The National Academies of SCIENCES ENGINEERING MEDICINE

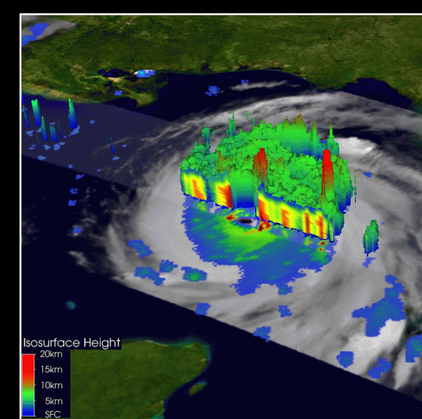
BOARD ON PHYSICS AND ASTRONOMY
Division on Engineering and Physical Sciences

Committee on Radio Frequencies Recent Activities

Meeting of the Board on Physics and Astronomy

April 27, 2022

Nathaniel Livesey, Chair of CORF
Scott Paine, Vice Chair of CORF



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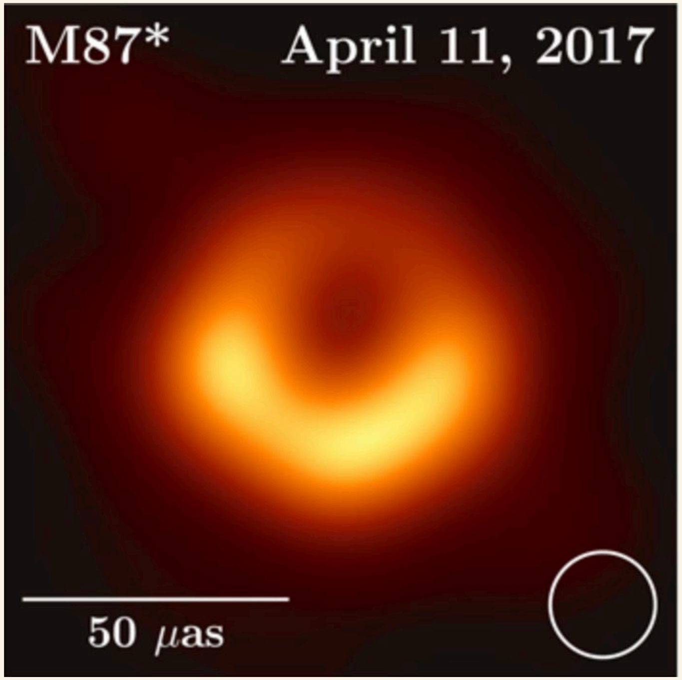
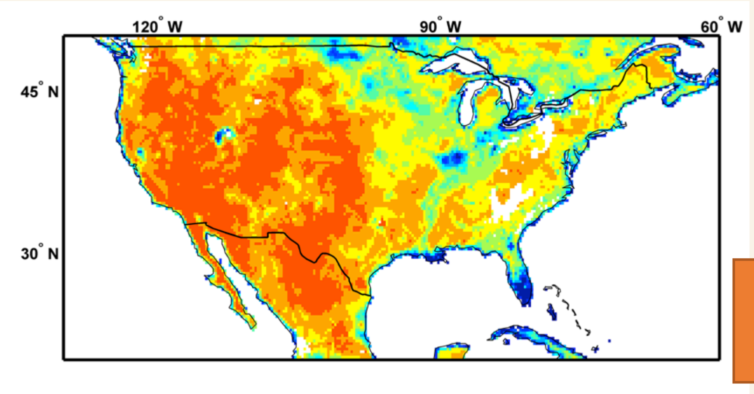
Scientific Use of the Radio Spectrum





- Radio frequencies have played a vital role in scientific discovery, as witnessed by Nobel Prizes awarded to Radio Astronomers, and to the IPCC, whose efforts were informed by passive microwave observations
- "Radio Astronomy Service" (RAS): origins and evolution of the Universe; chemistry and formation of stars and solar systems; matter in extreme environments; gravitational radiation; solar activity
- "Earth Exploration Satellite Service" (EESS): a critical tool for predicting weather and investigating climate change. Satellites provide data on issues including food, transportation, energy, and national security
- Together, these activities represents billions of dollars in federal investment in numerous satellites and radio observatories – each of which are national assets

Upper: EHT image of M87 black hole at 230 GHz.
Lower: Soil moisture (1–10 July 2013) at 1.41 GHz.

