018) reforecast
- Q2FY19: Start to produce retrospective runs (2-3 years)
- Q3FY19: Start users evaluation
- Q2FY20: GEFS v12 implementation

New Stochastic Physics Suite

Stochastic kinetic energy backscatter (SKEB) [Berner et al., 2009]

- Counteract excessive energy dissipation from numerical diffusion and interpolation, mountain and gravity wave drag, and deep convection
- Stream function is randomly perturbed to represent upscale kinetic energy transfer

- **Stochastically perturbed physics tendencies (SPPT)** [ECWMF tech memo #598]
  - Represents uncertainties in physical parameterizations
  - Multiplicative noise modifies total parameterized tendency
- ***Stochastically perturbed PBL humidity (SHUM)*** [Thompkins and Berner, 2008]
  - Represents variability in the sub-grid humidity field (important trigger for convection)
  - Similar to SPPT, but directly modifies low-level humidity field instead of tendency

*All use an AR(1) random pattern generator to produce spatially and temporally correlated perturbations

FV3GEFS experiment

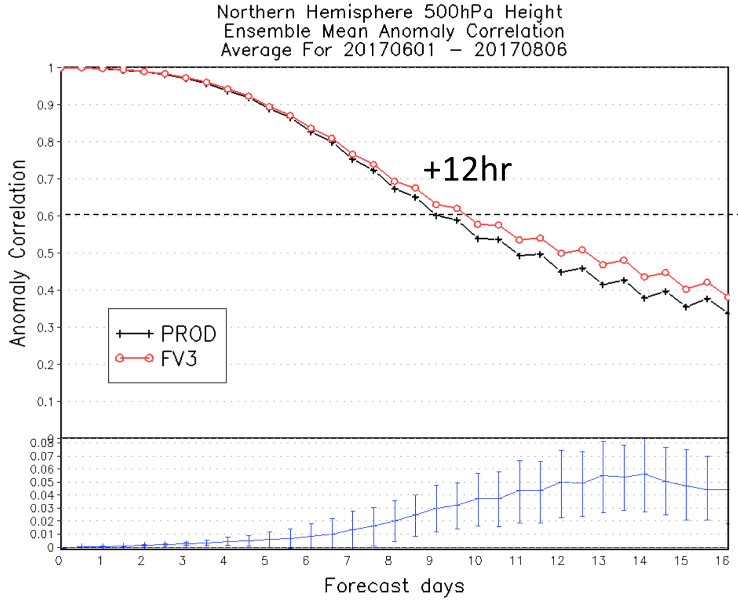
- Warm season: 20170601-20170806
- Cold season: 20171201-20180130
- 21 members
- Initial conditions: FV3GFS hybrid analysis and EnKF 6h-forecast
- Verification against own analysis

