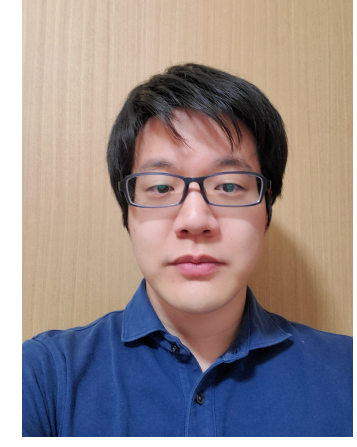


# Addition of microwave humidity sounder radiance data to all-sky assimilation in the JMA global NWP system

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## 1. Introduction

Microwave radiance data contain various information on geophysical parameters, e.g., **atmospheric temperature, water vapor, clouds, precipitation, surface wind** and **surface temperature** over ocean. To obtain water vapor information from cloudy and rainy areas, JMA began all-sky microwave radiance assimilation in the operational global NWP system on 11 December 2019.

All-sky assimilation scheme was applied to several microwave humidity sounders and microwave imagers. All-sky assimilation **improved forecast score (e.g. Z500 RMSE) and TC track forecasts**. However, some microwave humidity sounders have yet been assimilated in clear-sky condition.

Status of all-sky MW radiance assimilation developments in JMA global NWP system as of June 1, 2021

	All-sky assimilation	Clear-sky assimilation	Passive
MW - Humidity sounders(183GHz)	GMI, MHS	ATMS, SSMIS, SAPHIR	MWHS-2
MW- imagers	AMSU2, GMI, SSMIS, WindSat, MWRI		

**Research Objective**  
**Apply all-sky assimilation scheme to MW humidity sounders which have been assimilated in clear-sky condition.**

- Expect to improve analysis in cloudy and rainy areas.
- Atmospheric conditions of cloudy and rainy areas are sensitive to accuracy of severe weather event forecasting(e.g., heavy precipitation, tropical cyclone)

## 4. Summary & Future plans

### Summary

Experiments of addition of the clear-sky assimilation sensor or the unused sensor (ATMS, SSMIS, SAPHIR, and MWHS-2) to all-sky assimilation were implemented.

- Improved the humidity, temperature and wind fields of FG statistically
- Improved the forecast scores (e.g. Water vapor RMSE against ECMWF analysis)

