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5 August 2020

Federal Communications Commission
Ms. Marlene Dortch, Secretary
445 12th Street, S.W.
Washington, DC 20554

RE: Comments for WT Docket Nos. 20-133 and 10-153

Ms. Dortch:

The American Geophysical Union (AGU), American Meteorological Society (AMS), and National Weather Association (NWA), representing meteorologists and earth scientists throughout the United States, appreciate the opportunity to comment on the Notice of Proposed Rulemaking (NPRM) for Modernizing and Expanding Access to the 70/80/90 GHz bands. The meteorological community, reliant on federal and international weather satellites, are longstanding users of passive microwave spectrum in developing techniques for enhancing weather predictions with weather satellites. In advancing 5G, we ask that the FCC recognize the value of atmospheric 86-92 GHz emissions so that present weather conditions in the U.S. and worldwide can inform the seven-day weather forecast and enable meteorologists to track dangerous storms, such as Nor'easters and hurricanes. It is possible for new wireless communications to coexist with earth sensing only with careful considerations of how microwave weather instruments work, the observations they collect, and the guard bands necessary to ensure there is no contamination of observations with interfering terrestrial emissions.

The space-based radiometers that collect atmospheric signals are not communications receivers and common protection criteria for such receivers will not adequately protect weather instrumentation from collecting contaminated signals. In addition, passive microwave atmospheric signals are substantially weaker than the potential wireless emissions proposed in this NPRM. The types of wireless communications of greatest concern to passive earth sensing are those involving transmission to mobile platforms such as aircraft and ships, a use specifically outlined in the NPRM. Fixed, point-to-point backhaul transmissions are less concerning, though more information is needed about the network design for both arrangements, including the density of transmissions.

Earth sensing of atmospheric properties at 86-92 GHz is unique because the spectrum allocation is dependent on the characteristics of commonly observed atmospheric molecules, namely water. For this reason, 86-92 GHz is widely used in the meteorological community to observe humidity, clouds, and precipitation. Any weather satellite instrument detection of terrestrial wireless signals, especially those on mobile platforms that are not fixed in space and time, would diminish the applications of the collected imagery. Contamination of weather sensor imagery is harmful interference, which is unacceptable at any degree.

In this comment, we describe several active weather satellite missions that could observe contamination based on the plans outlined in the NPRM. However, it is as important to maintain the 86-92 GHz band for prospective future applications of passive earth sensing, including higher spatial resolution sensors that will likely drive advances in weather prediction and warning accuracy in the coming several decades. We specifically request involvement of federal government agencies operating weather satellites to provide input on this NPRM, clarifying the impacts, and expressing informed solutions, if warranted, for mitigating action.

I. Federal weather satellites sense important weather conditions at 86-92 GHz

The federal use of passive microwave sensing of the Earth atmosphere is widespread, important, irreplaceable, and essential as an input for numerical weather predictions and human analysis. Instruments that collect atmospheric emissions provide valuable inputs into numerical weather prediction models, driving and maintaining accuracy of local weather forecasts, and enabling meteorologists to determine the structure of threatening storms such as hurricanes.

Both the National Oceanic and Atmospheric Administration (NOAA) and National Aeronautics and Space Administration (NASA) operate satellites that observe the Earth atmosphere in the 86-92 GHz earth exploration-satellite sensing (EESS) band; the instruments do not emit or transmit at 86-92 GHz. The collected data is transmitted nearly instantaneously via direct broadcast services to federal and non-federal users, such as academic institutions and corporate weather information providers with antennas using L/X-band frequencies. The U.S. Department of Defense also operates weather satellites with a microwave sensor.

NOAA currently operates two polar-orbiting satellites with a 22-band Advanced Microwave Technology Sounder (ATMS), the most recent federal Earth-sensing satellite with a microwave sensor in orbit. Launches of three more satellites in the Joint Polar Satellite System (JPSS), each hosting an ATMS are anticipated through 2031; the mission will likely continue through the 2030s. Furthermore, it is highly likely that 86-92 GHz will remain an important band for passive microwave sensing on subsequent satellite missions beyond the end of JPSS.

