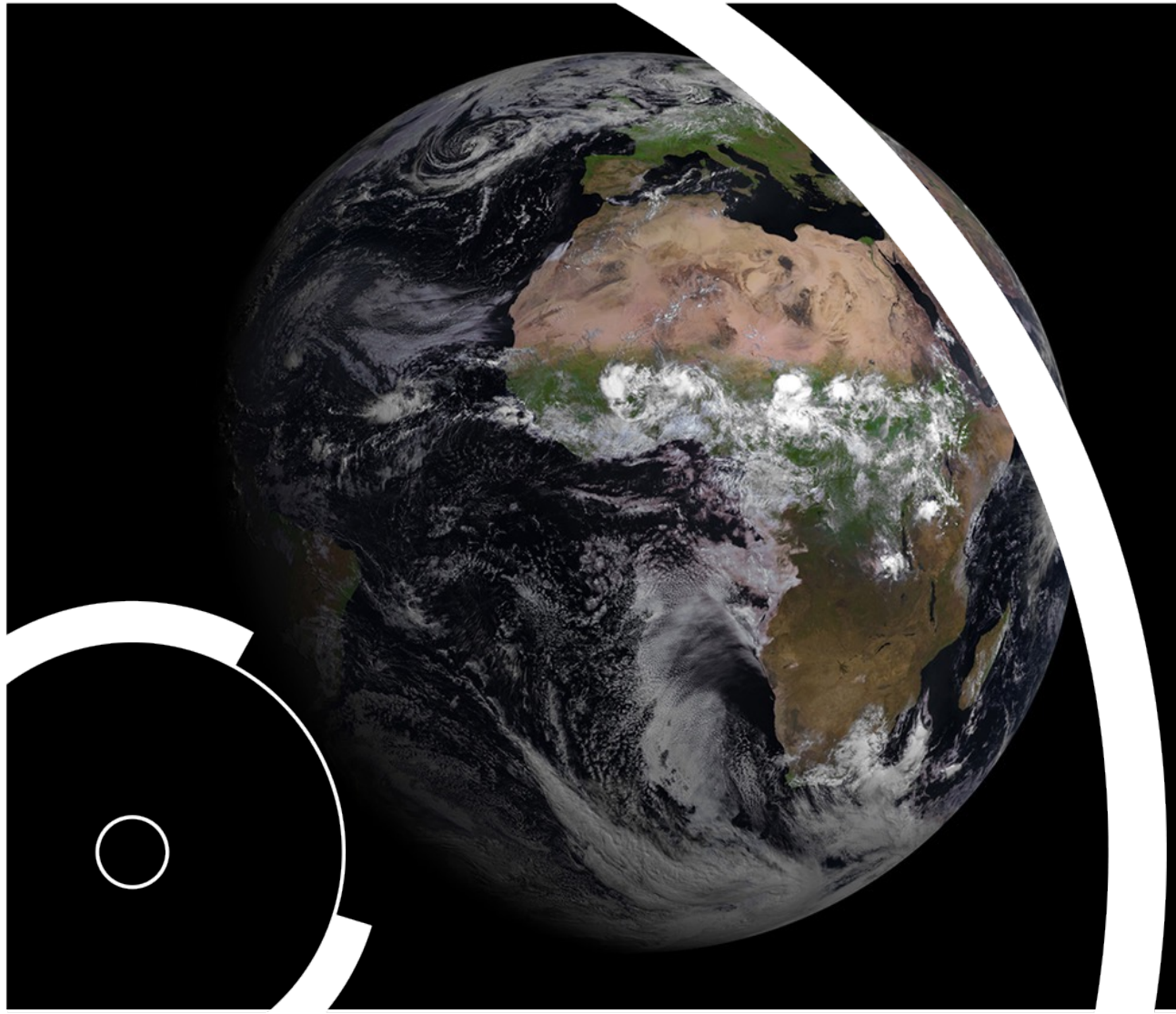
EUMETSAT



Applying inter-sensor harmonisation to various microwave humidity sounders

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1 EUMETSAT

