Assimilation of GOES Clear Air Water Vapor Atmospheric Motion Vectors in the NCEP Global Forecast System

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Investigate the use of CAWV AMVs from GOES-13/15 for GFS DAS

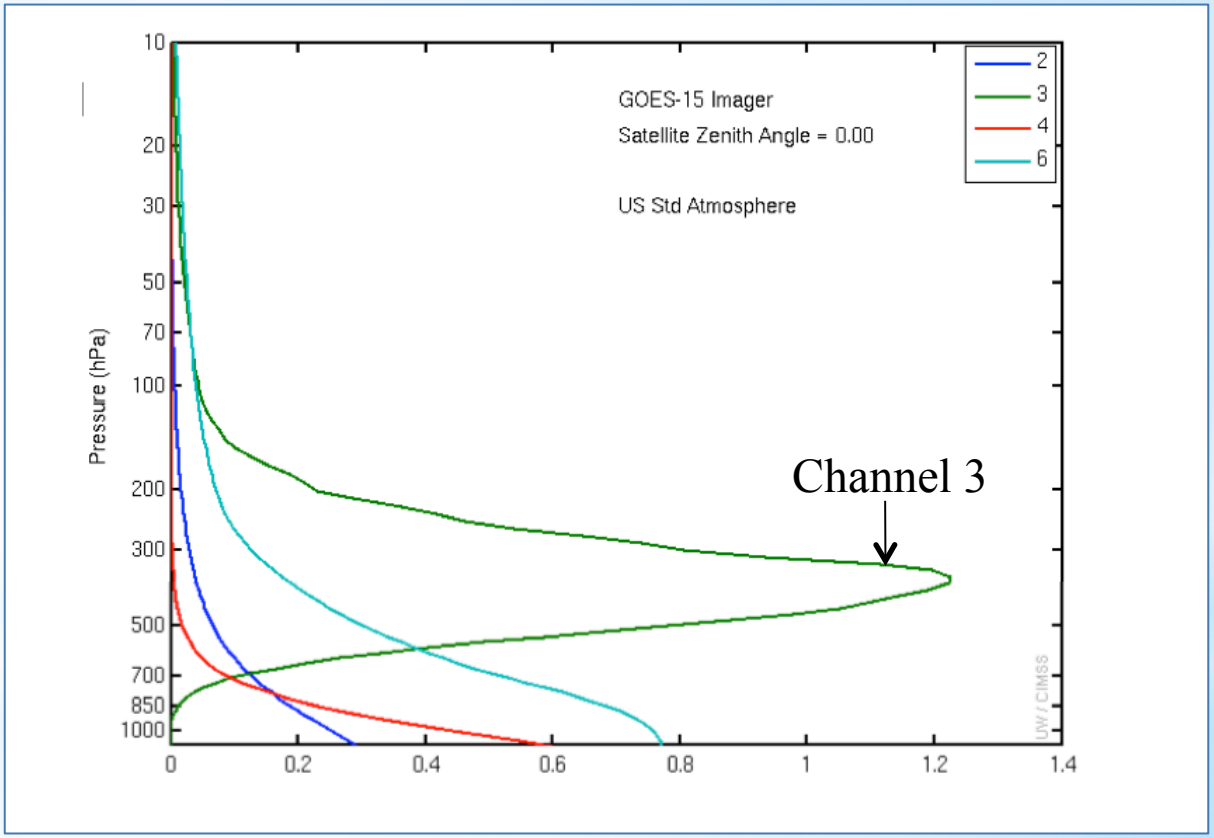
- Description and Motivation
- Quality Control
- Observation Error
- Analysis Impact
- Forecast Skill Impact

Clear Air Water Vapor AMVs

Description:

Motion derived by tracking moisture gradients in clear target scenes using GOES 13/15 Channel 3 with center frequency at 6.5 μm

Height is assigned using a cold sample of pixels in the scene which are compared to the forecast temperature profile for a height estimate