II. Other weather satellite missions at 86-92 GHz

There are legacy national and additional international polar-orbiting satellite missions that observe in the 86-92 GHz band. U.S. users, including NOAA and NASA, benefit from these missions just as other nations benefit from U.S. missions. A single polar-orbiting weather satellite observes the entire Earth, including the U.S., at least twice daily (once during the day and once at night), with a single satellite providing coverage of the poles every 100 minutes. As multiple polar-orbiting satellites are necessary to provide more frequent coverage for observing short-term changes in the weather, the satellites are staggered in orbit to achieve that.

Thus, the U.S. relies on passive microwave observations collected with satellites that the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) and Japan Aerospace

Exploration Agency (JAXA) operate.[1] Important instruments and their host mission with Earth-sensing passive microwave capability at 86-92 GHz include:

- Advanced Microwave Scanning Radiometer-2 (AMSR-2), part of the JAXA Global Change Observation Mission (GCOM)
- Advanced Microwave Sounding Unit – A (AMSU-A), part of NASA Aqua, NOAA-15, -18, -19, and EUMETSAT MetOp-A, -B, and -C
- Advanced Microwave Sounding Unit – B (AMSU-B), part of NOAA-15
- Advanced Technology Microwave Sounder (ATMS), part of the NOAA Suomi National Polar-orbiting Partnership (NPP), JPSS-1 (NOAA-20), and future JPSS-2, -3, and -4 (aforementioned)
- Global Precipitation Mapper (GPM) Microwave Imager (GMI), part of NASA GPM
- Microwave Humidity Sounder (MHS), part of NOAA-18, -19, and EUMETSAT MetOp-A, -B, and -C
- Special Sensor Microwave Imager/Sounder (SSMI/S), part of the U.S. Defense Meteorological Satellite Program (DMSP)

This list is presented for awareness of how widespread the U.S. 86-92 GHz sensing capability is; the sensitivity of these instruments, and their missions, to interference under the proposed terms of the NPRM is discussed further Section IV.

Contributing to the global constellation, Roscosmos (Russia), the China Meteorological Administration (CMA), and the Indian Space Research Organization (ISRO) also have meteorological satellites with sensors in the 86-92 GHz EESS band. The EUMETSAT follow-on polar-orbiting satellite mission, MetOp-SG (second generation), is of particular importance to the U.S., with satellites launching between 2023 and 2038 that will host a microwave imager and sounder in the 86-92 GHz EESS band.

III. Microwave band weather observations advance storm predictions

Earth-sensing satellites are typically equipped to passively observe at multiple frequency bands. The relationship between the observations of the same "footprint" (the resolution of the sensor) at different frequency bands is informative. The types of frequencies usually fit within one of two categories: visible-infrared and passive microwave (20 GHz and greater).

- Visible-infrared imagery provides meteorologists the ability to inspect the exterior of a storm, revealed through cloud tops and patterns.
- Passive microwave sensing enables meteorologists to identify the internal structure of the storm, such as which storm cells are producing precipitation and the intensity of that precipitation. Imagery of this type is particularly useful when a storm's exterior cannot be examined in visible-infrared imagery due to the presence of high-level cloudiness.
- Assessing the distribution of precipitation and structure of a cyclone is a widely established application of passive microwave imagery at 86-92 MHz.[2]

