Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Modifying Emissions Limits for the 24.25-24.45 GHz and 24.75-25.25 GHz Bands	)	ET Docket No. 21-186
	)	
	)	
	)	

COMMENTS OF THE
AMERICAN GEOPHYSICAL UNION,
AMERICAN METEOROLOGICAL SOCIETY and
NATIONAL WEATHER ASSOCIATION

Lexi Shultz
VP, Science Policy & Government Relations
American Geophysical Union

Stella Kafka
Executive Director
American Meteorological Society

Janice Bunting
Chief Executive Officer
National Weather Association

February 28, 2024

The American Geophysical Union (AGU), the American Meteorological Society (AMS) and the National Weather Association (NWA) appreciate the opportunity to provide comments on this Notice of Proposed Rulemaking (NPRM) proposing to align part 30 of the Commission's rules for mobile operations with the Resolution 750 limits on unwanted emissions into the passive 23.6-24.0 GHz band that were adopted at the World Radiocommunication Conference held by the International Telecommunication Union (ITU) in 2019 (WRC-19).

The membership of AGU, AMS and NWA include the world's preeminent atmospheric, oceanic, hydrological and other physical scientists as well as operational practitioners of environmental modeling and forecasting. These scientists and practitioners depend heavily on technology that is reliant on passive bands for their forecasts, models and research to better understand the Earth's atmosphere, oceans and land to predict natural hazards that impact lives, property and economies in the U.S. and across the world.

The following is consistent with the views expressed in the reply comment received on 27 July 2021 by our organizations in response to the Public Notice seeking input on Part 2 and Part 30 of the Commission's rules for out-of-band emission (OOBE) limits into the 23.6-24.0 GHz passive spectrum.[1]

Our organizations' response will respond directly to the requests for comment in the NPRM and reference them by paragraph number.

1. ***At a minimum*, the Commission should align its rules with the WRC-19 limits on emissions from active operations in the 24.25-25.25 GHz band into passive sensing in the 23.6-24.0 GHz band.**

Paragraphs 10, 13, 14
Our organizations support the Commission's proposal to adopt the Resolution 750 unwanted emissions limits adopted at WRC-19 *at a minimum*. Weather – and weather observations – are global. Excelling at local forecasts valid for several days in the future requires an assessment of conditions over a vast geographic area. While there are many different types of weather observations, only weather satellites depict broad atmospheric phenomena and their evolution.

It would be preferable to adopt stronger out-of-band emissions (OOBE) limits, such as those proposed in the National Academy of Sciences' Committee on Radio Frequencies (CORF) filing.[2]

Since 2021 when we submitted a reply comment to the Public Notice,[3] our organizations have agreed with CORF that further limits would better ensure the protection of critical satellite measurements of water vapor that have been crucial to improving weather forecasts over the past twenty years, protecting both lives and livelihoods in communities across the U.S. We seek to clarify statements in the NPRM referring to AGU/AMS/NWA/UCAR *Ex Parte* correspondence since our support has been consistent for higher protection levels for passive satellite observations adjacent to 24 GHz.

However, we recognize the Resolution 750 unwanted emissions limits adopted at WRC-19 were a compromise, and those limits are what most countries have adopted. **But we encourage the Commission together with the National Telecommunications and Information Administration (NTIA) and the National Science Foundation (NSF) (through its Spectrum Innovation Initiative) to support additional research to model and test interference between International Mobile Telecommunications (IMT) interference with Earth Exploration-Satellite Service (EESS) measurements.**

Paragraphs 11, 13, 14
The benefits of limits on unwanted OOBE, such as those defined in Resolution 750, but more decisively as described by CORF, are substantial to our organizations. We are concerned about contamination of information from satellite that is of critical importance to the generation of

[1] 27 July 2021. AGU, AMS and NWA. https://www.fcc.gov/ecfs/document/1072681501910/1.
[2] 25 June 2021. CORF. At 11. https://www.fcc.gov/ecfs/document/1062569869983/1
[3] 27 July 2021. AGU/AMS/ NWA at 3.

accurate and timely meteorological forecasts and warnings, particularly those generated by computer-based atmospheric models, often referred to as numerical weather prediction.

Experts from AGU, AMS and NWA are concerned about contamination of passive measurements at 23.6-24.0 GHz and other key passive bands of critical importance to the generation of accurate and timely meteorological forecasts particularly through numerical weather prediction. The 23.6-24.0 GHz passive band is a unique spectral feature of very high importance to operational forecasting services. In addition, the specific frequency location for these passive measurements between 23.6 and 24.0 GHz is defined by the laws of physics (quantifiable mechanical properties of matter) and cannot be changed or moved.

