RetrospectIve Calibration of Historical Chinese FengYun Satellite Data (RICH-FY)

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National Satellite Meteorological Center

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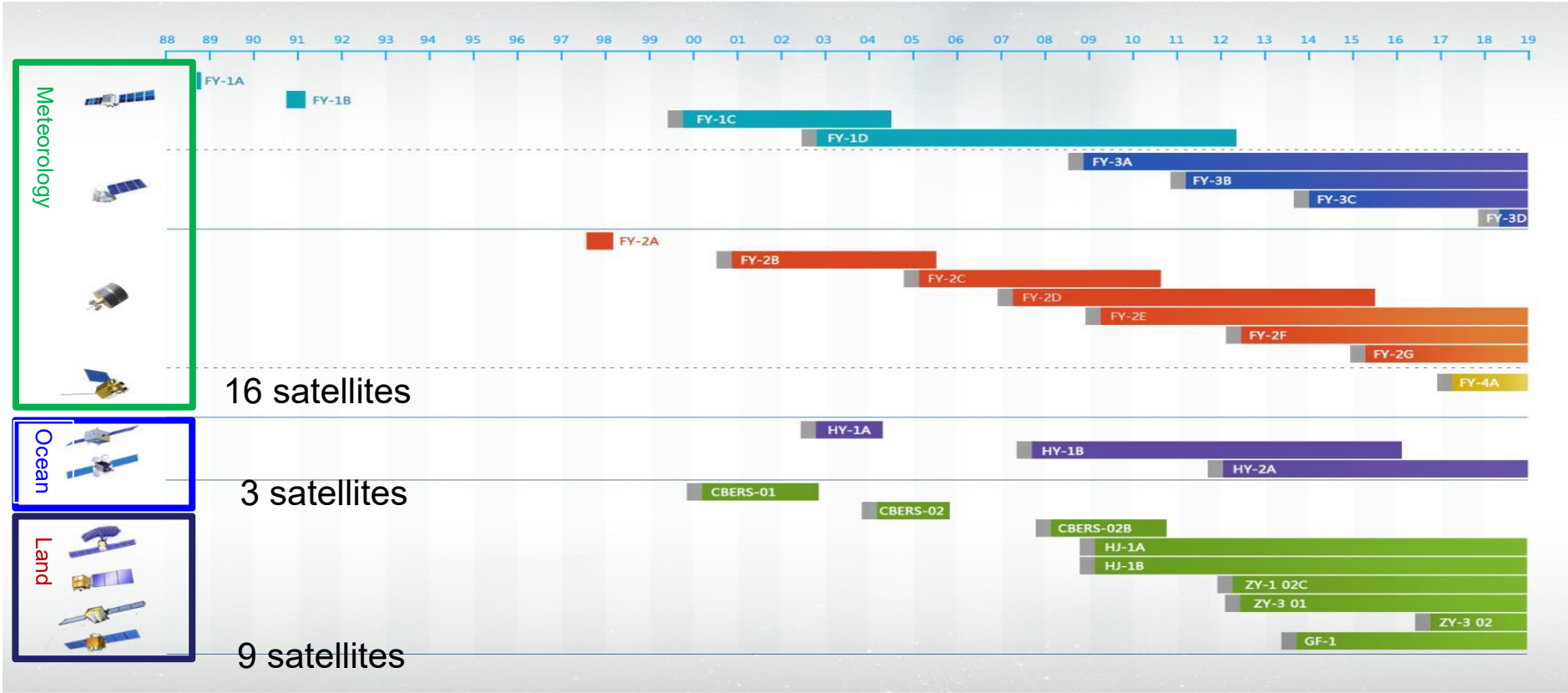
Outline

- Project Background
- Problem and Solution
- Latest Progress
- Some Demonstrations
- Summarization

1. Project Background

30 years' Chinese historical Satellite data (2018-2022)

Amount √ **Quality ?**



RetrospectIve Calibration of Historical Chinese Eerth Observation Satellite Data (RICH-CEOS)

中华人民共和国科学技术部
Ministry of Science and Technology (MoST)

National Key R&D Program of China
Founded since 2018

18 Institutions Involved

RICH-FY： Chinese Meteorological Satellites

RICH-ZY： Chinese Land Resources Satellites

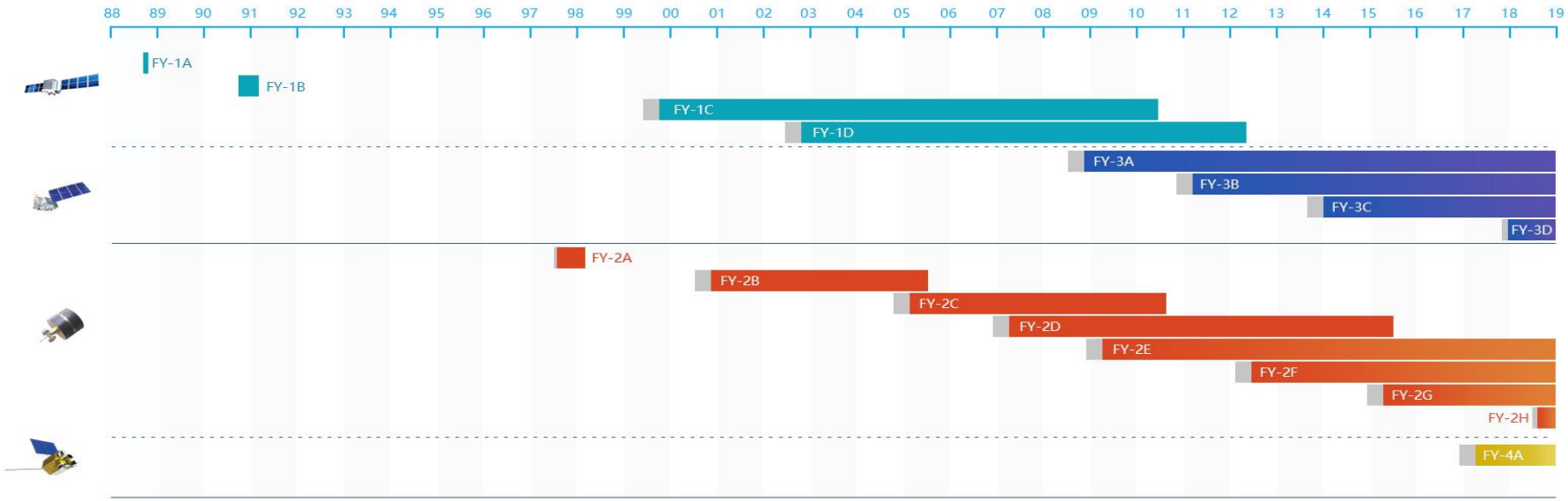
RICH-HY： Chinese Marine Satellites

- National Satellite Meteorological Centre (NSMC)
- National Satellite Ocean Application Center (NSOAC)
- China Center for Resources Satellite Date and Application (CRESDA)

FY: 13 satellites and 7 instruments

Satellite	Instrument	Wavelength	Total Channel No.	Spatial Resolution	Lifetime
FY-1A	VIRR	0.48 – 12.5 μm	5	1.1 km	1988.9.8（1988.9.7） – 1988.10.17（1988.10.17）
FY-1B	VIRR	0.48 – 12.5 μm	5	1.1 km	1990.9.3 （1990.9.3） – 1991.2.15（1991.2.15）
FY-1C	VIRR	0.43 – 12.5 μm	10	1.1 km	1999.5.10（1999.5.10） – 2004.4.26（2004.4.26）
FY-1D	VIRR	0.43 – 12.5 μm	10	1.1 km	2002.5.15（2002.5.15） – 2012.4.1（2012.4.1）
FY-2A	VISSR	0.5 – 12.5 μm	3	1.25 km, 5 km	1997.6.10（1997.6.10） – 1998.2.12（1998.2.12）
FY-2B	VISSR	0.5 – 12.5 μm	3	1.25 km, 5 km	2000.7.19（2000.6.25） – 2005.6.2（2005.6.2）
FY-2C	VISSR	0.5 – 12.5 μm	5	1.25 km, 5 km	2004.10.27（2004.10.19） – 2010.8.2（2010.8.2）
FY-2D	VISSR	0.5 – 12.5 μm	5	1.25 km, 5 km	2006.12.19（2006.12.8） – 2015.6.30（2015.6.30）
FY-2E	VISSR	0.5 – 12.5 μm	5	1.25 km, 5 km	2009.2.17（2008.12.23） – 今
FY-2G	VISSR	0.5 – 12.5 μm	5	1.25 km, 5 km	2015.6.3（2014.12.31） – 今
FY-3A	VIRR 2	0.43 – 12.5 μm	10	1.1 km	2008.5.29（2008.5.27） – 2018.3.6（2018.3.6）
	MERSI 1	0.41 – 11.25 μm	20	250 m, 1 km	2008.6.2（2008.5.27） – 2018.2.11（2018.3.6）
	IRAS	0.69 – 1.64 μm & 3.76 – 14.95 μm	26	17 km	2008.6.26（2008.5.27） – 2016.8.13（2018.3.6）
	MWTS 1	50 – 57 GHz	4	50 – 60 km	2008.6.8（2008.5.27） – 2013.5.6（2018.3.6）
	MWHS 1	150 GHz, 183 GHz	5	15 km	2008.5.31（2008.5.27） – 2016.8.13（2018.3.6）
	MWRI	10 – 89 GHz	10	12 – 75 km	2008.6.6（2008.5.27） – 2010.5.18（2018.3.6）
FY-3B	VIRR 2	0.43 – 12.5 μm	10	1.1 km	2010.11.18（2010.11.5） – 今
	MERSI 1	0.41 – 11.25 μm	20	250 m, 1 km	2010.11.18（2010.11.5） – 今
	IRAS	0.69 – 1.64, 3.76 – 14.95 μm	26	17 km	2010.11.18（2010.11.5） – 今
	MWTS 1	50 – 57 GHz	4	50 – 60 km	2010.11.18（2010.11.5） –2014.2.21
	MWHS 1	150 GHz, 183 GHz	5	15 km	2010.11.18（2010.11.5） – 今
	MWRI	10 – 89 GHz	10	12 – 75 km	2010.11.18（2010.11.5） – 今
FY-3C	VIRR 2	0.43 – 12.5 μm	10	1.1 km	2013.9.25（2013.9.23） – 今
	MERSI 1	0.41 – 11.25 μm	20	250 m, 1 km	2013.9.30（2013.9.23） –2015.5.30
	IRAS	0.69 – 1.64, 3.76 – 14.95 μm	26	17 km	2013.9.29（2013.9.23） – 今
	MWTS 2	50 – 57 GHz	4	50 – 60 km	2013.9.30（2013.9.23） – 今
	MWHS 2	150 GHz, 183 GHz	5	15 km	2013.9.30（2013.9.23） – 今
	MWRI	10 – 89 GHz	10	12 – 75 km	2013.9.29（2013.9.23） – 今

