Use of satellite microwave observations in JMA global NWP system and some evidences of RFI in AMSR2 observation

Hidehiko MURATA, Masahiro KAZUMORI , Japan Meteorological Agency (JMA)

Akira Shibata, Mieko Seki, Remote Sensing Technology Center of Japan

Keiji Imaoka, Yamaguchi University

Misako Kachi, Japan Aerospace Exploration Agency

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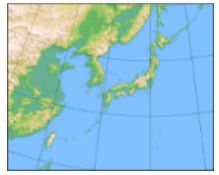
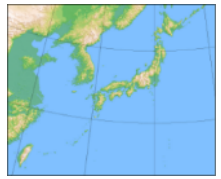
Impacts of MW data in JMA global NWP system

JMA's deterministic NWP models and DA systems

	In Operation		
	Global Spectral Model GSM	**Meso-Scale Model MSM**	**Local Forecast Model LFM**
Objectives	Short- and Medium-range weather forecast	Disaster reduction Aviation forecast Precipitation forecast	Aviation forecast Disaster reduction
Forecast domain	Global 	Japan and its surroundings (4080 km x 3300 km) 	Japan and its surroundings (3160 km x 2600 km) 
Horizontal resolution	TL959, approx. 20 km (0.1875 deg.)	5 km	2 km
Vertical levels / Top	128 0.01 hPa	76 21.8 km	58 20.2 km
Forecast Hours (Initial time)	264 hours (00, 12 UTC) 132 hours (06, 18 UTC)	51 hours (00, 12 UTC) 39 hours (03, 06, 09, 15, 18, 21 UTC)	10 hours (00-23 UTC hourly)
Initial Condition	Global Analysis (Hybrid 4D-Var)	Meso-scale Analysis (4D-Var)	Local Analysis (3D-Var)

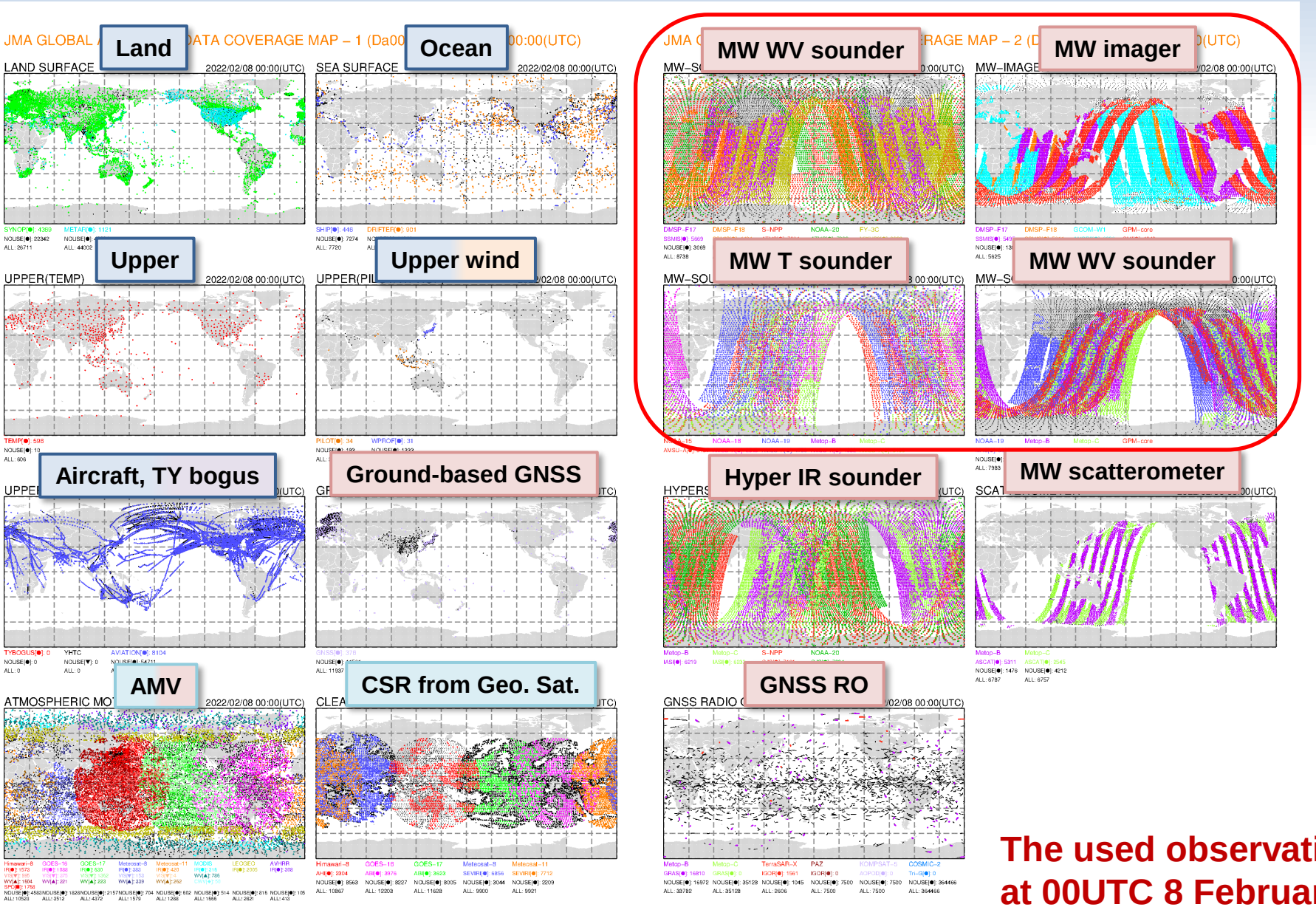
Satellite and conventional data are assimilated in data assimilation (DA) systems.

Global Analysis
6-hourly DA for delayed and early analysis
6-hr data assimilation window
Data cut-off time 2hr 50min. (earliest case)

Meso-scale Analysis
3-hourly DA
3-hr data assimilation window
Data cut-off time 50 min.

Local Analysis
Hourly DA
3-hr data assimilation window
Data cut-off time 30 min.

Observation data used in JMA global NWP system



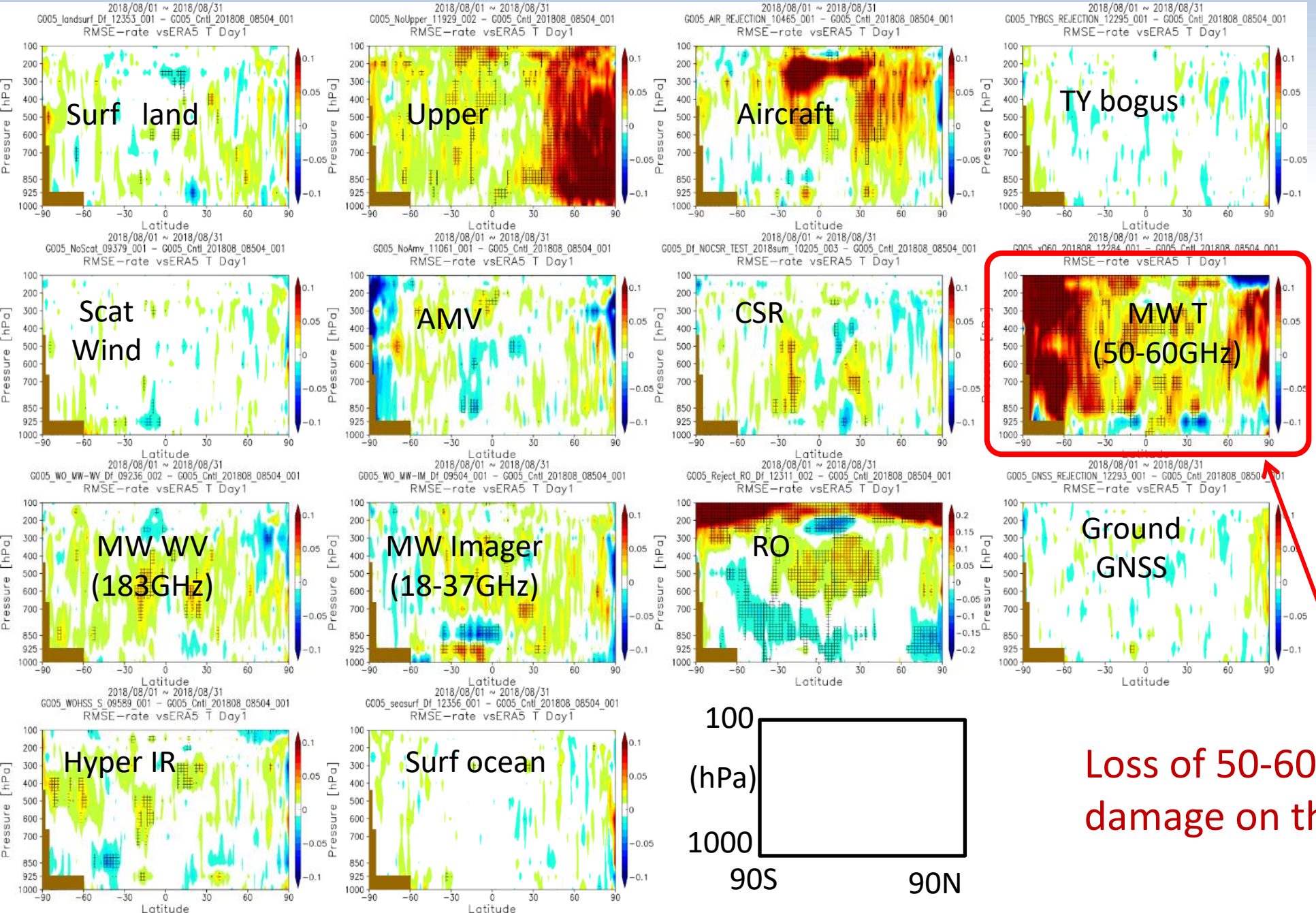
Space-based and ground-based observations are assimilated to produce initial conditions in JMA global NWP system

