# Implement and preliminary experiment of FY-3 and NPP microwave satellite data assimilation in WRFDA

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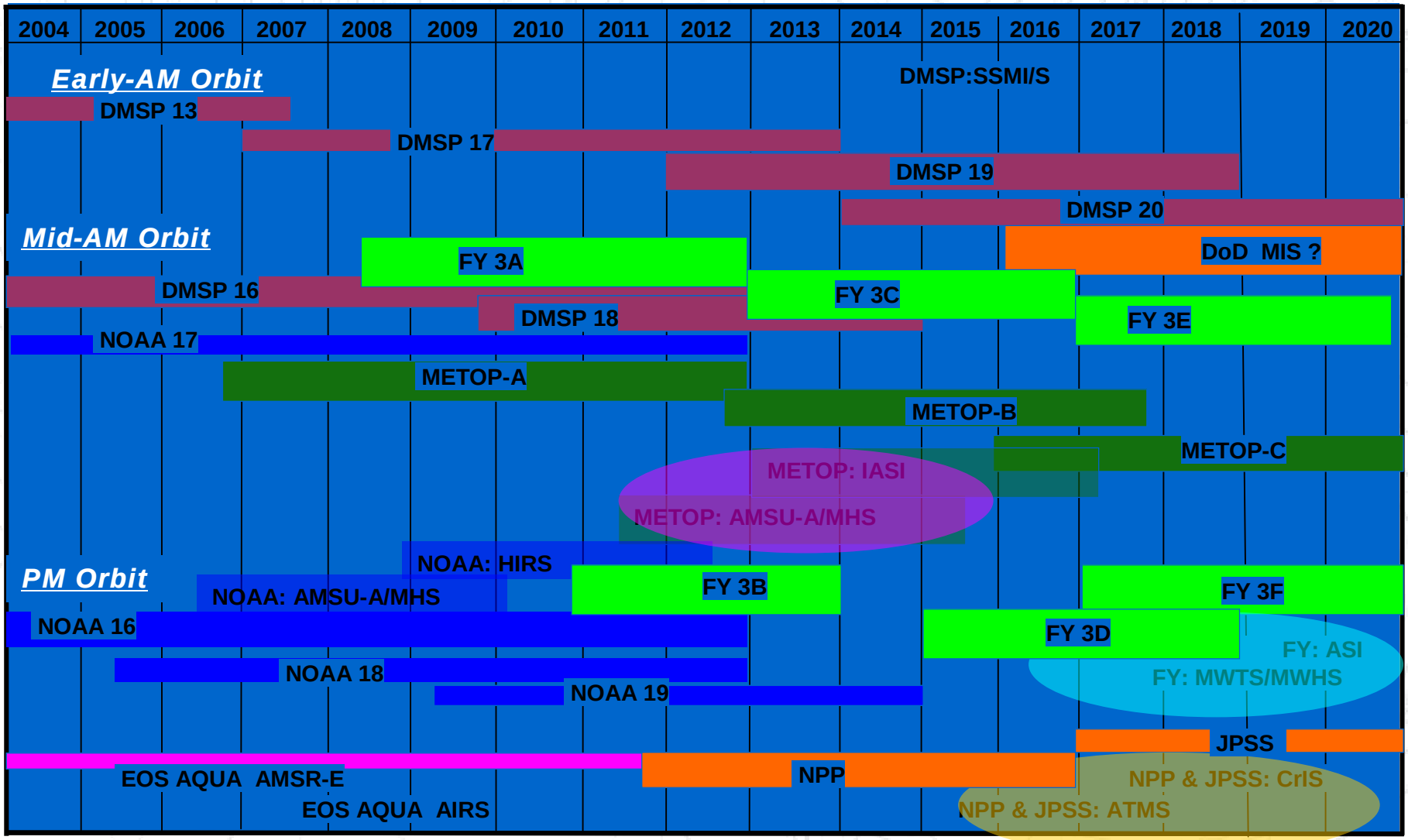
# Outline

- Background
- The implement of FY-3 and NPP microwave satellite data assimilation in WRFDA
- The preliminary experiment of FY-3 and NPP microwave satellite data assimilation in WRFDA
- The extension of RTTOV microwave particle scattering module in WRFDA
- Conclusion and discussion

# 1 Background

ø In the near future decade, NPP/JPSS together with METOP, and FY3, are the important meteorological satellites for NWP.



# 1 Background

- Compared to AMSUA/MHS, MWTS/MWHS and ATMS onboard on FY-3A/B and NPP, respectively are two new microwave sensors.

- Microwave satellite observation is the top contributor to the improvement of numerical weather forecast.

- The use of those microwave satellite observation in data assimilation system is developed or going on:
  FY-3A in ECMWF (Lu et al., 2011)
  ATMS in ECMWF (NIELS B et al., 2012)
  ATMS in NCEP (Collard, A et al., 2012)
  ……

- The implement of FY-3 and NPP microwave satellite data assimilation in WRFDA is a crucial issue.

# 2 The implement of FY-3 and NPP microwave satellite data assimilation in WRFDA

Table 1 The characteristics of sensor MWTS/MWHS compared to AMSUA/MWHS

| Channel Number | | Centre Frenquency (GHz) | | Bandwidth (MHz) | | NEΔT（K） | | Nadir Resolution (km) | | Weight Function Peak (hPa) | | Swath Width （km） | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AMSU-A | MWTS | AMSU-A | MWTS | AMSU-A | MWTS | AMSU-A | MWTS | AMSU-A | MWTS | AMSU-A | MWTS | AMSU-A | MWTS |
| 3 | 1 | 50.30(V) | | 180 | | 0.40 | 0.50 | 48 | 62 | surface | Surface | 2300 | 2250 |
| 5 | 2 | 53.596±0.115(H) | | 2*170 | | 0.25 | 0.40 | 48 | 62 | 700 | 700 | 2300 | 2250 |
| 7 | 3 | 54.94(V) | | 400 | | 0.25 | 0.40 | 48 | 62 | 270 | 300 | 2300 | 2250 |
| 9 | 4 | 57.29(H) | | 330 | | 0.25 | 0.40 | 48 | 62 | 90 | 70 | 2300 | 2250 |
| **Channel Number** | | **Centre Frenquency (GHz)** | | **Bandwidth (MHz)** | | **NEΔT（K）** | | **Nadir Resolution (km)** | | **Weight Function Peak (hPa)** | | **Swath Width （km）** | |
| MHS | MWHS | MHS | MWHS | MHS | MWHS | MHS | MWHS | MHS | MWHS | MHS | MWHS | MHS | MWHS |
| 1 | 1 | 89(V) | 150(V) | 1000*2 | | 0.84 | 0.90 | 15 | 15 | surface | Surface | 2250 | 2700 |
| 2 | 2 | 157(V) | 150 (H) | 1000*2 | | 0.84 | 0.90 | 15 | 15 | surface | Surface | 2250 | 2700 |
| 3 | 3 | 183.31±1(H) | 183.31±1(H) | 500*2 | | 0.60 | 1.10 | 15 | 15 | 400 | 400 | 2250 | 2700 |
| 4 | 4 | 183.31±3(H) | 183.31±3(H) | 1000*2 | | 0.70 | 0.90 | 15 | 15 | 600 | 600 | 2250 | 2700 |
| 5 | 5 | 183.31±7(H) | 183.31±7(H) | 2000*2 | | 1.06 | 0.90 | 15 | 15 | 800 | 800 | 2250 | 2700 |