2. Measuring Interference to Passively Sensed Data Differs from Interference Detection in Active Measurements

As noted in our reply comment to the Public Notice, the operation of passive systems differs substantially from those of communications receivers, such as smartphones or ground stations. While traditional communications devices are designed to detect and maximize the signal content while discarding noise, passive devices, specifically radiometers, are designed to detect small changes in that noise level caused by properties in the atmosphere.[4]

As described by the Geoscience and Remote Sensing Society of the Institute of Electrical and Electronics Engineers (IEEE GRSS) submission in response to the Public Notice, "*There are three levels of contamination to passive measurements … **Obvious, Insidious, and Undetectable**.*" **Undetectable** is below the measurement threshold of passive sensors, while **Obvious** is high enough to indicate a non-natural source and is discarded, leaving that location as unmeasured. The real problem is in the middle range with **Insidious** contamination.

Insidious contamination refers to when the corrupting signal is small enough to realistically look like desired natural emissions, but large enough to affect the data. We are concerned that quality checks of data staged for computer-based model forecasts would not reject this data as invalid, as would happen with obvious contamination, which would mean the data may be used in numerical weather predictions, corrupting the accuracy of them.

The IEEE GRSS comment in the earlier proceeding describes why these measurements are important.

"Measurements are required worldwide (throughout the volume of the atmosphere) to obtain initial conditions for the global numerical weather prediction models necessary for weather forecasting. Passive microwave observations contribute around 40 percent of the overall improvement of short-range weather forecast accuracy, plus a further 10 percent from active microwave."[5]

Characteristics of terrestrial emissions, such as power levels, deployment schedule, and direction of emissions, will determine if contamination of adjacent passive bands alters the accuracy of weather forecasts that are an output from complex numerical weather prediction models.

---

[4] 27 July 2021. AGU/AMS/ NWA at 9.
[5] Final report of the Radio Frequency Interference (RFI) Workshop, European Centre for Medium-Range Weather Forecasts (ECMWF), Reading, UK, September 13-14, 2018.

3. Passively Sensed Data at 23.824 GHz is Important to Weather Forecasts

Passive sensing at 23.8 GHz is important to quantify the amount of water vapor in the Earth's atmosphere. Water vapor is transient; understanding where water vapor is changing is essential for improving weather forecast skill, including track and intensity forecasts of major storm systems. Because satellites provide global coverage in their orbits around the Earth, they are the most comprehensive source of atmospheric water vapor information.

Water vapor is most often quantified in terms of total precipitable water, or TPW. This quantity is measured in inches as if water molecules in an imaginary column of the atmosphere are condensed into rain and fall into a rain gauge. There is usually more water vapor near the surface, where 23.6-24.0 GHz sensing is particularly valuable and unique, and less at greater altitude. **Given the importance of these measurements at the surface level, interference from mobile transmitters on the ground is of particular concern as a source of OOBE to the delicate passive measurements of water vapor in these areas.**

Meteorologists use TPW as an indicator for precipitation predictions and particularly whether flooding might be anticipated from thunderstorms.

Without the use of an Earth sensing band at 23.8 GHz, satellite-based estimates of TPW over the contiguous United States may degrade more than 15%. Explained differently, 23.8 GHz is responsible for refining estimates of TPW to more than a quarter of an inch on humid summer days, which could alter forecasts for the eventual coverage and intensity of afternoon thunderstorms, which is crucial to the transportation industry (especially aviation).

It cannot be understated that measurements at 23.6-24.0 GHz provide critically important global measurements of atmospheric temperature and TPW that cannot be replicated by other measurement methods in such a comprehensive way. In addition, once interference occurs it is highly problematic. If errors get injected into numerical weather prediction models, which are continuously tuned based upon existing data that is processed in high performance computing environments, the errors would degrade downstream forecasts and warnings, and negatively impact decision making for public safety and weather-sensitive industries (such as aviation, agriculture, recreation and public events) into the future.