MW radiance data are key data set among operationally used observation data in JMA NWP system.

MW T sounding sensor
AMSU-A, ATMS
MW WV sounding sensor
MHS, ATMS, SSMIS, GMI, SAPHIR,MWHS-2
MW imager sensor
AMSR2, GMI, SSMIS

The used observation data coverage at 00UTC 8 February 2022 delayed analysis.

Degradation of forecast accuracy in Data Denial Experiments (**Temperature**)



Normalized change of RMSE of Temperature Day 1 forecast

Control : JMA operational global NWP as of 2020 Jan.

Test: Data denial experiment

Period : Aug. 2018

Data denial experiment demonstrated **microwave temperature sounding data** has the largest impact for the forecast accuracy.

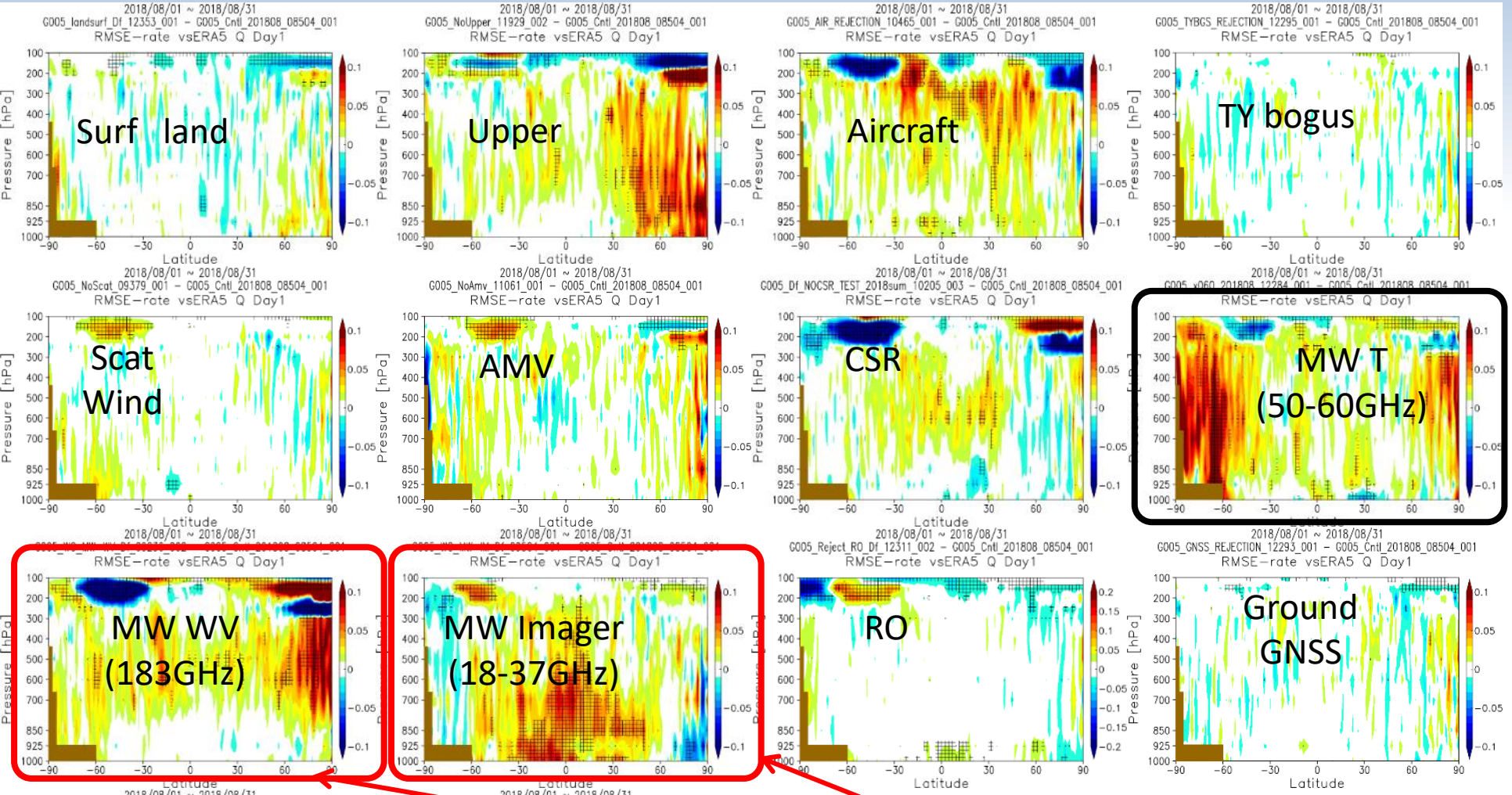
Warmer: degradation

Colder: improvement

Reference: ERA5

Loss of 50-60 GHz band is huge damage on the forecast score.

Degradation of forecast accuracy in Data Denial Experiments (**Water vapor**)



