Communicating the value of passive bands used by TOVS-heritage microwave instruments in the context of radio frequency interference and spectrum allocation

Including outcomes of an RFI workshop at ECMWF

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With thanks to all participants at the ECMWF RFI workshop, in particular **Niels Bormann, Alan Geer, and Masahiro Kazumori** for slides shown in this presentation

ECMWF

The Guardian

5G signal could jam satellites that he
with weather forecasting

New mobile system to be launched this year 'will put lives

THE HILL

Mixing 5G and w
could skew forecas
storm

6 APRIL 2019

nature
International journal of science

Global 5G wireless networks
threaten weather forecasts

INION CONTRIBUTOR — 07/01/19 06:30 PM EDT
BY CONTRIBUTORS ARE THEIR OWN

PHYSICS TODAY

NOAA warns of threat to weather
forecasts from 5G spectrum

New mobile system to be launched this year 'will put lives at risk'

Why we need to protect weather prediction from radio frequency interference

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Critical spectrum for Earth observation from space

Le Point Tech & Net

Les prévisions météo menacées par l
de la 5G ?

"For these numerical weather prediction applications, radio-frequency spectrum is crucial for satellite weather observations as well as communications."

Stephen English
Head of the Earth System Assimilation Section, European Centre for Medium-Range Weather Forecasts (ECMWF)

FOGGY OUTLOOK UK weather forecasts
could get even WORSE as 5G 'risks
confusing satellite networks'

ccuracy of forecasts could dro

Radio-Frequency Interference (RFI) Workshop

13 –14 September 2018

Goal

To better quantify value of MW spectrum to Numerical Weather Prediction and to bring NWP experts and frequency managers together

Organisers

NWP: Stephen English (ECMWF)

Frequency Management: Rich Kelley (NOAA)

ECMWF

With thanks to the 21 participants in the ECMWF RFI Workshop

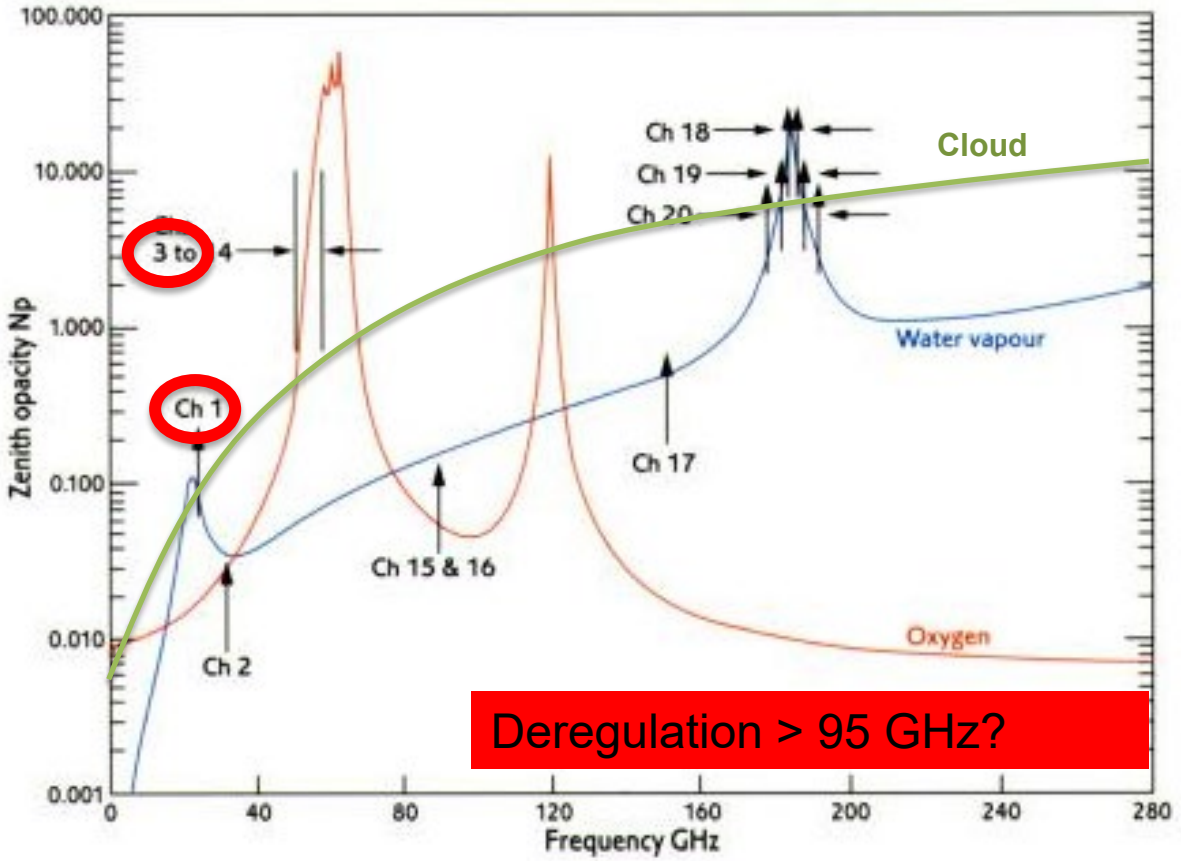
Spectrum Managers: **ITU**: Vadim Nozdrin, **EUMETSAT**: Markus Dreis, **ESA**: Elena Daganzo-Eusebio, NOAA: Rich Kelley, **Met Office**: Mike Banks.

