Forecast Impact of GOES-13 and -15 Winds Derived Using GOES-R AMV Derivation Scheme on JMA NWP System

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CONTENTS

- Introduction
- Expected change of characteristics in GOES AMVs
- Quality of AMVs computed by GOES-R algorithm
- Assimilation experiment
- Summary and future plans

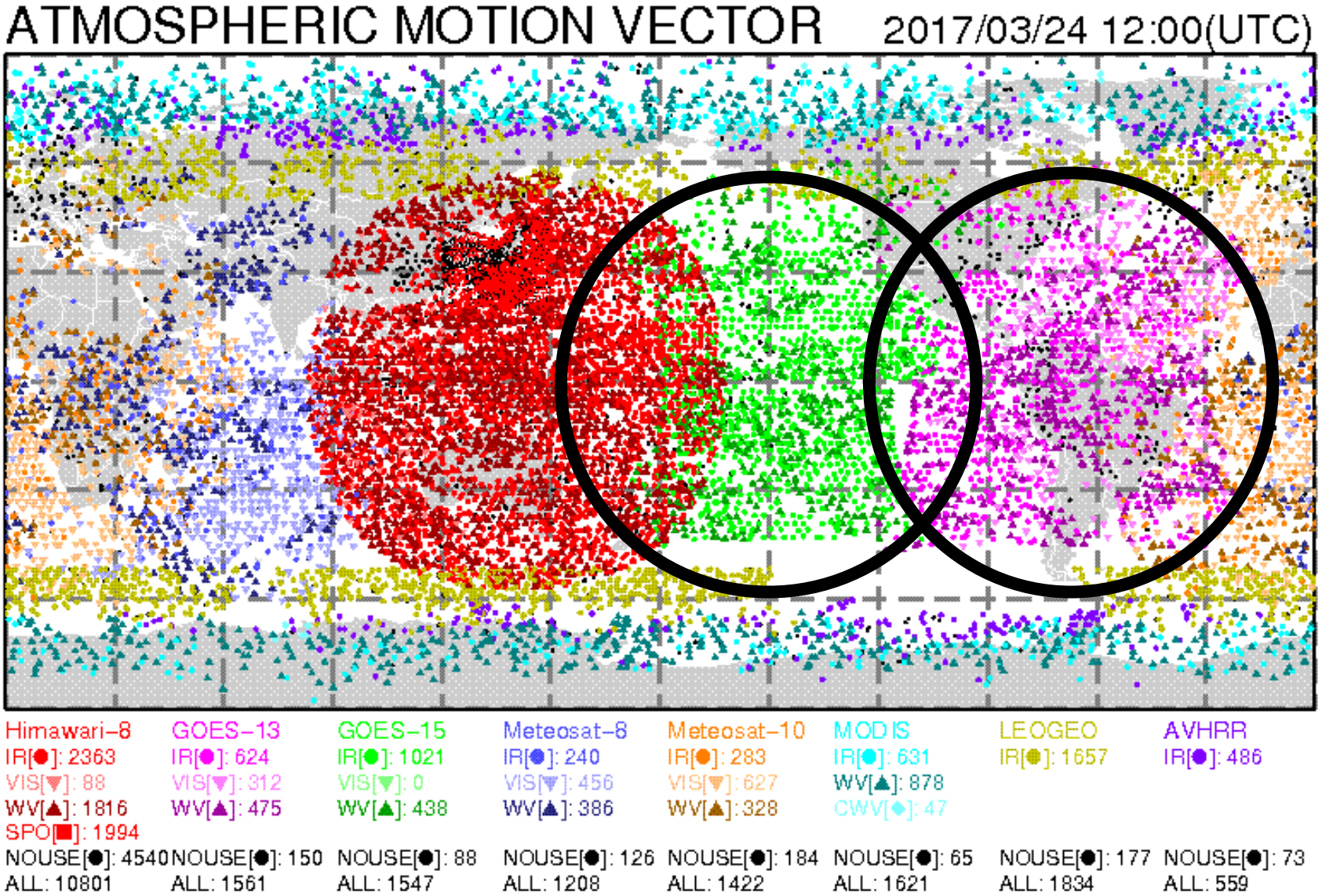
Introduction

- NOAA / NESDIS has developed an AMV derivation algorithm for the start of operation of the third generation geostationary meteorological satellite GOES - 16. This algorithm is called GOES-R AMV algorithm.

- NOAA / NESDIS has started to compute and disseminate GOES-13 and -15 AMVs by the GOES-R algorithm. These AMVs by new algorithm become available on Spring 2018.

- In order to investigate the change of the characteristics of AMV from GOES-13 and -15 with the GOES-R algorithm and the impact on NWP, assimilation experiments were run.

AMV coverage map of JMA GSM



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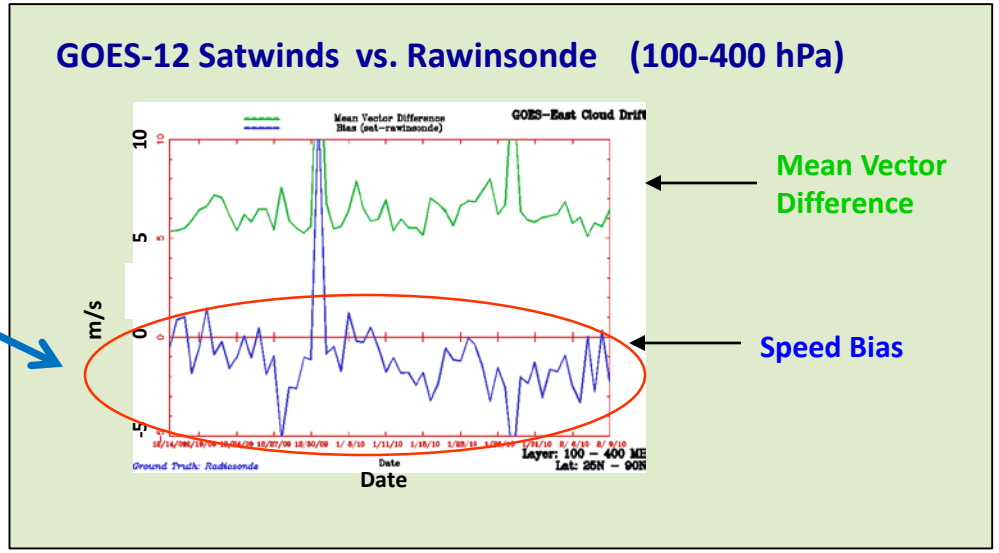
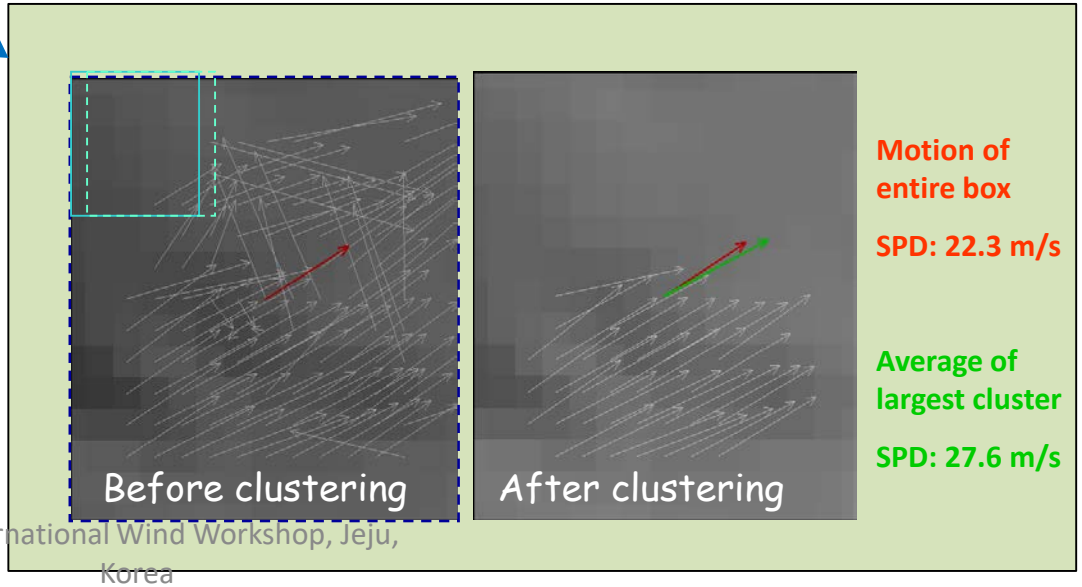
Nested Tracking Approach

- Designed to minimize observed slow speed bias of satellite winds; a long standing concern of the NWP community
- Computes local motions (nested) within a larger target scene, together with a clustering algorithm, to arrive at a motion solution(s)
- Potential for determination of motion at different levels and/or different scales
- Cloud heights at pixels belonging to the largest cluster are used to assign a representative height to the derived motion wind

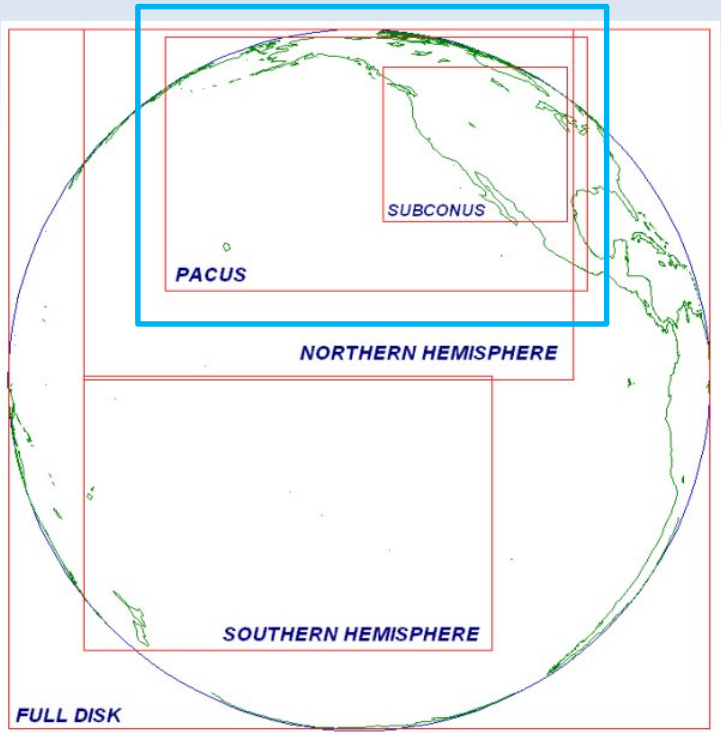




Courtesy of Jaime Daniels (from IWW12 talk)