Normalized change of RMSE of Water vapor Day 1 forecast

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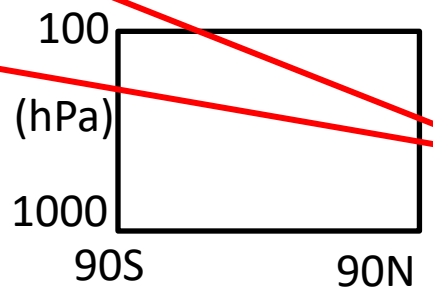
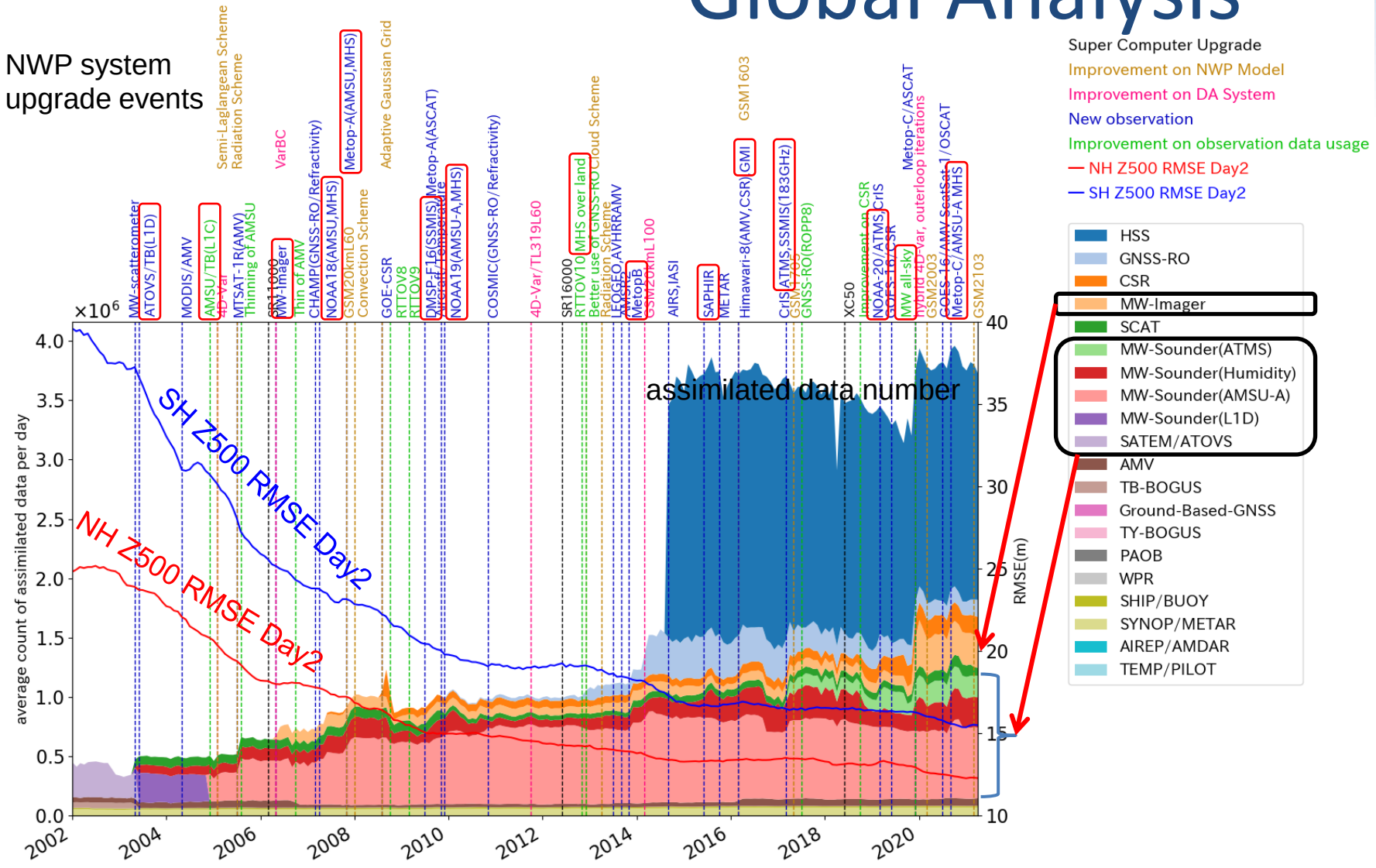


MW WV (183GHz) and MW Imager (18-37GHz) have large contribution on the accuracy of water vapor prediction

Assimilated Data Amount History - Global Analysis -



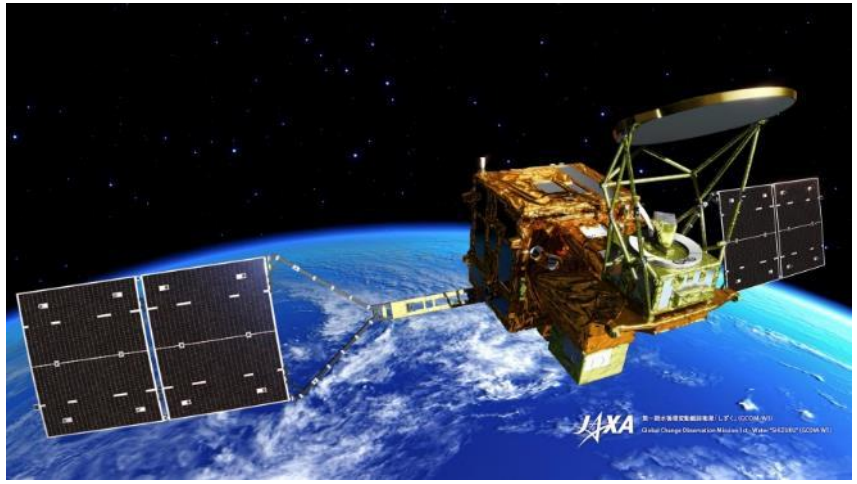
Major events in MW data use

2004: NOAA/AMSU radiance (L1D) data assimilation started.
2005: AMSU radiance (L1C) data assimilation started.
2006: MW Imager radiance data assimilation started.
2007: NOAA-18/AMSU, Metop-A/AMSU
2009: DMSP/SSMIS, NOAA-19/AMSU
2013: MHS radiance data use over land.
GCOM-W/AMSR2 radiance data assimilation started
2014: Metop-B AMSU radiance data assimilation started.
2015: SAPHIR radiance data assimilation started.
2016: GMI radiance data radiance data assimilation started.
2017: ATMS radiance data use
2019: NOAA20/ATMS radiance data assimilation started.
All-sky assimilation of MW imager and MW humidity sounder started
2020: Metop-C/AMSU radiance data assimilation started.
2021: additional all-sky assimilation of MW humidity sounder started.

MW radiance data introduction contributed to reduction of RMSE at 500 hPa height.

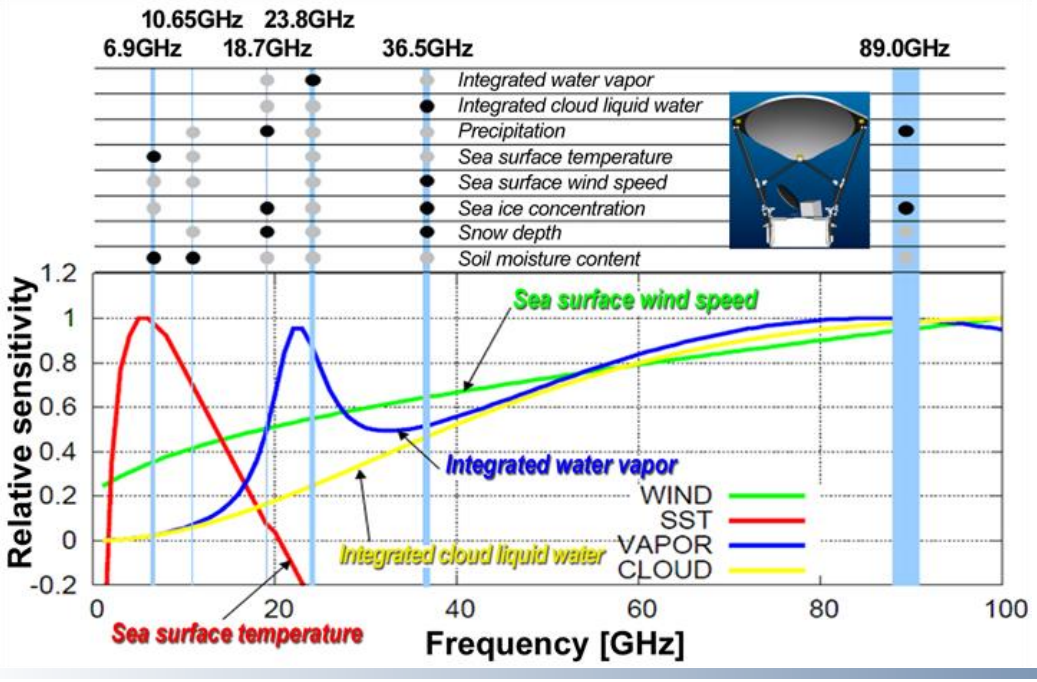
RFI in AMSR2 observation

GCOM-W/AMSR2



AMSR2 observation

- The Advanced Microwave Scanning Radiometer 2 (AMSR2) onboard the GCOM-W satellite developed by JAXA is a remote sensing instrument for measuring weak microwave emission from the surface and the atmosphere of the Earth.
- AMSR2 radiance data have been assimilated in JMA's NWP systems and contribute to improve its forecast skills.
- SST (sea surface temperature) retrieved from AMSR2 is also utilized in JMA SST analysis. It is used as boundary conditions for the NWP systems.