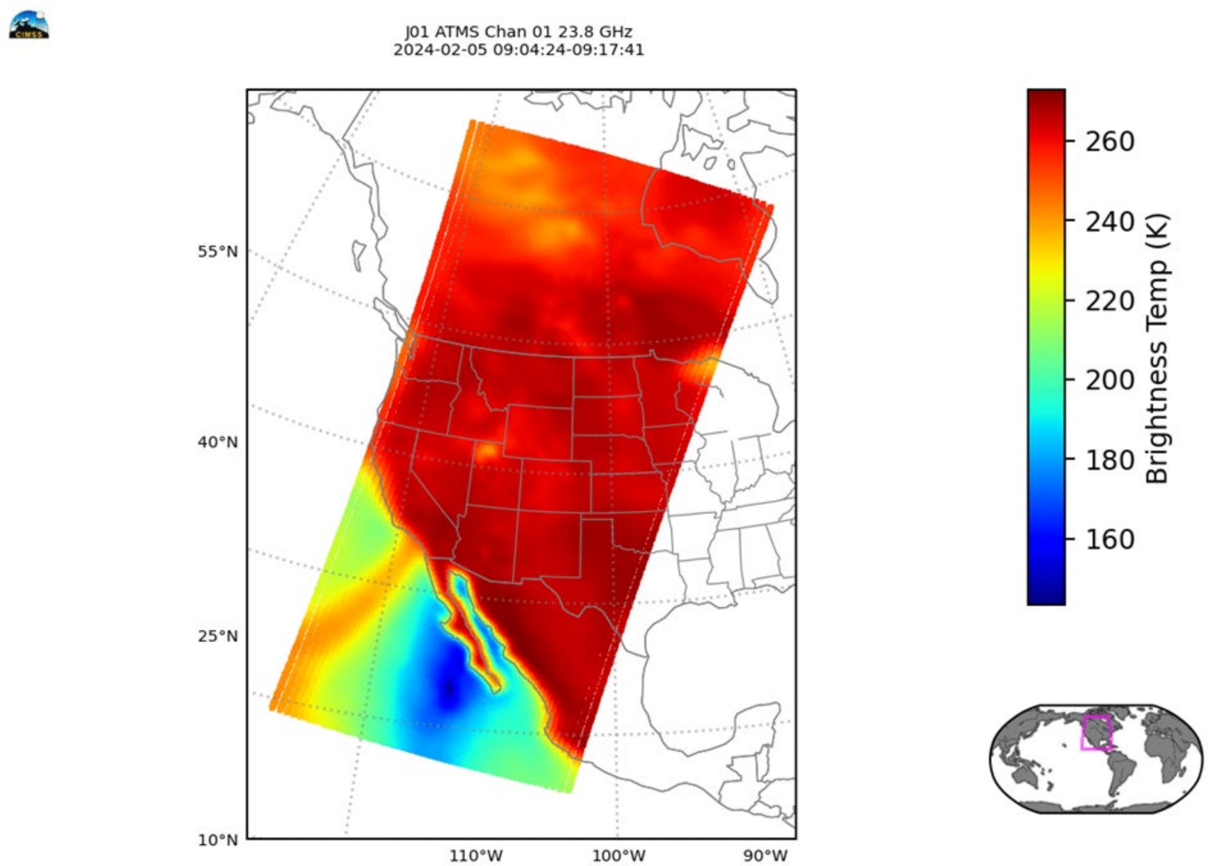
4. Water Vapor Measurements near 24 GHz are Becoming More Crucial as Flash Flooding and Atmospheric Rivers Occur More Frequently

Paragraphs 11, 14
On and around February 5, 2024, heavy rains totaling several inches fell on Los Angeles and surrounding areas, leading to downed trees, flooding, and power outages. This record event was the result of an atmospheric river, which are narrow bands of enhanced atmospheric water vapor (moisture) that originate in the tropics. Particularly impactful near coastal areas, they are often responsible for heavy precipitation that produces flooding in susceptible regions, such as those with substantial terrain like southern California. The National Weather Service offices serving Americans in central and southern California issued many flood warnings and alerts to inform people of the dangers associated with this event. There were flash floods reported in Orange County, while in Los

Angeles work crews and residents cleaned up damage from more than 475 mudslides and nearly 400 fallen trees that week.[6]

Meteorologists benefitted from NOAA's on-orbit satellite radiometers, called the Advanced Technology Microwave Sounder (ATMS) instrument, and its 23.8 GHz imagery for forecasting the atmospheric river before it eventually entered California. By analyzing the development, intensity, and movement of moisture using 23.8 GHz, meteorologists can track the evolution of atmospheric rivers and more accurately predict its impacts on local weather conditions, including precipitation amounts, timing, and potential hazards such as flooding and resulting landslides. This is particularly the case when meteorologists combine 23.8 GHz and other satellite imagery with numerical weather prediction output that is based in part on 23.8 GHz and other observations.

