Recent Developments in Satellite Data Assimilation at CMA

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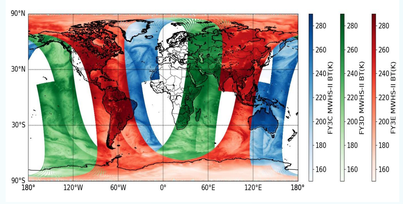
Abstract

This poster presents an overview of the recent developments and ongoing research in satellite data assimilation at CMA, and highlights some recent studies on the use of data from FY-3E , FY4B and HY-2B. Updates in satellite observations include the following: Evaluation of FY-4B GIIRS /AGRI,FY-3E MWTS/MWHS/HIRAS and HY-2B Scanning Microwave Radiometer (SMR); Assimilation of FY-4A GIIRS water vapor sounding channels[1] and FY-3E MWHS since August 2022; Ongoing developments include: All-surface radiance assimilation by surface emissivity retrieval using AMSU-A; All-sky radiance assimilation using FY-3D MWRI; Targeted observation DA experiments for tropical cyclone Mulan in August 2022; developments of satellite radiance observation operator ARMS and spaceborne radar observation operator for FY3G(RM).

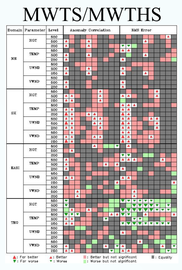
New sensors

1. FY-3E

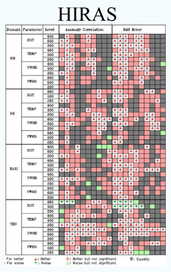
FY3E is the world's first early-morning-orbit meteorological satellite for civil use([5])



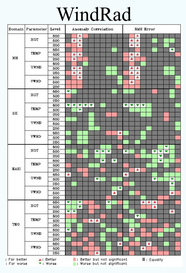
MWTS/MWTHS



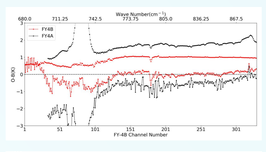
HIRAS

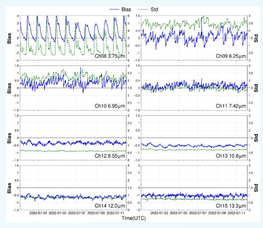


WindRad

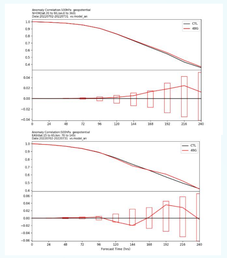


2. FY-4B

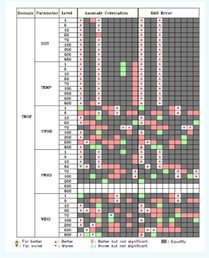




GIIRS

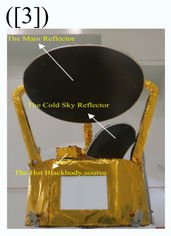


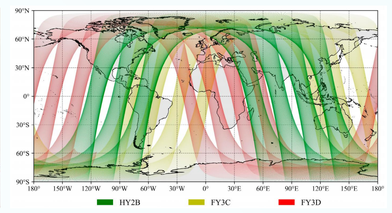
AGRI

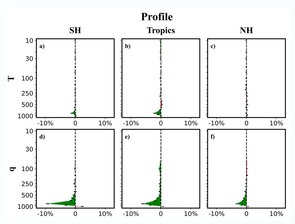


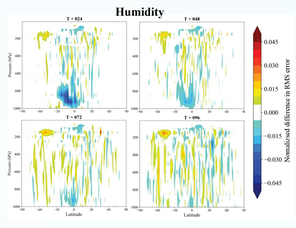
3. HY-2B

HY-2B SMR covers the gap between FY3C/D MWRI ([3])