Observation schedule of GOES-13 and -15

GOES-15

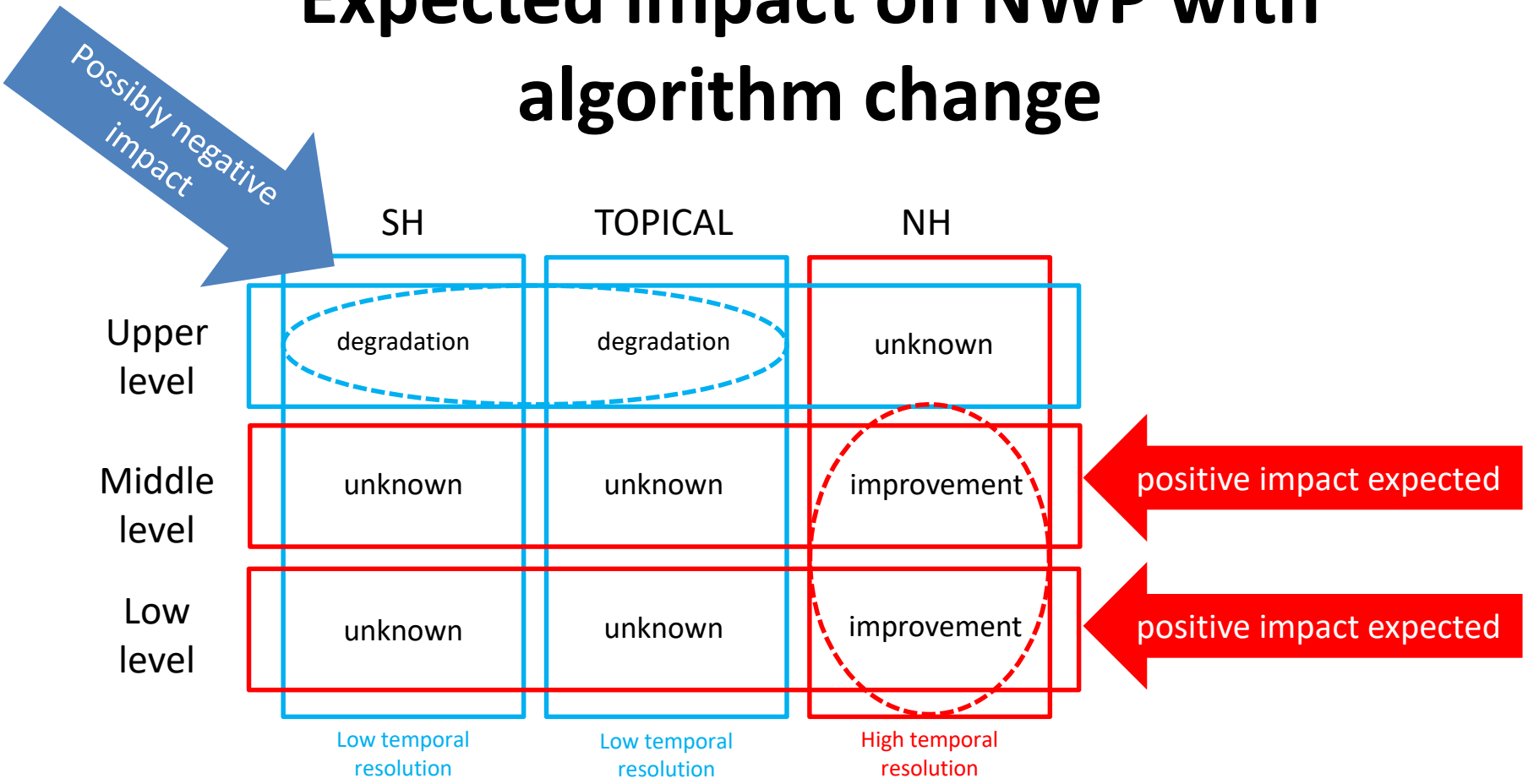


GOES-13

- North America area observed every 15 minutes
- Other areas are observed every 30 minutes

Good impact around the USA (15 minute observation area) is expected.
But in 30 minutes observation area, there is a possibility of decrease in spatial coverage and quality.

Expected impact on NWP with algorithm change



- Accuracy increases in the northern hemisphere (good even for small target sizes because the observation frequency is high)
- Accuracy decreases in tropical and southern hemisphere (disadvantage of using small target size because observation frequency is low)
- Accuracy improves for middle and lower layer AMV (cloud features are easily captured even with small target size)
- The accuracy of the upper layer AMV decreases (features of the upper cloud are difficult to track by small target sizes)
- The accuracy of water vapor AMV decreases (it is difficult to follow because water vapor image features are poor at small target sizes)
- The accuracy of the upper layer AMV of the summer hemisphere decreases (the number of upper clouds increases = the number of targets with less features increases)

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- Quality of AMVs computed by GOES-R algorithm
- Changes of forecast and analysis fields
- Summary and future plans

GOES - 15 IR AMV : O-B histogram of low level (700hPa-ground)

summer

winter

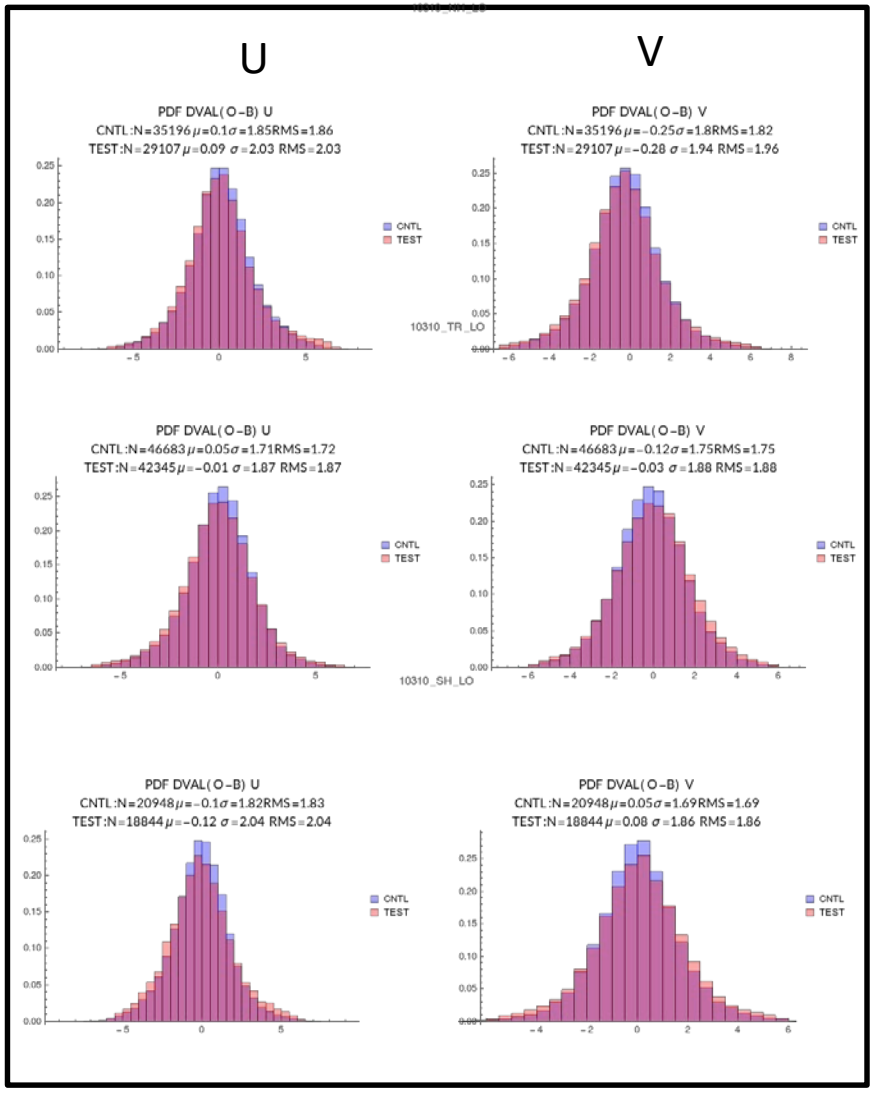
U

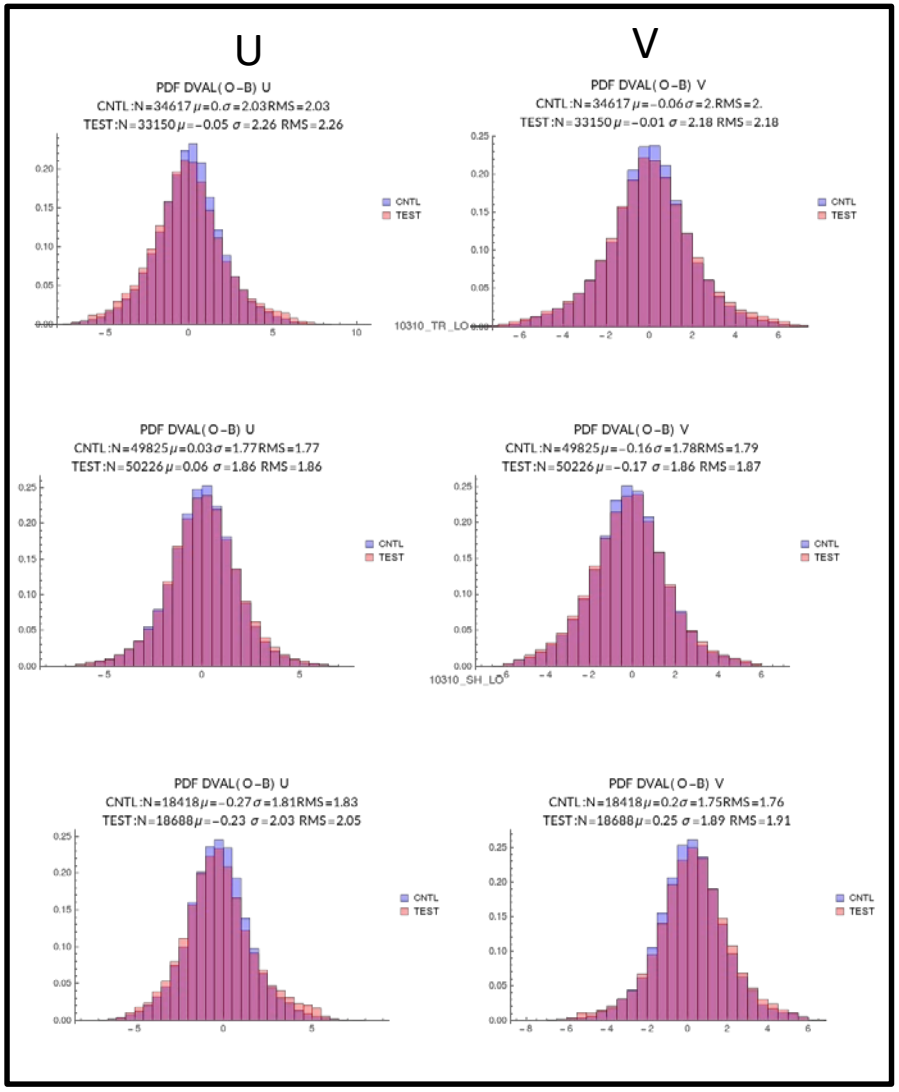
V

NH

TR

SH





- The IR low level AMV has almost the same characteristics as the heritage AMV
- peak of PDF has declined (standard deviation become larger)

