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

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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

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Satellites</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMSU-A</td>
<td>Metop-B,-C NOAA-15,-18,-19</td>
</tr>
<tr>
<td>MHS</td>
<td>Metop-B,-C NOAA-18,-19</td>
</tr>
<tr>
<td>ATMS</td>
<td>Suomi-NPP NOAA-20</td>
</tr>
<tr>
<td>SSMIS</td>
<td>DMSP-F17</td>
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<tr>
<td>AMSR-2</td>
<td>GCOM-W</td>
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<tr>
<td>GMI</td>
<td>GPM</td>
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<tr>
<td>MWHS-2</td>
<td>FY-3C,-3D</td>
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<tr>
<td>MWTS-2</td>
<td>FY-3D</td>
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<tr>
<td>MWRI</td>
<td>FY-3D</td>
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</tbody>
</table>
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)

All observations / 20210501T0000Z-20210531T1800Z
Relative total impact (%)

FSOI impacts by instrument
May 2021
Microwave soundings in NWP at the Met Office: impact (3)

Suomi NPP ATMS by channel / 20210501T0000Z-20210531T1800Z
Total impact (J/kg)
ATMS
Suomi NPP

q + w

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)
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
Temperature sounding

52-57 GHz vs 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
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