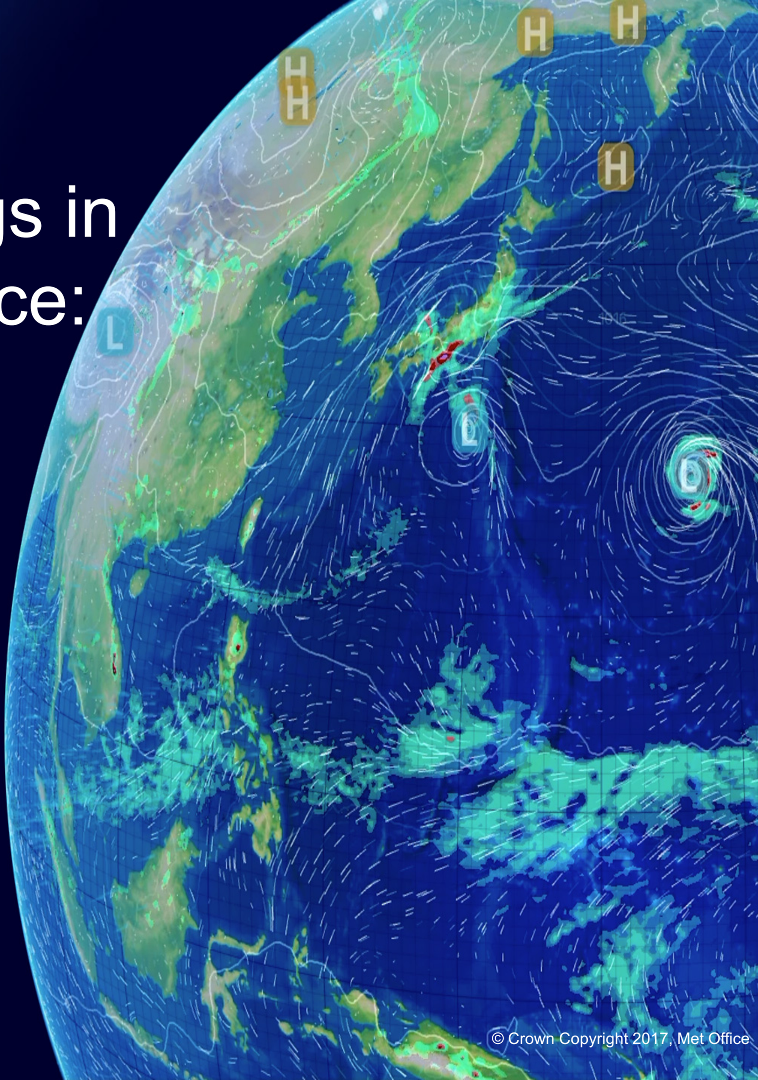
Met Office

Microwave soundings in NWP at the Met Office: experience and suggestions for future systems

John Eyre
Met Office, UK

NOAA Workshop on MW sounders
28 July 2021



Microwave soundings in NWP at the Met Office: experience and suggestions for future systems