Spectrum Management and Policy

- The radio spectrum is shared between commercial, governmental, and scientific users (the latter both "passive" and "active")
- Radio regulations are codified both internationally (by the International Telecommunication Union, ITU) and domestically (by the Federal Communications Commission, FCC, and the National Telecommunications and Information Administration, NTIA)
  - Much of the ITU work is focused on "World Radiocommunication Conferences" WRCs, held roughly every four years (next is WRC-23)
- There is an ever-increasing commercial demand for and usage of radio frequencies, driven in part by recent advances in telecommunications technologies
  - The 2021 FCC auction of 3.70–3.98 GHz raised $81.1 billion!
  - (By contrast, NOAA estimates $3 trillion of the US economy is weather-sensitive, and $35 billion in annual economic benefit derives from weather forecasting*)
- This increases the need for spectrum sharing and coordination
  - The passive use of the spectrum is under an ever-growing threat
  - It is difficult to reverse regulations and recover spectrum when passive services are negatively impacted

* https://www.noaa.gov/weather and https://www.performance.noaa.gov/economics/

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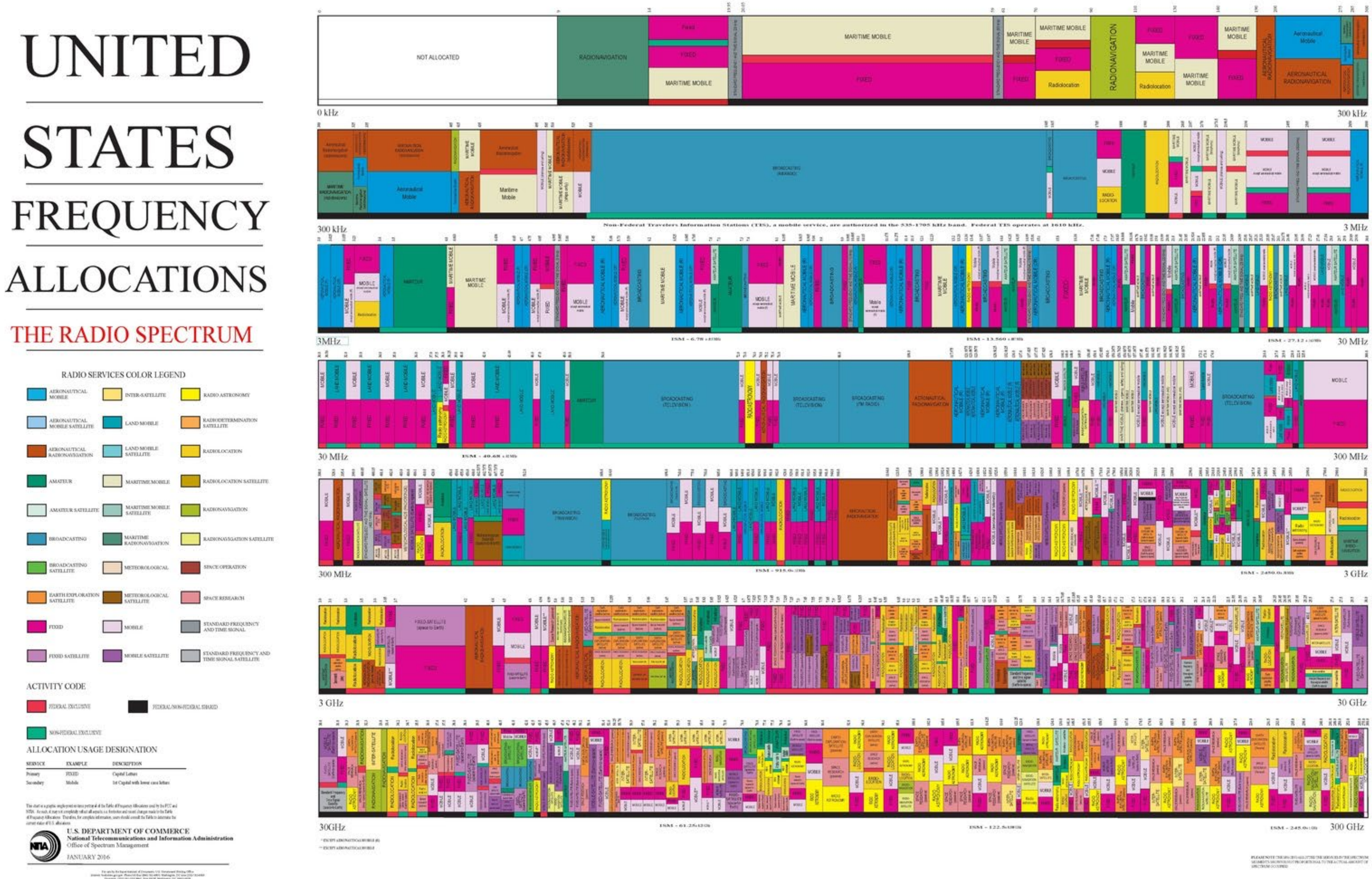