Goal for FY series: FCDR



Instruments:

- **VIRR:** FY-1A/B/C/D FY-3A/B/C
- **MERSI/IRAS/MWTS/MWHS/MWRI:** FY-3A/B/C
- **VISSR:** FY-2A/B/C/D/E/G

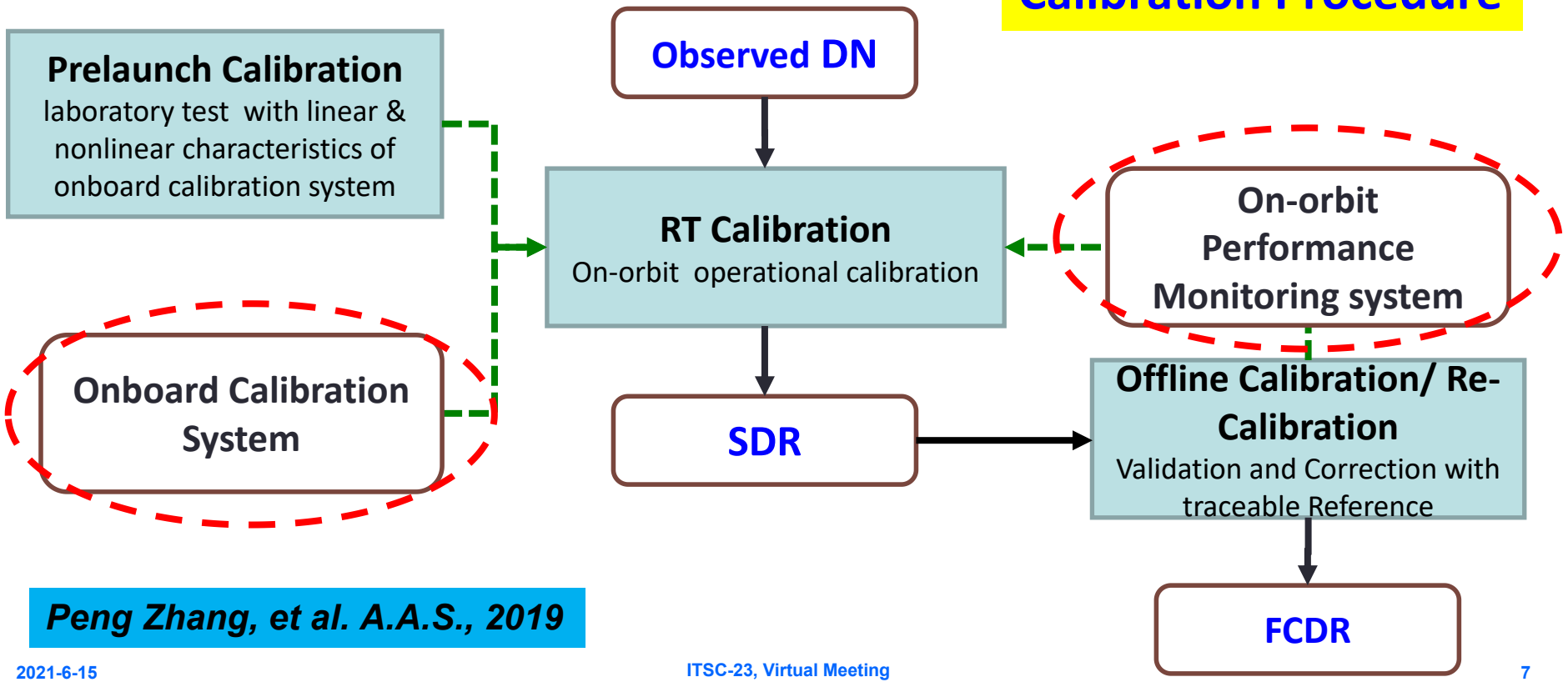
Accuracy:

- RSB: 8%(R&D), 5%(O)
- TIR: 1K(R&D), 0.5K(O)
- MW: 1K(Absorption),1.5K(Window)

2. Problem and Solution

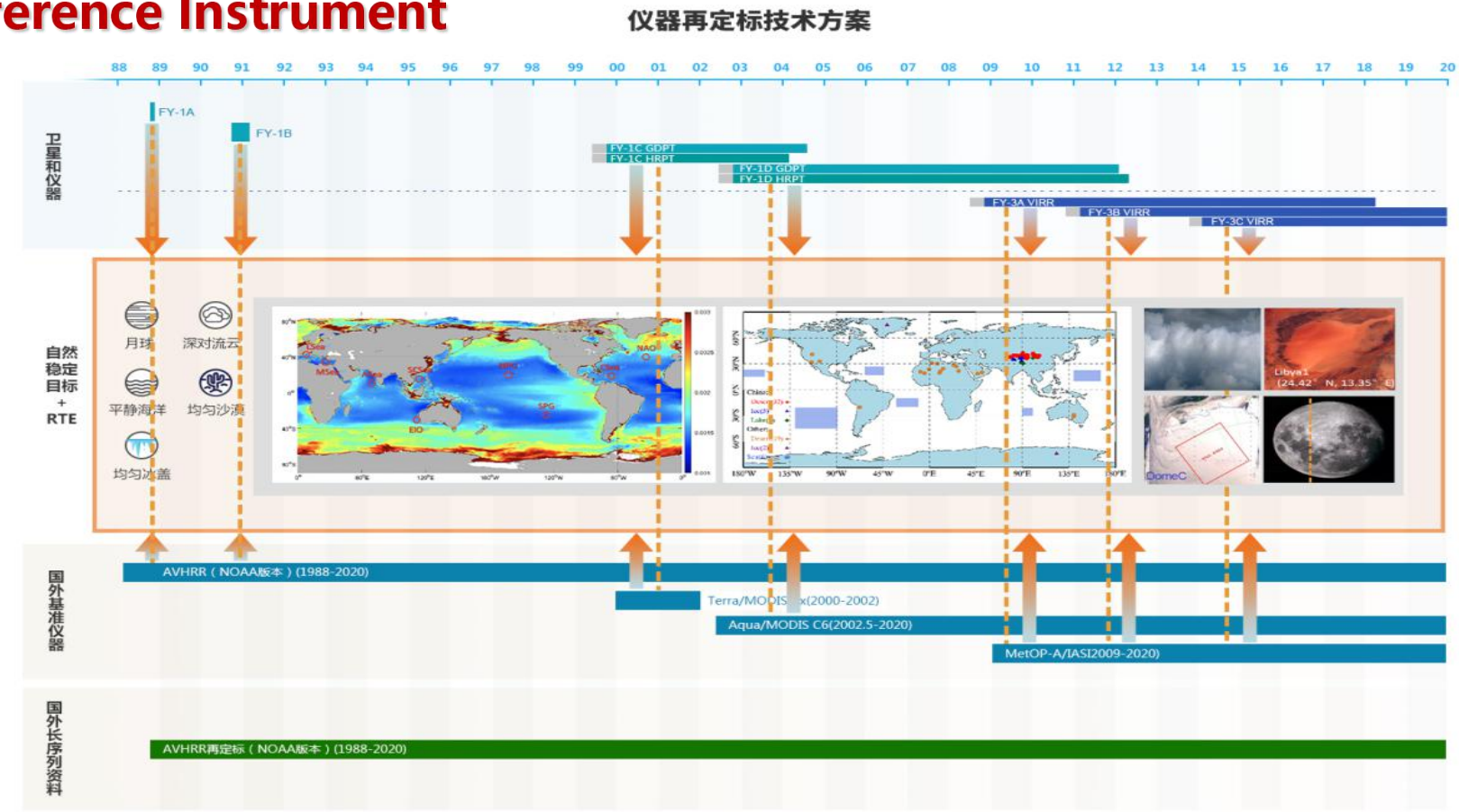
- All Calibration Chain Correction
- All lifetime Correction