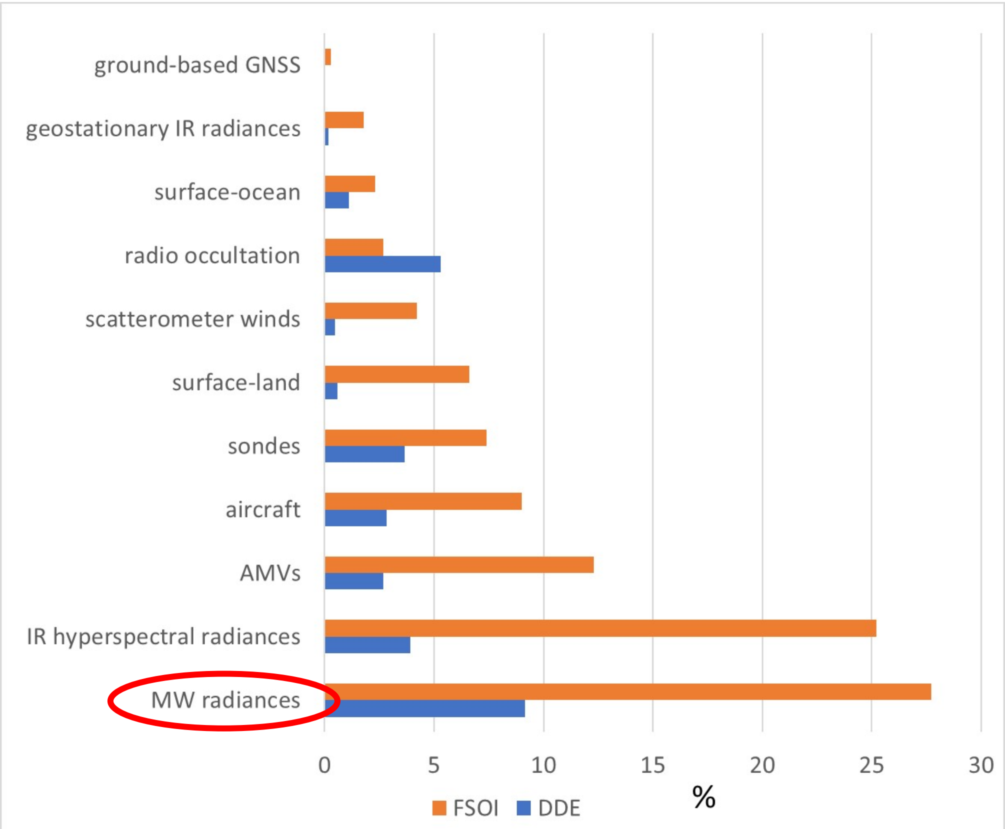
- Met Office use of MW sounder data in NWP
  - Observations used
  - Impacts
  - Monitoring
- Future MW sounding systems
  - What's important?
- Comments on NOAA requirements
- Conclusions

Thanks to: Nigel Atkinson, Brett Candy, Chawn Harlow

Microwave soundings in NWP at the Met Office: instruments used

• AMSU-A	Metop-B,-C	NOAA-15,-18,-19
• MHS	Metop-B,-C	NOAA-18,-19
• ATMS	Suomi-NPP	NOAA-20
• SSMIS	DMSP-F17	
• AMSR-2	GCOM-W	
• GMI	GPM	
• MWHS-2	FY-3C,-3D	
• MWTS-2	FY-3D	
• MWRI	FY-3D	

Microwave soundings in NWP at the Met Office: impact (1)



Data denial experiments

Aug-Oct 2019

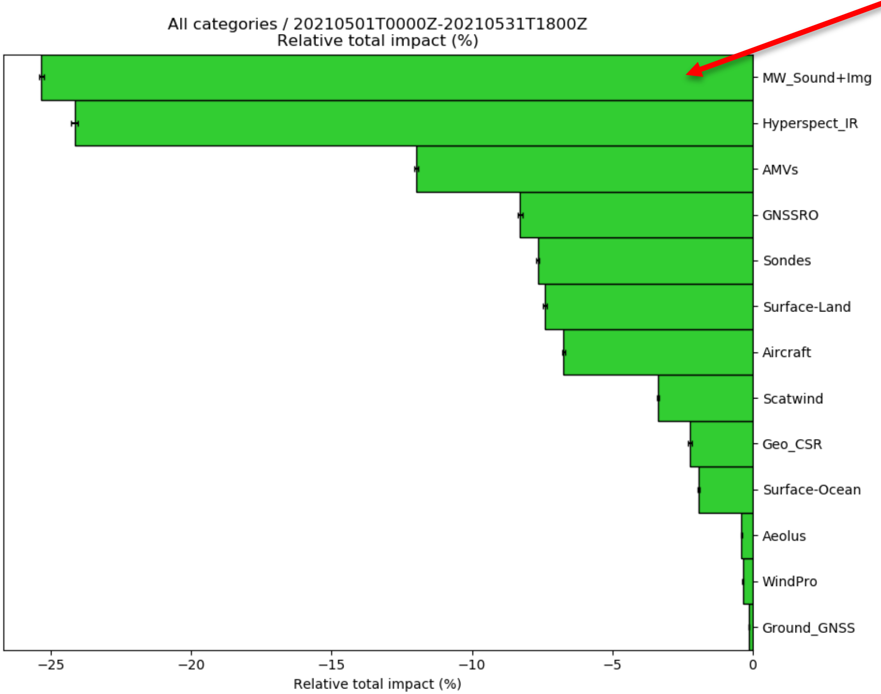
%impact on error variance of 24h forecast
- by DDE
- by FSOI

