

Risks of RFI with environmental satellite sensing based on spectrum proceedings and regulations

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RFI and Frequency Management

- **ITU (International Telecommunication Union) WRC (World Radio Conference)** is held every four years to update the **RR (Radio Regulation)**:
 - **RR** is the international treaty governing the use of the radio-frequency spectrum and the geostationary-satellite and non-geostationary-satellite orbits.
 - Revisions are made on the basis of an agenda determined by the ITU Council, which considers recommendations made by previous world radiocommunication conferences.
- **The general scope of the agenda of World Radiocommunication Conferences is established four to six years in advance, with the final agenda set by the ITU Council** two years before the conference, with the concurrence of a majority of Member States.



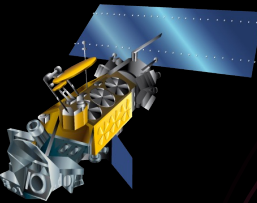
Some technical ITU jargon

- RR 5.340 – All emissions prohibited
 - Including (but not exclusively) **23.6-24 GHz**, 31.3-31.5 GHz (or 31.8 GHz for Americas), **50.2-50.4 GHz**, **52.6-54.25 GHz**, 86-92 GHz, 100-102 GHz, 109.5-111.8 GHz, 114.25-116 GHz, 148.5-151.5 GHz, 164-167 GHz, 182-185 GHz, 190-191.8 GHz, 200-209 GHz, 226-231.5 GHz, 250-252 GHz
 - In the United States, implemented as Allocation Table footnote US246
- Res. 750 – Addresses compatibility between the Earth exploration-satellite service (EESS, passive) and relevant active services



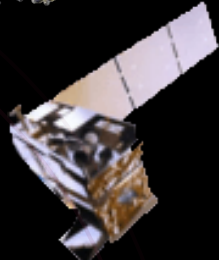
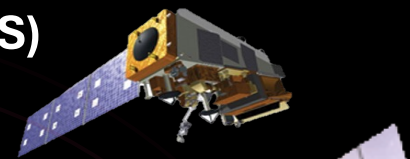
Satellites with Microwave Sensors

19.350 GHz
22.235 GHz
37 GHz
50.3 GHz
50.5 GHz
52.8 GHz
53.2 GHz
53.596 GHz
54.35 GHz
54.4 GHz
54.9 GHz
55.5 GHz
57.290 GHz
58.4 GHz
58.825 GHz
59.4 GHz
60.793 GHz
63.283 GHz
91.655 GHz
150 GHz
183.31 GHz

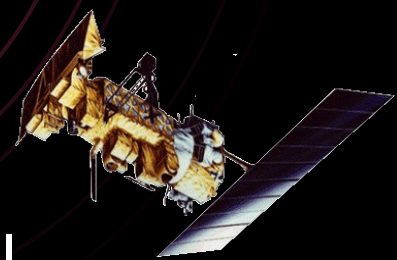


**DMSP
(SSMIS)**

**JPSS/NOAA-20/21
(ATMS)**



**SNPP
(ATMS)**



**POES/Metop
(AMSU-A)**

23.8 GHz
31.4 GHz
50.3 GHz
51.76 GHz
52.8 GHz
53.596 GHz
54.4 GHz
54.94 GHz
55.5 GHz
57.290 GHz
89.5 GHz
165.5 GHz
183.31 GHz

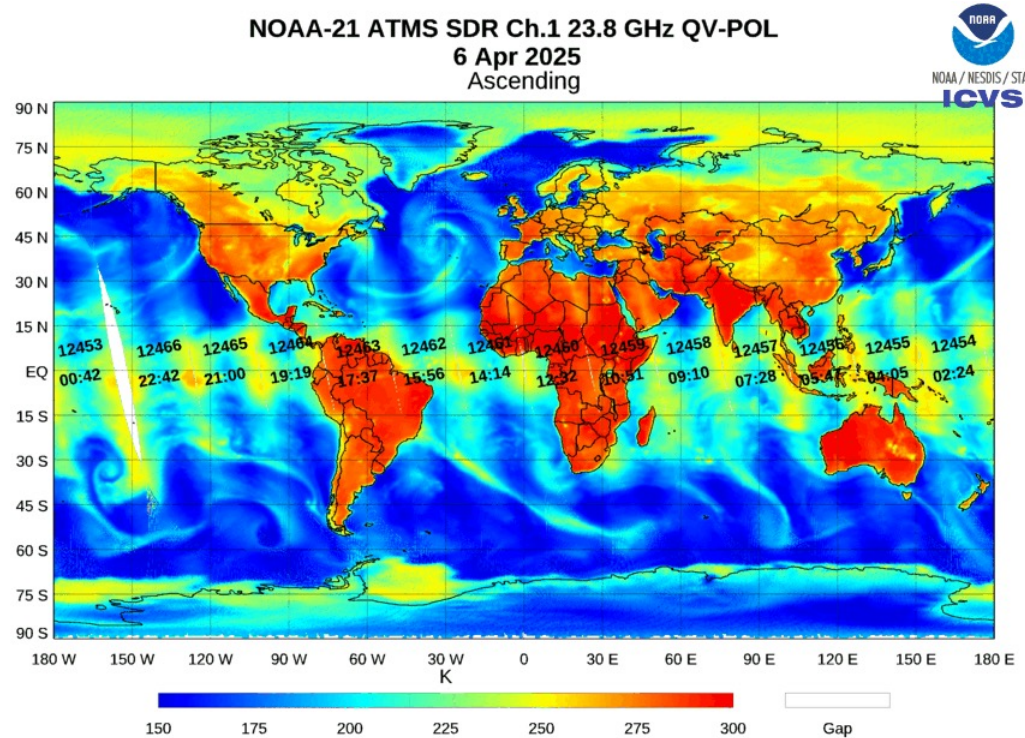
23.8 GHz | 31.4 GHz | 50.3 GHz | 52.8 GHz |
53.596 GHz | 54.4 GHz | 54.94 GHz | 55.5 GHz | 57.290 GHz |
89 GHz | 157 GHz | 183.31 GHz | 190.311 GHz