Calibration Procedure

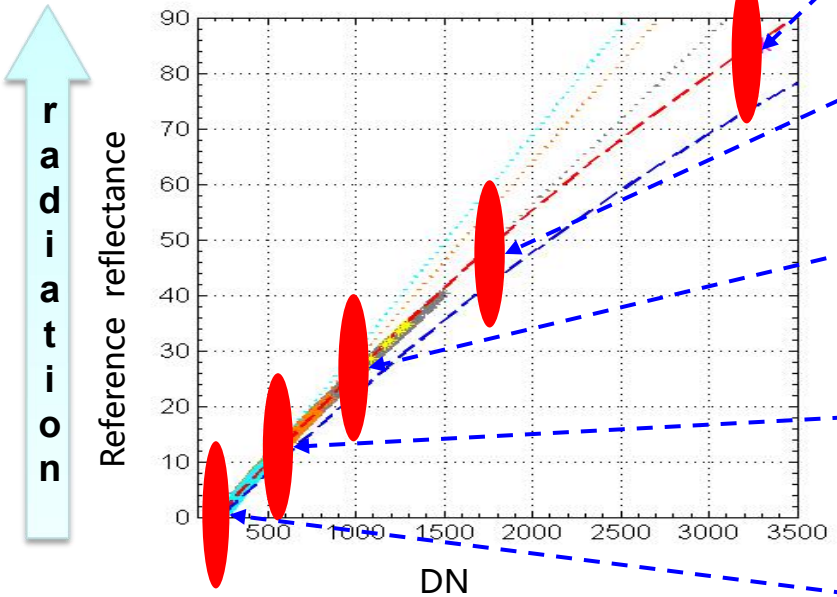


Peng Zhang, et al. A.A.S., 2019

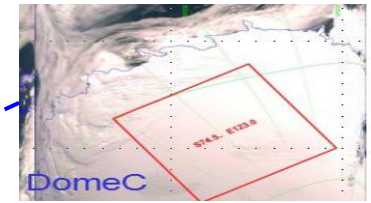
Reference Instrument



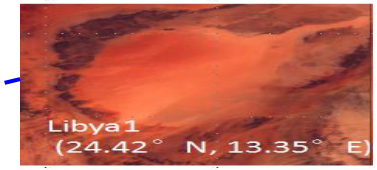
Pseudo-Invariant Calibration Targets



DCC
> 90%



Glacier
50-80%

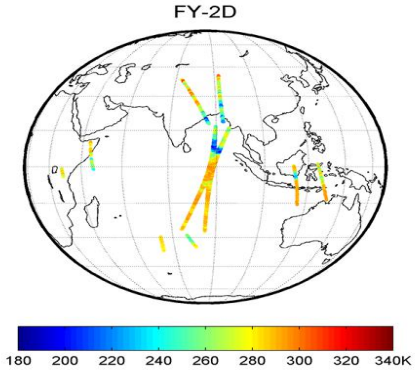


Desert
20-30%

Moon
5-10%

ocean
< 5%

Inter-calibration with reference sensors



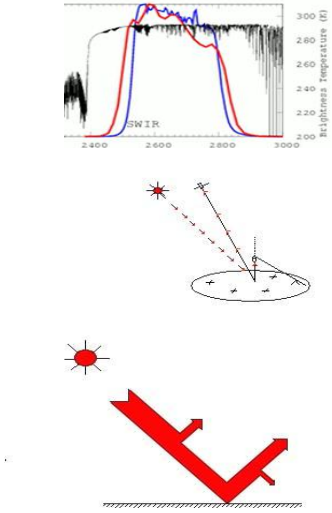
Geo-Leo

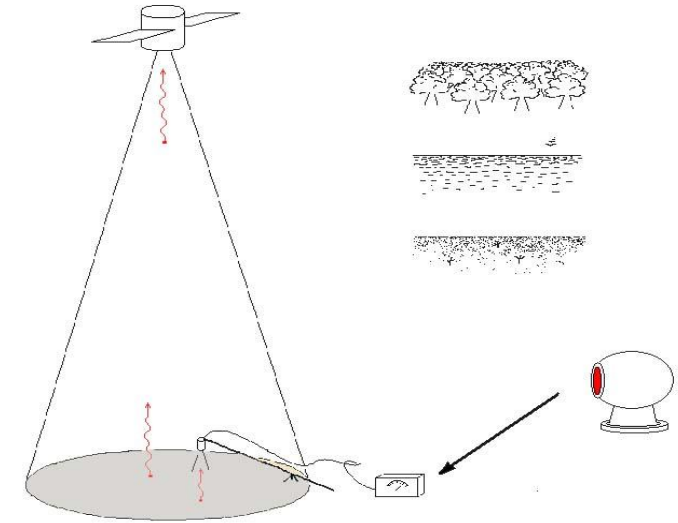
Leo-Leo

Direct Inter-calibration with global data matching

- Space
- Time
- Geometry
- Spectral

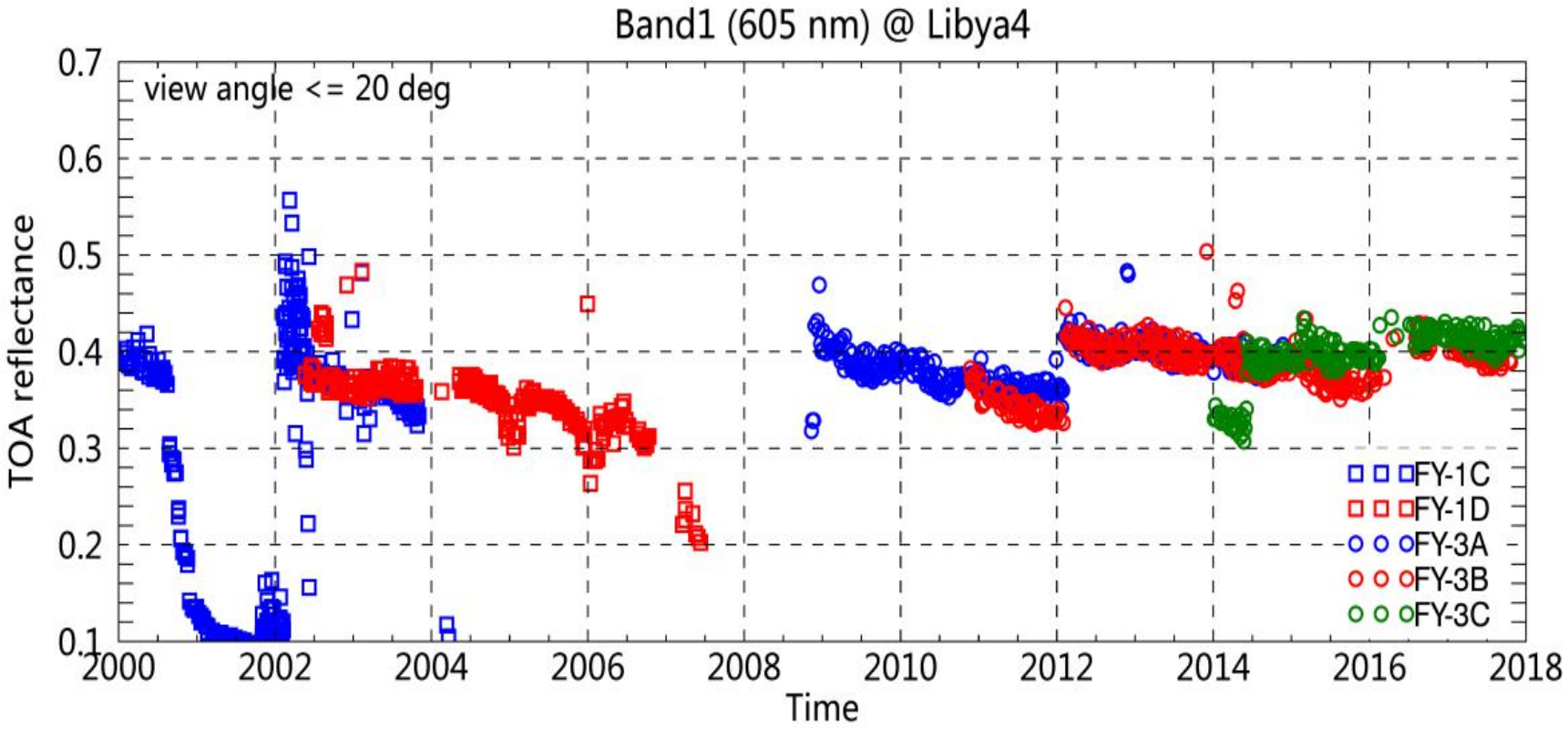
Indirect Inter-calibration with PICS





RSB channels Degradation monitoring by PICS

VIRR Harmonization Check with Libya 4



3. Latest Progress

Retrospective Recalibration of Historical Fengyun Satellite Data

Period: 2018.05-2022.04

Sensors included:

- **Optical imager: FY-1/3 VIRR, FY-3 MERSI, FY-2 VISSR**
- **Optical sounder: FY-3/IRAS**
- **Microwave sounder: FY-3/MWHS&MWTS**
- **Microwave imager: FY-3/MWRI**

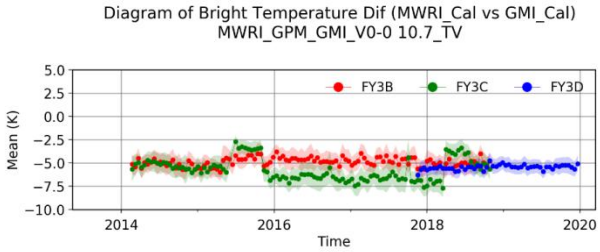
Version	V1 (beta)	V2 (trial)	V3 (formal)
Status	Completed in 2019	Partly completed	To be finished at 2021/12
Main concerns	Lifetime recalibration of each instrument using consistent calibration framework	Focus on the recalibration model improvement to achieve the accuracy and stability	Focus on the inter-instrument consistency, gridded climate dataset