Candy B et al., 2021
Met Office FRTR 641

Eyre J, 2021. QJRMS
DOI: 10.1002/qj.4123

Microwave soundings in NWP at the Met Office: impact (1)

MW sounders and imagers

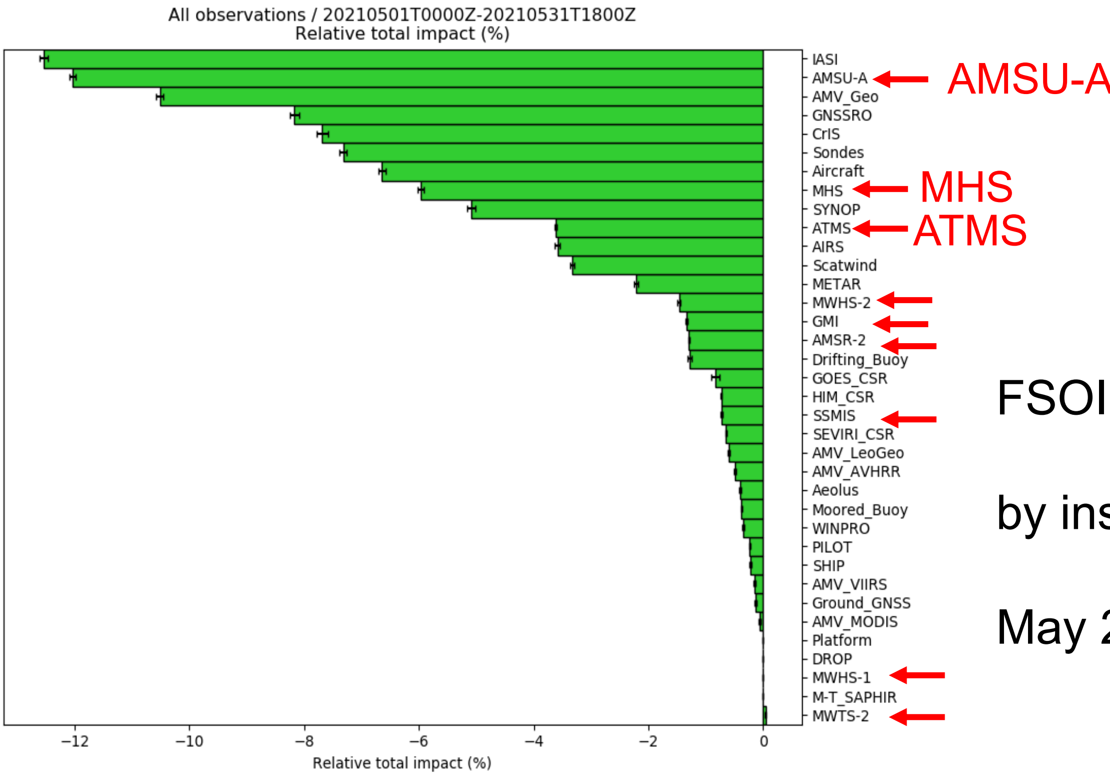


FSOI impacts

by technology type

May 2021

Microwave soundings in NWP at the Met Office: impact (2)