The 23.8 GHz image below shows a finger (orange) of enhanced moisture adjacent to the southern California coast. This image is enhanced to show the atmospheric river over the ocean. **(Source: Cooperative Institute for Meteorological Satellite Studies (CIMSS)/Space Science and Engineering Center (SSEC) at University of Wisconsin-Madison.)**



[6] Gorman, S. and J. Ross. "Lingering atmospheric river soaks California, threatening more flooding, mudslides." Reuters. 7 Feb 2024. https://www.reuters.com/world/us/lingering-atmospheric-river-soaks-california-threatening-more-flooding-mudslides-2024-02-06/

Events like these atmospheric rivers and flash flood events have been happening more frequently in the U.S. For example, the atmospheric setups that fuel flash flood events have been leading to higher rain totals in short time periods.[7] Summer thunderstorms in the southern Plains and southeast U.S. have led to multiple (what used to be considered) 1-in-1,000-year rain events,[8] but are happening much more frequently. Satellite sensors like ATMS relying on measurements between 23.6 and 24.0 GHz are crucial to predicting the watches, warnings and evacuations crucial to protecting lives and livelihoods in these situations.

5. Authoritative U.S. climate reports point to increasing incidence of severe rain events that are predicted using satellite observations near 24 GHz

Sections 11, 14
The Fourth and Fifth National Climate Assessments (NCA),[9] released by the U.S. Global Change Research Program (USGCRP) in 2018 and 2023, respectively, both highlight the increased frequency of severe rain events occurring across the U.S.

The Fourth NCA found that the amount of rain that falls in the top one percent of events has increased by 27 percent in the Southeast,[10] and 42 percent in the Midwest,[11] over the past 60 years. The probable increase in such devastating rain events moving forward given the reality of current and anticipated future climatic conditions further underlies the importance of protecting 23.6-24.0 GHz measurements from OOBE.

6. Reliable Passive Measurements Are Crucial to Accurate Forecasts as the Costs of Climate Change Impacts and Disasters Increase

Paragraphs 11, 13, 14
In 2023, there were a record number of 28 confirmed weather/climate disaster events with losses exceeding $1 billion each that affected the United States – with a cumulative loss of $92.9 billion and 492 deaths last year.[12] These events included four major flooding events with each exceeding $1

---

[7] Feuerstein. "How two 1-in-1,000-year rain events hit the U.S. in two days." Washington Post. 29 July 2022. https://www.washingtonpost.com/climate-environment/2022/07/29/kentucky-stlouis-flood-climate-explainer/

[8] A thousand-year rain event describes an amount of rain that has only a 0.1 percent chance of falling in a given year. Some places may see multiple 1000-year-events over 1000 years, while other areas might not see any. Due to climate change, a 1000 rain event a few decades ago no longer means what it does today since it is so much warmer and more humid on average today. The fourth National Climate Assessment found that the amount of rain that falls in the top 1 percent of events has increased by 27 percent in the Southeast, and 42 percent in the Midwest, over the past 60 years.

[9] The NCA is the congressionally mandated U.S. Government produced report on climate change impacts, risks, and responses that provides the scientific foundation to support informed decision-making across the U.S.

[10] Carter, L., A. Terando, K. Dow, K. Hiers, K.E. Kunkel, A. Lascurain, D. Marcy, M. Osland, and P. Schramm, 2018: Southeast. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 743–808. doi: 10.7930/NCA4.2018.CH19

