Passive Spectrum & Weather Forecasting

Policy Realities and Opportunities

RFI 2022

RFI on NWP across the Weather Enterprise

A Case Study on 24 GHz Policy Developments in the U.S.

Prepared by:

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iPhone 13

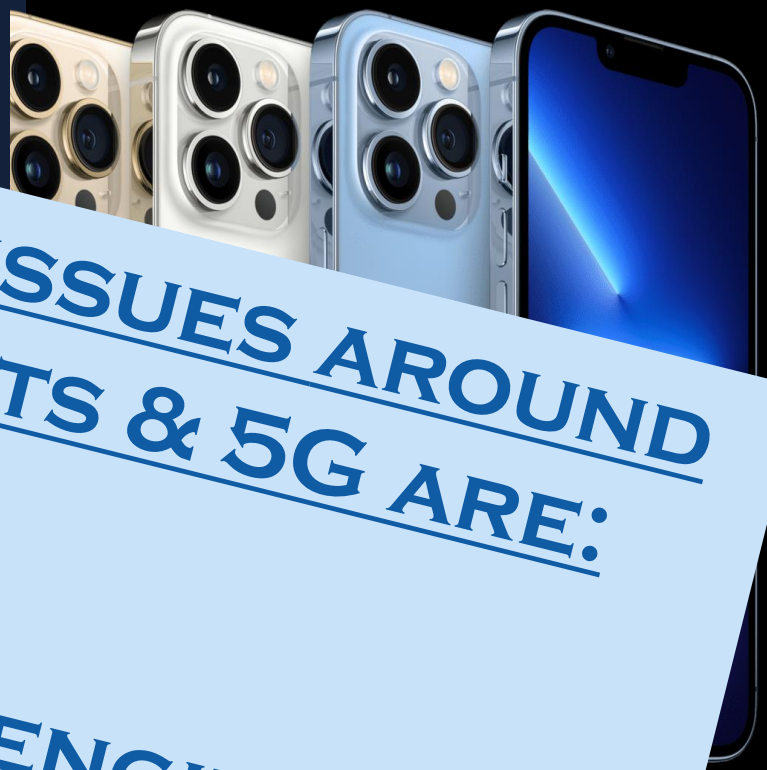
Your new superpower.

Available starting 9.24.

Source: Time Magazine / Apple.com

But the broader issues around Weather Forecasts & 5G are:

- More Complex
- More Nuanced
- Even more Challenging



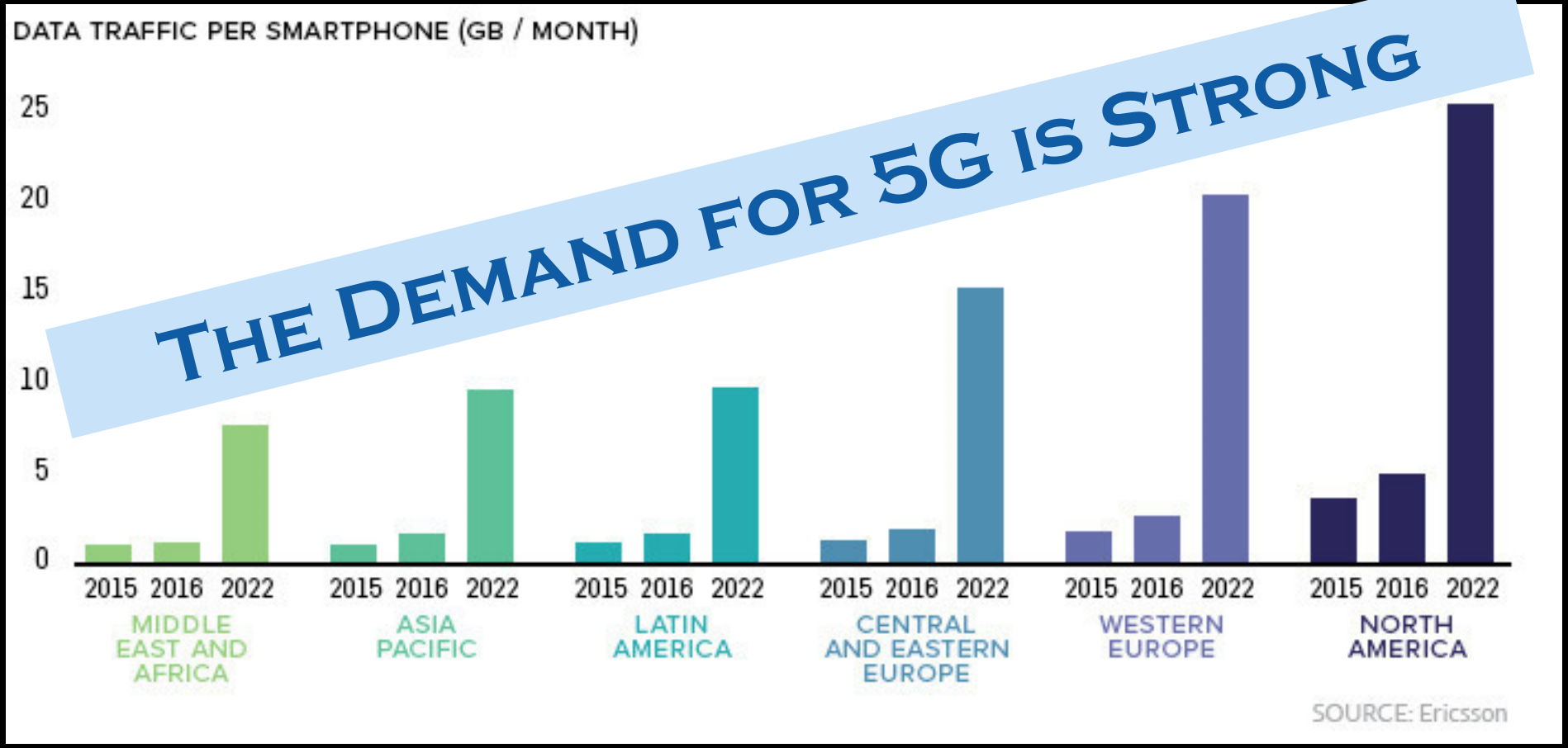
IPhone 13 Will Operate in:

