Effect of bias correction sample selection on FY-3D satellite microwave humidity data assimilation in CMA_GFS model

Xi Shuang, Han Wei, Hu Hao
xishuang@cma.gov.cn

China Meteorological Administration Earth System Modeling and Prediction Centre

2025.5.12

Outline

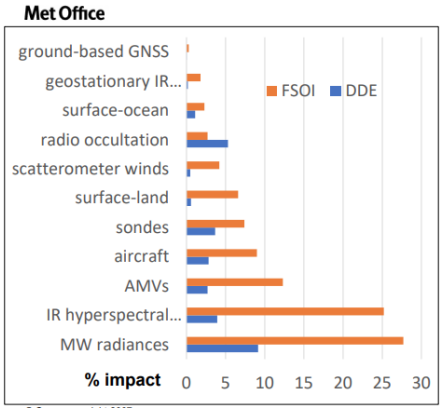
01 Research Background

02 Observation Error, Quality Control and Bias Correction

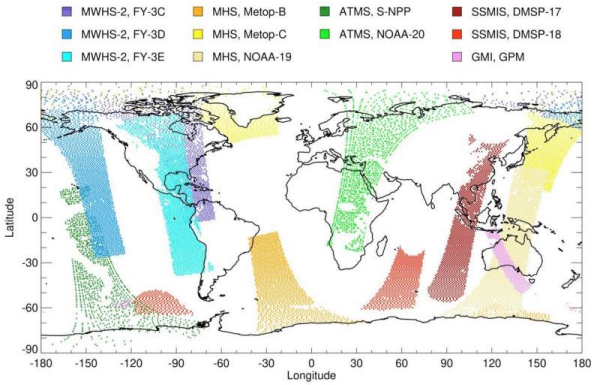
03 Data Assimilation Experiments and Forecast Experiments

04 Conclusions and Future Plans

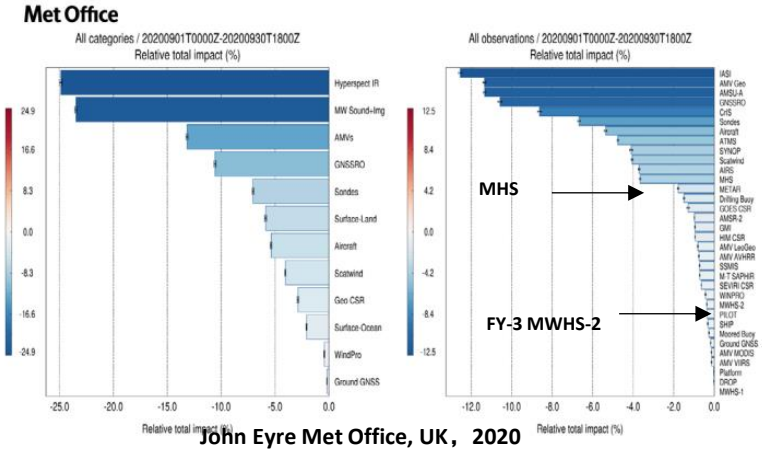
Research Background



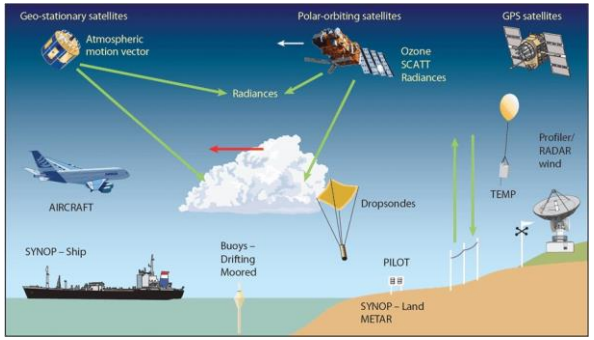
UK. B Candy et al 2020



Liam Steele, ECMWF, Reading, UK et al 2023

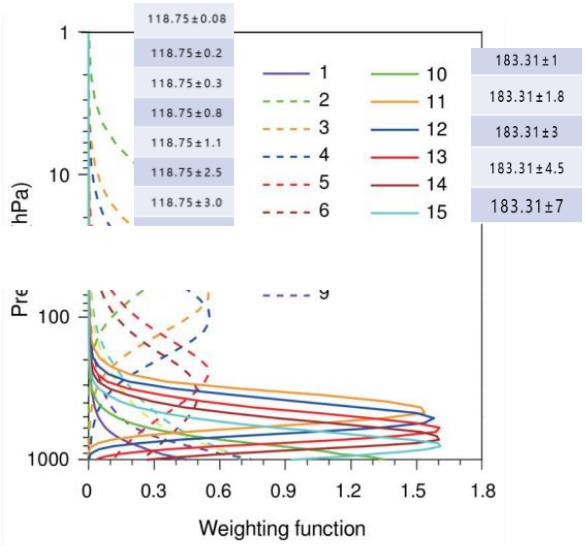


John Eyre Met Office, UK，2020

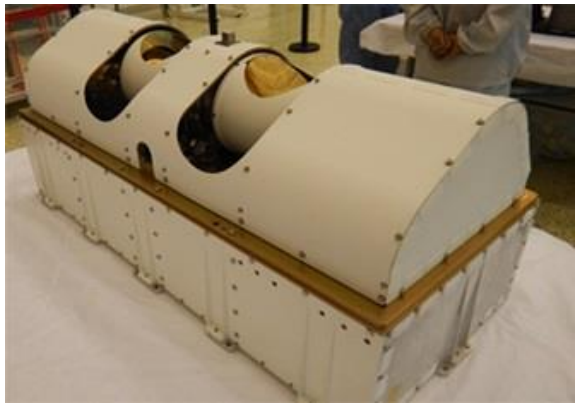


Noodweer.be

FY-3C/D/E/F MWHS-2(Microwave Humidity Sounder 2)



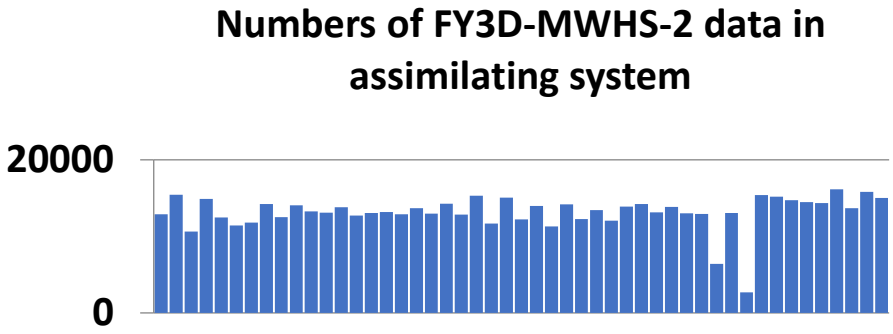
- 5 channels centered 183.31GHz for detecting water vapor
- 8 unique channels centered 118GHz for detecting temperature
- 2 channels centered 89GHz or 150GHz for cloud screening