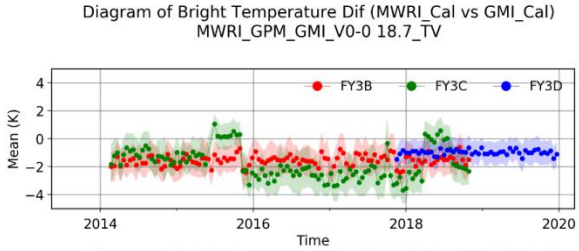
- **The beta version (V1) datasets have been finished through the lifetime recalibration of each instrument in 2019.**
- **At present, the trial version (V2) datasets are finished for MWRI, MWTS and VIRR solar bands, meanwhile others are still ongoing.**

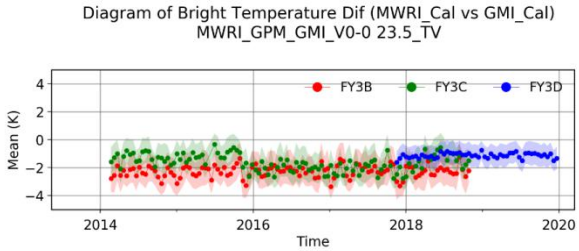
FY-3/MWRI FCDR V1/V2

SNO&DD VS. GMI

Operational





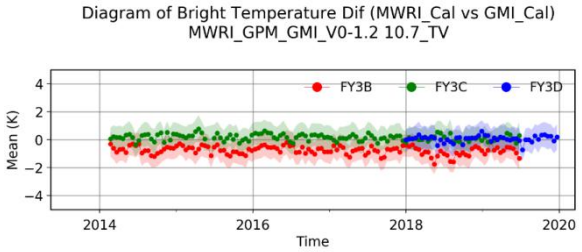


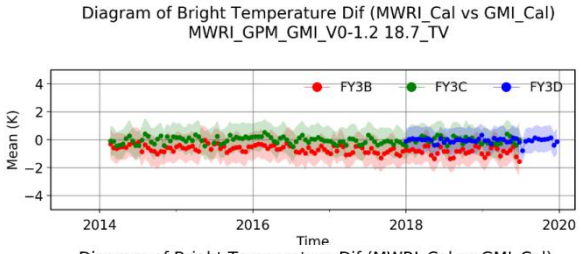
Sensor	Time range
FY-3B/MWRI	2010/11/11-2018/11/30
FY-3C/MWRI	2013/09/29-2019/06/30
FY-3D/MWRI	2017/11/25-present

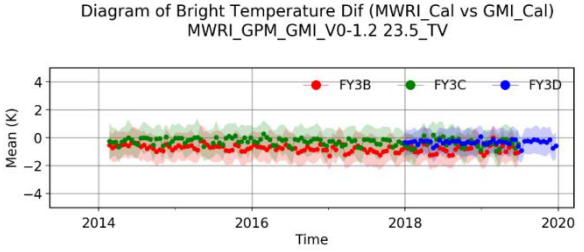
- V2 dataset is finished, covering FY-3B/C/D from 2010 to 2019 .
- 5 major issues improved: hot reflector back lobe correction, hot reflector emissivity correction, hot load efficiency correction, non-linear correction, and cold reflector correction.

V2: Bias mostly within 0.5K;
RMSE all within 1.5K, mostly around 1K.

Re-processed V2





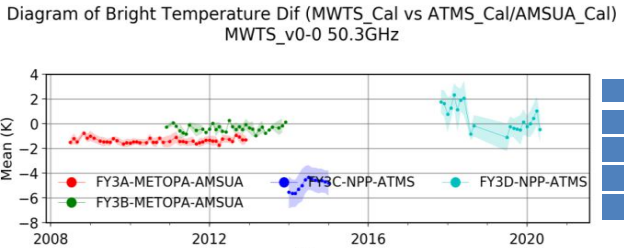


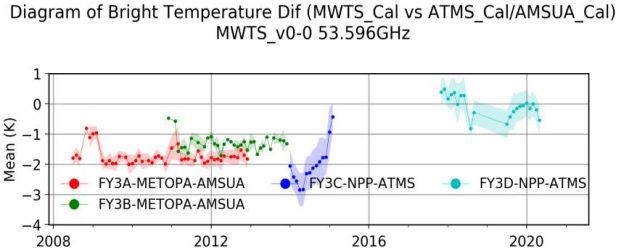
Data DOI: 10.12185/NSMC.RICHCEOS.FCDR.MWRIRecalOrb.FY3.MWRI.L1.GBAL.POAD.NUL.010KM.HDF.2021.2.V1

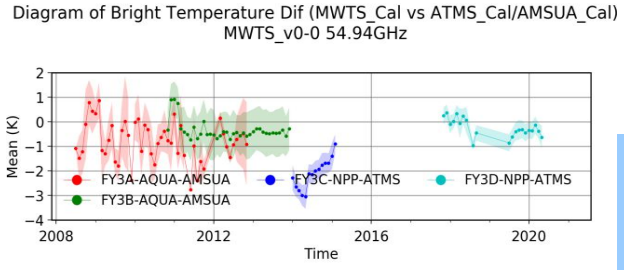
FY-3/MWTS FCDR V2

SNO VS. AMSUA/ATMS

Operational





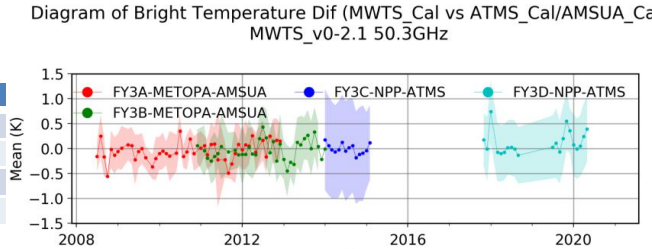


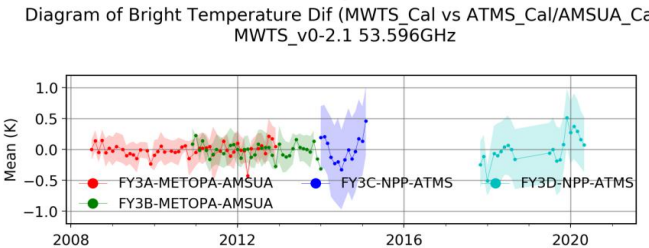
Sensor	Time range
FY-3A/MWTS	2008/07/01-2013/05/06
FY-3B/MWTS	2010/11/11-2014/02/21
FY-3C/MWTS	2013/09/30-2015/02/28
FY-3D/MWTS	2017/11/25-present

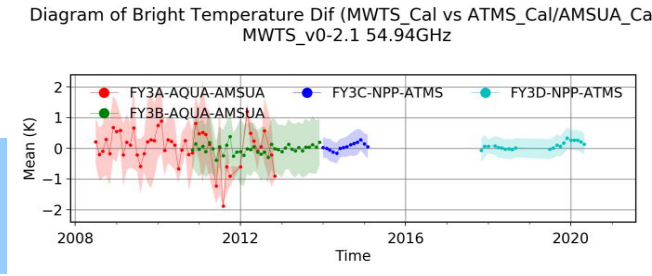
- V2 dataset is finished, covering FY-3A/B/C/D from 2008 to 2020.
- Applying new static calibration parameters from pre-launch thermal/vacuum test, data quality control, cold/hot target and nonlinear correction.

