Evaluation of Assimilation and Prediction Effects of Different Satellite Observation Operators in CMA-GFS

ARMS

Jun Yang[1,2], Fuzhong Weng[1,2], Yang Han[1,2], Hao Hu[1,2], Yining Shi[1,2]

[1.] CMA Earth System Modeling and Prediction Centre

[2.] State Key Laboratory of Severe Weather, Chinese Academy of Meteorological Sciences

中国气象局地球系统数值预报中心
CMA EARTH SYSTEM MODELING AND PREDICTION CENTRE

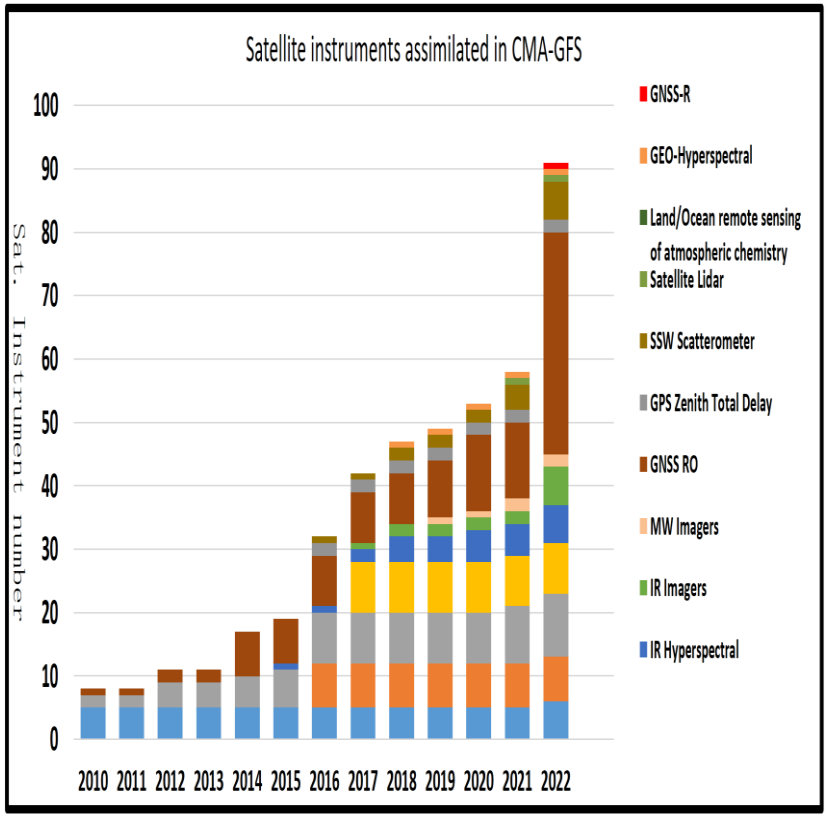
CONTENT

01| Current status of CMA-GFS

- In 2023, the CMA-GFS model has updated to version 4.0. The horizontal resolution of model has reached 12.5km, and more than 90 satellite instruments have been assimilated.

- In the past many years, RTTOV had supported the application of satellite data assimilation in CMA-GFS model.

- ARMS, as a satellite observation operator developed by the China Meteorological Administration, has become increasingly mature after five years of development.



For more details about ARMS, you can find in

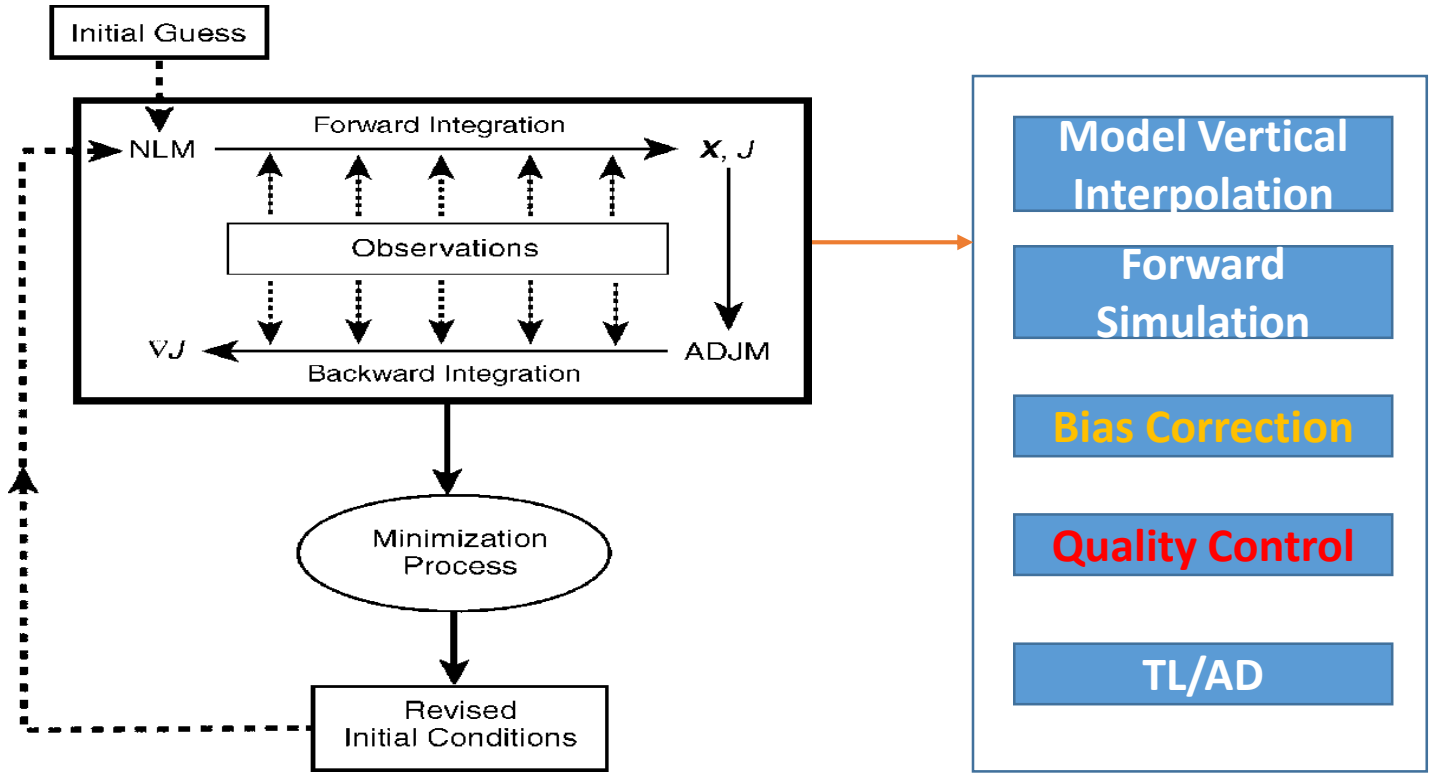
Session 1. 04 : All-sky Radiative Transfer simulation based on the Advanced Radiative transfer Modeling System (ARMS).

Session 15.03 : Assimilation of FengYun Satellite Data in CMA-GFS using Advanced Radiative transfer Modeling System (ARMS).

ARMS can well support all assimilated satellite radiance data in CMA-GFS, and we have carried out a one-year test to evaluate the performance of ARMS and RTTOV.

