Overview on a growing concern in EO Missions: Frequency Management and RFI monitoring

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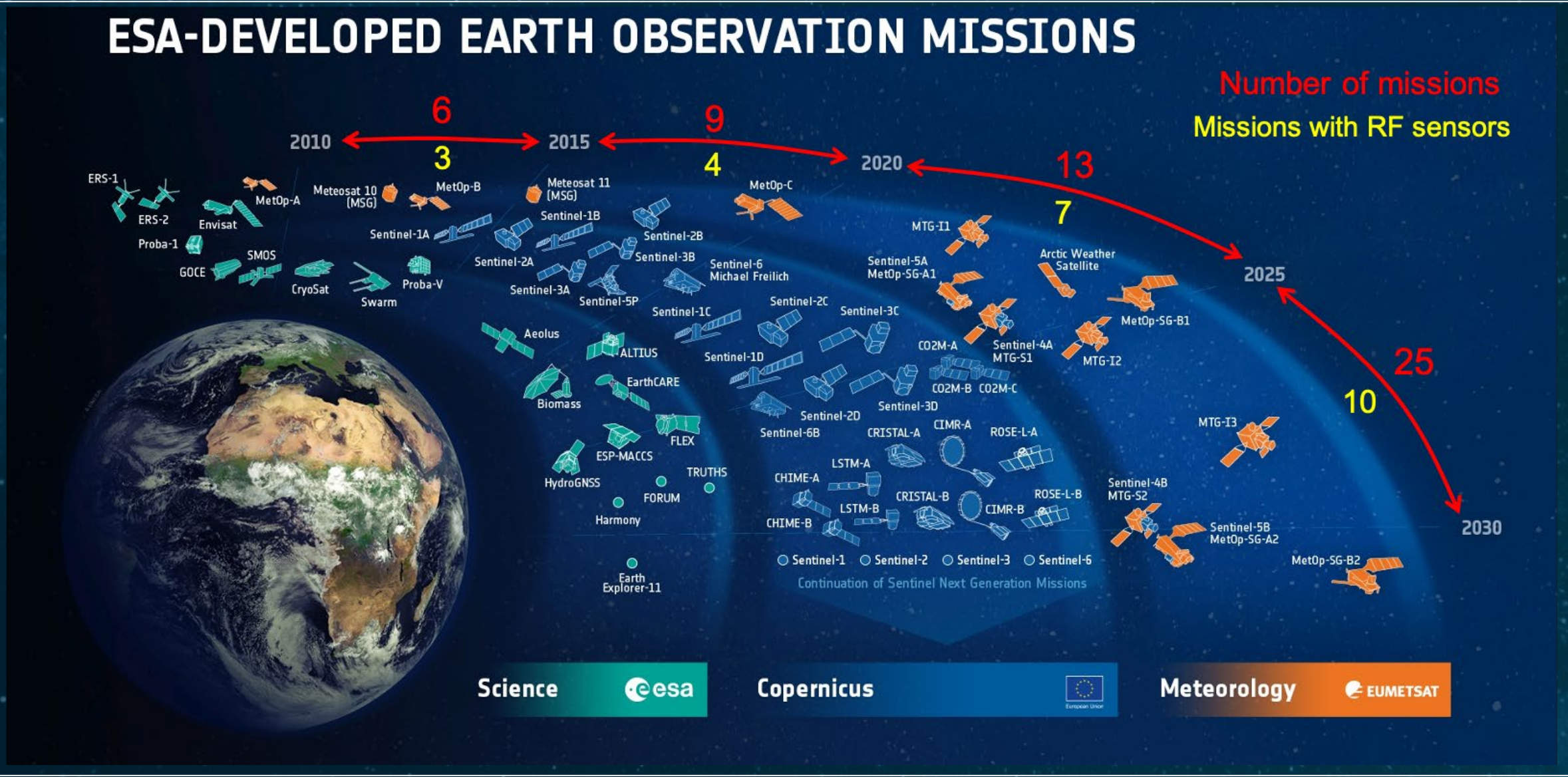
Outline