24 GHz

Primary application:

Total column water vapor



AMSU -A	ATMS	Central Frequency (GHz)	Bandwidth (MHz)	NWP Centers
1	1	23.800	270	Few
2	2	31.400	180	Few
3	3	50.300	180	Few
	4	51.760	400	Few
4	5	52.800	400	Some
5	6	53.596 ± 0.115	170	Most
6	7	54.400	400	All
7	8	54.940	400	All
8	9	55.500	330	All
9	10	f0 = 57.290344	330	All
10	11	f0 ± 0.217	78	Most
11	12	f0 ± 0.3222 ± 0.048	36	Most
12	13	f0 ± 0.3222 ± 0.022	16	Most
13	14	f0 ± 0.3222 ± 0.010	8	Most
14	15	f0 ± 0.3222 ± 0.0045	3	Most



WRC 2019

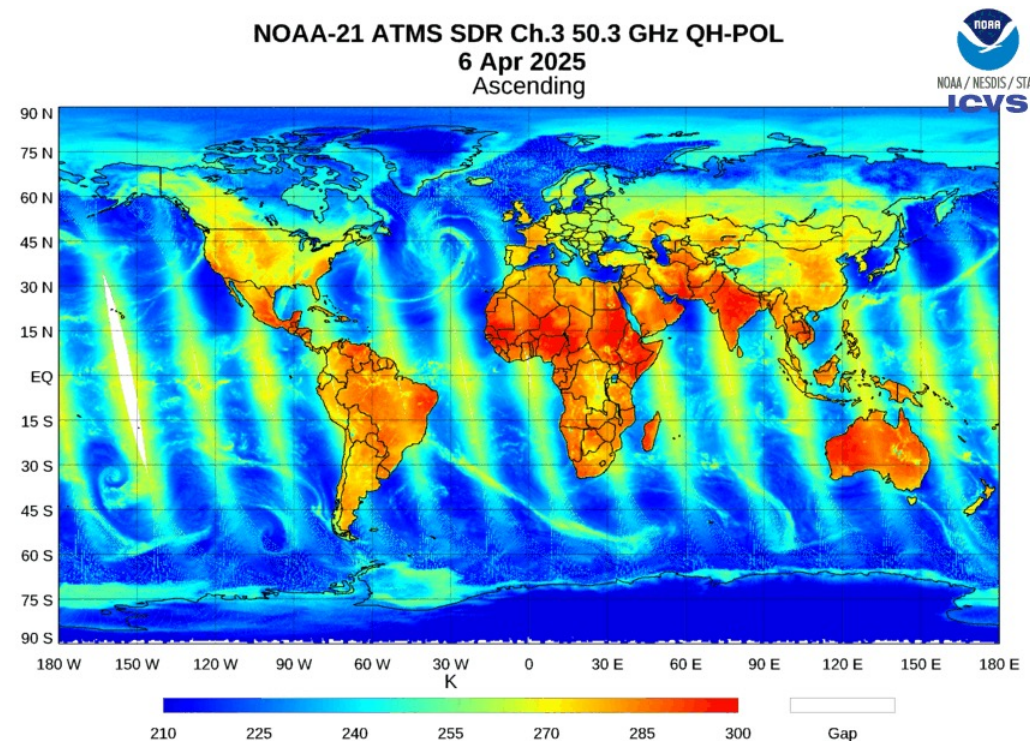
Agenda item 1.13: IMT at 26 GHz

- Resolution **750 (Rev.WRC-19)** establishes limits on unwanted emissions in the frequency band 23.6-24 GHz from IMT base stations and IMT mobile stations within the frequency band 24.25-27.5 GHz.
- **Base stations:** Limit of -39 dB (W/200 MHz) will apply to IMT base stations brought into use after 1 September 2027.
 - This limit will not apply to IMT base stations which have been brought into use prior to this date.
 - For those IMT base stations, the limit of -33 dB (W/200 MHz) will continue to apply after this date.
- **Mobile stations:** Limit of -35 dB (W/200 MHz) will apply to IMT mobile stations brought into use after 1 September 2027.
 - This limit will not apply to IMT mobile stations which have been brought into use prior to this date.
 - For those IMT mobile stations, the limit of -29 dB (W/200 MHz) will continue to apply after this date.



36-54 GHz

Primary application:
Low-level rain water, temperature



AMSU -A	ATMS	Central Frequency (GHz)	Bandwidth (MHz)	NWP Centers
1	1	23.800	270	Few
2	2	31.400	180	Few
3	3	50.300	180	Few
	4	51.760	400	Few
4	5	52.800	400	Some
5	6	53.596 ± 0.115	170	Most
6	7	54.400	400	All
7	8	54.940	400	All
8	9	55.500	330	All
9	10	$f_0 = 57.290344$	330	All
10	11	$f_0 \pm 0.217$	78	Most
11	12	$f_0 \pm 0.3222 \pm 0.048$	36	Most
12	13	$f_0 \pm 0.3222 \pm 0.022$	16	Most
13	14	$f_0 \pm 0.3222 \pm 0.010$	8	Most
14	15	$f_0 \pm 0.3222 \pm 0.0045$	3	Most



WRC 2027

Agenda Item 1.6: Fixed Satellite (FSS)

- **This item covers technical and regulatory measures for fixed-satellite networks/systems in the frequency bands 37.5-42.5 GHz (space-to-Earth), 42.5-43.5 GHz (Earth-to-space), 47.2-50.2 GHz (Earth-to-space) and 50.4-51.4 GHz (Earth-to-space) to establish equitable access to these frequency bands.**