**Special items:**

**1) MWTS has four channels;**

**2) Difference in window channel:**

- **MWTS has ONLY one window channel;**
- **MWHS channel 1 is switched from 89 to 150 GHz, the same as channel 2 except the polarization.**

The characteristics of sensor MWTS/MWHS compared to AMSUA/MHS

# The characteristics of sensor ATMS compared to AMSUA/MHS

**Unique characteristics:**

**1) ATMS has seven channels in humility unit;**

**2) Difference in window channel:**

- **Channel 4 is added while channel 15 is taken away in AMSUA temperature unit;**
- **The frequency of channel 17 is changed from 150 in MHS to 165 GHz;**

**3) The increase of swatch width and observation number, especially in temperature unit.**

Table 2 The characteristics of sensor ATMS compared to AMSUA/MHS

| ATMS Channel Number | AMSU Channel Number | Centre Frenquency (GHz) | Absobr | Weight Function Peak | Polarisation | |
|---|---|---|---|---|---|---|
| | | | | | ATMS | AMSU |
| 1 | 1 | 23.8 | $H_20$ | Surface | V | V |
| 2 | 2 | 31.4 | $H_20$ | Surface | V | V |
| 3 | 3 | 50.3 | $0_2$ | Surface | H | V |
| 4 | | 51.76 | $0_2$ | Surface | H | |
| 5 | 4 | 52.8 | $0_2$ | Surface | H | V |
| 6 | 5 | 53.596+/-0.116 | $0_2$ | 700 hPa | H | H |
| 7 | 6 | 54.4 | $0_2$ | 400 hPa | H | H |
| 8 | 7 | 54.94 | $0_2$ | 250 hPa | H | V |
| 9 | 8 | 55.5 | $0_2$ | 180 hPa | H | H |
| 10 | 9 | $f_0$ =57.290334 | $0_2$ | 90 hPa | H | H |
| 11 | 10 | $f_0$ +/-0.217 | $0_2$ | 50 hPa | H | H |
| 12 | 11 | $f_0$ +/-0.3222+/-0.048 | $0_2$ | 25 hPa | H | H |
| 13 | 12 | $f_0$ +/-0.3222+/-0.022 | $0_2$ | 10 hPa | H | H |
| 14 | 13 | $f_0$ +/-0.3222+/-0.010 | $0_2$ | 6 hPa | H | H |
| 15 | 14 | $f_0$ +/-0.3222+/-0.0045 | $H_20$ | 3 hPa | H | H |
| 16 | 15/16 | 88.2 | $H_20$ | Surface | V | V |
| 17 | 17 | 165.5+/-0.925 | $H_20$ | 1000 hPa | H | V |
| 18 | 20 | 183.31+/-7.0 | $H_20$ | | H | V |
| 19 | | 183.31+/-4.5 | $H_20$ | | H | |
| 20 | 19 | 183.31+/-3.0 | $H_20$ | 800 hPa | H | H |
| 21 | | 183.31+/-1.8 | $H_20$ | | H | |
| 22 | 18 | 183.31+/-1.0 | $H_20$ | 440 hPa | H | H |

# 2 The implement of FY-3 and NPP microwave satellite data assimilation in WRFDA

1) Namelist setup

```
rtminit_nsensor=5,
rtminit_platform=23,23,23,23,17  # 23 for FY3 and 17 for NPP
rtminit_satid=1,1,2,2,0   # 1 for FY-3A,2 for FY-3B,0 for NPP
rtminit_sensor=40,41,40,41,19 # 40 for MWTS,41 for MWHS,
                                19 for ATMS
```

2) Radiance data ingest

The radiance data are named by instrument name and each file contains global brightness temperature within 6-hour assimilation window. FY3 is CMA binary format and ATMS is NCAP BUFR file. The former is not, and the latter is available through public ftp server. The naming convention is:

| CMA binary file names | WRF-Var naming convention |
|---|---|
| fy3_yyyymmddhh_mwt.dat | mwtsa.dat or mwtsb.dat |
| fy3_yyyymmddhh_mwh.dat | mwhsa.dat or mwhsb.dat |

| NCEP bufr file name | WRF-Var naming convention |
|---|---|
| atms.gdas.yyyymmddhh | atms.bufr |

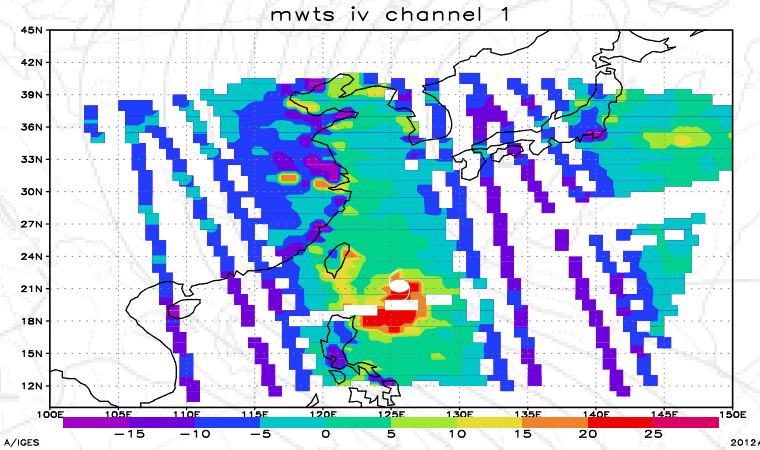
# 2 The implement of FY-3 and NPP microwave satellite data assimilation in WRFDA

3) Other processing of radiance data including atms noise reducing, quality control, cloud detection and so on, is implemented inside WRFDA.

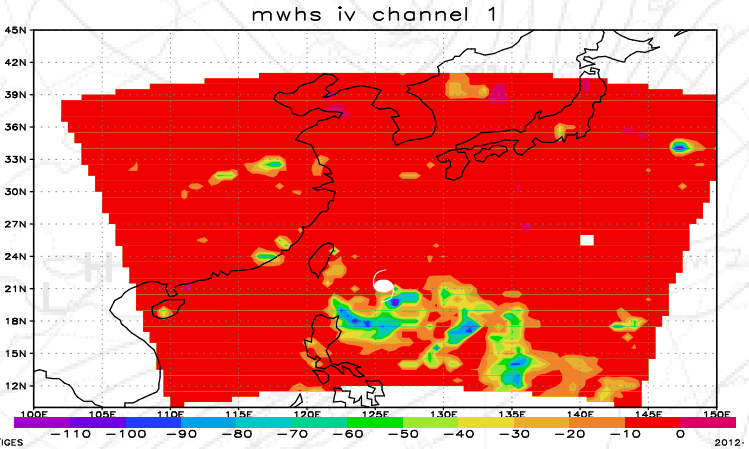
| | FY-3 MWTS/MWHS | NPP ATMS | NOAA AMSUA/MHS |
|---|---|---|---|
| Noise reducing | none | average | none |
| Channel selection | 1) MWTS 1～4 and MWHS 1～5 are not used for mixed surface;<br>2) MWTS 1～3 and MWHS 1～5 are discarded for land, ice and snow;<br>3) MWTS 2 and MWHS 5 are aborted when Ps<850 hPa and Ps<800 hPa, respectively。 | 1) All channels 1～22 are not used for mixed surface;<br>2) 1～8 and 16～22 are discarded for land, ice and snow;<br>3) channel 6 and 18 are aborted when Ps<850 hPa and Ps<800 hPa, respectively;<br>4) 11～15 are not used. | 1) AMSUA 1～15 and MHS 1～5 are not used for mixed surface;<br>2) AMSUA 1～7 and MHS 1～5 are discarded for land, ice and snow;<br>3) AMSUA 5 and MHS 5 are aborted when Ps<850 hPa and Ps<800 hPa, respectively;<br>4) AMSUA 10～14 are not used. |
| Cloud detection | 1）MWTS 1 dtb, not use MWTS 1～3;<br>2）MWHS 1 dtb, not use MWHS 1～5. | 1）channel 3 abs(dtb), not use 1～8 and 16～22;<br>2）channel 1 dtb，not use 1～8 (test);<br>3）scattering Insex combined channel 16 and 17, not use 16～22 (test). | 1）scattering Index combined AMSUA 1 and 15, not use AMSUA 1～7;<br>2）scattering Index combined MHS 1 and 2, not use MHS 1～5. |
| Outermost scan | MWTS 3～13<br>MWHS 9～89 | 1～96 | AMSUA 4～27<br>MHS 9～82 |
| Bias correction | VarBC | VarBC | VarBC |