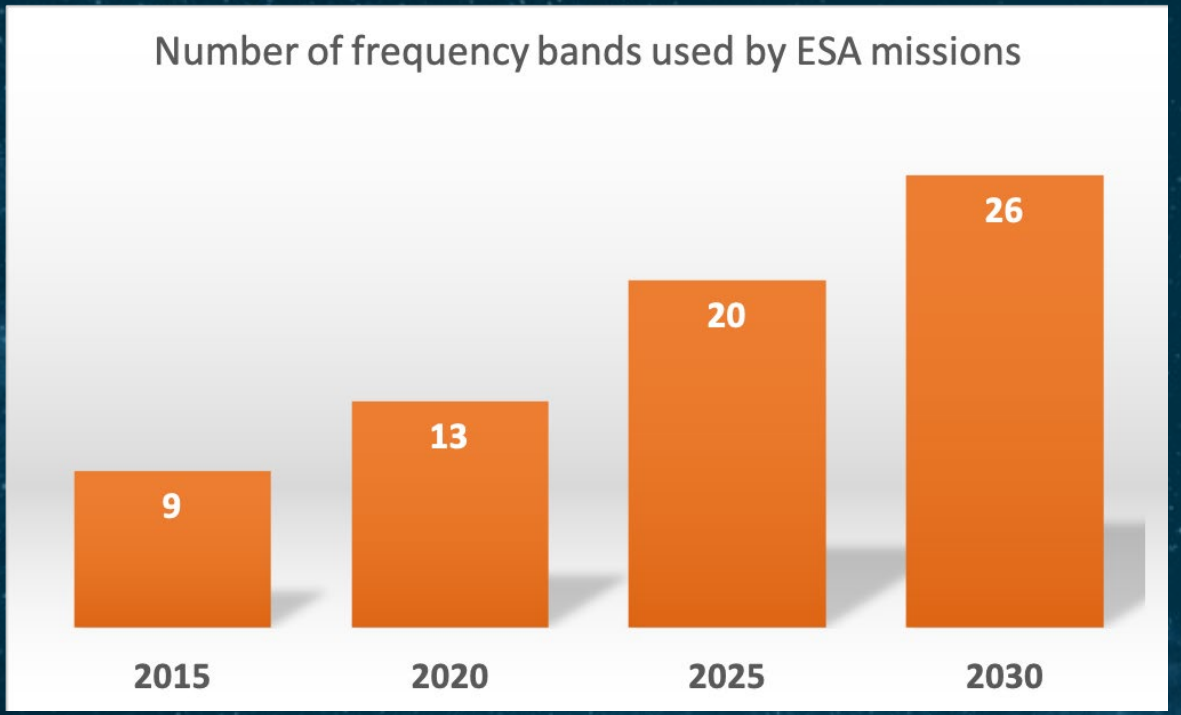
- ESA EO missions
- ESA usage of the spectrum
- RFI/Freq mgmt issues in EO bands
- Coping with RFI
- Frequency allocation process
- Select topics under discussion
    - SST measurements near 7 GHz
    - Ice cloud imagers near 243 GHz
    - 6G networks
- Conclusions & way forward

ESA EO missions



Increasing use of the spectrum

The number of ESA missions with microwave sensors is increasing, and so is ESA's presence in the spectrum.



This implies an **improved ability to observe the Earth system**.

But it also implies **more RFI issues** and the need for involvement in more frequency management activities.