- **Providing accurate initial field information on atmospheric humidity and temperature for numerical weather prediction**
- **Early warning capabilities for typhoons, rainstorms, and other severe weather events.**

Background of the Work

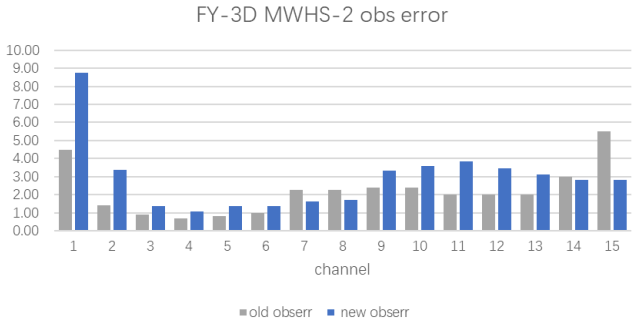
- FY-3D MWHS-2 data assimilation in CMA-GFS was suspended in 2022 due to unstable biases and noise fluctuations.
- In early 2023, the data quality has been improved, and it was reintroduced after our assessment .



◆This work includes:

- Adding six channels for assimilation (five for water vapor and one for temperature).
- Updating channels selection
- Updating observation error file
- Updating quality control scheme.
- Updating the coefficient files for bias correction.
- Experiments with different bias correction schemes.
- Continuous cycling assimilation experiments.
- 10-day forecast verification.

Updating observation error file



Blue : before reuse in 2023 ; grey ： before 2022.

Observation errors changed a lot during years.

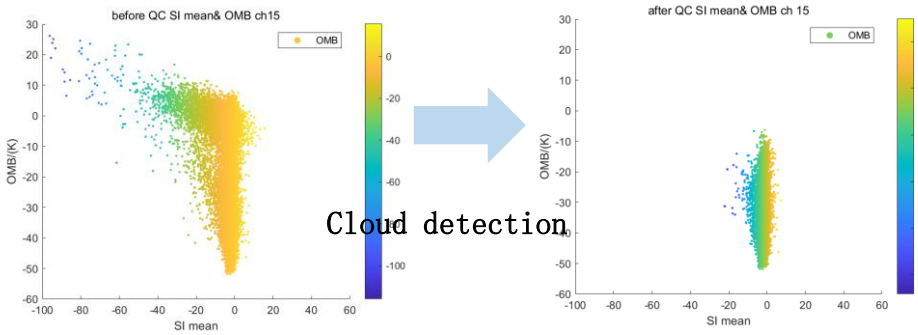
Before, all MWHS-2 share the same observation error file in CMA-GFS, without the consideration of the difference among satellites.

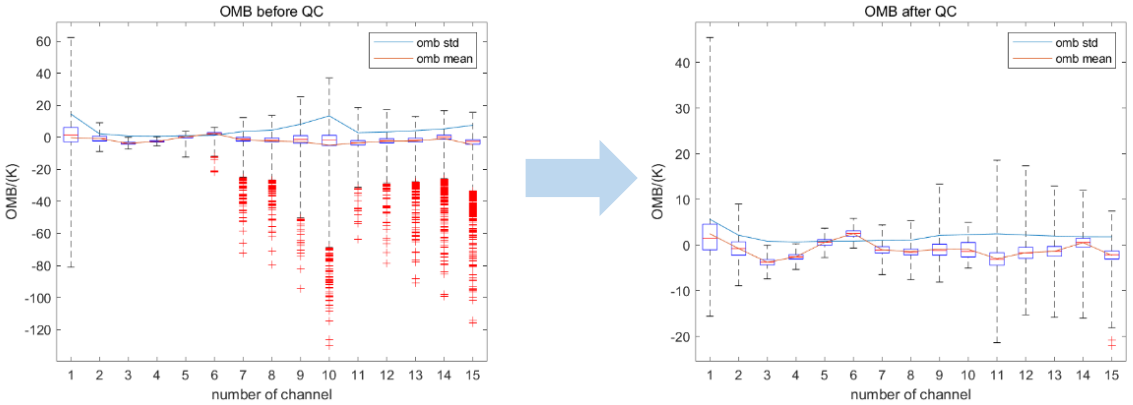
- Specifically added a separate error file for FY-3D MWHS-2.

Quality Control

Rejecting the observations :

a) on mixed surface, land, sea ice, ice or snow (surface temperature less than 271.45K)
b) those affected by clouds (scattering index >= 10 or channel 15 < 260K)



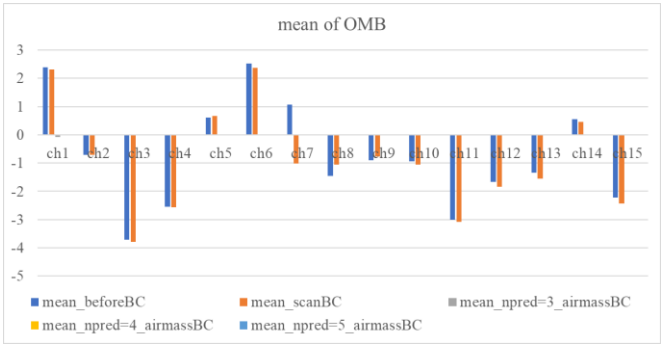


Design of Bias Correction Predictors

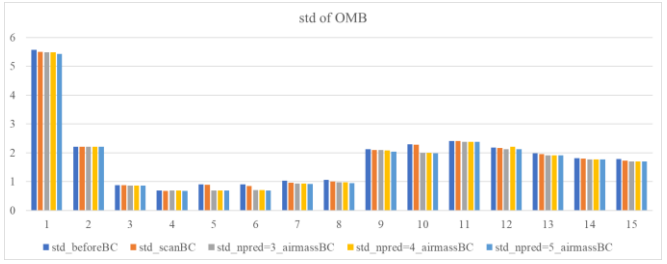
	1	2	3	4	5
Num	300-1000hPa thickness of air mass	50-200hPa thickness of air mass	300-1000hPa moisture	Surface temperature	5-50hPa thickness of air mass
3	√	√	√		
4	√	√	√	√	
5	√	√	√	√	√

No obvious differences

(a)



(b)



The mean（a） and std. （b）of O-B

Bias correction sample selection

No.	Types of sample (20days)
1	NCEP GFS forecast
2	CMA-GFS forecast

Obvious difference of coefficients

- **Channels for temperature： coefficients differences vary by channel, the lower , the bigger**
- **Channels for detecting water vapor ： no channel difference, but systematic bias between two models**

Experiment design

Channel Selection：

Using channel 2、3、4、5、6（for temperature）和11、12、13、14、15 （for vapor）on the sea。

CMA_GFS 4.0，

Cycling 4DVar assimilation per 6h，20230218-20230331,

Forecast: prediction for the following 10 days per 6h.