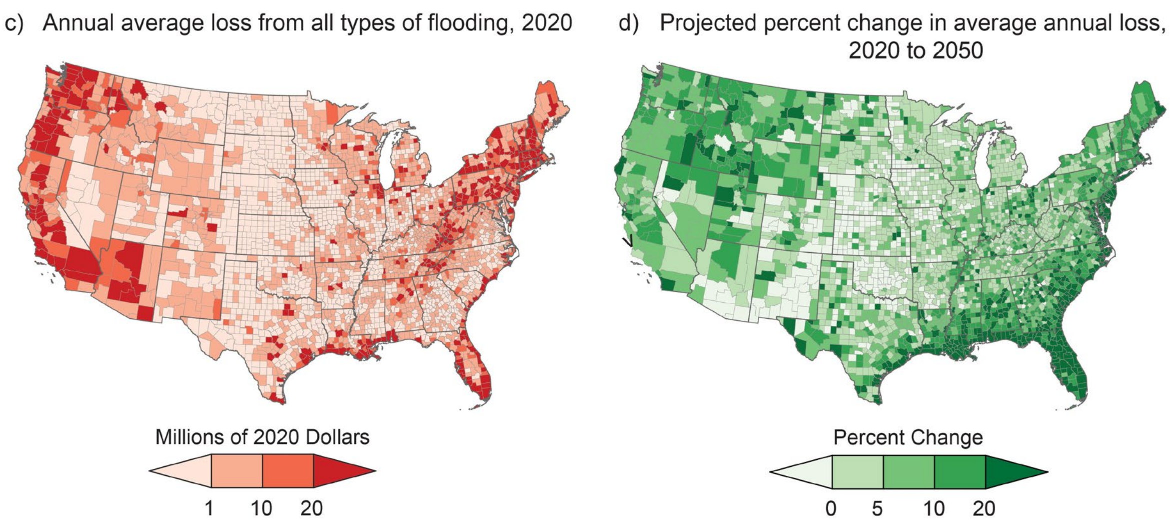
[11] Angel, J., C. Swanston, B.M. Boustead, K.C. Conlon, K.R. Hall, J.L. Jorns, K.E. Kunkel, M.C. Lemos, B. Lofgren, T.A. Ontl, J. Posey, K. Stone, G. Takle, and D. Todey, 2018: Midwest. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 872–940. doi: 10.7930/NCA4.2018.CH21

[12] NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2024). https://www.ncei.noaa.gov/access/billions/, DOI: 10.25921/stkw-7w73

billion in losses, including atmospheric river-caused flooding in the Pacific Northwest and Southern California, and heavy rain events in the Mid-Atlantic and New England, including multiple flood events in Vermont. The passive observations near 24 GHz were critical elements used in the heavy rain forecasts, and those forecasts informed the public in harm's way and helped mitigate some hazard losses.

The Fifth NCA also reinforces these results noting that:[13]
Climate change directly impacts the economy through increases in temperature, rising sea levels, and more frequent and intense extreme events. These impacts can also lead to indirect effects on markets, budgets, trade, and employment—creating both risks and opportunities. Economic consequences of these impacts affect certain regions, industries, and communities more than others.[14]

In addition, the losses associated with floods in the U.S. in 2020 are expected to be far exceeded by those faced across the U.S. in 2050, as noted in this map from the Fifth NCA.[15] **(Source: USGCRP)**



As climate change accelerates, the economic impacts will only increase, and any tools to help mitigate those costs, such as spectrum-dependent Earth observations, like those reliant on 24 GHz, become more economically valuable and critical for society.

However, if increased OOBE emissions cause increased harmful interference at 23.6-24.0 GHz, these passive observations will not be able to provide as much benefit as the past. Interference threats mean more observations will need to be omitted from forecasting models due to threat of contamination, or contaminated data will be included in forecast models and reduce their accuracy.

Much as the costs of disaster losses and climate change impacts are vast and increasing, the value of accurate weather forecasts is substantial. A nationwide survey indicated that weather forecasts generated

---

[13] USGCRP, 2023: Fifth National Climate Assessment. Crimmins, A.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, B.C. Stewart, and T.K. Maycock, Eds. U.S. Global Change Research Program, Washington, DC, USA. https://doi.org/10.7930/NCA5.2023
[14] USGCRP 2023 at Chapter 19 https://nca2023.globalchange.gov/chapter/19/
[15] USGCRP 2023 at Overview Section 3. https://nca2023.globalchange.gov/#overview-section-3

$35 billion in economic benefits to U.S. households in 2016.[16] Since this only addresses households and weather, the value of the spectrum-reliant environmental information that these forecasts are dependent on is likely far larger. Spectrum-dependent environmental observations also support weather forecasts and warnings more broadly that contribute to a range of economic activity. Some examples include local governments making evacuation decisions and grocery stores planning their supply schedules and routes.

7. Limits to OOBE Near 24 GHz Can Promote Equity and Accessibility of Critical Flash Flood Information to Underserved Populations

Paragraphs 13, 14, 30
There have been important discussions within the weather community about how to improve the accuracy of forecasts and their reach to underserved populations across the U.S. The Fifth NCA also highlighted multiple examples of how climate change is exacerbating existing societal and economic disparities, and particularly the increased risks associated with underserved populations and racial and ethnic minorities, particularly in urban environments. But of particular relevance to this proceeding are the Fifth NCA findings noting: *Communities of color and low-income communities face disproportionate flood risks.*[17]