GOES-15 Imager Weighting Functions

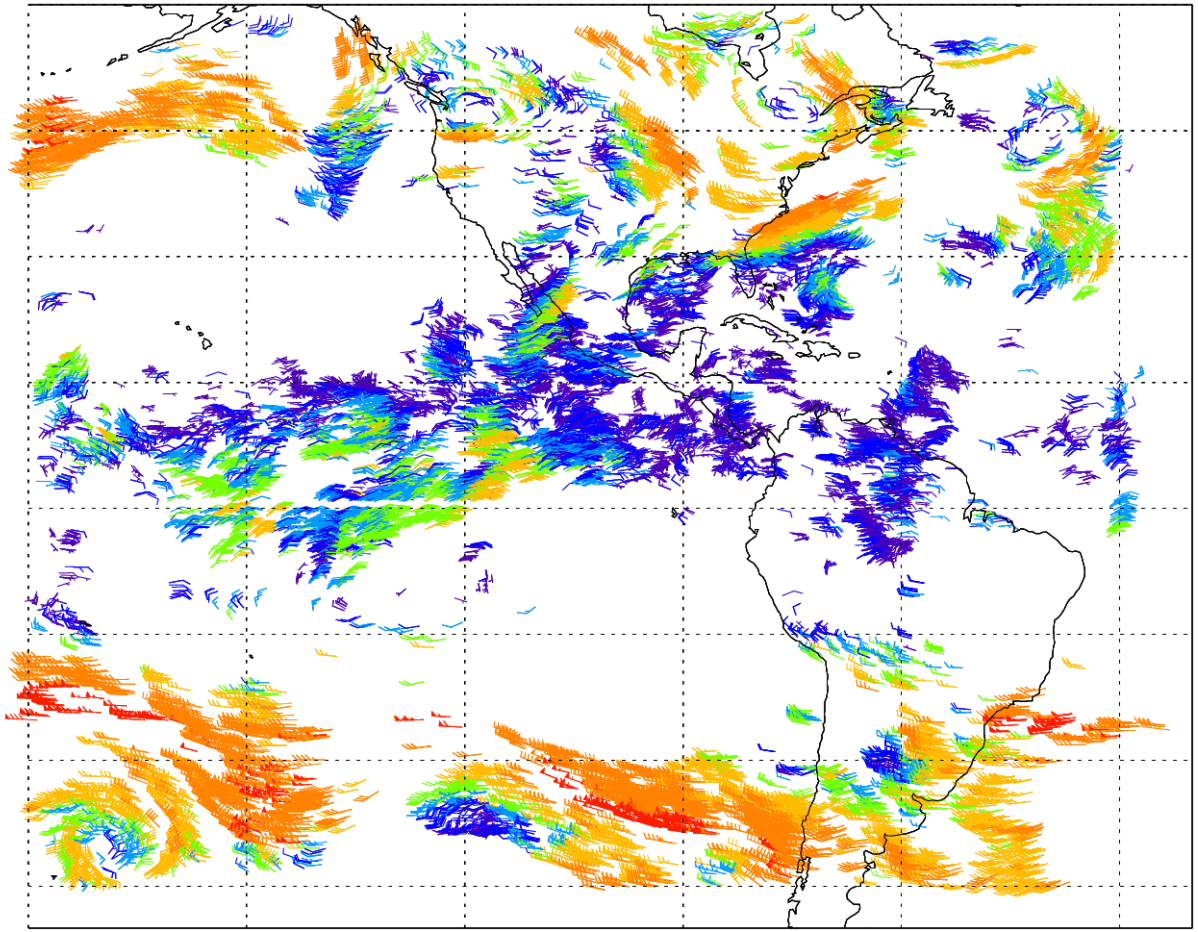
All AMV except CA WV

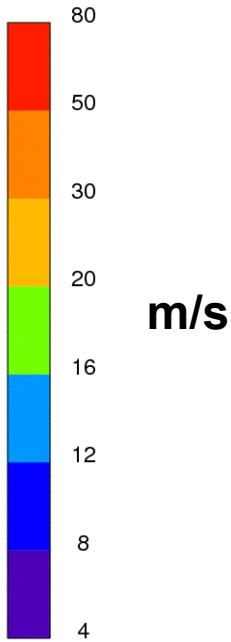
Results for 2014081518 to 2014081518

Motivation: Improve data coverage in the tropics

GOES IR & Cloud Top WV AMV above 500 hPa

No Clear Air WV AMVs





m/s

18Z 15 Aug 2014

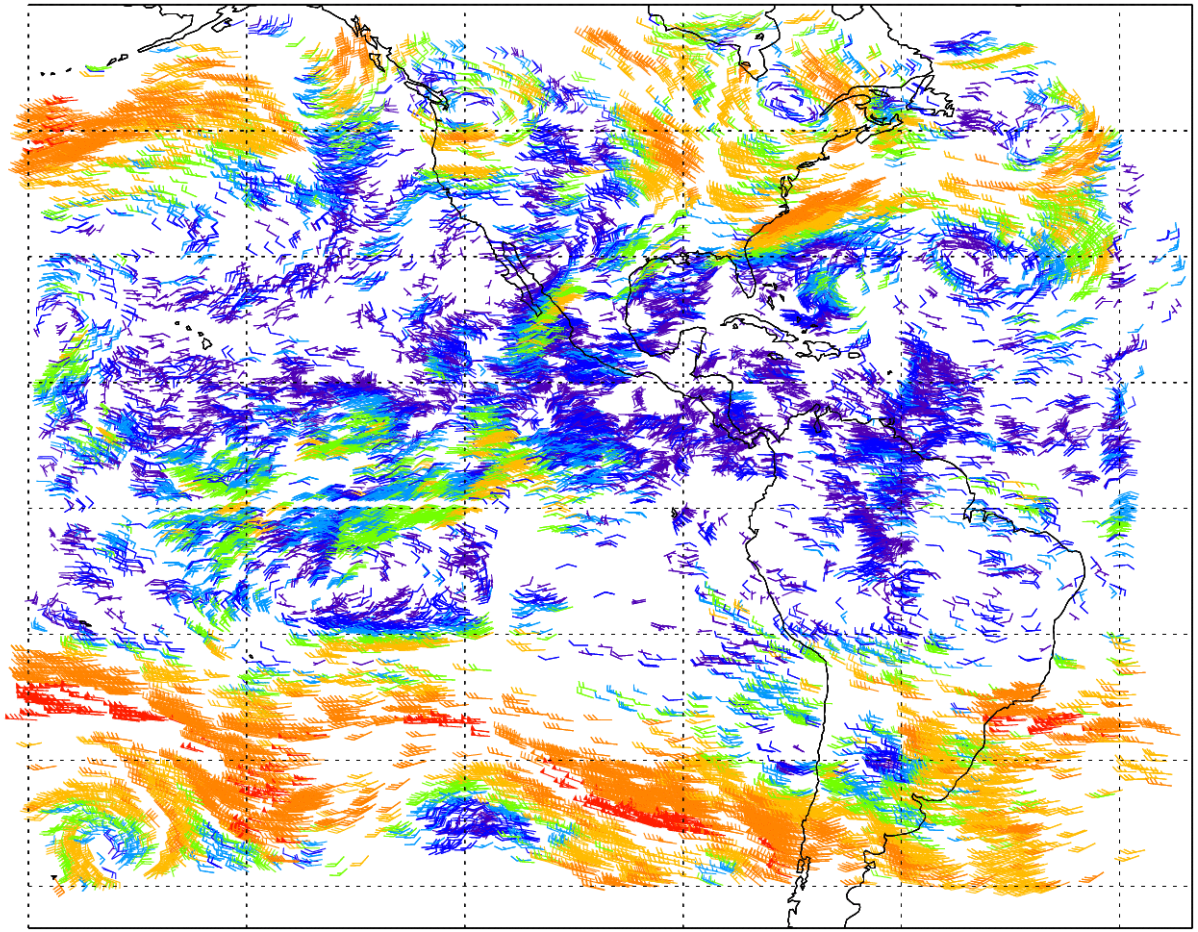
All AMV

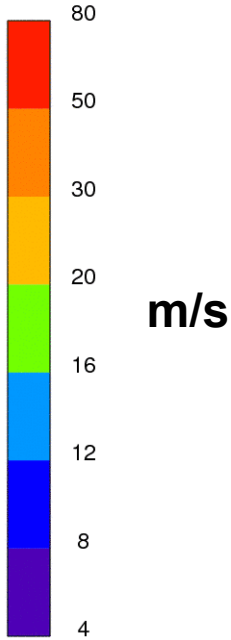
Results for 2014081518 to 2014081518

Motivation: Improve data coverage in the tropics

GOES IR & Cloud Top WV AMV above 500 hPa

With Clear Air WV AMVs





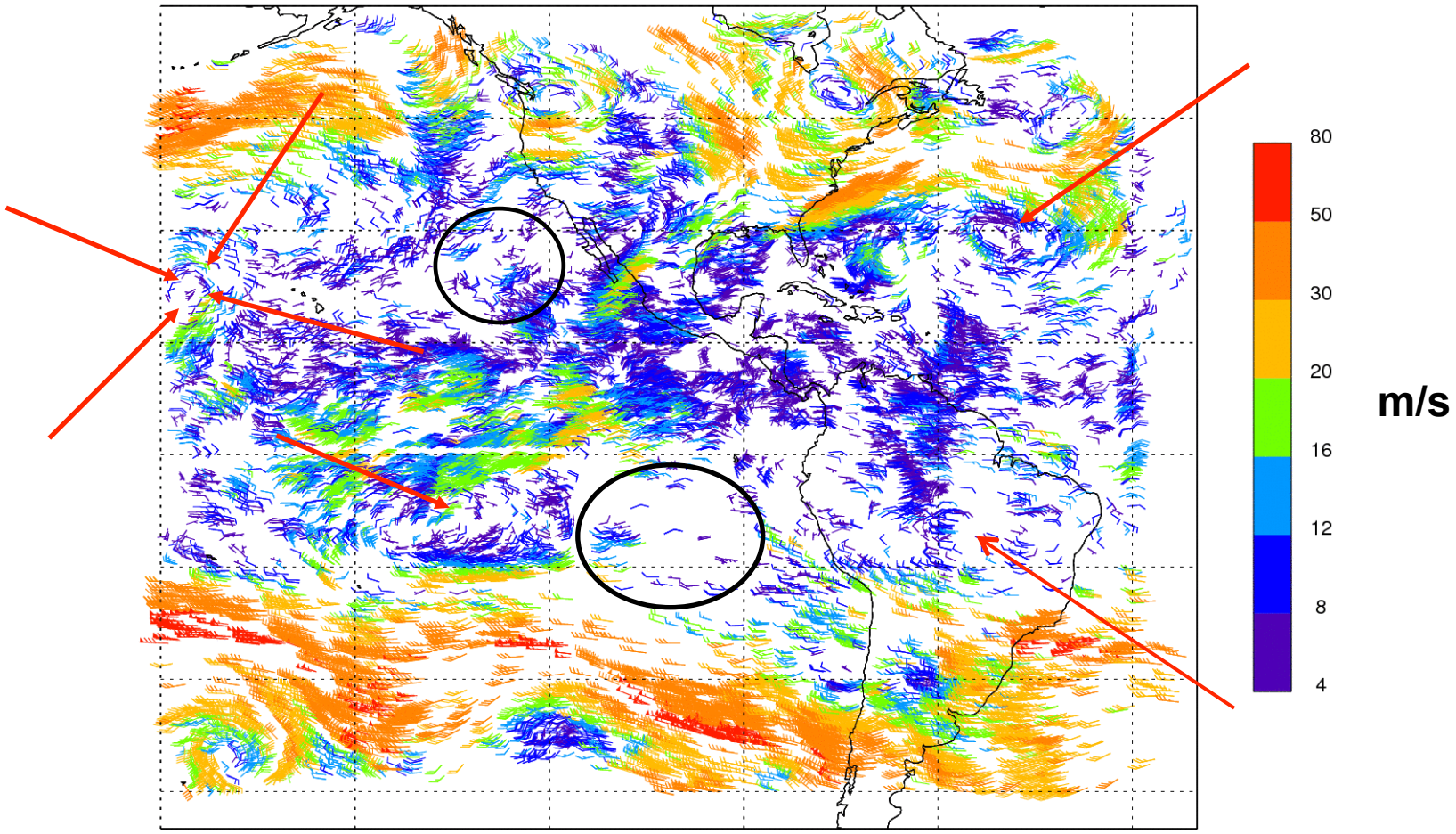
m/s

18Z 15 Aug 2014

All AMV
Results for 2014081518 to 2014081518

Motivation: Improve data coverage in the tropics

GOES IR & Cloud Top WV AMV above 500 hPa With Clear Air WV AMV

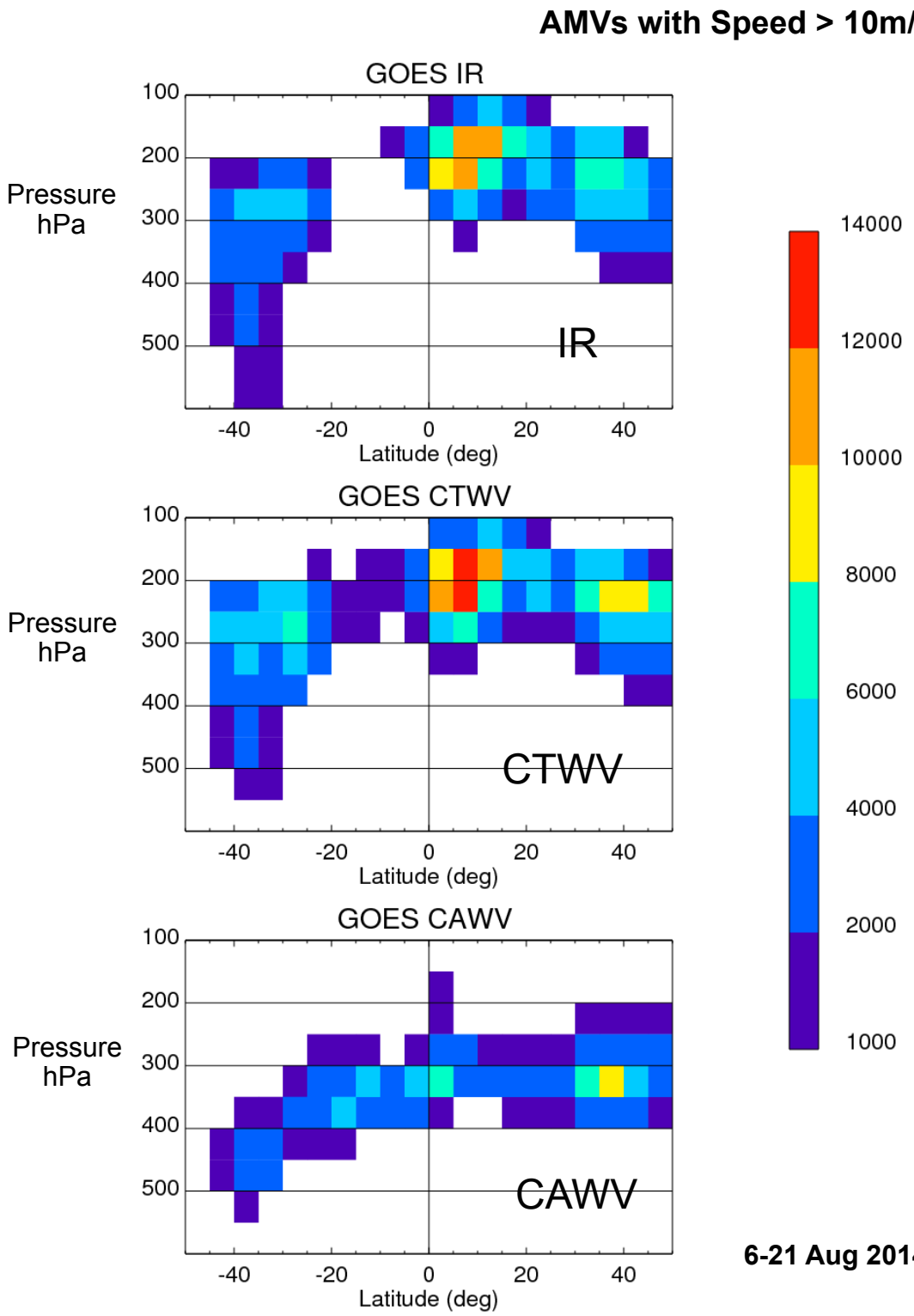


Features that need to be in the analysis

Regions where QC is needed
How can consistency be improved?

Location of GOES AMVs

CAWV are located lower than IR and CTWV



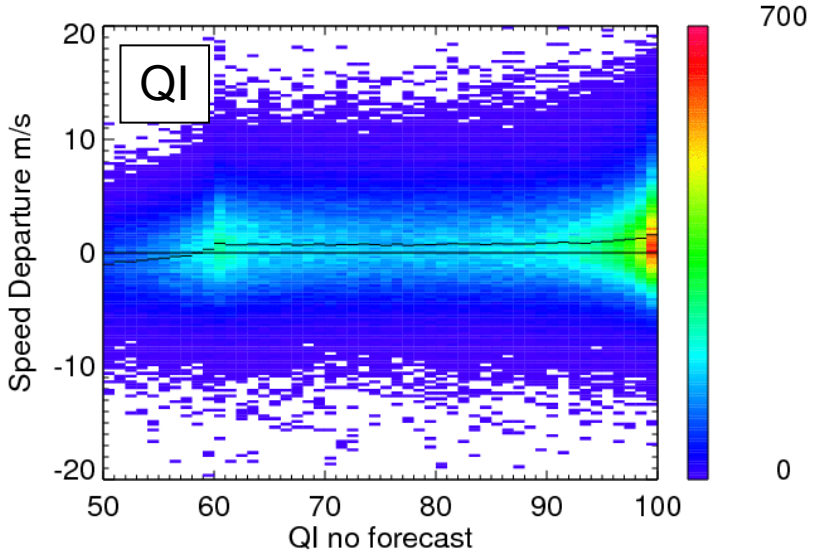
Quality Control

Quality Indicator (QI) without the forecast component and Expected Error (EE)

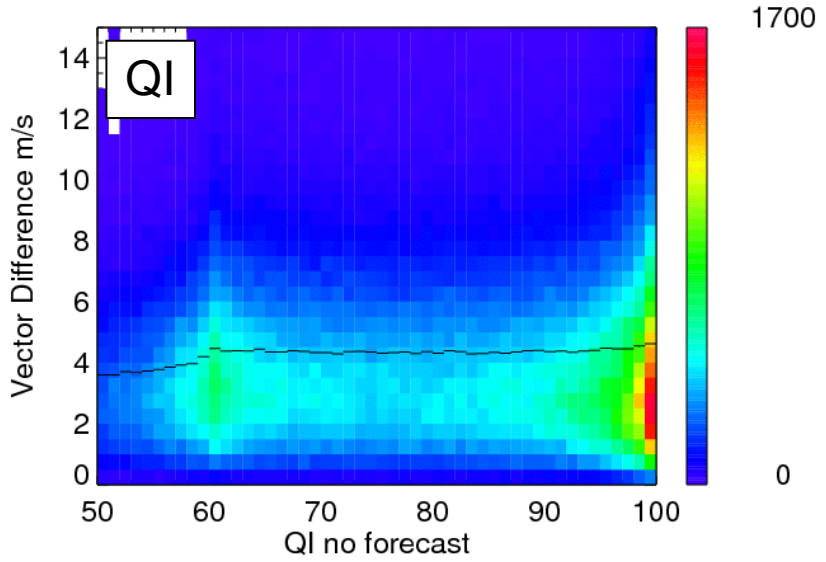
High values of QI and low values of EE should indicate better quality AMV data

Neither parameter show skill in predicting AMV departure from the GFS first guess

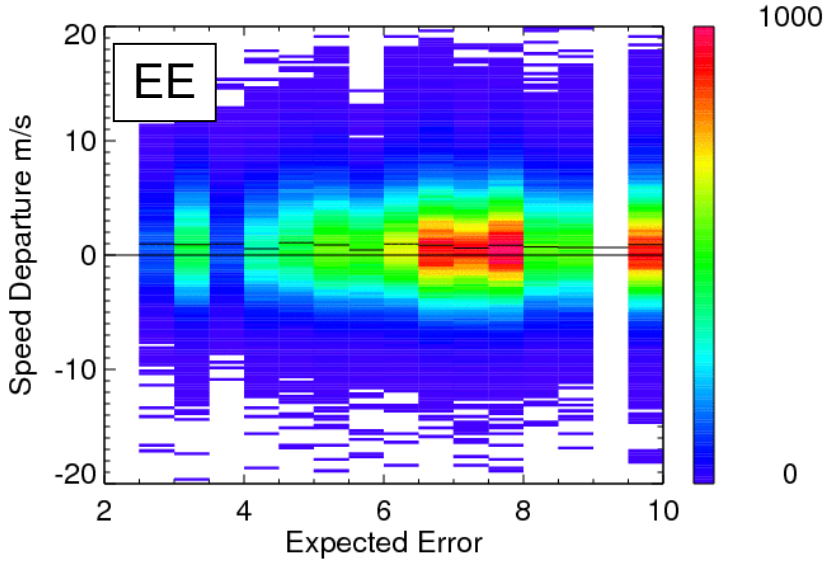
Speed OMB



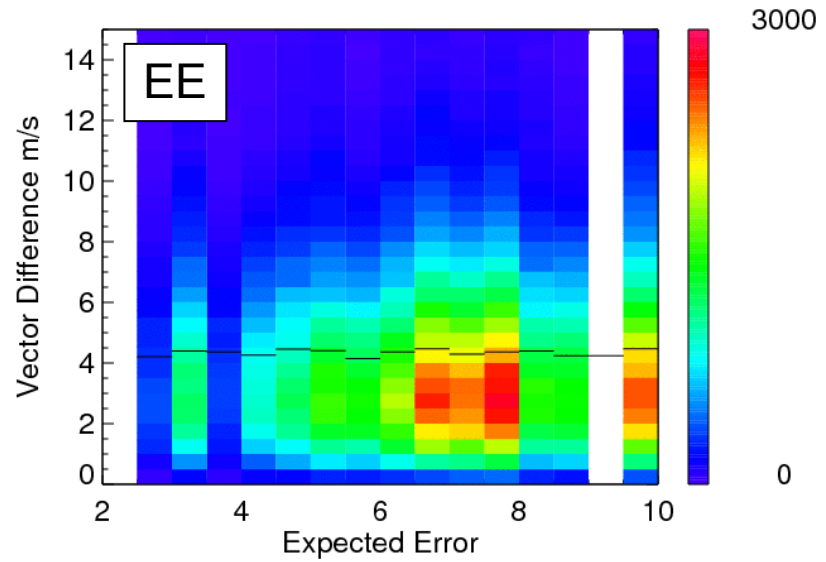
Vector Difference OMB



Speed OMB



Vector Difference OMB



Vector Difference = sqrt[$(U_{AMV}-U_{GFS})^2 + (V_{AMV}-V_{GFS})^2$]

Color indicates number of data in the 2d histogram bin

Black line shows average value for the given x bin

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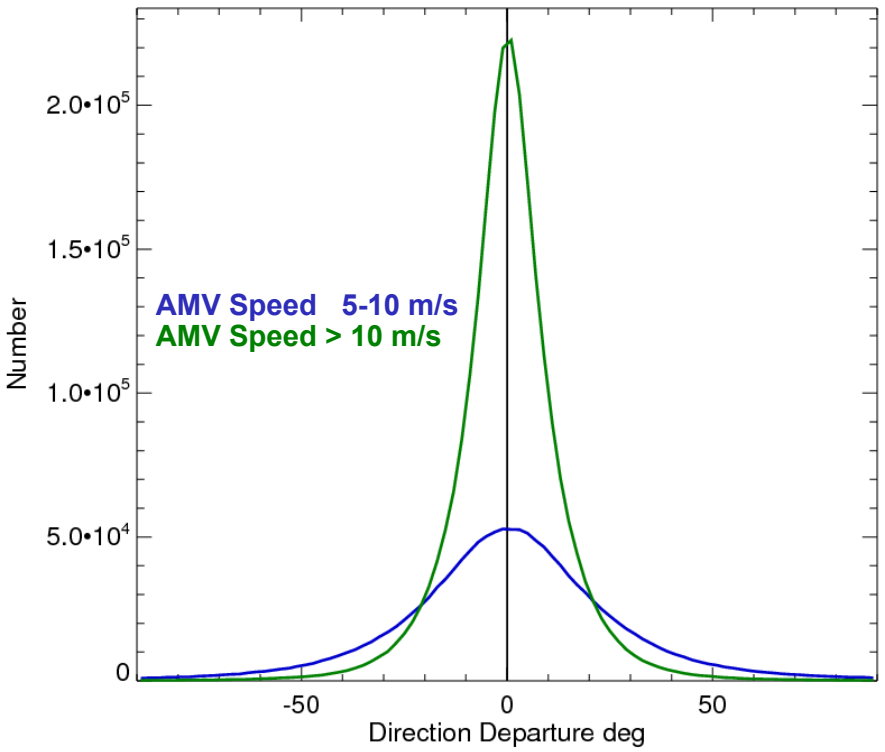
Quality Control

