Prepared by CMA
Agenda Item: GII.1
Discussed in WG-II

# FY-3 MW Instruments Calibration Anomalies

Summary of the Working Paper.

In response to Action 38.20, this paper is prepared to report the FY-3 microwave instruments calibration anomalies. It started with a briefing on the instrument status and informs CGMS that the MicroWave Temperature Sounder (**MWTS**), the MicroWave Humidity Sounder (**MWHS**), and the MicroWave Radiation Imager (**MWRI**) are the MW payloads on FY-3A and FY-3B satellites. The three instruments onboard the FY-3A had got some problems, but the ones on FY-3B work well. The paper then presented the histograms from the results of an integrated calibration and validation campaign for these three instruments in comparison with the corresponding instruments flying on NOAA 18 satellite, and AQUA satellite, which illustrated the good results when making the O-B checking for **MWHS** with the NOAA-18/MHS corresponding channels at 183GHz. For **MWTS** on FY-3B, except for channel 4, the biases for channels 1-3 are smaller than or as much as the AMSU-A/NOAA18. The paper gives the test results of **MWRI** with the conclusion of analysis that the on-orbit calibration of MWRI is stable, and the MWRI observation is highly consistent with that of AMSR-E and model simulation.

## 1 Instrument status

MicroWave Temperature Sounder (**MWTS**), MicroWave Humidity Sounder (**MWHS**), and MicroWave Radiation Imager (**MWRI**) are payloads on FY-3A (launched in May 2008) and FY-3B (launched in Nov 2010).

During the FY-3A mission, the MWRI was switched off most of the time for fear of its spinning antenna that affects the satellite attitude with its residue rotational inertia. The MWHS channel 1 failed for the mixer hitch. The MWTS showed measurement bias on channels frequency. In the FY-3B mission, MWTS, MWHS and MWRI work well.

## 2 Integrated calibration and validation

At CMA/NSMC, each individual FY-3 instrument performance is monitored. This paper reports only the results of MWHS, MWTS, and MWRI.

### 2.1 *MWHS*

The O-B checking method (the observation minus the model) was used for MWHS. We got good results when making the O-B checking for FY-3/MWHS with the NOAA-18/MHS corresponding channels at 183GHz. The bias of FY-3B/MWHS is less than that of FY-3A/MWHS. Figure 1 is the O-B checking for FY-3/MWHS channel 3 with NOAA-18/MHS channel 3; Figure 2 is for FY-3/MWHS channel 4 and NOAA-18/MHS channel 4; Figure 3 is FY-3/MWHS channel 5 and NOAA-18/MHS channel 5.

