Microwave Humidity Sounder FCDR for the Copernicus Climate Change Service

Climate Change

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outline

1. What is the Copernicus Climate Change Service (C3S)?
2. What is EUMETSATs task in C3S?
3. The objectives of the MW humidity FCDR
4. Comparing the different sensors
5. How to process the FCDR
6. Summary & Outlook

1) Introduction to the C3S

- The Copernicus Climate Change Service (C3S) is one of 6 services of the European Copernicus Earth Observation Programme.

- C3S responds to environmental and societal challenges associated with natural and human-induced climate changes.

- C3S provides climate monitoring data from sustained networks of in situ data and satellite-based observations as well as climate predictions and projections from its recently opened Climate Data Store (https://cds.climate.copernicus.eu/#!/home).

- C3S also provides access to several climate indicators (e.g. temperature increase, sea level rise, ice sheet melting, warming up of the ocean) for identifying climate drivers and the expected climate impacts.

2) C3S @ EUMETSAT

- Within C3S EUMETSAT:
  - Provides elaborated best possible L1 and L2 data records for many instruments (IR and MW sounding and imaging, radio occultation, scatterometer, atmospheric motion vectors, etc.) as input for the ECMWF and other global reanalyses;
  - Explores ways to generate consistent extensions of such data records with high timeliness (so called Interim Climate Data Records);
  - Increases confidence in climate data records through quantification of uncertainties as part of the data records and intensive quality control;
  - Supports C3S in satellite data rescue with data analysis and stewardship activities.

- This presentation is addressing the development of microwave humidity sounder FCDRs.

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3) Microwave humidity sounder FCDR

- For the microwave humidity FCDR, we address data from several instruments aboard operational weather satellites:
    - MHS (NOAA18, NOAA19, Metop-A, Metop-B)
    - MWHS/1 (FY-3A, FY-3B)
    - ATMS (SUOMI/NPP, NOAA20)
- We apply methodologies for uncertainty quantification developed in the EU H2020 FIDUCEO project in a collaboration with the University of Hamburg, Germany and CMSAF (UK Met Office)
- This is based on:
    - Metrological principles using a measurement equation that considers all aspects of the instrument calibration process;
    - A harmonisation of the data from different instruments, that reduces inter-instrument differences to those which are expected, e.g., small difference in centre frequency or passband positions.
- This provides pixel level estimates of uncertainty caused by random and systematic effects in the measurements.

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4) Comparison of MHS, MWHS, and ATMS

Analysis of the status quo data quality

Based on level 1C data as provided by the near real time processing (AAPP for MHS)

Comparison noise equivalent temperature difference (NEΔT) & SNO bias between the different sensors

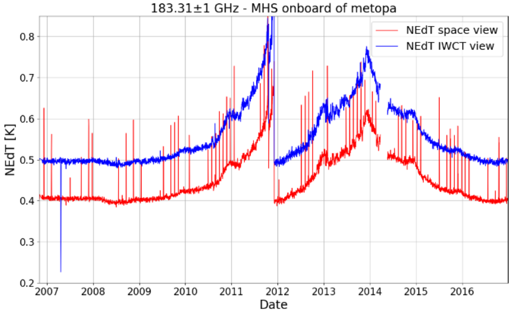
4) Comparison of MHS, MWHS, and ATMS(1)

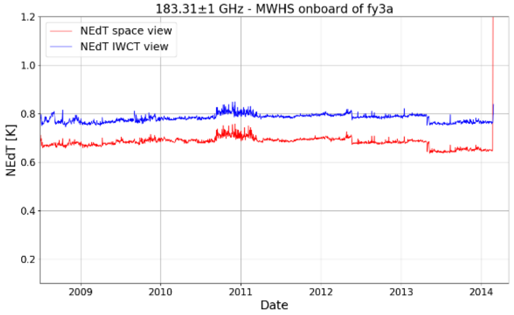
NEΔT at 183±1 GHz

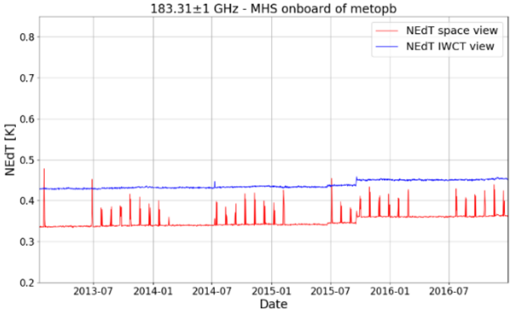
Will be a major contribution to the estimates of the uncertainty

