CGMS-37, CMA-WP-07

Prepared by CMA
Agenda Item: II/3
Discussed in WG II

PROGRESS OF FY-3A ATMOSPHERIC SOUNDING DATA ASSIMILATION

Summary of the Working Paper

FY-3A carries VASS (Vertical Atmospheric Sounder System) for vertical sounding of the global atmosphere. Experiment has been performed to assimilate VASS radiance into operational GFS in CMA and ECMWF. The paper introduces the analysis of VASS radiance distribution in GFS assimilation window. After 'thinning', bias correction and quality control, the impact study shows that assimilation of VASS data prolonged efficient forecast of CMA GFS at least by 3 hours in north hemisphere and 12 hours in south hemisphere. To investigate the effects of the FY-3A VASS data in IFS of ECMWF, several experiments for weather forecast score evaluation are conducted from 21 Aug 2008 to 31 Sep 2008. The experiment showed that assimilating FY3 VASS data improved the forecast skill in both North Hemisphere and South Hemisphere.

ASSIMILATION OF FY-3A VASS RADIANCE IN NWP MODEL

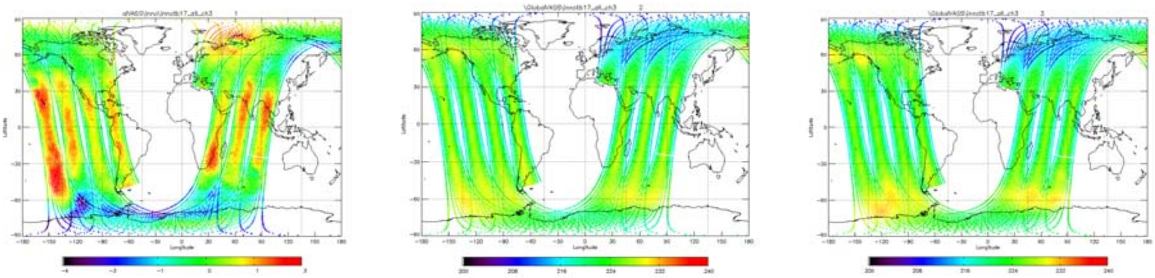
1 Introduction

FY-3A carries **VASS** (Vertical Atmospheric Sounder System) for vertical atmospheric temperature and humidity sounding with 35 channels in infrared and microwave spectral region. With VASS, we can retrieve atmospheric temperature and humidity profiles, and also assimilate the radiance into NWP model to improve forecast skills.

2 Assimilation of FY-3A MWTS radiance in NWP model

2.1 Assimilation of FY-3A VASS radiance in CMA GFS

2.1.1 Distribution in 6-hours assimilation window



Innovation Simulation observation

Figure 1. Distribution of FY3A MWTS channel 3 in 6-hours assimilation window

Figure 1 shows that radiance data of FY3A MWTS channel 3 are sequential in the orbit coverage during the 6-hours assimilation in CMA GFS. Outputs by RTTOV7 are consistent with observations and the maximum departures are less than 5K in most regions.

2.1.2 bias correction

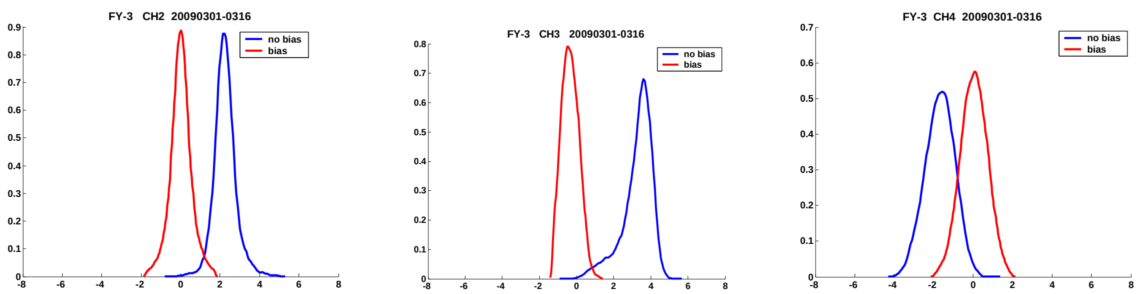


Figure 2. Bias correction to MWTS channel 2-4

Bias corrections, depending on viewing angles and air mass, are necessary to be accounted for in assimilation. Better Gauss distribution can be archived to each MWTS channel after bias correction (in figure 2, see the red line).