NWP: **ECMWF**: Stephen English Niels Bormann, **Met Office**: John Eyre, Chawn Harlow, Brett Candy, **Météo-France**: Jean-Francois Mahfouf, **CMA**: Wei Han, **NRL**: Ben Ruston and Steve Swadley, **NOAA**: Andrew Collard, **Env. Canada**: Mark Buehner, **DWD**: Christina Kopken-Watts, **Met Norway / HIRLAM**: Roger Randriamampianina, **KIAPS**: In-Hyuk Kwon, **JMA**: Masahiro Kazumori, **BoM**: Chris Tingwell and Fiona Smith

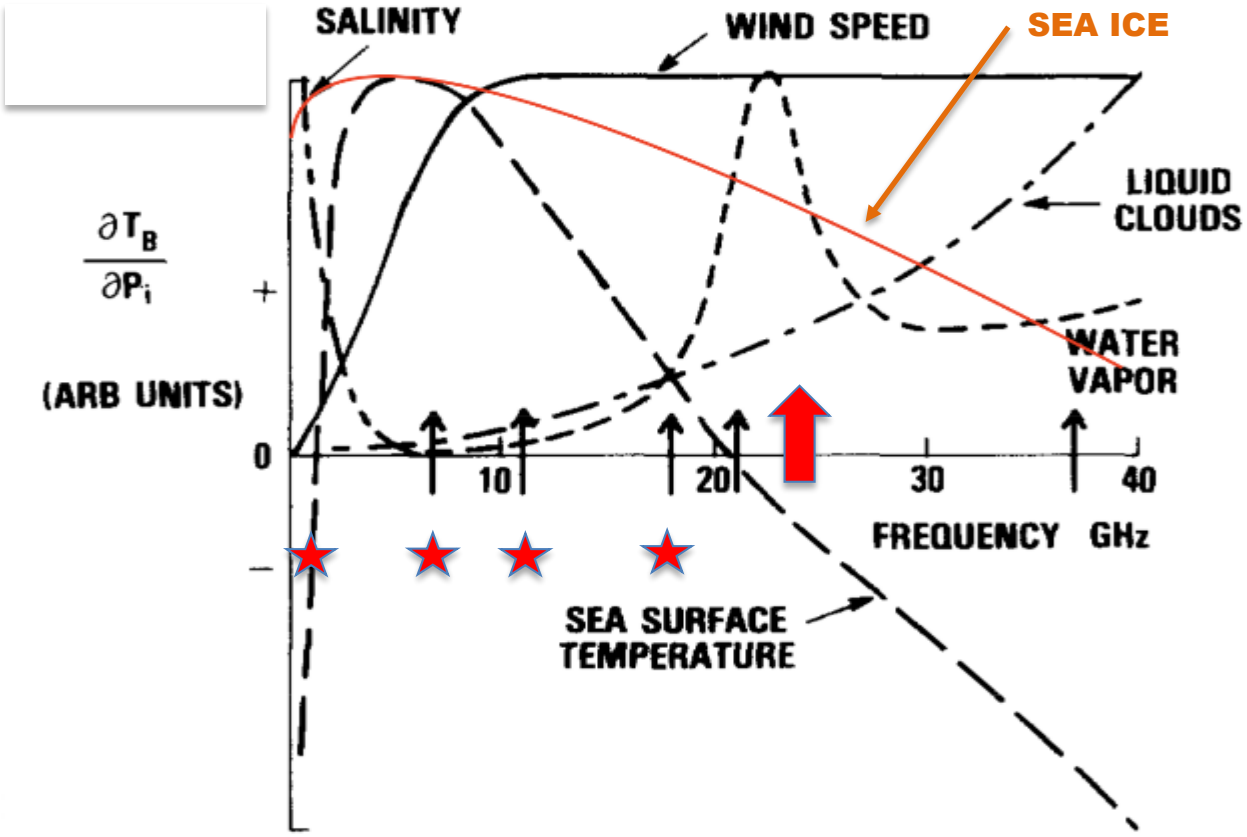
Concerns for future of lower frequency channels of sounders and imagers
WRC-19 discussion on 24 and 50 GHz

