Radio Frequency Interference Impacting Operational Weather Satellite and Radar Observations and Delivery

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Observations

High-power terrestrial wireless emissions in or near spectrum allocated for earth sensing will reduce consistent and reliable global weather observations

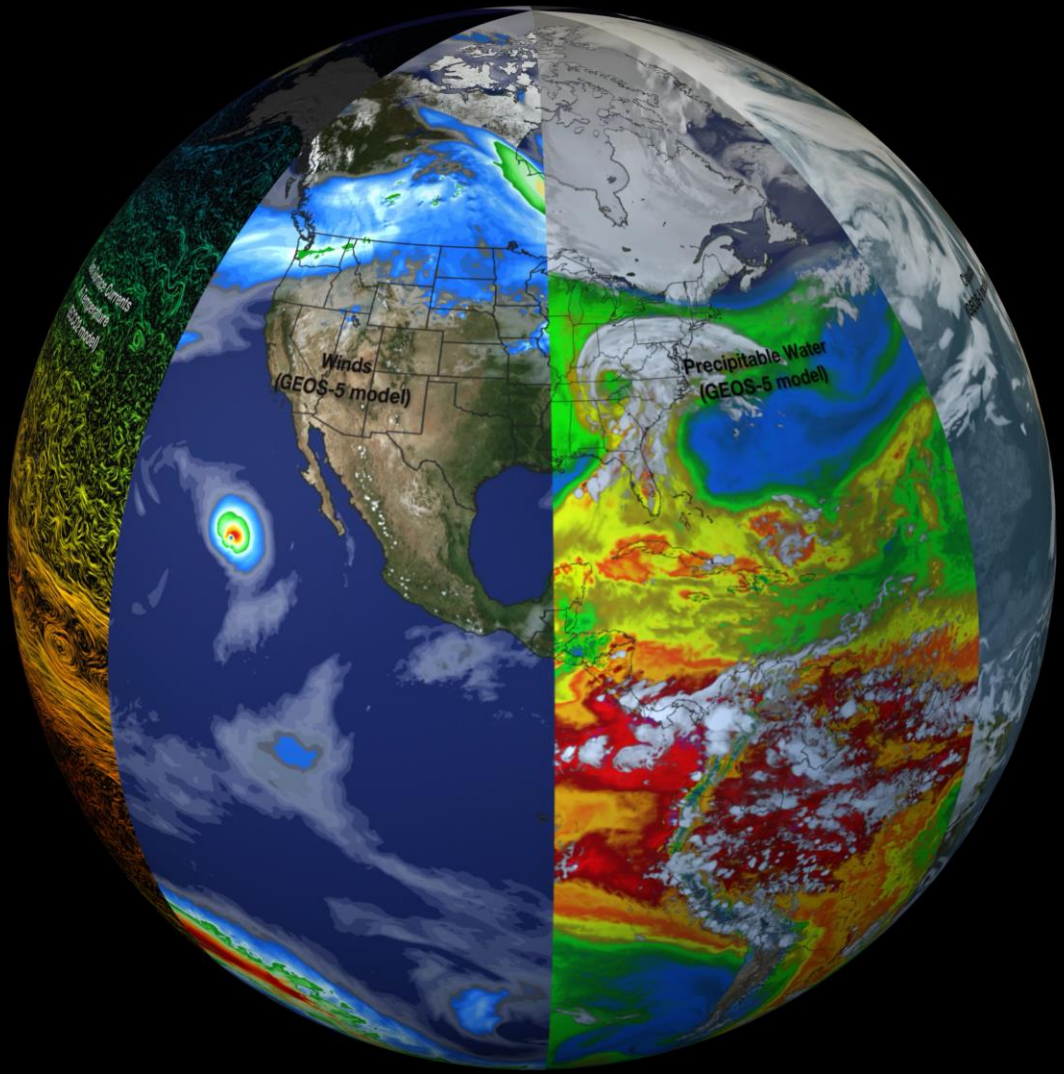
Transmissions

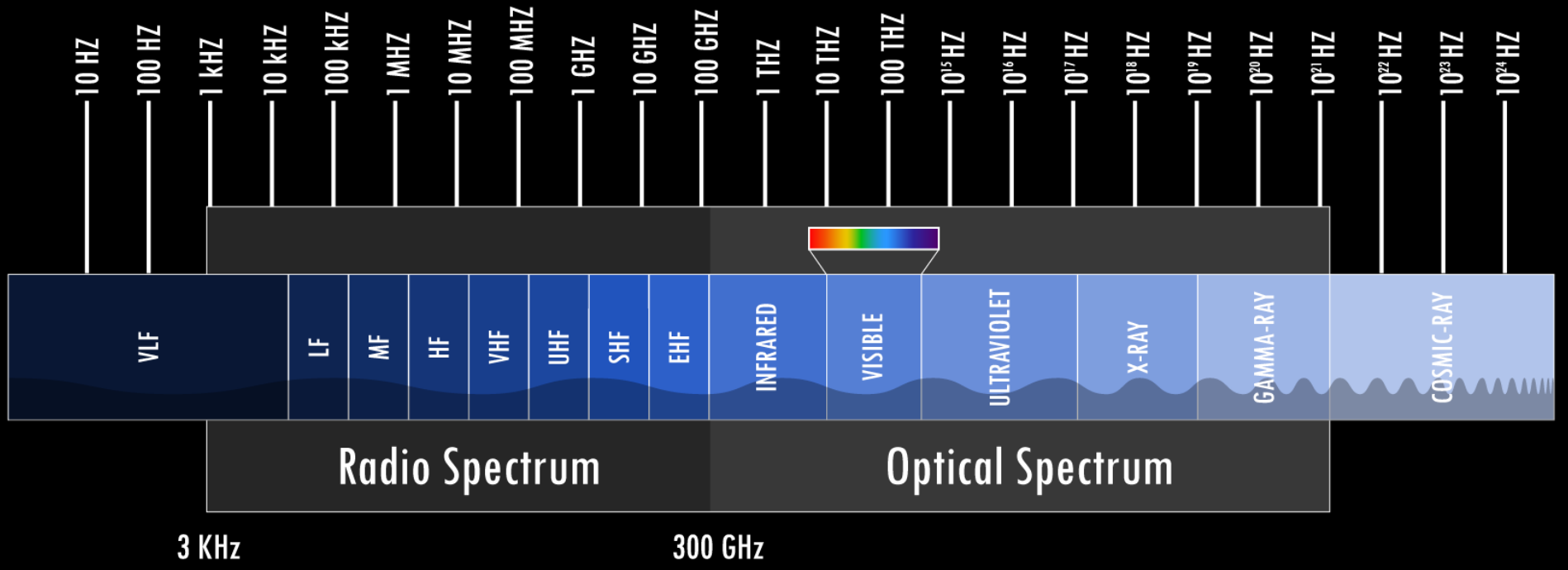
Sharing of space-to-Earth radio frequencies could also threaten the timely and routine transmissions of weather satellite imagery and products

Inconsistency

The risk of spectrum sharing is not a sudden decrease in forecast skill or a complete loss of observations, but an inability to deliver consistent weather services