2.1.3 thinning

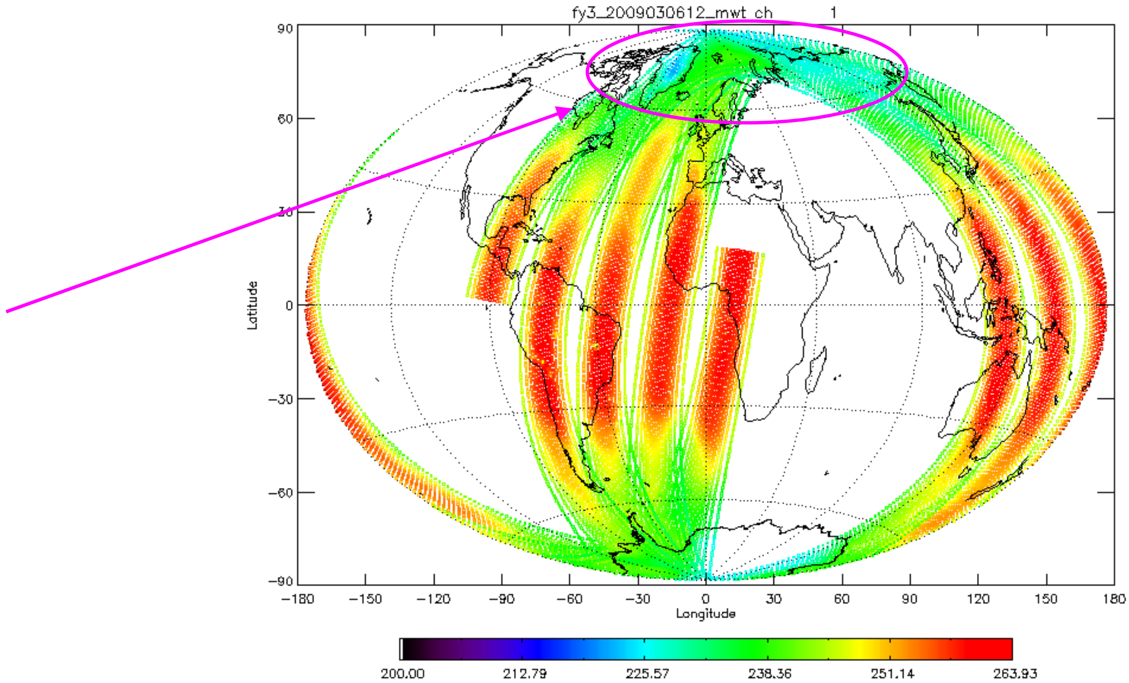
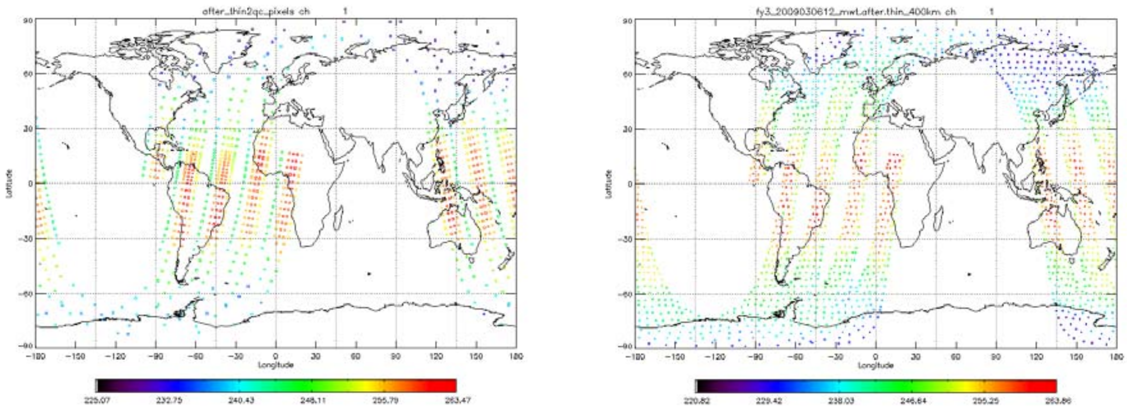


Figure 3. Data overlap of MWTS chanel1 in polar region

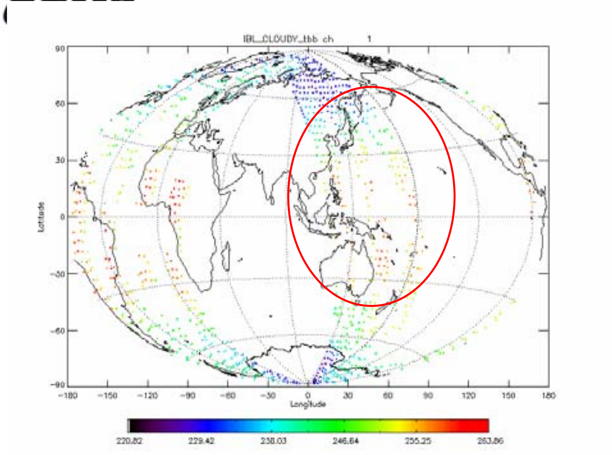


Old scheme New scheme

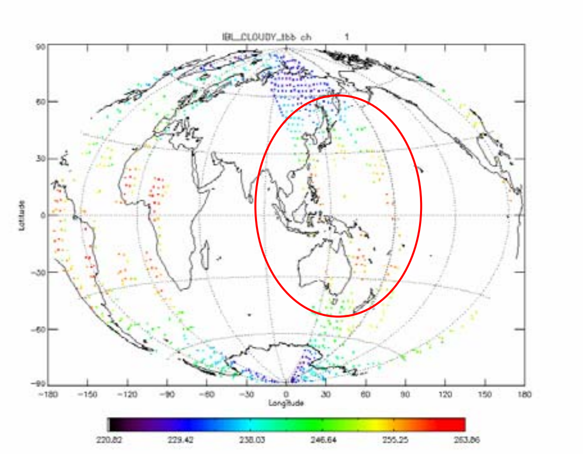
Figure 4. Comparison between old thinning scheme and new scheme

