Assimilation of NOAA-21/ATMS and CrIS in the JMA's NWP systems

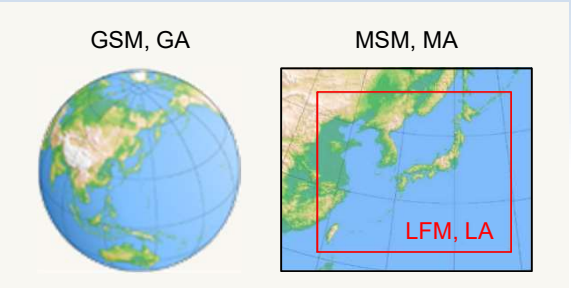
2023/11/8 AOMSUC-13

Tomoya Urata

Numerical Prediction Division, Japan Meteorological Agency

Introduction

- JMA's deterministic forecast models and data assimilation systems
  - Global Spectral Model & Analysis (GSM, GA)
  - Meso-scale Model & Analysis (MSM, MA)
  - Local Forecast Model & Analysis (LFM, LA)



Domains of each NWP system

- We plan to start assimilating NOAA-21/ATMS and CrIS data in March 2024.
  - NOAA-21 is the latest satellite of the JPSS series, following Suomi-NPP and NOAA-20.
  - NOAA-21 will be assimilated into GA, MA, and LA with the same preprocesses as NOAA-20.

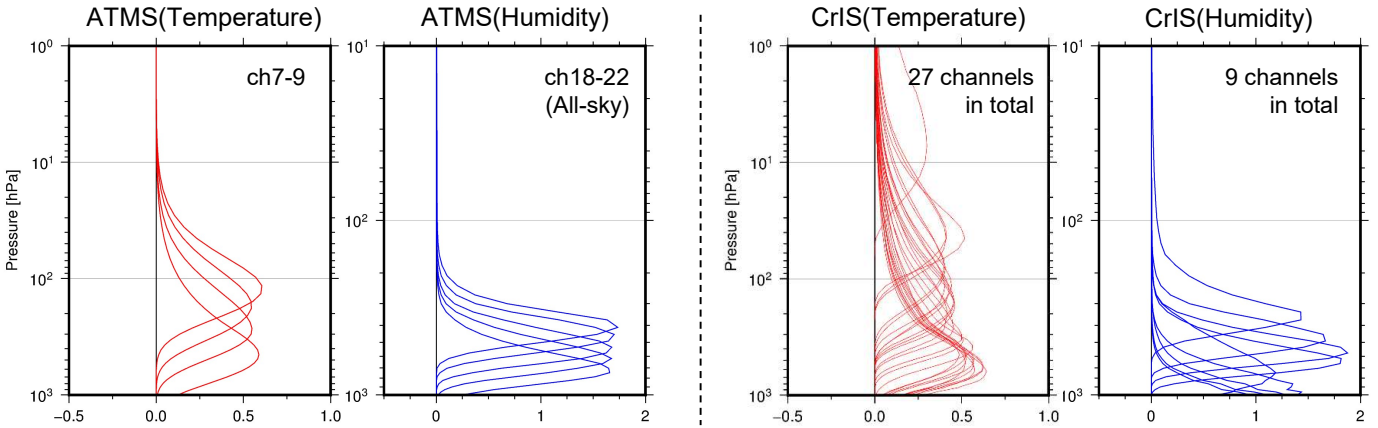
Satellite data used in the operational assimilation systems as of Nov. 2023 (show only MW/IR Sounder)

Type	Satellite/Instrument	Global Analysis	Meso-scale Analysis	Local Analysis	
MW Sounder	NOAA-15,18,19, Metop-B,C/AMSU-A	Radiance (T)	Radiance (T)	Radiance (T)	
	NOAA-19, Metop-B,C/MHS	Radiance (H)	Radiance (H)	Radiance (H)	
	DMSP-F17,18/SSMIS	Radiance (H)	-	-	
	Suomi-NPP, NOAA-20/ATMS	Radiance (T, H)	Radiance (H)	Radiance (H)	JPSS
	FY-3C/MWHS-2	Radiance(H)	-	-	
IR Sounder	Metop-B,C/IASI	Radiance (T, H)	Radiance (T, H)	Radiance (H)	
	~~Suomi-NPP,~~ NOAA-20/CrIS	Radiance (T, H)	Radiance (T, H)	Radiance (H)	JPSS