Roles of CORF

- CORF represents interests of U.S. researchers using radio frequencies: both radio astronomers and Earth scientists
- CORF coordinates the views of U.S. scientists and acts as a channel to represent their interests
- We recommend requirements and limits necessary to protect scientific use of the radio spectrum from interference
    - This is largely through filing comments in public proceedings of Federal Communications Commission (FCC)
    - Comments are drafted by CORF and its legal counsel, then reviewed per standard NAS protocols and approved and signed by the NAS President
- CORF also performs specific studies, maintains a Handbook and conducts various forms of outreach to scientists and industry
- CORF is funded by NSF and NASA

Membership of CORF

Committee Members

Nathaniel Livesey, JPL (Chair) – EESS

Scott Paine, CfA (Vice Chair) – RAS

Nancy Baker, NRL – EESS

Laura Chomiuk, Michigan State – RAS

Dara Entekhabi (NAE), MIT – EESS

Phil Erickson, Haystack Observatory – EESS

Kelsey Johnson, U Virginia – RAS

Christopher Kidd, GSFC/UMD – EESS

Karen Masters, Haverford – RAS

Mahta Moghaddam (NAE), USC – EESS

Frank Schinzel, NRAO – RAS

Consultants

Darrel Emerson, Ariz., retd. – RAS

Tomas Gergely, NSF, retd. – RAS

Paul Feldman, Esq., Fletcher, Heald and Hildreth – Legal counsel

Staff

Colleen Hartman, Director, Space, Physics, and Aeronautics

Greg Mack, Senior Program Officer

Neeraj Gorkhaly, Linda Walker

Recent CORF FCC Filings

- Four filings for 2021 thus far
  - 23.6 GHz: Implications of international Mobile (i.e., 5G) – June
  - 57 GHz: New approvals for short-range devices – September
  - 4.9 GHz: 8th FNPRM on public safety use – November
  - 70/80/90 GHz: Airborne Internet revisit – December
- No filings completed in 2022 thus far

70/80/90 GHz for Commercial Aircraft

- FCC solicited comments on use of 70/80/90 GHz bands to provide internet to commercial aircraft via – ground-to-air, air-to-ground, and air-to-air links
- CORF opposed use of the 80 GHz band (81–86 GHz) for downlinks and for aircraft-to-aircraft transmission
- CORF noted the need for guard bands to protect EESS from Out of Band Emissions (OOBE) at 86–92 GHz (an "All Emissions Prohibited" band).
- CORF also recommended updating OOBE limits to match those in ITU-R Res. 750.
- CORF further recommended an active tracking system be employed to null emissions in direction of orbiting EESS sensors
- A subsequent FCC Public Notice solicited further inputs, particularly related to use of High Altitude Platform Stations (HAPS – stratospheric balloons/airships)
- We filed a brief note stating our same concerns apply equally to these other platforms

Concept for dynamic ground-to-air, air-to-ground, air-to-air internet links

CORF at the International Level

- ITU-R Study Groups (and Working Parties) are well into the study cycle for WRC-23
- SG 1: Spectrum Management
  - WP 1A: Spectrum Engineering Techniques
- SG 3: Radiowave Propagation
  - Multiple working groups, but usually meeting in plenary
- SG 4: Satellite Services
- SG 5: Terrestrial Services
- SG 6: Broadcasting Services
- SG 7: Science Services
  - WP 7C: Earth Remote Sensing Systems
  - WP 7D: Radio Astronomy

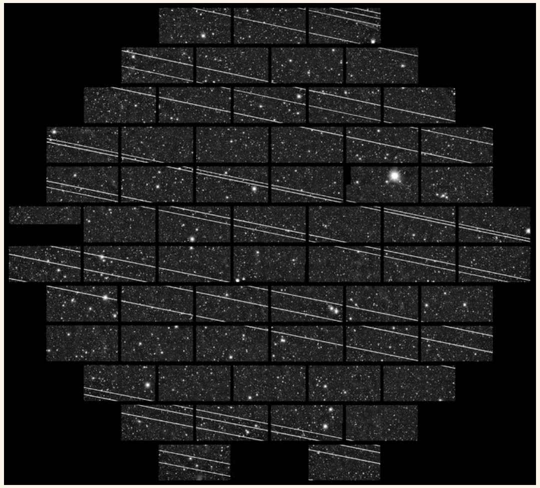
CORF at the International Level (cont.)