AMSU-A, AMSU-B, MHS, ATMS, MWTS, MWHS, MTVZA-GY, SSMIS, GMI, AMSR-2, SAPHIR...

AMSR-2, GMI, MWRI, SMAP, SMOS, Aquarius, CIMR, WindSat…



English *et al*, 1979, adapted



Wilheit, 1979, adapted Kilic 2019, adapted again for this presentation

Bands being actively used or prepared for by NWP centres

Frequency GHz	*Instruments*	*Application area*
1.4-1.427P	SMOS (ESA), SMAP (NASA), Aquarius (NASA) , CIMR (ESA)	Soil moisture, salinity, thin sea ice
6.425-7.25	AMSR-2 (JAXA) , CIMR (ESA)	SST
10.6-10.68p 10.68-10.7P	AMSR-2 (JAXA), GMI (NASA), MWRI (CMA) , CIMR (ESA)	Heavy Precipitation
18.6-18.8p	AMSR-2 (JAXA), GMI (NASA), AMR (NOAA), MWRI (CMA) , CIMR (ESA) , MWI (EUMETSAT)	Ocean near surface wind,
23.6-24P	**SU-A (NOAA/EUMETSAT), ATMS (NOAA), SSMIS (DOD), GMI MR (NOAA), MTVZA-GY (Roscosmos), MWRI (CMA), +I (EUMETSAT), AMSR-2 (JAXA)**	**Total column water vapour**
31.3-31.5P 31.5	SU-A (NOAA/EUMETSAT), ATMS (NOAA), GMI (NASA), MTVZA-Roscosmos), MWS+I (EUMETSAT)	Total column cloud liquid
37 GHz	SSMIS (DOD), GMI (NASA), AMSR-2 (JAXA), MWRI (CMA), CIMR (ESA)	Liquid water path and cloud detection on 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), MWS (EUMETSAT)**	**Temperature profile**
86-92P	AMSU-A (NOAA/EUMETSAT), ATMS (NOAA), SSMIS (DOD), MWHS-2 (CMA), MTVZA-GY (Roscosmos), MWRI (CMA), MWS (EUMETSAT), AMSR-2 (JAXA)	Precipitation
100-102P 109.5-111.8P 114.25-116P 116-122.25p	MWHS-2 (CMA), TROPICS (NASA), MWI (EUMETSAT)	Temperature profile, cloud
148.5-151.5P 155.5-158.5p 164-167P	ATMS (NOAA), GMI (NASA), MHS (EUMETSAT), MWHS-2 (CMA), MTVZA-GY (Roscosmos), SSMIS (DOD) , MWS+I (EUMETSAT)	Precipitation, water vapour
174.8-182.0p 182.0-185.0P 185.0-190.0p 190.0-191.8P	AMSU-B (NOAA), MHS (EUMETSAT), ATMS (NOAA), SSMIS (DOD), MWHS-2 (CMA), GMI (NASA), SAPHIR (CNES-ISRO), TROPICS (NASA), MTVZA-GY (Roscosmos), MWS+I (EUMETSAT)	Water vapour
200-209P 226-231.5P	TROPICS (NASA), MWS (EUMETSAT)	Ice cloud

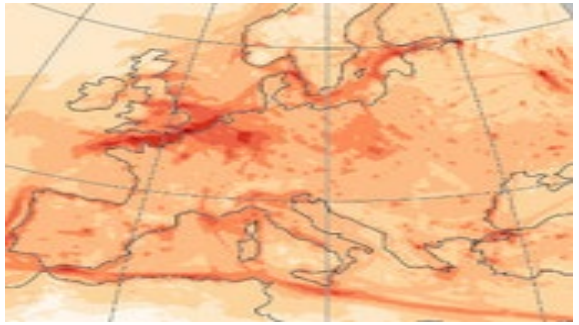
51.76 GHz on ATMS obliterated!