- **Control Exp.：** No FY-3D MWHS-2,
- **Assimilation Exp.：** FY-3D MWHS-2.
- Static Bias correction ： in the first 10 days
- dynamic bias correction ： in the following 30 days.

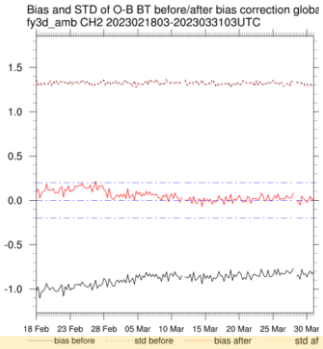
When do static BC offline，using：

1，NCEP_GFS samples；2，CMA_GFS samples.

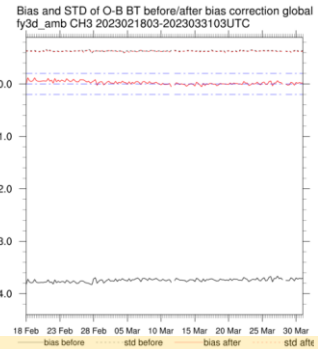
40-day Bias Correction results (NCEP GFS samples, a sudden transfer)

Bias(solid line) and std.(dashed line) of OMB; Before BC, after BC

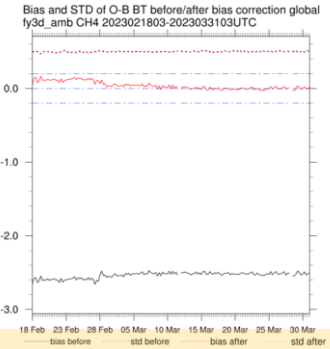
Ch2 T 30hPa



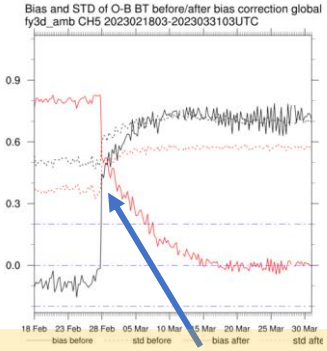
Ch3 T 60hPa



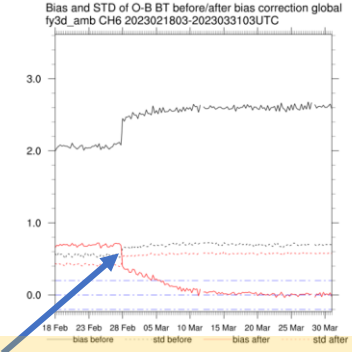
Ch4 T 100hPa



Ch5 T 250hPa



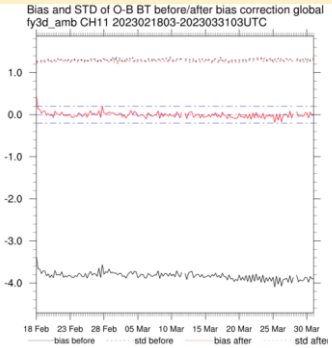
Ch6 T350hPa



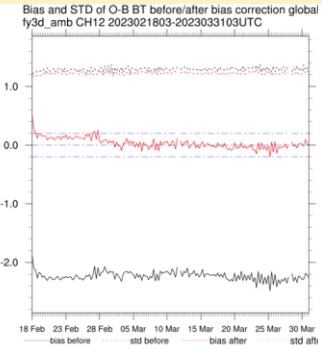
(1) The dynamic BC effect of most channels is better than that of static bias correction.

(2) Static BC has no effect on channels 5, 6 and 14;

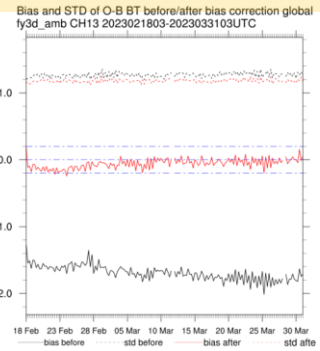
(3) After initiating the dynamic BC, O-B of channels 5 and 6 suddenly increased.



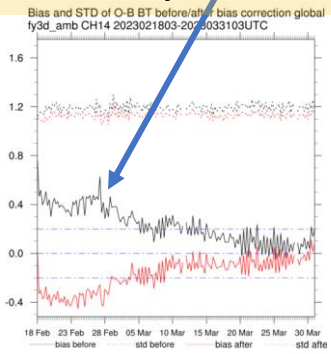
Ch 11水汽450hPa



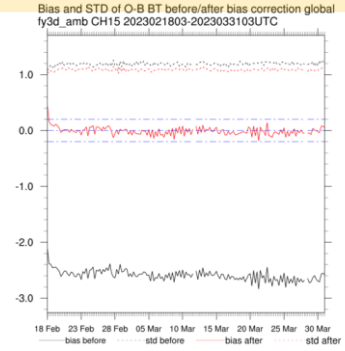
Ch12 500hPa



Ch13 600hPa



Ch14 700hPa

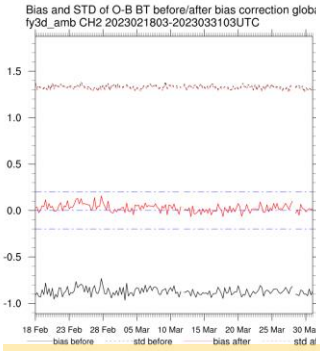


Ch15 800hPa

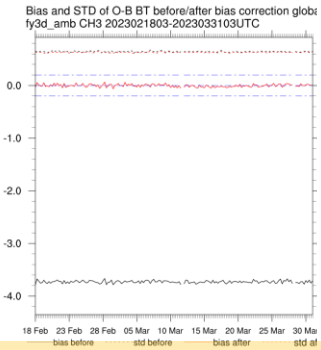
40-day Bias Correction results (CMA GFS samples, stable)

