In Support of the NESDIS Next-Gen Architecture (relative to sounders, 3Dwinds)

Comparative OSE-based Assessment of space-based atmospheric wind, on NOAA's NWP (AMVs, Aeolus and MW/IR sounders series)

Work commissioned by Systems performance Assessment Team (SAT)

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Work done by:

NESDIS/OSAAP Systems performance Assessment Team (SAT) Internal Analysis Team, Part of the DEEVA Team

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Motivation

- **Strategic Question(s) in Support of the Next-generation Architecture Design & Planning (including the LEO Sounding constellation):**
  - **How important is the Wind measured from satellite to the NWP system?**
  - **What is the relative impact of various observing systems (Active and Passive)?**
  - **In the case of Microwave and Infrared Sensors, how many are optimal? Do they saturate in their impact?**
  - **Can we get wind information from moisture tracking? How does it compare to direct measurements?**
- **Approach:**
  - **Use Real data for the assessment (OSEs) on the NOAA global NWP System.**
  - **The Observing Systems tested are:**
    - Conventional Data (radiosondes, airborne, etc)
    - Wind lidar (Aeolus) -Active
    - AMVs from GEO/LEO sensors -Passive
    - Microwave Sounders (1,2,3,5 sensors) -Passive
    - Infrared Sounders (1,3,4 sensors) -Passive

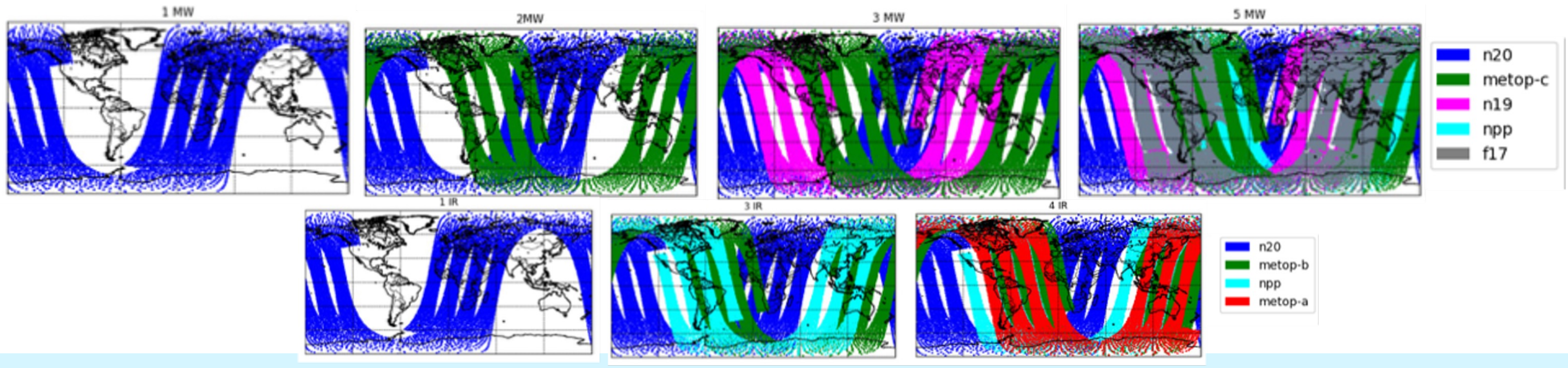
Experiment Setup

Exps	Satellites/Observations
No Sats	Conventional Only
Aeolus	Conventional + Aeolus
AMVs	Conventional + AMVs
1 MW	Conventional + **NOAA20** (ATMS)
2 MW	Conventional + **NOAA20** + **MetOP-C**(AMSUA,MHS)
3 MW	Conventional + **NOAA20**+ **MetOP-C**(AMSUA,MHS) +**NOAA19**(AMSUA,MHS)
5 MW	Conventional + **NOAA-20**+**Metop-C**+ **NOAA-19**+**F17**(SSMIS)+**NPP**(**ATMS)**
1 IR	Conventional + **NOAA20** (CrIS)
3 IR	Conventional + **NOAA20**+ **MetOP-B**(IASI) +**NPP**(CrIS)
4 IR	Conventional + **NOAA20**+ **MetOP-B**(IASI) + **NPP**(CrIS)+**MetOP-A**(IASI)