Note：dtb is the bias of observed and simulated brightness temperature and abs is absolute value.

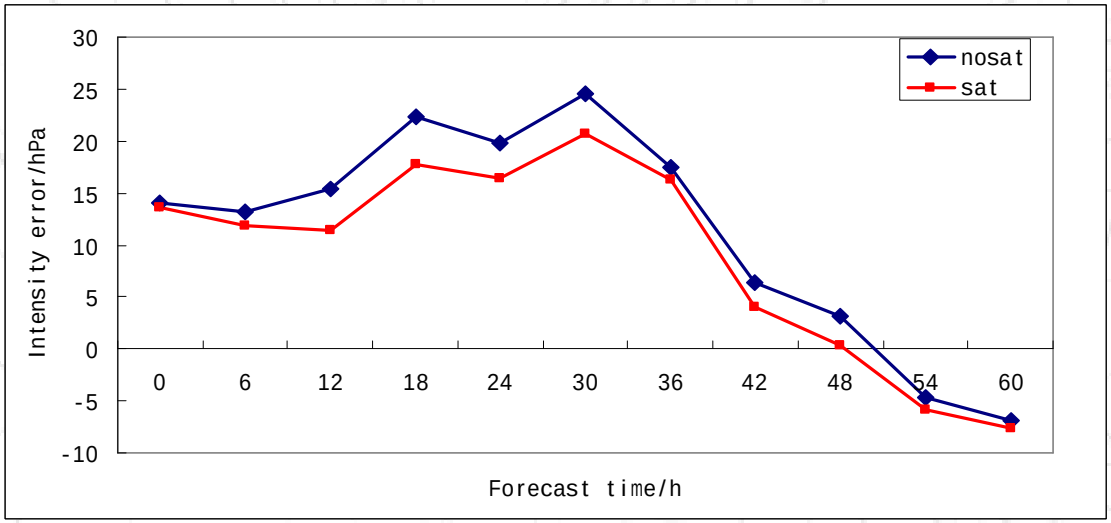
# 3 The preliminary experiment of FY-3 and NPP microwave satellite data assimilation in WRFDA




MWTS channel 1

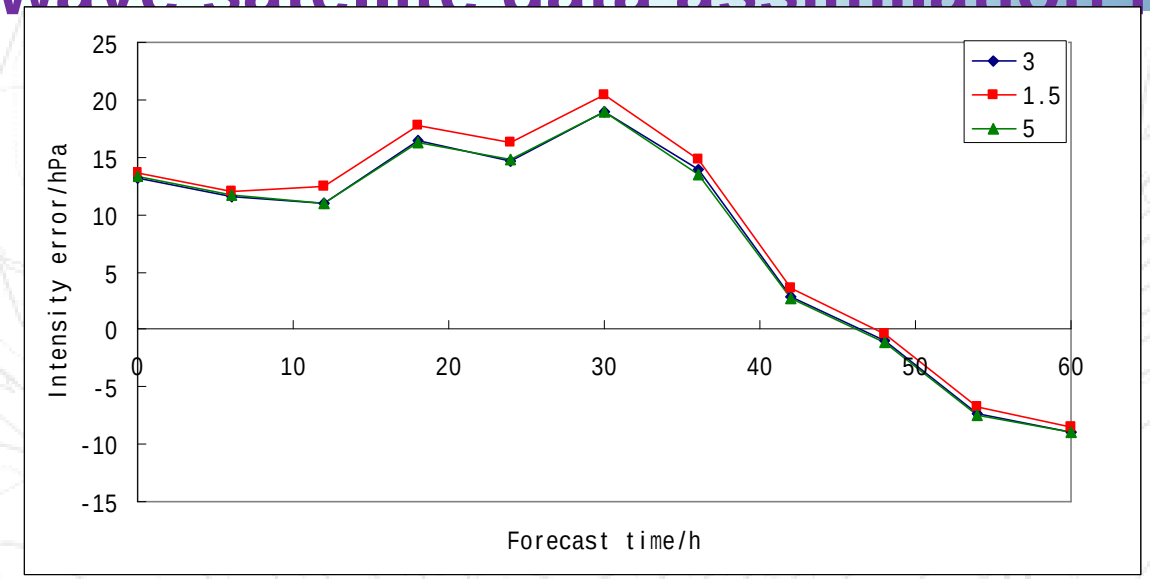



MWHS channel 1

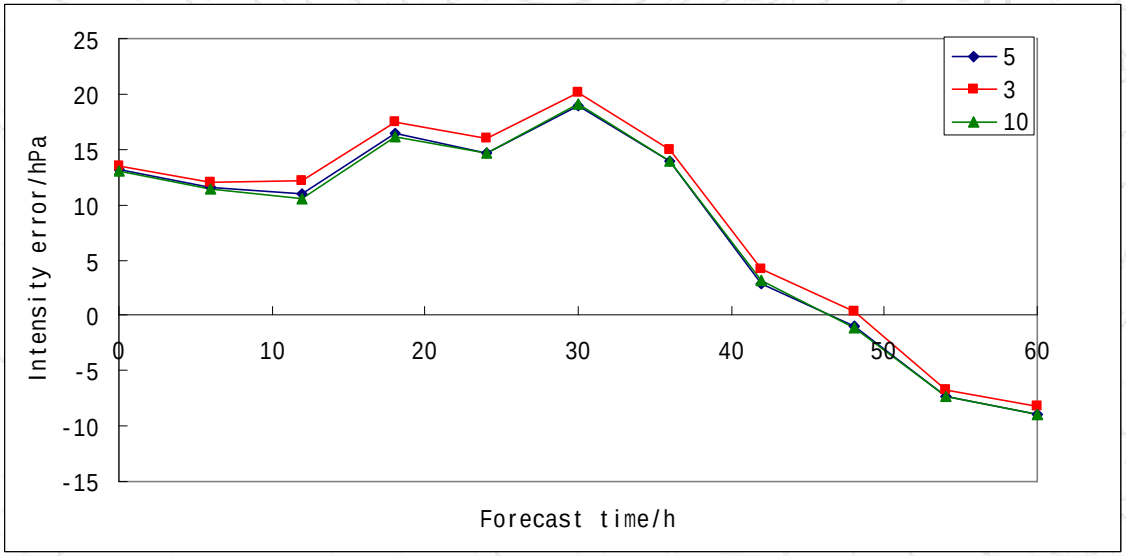



The use of FY-3A MWTS/MWHS data and its effect on the intensity forecast error for typhoon "Fungwong" (2008)