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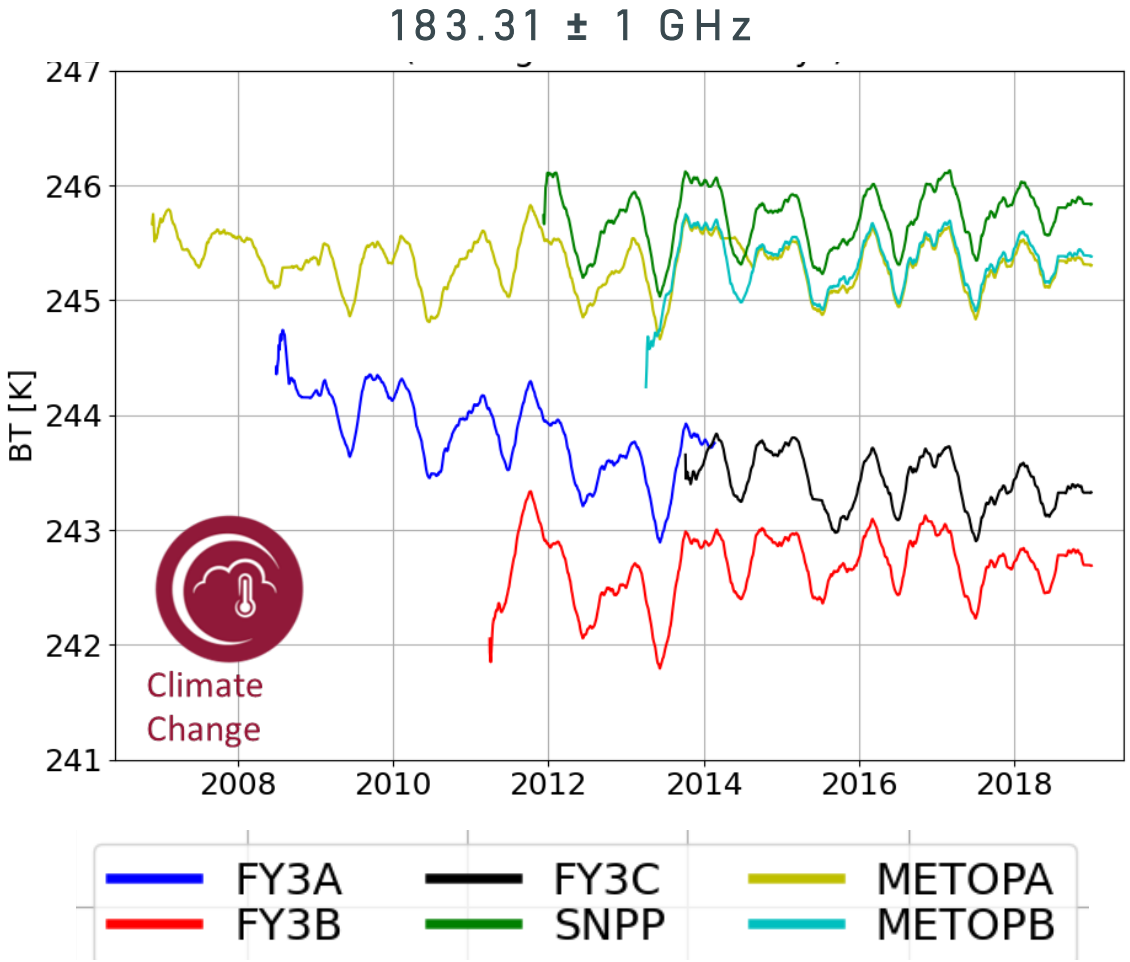
International TOVS Study Conferences ITSC-24 2023
Tromsø, 17.03.2023