24.25-27.50 GHz

250 MHz above NOAA JPSS' ATMS sensor Ch 1

37.00 – 40.00 GHz

adjacent to 36-37 GHz passive band used by U.S. Dept of Defense (DoD) and others



Data Traffic Per SmartPhone in GB per month
Each World Region in 2015, 2016, and projected to 2022
(as of 2018)

Source: https://www.weforum.org/agenda/2018/07/the-breathtaking-complexity-of-the-wireless-spectrum/

Key Questions

- Why are passive measurements crucial to meteorology?
- How did weather forecasting and 5G get so political?
- What are the "lessons learned" for the *weather enterprise*?

WHAT IS THE WEATHER ENTERPRISE?

The sectors that contribute to the science of weather -- academia, government, industry & supporting organizations

Private Sector Weather Companies	Weather Broadcasters	Environmental Satellite/ Technology Manufacturers	American Geophysical Union (AGU)	American Meteorological Society (AMS)
Science Agency Government Contractors.	Weather Affected Industries (Agriculture, Energy)	Certified Consulting Meteorologists (and other consultants)	American Weather and Climate Industry Association (AWCIA)	National Weather Association (NWA)

State / Local Government Agencies	Federal Government Agencies	Universities / Colleges	FFRDCs (federally funded R&D centers)

Terminology developed by the U.S. National Academy of Sciences in early 2000s, embraced by the AMS, NOAA and other entities.

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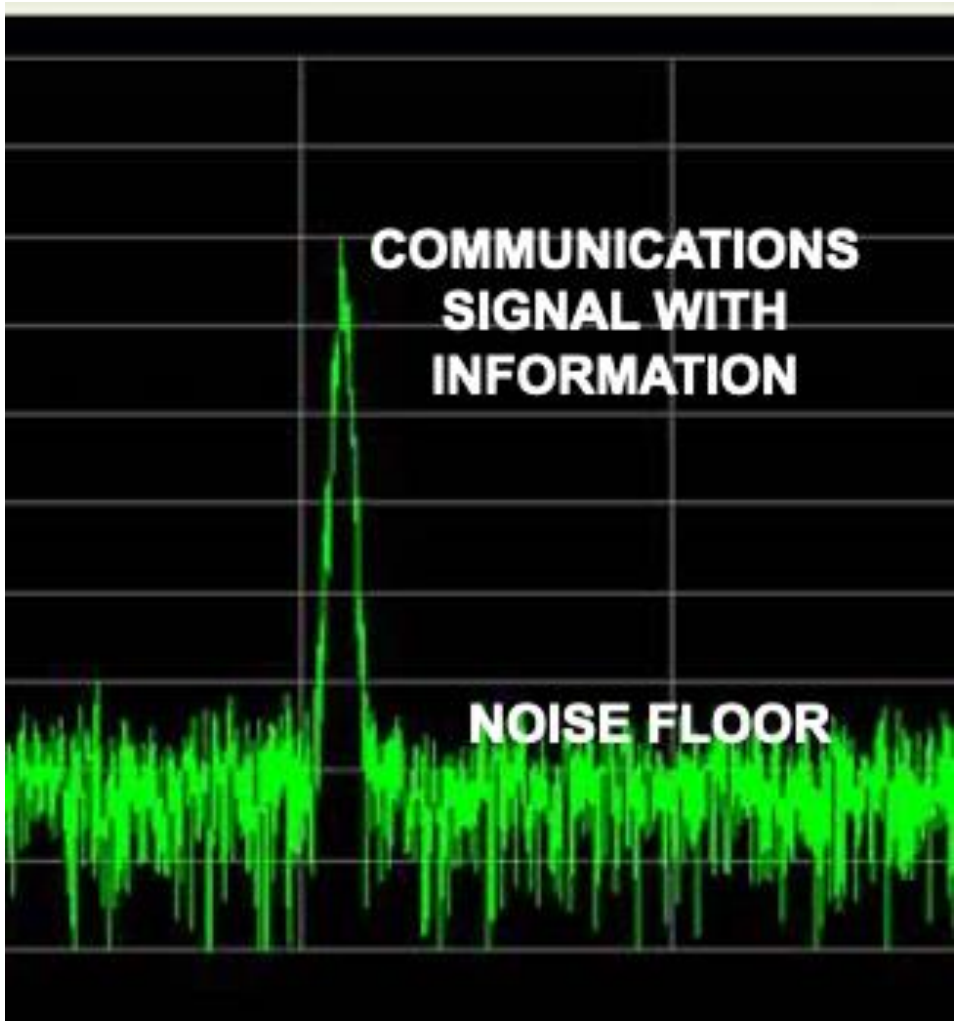
Passive Observations: Critical to Forecast Accuracy