# 3 The preliminary experiment of FY-3 and NPP microwave satellite data assimilation in WRFDA



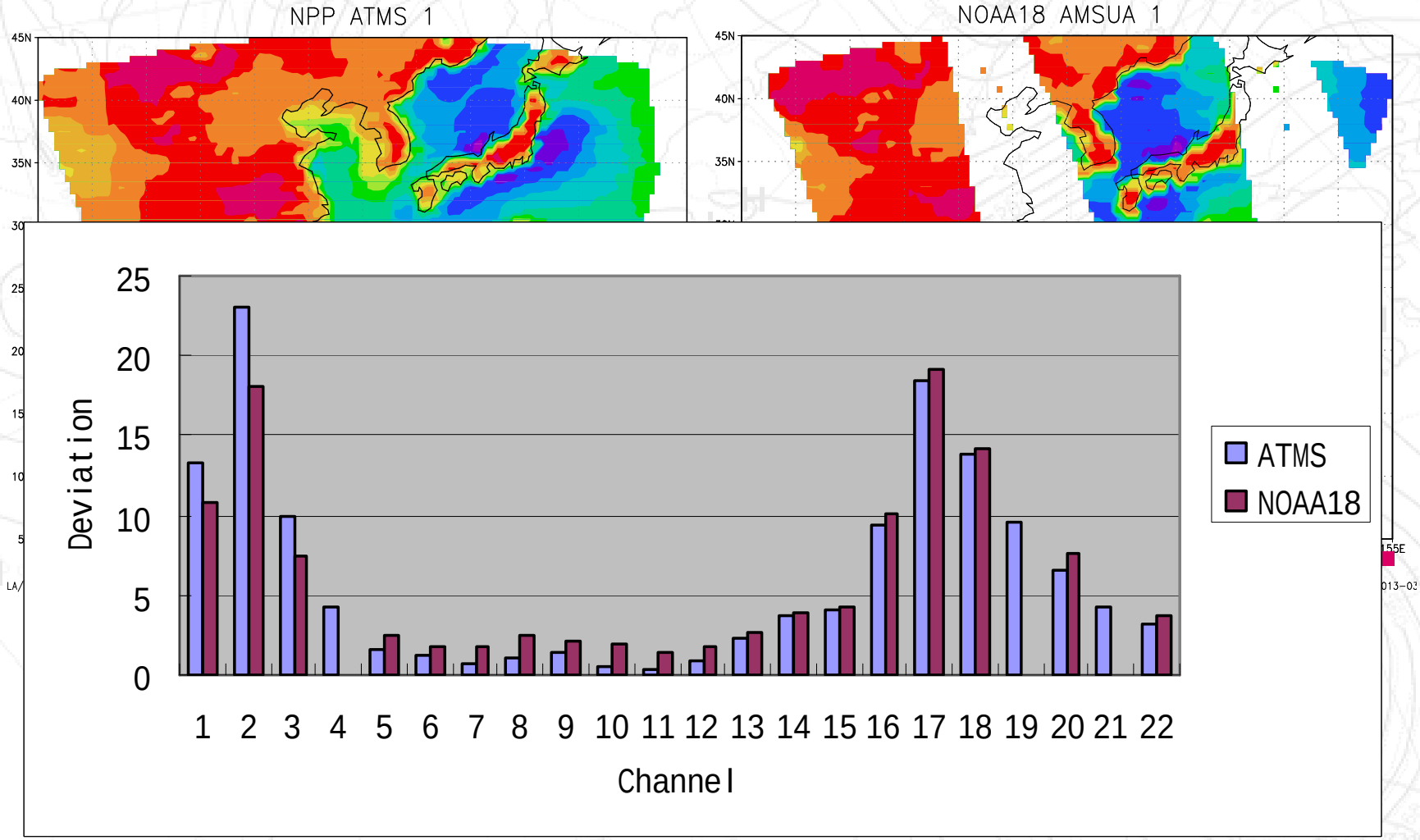

MWTS




MWHS

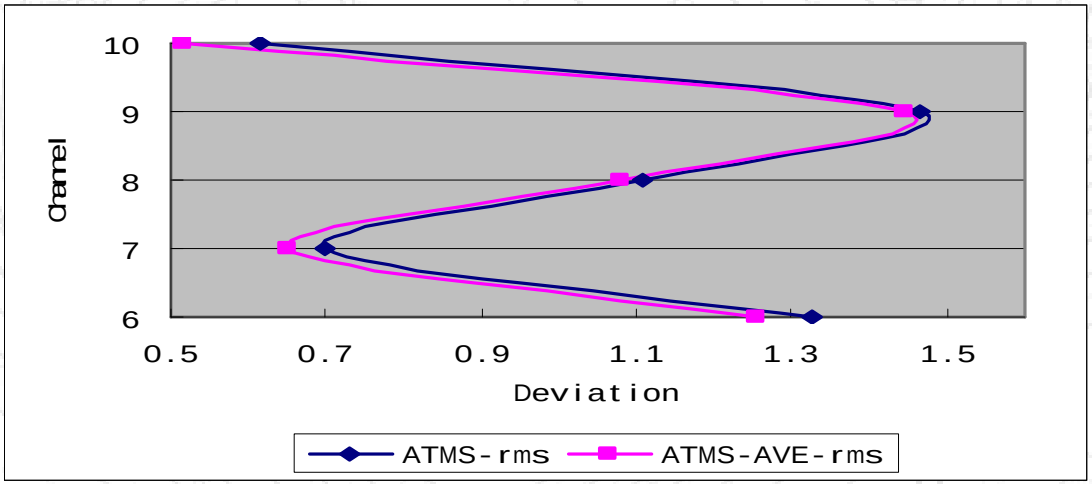
The experiment of cloud examination scheme in the use of FY-3A microwave satellite data

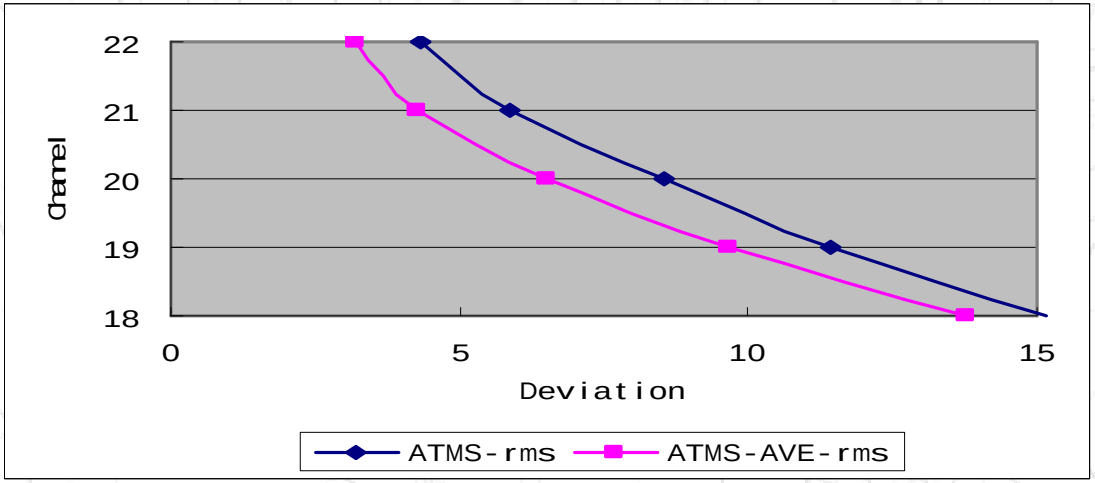
# 3 The preliminary experiment of FY-3 and NPP microwave satellite data assimilation in WRFDA




