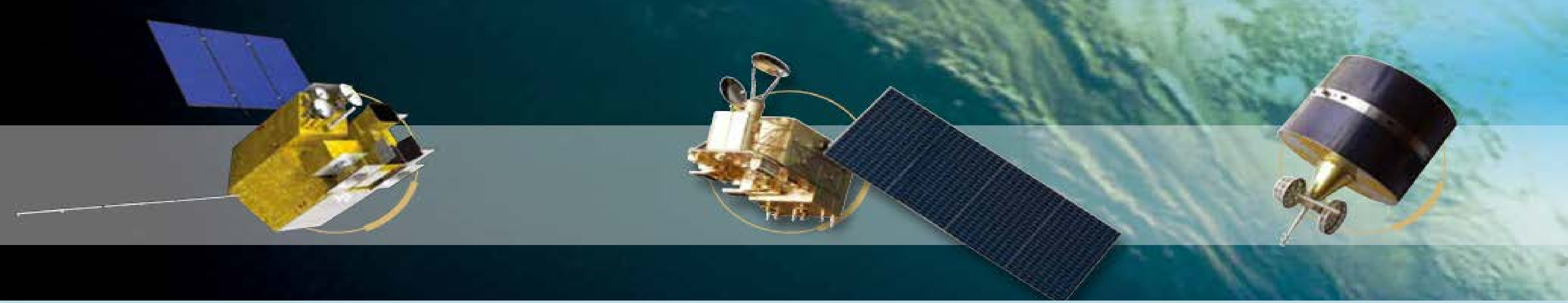

THE STATUS OF FY-3C IN NWP AND THE PREPARATION OF FY-3D AND FY-4A FOR NWP

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Qifeng Lu Chunqiang Wu, Chengli Qi, Xuan Feng, Yang Guo, Miao Zhang, Mi Liao, Shengli Wu, Dawei An, Xianjun Xiao, Fangli Dou, Juyang Hu

National Satellite Meteorological Center ,CMA

Juan Li, Yan Liu, Jincheng Wang, Wei Han

NWPC, CMA

Heather Lawrence, Nigel Atkinson and Fabien Carminati, Katie Lean, Niels Bornman, William Bell, Stephen English, Alan Geer, Sean Healy

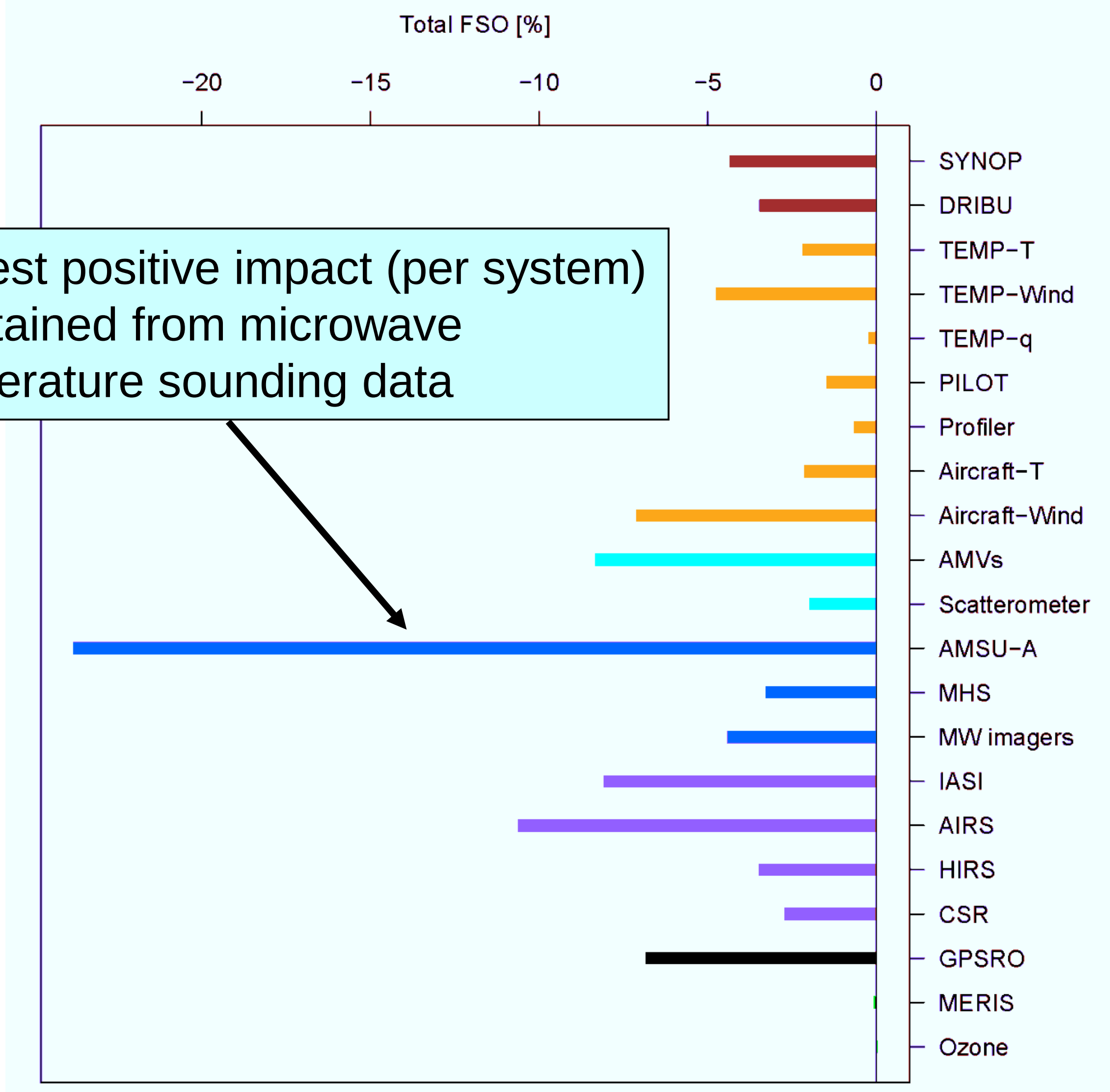
ECMWF, Met Office

Outline

- **The evolution of FY-3 for NWP**
- **The status of FY3 in NWP**
- **The preparation of FY-3D and FY-4A for NWP**

1. The evolution of FY-3 for NWP

Largest positive impact (per system) is obtained from microwave temperature sounding data



Forecast sensitivity to observations (FSO)
Is an adjoint based technique for assessing the influence of observing systems on forecast accuracy

(from C. Cardinali, ECMWF)

The FY-3A/B/C/D/E Instrument Suites for NWP

Infrared Atmospheric Sounder (IRAS) 20 channels (~HIRS/3)
HIRAS(1370channels)

Microwave Temperature Sounder (MWTS)
4 channel (~MSU)
13 channels
17 channels

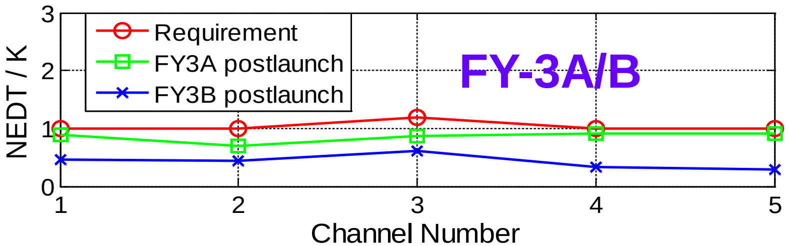
Microwave Humidity Sounder (MWHS)
5 channel (~MHS)
15channels with channels at 118 GHz

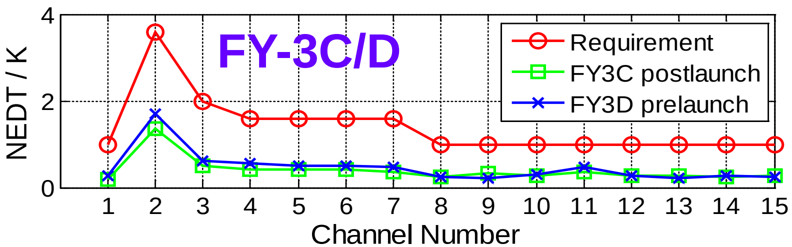
WindRAD
C ,Ku
HH, VV

Microwave Radiation Imager
10 channels
(~AMSR-E)

GNSS Radio-Occultation Sounder (GNOS)
(~GPS)

Microwave temperature and humidity sounder





TIROS-N/ MSU
50-60GHz,
launched, 1978,
out of service.

DMSP/ SSM/T
50-60GHz (7) ,
launched, 1979,
out of service.

DMSP/ SSM/T-2
90,150,183GHz (5)
launched, 1991,
out of service.

NOAA/ AMSU-A/B
50-60,90GHz
150,183GHz,
launched, 1998,
On service.

Aqua/ HSB
90,150,183GHz,
launched, 2002,
On service.

Metop/AMSUA/
MHS
90,150,183GHz,
launched, 2006,
On service.

Suomi-
NPP/ATMS
50-60,90GHz
150,183GHz,
launched, 2009,
On service.

FY3A/ MWTHS
50-60GHz(4)
150 (2)
183GHZ(3)
launched, 2008

FY3B/ MWTHS
50-60GHz(4)
150 (2)
183GHZ(3)
launched, 2010

FY3C/ MWTHS
50-60GHz(13)
89GHz(1)
118GHZ(8)
150/166(1)
183GHZ(5)
launched, 2013

FY3D/ MWTHS
50-60GHz(17)
89GHz(1)
118GHZ(8)
150/166(1)
183GHZ(5)
to be launched
in 2017

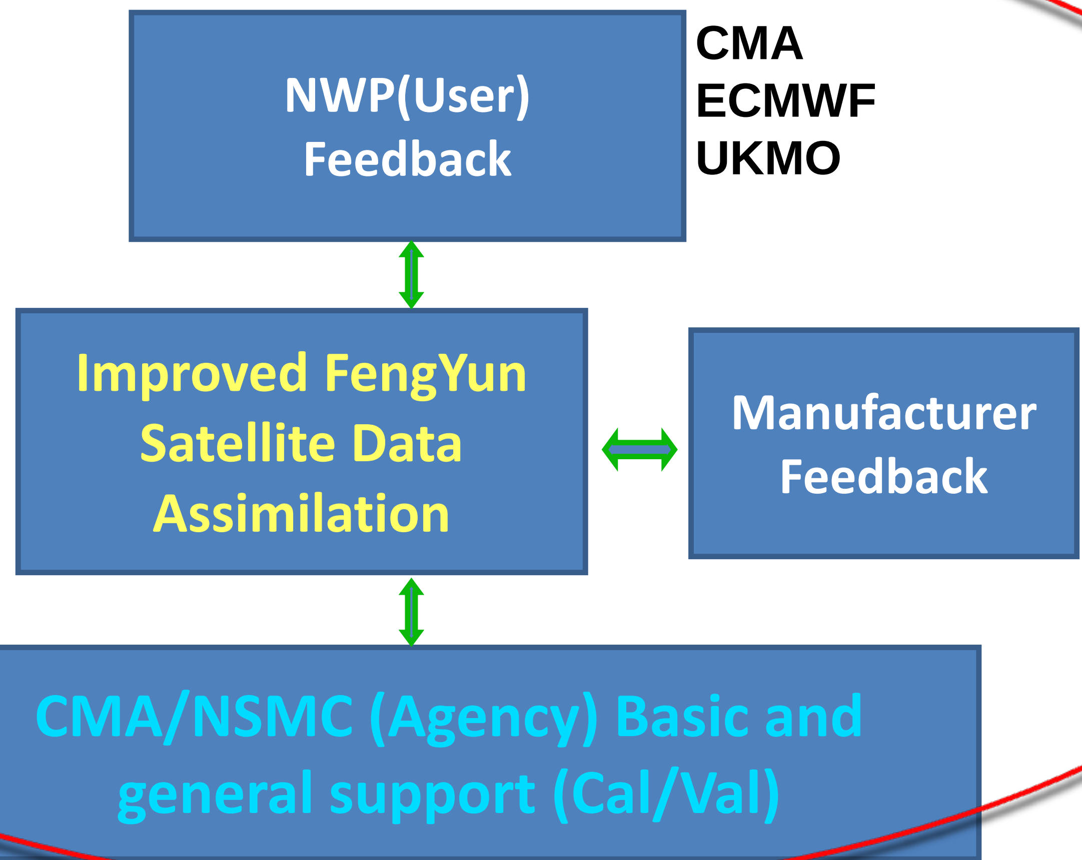
2. The status of FY3C in NWP

Since FY-3C, closer collaborations was encouraged

--improve the misunderstanding and fill the gap from requirements

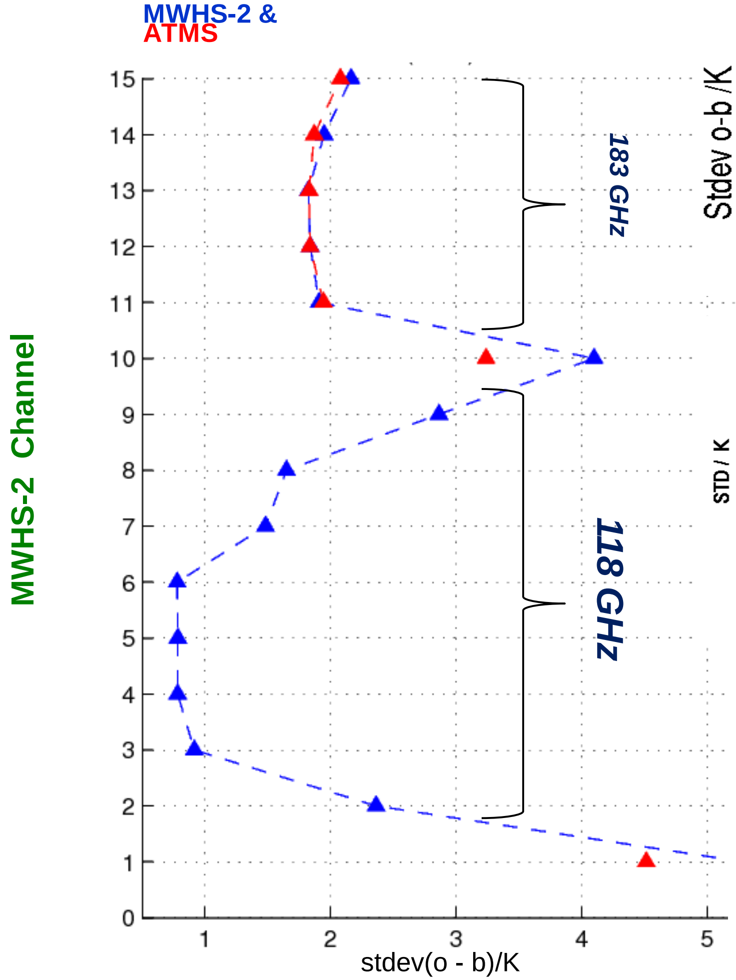
Share; early evaluation; preparation before launch

