Environment and Climate Change Canada | Environnement et Changement climatique Canada

Potential impact of RFI on NWP: a Canadian perspective

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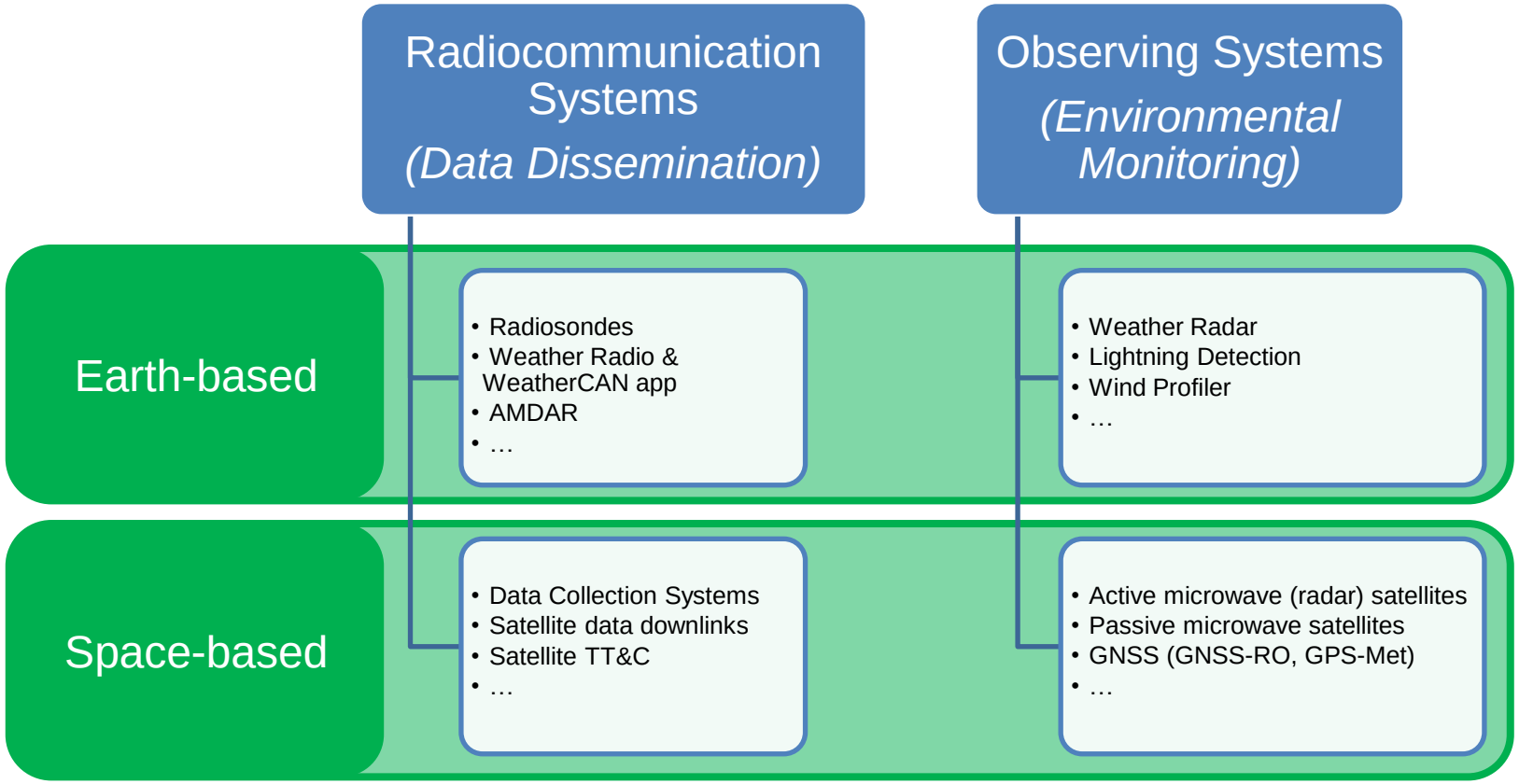
RFI 2022