ATMS and NOAA18 AMSUA/MHS observation and bias of observed and simulated brightness temperature over sea

# 3 The preliminary experiment of FY-3 and NPP microwave satellite data assimilation in WRFDA




The RMS of observed and simulated brightness temperature without and with reducing the noise to ATMS data over sea

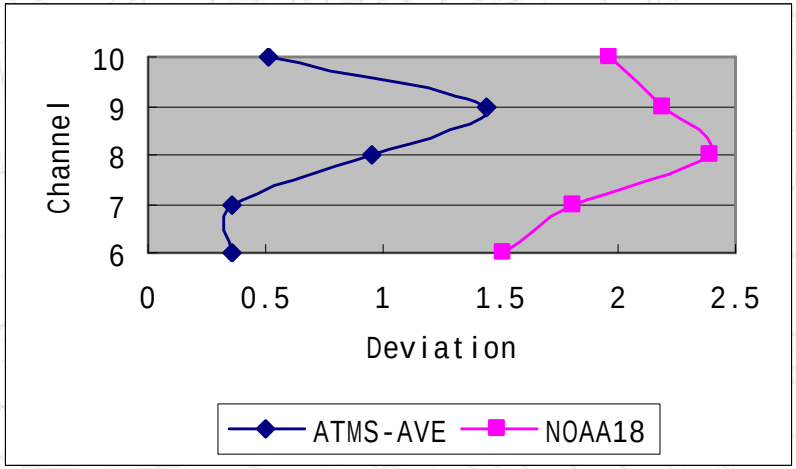
# 3 The preliminary experiment of FY-3 and NPP microwave satellite data assimilation in WRFDA

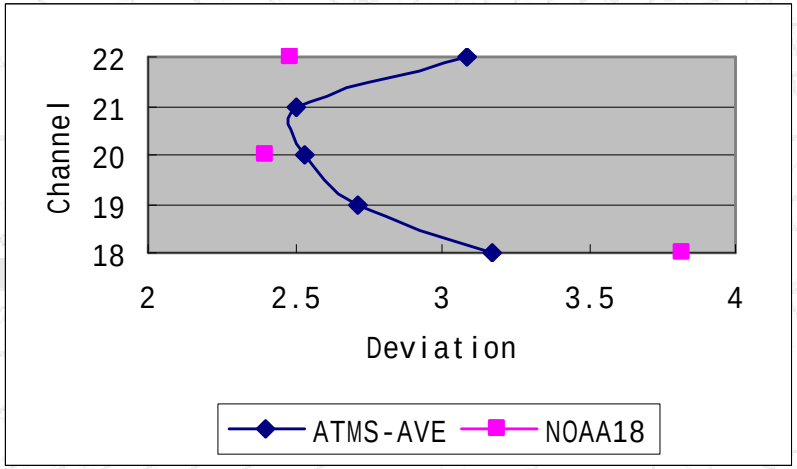
The number of observations passing rain and cloud-related quality control over sea for ATMS and NOAA18 AMSUA/MHS

| ATMS | 6 | 7 | 8 | 18 | 19 | 20 | 21 | 22 |
|---|---|---|---|---|---|---|---|---|
| Observation number | 12123 | 12123 | 12123 | 12123 | 12054 | 11979 | 11974 | 11972 |
| Passed channel 3 abs(dtb) | 3710 | 3710 | 3710 | 3710 | 3710 | 3690 | 3690 | 3690 |
| Passed channel 1 dtb and scattering Index combined 16 and 17 | 9156 | 9156 | 9156 | 10838 | 10836 | 10831 | 10831 | 10831 |
| Passed all exminations | 3495 | 3495 | 3495 | 3665 | 3665 | 3665 | 3665 | 3665 |

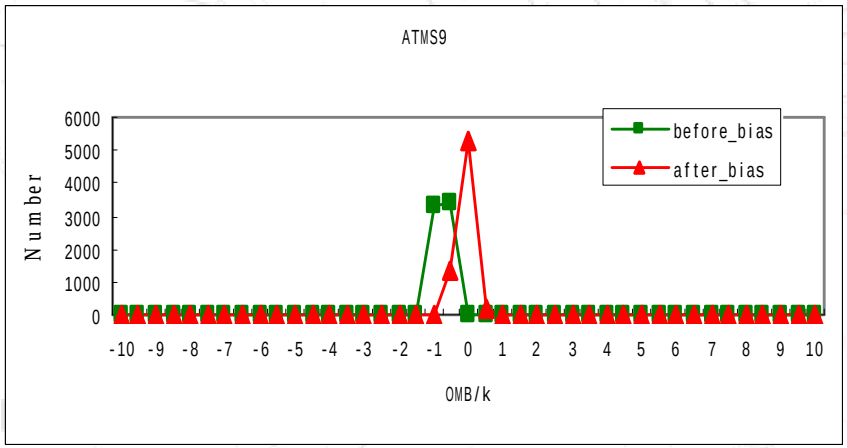
| AMSUA/MHS | 5 | 6 | 7 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Observation number | 3003 | 3003 | 3003 | 3322 | 3322 | 3322 |
| Number of data passed | 2940 | 2940 | 2940 | 2919 | 2919 | 2919 |

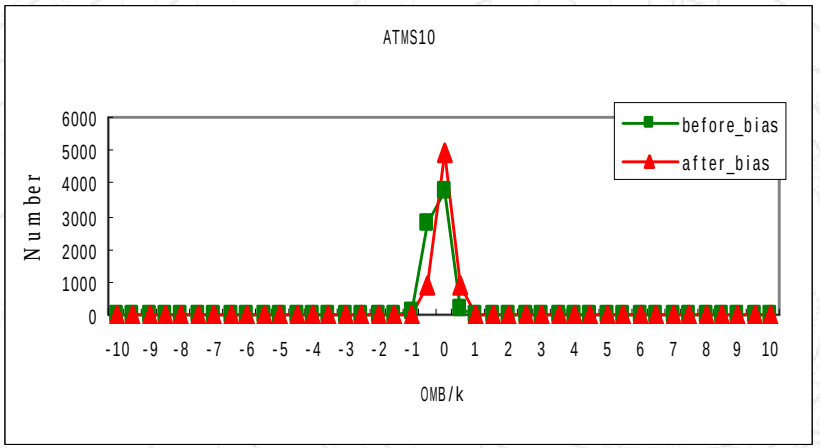
# 3 The preliminary experiment of FY-3 and NPP microwave satellite data assimilation in WRFDA