Collaboration Team

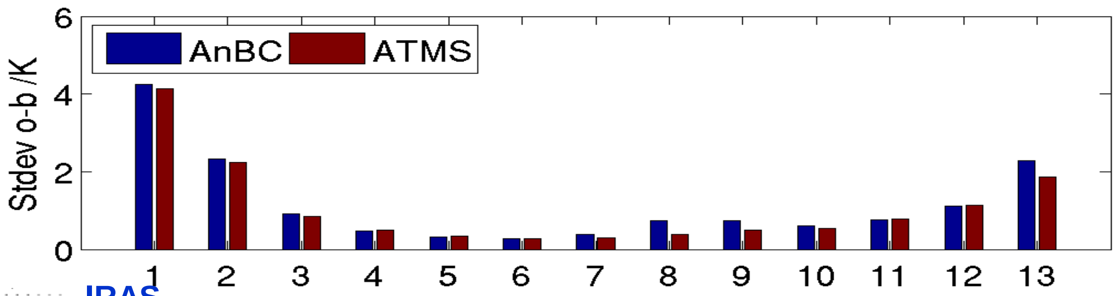


The telecommunication conference is held since Dec 2014 to communicate the progress on evaluating, improving and assimilating FY-3C data in NWP models

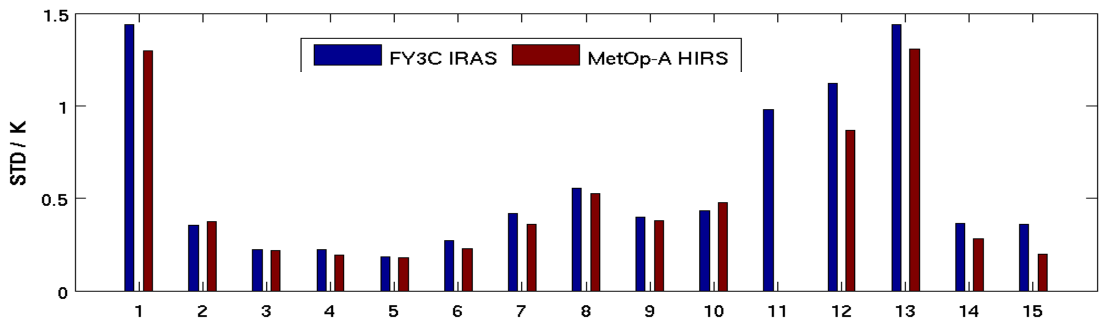
The comparable data quality of FY-3C sounding instruments to its counterparts



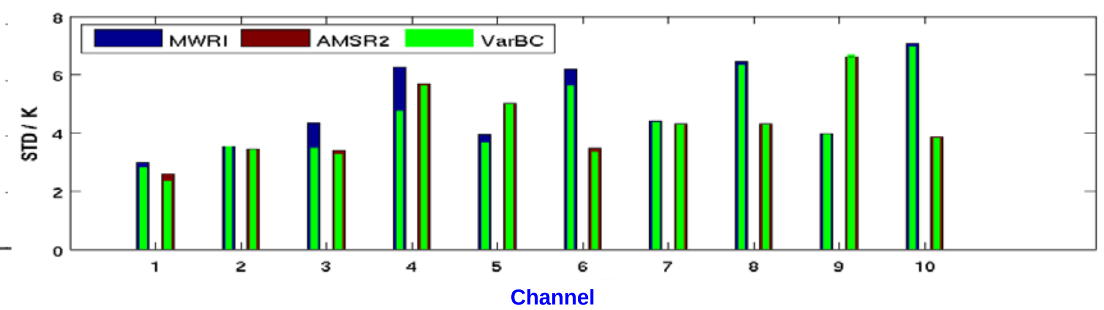
MWTS-2



IRAS



MWRI



The plan and status of FY-3C in NWP model from three centers..

ECMWF			
	2014	2015	2016
FY-3B MWHS	Op DA	Op DA	Op DA
FY-3C MWTS2	Evaluation	Evaluation (Now dead)	Evaluation (Now dead)
FY-3C MWHS2	Evaluation	Monitoring	Op DA
FY-3C MWRI	Evaluation	Evaluation	To be Moni
FY-3C IRAS	Evaluation	Evaluation	Monitoring
FY-3C GNOS	Sample data	Sample data	Evaluation

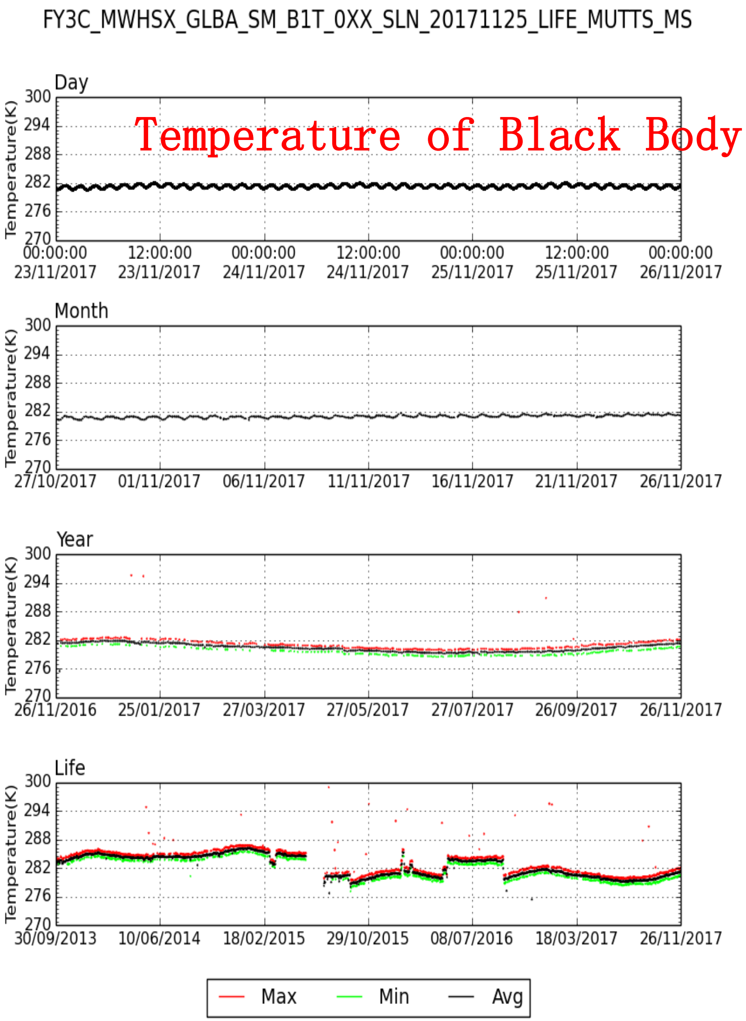
UKMO			
	2014	2015	2016
FY-3B MWHS	Evaluation	Monitoring	To be Op DA
FY-3C MWTS2	Evaluation	Evaluation (Now dead)	Evaluation (Now dead)
FY-3C MWHS2	Evaluation	Monitoring	Op DA
FY-3C MWRI	Evaluation		To be Moni
FY-3C IRAS			
FY-3C GNOS	Evaluation	Evaluation	Evaluation

CMA NWPC			
	2014	2015	2016
FY-3B MWHS	Evaluation	Evaluation	To be Moni
FY-3C MWTS2	Evaluation	Evaluation (Now dead)	Evaluation (Now dead)
FY-3C MWHS2	Evaluation	To be Op Da	Op DA
FY-3C MWRI	Evaluation		To be Moni
FY-3C IRAS			
FY-3C GNOS	Evaluation	To be Op Da	Op DA

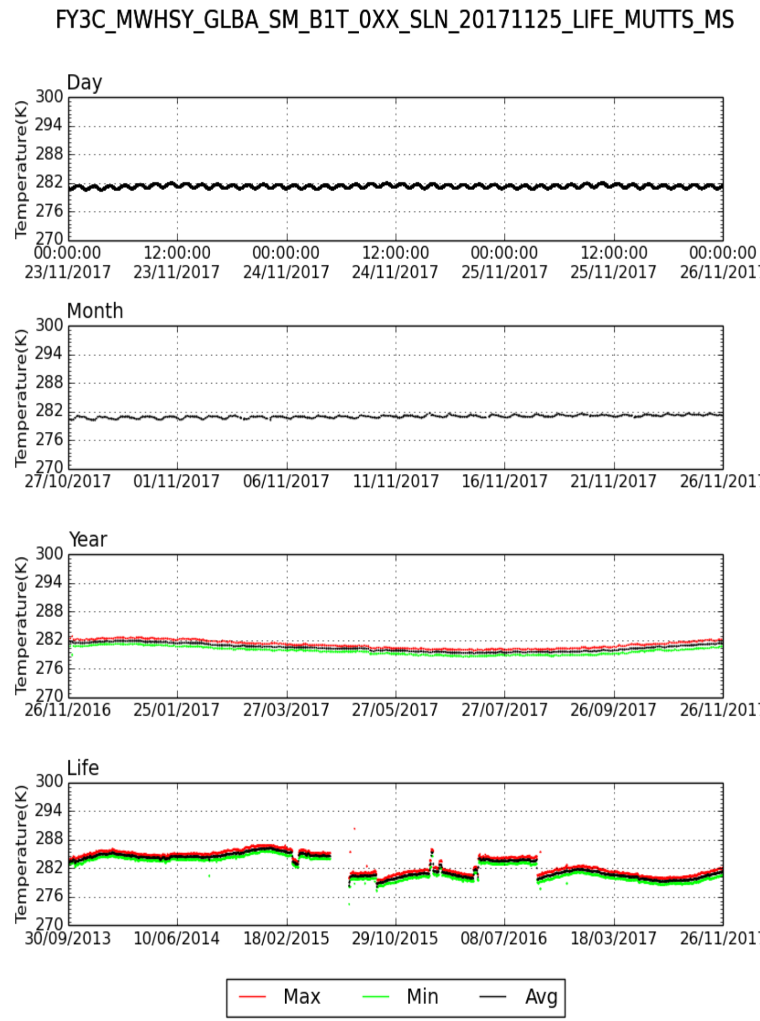
- **FY3C MWHS-2 has been operationally assimilated and monitored in the Met Office global model on 15 March 2016, and in ECMWF IFS system on 4 April 2016 .**
- **Operational assimilation of MWHS-2 with 183 GHz channels globally and GNOS in CMA/GRAPES have been activated in April 2016.**

Monitoring OMB against the instrumental parameter to indicate the performance on orbit