Lots of observations of polar orbit satellite are overlapped in polar region(figure 3). A new thinning scheme is developed in CMA GFS satellite data assimilation. More satellite observations in middle and high latitude regions can be introduced into the model with this new thinning scheme (figure 4).

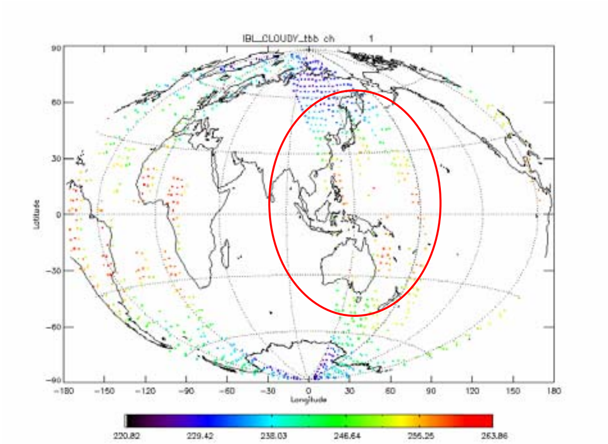
2.1.4 Cloud mask

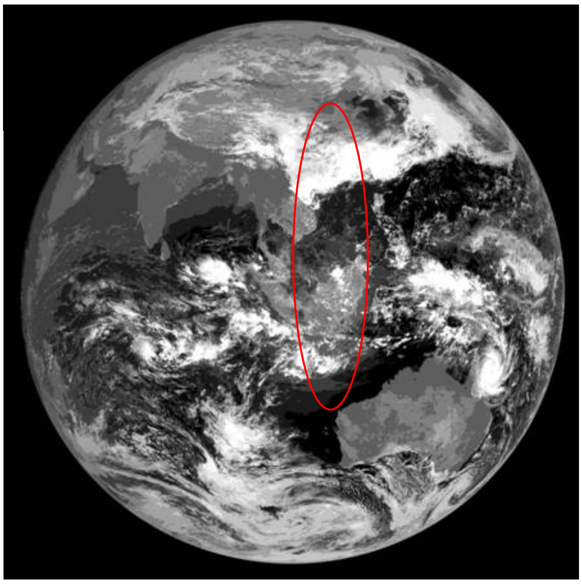


window channel d-tbb >3k



window channel d-tbb >4k



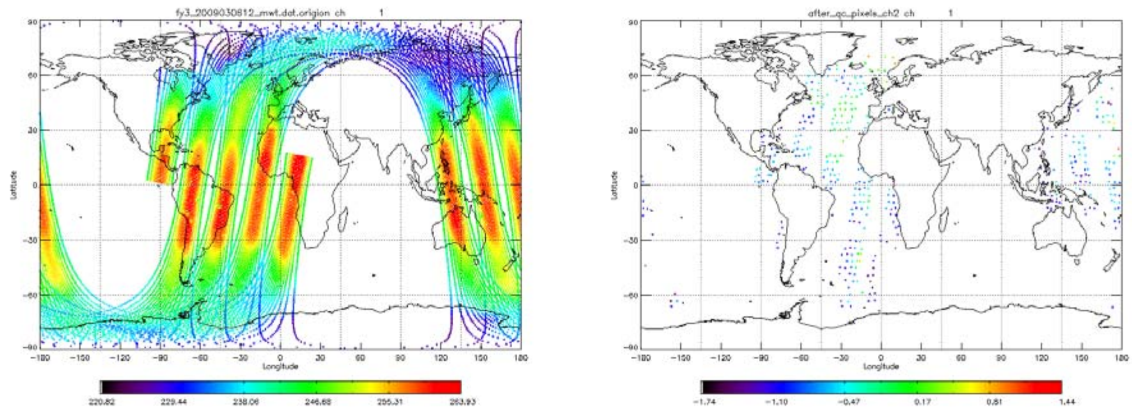


window channel d-tbb >3.5k

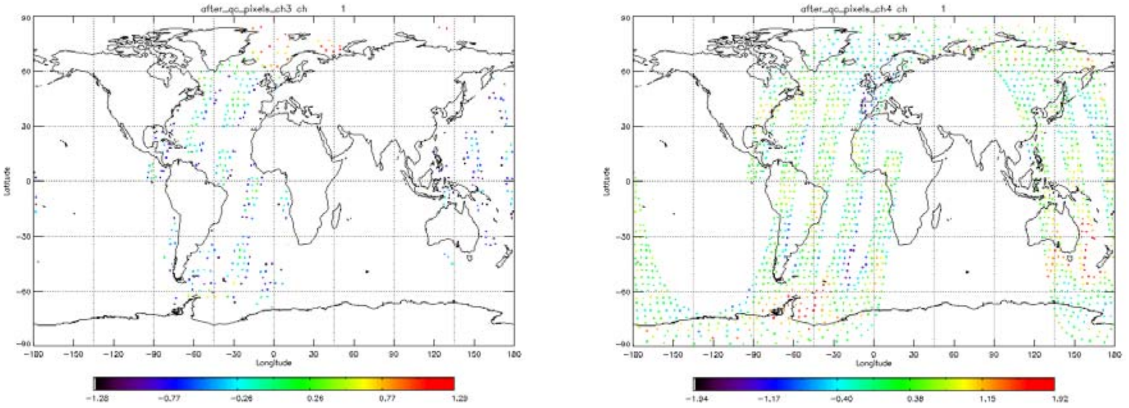
Figure 5. Cloud detection with only MWTS channel 1 data used

Because IRAS has broken down, no cloud detection with infrared data. It could not be used in satellite data assimilation. A new method for cloud mask has been developed in CMA GFS by analyzing deviation between observed brightness temperature of MWTS channel 1 