Frequency usage of ESA EO missions

Freq. band [GHz]	0.432 0.438	1.215 1.300	1.400 1.427*	5.25 5.57	6.425 7.250	10.6 10.7	13.25 13.75	18.6 18.8	23.6 24.0*	31.3 31.8*	33.65 34.35	35.5 36.0	36 37	50.2 50.4*
AWS														Radiom
Biomass	SAR													
CIMR			Radiom		Radiom	Radiom		Radiom					Radiom	
CRISTAL							Altim	Radiom	Radiom		Radiom	Altim		
CryoSat-2							Altim							
EarthCARE														
Harmony				SAR										
MetOp				Scatt					Radiom	Radiom				Radiom
MetOp-SG-A									Radiom	Radiom				Radiom
MetOp-SG-B				Scatt				Radiom	Radiom	Radiom				Radiom
ROSE-L		SAR												
Sentinel-1				SAR										
Sentinel-1 NG				SAR										
Sentinel-3				Altim			Altim		Radiom				Radiom	
Sentinel-6				Altim			Altim	Radiom	Radiom		Radiom			
SMOS			Radiom											
Main issues	Exclu-sion zones	RFI + avoid inter-fering	Terres-trial RFI	Space-borne & Terres-trial RFI	No alloca-tion	RFI + Space-borne OOBE		Space-borne & Terres-trial RFI	RFI + 5G (WRC-19)		Powerful military radars (e.g. KREMS)		Military radars & other RFI	
Missions	Biomass	ALOS2, SMAP	SMOS, SMAP	S1, RCM	AMSR-E, -2	AMSR-E, -2		GMI	Jason-1 and -2		CRISTAL, S6		S3	

Frequency usage of ESA EO missions

Freq. band [GHz]	52.6 59.3	86 92*	94.0 94.1	114.25 122.25	127.5 132.5	155.6 158.4	164 167*	165.5 170.5	174.8 191.8	226.0 231.5*	239.2 247.2	313 356	439 467	657 692
AWS	Radiom	Radiom					Radiom		Radiom			Radiom		
Biomass														
CIMR														
CRISTAL		Radiom			Radiom			Radiom						
CryoSat-2														
EarthCARE			CPR											
Harmony														
MetOp	Radiom	Radiom				Radiom			Radiom					
MetOp-SG-A	Radiom	Radiom					Radiom		Radiom	Radiom				
MetOp-SG-B	Radiom	Radiom		Radiom			Radiom		Radiom		Radiom	Radiom	Radiom	Radiom
ROSE-L														
Sentinel-1														
Sentinel-1 NG														
Sentinel-3														
Sentinel-6		Radiom			Radiom			Radiom						
SMOS														
Main issues		FOD + RSTT	FOD + RSTT + Protect RAS	6G + short range devices in Europe + no allocation (for some)							6G + WRC23 AI 1.14			
Missions		AWS, MetOp	Earth-CARE	AWS, CRISTAL, MetOp, S6							MetOp-SG			

Coping with RFI

After RFI occurs (see Ekhi's presentation!):