Server Terminal: http://satellite.nsmc.org.cn

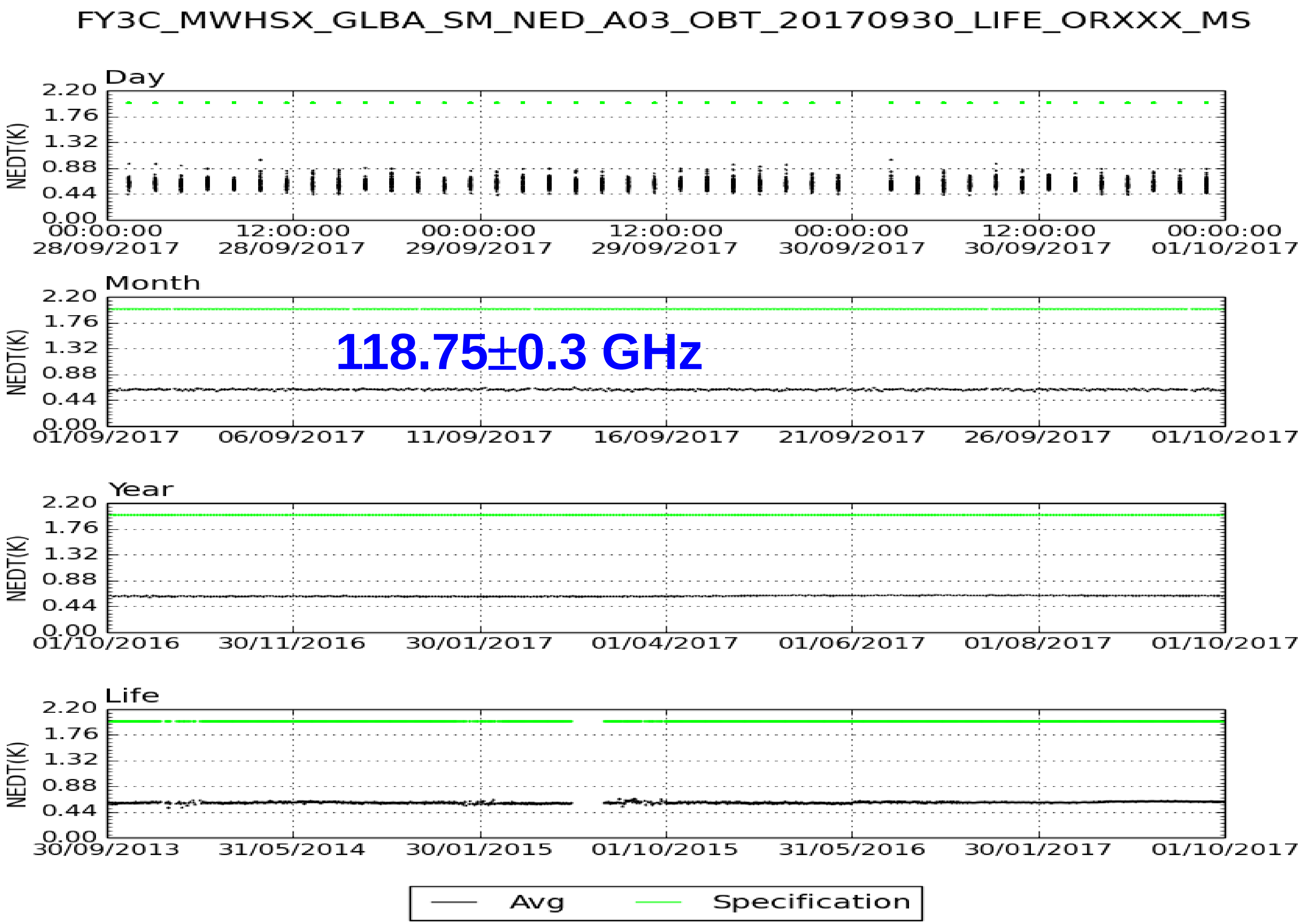


Before QC

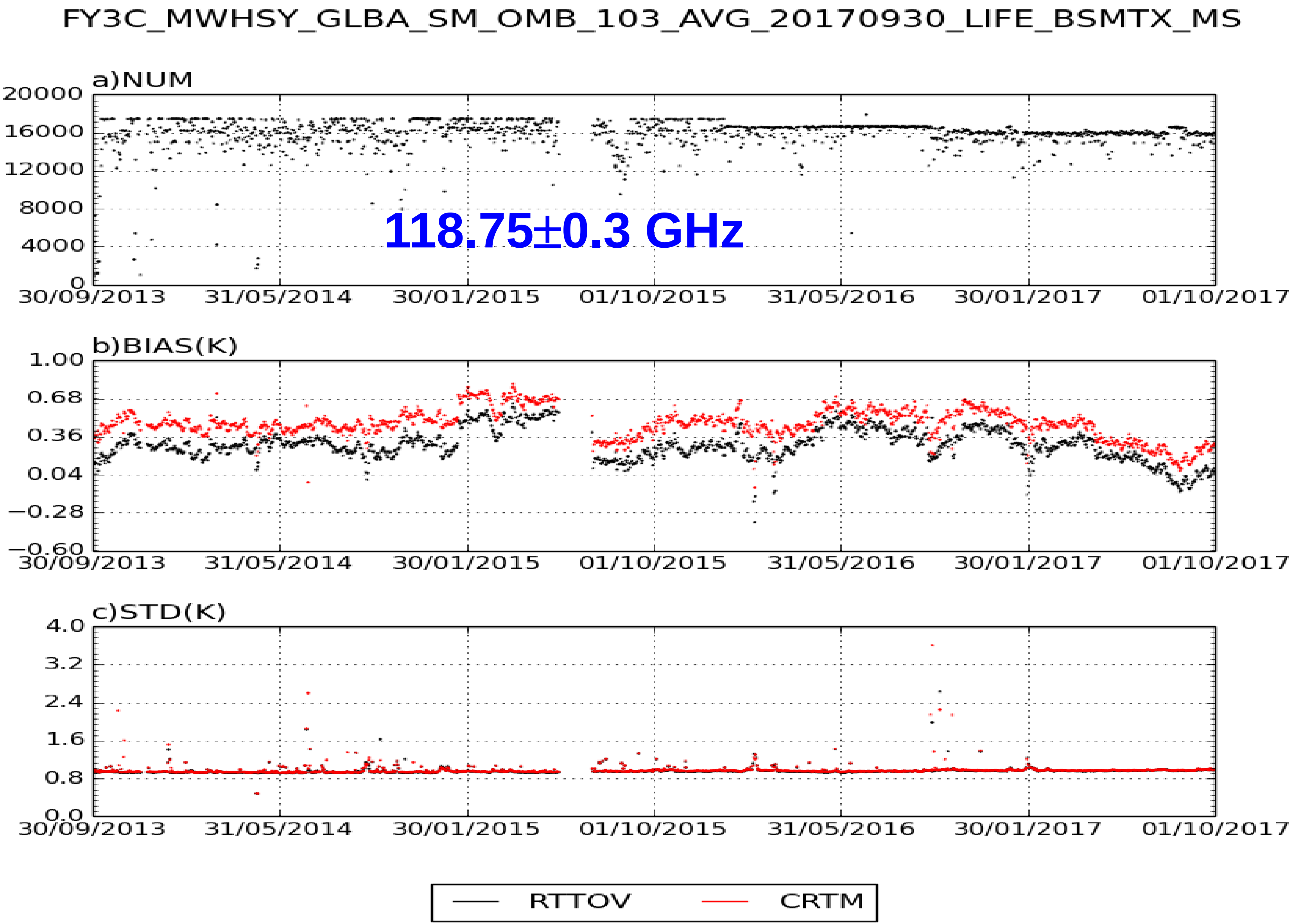


After QC

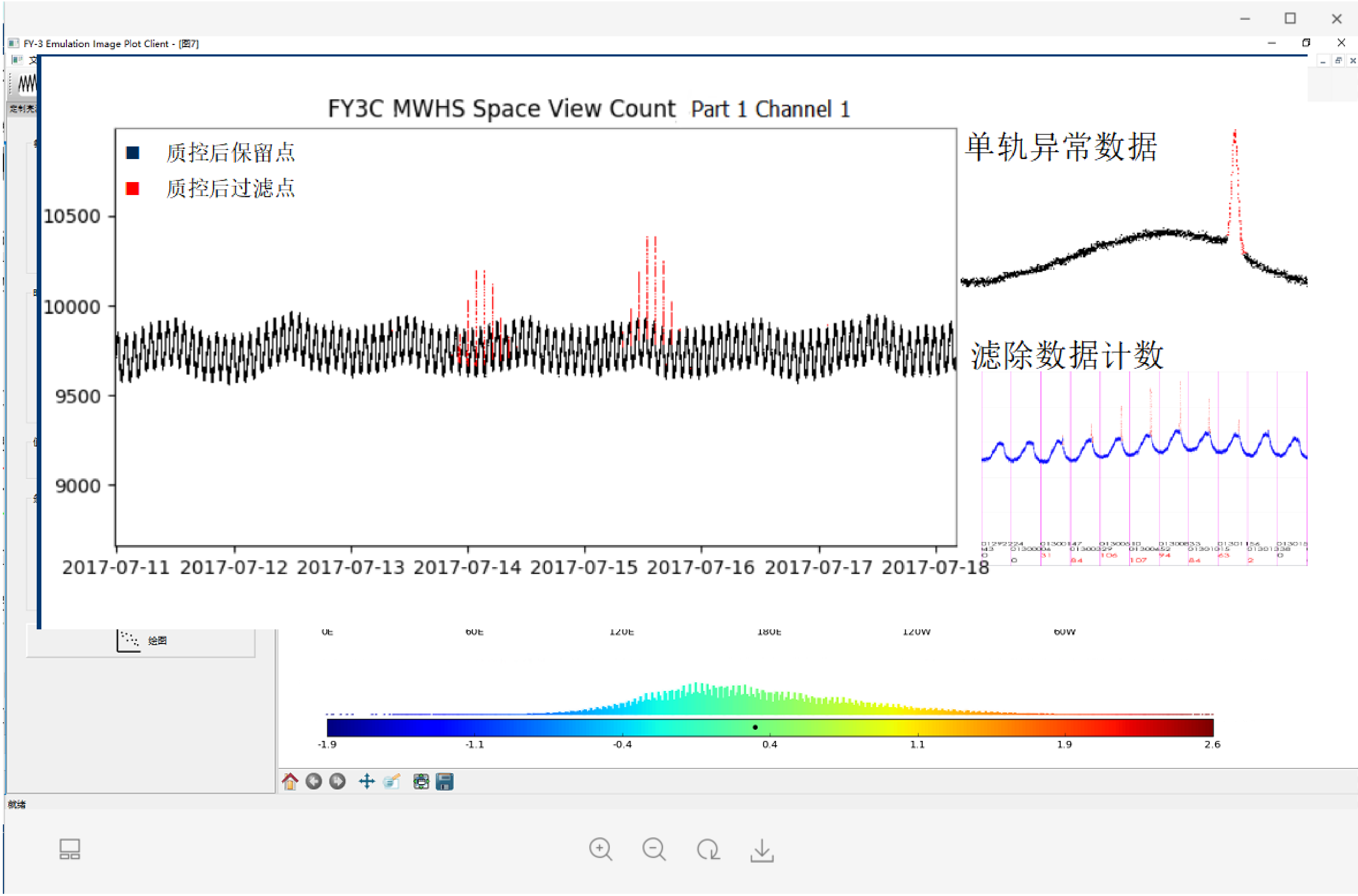
Monitoring OMB against the instrumental parameter to indicate the performance on orbit



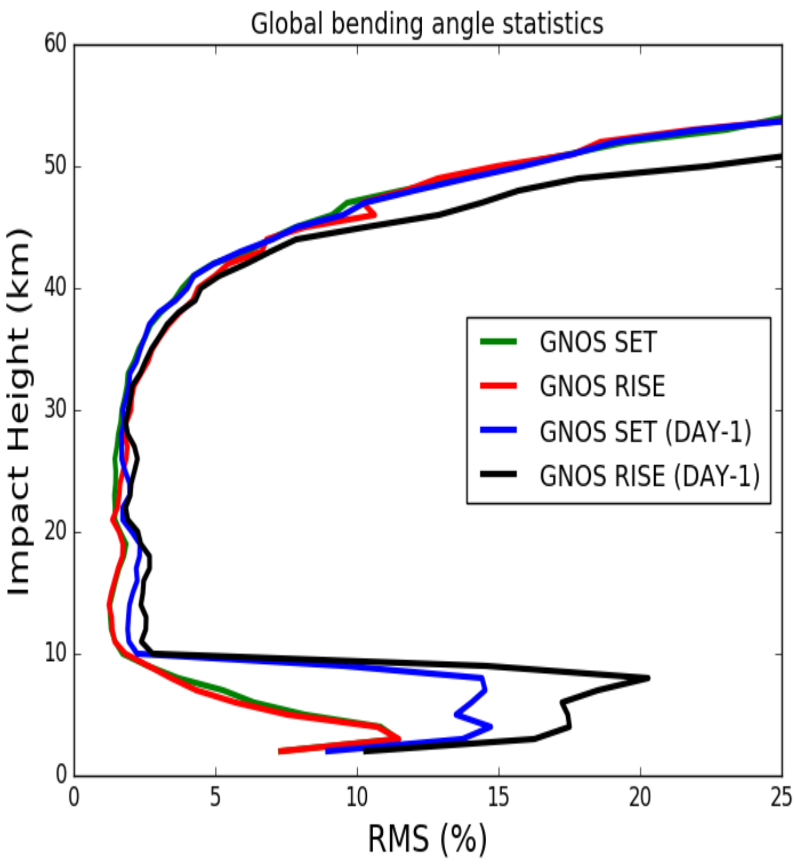
Monitoring OMB against the instrumental parameter to indicate the performance on orbit

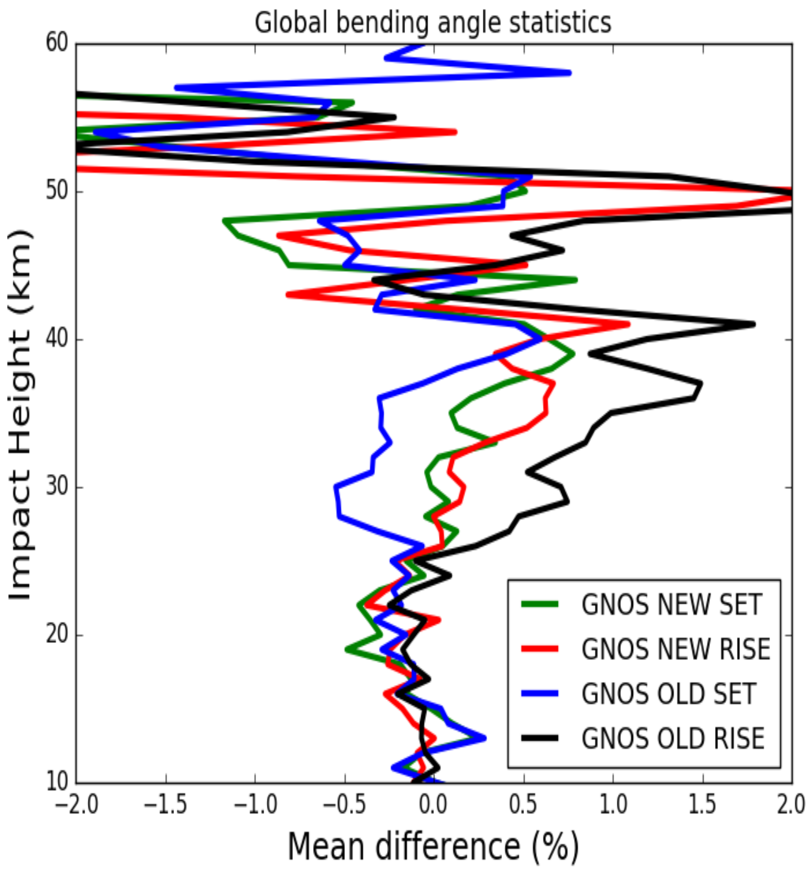


Client Software



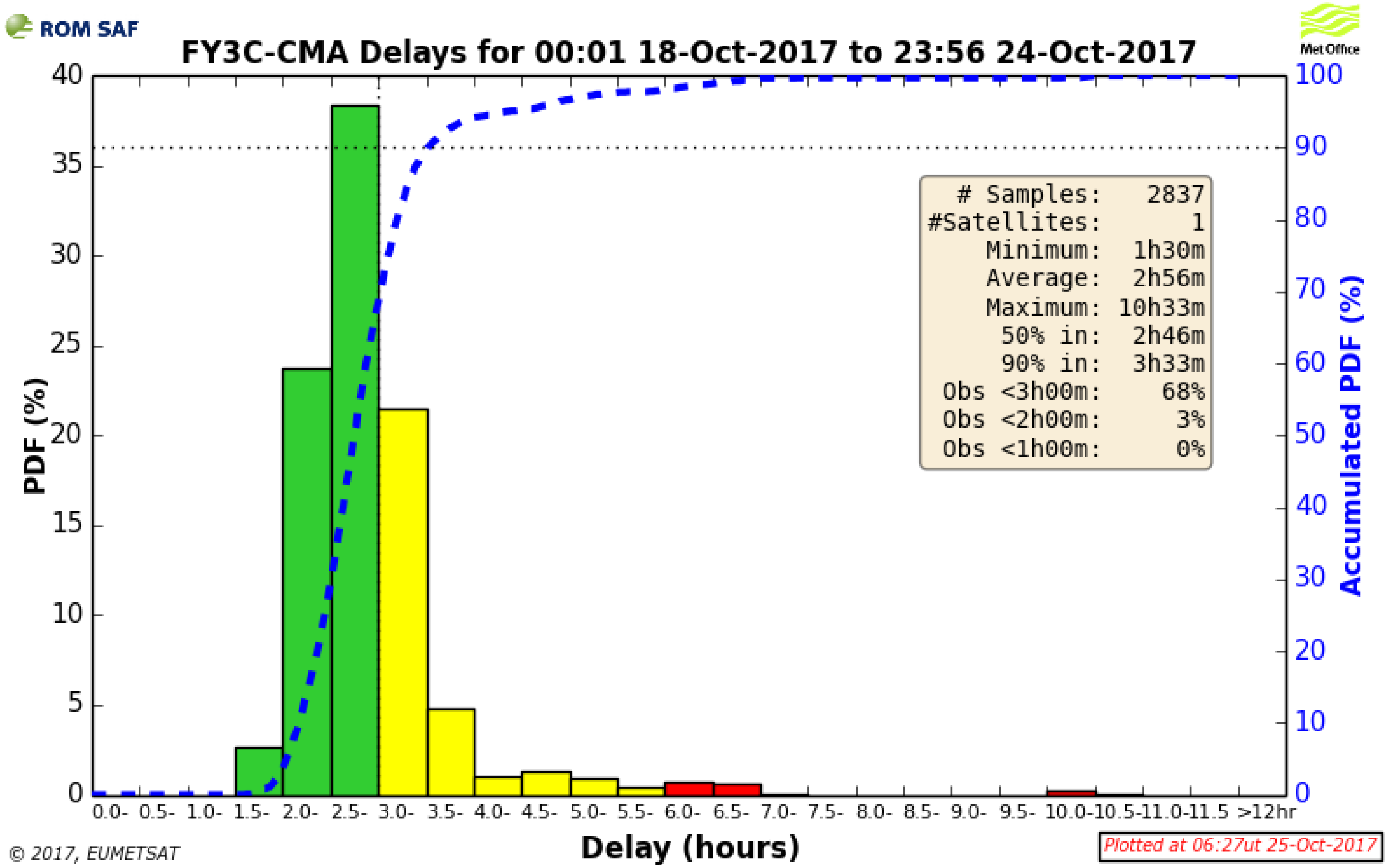
GNOS improvement from Mi Liao and Sean Healy



