

# **FV3 – Final Solution for GEFS?**

**- Based on what we have right now**

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Bo Yang and Dingchen Hou

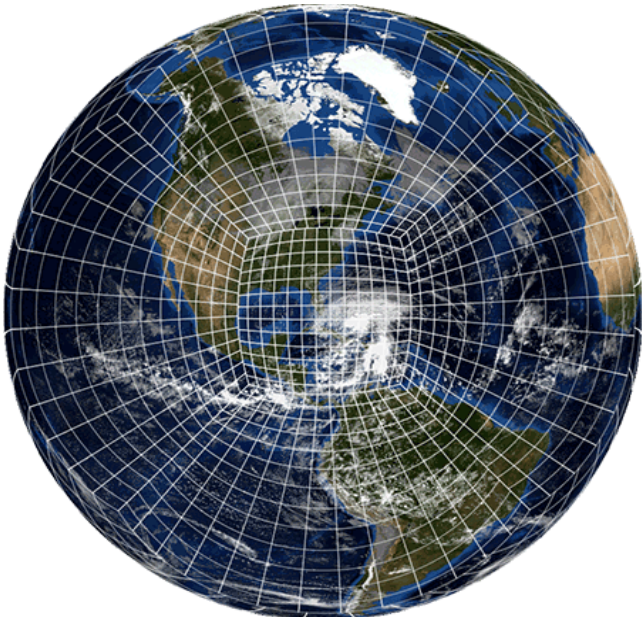
Contributors: Yan Luo, Jiayi Peng and all ensemble team members.  
Model developers: Ruiyu Sun and Fanglin Yang

Update: 12/06/2018

# FV3 Dycore and Global Models

## *GFS (Deterministic)*

- March 2018: Real Time FV3GFS Beta Version
  - C768L64 (~13km)
  - GFDL MP
- Q2 2019: Implement FV3GFS Beta Version



## *GEFS (Ensemble) v12*

- Configuration
  - C384L64 (~25km)
  - 31 members, 4 cycles/day, out to 16 days
  - Extend 35 days forecast at 00UTC
- Q3FY18: Start to produce 20 years (1999-2018) reanalysis
- Q4FY18: Start to produce 30 years (1989-2018) reforecast
- Q2FY19: Start to produce retrospective runs (2.5 years)
- Q3FY19: Start users evaluation
- **Q2FY20: Implement FV3GEFS operational version (v12)**

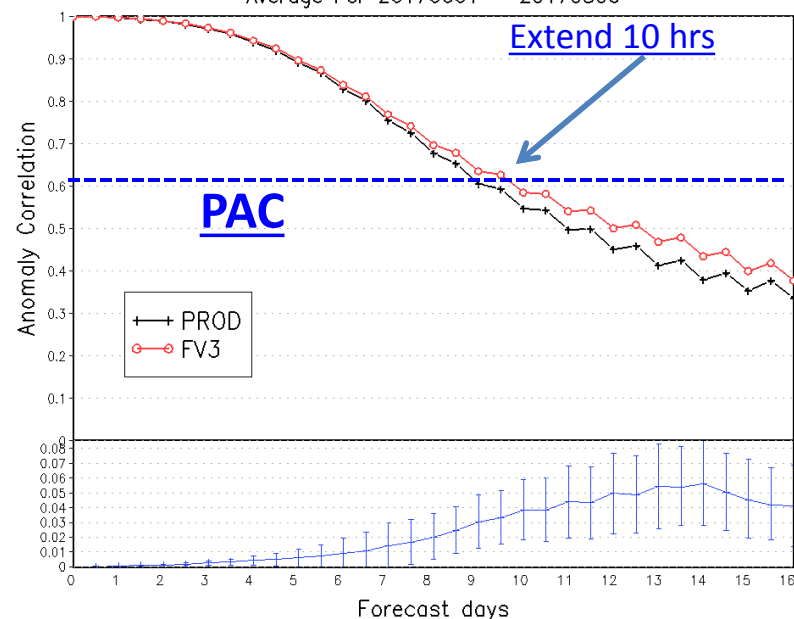
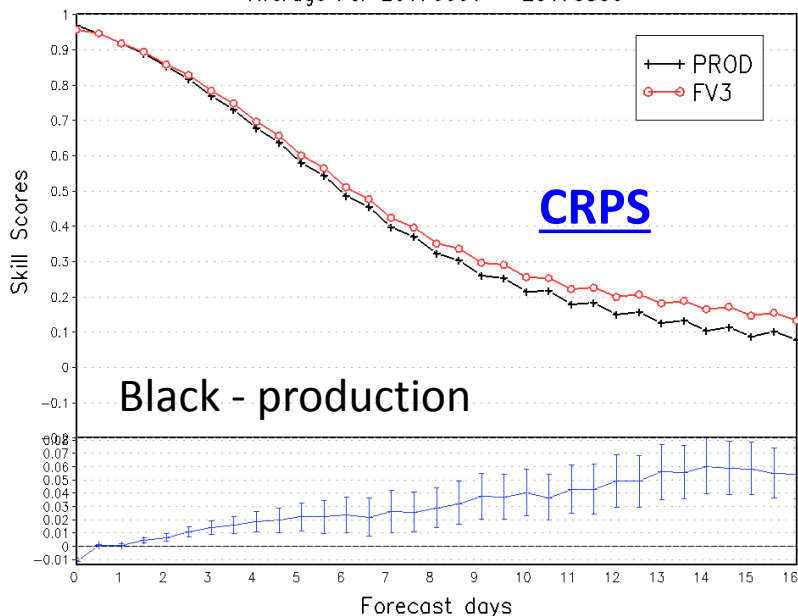
# FV3-GEFS design

- Resolution – C384 (~25km)
- **Lead time – 16 days**
- Ensemble members – 20 perturbed + 1 control
- Experiments period:
  - 06/01 – 08/06/2017 (67 cases)
  - 12/01/2017 – 01/31/2018 (62 cases)
  - 08/16 – 09/30/2018 (92 cases)
- Model and initial perturbations
  - Early/latest version with all possible bugs fixed (old: before 6/1/2018)
  - GFS physics with GFDL MP (Ruiyu's fix after SW radiation fix)
  - NSST – assimilate diurnal variation
  - **EnKF f06 for ensemble initial perturbation (FV3 GFS retrospective)**
- Sciences
  - Stochastic schemes
    - SKEB (1.0), SPPT and SHUM – reference
    - SKEB (**0.6**) and SPPT – new experiments
  - 2-tierd SST
  - New SA convective parameterization scheme
- Early bench mark:
  - Hord=6; SPs (SPPT; SHUM; SKEB=1.0) – include all bugs we have found later.
- Latest test:
  - **Latest FV3-GFS version + hord=5; SPs (SPPT; SKEB=0.6); Ruiyu's GFDL MP changes**

Northern Hemisphere 500hPa Height  
Continuous Ranked Probability Skill Scores  
Average For 20170601 – 20170806

## NH 500hPa height

Northern Hemisphere 500hPa Height  
Ensemble Mean Anomaly Correlation  
Average For 20170601 – 20170806



## Background – early tests for last summer

FV3-GEFS early test – our first bench mark (FV3-GEFS early summer frozen version for their retrospective runs)

FV3-GEFS setting – hord=6, full SPs

2-tiered SST

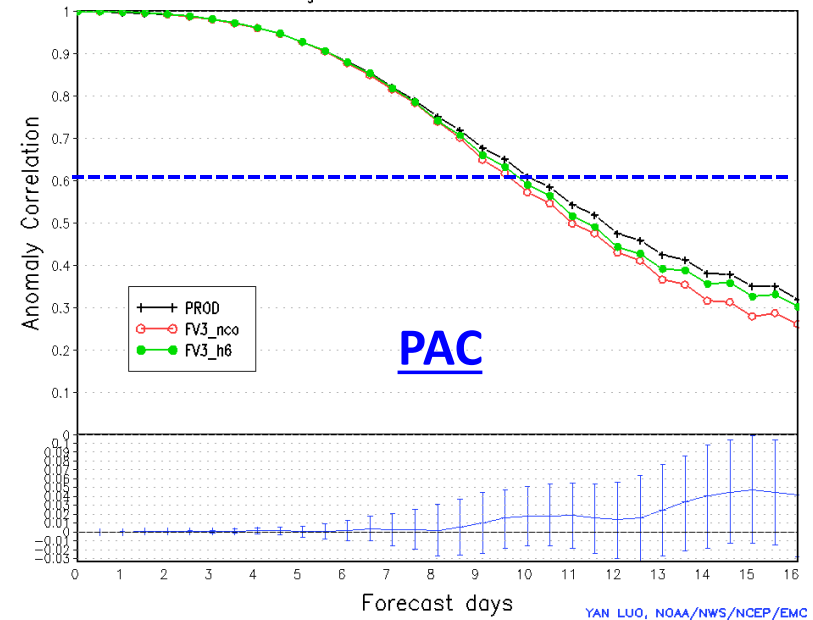
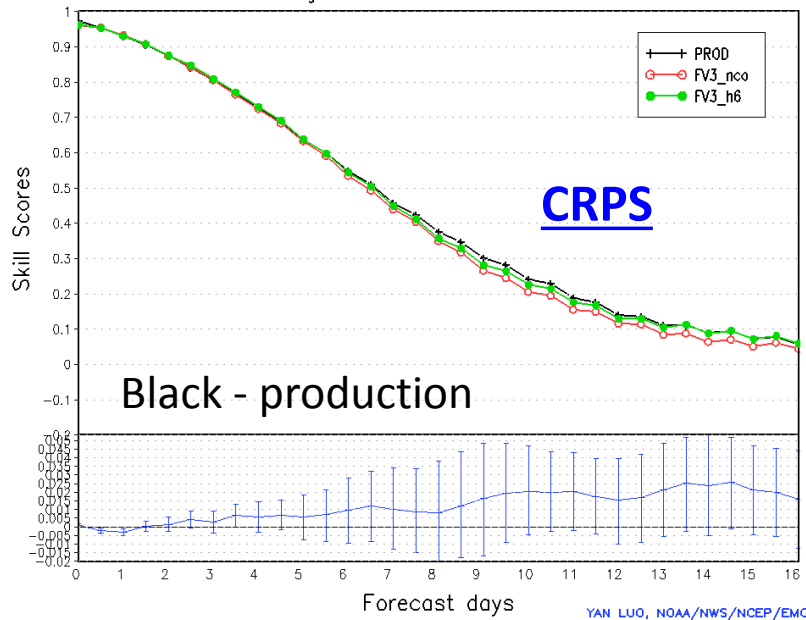
Looks FV3 is very promised to improve the skills

This results (stats) has been presented in summer 2018

Northern Hemisphere 500hPa Height  
 Continuous Ranked Probability Skill Scores  
 Average For 20180830 – 20180930

## NH 500hPa height

Northern Hemisphere 500hPa Height  
 Ensemble Mean Anomaly Correlation  
 Average For 20180830 – 20180930



Later – early October, we have tested the same setting for this summer

Green line – the same as last summer (hord=6; full SPs and 2-tier SST); we have seen a slight degradation for both CRPS and PAC.

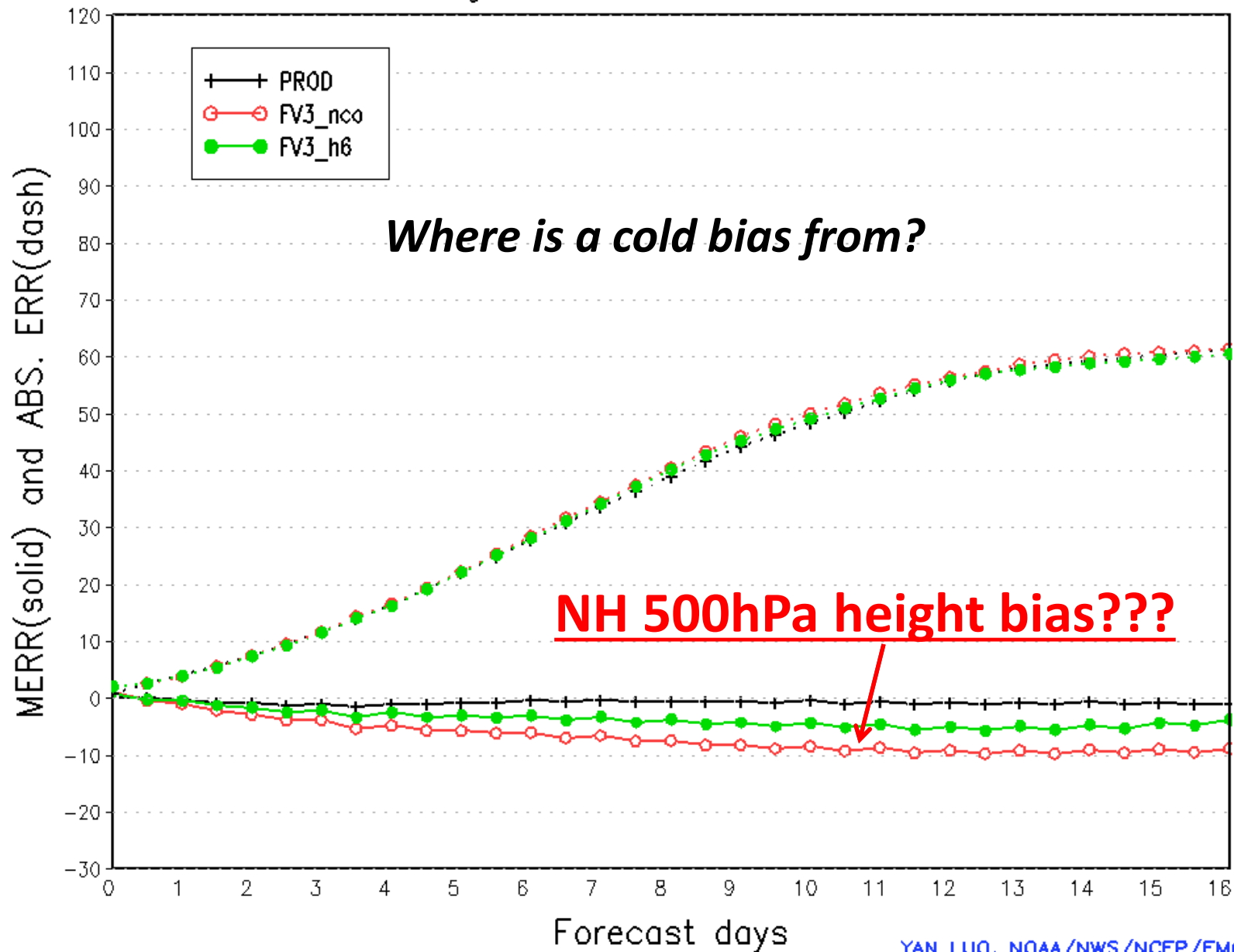
A little surprise, FV3-GEFS received further degradation when switched to FV3-GFS final version (9/18/2018). - **include NSST justification and SW radiation bug-fix.**

Red line – main difference from green; hord=5; latest FV3-GFS version.

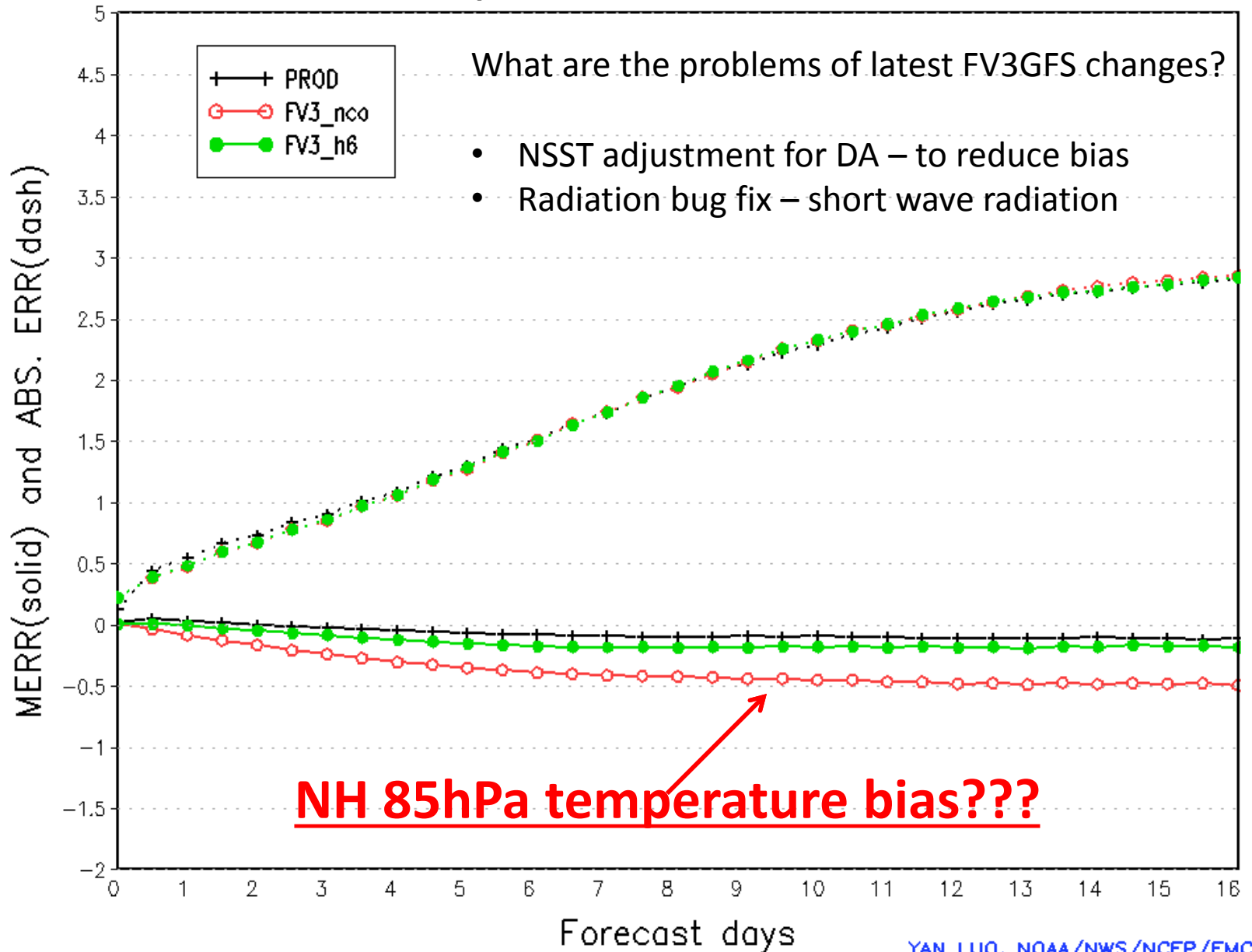
We have tested There is no big difference for hord=6 and hord=5

***What is the problem?***

Northern Hemisphere 500hPa Height  
Ensemble Mean Error and Ensemble Abs. Error  
Average For 20180830 – 20180930



Northern Hemisphere 850hPa Temp.  
Ensemble Mean Error and Ensemble Abs. Error  
Average For 20180830 – 20180930



After a set of sensitivity testing, we  
have identified the cold bias come  
from GFDL MP

Please note that:  
We have similar tests for change “hord” and SPs  
(not shown here)



# Fixed GFDL MP after SW radiation changes

- Code change from **Ruiyu Sun**
  - The GFDL MP produces mixing ratios for the cloud water, cloud ice, rain, snow and graupel.
  - In the current FV3GFS, radiation calculations use two species, cloud liquid and cloud ice. All the species are combined and re-partitioned based on the temperature into the two species.
  - In the test, individual species and their corresponding radii are fed into radiation for the radiative flux calculations
  - Experiments – three periods have been finished

Summer 2017 experiment (20170601-20170806; 67 cases):

1. Production; 2. Experiments of early FV3 version; 3. Experiments of latest version

[http://www.emc.ncep.noaa.gov/gmb/ylo/GEFS\\_VRFY/GEFS\\_FV3NCO\\_ruiyu\\_VRFY\\_sum2017.html](http://www.emc.ncep.noaa.gov/gmb/ylo/GEFS_VRFY/GEFS_FV3NCO_ruiyu_VRFY_sum2017.html)

[http://www.emc.ncep.noaa.gov/gmb/ylo/GEFS\\_VRFY/GEFS\\_fv3nco\\_ruiyu\\_ts\\_sum2017\\_00Z.html](http://www.emc.ncep.noaa.gov/gmb/ylo/GEFS_VRFY/GEFS_fv3nco_ruiyu_ts_sum2017_00Z.html)