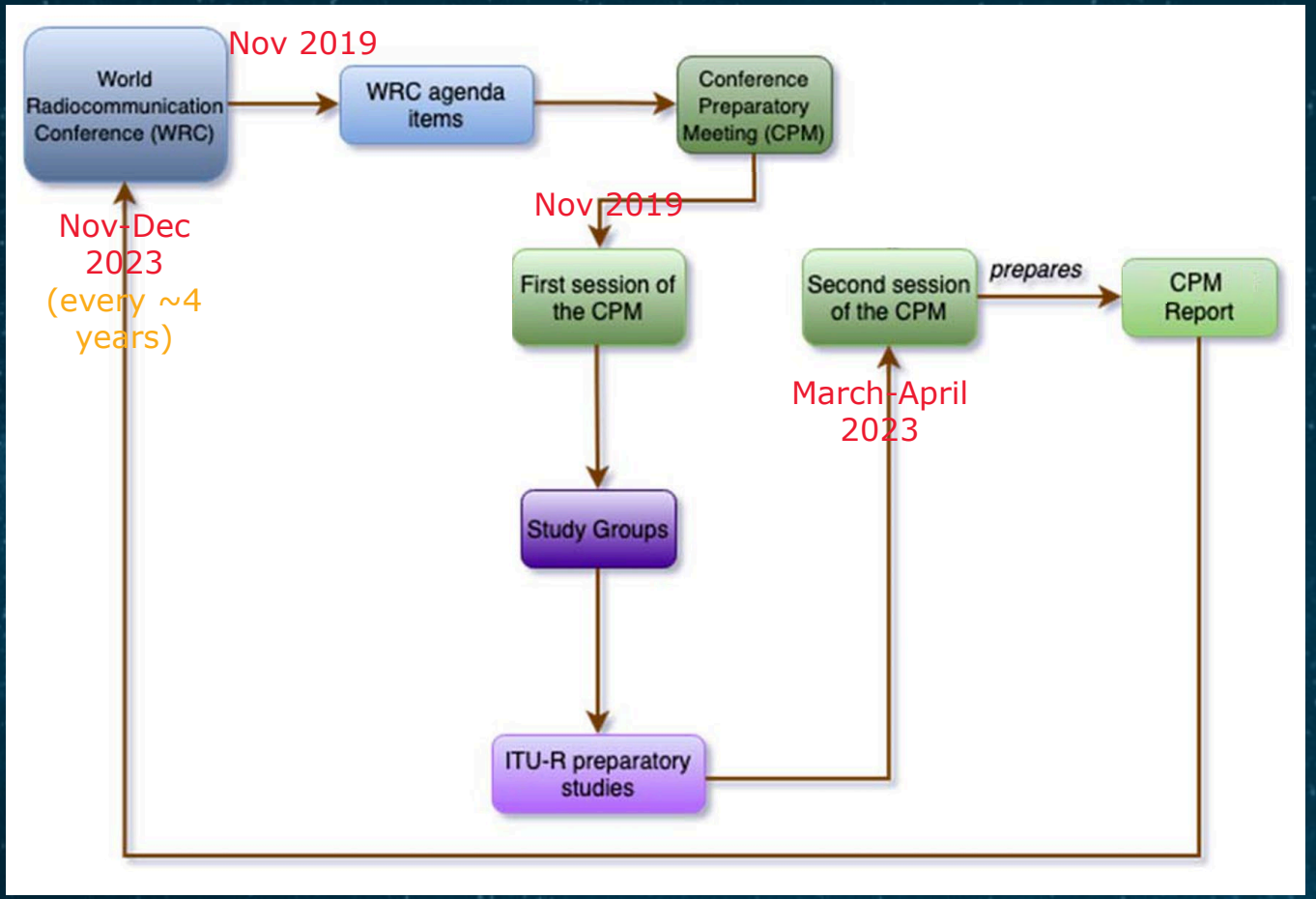
- RFI detection → Improve the quality of the data as much as possible
- RFI reporting → May lead to switching off RFI

Before RFI occurs:

- **Influence decisions on frequency regulations**
  - Contributions to frequency management activities in ITU and CEPT
  - Coordination with other space agencies (e.g. EUMETSAT, NASA, NOAA, JAXA) → SFCG
  - Coordination with administrations and institutions (e.g. ECMWF, EC DG-DEFIS)
- Carry out system analysis activities
  - Develop new HW/SW solutions
  - Support future missions (e.g. RF filter design)

Frequency allocations process

Spectrum is allocated to “services” by the WRC (World Radiocommunications Conference).