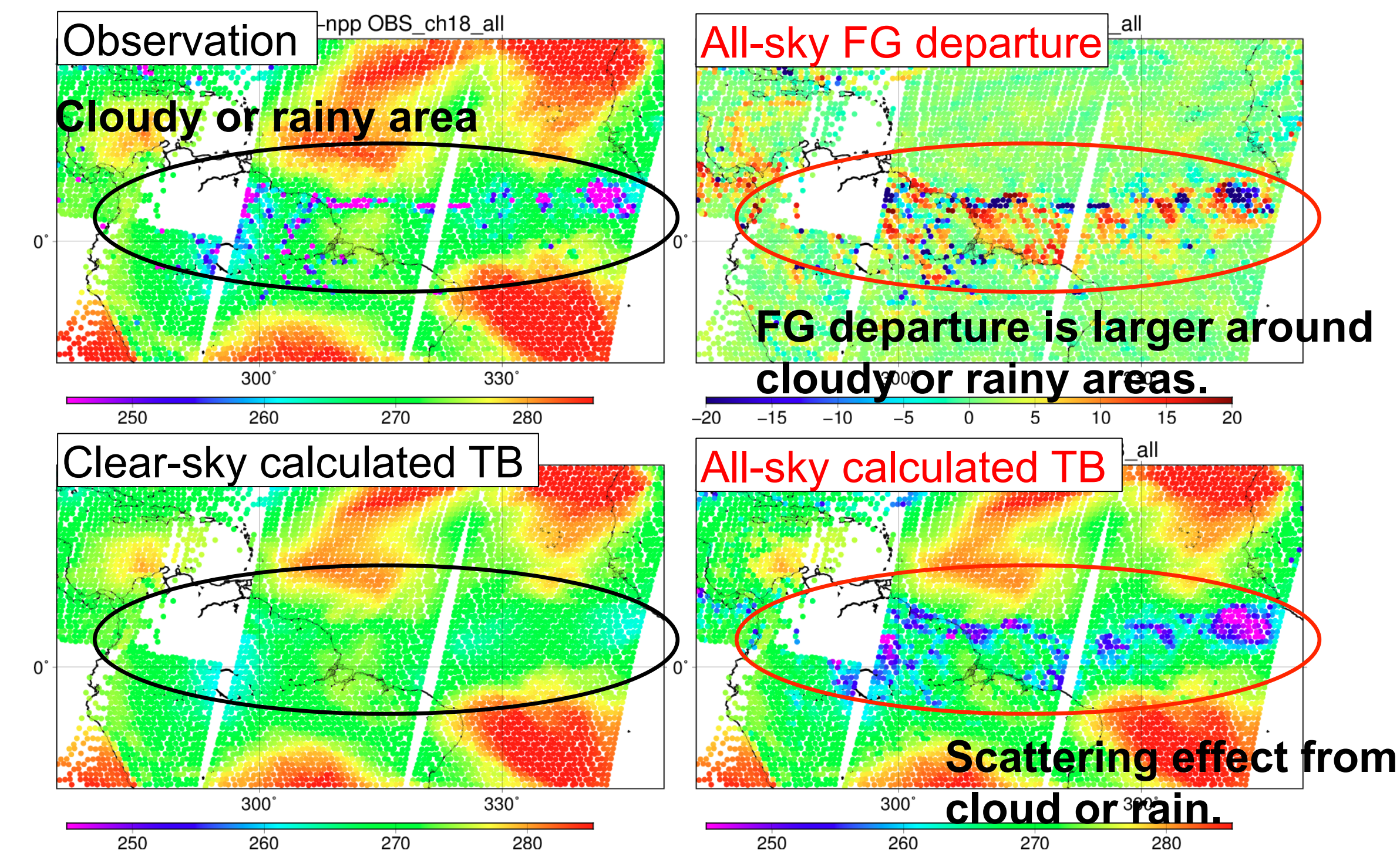
The all-sky assimilation will be implemented to the JMA operational NWP system in late June, 2021.

### Future plans

- Use surface sensitive data. → Dynamic emissivity
- Utilize the other instrument or channel with all-sky assimilation approach.
  - Addition of FY-3D / MWRI, MWHS-2.
  - Addition of temperature sounding channel to all-sky assimilation.
    - MWHS-2 radiance data at 118 GHz channels, AMSU-A, ATMS.
- Apply all-sky assimilation scheme to Meso-scale NWP system.

## 2. All-sky assimilation scheme

### All-sky calculation and observation



	Clear-sky Assimilation	All-sky Assimilation
Radiance Transfer Calculation	Calculate assuming clear-sky	Consider effect from cloud and rain
Observation Error	Constant value	Inflates observation error as a function of symmetric cloud amount

### Observation error models

Unified observation error model can be applied to various weather situations

Scattering index (SI) is used as a measure of cloud amount. (Geer et al. 2014)

90 and 150GHz are available

$$SI = (TB_{90} - TB_{150}) - (TB_{90}^{clr} - TB_{150}^{clr})$$

Scattering + water vapor absorption (red) / water vapor absorption (blue)