[http://www.emc.ncep.noaa.gov/gmb/ylo/GEFS\\_VRFY/FV3nco\\_ruiyu\\_ENSQPFvrfy\\_sum2017\\_0.5deg.html](http://www.emc.ncep.noaa.gov/gmb/ylo/GEFS_VRFY/FV3nco_ruiyu_ENSQPFvrfy_sum2017_0.5deg.html)

Winter 2017-2018 experiments (20171201-20180131; 62 cases):

1. Production; 2. Experiments of early FV3 version; 3. Experiments of latest version

[http://www.emc.ncep.noaa.gov/gmb/ylo/GEFS\\_VRFY/GEFS\\_FV3NCO\\_ruiyu\\_VRFY\\_win1718.html](http://www.emc.ncep.noaa.gov/gmb/ylo/GEFS_VRFY/GEFS_FV3NCO_ruiyu_VRFY_win1718.html)

[http://www.emc.ncep.noaa.gov/gmb/ylo/GEFS\\_VRFY/GEFS\\_fv3nco\\_ruiyu\\_ts\\_win1718\\_00Z.html](http://www.emc.ncep.noaa.gov/gmb/ylo/GEFS_VRFY/GEFS_fv3nco_ruiyu_ts_win1718_00Z.html)

[http://www.emc.ncep.noaa.gov/gmb/ylo/GEFS\\_VRFY/FV3nco\\_ruiyu\\_ENSQPFvrfy\\_win1718\\_0.5deg.html](http://www.emc.ncep.noaa.gov/gmb/ylo/GEFS_VRFY/FV3nco_ruiyu_ENSQPFvrfy_win1718_0.5deg.html)

Summer 2018 experiments (20180830-20180930; 32/92 cases):

1. Production; 2. Experiments of final FV3-GFS version; 3. Experiments of latest version

[http://www.emc.ncep.noaa.gov/gmb/ylo/GEFS\\_VRFY/GEFS\\_FV3\\_Q2FY19\\_VRFY\\_sum2018.html](http://www.emc.ncep.noaa.gov/gmb/ylo/GEFS_VRFY/GEFS_FV3_Q2FY19_VRFY_sum2018.html)

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[http://www.emc.ncep.noaa.gov/gmb/ylo/GEFS\\_VRFY/FV3nco\\_q2fy19\\_ENSQPFvrfy\\_sum2018\\_0.5deg.html](http://www.emc.ncep.noaa.gov/gmb/ylo/GEFS_VRFY/FV3nco_q2fy19_ENSQPFvrfy_sum2018_0.5deg.html)

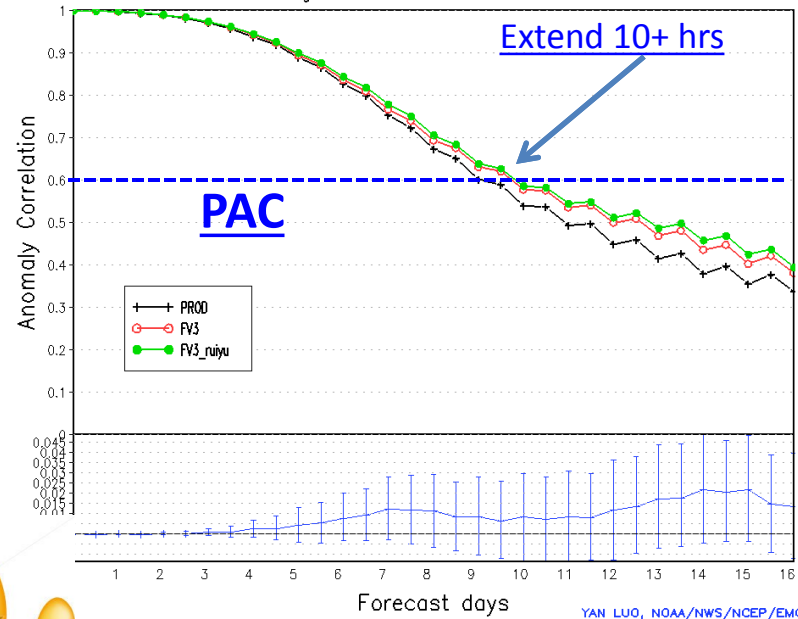
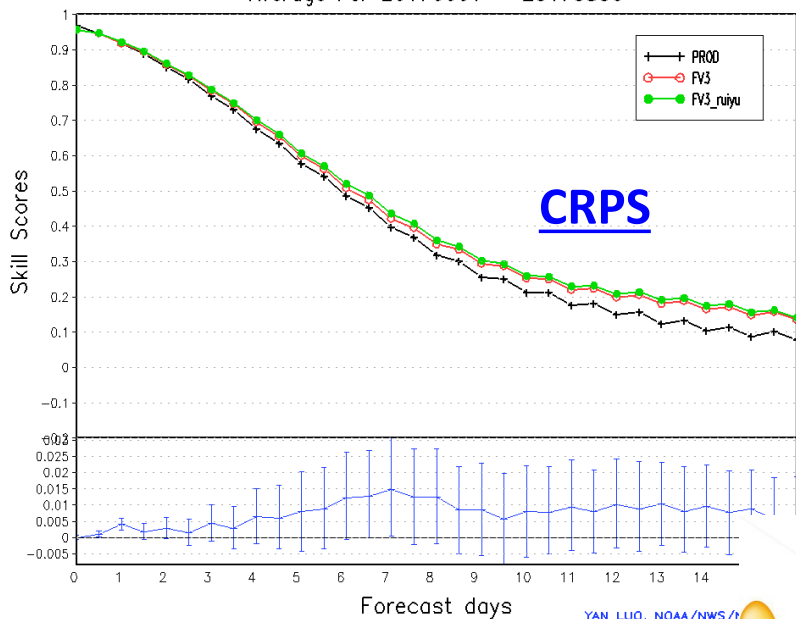
Period one

06/01 – 08/06/2017 (67 cases)

Northern Hemisphere 500hPa Height  
Continuous Ranked Probability Skill Scores  
Average For 20170601 – 20170806

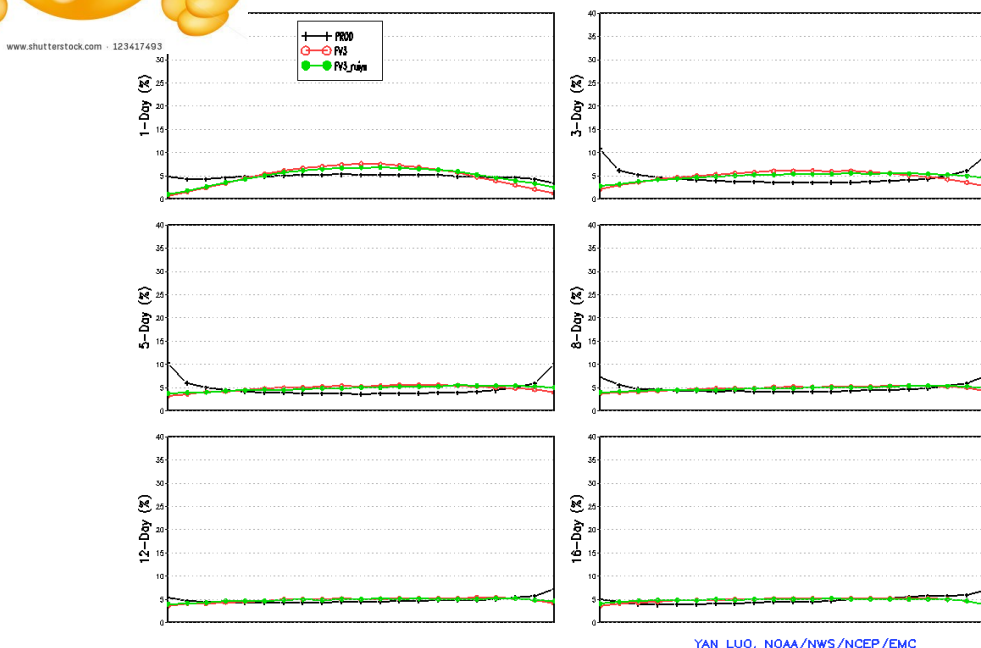
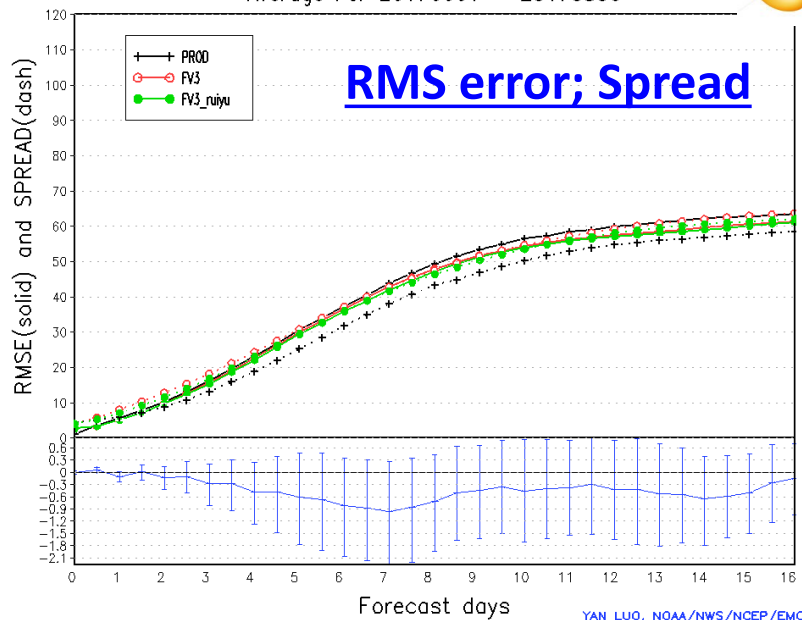
# NH 500hPa height

Northern Hemisphere 500hPa Height  
Ensemble Mean Anomaly Correlation  
Average For 20170601 – 20170806



Northern Hemisphere 500hPa Height  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20170601 – 20170806

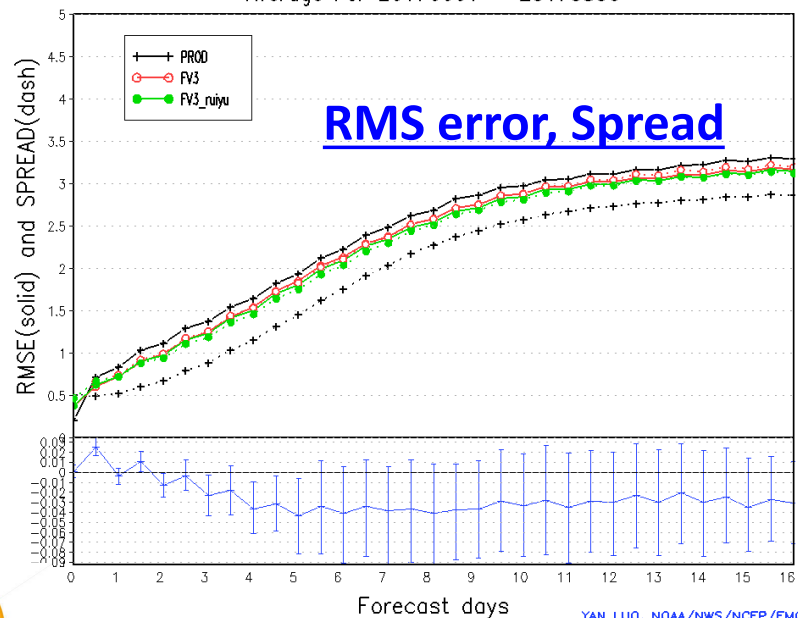
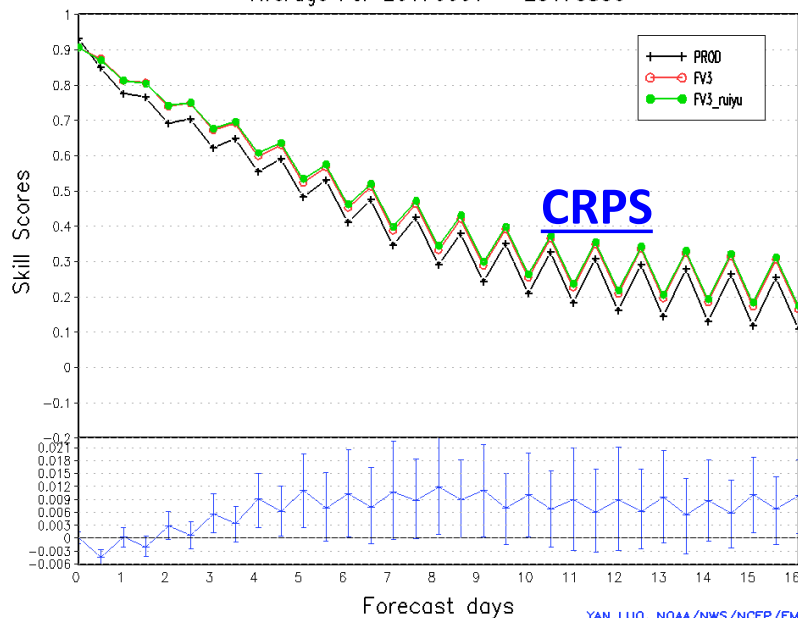
Northern Hemisphere 500hPa Height Histogram Distribution  
Average For 20170601 – 20170806



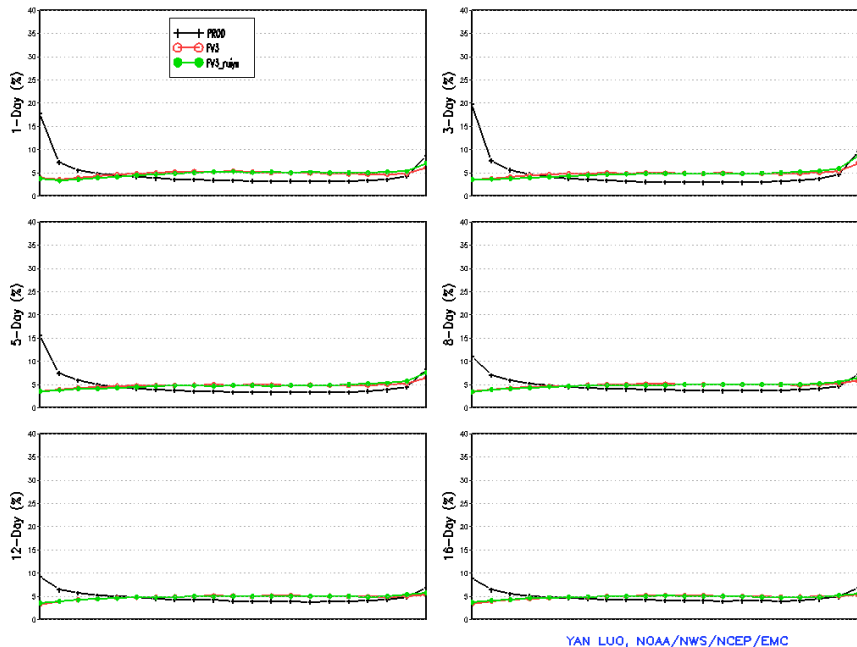
Northern Hemisphere 850hPa Temp.  
 Continous Ranked Probability Skill Scores  
 Average For 20170601 – 20170806

# NH 850hPa Temp

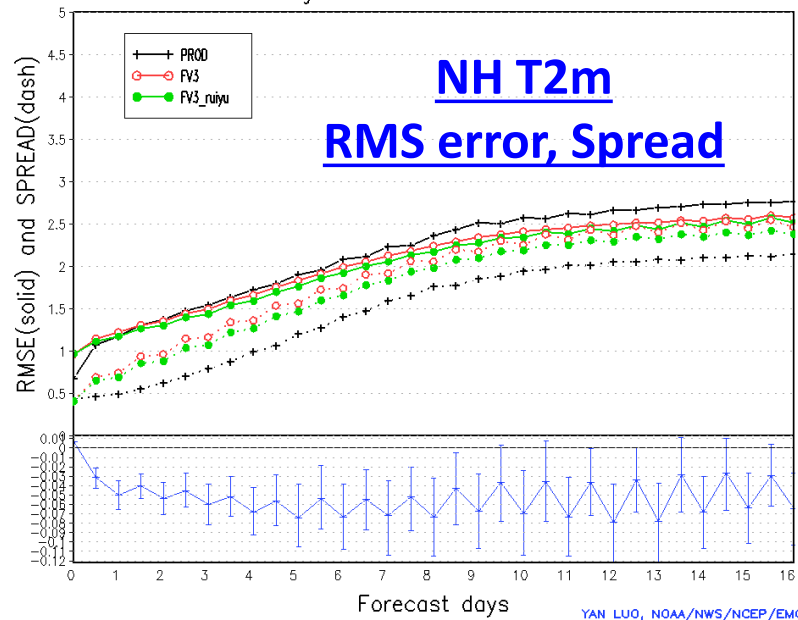
Northern Hemisphere 850hPa Temp.  
 Ensemble Mean RMSE and Ensemble SPREAD  
 Average For 20170601 – 20170806



Northern Hemisphere 850hPa Temp. Histogram Distribution  
 Average For 20170601 – 20170806



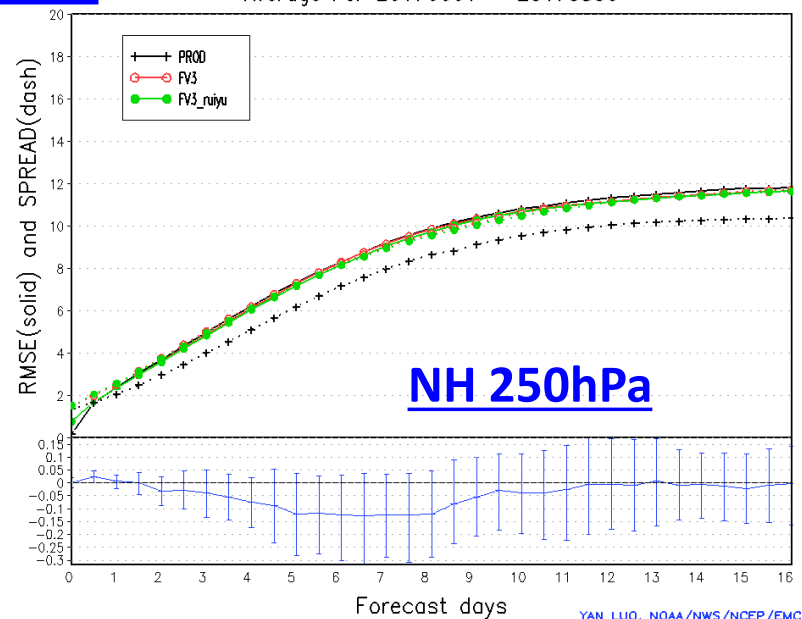
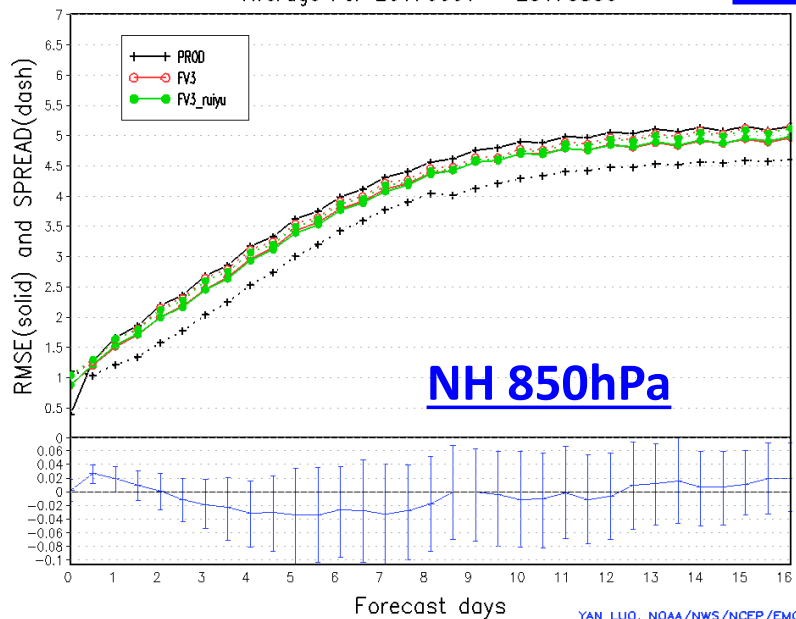
Northern Hemisphere 2 Meter Temp.  
 Ensemble Mean RMSE and Ensemble SPREAD  
 Average For 20170601 – 20170806



