Assimilation of hyper spectral infrared sounder radiances in the JMA's meso-scale NWP system

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Introduction

- Assimilation of hyper spectral infrared sounder (HSS) radiances observed by satellite is beneficial for improving temperature and water vapor profiles in numerical weather prediction (NWP).
- JMA has been assimilating HSS radiances in the global NWP system.
- We are now working on assimilation of HSS radiances in the regional NWP systems.

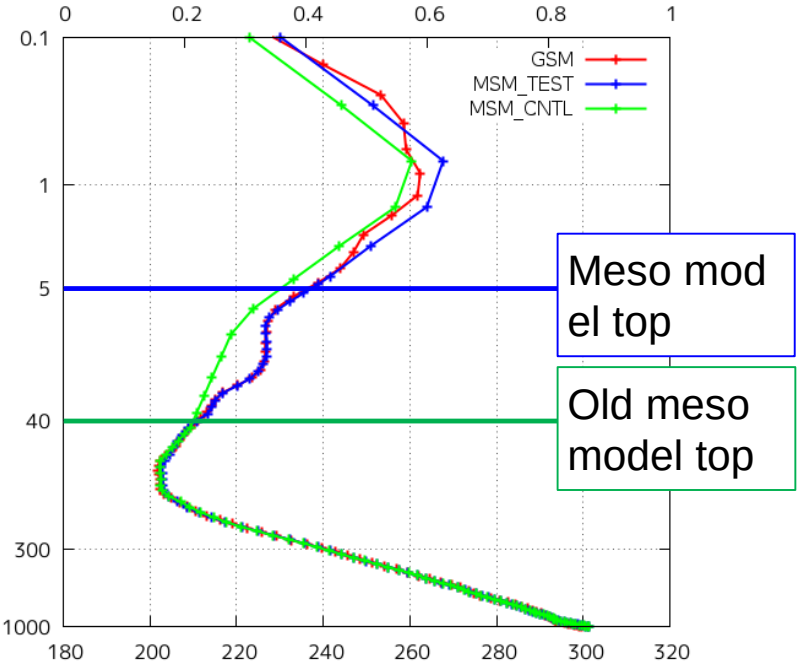
Specifications of JMA's NWP system as of Nov. 2022

	Global analysis	Meso-scale analysis	Local analysis
Horizontal resolution	Outer: approx. 20km Inner: approx. 55km	Outer: 5km Inner: 15km	5km
Model top height (hPa)	0.01hPa	Approx. 5hPa	Approx. 40hPa
Domain			
Observations (show only HSS data)	Metop-B,C/IASI S-NPP,NOAA20/CrIS	Not used	Not used

Radiative transfer calculation in regional model

- The atmospheric profiles from the regional model are extrapolated from that's model-top height using the U.S. Standard Atmosphere lapse rates in the radiative transfer calculations.
- The accuracy of the radiative transfer calculations were degraded for certain higher peaking channels.
- Channels were selected from already used in the global system considering the regional model top height.

Comparison of temperature profiles on each system



Channel screening considering the model top height

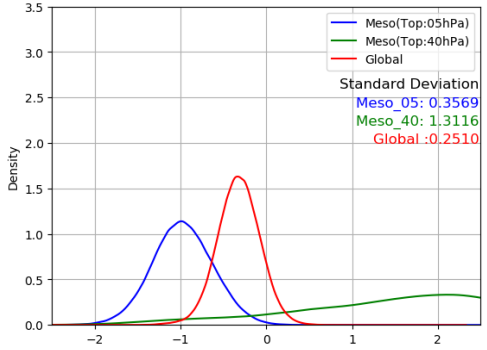
- Differences of O-B statistics between global system and meso-scale system were examined.