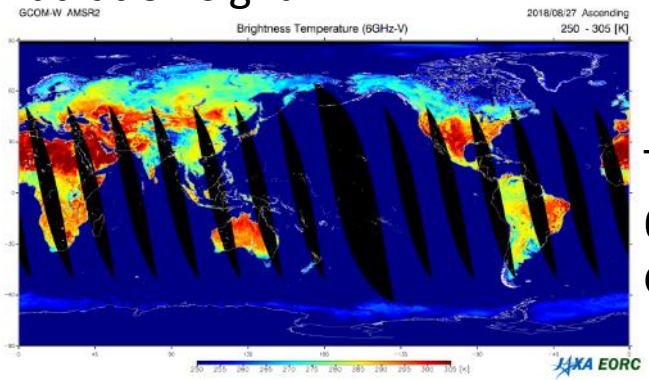
AMSR2 Channel Set

Center Freq.	Band width	Pol.	Beam width	Ground res.	Sampling interval
GHz	MHz		degree	km	km
6.925/7.3	350	V/H	1.8	35 x 62	10
10.65	100		1.2	24 x 42	
18.7	200		0.65	14 x 22	
23.8	400		0.75	15 x 26	
36.5	1000		0.35	7 x 12	
89.0	3000		0.15	3 x 5	5

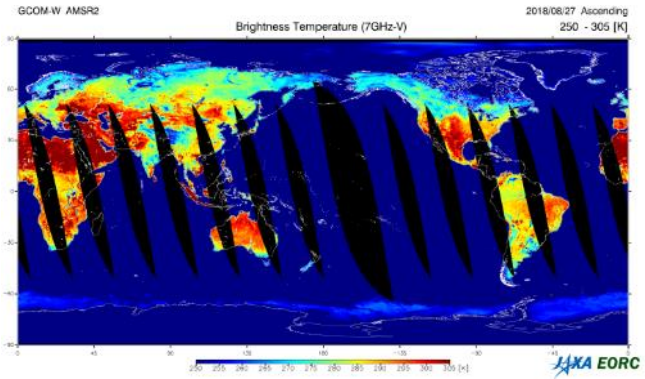
https://suzaku.eorc.jaxa.jp/GCOM_W/w_amsr2/whats_amsr2.html

AMSR2 C-band RFI (6.925 and 7.3 GHz)

- The current sensor, AMSR2, has 6.925 and 7.3 GHz dual polarized channels. There is no frequency allocation in C-band for the Earth observation (passive observation). Therefore, RFI contamination for these channels from human activity is inevitable.
- Except of water vapor absorption at 22 GHz and oxygen absorption at 50-60 GHz, there is no strong spectral line in microwave low-frequency range. Therefore, the frequency dependence of the sensitivity to geophysical parameters is relatively smooth.
- The closely located channels (6.925 and 7.3 GHz) are expected to have similar characteristics for natural microwave radiation signal.

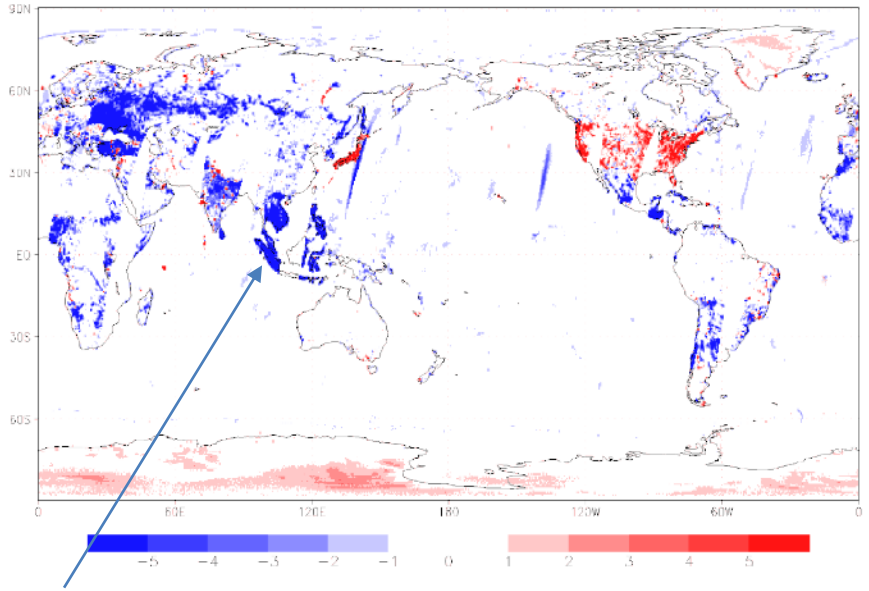


Tb 6.925 GHz V



Tb 7.3 GHz V

TB difference of 6.925 and 7.3 GHz

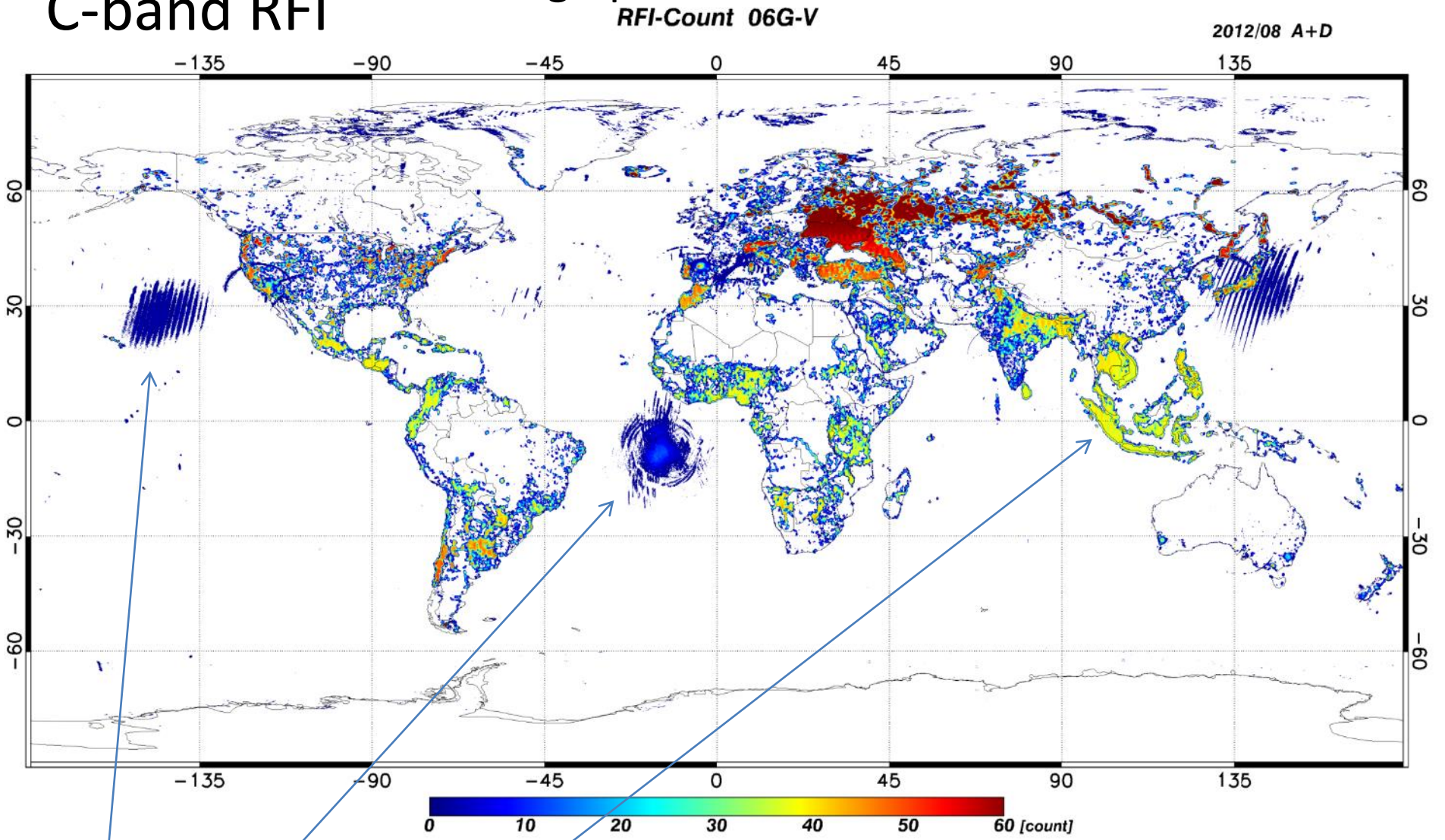


Large differences indicate RFI signal

https://suzaku.eorc.jaxa.jp/cgi-bin/gcomw/jasmes_daily/jasmes_daily_detail_v3.cgi