Historic Flooding in Houston, Texas following Hurricane Harvey, August 2017

Credit: LM Otero / AP via The Atlantic

Passive Data & Weather Forecasts

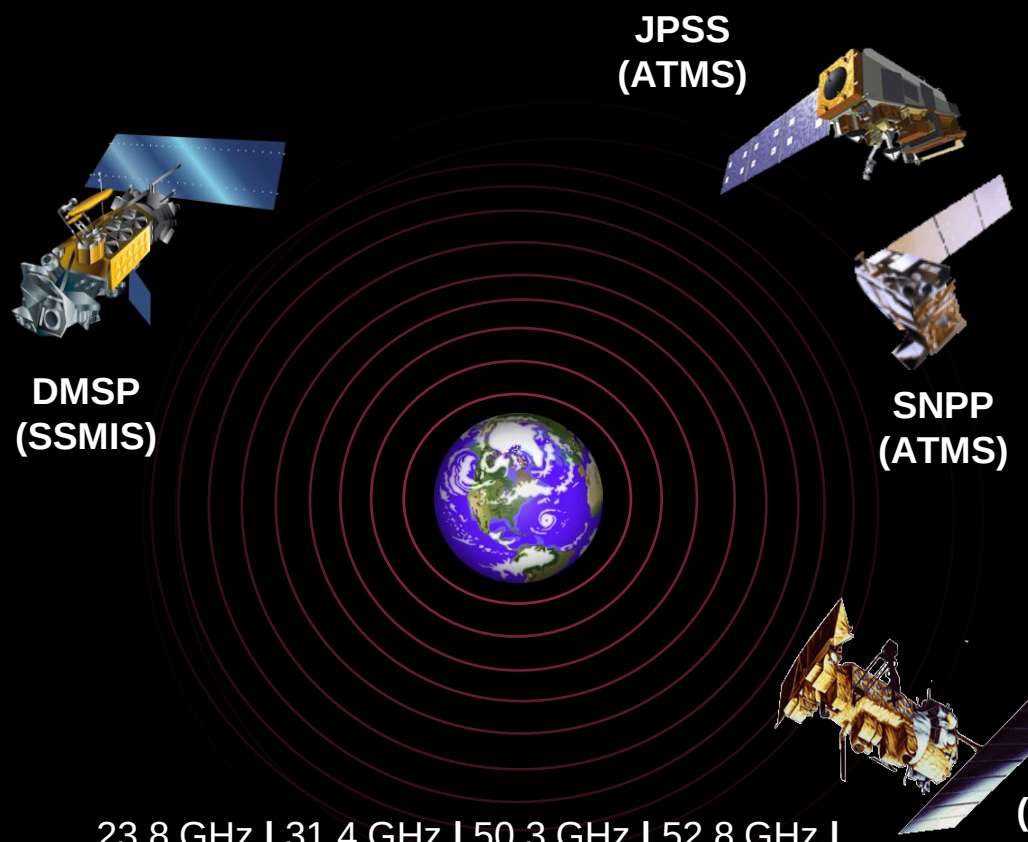
"Space-based radiometers use the radio spectrum noise floor to measure the weak emissions of the atmosphere. From these data, temperature, water vapor and other values may be determined."



Source: Testimony by David Lubar to U.S. House of Representatives; Hearing of the Science, Space & Technology Committee; July 2021

Radiometer Sensors on U.S. Operational Environmental Satellites

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



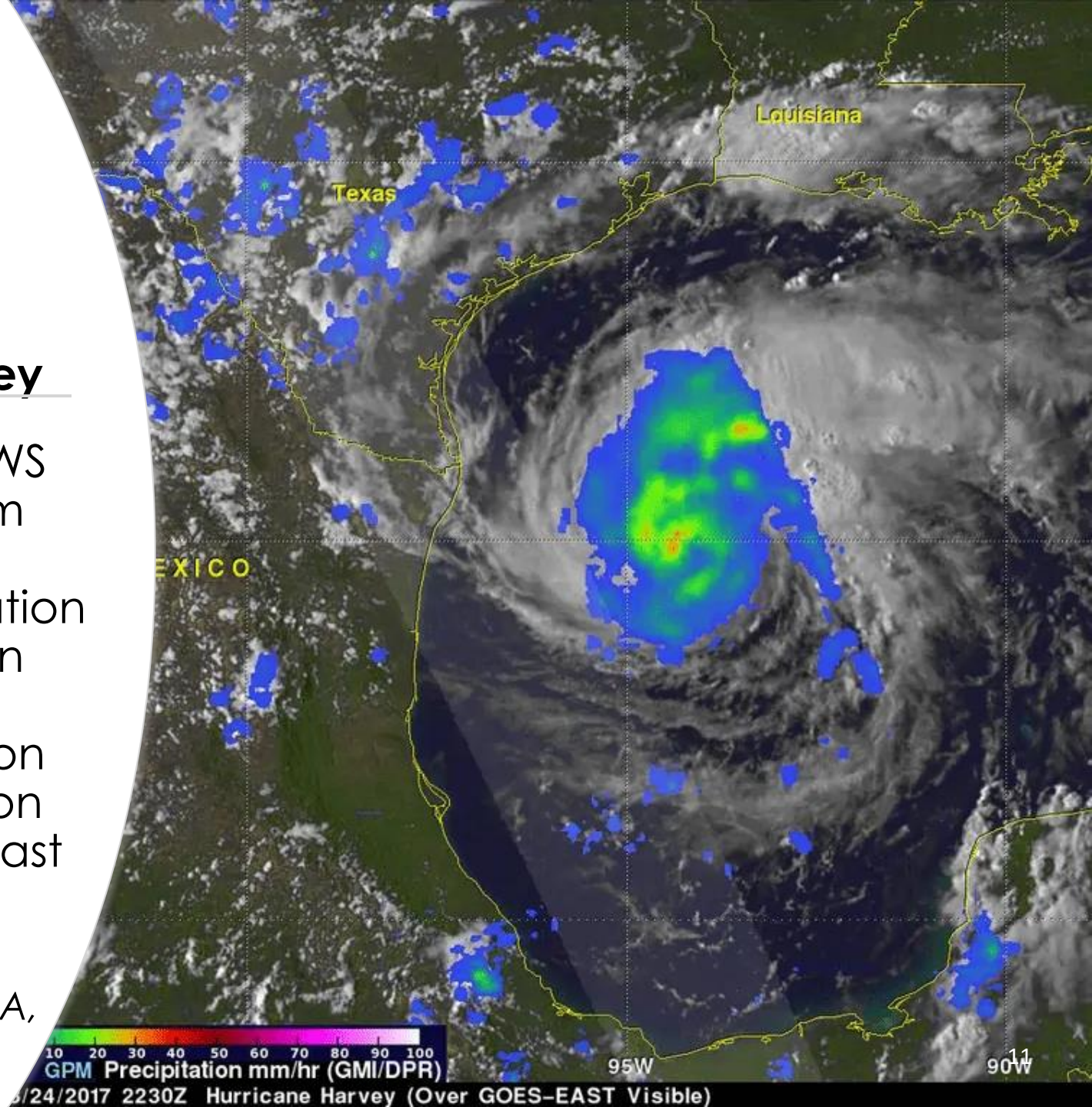
23.8 GHz
31.4 GHz
50.3 GHz
51.76 GHz
52.8 GHz
53.596 GHz
54.4 GHz
54.94 GHz
55.5 GHz
57.290 GHz
89.5 GHz
165.5 GHz
183.31 GHz