Global
Meso (Top: 5hPa)
Old meso (Top: 40hPa)

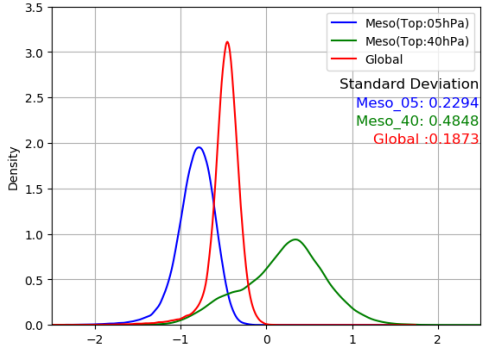
CrIS

Histograms of O-B in each system

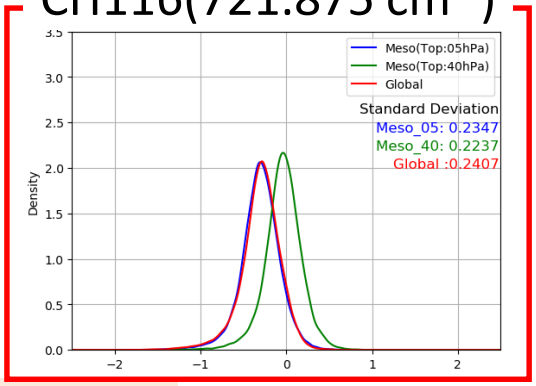
CH27(666.25 cm^{-1})



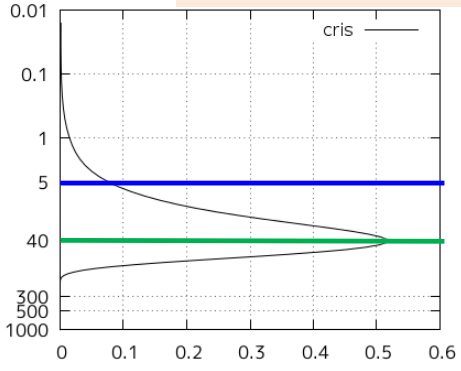
CH80(699.375 cm^{-1})

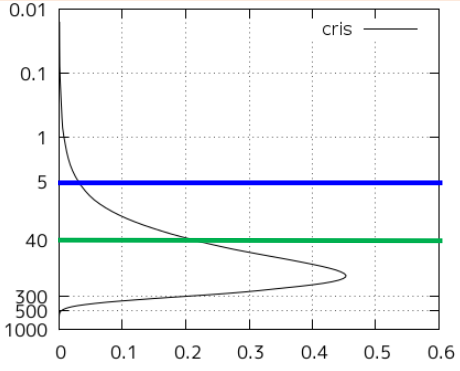


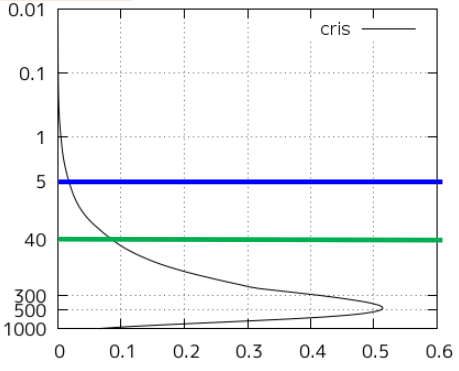
CH116(721.875 cm^{-1})