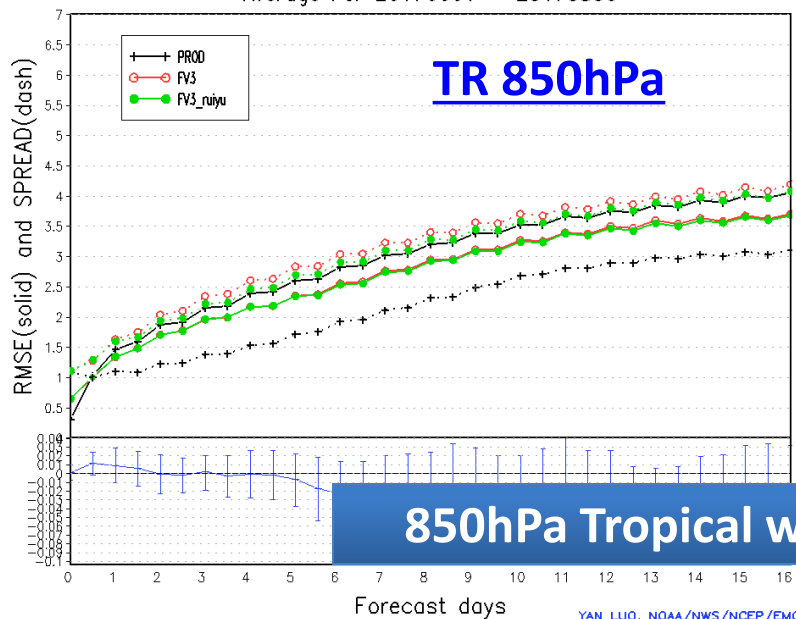
Northern Hemisphere 850hPa U Wind  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20170601 – 20170806

# Zonal Wind

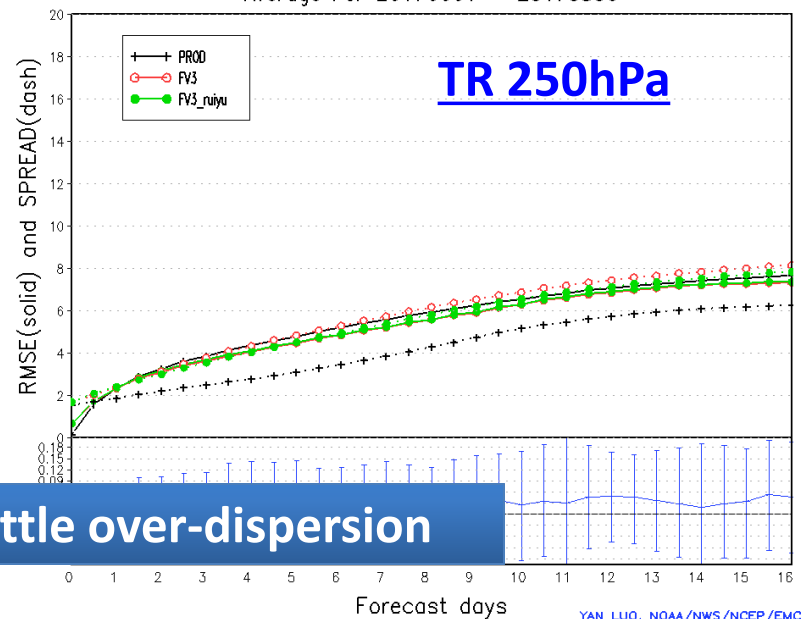
Northern Hemisphere 250hPa U Wind  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20170601 – 20170806



Tropical 850hPa U Wind  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20170601 – 20170806



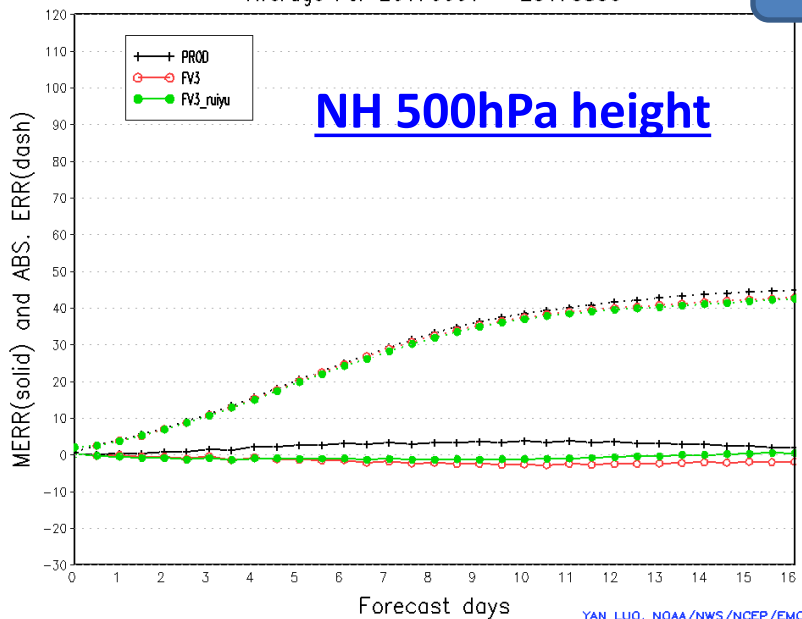
Tropical 250hPa U Wind  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20170601 – 20170806



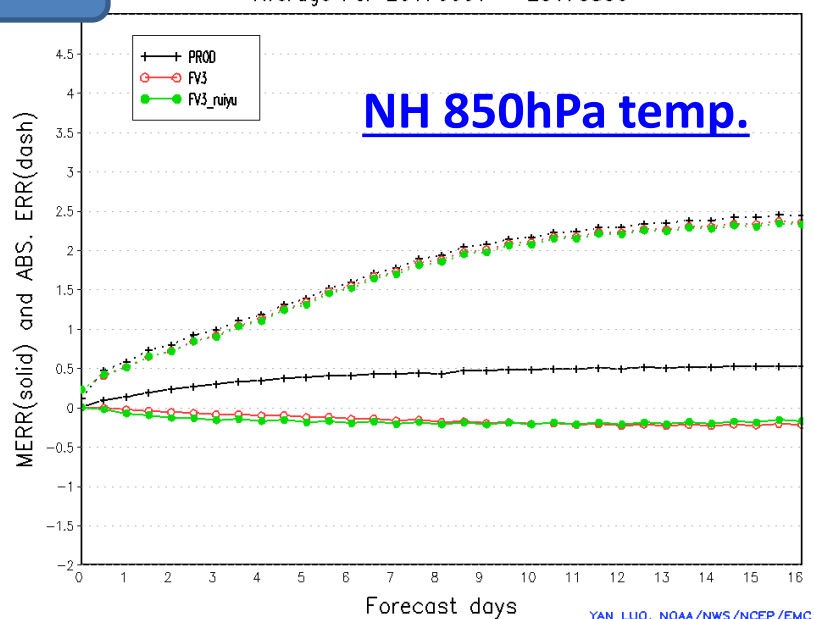
850hPa Tropical winds, a little over-dispersion

# Bias

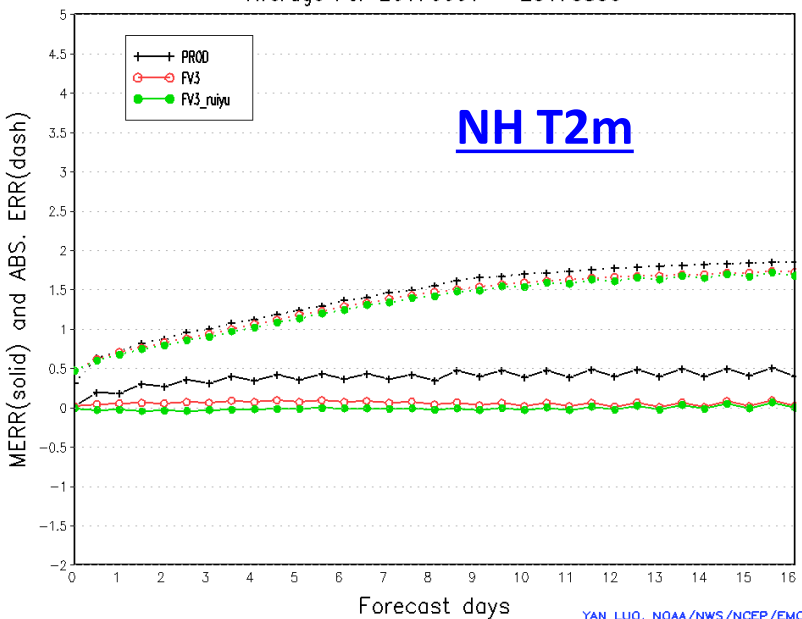
Northern Hemisphere 500hPa Height  
Ensemble Mean Error and Ensemble Abs. Error  
Average For 20170601 – 20170806



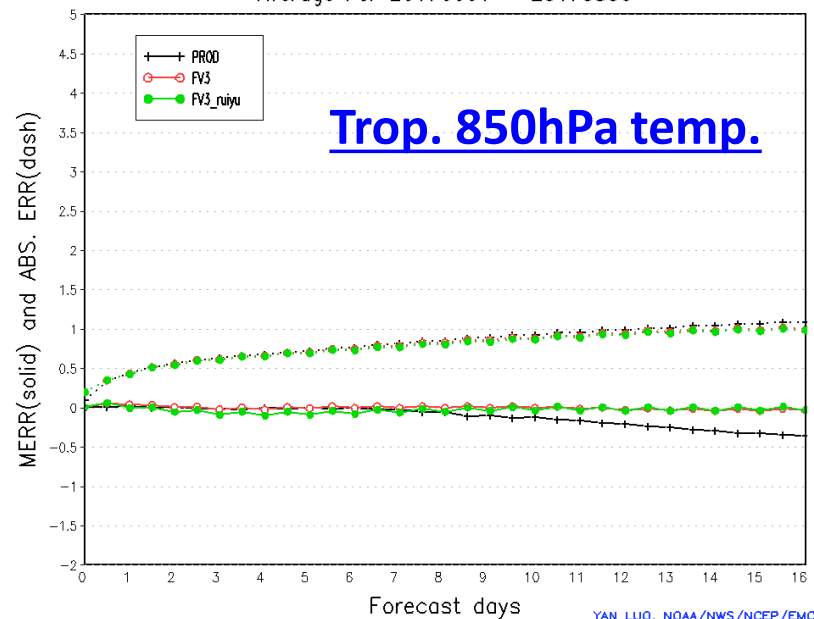
Northern Hemisphere 850hPa Temp.  
Ensemble Mean Error and Ensemble Abs. Error  
Average For 20170601 – 20170806



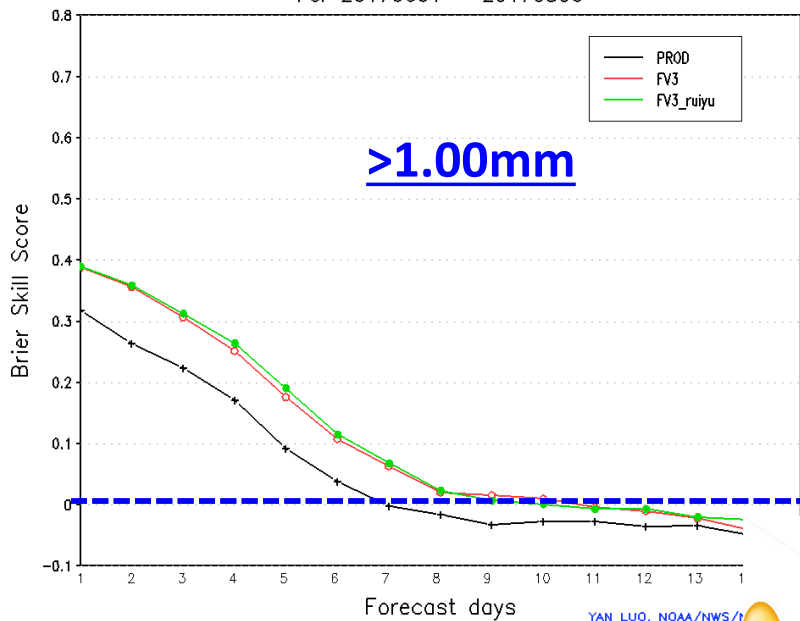
Northern Hemisphere 2 Meter Temp.  
Ensemble Mean Error and Ensemble Abs. Error  
Average For 20170601 – 20170806



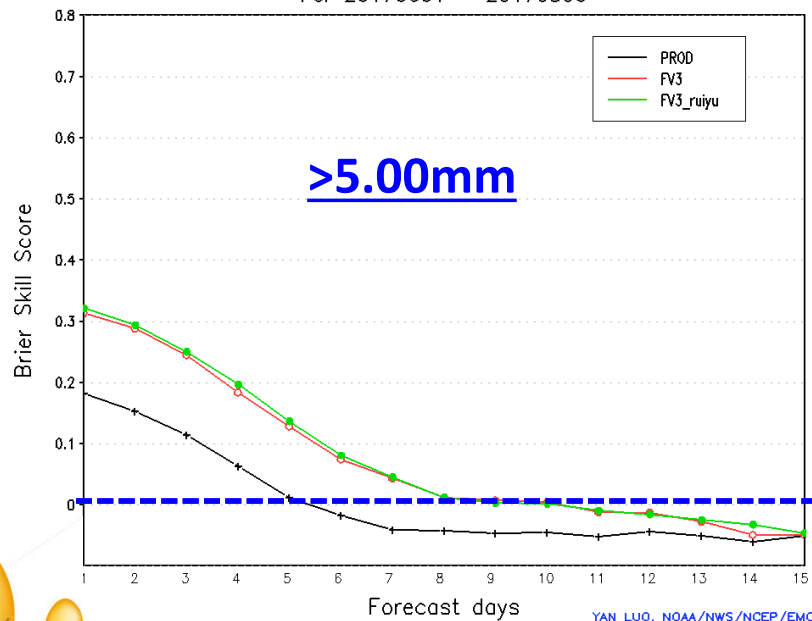
Tropical 850hPa Temp.  
Ensemble Mean Error and Ensemble Abs. Error  
Average For 20170601 – 20170806



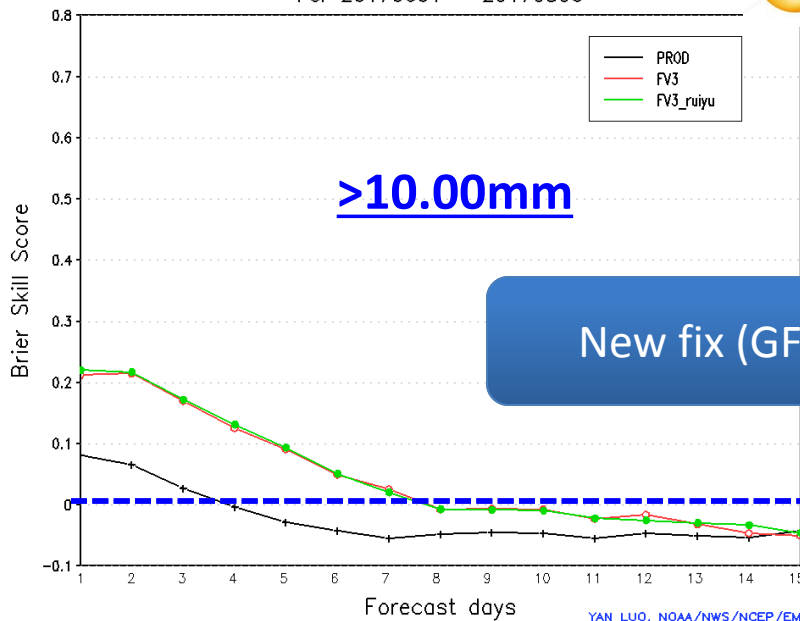
Ensemble Precipitation Verification for CONUS  
 Brier Skill Score for threshold > 1.00mm/24hours  
 For 20170601 - 20170806



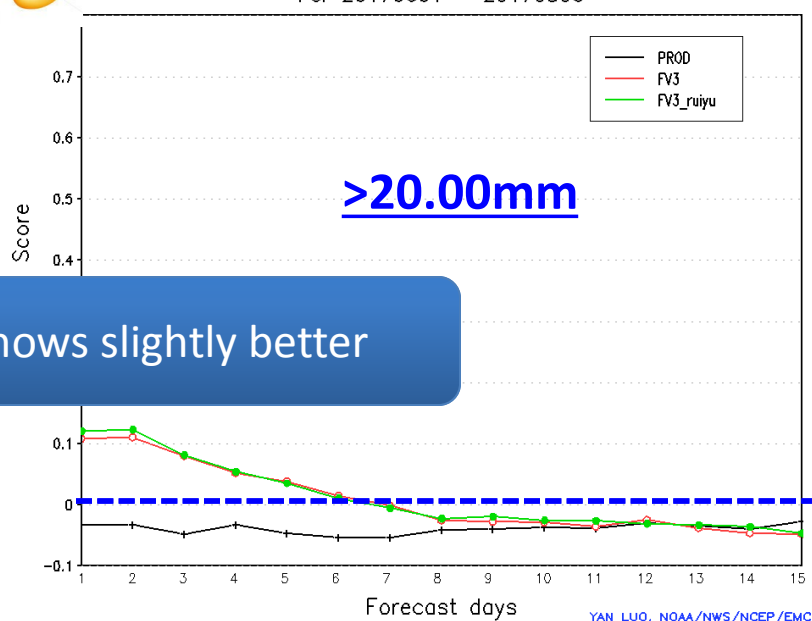
Ensemble Precipitation Verification for CONUS  
 Brier Skill Score for threshold > 5.00mm/24hours  
 For 20170601 - 20170806



Ensemble Precipitation Verification for CONUS  
 Brier Skill Score for threshold > 10.0mm/24hours  
 For 20170601 - 20170806