14-18 February 2022

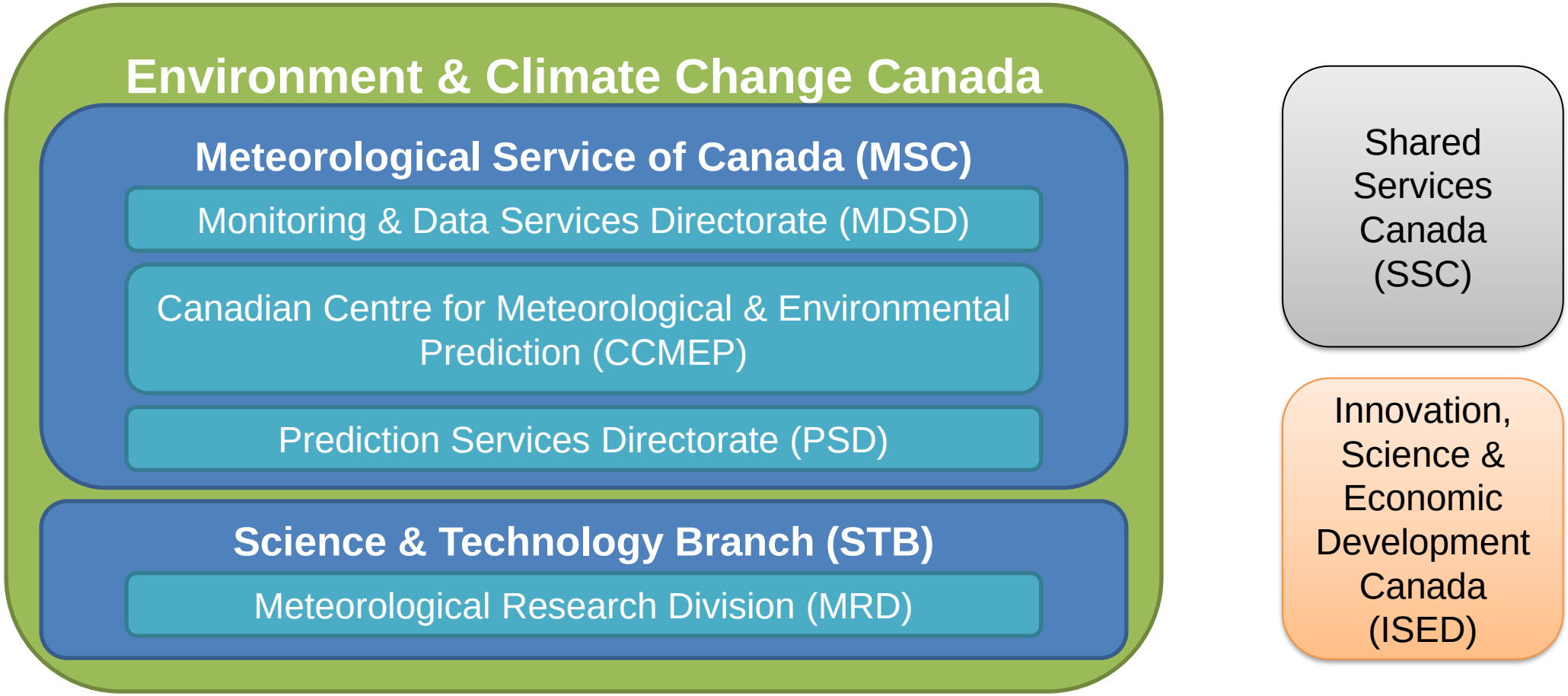
Canada

The Meteorological Service of Canada (MSC) has many RF dependencies…



…including earth- and space-based communication and observation systems

Management of the MSC's RF dependencies involves numerous parties…

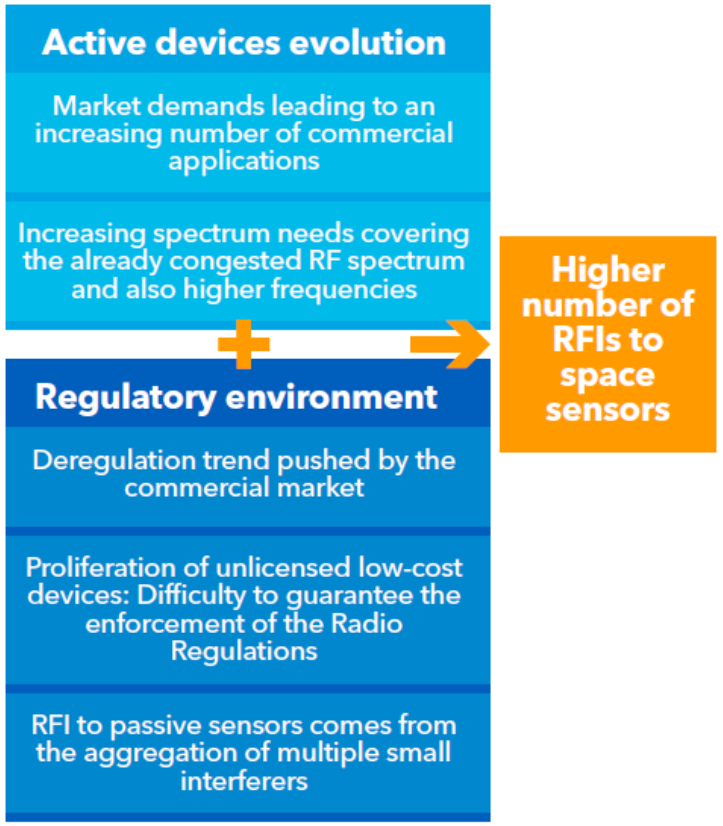


…who work together to ensure continued access to and effective use of radio spectrum

The growing demand for radio spectrum is placing increased pressure on the MSC's RF dependencies…

- Spectrum trends…
  - More users/devices/data
  - Faster service, lower latency
  - Wider bandwidth
  - Use of higher frequency bands
  - Global access & harmonization
- …are leading to an increasing number of issues and topics for the MSC to monitor

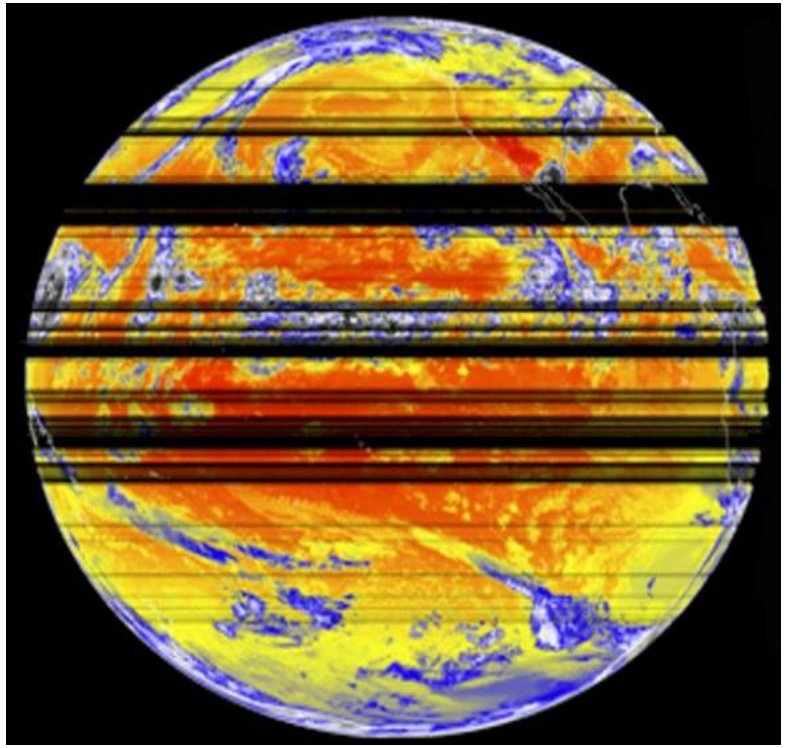
	# of Agenda Items & Topics of interest
WRC-19	14
WRC-23	16



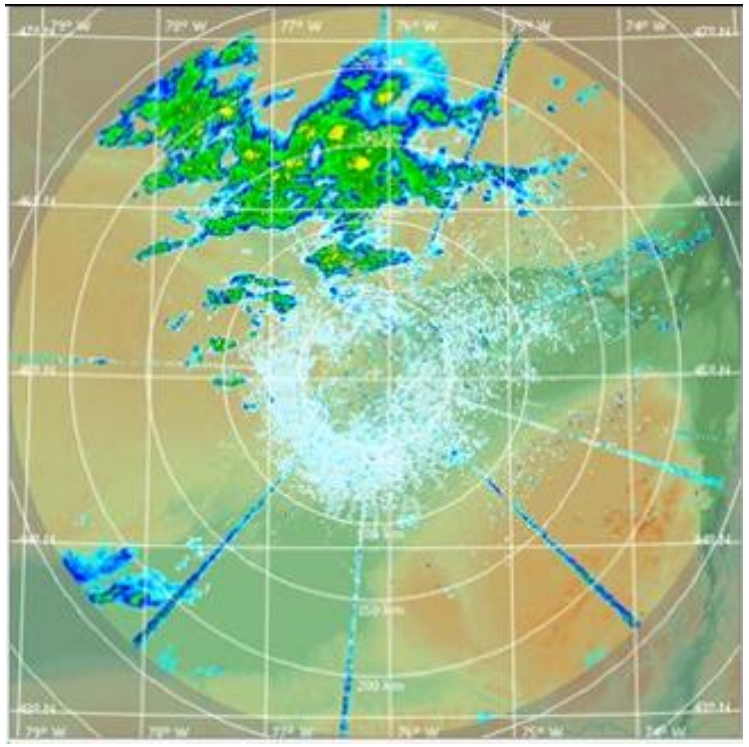
Source: ITU News Magazine (No. 1, 2019)