and outputs from RTTOV7. According to cloud mask in the key regions(circled by red line) of geostationary satellite, many observations in the clouds can be kept when the clear foot point is defined with the deviation less than 3K. But fewer foot points can be kept with the deviation in 4K. So the deviation in 3.5K can be the best critical value to check whether the foot point is contained by cloud or not.

2.15 Quality control



Origion Qc after ch2



Qc after ch3 Qc after ch4

Figure 6. Quality control to MWTS radiance

Quality control is very important in satellite data assimilation。In figure 6, especially over land, more data can be introduced into assimilation with higher observed height of MWTS channel.

2.1.6 MWTS data Assimilation in CMA GFS

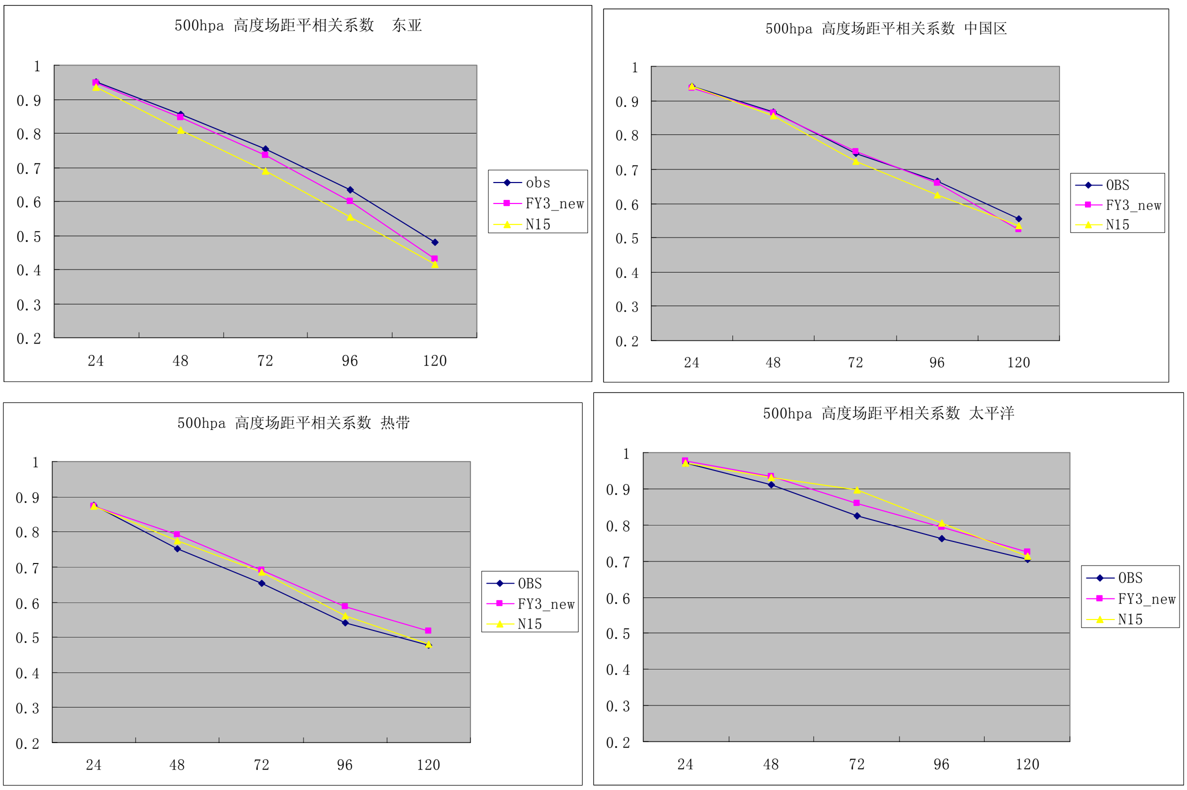


Figure 7. Improvement to forecast skill in typical region after MWTS radiance assimilated