Key areas benefiting from EESS bands via NWP application

Public weather advice

Public snow, flood & fire

Hurricane & tornado



Air quality

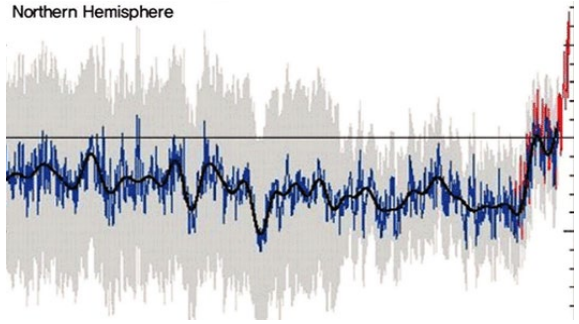
Warnings, public safety, protection of life and property

Transport

Energy

Agriculture

Tourism



Climate change Monitor

Public health and famine

Business and commerce

Defence

Key conclusions

- Microwave observations are critical to NWP
- NWP is critical to WMO Member State National Warning Systems and many socio-economic sectors (previous slide)
- Passive microwave observations contribute around 40% of the overall improvement of short-range forecast skill, plus a further 10% from active microwave.
  - 50-60 GHz and 176-190 GHz remain the two most critical spectral bands (176-190 much more than 10y ago).
  - 18.7, 23.8, 31.4, 37, 89, 166 essential for direct measurements as well as indispensable in combination with the bands listed above (50-60 GHz and 176-190 GHz)
  - 1.4, 6.8, 10.7, 209, 229 important for emerging applications
- Many countries have detailed financial assessments of the value of their weather and environment services
  - https://www.metoffice.gov.uk/about-us/what/pws/value UK $2.0B per year, USA $11.4B per year
- Harder to quantify benefits in military sector in $