RED:GOES-R algorithm

BLUE: heritage

GOES-15 IR AMV : O-B histogram of upper level (100-400hPa)

summer

winter

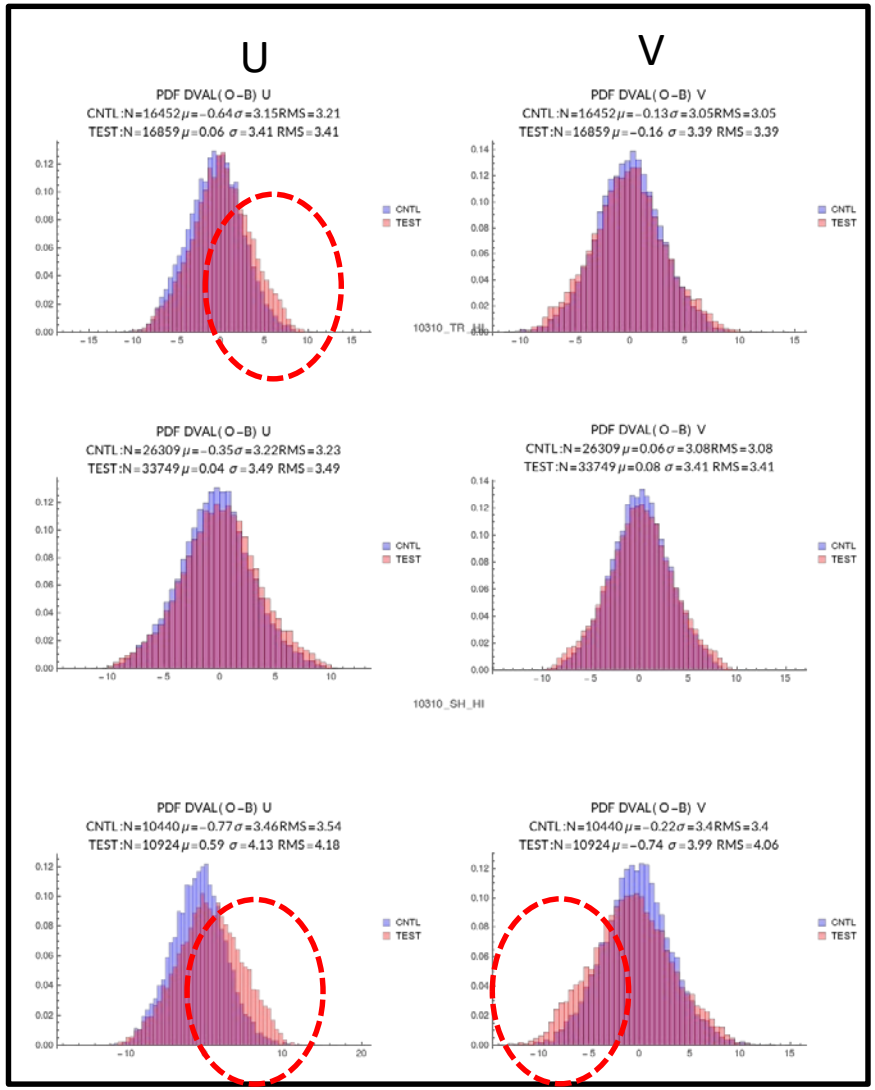
NH

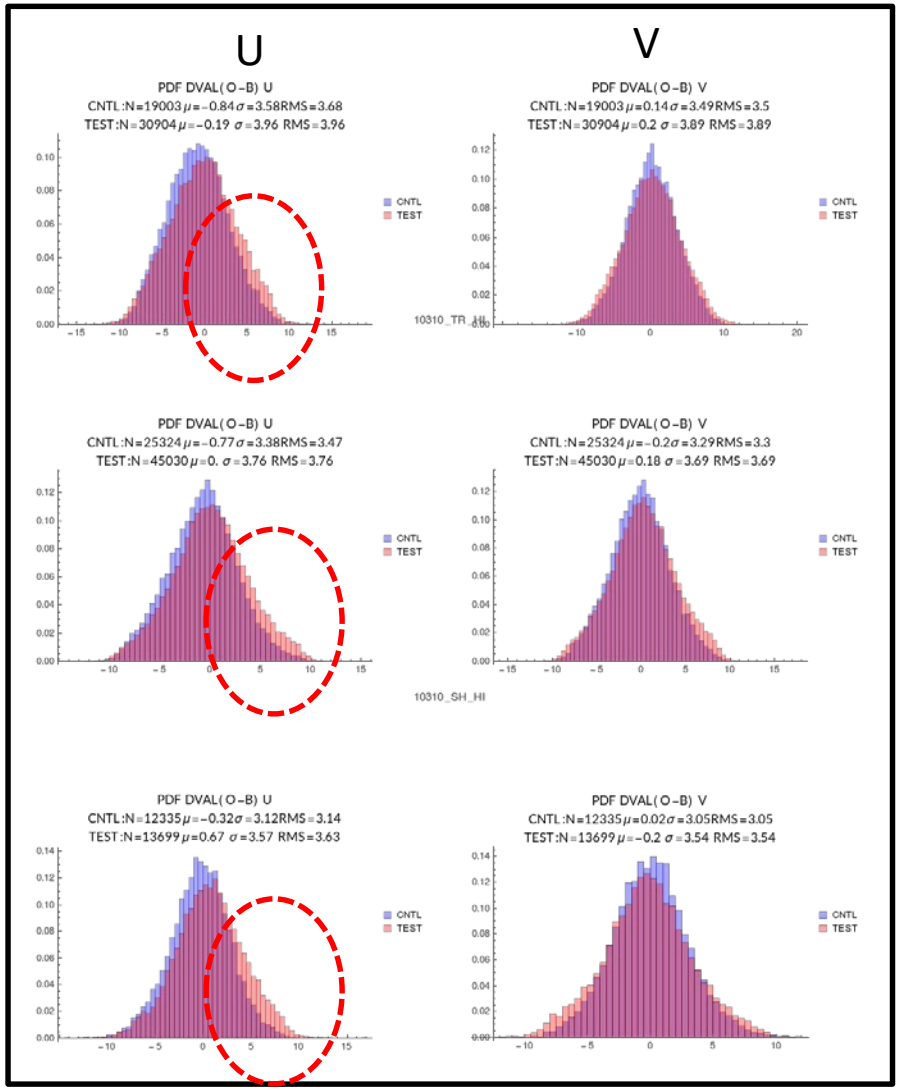
TR

SH

U

V





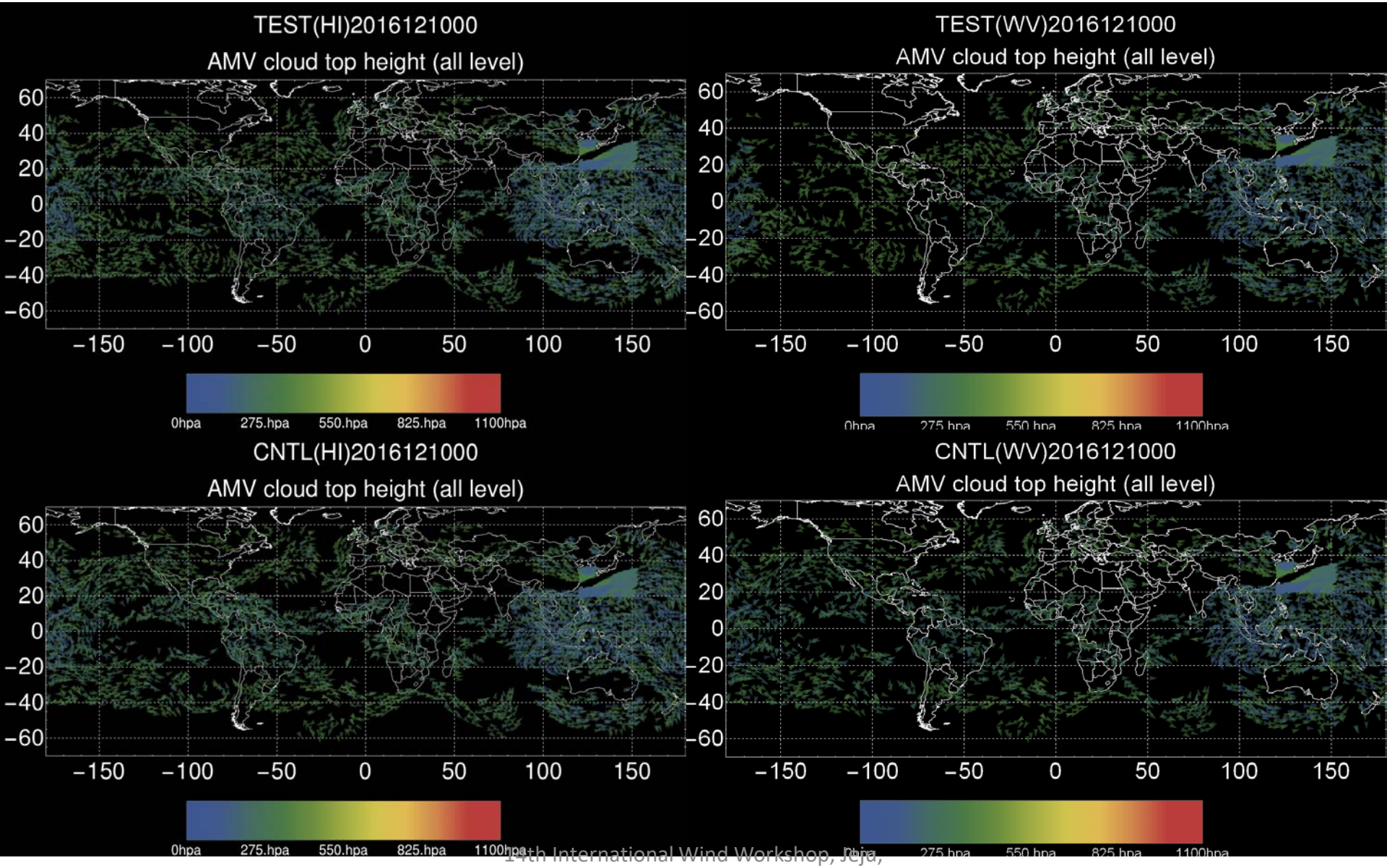
- accuracy seems to be degraded
- unnatural skewness appears in PDF

RED:GOES-R algorithm BLUE: heritage

Spatial coverage of upper level AMV (used data)