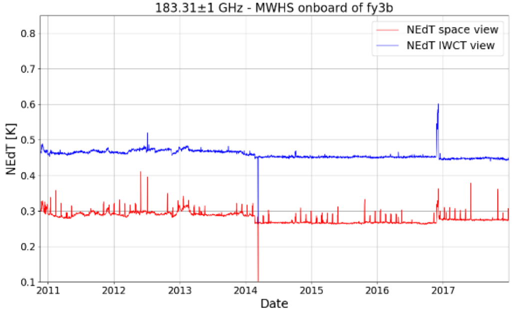
Very different behavior

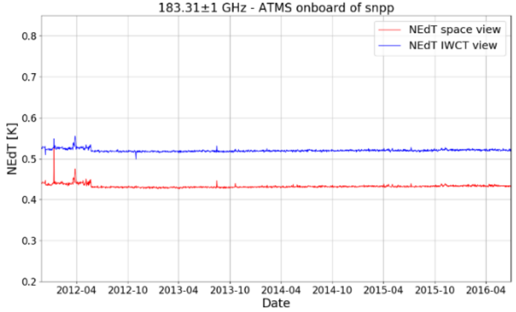
- Strong variation of the noise for MHS (Metop A) → switch of local oscillator and adjustment of the gain











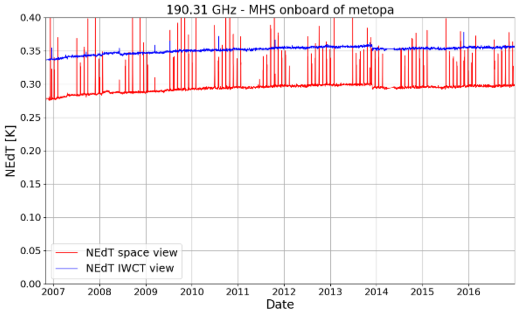
4) Comparison of MHS, MWHS, and ATMS(2)

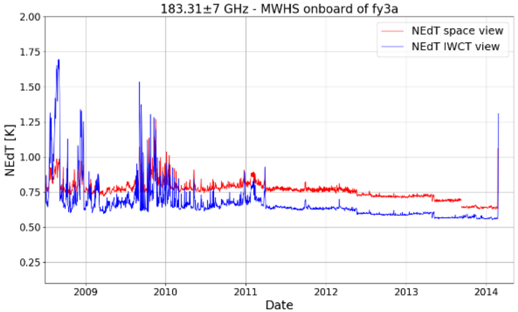
NEΔT at 183±7 GHz

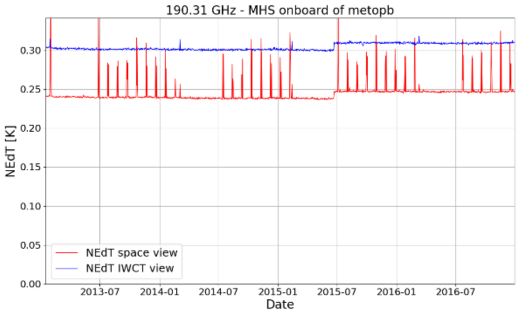
Will be a major contribution to the estimates of the uncertainty