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

Environmental Satellite Information in Action: Hurricane Harvey

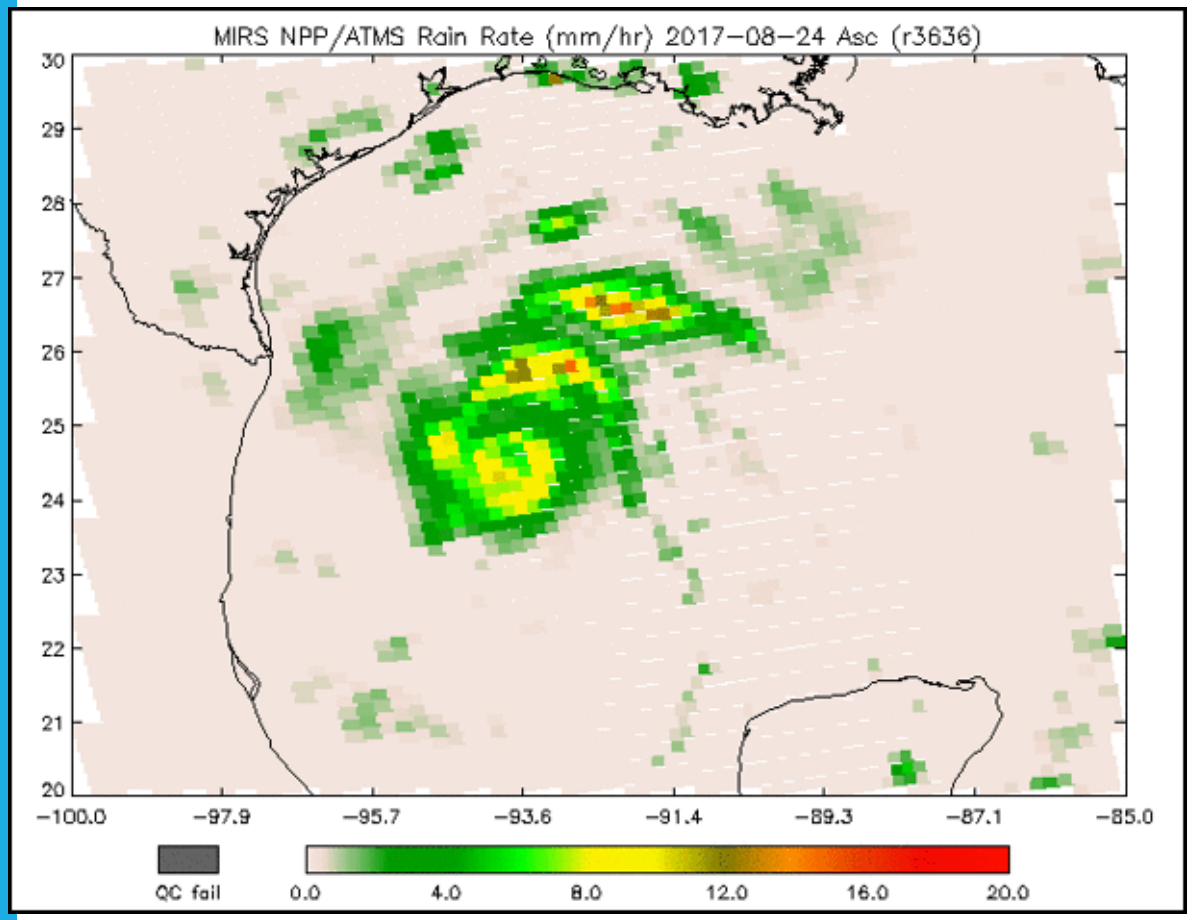
This image SHOWS rainfall rates from the NASA/JAXA Global Precipitation Mission (GPM) on August 24, 2017. GPM Precipitation Radar overlaid on NOAA's GOES-East Visible.

Image: NASA /JAXA, Hal Pierce



Passive Sensors in Action: Hurricane Harvey

This video time loop from 24-27 August 2017 SHOWS a rain rate product using passive microwave data from NOAA's ATMS sensor on the SNPP satellite.