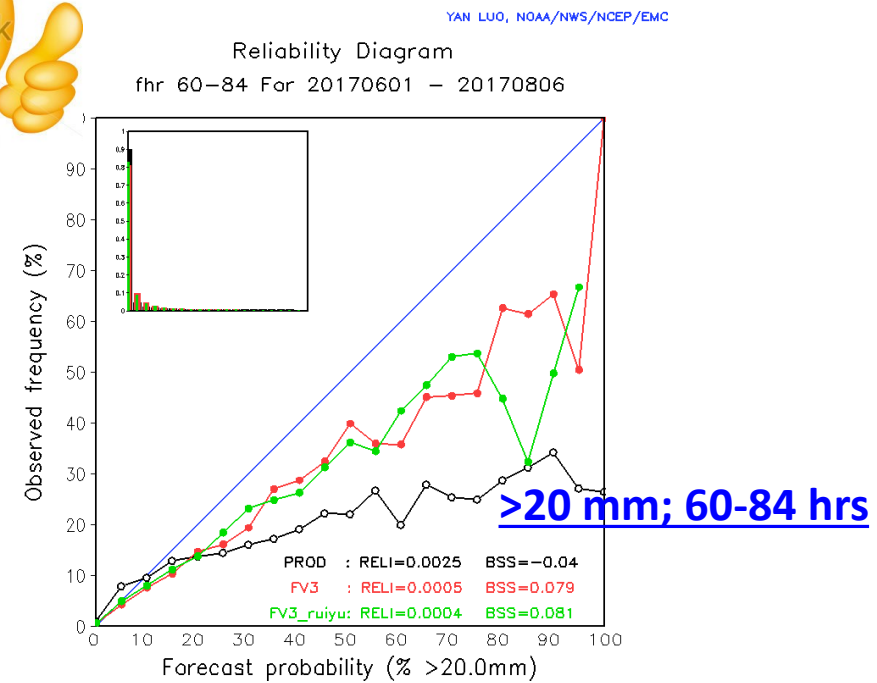
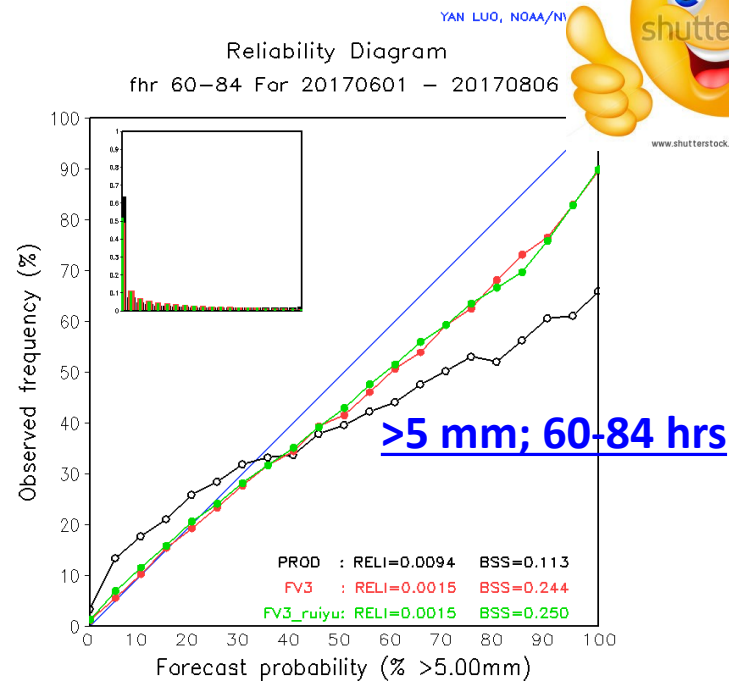
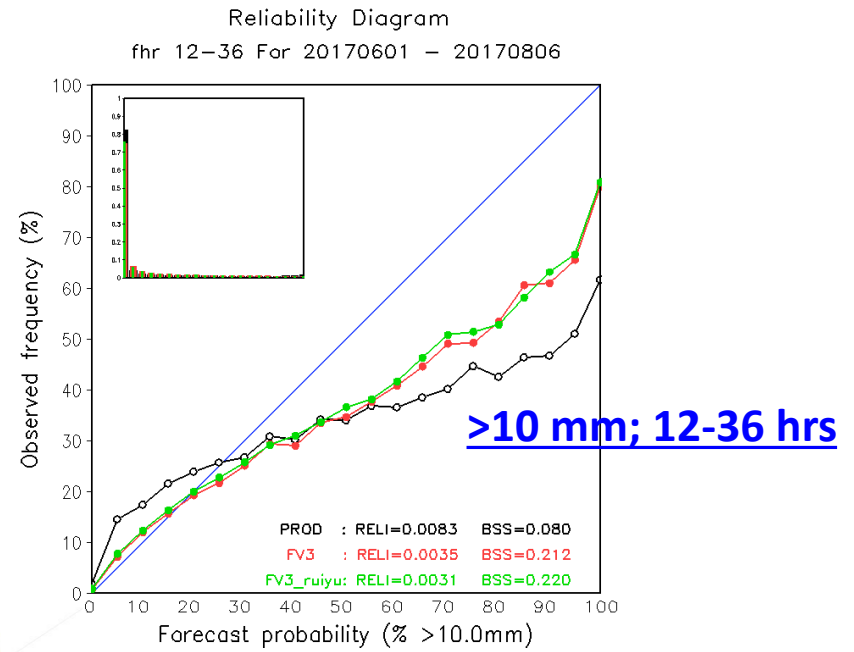
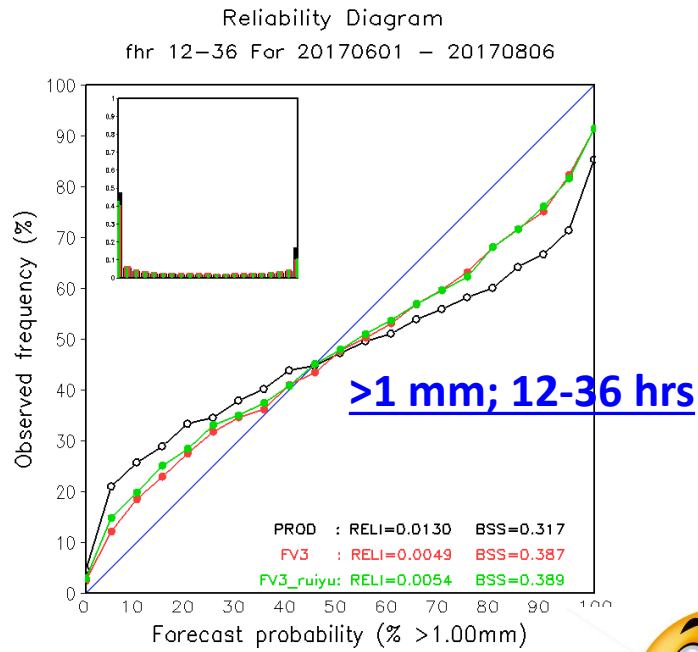


Ensemble Precipitation Verification for CONUS  
 Brier Skill Score for threshold > 20.0mm/24hours  
 For 20170601 - 20170806



New fix (GFDL MP) shows slightly better





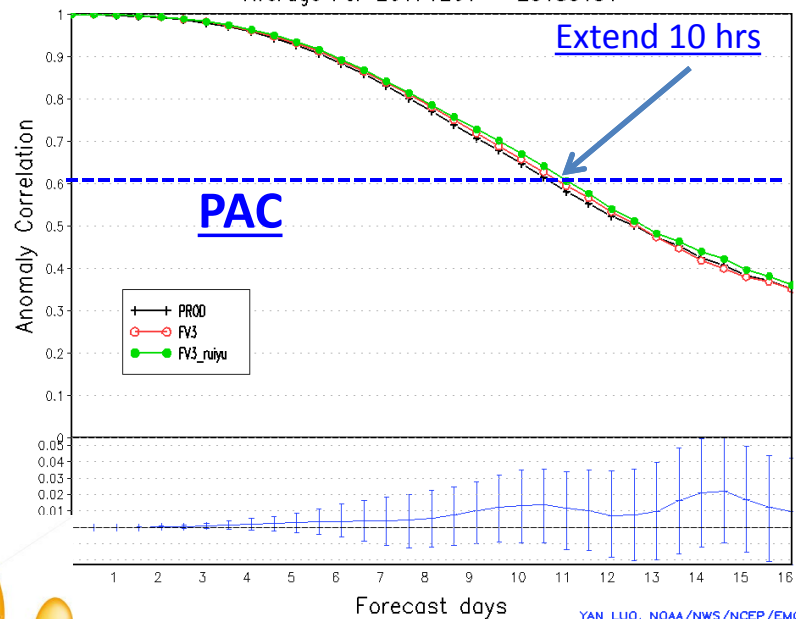
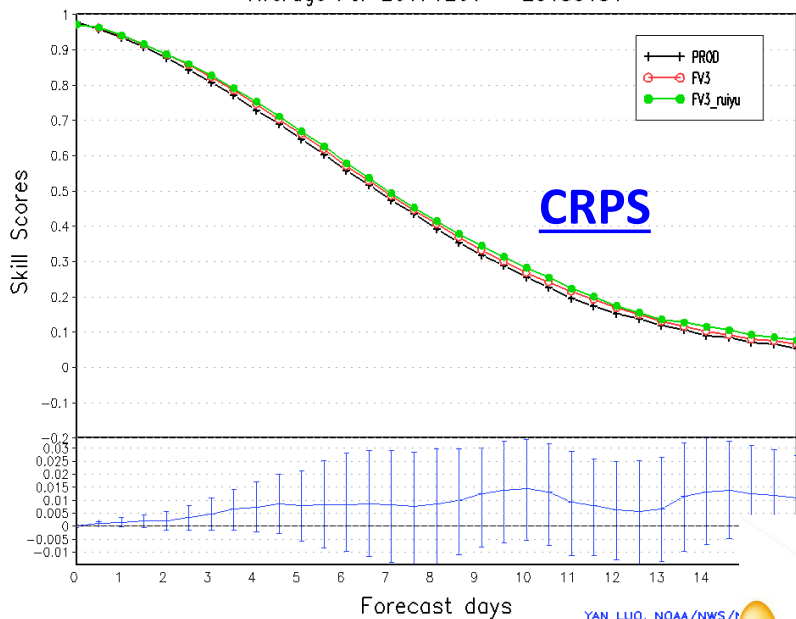
## Period two

12/01/2017 – 01/31/2018 (62 cases)

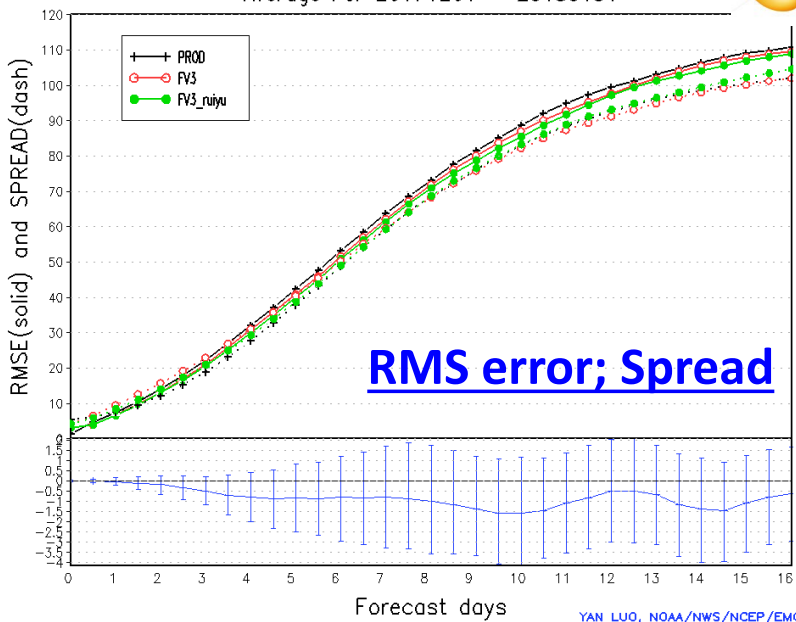
Northern Hemisphere 500hPa Height  
Continuous Ranked Probability Skill Scores  
Average For 20171201 - 20180131

# NH 500hPa height

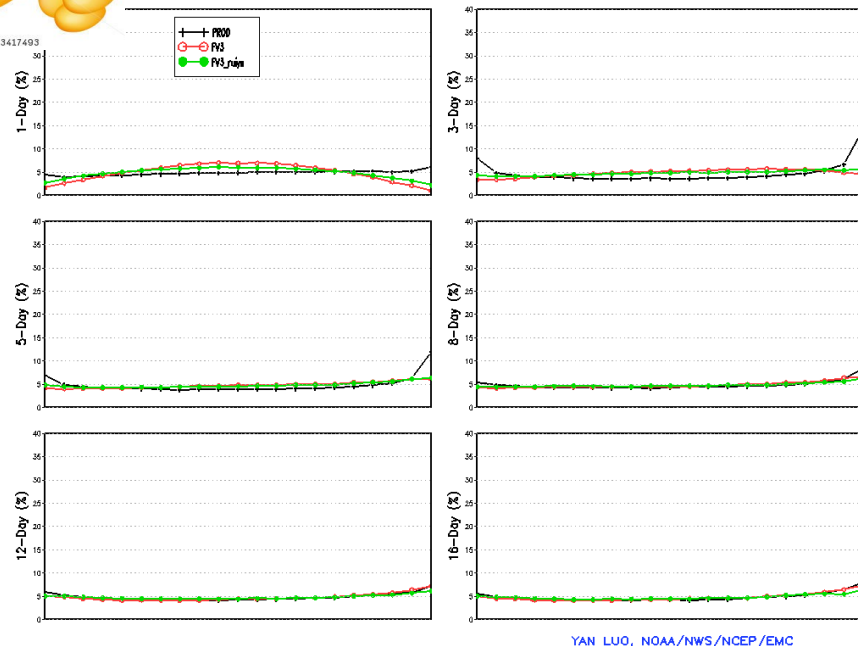
Northern Hemisphere 500hPa Height  
Ensemble Mean Anomaly Correlation  
Average For 20171201 - 20180131



Northern Hemisphere 500hPa Height  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20171201 - 20180131



Northern Hemisphere 500hPa Height Histogram Distribution  
Average For 20171201 - 20180131



YAN LUO, NOAA/NWS/

YAN LUO, NOAA/NWS/NCEP/EMC

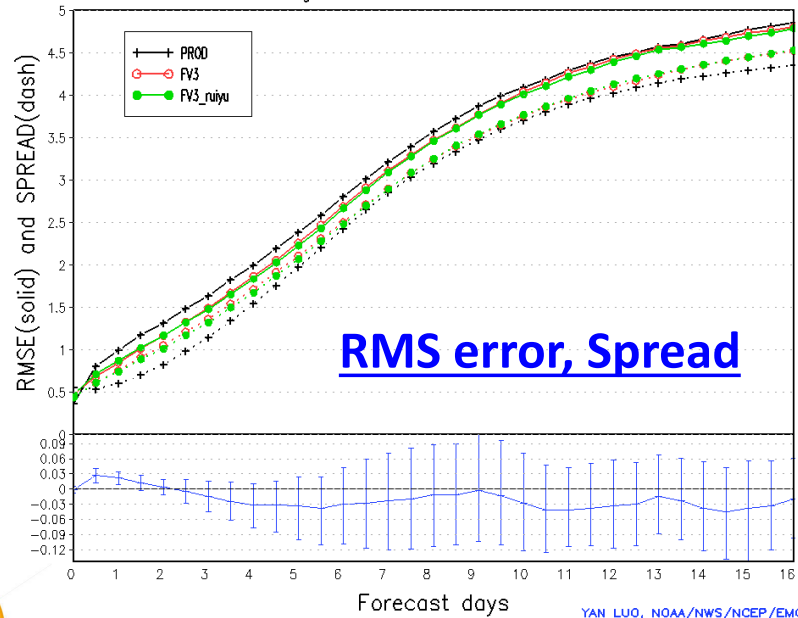
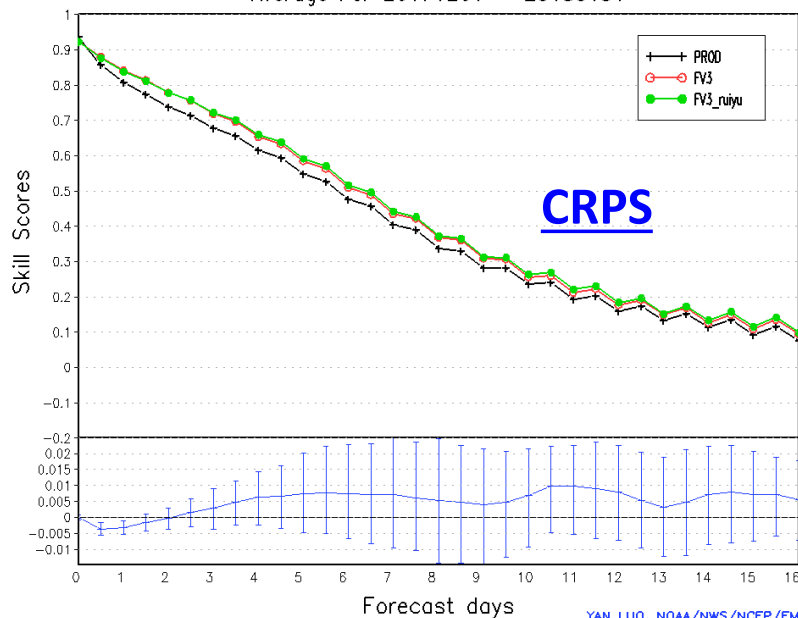
YAN LUO, NOAA/NWS/NCEP/EMC

YAN LUO, NOAA/NWS/NCEP/EMC

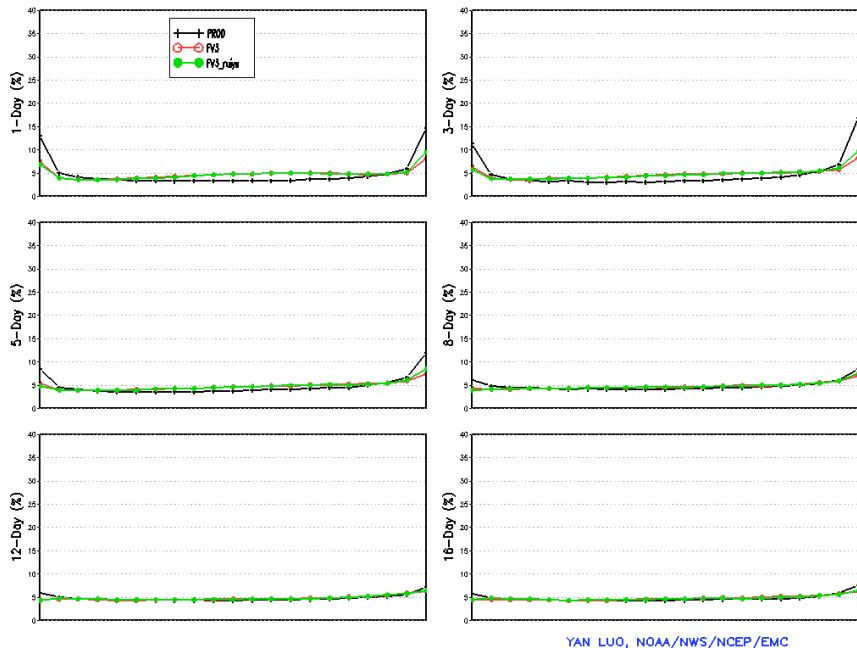
Northern Hemisphere 850hPa Temp.  
 Continous Ranked Probability Skill Scores  
 Average For 20171201 - 20180131

# NH 850hPa Temp

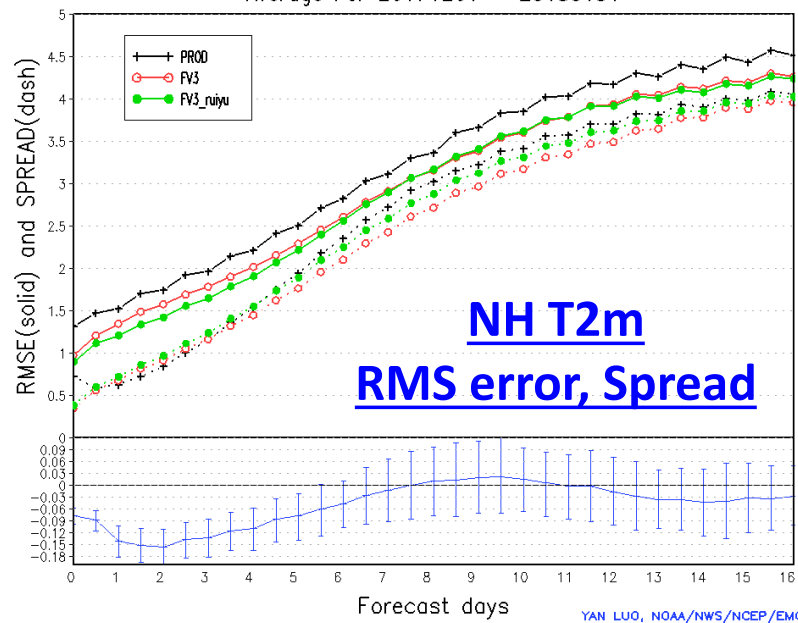
Northern Hemisphere 850hPa Temp.  
 Ensemble Mean RMSE and Ensemble SPREAD  
 Average For 20171201 - 20180131



Northern Hemisphere 850hPa Temp. Histogram Distribution  
 Average For 20171201 - 20180131



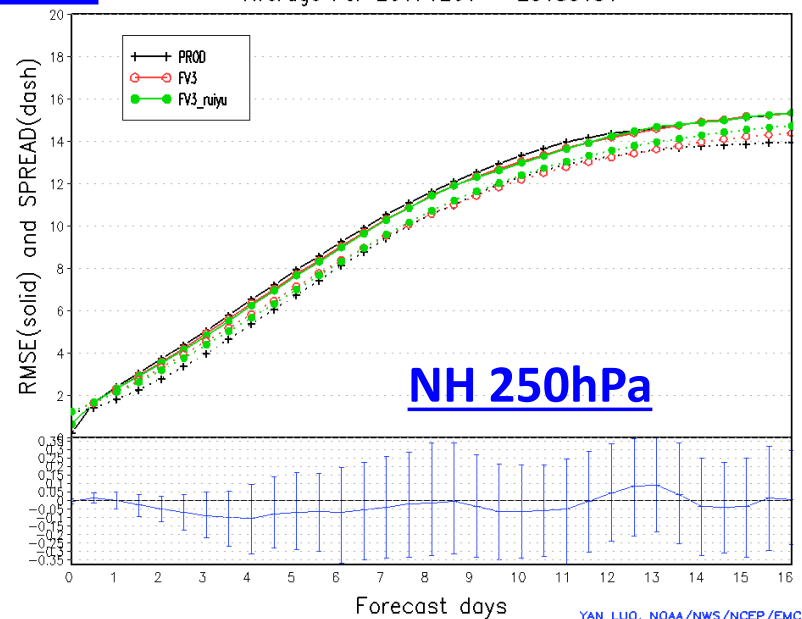
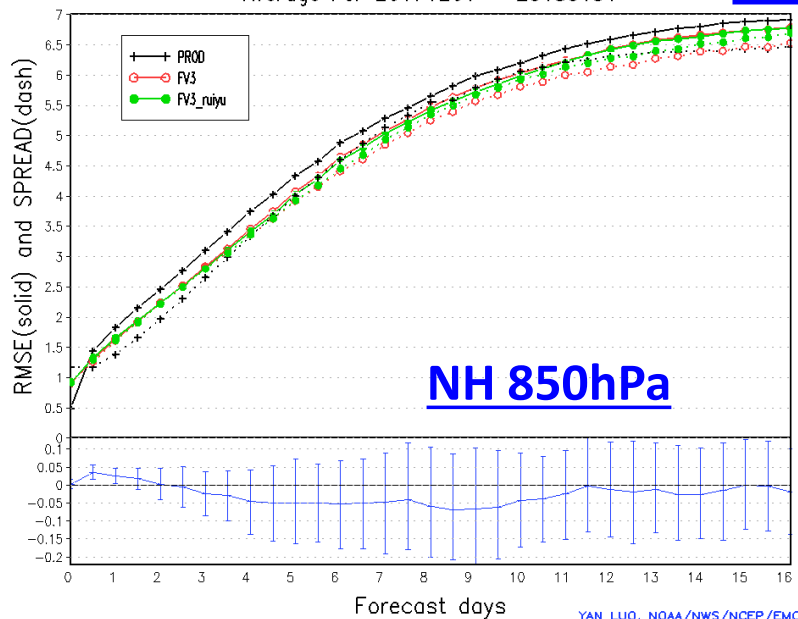
Northern Hemisphere 2 Meter Temp.  
 Ensemble Mean RMSE and Ensemble SPREAD  
 Average For 20171201 - 20180131