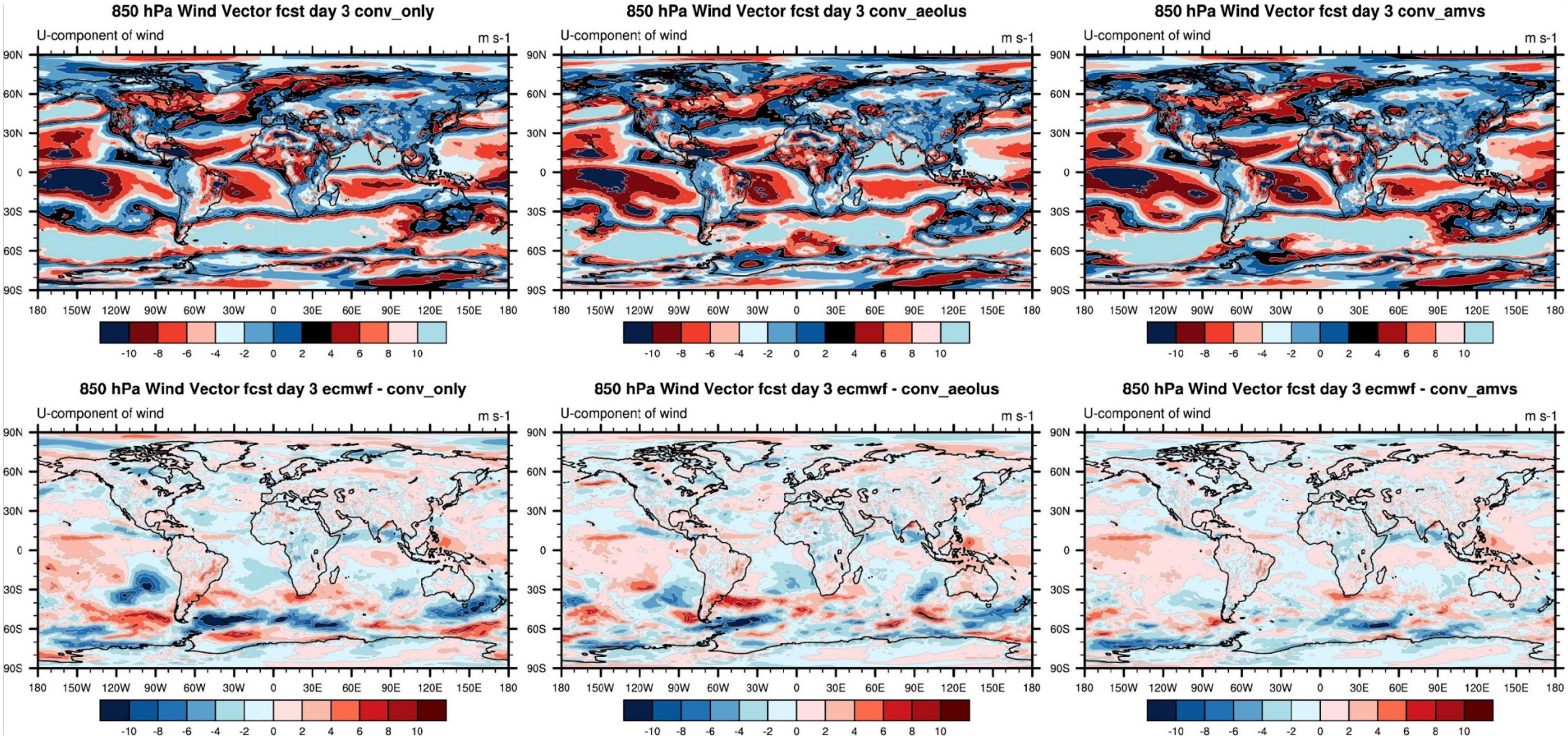
- GFS/FV3 Version : 16.1.4

- Analysis Res=384
- Ensemble Res=192
- Ensemble members=80
- Experiment Period: August 1st 2020 to September 30th 2020

*A month of all experiments completed. The results shown are over the month of August after 5 days spin up.



Day 3 forecast Wind Vector maps 850hPa for each exp and their diff with ECMWF valid at the 00Z analysis time



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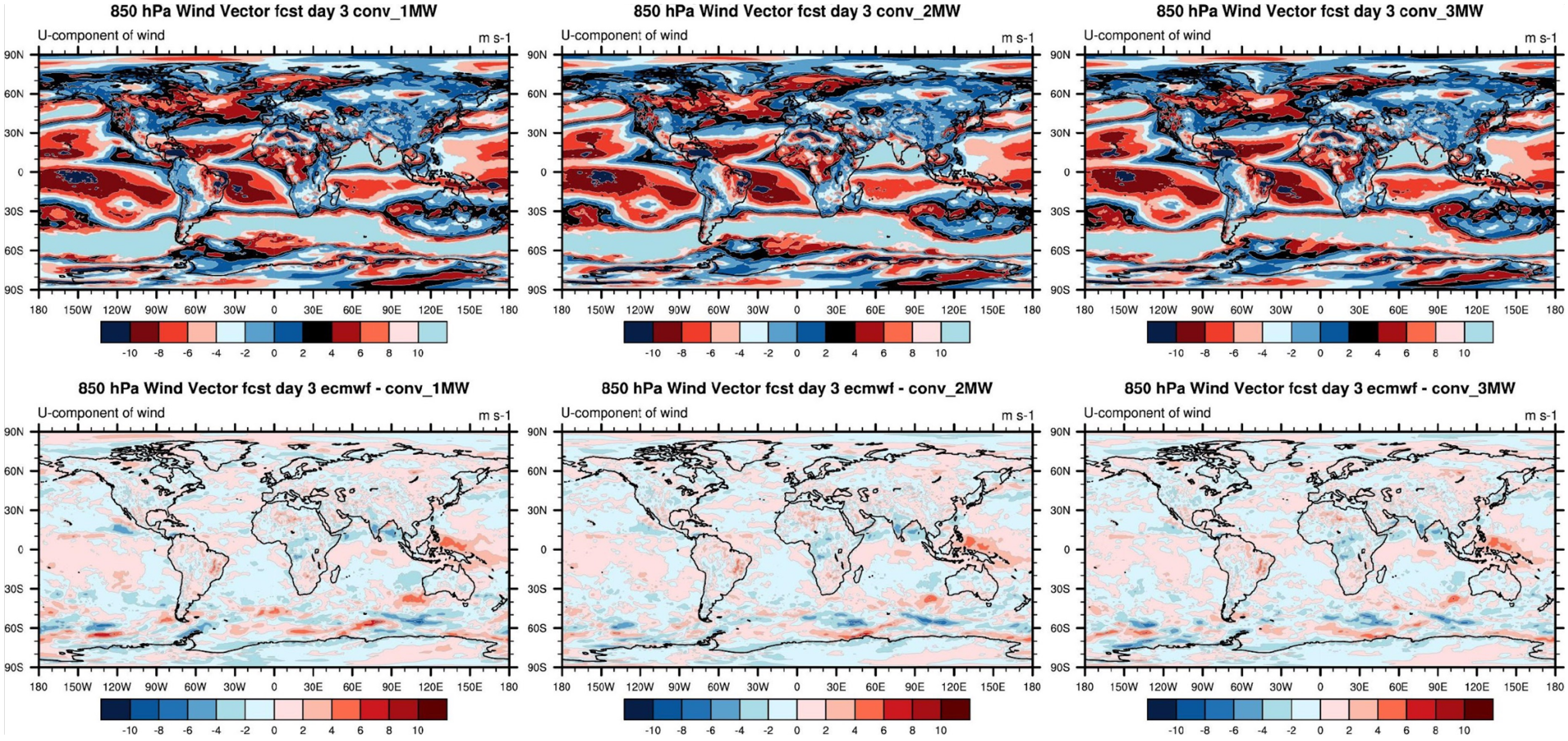