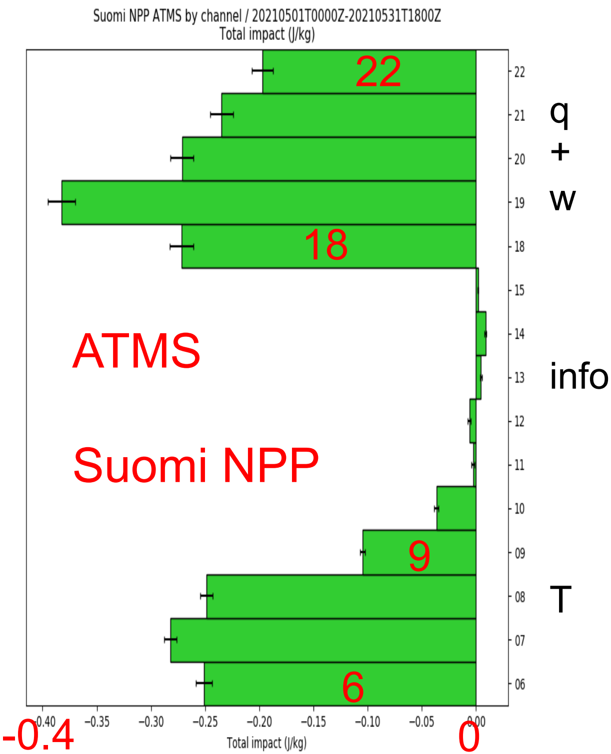


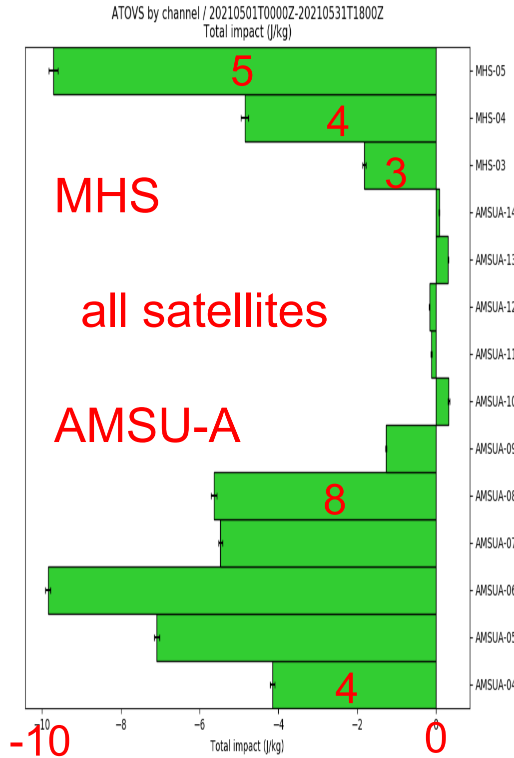
FSOI impacts

by instrument

May 2021

Microwave soundings in NWP at the Met Office: impact (3)





FSOI impacts

by MW channel

May 2021

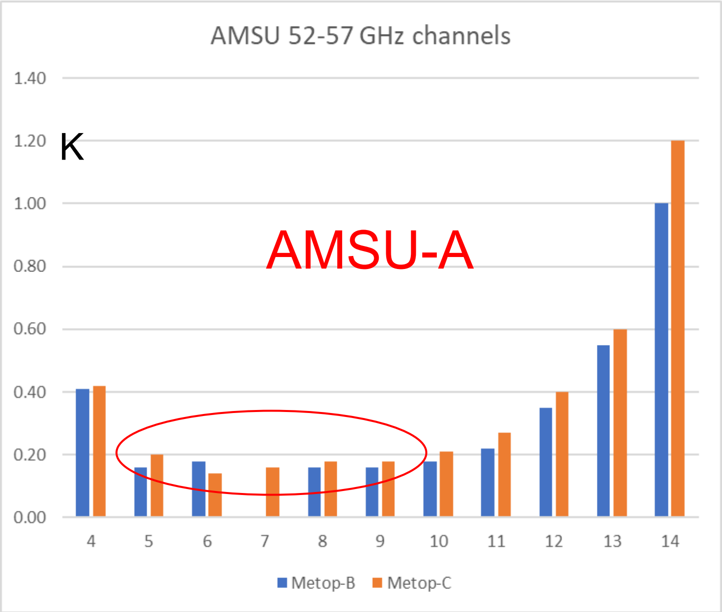
Microwave soundings in NWP at the Met Office: monitoring (1)