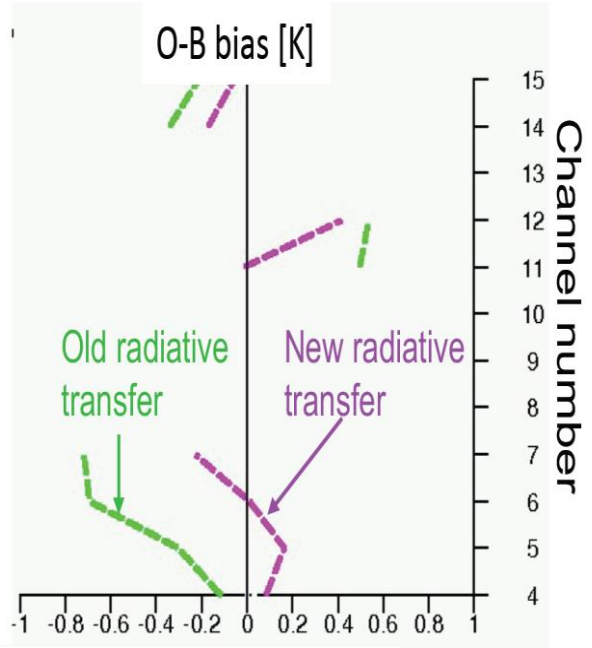
02| Influence of updating observation operator

- There are at least five steps in NWP model associated with satellite observation operator.
- The updating of the same observation operator also needs to reconsider the bias correction and quality control.



Schematic Diagram of the 4DVAR (from Park and Zupanski, 2003)

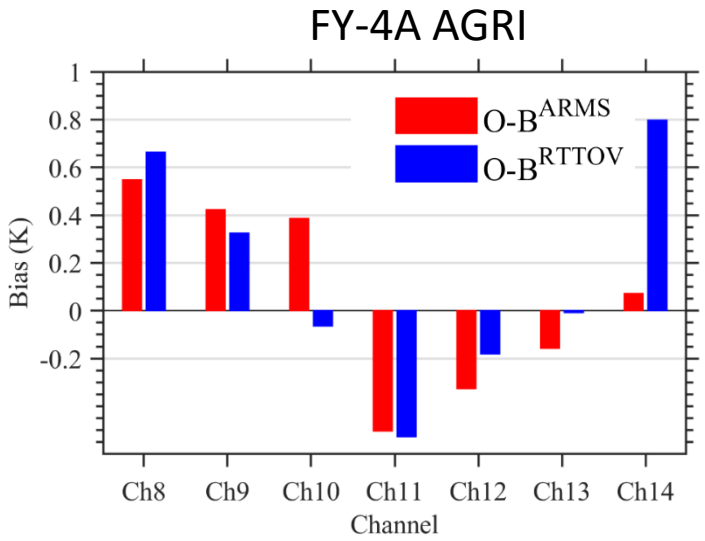
Change in bias for HIRS resulting from an update of the Radiative Transfer model:

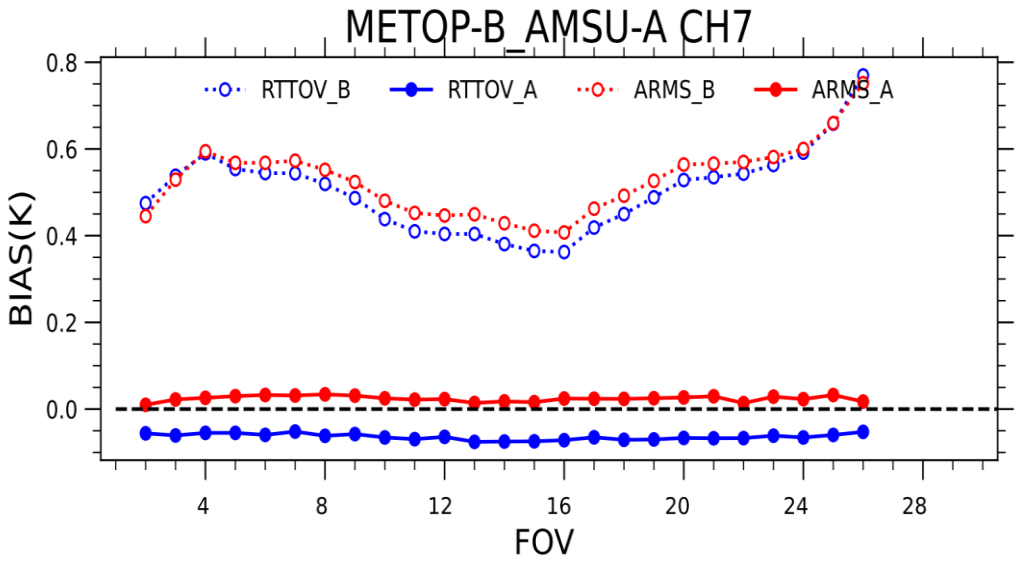


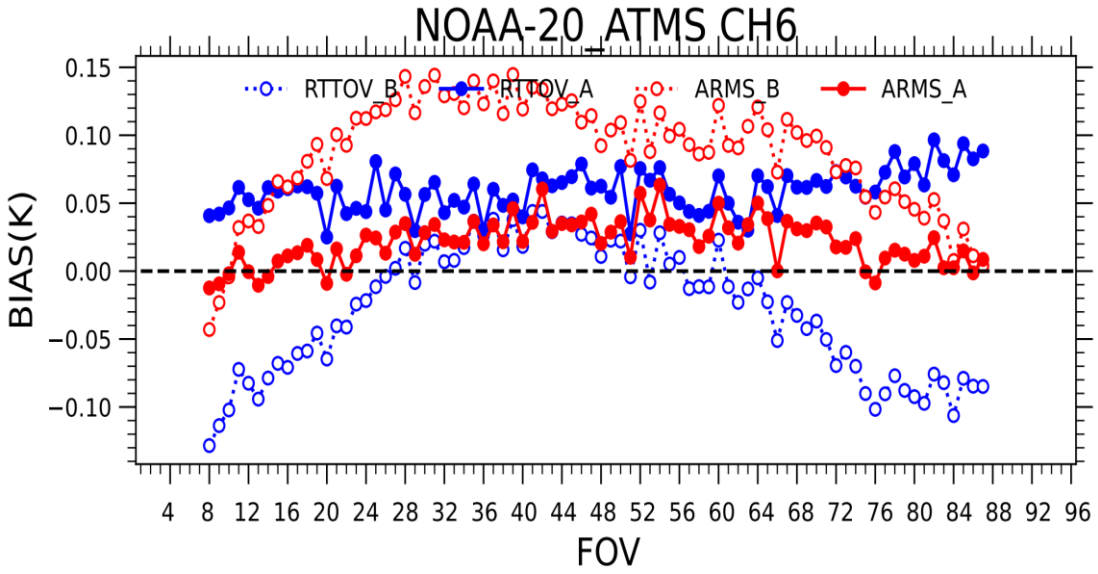
(from Hersbach and Dee, 2014)

02| Influence of updating observation operator

- Satellite observed radiances and observation operators always have errors inevitably.
- Each satellite channel has a constant bias, some channels even have periodic bias, especially in a geostationary satellite.
- For cross-track scanning devices, there generally exists bias vary with scanning angle.
- For polar orbiting instruments, there is also air-mass dependent bias.