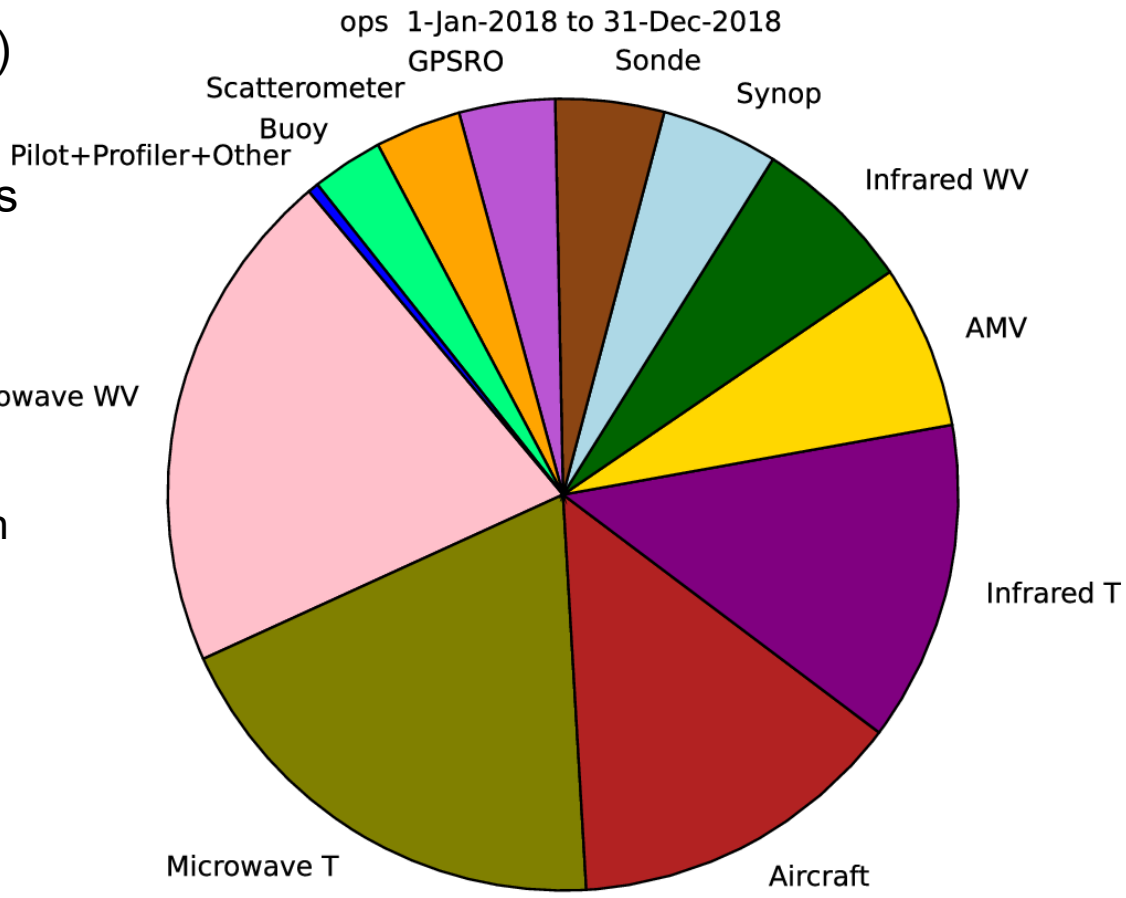
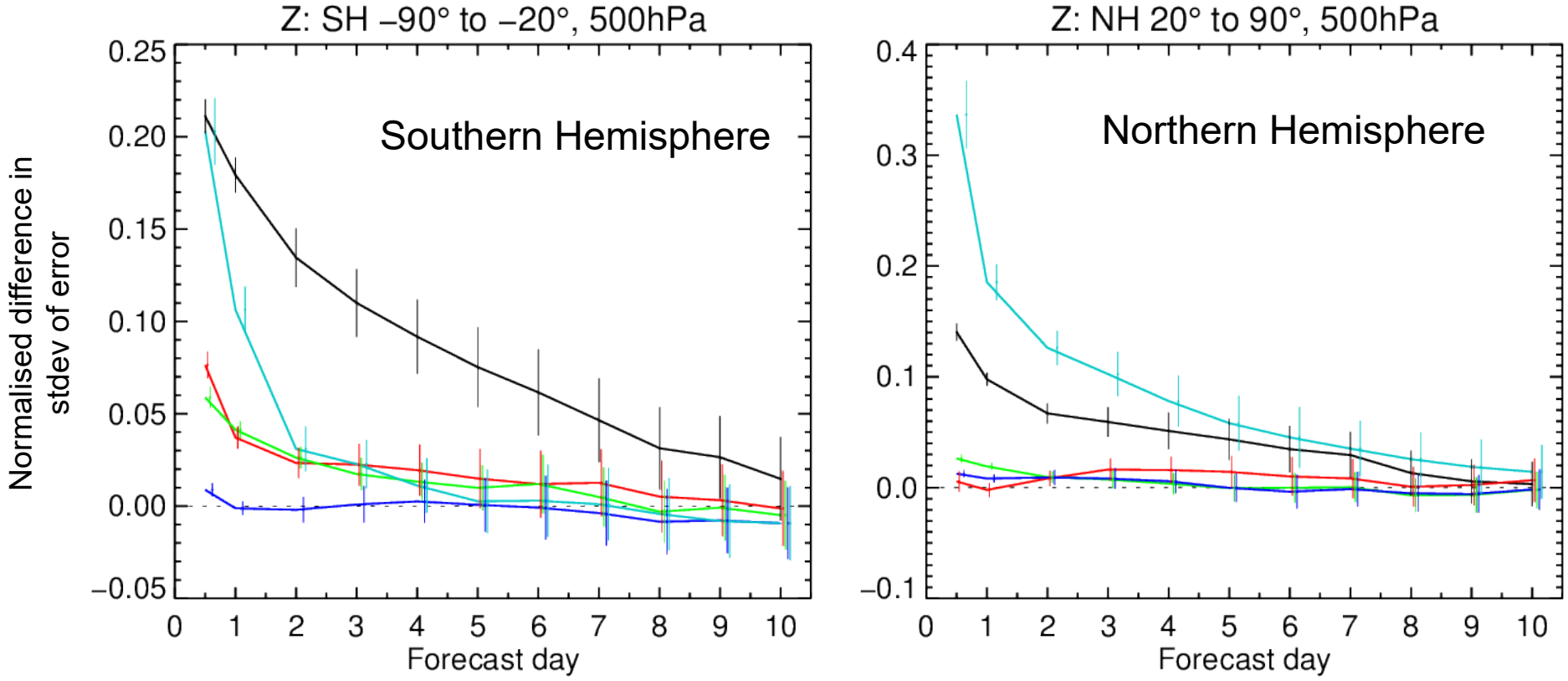