Select topics under discussions

Topic	Threat vs opportunity	Goals
Future of **SST** measurements	Threat	Ensure long-term solution for SST measurements
WRC23: AI 1.12 (satellite radars sounders at **45 MHz**)	Opportunity	Get new secondary allocation
WRC23: AI 1.14 (ice clouds imagers near **243 GHz**)	Opportunity	Get new primary allocation
WRC23: AI 1.16 (NGSO ESIM near **18 GHz**)	Threat	Protect passive sensors in the 18.6-18.8 GHz band
WRC23: AI 1.17 (Inter-satellite links near **18 GHz**)	Threat and opportunity	1) Protect passive sensors at 18.6-18.8 GHz 2) Assess opportunities for future EO missions
6G mobile networks	Threat	Protect EO sensors

Select topics under discussions (3 examples)

Topic	Threat vs opportunity	Goals
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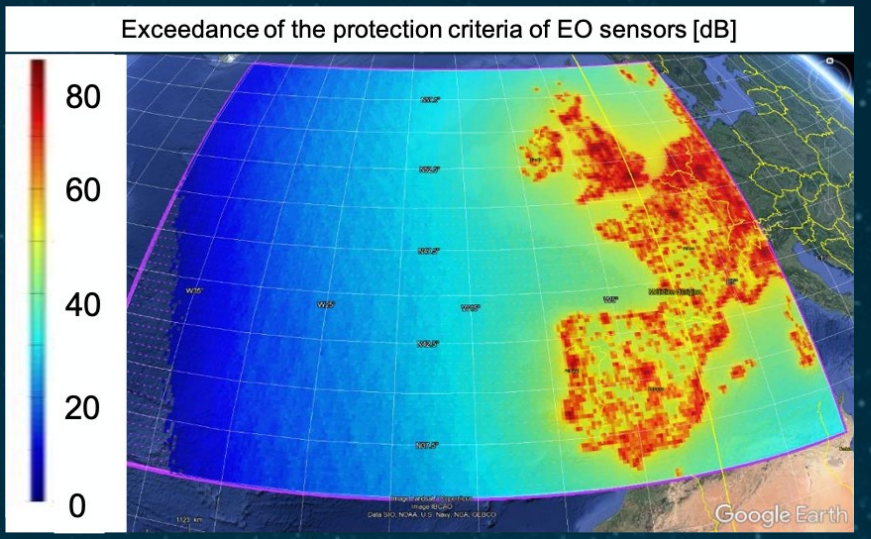
6G mobile networks	Threat	Protect EO sensors

Future of SST measurements

SST measurements are carried out near 7 GHz.

But **5G** in 6.425-7.125 GHz (WRC-23 AI 1.2) would affect measurements up to **~2000 km** away from the coast.

And **WiFi 6E** is targeting the same band!

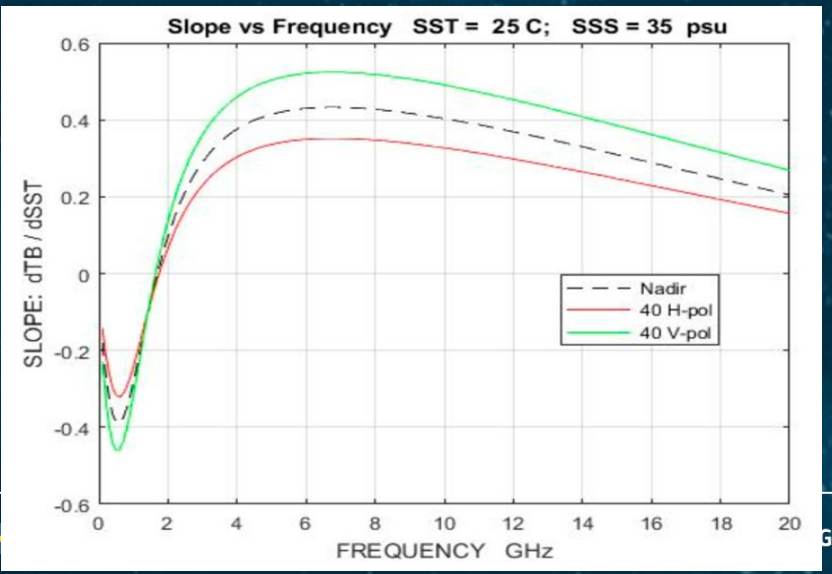


Credit: ANFR/French contribution to ITU (7C/306)

No allocation to EO near 7 GHz.