Credit: NOAA NESDIS/STAR MiRS team: Chris Grassotti, S. Liu, J. Chen, Q. Liu

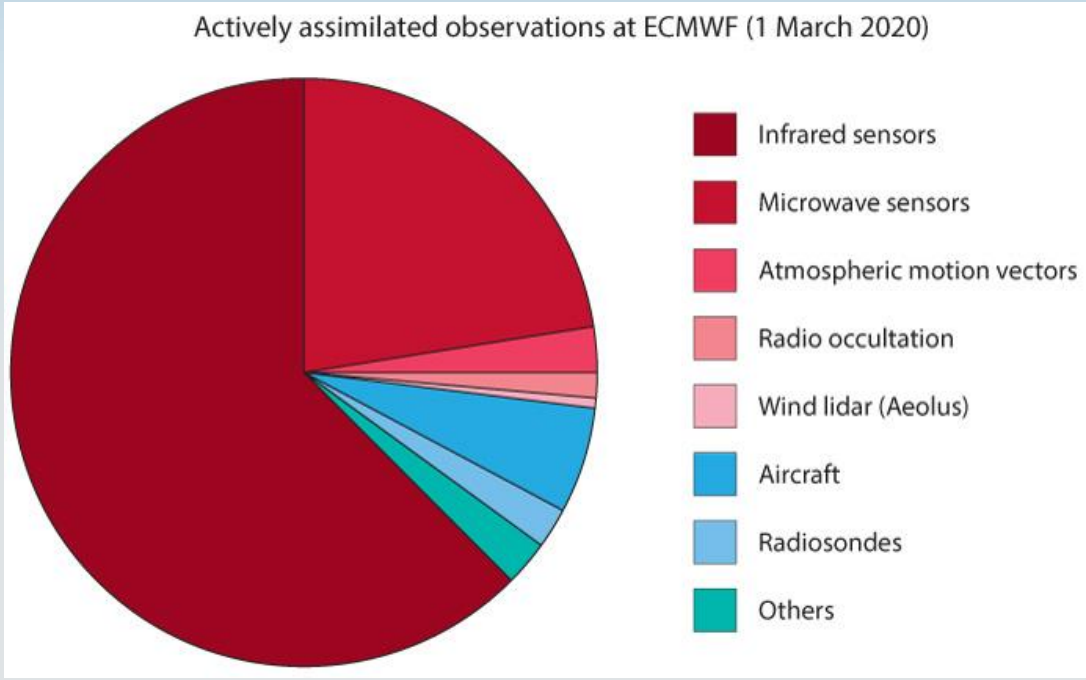
Passive Satellite Data: Critical to Numerical Weather Prediction

Source: NOAA

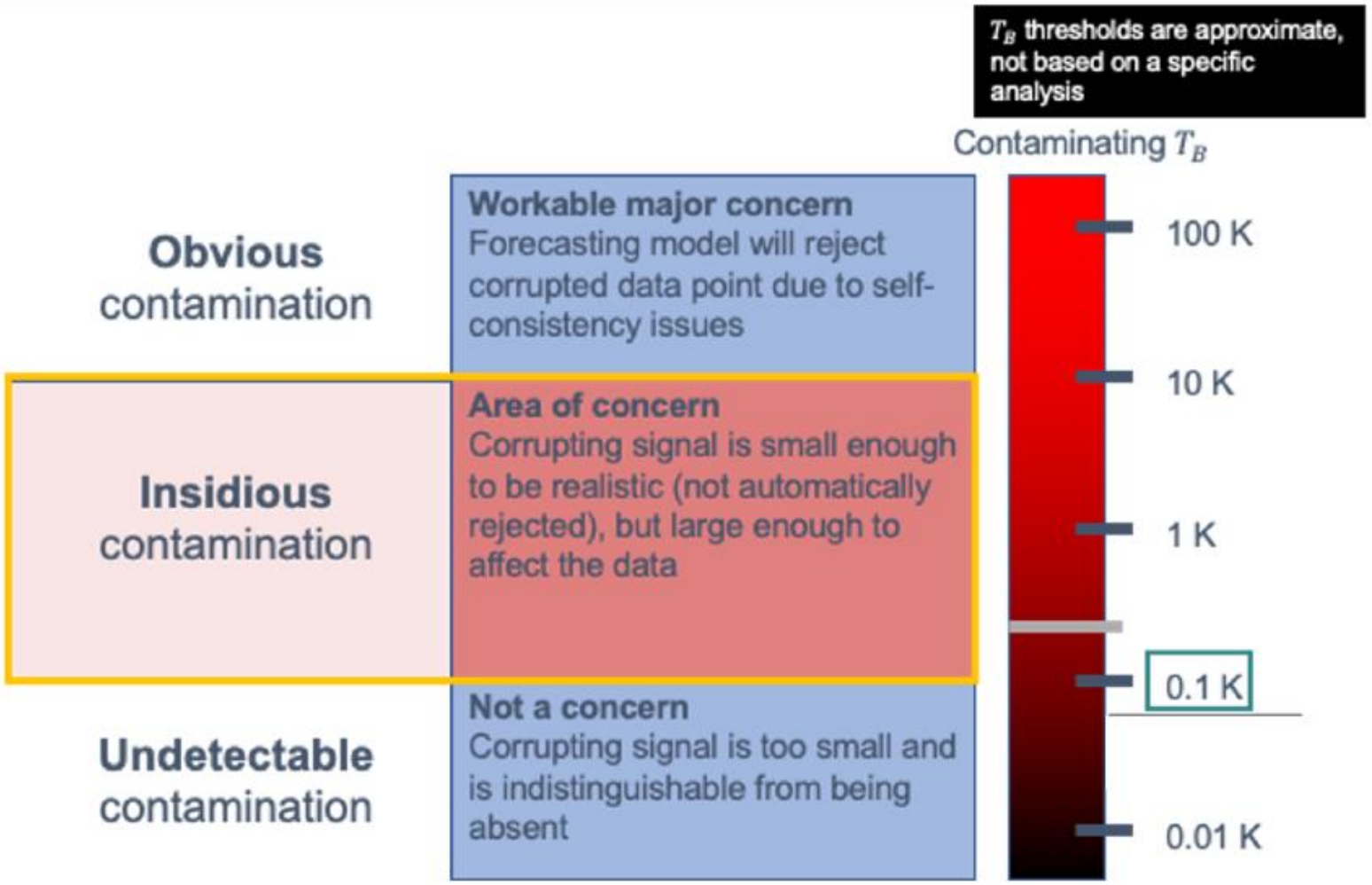
- 99% (approx.) of observations that modeling supercomputers receive originate from satellites
- After QA/QC, 90% (approx.) of observations assimilated are from satellites