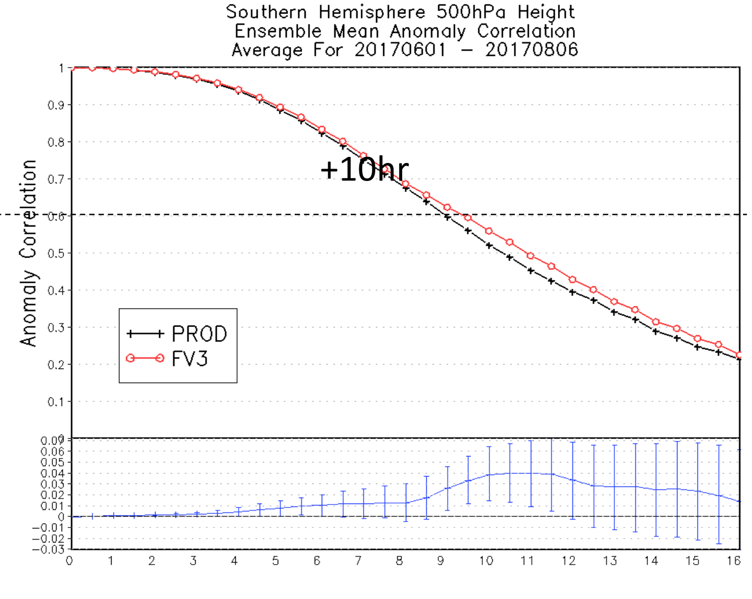
Z500 PAC and CRPS Summer

NH

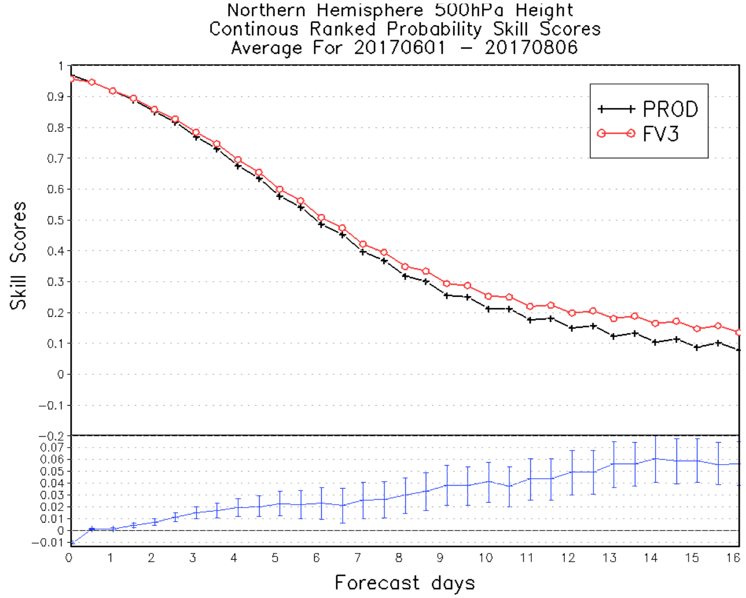
SH

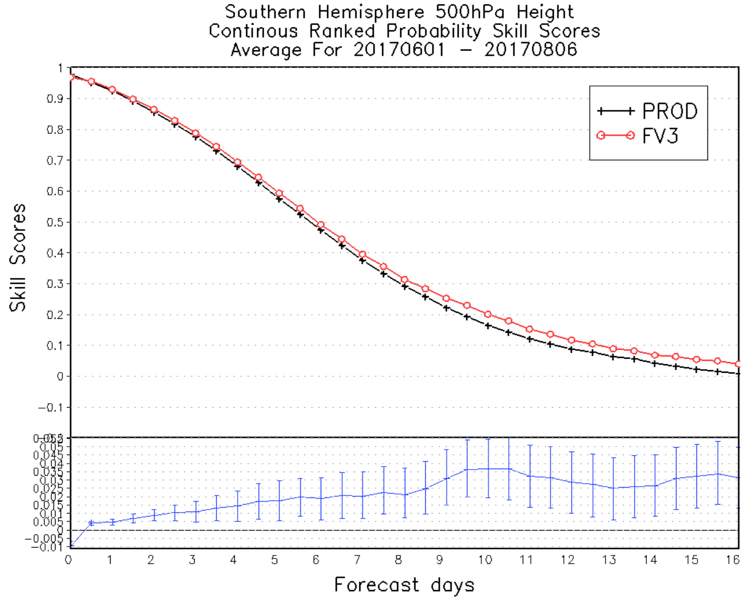
PAC





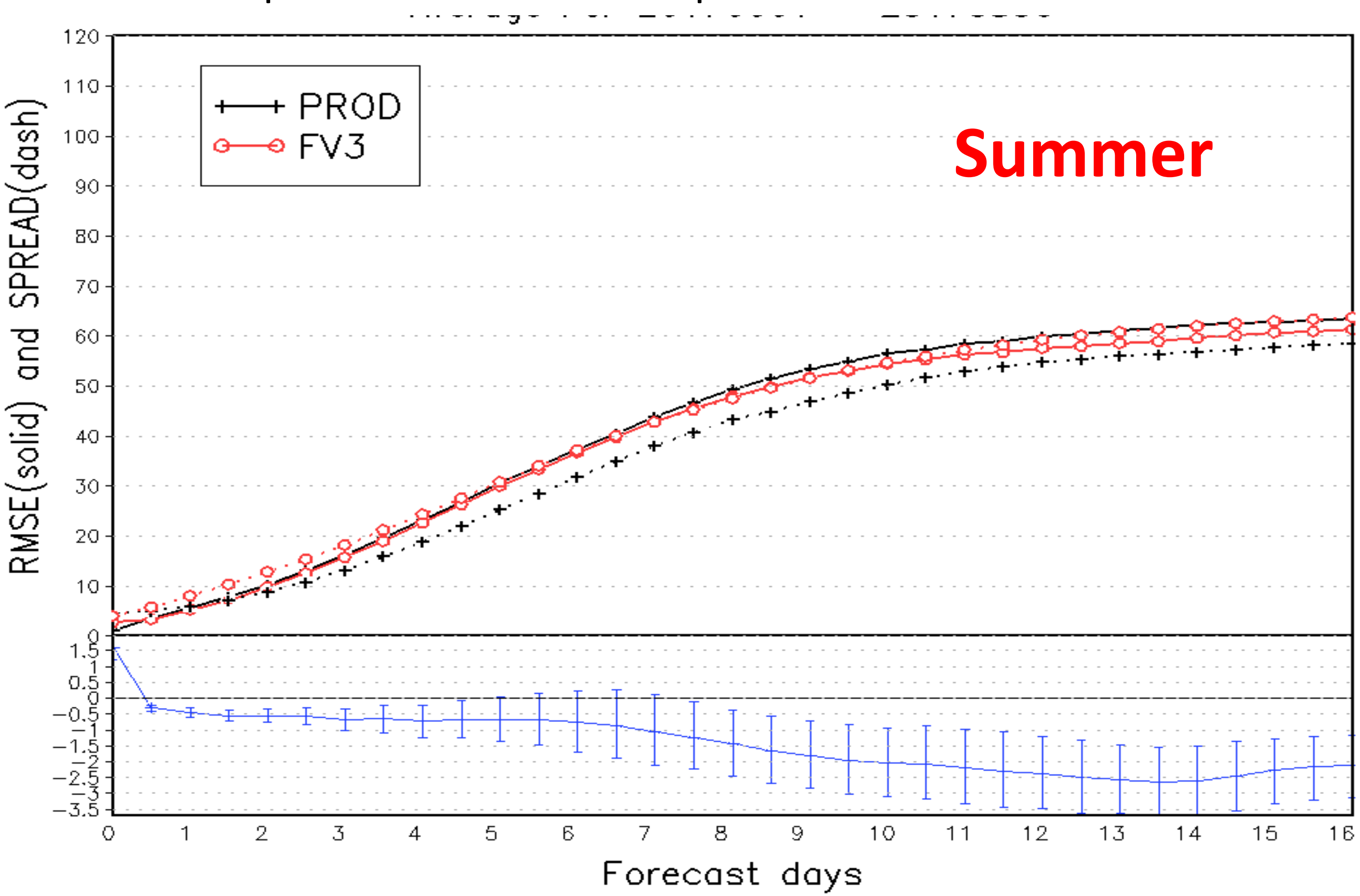
CRPSS





NH RMSE and Spread: Z500

Better spread-error relationship