Minimum speed requirement: 10 m/s. Conservative, could be relaxed for GOES-R
Maximum direction departure: 50°
Near surface check over land
Apply the Log Normal Vector Difference (LNVD) constraint: LNVD < 3

$$\mathrm{LNVD} = \frac{\mathrm{Sqrt}\left[(U_{AMV}-U_{GFS})^2 + (V_{AMV}-V_{GFS})^2 \right]}{\mathrm{LN}\,(\mathrm{Speed}_{AMV})} < 3$$



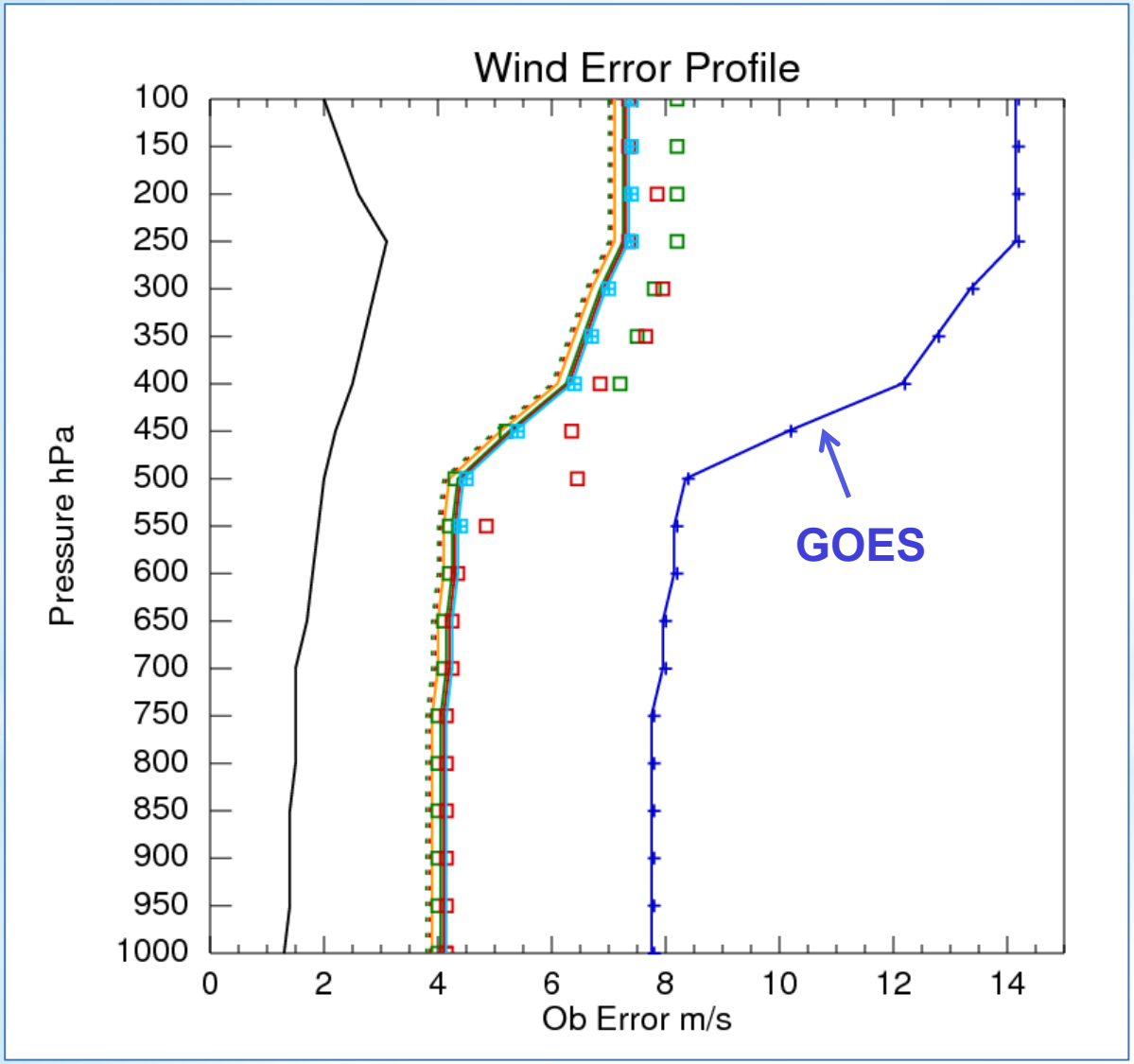
July 2015 Direction OMB

More about LNVD:

- LNVD was first introduced for MODIS AMV QC
- As AMV speed increases, allowed speed departure increases while allowed direction departure decreases
- For slow AMVs, less speed departure allowed but larger direction departure is allowed
- Should reevaluate limit for regional or hurricane applications or remove entirely
- With a speed minimum of 10 m/s, the LNVD<3 also limits the direction departure to less than 50°

Observation Error Current settings for AMV observation errors in GFS

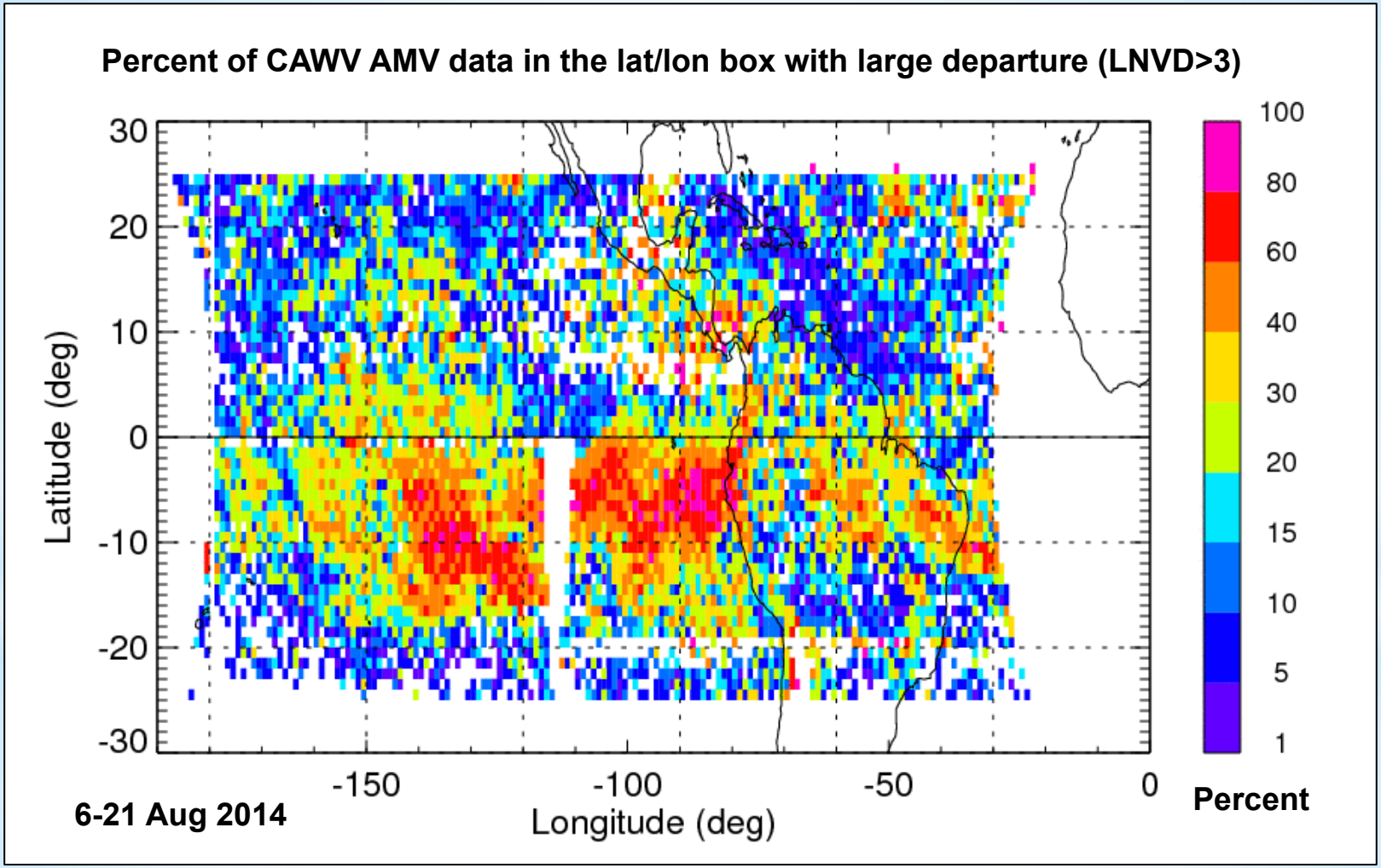
GOES IR and CTWV AMV error profiles
Increased to account for the higher data volume when temporal frequency increased to hourly winds



Observation Error

Justify using same error settings by comparing OMB statistics of IR and CTWV with CAWV

OMB Departures for CAWV are largest in the Eastern Pacific where current operational data is sparse.



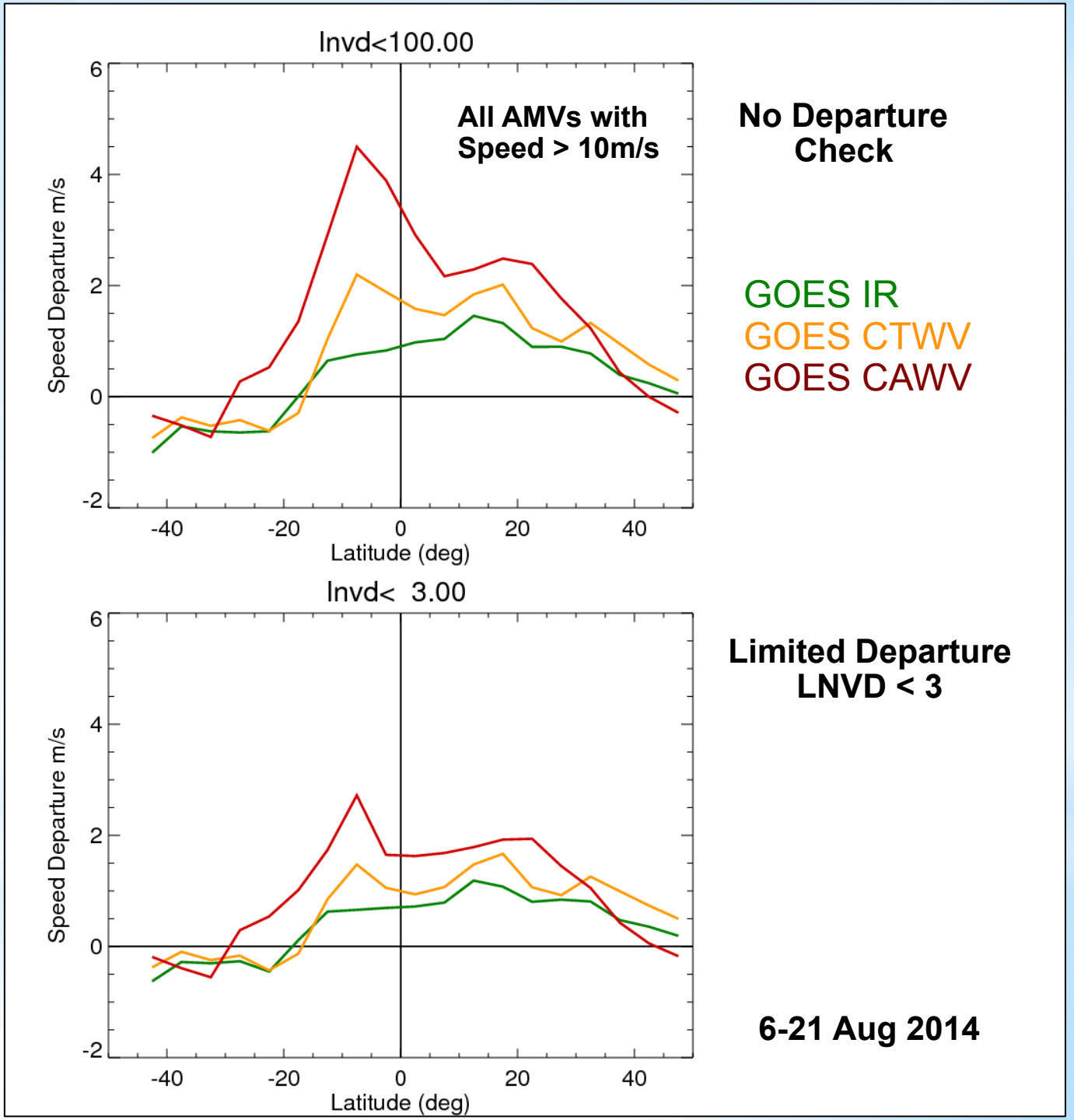
Observation Error

Mean Speed OMB m/s
as a function of Latitude

CAWV have larger positive speed bias but similar behavior

Setting the minimum speed to 10 m/s increases the mean speed OMB for all AMV types but similar relationship exists