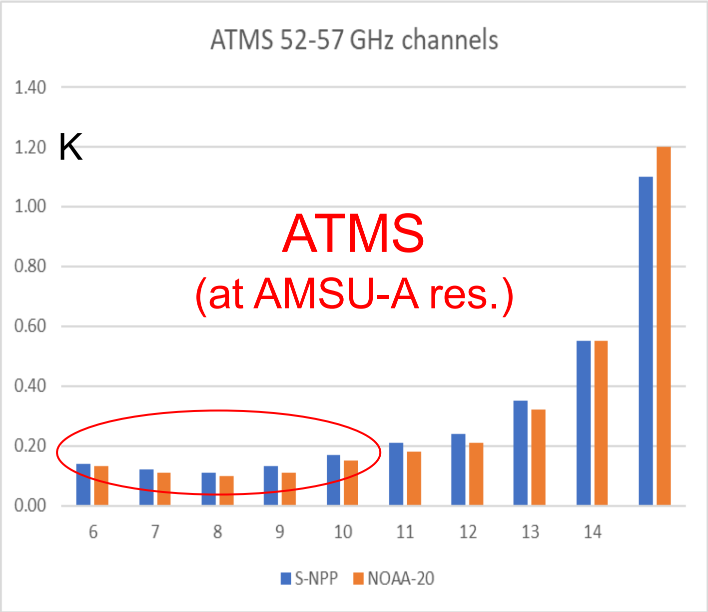
Routine monitoring includes:

- mean and standard deviation of observed-minus-forecast brightness temperatures, “O-Bs”
- for each channel
- for each assimilation cycle

Following data are averages for 2 weeks in June-July 2021

Monitoring statistics: standard deviations of observed-minus-forecast brightness temps (2)





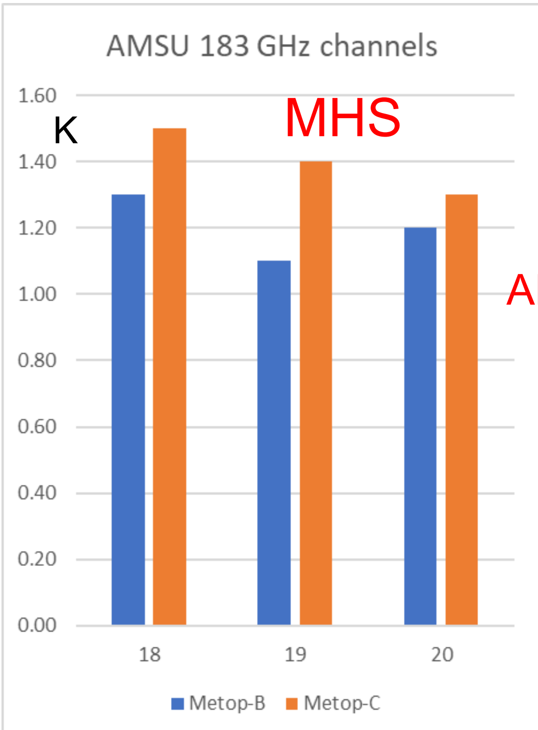
*** For key tropospheric temperature sounding channels, SD of (O-B) is 0.1-0.2 K ***

Microwave soundings in NWP at the Met Office: monitoring (3)