Figure from Alan Geer, ECMWF

Current impact of various observing systems: Z 500 hPa



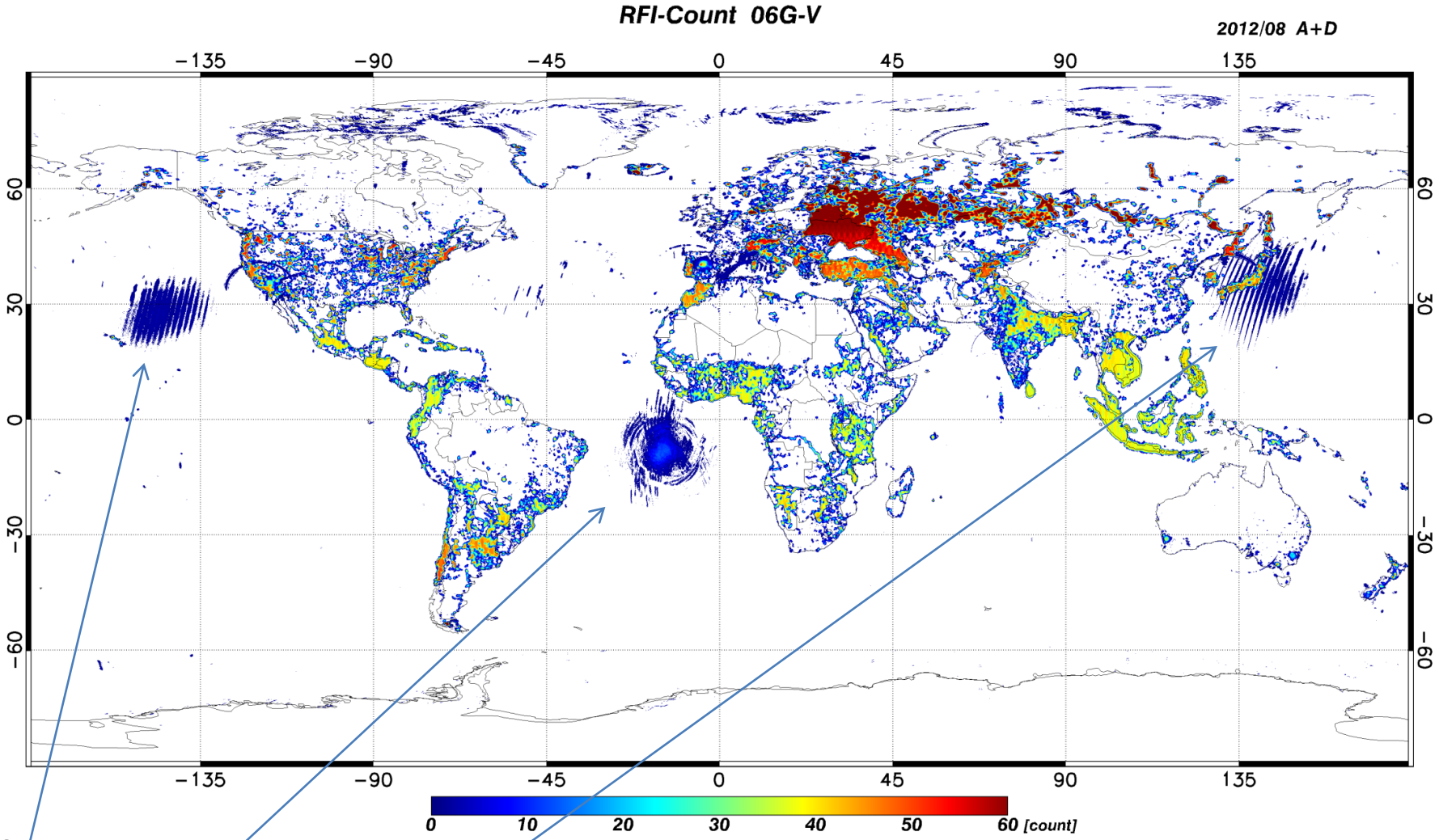
MW radiances are the leading satellite observing system.