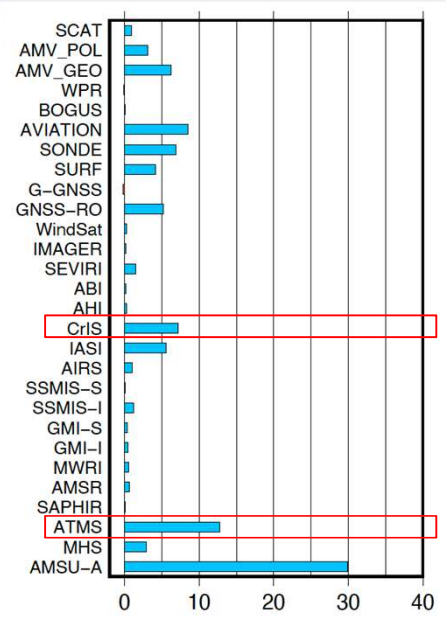
(T): Temperature, (H): Humidity

Motivation

- NOAA-21: launched in Nov. 2022, declared operational in Mar. 2023
  - Tertiary satellite on 13:30 JPSS orbit – planned to be primary in early 2024
  - Same sensors as Suomi-NPP and NOAA-20 are equipped



Weighting functions of ATMS and CrIS (show only channels assimilated in GA)



Relative FSOI[%] in the JMA's global NWP system for Jul.-Sep. 2018

- FSOI suggests major contribution of ATMS and CrIS to the JMA's NWP systems.

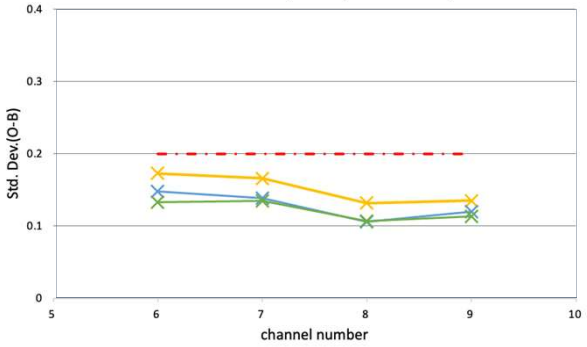
➢ Early operational use of NOAA-21 is very important in terms of

1. Possible improvement in the forecast field through increase in the number of observational data
2. Backup option in case of other JPSS satellites' anomaly
   (e.g., S-NPP/CrIS LWIR data is no longer available since Aug. 2023.)

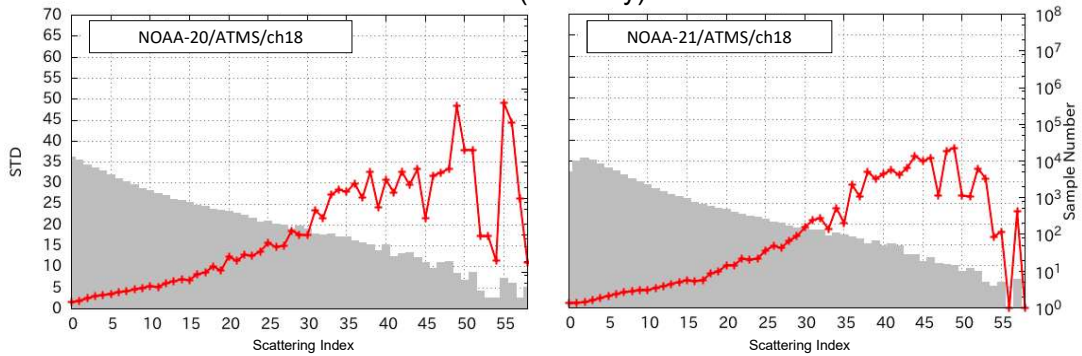
Estimation of NOAA-21 observation error

- Observation error can be estimated from the standard deviation of “O-B” (difference between observation and first guess).
  - Std(O-B) of NOAA-21/ATMS, CrIS are equal to or slightly smaller than those of Suomi-NPP & NOAA-20.
  - ➢ Consistent with the reports from other NWP centers (cf. EUMETSAT Conference 2023)

