Preparations for EPS-SG Microwave Instruments at ECMWF

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Abstract

The microwave instruments on the Metop-SG-A and -B satellites – MWS, MWI, and ICI – will provide sounding and imaging capabilities from 18 to 664 GHz. The wealth of data and information content from microwave instruments in the EPS-SG programme constitute a great opportunity but also a significant challenge, both at a technical level and for full scientific exploitation of the data. *To prepare for these instruments at ECMWF, significant effort has gone into data pre-processing and monitoring capabilities*. These developments should enable quick feedback to the EUMETSAT Cal/Val teams and facilitate assimilation trials early in the missions of both satellites.

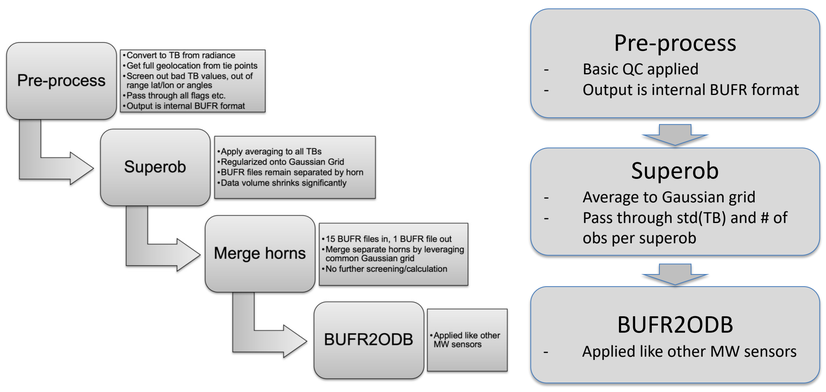
At ECMWF, MWI and ICI will be treated together as a single 'super-sensor' named "MWIICI." The L1B radiances are spatially averaged in a superobbing procedure prior to combining the instruments. This serves several purposes: data volume reduction, addressing representation error, regularizing the separate geolocations from each feedhorn, and reducing effective radiometric noise. Averaging MWIICI radiances onto a 40km Gaussian grid reduces L1 radiances by roughly two orders of magnitude.

RT simulations for MWS and MWIICI will use measured spectral response functions and account for variable ozone profiles. As ozone sensitivity generally increases with frequency, the use of climatological ozone profiles cause forward model errors of about 1K at ICI sub-mm channels. The SURFEM-Ocean emissivity model supports the sub-mm channels over sea. For MWS, the initial treatment will follow that of established heritage sensors, using an all-sky approach. Particular attention will be paid to the novel channels available from MWS, such as the lower-peaking 50-GHz channels as well as the new 229 GHz channel.

Data Flow

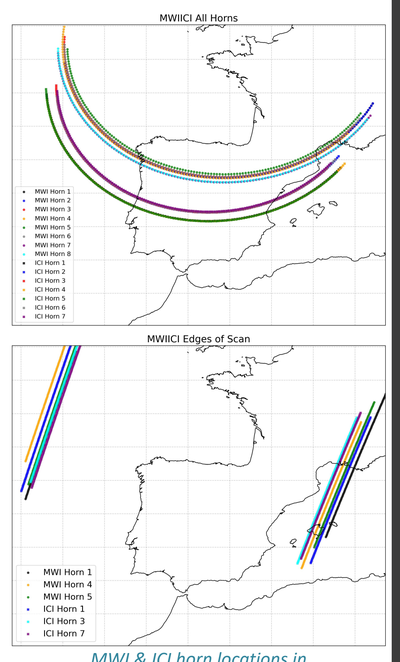
Pre-processing of Metop-SG radiances is a critical element of using the data

- MWI has 8 feedhorns and ICI has 7 feedhorns – *15 distinct geolocations, not all overlapping*
- MWI & ICI spatially over-sample more than any previous MW imager – 1392 and 810 observations per scanline, respectively
- MWS pre-processing is simpler due to co-located channels
- Each instrument has grid-based averaging (superobbing) applied
  - ➢ Preliminary settings are 40km for MWIICI, 50km for MWS