Before BC, after BC

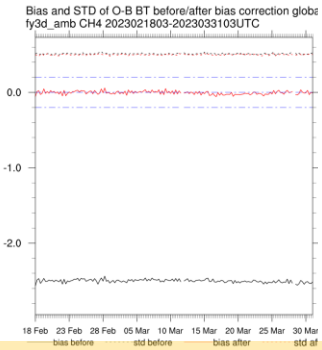
Ch2 T 30hPa



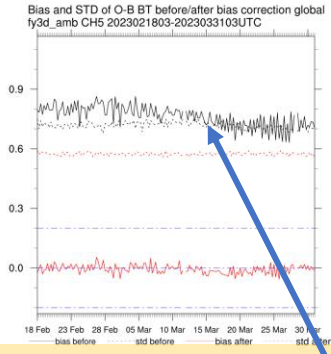
Ch3 T 60hPa



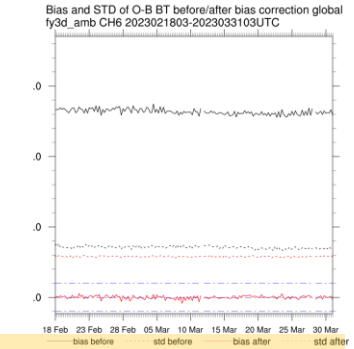
Ch4 T 100hPa



Ch5 T 250hPa

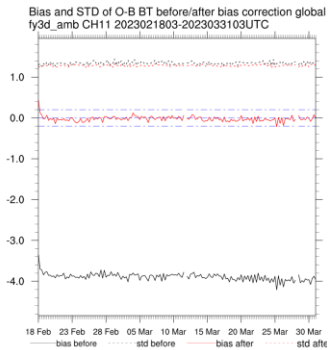


Ch6 T 350hPa

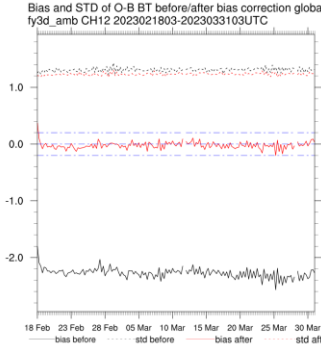


(1) The bias effect is good; (2) Consistently stable;

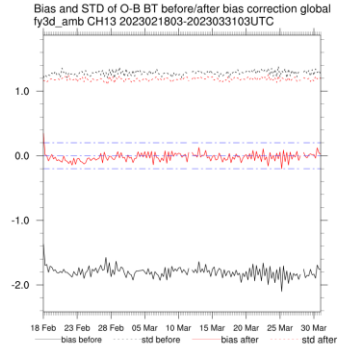
(3) Channel 5 shows that the background field tends towards the direction with smaller bias.