…requiring increasing resources and effort to manage our RF dependencies

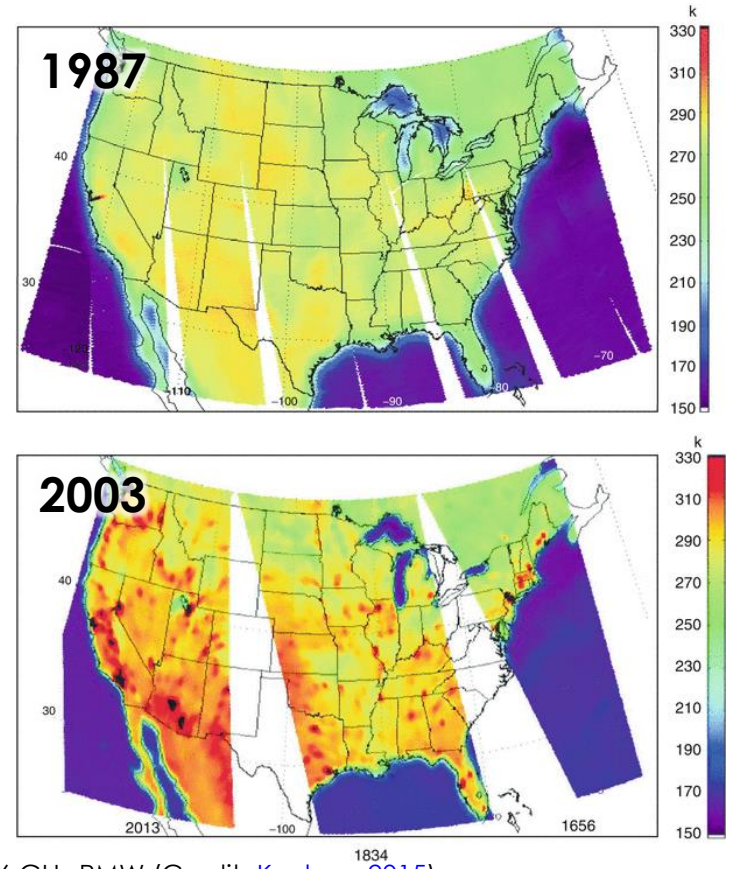
The MSC has experienced RFI…



GOES-R downlink (Credit: CIMSS/SSEC (Gerth, 2018))



MSC CWRRP meteorological radar
(Credit: MSC, Qian Li, 2022)

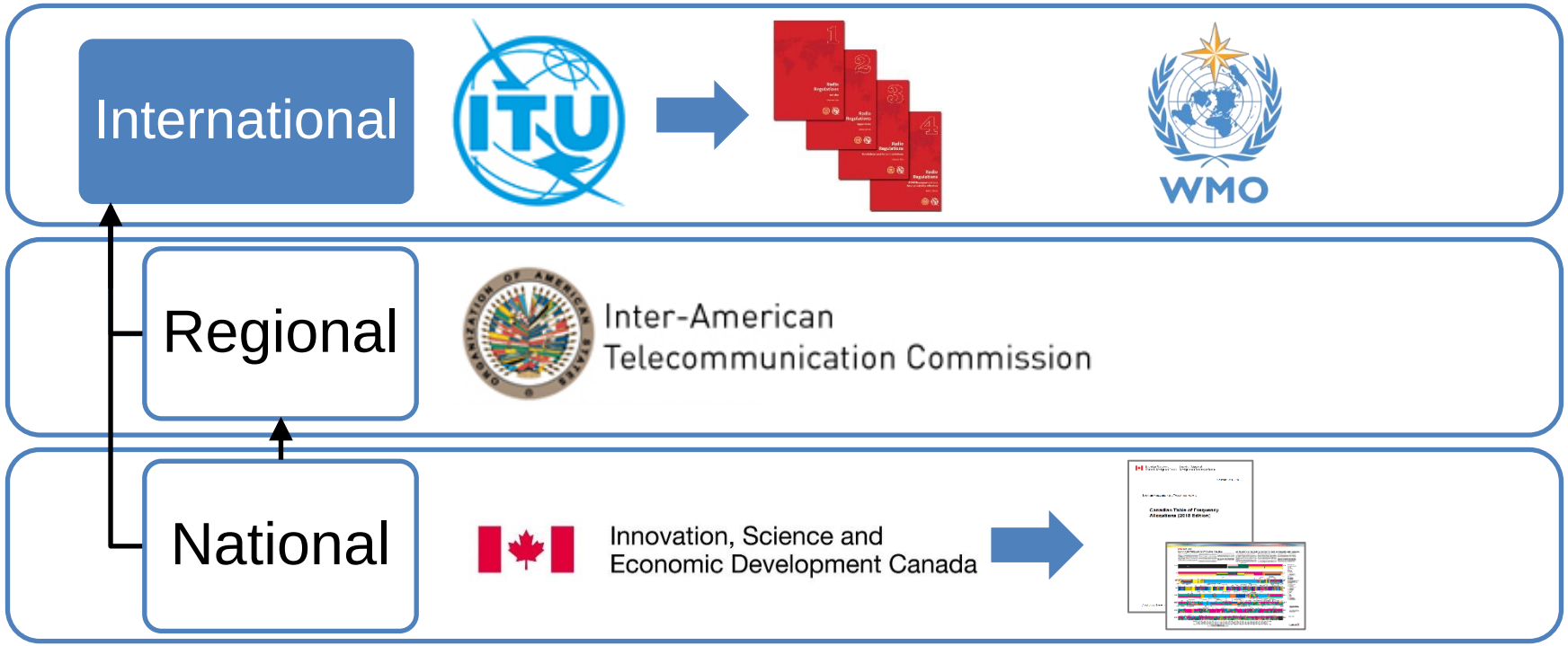


6 GHz PMW (Credit: Kunkee, 2015)

…to space-based and ground-based observation systems and data dissemination systems