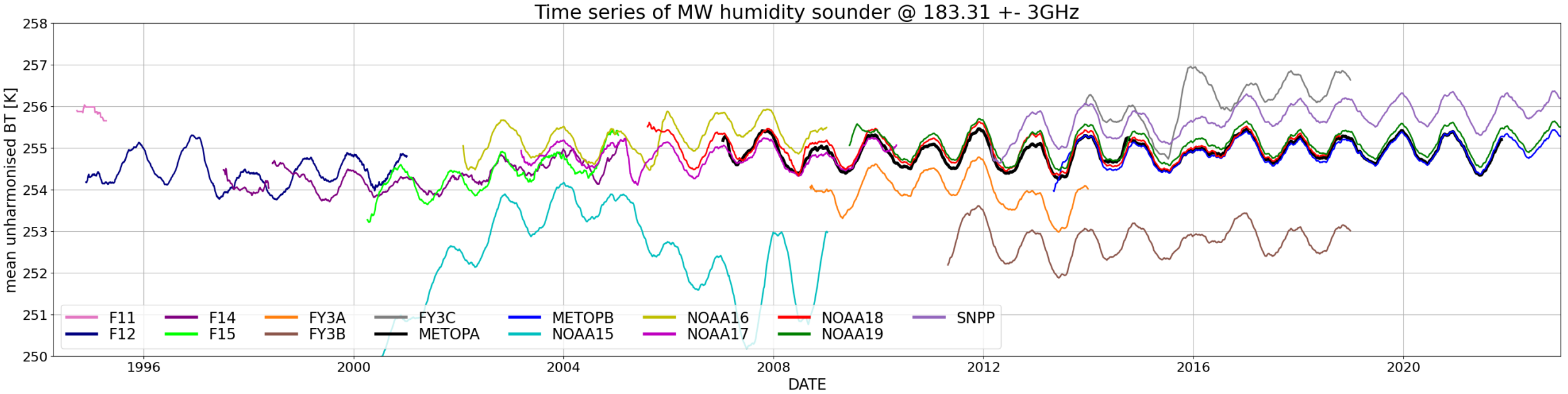
Starting point



- Fundamental climate data record on Microwave Humidity Sounder (MW-FCDR) data released by EUMETSAT in 2021:
  - MHS on-board Metop A/B: 10.15770/EUM_SEC_CLM_0033
  - ATMS on-board SNPP: 10.15770/EUM_SEC_CLM_0034
  - MWHS on-board FY-3A/B: 10.15770/EUM_SEC_CLM_0035
  - MWHS/2 on-board FY-3C: 10.15770/EUM_SEC_CLM_0052
- Measurements around water vapour absorption at 183.31 GHz are included:
  - 183.31 ± 1 GHz for all sensors
  - 183.31 ± 3 GHz for all sensors
  - 183.31 ± 7 GHz for all sensors except MHS (MHS only 190,31 GHz)
- Including traceable uncertainty estimates (FIDUCEO[1] style)
- Covering 12 years

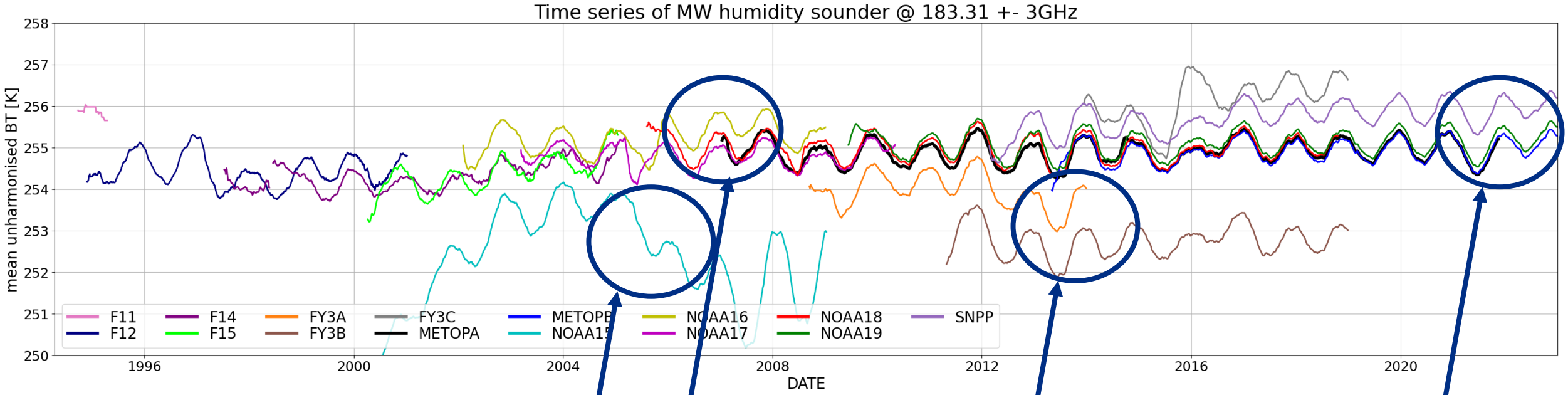
[1] FIDUCEO – Fidelity and uncertainty in climate data records from Earth Observations has received funding from the European Union's Horizon 2020 Programme for Research and Innovation