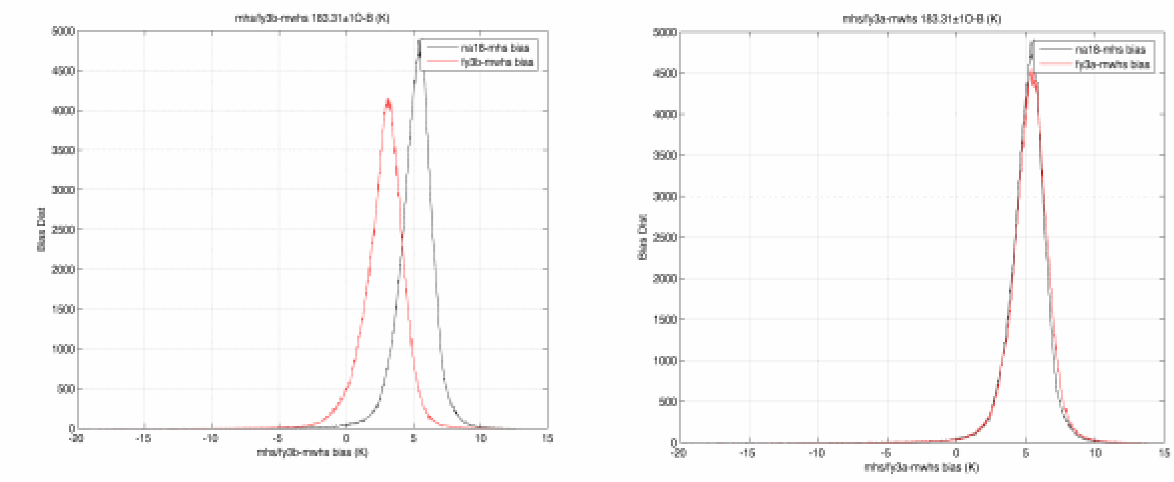



Fig.1 O-B checking for FY-3/MWHS channel 3 and NOAA-18/MHS channel 3

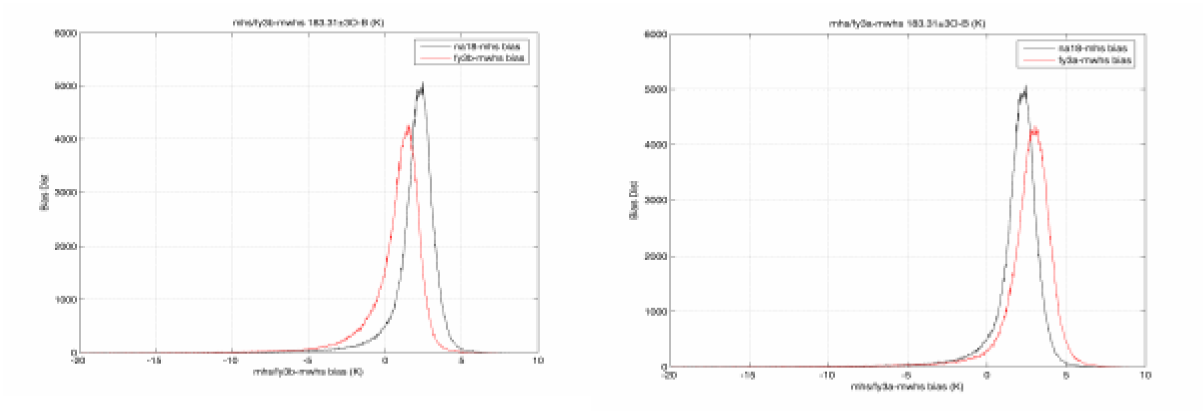


Fig.2 O-B checking for FY-3/MWHS Channel 4 and NOAA-18/MHS channel 4

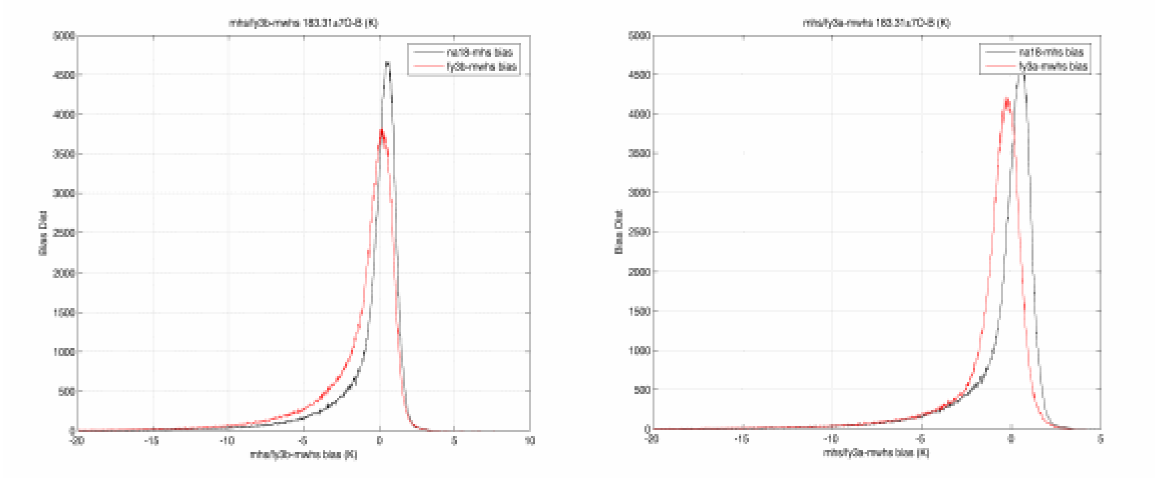


Fig.3 O-B checking for FY-3/MWHS channel 5 and NOAA-18/MHS channel 5

## *2.2 MWTS*

For FY-3A/MWTS, the sensor showed a little bias on channels frequency, which was found in the sensor bias analysis by O-B method. The reason for the bias was that the resonant frequencies with air inside were a little different from the ones without air inside. There was atmosphere inside the resonator of FY-3A/MWTS when its frequencies were tested in the laboratory, whereas it was gas-absent in space.

For FY-3B/MWTS, we got good results during the O-B test. The FY-3B/MWTS channels 1, 2, 3, and 4 are matched with NOAA-18/AMSU-A channels 3, 5, 7, and 9. The radiative transfer model used is CRTM. The GDAS data is used as the input data. Considering the emissivity complexity over land, only the data over ocean is included in the statistics. The O-B results for 4 matched channel pairs are showed as figure 4 and 5. The two figures indicate that except for channel 4, the biases for MWTS/FY-3B channels 1-3 are smaller than or as much as the AMSU-A/NOAA18.