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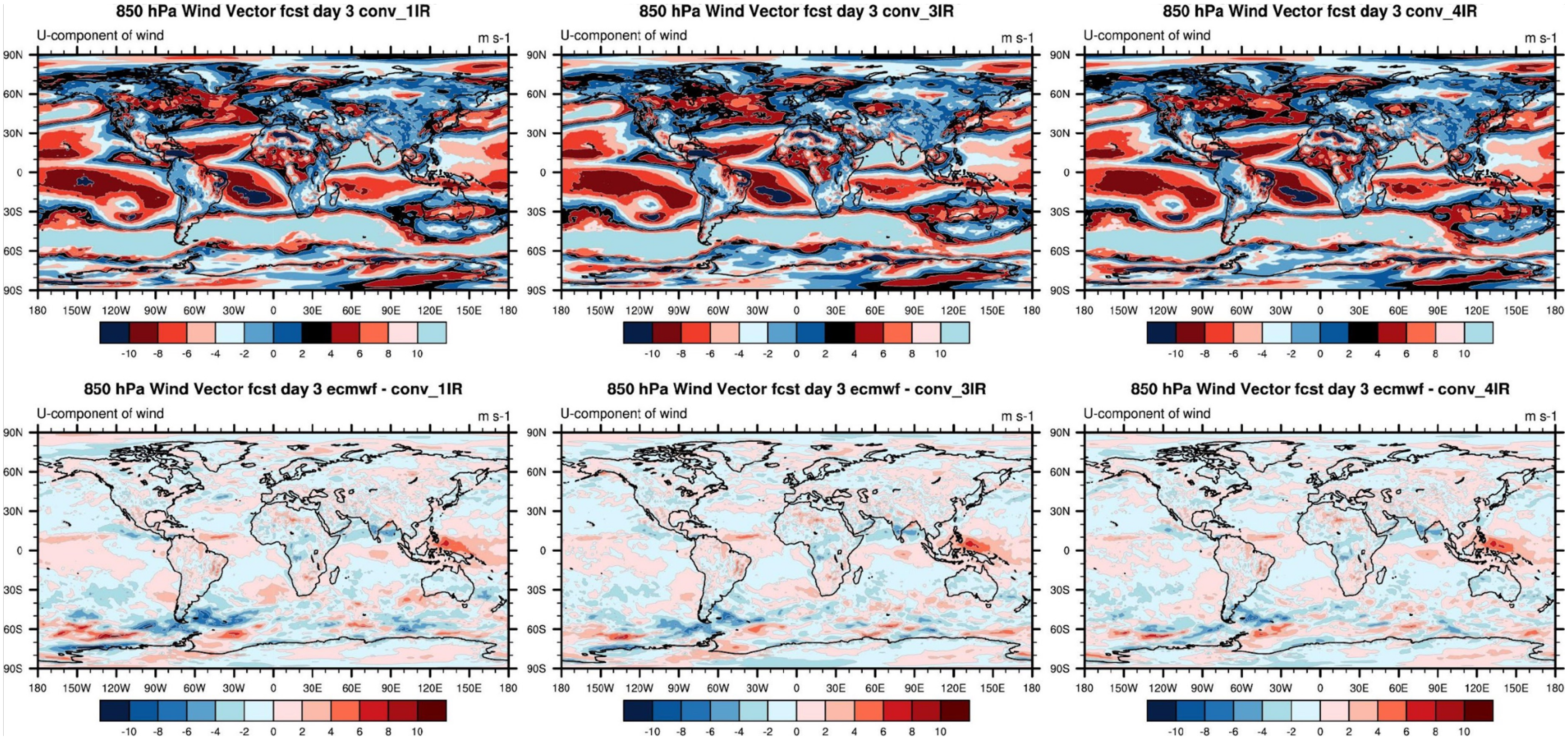
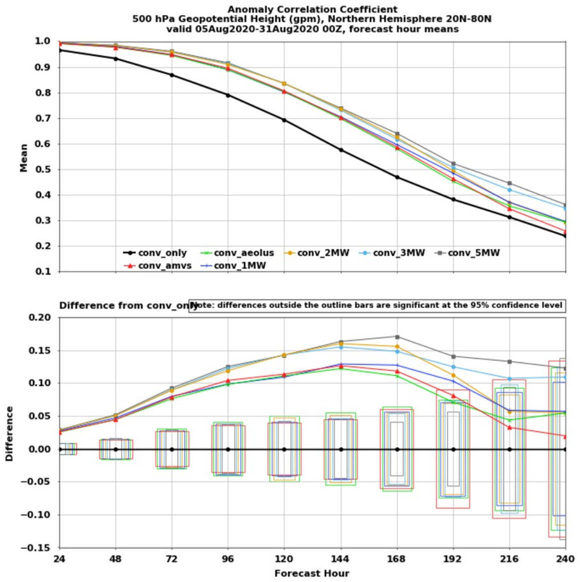
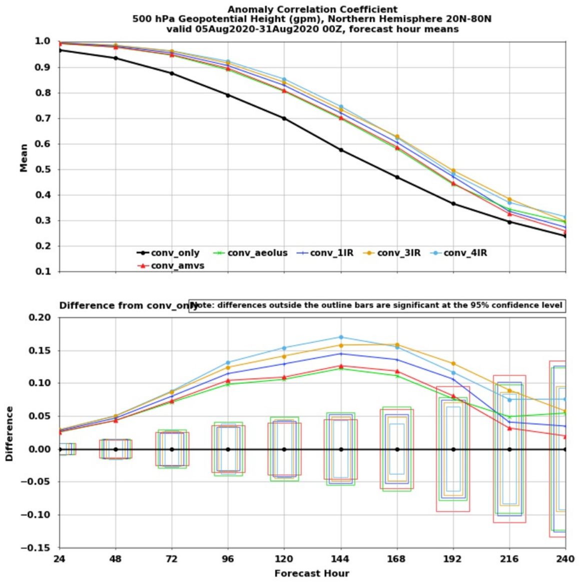