NASA Animation

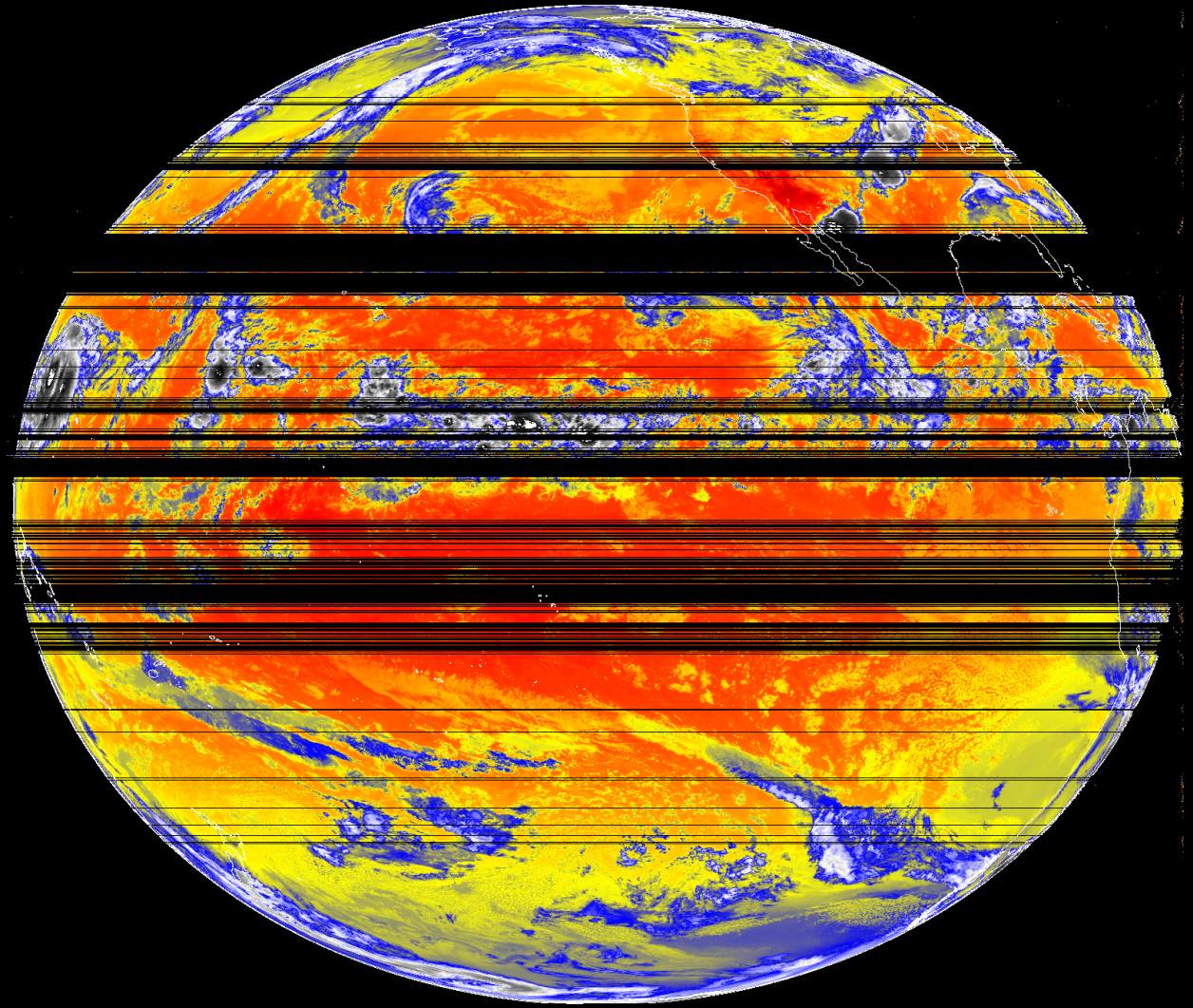



10 HZ
100 HZ
1 kHZ
10 kHZ
100 kHZ
1 MHZ
10 MHZ
100 MHZ
1 GHZ
10 GHZ
100 GHZ
1 THZ
10 THZ
100 THZ
10^15 HZ
10^16 HZ
10^17 HZ
10^18 HZ
10^19 HZ
10^20 HZ
10^21 HZ
10^22 HZ
10^23 HZ
10^24 HZ
VLF
LF
MF
HF
VHF
UHF
SHF
EHF
INFRARED
VISIBLE
ULTRAVIOLET
X-RAY
GAMMA-RAY
COSMIC-RAY
Radio Spectrum
Optical Spectrum
3 KHz
300 GHz

NASA Figure

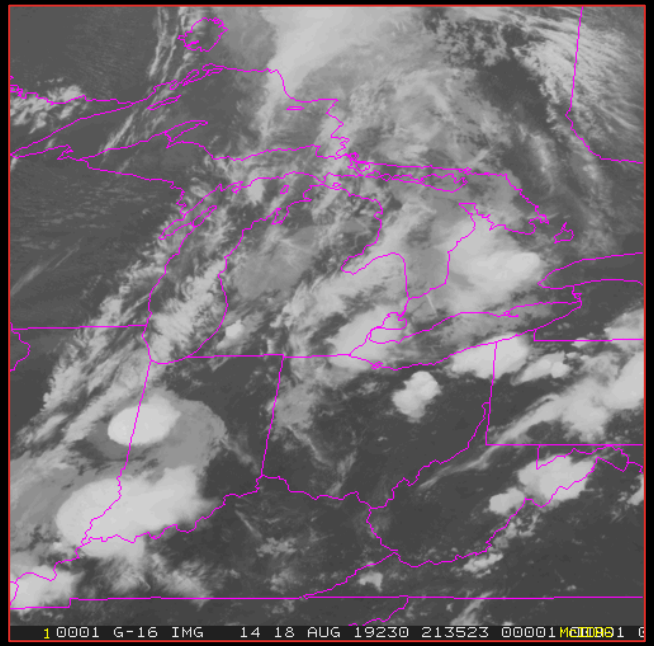
Summary of Spectrum Matters for Weather Enterprise (April 2021)

Frequency	Use	Status	Concern	Advocacy
L band (GPS and 1675-1680 MHz)	GOES-R era DCPR (Relay) and GRB (Rebroadcast)	Awaiting possible FCC rulemaking on 1675-1680 MHz; Congressional action following summer GPS rulemaking	**High**; Related to delivery; Currently no good alternatives provide high reliability and consistent downlink of geostationary satellite imagery and remote data collection stations	Numerous filings in FCC dockets from AMS, industry, and academia; Op-eds; Coalition letters to lawmakers; Ex parte briefings over many years
C band (3.7-4.2 GHz)	NOAAPort	3.7-3.98 GHz Auction 107 raised $81B; funding available for previously registered earth stations	**Very Low**; Related to delivery; NOAAPort is currently at 4.04 GHz and should avoid interference from new terrestrial signals	AMS filing in FCC docket
K band (24 GHz)	Microwave passive remote sensing, including ATMS and heritage sensors	Compromise at WRC-19; lower power threshold starting in 2027	**High**; Related to observations; Possible impact on precipitation estimates and model forecast skill	Numerous media interviews in 2019
W band (86-92 GHz)	Microwave passive remote sensing, including ATMS and heritage, and cloud radar active sensing	Comment period for notice of proposed rulemaking ended in September	**Moderate**; Related to observations; Possible impact on tropical cyclone analyses and model forecast skill; No petition for terrestrial operations above 92 GHz	AMS filing in FCC docket with NAS CORF, ECMWF, EUMETSAT/ESA, and WMO in support