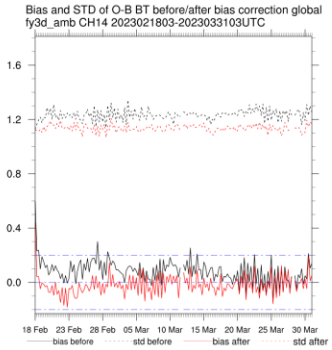
Ch 11 vapor 450hPa



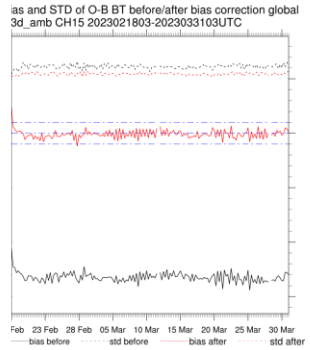
Ch12 vapor 500hPa



Ch13 vapor 600hPa



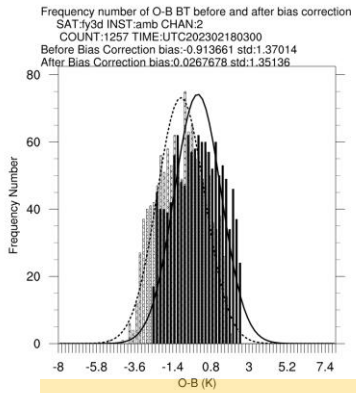
Ch14 vapor 700hPa

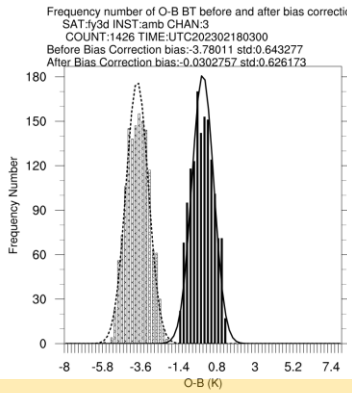


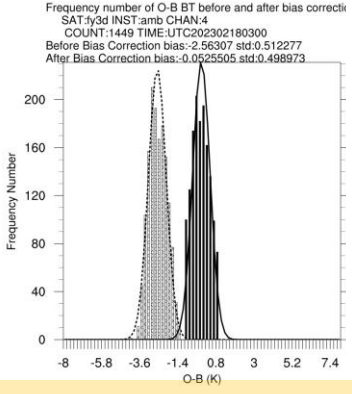
Ch15 vapor 800hPa

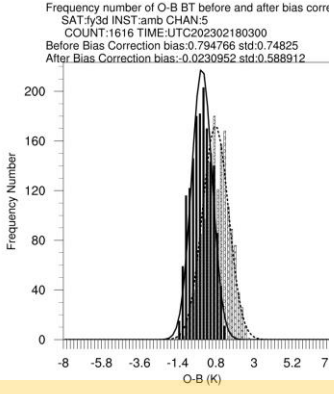
Static Bias Correction Results

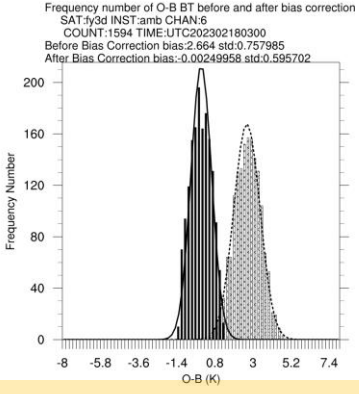
With CMA GFS samples



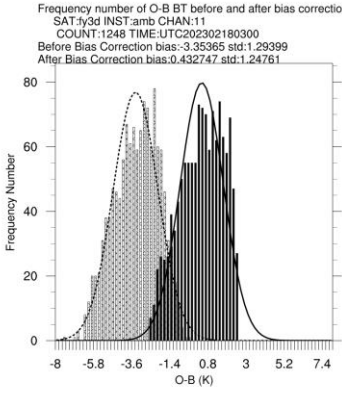


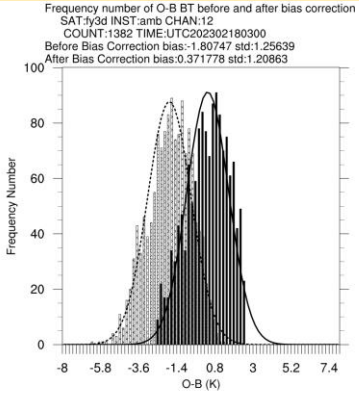


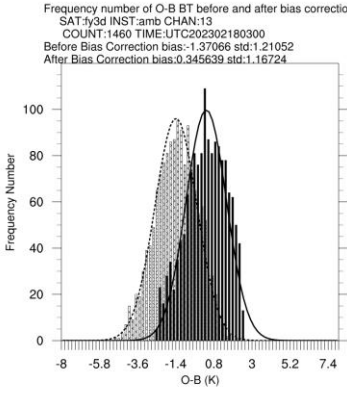


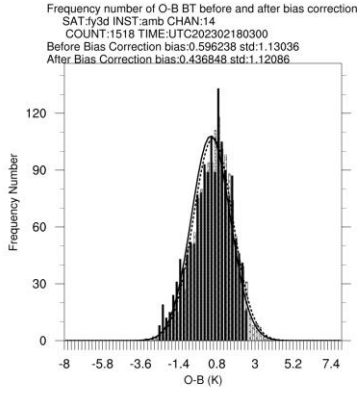


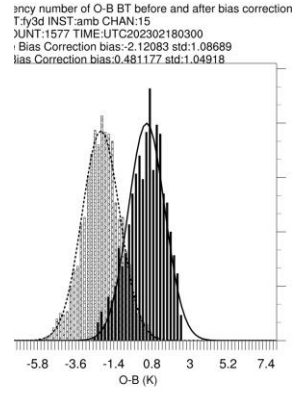
Positive Impacts





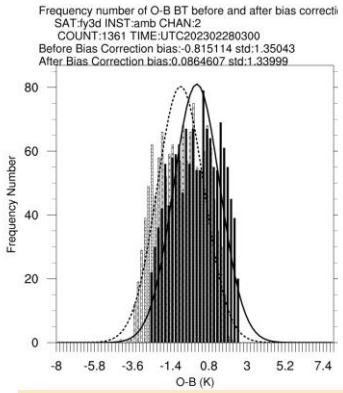


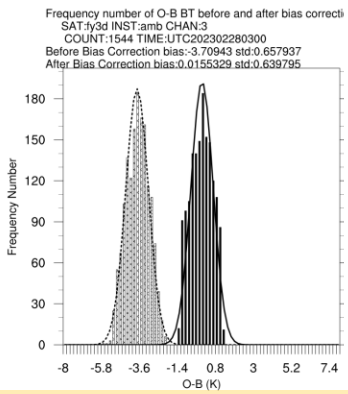


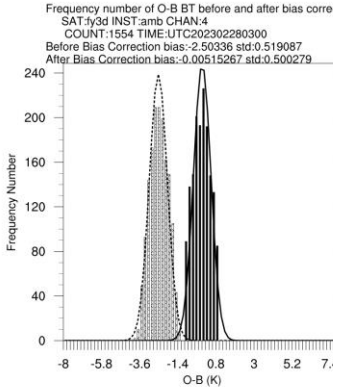


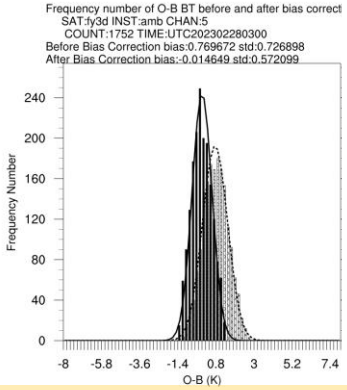
Dynamic Bias Correction Results