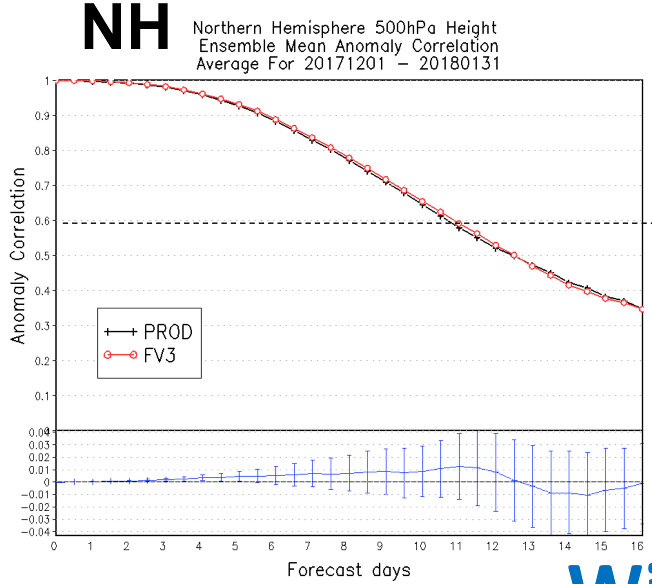


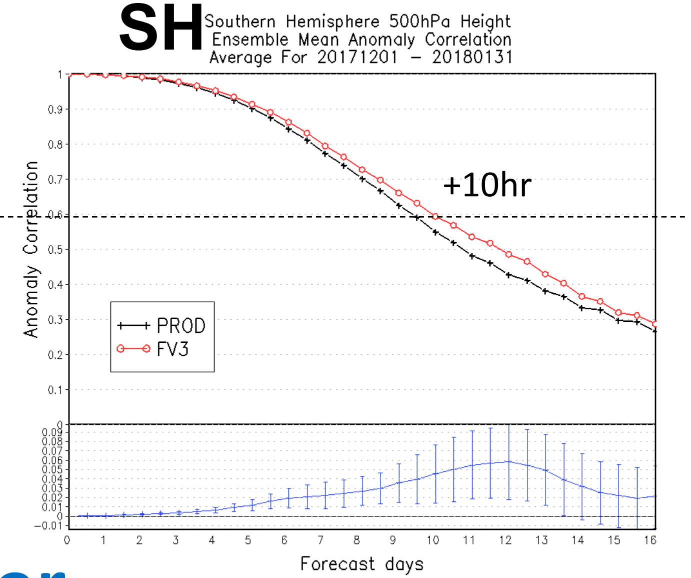
PAC and CRPS: 500hPa height

NH

SH

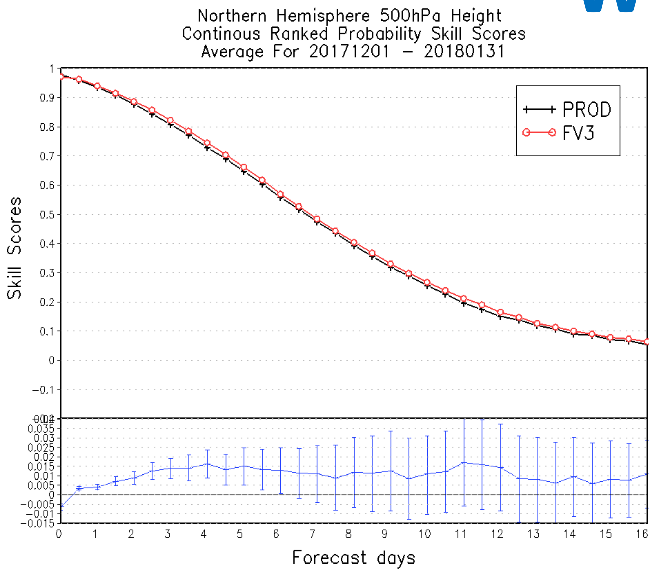
PAC

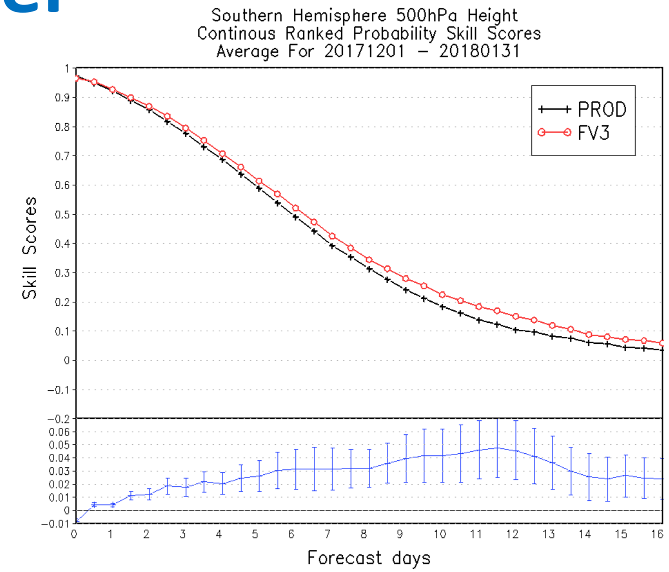




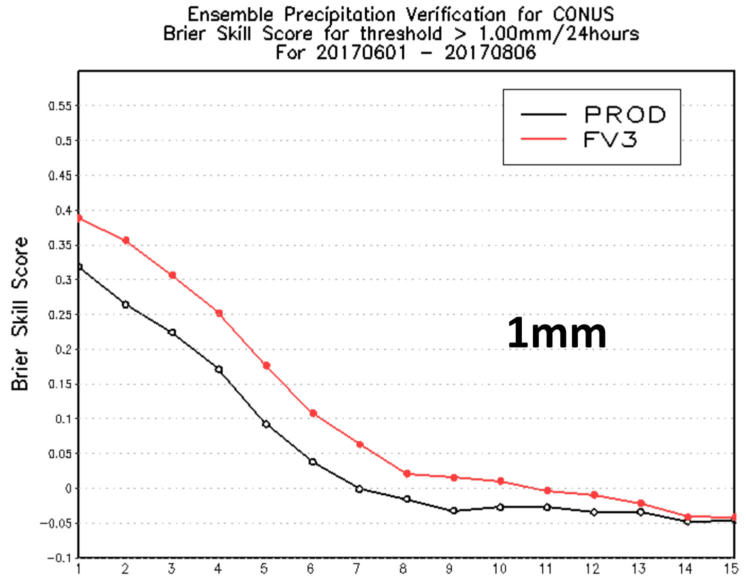
Winter

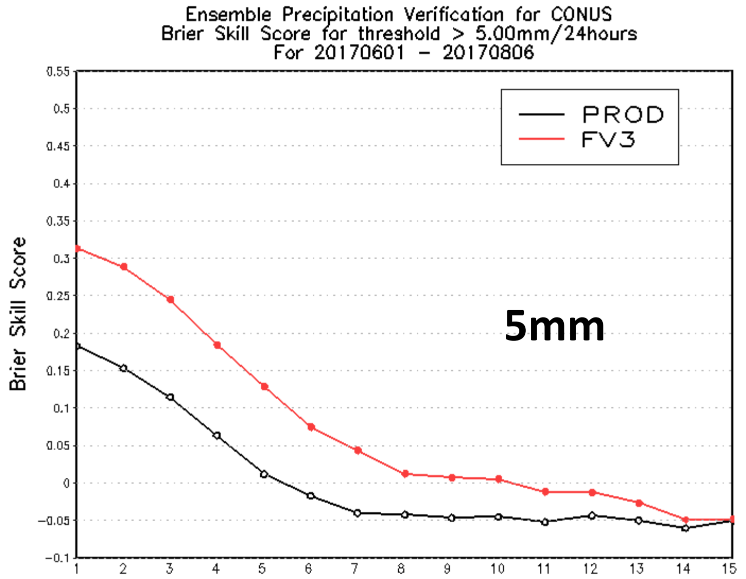