Anomaly Correlation HGT P500 NHX and SHX

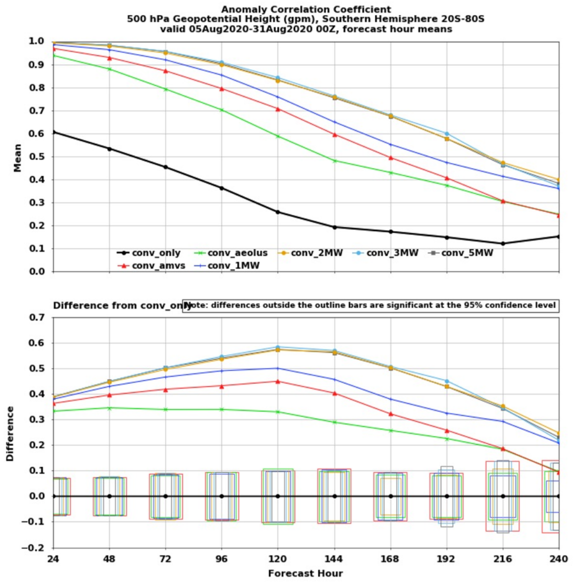
Verified against ECWMF analysis

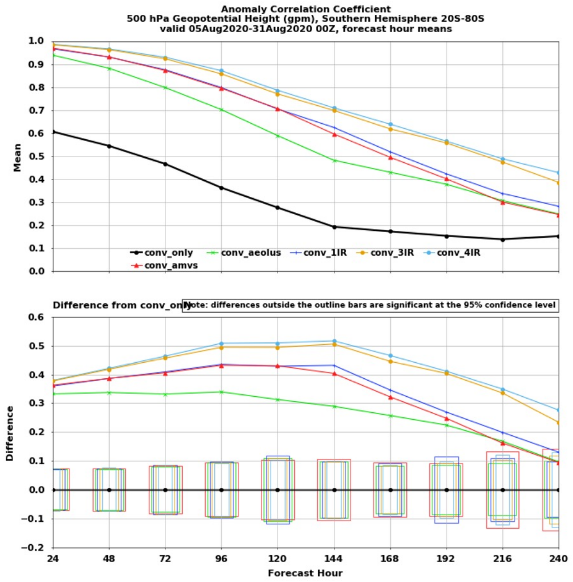
North Hemisphere





South Hemisphere





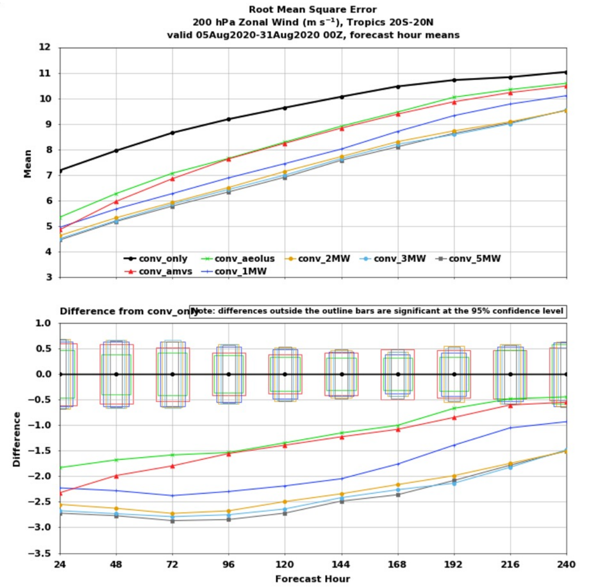
Anomaly Correlation improves as we add wind observations and MW and IR observations. More improvement for AMVS over Aeolus. More improvement for MW and IR over AMVS