- The scope should be limited to addressing equitable access between FSS operators and should not result in any changes that will impact science interest, but FSS issues with EESS (passive) in the bands 36-37 GHz and 50.2-50.4 GHz may remain.



WRC 2027

Agenda Item 1.1: ESIM at 50 GHz

- **This item is to study the use of the frequency bands 47.2-50.2 GHz and 50.4-51.4 GHz in the Earth-to-space direction by aeronautical and maritime Earth stations in motion (ESIMS) communicating with GeoStationary Orbit (GSO) and Non-GeoStationary Orbit (NGSO) space stations operating in the fixed-satellite service (FSS).**
- Potential for increased interference to the EESS (passive) operating in the adjacent frequency band 50.2-50.4 GHz. The protection of the EESS (passive) in the adjacent frequency band 50.2-50.4 GHz continues to be ensured through mandatory unwanted emission limits in Resolution **750**.



WRC 2027

Agenda Item 1.3: Fixed Satellite (FSS)

- This item revises conditions on the use of the primary allocation for 51.4-52.4 GHz to enable use by gateway Earth stations transmitting (Earth-to-space) to NGSO systems in the FSS.
- Risk of a potential for increased interference to the EESS (passive) in the 52.6-54.25 GHz frequency band.
 - In the 52.6-54.25 GHz band, both footnote RR No. **5.340** and Resolution **750** apply.
 - Resolution **750 (Rev.WRC-19)**: Unwanted emissions limits are applicable to GSO FSS (Earth-to-space) networks in the band 51.4-52.4 GHz for the protection of EESS (passive) in the band 52.6–54.25 GHz.

WRC 2027

Agenda Item 1.18

This item intends to address the protection of EESS (passive) and radio astronomy in a number of bands above 76 GHz from unwanted emissions from active services operating in adjacent or nearby bands (through new allocations and RR No. 5.340).

ATMS	GMI	Central Frequency (GHz)	Bandwidth (MHz)	NWP Centers
16		88.2	2000	Few
	8 / 9	89.0 (V / H)	6000	Few
17		165.5	3000	Few
	10 / 11	166.5 (V / H)	4000	Few
18	13	183.31 ± 7.0	2000	Most (Sounder), Few (Imager)
19		183.31 ± 4.5	2000	Most
20	12	183.31 ± 3.0	1000 / 2000	All (Sounder), Few (Imager)
21		183.31 ± 1.8	1000	Most
22		183.31 ± 1.0	500	All