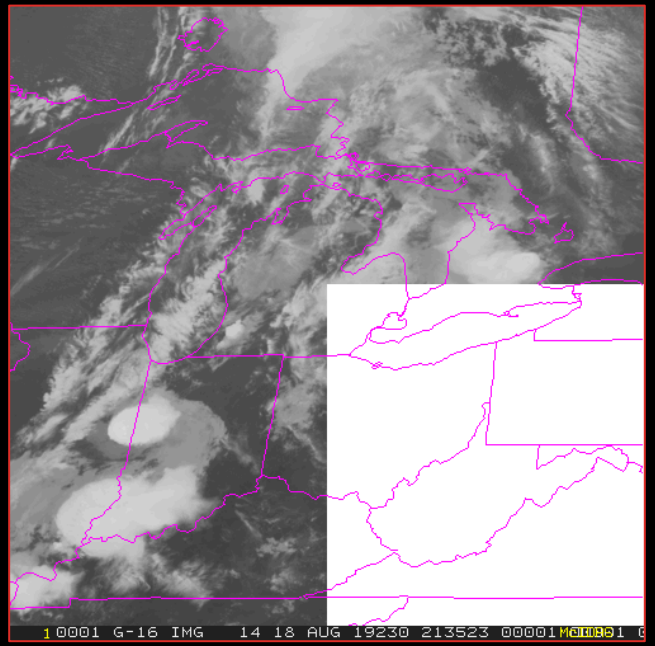


GOES-15
17 August 2015

18 AUGUST 2019 21:35 UTC GOES-16 LOST DATA EXAMPLE



CIMSS

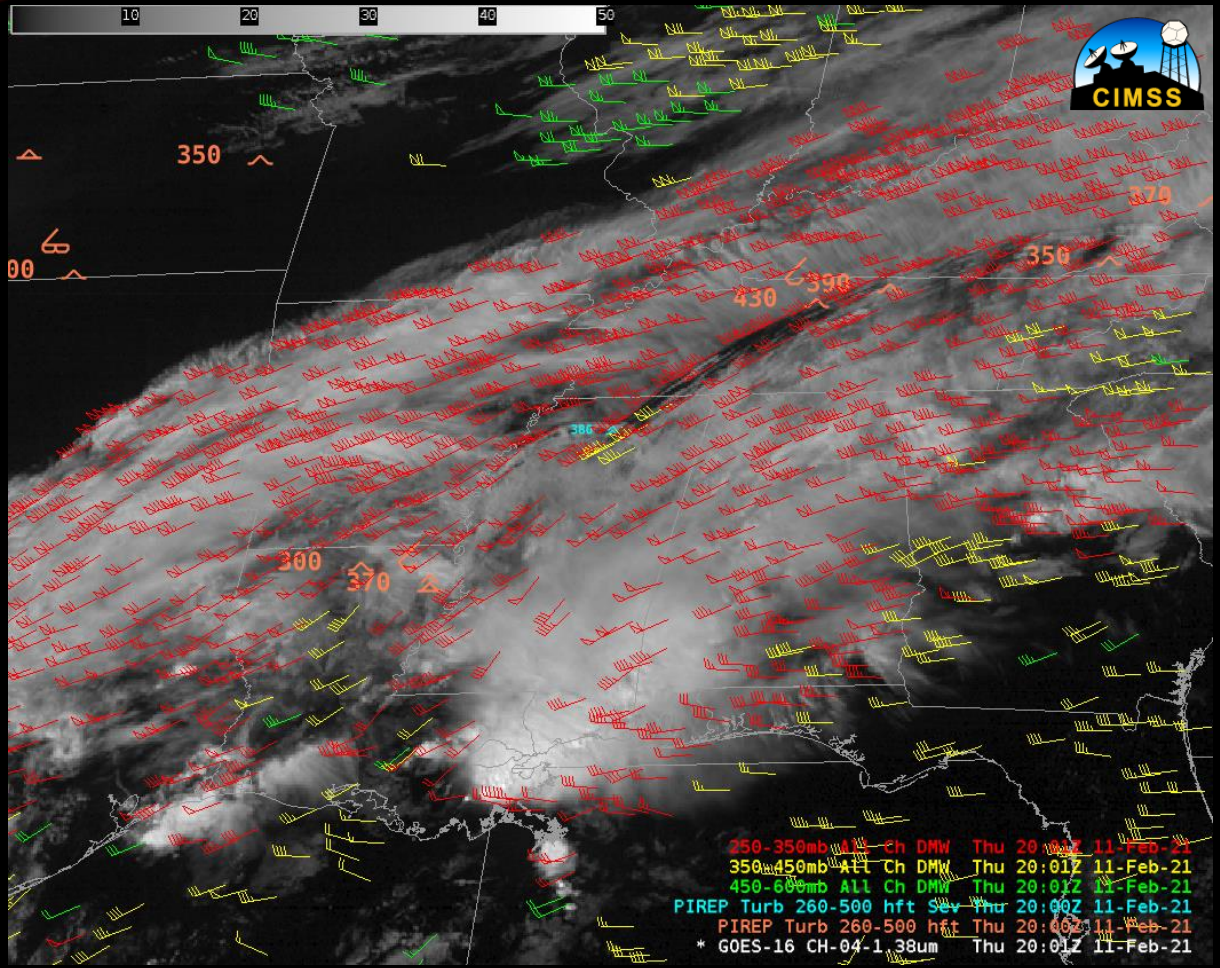