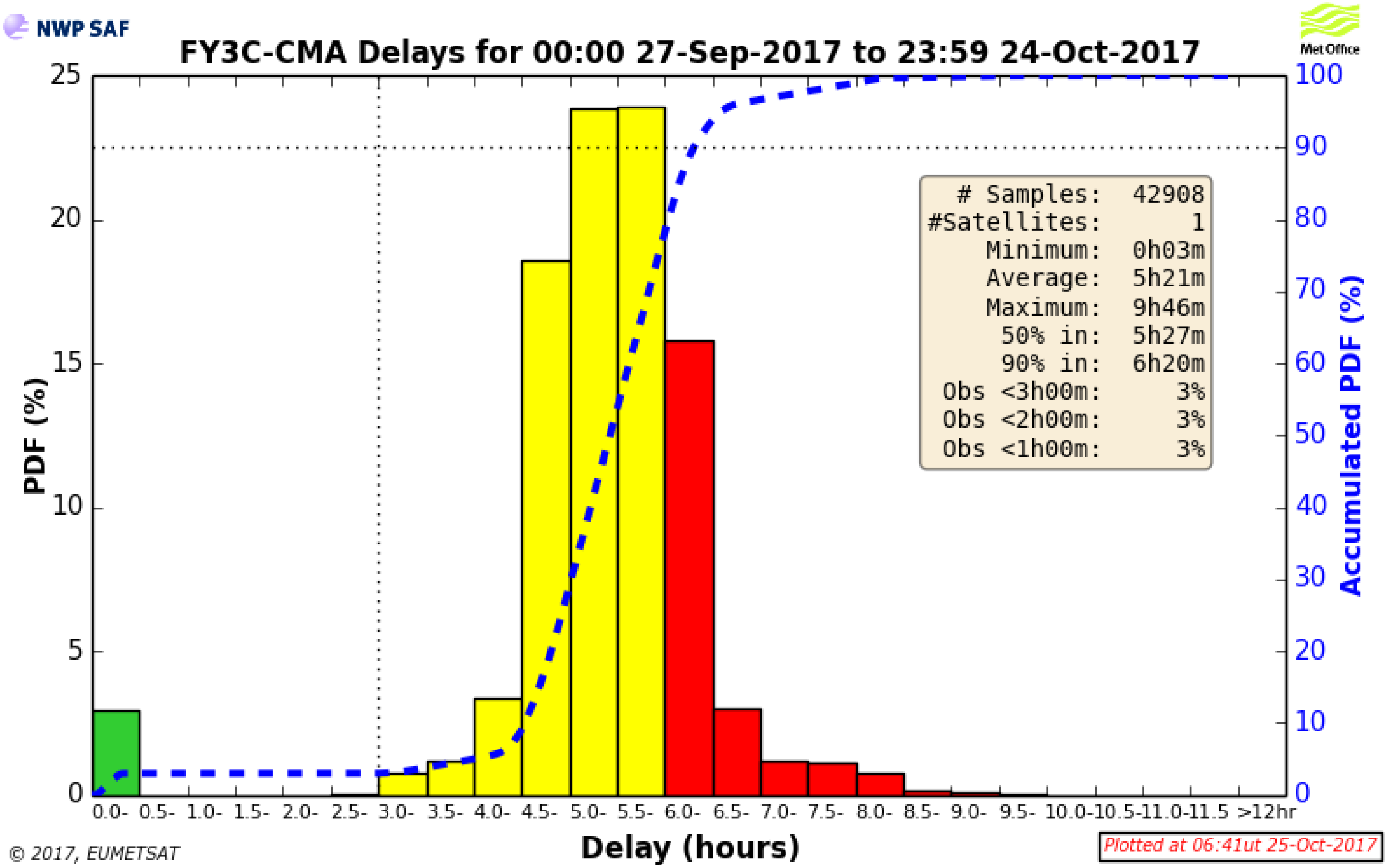


- Monitored passively at ECMWF and being prepared for operational assimilation

FY-3C Latency (GNOS) (from Mikael Rattenborg)



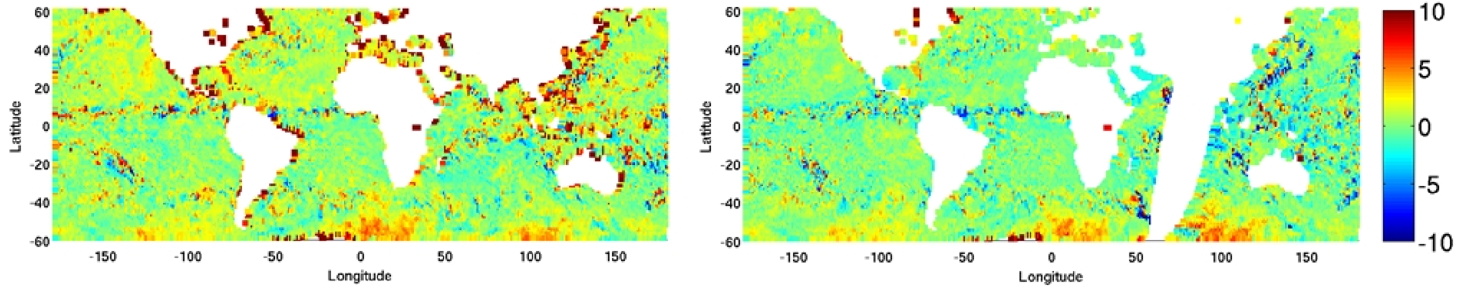
FY-3C Latency (MWHS) (from Mikael Rattenborg)



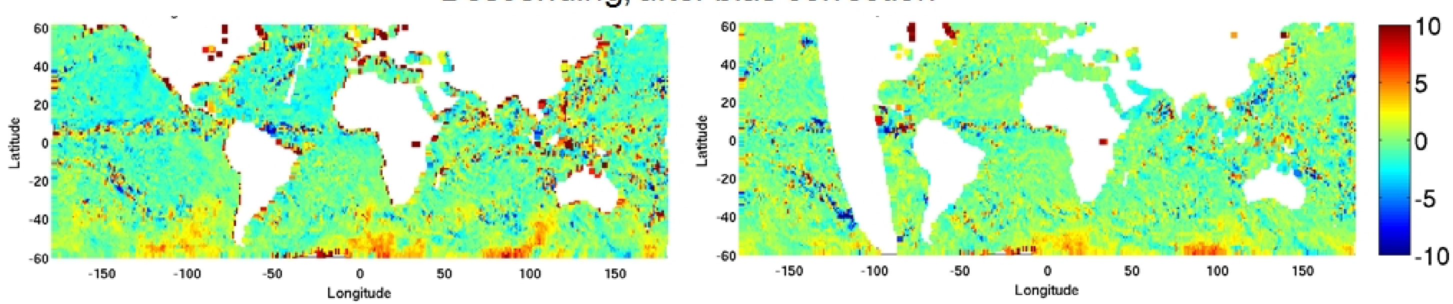
MWRI: Ascending/descending biases

MWRI; 18.7 GHz v | **AMSR-2; 18.7 GHz v**

Ascending, after bias correction

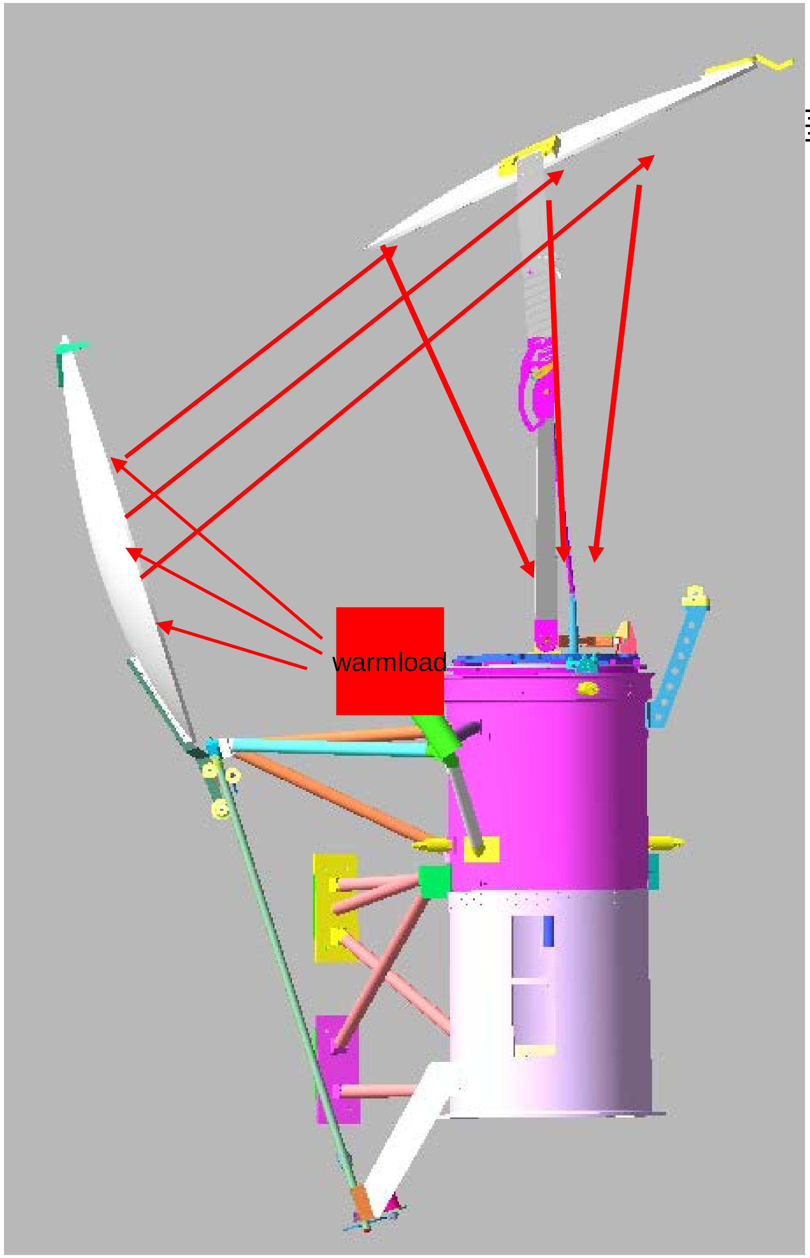


Descending, after bias correction



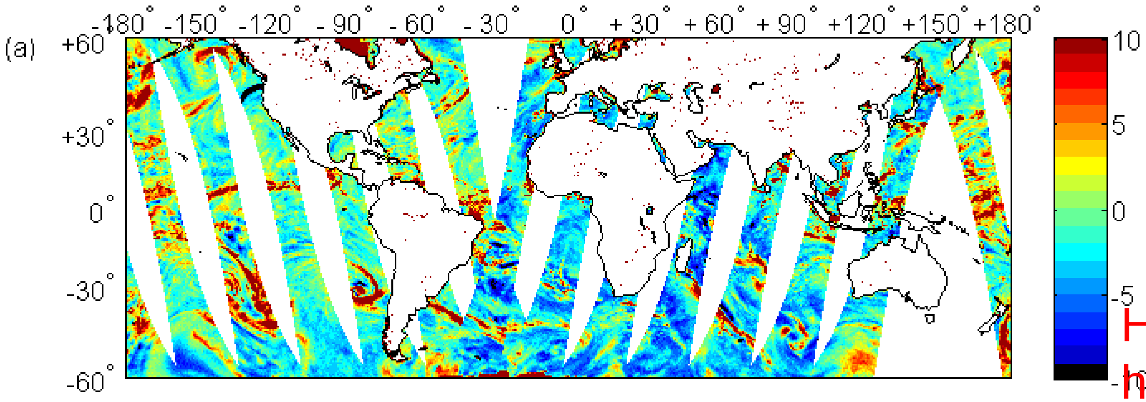
Mean (o-b), 8-12 June 2014

The improvement from MWRI Calibration



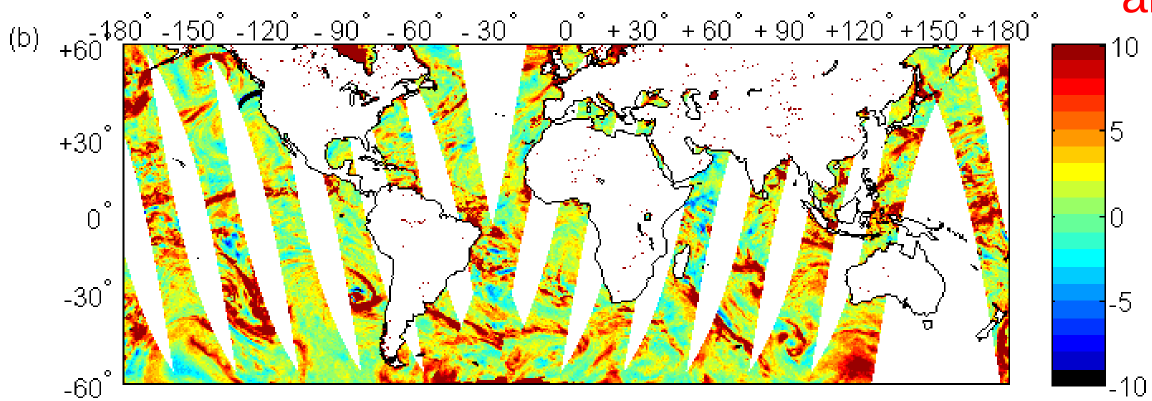
Instrument Characteristics

Frequencies (GHz)	10.65	18.7	23.8	36.5	89
Polarization	V.H.	V.H.	V.H.	V.H.	V.H.
Bandwidth (MHz)	180	200	400	900	3000
Sensitivity (k)	0.5	0.5	0.8	0.5	1.0
Calibration error (k)	1.0	2.0	2.0	2.0	2.0
Dynamic Range (k)	3－340				
Sampls/scan	240				
Main beam efficiency	≥ 90%				
Groun Resolution ≤ (km × km)	51 × 85	30 × 50	27 × 45	18 × 30	9 × 15
Scan mode	Conical scanning				
Orbit width (Km)	1400				
Viewing Angle (°)	45 ± 0.1				
Scan period (s)	1.7 ± 0.1				