MWIICI data flow, from L1B BUFR to ODB

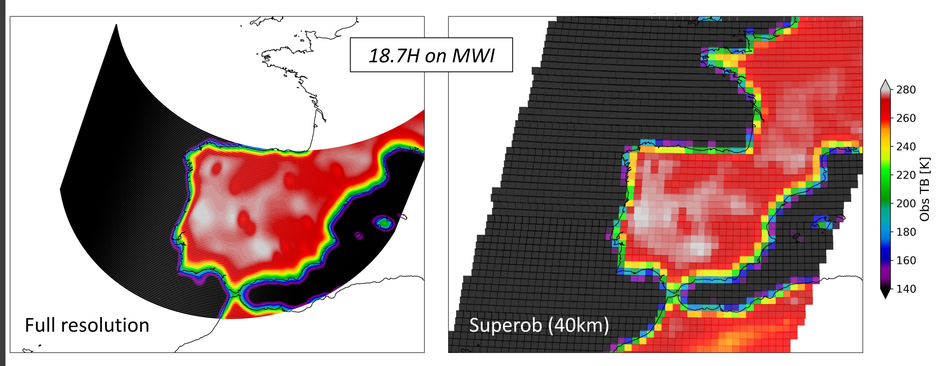
MWS data flow, from L1B BUFR to ODB

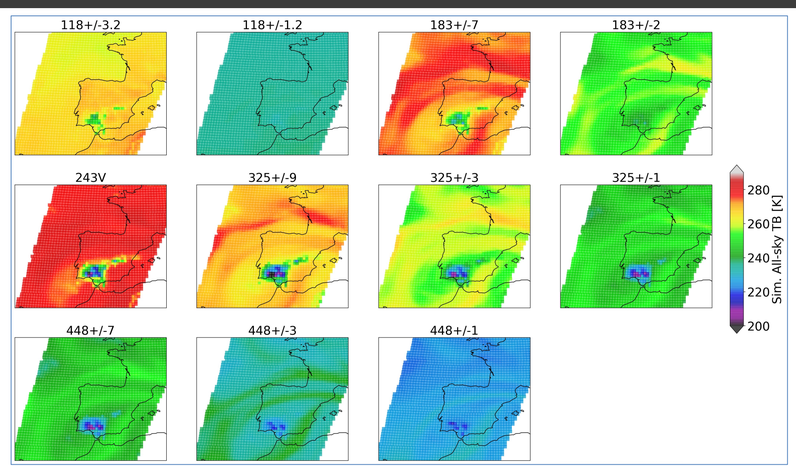


MWI & ICI horn locations in EUMETSAT test data

MWI & ICI simulation in the IFS

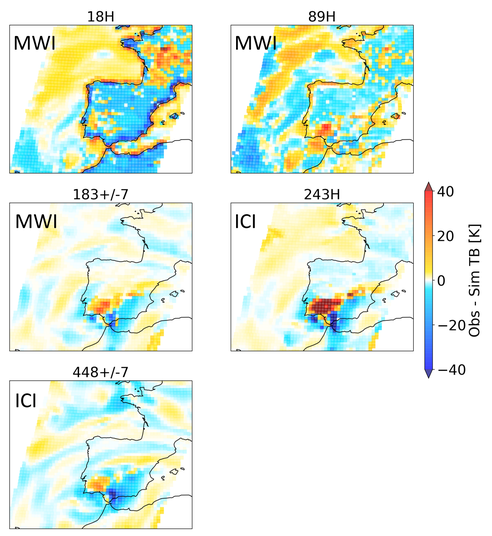
In the Integrated Forecasting System (IFS), the MWI and ICI radiometers are averaged into 40km super-observations (below) and combined into a 39-channel observation vector





Simulated all-sky TBs from the IFS for selected MWIICI channels

Forward simulations use RTTOV-SCATT v13.2 with SURFEM-Ocean (IFS Cycle 49r1), here compared to test data provided by EUMETSAT