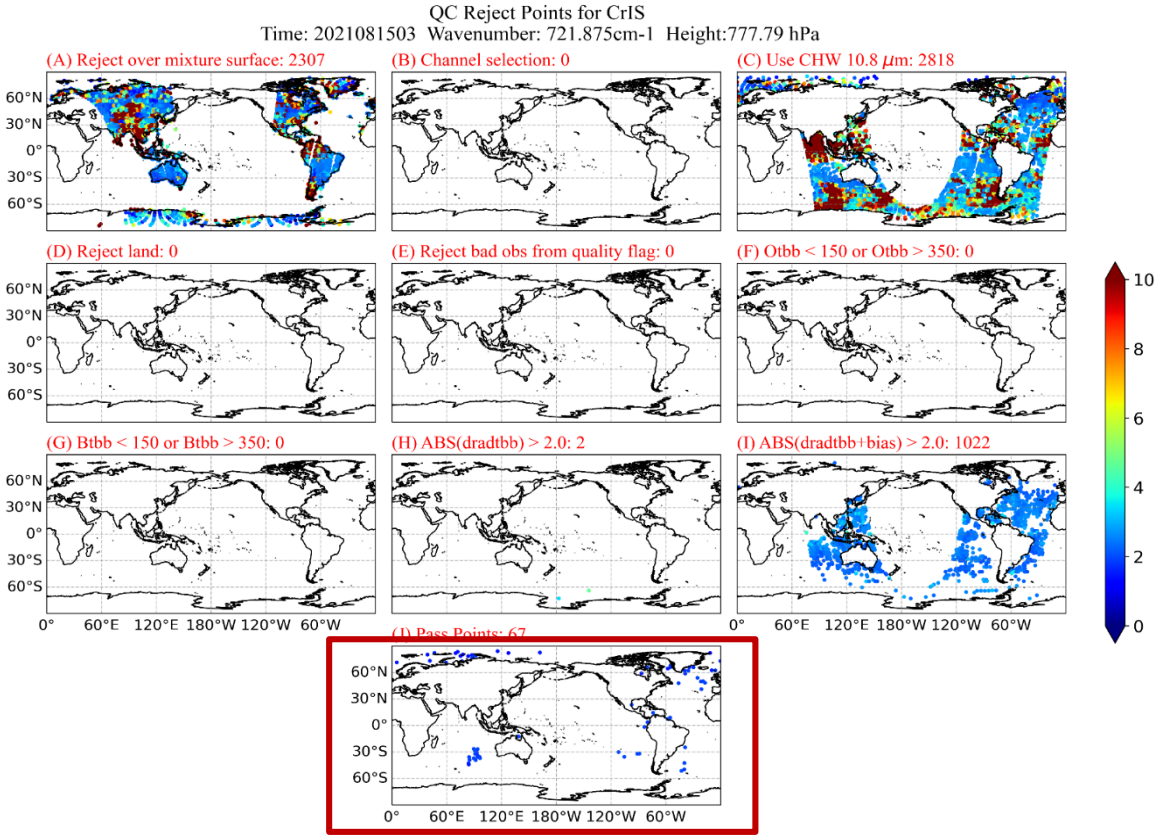




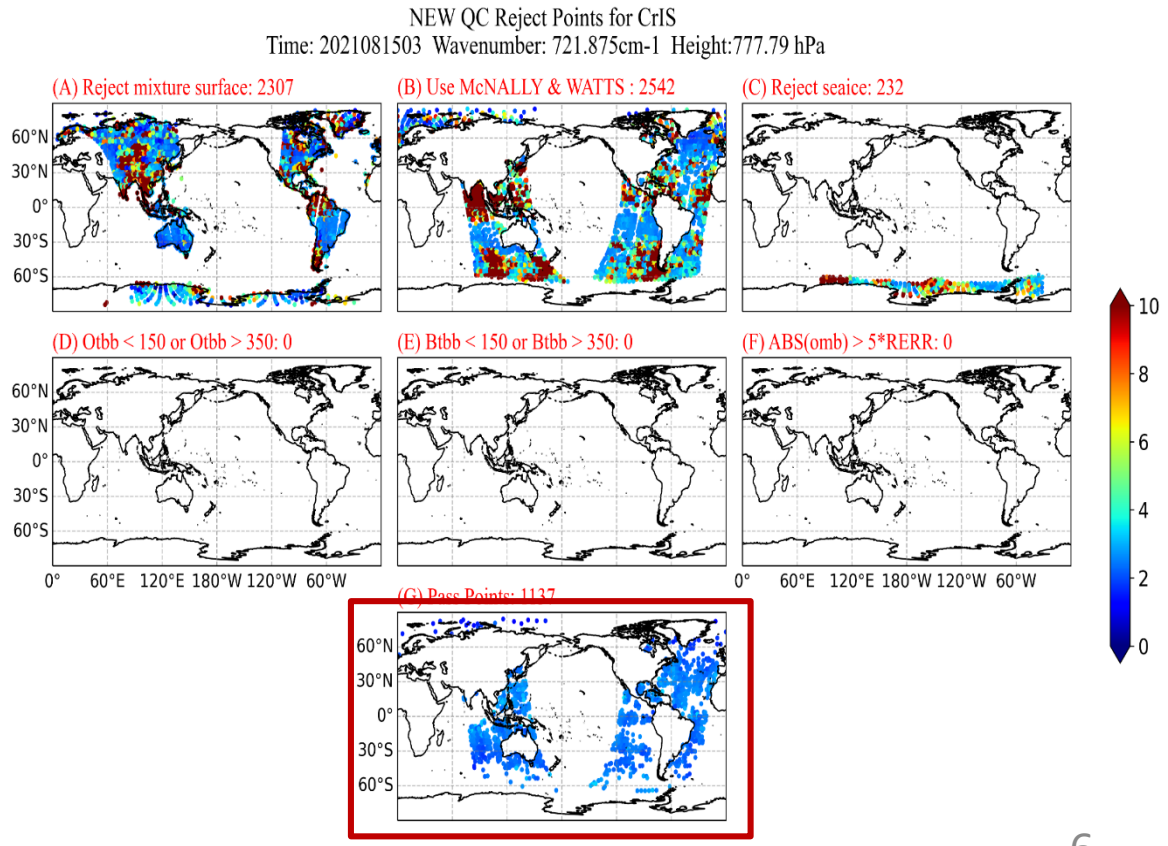


02| Influence of updating observation operator

- Generally, some threshold settings in quality control always depend on observation operator.
- The quality control scheme that performs well for one observation operator is not necessarily suitable for another observation operator.



QC based on RTTOV but used for ARMS



QC based on ARMS

03| Evaluation between ARMS and RTTOV

- One-year test of CMA-GFS using different version from September 2021 to August 2022