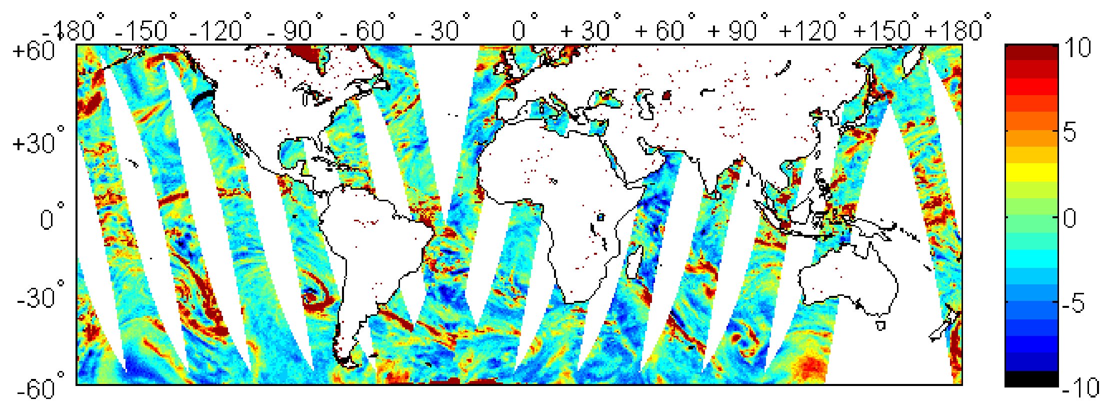


original

High values of antenna emission have been observed from TMI and SSMIS.

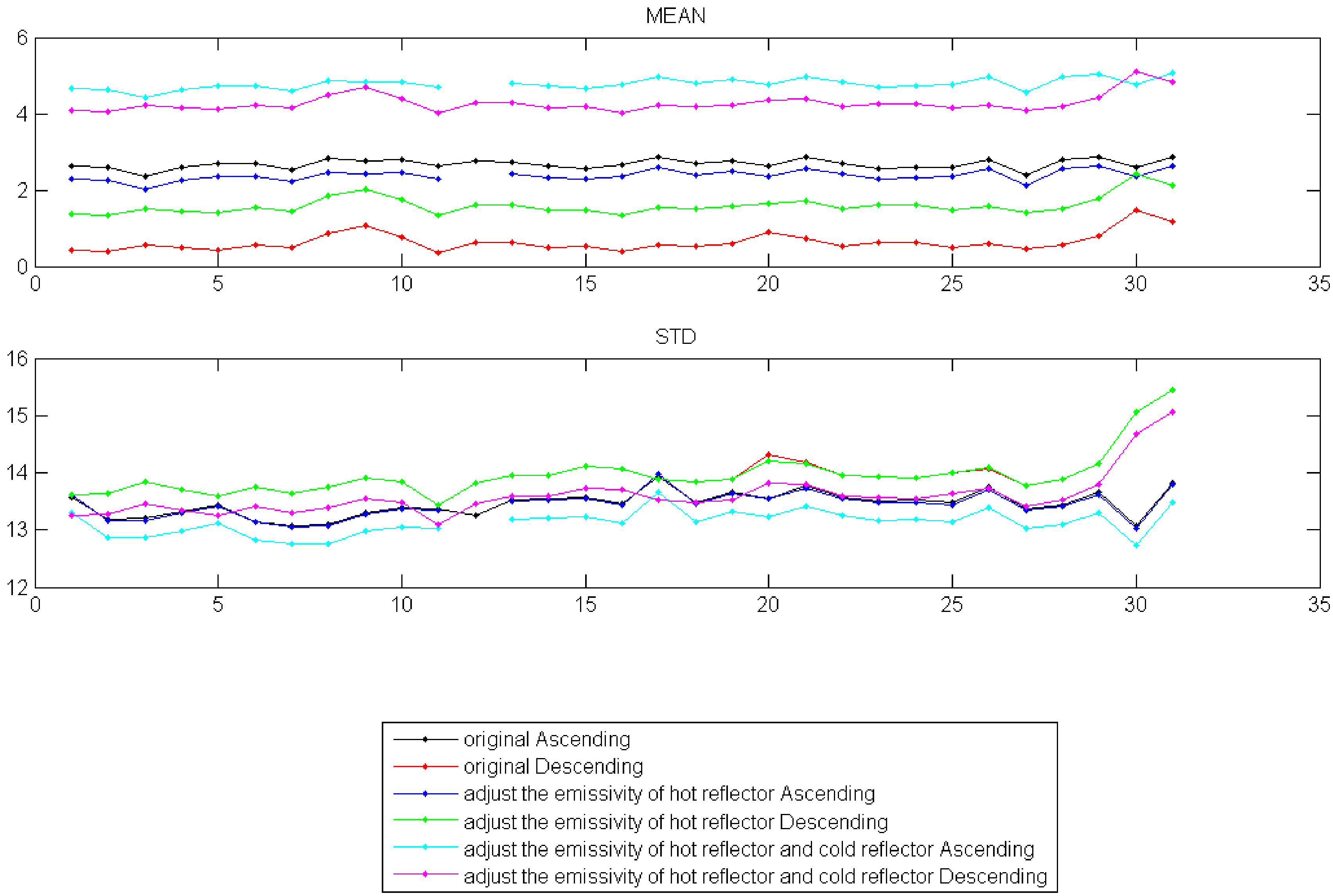


adjust the emissivity of hot reflector and cold reflector



adjust the emissivity of hot reflector

The statistics of OMB



3. The preparation of FY-3D and FY-4A for NWP

Five payloads from FY-3D are of particular interest to NWP community

- **MicroWave Temperature Sounder 2 (MWTS-2)**
- **MicroWave Humidity Sounder 2 (MWHS-2)**
- **High spectral Infrared Atmospheric Sounder (HIRAS)**
- **Global Navigation Satellite System Occultation SoundeR (GNOS);**
- **Microwave Radiation Imager (MWRI)**

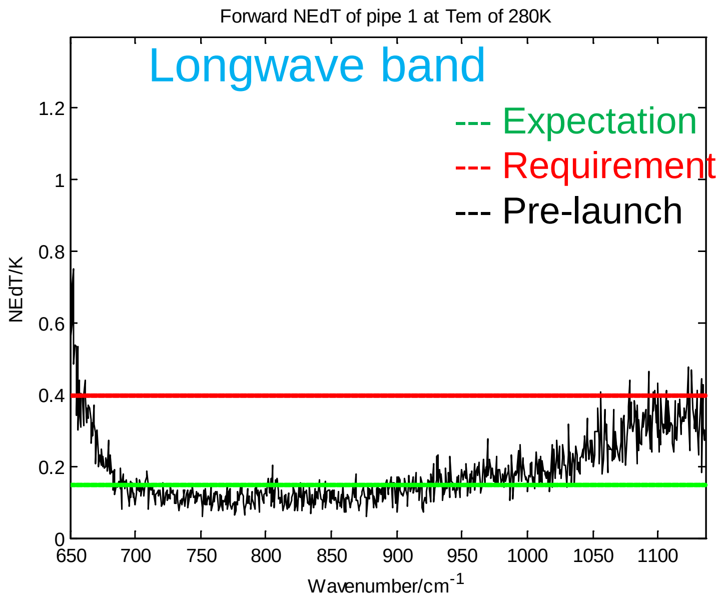
Two payloads from FY-4A are of particular interest to NWP community

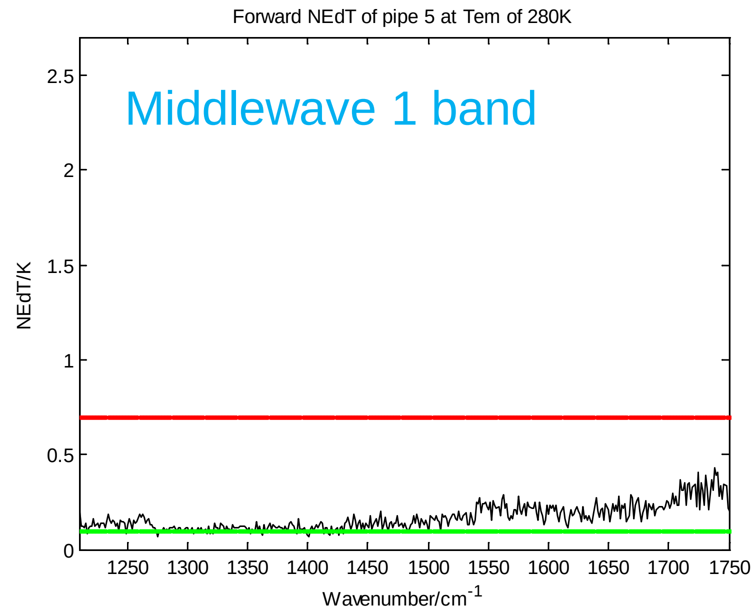
- **Geostationary Interferometric Infrared Sounder (GIIRS)**
- **Advanced Geosynchronous Radiation Imager (AGRI)**

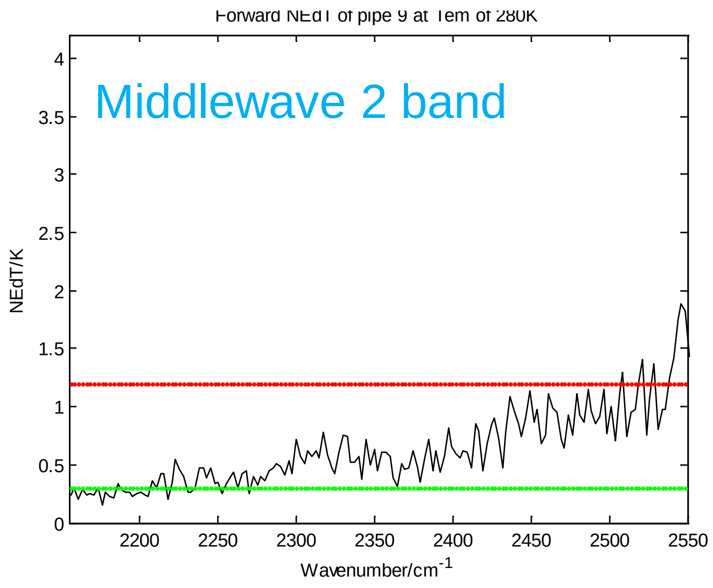
HIRAS instrument specification improvement from FY-3D to FY-3E

Band	Spectral Range (cm^{-1})	Spectral Resolution (cm^{-1})	Sensitivity (NEΔT@280K)			Num of Channels
			FY-3D	FY-3E		
LWIR	650～1136 （15.38μm～8.8 μm）	0.625	0.15(Expectation) 0.4K(Requirement)	650 ～667 cm^{-1}	0.8K	778
				667～689 cm^{-1}	0.4K	
				689～1000 cm^{-1}	0.2K	
				1000～1136 cm^{-1}	0.4K	
MWIR1	1210～1750 （8.26μm～5.71 μm）	1.25	0.1(Expectation) 0.7K(Requirement)	1210～1538 cm^{-1}	0.2K	433
				1538～1750 cm^{-1}	0.3K	
MWIR2	2155～2550 （4.64μm～3.92 μm）	2.5	0.3(Expectation) 1.2K(Requirement)	2155～2300 cm^{-1}	0.3	159
				2300～2550 cm^{-1}	0.5	