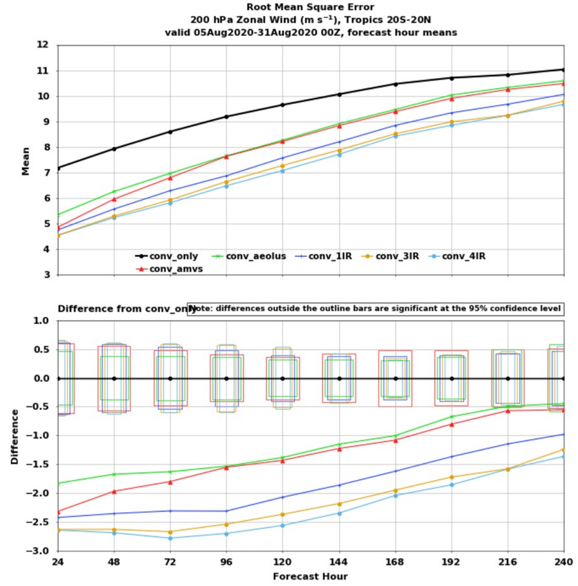
RMSE Wind P200 and P850 for TRO

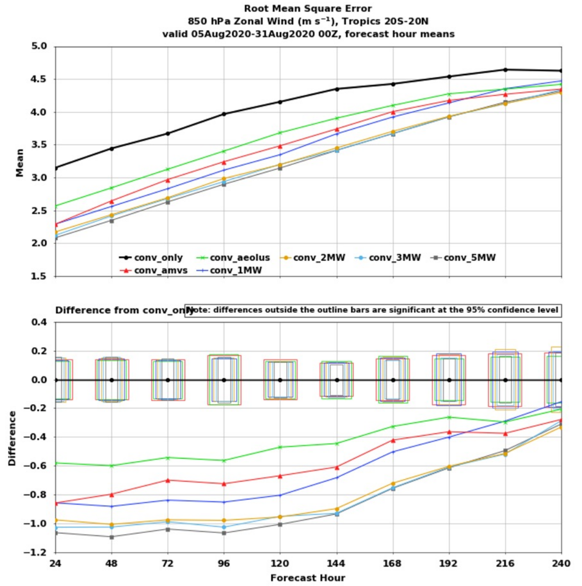
Verified against ECWMF analysis

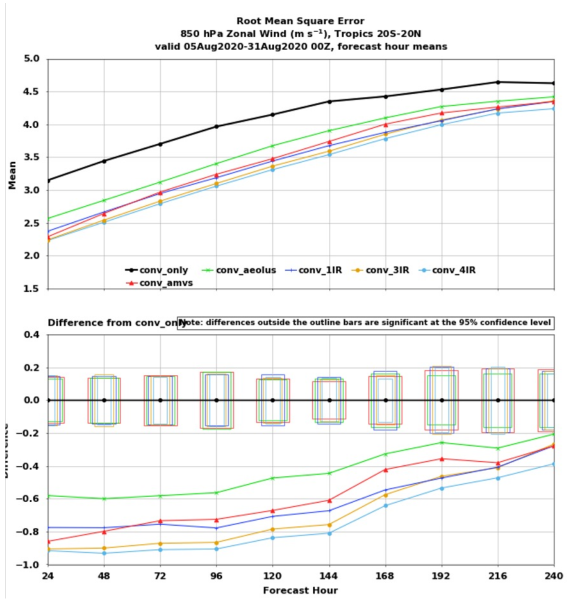
850 hPa

200 hPa



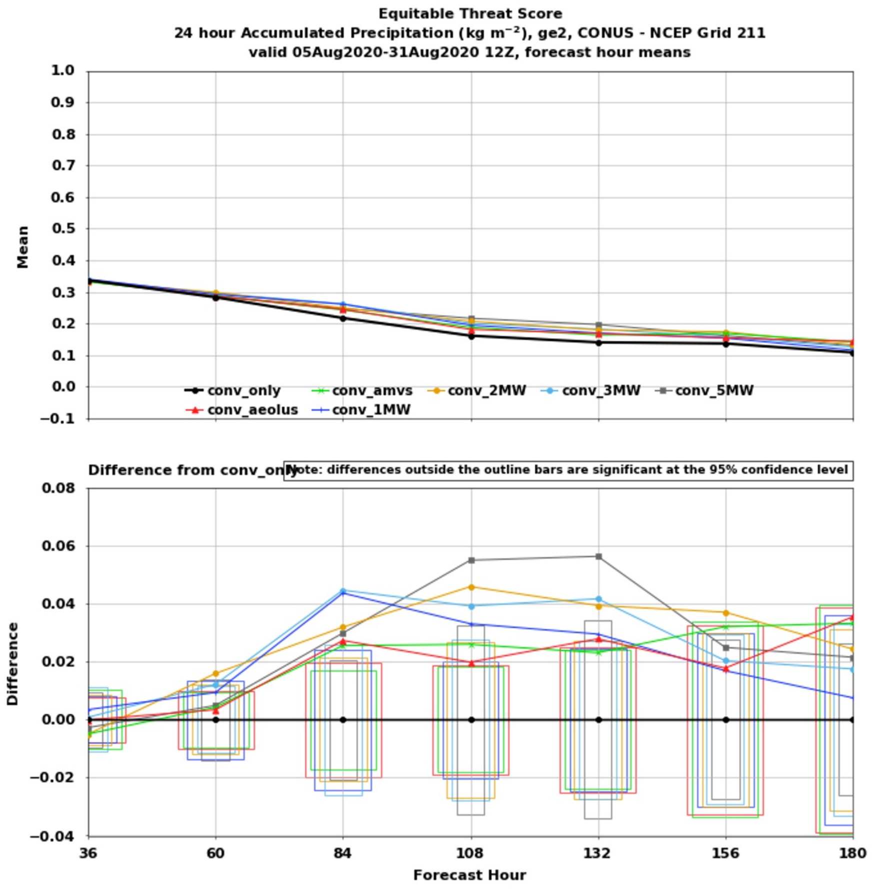


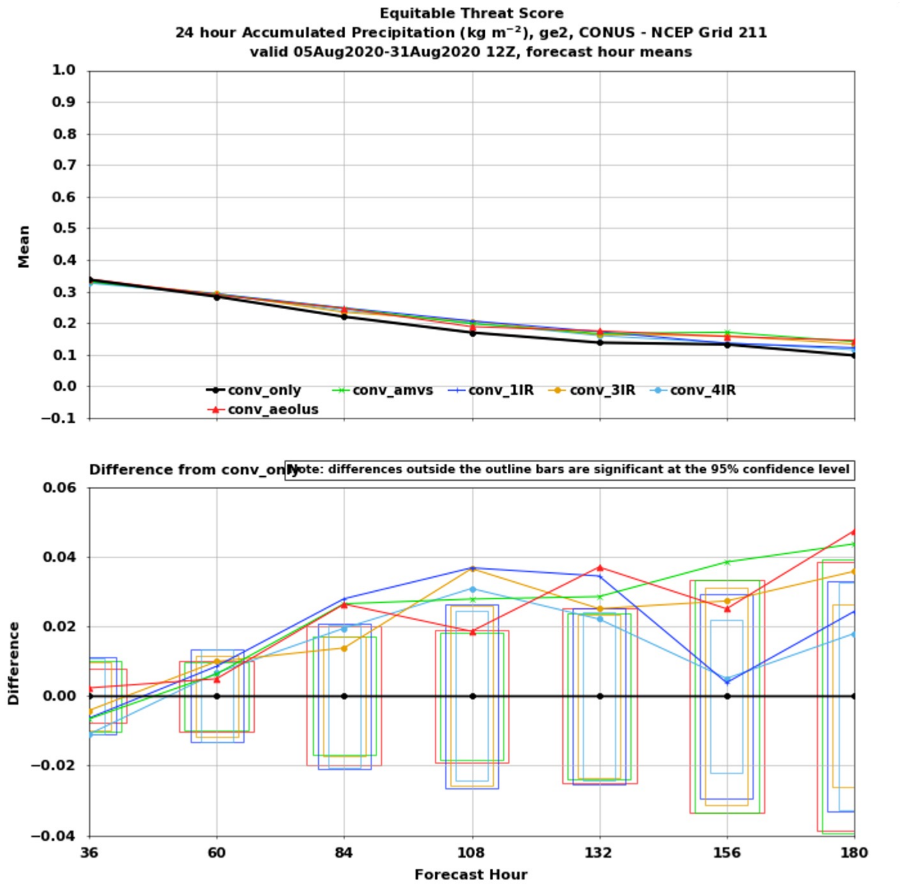




RMSE decreases as we add wind observations and MW and IR observations.
AMVS and Aeolus are about the same at 200hPa. More improvement for AMVS over Aeolus at 850hPa. More improvement for MW and IR over AMVS