Relationship of the model top height and weighting function



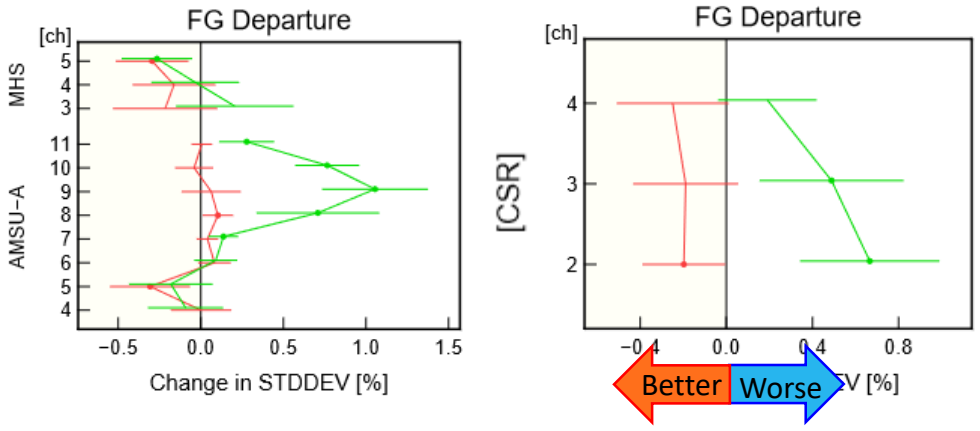




Preliminary experiments in the meso-scale NWP system

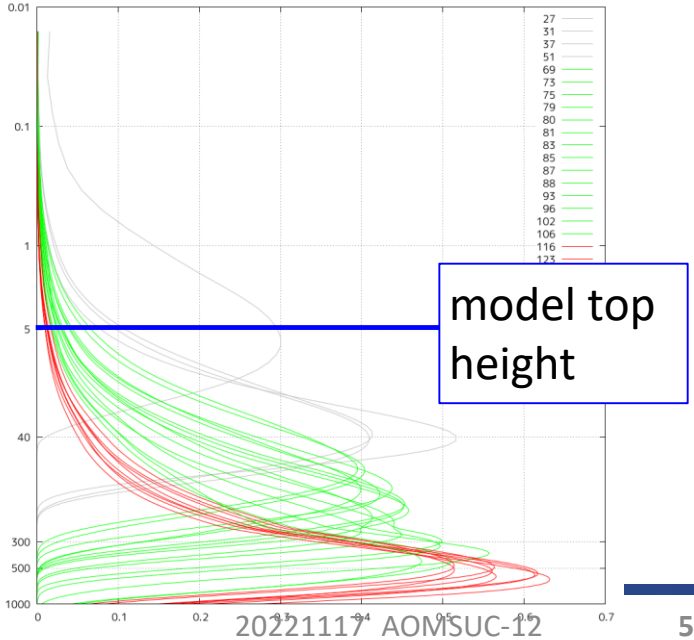
- CNTL: same as operating system in March 2022
  (Model top height : 5hPa)
- TEST(a): CNTL + CrIS (channels were selected subjectively with reference to weighting functions)
- TEST(b): CNTL + CrIS (channels were selected based on O-B statistics)

Changes of STD of FG departure against CNTL



Relationship of the model-top height and the weighting functions of channels assimilated in each experiment

Green: channels used in TEST(a)
Red: channels used in TEST(a) and TEST(b)



It is important to remove channels even slightly sensitive to atmosphere upper the model-top height.

Experiments for the impact study in the meso-scale NWP system

- CNTL: Same as JMA operational system in March 2022.
- TEST①: CNTL + HSS (only temperature channels)
  - Observation error settings and quality control processes are based on those implemented in the global system.
  - Data are horizontally thinned to divisions of 45km.
  - Cloud top estimation and cloud screening (Eyre and Menzel 1989).
  - Brightness temperature biases are removed by variational bias correction (VarBC) scheme with simple predictor variables.
    - Surface temperature, satellite zenith angle and constant.
- TEST②: CNTL + HSS (TEST① + water vapor channels)

- Experimental period
  - Summer(26 June. 2020 - 31 July. 2020)
  - Winter(18 Dec. 2019 – 31 Jan. 2020)

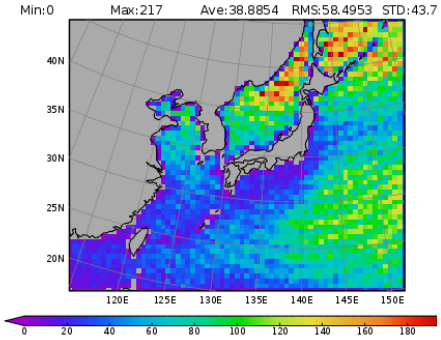
Data coverage

◆Distribution of accumulated data usage during the experimental periods

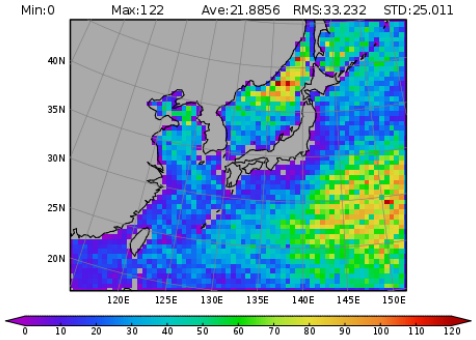
IASI

Summer

246ch(706.25 cm^{-1})