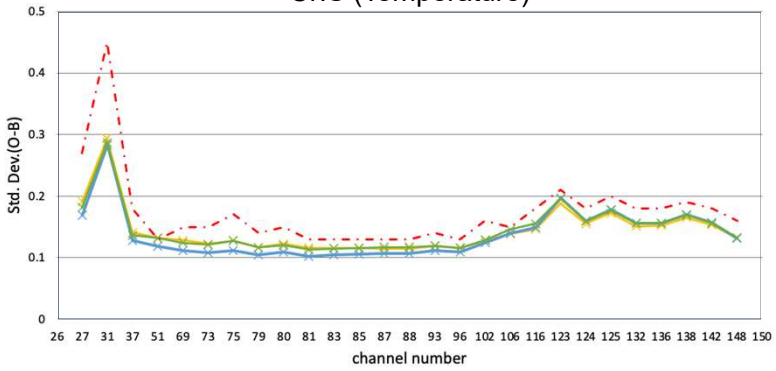
ATMS (Temperature)



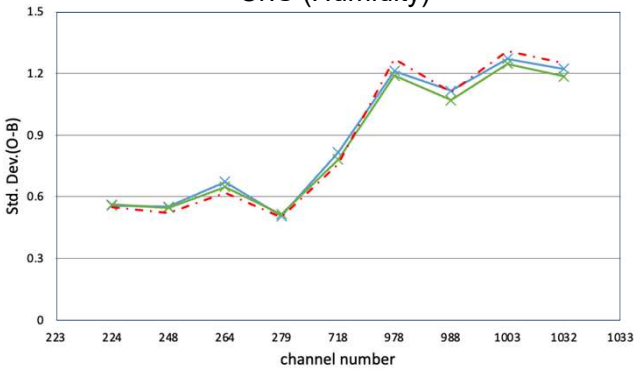
ATMS (Humidity)



CrIS (Temperature)



CrIS (Humidity)



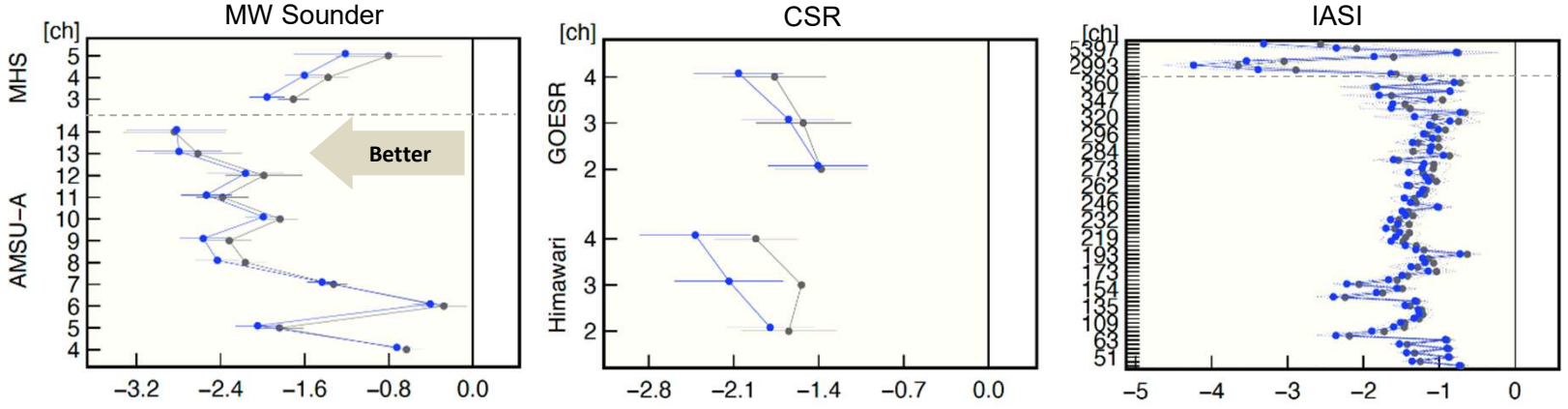
S-NPP NOAA-20 NOAA-21 Observation Error (setting) Calculated from 15-day samples in June 2023