FY-3D/HIRAS TVAC





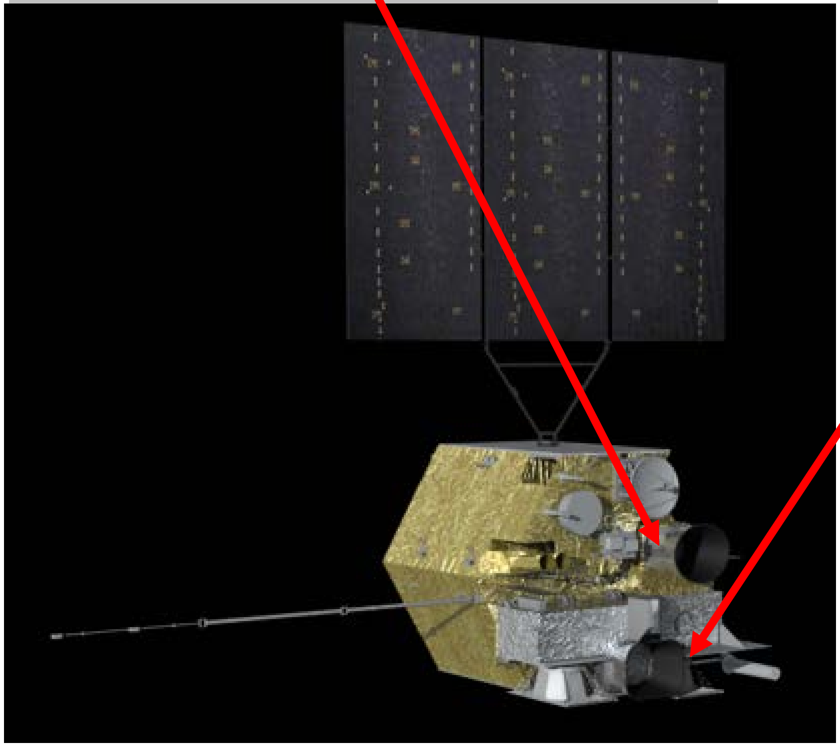


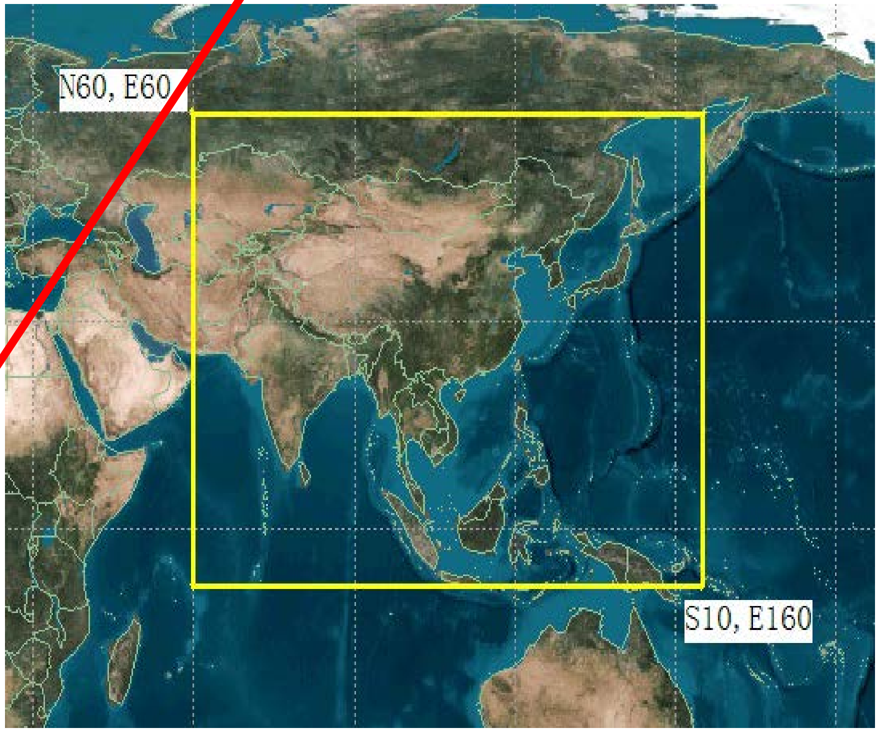
FY-3D /HIRAS instrument NEdT
MW1 : All channels meet NEdT specification
LW&MW2: Most of channels meet NEdT specification except few of edge channels

The FY-4A Instrument Suites for NWP

Geo. Interferometric Infrared Sounder(GIIRS)(1650channels) by the Shanghai Institute of Technical Physics of the Chinese Academy of Sciences

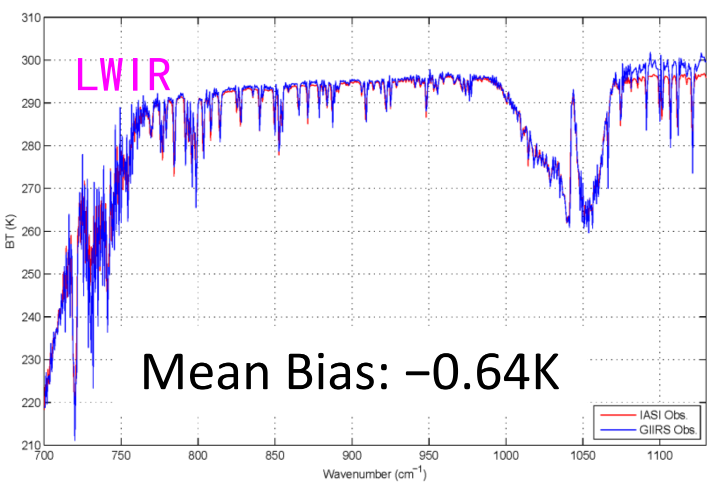
Advanced Geostationary Radiation Imager (AGRI))(16channels)

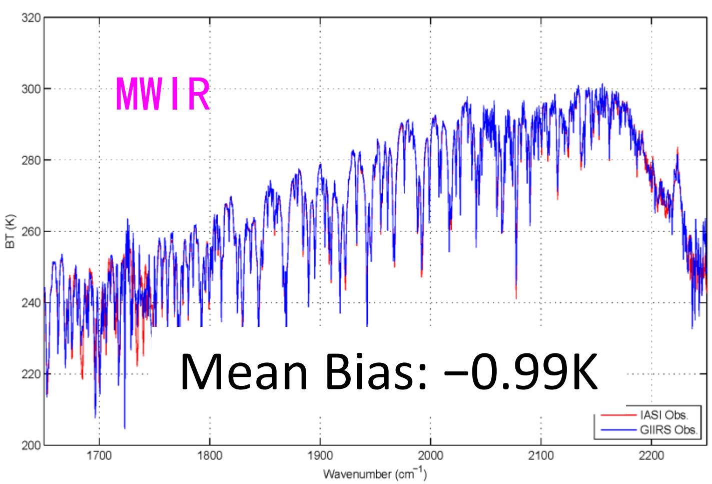




The initial evaluation results of GIIRS

- The on-orbit spectral resolution for LWIR and MWIR are 0.625cm^{-1} , better than the specified (0.8/1.6 cm^{-1}) , similar to NPP/CrIS;
- The NEDT for all the 1650 channels except some contaminated channels, generally is less than 0.1K, consistent with the specified;
- The comparisons of LWIR and MWIR with the counterpart channels from METOP-A/IASI shows that the calibration difference is about 0.64K and 0.99K separately, spectral difference is about 8ppm.

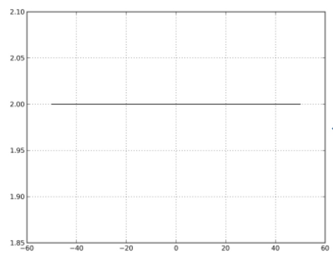




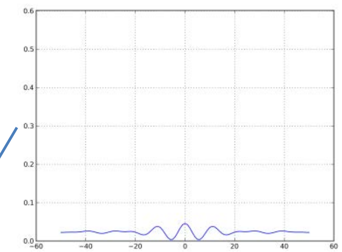
Spectrum Comparison with METOP/IASI

What we are doing for the interferometer

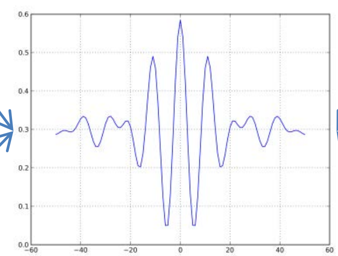
Generally, there are 4 components of energy received by the detector



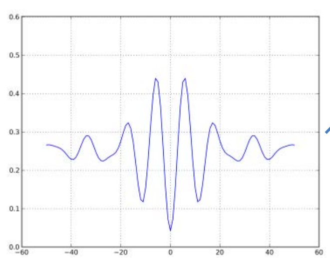
Instrument emission without interfere



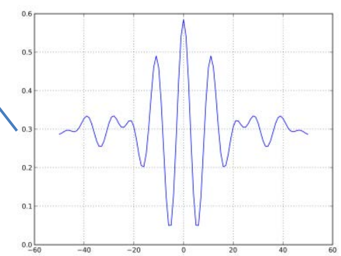
Beam splitter emission after interfere



Final energy received by the detector



Instrument emission after interfere



Earth scene radiance after interfere

Items affecting calibration precision

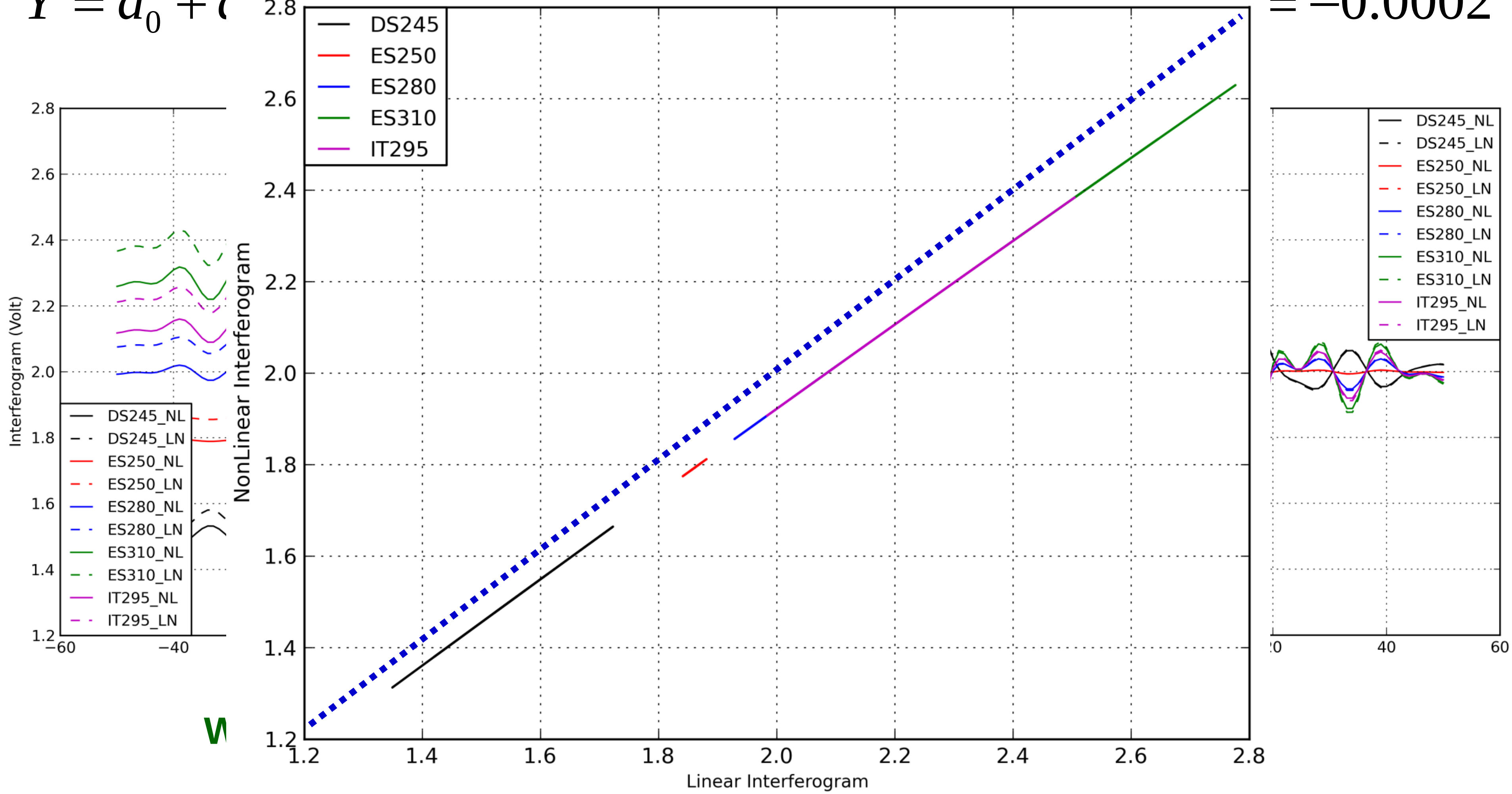
Modules that have been or will be incorporated in the ground segment algorithms:

- Interferogram alignment
- Non-linearity correction
- Self apodization correction
- Different calibration equation
- Doppler shift correction
- Polarization correction --- not been incorporated yet

The nonlinear simulation of interferometer

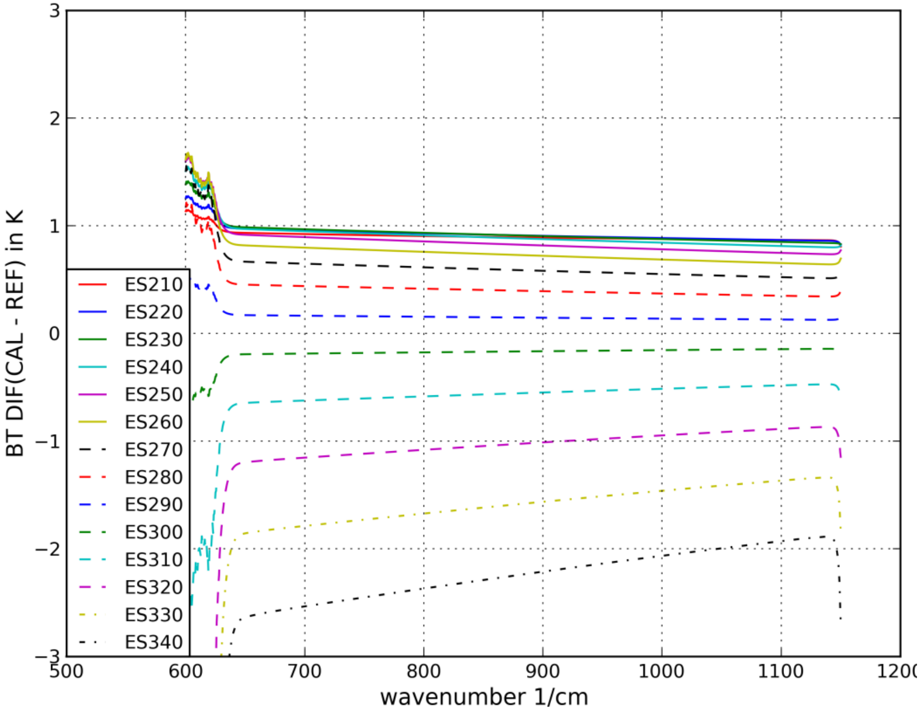
1.*Polynomial* :