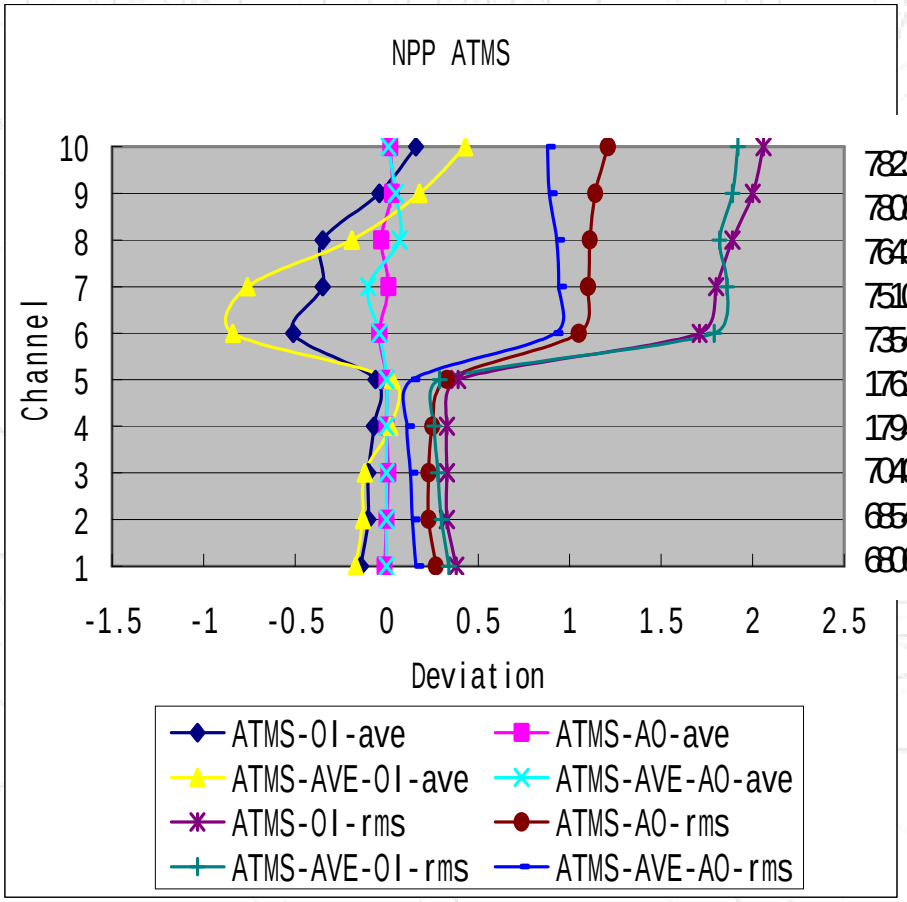

The RMS of observation and simulated brightness temperature

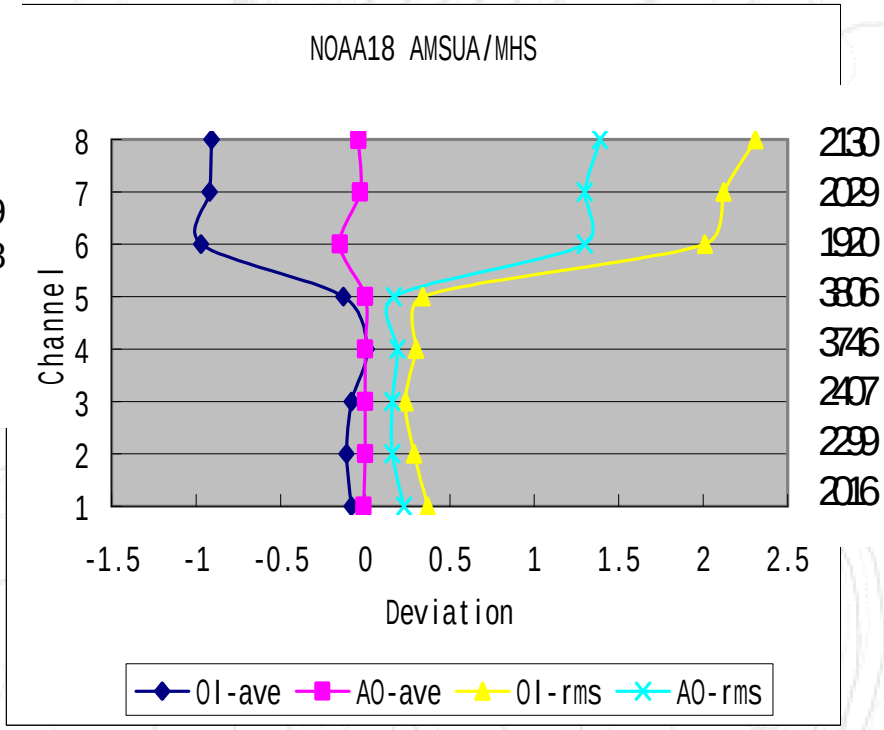



Bias correction for ATMS channel 9 and 10

# 3 The preliminary experiment of FY-3 and NPP microwave satellite data assimilation in WRFDA

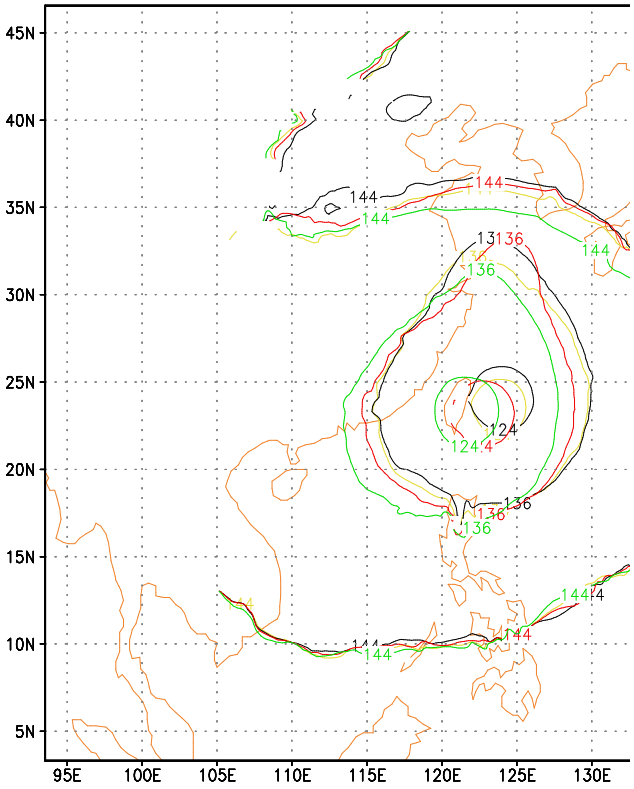


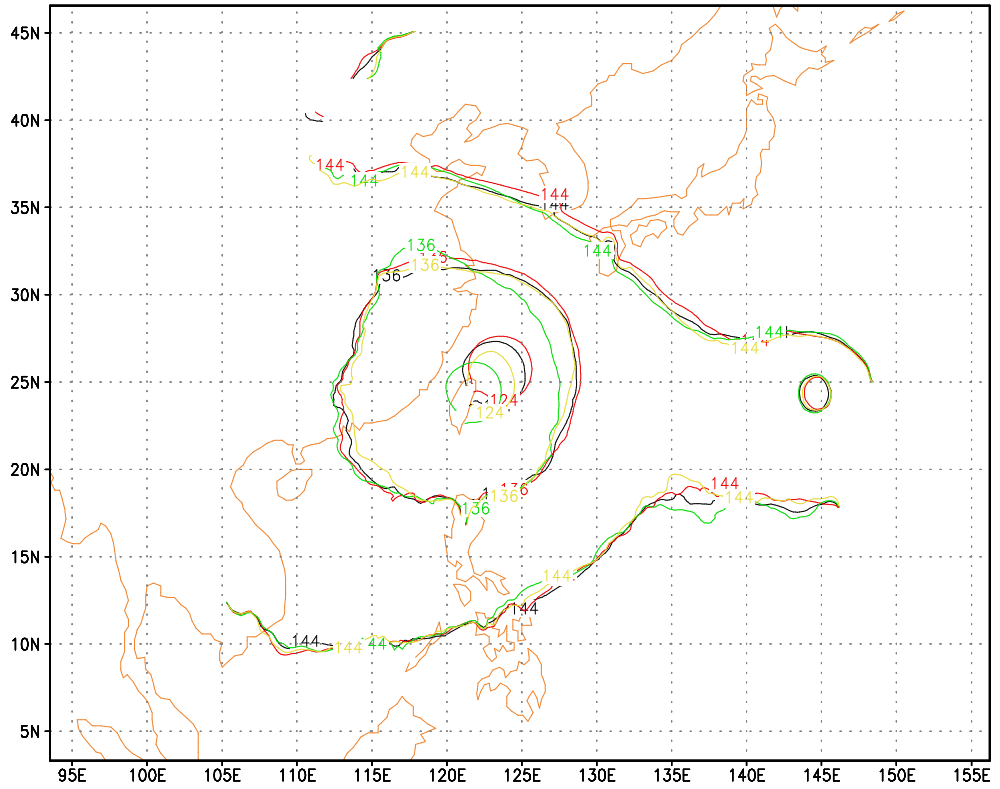