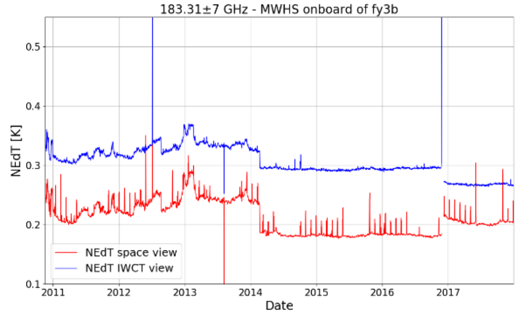
Very different behavior

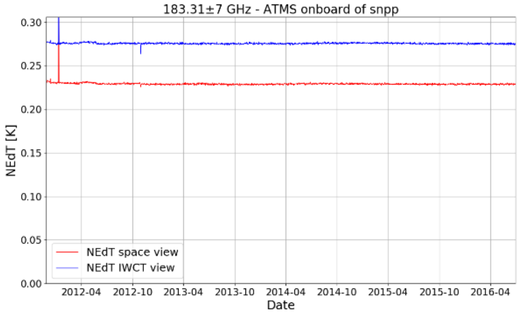
- High noise for MWHS/1 (FY-3A) in the first years
- Much lower noise for MHS, ATMS, and FY-3B
- Stable noise for MHS and ATMS











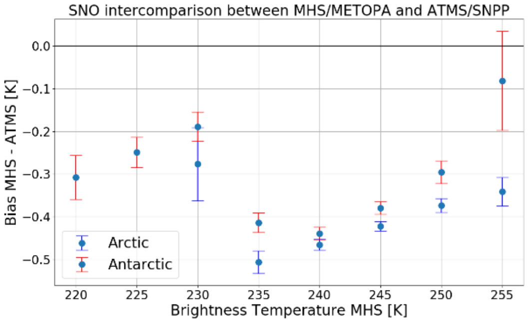
4) Comparison of MHS, MWHS, and ATMS(3)

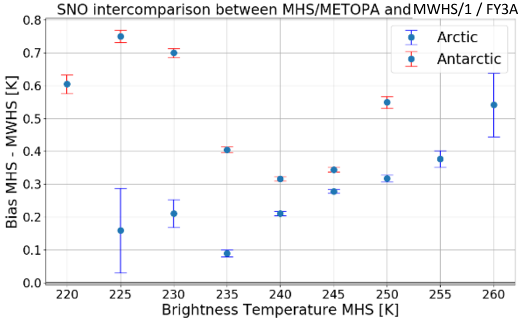
SNO bias against MHS (Metop A) for 183±1 GHz

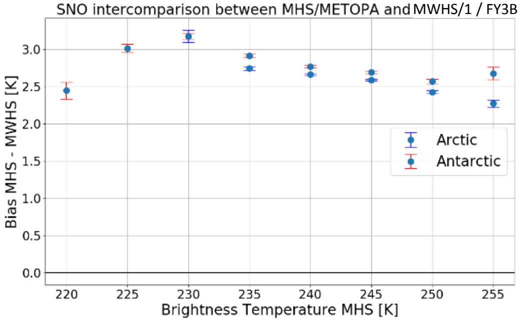
(data 2012)

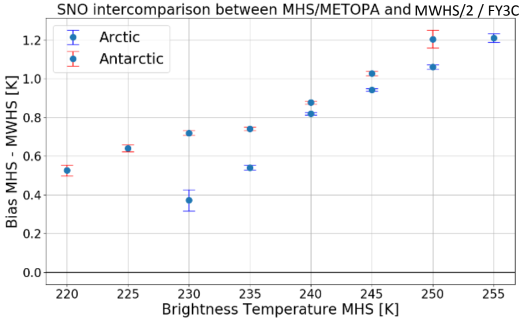
- 5 minutes
- 5 kilometer
- 5 degrees to nadir in VZA

Needs to be considered within the harmonisation









- Constant offset for MWHS/1 (FY-3B)
- Significantly different behavior between the northern and southern hemispheres, especially for MWHS/1 (FY-3A)
- Scene temperature dependency for all instrument pairs

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5) Microware reprocessing approach