CRPSS

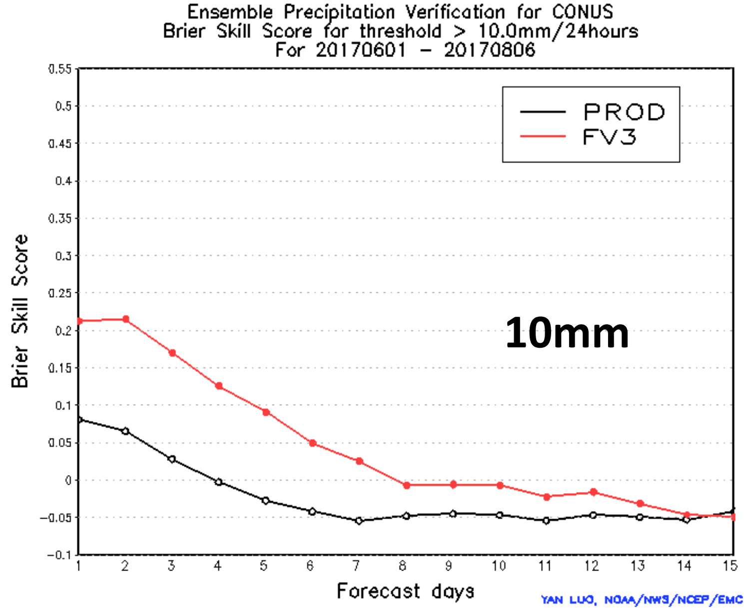


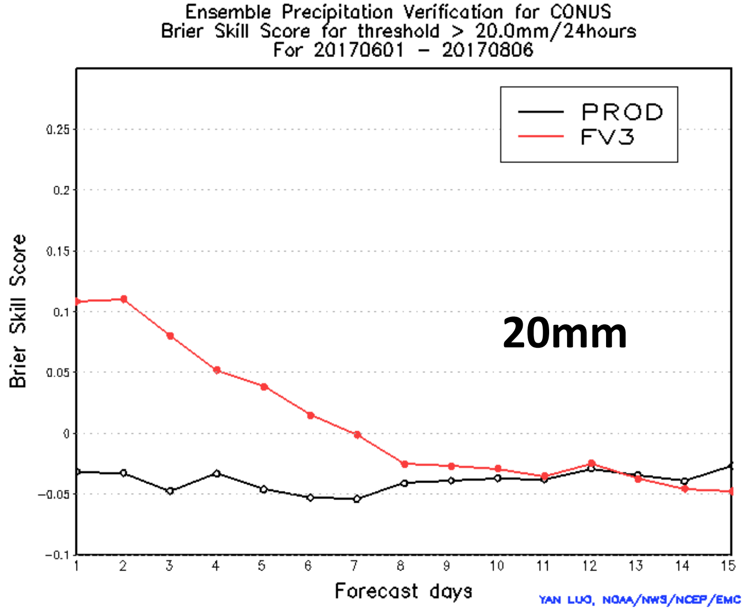


Precipitation 24h (CONUS): BSS

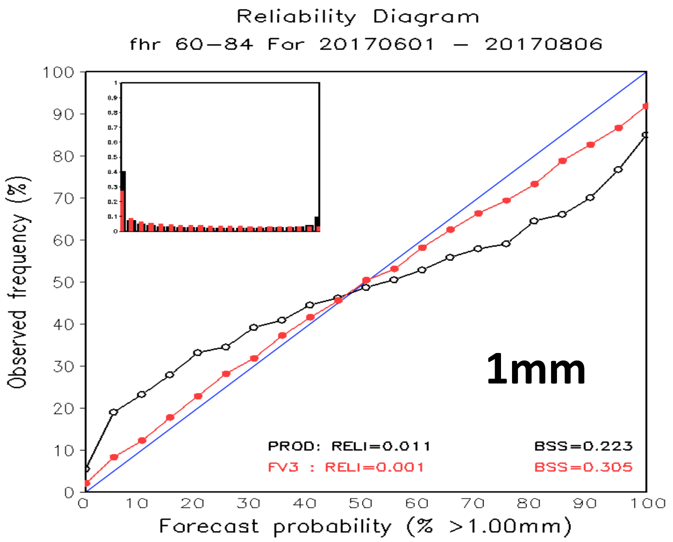


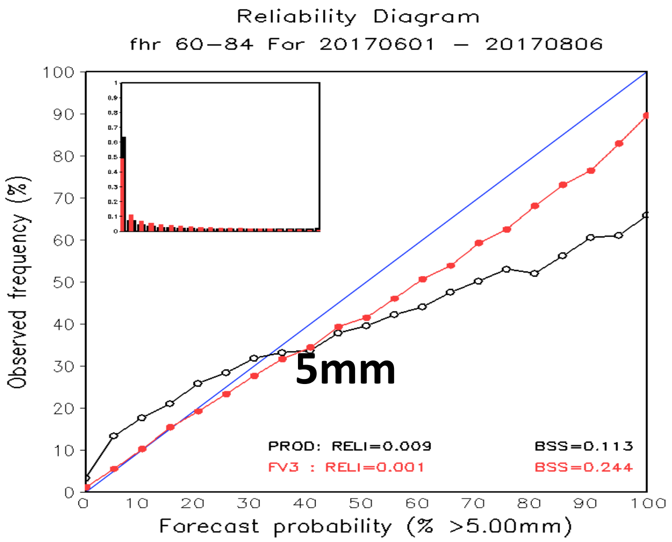




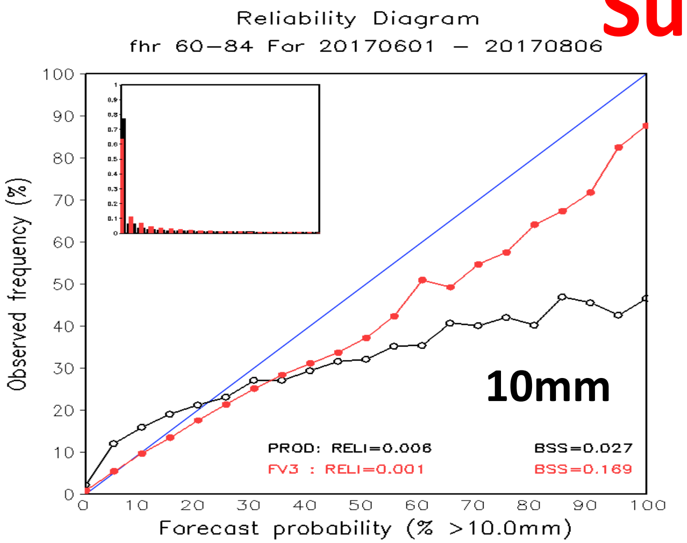


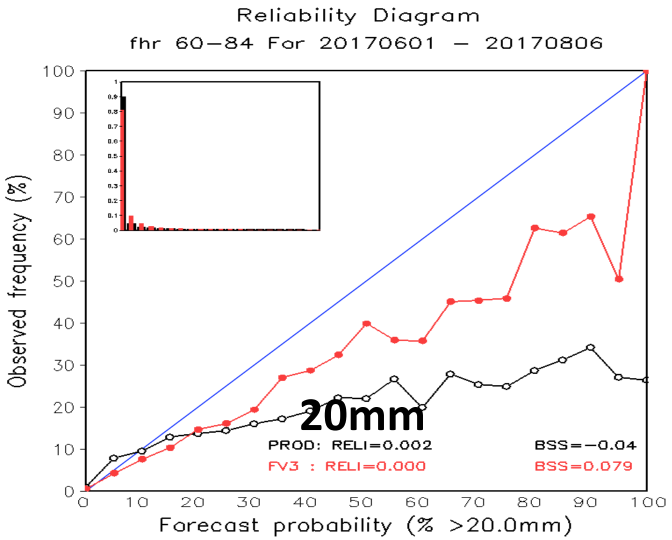