- WP 7C – Earth Remote Sensing
  - CORF members are participating in US WP 7C
  - Numerous NASA/NOAA representatives on US Delegation
- WP 7D – Radio Astronomy
  - CORF members are participating in US WP 7D and in ITU WP 7D this week
  - CORF has sent one of its consultants to ITU WP 7D for many decades; more recently, sending its former Chair as well
  - In this virtual world, more people are participating in the international meetings. This led to a disproportionate presence and influence of industry representation on the US WP 7D delegations during 2020
  - Recognizing this, Liese van Zee (prior CORF chair) urged more participation by RAS scientists. This has worked well (plan for in person meetings TBD)
    - Multiple US delegates (CORF members and others)
    - Valuable US-originated reports being developed (documentation of the EHT, low-frequency arrays, bolometers, and threats posed by harmonics)

Upcoming CORF spring meeting

- We have finalized the agenda for our (virtual) Spring meeting May 17 and May 19, 2022
- Our Spring meeting focuses on reports from and discussions with the various government entities CORF engages with (FCC, NTIA, NSF, NASA, NOAA) – pre COVID it was held in DC, and it would be good for this to resume next year
- We will also have two science talks – one on using “Signals of Opportunity” for Earth remote sensing, the other on results from MeerKAT
- As ever, this is mostly a public meeting, and all are welcome