- Three different versions：

  CTL （25km， Abbreviated as： CMAv3.3）

  Improvements in physical processes and assimilation of more satellite data

  CMA-GFSv4.0 (RTTOV) （12.5km， Abbreviated as： CMAv4.0）

  CMA-GFSv4.0 (ARMS) （12.5km， Abbreviated as： ARMS125）

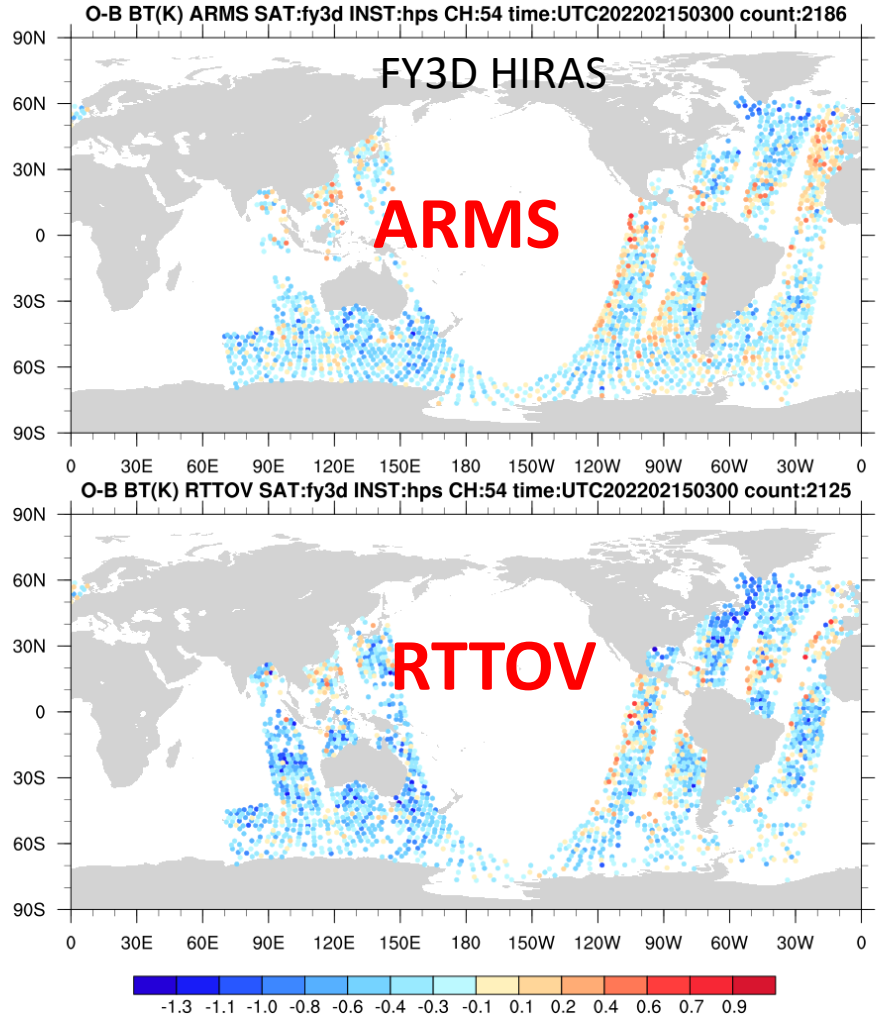
- Two comparisons：

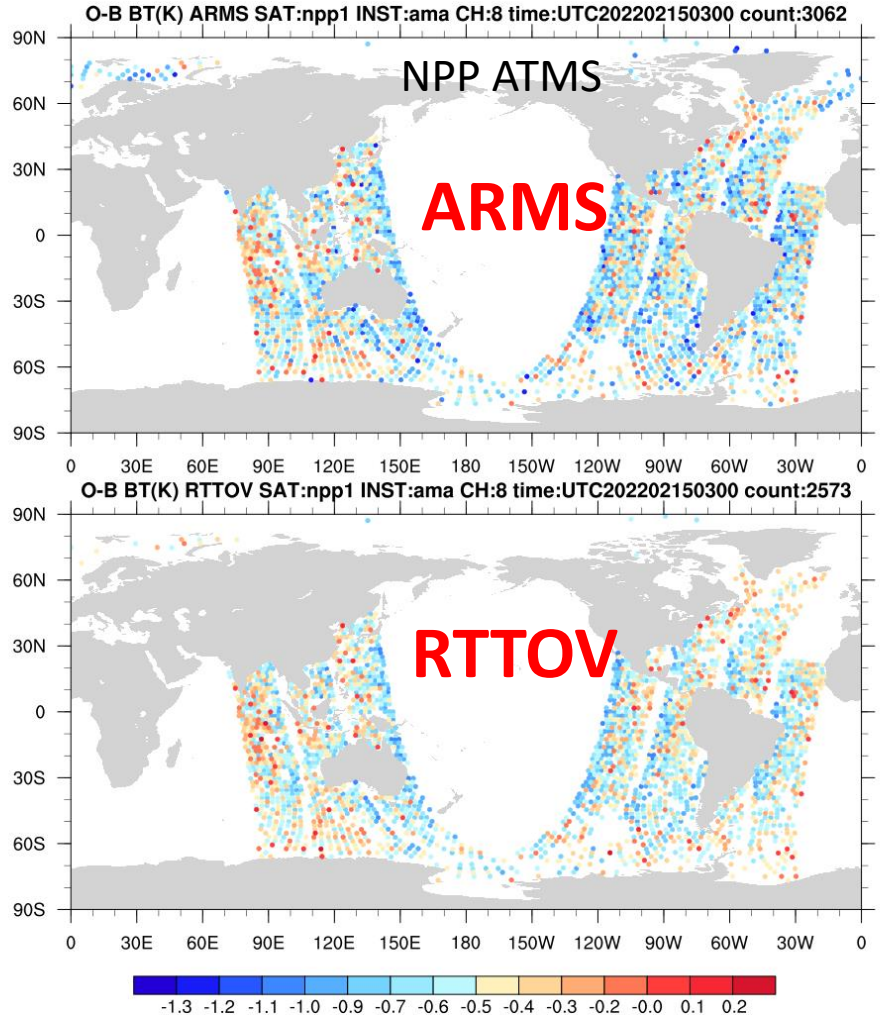
  Analysis field 、 Forecast field (CMA-GFSv4.0 against CTL)

  OMB (CMA-GFSv4.0 using RTTOV and ARMS, separately)

03| Evaluation between ARMS and RTTOV

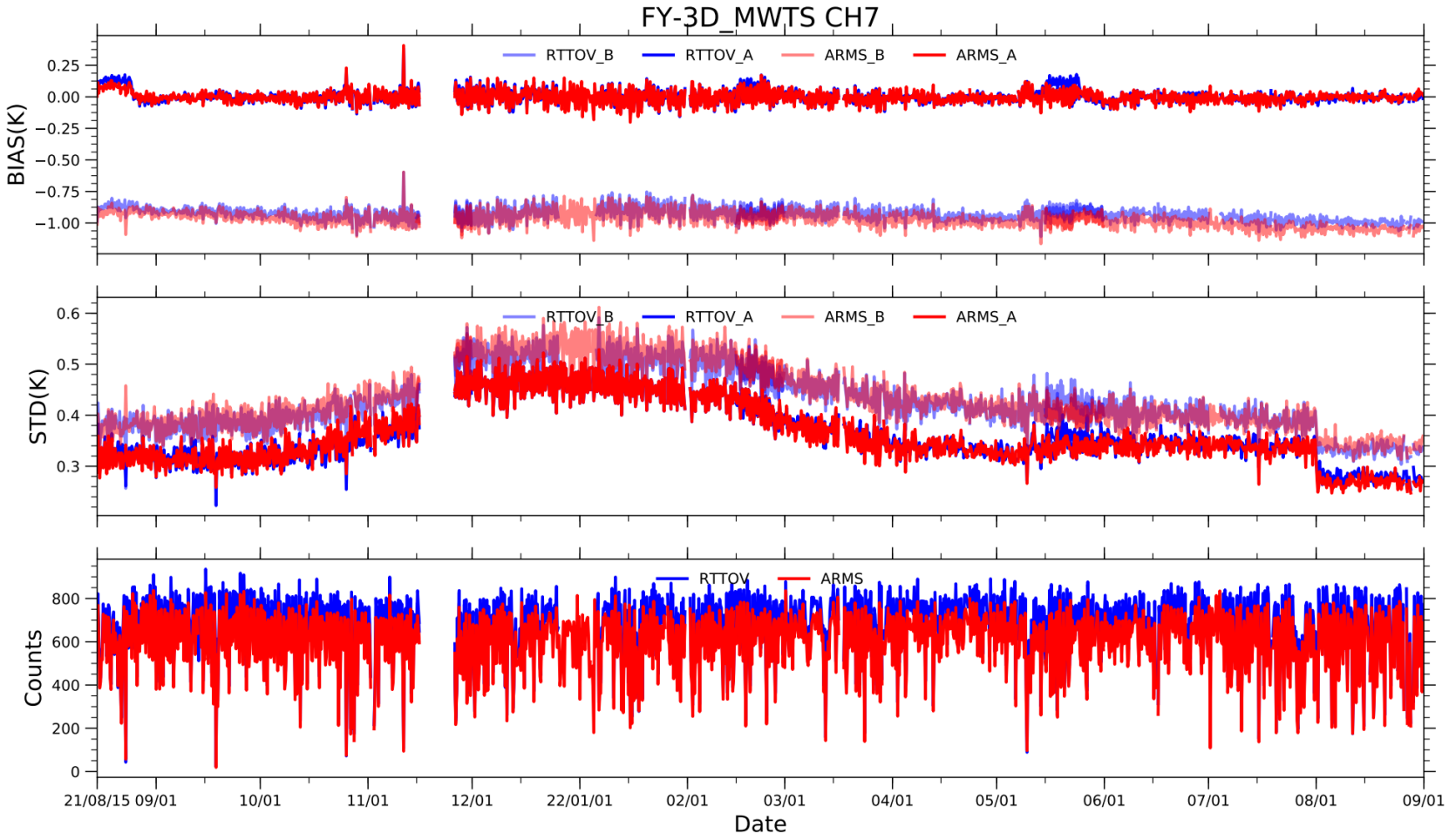
In the 6-hour time window, the amount of data assimilated by the two observation operators is basically the same, and OMB for most channels are also comparable.