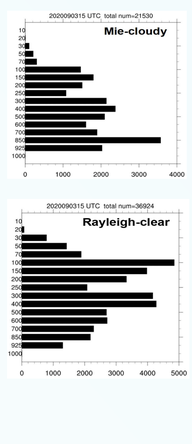




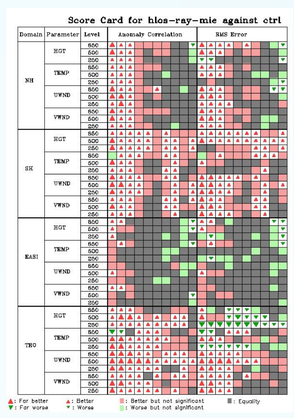


4. Aeolus ALADIN winds

Observation Number

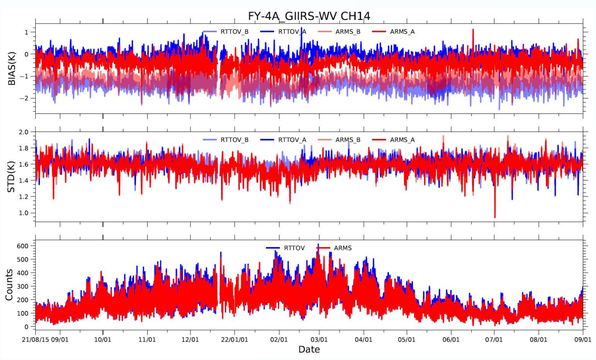


Forecast Score Card



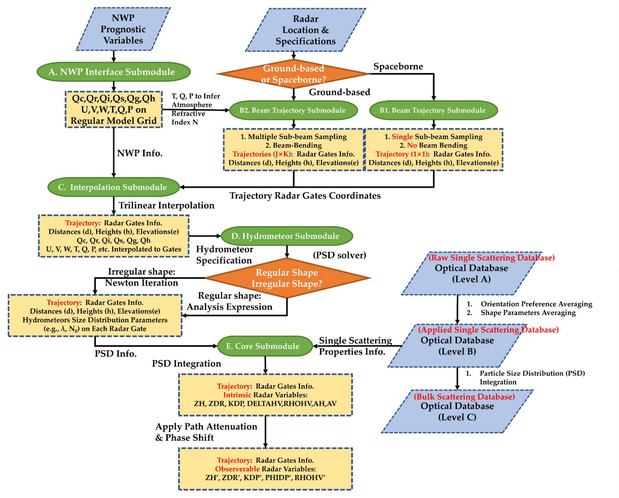
Observation Operators

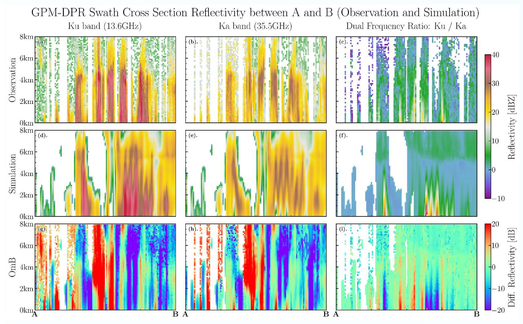
1. ARMS (Advanced Radiative transfer Modelling System)



- ARMS([2]) has been integrated into CMA-GFS, and one-year test has shown that its assimilation and forecasting capabilities are comparable to RTTOV
- The OmB bias, STD and counts for FY-4A GIIRS water vapor channel No.14, by radiative transfer model ARMS / RTTOV
- Improvements was found by using ARMS in current DA system of GRAPES

2. Radar operator for spaceborne radar onboard FY3G(RM)





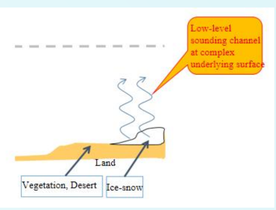
- The Flow chart of spaceborne radar operator
- FY3G(RM) is to be launched in 2023, pre-research was performed using proxy-observation offered by GPM-DPR
- A vertical cross section of Ku/Ka band simulated and observed reflectivity (case Typhoon Haishen on Sept. 5th, 2020)

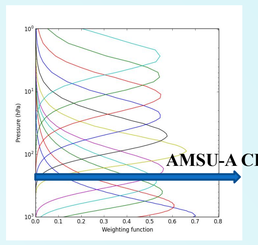
New Techniques

1. Progress in all-surface DA

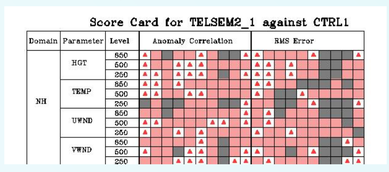
- **Surface emissivity retrieval for lower tropopause sounding channels**

$$\varepsilon_{(p,v)} = \frac{R_{(p,v)} - R\uparrow - R\downarrow\Gamma}{\Gamma\left(R_s - R\downarrow\right)},$$