Positive bias could be due to height assignment for the layer movement



No Departure Check

GOES IR
GOES CTWV
GOES CAWV

Limited Departure LNVD < 3

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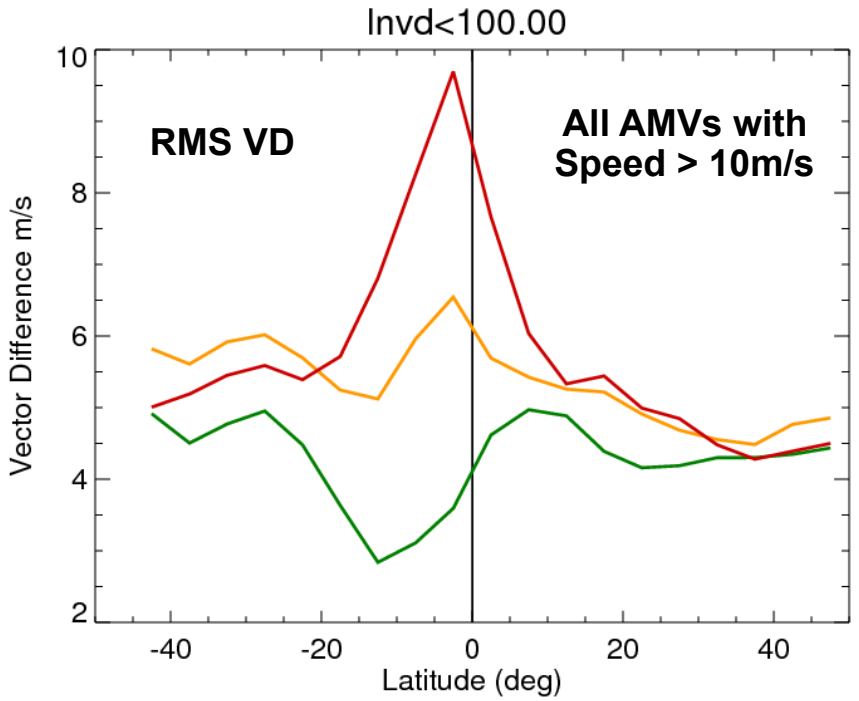
Observation Error

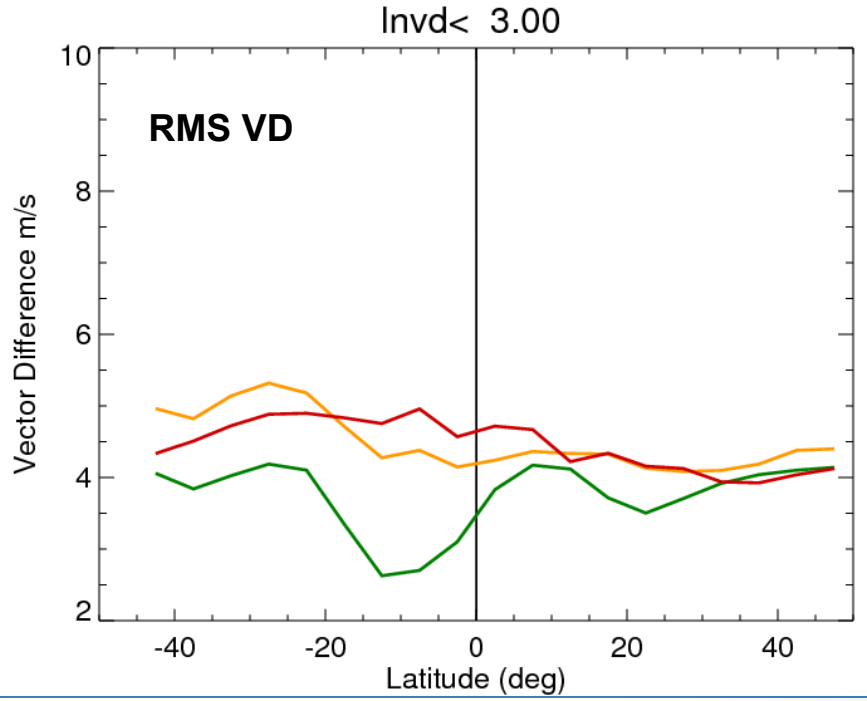
RMS Vector Difference OMB as a function of Latitude

CAWV have similar RMS vector difference largest in the tropics and is much lower than the 12-14 m/s error specified For GOES IR and CTWV AMVs



No Departure Check

GOES IR
GOES CTWV
GOES CAWV



Limited Departure LNVD < 3

6-21 Aug 2014

Analysis and Forecast Skill Impact

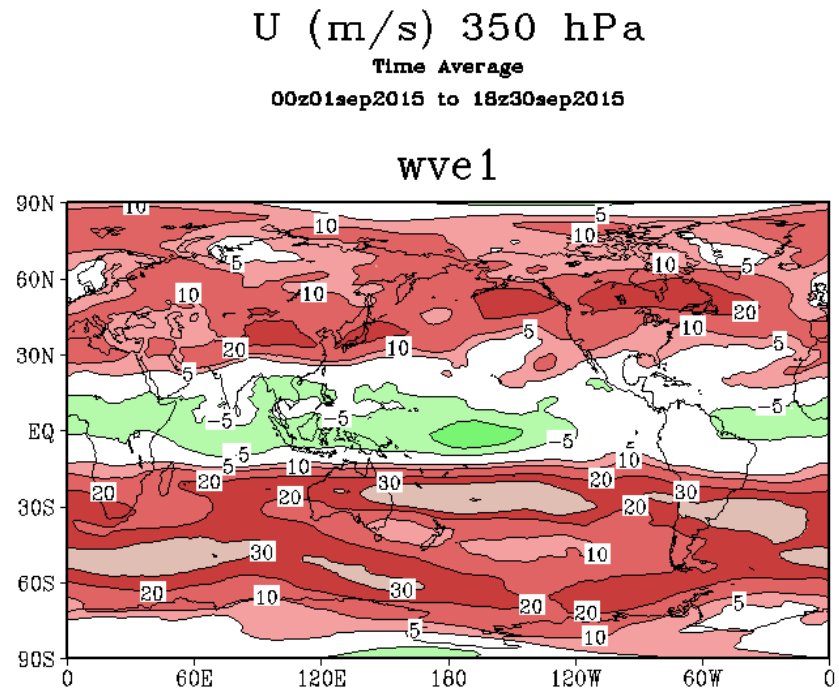
GFS Hybrid ENKF T670-T254 – 2 seasons

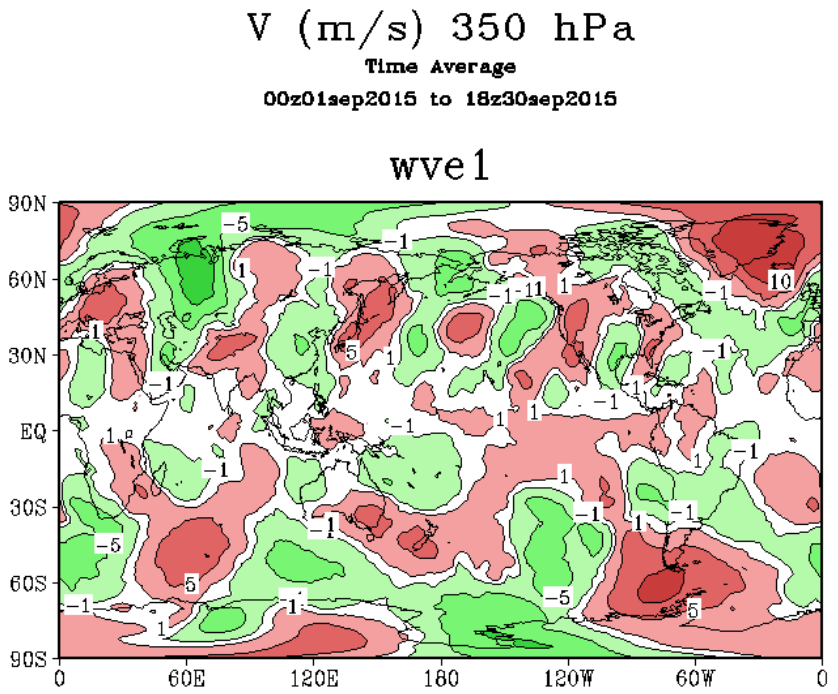
1. July-Sep 2015 Experiment wve1, Control wvc1
2. Feb-Mar 2015 Experiment wve2, Control wvc2

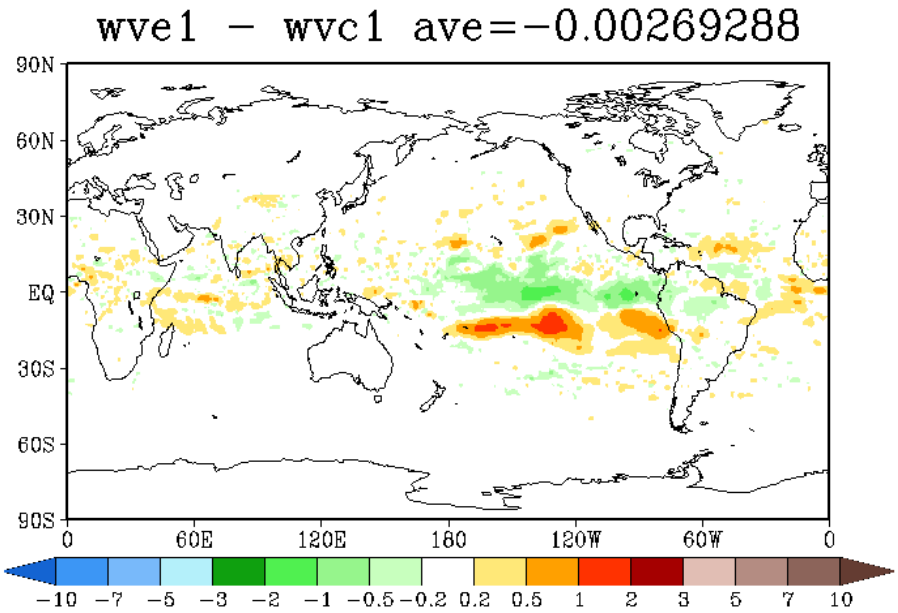
Results show changes to the analysis circulation
~350 hPa in the tropics

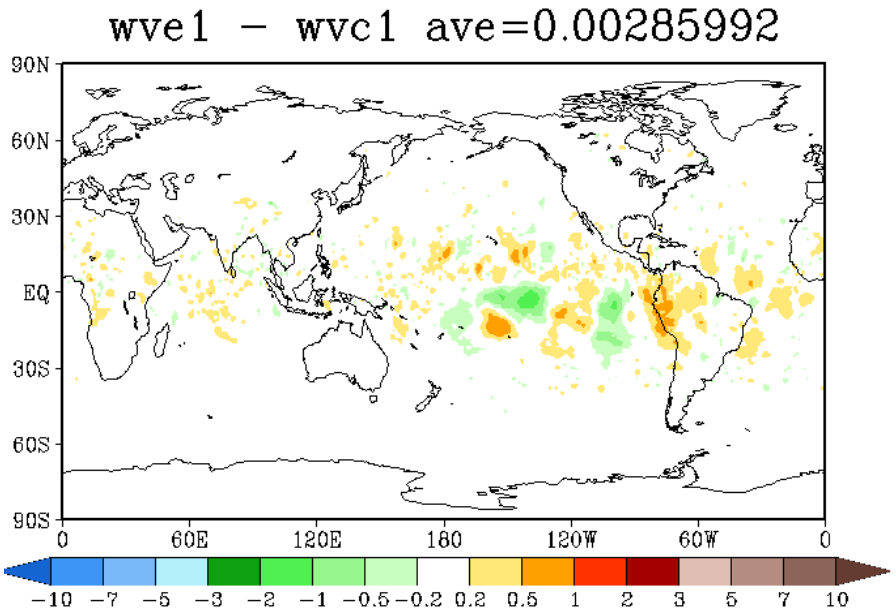
Short term impact ~24 hours on the wind forecast skill
otherwise neutral impact in global and regional statistics