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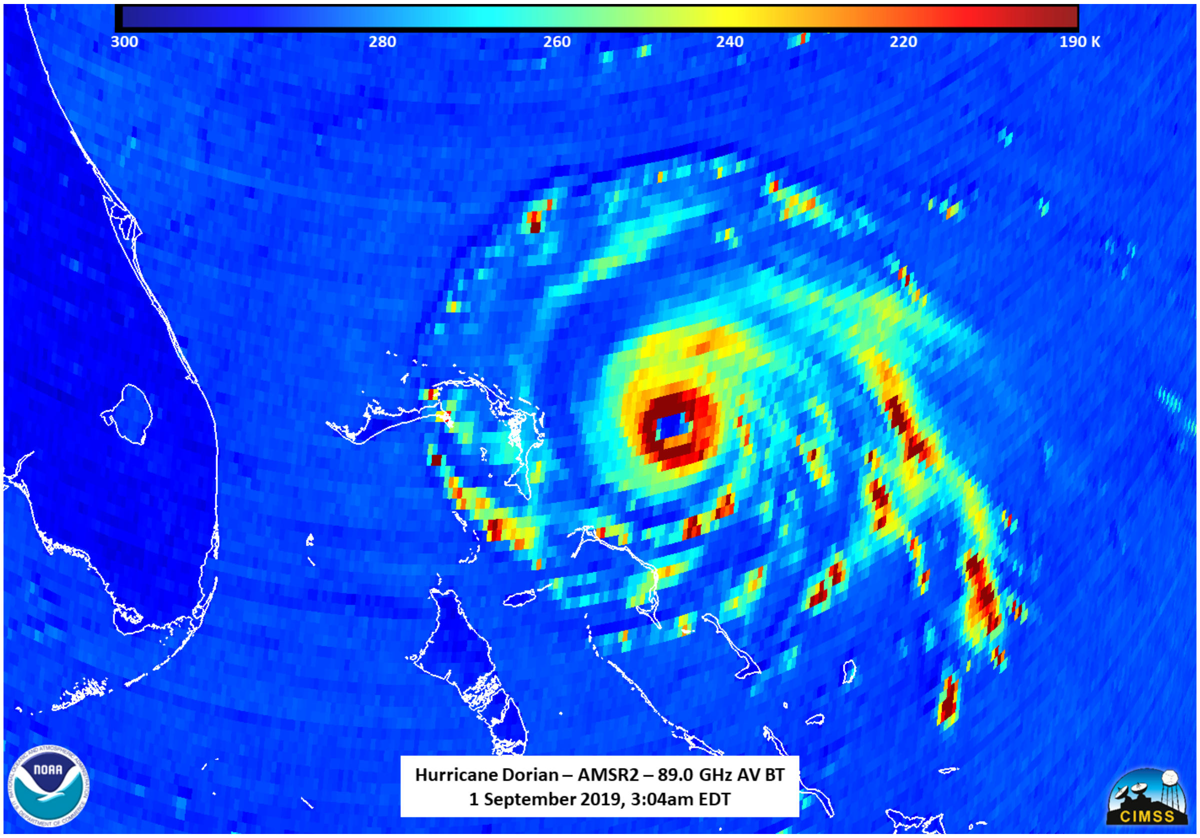
[1] NOAA and EUMETSAT signed an agreement in 2015 to form the Joint Polar System. Under this agreement, Europe covers the mid-morning crossing orbit and the U.S. covers the early afternoon crossing orbit worldwide. Ground processing support and data are freely shared between the entities.

[2] See "Interpretation of TRMM TMI Images of Tropical Cyclones" from Thomas F. Lee et al., January 2002, at https://journals.ametsoc.org/ei/article/6/3/1/667/Interpretation-of-TRMM-TMI-Images-of-Tropical.



The above 89 GHz image[3] of Hurricane Dorian captured with the JAXA AMSR-2 during the early morning hours of 1 September 2019 shows a clearly defined eye, eye wall, and several bands of thunderstorms extending outward from the central portion of the cyclone. At the time this image was captured, Hurricane Dorian was a Saffir-Simpson category 'four', an intensity rating that was in part informed by this structure.[4] Hurricane Dorian was analyzed as a category 'five' storm as it intensified later that day, with winds over 157 mph eventually causing catastrophic damage to islands of the Bahamas, while slowing precariously close to Florida. Without microwave imagery, meteorologists would not have been able to rule out impacts to other Gulf Coast states.[5]

The 89 GHz band is also sensed with ATMS (88.2 GHz with a 2 GHz bandpass); the other two "window" bands on ATMS are around 23.8 GHz and 31.4 GHz. A "window" band is one where the atmospheric molecules (such as oxygen and water vapor) are weakly detectable or not detectable at all, allowing meteorologists to ascertain information about surface and near-surface conditions or cloud properties.