Precipitation (CONUS): 60-84hr reliability





Summer





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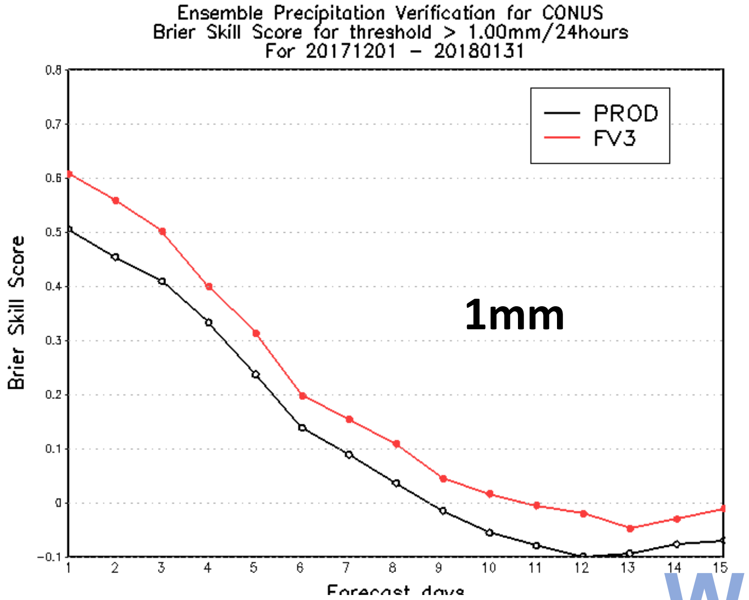
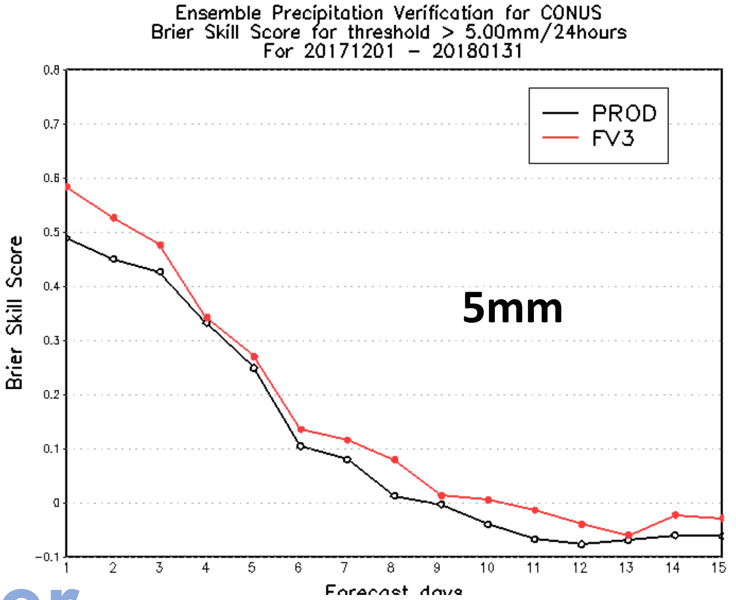
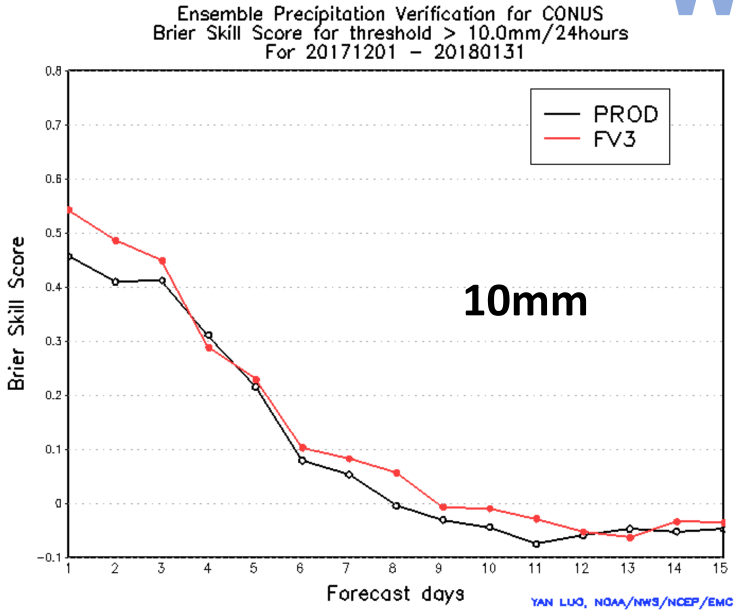
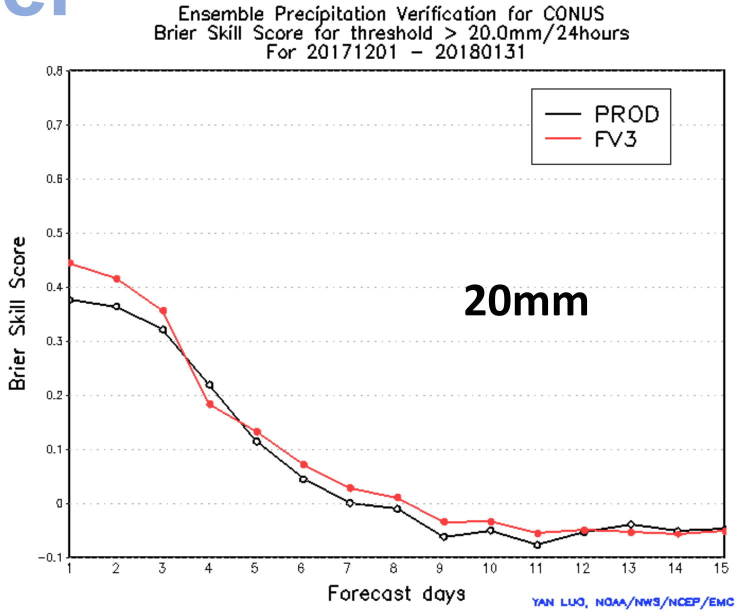