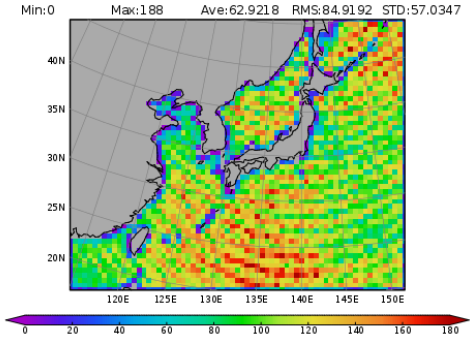


356ch(733.75 cm^{-1})

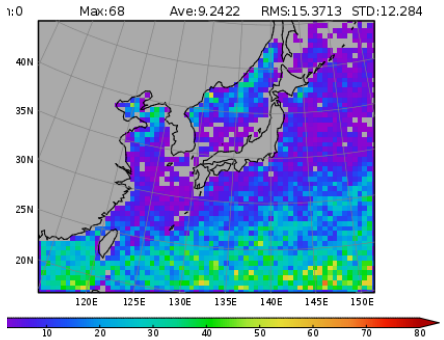


Winter

246ch(706.25 cm^{-1})



356ch(733.75 cm^{-1})

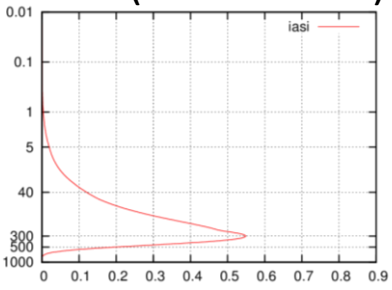


Summer: Data usage was fewer due to Baiu frontal activity.

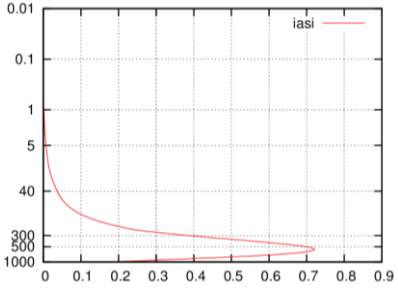
Winter: Data usage of the lower sensitive channel was fewer due to shallow convective clouds caused by a cold air outbreak near Japan.

Weighting function

246ch(706.25 cm^{-1})



356ch(733.75 cm^{-1})

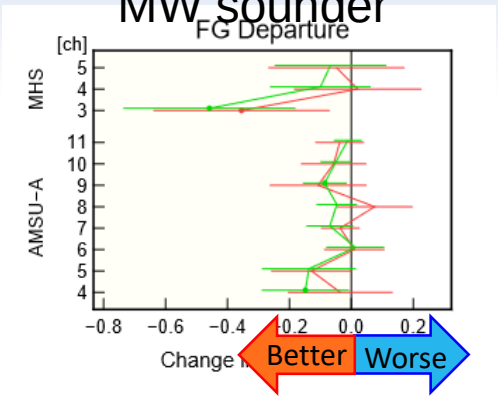


Changes in STD of FG departure of other observations against CNTL

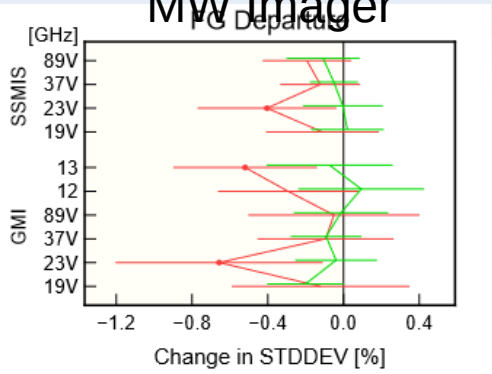
Red : summer
Green : winter

TEST①(temperature ch. only)