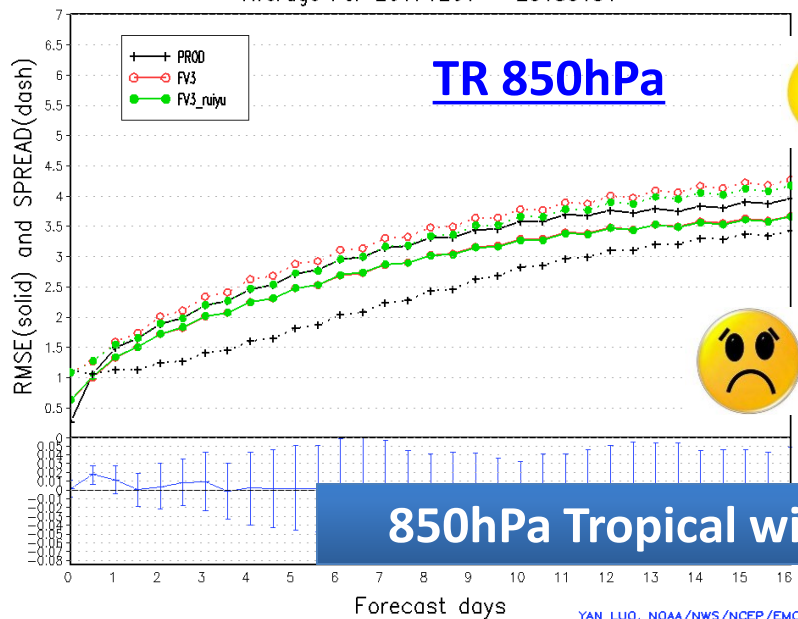
Northern Hemisphere 850hPa U Wind  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20171201 – 20180131

# Zonal Wind

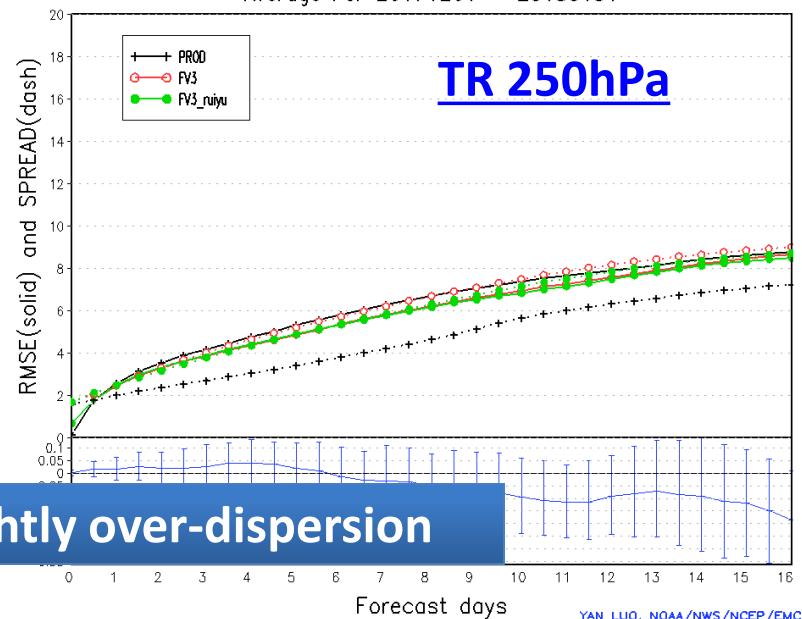
Northern Hemisphere 250hPa U Wind  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20171201 – 20180131



Tropical 850hPa U Wind  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20171201 – 20180131



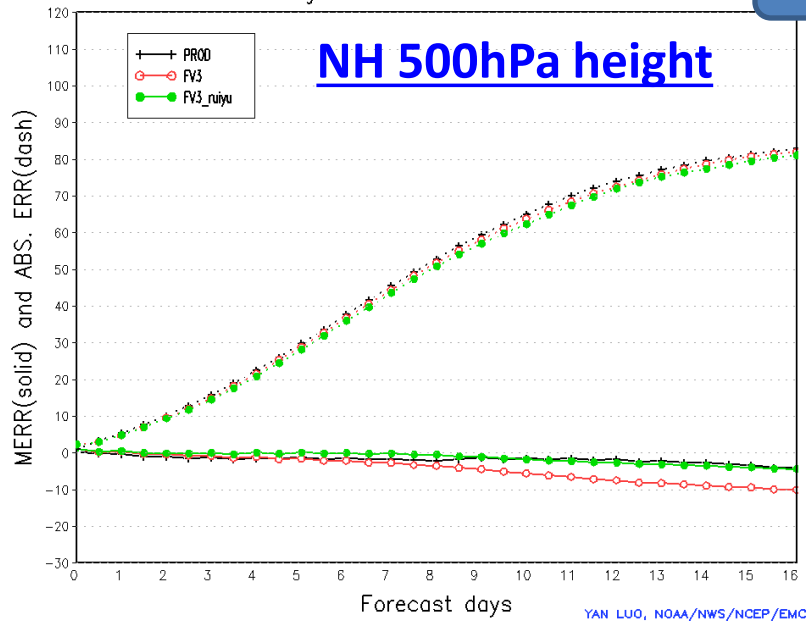
Tropical 250hPa U Wind  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20171201 – 20180131



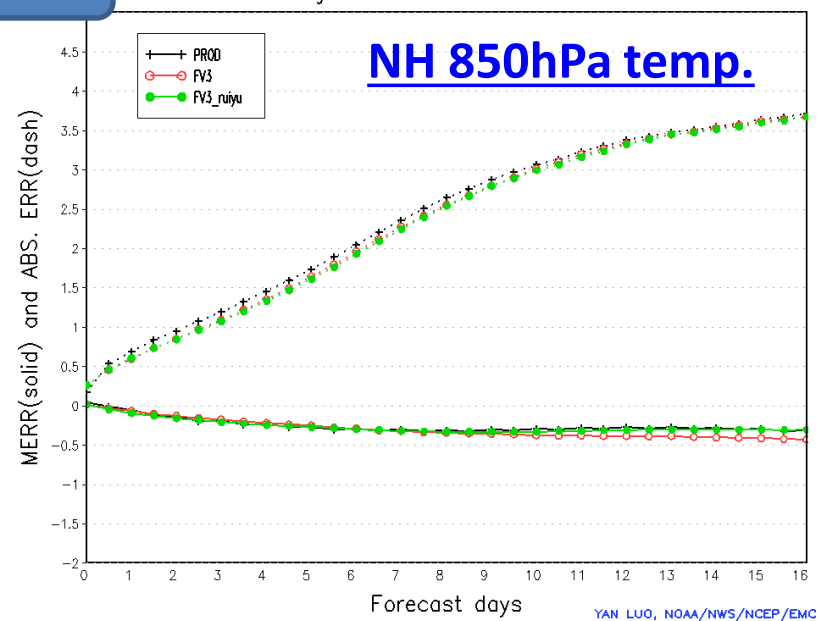
**850hPa Tropical winds, slightly over-dispersion**

# Bias

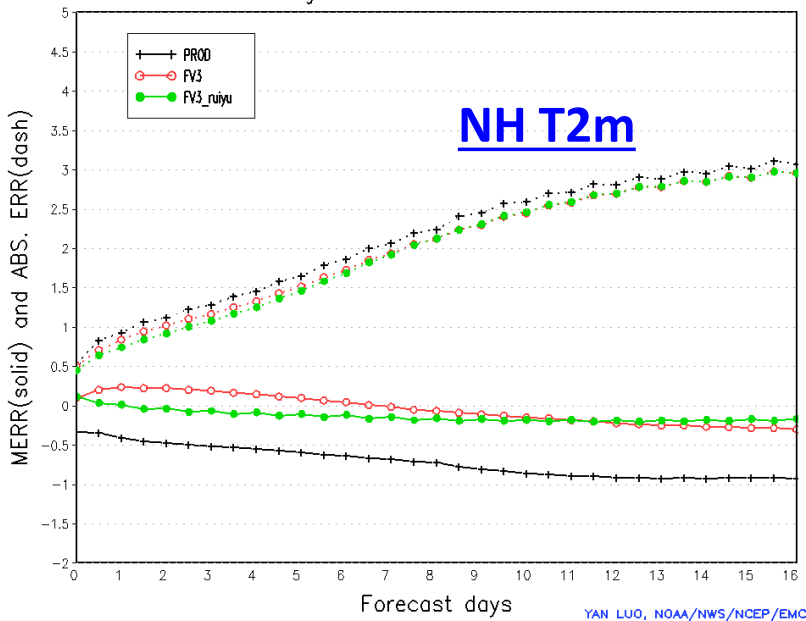
Northern Hemisphere 500hPa Height  
Ensemble Mean Error and Ensemble Abs. Error  
Average For 20171201 – 20180131



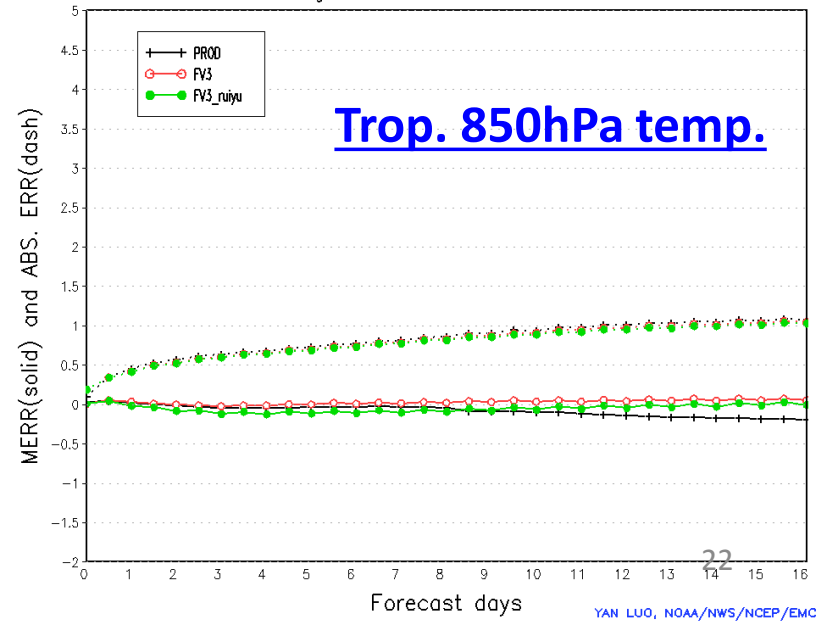
Northern Hemisphere 850hPa Temp.  
Ensemble Mean Error and Ensemble Abs. Error  
Average For 20171201 – 20180131



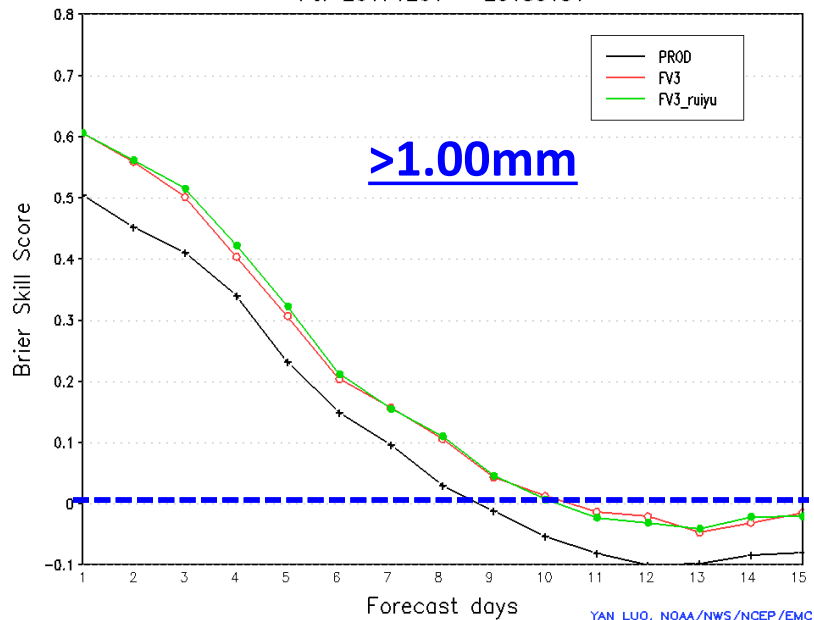
Northern Hemisphere 2 Meter Temp.  
Ensemble Mean Error and Ensemble Abs. Error  
Average For 20171201 – 20180131



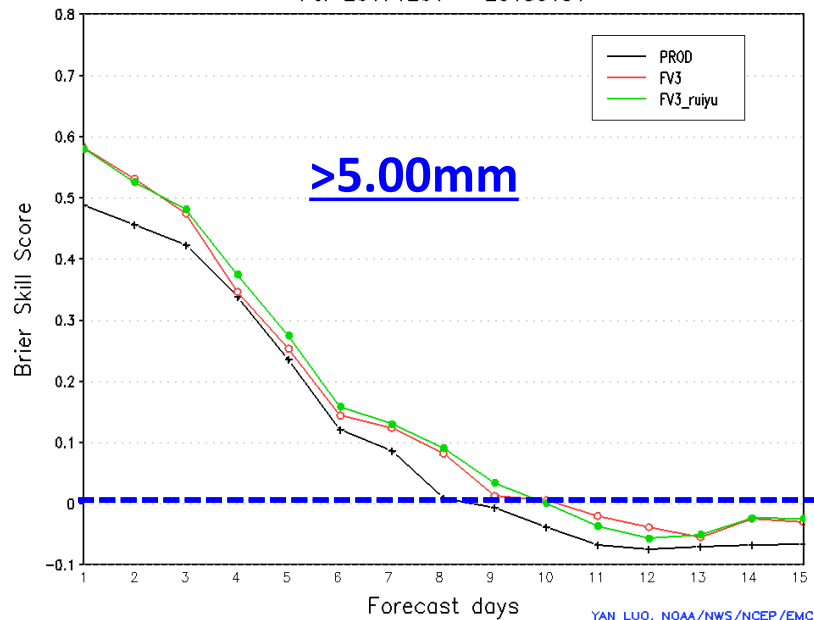
Tropical 850hPa Temp.  
Ensemble Mean Error and Ensemble Abs. Error  
Average For 20171201 – 20180131



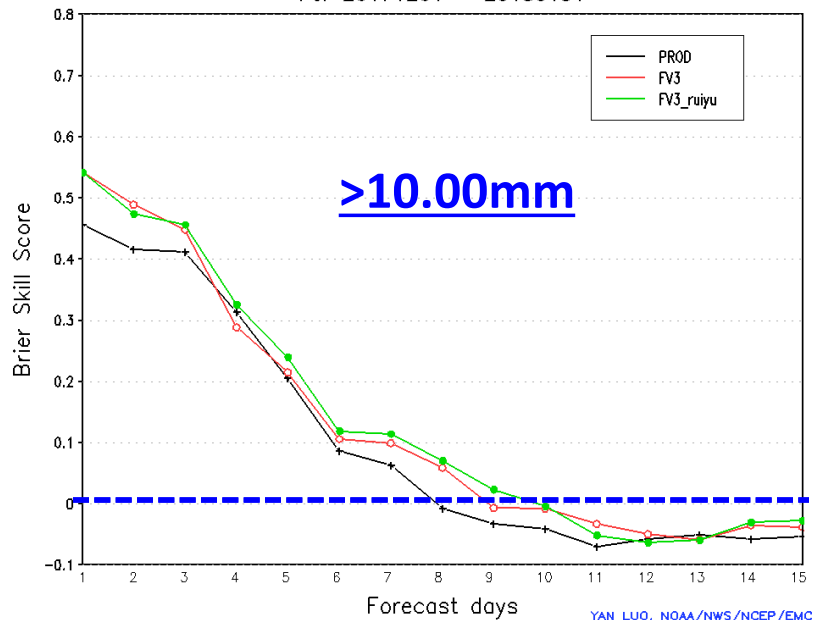
Ensemble Precipitation Verification for CONUS  
Brier Skill Score for threshold > 1.00mm/24hours  
For 20171201 - 20180131



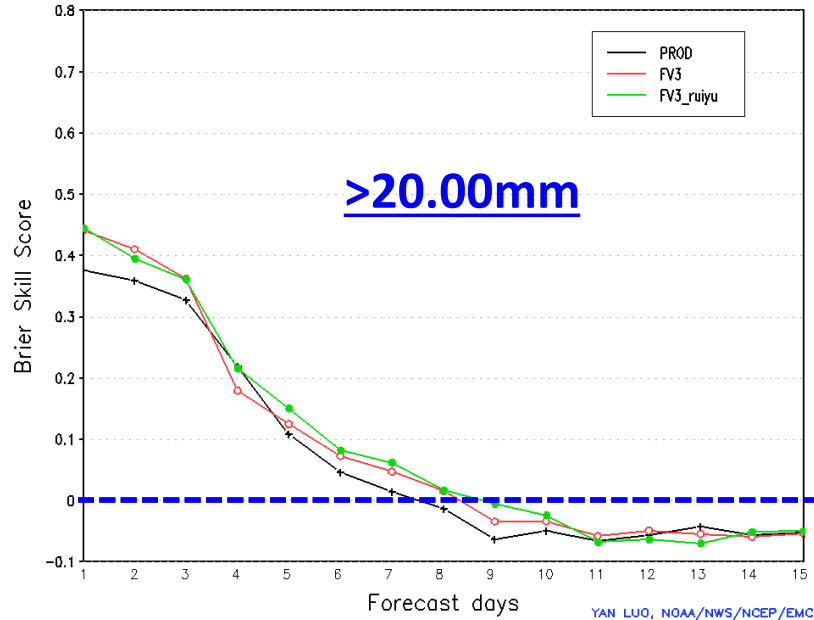
Ensemble Precipitation Verification for CONUS  
Brier Skill Score for threshold > 5.00mm/24hours  
For 20171201 - 20180131