Assimilation experiments in the global system

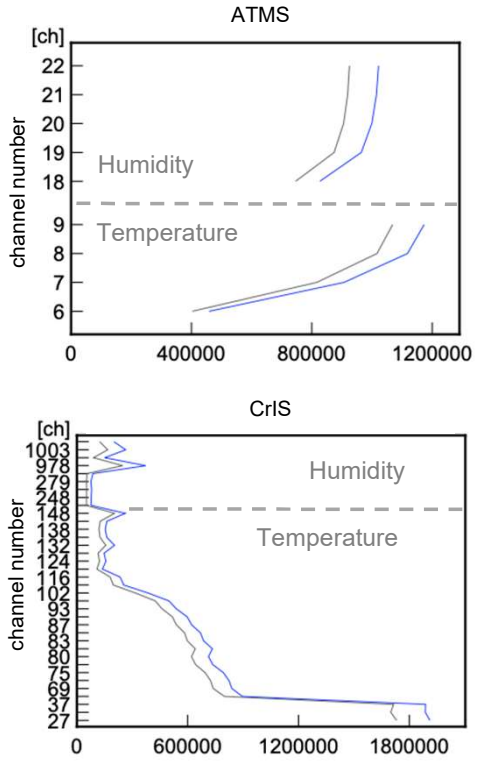
- Some experiments in the global NWP system were conducted for the period from 16th May to 15th June 2023.

> **Baseline** : Same as Control, but without assimilation of any ATMS or CrIS
>
> **Control** : Environment equivalent to the operational NWP system as of May 2023
>
> **Test** : Control + NOAA-21/ATMS, CrIS

- Statistical verification of O-B against **Baseline** experiment suggests that temperature and humidity of first guess fit better with observations when assimilating ATMS and CrIS.
- Use of NOAA-21 data has additional improvements.



Changes [%] in Std(O-B) from **Baseline** experiment



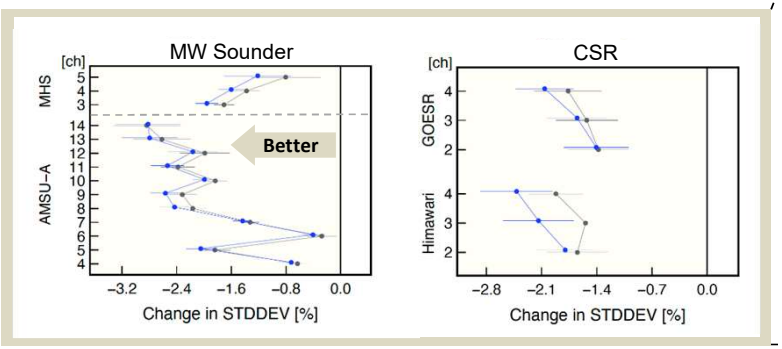
Number of assimilated data

Blue line: **Test1** Gray line: **Control** Horizontal bars: 95% confidence range