In FY3A MWTS radiance assimilated in CMA GFS and T213 forecast as background in a 20 days test, the impact is larger than that only with AMSUA of NOAA 15 (the yellow line) and a little less than the one only with surface sounding (the blue line). In figure 7, Contrast to traditional observation in the surface, assimilation of MWTS radiance make the efficient forecast prolong 4-6 hours in tropical and 6-8 hours in Pacific. In figure 8, efficient predictions are prolonged about 3 hours in north hemisphere and 12 hours in south hemisphere.

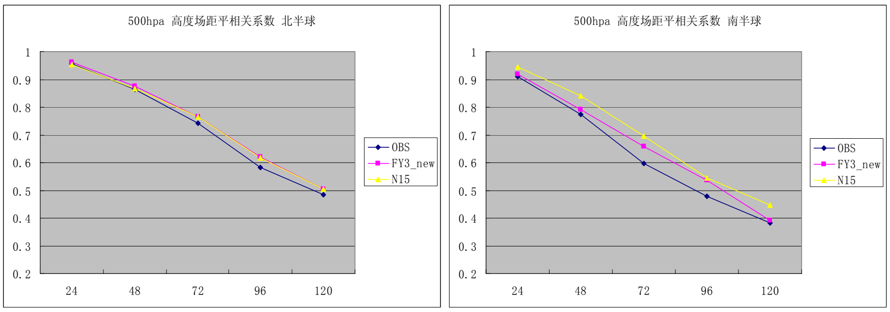


Figure 8. Improvement to global forecasting skill after MWTS radiance assimilated

3.2 Assimilation of FY-3A MWTS/MWHS radiance in ECMWF IFS

3.2.1 Compare MWHS with AMSUB before bias correction:

The check of first guess departure before bias correction indicates that the FY3A VASS instruments have the similar or a little larger magnitude of noise signal to or than ATOVS counterparts, here only, the comparisons of first guess departure between MWHS with AMSUB data from different satellites (NOAA15, NOAA16, NOAA17, NOAA18) is given in figure 9, showing that MWHS is very similar to AMSUB and could be assimilated further.