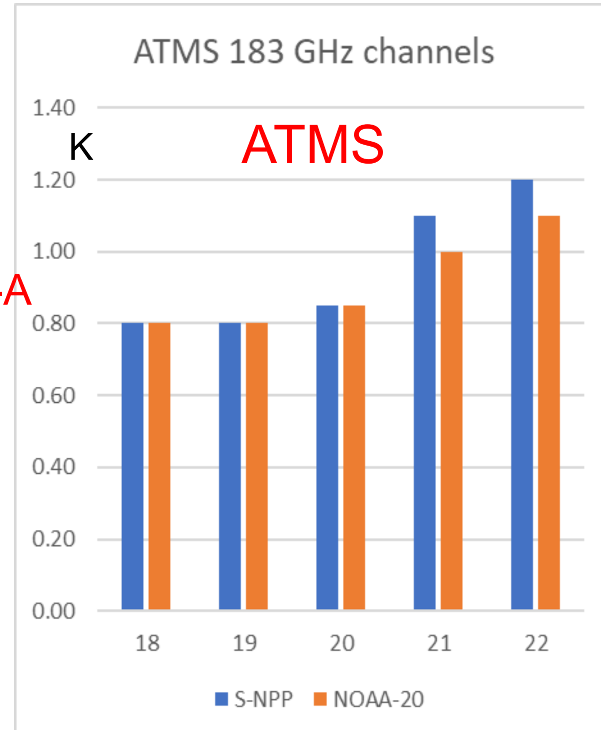
*** For key tropospheric temperature sounding channels, SD of (O-B) is 0.1-0.2 K ***

- includes observation error and forecast error!

Monitoring statistics: standard deviations of observed-minus-forecast brightness temps (4)



at AMSU-A res.



Microwave soundings in NWP at the Met Office: monitoring (5)

*** For key tropospheric humidity sounding channels, SD of (O-B) is 0.8-1.5 K ***

- includes observation error and forecast error!

Future MW sounding systems: what's important? (1)

Temperature sounding

- Low NEdT – 0.2 K is already marginal
- … at 50 km (AMSU-A) resolution
- NEdT spec should include 1/f noise ("striping")

- Calibration stability should be better than this
- … particularly around the orbit,
- … and over periods of 1-2 days.
- NWP bias correction (VarBC) can handle changes on slower time scales, and the occasional jump

Future MW sounding systems: what’s important? (2)

Temperature sounding

Horizontal resolution – 50 km is OK!

Why?

- Low vertical resolution + aspect ratio of atm^{c}. features
- → can’t see horizontal features <50 km

but

- higher resolution useful for quality control
- … and for features with different structure and bigger signals, e.g. tropical cyclones

Future MW sounding systems: what’s important? (3)

Temperature sounding

52-57 GHz v 118 GHz ?

- 118 GHz not preferred

Why?

- lower vertical resolution
- greater impacts of water vapour and cloud
- typical forecast errors in temperature still lead to signals of 0.1-0.2 K in BT space

Future MW sounding systems: what's important? (4)

Humidity sounding

183 GHz

- Direct sounding of humidity
- Indirect sounding of wind through tracer effect
  - tracking humidity and cloud/precip features over time