03| Evaluation between ARMS and RTTOV

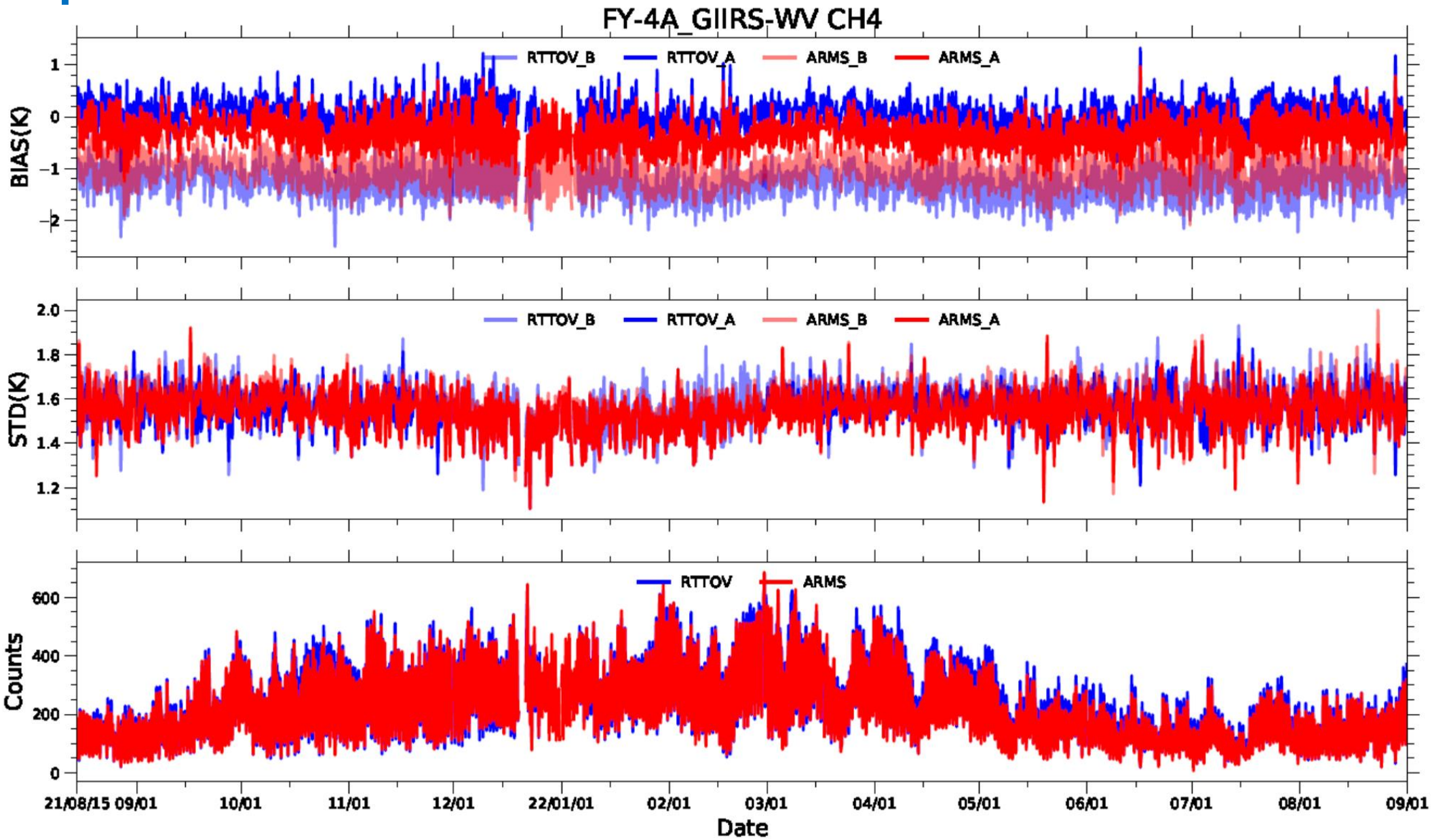
From the time series of one year, the OMB deviations of the two observation operators have good stability and consistency.