$$Y = a_0 + \ldots = -0.0002$$

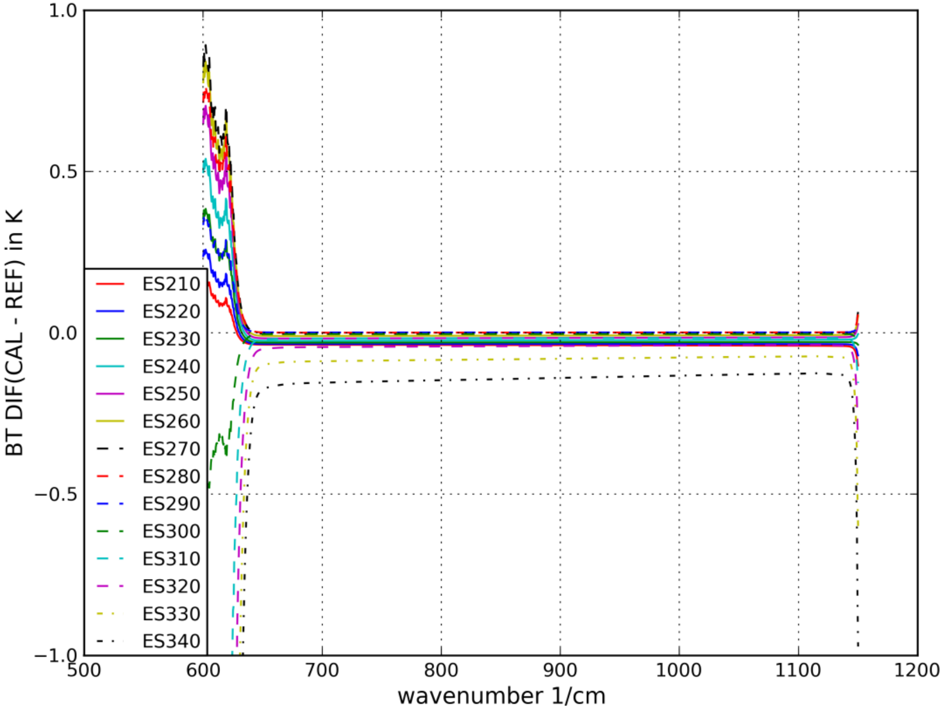


Effect of Nonlinear Correction, simulation

Before Correction



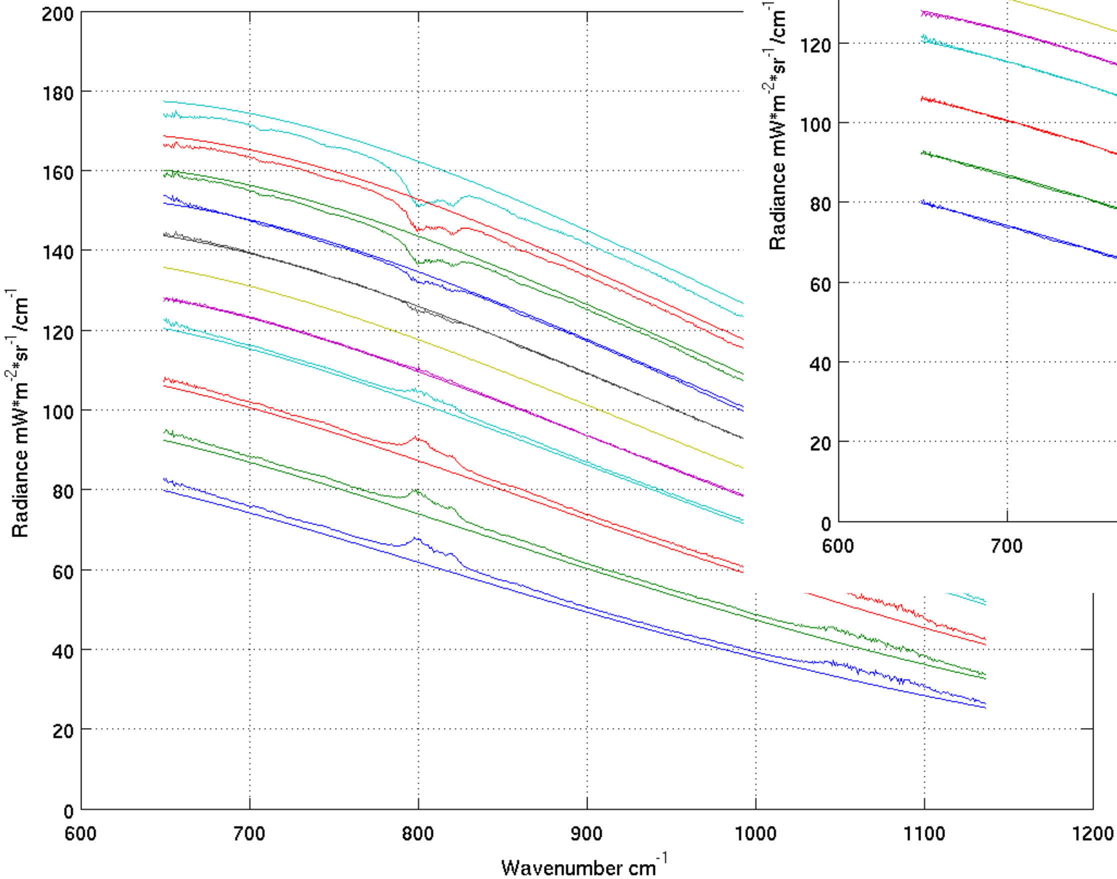
After Correction

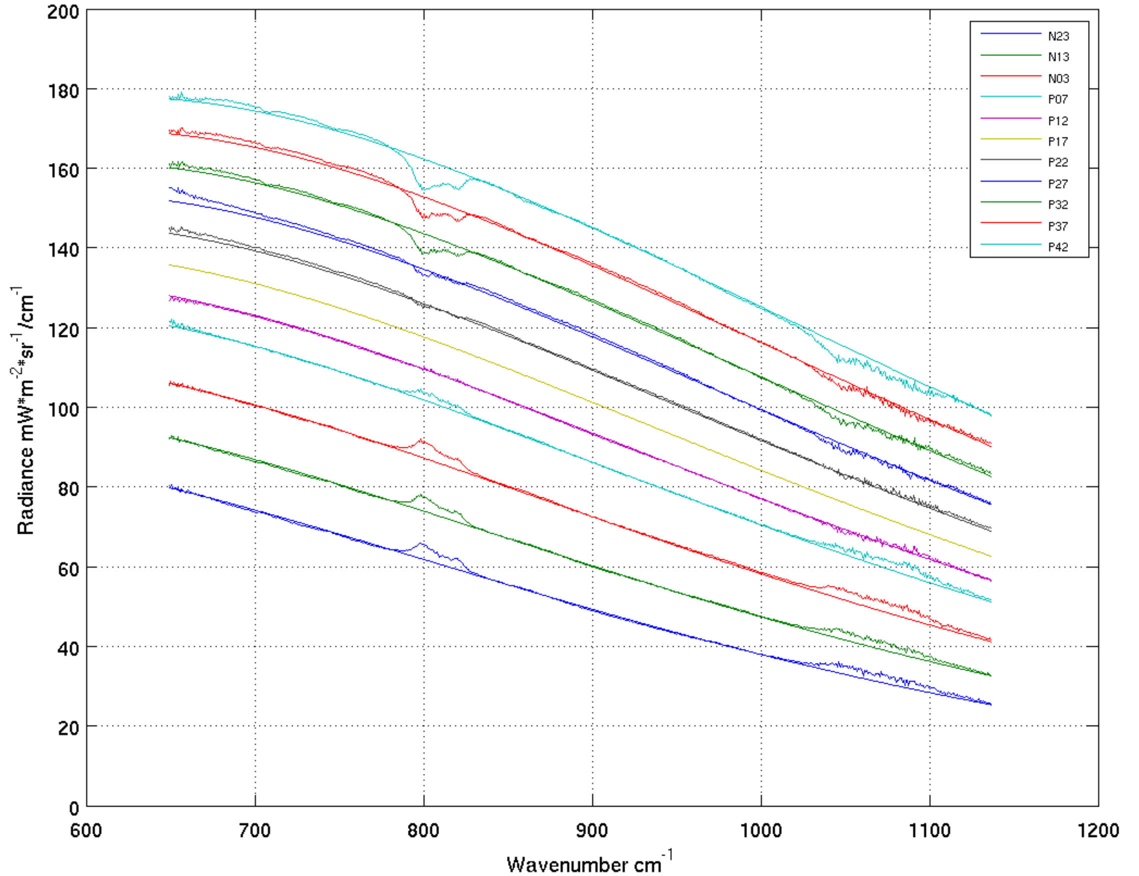


Polynomial

Effect of Nonlinear Correction, TVAC

FOV1
Before correction

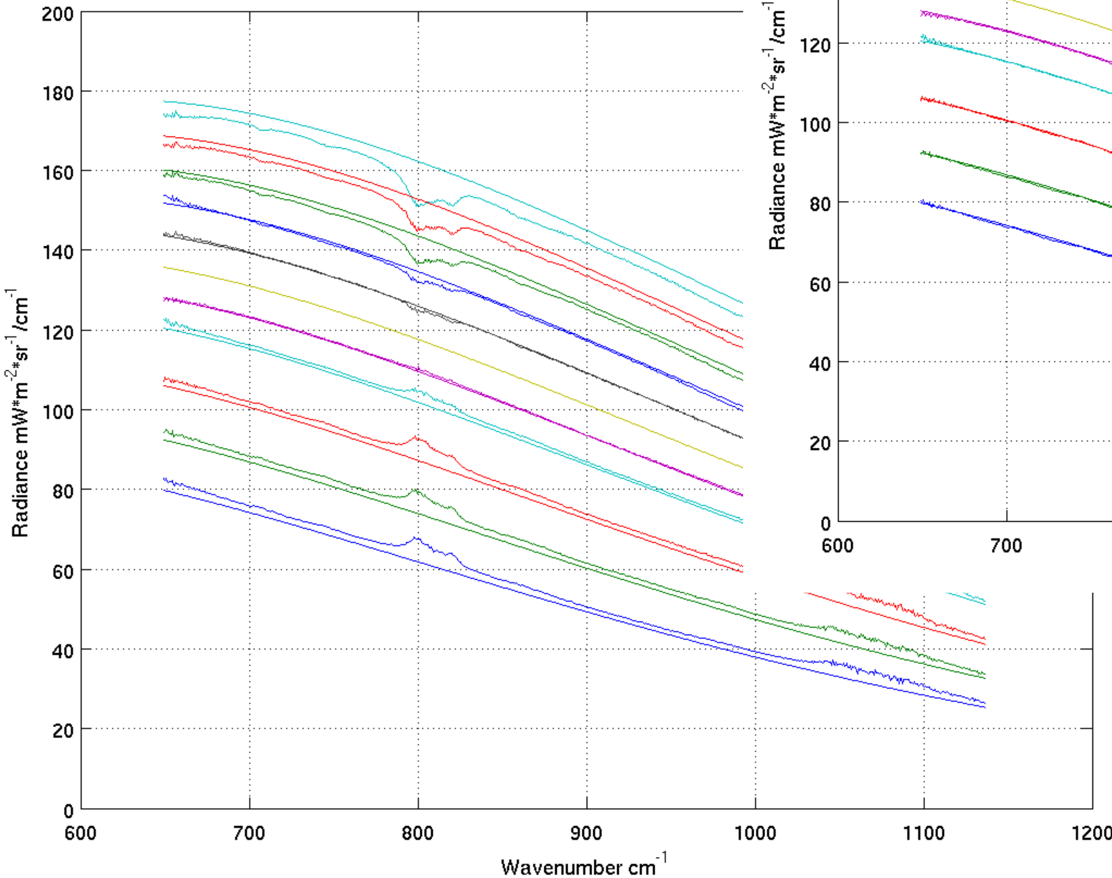


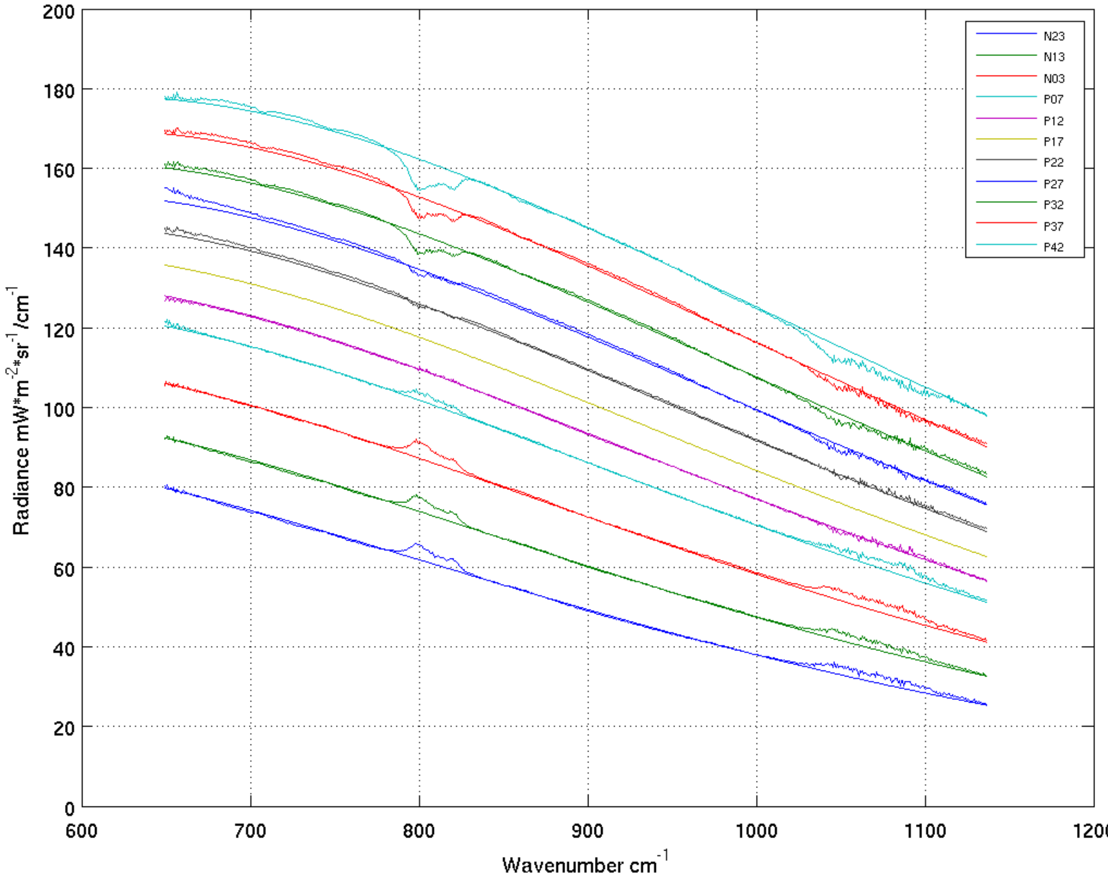


FOV1
After Correction

Effect of Nonlinear Correction, TVAC

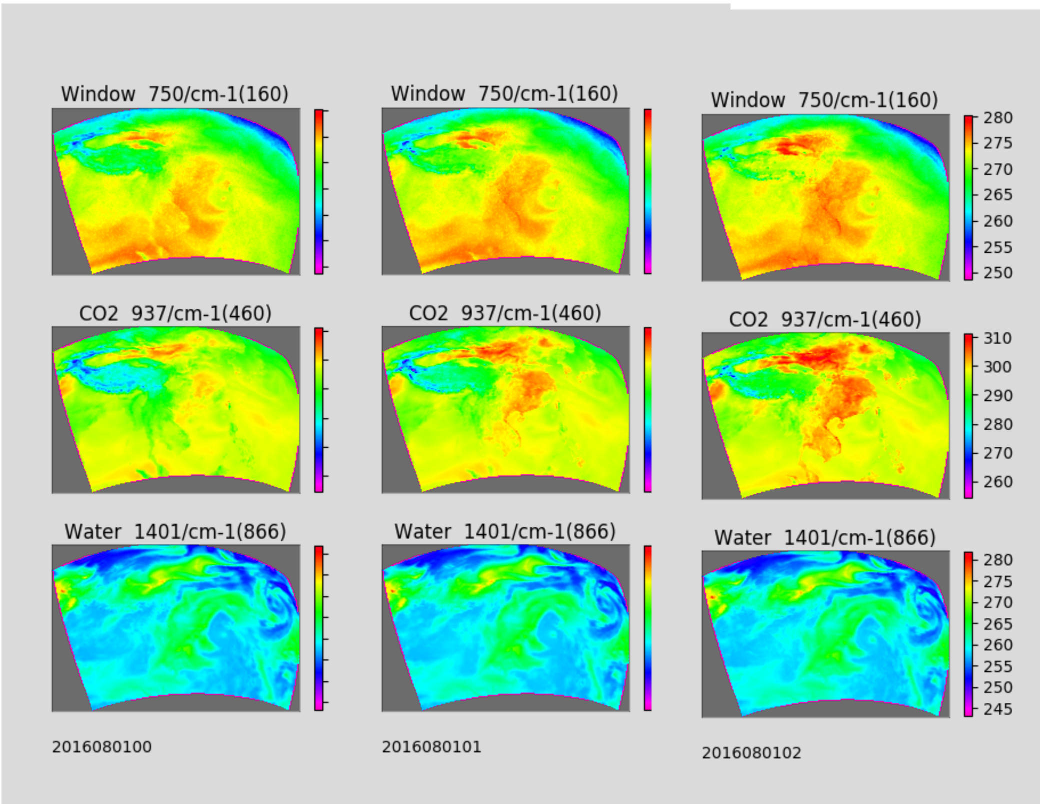
FOV1
Before correction

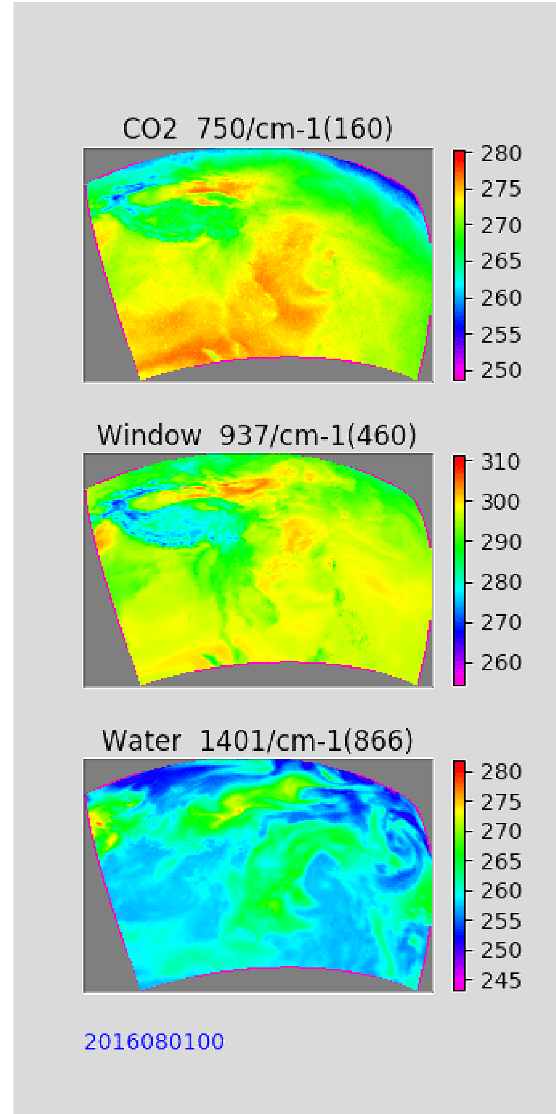




FOV1
After Correction

Simulation of the GIIRS





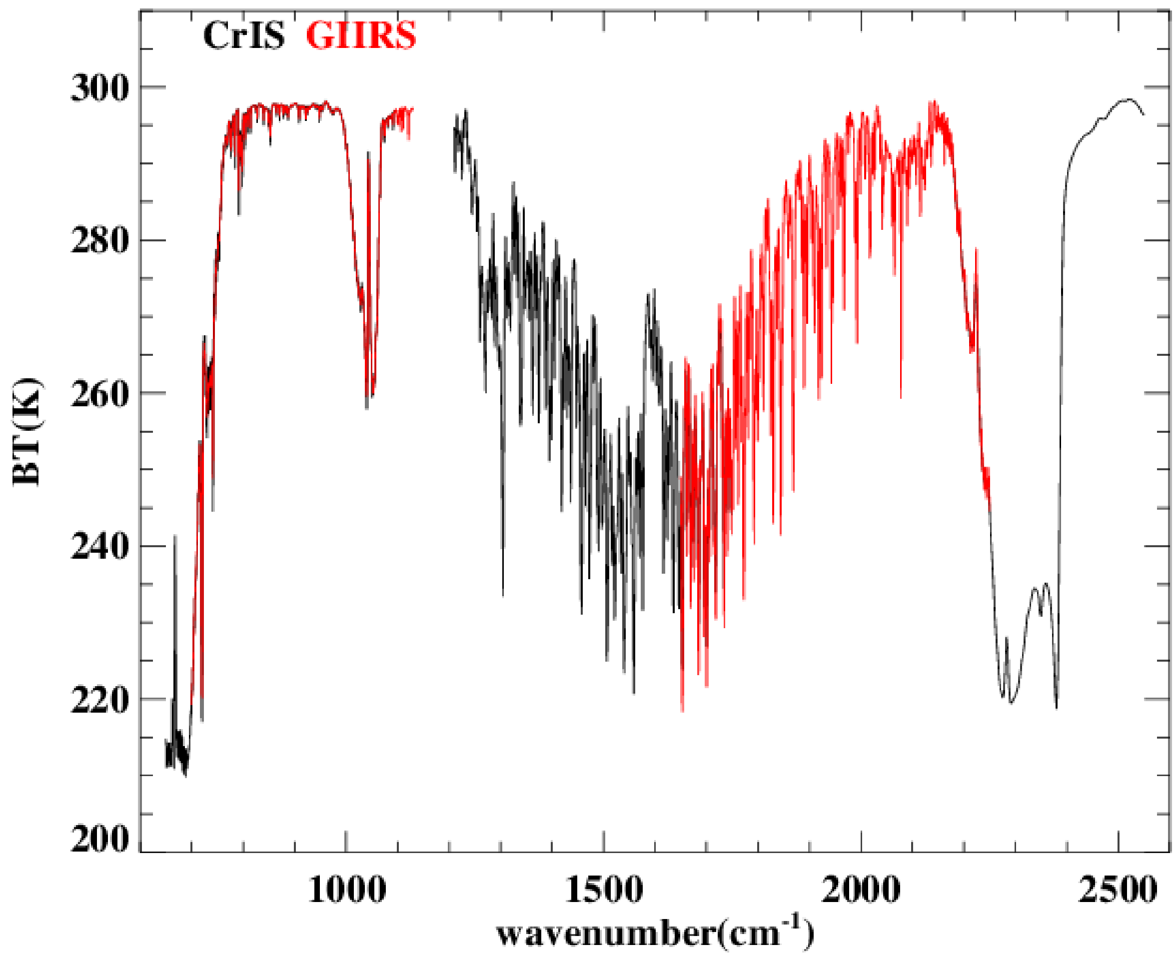
RTM：RTTOV

NWP field：WRF

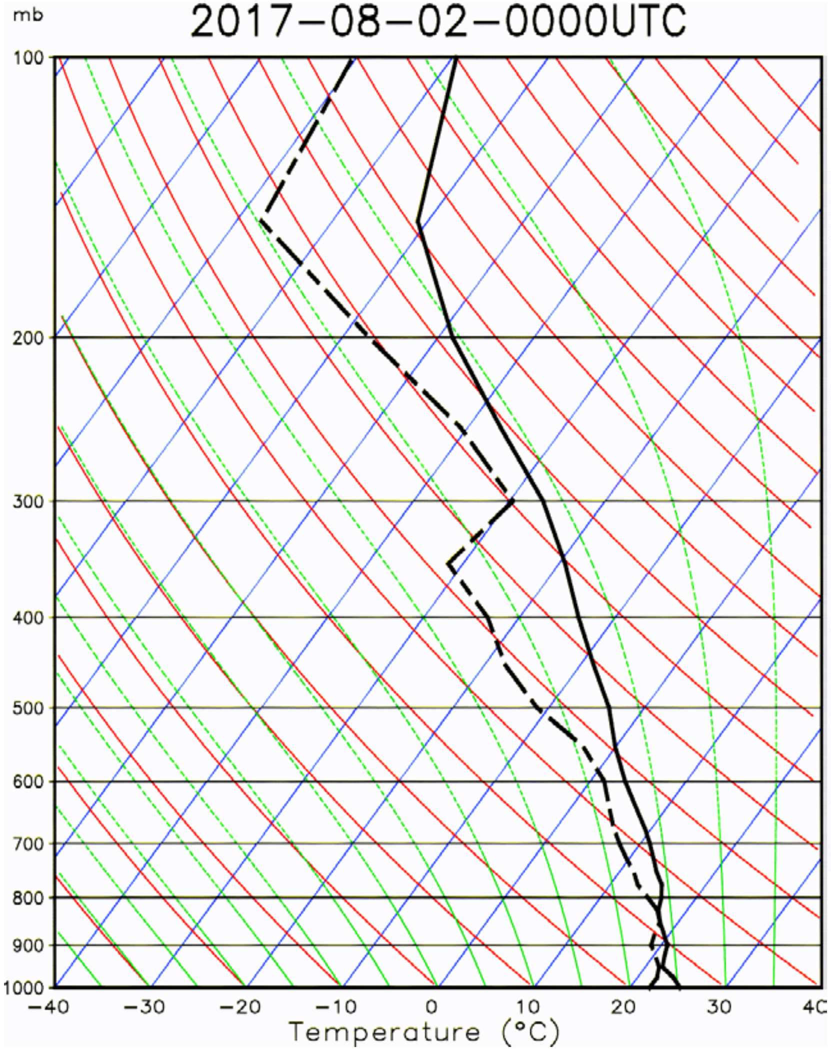
date：20160801~20160823

Simulation of the GIIRS

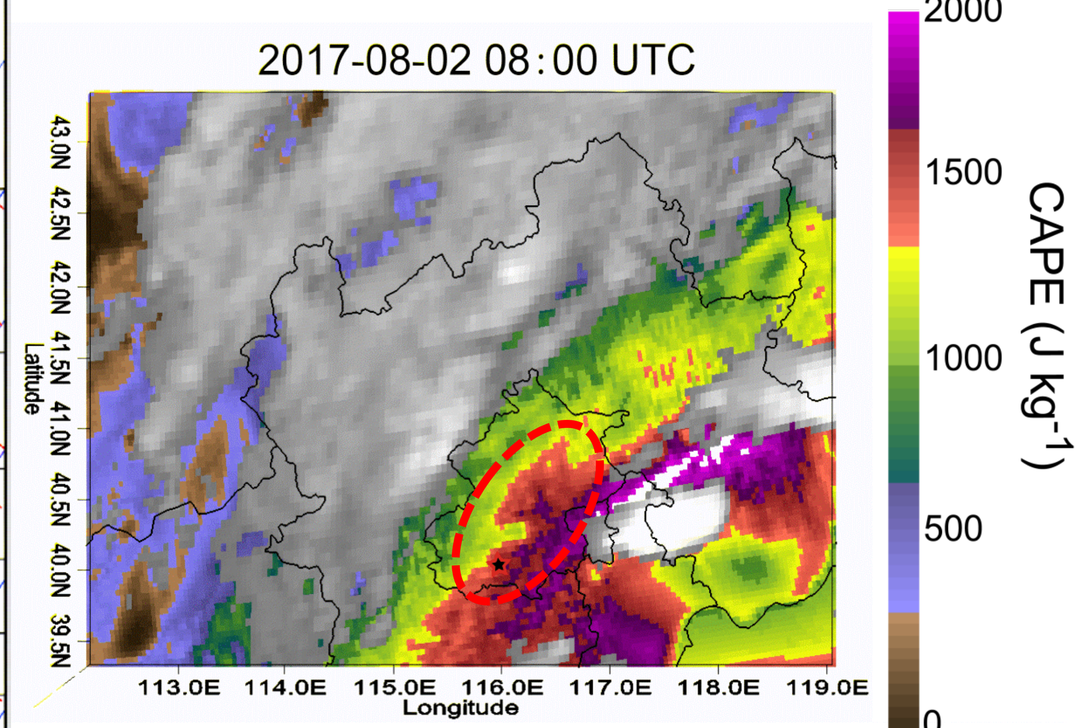
The comparison of CRIS and GIIRS



With LMI+AGRI+GIIRS, what can we see?



Skew T-lnP diagram over Fangshan, Beijing during 00:00 UTC-12:00 UTC (08:00-20:00 LST) 02 Aug 2017



Convective Available Potential Energy (CAPE) map during 00:00 UTC-12:00 UTC (08:00-20:00 LST) 02 Aug 2017 (grey to white areas represent cloud observed by FengYun-4 satellite; the asterisk denotes the location of Fangshan of Beijing)

OSSE: Preparing FY-3D and FY-4A for NWP

Improve the data precision and stability

- **Monitor the OMB and instrumental parameters to indicate the data quality**
- **Characterize the instrumental biases**
- **Control the data quality**

Support the earlier preparation of data assimilation

- **Generate the initial coefs of the fast radiative transfer modeling for NWP data assimilation**
- **Simulate the sample data by RTM**
- **Release the sample data to cooperative users (after the agreed coordination of CMA and WMO)**
- **Prepare the assimilation in NWP model**

Optimize the performance

- **Evaluate/improve the data quality and its impact on NWP model**