IR(upper)+WV

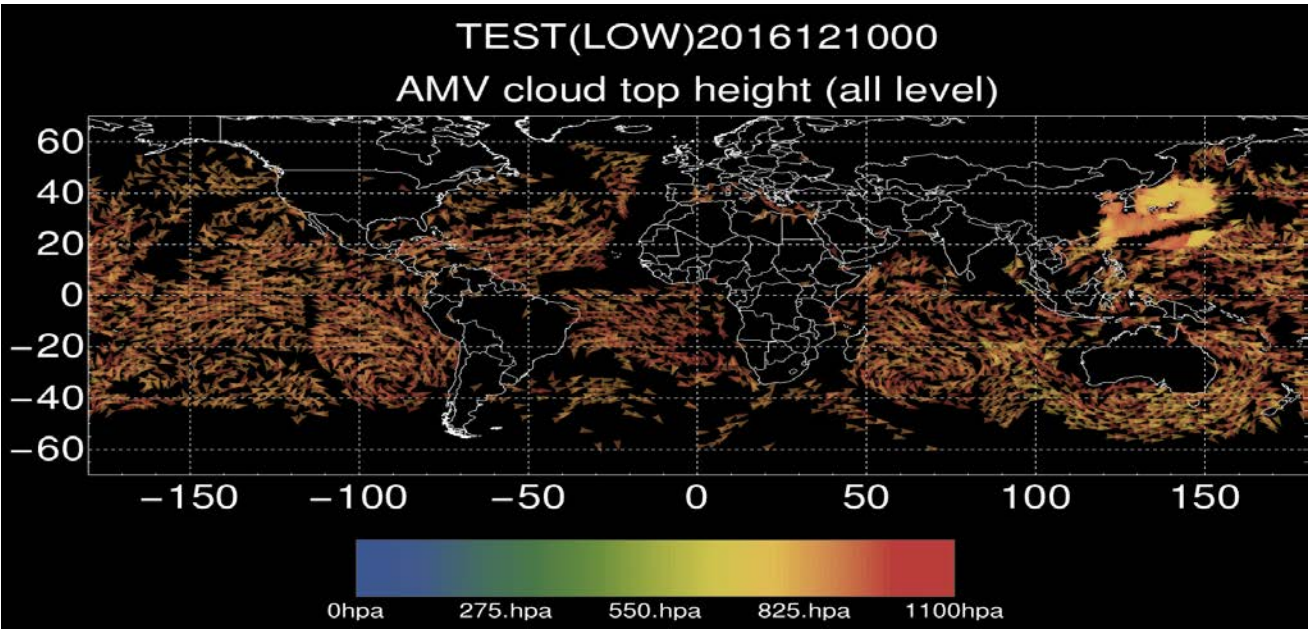
WV only

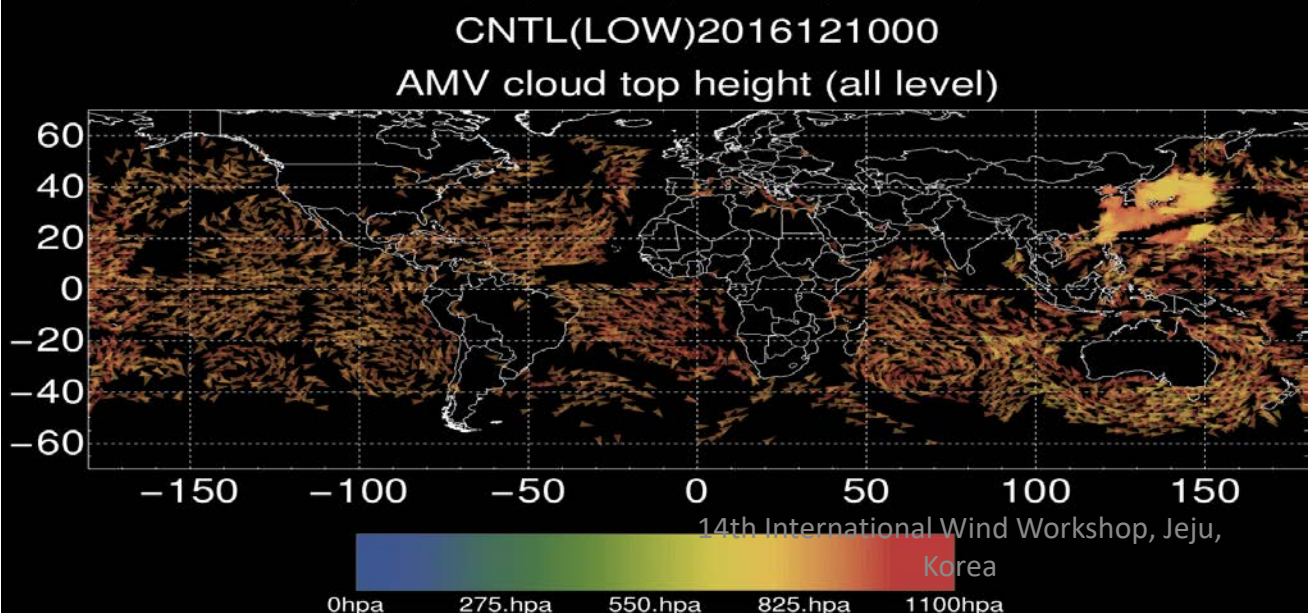


- Coverage reduction with WV AMV around the Amazon area

Spatial coverage of low level AMV (used data)

IR（low）+VIS





- **No significant change on coverage**

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Experimental design for global NWP system

CNTL : GOES-13 and 15 AMV by heritage algorithm
TEST : GOES-13 and 15 AMV by GOES-R algorithm
BASE : both of GOES-13 and 15 AMV rejected

- Assimilation scheme: 4D-Var
  - Outer: TL959(20 km) , 100 Layers up to 0.01 hPa
  - Inner: TL319(55 km) , 100 Layers up to 0.01 hPa
- Forecast scheme
  - TL959(20 km), 100 Layers up to 0.01 hPa

- Verification period
  - Summer season :
    - analysis : 2016/08/21 – 2016/10/11
    - forecast : 2016/09/01 – 2016/09/30
  - Winter season :
    - analysis : 2016/12/21 – 2017/02/11
    - forecast : 2017/01/01 – 2017/01/31

✓ scheme of the 200 km thinning in the 6 hour time window for all experiments
✓ QC (QI > 60 and reject mid-level) and observation error are same for all experiments

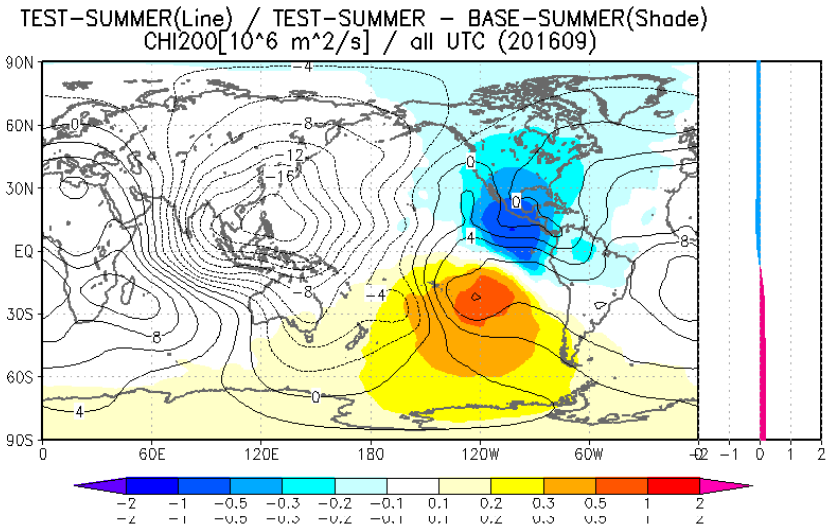
Change in Analysis Field (summer: upper level)