Discussion started in ITU on potential new EO allocation in the 4-10 GHz range for SST measurements.

Le Vine and Dinnat, 2020



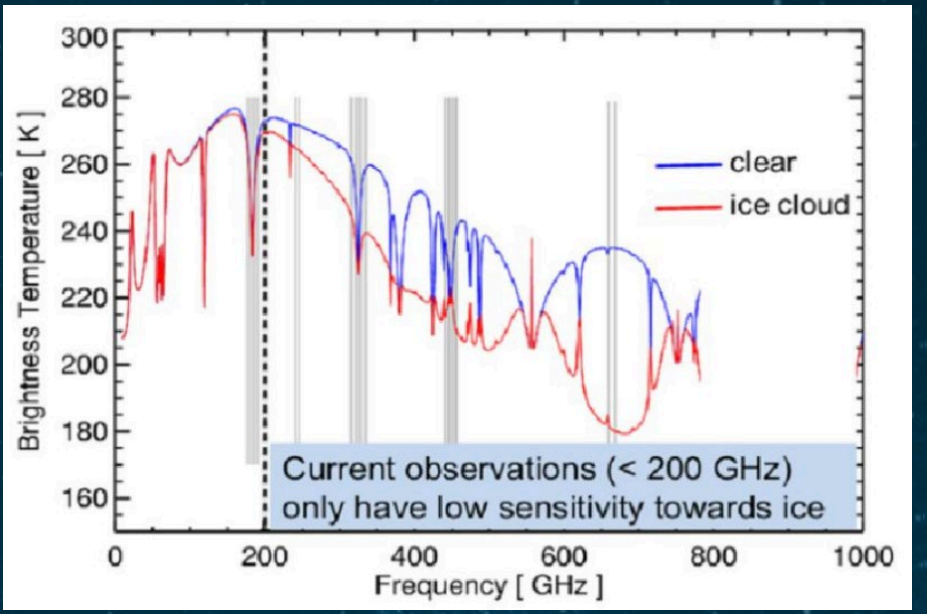
Ice cloud imagers near 243 GHz (AI 1.14)

Goal of ICI (Ice Cloud Imager), on MetOp-SG-B: use the band 239-247 GHz, where there is sensitivity to ice clouds.

But if the Mobile/Fixed services deploy systems in that band, they would interfere with ICI.

Proposal: move the Fixed and Mobile allocations to another band, where they will have more spectrum.