V2: RMSE within 1K for channels at 50.3 GHz, 53.596 GHz, 54.94 GHz and 57.29 GHz

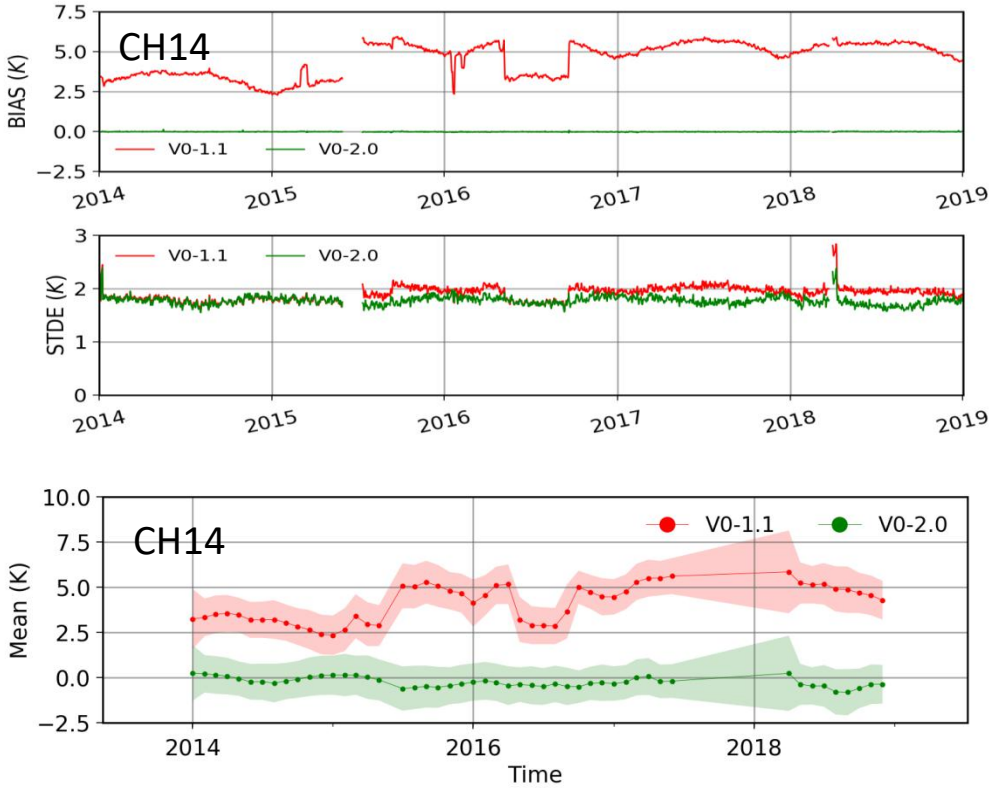
Re-processed V2







FY-3/MWHS FCDR V2



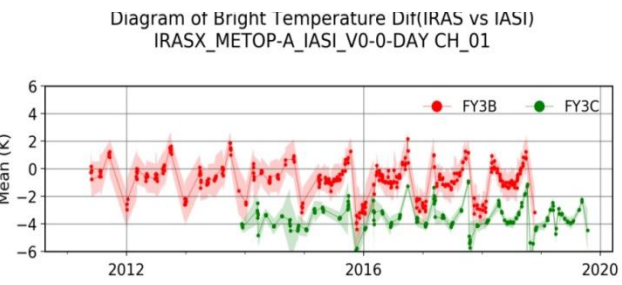
OMB

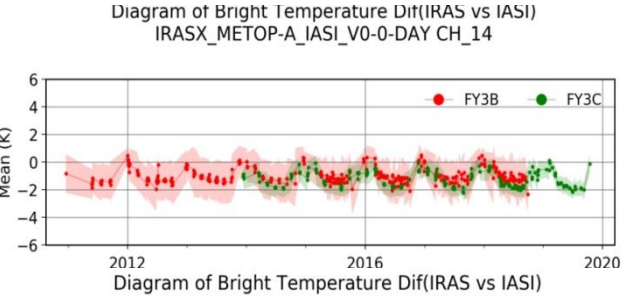
SNO VS. ATMS

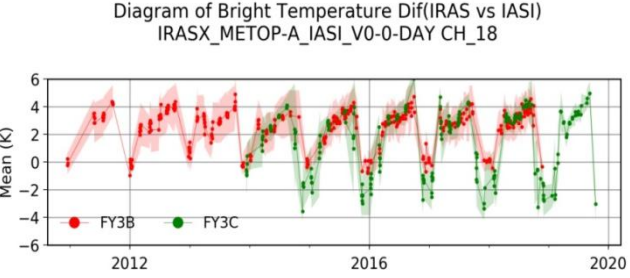
FY-3C/IRAS FCDR V2

SNO VS. IASI

Operational





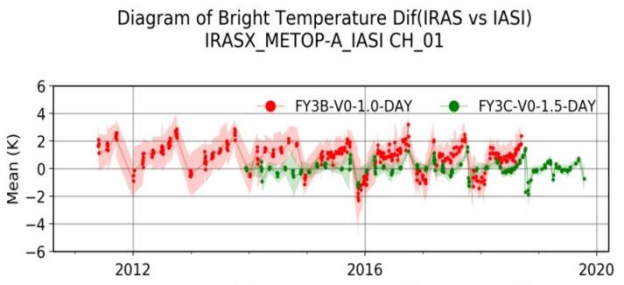


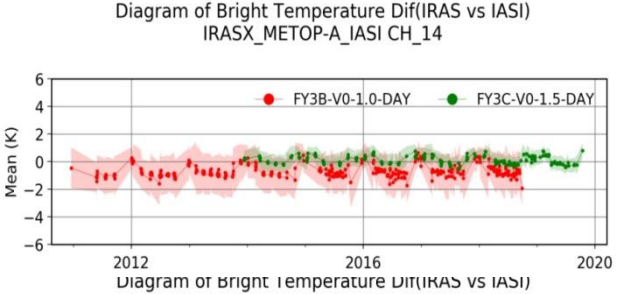
Sensor	Dataset coverage
FY-3B/IRAS	2010/11/18-present
FY-3C/IRAS	2013/09/30-2019/10/19

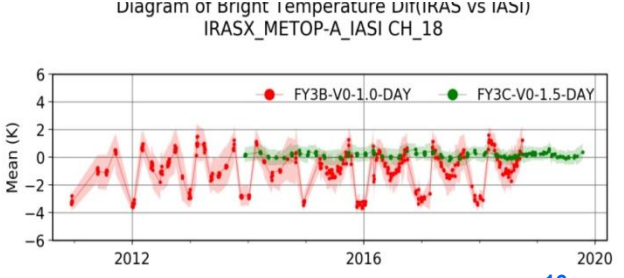
- V1 dataset covers FY-3B/C from 2010 to 2019, by system bias correction with referenced to IASI.
- V2 dataset is finished with refined model for FY-3C.

- **System biases are corrected for most channels, RMSE in range of 0.5~1.0 K.**
- **Seasonal fluctuation of FY-3C are corrected using V2 refined model .**

Re-processed V2



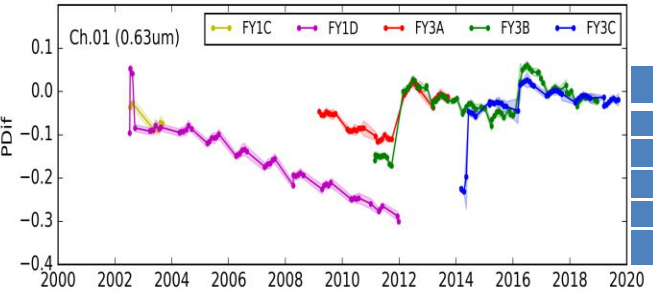


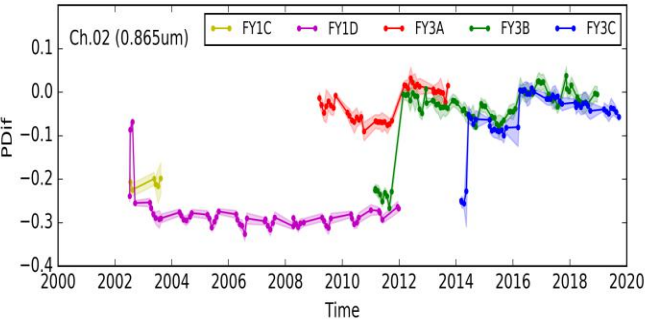


FY/VIRR FCDR V2 (RSBs)

SNO VS. MODIS

Operational

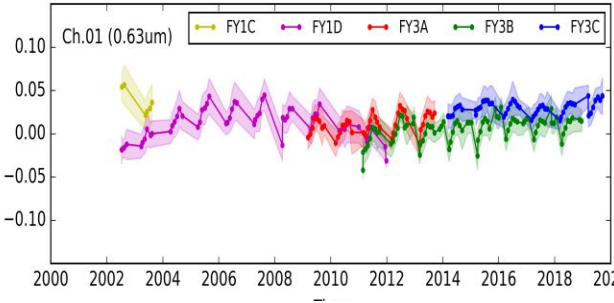


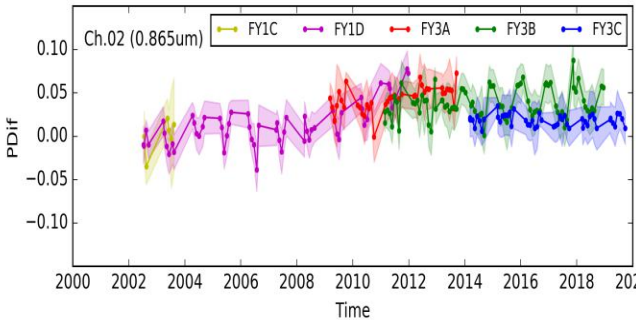


Sensor	Time range
FY-1C/VIRR2	2000/01/21–2004/06/30
FY-1D/VIRR2	2002/07/11–2012/01/13
FY-3A/VIRR3	2008/07/01–2015/01/04
FY-3B/VIRR3	2010/11/14–present
FY-3C/VIRR3	2013/10/01–present

- V2 dataset is finished, covering the time span from 2000 to 2019, using daily gains derived by vicarious calibration approach and the record calibration reference is further traced to Aqua MODIS C6.1 by a systematic correction derived from Libya desert.

Re-processed V2

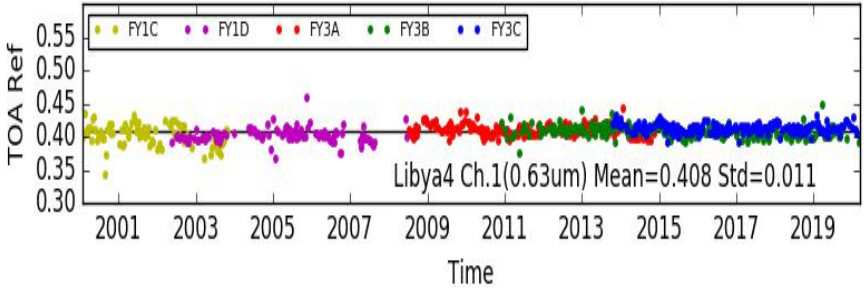


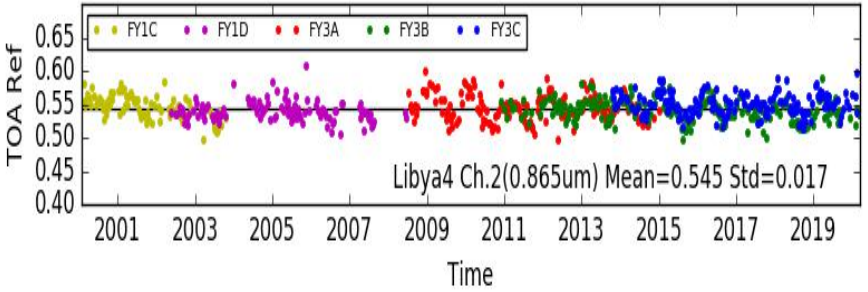


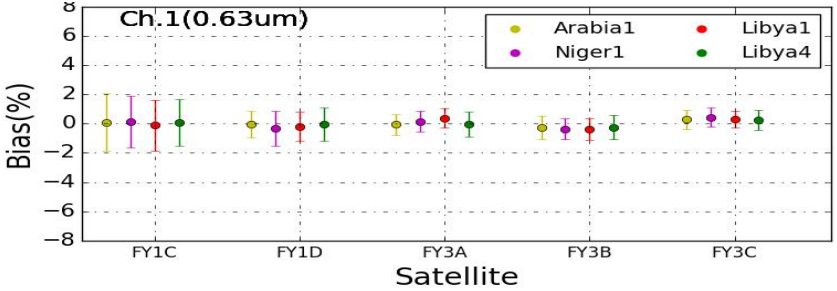
- **Variation of sensor radiometric response both gradual and sudden degradation is corrected, and the radiometric stability and inter-platform consistency is improved after recalibration.**
- **Life-time RMS of the relative difference is within 5% for Ch1, 2, 6, 7, 8, while relatively larger for Ch9 at low signal.**