Winter





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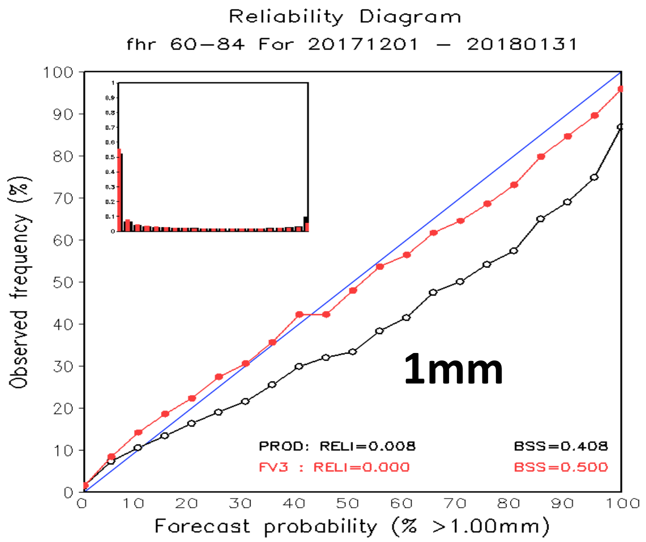
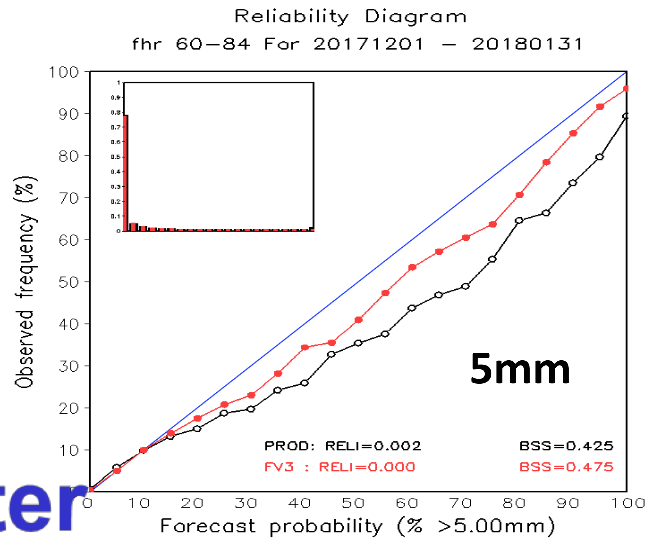
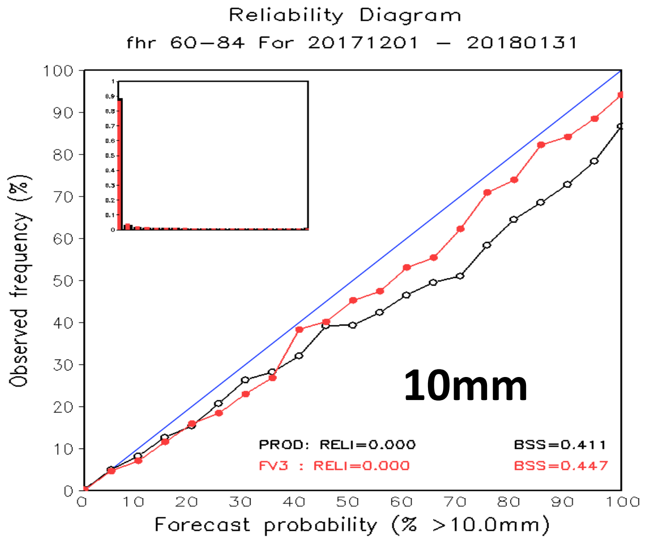
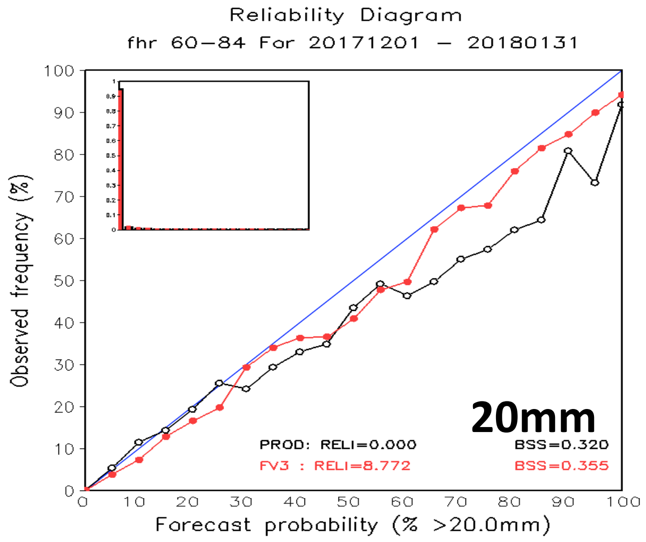




Winter





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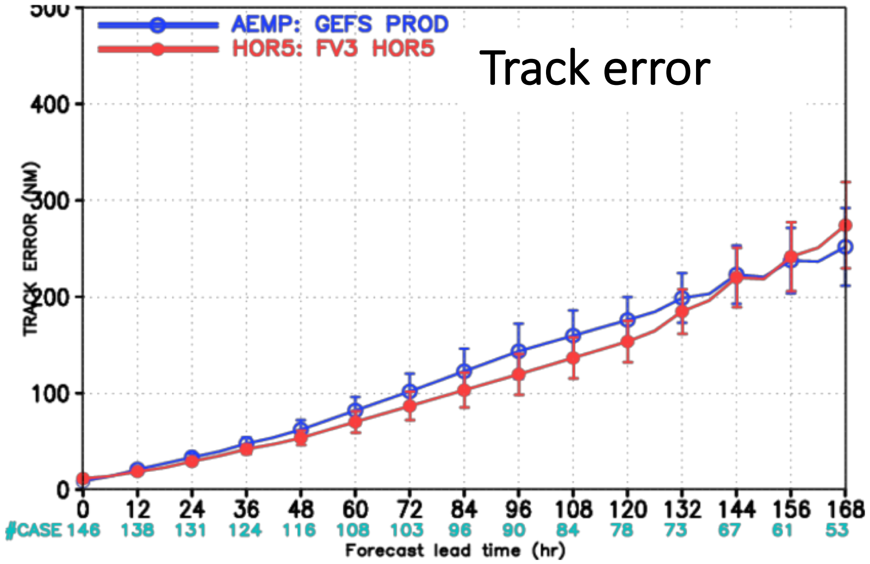
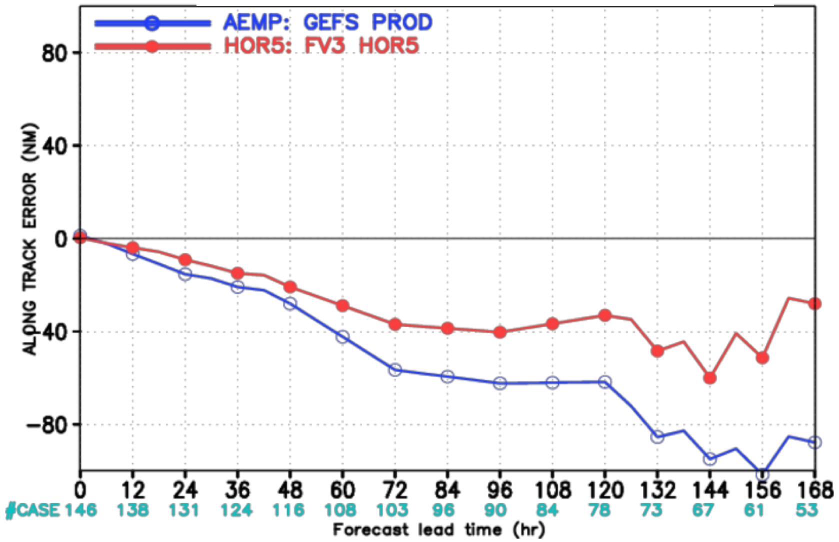
Tropical Cyclone track forecast errors over ATL in 2017 hurricane season