C-band RFI

Geographical distribution



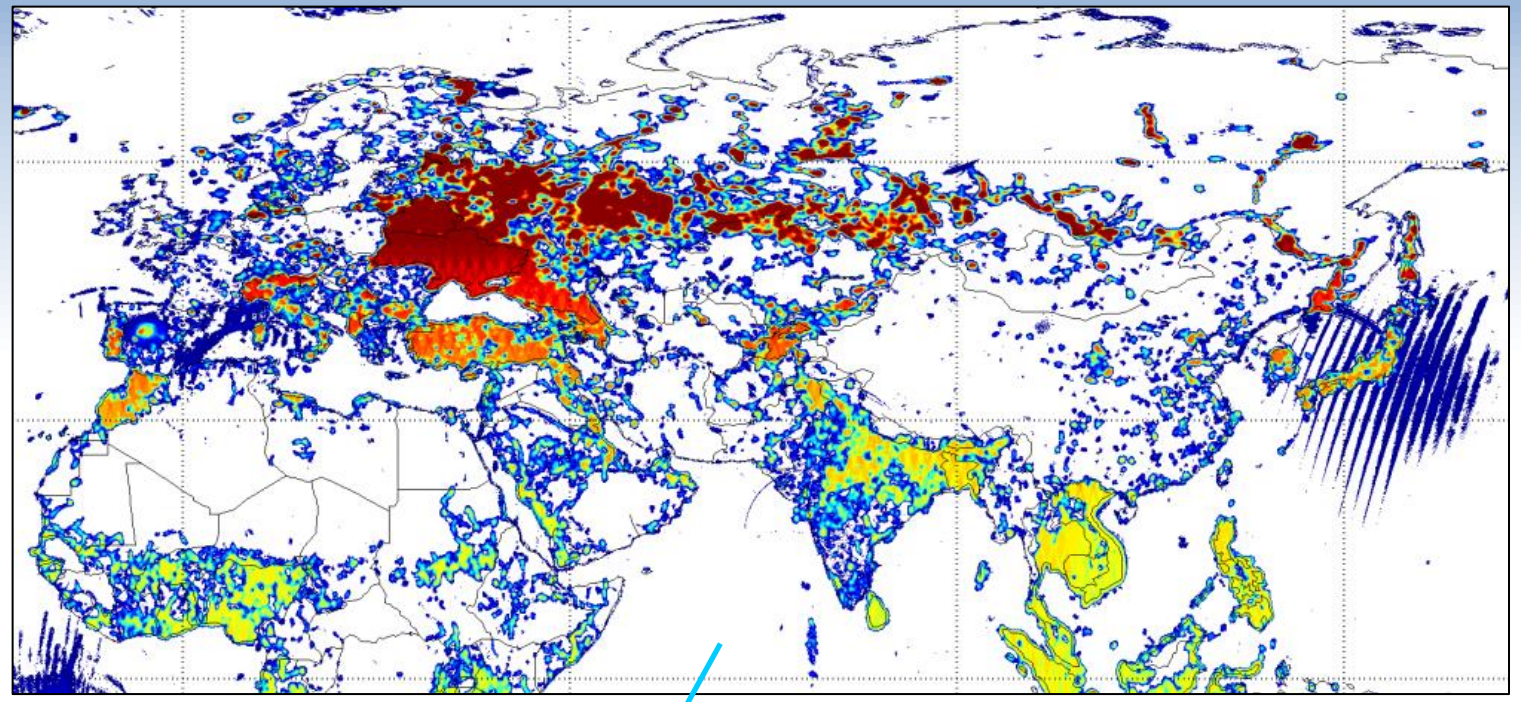
RFI sources:

1. Globalstar (satellite phone)
2. Ascension island(Ground-Satellite communication)
3. Japan, South-east Asia (ground-ground communication)

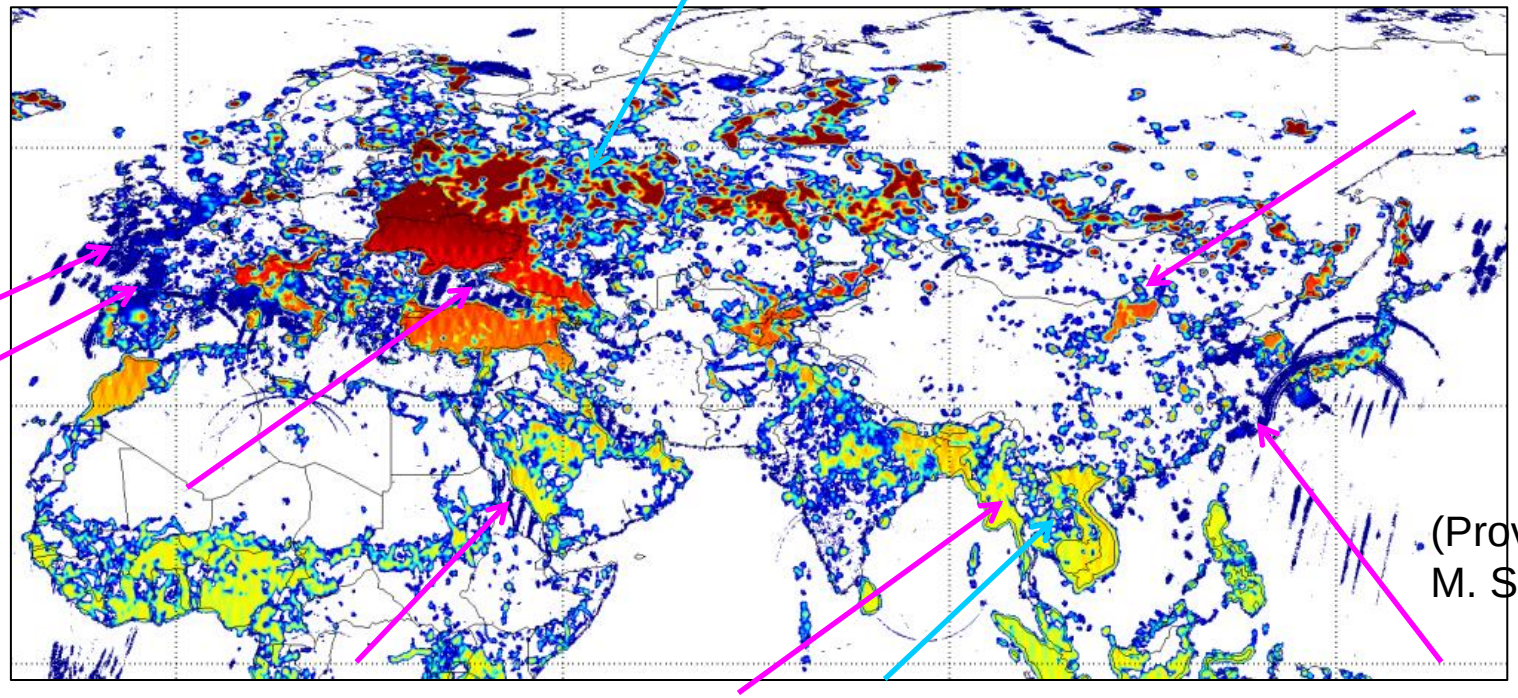
(Provided by JAXA & M. Seki, RESTEC)