The Fifth NCA also highlights factors impacting specific geographies in the U.S. For example, in the Northeast:[18]
Extreme heat, storms, flooding, and other climate-related hazards are causing disproportionate impacts among certain communities in the Northeast, notably including racial and ethnic minorities, people of lower socioeconomic status, and older adults. These communities tend to have less access to healthcare, social services, and financial resources and to face higher burdens related to environmental pollution and preexisting health conditions. Social equity objectives are prominent in many local-level adaptation initiatives, but the amount of progress toward equitable outcomes remains uneven.
Similar points were made in the Fifth NCA related to the Southern Great Plains[19] and the Southeast.[20]

In addition, the fifth NCA highlighted the structural societal issues (such as population dynamics, and social and economic inequities) associated with the governance of disasters for those underserved, which highlights the need to avoid all possible degradation of relevant weather and climate information that can inform underserved areas, especially urban and those with aging infrastructure.

Passive measurements relying on spectrum near 24 GHz have become crucial to effective forecasting of heavy rain events. Since flash floods disproportionately affect underserved populations, the conclusion can be drawn that interference to these passive observations (causing this information to be corrupted or eliminated from forecasting models) would provide greater harm to such populations. **This further reinforces the need to ensure these observations are protected from interference and provides an equity argument for increased OOBE limits near 24 GHz.** The proposal to limit OOBE under Resolution 750, and even more so the limits

[16] Lazo, J. K., Morss, R.E. and Demuth, J.L. (2009). 300 billion served: Sources, perceptions, uses, and values of weather forecasts. Bulletin of the American Meteorological Society 90(6), 785-798. *Updated for inflation by NOAA in 2016.*
[17] USGCRP 2023 at Chapter 21 Key Message 3. https://nca2023.globalchange.gov/chapter/21/#key-message-3
[18] USGCRP 2023 at Chapter 21 Key Message 3. https://nca2023.globalchange.gov/chapter/21/#key-message-3
[19] USGCRP 2023 at Chapter 23 Key Message 4. https://nca2023.globalchange.gov/chapter/26/#key-message-4
[20] USGCRP 2023 at Chapter 22 Key Message 3. https://nca2023.globalchange.gov/chapter/22/#key-message-3

proposed by CORF, could promote advancements in equity and accessibility to critical weather forecasts.

8. Additional Research is Needed – Especially Studies and Dialogues Bridging Atmospheric Science, Wireless Networks and Spectrum Allocation

Paragraph 29
The impacts and anticipated losses associated with a changing climate fuel the need for continued access to (and improvement of) passive measurements adjacent to 24 GHz. These shifting realities require additional research to be able to ensure climate impacts and increasing weather forecasting technology needs are considered in continued spectrum allocation decisions.

Further, as noted at the end of section 3 in this comment, there is a need for further studies on OOBE interference to passive measurements and its impact on operational forecasting products supporting public safety and numerous weather-dependent economic sectors. These studies are important near 24 GHz, but also other related passive spectral areas with unique atmospheric science properties (such as 50-58 GHz).

But the wireless network, atmospheric science and spectrum allocation communities are without overlapping motivations, which requires the government to be more intentional to fund and facilitate more cross-disciplinary research and engagement in these areas.

Of particular note, the National Science Foundation and its projects under its Spectrum Innovation Initiative should be encouraged to pursue interdisciplinary research on science uses of passive spectrum such as near 24 GHz. In addition, NOAA should add additional funding to its Detection, Characterizing, and Mitigation of Passive Sensor Data Corrupting Emissions (DMiPS) research opportunity to fund additional and larger studies that explore methodologies, services, specific tools, capabilities, and approaches that can be applied towards detecting, identifying, characterizing, and mitigating anthropogenic radio frequency (RF) emissions within or adjacent to designated Earth exploration satellite passive frequency bands.[21]

There have been a few recent research papers that encapsulate some understanding of spectrum allocation, atmospheric science and operational forecasting, but there is a need for more with greater cross-industry and sector dialogue on these important issues.

- For example, the paper by Yousefvand et al[22] from Rutgers University studied the impact of 5G leakage on the accuracy of weather prediction algorithms and characterizing the resulting inaccuracies when using a computer model to predict temperature and rainfall.