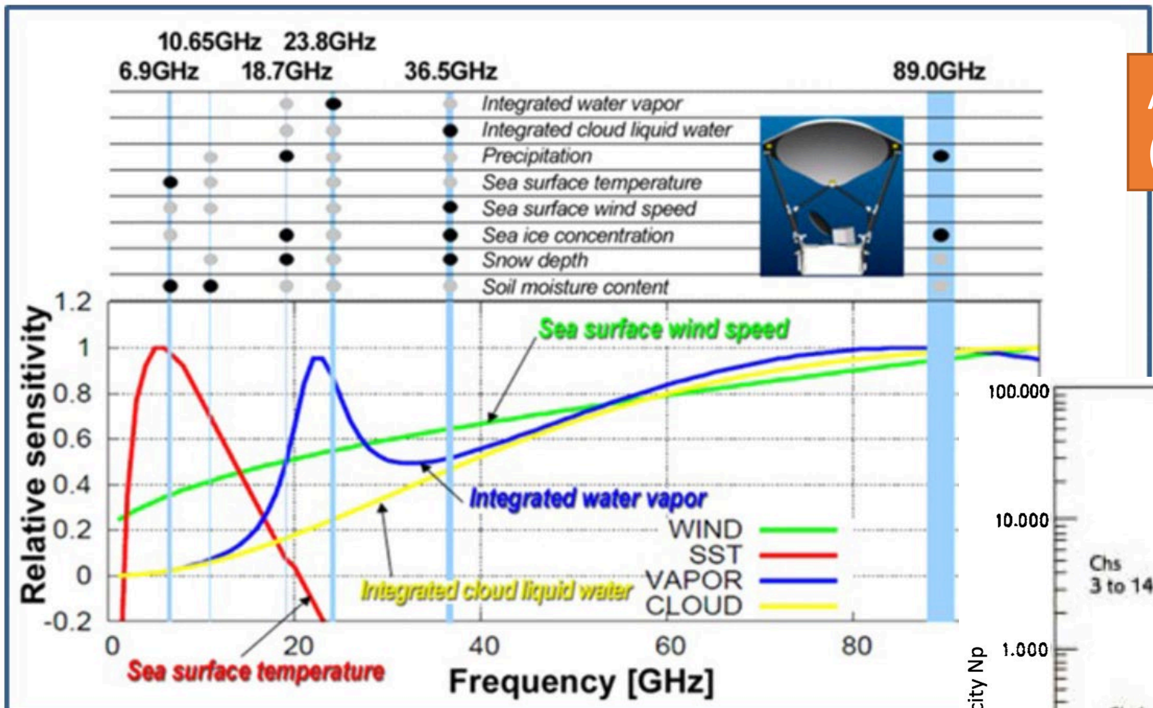
Other "Hot Button" Issues



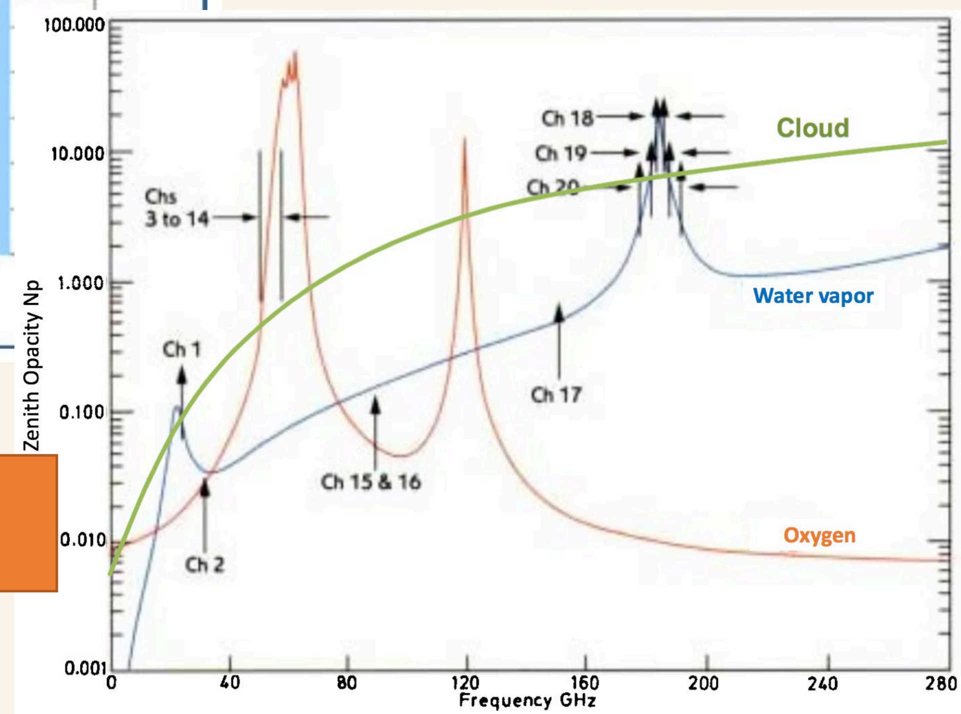
- Constellations with thousands of satellites
- National Radio Dynamic Zones
  - ➢ Dynamic spectrum sharing for the ngVLA?
- NSF Spectrum Innovation Initiative program
  - ➢ Recent selection of "Spectrum X" consortium includes participation by current and previous CORF members
- Spectrum Management
  - ➢ Next generation of leaders
- Threats to "all emissions prohibited" restrictions > 95 GHz
  - ➢ We are resisting efforts from industry to undermine/revise the "All emissions prohibited" status of all the passive bands in the region of the spectrum above 95 GHz currently having that protection
  - ➢ These efforts started within the US process, but have moved to the international arena (and the FCC are full-throated in their support)