Comparing simulated O-B for selected MWIICI channels

Ch. No.	*Freq. [GHz]*	*Horn*	
1, 2	18.7	1	MWI
3, 4	23.8	2	
5, 6	31.4	3	
7, 8	50.3	4	
9, 10	52.70	4	
11, 12	53.24	4	
13, 14	53.75	4	
15, 16	89.0	5	
17	118.7503 ± 3.2	6	
18	118.7503 ± 2.1	6	
19	118.7503 ± 1.4	6	
20	118.7503 ± 1.2	6	
21	165.5 ± 0.725	7	
22	183.31 ± 7.0	8	
23	183.31 ± 6.1	8	
24	183.31 ± 4.9	8	
25	183.31 ± 3.4	8	
26	183.31 ± 2.0	8	
27	183.31 ± 7.0	1	ICI
28	183.31 ± 3.4	1	
29	183.31 ± 2.0	1	
30, 31	243.2 ± 2.5	2/3	
32	325.15 ± 9.5	4	
33	325.15 ± 3.5	4	
34	325.15 ± 1.5	4	
35	448 ± 7.2	5	
36	448 ± 3.0	5	
37	448 ± 1.4	5	
38, 39	664 ± 4.2	6/7	

Cal/Val monitoring via NWP departures

Preparing for Metop-SG, application to GMI, AMSR2, SSMIS

- By using the NWP model as a transfer standard, O-B differences permit cal/val analysis globally over millions of data points
- A method is developed to use all-sky simulations to screen out heavily cloud-affected and surface-sensitive scenes
- The cal/val sample screens out cloud and precipitation "symmetrically" – in both the observation and the model
- Consideration of scattering from hydrometeors is key for higher frequencies of ICI in particular

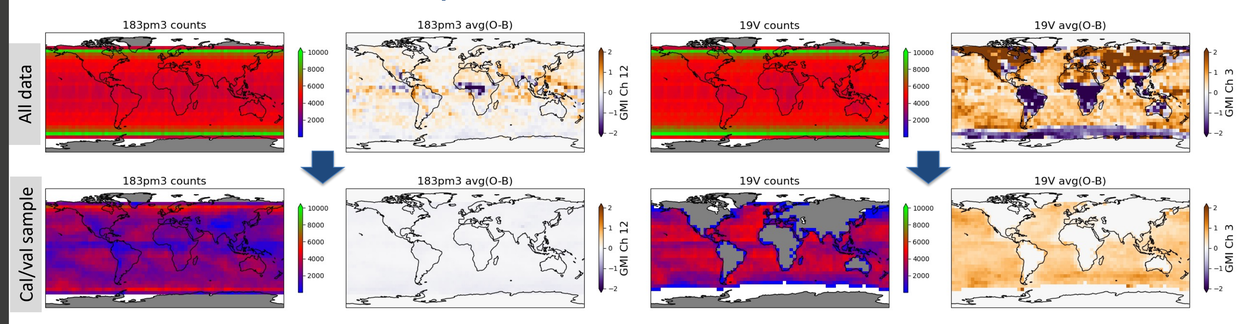
$$CI_{Ch} = |O_{Ch} - B_{Ch,clr}|/2 + |B_{Ch} - B_{Ch,clr}|/2$$

Obs. Clear-sky B All-sky B

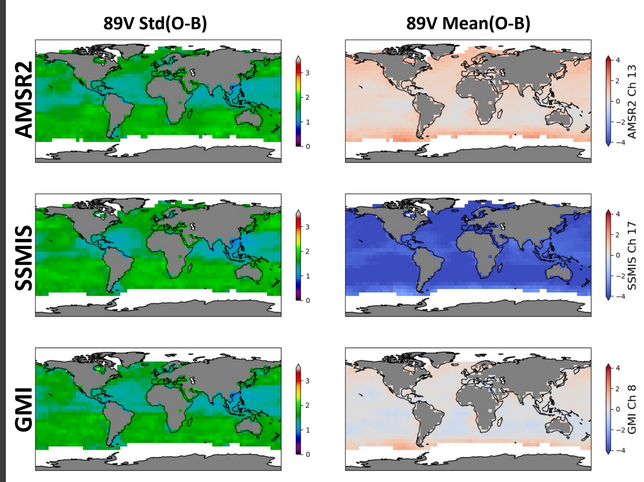
Cloud Impact (CI) definition per channel

Channel Group	Cal/Val Criteria
Window channels	land< 1%, $CI < 2K$, $SST > 277K$
Sounder channels	$\tau < 0.02$ or land< 0.01, $CI < 0.5K$