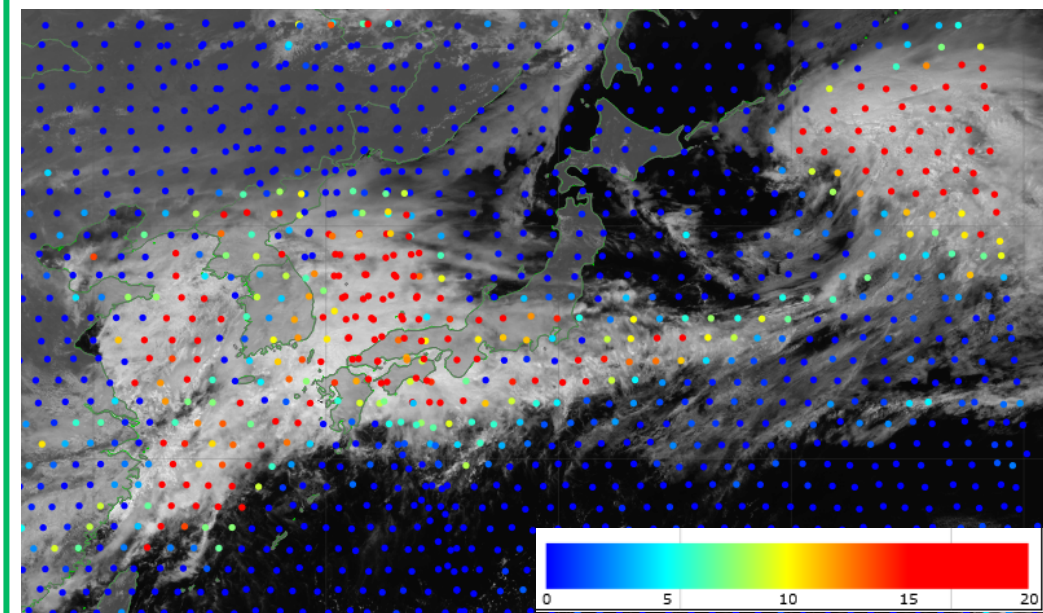
90 and 150GHz are not available

- Metop-A/MHS (150 GHz channel is broken after March 2020)
- Megha-Tropiques/SAPHIR (No 90 GHz nor 150 GHz) (Philippe and Geer 2017)

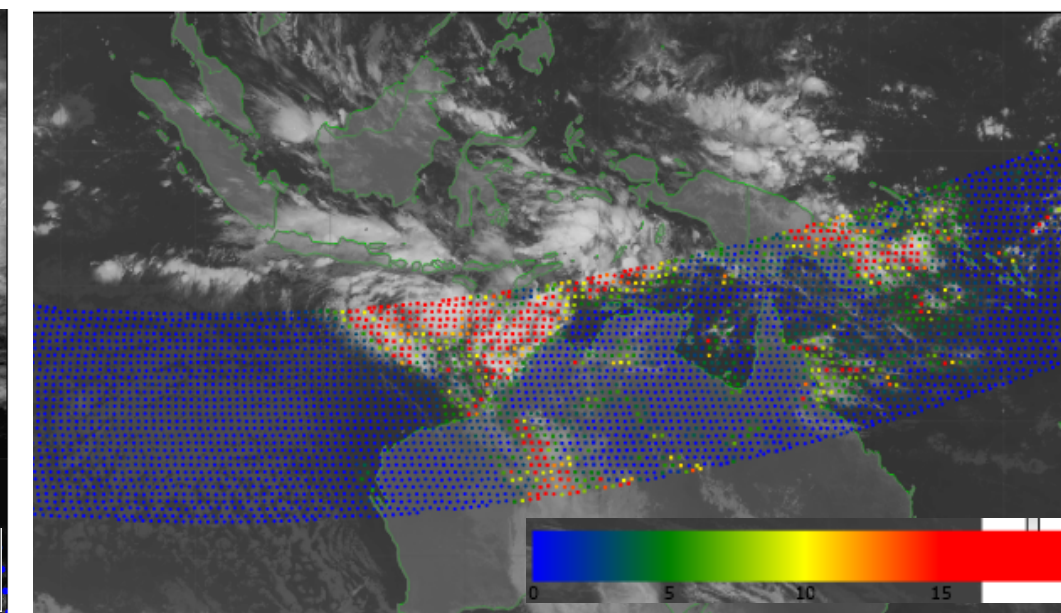
$$SI = TB_{183}^{clr} - TB_{183}$$

Not contain Scattering effect (blue) / Contain scattering effect (red)

SI<sub>SYM</sub> of ATMS (background : satellite visible imagery)