Bergadá et al., 2016

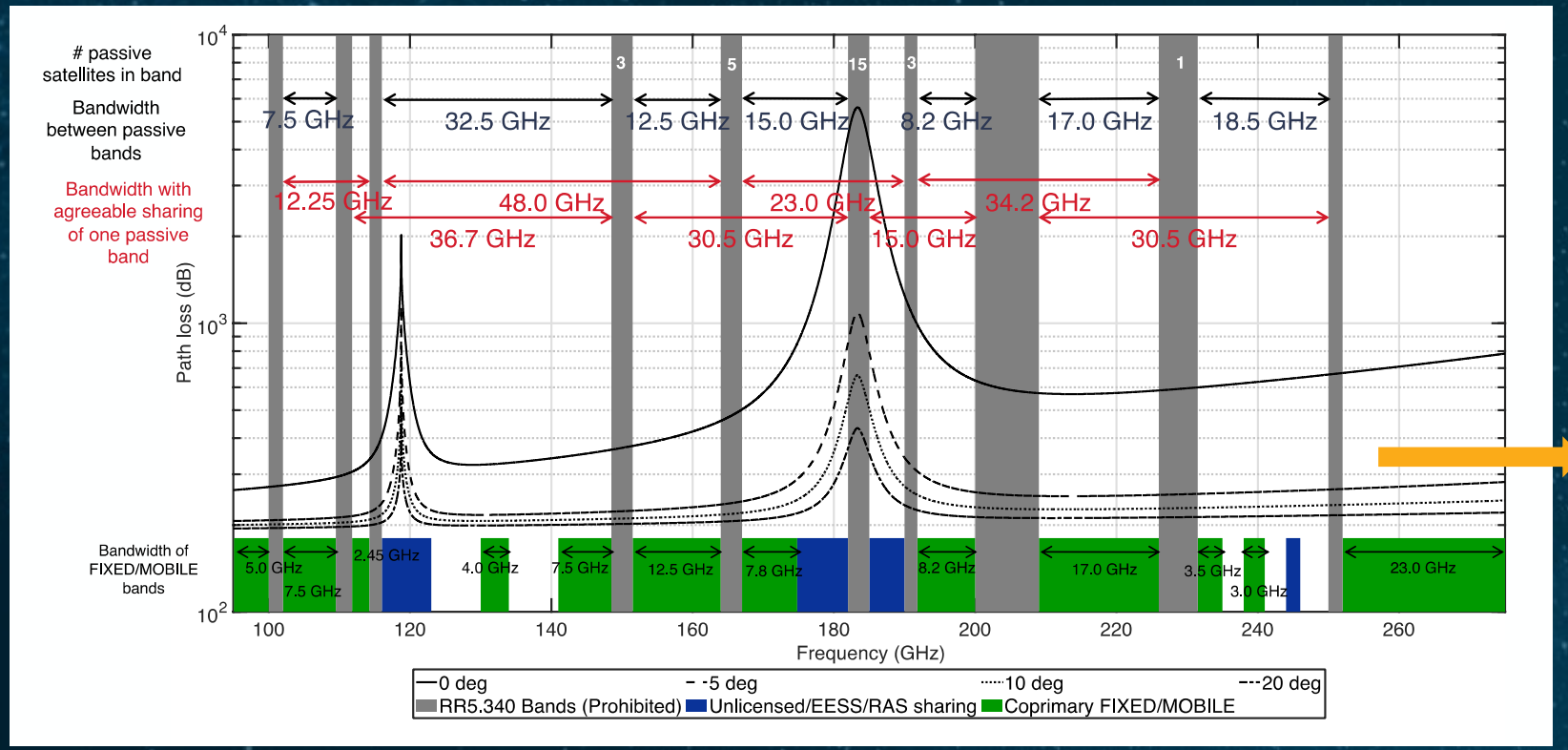


231.5-232 GHz	232-235 GHz	235-238 GHz	238-239.2 GHz	239.2-240 GHz	240-241 GHz	241-242.2 GHz	242.2-244.2 GHz *	244.2-247.2 GHz *
		EESS (passive) [limb]		Possible new EESS (passive)				Possible new EESS (passive)
FIXED	FIXED	FIXED	FIXED	~~FIXED~~	~~FIXED~~			
MOBILE	MOBILE	MOBILE	MOBILE	~~MOBILE~~	~~MOBILE~~			

Next mobile threat: 6G

6G (approx. 2030) is targeting large portions of the spectrum above 86 GHz.

From what we see now, it will be a difficult topic.



Grey bands (purely passive) are extremely important for **Science** and **Meteorology**!!

Credit: Northeastern University (UKSPF THz spectrum workshop)

Conclusions & way forward

Increased use of spectrum for EO missions

Increased use of spectrum from many other users

More difficult coexistence to be expected

Need to improve how we cope with RFI in the design phase and in the operational phase of missions

Need of more involvement from the scientific community in the frequency regulatory process

What you can do:

- Publish: e.g. about RFI; about the link between frequency bands and high-level science goals;
- Get involved in the frequency regulatory process: e.g. via FARS, your institution and/or your administration

Thank you for your attention!

Questions?

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Bonus

Frequency allocation table