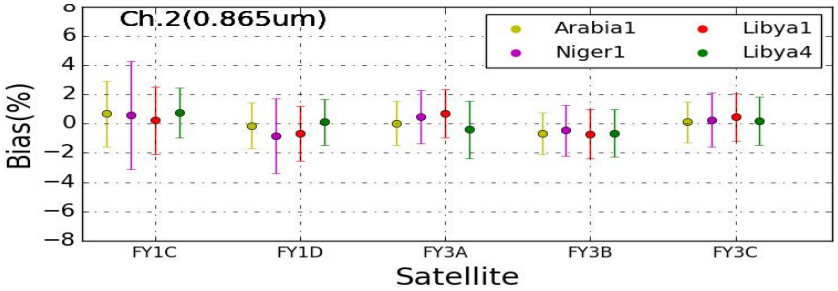
FY/VIRR FCDR V2 (RSBs)

Clear-sky normalized reflectance of invariant deserts



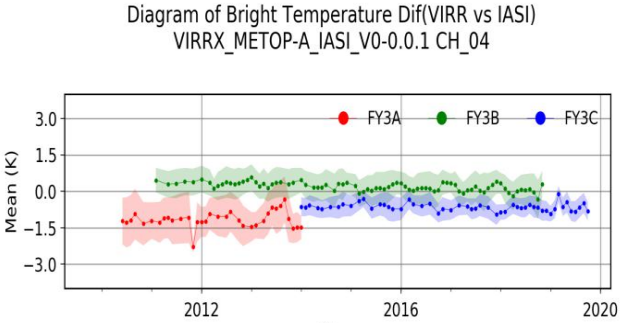


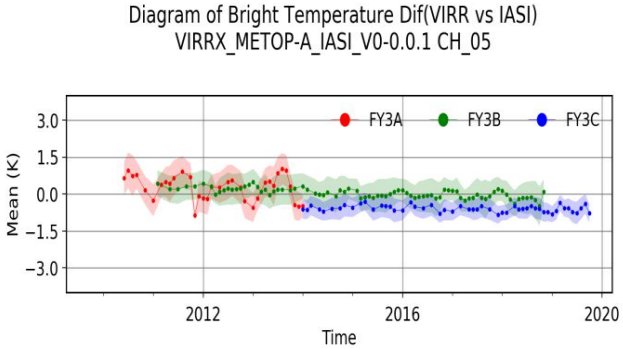




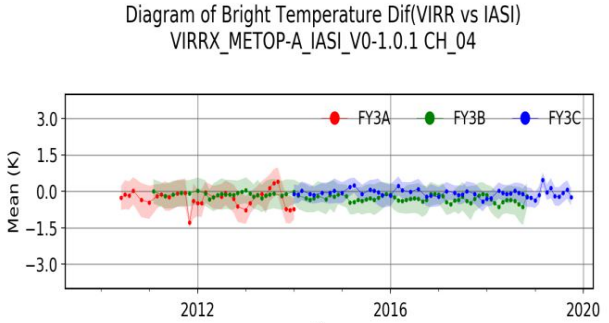
In general, after anisotropic and spectral correction, the TOA reflectance means for each instrument are within 1% of the 20-yr average for channels 1 and 2.

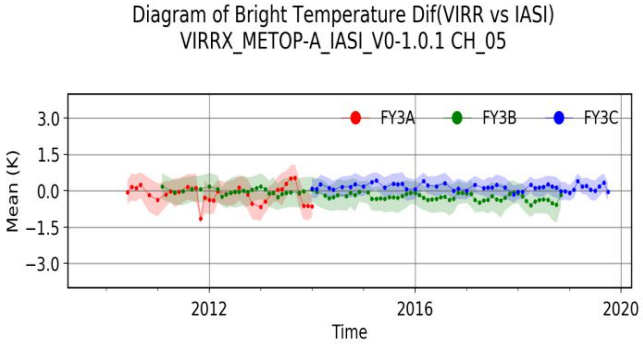
FY/VIRR FCDR V1 (TEBs)





- **In V1, the IR recalibration focuses on the correction of the nonlinear response derived by SNO analysis using IASI.**
- **The deviation time series shows that the inter-platform consistency is improved after recalibration, while the seasonal variation still exists.**
- **The lifetime mean biases of 3 instruments are less than 0.4K, and the RMSE is less than 0.65K, 0.6K and 0.5K for FY-3A, FY-3B, FY-3C, respectively.**

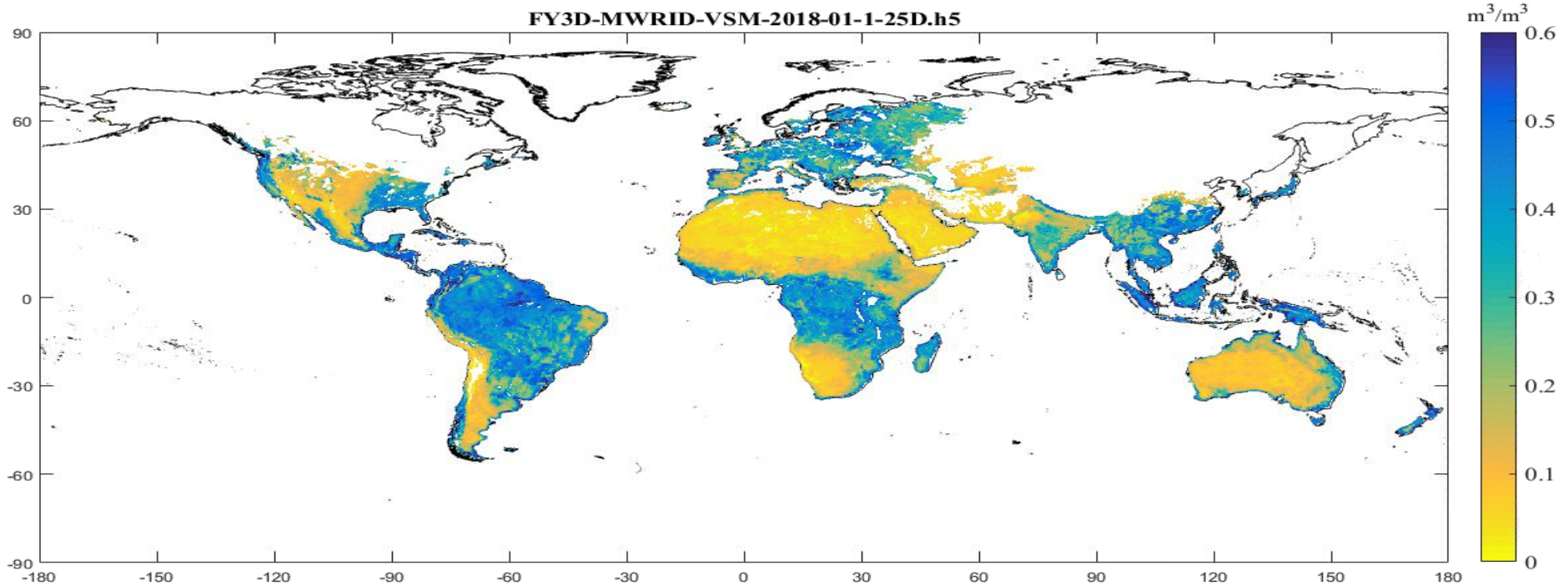




- **In V2, the refined TEB onboard recalibration model is developed,which corrects the radiance from the internal blackbody and the effects of instrument temperature. The evaluation of V2 VIRR TEB dataset is ongoing.**

4. Some Demonstrations

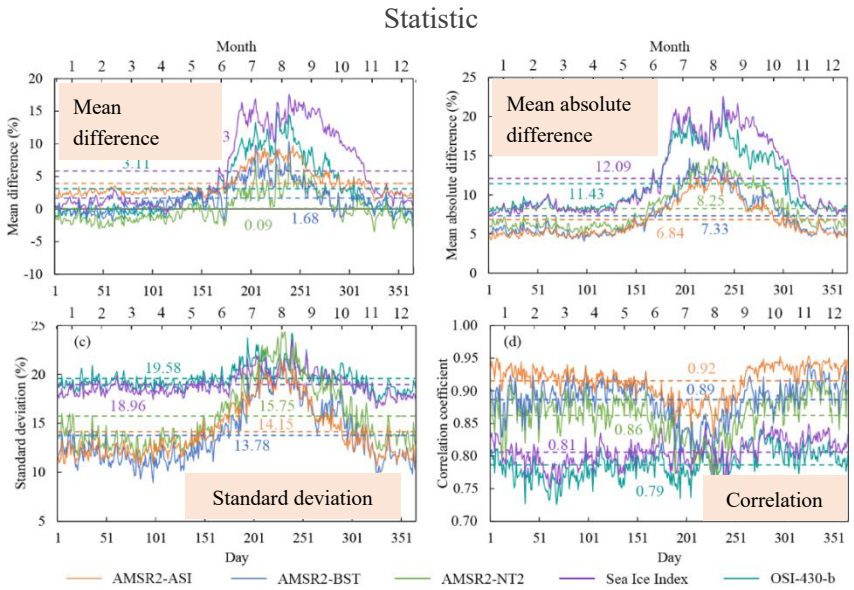
FY-3D 10-days SM of 2018



Kang, C. S. , Zhao, T. , Shi, J. , et al. 2020, Global soil moisture retrievals from the chinese FY-3D microwave radiation imager. IEEE Transactions on Geoscience and Remote Sensing