---

[21] NOAA NESDIS. 13 April 2023. Broad Agency Announcement: Examining Approaches and Methodologies for the Detection, Characterizing, and Mitigation of Passive Sensor Data Corrupting Emissions (DMiPS). https://sam.gov/opp/a5a00aa55bbe44d98436051eaad35449/view

[22] Yousefvand, M., Wu, C., Wang, R., Brodie, J. and Mandayam, N. "Modeling the Impact of 5G Leakage on Weather Prediction." Rutgers University. Sept 2020. http://www.winlab.rutgers.edu/~narayan/PAPERS/5GWF_Conf_Paper_Final.pdf

- The paper by Palade et al.[23] at RWTH Aachen University studied whether realistic 5G mm-wave cellular networks would cause harmful out-of-band interference to weather satellites sensing in the 23.8 GHz band, estimating interference from a single interferer and a network of interferers in New York City, using real three-dimensional building data and realistic antenna patterns. By calculating the interference from reflected 24 GHz transmission (from buildings and ground), this **paper shows that the models used to inform WRC-19 Resolution 750 (which only take into account line-of-sight transmissions) underestimates the interference from 5G networks**.

The proposal from Choyu Networks is an interesting one that should be encouraged and further developed through additional research funds via multiple stakeholder federal agencies. Furthermore, reasonable dialogue around this and other potential innovations must be encouraged and facilitated across sectors and industries.

As noted above, there are not many overlaps between the Earth science and meteorology communities and the wireless industry. While contact with the wireless industry has been attempted by our community, we believe the government, and perhaps through NSF's Spectrum Innovation Initiative, and specifically SpectrumX, should be funded to facilitate further dialogues across sectors and disciplines on these issues since they are likely to emerge again in other passive spectral areas. Our organizations would welcome and prioritize engagement in such dialogues.

There is need for more research not only as wireless companies begin to operate more near 24 GHz, but also as more passive satellite sensors get deployed on satellites in the U.S. and around the world. Currently, according to the World Meteorological Organization (WMO), there are approximately 70 current and known future satellite systems (21 of which are U.S.) with sensors that detect atmospheric signals near 23.6-24.0 GHz.[24] Many of these systems have 400 MHz sensor detection bandwidths, which places the detection window edge close to 24 GHz. So, while an OOBE level might be acceptable at 23.8 GHz, that level will increase with proximity to 24 GHz, which could then contaminate the 23.8 GHz measurement. An OOBE limit established for 23.8 GHz is not a "step function" below 24 GHz.

9. **Licensees should be encouraged to comply with the 2027 OOBE limits as soon as practicable, with only 2027 OOBE acceptable equipment allowed starting as of the end of 2026, with all pre-2027 heritage equipment replaced or retrofitted by Sept 1, 2028.**

Paragraphs 20, 21, 24
In our earlier reply comment to the Public Notice, our three organizations supported the NTIA in its statement urging the Commission to have licensees comply with the -39 dBW limit as soon as practical and not wait until the ITU prescribed September 1, 2027.[25] Echoing the statement of Chairwoman Rosenworcel on 16 July 2020 about the "pivot from millimeter wave to mid-band

[23] A. Palade, A. M. Voicu, P. Mähönen and L. Simić, "Will Emerging Millimeter-Wave Cellular Networks Cause Harmful Interference to Weather Satellites?" in IEEE Transactions on Cognitive Communications and Networking, vol. 9, no. 6, pp. 1546-1560, Dec. 2023, doi: 10.1109/TCCN.2023.3298897
[24] World Meteorological Organization. Observing Systems Capability Analysis and Review Tool (OSCAR). Accessed 15 Feb 2024. https://space.oscar.wmo.int/
[25] 27 July 2021. AGU/AMS/ NWA at 5.

spectrum,"[26] we believe the more important question now is about the timing of deployment of equipment compliant with the post-2027 OOBE limits.

Our three scientific organizations would like to support the call to clarify the Commission rules to remove ambiguity to clarify in Part 30 that base stations and user equipment modified or replaced after September 1, 2027, must comply with the post-2027 (e.g., -39 dBW) OOBE levels. We would like to further recommend that **all heritage equipment installed prior to 2027 that does not meet the more stringent limits be given a sunset date of September 1, 2028, for retrofit or replacement** to comply with the more stringent -39 dBW OOBE limit. In addition, we recommend the Commission **prohibit the grant of new equipment certifications for, or the importation of, equipment not complying with the phase two unwanted emission limits as of January 1, 2027.**

These guidelines are necessary for meteorological applications because transmitter performance must be well characterized to increase the likelihood that any interference is determinable. Given this, there should be no double standards for legacy and new equipment with firm transition dates between them, as recommended above. Ideally, since weather is global, such transitions would coincide with the rest of the world. Otherwise, American meteorologists will face Earth sensing challenges on at least three fronts.