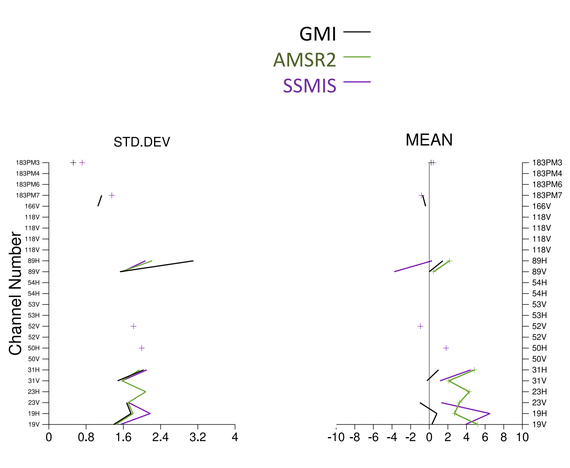
Examples from GMI channels 183±7 & 19V:



- Can use GMI as a calibration reference
- Applying the method above we see calibration biases found in the literature: e.g. orbital biases on SSMIS, positive biases on AMSR2, near-zero for most GMI channels
- Areas of known model biases are screened out – sea-ice, high orography, cold SSTs, cold-air outbreak regions. This makes the bias evaluation more reliable.



Std(O-B) and Mean(O-B) for the cal/val sample from 89V on GMI, AMSR2, and F17 SSMIS over June & July 2023.

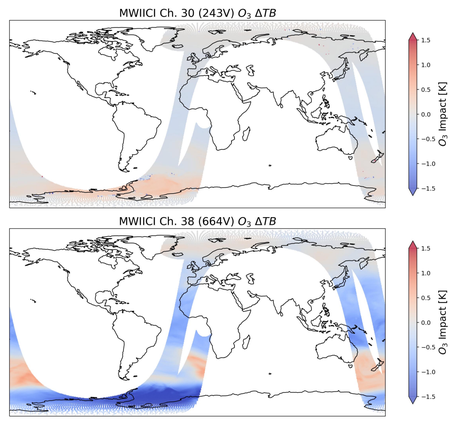


Std(O-B) and Mean(O-B) for the cal/val sample from GMI, AMSR2, and F17 SSMIS over June & July 2023, indexed to MWIICI channels.

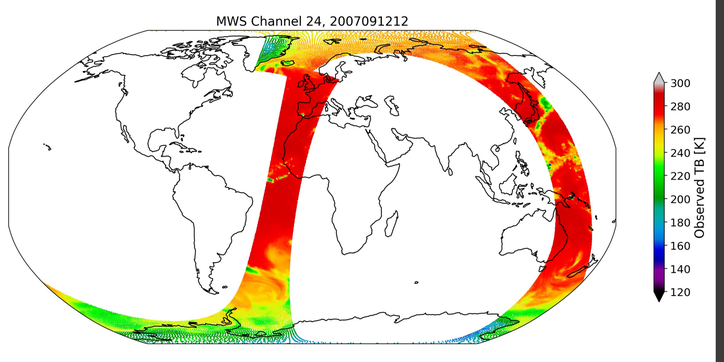
Preparing for MWS launch

Metop-SG-A1 is scheduled to launch in August 2025

- Monitoring tools are being prepared for assessment of data quality from the very earliest mission data available
- Analysis uses the all-sky system, following the techniques developed for AMSU-A, MHS, and more recently AWS
- Forward modelling will account for variable O3 profiles and use measured spectral response functions (SRFs)



Impact on TB from using IFS O3 profiles versus a climatological profile for RTTOV simulations



Conclusions

- MWI and ICI have custom pre-processing in the IFS to merge the instruments together, providing synergies for monitoring and eventually assimilation
- An all-sky cal/val methodology was developed for MWIICI, applied first to the simulated test data from EUMETSAT and then current imagers GMI, AMSR2, and SSMIS; results look good particularly for GMI, giving confidence in the method
- A tailormade monitoring website has been developed for Metop-SG, allowing comparison of MWIICI with current imagers in the IFS over various axes
- The same method will be followed for MWS in autumn 2025, with appropriate adjustments made for the low-noise sounding channels

References

Duncan, D. I., A. Geer, N. Bormann, M. Dahoui, "Vicarious calibration monitoring for MWI and ICI using NWP fields," EUMETSAT contract report, Mar. 2023. https://doi.org/doi:10.21957/7c2d18d2e1

Duncan, D. I., N. Bormann, and coauthors, "Assessment and assimilation of the Arctic Weather Satellite at ECMWF," in preparation.