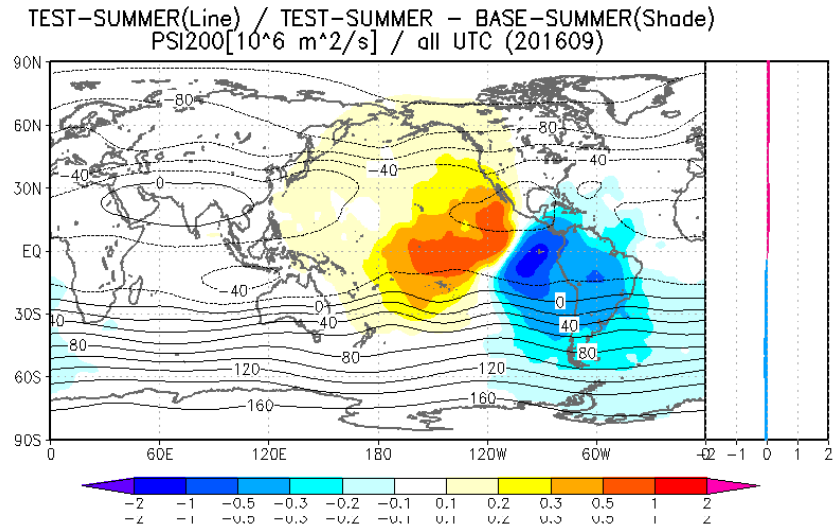
CHI200

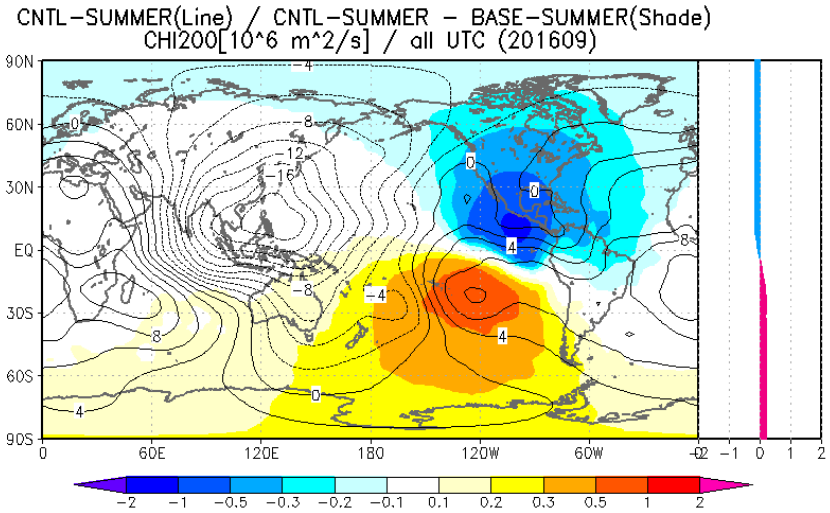
PSI200

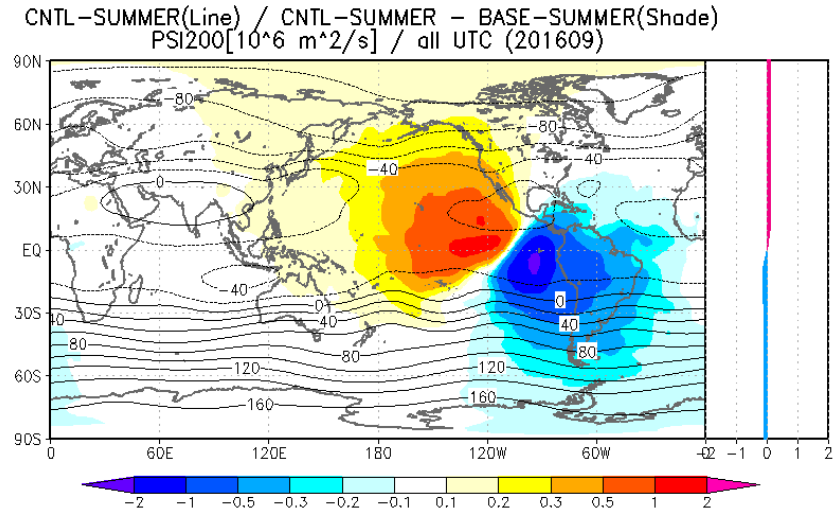
TEST-BASE

CNTL-BASE









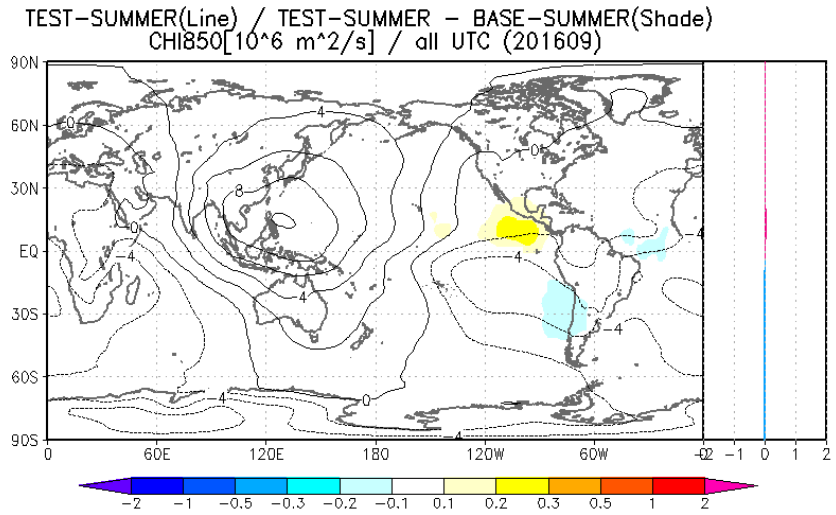
- Both enhance water vapor flow from summer hemisphere to winter hemisphere
- Impact on the analysis field is relatively smaller in TEST than CNTL

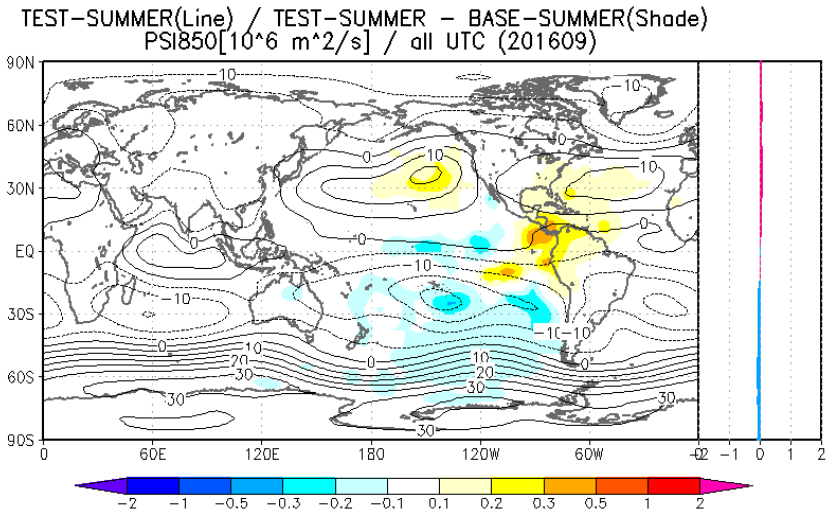
Change in Analysis Field (summer: low level)

CHI850

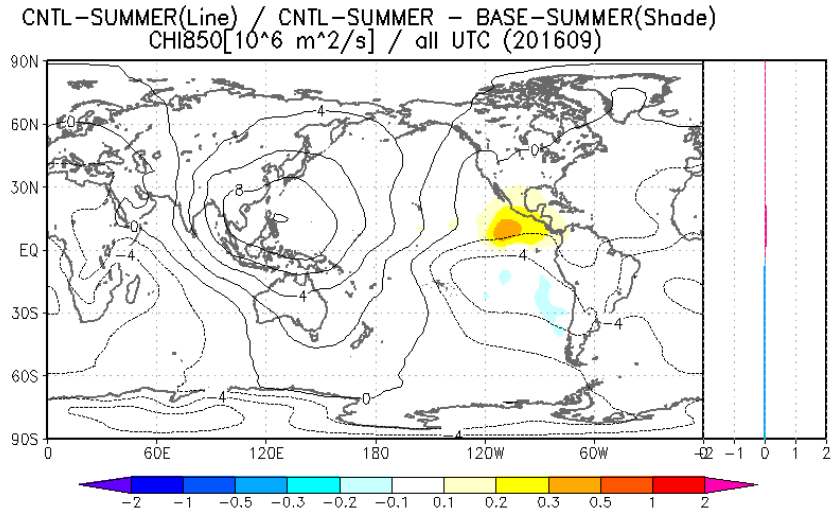
PSI850

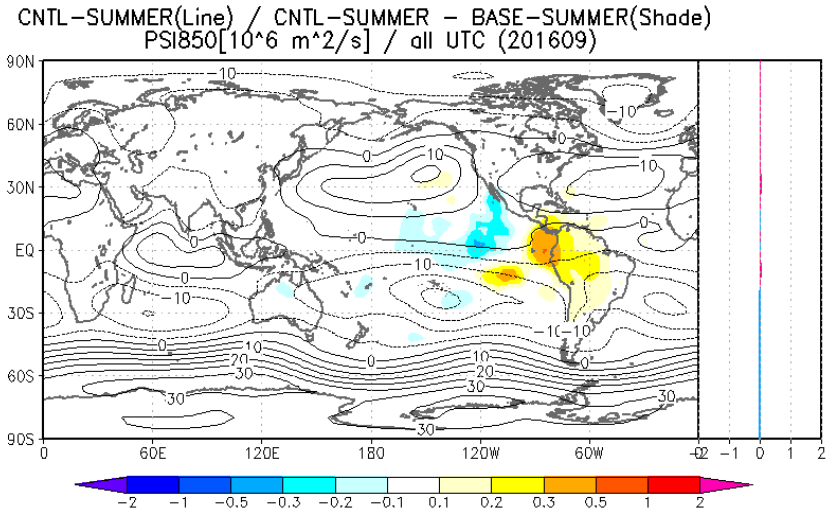
TEST-BASE





CNTL-BASE

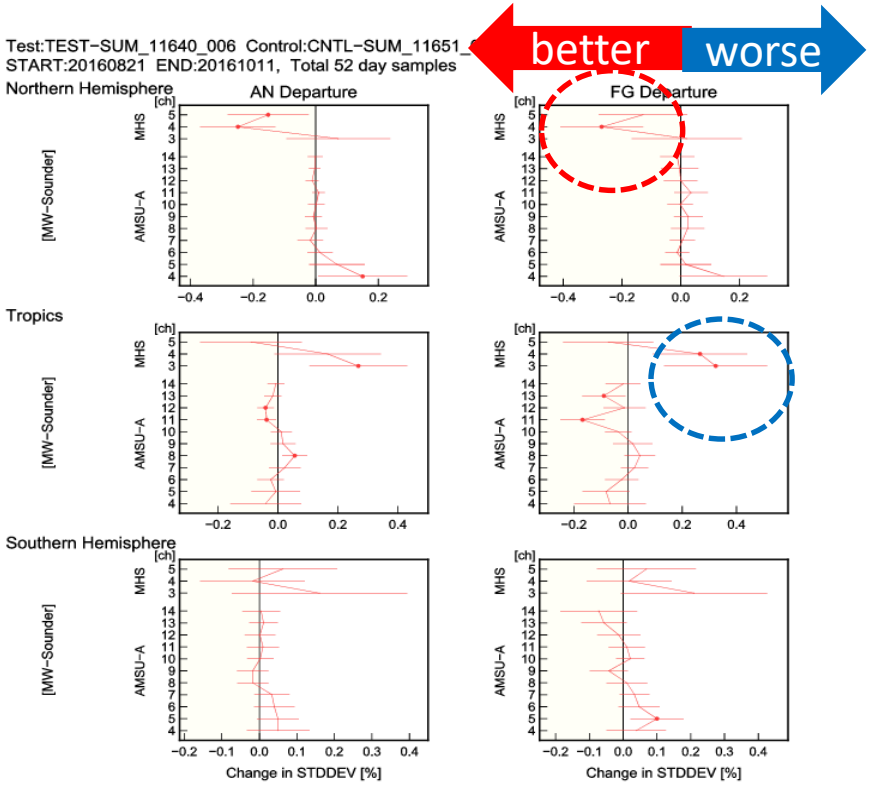




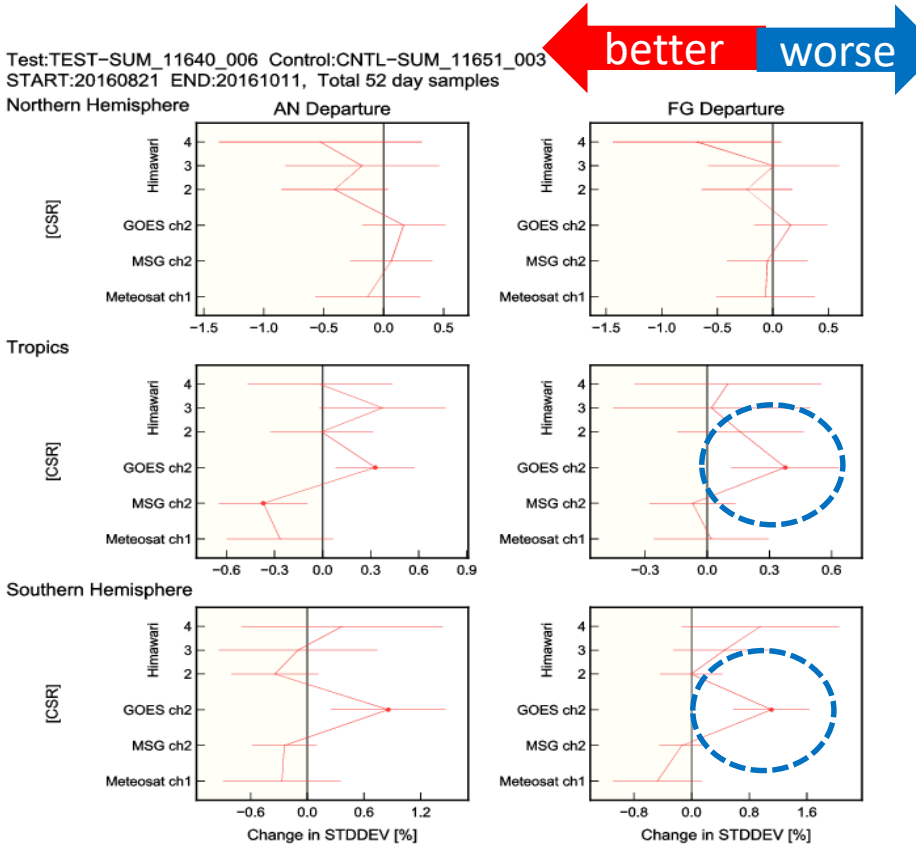
- Change of analysis field is larger in TEST than CNTL (opposite tendency to upper level)