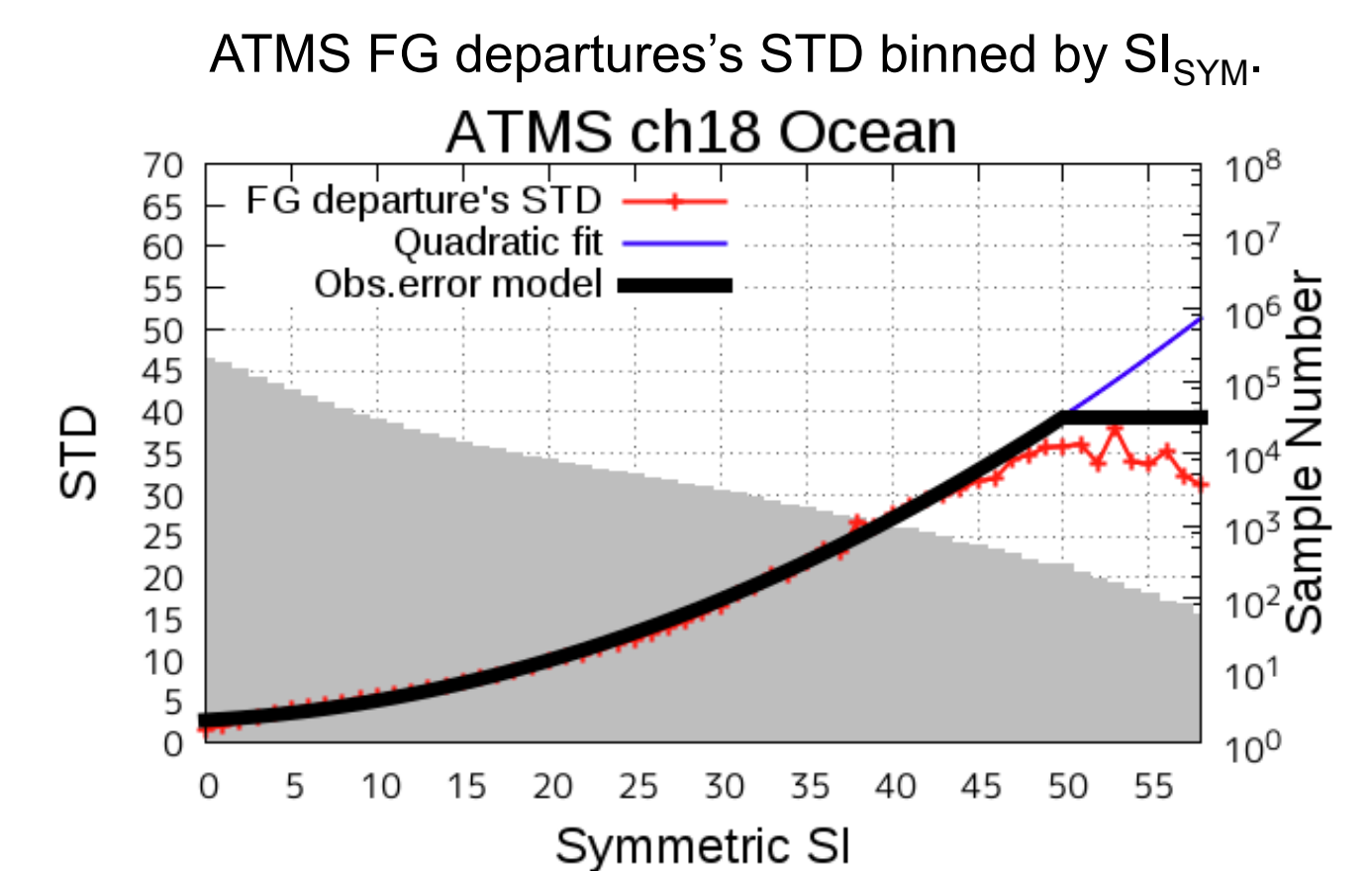
SI<sub>SYM</sub> of SAPHIR (background : IR satellite imagery)



Observation error based on the symmetric cloud amount (Geer and Bauer 2011) is used.

$$SI_{SYM} = (SI_{obs} + SI_{FG}) / 2$$

SI<sub>obs</sub>: calculated from observation. SI<sub>FG</sub>: calculated from model First Guess.