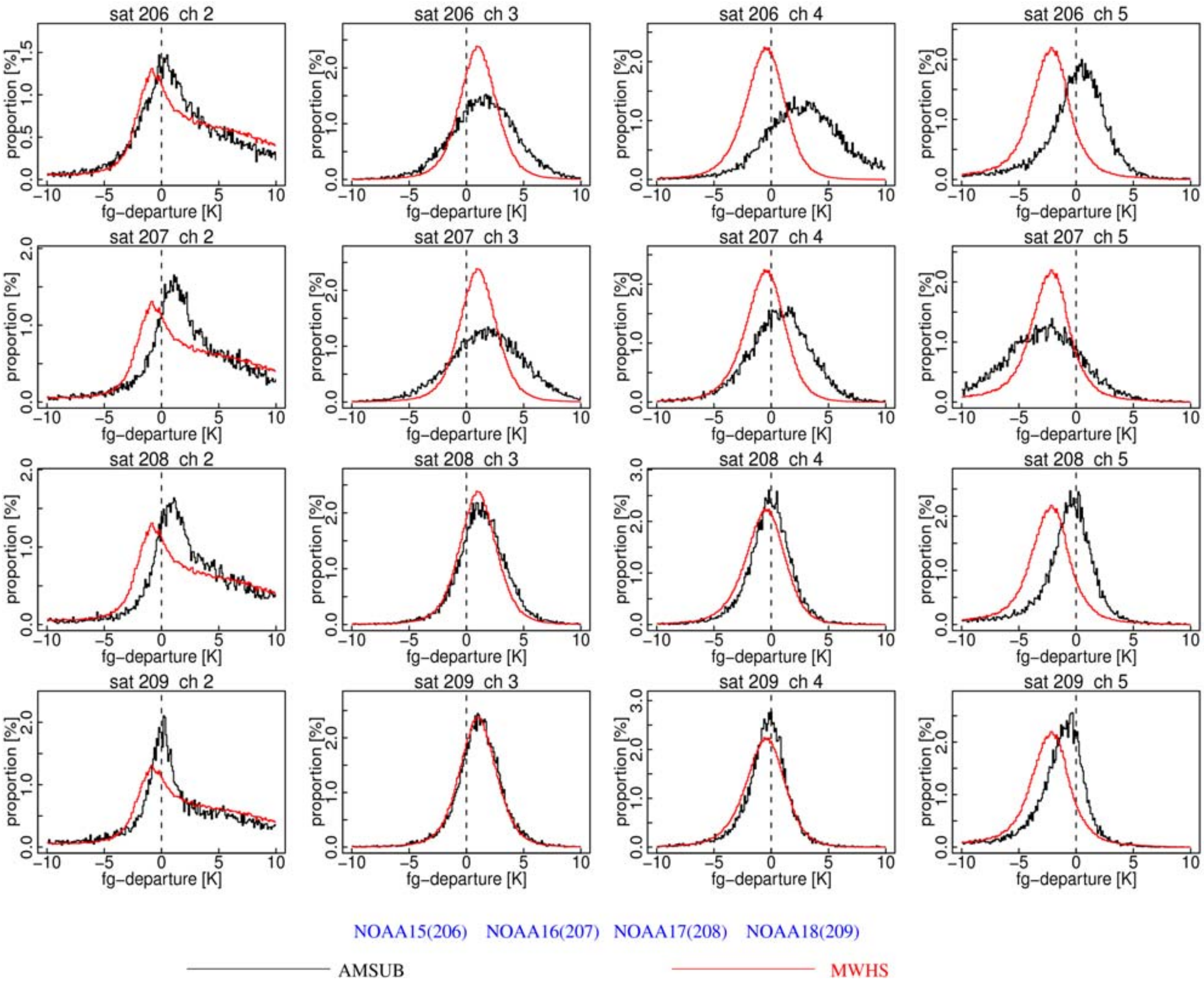


Figure 9. Compare MWHS with AMSUB

3.2.2 Bias correction

Also take MWTS as example to show the bias correction. In figure 10 the first guess departures after bias correction against the scan position show that most of the scan angle and air mass bias has been corrected and less 0.5 K the first guess departure in channel 2, 3 and 4 could be expected.