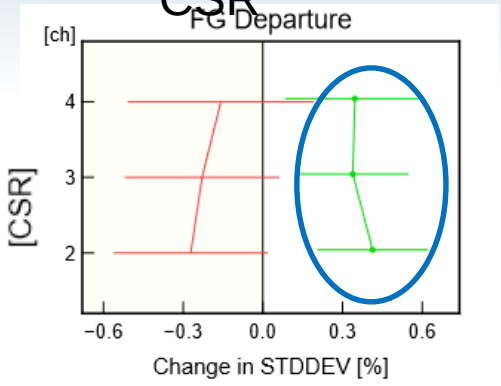
MW sounder



MW Imager

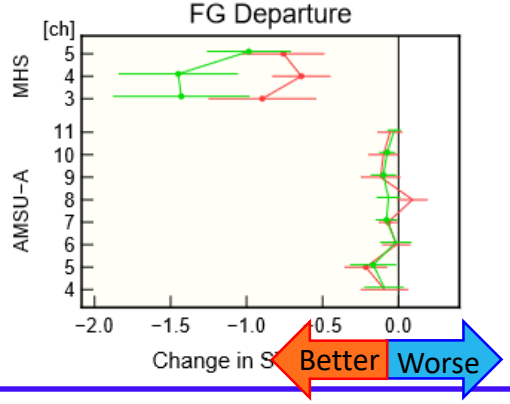


CSR

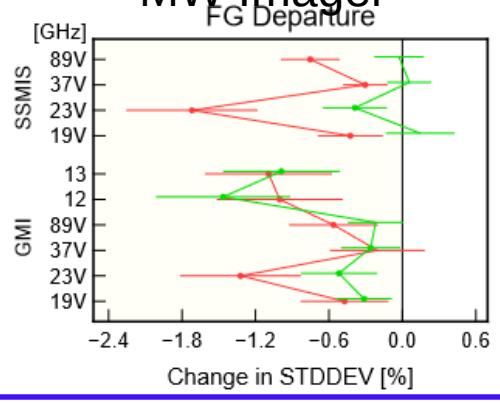


TEST②(temperature + water vapor)

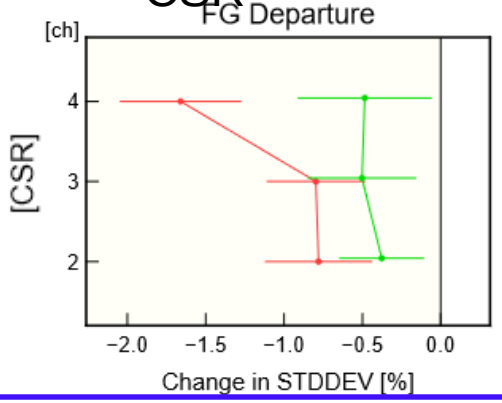
MW sounder



MW Imager



CSR



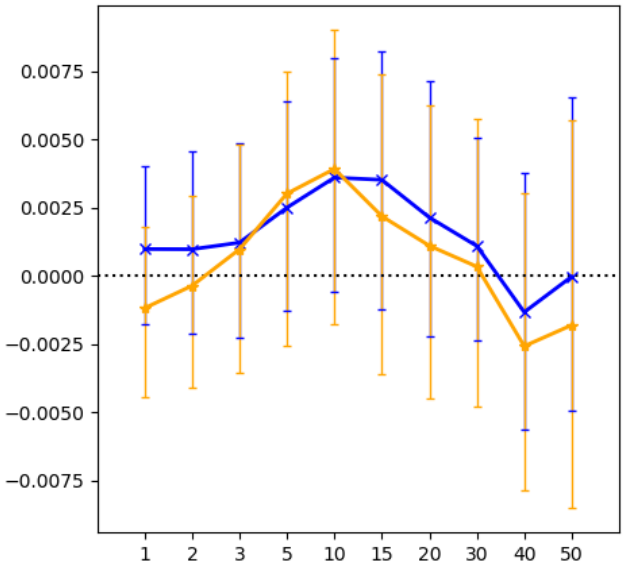
Water vapor and temperature fields were improved in the FG.