The Bias and RMS of observation and simulated brightness temperature before and after assimilation for ATMS and NOAA18 AMSUA/MHS

# 3 The preliminary experiment of FY-3 and NPP microwave satellite data assimilation in WRFDA


54 h Height Forecast@




54 h Height Forecast@850 hPa

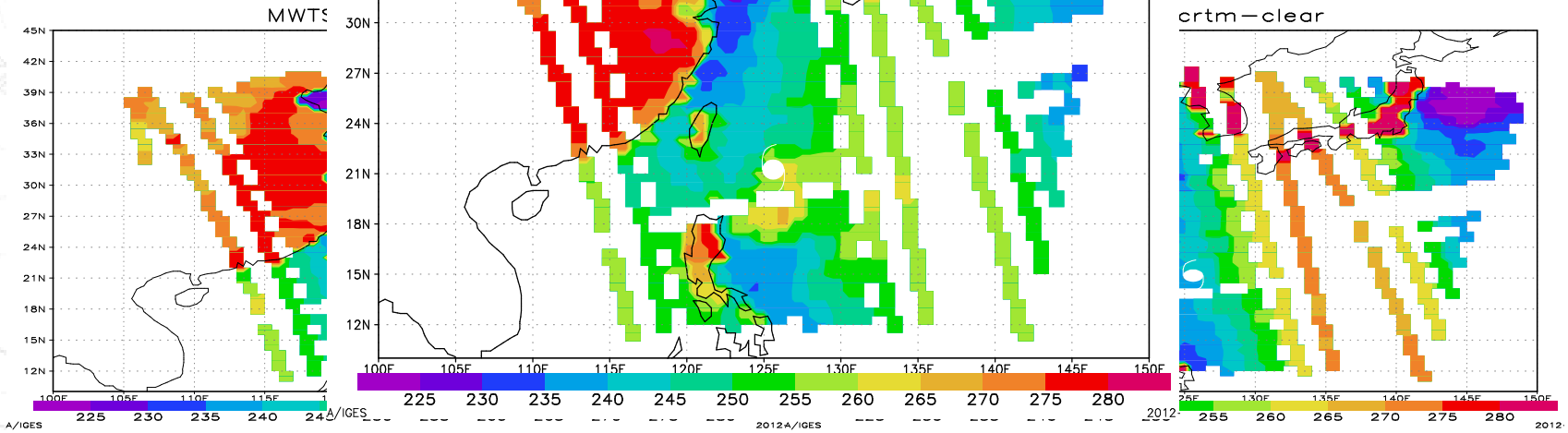



The impact of microwave satellite data on the typhoon " SAOLA" (2012) trace forecast (black:Control; green:ATMS; red: FY-3B; yellow: NOAA18)