### Quality Control for MW humidity sounder

- Gross error check.
  - ✓ To remove strongly convective situations.
  - ✓ Remove surface sensitive data.
  - ✓ TCPW less than 5.0 for land or sea ice area.
  - ✓ High orography.
- ✓ Data removal in snow-covered surfaces and sea-ice for lowest peaking channel. (rejecting temperature lower than 273.15 K)

## 3. Impacts in the full observing system

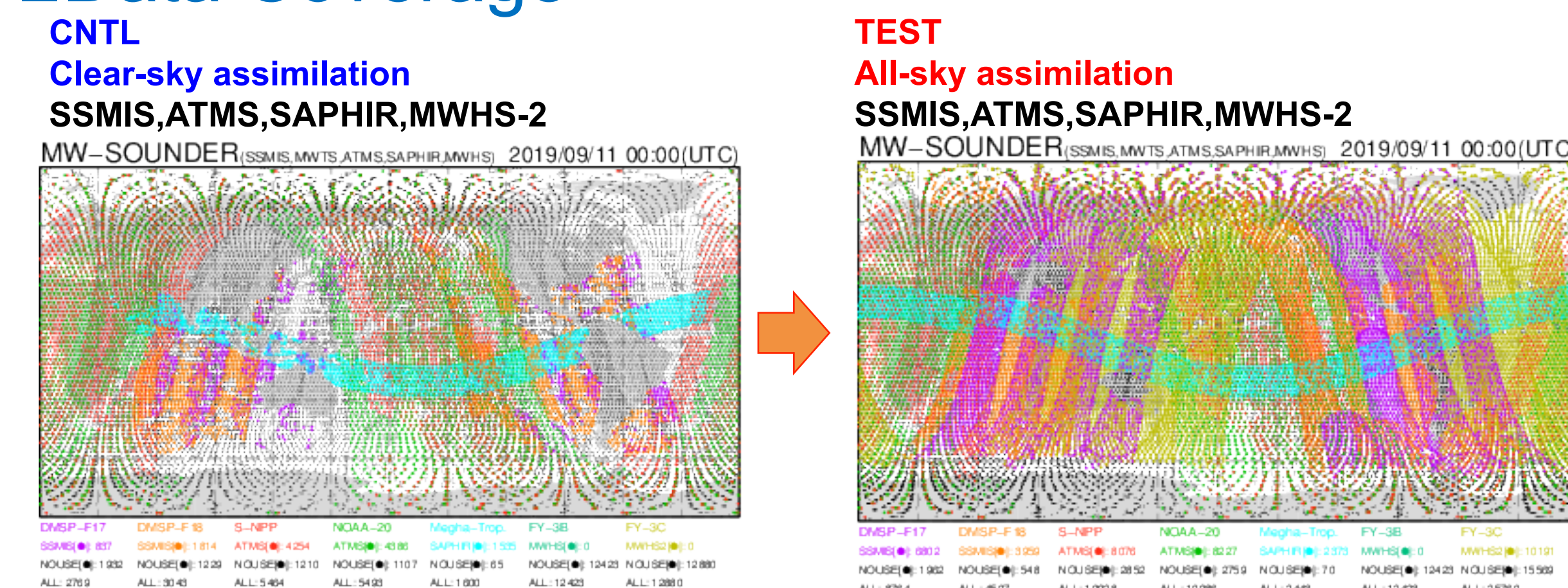
### Experimental settings

- CNTL: Same as JMA operational system in September 2020
- TEST: CNTL + all-sky MW humidity sounder assimilation
  1. Applied the all-sky assimilation scheme to ATMS, SSMIS, SAPHIR and MWHS-2.
  2. Some minor Quality control changes ( such as data thinning )