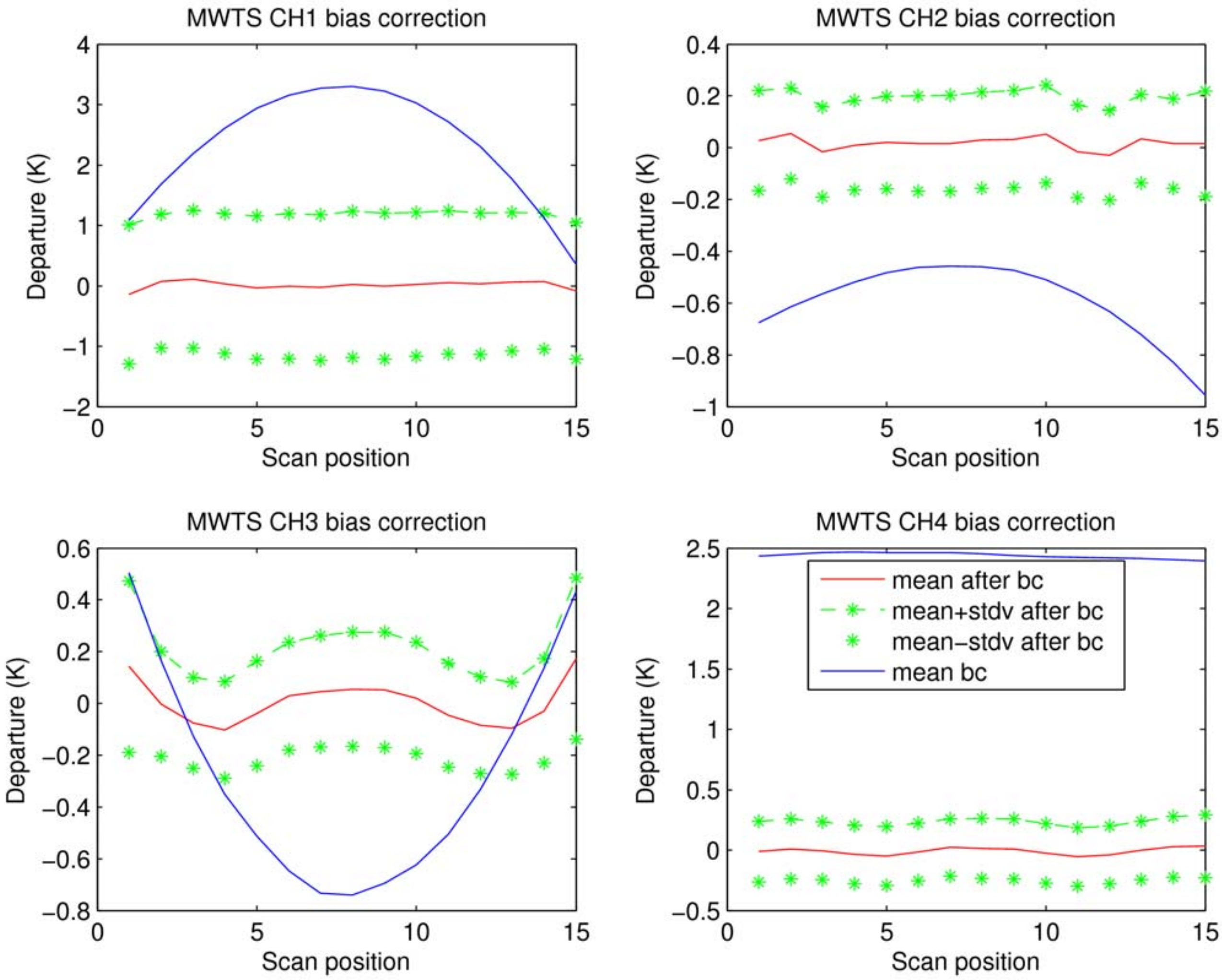


Figure 10. bias correction

3.2.3 Compare MWTS with NOAA18/ASMUA corresponding channels:

Here the first guess departure of MWTS channel 2 after bias correction has compared with NOAA18/AMSUA corresponding channel 5 (as an example) in figure 11, showing the after bias correction, the MWTS data get a better standard deviation going to the assimilation and also the data are usable.

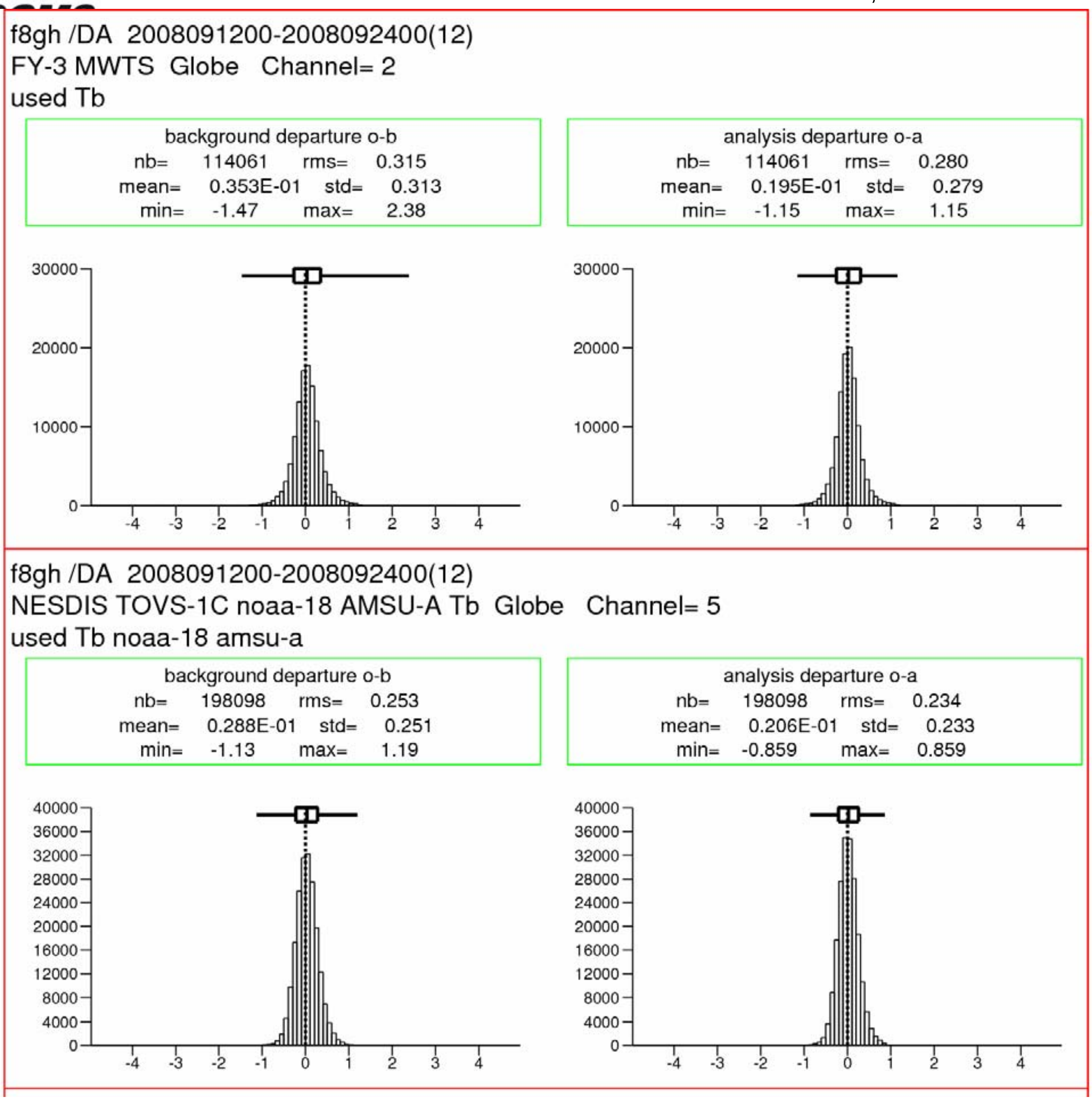


Figure 11. Compare MWTS channel 2 with NOAA18/ASMUA corresponding channel5

3.2.4 Assimilation

To investigate the effects of the FY-3A VASS data in IFS, several experiments for weather forecast score evaluation are conducted from 21 Aug 2008 to 31 Sep 2008, with one control experiment (and also to make the effects of the FY-3A VASS data more obvious, excluding all other data, such as, ATOVS data, AIRS and IASI data into the assimilation system, only conventional sounding data was assimilated in control experiment as baseline, shorten as control) and with a sets of control based assimilation experiments conducted: one is single instrument data assimilation experiment, i.e., individually assimilating IRAS, MWTS and MWHS.