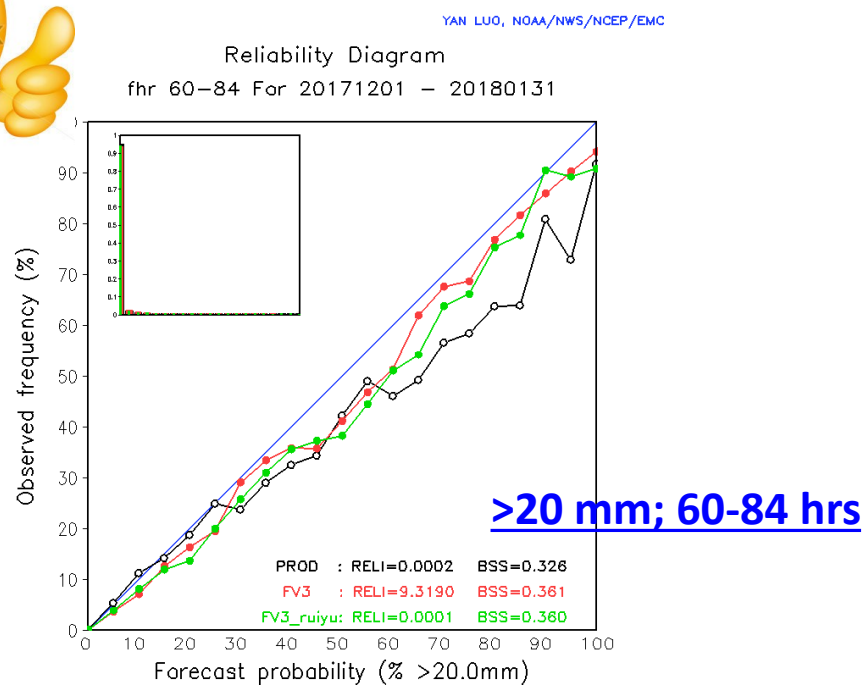
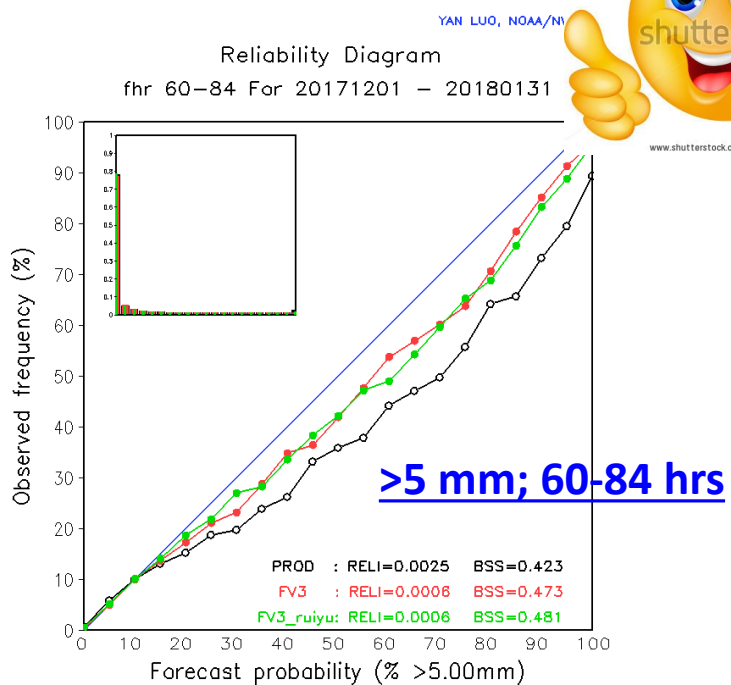
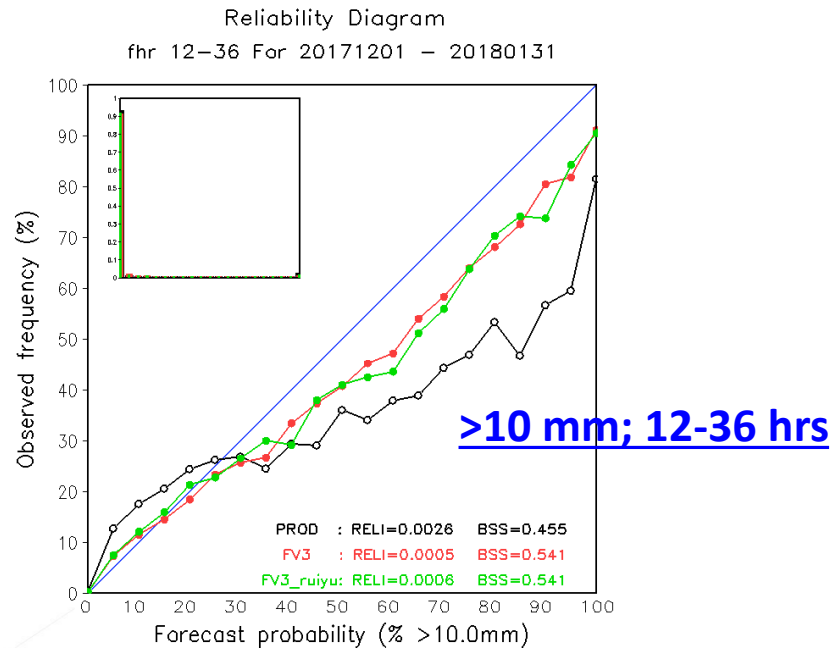
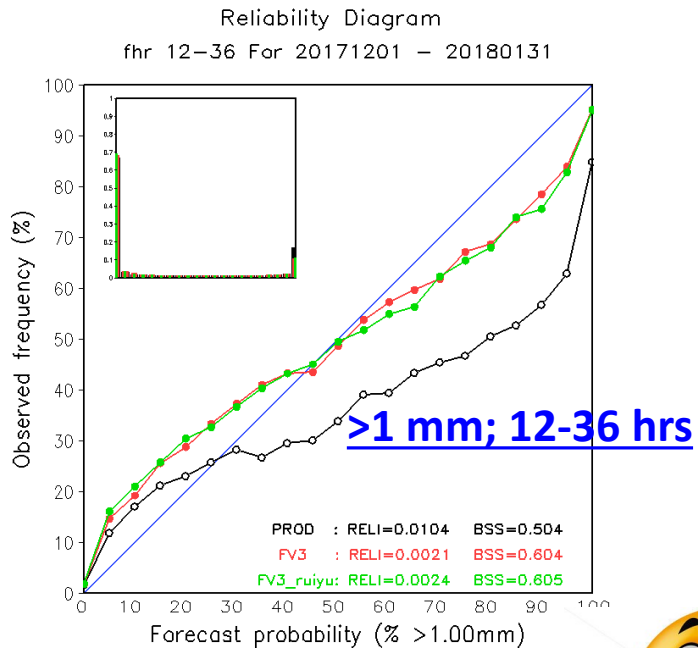


Ensemble Precipitation Verification for CONUS  
Brier Skill Score for threshold > 10.0mm/24hours  
For 20171201 - 20180131



Ensemble Precipitation Verification for CONUS  
Brier Skill Score for threshold > 20.0mm/24hours  
For 20171201 - 20180131







## Period three

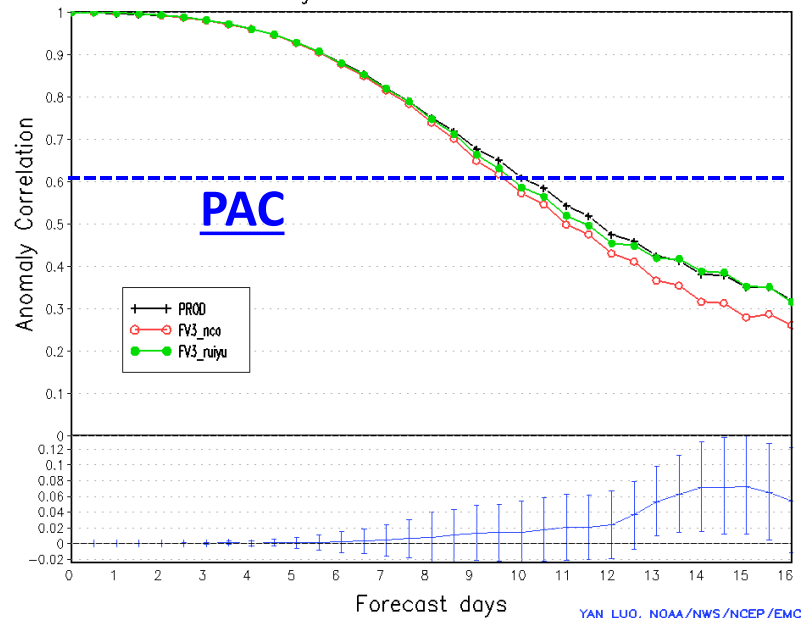
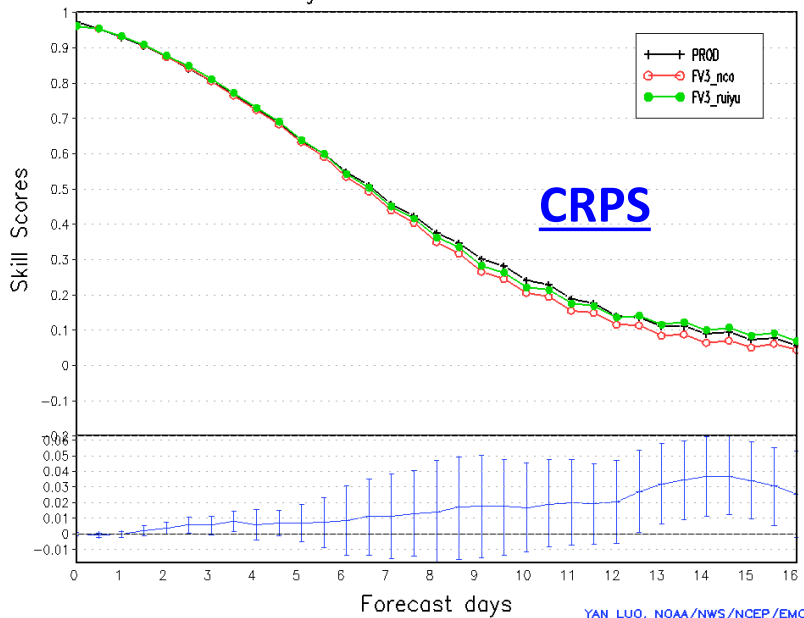
08/30 – 09/30/2018 (32 cases)

08/16 – 9/30/2018 (92 cases for hurricanes)

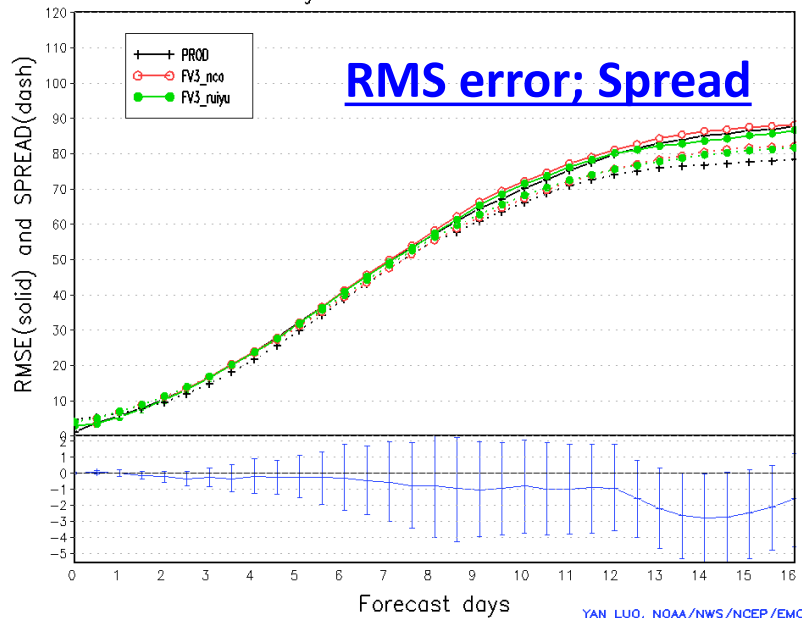
Northern Hemisphere 500hPa Height  
Continuous Ranked Probability Skill Scores  
Average For 20180830 – 20180930

# NH 500hPa height

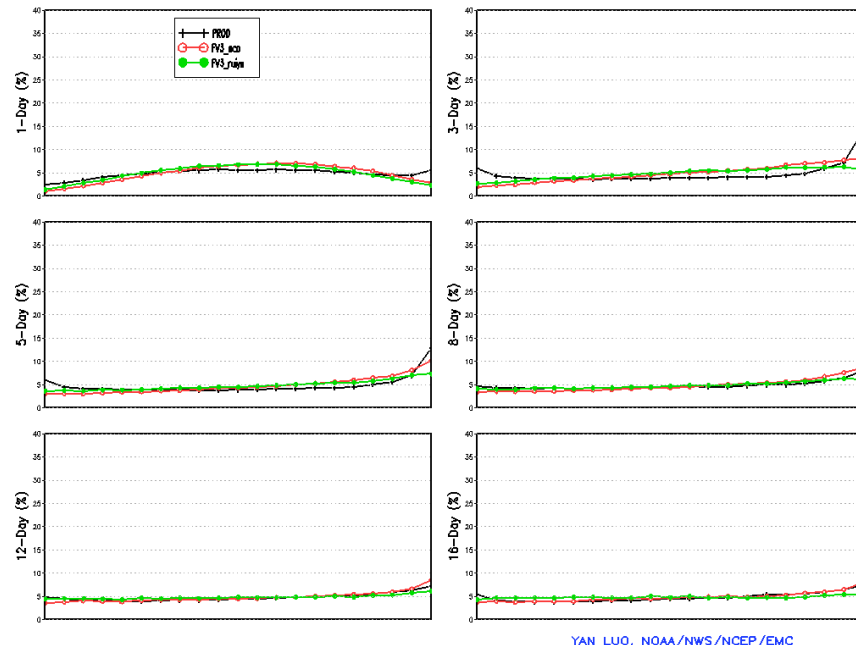
Northern Hemisphere 500hPa Height  
Ensemble Mean Anomaly Correlation  
Average For 20180830 – 20180930



Northern Hemisphere 500hPa Height  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20180830 – 20180930



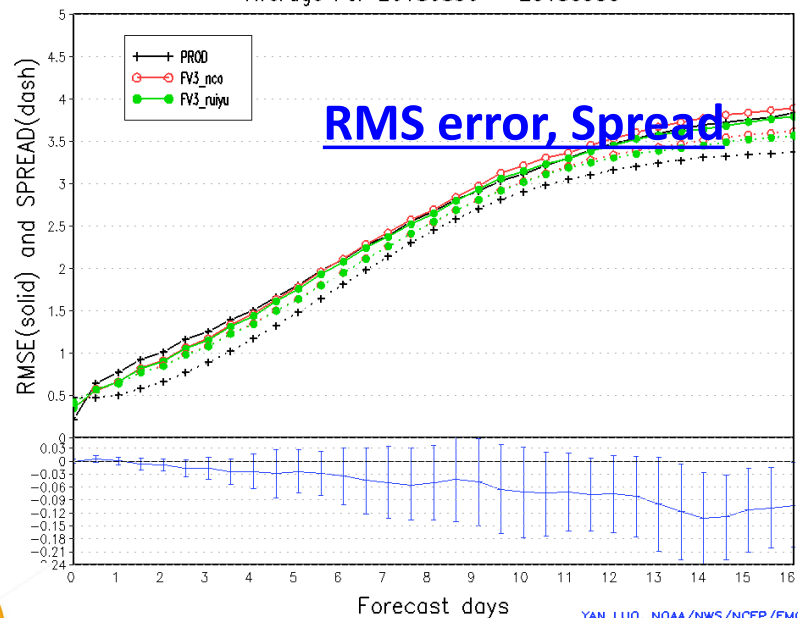
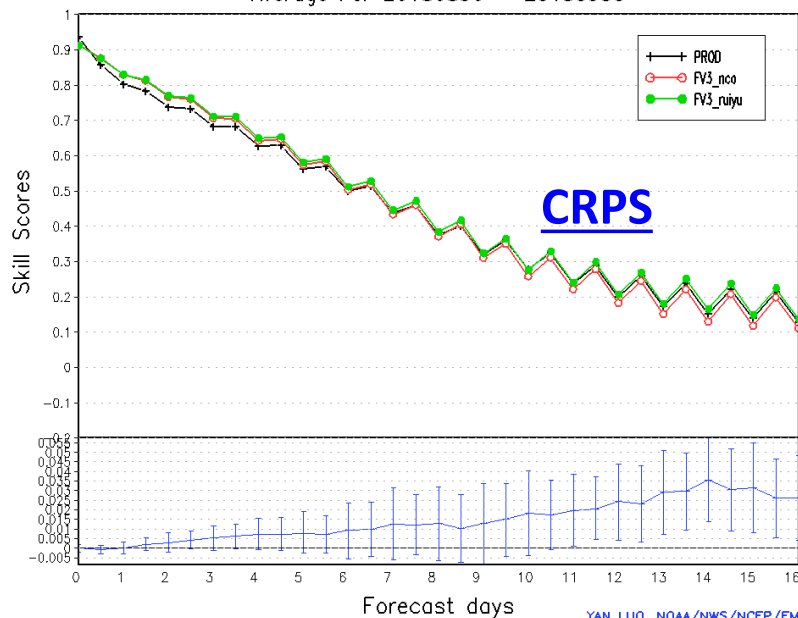
Northern Hemisphere 500hPa Height Histogram Distribution  
Average For 20180830 – 20180930



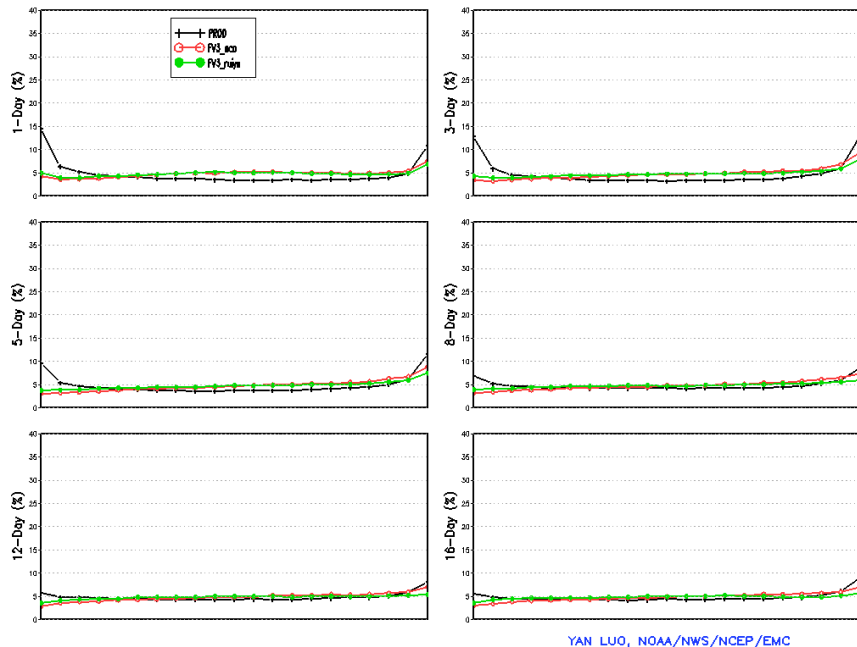
Northern Hemisphere 850hPa Temp.  
 Continous Ranked Probability Skill Scores  
 Average For 20180830 – 20180930

# NH 850hPa Temp

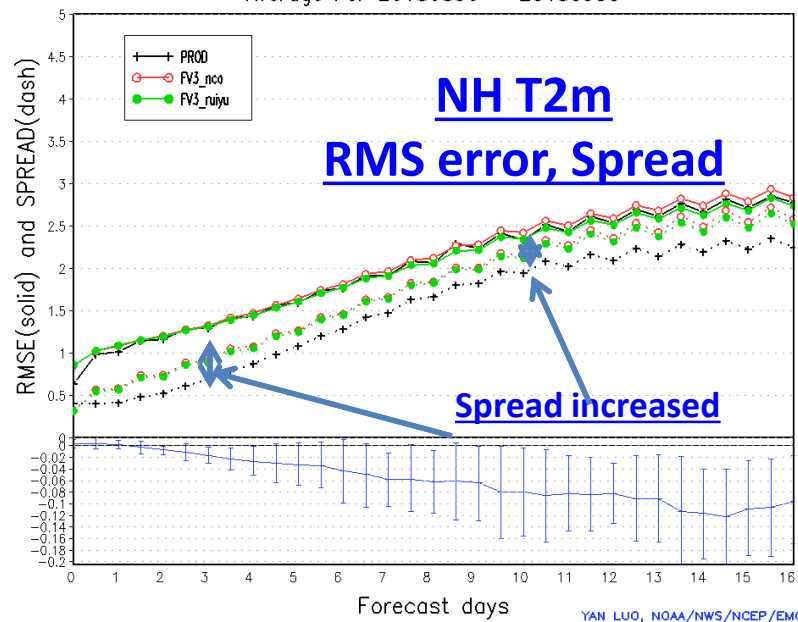
Northern Hemisphere 850hPa Temp.  
 Ensemble Mean RMSE and Ensemble SPREAD  
 Average For 20180830 – 20180930



Northern Hemisphere 850hPa Temp. Histogram Distribution  
 Average For 20180830 – 20180930