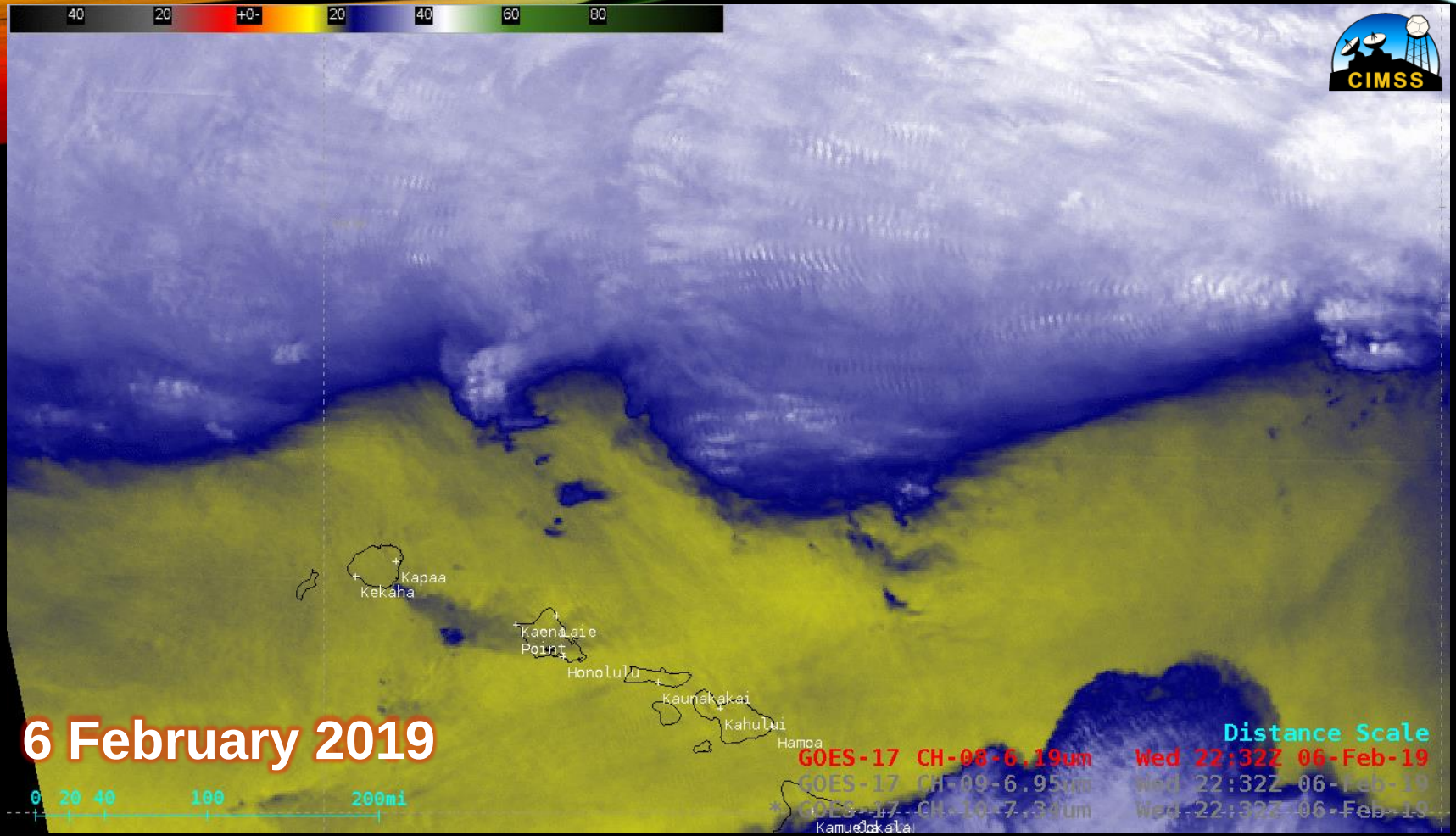
11 February 2021

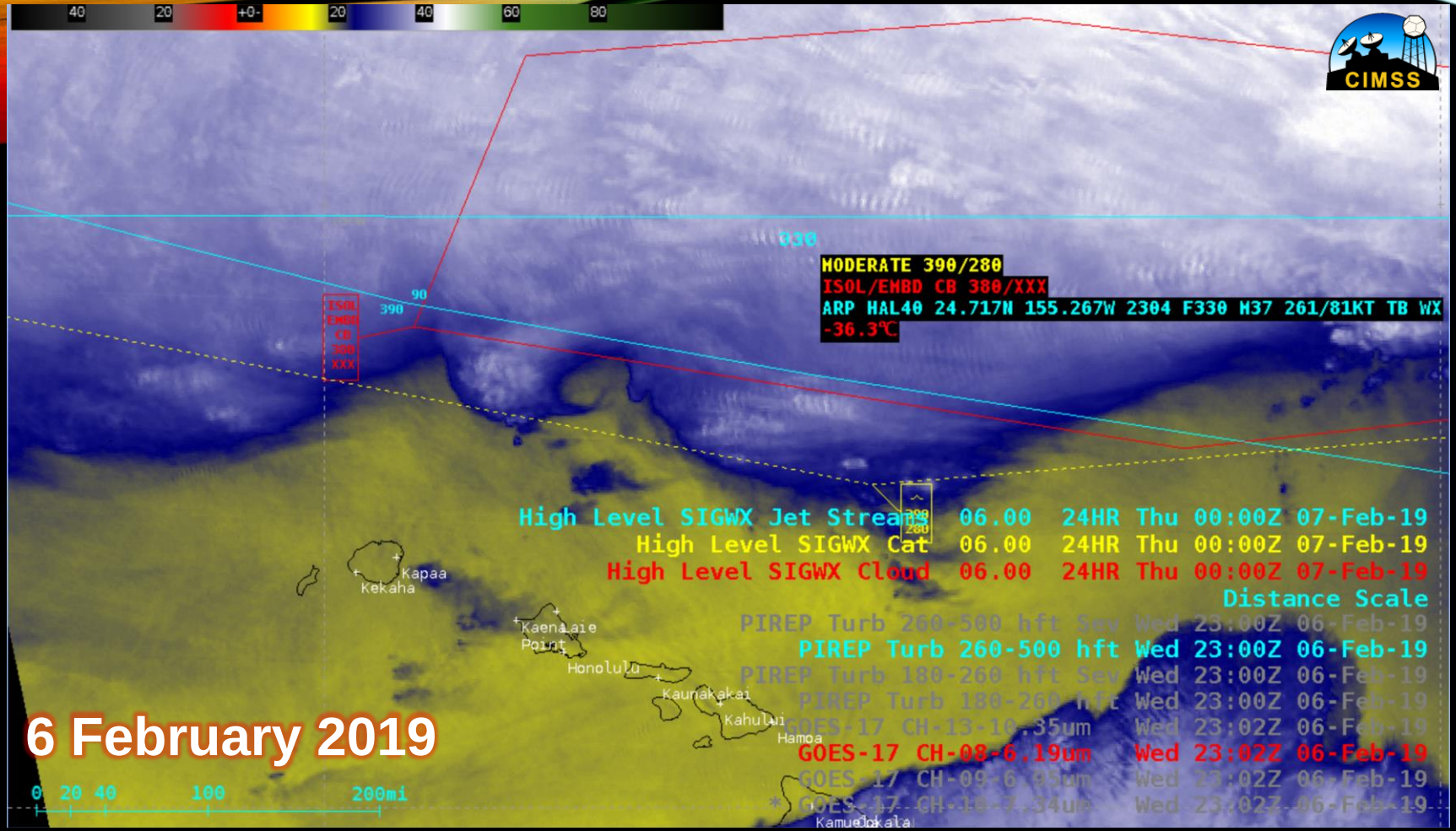
Satellite-derived winds are one of the most impactful observations for numerical models

