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Preliminary studies for the assimilation of Himawari-10/GHMS in the JMA's NWP systems

Tomoya URATA
Numerical Prediction Division, Japan Meteorological Agency (JMA)
urata*[at]*met.kishou.go.jp

1. Introduction

- JMA's upcoming satellite **Himawari-10** is planned to be operational in 2029 with the hyperspectral infrared sounder **Geostationary HiMawari Sounder (GHMS)** onboard.
- Preliminary studies are ongoing using **the simulated data of GHMS** derived from ERA5 and RTTOV.
- In this paper, I briefly describe some results of **Observing System Simulation Experiments (OSSEs)**.

2. Specification of GHMS Simulated Data

- Input: **ERA5** (every hour, ~20km resolution)
- Radiative Transfer Model: RTTOV ver. 13.1
- Wave number: [LW] 680 - 1,095 cm^{-1}, [MW] 1,689 - 2,249.625 cm^{-1}
- Sampling resolution: 0.625 cm^{-1}
- Not taking account of the noise property
- Hamming apodization (same as applied to CrIS)

The simulated observation data for GHMS was created with contributions from JAMSS, commissioned by JMA, and the contractor of JAMSS, L3Harris in the US. The RTTOV coefficient file used to create the simulated observation data was created by Météo-France, based on the information under design of GHMS by L3Harris.

3. Observing System Simulation Experiments (OSSEs)

- OSSEs are conducted in the JMA's NWP systems for summer period of 2021.
  - Global Analysis (GA), Meso-scale Analysis (MA), Local Analysis (LA) and their respective forecast models (see *JMA 2025* for details).
- **Purposes**:
  1. Investigate the impact of GHMS against forecast.
     - Already reported in *Okamoto et. al (2020).*
  2. **Explore better settings of assimilation** such as Quality Controls (QCs) and channel selection for GHMS.
- **QCs**: Same processes as for IASI and CrIS are applied.
  - Horizontally thinned to 200km for GA and 45km for MA and LA.
  - Clear Sky Assimilation
    - Detection of Cirrus Cloud (**Split window**, *Inoue 1985*)
    - Estimation of Cloud Top Height (**CO_2 slicing**, *Eyre and Menzel 1989*)
      - **Channels sensitive below the estimated cloud top height are rejected**.
  - Over land and sea ice, channels sensitive to troposphere are rejected.
  - VarBC Predictors: a global offset and 4 thicknesses (850-300, 200-50, 20-5, 10-5 hPa thickness)
- **59 temperature channels** and **27 humidity channels** are selected for assimilation based on their Jacobians.
  - Observation errors are set based on diagnosed values (Desroziers et al. 2005), also referring to Std(O-B) of IASI and CrIS actual observation.
  - For MA and LA, channels sensitive to the model tops are rejected.