24 hour Precipitation Equitable Threat Score over CONUS

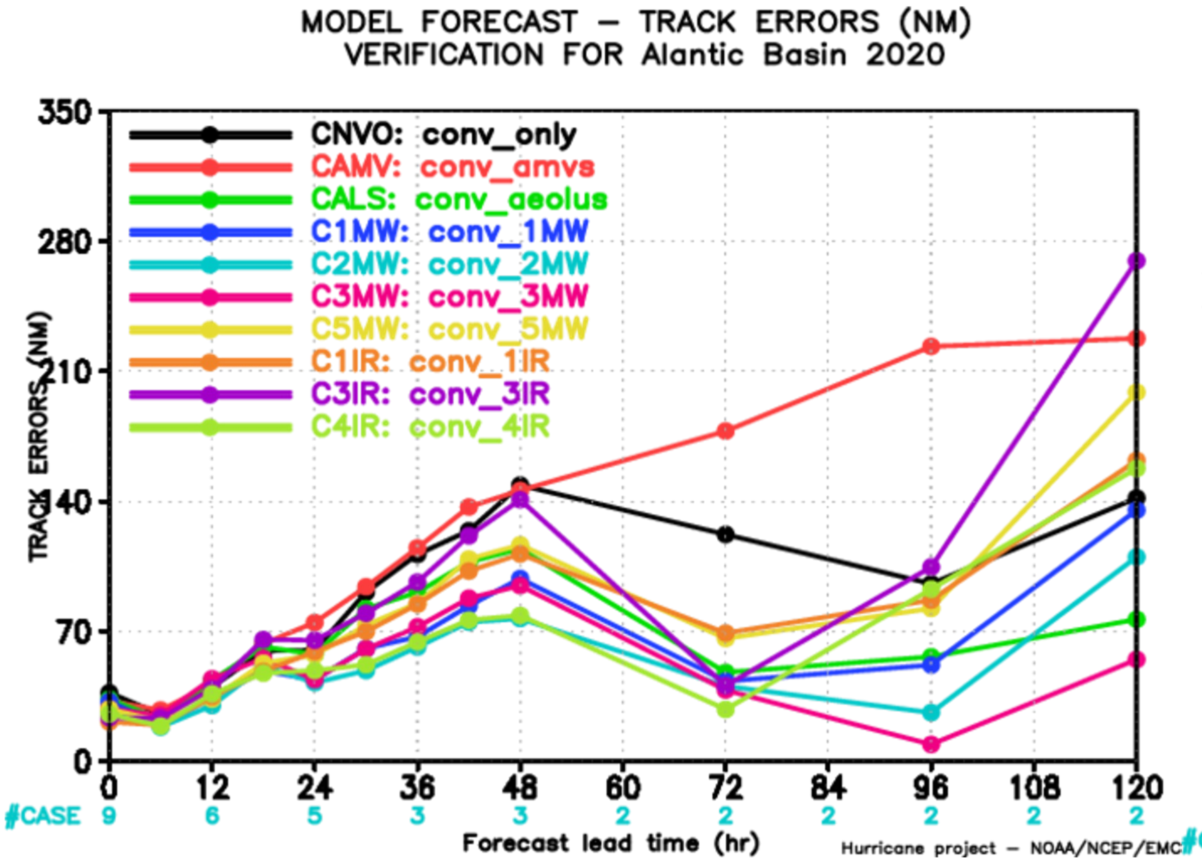


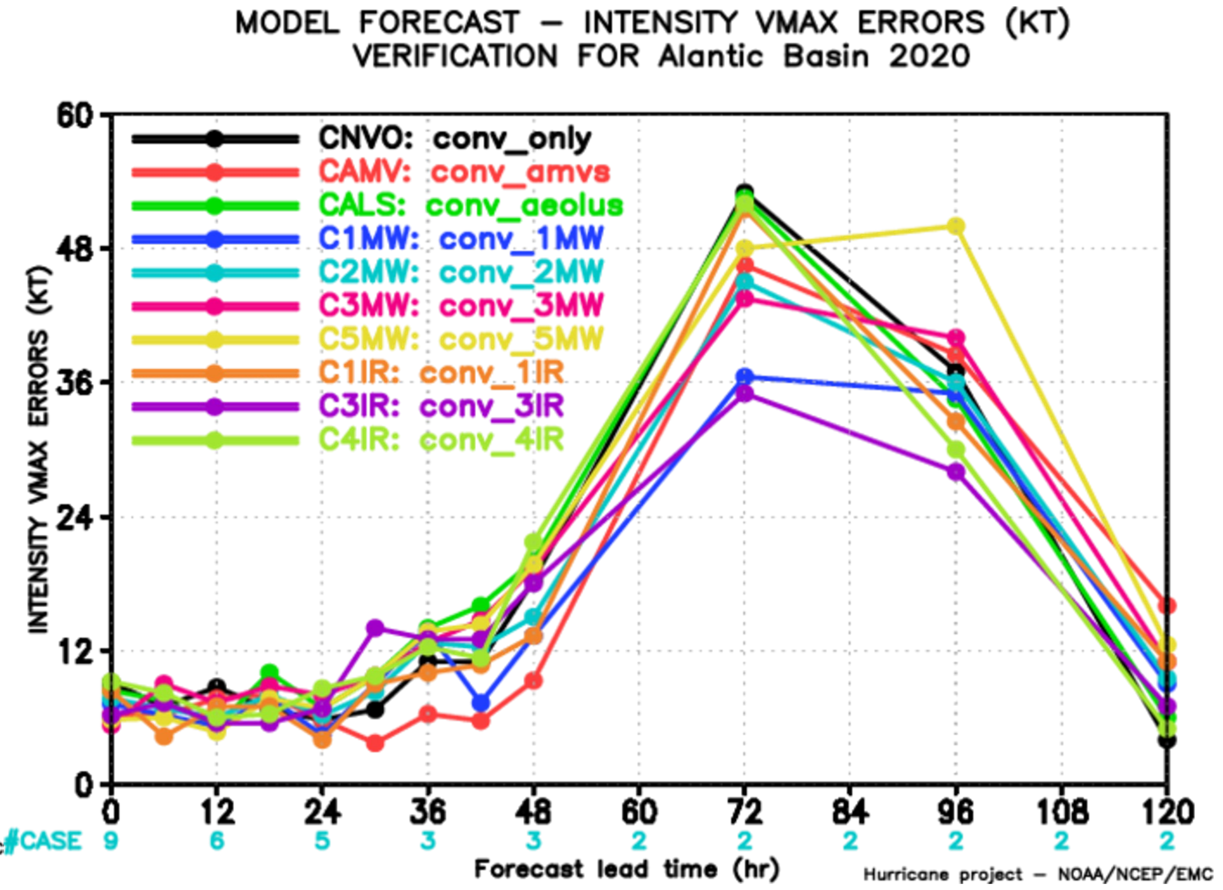


Precipitation score improves as we add wind obs and MW and IR observations.

Hurricane Track and intensity

Includes 3 hurricane in August 2020 (Laura, Kyle, and Marco)

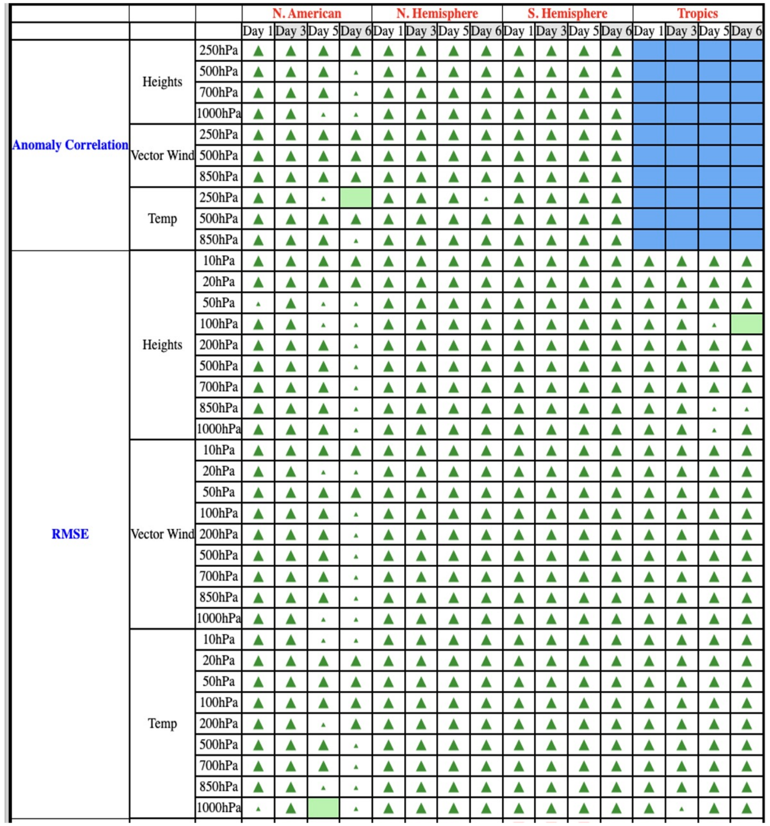




The track error has the highest error at most forecast hours for AMVS and and lowest error for 4IR for the first 72 hours and 3MW after 72hour. About the same for the first 24hour for intensity lowest error for 3IR and 1WM