Summer: Change in the Standard Deviation of FG for MW-SOUNDER and CSR

MW-SOUNDER

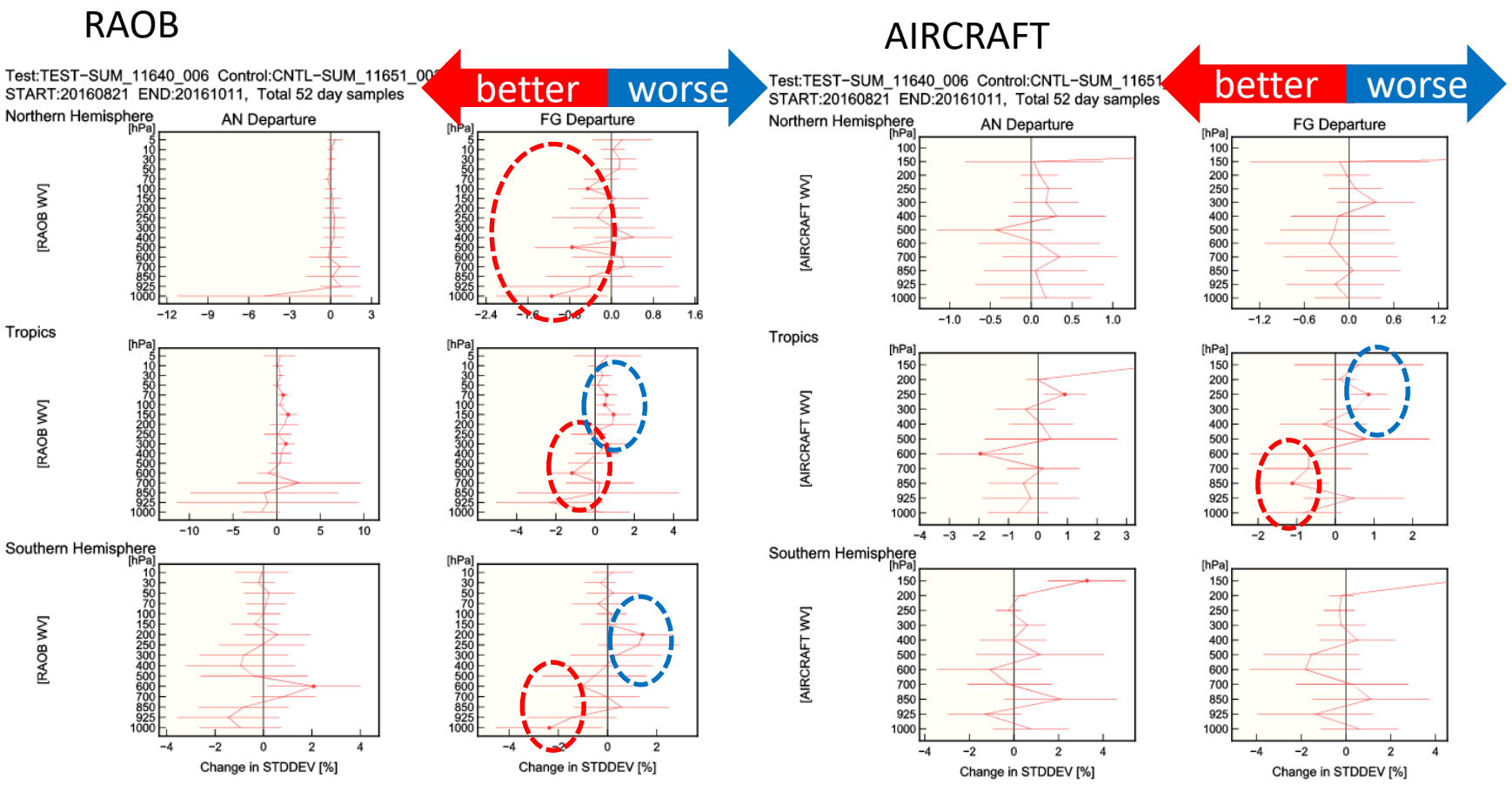


CSR



- STDV of O-A and O-B for MHS and CSR reduced in the northern hemisphere
- Conversely, the STDV increased in the tropical and southern hemisphere
- Information of the upper level water vapor flow improves in the northern hemisphere, but seems to be degraded in the tropical and the southern hemisphere

Summer: Change in the Standard Deviation of FG for wind observation (sonde, aircraft)

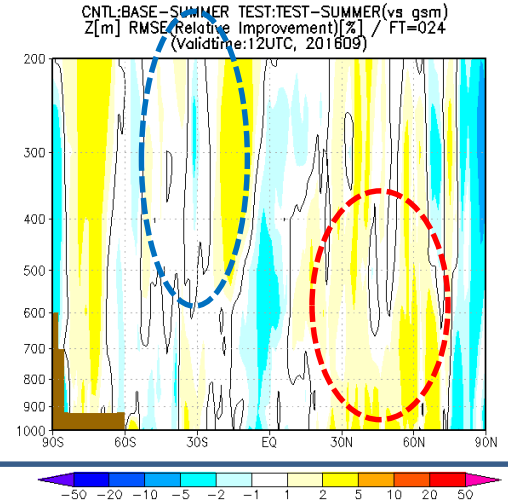


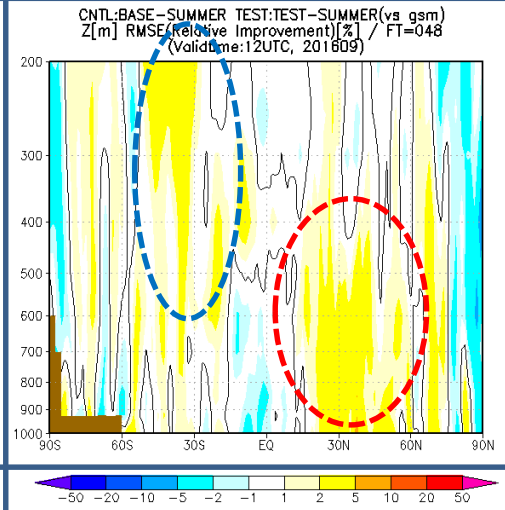
- Standard deviation in all level over the Northern Hemisphere (RAOB)
- Improve fit in the low level over the tropical and the southern hemisphere but degradation seen in upper level

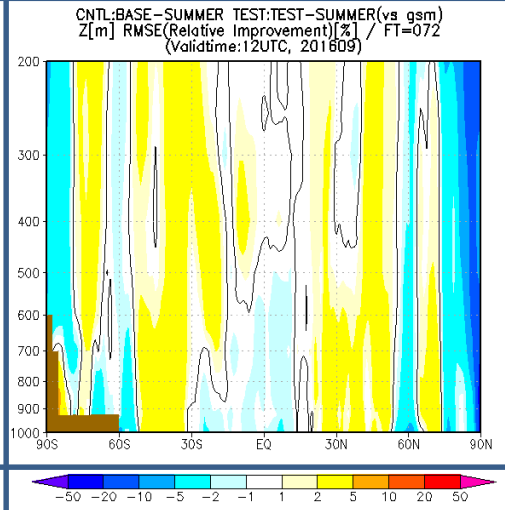
Summer: Change in Forecast RMS Error against Analysis for Geopotential Height

FT24 | FT48 | FT72

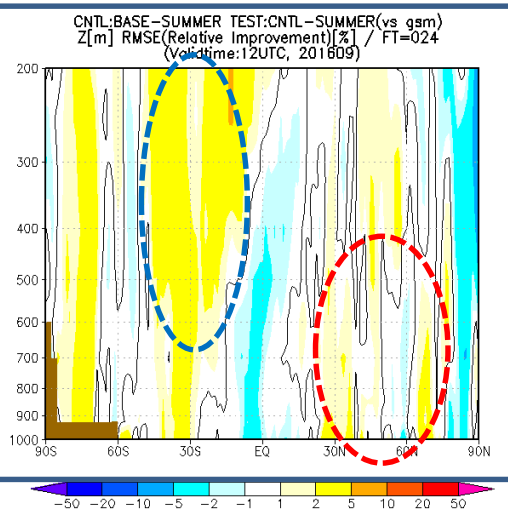
TEST-BASE

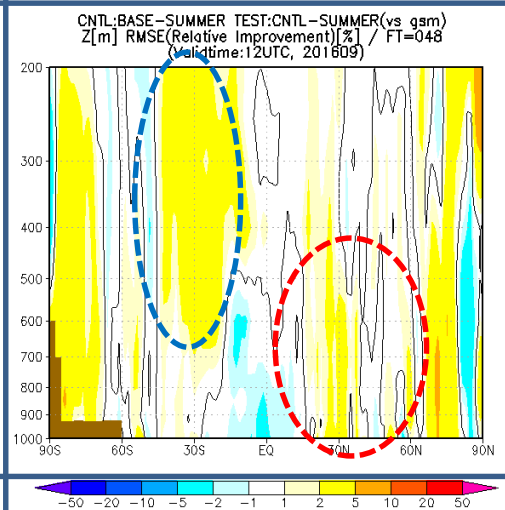


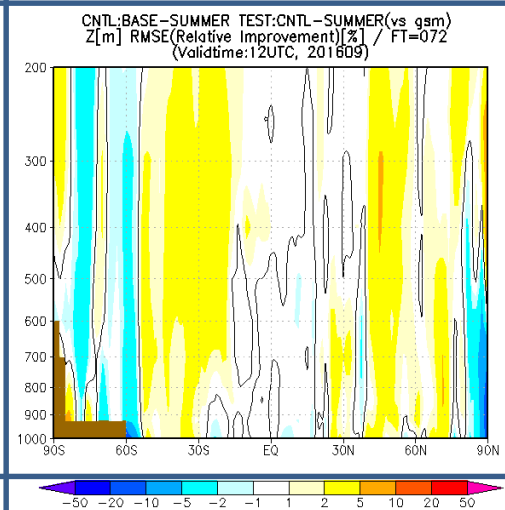




CNTL-BASE







- Error mitigated at low level over NH
- Error increased at upper and middle level over SH