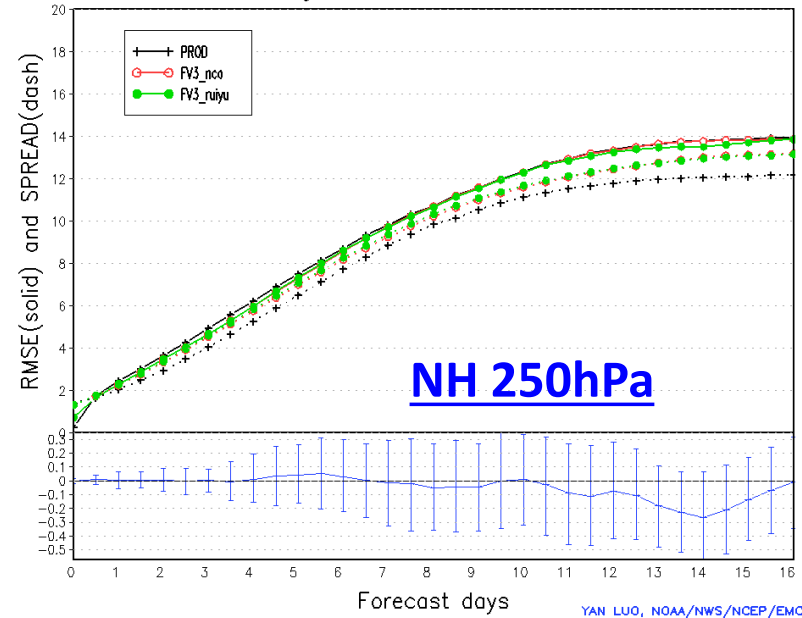
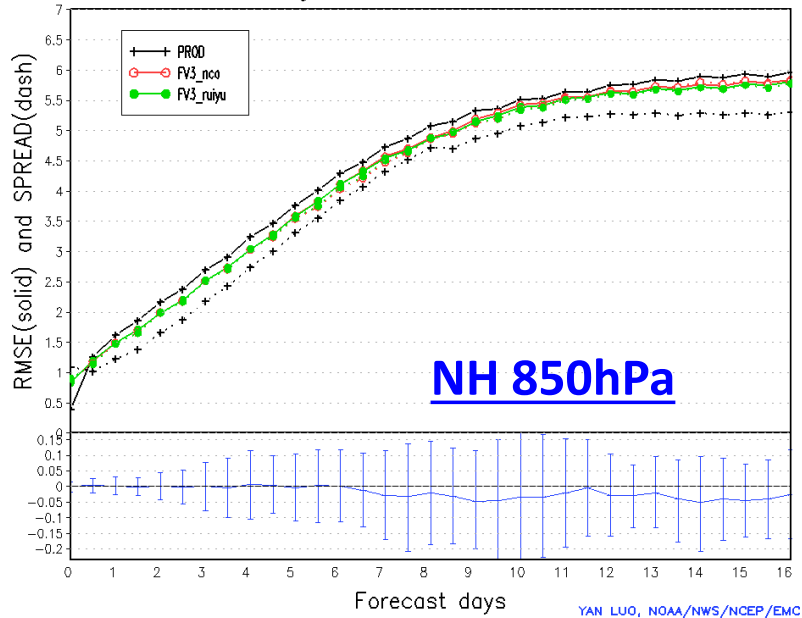
Northern Hemisphere 2 Meter Temp.  
 Ensemble Mean RMSE and Ensemble SPREAD  
 Average For 20180830 – 20180930



Northern Hemisphere 850hPa U Wind  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20180830 – 20180930

# Zonal Wind

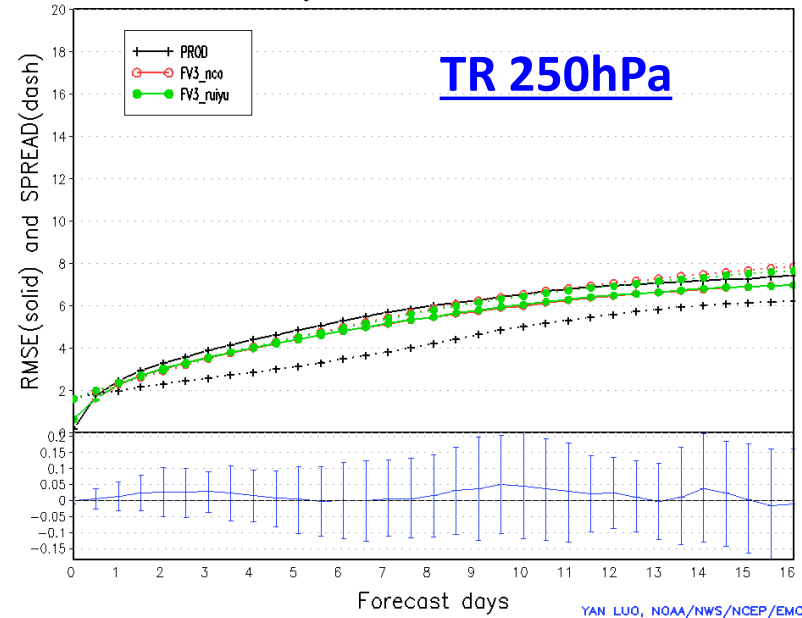
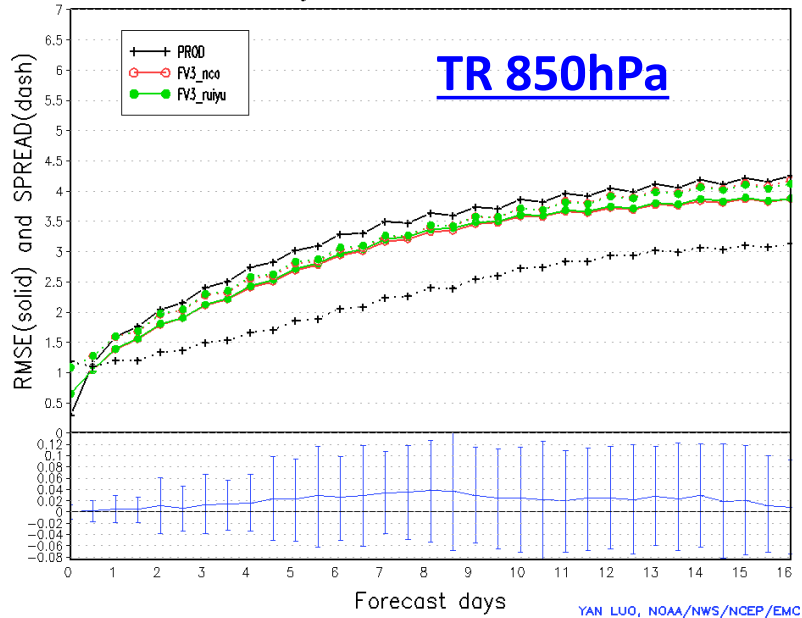
Northern Hemisphere 250hPa U Wind  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20180830 – 20180930



Tropical 850hPa U Wind  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20180830 – 20180930



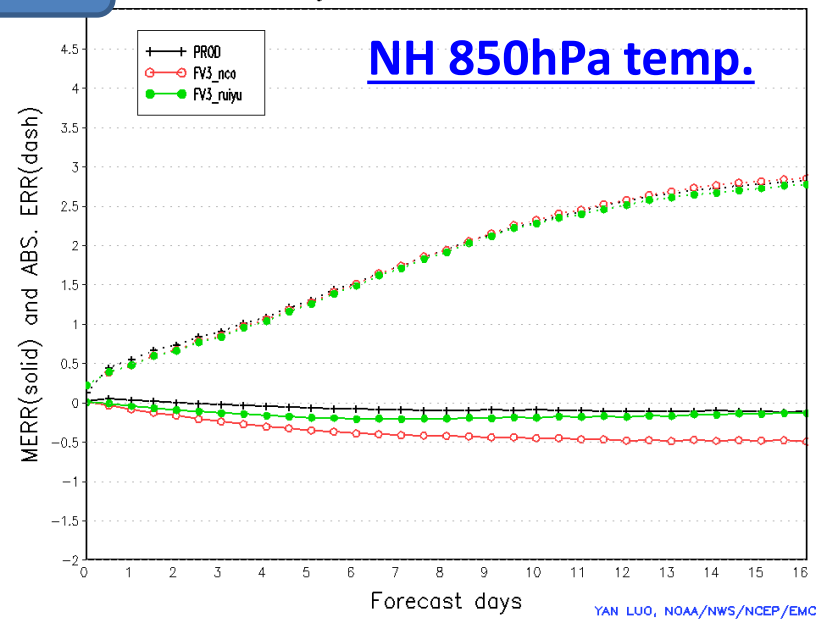
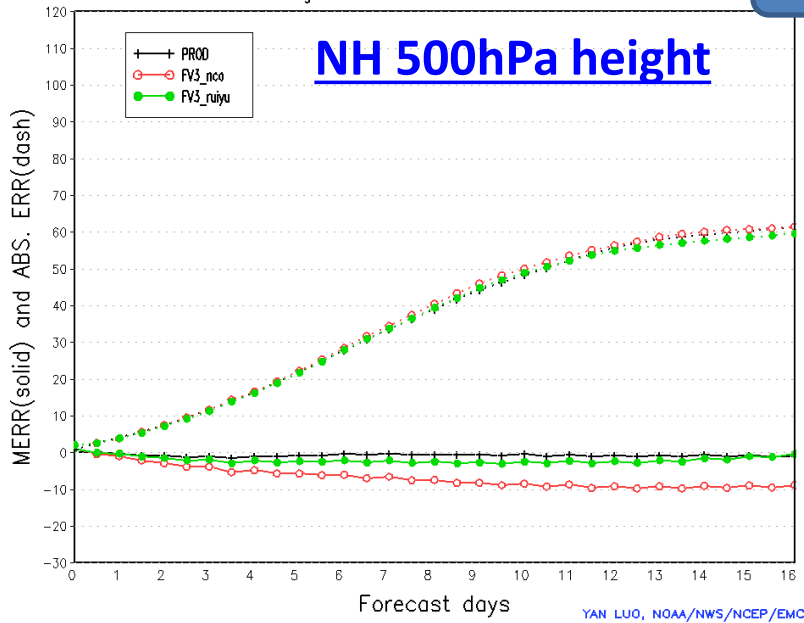
Tropical 250hPa U Wind  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20180830 – 20180930



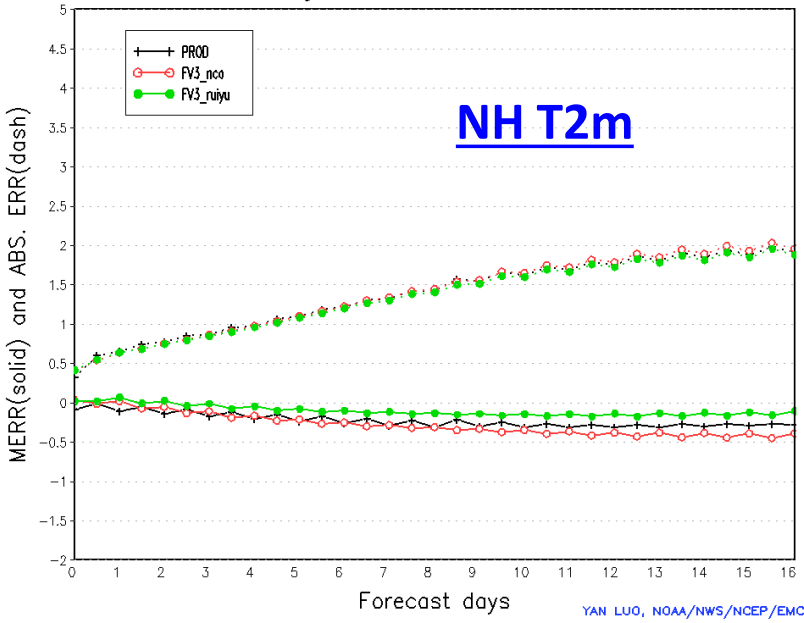
Northern Hemisphere 500hPa Height  
Ensemble Mean Error and Ensemble Abs. Error  
Average For 20180830 – 20180930

**Bias**

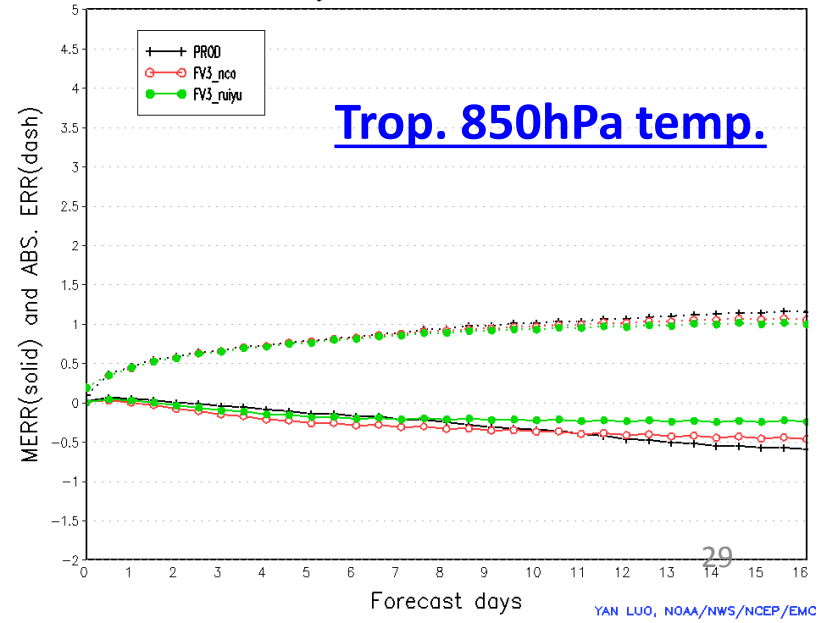
Northern Hemisphere 850hPa Temp.  
Ensemble Mean Error and Ensemble Abs. Error  
Average For 20180830 – 20180930



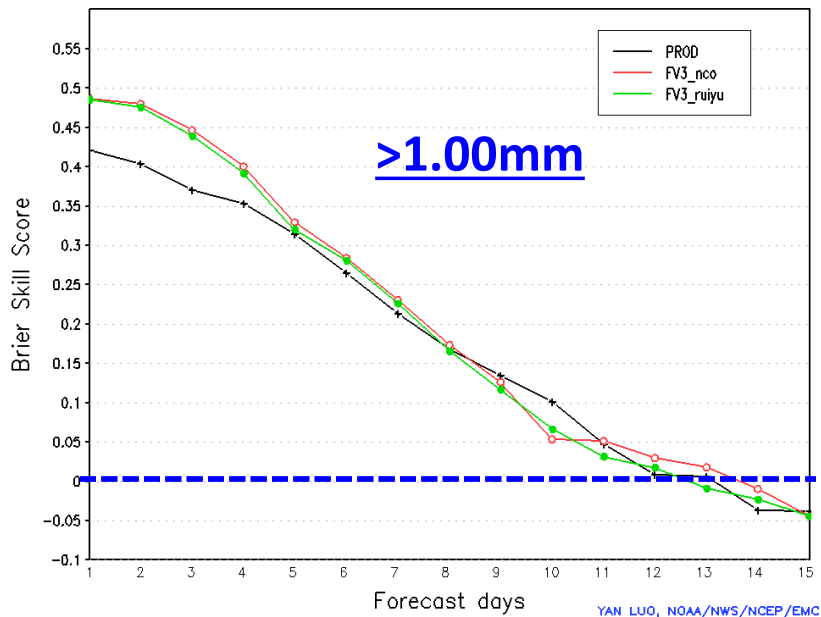
Northern Hemisphere 2 Meter Temp.  
Ensemble Mean Error and Ensemble Abs. Error  
Average For 20180830 – 20180930



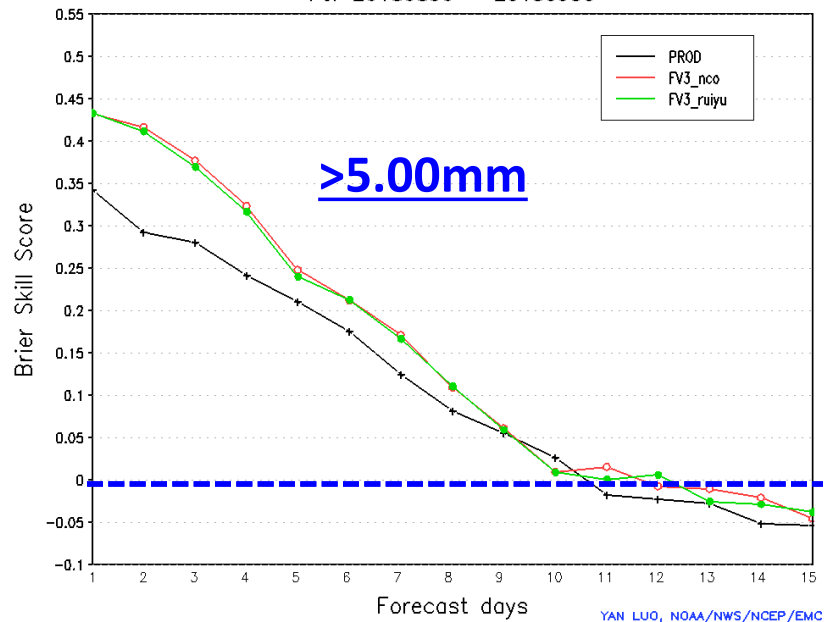
Tropical 850hPa Temp.  
Ensemble Mean Error and Ensemble Abs. Error  
Average For 20180830 – 20180930



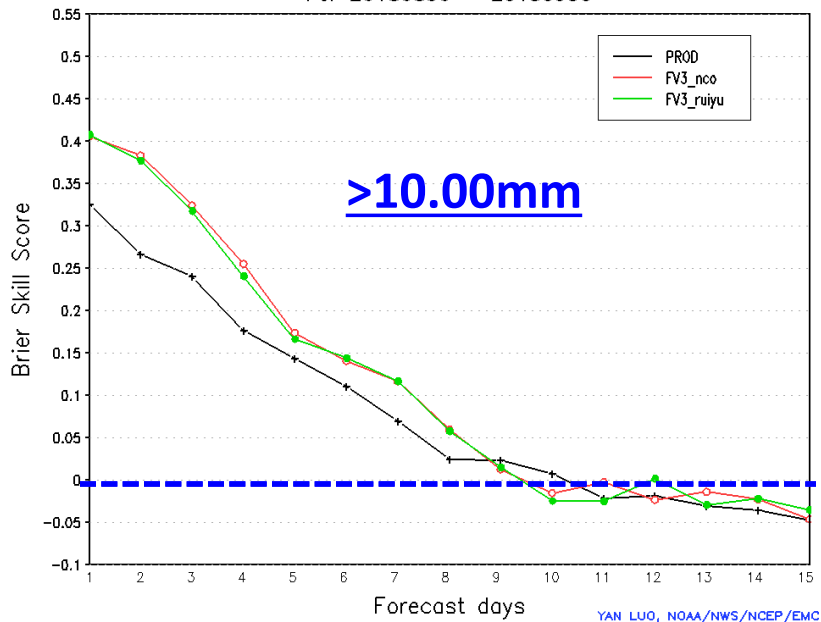
Ensemble Precipitation Verification for CONUS  
Brier Skill Score for threshold > 1.00mm/24hours  
For 20180830 - 20180930



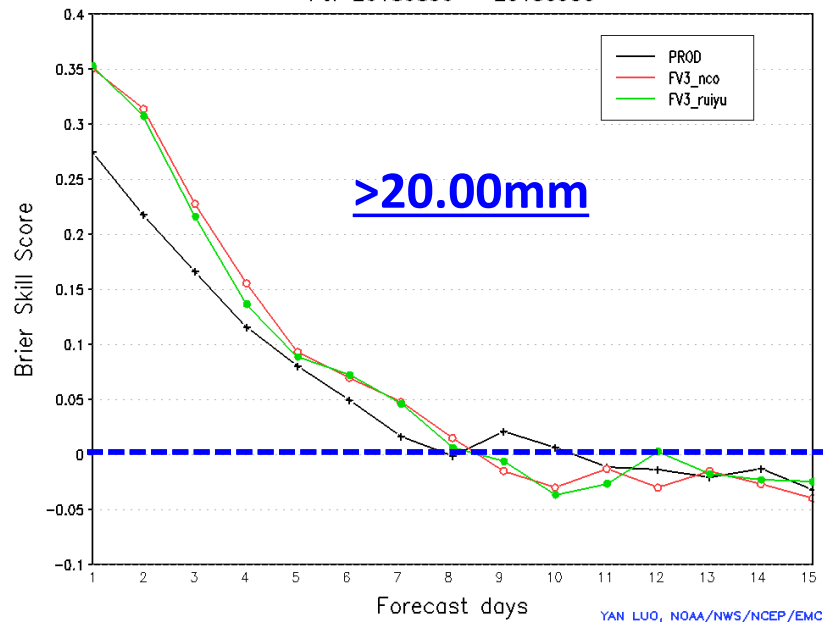
Ensemble Precipitation Verification for CONUS  
Brier Skill Score for threshold > 5.00mm/24hours  
For 20180830 - 20180930