- First, if there is interference and it's obvious, there will be a degradation in the computer-based weather forecasts if bad observations – those that mix transmitter signals with natural Earth emissions – are integrated into computer-based weather analyses. Therefore, these data are discarded, and not assimilated into models.
- Second, if it is unclear whether interference is impacting the data, then it is crucial that the data either be eliminated or "devalued" in the weather models. Unfortunately, if there is a chance the data is corrupted, then modelers must assume it is corrupt to not risk degrading the overall "skill" (or accuracy of the resulting forecasts) of the model with bad data. There is no way to detect the difference between actual data and data that is contaminated with interference with current systems and capabilities.
- Third, if meteorologists and their computer-based models are discarding or devaluing observations from satellite instrument data, this means that Americans are losing their taxpayer investment in that satellite mission. This completely changes the economic analysis that drove the government to build that satellite with that instrument in the first place. And worse, it may dissuade nascent private ventures from launching complementary capabilities if observational integrity is not assured.

10. **The Commission should require licensees to use only Total Radiated Power (TRP) to measure compliance with these emission limits to aid the Earth science community in estimating impacts to passive band sensing measurements.**

Paragraph 25

In our earlier reply comment to the Public Notice, our three organizations agreed with NTIA that TRP should be used.[27] The scientific community requires a method to take the measurement data from licensees and determine if those levels may be detrimental to passive sensing measurements.

---

[26] "Watch: A conversation on America's digital connectivity." Axios Events. 16 July 2020. https://www.axios.com/axios-event-5g-future-fcc-chair-302fecf5-f6af-4f8f-99a7-4d9ce0fa37e9.html

[27] 27 July 2021. AGU/AMS/ NWA at 7.

The calculation process is not straightforward, and the use of multiple methods by the industry would only contribute to the difficulty. We recommend only one measurement method be utilized by equipment providers and licensees, TRP.

11. Emissions Limits per Resolution 750 *at a minimum* should be applied to mobile and fixed operations, including point-to-point and point-to multipoint operations.

Paragraphs 16, 17
In our earlier reply comment to the Public Notice, our three organizations noted our agreement that the unwanted emission limits should apply to all mobile operations in Parts 2 and 20 of the Commission's rules. In addition, emission limits should be applied to fixed services as well, but studies should be undertaken to determine if OOBE from fixed systems may need to be stricter. Note the analysis provided in our previous reply comment related to how -13 dBm/MHz protection levels are problematic.[28]

12. Summary

The use of passive microwave spectrum allocations for Earth exploration-satellite services is an essential component to the development of weather forecasts. Characteristics of terrestrial emissions, such as power levels, deployment schedule, and direction of emissions, will determine if contamination of adjacent passive bands alters the accuracy of weather forecasts that are an output from complex numerical weather prediction models. Improvements in numerical weather prediction performance over the past 20 years can be attributed to satellite observations, especially microwave sensing of water vapor, such as 23.6-24.0 GHz and other frequencies.[29]

To achieve global uniformity in the quality of passive microwave meteorological observations, the Commission should adopt the ITU limits from Resolution 750 *at a minimum*. The Commission should prohibit the grant of new equipment certifications for, or the importation of, equipment not complying with the phase two unwanted emission limits as of January 1, 2027. Finally, the Commission should apply the stringent limits to all transmitters after September 1, 2028, to enable consistent use of the 23.6-24.0 GHz sensing band and to reduce the interference potential from older equipment.

To minimize future conflicts related to passive bands, the Commission should develop processes for further and continued dialogue with the science community to develop Service Rules and OOBE levels for passive bands. Doing so would establish baseline expectations for allowable deployment strategies ahead of subsequent proceedings for frequencies adjacent to existing passive Earth sensing. Contamination from radio frequency interference will have wide ranging ramifications, leading to a degradation in weather forecasts important to numerous economic sectors, and/or a reduction in the amount of warning lead time for dangerous weather events, especially if contamination occurs in multiple Earth exploration-satellite service bands.

We appreciate the opportunity to provide input into this proceeding.

---

[28] 27 July 2021. AGU/AMS/ NWA at 10.
[29] Geer, A. J., F. Baordo, N. Bormann, P. Chambon, S. J. English, M. Kazumori, H. Lawrence, P. Lean, K. Lonitz, and C. Lupu. "The Growing Impact of Satellite Observations Sensitive to Humidity, Cloud and Precipitation." Quarterly Journal of the Royal Meteorological Society 143, no. 709 (October 2017): 3189–3206. https://doi.org/10.1002/qj.3172.