New upcoming microwave sounder data record



- Additional sensors included:
  - AMSU-B on board of NOAA15 – 17;
  - SSM/T2 on board of F11, F12, F14, F15;
  - MHS on board of NOAA18 and NOAA19;
- Time series is now starting in 1994 and ending in 2022;

New upcoming microwave sounder data record



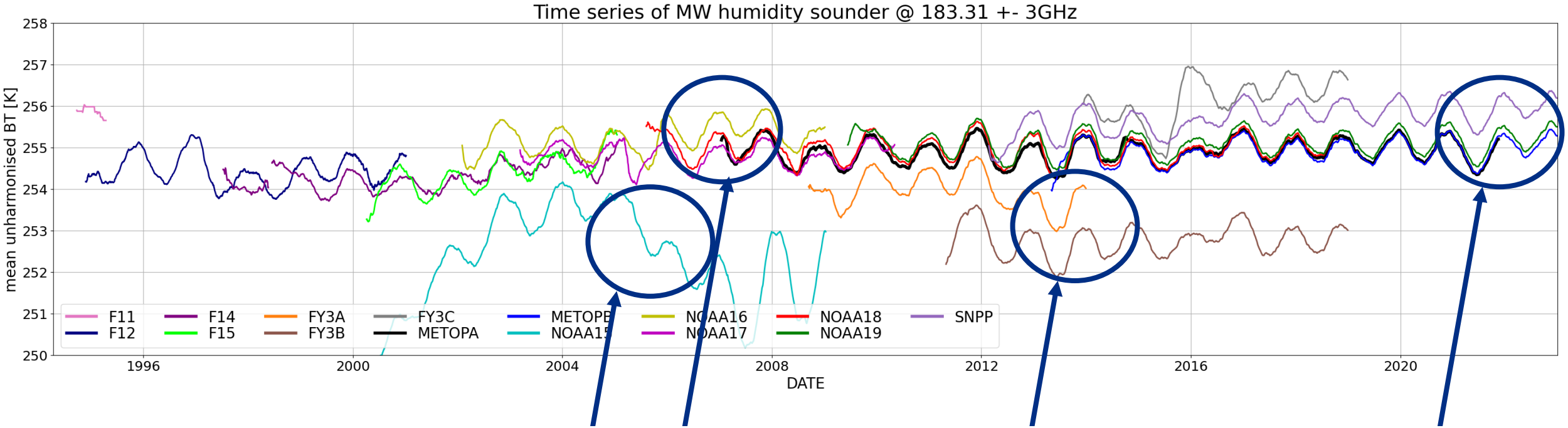
AMSU-B/NOAA 15 shows bad performance

AMSU-B/NOAA16 shows an offset of ~0.3K to the other sensors

MWHS/FY-3A/B show larger offset to the other sensors

ATMS/SNPP shows an offset of ~0,5K to the other sensors

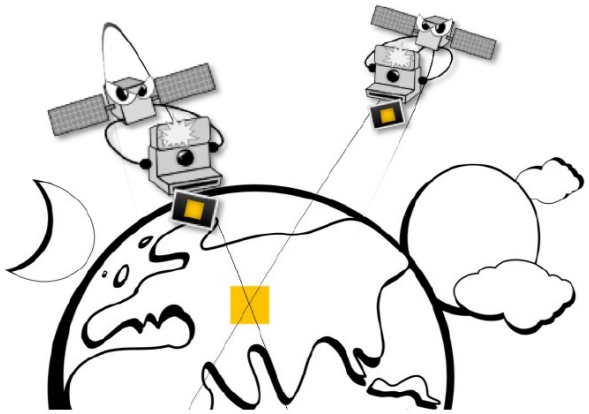
New upcoming microwave sounder data record