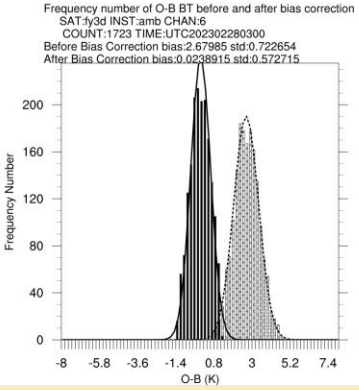
With CMA GFS samples



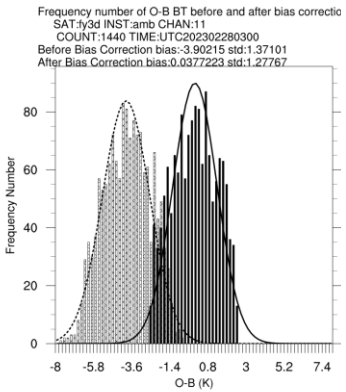


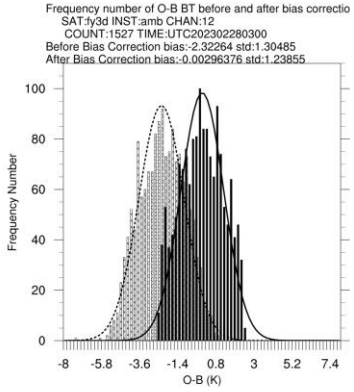


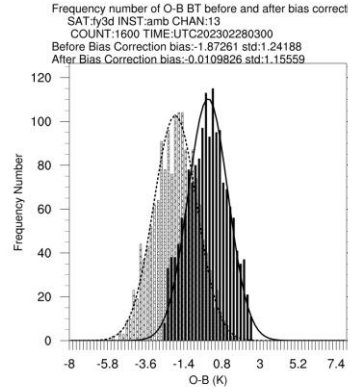


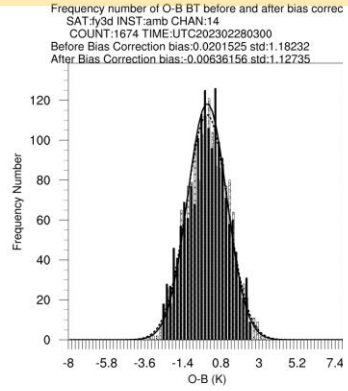


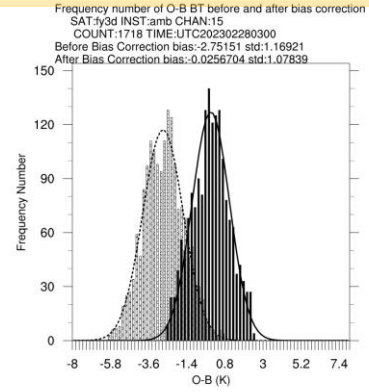
Positive Impact





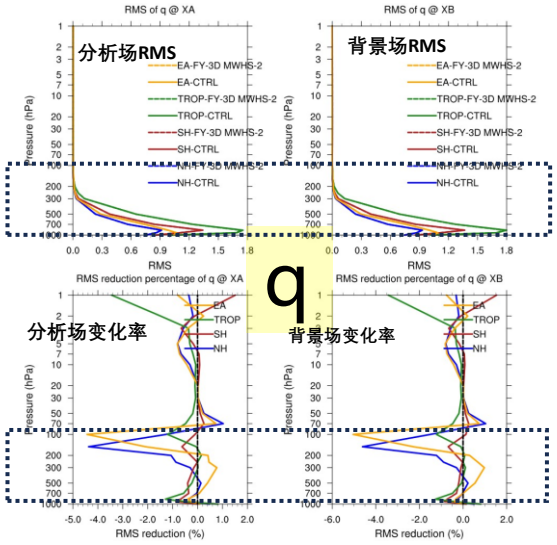




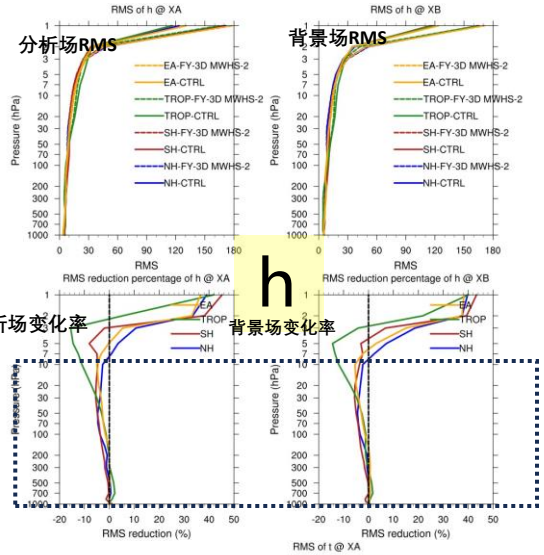


30-day assimilation Results

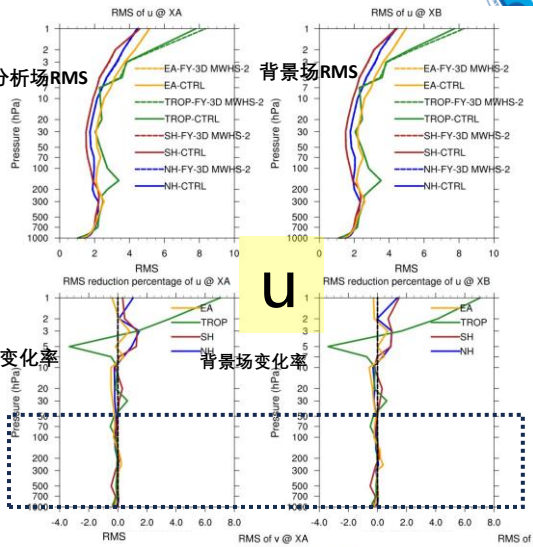
Compared with NCEP FNL



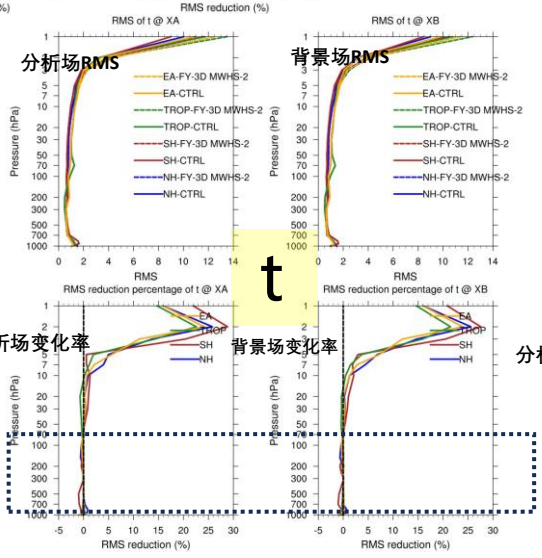
q



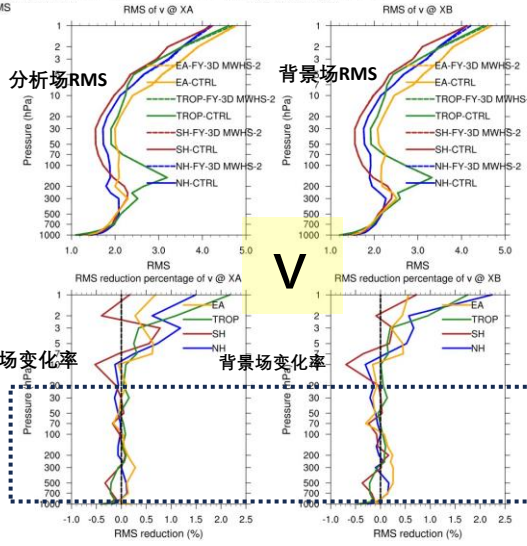
h



u



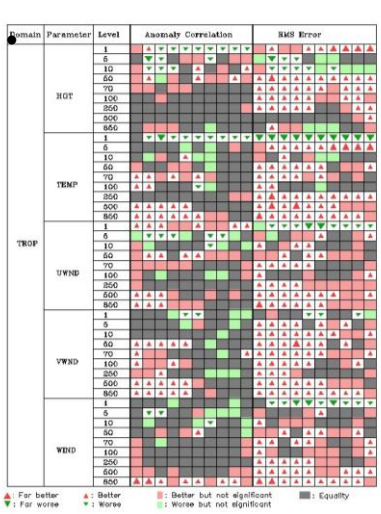
t



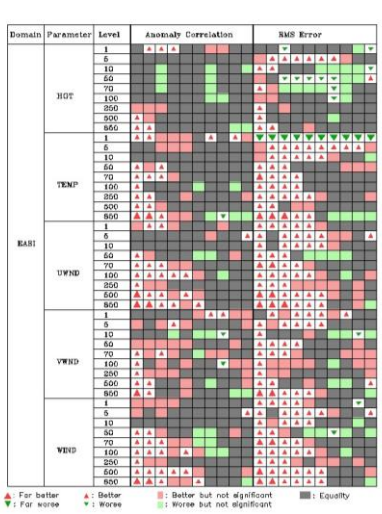
v

The reduction of RMS :
q (1000~100hPa),h (1000 -10hPa),t (1000-70hPa), and u and v (1000-30hPa).

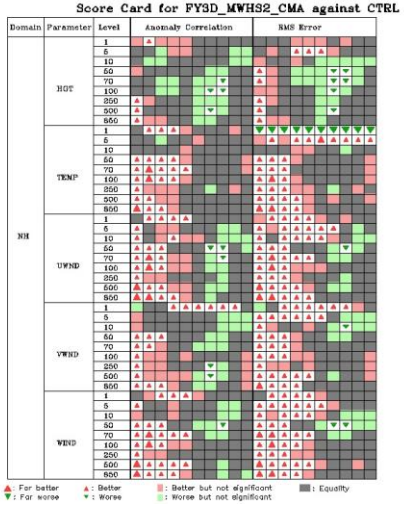
40-day forecast results (Comprehensive Scorecards)