The MSC is active in RF coordination activities…

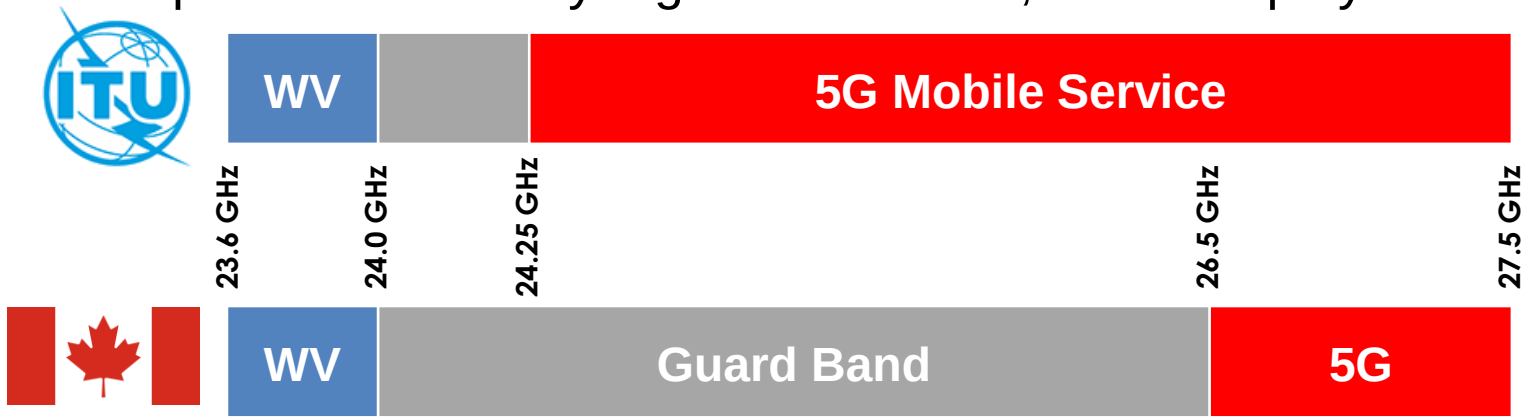
- Participating in various spectrum management fora:



…and is exploring opportunities to expand our capacity in this role

The MSC is monitoring developments related to the 23.8 GHz passive band…

- Canadian decision (SLPB-003-19) limits 5G to the upper portion of the 26 GHz mobile band identified at WRC-19
  - Provides a large guard band between passive and 5G systems
  - 26.5-27.5 GHz spectrum has not yet gone to auction; no 5G deployments to date

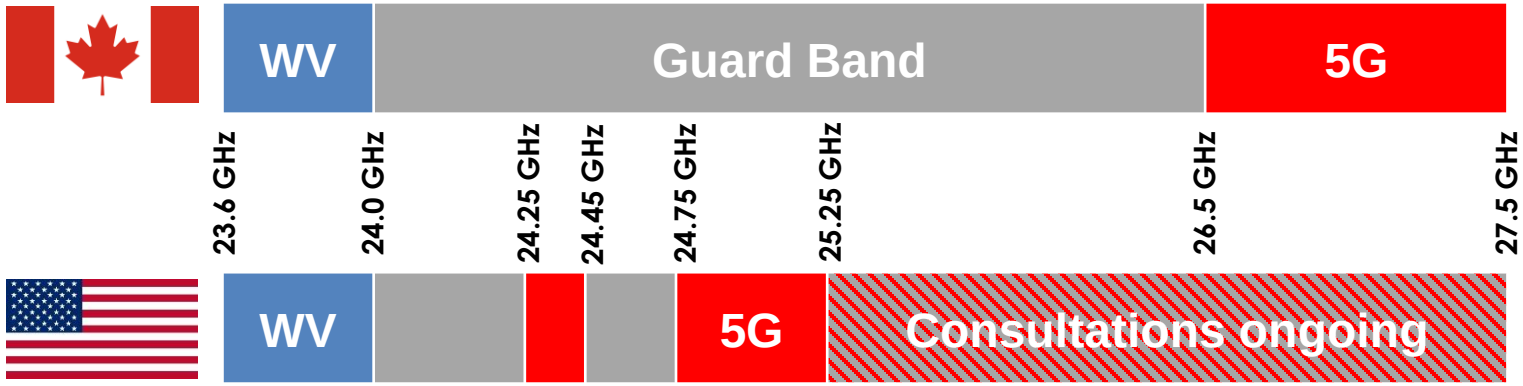


- Canada's Spectrum Outlook indicates allocations in the 24 GHz band (24.25-26.5 GHz) may be reconsidered in the future

…and domestic regulatory decisions should mitigate potential impacts over Canada

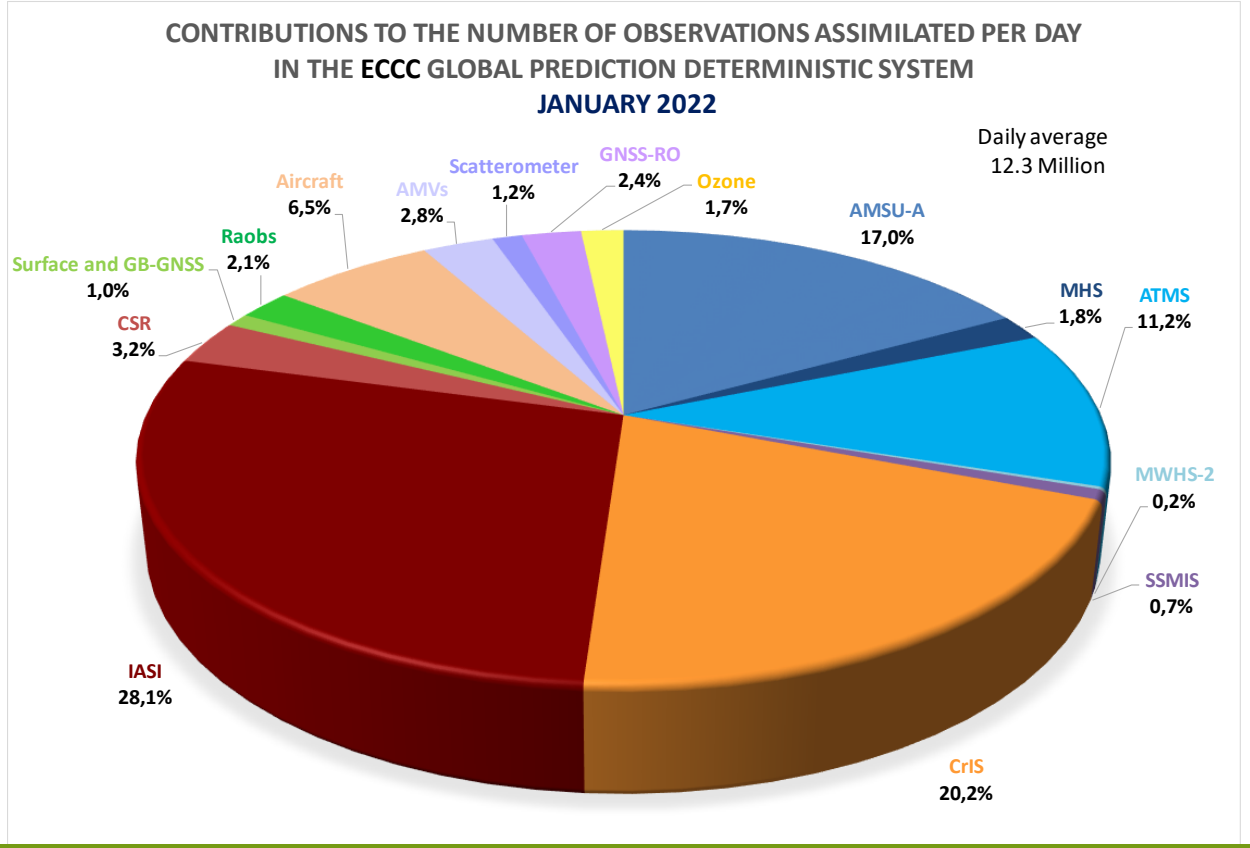
However, foreign decisions could impact our operations…