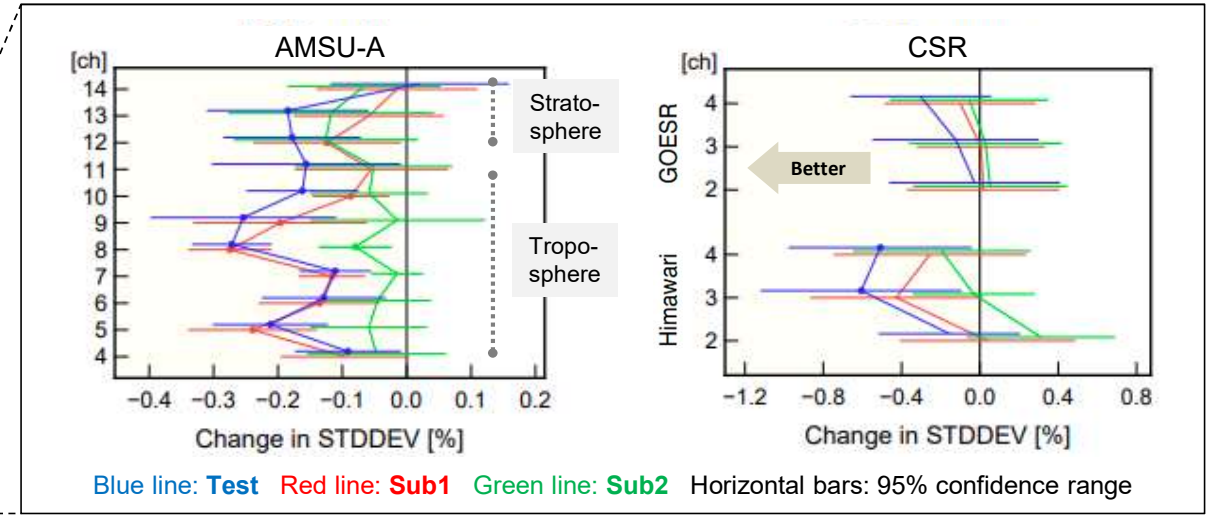
Separation of ATMS and CrIS impact

- Additional experiments were conducted to assess each impact from NOAA-21/**ATMS** and **CrIS**.

> **Control** : Environment equivalent to the operational NWP system as of May 2023
>
> **Test** : Control + NOAA-21/ATMS, CrIS
>
> **Sub1** : Control + NOAA-21/ATMS
>
> **Sub2** : Control + NOAA-21/CrIS



Change[%] in Std(O-B) from Baseline (reprinted)