Annual variation of AMSR2 C-band RFI

Aug. 2012



Aug. 2018



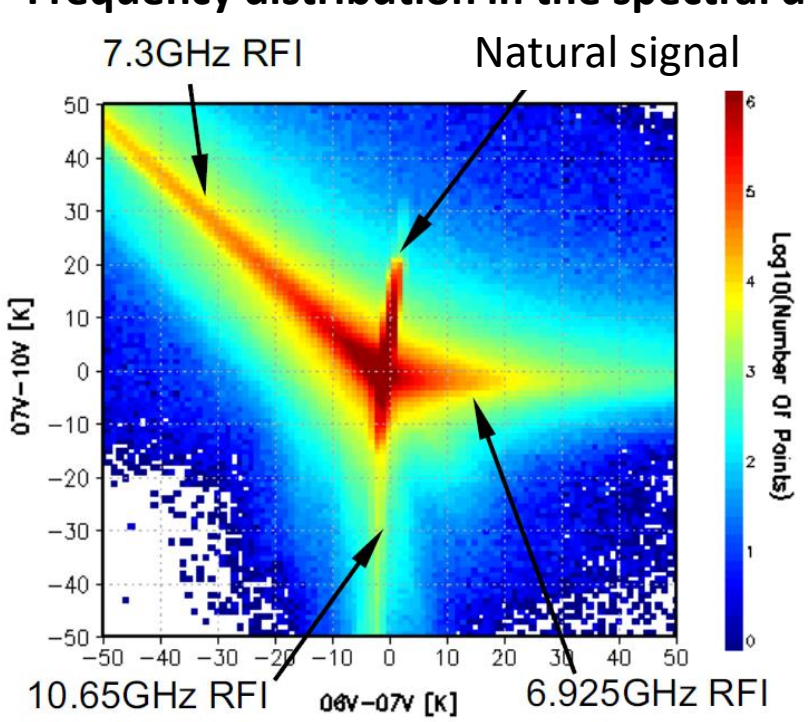
Increased
Decreased

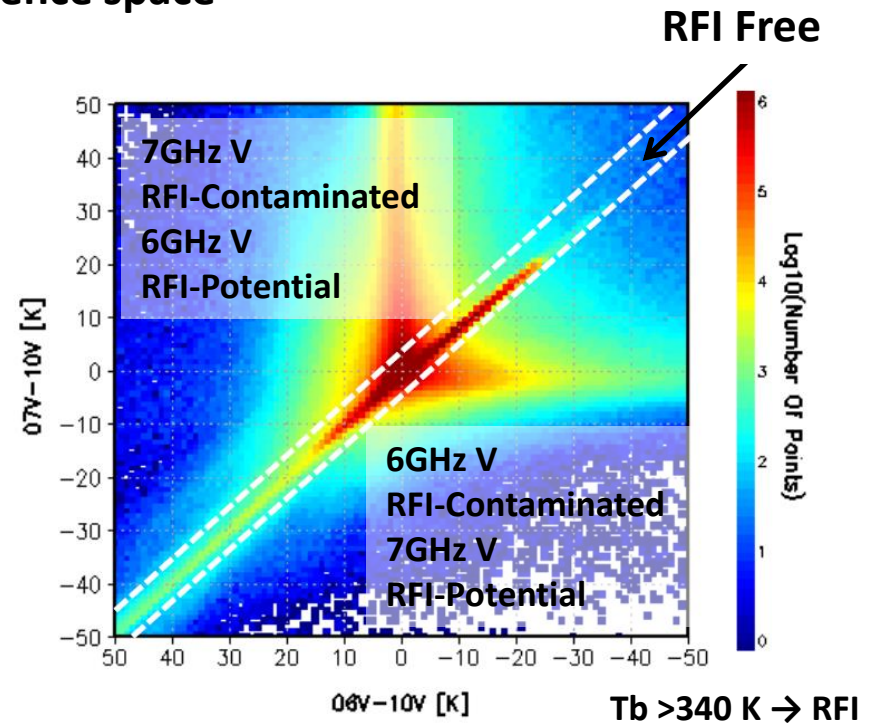
(Provided by JAXA & M. Seki, RESTEC)

AMSR2 C-band RFI (6.925 and 7.3 GHz)

- RFI signals from human activity are strong and narrow compared to natural signal. Either one channel can detect the RFI signal.
- RFI flags are added for C-band channels in AMSR2 Level 1B data
- Determination of RFI flagging is based on the spectral differences

Frequency distribution in the spectral difference space





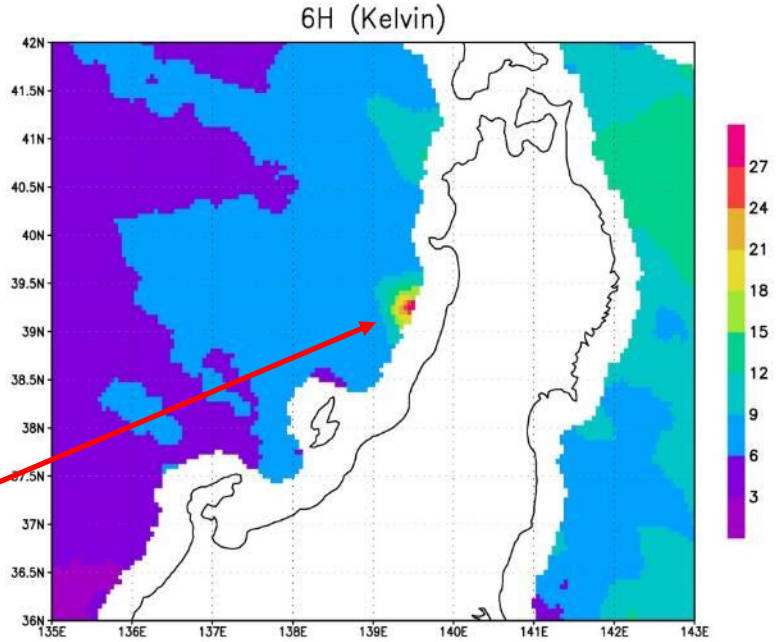
(Provided by K. Imaoka, JAXA (current affiliation: Yamaguchi Univ.))

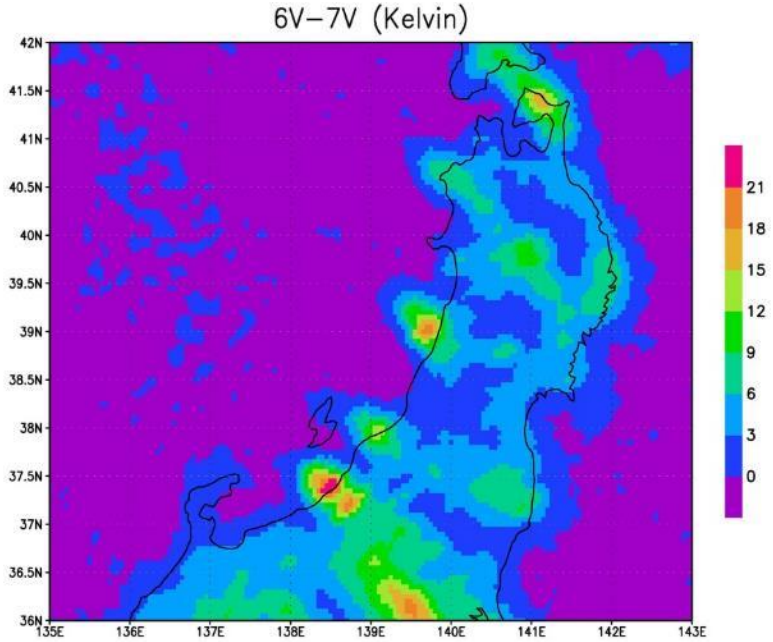
Leakage of RFI from land to ocean (6H)