- Weather systems do not observe political boundaries
  - Regional and global NWP models rely on data collected outside Canada
- US FCC auctioned spectrum down to 24.25 GHz (Auction 102)
- US FCC has completed a consultation on out-of-band emission limits into the 23.8 GHz passive band, but a decision is still pending (ET Docket No. 21-186)



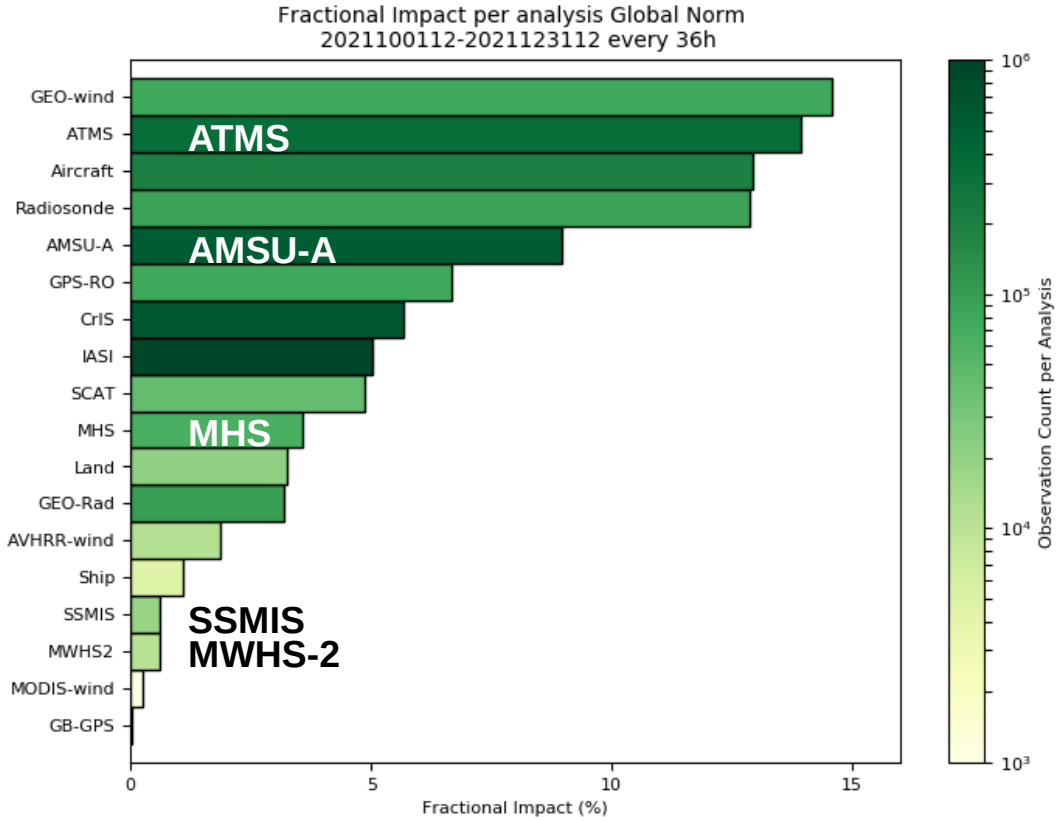
…particularly for observations acquired over the USA

Microwave radiances are a significant input dataset for our NWP systems…



…accounting for more than 30% of all data assimilated in our global deterministic system in January 2022

A Forecast Sensitivity to Observation Impact system is being developed at ECCC…



- A three-month average (Oct-Dec 2021) of fractional impact based on the current setup of our global deterministic model have shown:
  - Passive microwave sounders ATMS and AMSU-A are the most beneficial sources of radiance observations
  - Passive sounders CrIS and IASI then follows as most beneficial infrared radiance observations

…and all five assimilated MW instrument types accounted for 28% of total forecast error reduction

The MSC's NWP deterministic models assimilate numerous passive microwave channels…

Assimilated Microwave Sounder radiances				
Instruments	Satellites	Channels frequency (Ghz) assimilated over …		
		sea	sea/low topo	sea/land
ATMS	NPP NOAA-20	52, 53, 165, 183 (2)	54 (2), 183 (3)	55, 57 (6)
AMSU-A	NOAA-15/18/19 Metop-B/C	52, 53	54	54, 55, 57 (6)
MHS	NOAA-19 Metop-B/C	157, 190		183 (2)
MWHS-2	FY-3C	150, 183 (2)	183 (3)	

Assimilated of Microwave Imager radiances				
Instruments	Satellites	Channels frequency (Ghz) assimilated over …		
		sea	sea/low topo	sea/land
SSMIS	DMSP-17/18	19 (2), 22, 37 (2), 91 (2)		

Values in parentheses indicate the number of channels having that frequency

- Atmospheric temperature profiling is done in the 52 to 57 GHz frequency range.
- Atmospheric water vapor profiling is done in the 183 and 190 GHz frequencies.