### Configuration of JMA global NWP system:

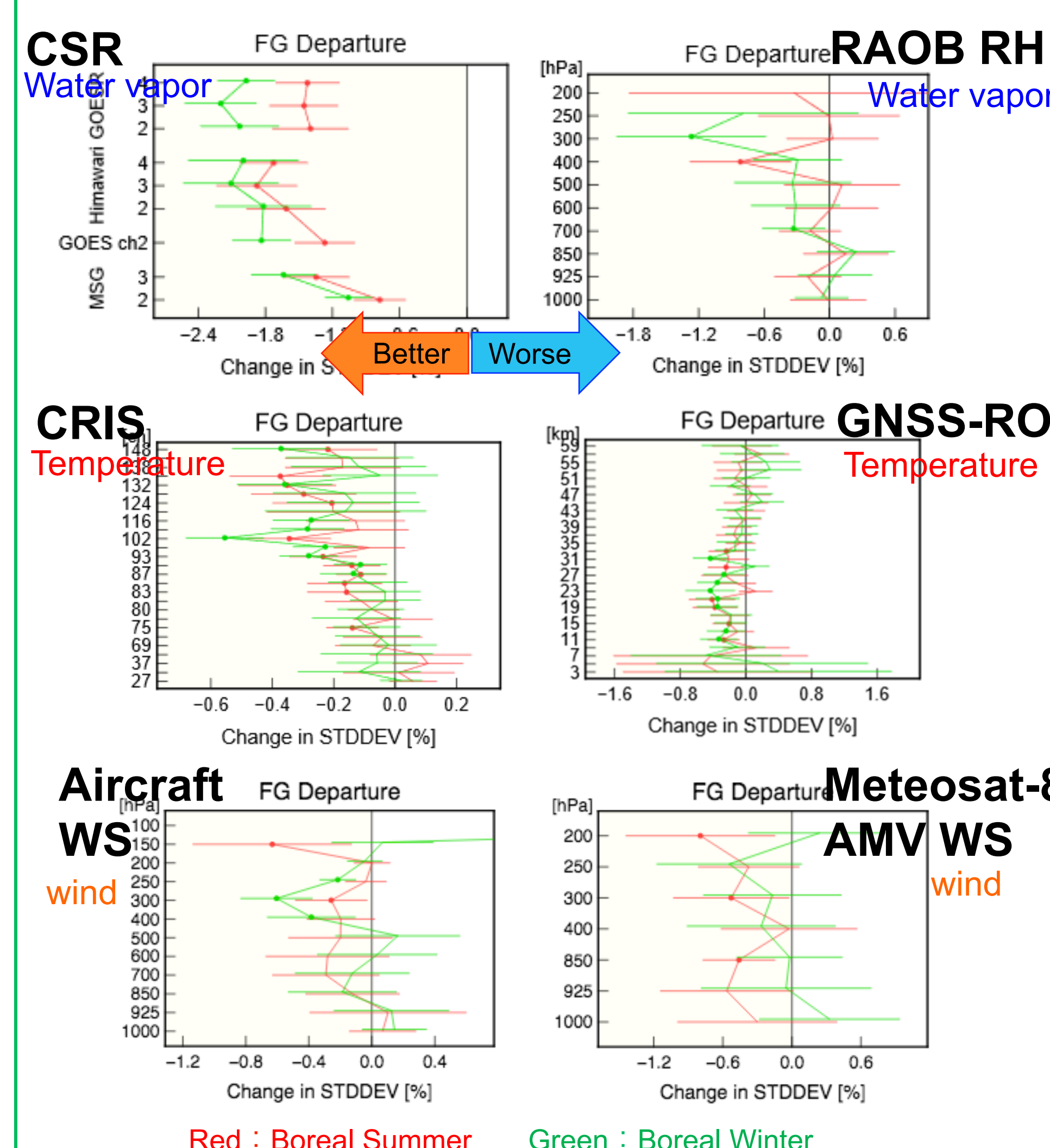
- JMA global model (JMA-GSM)
- Hybrid 4D-Var DA system with outer-loop iterations
  - Outer model: TL969L100, 20km horizontal resolution, 100 layers, the model top 0.01 hPa
  - inner model: TL319L100, 55km horizontal resolution, 100 layers, the model top 0.01 hPa
- RTM: RTTOV10.2
- Periods: ① Boreal Summer 10 July – 11 Sep. 2019  
 ② Boreal Winter 10 Dec. – 11 Feb. 2020

### Data Coverage



MW humidity sounder radiance data coverage in the 00UTC assimilation window on 11 Sep. 2019  
**Increase of assimilated MW humidity sounder radiance data due to all-sky assimilation.**