Sept Mean U and V at 350 hPA

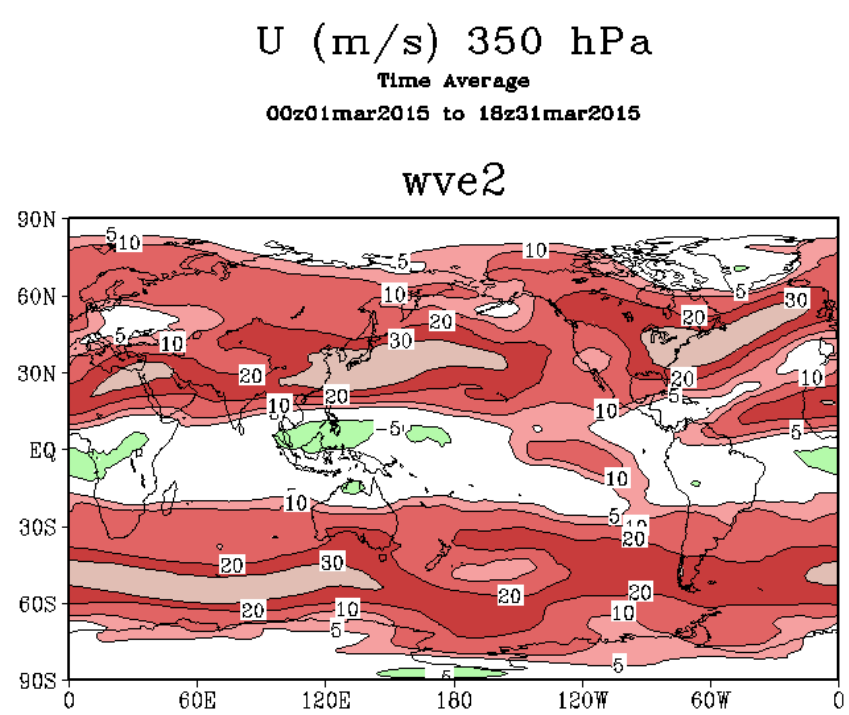


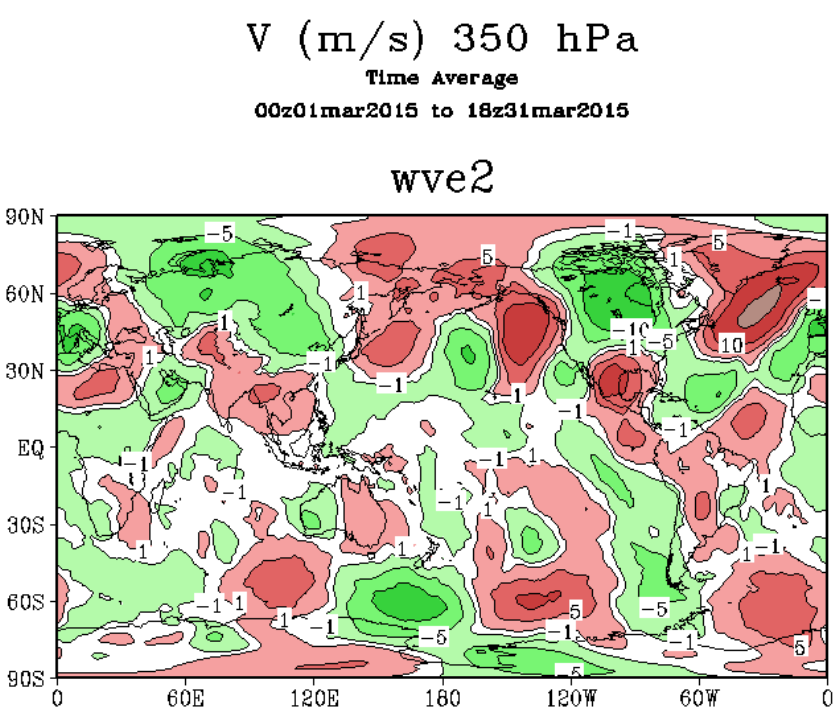


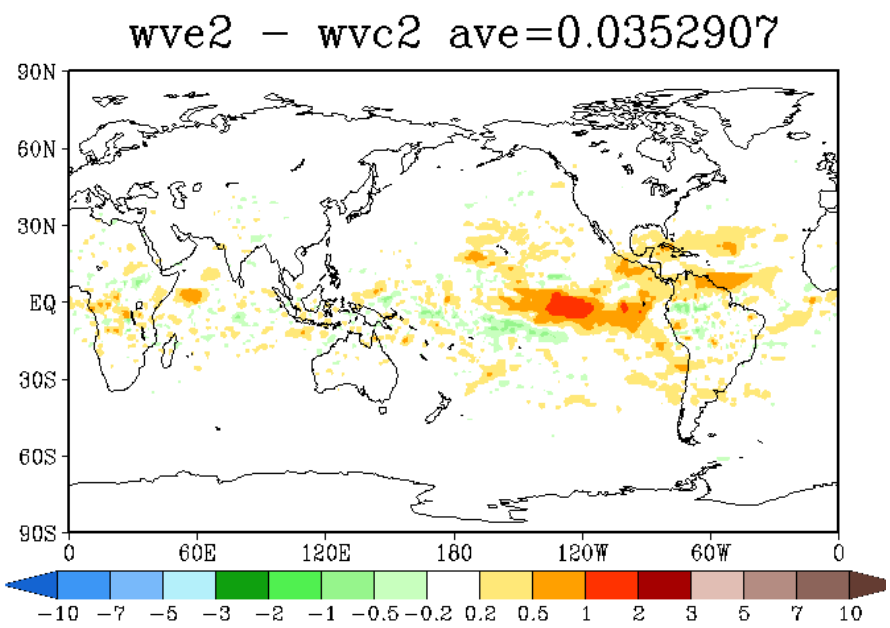


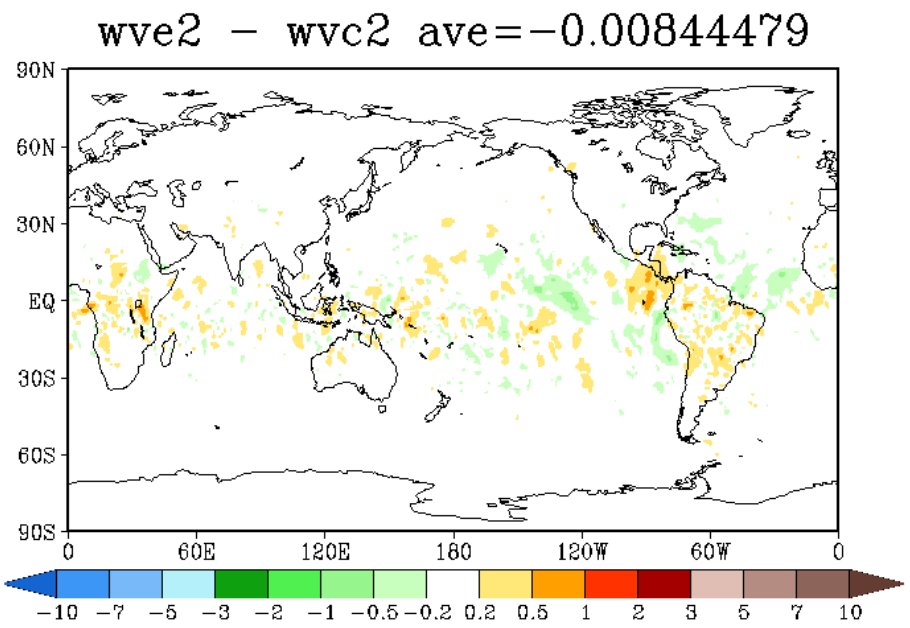


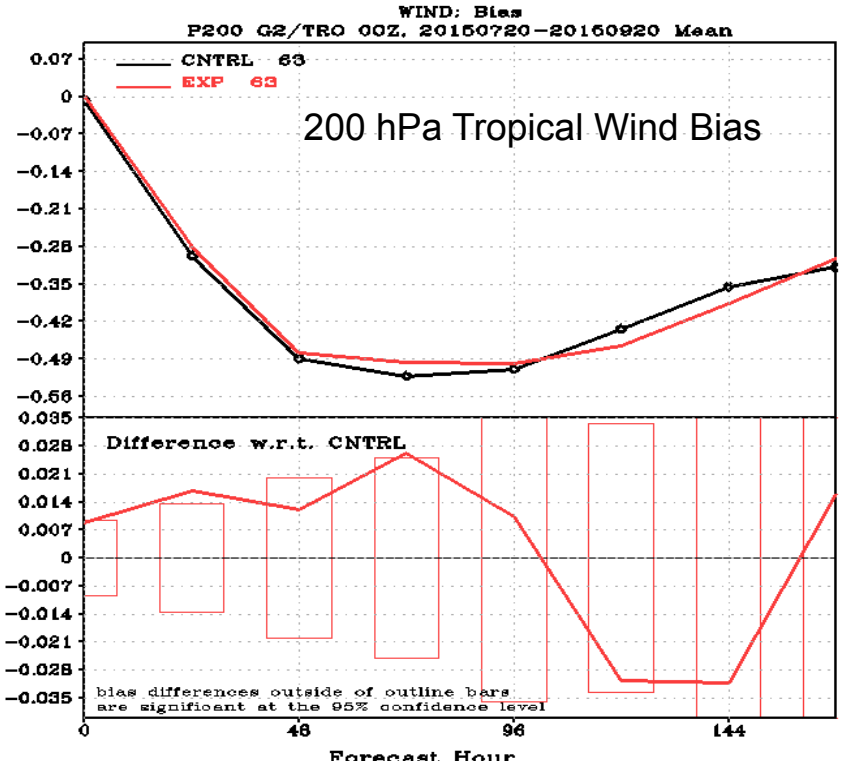
March Mean U and V at 350 hPA

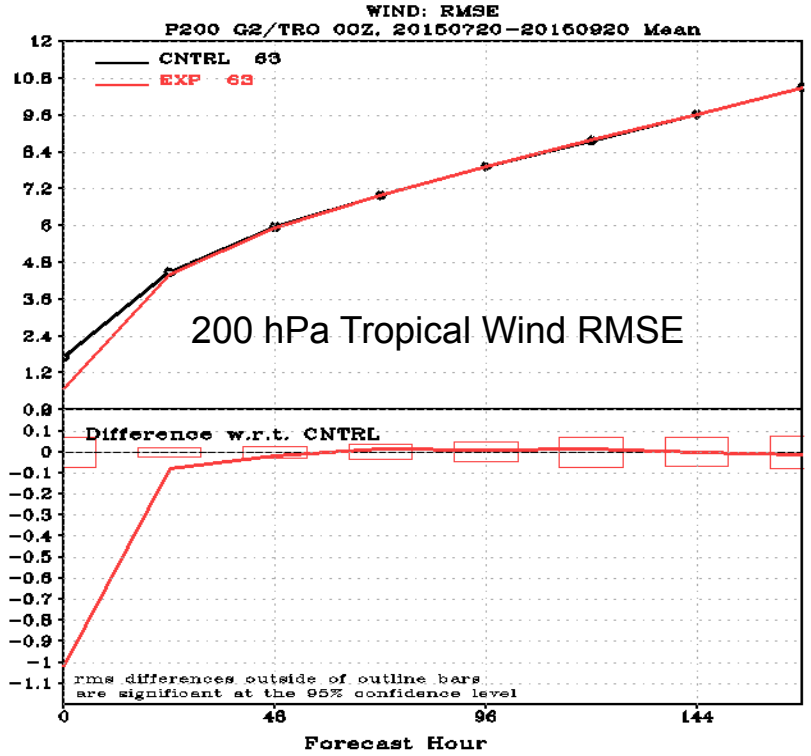




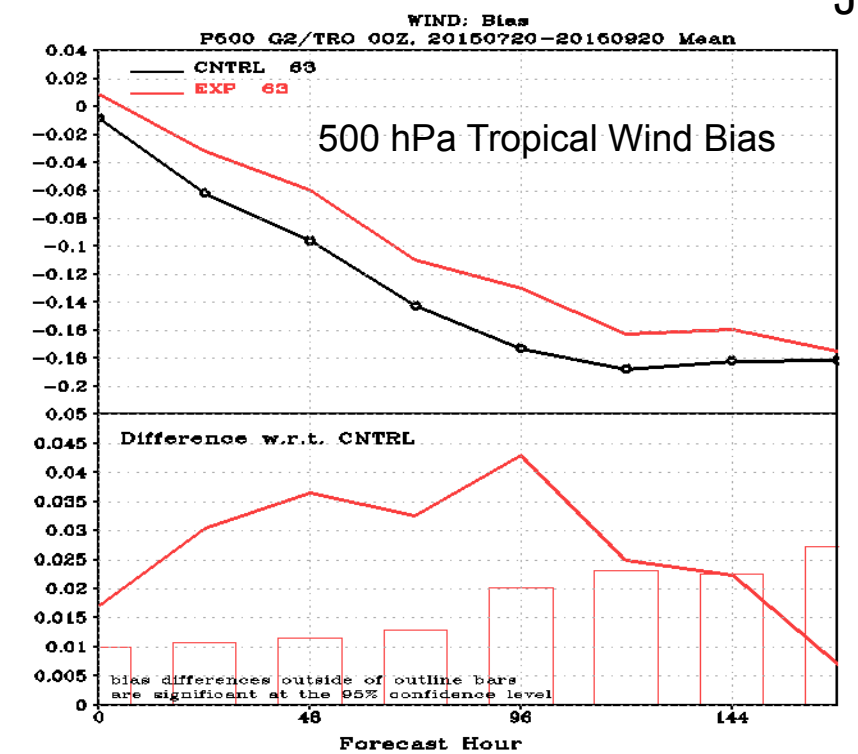


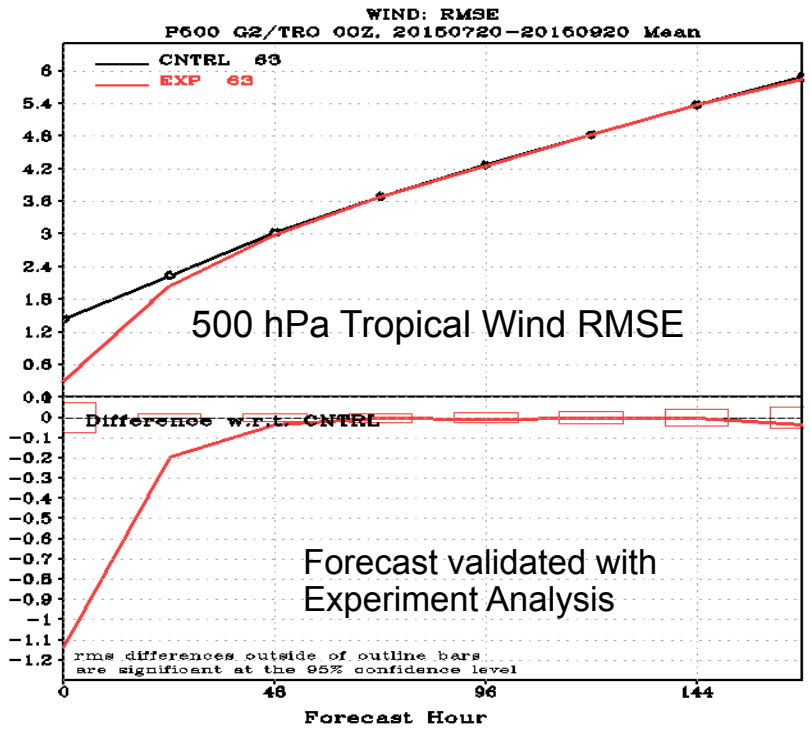


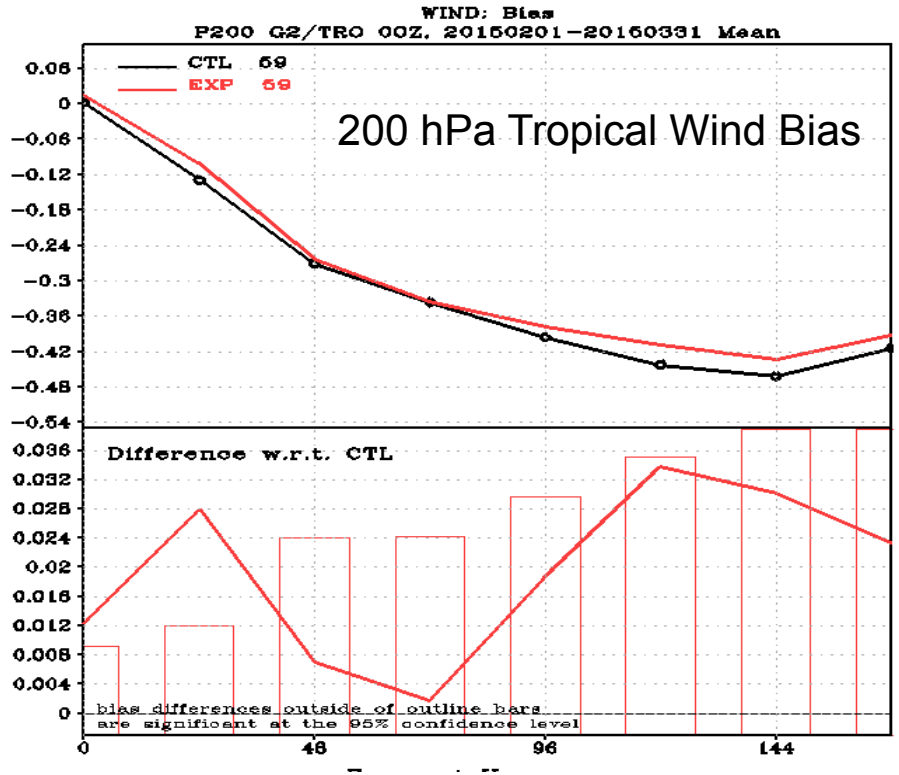


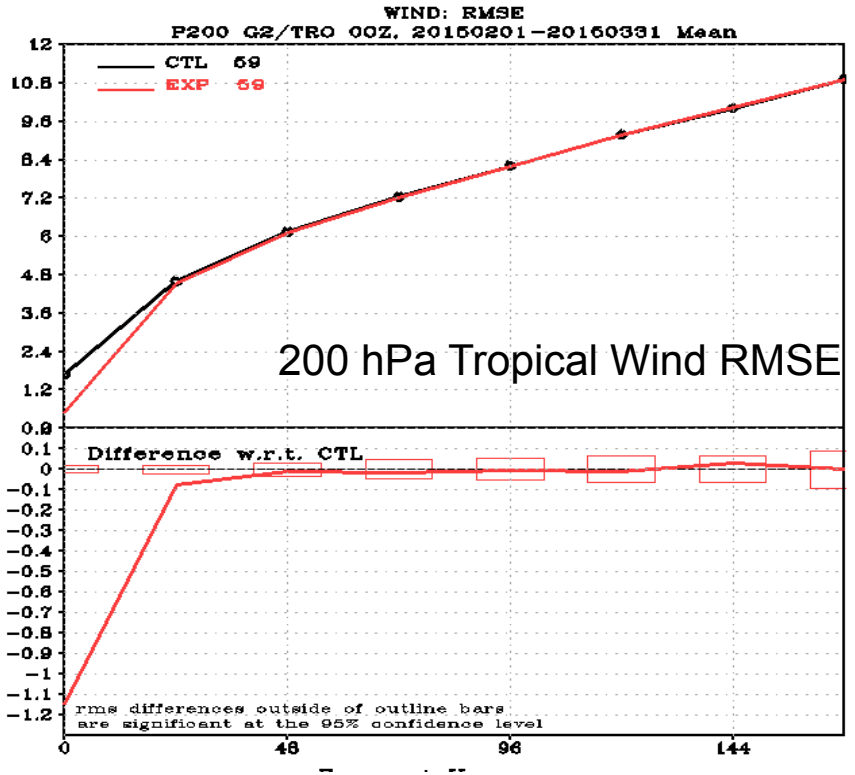