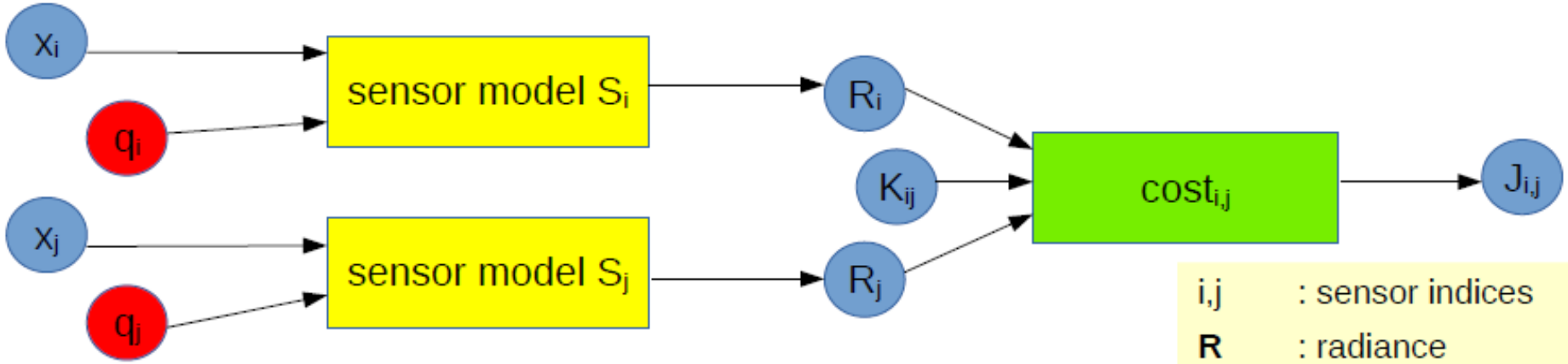
- For any downstream use (e.g. retrieving UTH), biases between observations from several sensors need to be minimised;
- Even after consistent re-calibration of all sensors significant biases remain.
- -> Need to apply further methods such as a harmonisation against a reference sensor to minimise those.

Sensor harmonisation

- The method for harmonisation based on metrological principles optimises calibration parameters in the measurement equation.
- Harmonisation:
  - uses fundamental measurements, i.e. raw measurements (counts);
  - considers uncertainties;
  - does not minimise differences caused by different spectral characteristics;
  - uses a reference within the set of satellites, here MHS on Metop-A, multi-instrument collocations transfer the reference forward/backward in time
  - uses cold match-ups from simultaneous satellite overpasses
  - uses warm match-ups at lower latitudes over temporally homogeneous scenes identified in geostationary images;



Harmonisation Framework



$$J = \sum_{i,j,i<j} J_{i,j}$$

$$J_{i,j} = \frac{1}{2}(R_i - R_j - K_{ij})^t \, (C_i + C_j + C_{kij})^{-1} \, (R_i - R_j - K_{ij})$$

$$R_i = S_i(x_i, q_i)$$

$$C_i = \left(\frac{\partial S_i}{\partial q_i}\right) \; W \; C_q \; W^t \; \left(\frac{\partial S_i}{\partial q_i}\right)^t$$

i,j	: sensor indices
R	: radiance
K	: expected difference in radiance
J	: cost function
X	: calibration parameters of sensor model
q	: sensor state variables
C	: error covariance matrix
C_{kij}	: uncertainty of match and expected difference in radiance
C_i	: uncertainty of sensor radiance
W	: averaging matrix
C_q	: uncertainty of sensor state variables