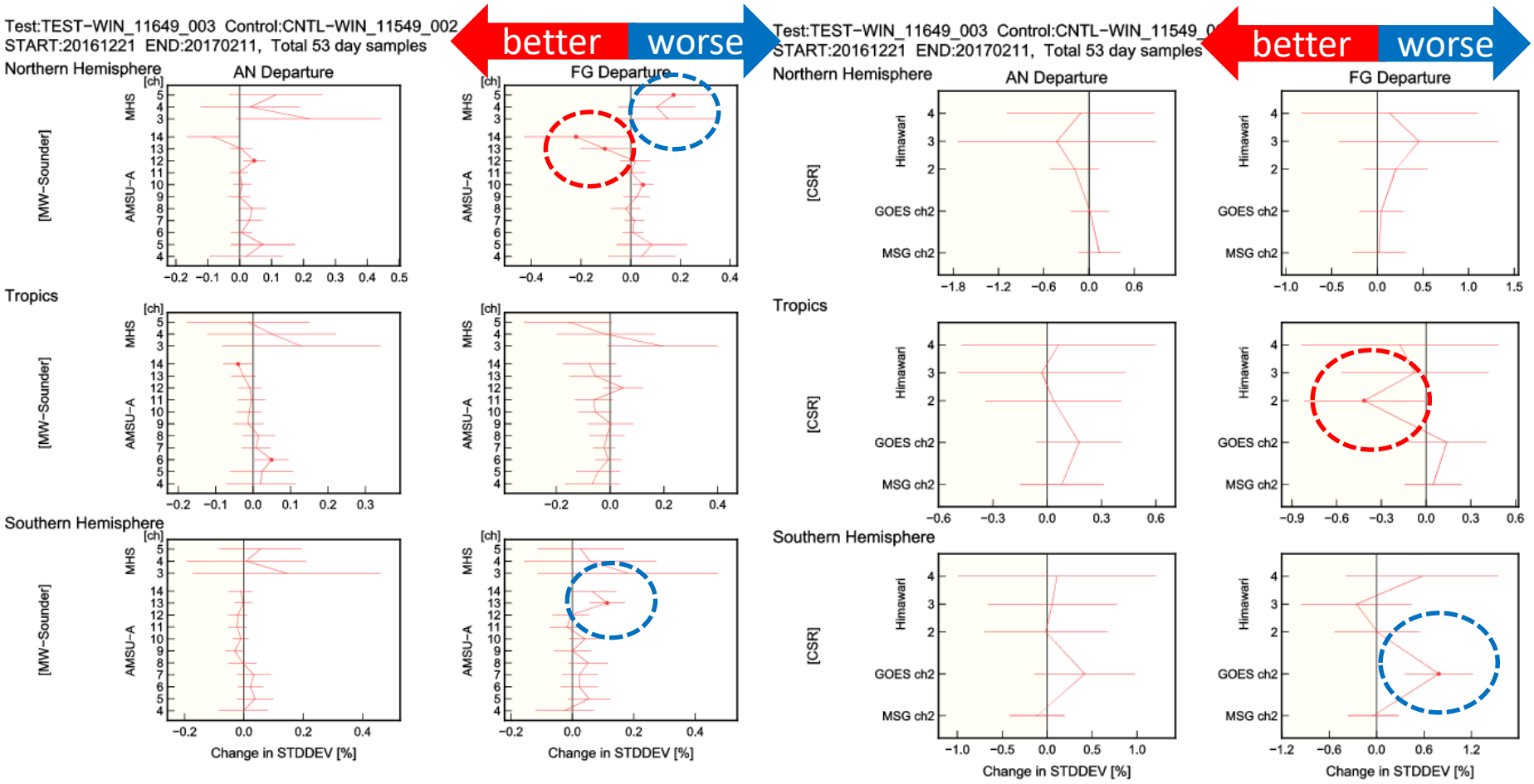
warmer color: RMS decreased

cooler color : RMS increased

Winter: Change in the Standard Deviation of FG for MW-SOUNDER and CSR)

MW-SOUNDER

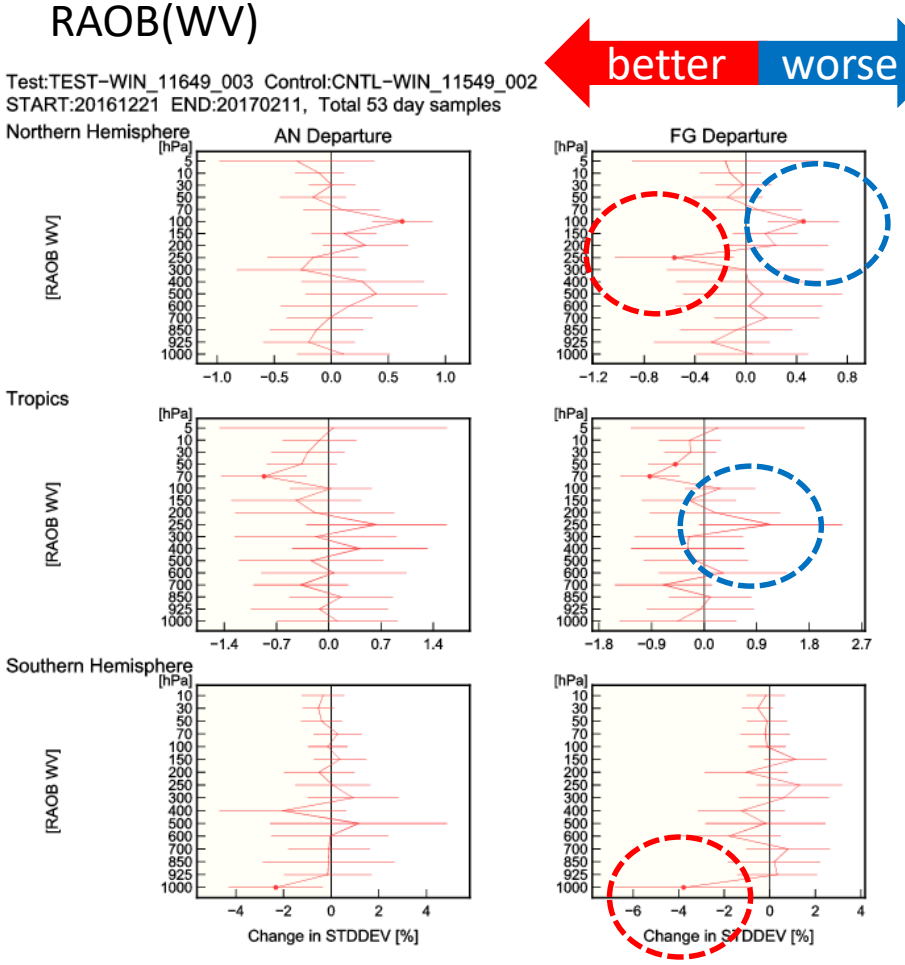
CSR



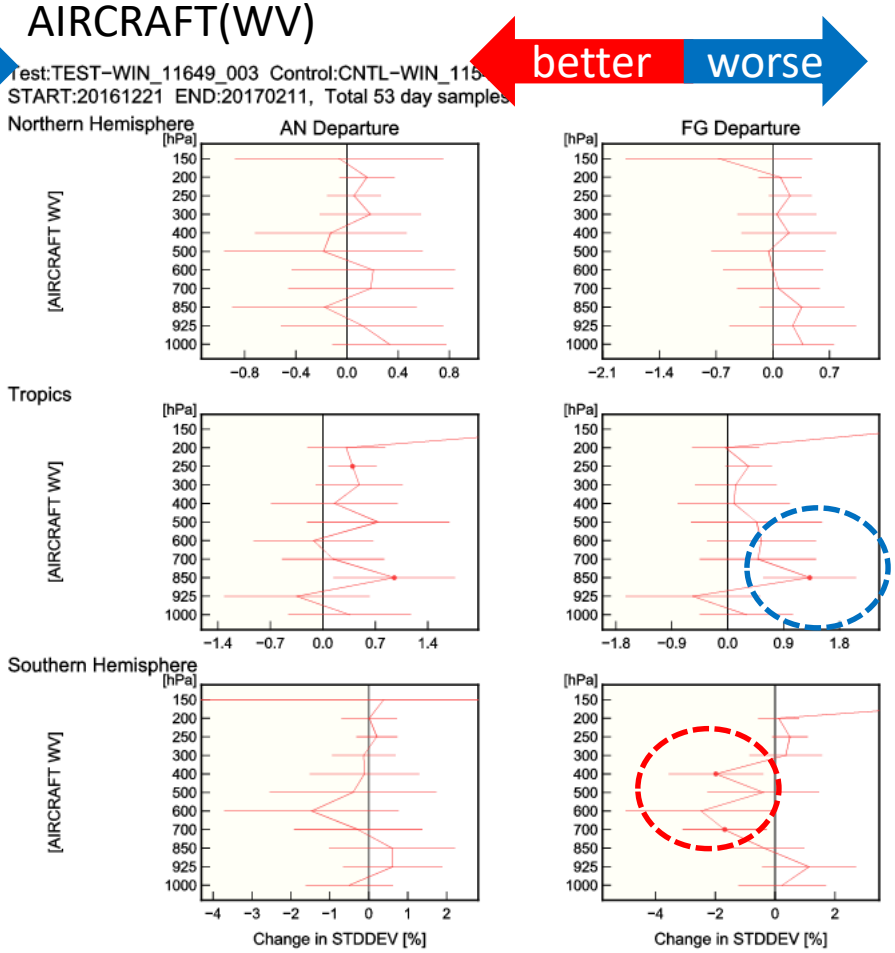
- STDV of FG for MHS increased over NH, but reduced to temperature-sensitive observation (AMSUA)
- STDV of FG for GOES-CSR increased over SH (WV flow at upper level debased)

Winter: Change in the Standard Deviation of FG for wind observation (sonde, aircraft)

RAOB(WV)