July-Sep 2015

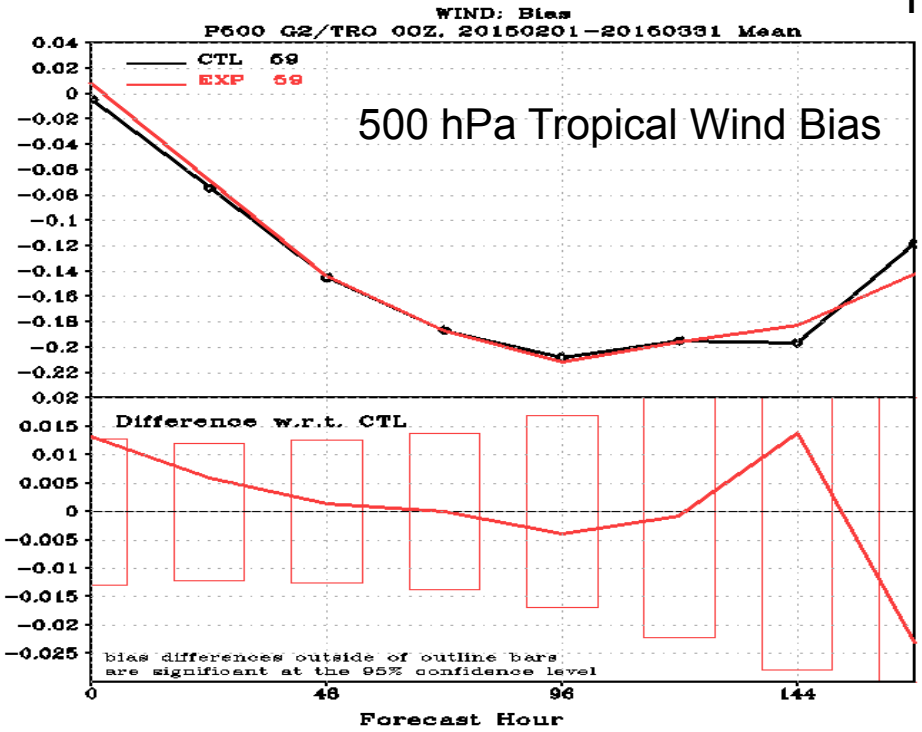


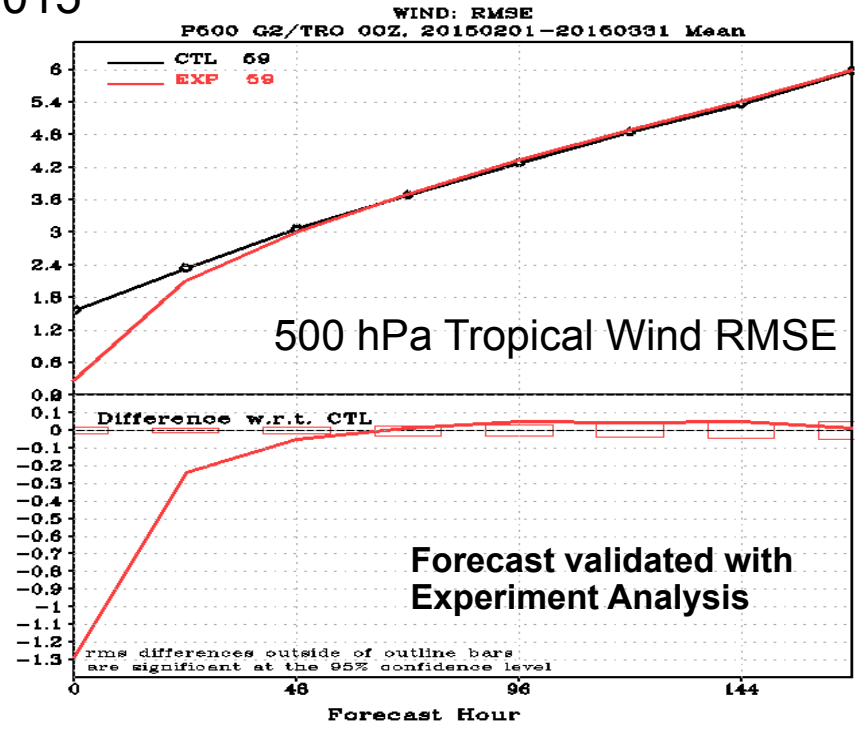






Feb-Mar 2015



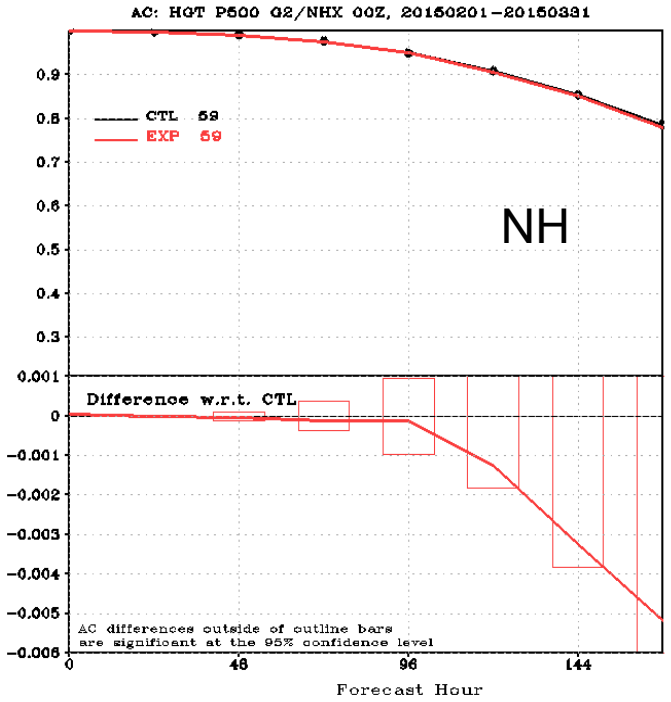


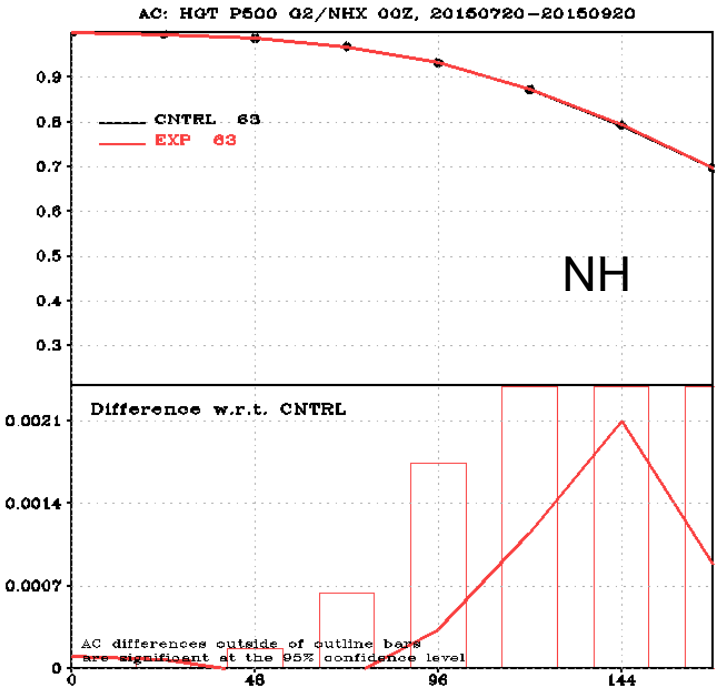
Forecast validated with Experiment Analysis

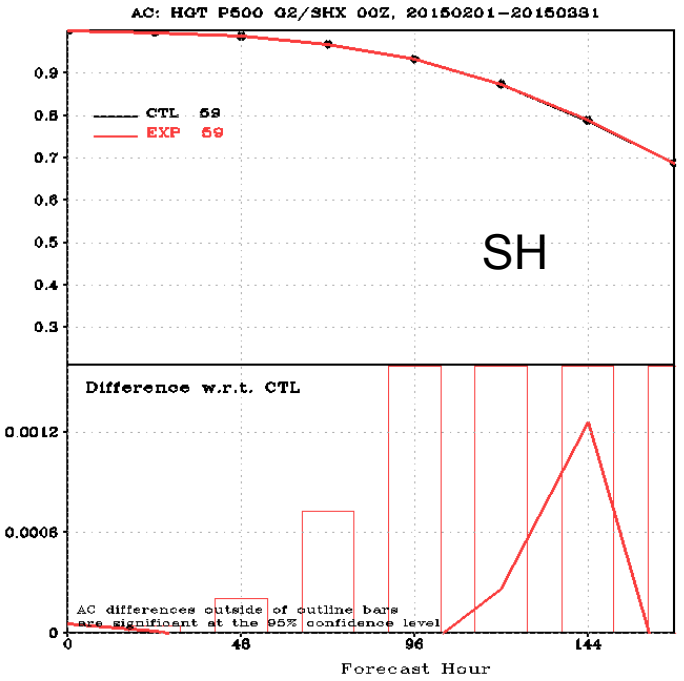
Feb-Mar 2015

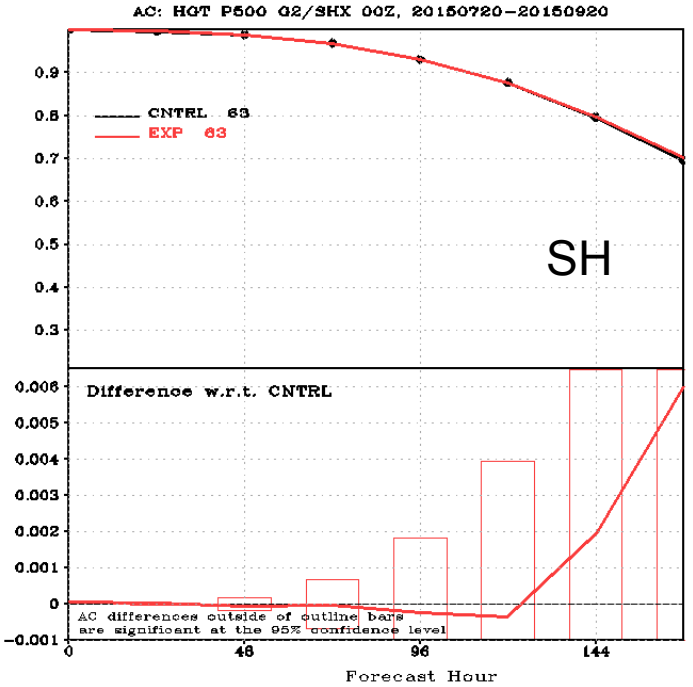
AC HGT 500 hPA

July-Sep 2015









Summary

Clear Air Water Vapor AMVs provide data coverage in locations which currently do not have other AMVs