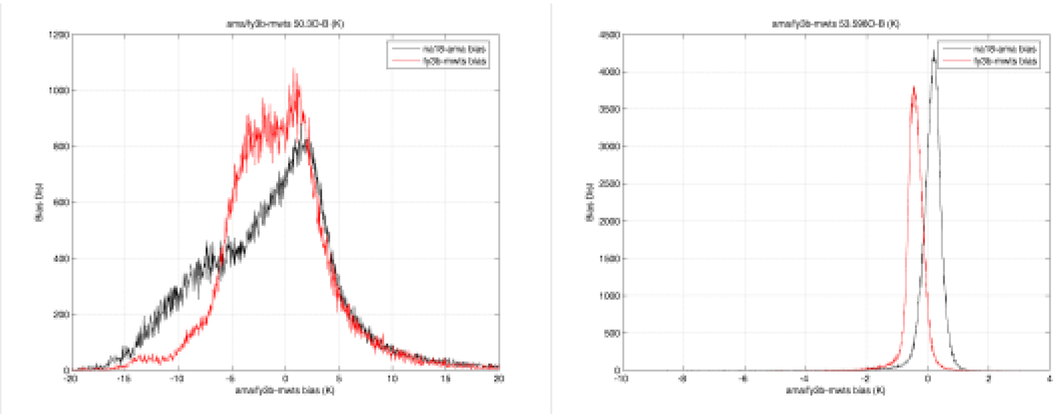


Fig.4 O-B results for FY-3B/MWTS channel 1, 2, and NOAA-18/AMSU-A channels 3, 5

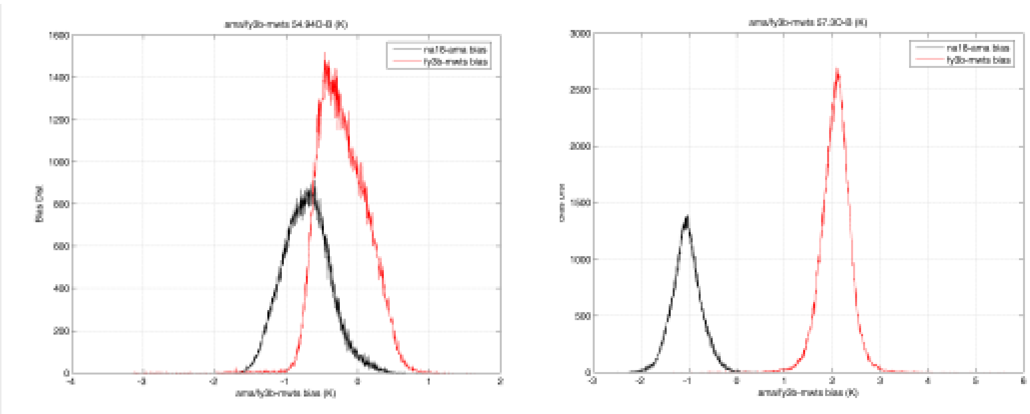


Fig.5 O-B results for FY-3B/MWTS channel 3, 4, and NOAA-18/AMSU-A channels 7, 9

## 2.3 *MWRI*

The FY3B-MWRI instrument has got continuous and stable earth observation dataset since its launch. Compared with FY3A-MWRI, the FY3B-MWRI is more stable and with low non-linearity [1]. This paper mainly focuses on the evaluation of FY3B-MWRI measurement accuracy.

The satellite observation was compared with forward model simulation. The so called O-B results were obtained. In this work, CRTM was used to simulate the MWRI observations, with GDAS data as model input. Only model output over ocean between N450 and S450 was used to generate O-B results