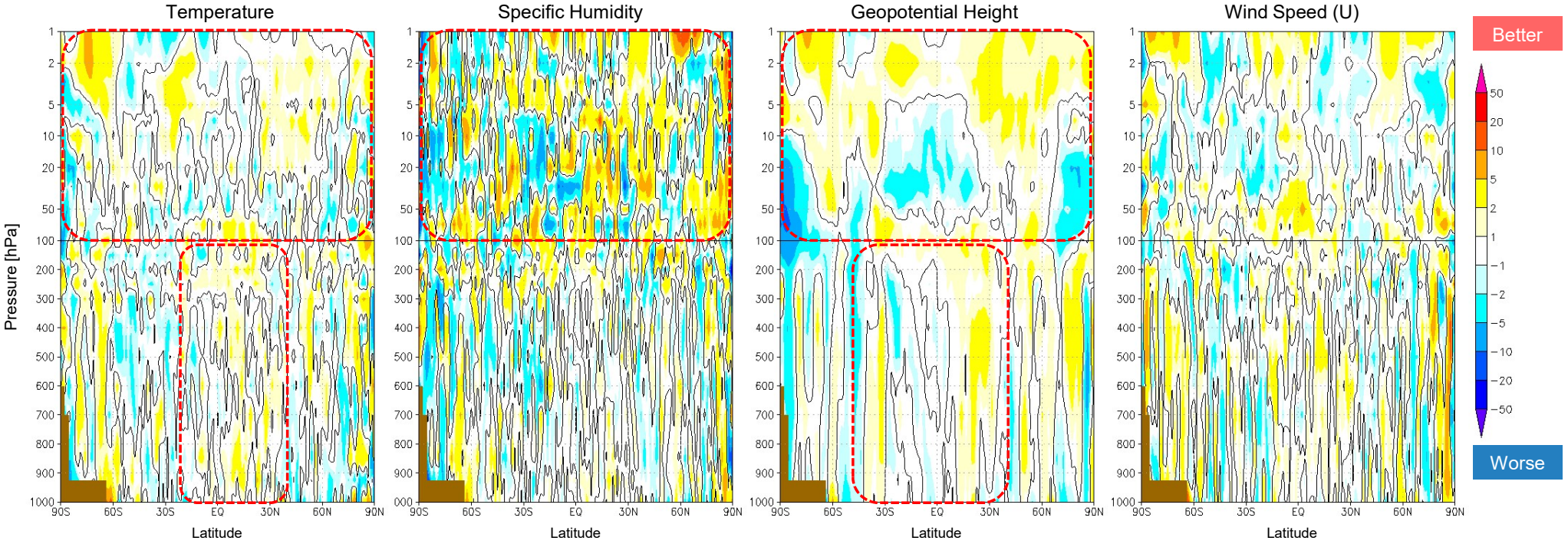
Change[%] in Std(O-B) from **Control**

- Changes in Std(O-B) of AMSU-A (MW Temperature Sounder) suggest that
  - **ATMS** gives significant contribution to tropospheric temperature improvement,
  - while **CrIS** improves stratospheric temperature.
- Contribution to the humidity improvement is suggested to be comparable between ATMS and CrIS.

Forecast impact

Calculated from 20th June to 11th Aug. 2023.
Show only results of
Test: Control + NOAA-21/ATMS, CrIS
against **Control:** Equivalent to the operational system

- Latest experiment for longer period was conducted to assess the impact on forecast fields.
- Compared to own analyses or ERA5 (not shown), 24-hour forecasts tend to improve in
  - Stratospheric temperature, humidity, and geopotential height
  - Tropospheric temperature in tropics