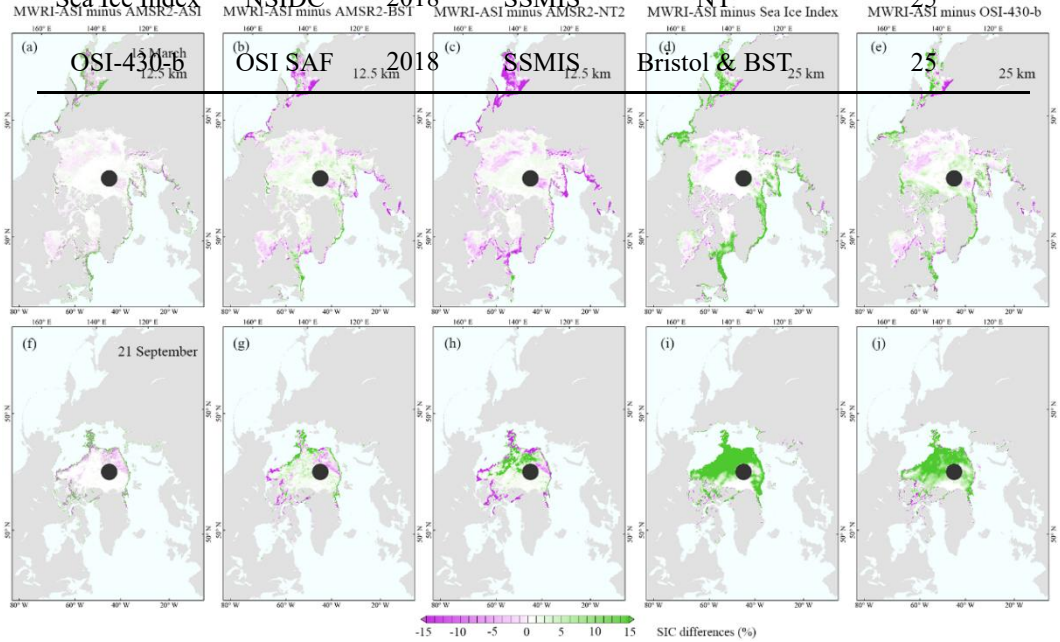
Published SIC products

（Xi Zhao et al., IEEE TGRS 2021, Ying, Zhao et al. Big Earth Data 2021）



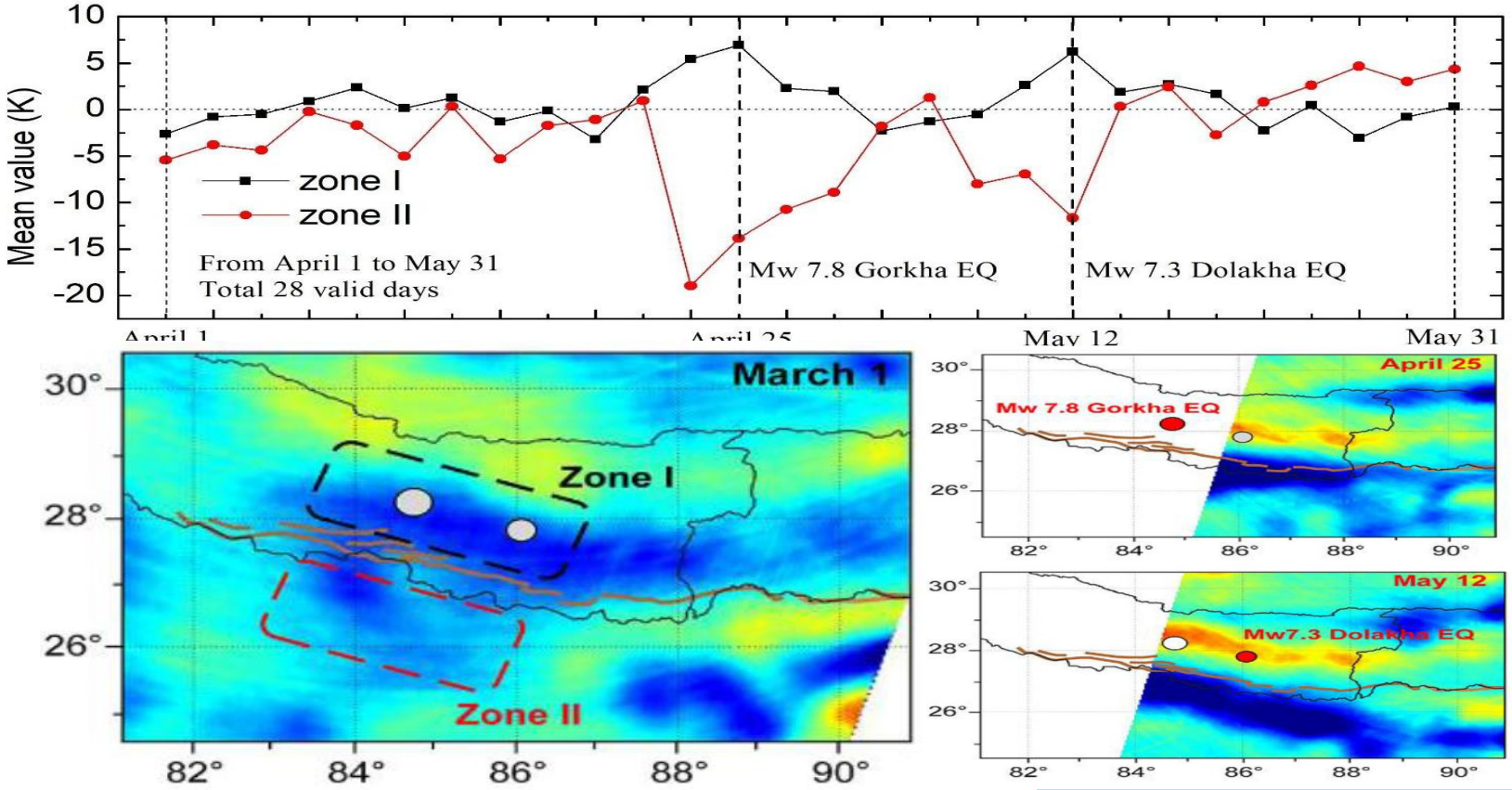
Dataset	Source	Period	Sensor	Algorithm	Resolution (km)
AMSR2-ASI	IUP	2018	AMSR2	ASI	6.25
AMSR2-BST	NSIDC	2018	AMSR2	BST	12.5
AMSR2-NT2	NSIDC	2018	AMSR2	NT2	12.5
Sea Ice Index	NSIDC	2018	SSMIS	NT	25
OSI-430-b	OSI SAF	2018	SSMIS	Bristol & BST	25

- Lowest difference: AMSR2-ASI
  Mean absolute difference：6.84%
  Correlation coefficient：0.92
- Highest difference: Sea Ice Index、OSI-430-b
  Standard deviation：18.96%、19.58%
  Correlation coefficient：0.81、0.79
- Seasonal trend
  Jan – Jun , Oct – Dec: Mean absolute difference < 10%
  Jul – Sept: Mean absolute difference 10% - 23%。
- Larger difference at ice edge



Differences maps of SIC between MWRI-ASI and the published SIC products

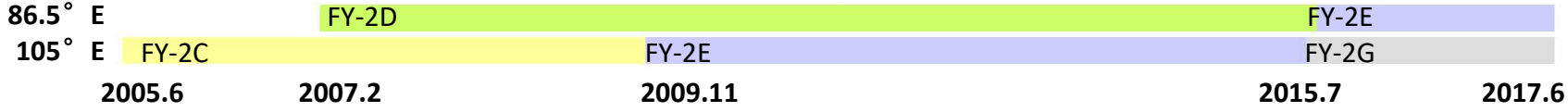
Microwave Brightness Temperature Anomalies Associated With the 2015 Mw 7.8 Gorkha and Mw 7.3 Dolakha Earthquakes in Nepal