Scorecards

Conv_only vs Aeouls



EMC Verification Scorecard

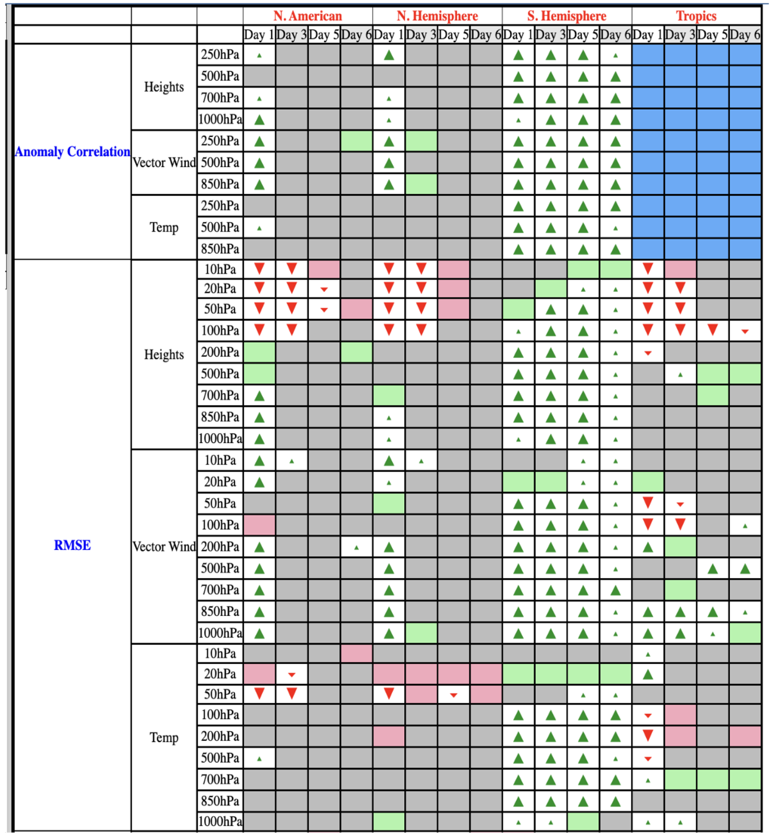
Symbol Legend

- ▲ CONV_AEOLUS is better than CONV_ONLY at the 99.9% significance level
- ▴ CONV_AEOLUS is better than CONV_ONLY at the 99% significance level
- (green) CONV_AEOLUS is better than CONV_ONLY at the 95% significance level
- (grey) No statistically significant difference between CONV_AEOLUS and CONV_ONLY
- (pink) CONV_AEOLUS is worse than CONV_ONLY at the 95% significance level
- ▾ CONV_AEOLUS is worse than CONV_ONLY at the 99% significance level
- ▼ CONV_AEOLUS is worse than CONV_ONLY at the 99.9% significance level
- (blue) Not statistically relevant

Start Date: 2020080500

End Date: 2020083100

Aeouls vs AMVS



EMC Verification Scorecard

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- ▴ CONV_AMVS is better than CONV_AEOLUS at the 99% significance level
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- (pink) CONV_AMVS is worse than CONV_AEOLUS at the 95% significance level
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Start Date: 2020080500

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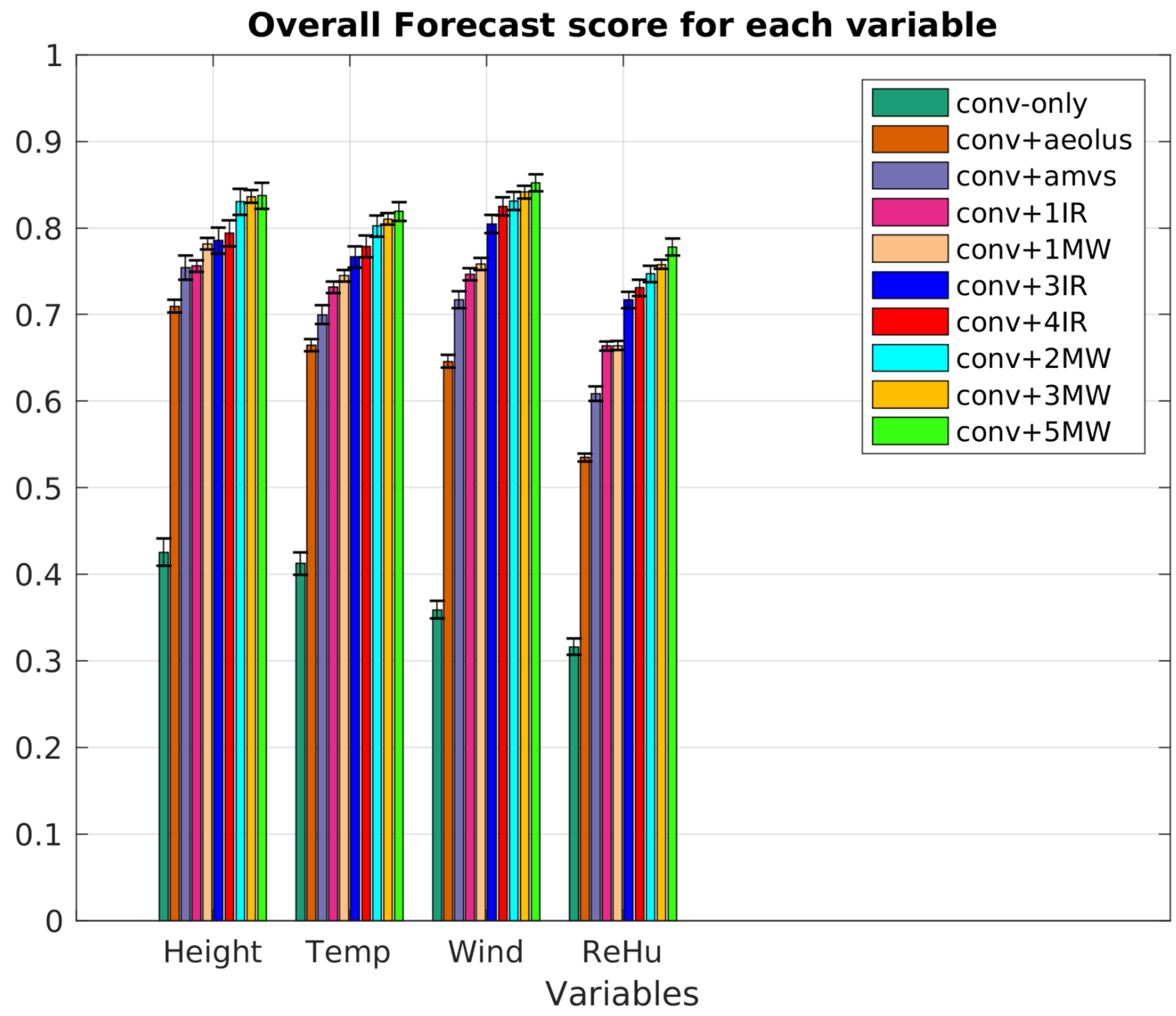
Overall Forecast score