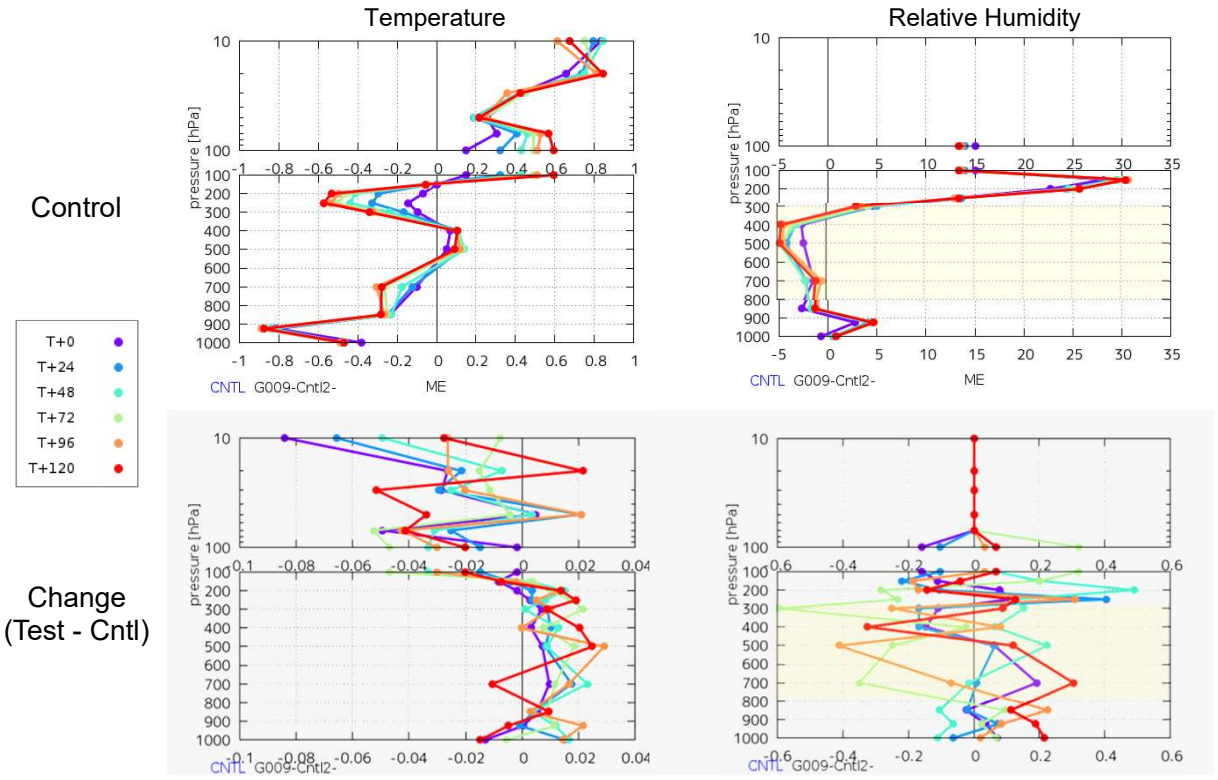


Improvement rate[%] in the RMSE between 24-hour forecasts and own analyses

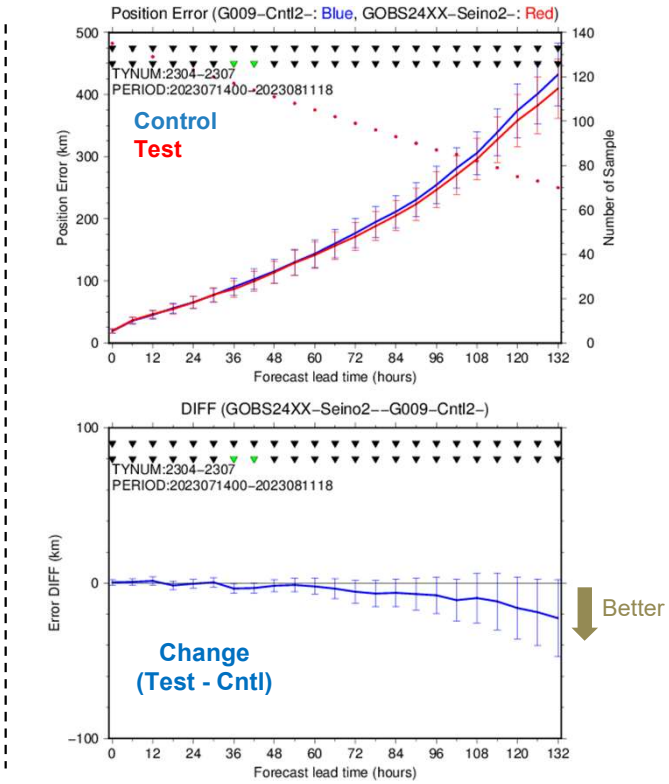
Control: Equivalent to the operational system
Test: Control + NOAA-21/ATMS, CrIS

Forecast impact

- Temperature and humidity forecasts in the tropics get closer to the radiosonde observation.
- Improvement can also be observed as the reduced position error in typhoon forecast.



ME of radiosonde observation in tropics
(colder color indicates shorter-range forecast)