# 4 The e … wave particle scatterin…

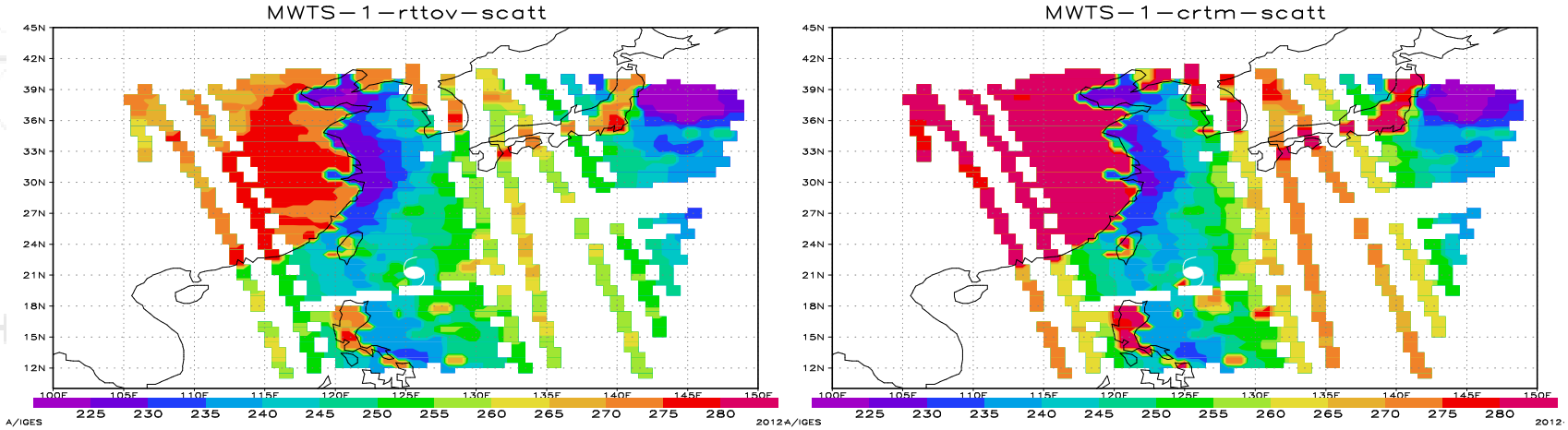
RTTOV10.2== …

rttov_scatt_… n namelist



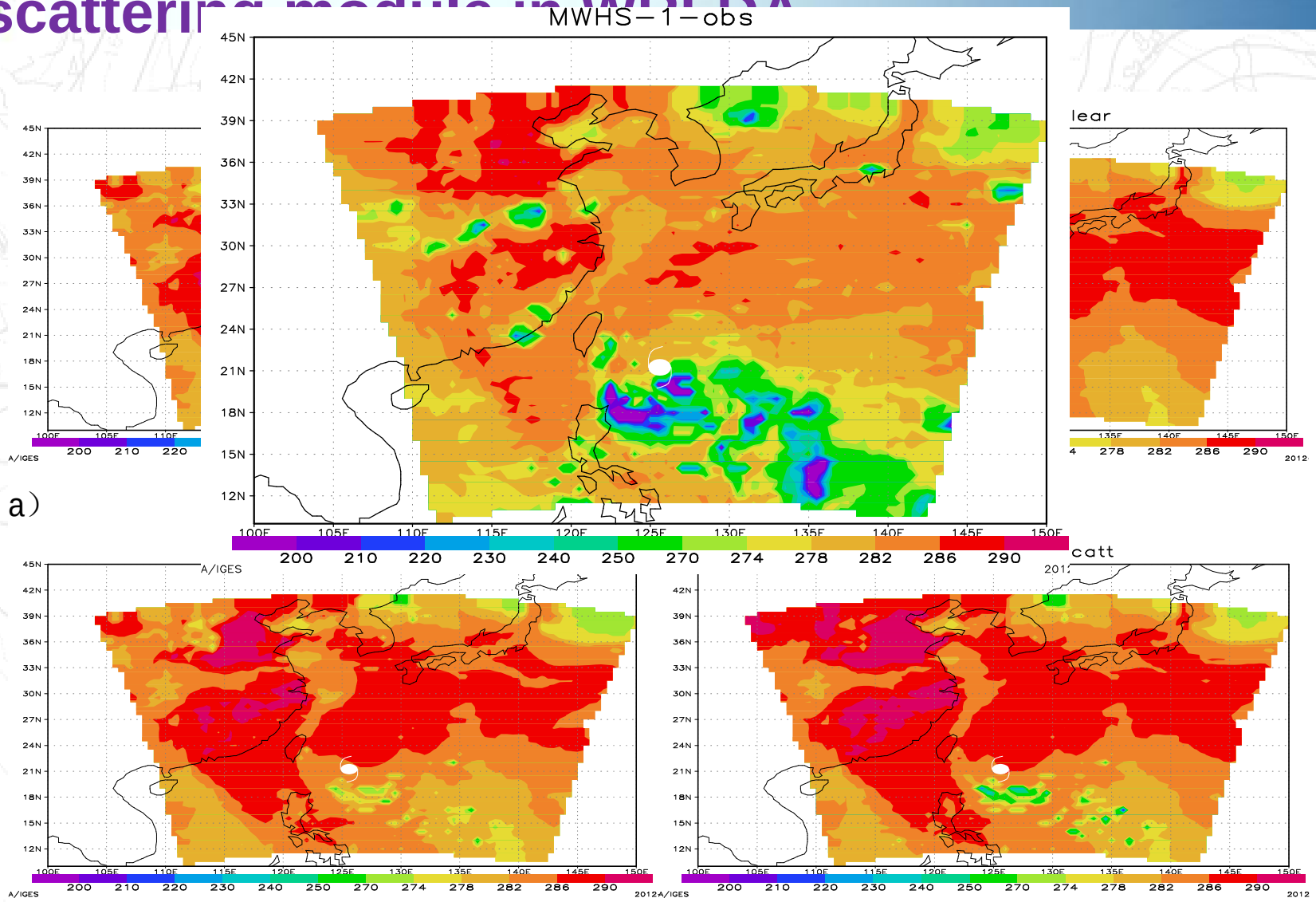

a）

b）



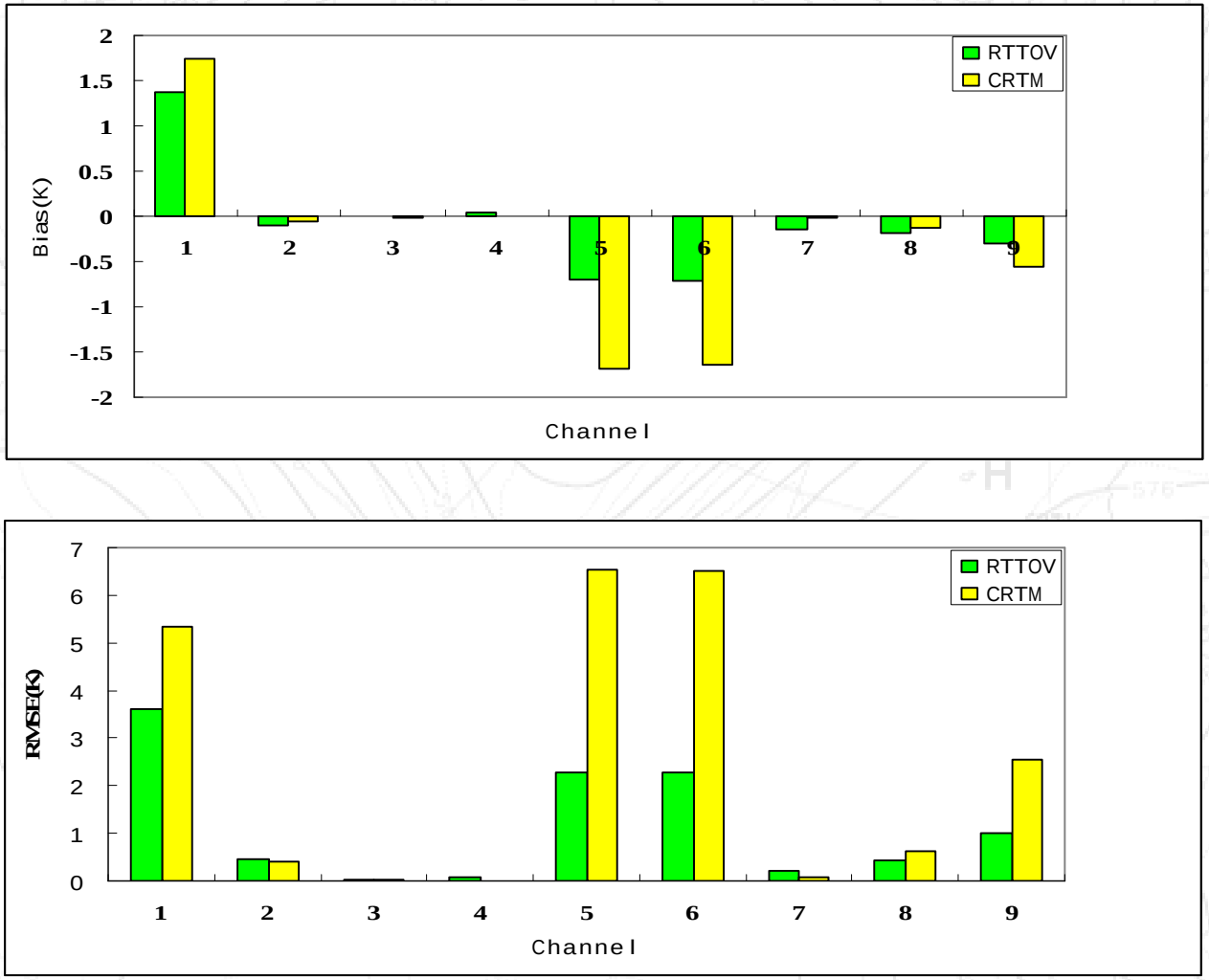

The observed and simulated brightness temperature for FY-3A MWTS

# 4 The extension of RTTOV microwave particle scattering module in WRFDA




The observed and simulated brightness temperature for FY-3A MWHS

# 4 The extension of RTTOV microwave particle scattering module in WRFDA




The bias (top) and RMS (bottom) of brightness temperature between clear and cloudy simulation of FY-3A MWTS/MWHS for both RTTOV and CRTM

# 5 Conclusion and discussion

- WRFDA has been extended to have the capability of assimilating FY-3A/B and NPP microwave satellite data. Preliminary experiments show that the use of those satellite data benefits the improvement of numerical forecast.

- Specially, there is a need to revise and investigate the cloud detective scheme in the implement of FY3 and NPP microwave satellite data because the windows channel has changed significantly compared to AMSUA/MHS. More followed experiment should be carried out with the tuning of cloud detection, together with bias correction and observation error and so on.

- Additionally, RTTOV microwave particle scattering module is implemented to make the calculation under cloudy condition available by using both RTTOV and CRTM in the coincident framework of WRFDA.

# Thanks for your attention

Thanks for your attention