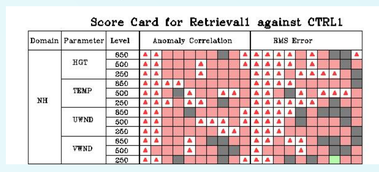




AMSU-A by Traditional TELSEM2



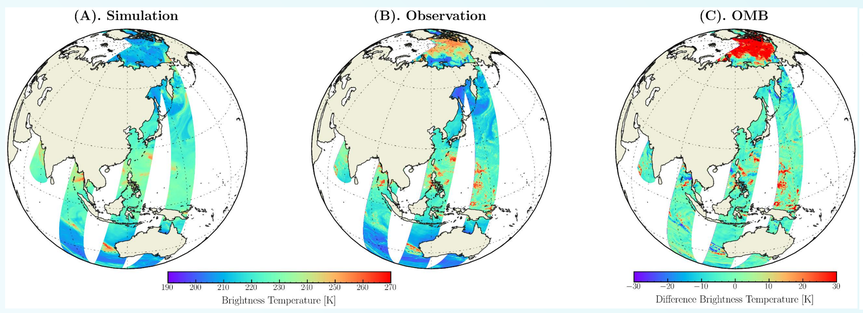
AMSU-A by Window Channel Retrieval

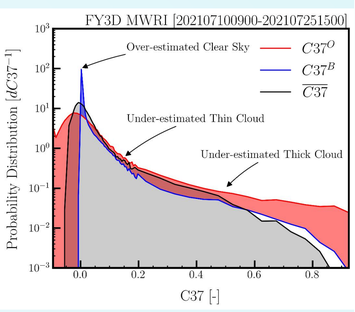


- **Scores was significantly improved by all-surface techniques and window channel retrieval methodology applied for AMSU-A channels 5&6, especially in N.H. with wider coverage of land surface**

2. Progress in all-sky DA

- **FY3D-MWRI 37GHz V pol. OmB (Simulated by RTTOV-SCATT v12.3)**





- The PDFs of **observed-cloud-proxy** and **simulated-cloud-proxy** has large discrepancies, which may spoil the meaning of 'averaging' in generating 'symmetric-cloud proxy'.
- Model Cloud Bias Correction: Conducted with Cumulative Density Functions (CDFs).

All-sky Observation Error Model *(Geer and Bauer, 2011)*

$$\overline{C_{37}} = \frac{C_{37V}^{O} + C_{37V}^{S}}{2}$$

$$p = \Phi(C_{37})$$

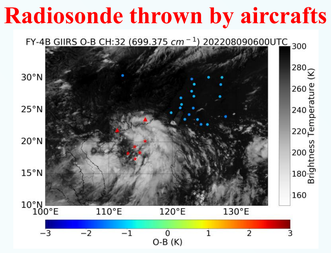
$$C_{37}^{B*} = \Phi_O[\Phi_B^{-1}(C_{37}^{B})]$$

Cloud-Proxy BC	Traditional Cloud-Factor BC
1. Work on **Observation error model**. 2. Affect all-sky QC.	1. Work on **OmB**. 2. Affect all-sky QC.

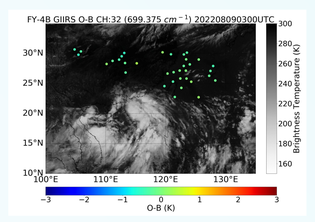
- All-sky against clear-sky: **Significant improvement found in Tropics**

3. Progress in Targeted Observation DA

Radiosonde thrown by aircrafts

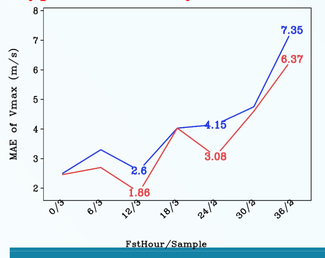


FY-4B GIIRS

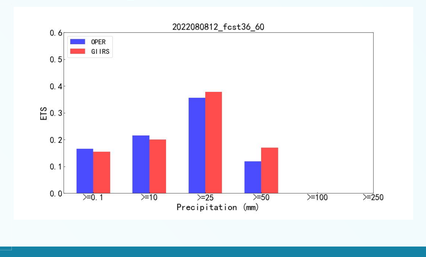


- Ground–space–sky observing system experiment during tropical cyclone Mulan in August 2022([4])
- Clear regions: FY-4B GIIRS observations of high temporal frequency
- Cloud regions: using observations of Radiosonde thrown by aircrafts

Typhoon intensity forecast scores



Precipitation forecast scores



- Ground-space-sky targeted observations was assimilated into CMA-GFS 4DVar system
- Significant improvements were found for typhoon intensity and precipitation forecasts scores

References

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[5]. Xiao Hongyi ,Wei Han, Peng Zhang and Yihong Bai, 2023,Assimilation of data from the MWHS-II onboard the first early morning satellite FY-3E into the CMA Global 4D-VAR system, *Meteorological Applications* (accepted)