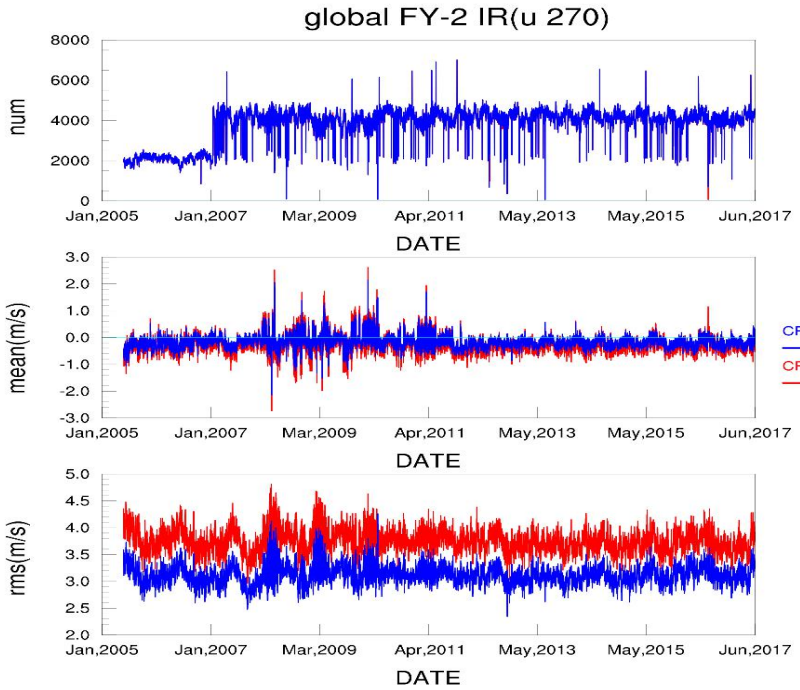


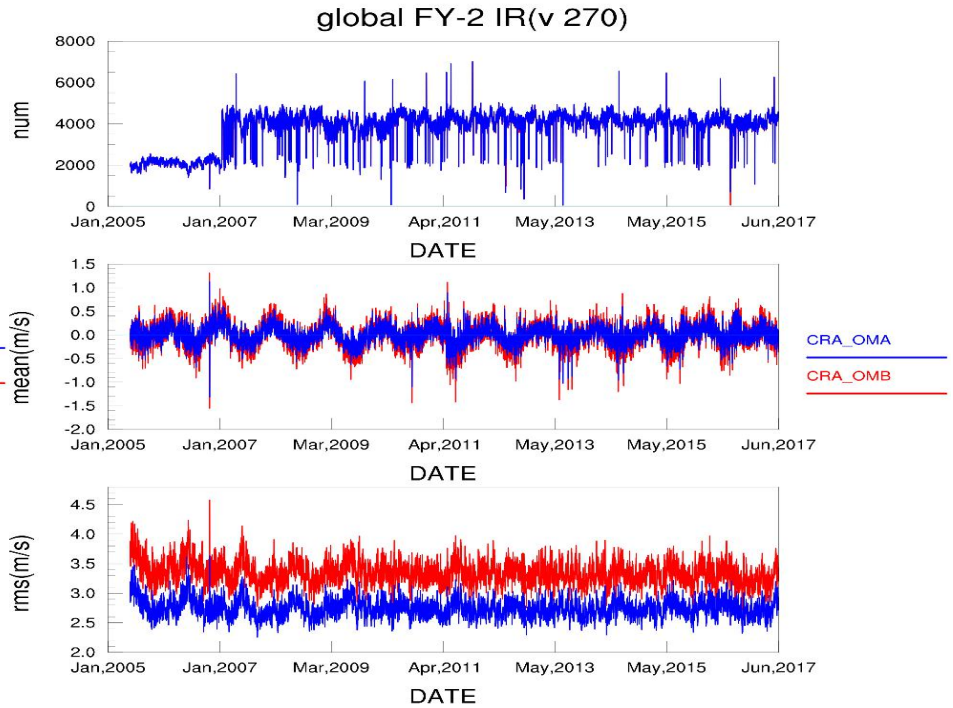
Qi Y, Wu LX et al., TGRS, 2021

13 years of Reprocessed FY-2 AMV by NMSC were assimilated in CRA

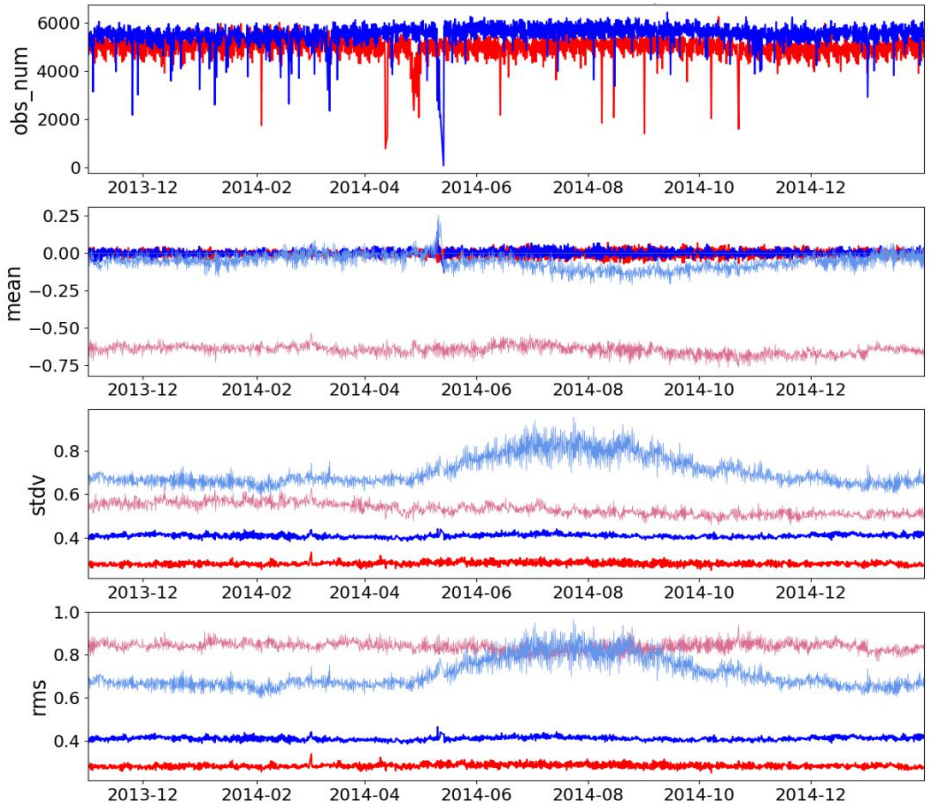
- Reprocessed FY-2C/D/E/G IR AMV (20005.6-2017.6) AMV were used in CRA
- The mean and rms of "O-B" and "O-A" are stable.

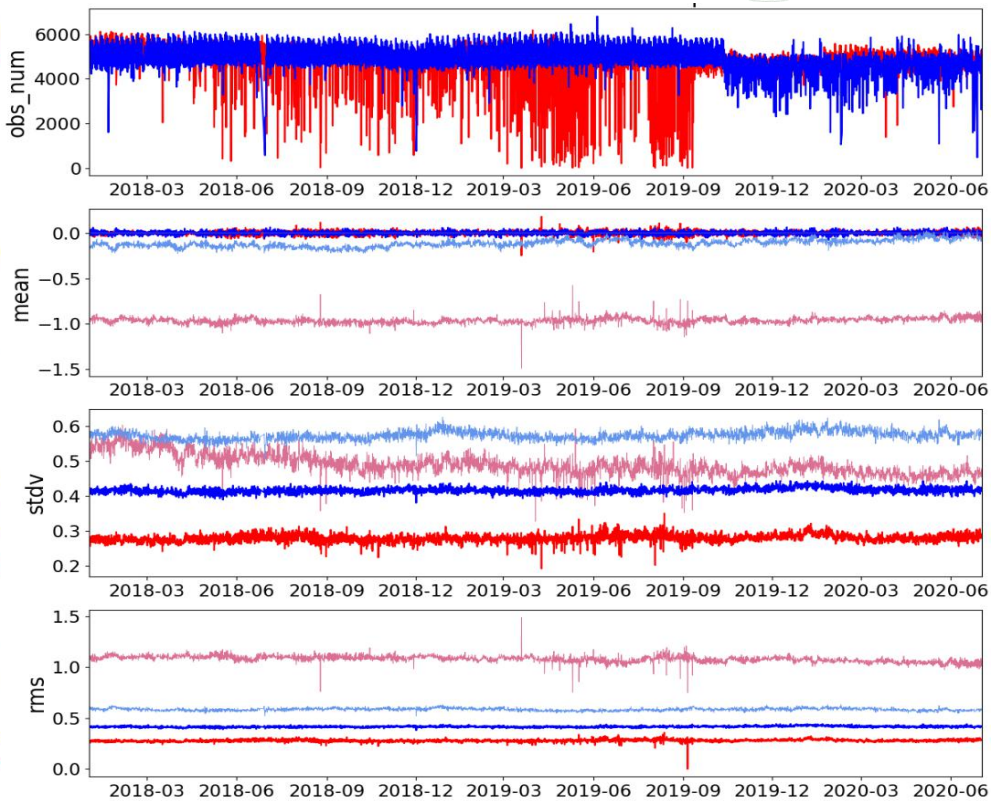






Evaluation of Reprocessed FY-3C/D MWTS against CRA





— MWTS2/FY3C CH3 OMB (with bias correction)
— MWTS2/FY3C CH3 OMB (without bias correction)
—ATMS/SNPP CH5 OMB (with bias correction)
—ATMS/SNPP CH5 OMB (without bias correction)

— MWTS2/FY3D CH3 OMB (with bias correction)
— MWTS2/FY3D CH3 OMB (without bias correction)
—ATMS/SNPP CH5 OMB (with bias correction)
—ATMS/SNPP CH5 OMB (without bias correction)

5. Summarization

- The beta version (V1) datasets have been finished through the lifetime recalibration of each instrument in 2019.
- The trial version (V2) datasets are completed for MWRI, MWTS and VIRR solar bands, meanwhile others are still ongoing and scheduled to be completed in June, 2021.
- Reprocessed dataset will be publicly released with registered DOI. (www.richceos.cn)
- User feedbacks are expected through using the recalibrated FCDR.

Make the data better and easier to use !