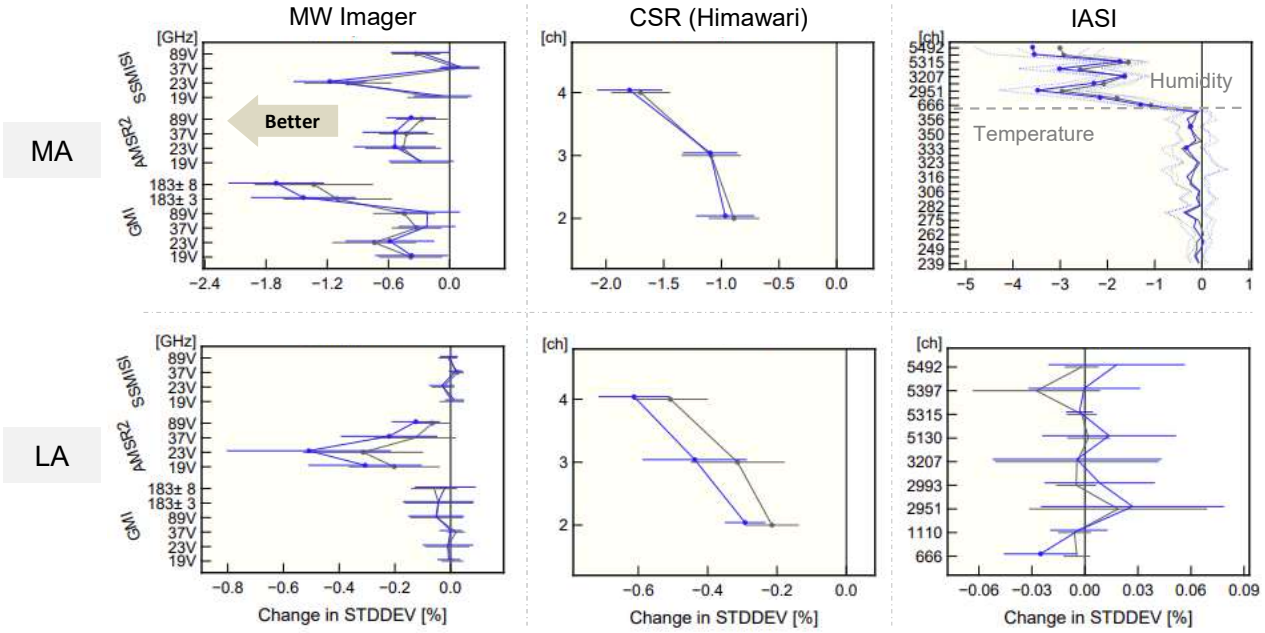


Mean position error of typhoon prediction
(compared to JMA's Best Track)

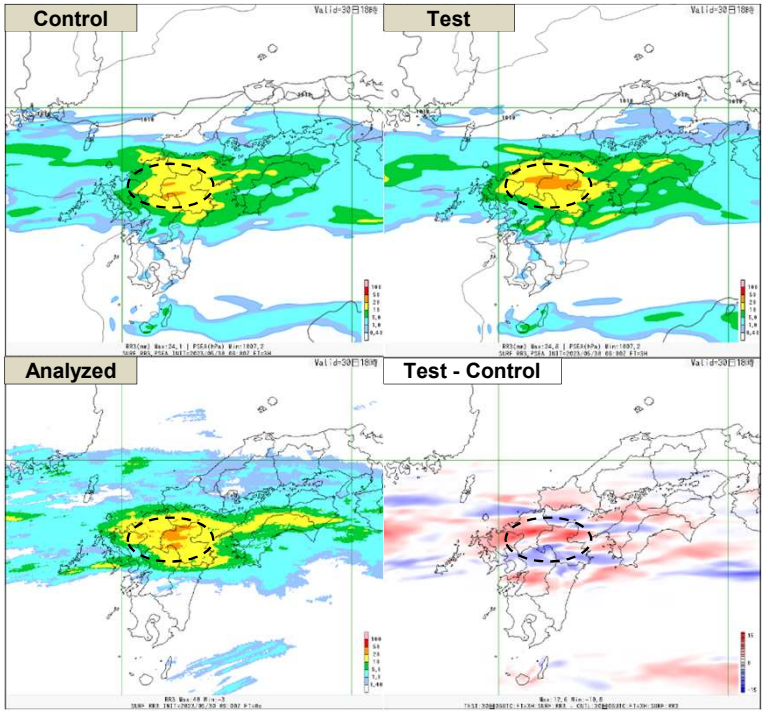
Experiments in the regional systems

Baseline: Control without any ATMS or CrIS
Control: Equivalent to the operational system
Test: Control + NOAA-21/ATMS, CrIS

- Experiments in the meso-scale and local NWP systems were also conducted for May-June 2023.
  - Reduction in Std(O-B) of humidity-sensitive observations from **Baseline** and **Control**
  - Severe precipitation forecast of **Test** is closer to the radar-analyzed precipitation than that of **Control**.



Changes [%] in Std(O-B) against Baseline experiment
Blue line: **Test** Gray line: **Control**



Comparison of the 3-hr accumulated precipitation forecast of MSM for 09UTC 30 May 2023 (Ini: 06UTC 30 May).

Summary

- Early operational use of NOAA-21 in the NWP systems is important in terms of **forecast improvement** and **backup option** in case of other satellites' anomaly.

- Suggested from the standard deviation of O-B, the observation error of NOAA-21 is **equal to or slightly smaller** than that of Suomi-NPP or NOAA-20.

- Some experiments were performed.
  - According to the experiments in the global NWP system, additional use of NOAA-21 data strengthens the existing improvements from Suomi-NPP and NOAA-20.
  - **Temperature** and **humidity** in the analysis and forecast fields get improved, especially in the stratosphere and tropics.
  - Forecast improvements are also observed in the experiments conducted in the regional NWP systems.

- Studies are going well on schedule, and we plan to start assimilating NOAA-21 data into the operational NWP systems (GA, MA, LA) in **March 2024**.