AMSR2 L1 Tb difference

6 GHz H-pol.

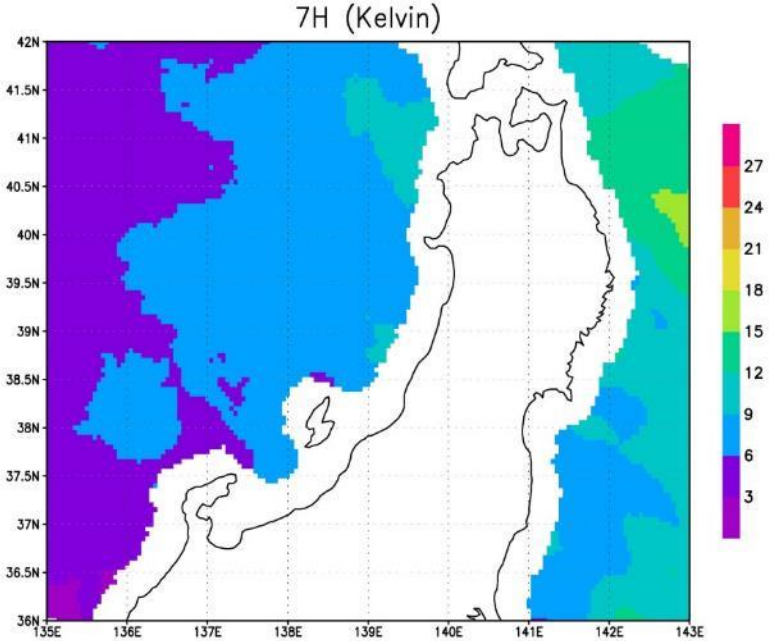
RFI can affect SST retrieval accuracy





AMSR2 20160101_202A

7 GHz H-pol.



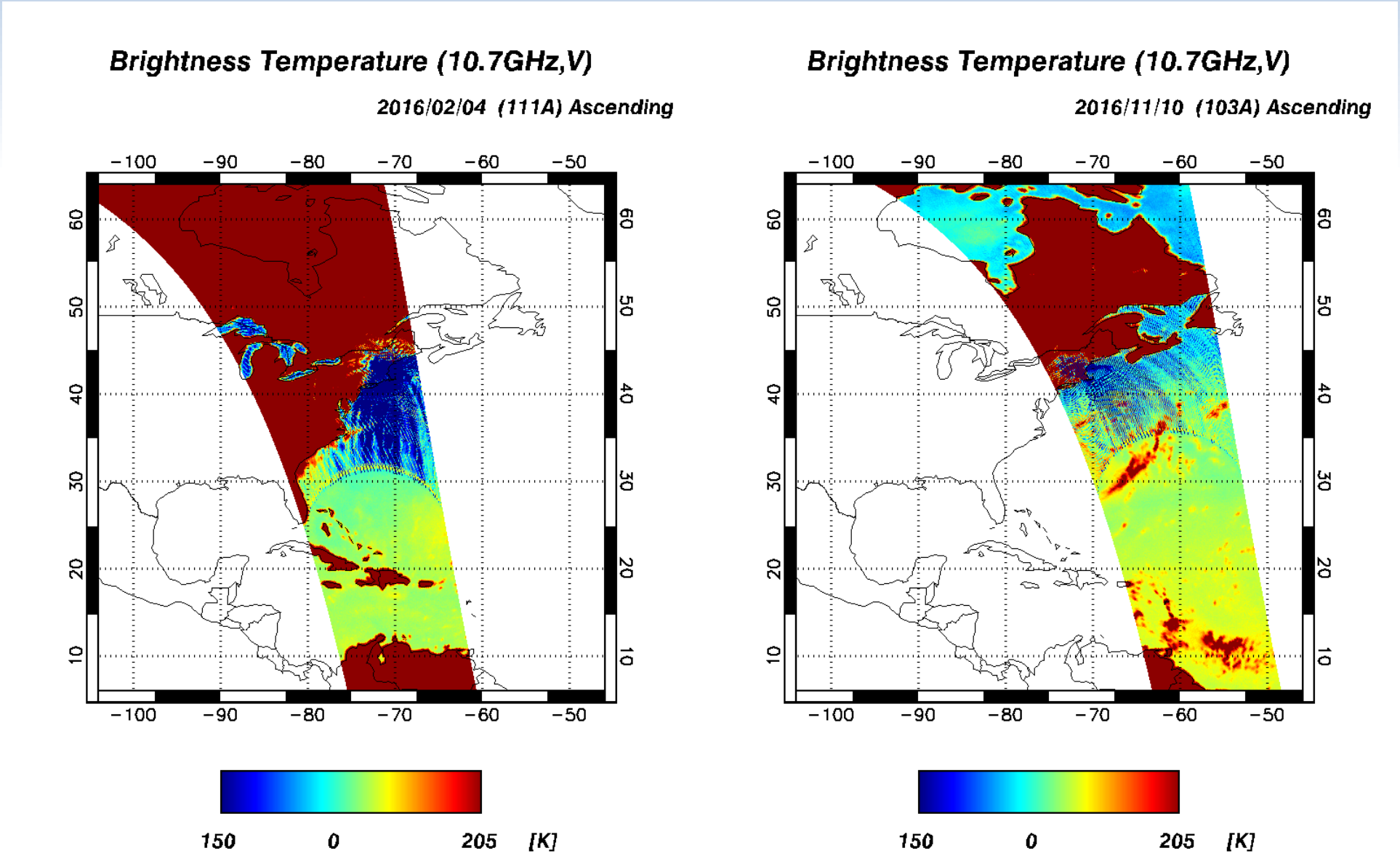
Tb with atmospheric correction.

6 GHz H-pol. RFI around coastline of Japan.
No RFI for 7 GHz H-pol. in this case.

The RFI signals are observed continuously.
Probably, the leakage of electromagnetic wave from ground communication.

(Provided by A. Shibata, RESTEC)

AMSR2 X-band RFI (10.7GHz)



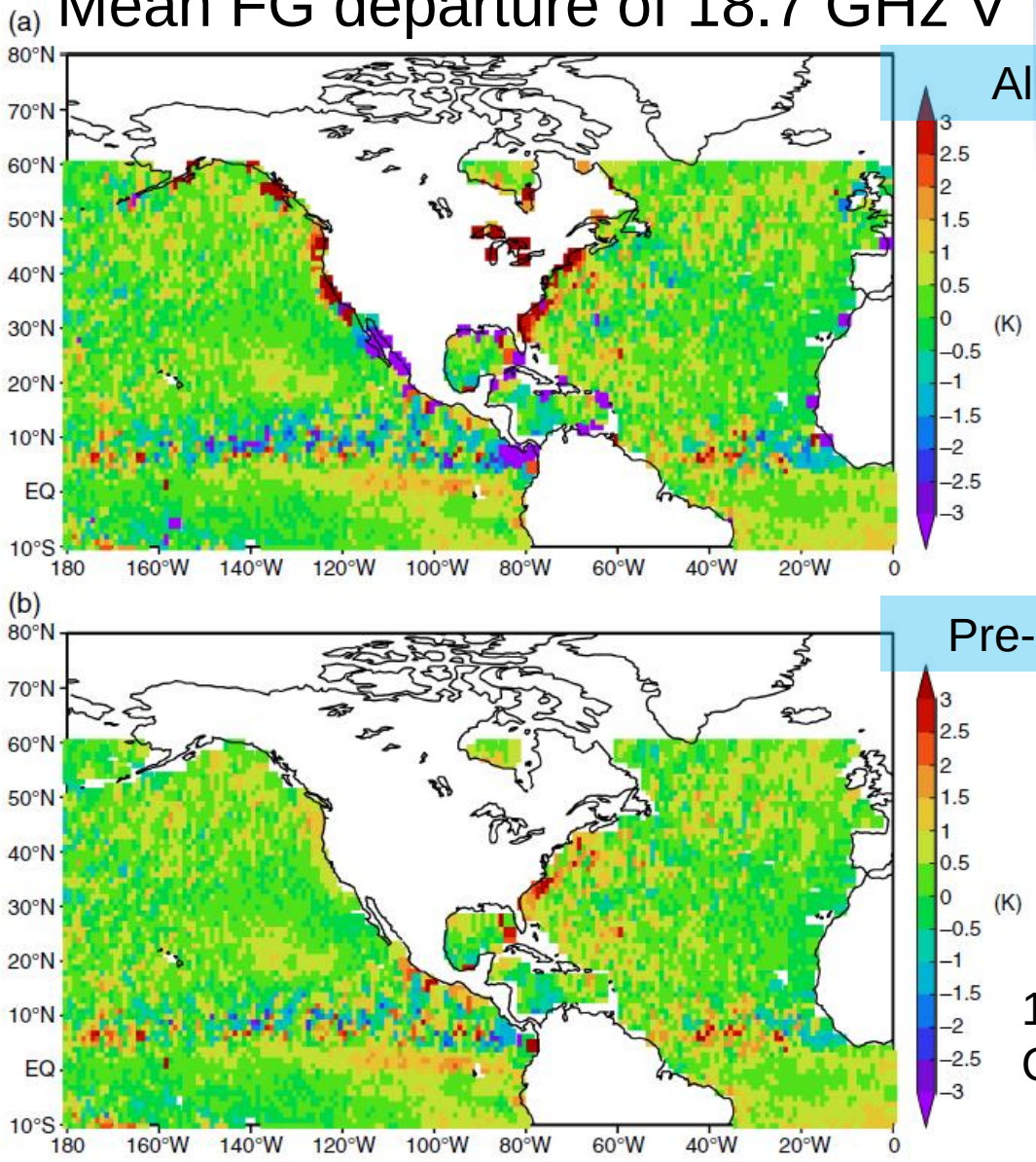
RFI contamination from a ground station. It causes degradation of data quality. (Provided by A. Shibata, RESTEC)