…that provide atmospheric temperature and water vapor profiles

Passive microwave channels are also used for quality control…

Quality control tests for Microwave Sounder Radiances

Instruments	QC test	Channels used in QC test	Channels impacted by QC test	Surface type where QC test applies
ATMS	Dryness Index	183 (2)	183 (3)	land / sea-ice
	Mean 183	183 (5)	89 165, 183 (5)	land / sea / sea-ice
	Cloud liquid water	23, 31	23, 31, 50, 51, 89 52, 53, 54 (2), 55, 165, 183 (5)	sea
	Scattering Index (1)	89 165	23, 31, 50, 51 52, 53, 54 (2), 55	land / sea / sea-ice
	Scattering Index (2)	89 165	23, 31, 50, 51, 89 52, 53, 54 (2), 55, 165, 183 (5)	sea
AMSU-A	Cloud liquid water	23, 31	23, 31, 50, 89 52, 53	sea
	Scattering Index	23, 31, 89	23, 31, 50, 89 52, 53, 54	sea
MHS	Dryness Index	183, 190	183 (2), 190	land / sea-ice
	Scattering Index	89 157	89 157, 183 (2), 190	land / sea / sea-ice

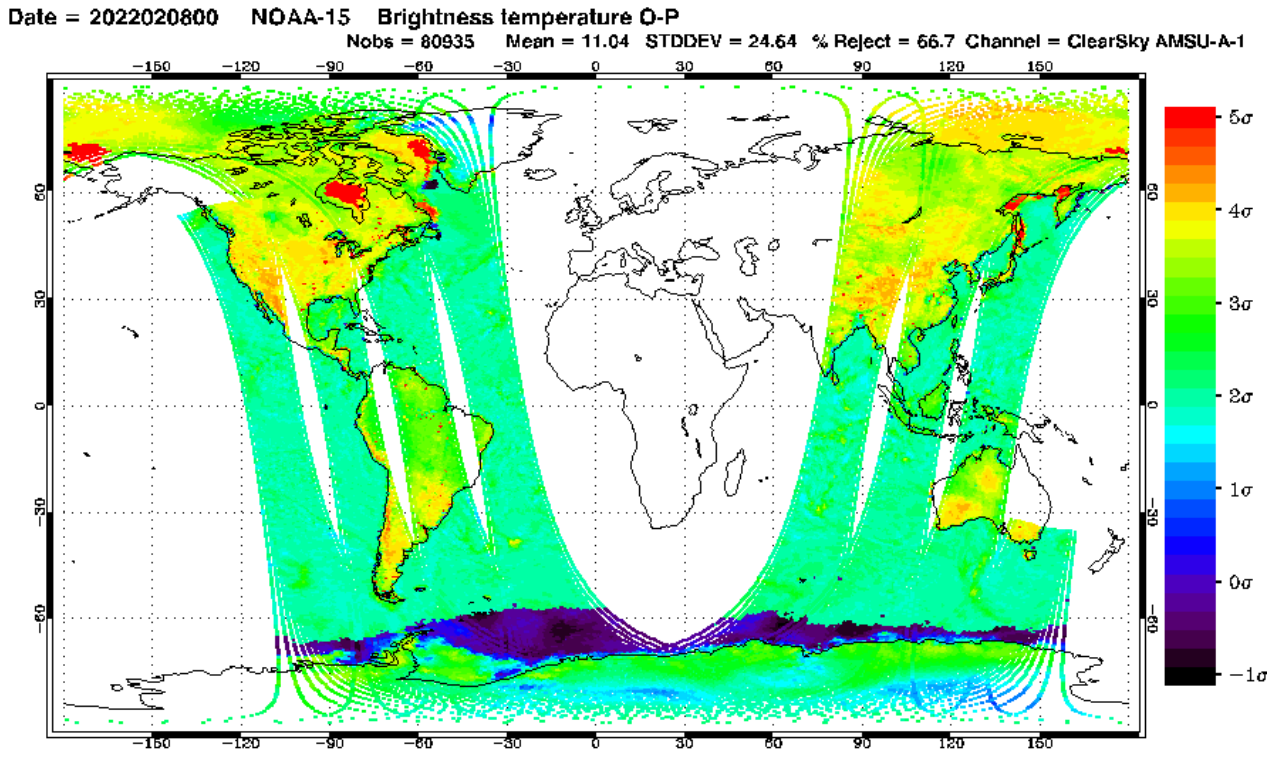
Values in parentheses indicate the number of channels with that frequency
Channels in red font are not currently assimilated

- Processing of assimilated channels requires the use of unselected channels in quality control (QC) tests.
- These unselected channels are sensitive to surface. Some tests are applied over land, where 5G is of concern.
- Work is ongoing to assimilate 52 and 53 GHz channels over land.
- Interference on unselected channels can skew QC tests and negatively impact decisions (flags) made to individual observations in assimilated channels.

…ensuring assimilated channels are used appropriately

The MSC is developing tools to monitor for RFI…

From our monitoring website:

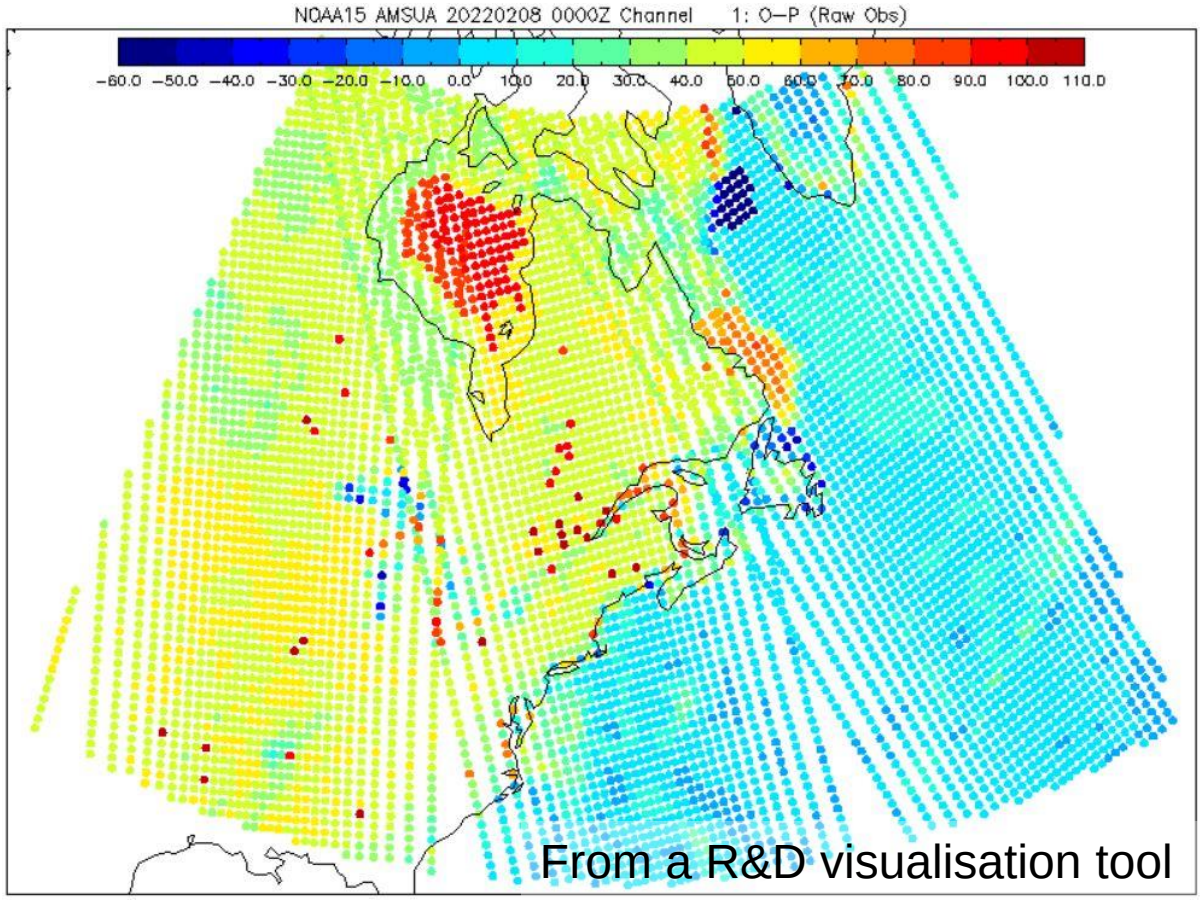


- In order to better assess RFI interference, we have recently added the *unselected channels* to our « O-P maps » in our monitoring website.
- It is shown here for channel 1 (23 GHz) of the AMSU-A instrument onboard the NOAA-15 satellite, for global model run of Feb 8, 2022 00Z.

O-P is « Observation » minus « Simulated (model equivalent) observation » in terms of brightness temperatures

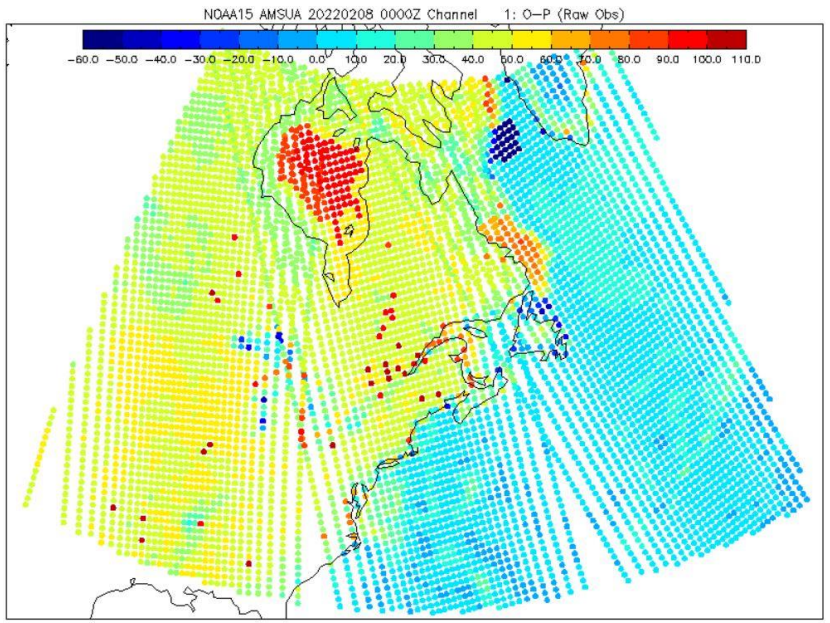
…with a first step being also the monitoring of unselected channels

The « O-P » maps detected rogue features…

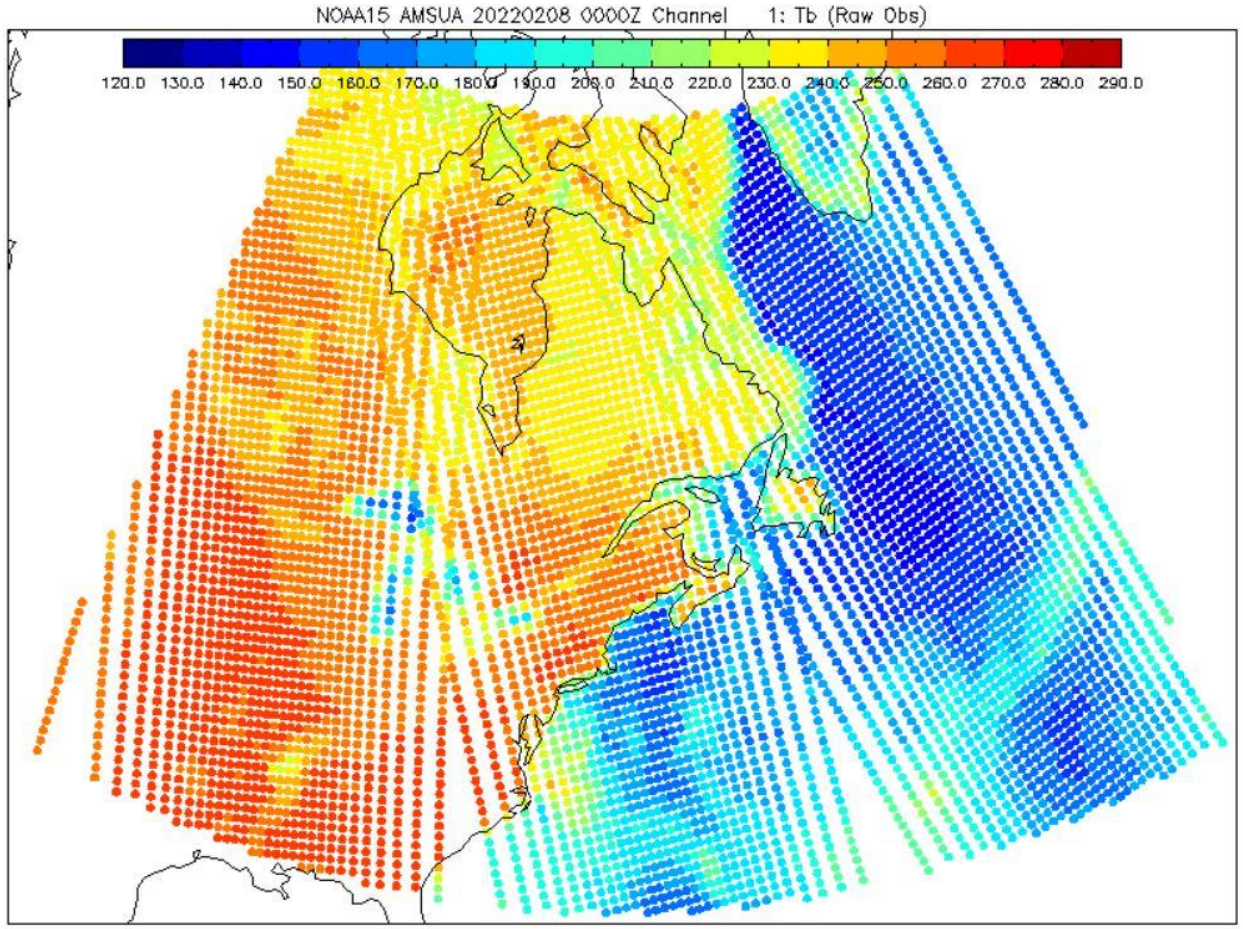


…but these *cannot* be linked to RFI interference.