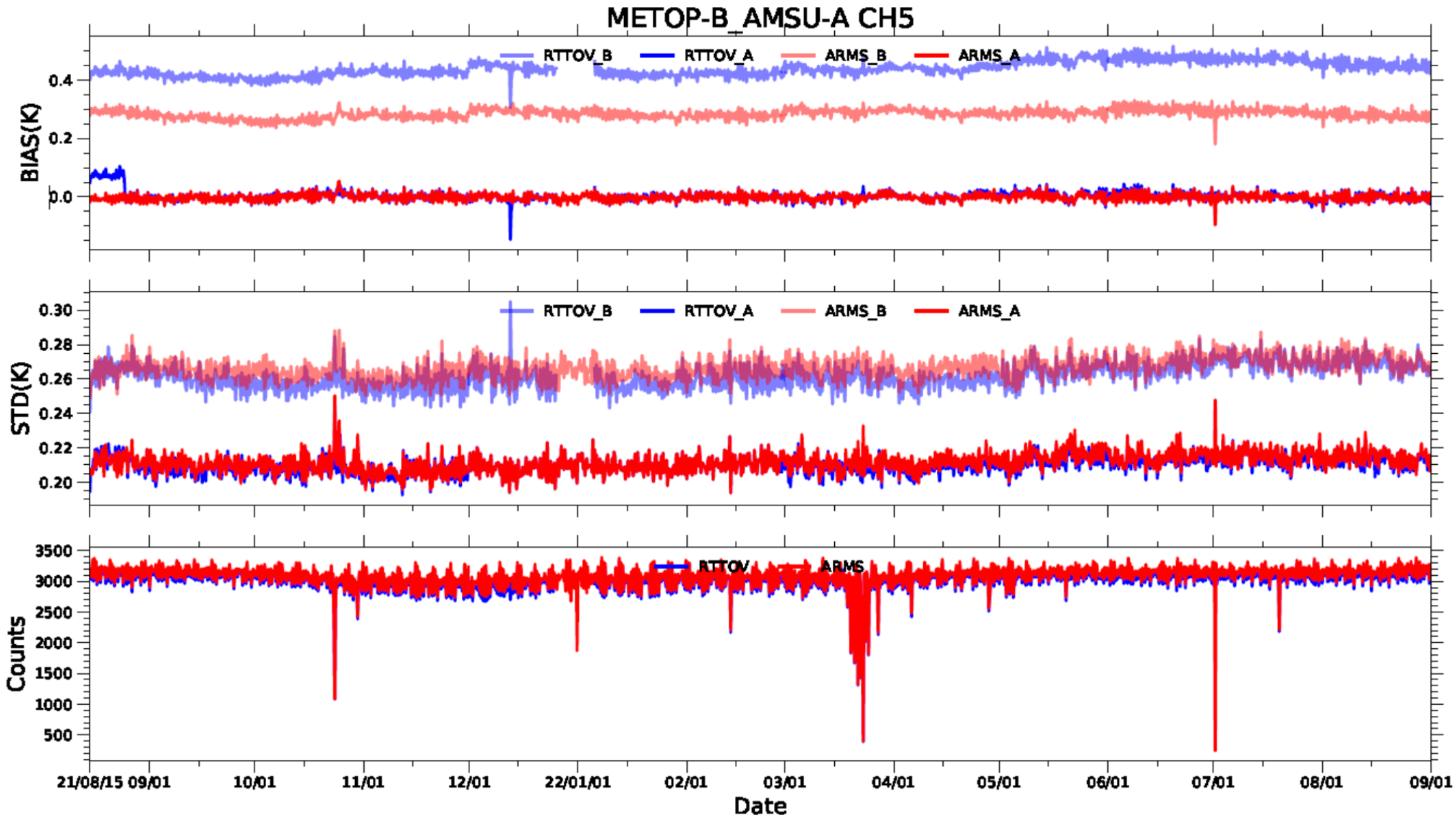
Blue line: RTTOV
Red line: ARMS

Light colored: before BC

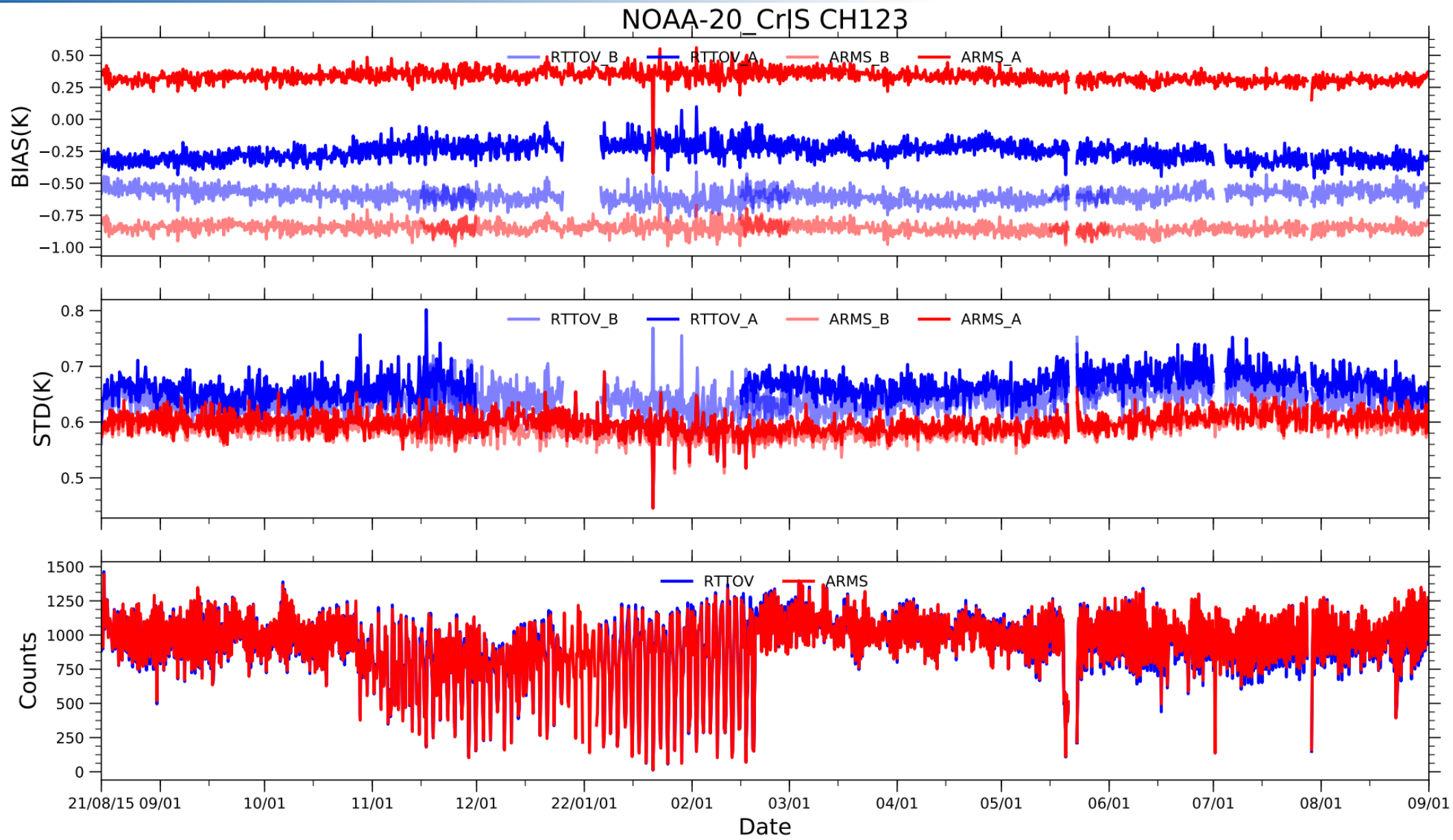
03| Evaluation between ARMS and RTTOV



03| Evaluation between ARMS and RTTOV



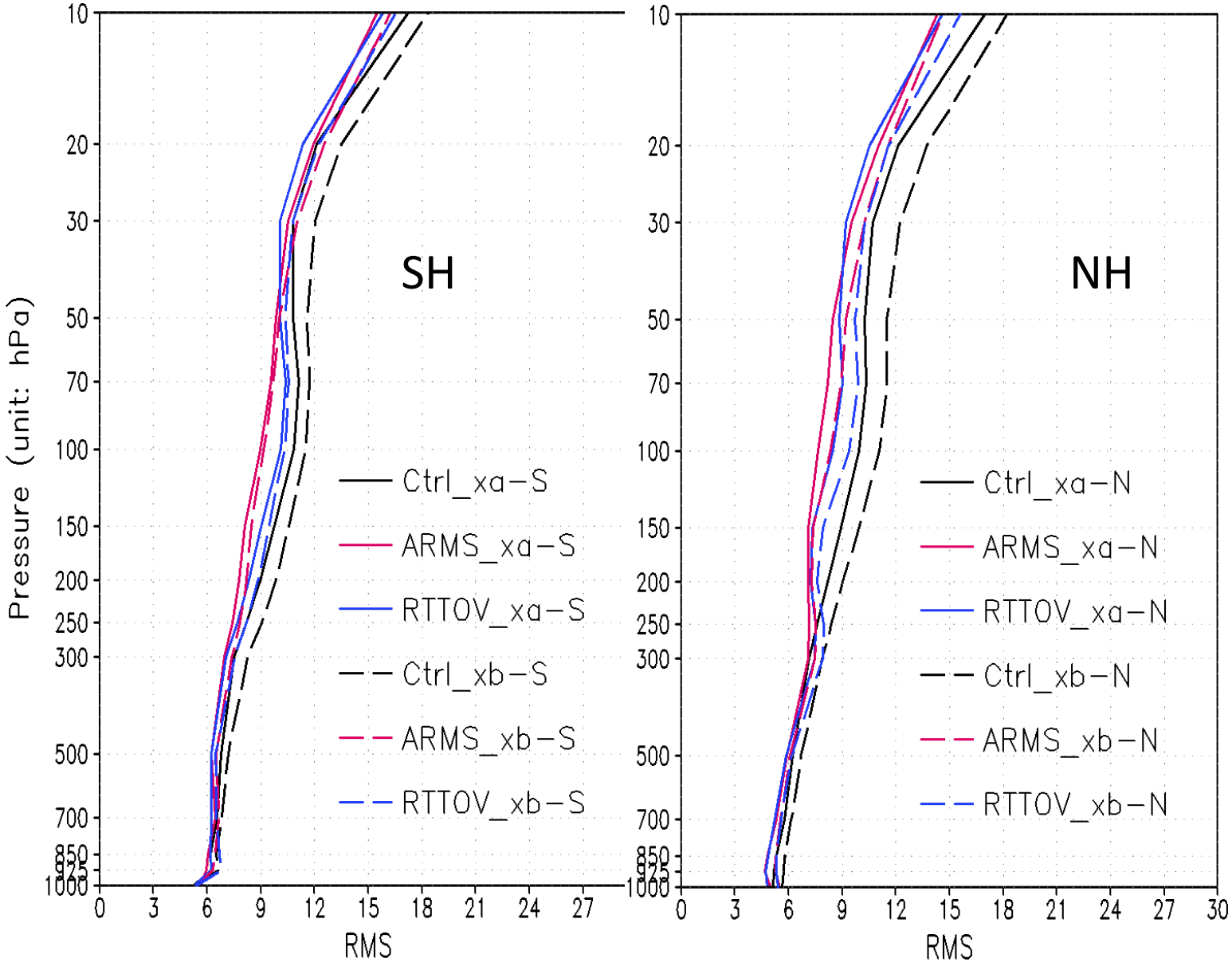
03| Evaluation between ARMS and RTTOV



03| Evaluation between ARMS and RTTOV

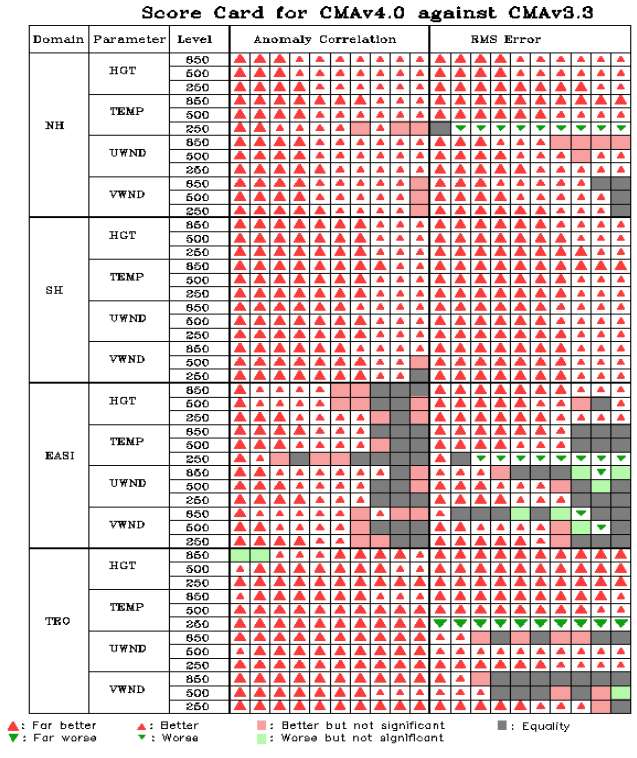
- From the analysis field of the model, benefiting from some new satellite data assimilation, the accuracy of the control variables of the model obtained by RTTOV and ARMS has been greatly improved at all altitudes compared with the control test.