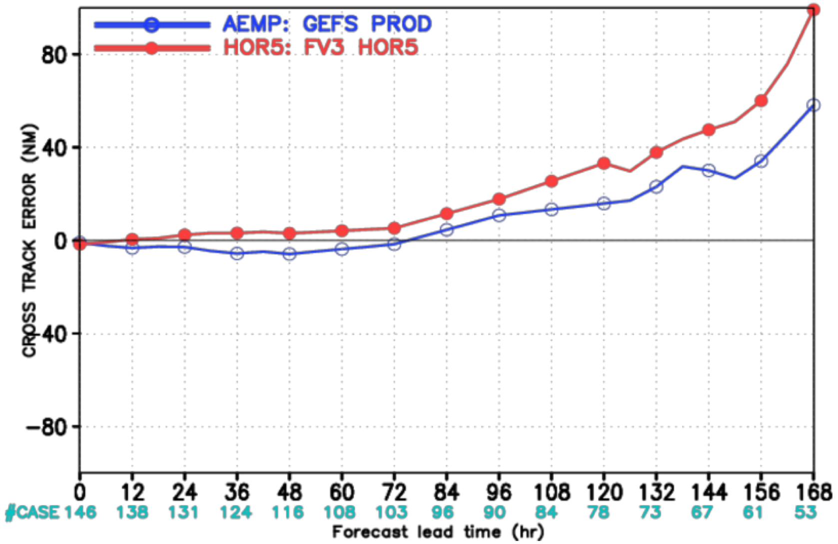
Blue: GEFS PROD

Red:FV3GEFS

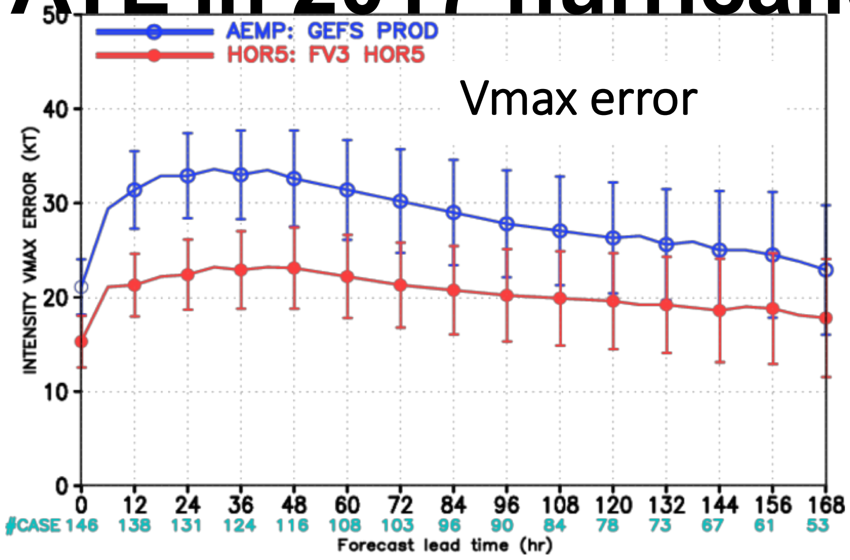
Along Track error



Cross Track error



Tropical Cyclone intensity forecast errors over ATL in 2017 hurricane season



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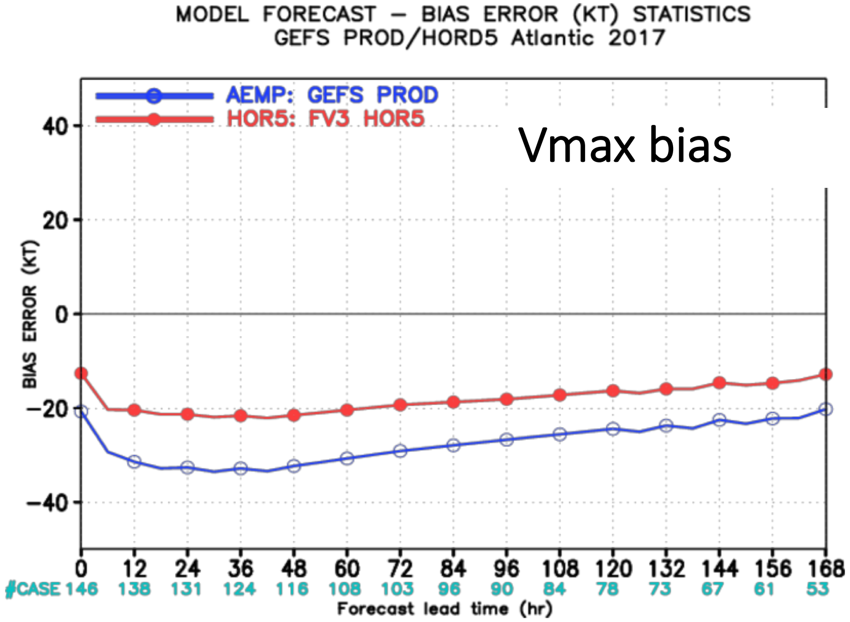
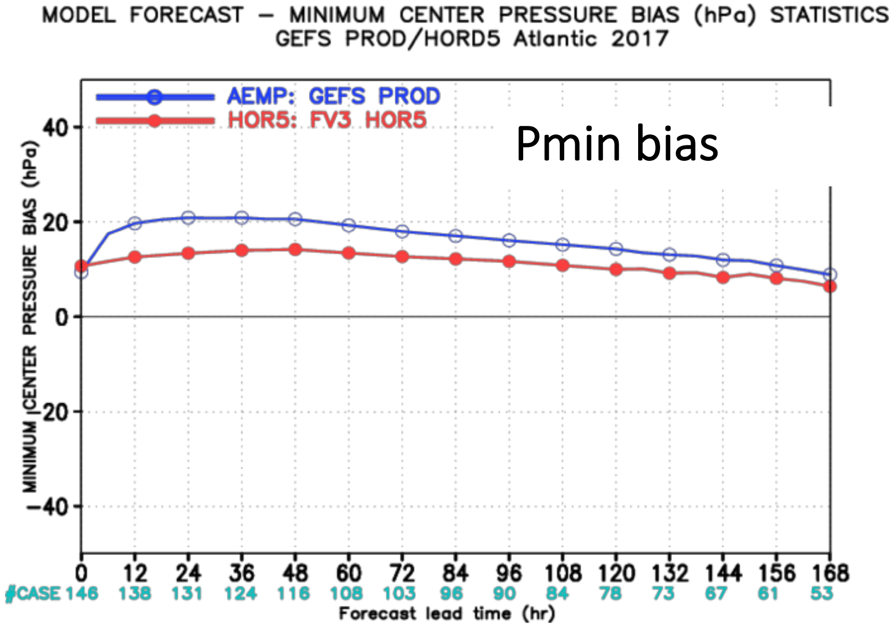
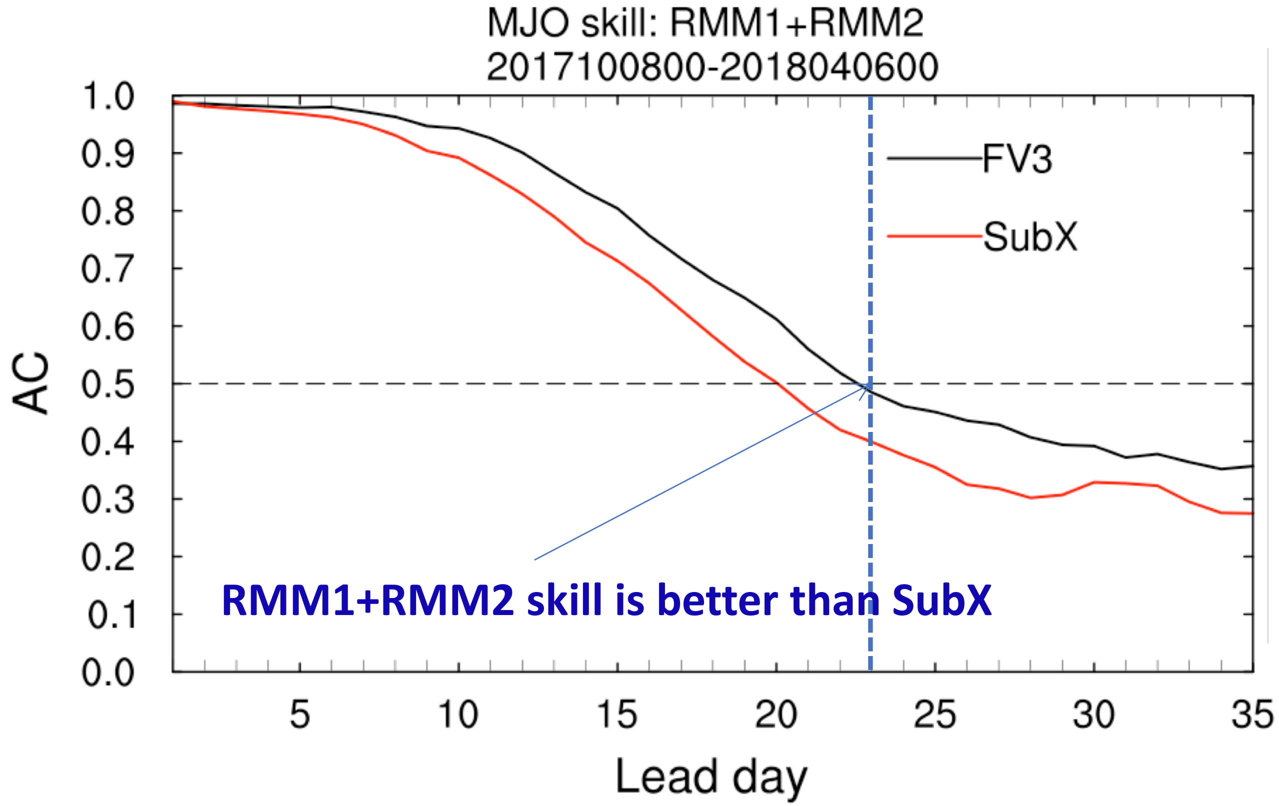
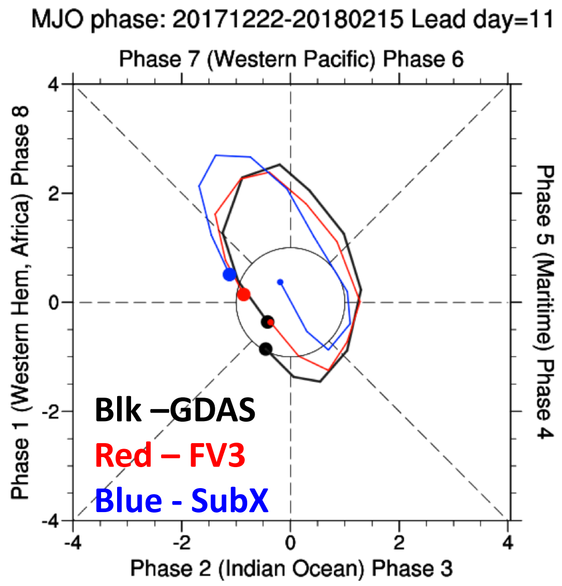
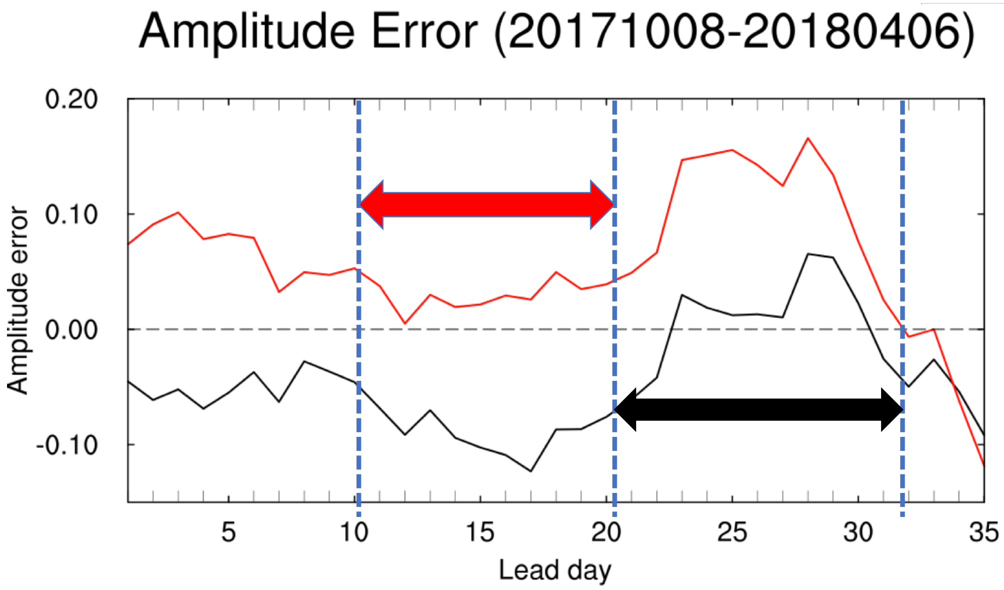