- 15- 30% (approx.) of satellite observations assimilated into weather models are from passive microwave sensors

Sources: Jordan Gerth testimony to U.S. House Hearing, July 2021 (above)
Fact sheet: ECMWF's use of satellite observations (right)



Passive Interference Challenges

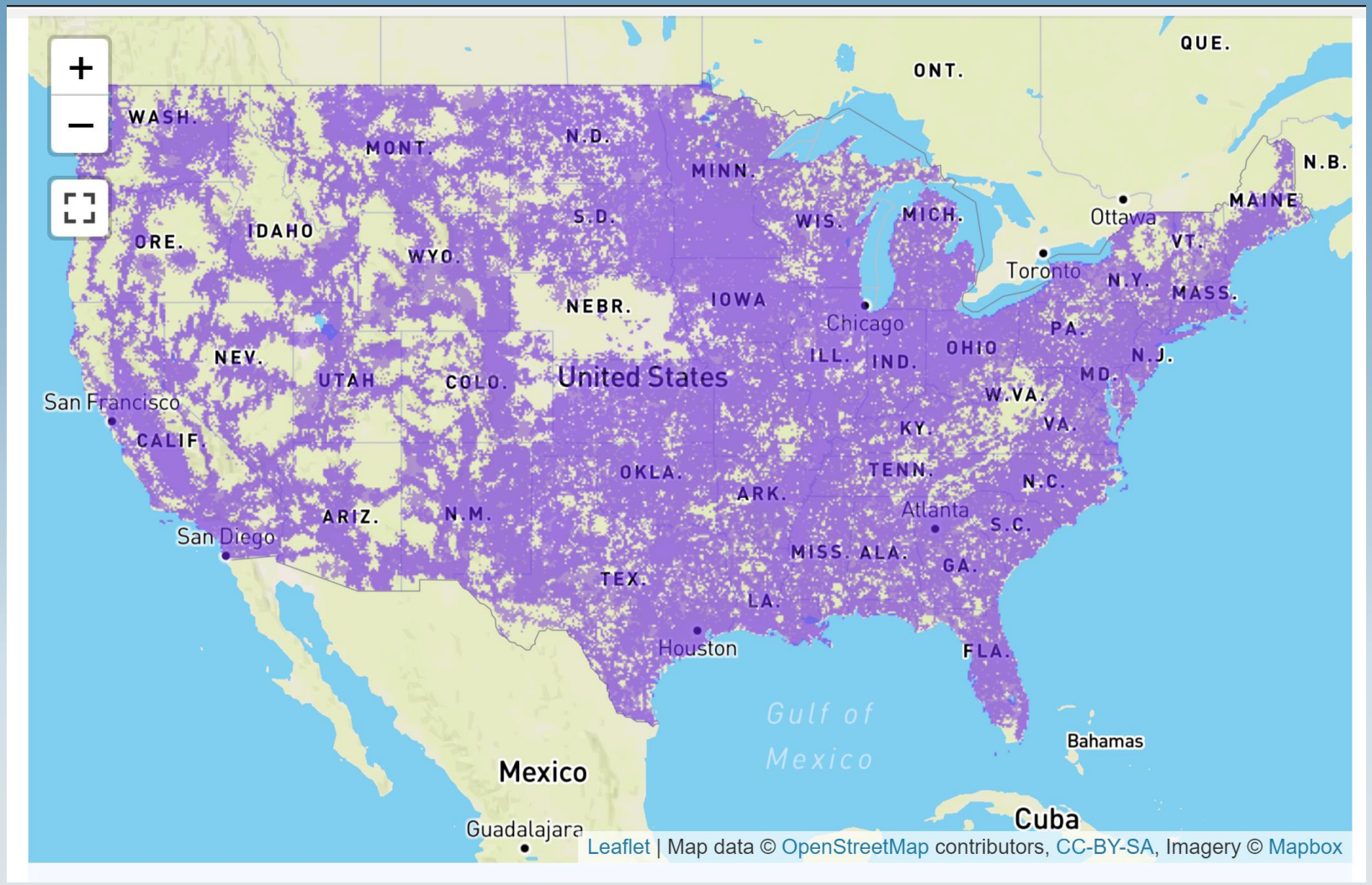


Source: Testimony by David Lubar to U.S. House of Representatives; Hearing of the Science, Space & Technology Committee; July 2021

FREQUENCY	INSTRUMENTS	APPLICATION AREA
23.6-24P	AMSU-A (NOAA/EUMETSAT), ATMS (NOAA), SSMIS (DoD), GMI (NASA), AMR (NASA), MTVZA-GY (Roscosmos), MWRI (CMA)	Total column water vapour
31.3-31.5P 31.5-31.8p	AMSU-A (NOAA/EUMETSAT), ATMS (NOAA), GMI (NASA), MTVZA-GY (Roscosmos)	Total column cloud liquid
36-37p	SSMIS (DoD), GMI (NASA), AMSR-2 (JAXA), MWRI (CMA), CIMR (ESA) (future)	Liquid water path and cloud detection o GMI
50.2-50.4P 52.6-54.25P 54.25-59.3p 59.3-59.5 60.40-61.15 63-63.5	AMSU-A (NOAA/EUMETSAT), ATMS (NOAA), SSMIS (DoD), MWTS-2 (CMA), MTVZA-GY (Roscosmos)	Temperature profile
86-92P	AMSU-A (NOAA/EUMETSAT), ATMS (NOAA), SSMIS (DoD), MWHS-2 (CMA), MTVZA-GY (Roscosmos), MWRI (CMA)	Precipitation
100-102P 109.5-111.8P 114.25-116P 116-122.25p	MWHS-2 (CMA)	
148.5-151.5P 155.5-158.5p 164-167P	ATMS (NOAA), C… (EUM…	
	…(CNES-	Water vapour
	…S (EUMETSAT) (future)	Ice cloud

No Easy Way to Mitigate Loss of these Observations

Source: Subset of table from Final Report of Radio-Frequency Interference (RFI) Workshop, 13-14 September 2018. ECMWF



5G Rollout in US: T-Mobile Largest 5G footprint as of Jan 2022

Source: Whistle Out, 5G Coverage Maps Compared: Who Has the Best 5G Coverage in Your Area? January 2022 (https://www.whistleout.com/CellPhones/Guides/5g-coverage-maps-compared)

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The Race to 5G in the U.S.