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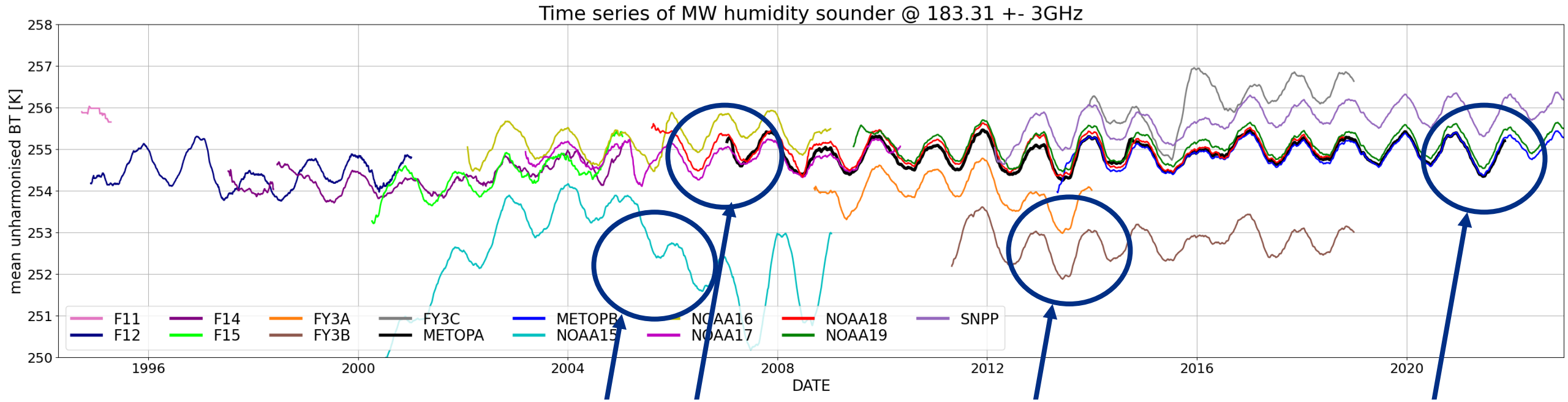
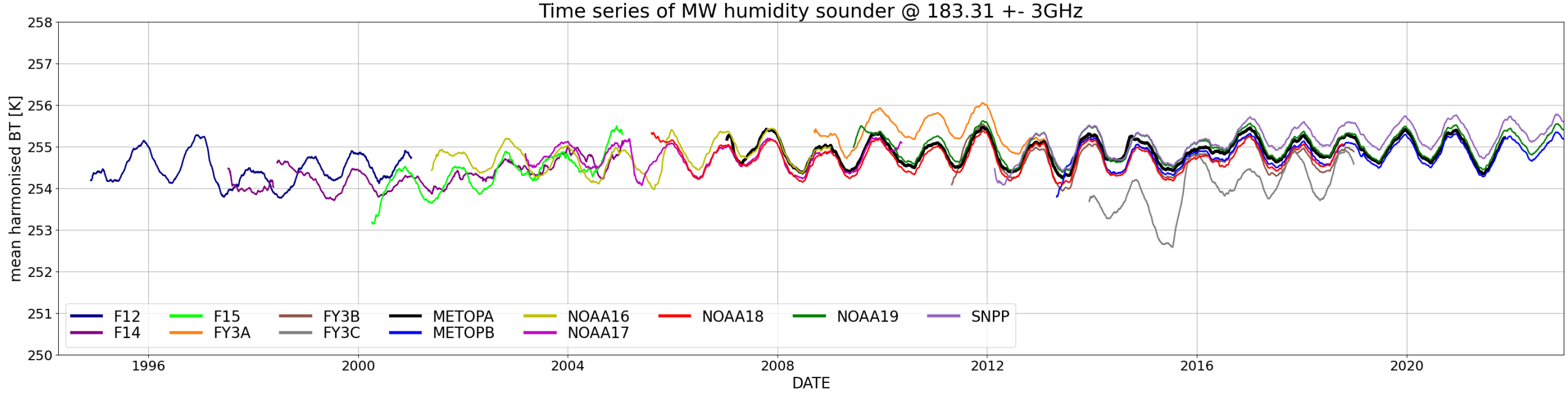
Results - 183.31 ± 3 GHz