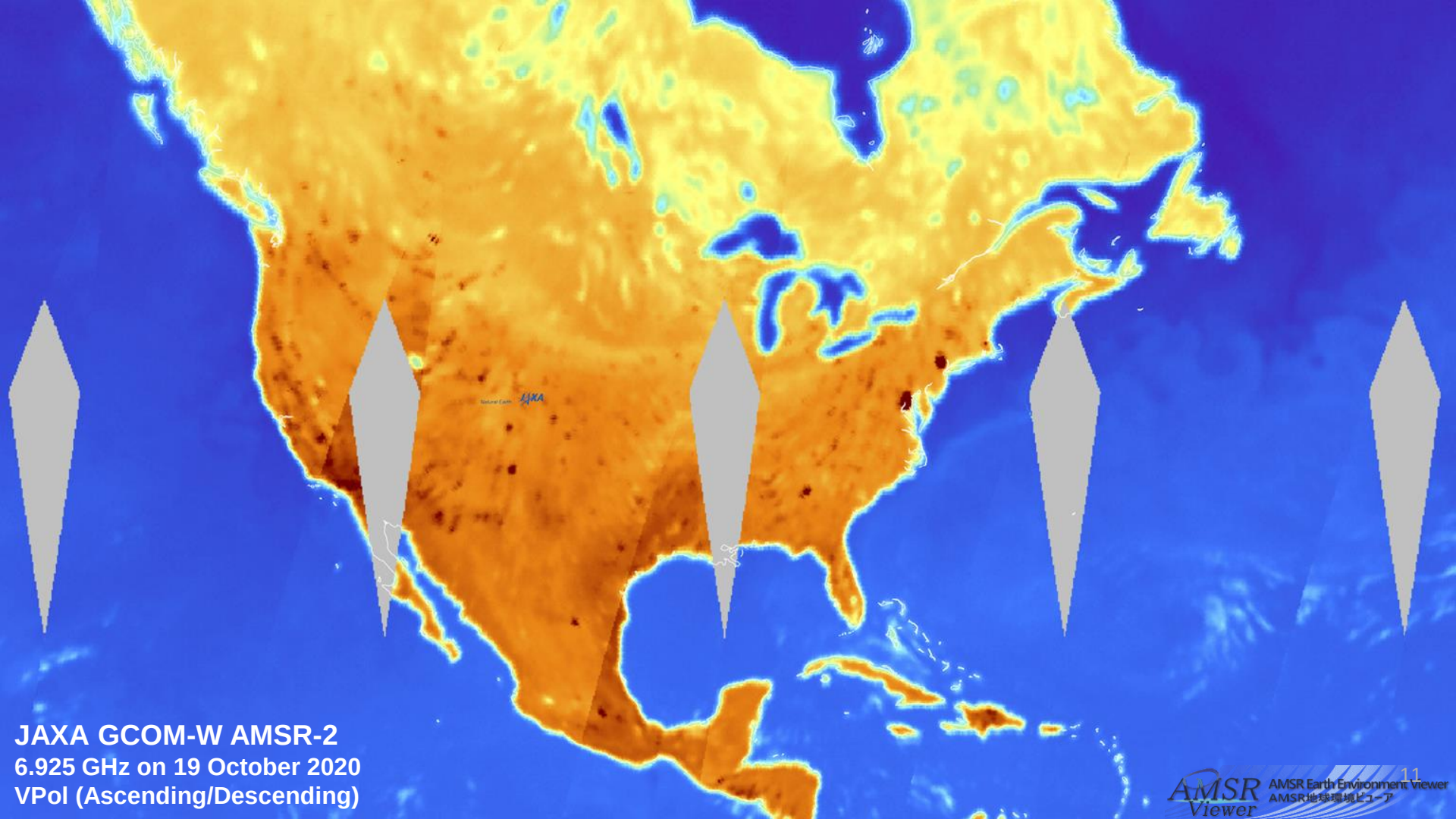
Satellite-derived winds require three consecutive images