Assimilation of water vapor channels have positive impact on water vapor fields in the FG.

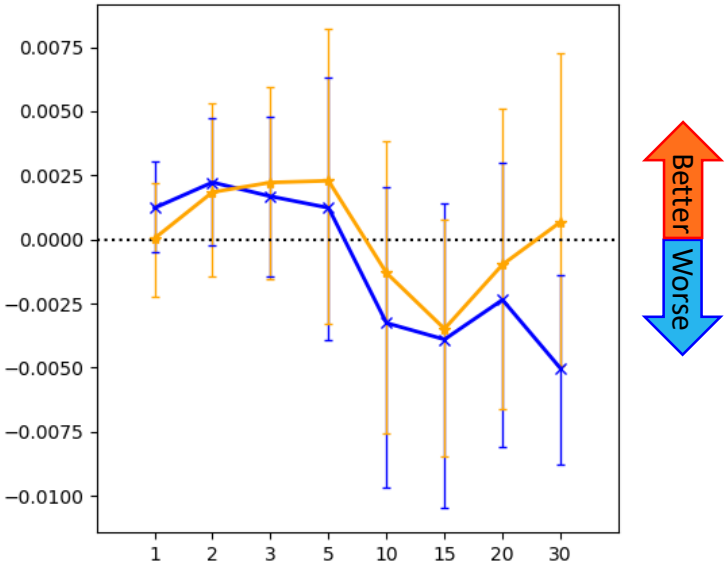
Changes of equitable threat score against CNTL

TEST①(temperature ch. only)
TEST②(temperature + water vapor)