- NEdT requirements more relaxed
- Higher horizontal resolution more useful

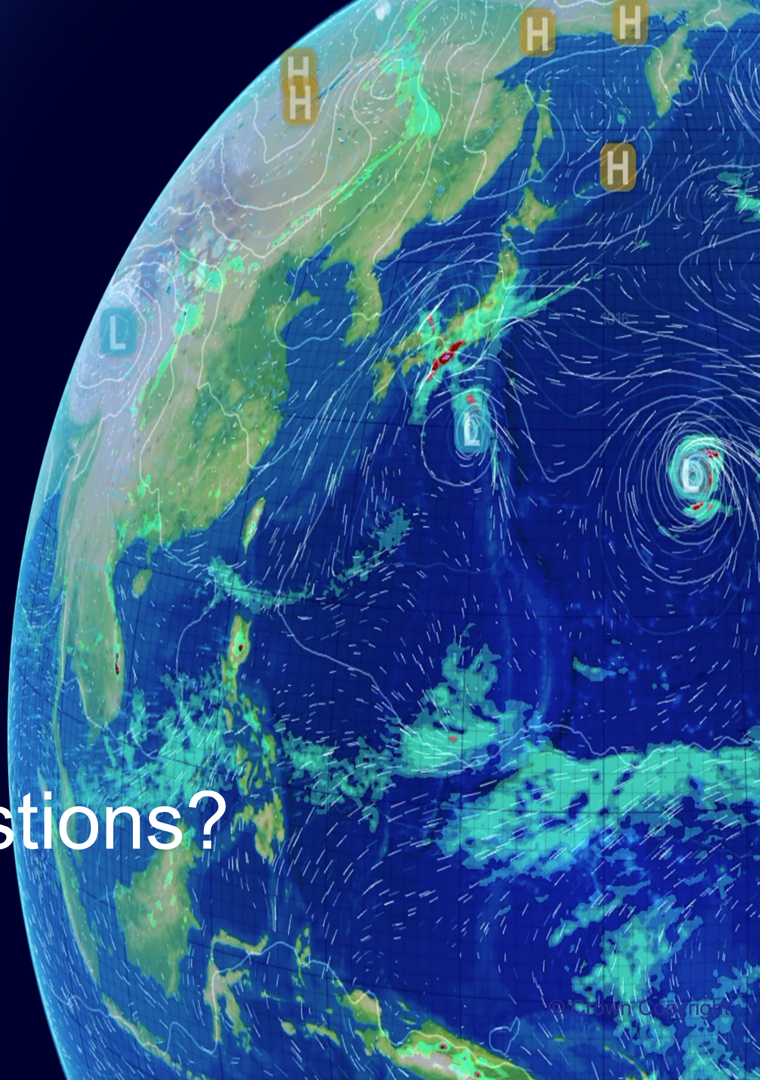
Comments on NOAA requirements

- Calibration accuracy
  - … is important – requirement of 1 K is marginal, but …
  - calibration stability is very important – should be < NEdT
- "Temperature measurement precision - ~2.0 K per 1 km layer"
  - not relevant for NWP - (What's the application for this?)
- NEdT at 52-57 GHz - "0.3-1.5 K at 32 km"
  - → 0.12-0.60 K at 50 km. Upper end of range not useful.
- NEdT at 183 GHz – OK.
- Important to retain backbone with ATMS-like performance
  - additional sounders in complementary orbits useful …
  - with focus on 183 GHz, if 52-57 GHz performance can't be met

Conclusions

- Microwave sounding radiances are crucial data for operational NWP performance
- Backbone of high-quality instruments will remain important – as WMO “Vision for WIGOS in 2040”
- Data from many instruments currently assimilated – no sign of saturation → keep old satellites flying if you can!
- Low NEdT (including 1/f noise) and calibration stability are crucial for temperature sounding

Met Office



Thank you! Questions?

Microwave soundings in NWP at the Met Office: monitoring (3A)

*** For key tropospheric temperature sounding channels, SD of (O-B) is 0.1-0.2 K ***

- includes observation error and forecast error!

SDs of (O-B):

- AMSU-A Metop-B < AMSU-A Metop-C
- ATMS < AMSU-A

Why?

- AMSU-A Metop-C assimilated on its own grid
- AMSU-A Metop-B first interpolated to HIRS grid
- AMSU-A beam width = 3.3 deg (~50 km)
- ATMS pre-processed to 3.3 deg beamwidth
    - more modern instrument (lower system noise temp)
- 1/f noise (“striping”) + instrument degradation complicate interpretation

Microwave soundings in NWP at the Met Office: monitoring (5A)

*** For key tropospheric humidity sounding channels, SD of (O-B) is 0.8-1.5 K ***

- includes observation error and forecast error!

SDs of (O-B):

- MHS Metop-B < MHS Metop-C
- ATMS < MHS

Why?

- MHS averaged 3x3 to AMSU-A grid → NRF=0.33
- AMSU-A Metop-C assimilated on its own grid
- AMSU-A Metop-B first interpolated to HIRS grid
- AMSU-A beam width = 3.3 deg (~50 km)
- ATMS pre-processed to 3.3 deg beamwidth → NRF = 0.23
  - + more modern instrument (lower system noise temp)
- 1/f noise ("striping") + instrument degradation complicate interpretation

NRF = noise reduction factor