DealBook Briefing: 5G Is the New Arms Race With China

The New York Times

28 Jan 2019

Trump says 'America must win' the 5G race.

The Washington Post 18 Apr 2019

The New York Times

25 Feb 2019

Why Controlling 5G Could Mean Controlling the World

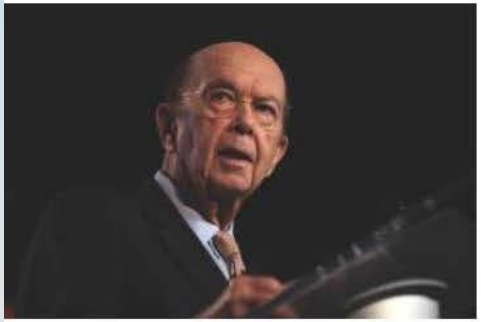
In the race to dominate the next generation of cellular networks, both the United States and China know there's much more at stake than ultrafast internet.

5G VS WEATHER

5G

Weathering the spectrum wars

5G trumps meteorology as FCC rebuffs NASA, NOAA call to halt auction

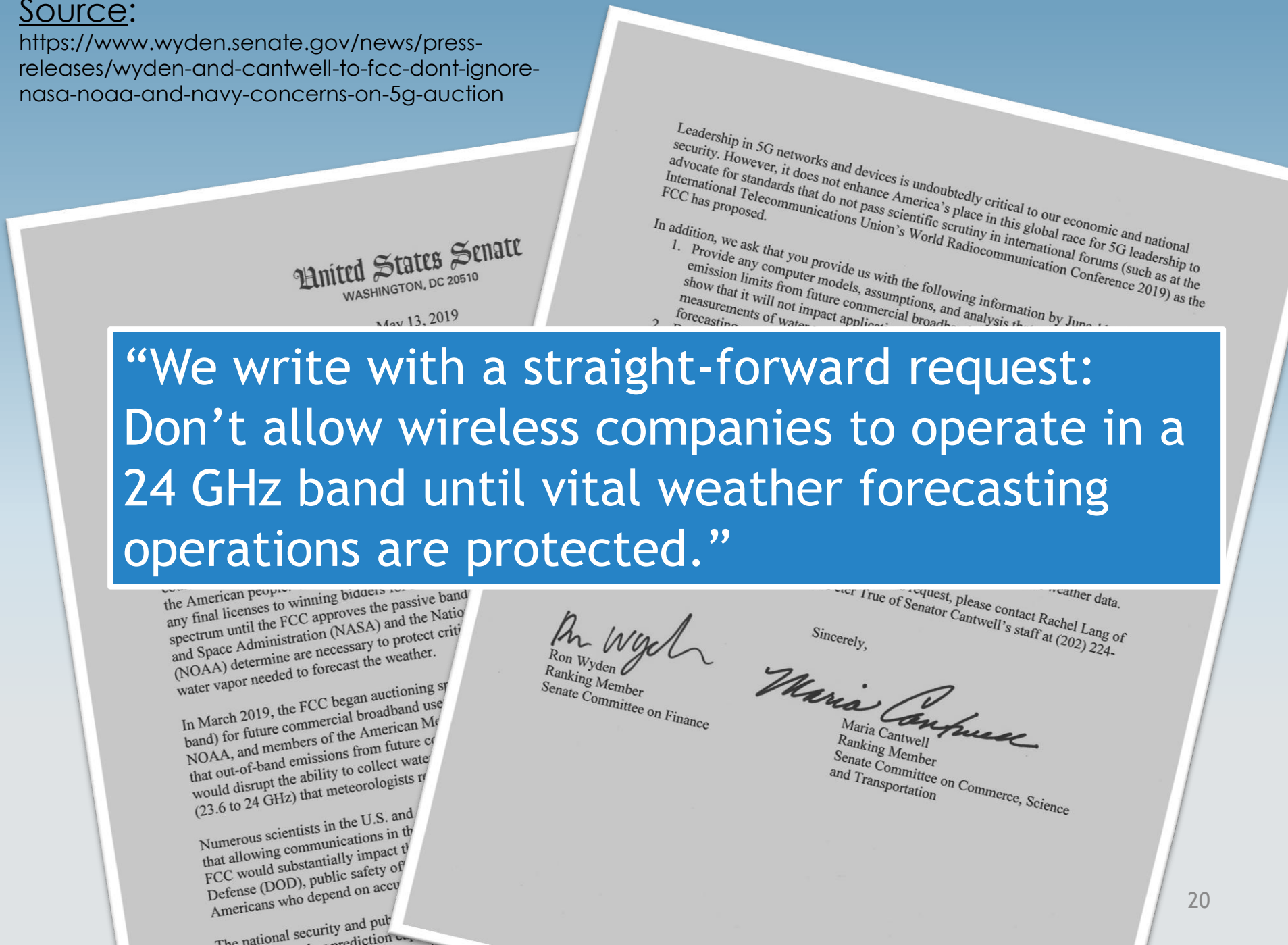


FCC Chairman Ajit Pai, center, denied a last-minute request by Commerce Secretary Wllbus Ross, left, and NASA Administrator Jim Bridenstine, right, to postpone a 5G spectrum auction out of concern for weather satellite interference.