Understanding where water exists in the atmosphere is an important aspect of the accuracy of weather forecasts. This is, in part, because as water condenses, energy is released. The ATMS bands at 23.8 GHz, 31.4 GHz, and 89 GHz collectively provide the means to characterize the water where it exists in the atmosphere: (1) as vapor, contributing to the humidity of the air, (2) as cloud, in either a droplet or small

[3] The source for this image in the Cooperative Institute for Meteorological Satellite Studies, Space Science and Engineering Center, at the University of Wisconsin-Madison: https://go.wisc.edu/y64ko0.
[4] U.S. National Hurricane Center (NHC) forecast discussions issued on and around 1 September 2019, such as https://www.nhc.noaa.gov/archive/2019/al05/al052019.discus.031.shtml, support this conclusion.
[5] The National Weather Service forecast office in Birmingham, Alabama, communicated via Twitter later on 1 September 2019 that Alabama would not see impacts from Hurricane Dorian, consistent with the forecast: https://twitter.com/NWSBirmingham/status/1168179647667814400.

ice particle, and (3) as precipitation. As computing capabilities advance, algorithms are increasingly developed to integrate input from multiple spectral bands in providing the best overall "picture" of the state of the storm and surrounding atmosphere and surface. 89 GHz, therefore, is valuable alone for some meteorological applications and in combination with other passive bands, such as 23.8 GHz and/or 31.4 GHz, for different applications.

IV. NOAA and NASA should fully inform the record and operating constraints

Because the physical properties of atmospheric molecules drive the passive sensing capability at 86-92 GHz, there are few options to mitigate impacts on the EESS allocation at 86-92 GHz other than power constraints on wireless emissions adjacent to existing satellite instrument sensing capabilities. Sensitive radiometers that collect atmospheric signals from space are not communications receivers and criteria developed to protect communication receivers would not adequately protect weather sensors. NOAA and NASA are best equipped to recommend the constraints on adjacent band use for their satellites and operations. We defer to their input via the National Telecommunications and Information Administration (NTIA) related to the NPRM question on constraints for new wireless operations.

More broadly, we encourage the FCC to develop a fully informed record based on NOAA and NASA input prior to further action on the NPRM for the 86-92 GHz EESS band. The power of potential wireless emissions for operations proposed in the NPRM, 57 dBW, is several orders of magnitude greater than the background atmospheric signal that Earth-sensing satellite instruments are currently collecting. Much more clarity is necessary in how these wireless transmissions would be implemented, including their power and transience.

The possibility of interference depends on the wireless emission, its maximum power, and its proximity to 86 and 92 GHz; our assessment below is based on a 57 dBW signal up to 86 GHz.[6] In addition, the aforementioned instruments have different sensing characteristics; some instruments will be more susceptible to out-of-band interference depending on whether it is sensing in a band central to the broader 86-92 GHz band, and the width of the sensing band. Complete information about the terrestrial emission is necessary to make a conclusive determination where the spectral guard band between a satellite sensing band and potential terrestrial wireless transmission is within 1.5 GHz of the 86-92 GHz band edge.

The following table outlines the characteristics of the 86-92 GHz band for instruments currently in orbit on aforementioned missions (Section II) and our present level of concern without further study.

Instrument[7]	Central Frequency	Bandwidth	Possibility of Interference
AMSR-2	89.0 GHz	3.0 GHz	Possible
AMSU-A	89.0 GHz	6.0 GHz	Possible, Elevated Concern
AMSU-B	89.0 GHz	1.0 GHz	Very Unlikely
ATMS	88.2 GHz	2.0 GHz	Possible
GMI	89.0 GHz	6.0 GHz	Possible, Elevated Concern
MHS	89.0 GHz	2.8 GHz	Unlikely
SSMI/S	91.7 GHz	2.8 GHz	Possible, Greatest Concern

[6] We determined that there was a possibility of interference based on the bandwidth between the edge of the sensing band and the edge of the EESS 86-92 GHz band provided power constraints in the NPRM. We do not assert that there definitively will or will not be interference at this stage of the FCC proceeding.
[7] The information in this table was retrieved from the NOAA Center for Satellite Applications and Research at https://www.star.nesdis.noaa.gov/mirs/instruments.php on 29 July 2020 and reconciled with other sources, such as the Observing Systems Capability Analysis and Review (OSCAR) Tool at https://www.wmo-sat.info/oscar/.