From figure 12, it is seen that after assimilating the FY3 VASS data, the forecast skill was improved greatly in both North Hemisphere and South Hemisphere, but for the South Hemisphere with more improvement; and the different instrument has different effects on NWP forecast; the microwave sounders have more contribution than infrared sounder.

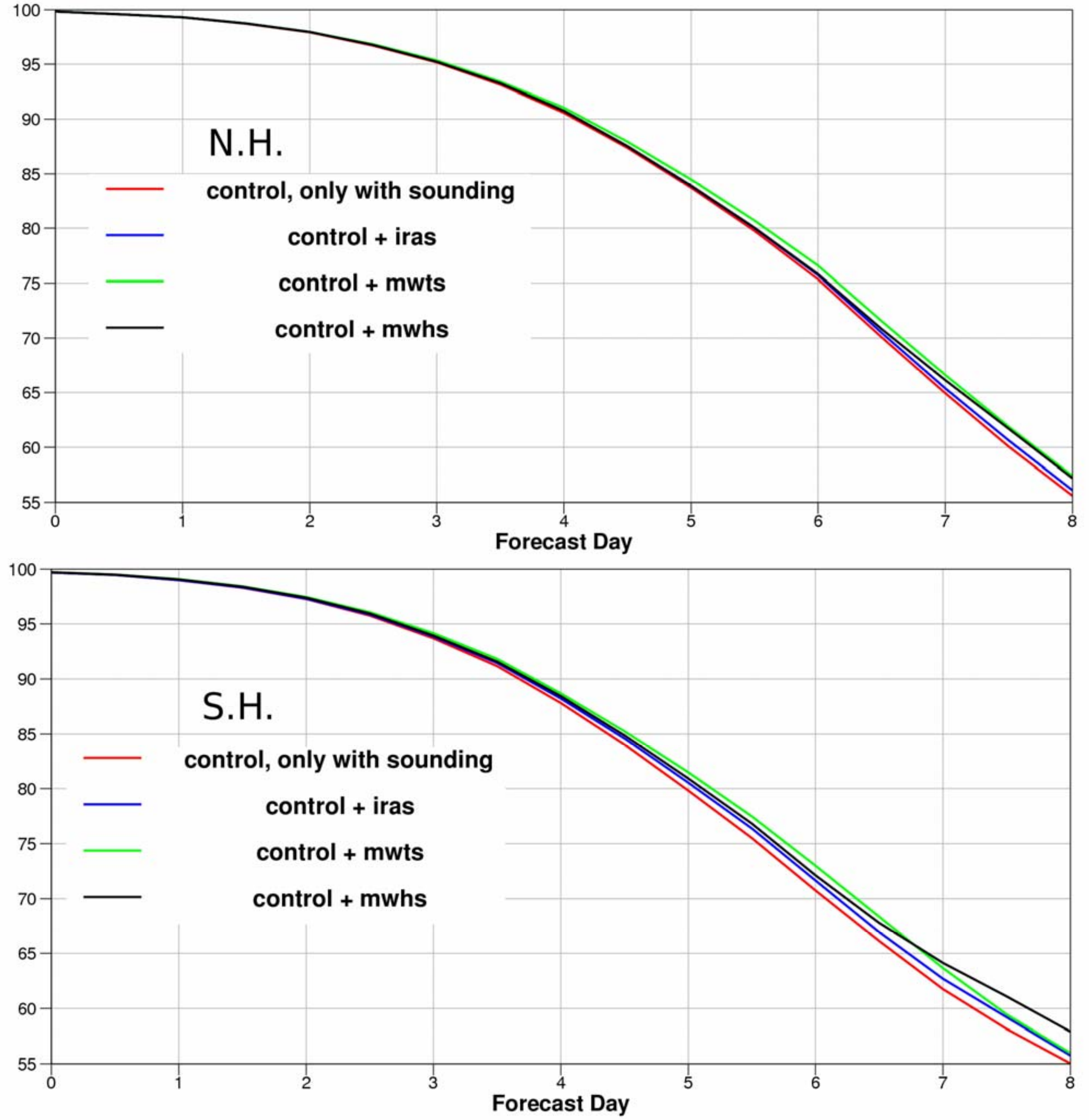


Figure 12. 500 hPa Geopotential Anomaly correlation forecast