« Observation maps » do not show specific problems…

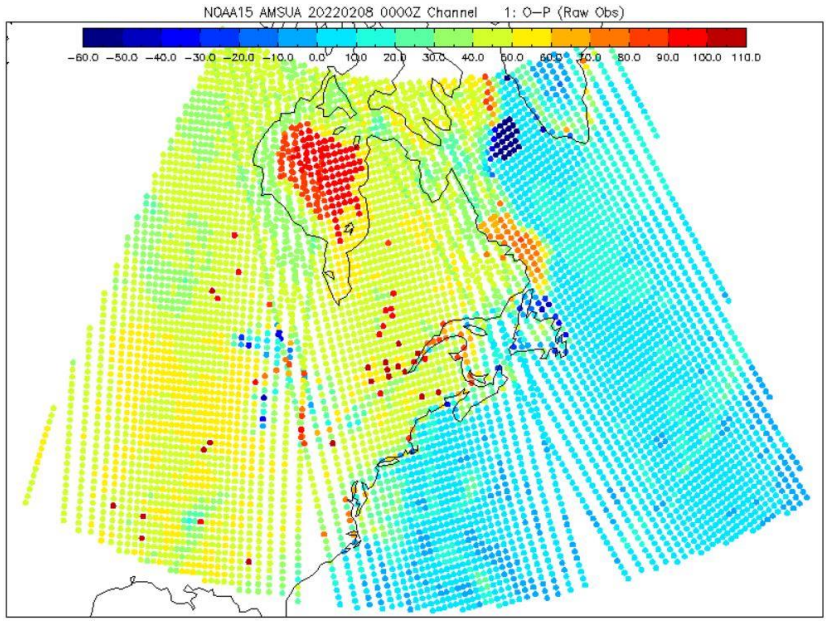


« O - P »

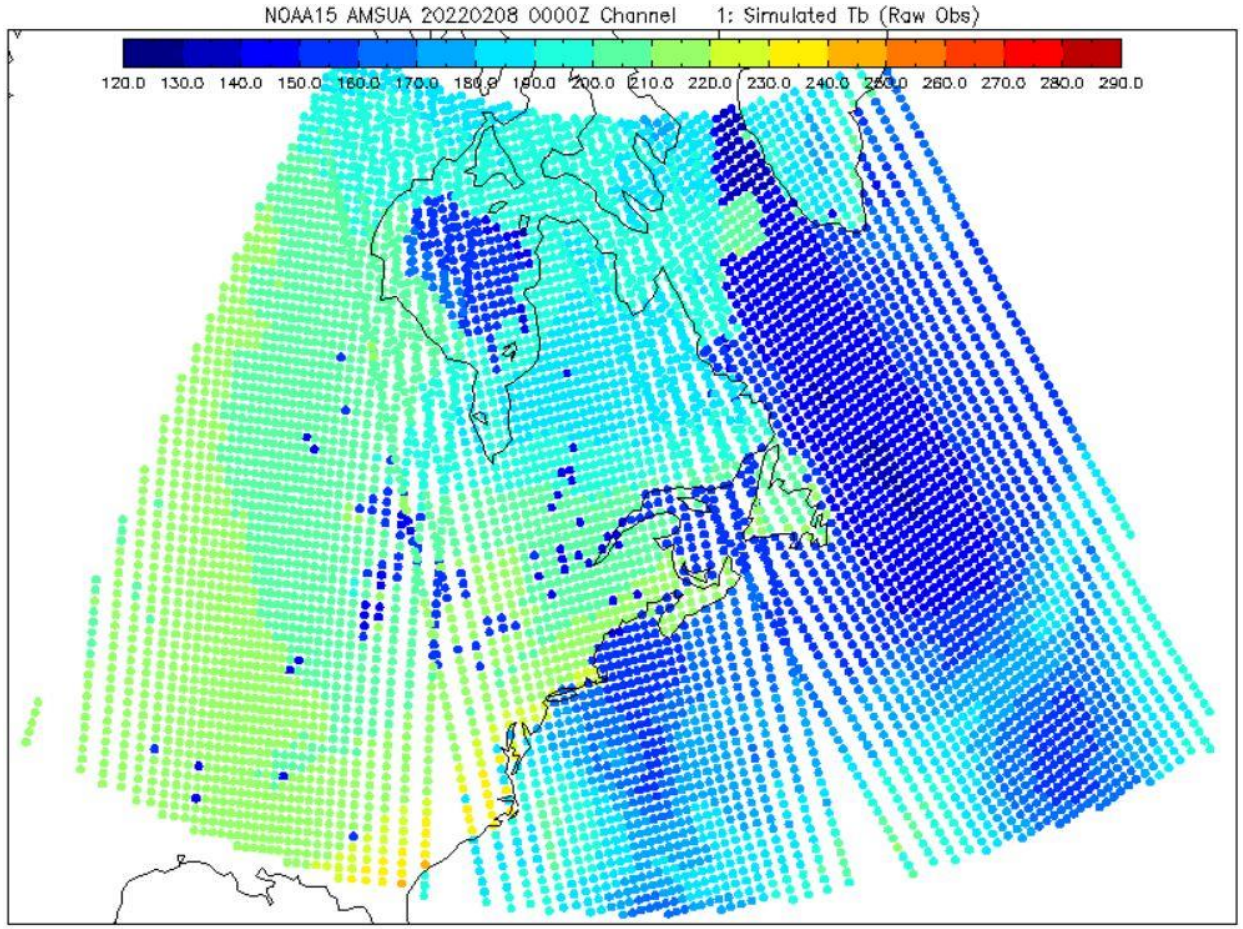


Tb observation

« Simulated observation » maps show it is the source of the discrepancies



« O - P »



« Simulated Tb observation »

Summary and Outlook

- The demand for radio spectrum continues to grow
- Safeguarding access to frequencies used for meteorological applications is critical so that the MSC can provide Canadians with access to accurate and timely information on weather and environmental conditions.
- Microwave sounders and imagers
  - Represent ~ 30% of assimilated data and forecast skill impact
  - Have channel frequencies used for either quality control or data assimilation that could be at greater risk of RFI as new commercial telecommunications services, such as 5G, come online.
- The MSC is looking at improving our RFI interference monitoring and will be considering RFI impact on our environmental systems.

Questions?

- MSC Points of Contact:
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  - NWP: Alain.Beaulne@ec.gc.ca