EESS Application vs. Adjacent Active Service

EESS Passive Band	Application	Active Service Band	Active Service
86-92 GHz	Precipitation, Sea ice	81-86 GHz	Fixed satellite (E-S), mobile
		92-04 GHz	Mobile, radiolocation
114.25-116 GHz	Temperature profiling	111.8-114.25 GHz	Fixed, mobile
164-167 GHz	Water vapor profiling	158.5-164 GHz	Fixed, fixed satellite (S-E), mobile, mobile satellite
		167-174.5 GHz	Fixed, fixed satellite (S-E), inter-satellite, mobile
200-209 GHz	Water vapor	191.8-200 GHz	Fixed, inter-satellite, mobile, mobile satellite, radionavigation and RNSS
		209-217 GHz	Fixed, fixed satellite (E-S), mobile



229-244 GHz

Primary application:
Ozone, cirrus clouds

Satellite	Agency	Launch	End of Life	Inst.	Frequency (GHz)	Bandwidth (MHz)	Application
Metop-SG-A1-3	EUMETSAT	≥2025	≥2037	MWS	229	2000	Window/Cirrus Clouds
Aura	NASA	2004	≥2025	MLS	230.5432	10	CO/Ozone
					230.5432	1250	CO/Ozone
					233.9515	1250	Ozone
					235.7151	10	Ozone
					235.7151	1250	Ozone
					239.66	15600	Ozone
Metop-SG-B1-3	EUMETSAT	≥2026	≥2048	ICI	243.2	8000	Window/Cirrus Clouds



WRC 2023

Agenda Item 1.14: EESS

- **Adjustment to the EESS allocation in the band 231.5-252 GHz:** The bands 239.2-242.2 GHz and 244.2-247.2 GHz could accommodate an allocation for passive sensors detecting cloud ice.
- To limit constraints on existing fixed and mobile services in the 239.2-242.2 GHz band, Europe proposed a “win-win” exchange of bands for these two services.
- Mobile and fixed services are therefore allocated in the 235-238 GHz band.
 - They cannot be constrained by the already existing EESS (limb sounder).



WRC 2027

Agenda Item 1.8: Radiolocation

- This item would establish additional spectrum allocations for radiolocation in 231.5-275 GHz and possible new identifications for radiolocation applications for millimetric and sub-millimetric wave imaging systems in 275-700 GHz.
- Potential that frequency bands under study will overlap, or be adjacent to, frequency bands allocated to EESS (passive) below 275 GHz or identified for EESS (passive) above 275 GHz:
 - 226-231.5 GHz is allocated to Space Research Service (SRS)/EESS (passive) and is subject to RR No. **5.340**
 - 235-238 GHz is allocated to EESS (passive) and SRS (passive) limited to limb sounders
 - 250-252 GHz is allocated to EESS (passive) and SRS (passive) and subject to RR No. **5.340**



WRC 2027

Agenda Item 1.8: Radiolocation

- No new allocations for the radiolocation service in 250-252 GHz where footnote RR No. **5.340** applies.
- No new identifications in 275-700 GHz, provided that the protection of the existing allocations to the EESS (passive and active) is ensured, from both in-band and/or out-of-band emissions of possible new radiolocation services.



Low-Latency Reception

- X-band is the single most significant spectrum portion for downlinking Earth observation data acquired by satellites.
- No current alternative to X-band downlink exists at scale, especially for LEO satellites with a geographically-dependent direct broadcast downlink.



WRC 2027

Agenda Item 1.7: IMT

The following frequency bands at 7/8 GHz are under study:

- Space Operation Service (SOS) (Earth-to-space): 7125 – 7155 MHz and 7190 – 7235 MHz
- EESS (Earth-to-space): 7190-7250 MHz
- MetSat (space-to-Earth) in 7450-7550 MHz and 7750-7900 MHz
- MetSat (Earth-to-space) in 8175-8215 MHz
- EESS (space-to-Earth) in 8025-8400 MHz

The U.S. is also studying this band as part of its National Spectrum Strategy.



Community Engagement

- Impact studies of bands in 50-54 GHz range, individually and in aggregate, for both “traditional/physical” NWP models and AI-based models are in demand.
 - Land+sea vs. only sea
- The risk of significant impacts from 50-54 GHz interference is believed to be high, especially considering the potential sources (Earth-to-space).
- Increased use and impact studies of bands at 88+ GHz would also be valuable, especially considering potential for RFI in lower MW bands and the addition of new missions.

Hyperspectral Microwave

- The U.S. is actively pursuing hyperspectral MW instrument development.
- Impacts for DA are still uncertain as the hyperspectral MW processing chain to identify RFI has not yet been demonstrated.
 - Due to hyperspectral data rates, some or all processing is likely necessary onboard spacecraft before conversion to L1+.
 - Investigations will include whether it is possible to reconstitute RFI-influenced observation from clean or cleaner spectrum.
- NEON Series 1 with Sounder for Microwave-Based Applications (SMBA) is expected to proceed on schedule for launch around 2032.

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