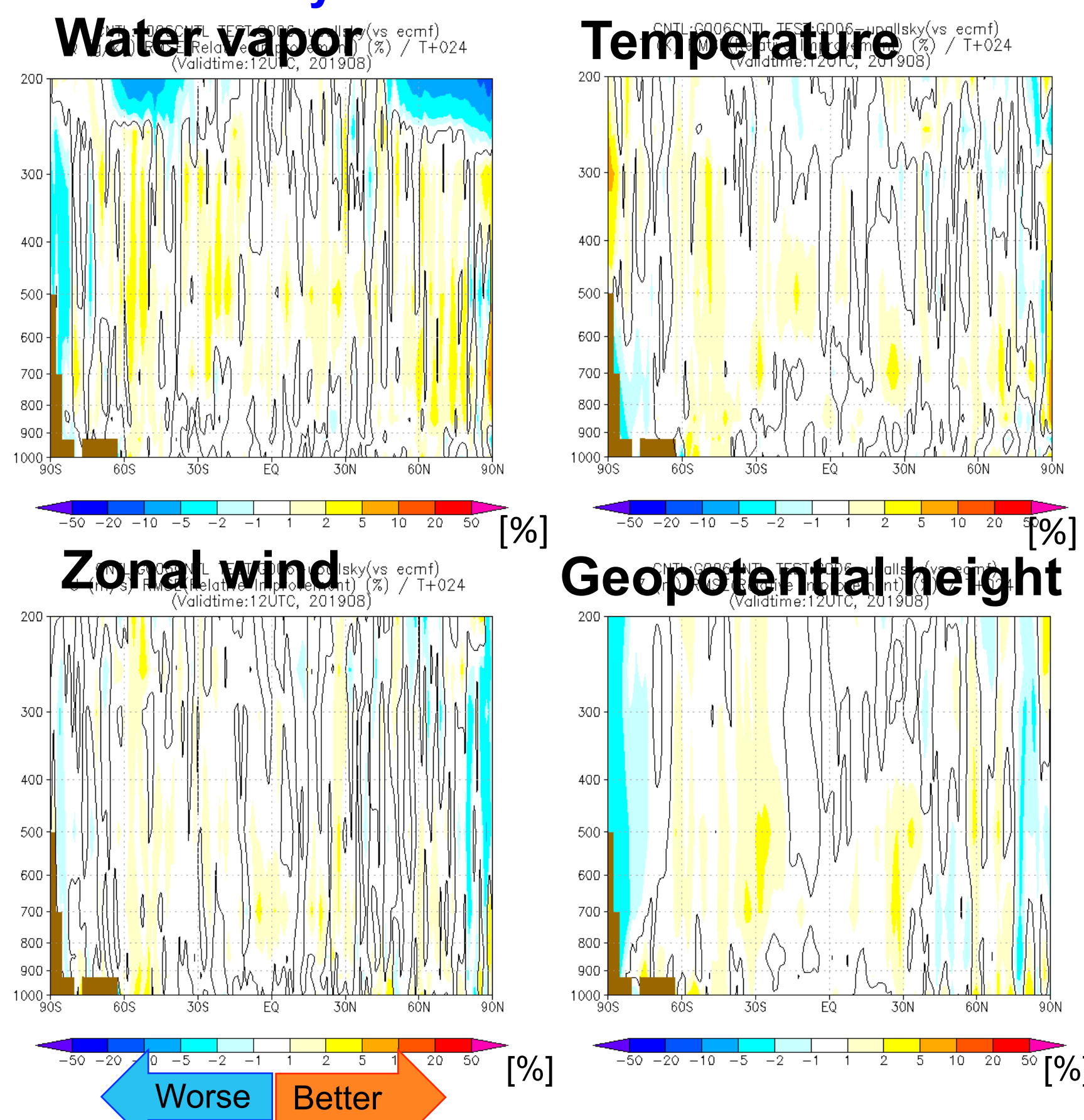
### Changes of STD of FG departure



Red : Boreal Summer Green : Boreal Winter  
 In the mid and upper troposphere, water vapor, temperature and wind fields were improved in the FG

### Forecast Score

1 Day Forecast Boreal Summer  
 Zonal mean improvement of RMSE against ECMWF analysis



- In the mid and upper troposphere, water vapor fields were significantly improved in the short range forecast.
- Temperature, zonal wind, geopotential height were also improved.