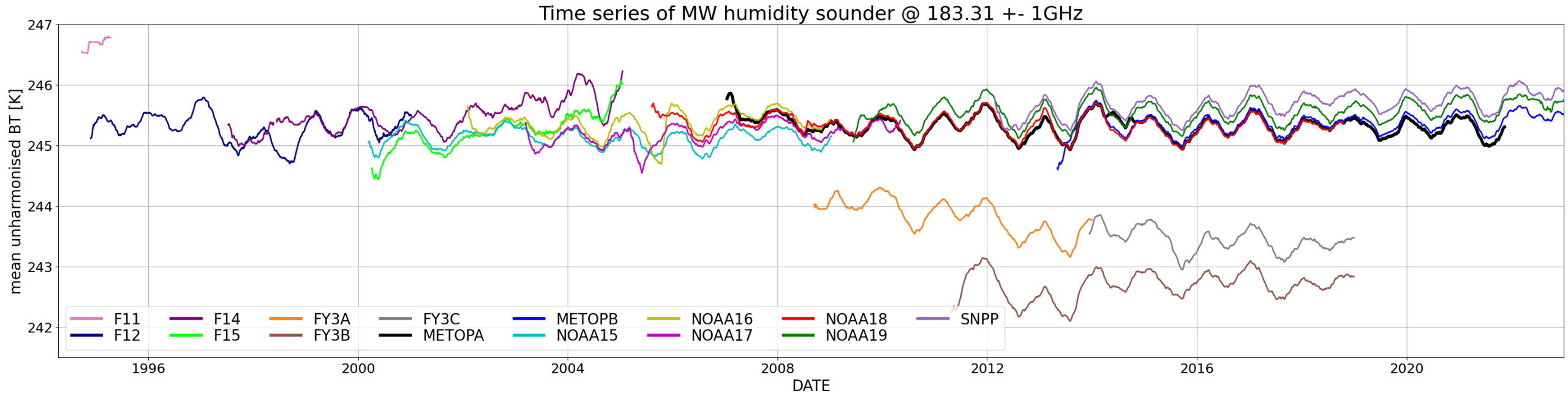
Summary

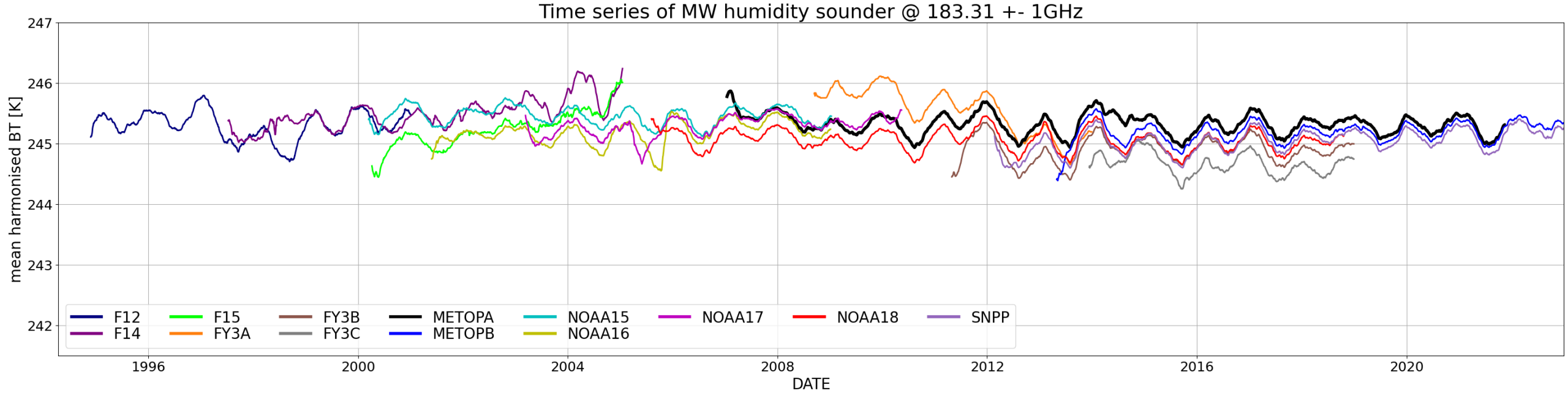
- The FIDUCEO harmonisation method has for the first time been applied consistently to a large set of microwave humidity sounder data
- The harmonisation method provides data with traceable uncertainty characteristics for all instruments
- Inter-sensor biases are reduced for most of the instrument channels, however instrument channels such as 183 ± 3 GHz on NOAA-15 suffering from RFI that is not considered in the measurement equation cannot be harmonised
- Tropospheric humidity retrievals and assimilation bias correction may benefit from reduced biases, but this still needs to be demonstrated
- EUMETSAT aims releasing a new data record in 2023 covering data from 1995 - 2022 (27 years)

Thank you!

Questions are welcome.

Results - 183.31 ± 1 GHz





Results - 183.31 ± 7 GHz