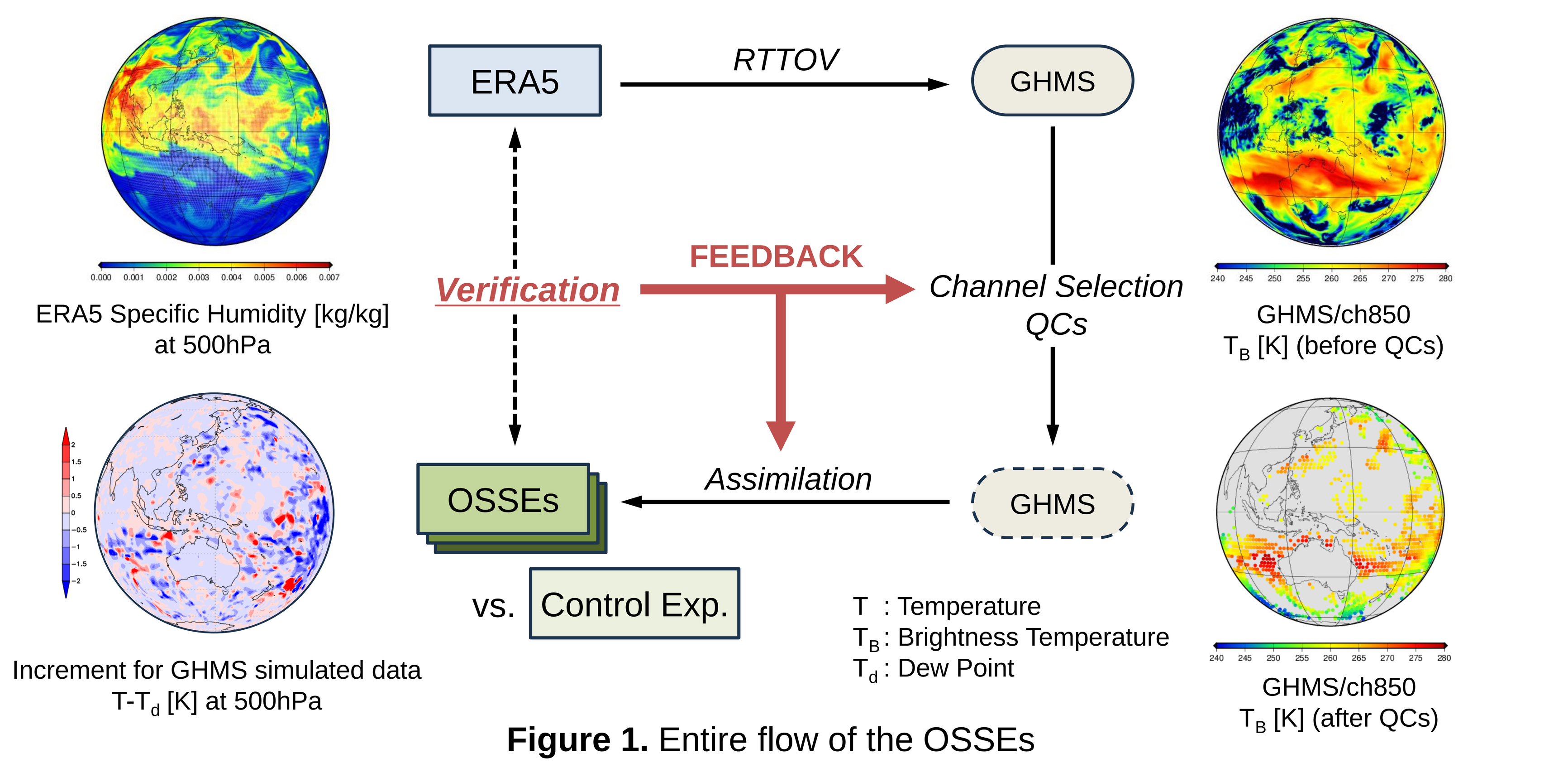

Figure 1. Entire flow of the OSSEs

4. Results

OSSEs in GA and Global Spectrum Model (GSM)

- Reduction in RMS against the initial fields of independent NWP models suggests **GHMS improves temperature and humidity forecasts** especially in tropics and mid-latitudes of SH (not shown).
- We expected Mean and RMS diff. against ERA5 get smaller, however, there are regions where **Mean changes away from ERA5** (OSSE ver.1 in Fig. 3).
  - Often seen in cloudy scenes.
  - It is likely that information from the channels sensitive to altitudes above cloud top height influences the analysis at lower altitudes.
- ➢ By tuning a parameter in **CO_2 slicing** and rejecting channels which are even slightly affected by clouds, the situation gets better (Fig. 2 and OSSE ver.2 in Fig. 3).