Per Resolution 750 of the 2015 World Radiocommunication Conference (WRC-15), the recommended maximum level of unwanted emission power between 87 and 91 GHz is -55 dBW/100 MHz, and less than -41 dBW/100 MHz between 86 and 87 GHz and 91 and 92 GHz. With a sufficient guard band informed by a NOAA/NASA study, no current instruments may find contaminating signals. Even if so, 86-92 GHz power protections should remain not only for current instruments in orbit but also possible new instruments with sensing characteristics that are different.

V. Potential strategies to mitigate interference are underdeveloped and special protections around storms may be necessary

We also understand that it may be possible to reduce 5G power emissions based on the overhead passage of an Earth-sensing satellite. Such a reduction in emissions can be achieved by limiting the number of active 5G sessions, pausing sessions that do not require low latency, or by reducing session transmission power. Constraints on power emissions are necessary only during satellite sensing windows, which are relatively short (less than a few seconds per satellite passage) and predictable (though vary daily).

We caution, however, that this type of strategy has not been implemented under field conditions, and adopters of this approach should not expect the number of satellite passes will remain constant in the future. While the 86-92 GHz EESS band sensing capability is currently limited to instruments in the polar, or low-earth, orbit, there is a possibility of new passive microwave sensing from the geostationary orbit. If developed, passive microwave sensing would become more frequent and limit the desirability of a time-synchronized power-modification approach.

The use of 86-92 GHz for weather forecasts is global, in part because weather is global, and an incomplete or misleading picture of weather systems would decrease forecast accuracy and preparation time ahead of major storms. Given the particular importance of passive sensing to hurricane forecasting, we encourage the FCC to impose an operational limitation of 500 mi radius from transient storm centers, as NOAA so determines, to constrain out-of-band interference and provide enhanced protection within the U.S. for the 86-92 GHz EESS band.

VI. Summary

As evidenced from the $18.8-billion U.S. lifecycle investment in the four-satellite JPSS, passive microwave earth sensing is a critical element of weather prediction, especially for major storms, including hurricanes. The FCC should not adopt a rule that would allow new wireless broadband services to illuminate adjacent allocations for EESS between 86 and 92 GHz. Even a slightly detectable wireless signal intrusion into a weather imager observing in this band could imperil the longstanding and future benefits to weather predictability.

Thank you for your consideration and attention to this matter. We look forward to working towards a solution that positions the U.S. as a leader in both 5G and global weather imaging. The undersigned invite the opportunity to address any questions.

Respectfully submitted,

American Geophysical Union[8]

American Meteorological Society[9]

National Weather Association[10]

cc:
Hon. Eddie Bernice Johnson (D-TX), Chair, House Committee on Science, Space, and Technology
Hon. Frank Lucas (R-OK), Ranking Member, House Committee on Science, Space, and Technology
Hon. Roger Wicker (R-MS), Chair, Senate Committee on Commerce, Science, and Transportation
Hon. Maria Cantwell (D-WA), Ranking Member, Senate Committee on Commerce, Science, and Transportation

[8] To address the American Geophysical Union (AGU) on this matter, contact Lexi Shultz, Vice President of Public Affairs. To learn more about the AGU, visit *www.agu.org*.
[9] To address the American Meteorological Society (AMS) on this matter, contact Keith Seitter, Executive Director, or Paul Higgins, Director of the AMS Policy Program. To learn more about the AMS, visit *www.ametsoc.org*.
[10] To address the National Weather Association (NWA) on this matter, contact Janice Bunting, Executive Director. To learn more about the NWA, visit *www.nwas.org*.