GOES CAWV AMV data is already available

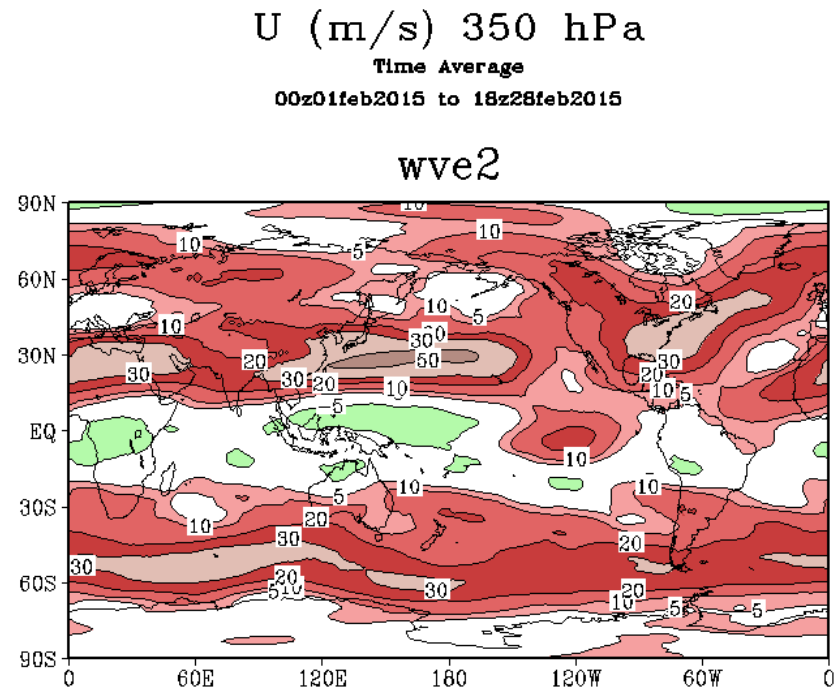
QC changes for GFS use were straight forward

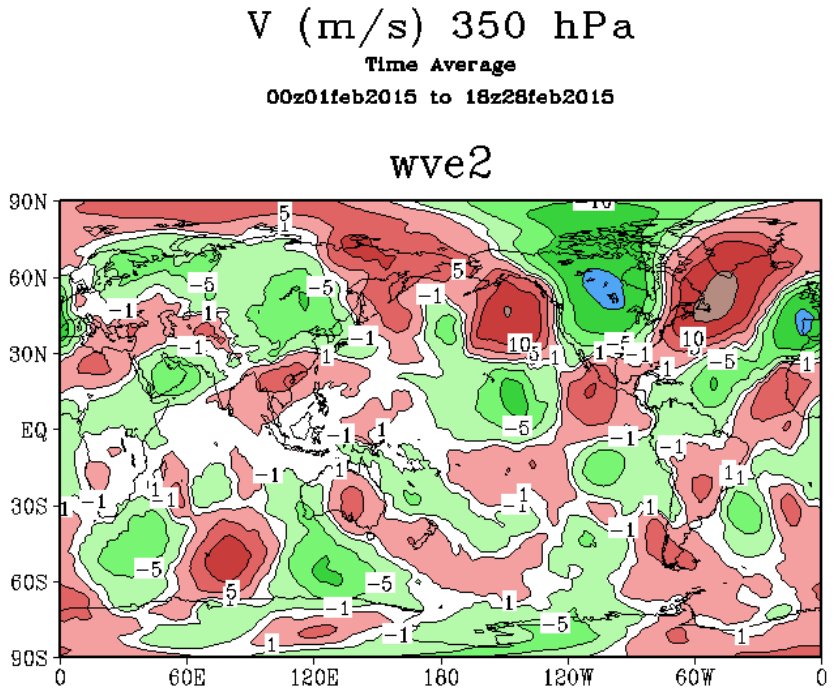
Analysis impact largest in tropics at 350hPa