If one image is degraded or missing, the winds cannot be computed

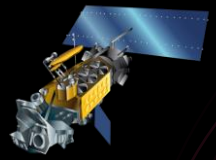



40
20
+0-
20
40
60
80
CIMSS
Kapaa
Kekaha
Kaena Point
Honolulu
Kaunakakai
Kahului
Hamoa
6 February 2019
Distance Scale
GOES-17 CH-08-6.19um Wed 22:32Z 06-Feb-19
0 20 40 100 200mi


40 20 +0- 20 40 60 80
CIMSS
030
MODERATE 390/280
ISOL/EMBD CB 380/XXX
ARP HAL40 24.717N 155.267W 2304 F330 H37 261/81KT TB WX
-36.3℃
ISOL EMBD CB 380 XXX
390
90
High Level SIGWX Jet Stream 06.00 24HR Thu 00:00Z 07-Feb-19
High Level SIGWX Cat 06.00 24HR Thu 00:00Z 07-Feb-19
High Level SIGWX Cloud 06.00 24HR Thu 00:00Z 07-Feb-19
Distance Scale
PIREP Turb 260-500 hft Sev Wed 23:00Z 06-Feb-19
PIREP Turb 260-500 hft Wed 23:00Z 06-Feb-19
PIREP Turb 180-260 hft Sev Wed 23:00Z 06-Feb-19
PIREP Turb 180-260 hft Wed 23:00Z 06-Feb-19
GOES-17 CH-13-10.35um Wed 23:02Z 06-Feb-19
GOES-17 CH-08-6.19um Wed 23:02Z 06-Feb-19
GOES-17 CH-09-6.95um Wed 23:02Z 06-Feb-19
GOES-17 CH-10-7.34um Wed 23:02Z 06-Feb-19
Kapaa
Kekaha
Kaenalaie Point
Honolulu
Kaunakakai
Kahului
Hamoa
Kamuela
Lokaia
6 February 2019
0 20 40 100 200mi

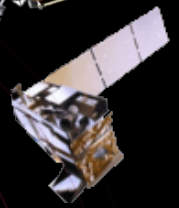


19.350 GHz
22.235 GHz
37 GHz
50.3 GHz
50.5 GHz
52.8 GHz
53.2 GHz
53.596 GHz
54.35 GHz
54.4 GHz
54.9 GHz
55.5 GHz
57.290 GHz
58.4 GHz
58.825 GHz
59.4 GHz
60.793 GHz
63.283 GHz
91.655 GHz
150 GHz
183.31 GHz



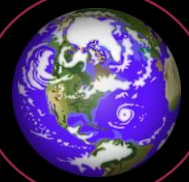
DMSP (SSMIS)

JPSS (ATMS)



SNPP (ATMS)

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



POES (AMSU-A)