** Loop processing for n (in surf, 1, 2, …, model top)*

$$\text{if} \left(\left| \frac{T_B^{clear} - T_B^{cloudy(n)}}{T_B^{clear}} \right| \times 100 > \alpha \right) \text{ then } H = n$$

T_B^{clear} : Simulated T_B by RTTOV (clear-sky)

$T_B^{cloudy(n)}$: Simulated T_B by RTTOV (an opaque black cloud on layer *n*)

H: The lower end of the channel sensitivity

α: Target parameter (set to 1.0 in OSSE ver.1 (original) and 0.5 in OSSE ver.2)

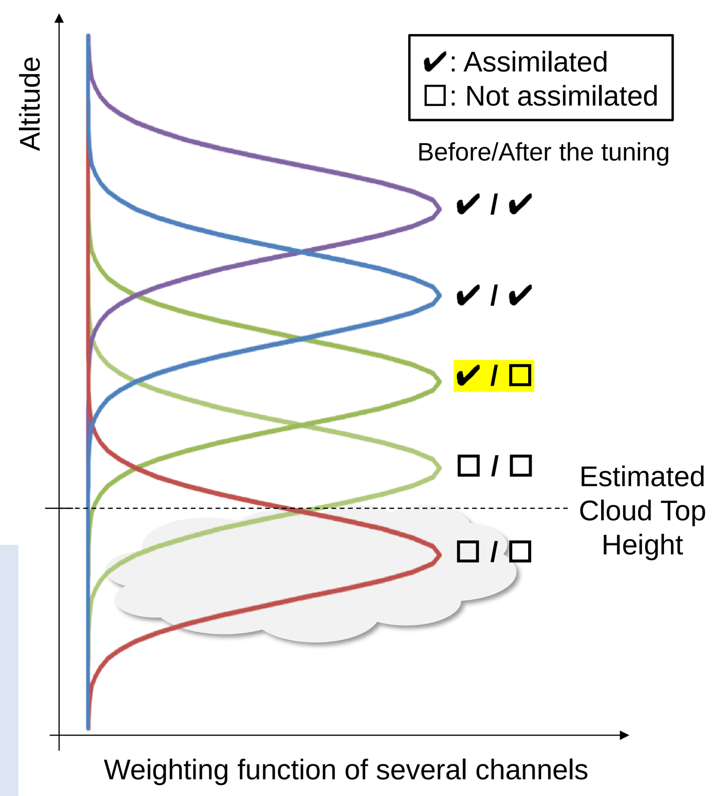

Figure 2. Illustrative image of the parameter tuning in CO_2 slicing

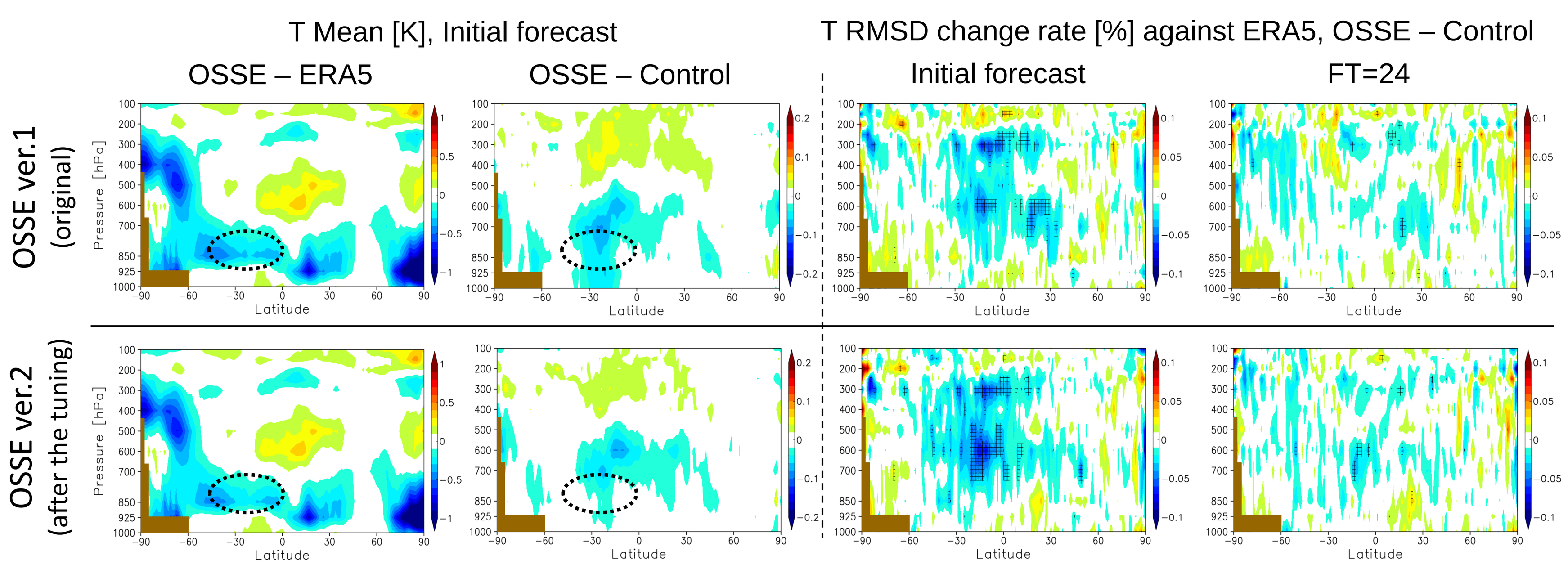

Figure 3. Verification of temperature distribution against ERA5 (calculated over August 2021). Control: Equivalent to the operational system as of 2024, OSSE: Control + GHMS simulated data.

OSSEs in MA and Meso-Scale Model (MSM)

- By assimilating GHMS simulated data, precipitation forecast improves in some cases (Fig. 4), but it's not statistically significant.