Backup material

EESS (passive) as a System



Advanced Scanning Radiometer 2 (AMSR2) onboard GCOM-W1

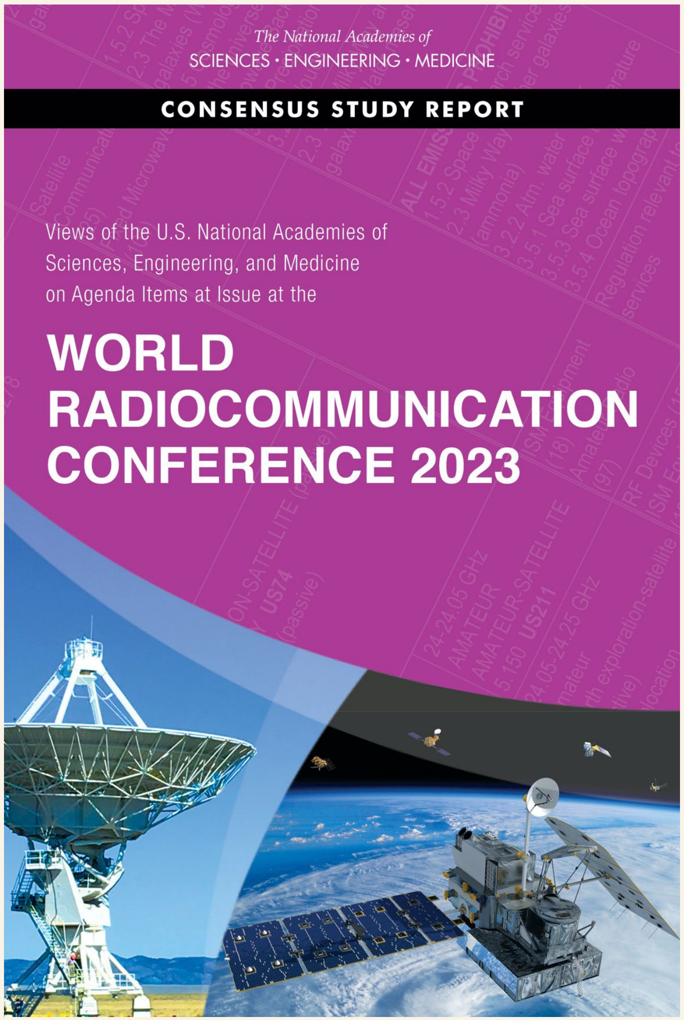


Advanced Microwave Sounding Unit (AMSU) on NOAA-15, NOAA-16, and NOAA-17.

CORF Activities: Outreach

- Participation with other groups around the world.
  - ITU-SG7; Working Parties – 7C (EESS), 7D (RAS), WP 1A, SG 3
  - IUCAF, CRAF, etc. – primarily RAS
  - IEEE-GRSS – Frequency Allocation Technical Committee
  - AMS – Radio Frequency Allocations Committee
- Presentations at professional meetings.
  - Panel discussion as part of NSF Spectrum Innovation Initiative
  - Presentation at meeting of the Wireless Innovation Forum (Nathaniel)
- CORF-related
  - Follow up on briefing to house science committee staffers (Nathaniel)

CORF Activities: WRC-23 Views Report



- Separate consensus committee
- Represents input from US scientists regarding agenda items at the World Radiocommunication Conference 2023 (WRC-23), and preliminary items for the WRC-27 agenda
- Decisions at the WRCs lead to international regulations under the ITU
- Multiple agenda items with potentially significant impact to RAS/EESS
  - NASA and NSF (and FCC) heavily involved
- More than 250 downloads from the National Academies Press since its June 2021 release
- Report briefed to NSF, NASA, and staffers from House Science Committee

Views on WRC-23 Agenda Items

1.2 International Mobile Telecommunication (IMT, cell phones) at 3.3–3.4, 3.6–3.8, 6.425–7.125, and 10.0–10.5 GHz

1.4 High Altitude Platforms (HAPS) as IMT (cell phone) Base Stations (HIBS) below 2.7 GHz

1.5 Review 470–960 MHz in Region 1

1.8 Fixed Satellite Services (FSS) and unmanned aircraft (10–15 GHz, 19.7–20.2 GHz, 29.5–30 GHz)

1.9 Aeronautical mobile in HF bands (adjacent to RAS at 13.36–13.41 MHz)

1.10 Aeronautical mobile at 15.4–15.7 and 22–22.1 GHz

1.11 Maritime distress services (1610–1626.5 MHz and 2483.5–2500 MHz)

1.12 EESS (active) radar sounders at 45 MHz

1.13 Space Research Services at 14.8–15.35 GHz

1.14 EESS (passive) at 231.5–252 GHz

1.15 Geostationary Earth Stations in Motion (GSO-ESMIS) at 12.75–13.25 GHz

And more. See the next slide

WRC-23 Agenda Items (cont.) and WRC-27 Items

1.16 nGSO-ESIMs at 17.7–18.6, 18.8–19.3, and 19.7–20.2 GHz, and others

1.17 Inter-satellite links at 18.1–18.6 GHz, 18.8–20.2 GHz, and others

1.19 Fixed Satellite Services (FSS, space-to-Earth) at 17.3–17.7 GHz in Region 2

9.1 Topic A: Space Weather

9.1 Topic B: Amateur Service at 1240–1300 MHz

9.1 Topic C: Mobile use (IMT, cell phones) in bands allocated to Fixed services

9.1 Topic D: Protection of EESS (passive) at 36–37 GHz

WRC-27 Preliminary Agenda Items:

- WRC-27 2.8 and 2.9 (1330–1350 MHz; 1610.6–1613.8 MHz; 1660–1670 MHz)
- WRC-27 2.2 and 2.3 (37.5–51.4 GHz)
- WRC-27 2.4, 2.5, and 2.7 (71–76 and 81–86 GHz)
- WRC-27 2.1 (231.5–275 GHz; 275–700 GHz)