The U.S. Federal Communications Commission began auctioning off radio frequency

SPACENEWS 25 Mar 2019

Source:
https://www.wyden.senate.gov/news/press-releases/wyden-and-cantwell-to-fcc-dont-ignore-nasa-noaa-and-navy-concerns-on-5g-auction


United States Senate
WASHINGTON, DC 20510

May 13, 2019

Leadership in 5G networks and devices is undoubtedly critical to our economic and national security. However, it does not enhance America's place in this global race for 5G leadership to advocate for standards that do not pass scientific scrutiny in international forums (such as at the International Telecommunications Union's World Radiocommunication Conference 2019) as the FCC has proposed.

In addition, we ask that you provide us with the following information by June
1. Provide any computer models, assumptions, and analysis th
emission limits from future commercial broadb
show that it will not impact applicat
measurements of wate
forecasting

the American people
any final licenses to winning bidders fo
spectrum until the FCC approves the passive band
and Space Administration (NASA) and the Natio
(NOAA) determine are necessary to protect criti
water vapor needed to forecast the weather.

In March 2019, the FCC began auctioning sp
band) for future commercial broadband use
NOAA, and members of the American Me
that out-of-band emissions from future c
would disrupt the ability to collect wate
(23.6 to 24 GHz) that meteorologists r

Numerous scientists in the U.S. and
that allowing communications in th
FCC would substantially impact t
Defense (DOD), public safety of
Americans who depend on accu

The national security and pub
prediction

weather data.
request, please contact Rachel Lang of
ter True of Senator Cantwell's staff at (202) 224-

Sincerely,

Ron Wyden
Ranking Member
Senate Committee on Finance

Maria Cantwell
Ranking Member
Senate Committee on Commerce, Science
and Transportation

"We write with a straight-forward request: Don't allow wireless companies to operate in a 24 GHz band until vital weather forecasting operations are protected."

May 14, 2019

THE WALL STREET JOURNAL.

U.S.

Meteorologists Worry 5G Expansion Could Interfere With Weather Forecasts

As FCC seeks more radio frequencies to support new technology, some worry signals could bleed into satellite readings used to predict hurricanes

May 14, 2019

ars TECHNICA

5G VS. WEATHER SATELLITES —

5G likely to mess with weather forecasts, but FCC auctions spectrum anyway

FCC auctions 24GHz spectrum despite likely interference with weather satellites.

JON BRODKIN - 5/14/2019, 3:06 PM

Outcome of WRC-19 November 2019

WORLD METEOROLOGICAL ORGANIZATION

"This WRC-19 decision has the potential to significantly degrade the accuracy of data collected in this frequency band which would jeopardize the operation of existing Earth observation satellite systems essential for all weather forecasting and warning activities of the national weather services,"

- WMO Secretary-General Petteri Taalas in a written intervention to the conference

New 5G Wireless Deal Threatens Accurate Weather Forecasts

Nature, 22 Nov 2019

"During the last four years the FCC, I believe, ran roughshod over concerns… on these airwave issues critical to weather data, adjacent to the 24 gigahertz band, critical to systems dependent on GPS and threatened by the Ligado decision."

– Statement of Chair Sen. Maria Cantwell (D-WA) Senate Commerce Committee Hearing on Nomination of Gina Raimondo as Secretary of Commerce (27 Jan 2021)

U.S. HOUSE OF REPRESENTATIVES COMMITTEE ON
SCIENCE, SPACE, & TECHNOLOGY

Eddie Bernice Johnson, Chairwoman

Congressional Hearing on 20 July 2021

SPECTRUM NEEDS FOR OBSERVATIONS IN EARTH AND SPACE SCIENCES

Bill Mahoney
NCAR

David Lubar
The Aerospace Corporation

Jordan Gerth
U of WI: SSEC

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NWA, AMS, AGU and others have participated in past FCC proceedings regarding spectrum allocation

CTIA @CTIA · May 21, 2019

"The dire predictions about the impact of #5G on current weather forecasting are wrong on the merits, on the facts, and on the process." - EVP Brad Gillen on how we can—and will—have 5G and weather forecasting. Read more: ctia.it/2MdJlur

CTIA was formerly known as the Cellular Telecommunications Industry Association

18 January 2022

Transportation

Wireless carriers to limit 5G near airports after airlines warn of major disruptions

AT&T and Verizon are planning to activate new high-speed networks Wednesday but agreed to concessions

WSJ

BUSINESS

Why 5G Rollout Is Concerning Airlines and Flight-Safety Regulators: What to Know

After delays caused by worries about flight safety, Verizon and AT&T introduced faster internet connection

19 January 2022

NOAA warns of threat to weather forecasts from 5G spectrum

The agency's administrator testified to Congress that the harm to weather models could set forecasters back decades.

Acting NOAA Administrator Neil Jacobs, testifying to the U.S. House Committee on Science, 16 May 2019

"This would degrade the forecast skill by up to 30%," Jacobs said. "If you look back in time to see when our forecast skill was roughly 30% less than it is today, it's somewhere around 1980. This would result in the reduction of hurricane track forecasts' lead time by roughly two to three days."

Source: Jonathan Behrens / Physics Today, 24 May 2019 (image NOAA)

Bipartisan Letter on 5 November 2021 seeking White House's Office of Science and Technology Policy (OSTP)

"…to prepare a report on strategies for protecting and enabling spectrum access and quality for science and operational applications.
"These findings should influence both the U.S. government's position at international proceedings, such as the World Radiocommunication Conferences (WRCs), and in domestic proceedings at the FCC."

<u>Goal:</u> Enhancing formal science engagement in future spectrum allocation decision making in U.S.

The Path Forward
What's Needed After 24 GHz?

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   - the wireless community has a lot of political resources
   - this is a political fight as much as a technical one

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