  - The investigation has been difficult because ERA5 cannot always be regarded as the truth, especially in representation of meso-scale phenomena.
  - Rainfall cases to investigate should be selected carefully.

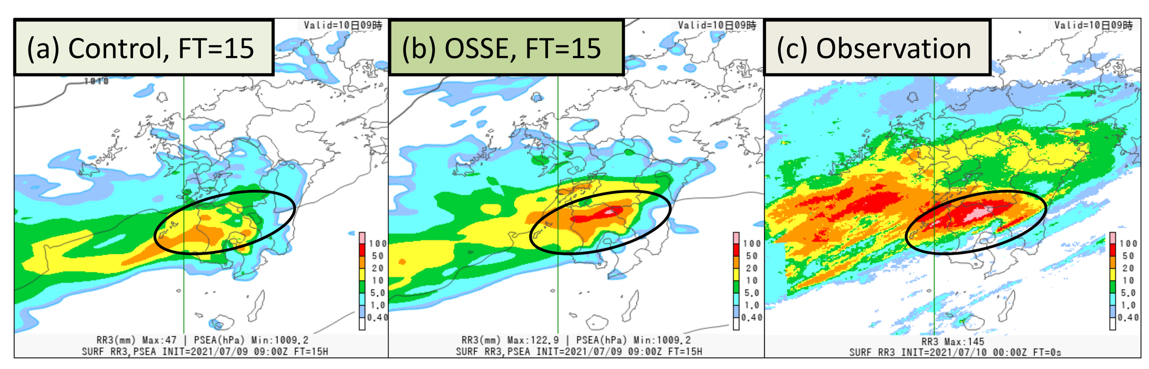

Figure 4. 3-hour accumulated rainfall (mm) valid at 00 UTC 10 July 2021 from the forecasts at 15h in (a) Control, (b) OSSE and (c) the radar/rain-gauge observations.

5. Plans

- Review of data usage in cloudy scenes including IASI and CrIS.
  - Treating cloud-related quantities as sink variables (McNally 2009).
  - All-sky assimilation for humidity channels (Okamoto et al. 2024)
- Observation System Experiments (OSEs) using actual data from FY-4B/GIIRS and MTG-S/IRS.
- Further research on the results of OSSEs in the regional models.

References

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