AMSR2 K-band RFI (18.7GHz)

In the AMSR2 18.7 GHz channels, RFI contamination was found in coastal areas of the United States in the descending orbit data.

One of the main sources is reflected microwave signals from geostationary satellites.

Mean FG departure of 18.7 GHz V



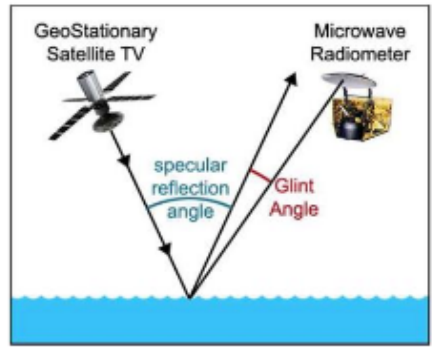
15 July to 15 October, 2013.

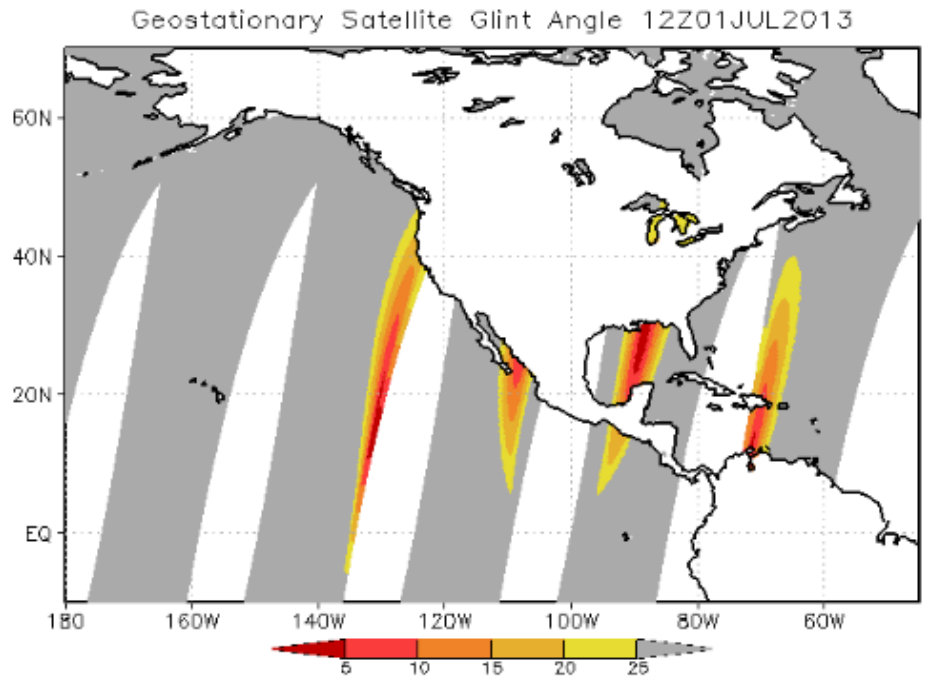
M. Kazumori et al. 2016: "Effects of all-sky assimilation of GCOM-W/AMSR2 radiances in the ECMWF numerical weather prediction system", *Q. J. R. Meteorol. Soc.* **142**: 721-737.

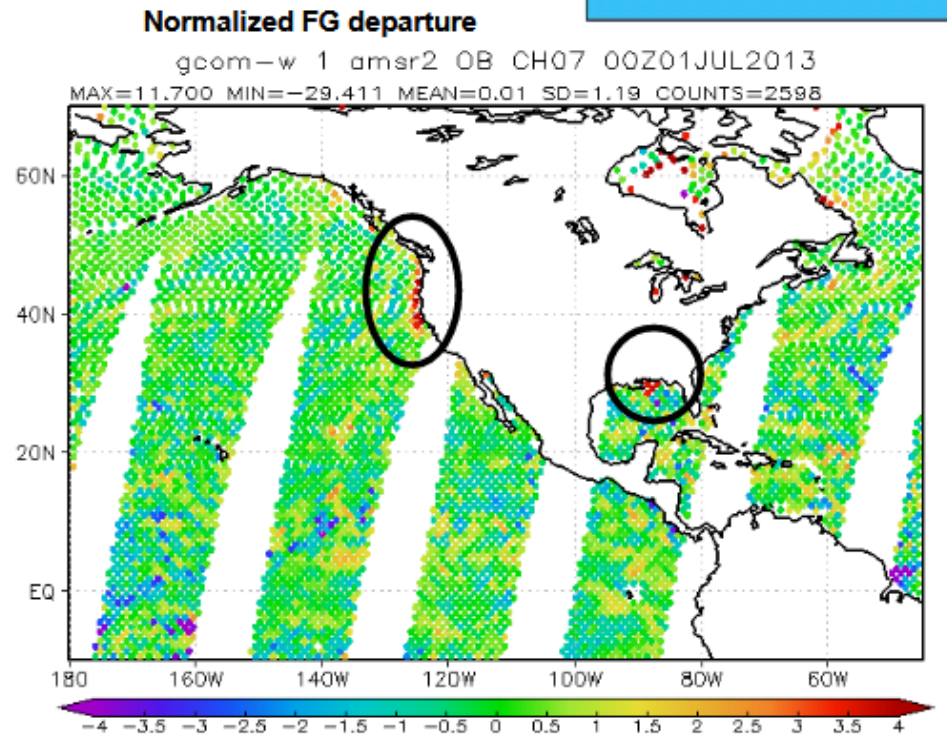
Figure 2. Mean AMSR2 19 GHz V FG departure distributions from 15 July–15 October 2013. (a) All ocean data, (b) pre-screened data.

AMSR2 K-band RFI (18.7GHz)

- The source of RFI contamination in descending AMSR2 18.7 GHz vertically and horizontally polarized channels is broadcasting activities from DirecTV satellite 10 in geosynchronous orbit at 102.8 West Longitude.
- RFI is identified in the U.S. coast and the intensity is affected by glint angle, geographic location, and surface roughness.







Summary

- Various meteorological observations using microwave spectrum are operationally used in JMA NWP systems.
- Observations from space-based passive microwave instruments have significant impact on the accuracy of NWP. These are crucial data source for NWP.

- Various types of RFI in AMSR2 observations are identified in the C, X and K band channels.
- RFI can affect the accuracy of the products and NWP.

- To maintain the accuracy of NWP, it is necessary to pay close attention to the impact of RFI.