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

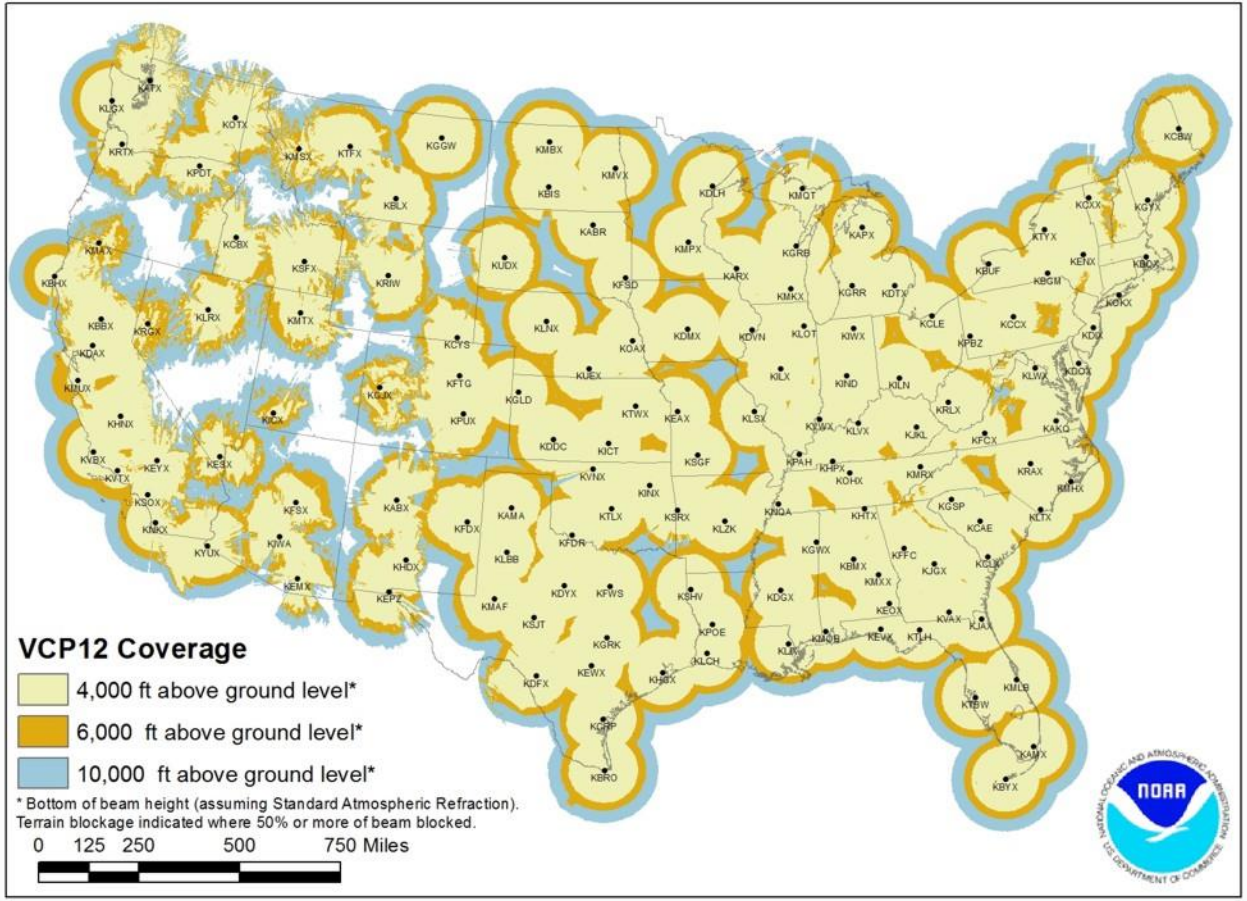
SATELLITE INTERFERENCE IMPACTS SUMMARY

The delivery of satellite weather data must always be **timely**, **consistent**, and **reliable**.

The value of microwave water vapor observations is not easily achievable through other means.

Continuing important observing capabilities maintains the value of our satellite constellations and quality of local and global weather forecasts.

NEXRAD Coverage Below 10,000 Feet AGL

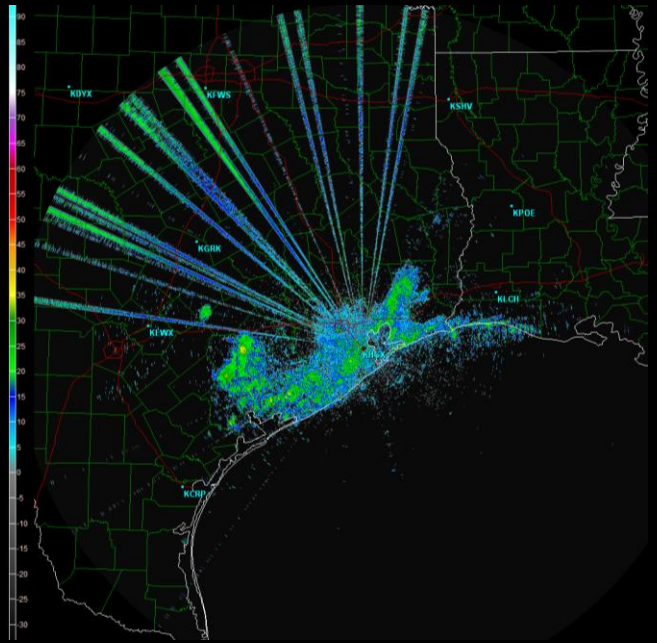


SOURCES OF NEXRAD INTERFERENCE

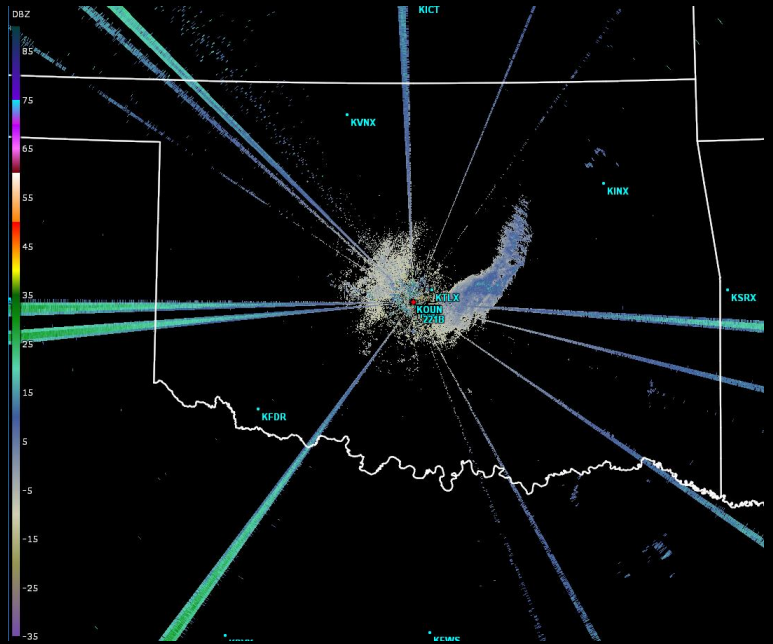
- NEXRAD occupies 2700 to 3000 MHz (S Band)

- Two Most Common Sources (See NTIA Report 13-490)
  - Other Radars
    - FAA and DOD ASR systems in the 2700-2900 MHz band
  - Cell Towers
    - 4G LTE and future 5G deployments in the upper 2496-2690 MHz Band (formerly inhabited by WiMAX). Out-of-band emissions affect NEXRADs up to 2765 MHz.
- Other Sources
  - Wireless ISPs
  - Radio/Television Towers
  - Co-channel NEXRADs
  - Airborne and Maritime Radar

EXAMPLES OF NEXRAD INTERFERENCE



Houston Interference from WiMAX, January 2014



Norman Interference from multiple cell towers, November 2019

RADAR INTERFERENCE IMPACTS SUMMARY

- The NEXRAD receives interference from a variety of sources but mostly from ASRs and cell towers.
- Good mitigation of RFI ultimately starts with proactive rulemaking by the NTIA and FCC.
- The NTIA Redbook does not adequately address the sensitivity of the NEXRAD receiver.

For more information:
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