- The direct comparison between RTTOV and ARMS also shows that ARMS even achieved better accuracy on some layers.

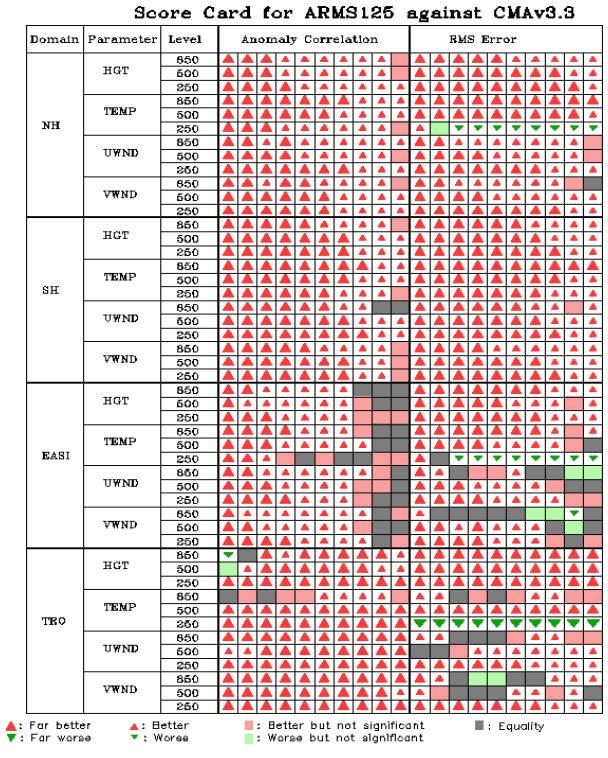


03| Evaluation between ARMS and RTTOV

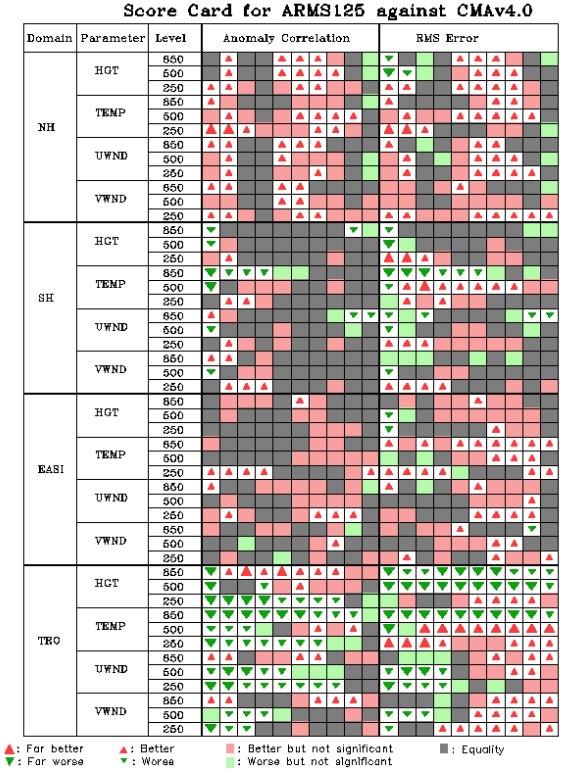
RTTOV vs CTL



ARMS vs CTL



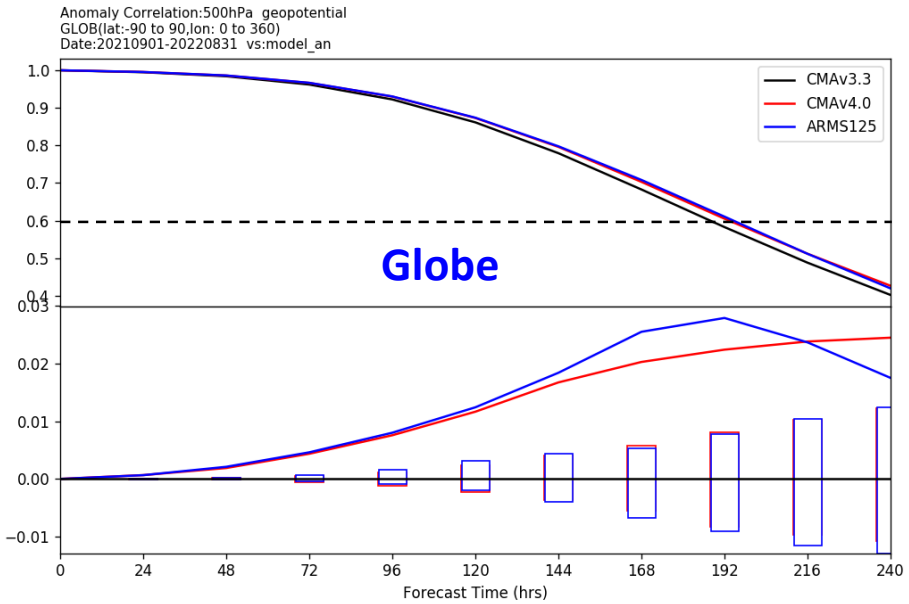
ARMS vs RTTOV



- Compared with the control test, CMA-GFS 4.0 showed significant improvement in prediction results almost globally, whether using RTTOV or ARMS as observation operator.
- After replacing RTTOV with ARMS in CMA-GFS 4.0, the evaluation effect in the Northern Hemisphere, East Asia and Southern Hemisphere has also been slightly improved.