These results are normalized (between MinMax) score for the each experiments for several metrics (RMS, AC), for several lead times (00-168 forecast hours), for different layers (250,500,700,850,1000hP levels), for different regions (NH ,SH , and Tropics region) averaged over for each forecast skills (HGT, Temp, Wind, and ReHu, Wind)



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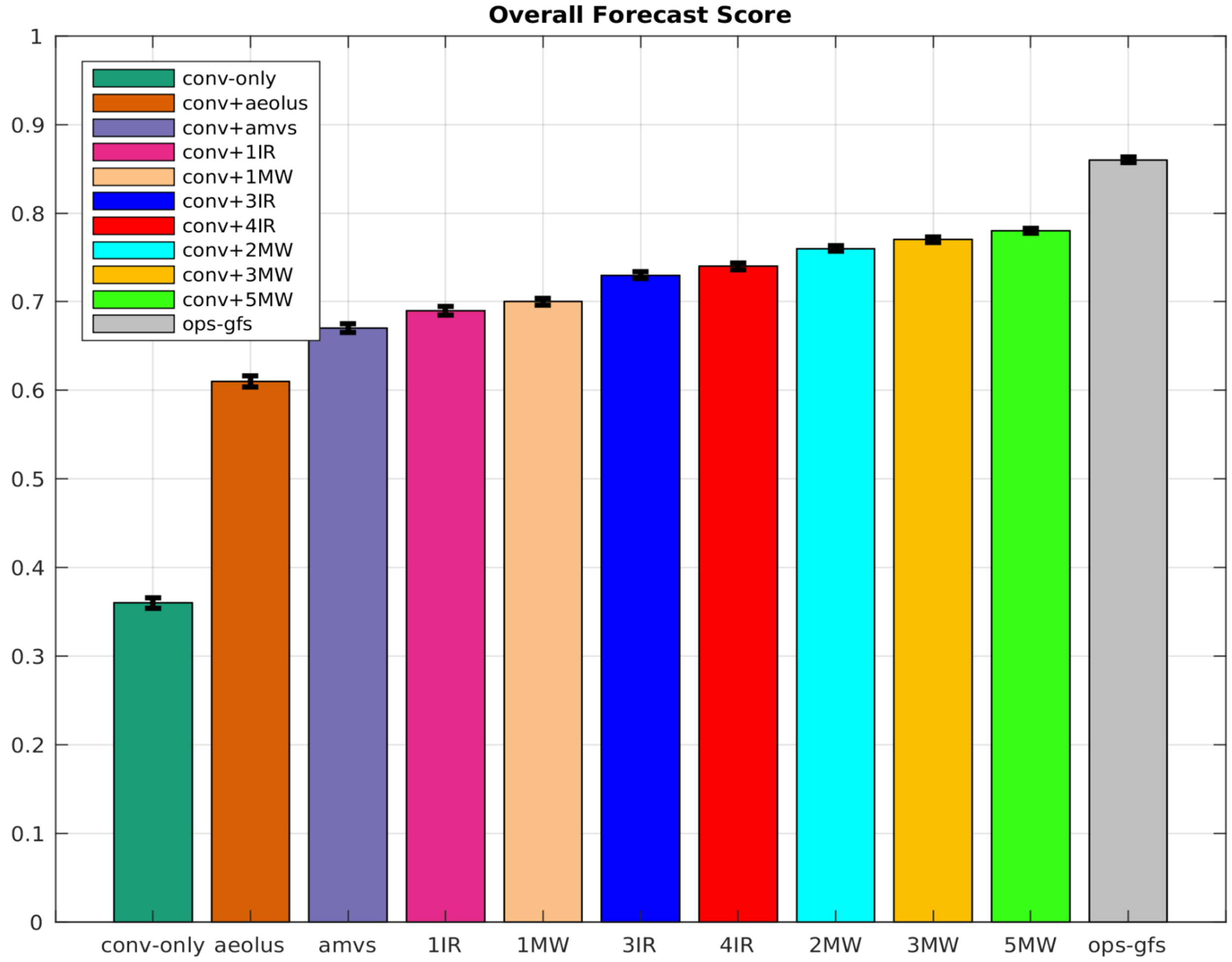

GFS operational is also being compared to all the experiments as reference here

Summary

- OSE experiments were performed to assess impact of real data of space-based wind on the NOAA NWP system.
- Work is still in progress but some preliminary results are indicative of the following:
  - All Observing systems assessed have significant value to NWP.
  - **Comparing different Observing Systems:** Order of highest Impact on NWP: (1) Microwave Sensors have the biggest impact on NWP followed by IR sensors (2) followed by AMVs from Geo/Leo sensors, (3) followed by Aeolus –based winds. This skill includes for T, Q, and wind.
  - **Assessing Optimal Number of Satellites:** For microwave sensors, five is better than three and two which is better than a single Microwave sensor (Increasing skills with increasing number of sensors). For IR sensors 4 is better than 3 and 1.
  - **Best way to capture wind information:** Consistent with the overall skills, Wind forecast skill is biggest when we assimilate MW and IR sensors (5MW is the best, 1MW and 1IR are about the same. 2MW and 3MW better than 3IR and 4IR). Multiple AMVs are better than one Aeolus based wind