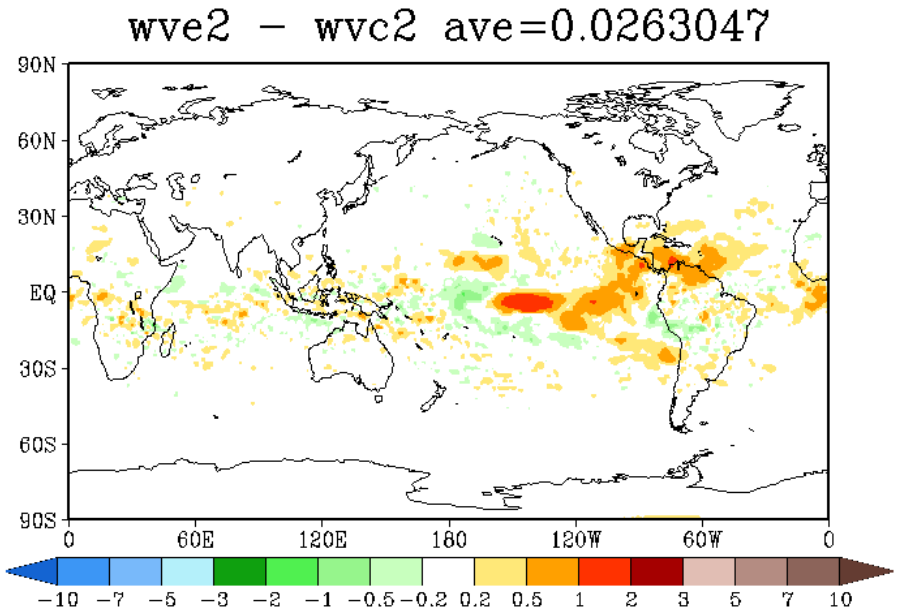
Forecast skill impact was neutral

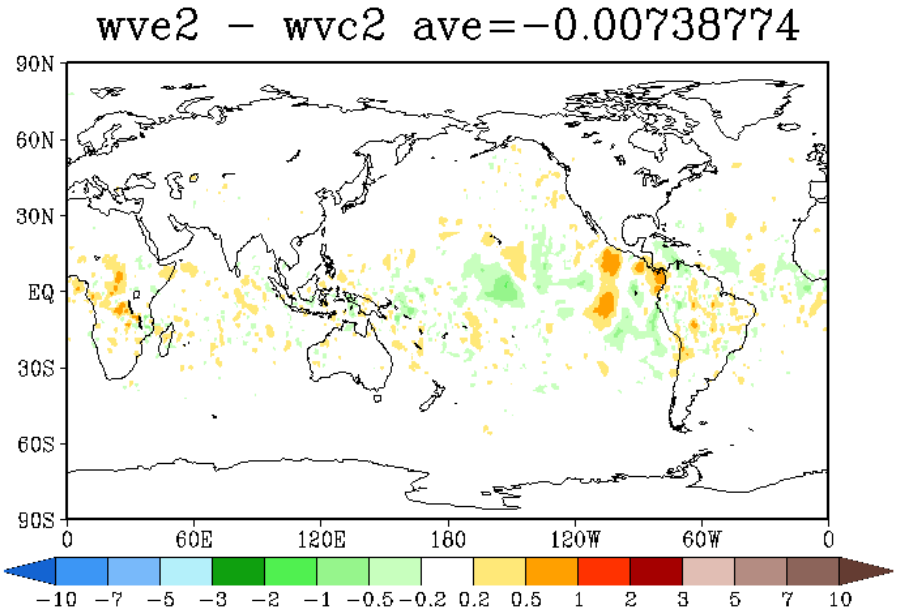
Extra slides

Feb Mean U & V at 350 hPA

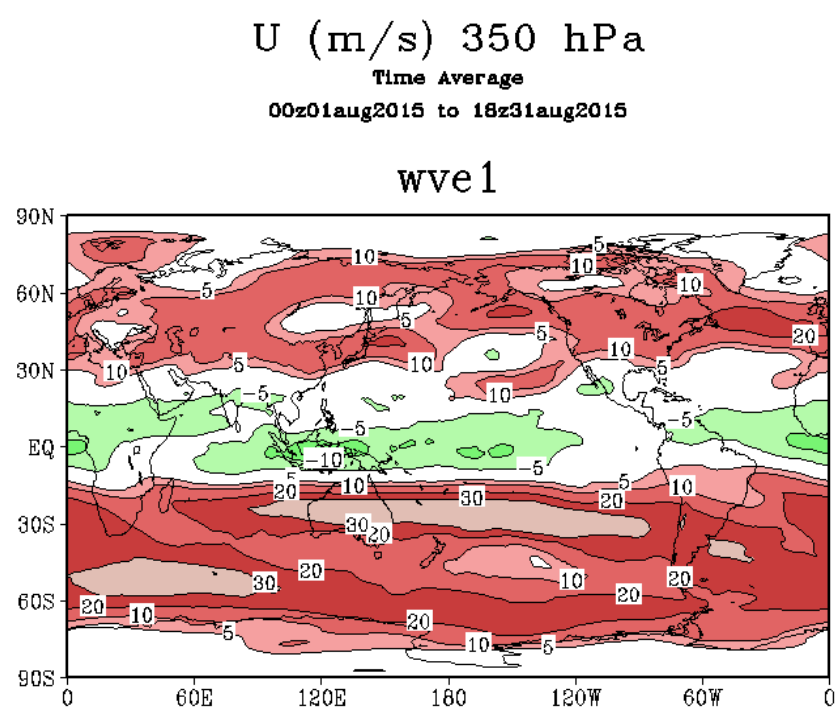


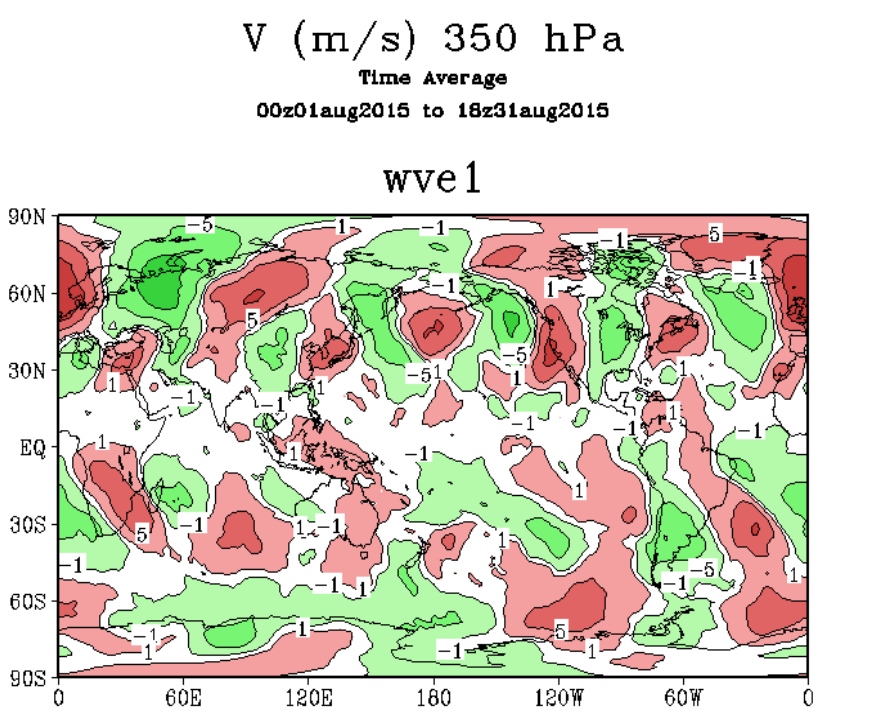


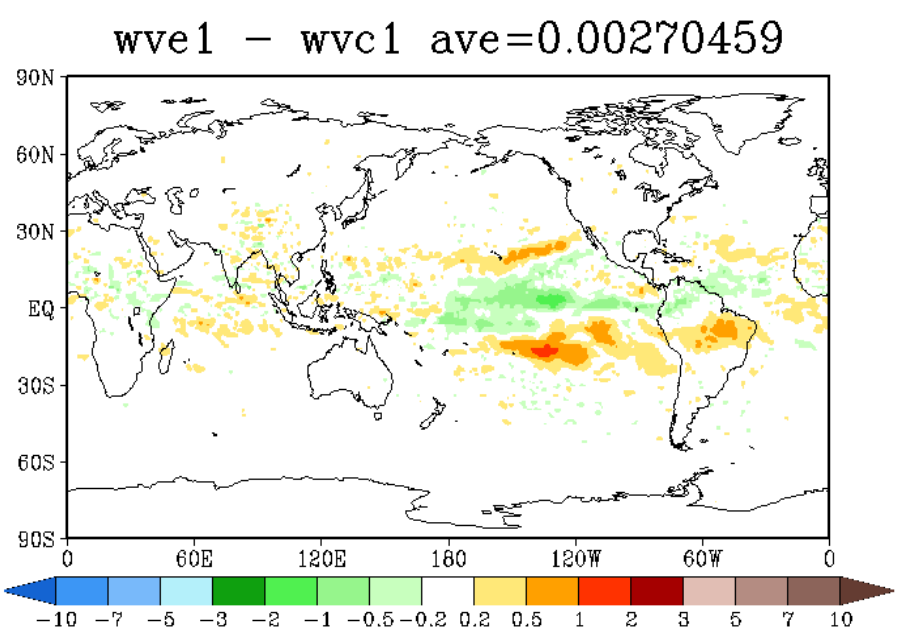


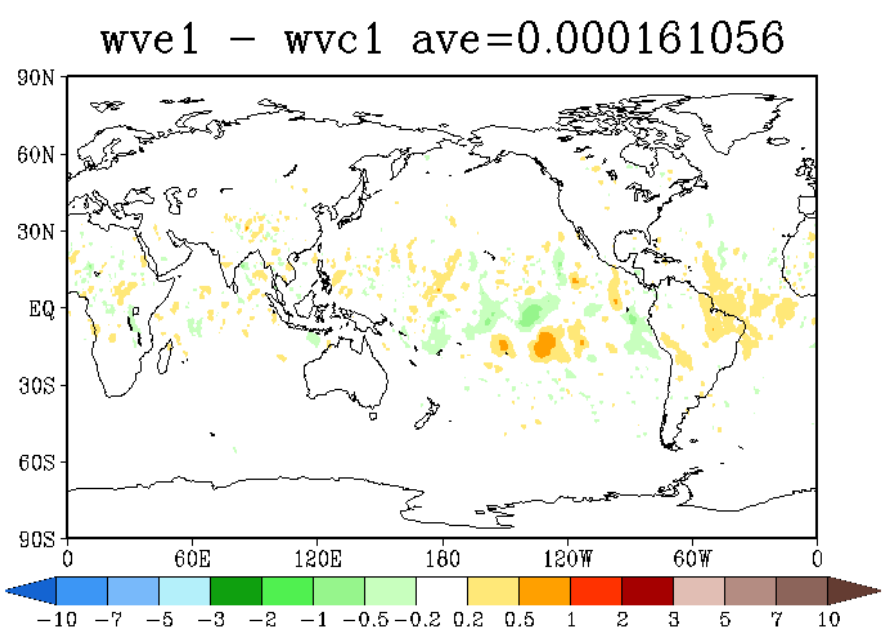


Aug Mean U & V at 350 hPA

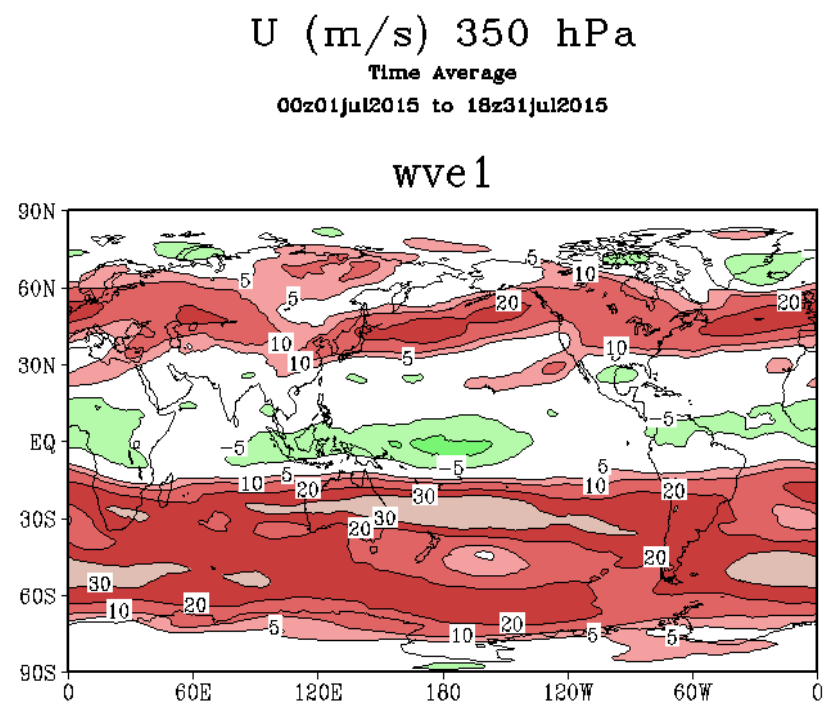


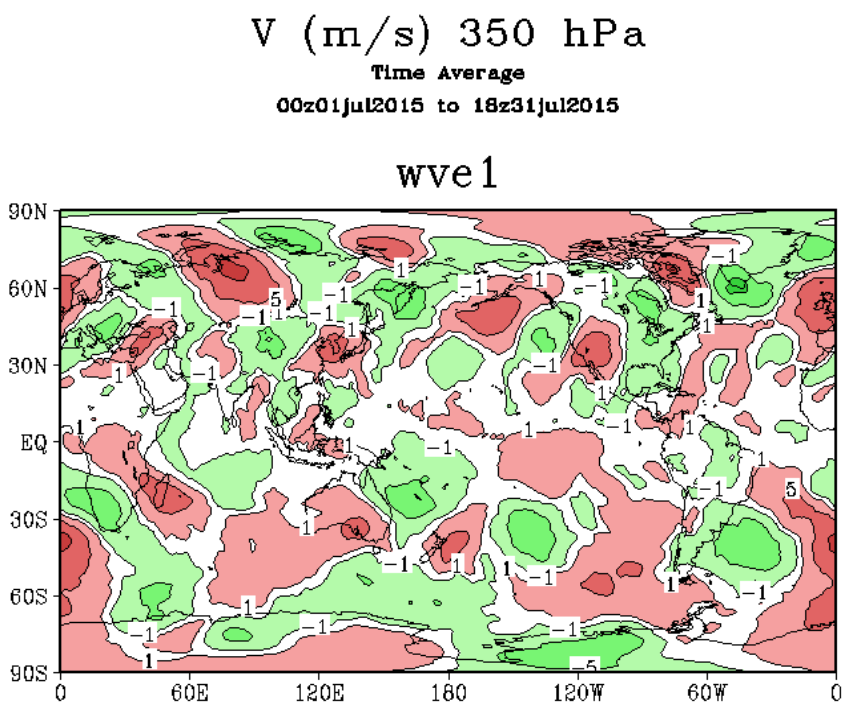


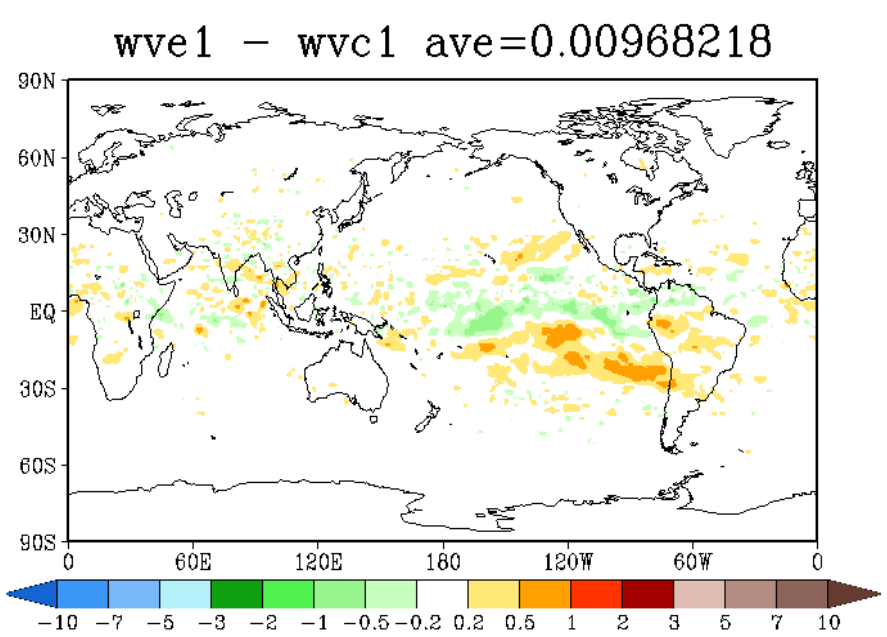


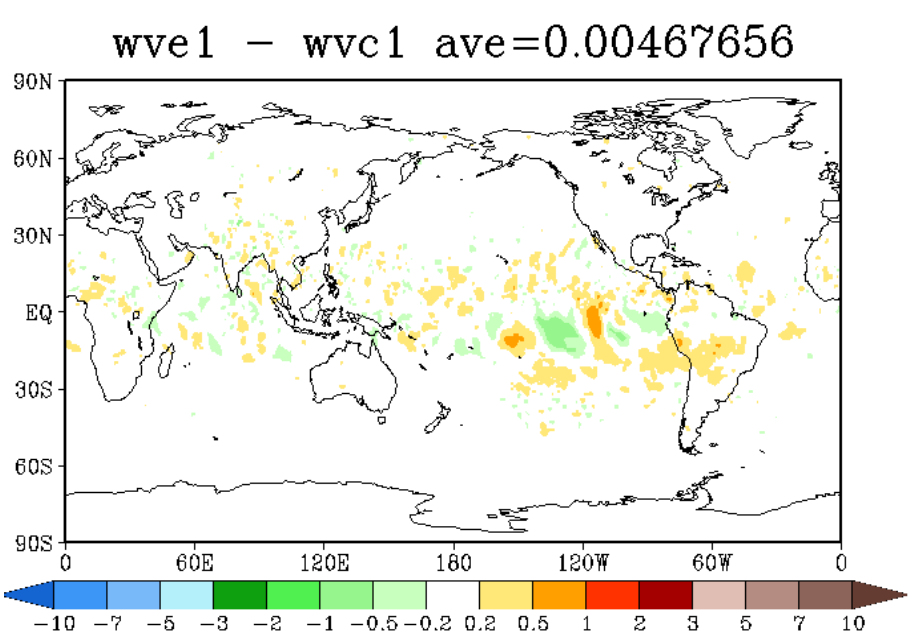


July Mean U & V at 350 hPA





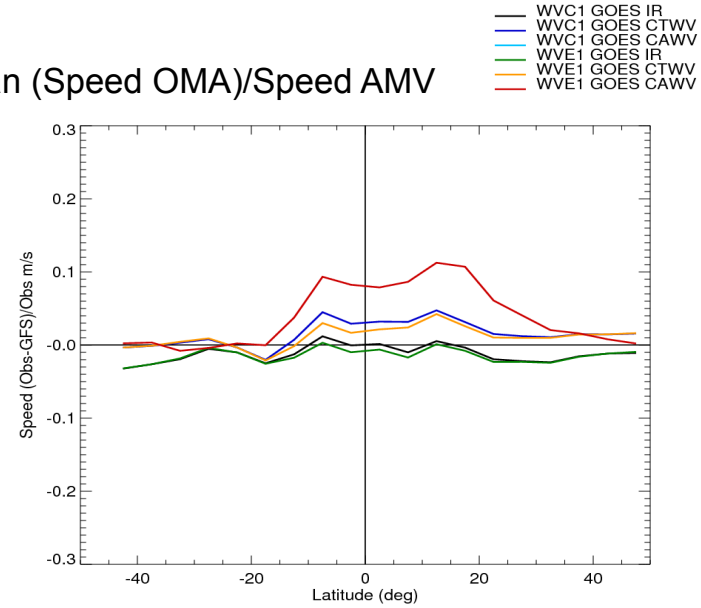




July OMA GOES CAWV, CTWV, IR

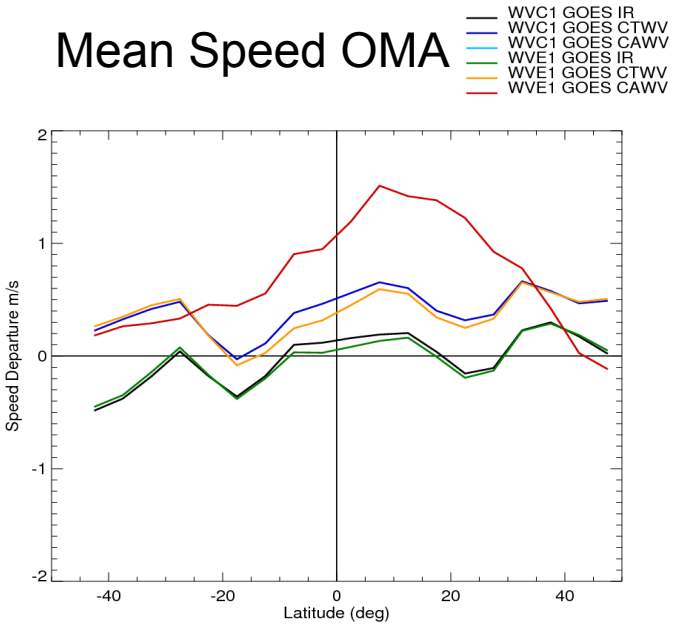
Anal use= 1.00 ALL Average Speed (Obs-GFS)/Obs m/s
Results for 2015090100 to 2015093018

Mean (Speed OMA)/Speed AMV



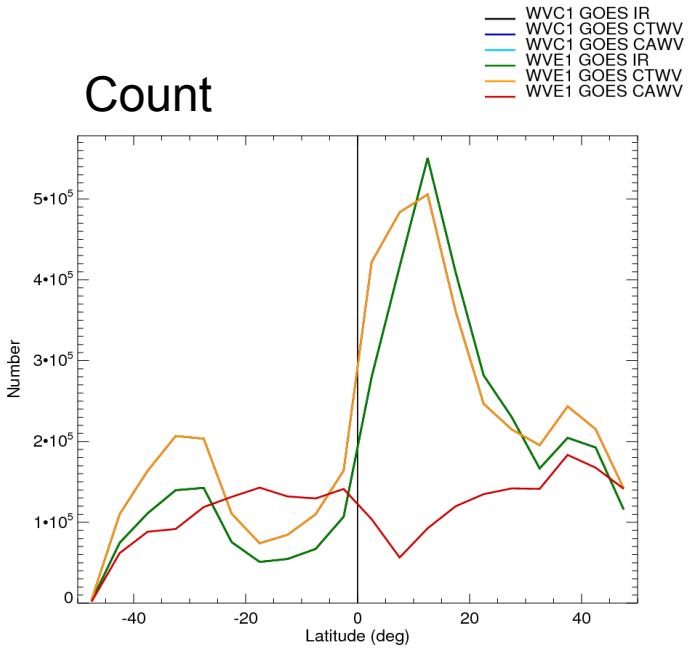
Anal use= 1.00 ALL Average Speed Departure m/s
Results for 2015070100 to 2015073118

Mean Speed OMA



Results for 2015070100 to 2015073118

Count



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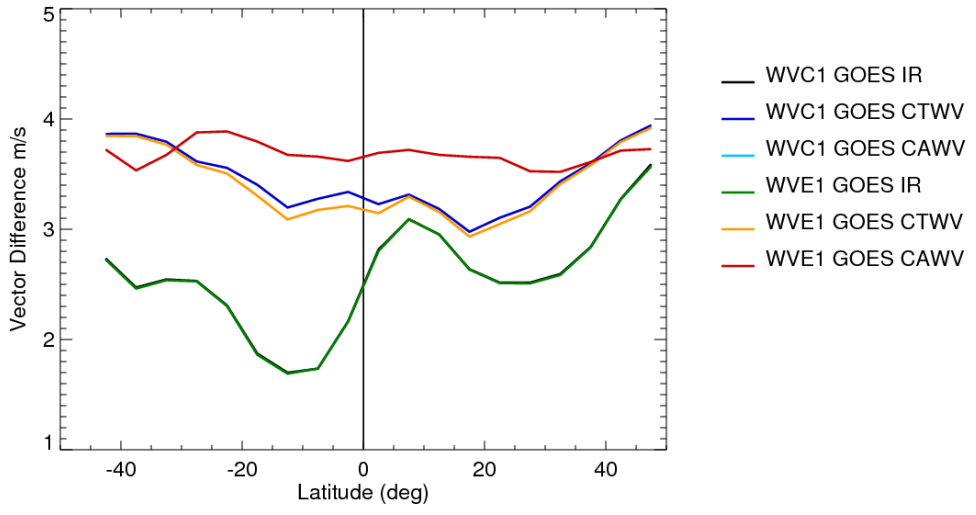
RMS VD OMA