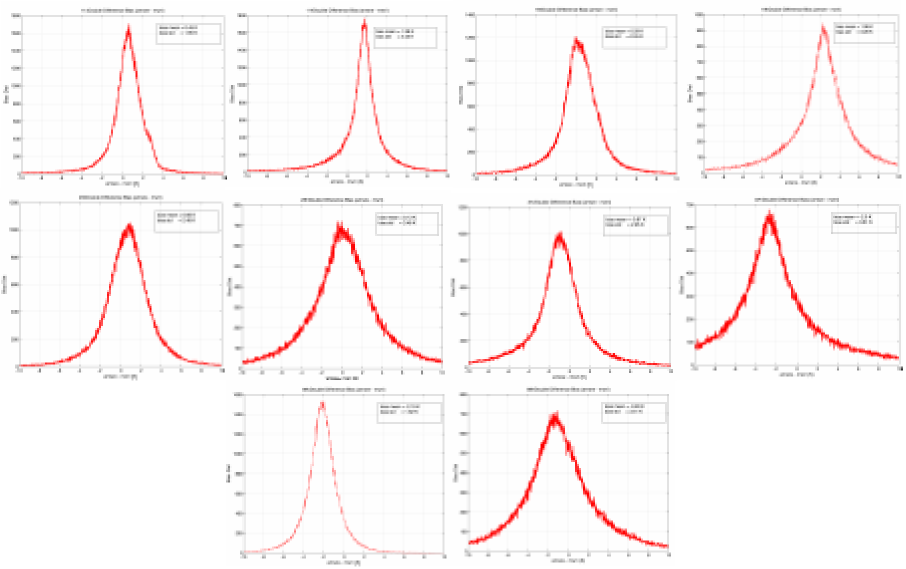
The O-B results can show the total satellite observation bias trends. Also it is a necessary step for satellite data assimilation in NWP model. The O-B results are listed in Table.1

Table.1 FY3B-MWRI channel bias/std

| Channel/bias (K) | FY-3b-MW channel bias mean/std (O-B results) | |
|---|---|---|
| | mean | std |
| 11v | 1.13 | 2.94 |
| 11h | 0.40 | 3.46 |
| 19v | 1.09 | 3.27 |
| 19h | -0.49 | 4.82 |
| 23v | -0.23 | 3.05 |
| 23h | 2.80 | 4.55 |
| 37v | 0.51 | 4.13 |
| 37h | 6.59 | 5.0 |
| 89v | 1.21 | 2.3 |
| 89h | 5.84 | 4.62 |

The results show that, frequencies lower than 37GHz have lower mean bias and standard errors. The maximum mean bias value appeared in 37H and 89H channels. The possible reason is that the CRTM model failed to simulate the satellite observation over rain and cloud areas due to lack of liquid water information in GDAS datasets, thus making the model underestimate the satellite observations.

In order to eliminate the model error involved in the O-B results, the “double difference” method was used to further evaluate the MWRI instrument measurement bias. As suggested by some researchers, the “double difference” method can cancel the model error; eliminate the effects of incident angle difference, and make the observation from two different satellites able to compare at regional scale [2]. In this paper, the “double difference” results for AQUA-AMSRE and FY3B-MWRI were presented. 5 days data from Dec.1 to 5 ,2011 were used to generate O-B results for AMSR-E and MWRI separately, and then the “double difference” results of these two instruments were derived by making difference of the two O-B results. Figure.6 shows the histogram of “double difference” between AMSR-E and MWRI. The “double difference” histogram shows that bias between AMSR-E and MWRI follow the normal distribution. Mean bias between these two sensors is from 0.45 to 2.0, as showed in Table.2



Fi ıannel, right line is H pol channel, from top to bottom is 10 to 89 GHz.

Table.2 Double difference of AMSR-E and MWRI

| Channel/bias (K) | Double difference of AMSR-E and MWRI | |
|---|---|---|
| | mean | std |
| 11v | 0.45 | 1.95 |
| 11h | 1.38 | 2.45 |
| 19v | 0.29 | 2.45 |
| 19h | 1.98 | 2.28 |
| 23v | 0.66 | 2.48 |
| 23h | 0.13 | 3.48 |
| 37v | -0.97 | 2.95 |
| 37h | -2.0 | 3.81 |
| 89v | -2.19 | 1.82 |
| 89h | -0.93 | 3.51 |

To eliminate the model error as well as the effect of incident angle difference over ocean, the “double difference” method was used to further illustrate the MWRI measurements bias characteristics. Results show that the maximum bias between AMSR-E and MWRI is -2.19K. Primary results show that: 1). the on-orbit calibration status of MWRI is stable, 2). the brightness temperatures from MWRI observation are highly consistent with those derived from AMSR-E and model simulation. Future work will focus on direct comparison between MWRI and other similar instruments on board different satellites in the collocated area.

## REFERENCES

[1] Hu Yang, Fuzhong Weng, Liqing Lv et al., "The FengYun-3 Microwave Radiation Imager On-orbit Verification", IEEE Geosci and Remote sensing, to be Published.

[2] Tim Hewison, "Double difference", presentation at GPM XCAL meeting 2010, university of Maryland