Summer



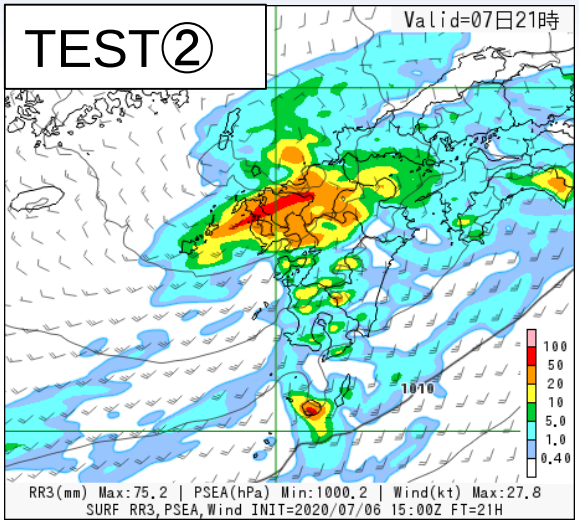
Winter

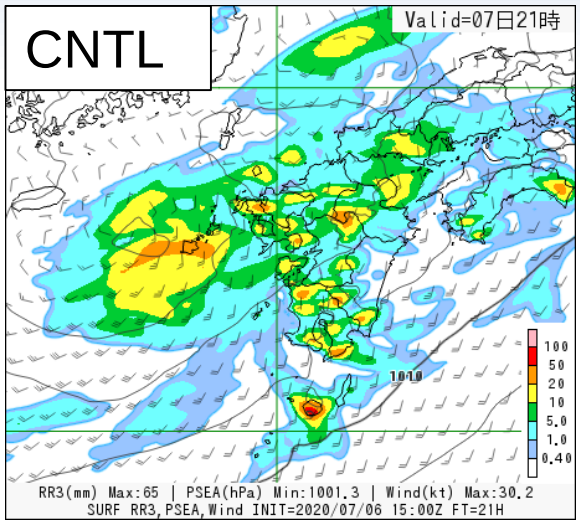


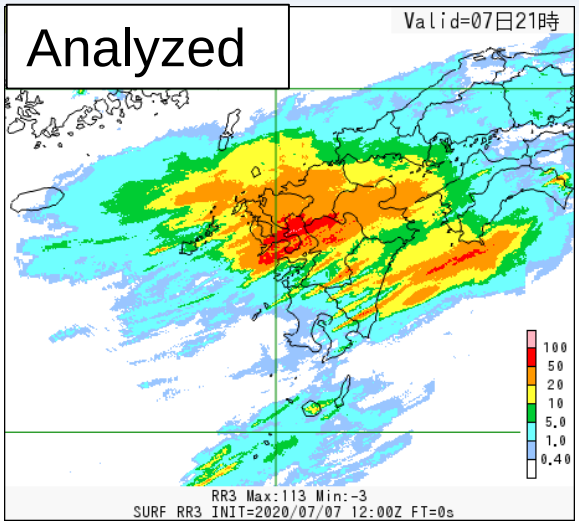
Water vapor channels have slightly positive impact on precipitation forecasts in summer period.

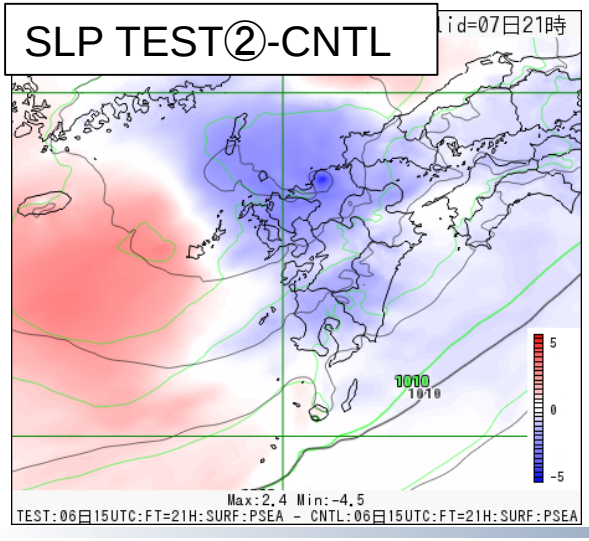
Case study

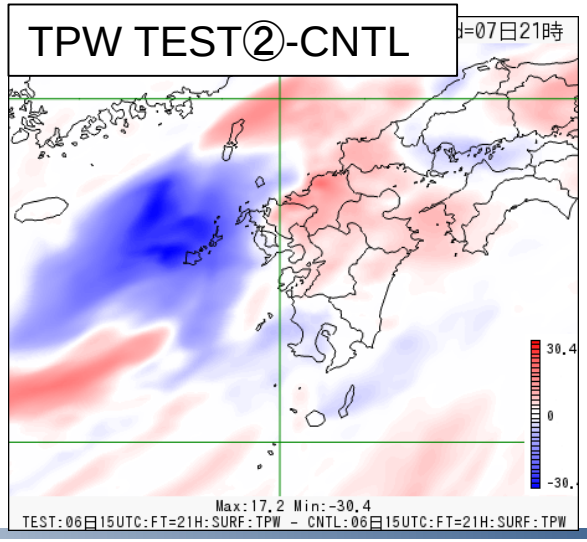
Comparison of the 3-hr accumulated precipitation forecast for 12 UTC 7 July 2022 (Ini: 15UTC 6 July).











Precipitation forecast of TEST② were closer to the analyzed radar precipitation than CNTL.

Summary

- The Impacts of HSS radiance assimilation was investigated in the JMA's meso-scale NWP system.
- Channel selection accounting for the height of the model top.
  - Higher sensitive channels are omitted based on the comparison of O-B statistics between global system and meso-scale system.
  - It is important to remove channels even slightly sensitive to atmosphere upper the model-top height.
- Data assimilation experiments were conducted.
  - Tropospheric temperature and water vapor forecasts were improved.
  - Addition of water vapor channels have slightly positive impacts for precipitation forecasts.

Future Plan

- Consider the way to reduce calculating error caused by lower model top height in the regional model.
  - Use the profile of the global model above the model-top height in the regional model.