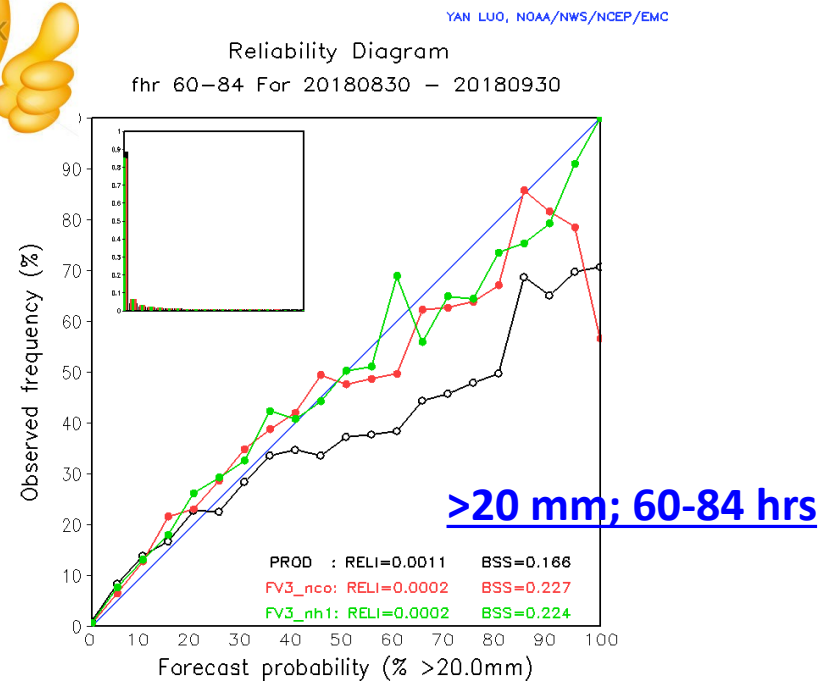
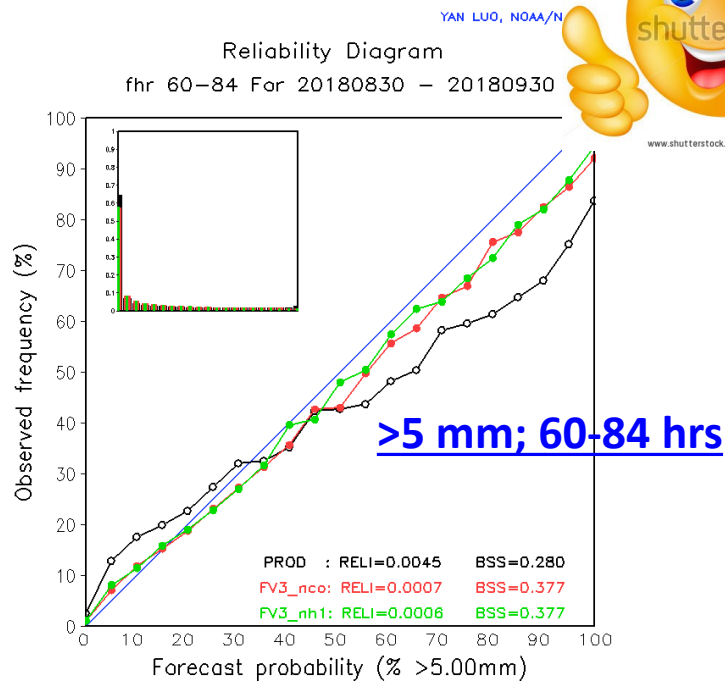
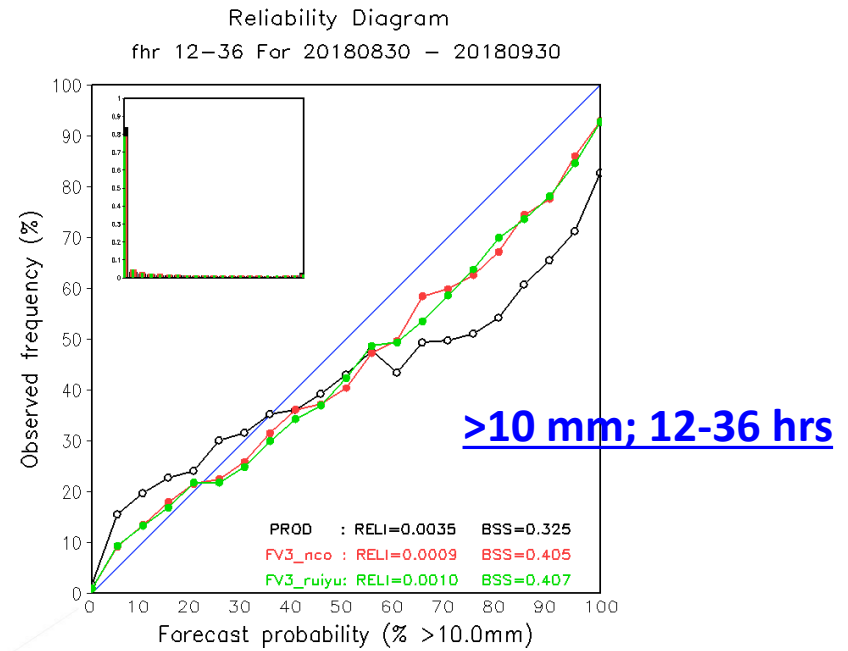
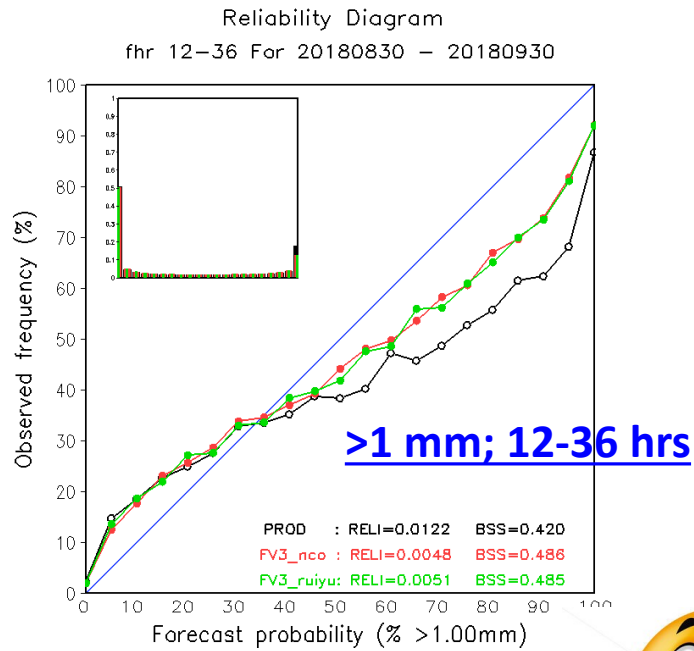


Ensemble Precipitation Verification for CONUS  
Brier Skill Score for threshold > 10.0mm/24hours  
For 20180830 - 20180930



Ensemble Precipitation Verification for CONUS  
Brier Skill Score for threshold > 20.0mm/24hours  
For 20180830 - 20180930





YAN LUO, NOAA/N

YAN LUO, NOAA/NWS/NCEP/EMC

YAN LUO, NOAA/NWS/NCEP/EMC

YAN LUO, NOAA/NWS/NCEP/EMC

## 2018 Summer cases (8/30 – 9/30/2018; 00UTC)

HOUR	00	12	24	36	48	72	96	120	144	168
AEMP	11.2	23.9	36.0	44.6	61.3	105.4	162.0	193.9	272.1	407.5
	---- gefs mean prod									
AEMB	14.4	23.8	37.0	48.8	68.7	108.7	167.3	223.1	319.7	458.4
	----gefs mean (Fanglin's bug-fix)									
CTRL	14.6	24.9	38.7	49.9	72.7	114.8	155.9	226.6	311.4	496.8
	---- gefs control (Fanglin's bug-fix)									
AEMR	14.4	23.5	37.1	48.5	68.1	110.7	166.9	224.2	315.2	452.7
	----gefs mean (Ruiyu's bug-fix)									
ACOR	14.6	24.7	38.0	48.8	72.3	116.4	158.8	208.8	281.7	499.1
	---- gefs control (Ruiyu's bug-fix)									
#CASES	45	41	39	36	33	29	24	20	16	13

### Conclusions:

- Less samples
- FV3GEFS degraded TS track forecasts
- There are no significant difference for latest bug-fix
- Ensemble mean is better than control for short lead-time, worse than longer lead-time



08/16-09/30, 2018 00Z/12Z  
Atlantic/East Pacific/West Pacific  
track verification

AL05-13

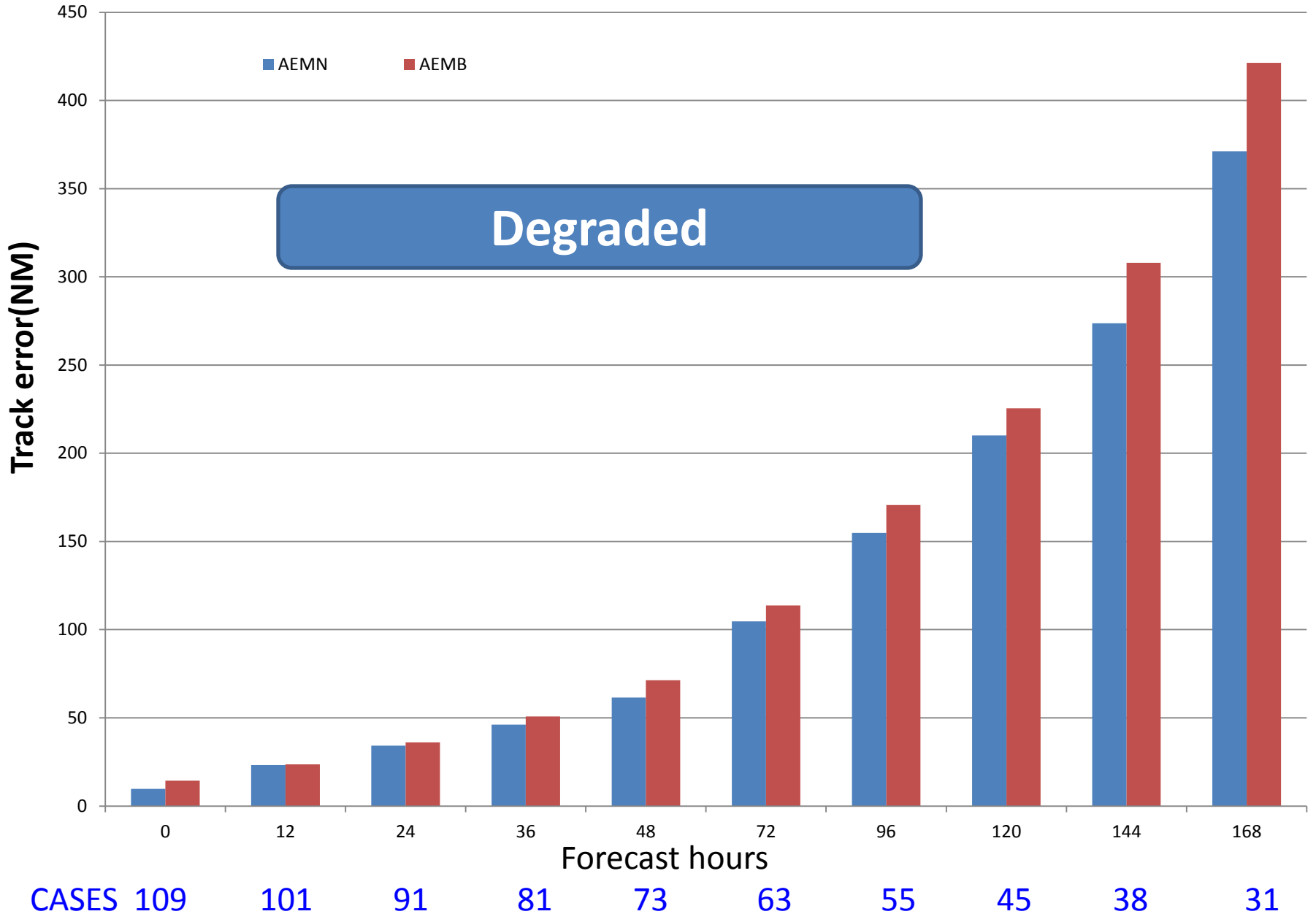
EP14-21

WP20-30

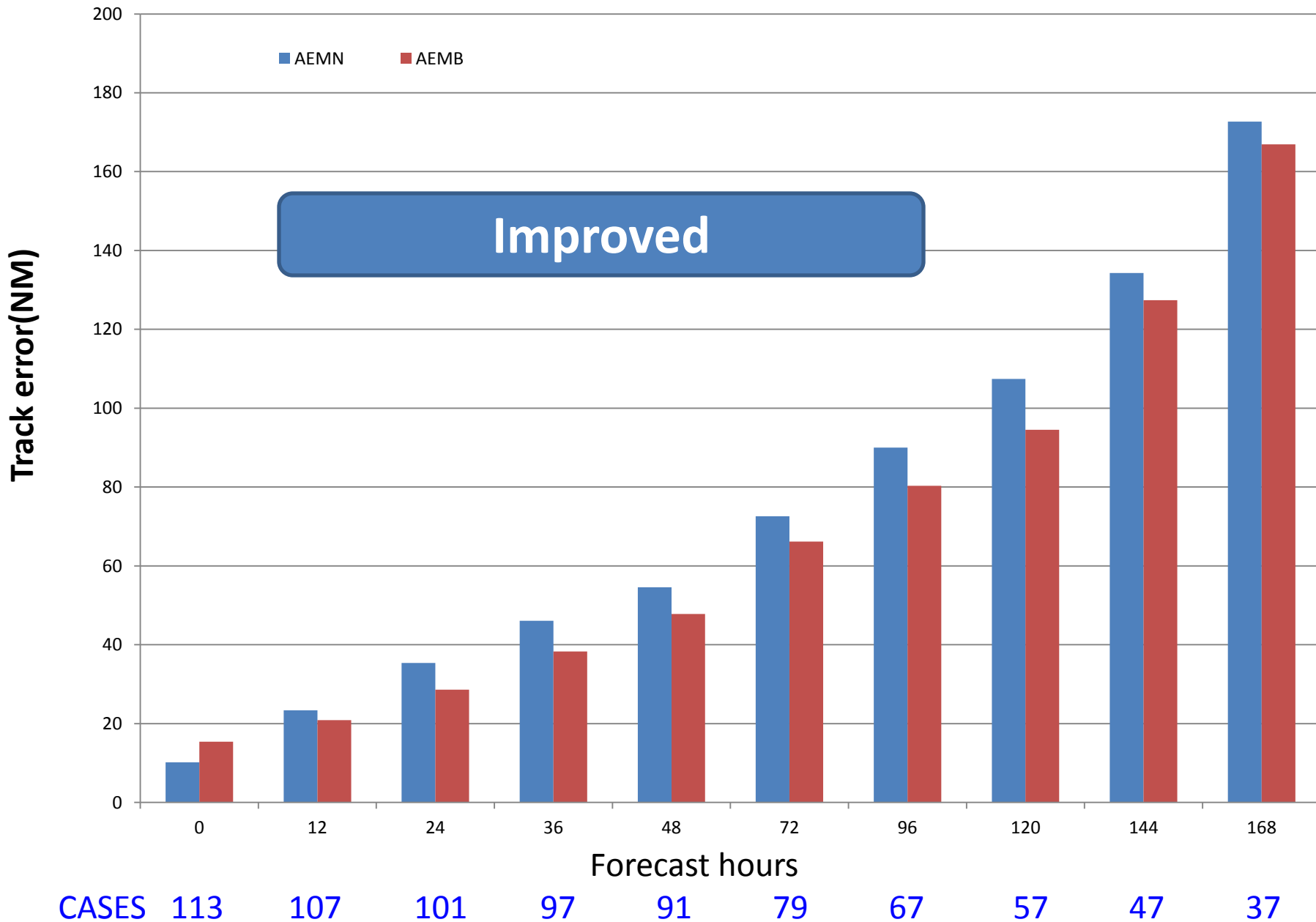
**AEMN: GEFS operational**

**AEMB: GEFS-FV3**

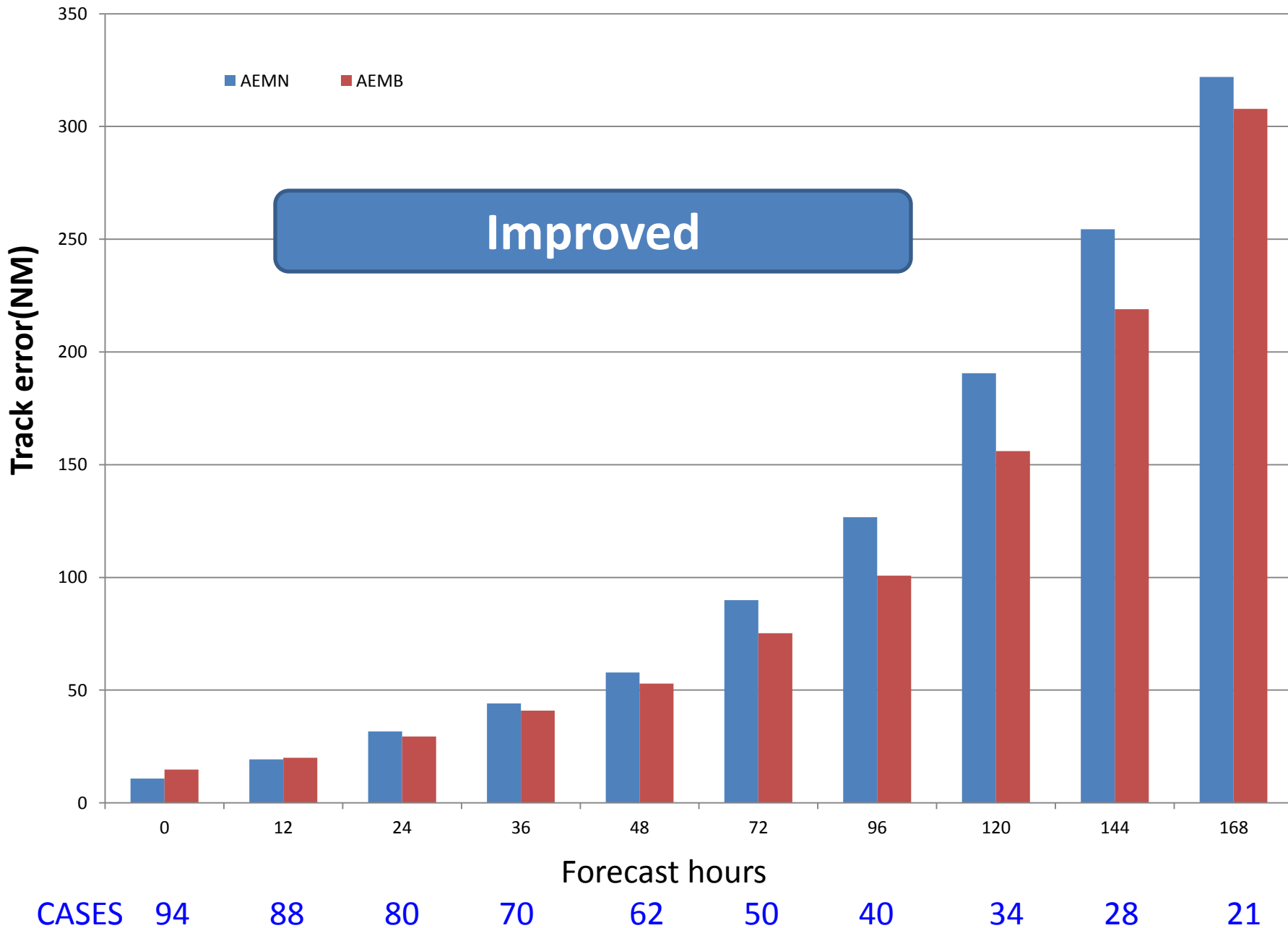
# Atlantic storms: August 16—September 30, 2018



# East Pacific storms: August 16—September 30, 2018



# West Pacific storms: August 16—September 30, 2017



# Summary

- Latest experiments with SW radiation bug-fix (FV3GFS final version) + GFDL MP bug-fix (Ruiyu Sun)
- Three periods with 16 days forecasts have been tested.
- Evaluations
  - Large scale patterns – it is better than production; and slightly better than early version
  - Precipitation – it is much better than production; and slightly better for 1<sup>st</sup> two periods, slightly degraded for last period than early version
    - A very minor degradation of reliability compares to early version
  - Bias of lower levels – much better over all
- Hurricane tracks – similar to early version, **but much degraded for all lead times than production for Atlantic Ocean**
  - Pacific is better
- 35 days experiments are on going now