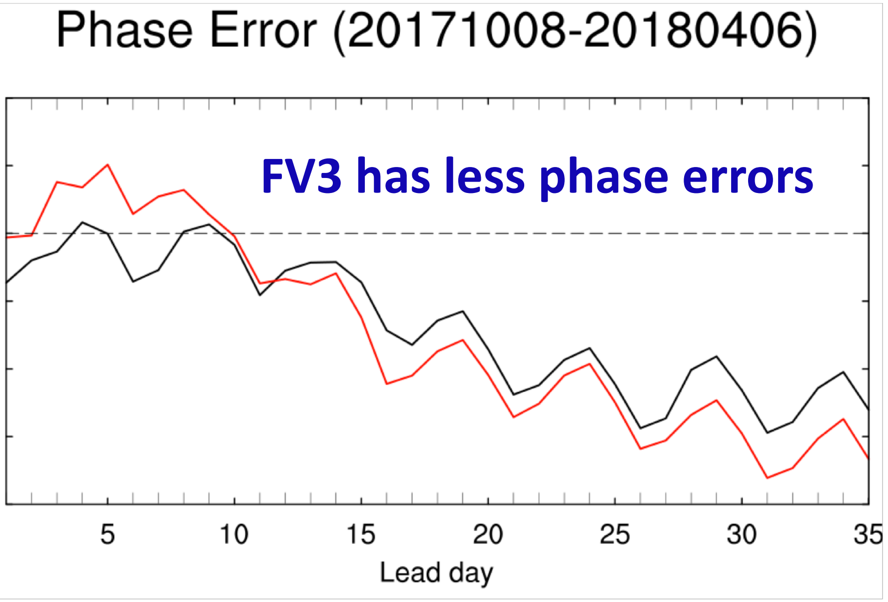






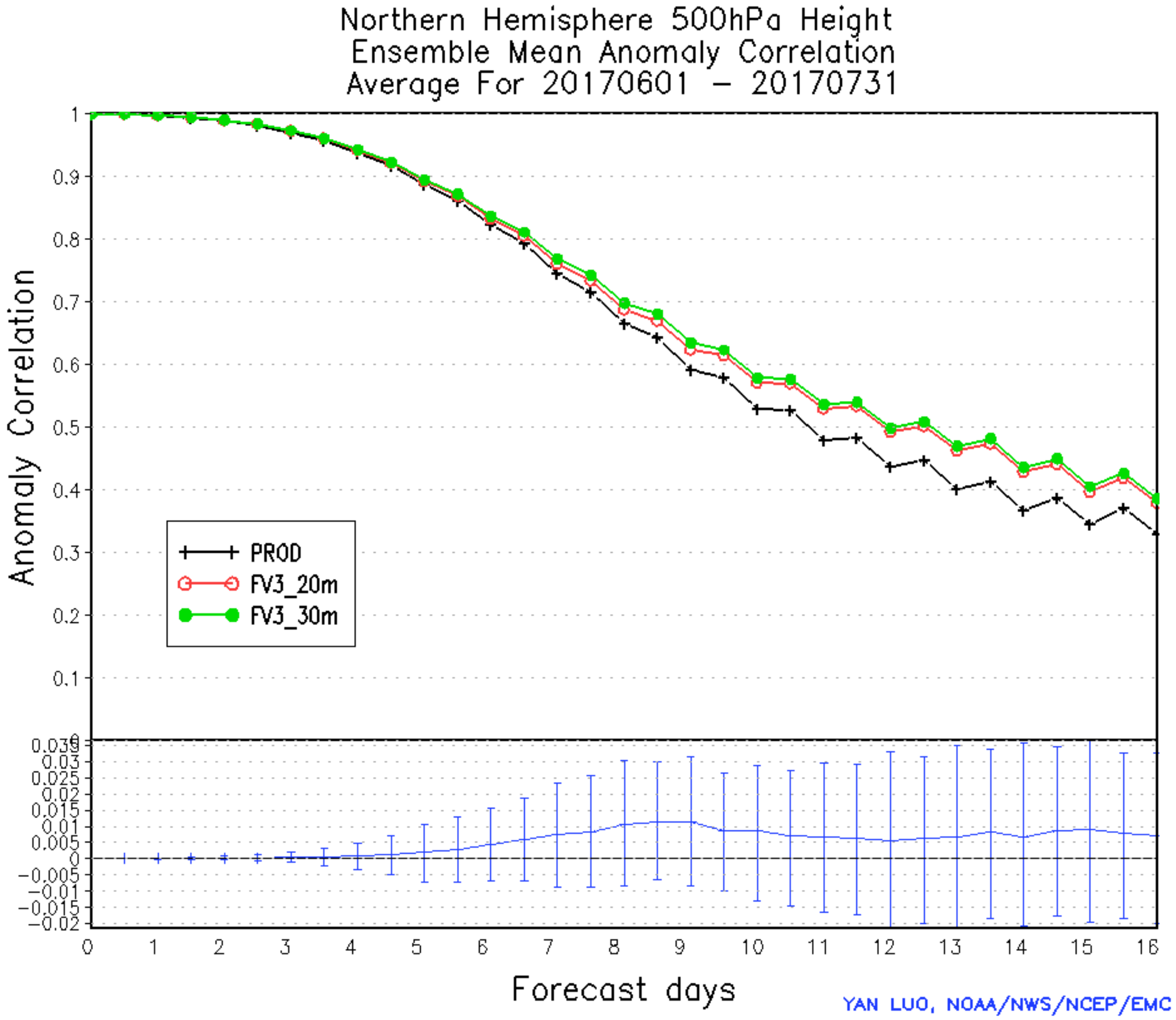
Example of one MJO phase (lead – 11 days)



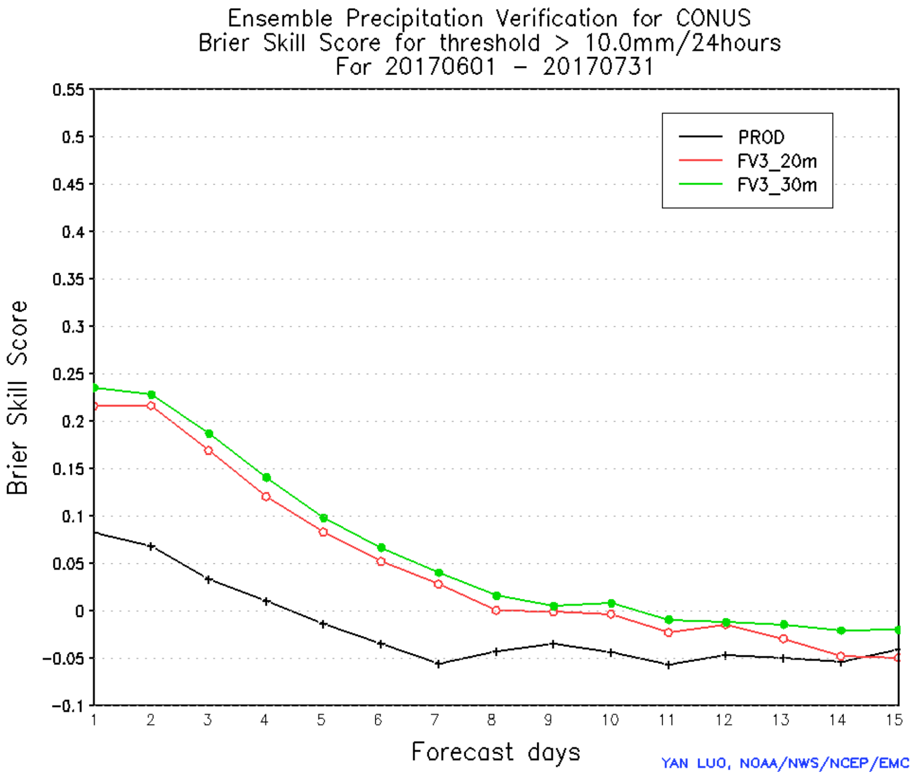


Ensemble size: 30 vs. 20

NH Z500 PAC



BSS (CONUS) >10mm Precipitation



FCST days

Summary

- FV3-GEFS shows improved skills in terms of most conventional verification metrics in both warm and cold seasons
- Significant improvements in the error-spread relationship
- Substantial improvement in precipitation forecasts in terms of reliability and BSS
- Better TC track forecast in the first 5-6 days and reduced TC intensity bias (limited samples)
- Better MJO forecast skills

Uncertainties of GEFS v13

- Initial perturbations – EnKF analysis from early cycle
- Coupled model

  -Coupling with Ocean, Land, Sea-ice, Wave and Aerosol
- Model uncertainties
- Ensemble resolution and size
- To cover monthly forecast to support CPC's daily operation

  -Out to 58 days
- Reanalysis(?)/Reforecast to support model upgrade
  - Still in plan
- Target implementation time
  - 2022-2023

THANK YOU~

FV3 dynamical core

- Vertically Lagrangian control-volume discretization based on 1st principles (Lin 2004)
- Physically based forward-in-time “horizontal” transport (between two Lagrangian surfaces)
- Combined use of C & D staggering with optimal FV representation of Potential Vorticity and Helicity
- Finite-volume integration of pressure forces (Lin 1997)
- For non-hydrostatic extension, the vertically Lagrangian discretization reduces the sound-wave solver into a 1-D problem