MW denial – Control
IR sounder denial – Control
GPSRO denial – Control
AMV denial – Control
Conventional obs denial – Control

(verified against operational analyses, both seasons combined)

Figure from Niels Bormann, ECMWF

Example of current RFI shown by JMA (Japan) in C band (unprotected)

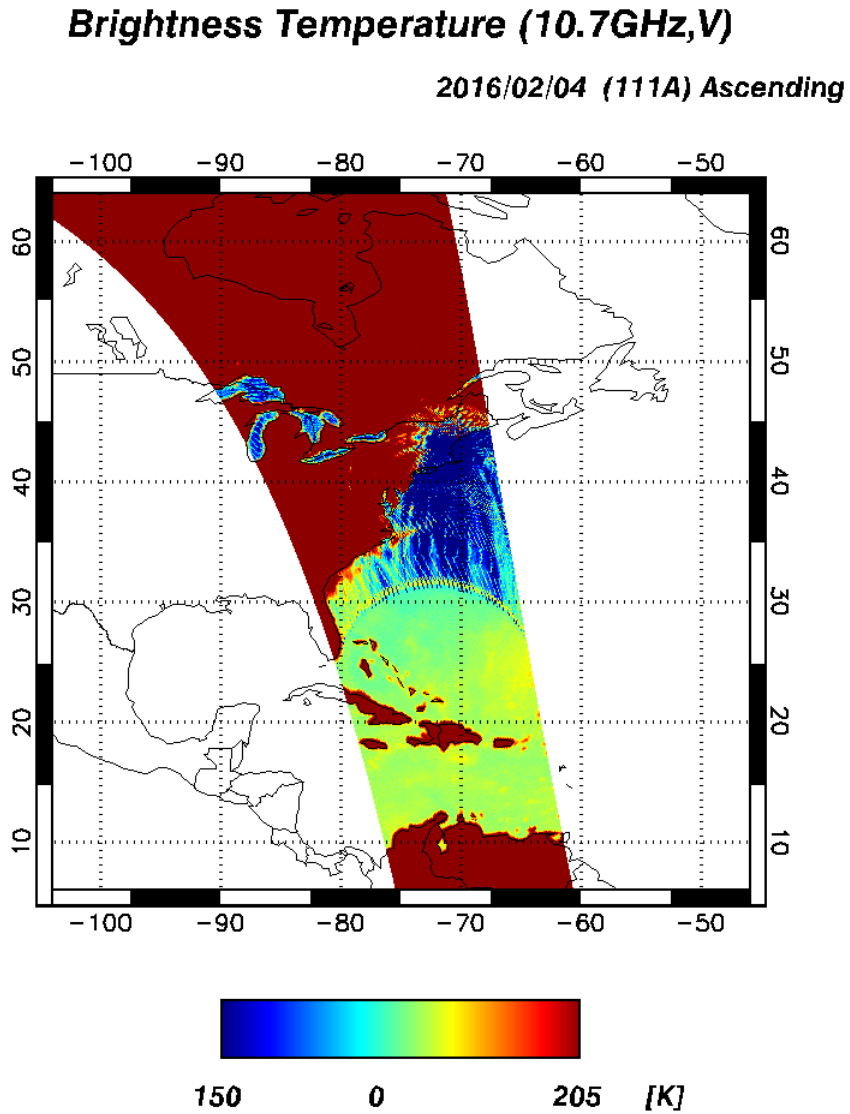


RFI sources:

1. Globalstar (satellite phone)
2. Ascension island(Ground-Satellite communication)
3. Japan, South-east Asia (ground-ground communication)