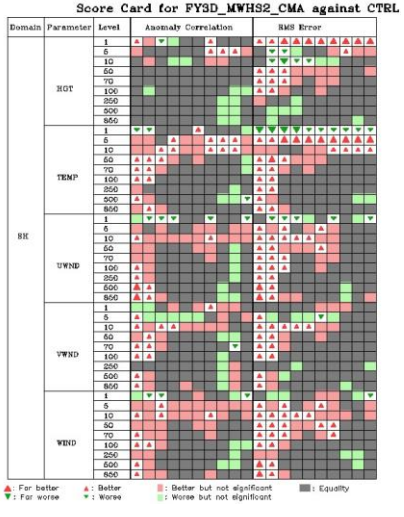
Tropical area



East-Asia



The Northern Hemisphere

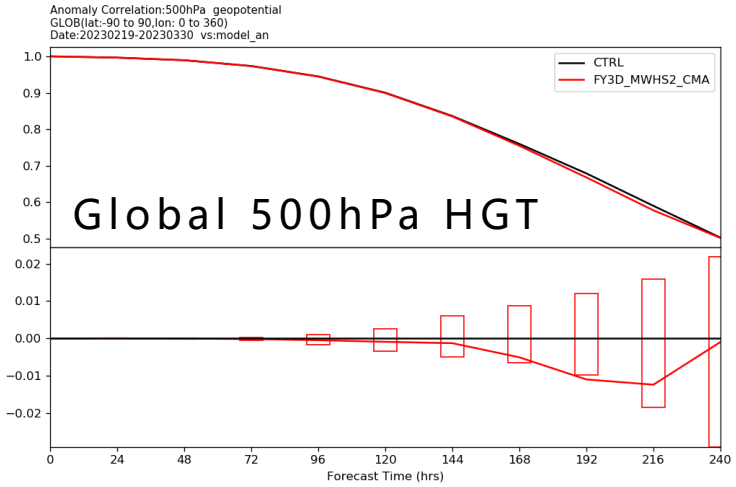


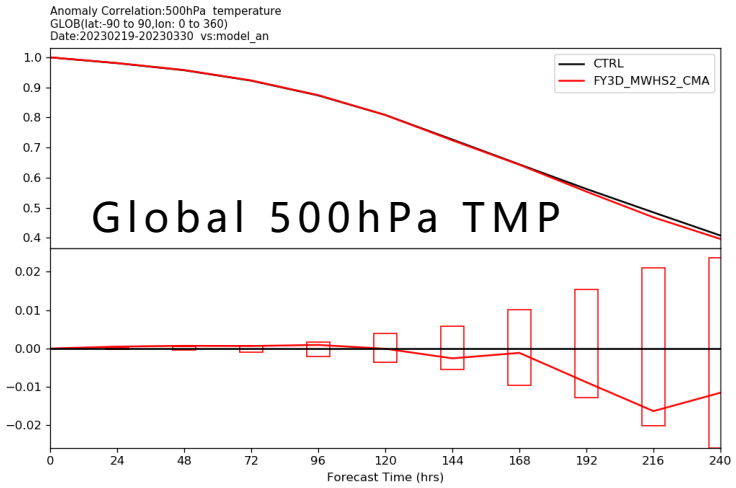
The Southern Hemisphere

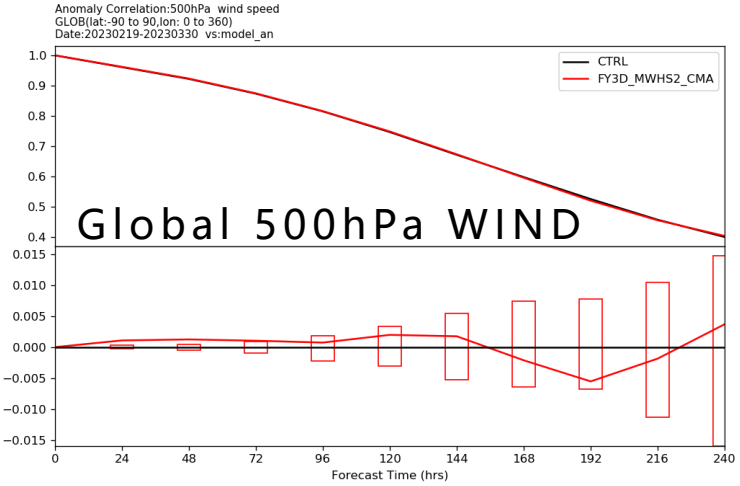
(1) The tropical regions are the best, while East Asia and the Northern Hemisphere have better effects than the Southern Hemisphere.

(2) During the first 7 days in the tropics, the first 5 days in East Asia, the first 3 days in the Northern Hemisphere and the first 2 days in the Southern Hemisphere, the temperature and wind field of almost the entire layer have a significant positive effect.

40-day Forecast Results (ACC)

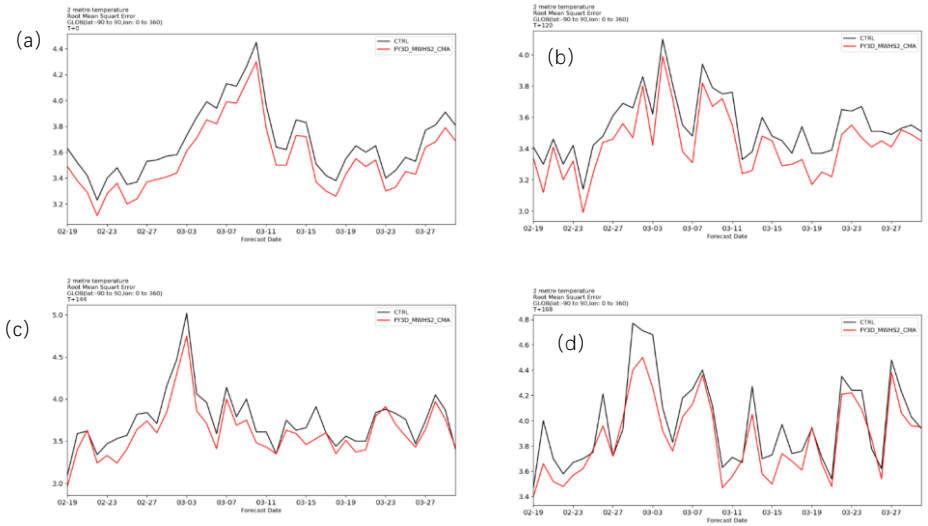






The correlation coefficient of potential height anomaly at 500hPa in the first 8 days was consistent with that of the control Exp.

40-day Forecast Results (2-m temperature)



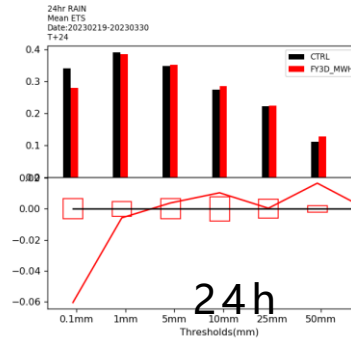
Positive impacts of 2-m temperature

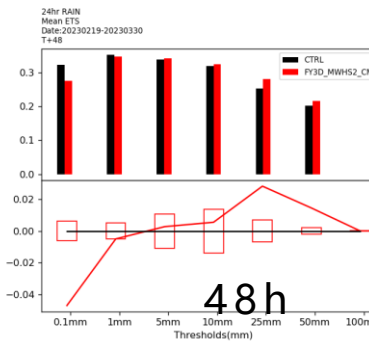
Control Exp.