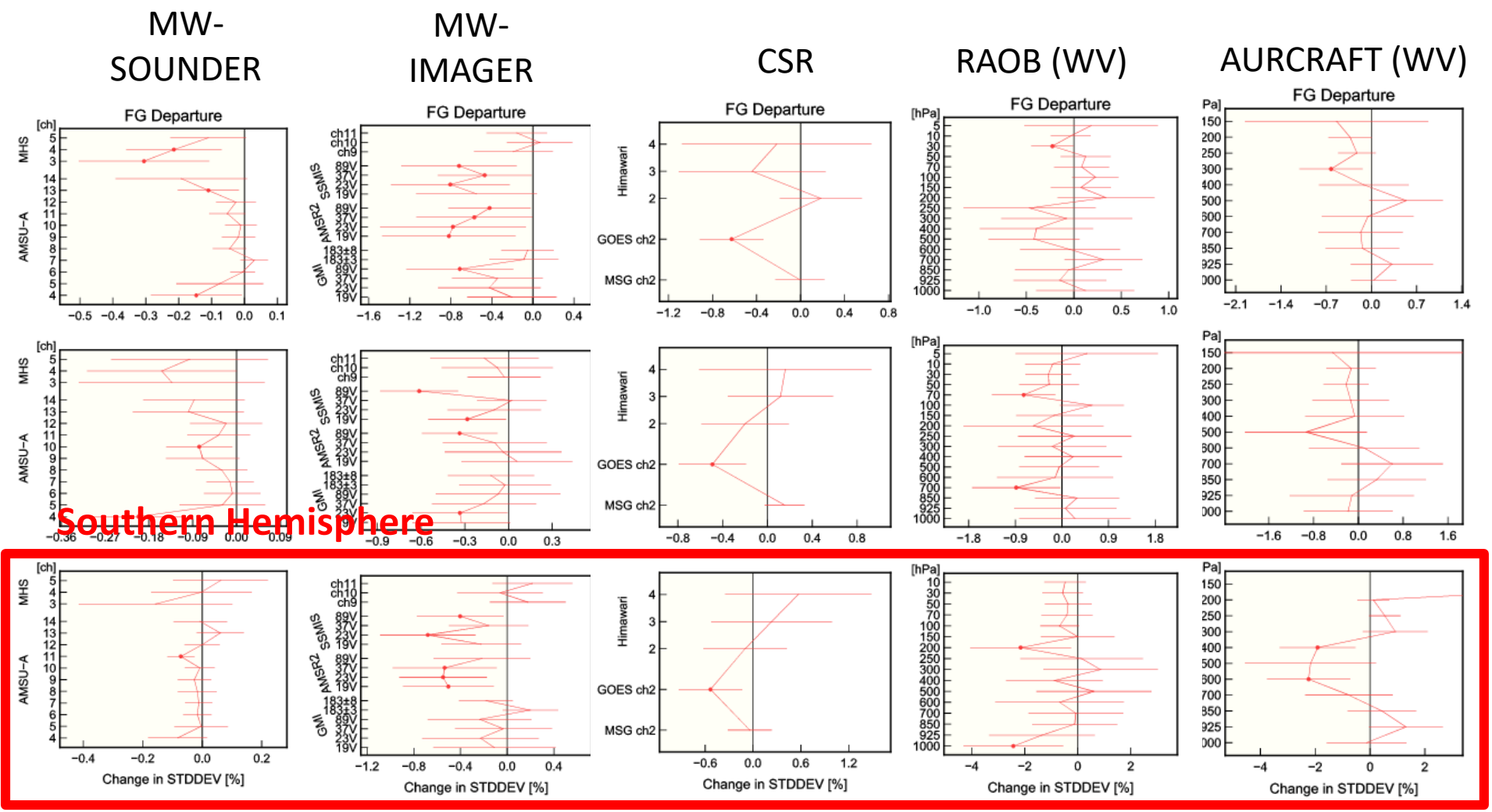


AIRCRAFT(WV)



- STDV of FG for sonde and aircraft wind observation reduced at low level over SH
- Error increase seen over the tropic

Observation fit to TEST-BASE

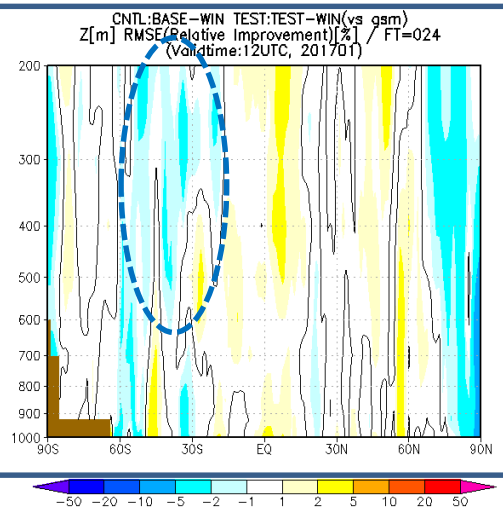


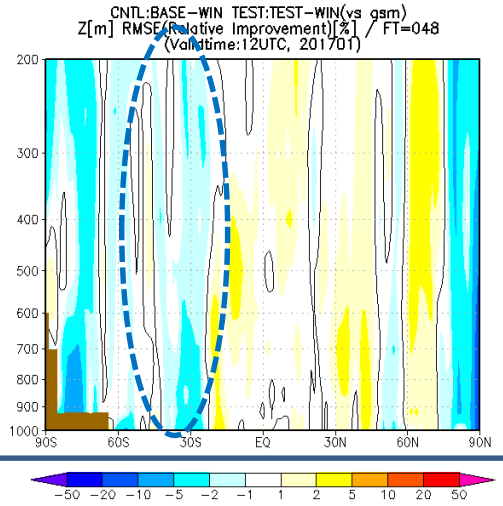
- TEST is better than BASE for many other observation….

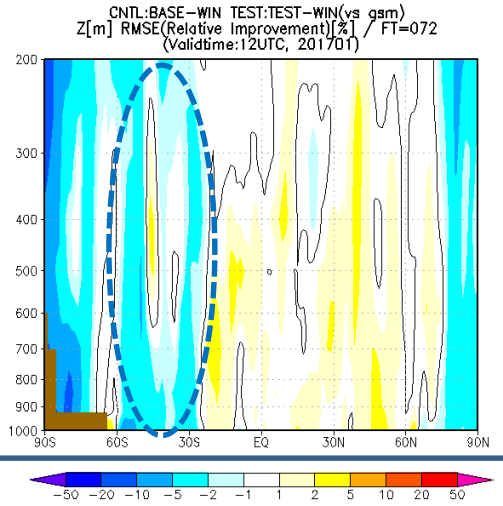
Winter: change in forecast RMS error against analysis for geopotential height

FT24 | FT48 | FT72

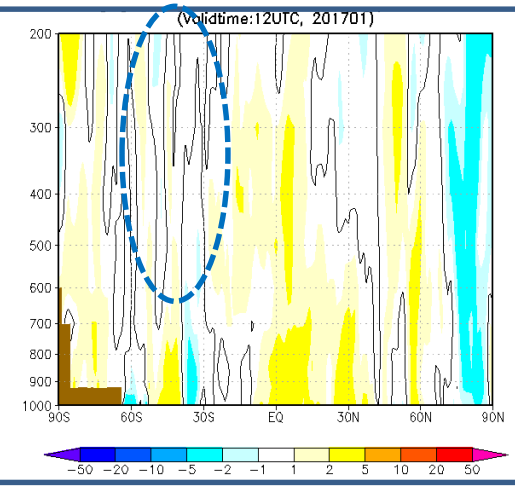
TEST-BASE

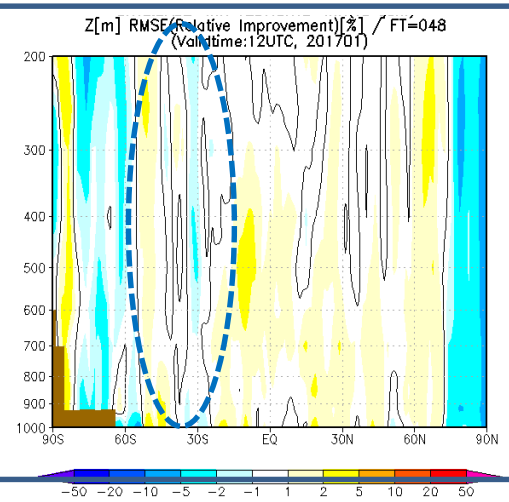


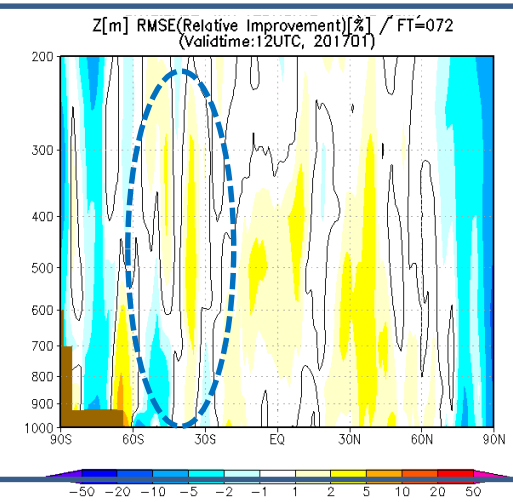




CNTL-BASE







- RMS increased even against BASE over SH

warmer color: RMS decreased

cooler color : RMS increased

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Summary (1)

- Expected change in characteristics of GOES-13 and -15 AMVs by GOES-R algorithm
  - ✓ Advantageous over the northern hemisphere due to observation frequency
  - ✓ Disadvantageous over the tropic and the Southern hemisphere instead
  - ✓ Advantageous to low level AMV by using small target box (smaller scale observable and image feature seems to be sufficient to track)
  - ✓ Disadvantageous to upper level (WV) AMV expected: image feature of upper level clouds which generally shows spatially very homogeneous are not sufficient to track using very small target box size

- Quality of GOES-13 and -15 AMV computed by GOES-R algorithm
  - ✓ standard deviation of O-B is comparable to that by heritage at low level
  - ✓ PDF of O-B shows skewness and reduction of spatial coverage with upper level AMVs over a specific area (around Amazon area)

Summary (2)

- Changes to analysis field
  - ✓ Effect to enhance atmospheric circulation is very similar with heritage AMV
  - ✓ Summer season: STDV of FG for other observation reduced over NH, but increased over the tropical and southern hemisphere.
  - ✓ Winter season: STDV of FG for WV-sensitive observation increase over SH, but STDV for wind observation is mitigated
- Changes to forecast field
  - ✓ Summer season over NH: forecast improved (TEST > CNTL > BASE)
  - ✓ Summer season over SH: forecast accuracy improved (CNTL > TEST > BASE)
  - ✓ Winter season over NH : forecast accuracy improved (CNTL > TEST > BASE)
  - ✓ Winter season over SH : forecast error increased (CNTL > BASE > TEST) but change of FG for observation data shows improvement

Some benefits for NWP can be confirmed over the northern hemisphere (high temporal resolution area). But similar positive change can not be seen over the tropic and the southern hemisphere (low temporal resolution area).

Future plans

- Evaluation and operational use for GOES-16 AMV
- Dynamic QC of situation-dependent error
- Adjustment of observation error
- Assimilation of Himawari-8 Rapid Scan AMVs for regional and limited-area models
- Introduction of QC not using QI with forecast
- Development of height correction method using clustering method
- Use of S-NPP/VIIRS, Dual Metop /AVHRR, Terra/MISR and Aqua/AIRS