M. Seki, presented by M Kazumori at RFI workshop

Examples of current RFI shown by JMA (Japan) in X band (protected)



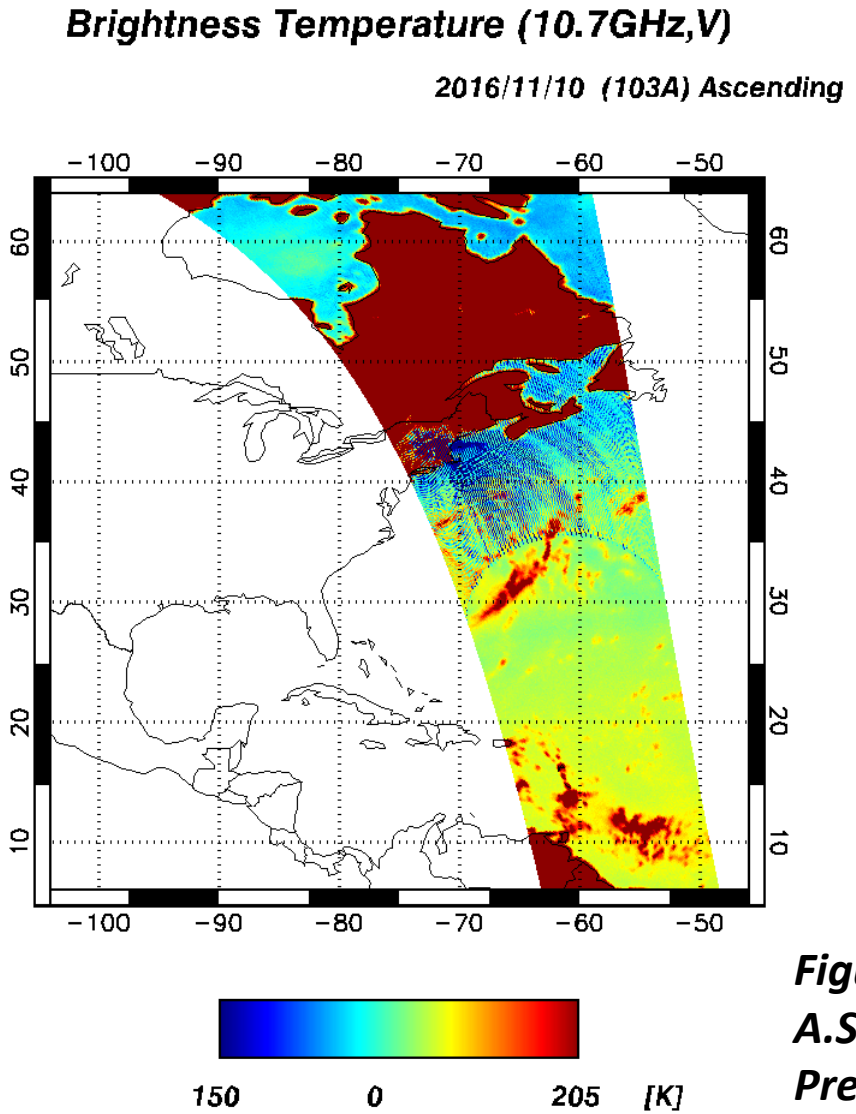


Figure from A.Shibata, JAXA Presented by M Kazumori at RFI workshop

Is WRC-19 the end of our worries?

- **No**

- e.g. in UK, “Spectrum: Mapping the Future”, London 10 September 2019, these sentiments were expressed:
  - “Maximise spectrum through sharing: use only where and when needed”
  - “No more ‘this is my band’: sharing is the future”
  - “De-regulation above 100 GHz because nobody knows how to use these frequencies”
  - “Weather community are working with yesterday’s paradigm, they need to adapt”

Conclusions

- NWP centres: MW observations provide 30-40% of all forecast error reduction from observations.
- MW exploitation is becoming ever more sophisticated: all-weather, all surfaces.
- The loss of MW would have a significant impact on NWP.
- If MW not available loss of IR, even temporarily, would have a catastrophic impact on NWP.
- The socio-economic impact of degraded NWP capability was summarized and is available in the Workshop report.

My opinion:

It is a concern that the direction of travel for spectrum regulation, internationally and nationally in many countries, may not be compatible with the needs of the meteorological community