Approach for common re-calibration and re-processing

From level 1a/b (Instrument counts with geolocation and calibration information attached but not applied) **to L1C** (calibrated brightness temperature)

Transfer the methodology from the research project (FIDUCEO) into operational processing in C3S

Fiduceo → Climate Change Service

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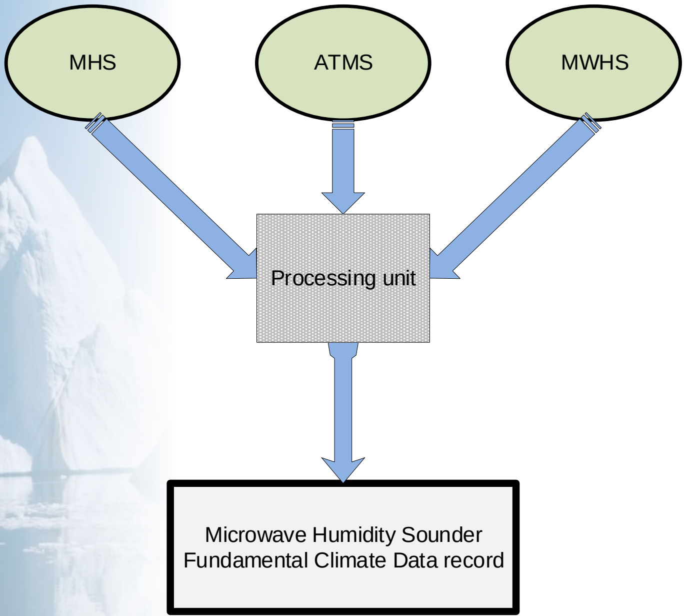
5) Microware reprocessing approach



The processing unit applies the **measurement equation** to the measurement counts, propagates single effects to the **uncertainty estimates,** and records issues, represented by **quality bit flags.**

$$L_{\mathrm{ME},i} = \tilde{L}_{\mathrm{MIWCT}} + \frac{\tilde{L}_{\mathrm{MIWCT}} - \tilde{L}_{\mathrm{MS}}}{\bar{C}_{\mathrm{IWCT}} - \bar{C}_{\mathrm{S}}}\left(C_{\mathrm{E},i} - \bar{C}_{\mathrm{IWCT}}\right) + \Delta L_{\mathrm{nl}} + \Delta L_{\mathrm{pol}} + 0$$

Measurement Equation taken from the FIDUCEO report (2017) “D2.2(Microwave): Report on the MW FCDR: Uncertainty” (Burgdorf et al.)

For each instrument a reader will pass the required information to the processing unit (Counts, antenna pattern, non-linearity coefficient, cold/warm target calibration count, PRT temperatures, etc.)

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5) Microware reprocessing approach

Issues to solve for processing level 1a/b data:

- Reading the ATMS RDR data is complex.
  -> The documentation is difficult to understand.
  -> Support from NOAA would be appreciated, who could we contact for this?
  -> Is a reader available, which can be shared?

- Interpreting the MWHS/1 metadata content is difficult (e.g., PRT temperatures, CV_Moon_Vector).
  -> Support from CMA would be appreciated, who could we contact for this?

- The MWHS/2 data content misses instrument and calibration counts and their metadata, which are provided with the MWHS/1 data.
  -> we would like to additionally include MWHS/2 into the FIDUCEO type analysis.

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6) Summary and outlook

- Based on the presented results, we find differences among the sensors
  - different dependencies on the scene temperatures
    → maybe this is the impact of the detector non-linearity?
  - differences between the hemispheres
    → maybe this is related to the detector polarization?
  - ➢ Compare observations against simulated observations

  - High noise for MWHS/1 onboard of FY-3A
    → was this also observed by others? I computed the NEΔT from the calibration counts, applying the Allan Deviation

- Verify the applicability of the measurement equation to all sensors
  → compare to NRT (operational) processing
- Integrate the harmonization between the sensors
- Final version of the FCDRs is planned to be available in late 2019.

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