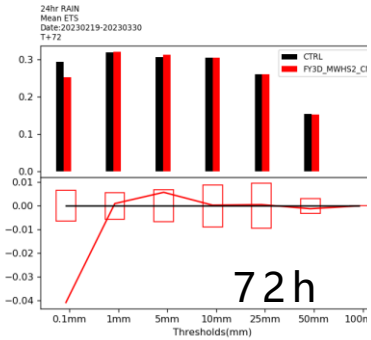
Assimilation Exp based on **CMA-GFS** samples

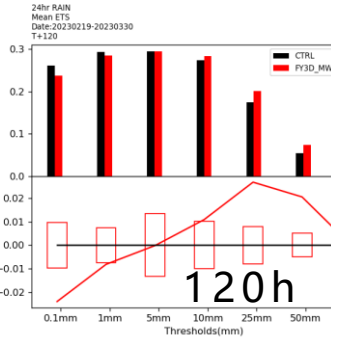
40-day Forecast Results (ETC score)

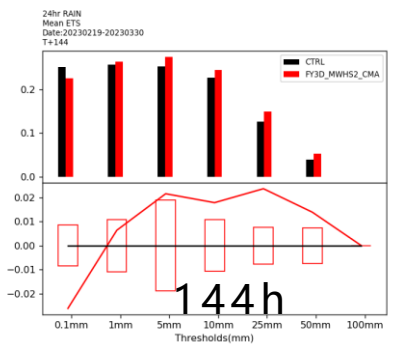
24-h precipitation in China



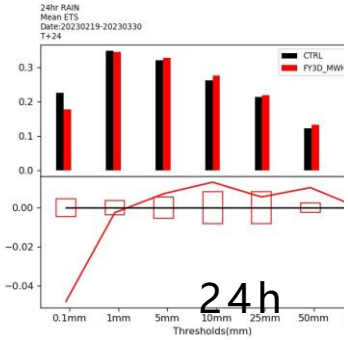


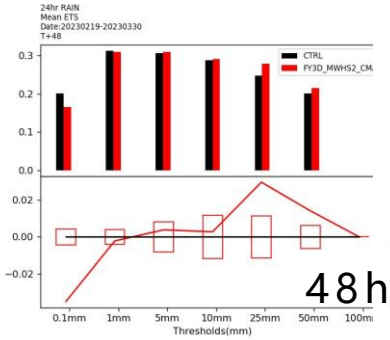


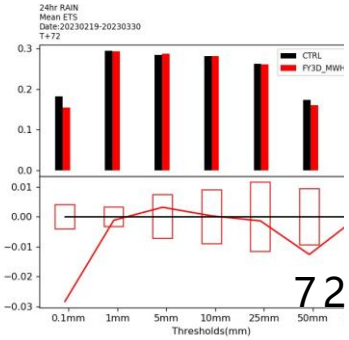


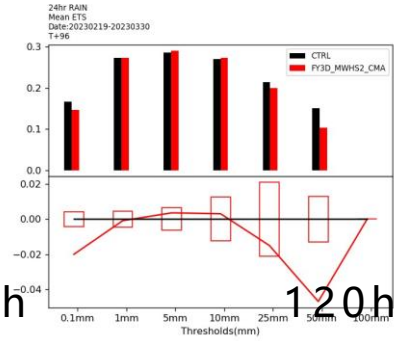


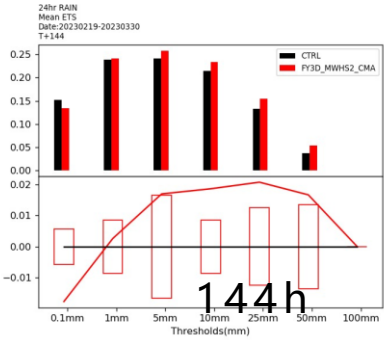
24-h global precipitation











Conclusions

This work adds the satellite data of the FY-3D MWHS-2 moisture channels into CMA-GFS4.0.

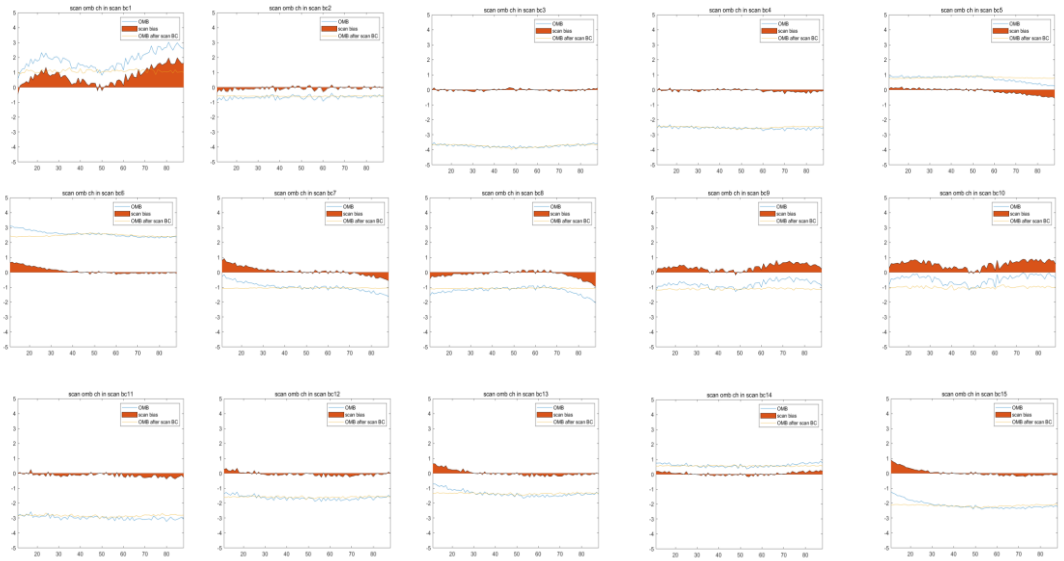
(1) The observation error with satellite attributes has been added to the model, which can be updated along with the changes in the instrument status (integrated into version CMA-GFS).

(2) The bias correction coefficient, generated from regression of the predictors of the CMA-GFS model , has good and continuously stable bias correction effects and assimilation effects (integrated into CMA-GFS).

(3) By assimilating the FY-3D MWHS-2 data, the humidity of 1000hPa-100hPa was improved, etc. The comprehensive scores of the 10-day forecast made positive contributions, and the ETS precipitation score increased.

Future Plans

- **Post-verification of observation error** （O-A & O-B）
- **Validation and calibration of scan bias**
  - The large-scale trend of scanning deviation has been removed, but there are still small-scale residues



- **DBNet FY-3 MWHS-2 data assimilation in CMA_MESO model (on going) and adjusting the bias correction coefficients for regional model**

Thank you！

xishuang@cma.gov.cn