03| Evaluation between ARMS and RTTOV

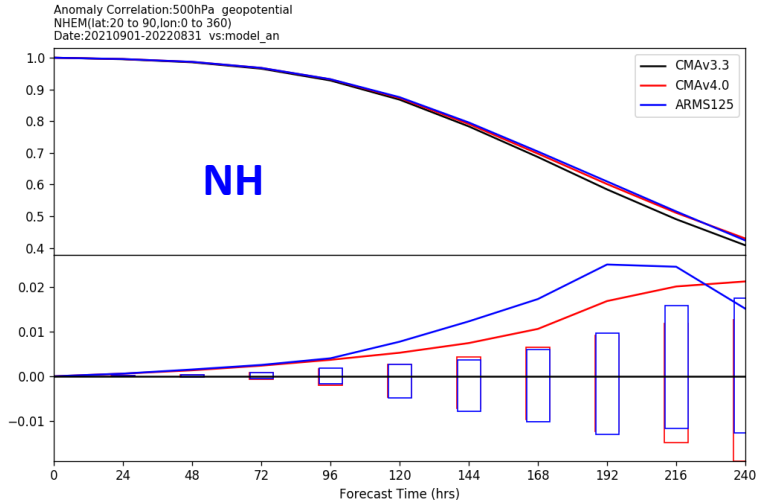
500hPa Globe ACC：

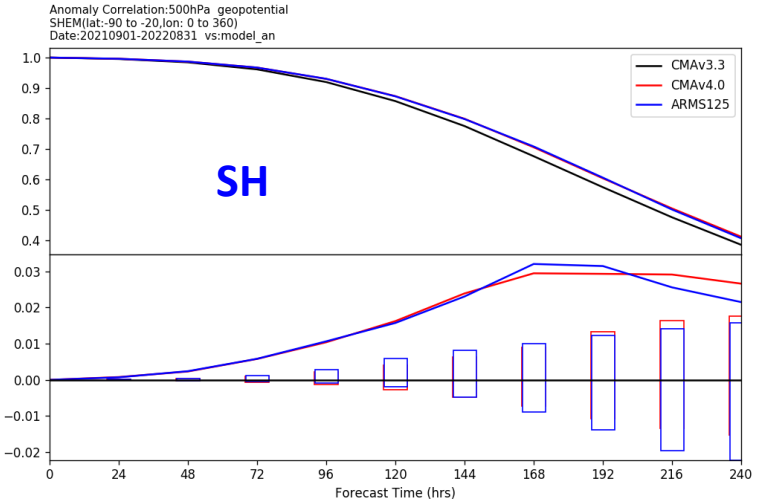


Black line: CTL

Red line: CMA-GFS 4.0 (RTTOV)

Blue line: CMA-GFS 4.0 (ARMS)

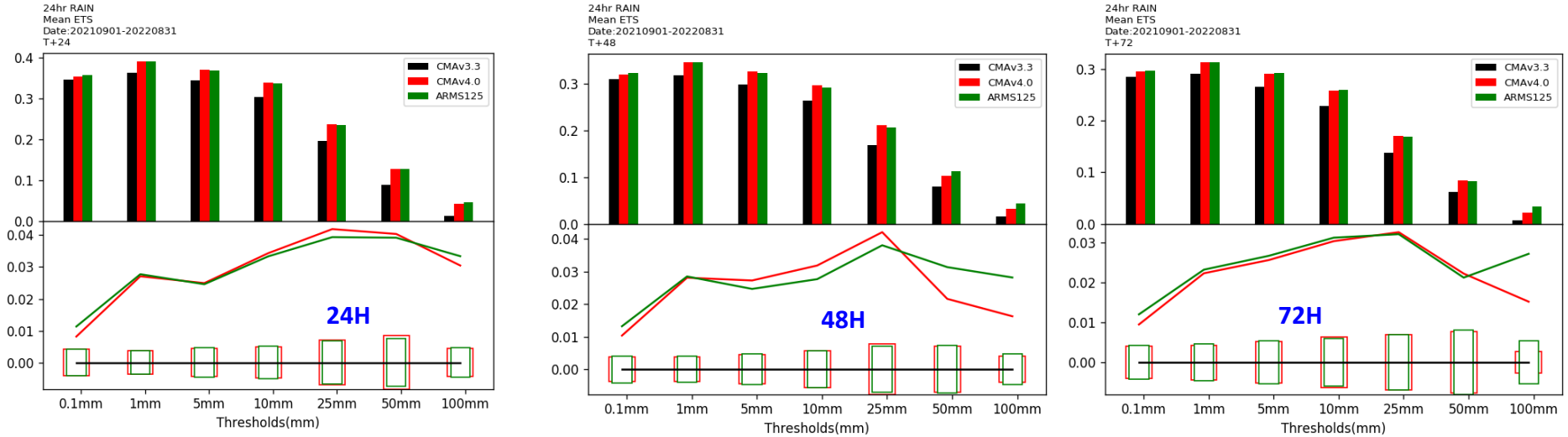




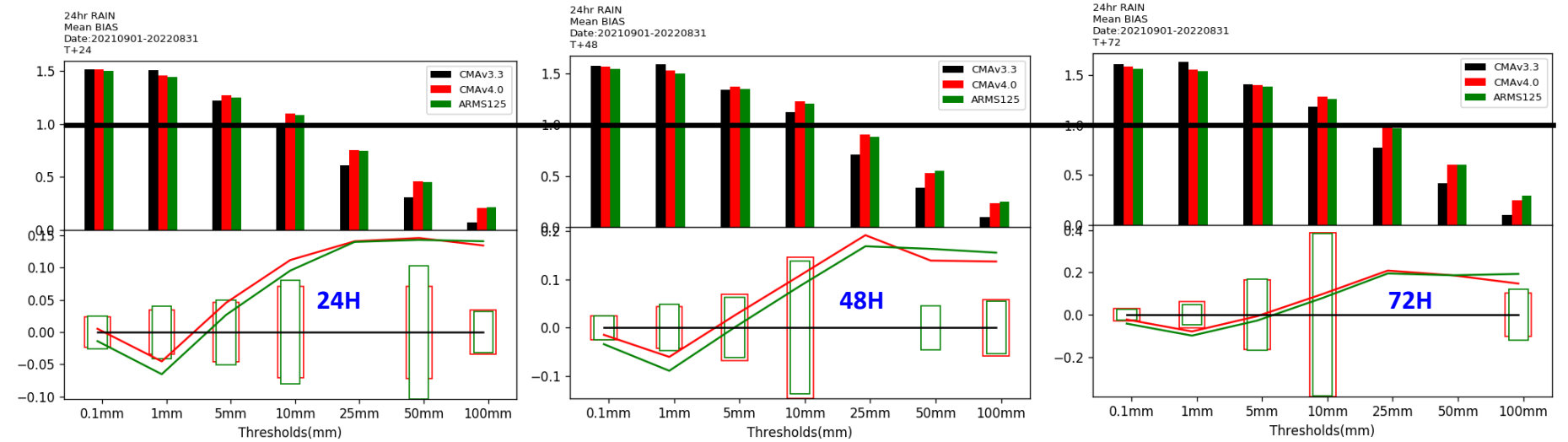
- Compared with the control test, the global ACC of CMA-GFS 4.0 shows obvious improvement.
- Compared with RTTOV version, the forecast performance of ARMS version within 8 days has also been slighting improved.

03| Evaluation between ARMS and RTTOV

ETS



BIAS



- **The false alarm rate of precipitation below 10mm has been reduced,**
- **The miss rate of precipitation above 10mm has been improved.**

04| Summary

- **ARMS has been integrated into CMA-GFS, and one-year test has shown that its assimilation and forecasting capabilities are comparable to RTTOV， and the overall operation is efficient and stable.**
- **CMA-GFS v4.0 is comprehensively improved compared with CTL.**
- **After replacing RTTOV with ARMS, the forecast available days, comprehensive scores and precipitation in CMA-GFS v4.0 remain stable and do not decrease.**
- **Special attention should be paid to bias correction and quality control.**