A consistently calibrated data record of the High-Resolution Infrared Radiation Sounder (HIRS) radiances

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Acknowledgements: C3S, NOAA

HIRS overview – why reprocess?

- ## HIRS had 4 instrument models:
  - HIRS/1 on Nimbus-6 (not part of this reprocessing)
  - HIRS/2 on TIROS-N – NOAA14
  - HIRS/3 on NOAA15 – NOAA17
    Changes include:
    - Spectral shift in channel 12 from 6.73 to 6.52 μm
    - Removal of Internal Cold Target → from 37 to 38 earth view scanlines per superswath
  - HIRS/4 on NOAA-18/19 and Metop-A/B
    - Smaller Field Of View from 20 to 10km at nadir
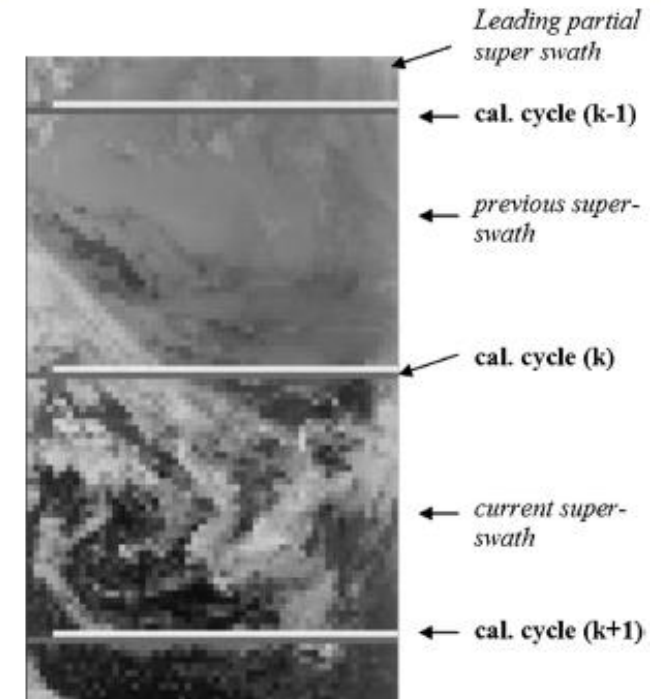
- ## HIRS was operationally calibrated using 3 different algorithms, in particular:
  - Version 2; uses calibration coefficients from closest calibration scanline
  - Version 3 (1998); interpolation of calibration coefficients, takes self-emission into account
  - Version 4 (2005); improved consideration of self-emission variability and quality control
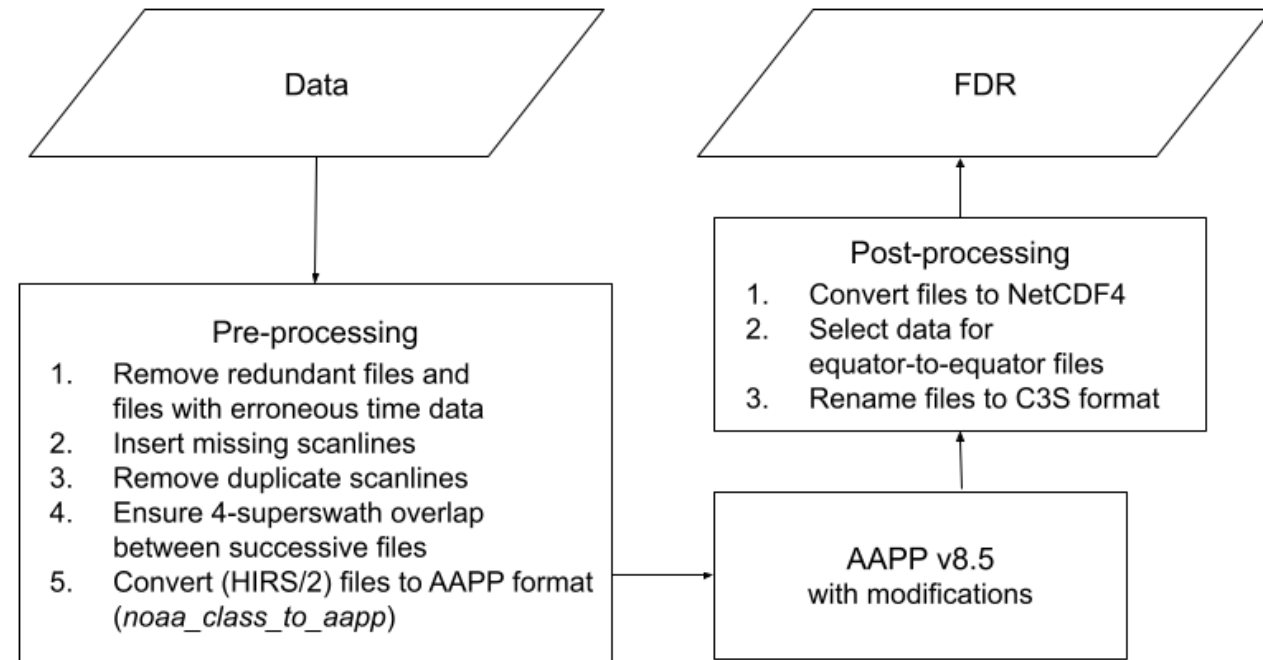
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HIRS reprocessing steps

- Input: operational data from NOAA/CLASS

- A pre-processing step prepares data for optimal calibration by AAPP

- Calibration by HIRS algoV4 (AAPP v8.5) with modifications (see next slide)

- Final files in equator-to-equator NetCDF4 format

The new processing includes:
- NEDT for all instruments
- Improved quality control and self-emission corrections
- Consistent treatment of calibration cycles (3 calibration cycles are used)
- * No correction for inter-satellite biases

Data

Pre-processing
1. Remove redundant files and files with erroneous time data
2. Insert missing scanlines
3. Remove duplicate scanlines
4. Ensure 4-superswath overlap between successive files
5. Convert (HIRS/2) files to AAPP format (*noaa_class_to_aapp*)

AAPP v8.5 with modifications

FDR

Post-processing
1. Convert files to NetCDF4
2. Select data for equator-to-equator files
3. Rename files to C3S format

Algorithm version 4 (Cao et al.) description:
https://doi.org/10.1175/JTECH2037.1

Implementation in AAPP:
https://nwp-saf.eumetsat.int/site/download/ documentation/aapp/NWPSAF-MF-UD-001_Science_v8.1.pdf

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Processing highlights

File extensions:
HIRS AlgoV4 uses three superswaths.
Added overlap between files prevents discontinuities.

NEDT:
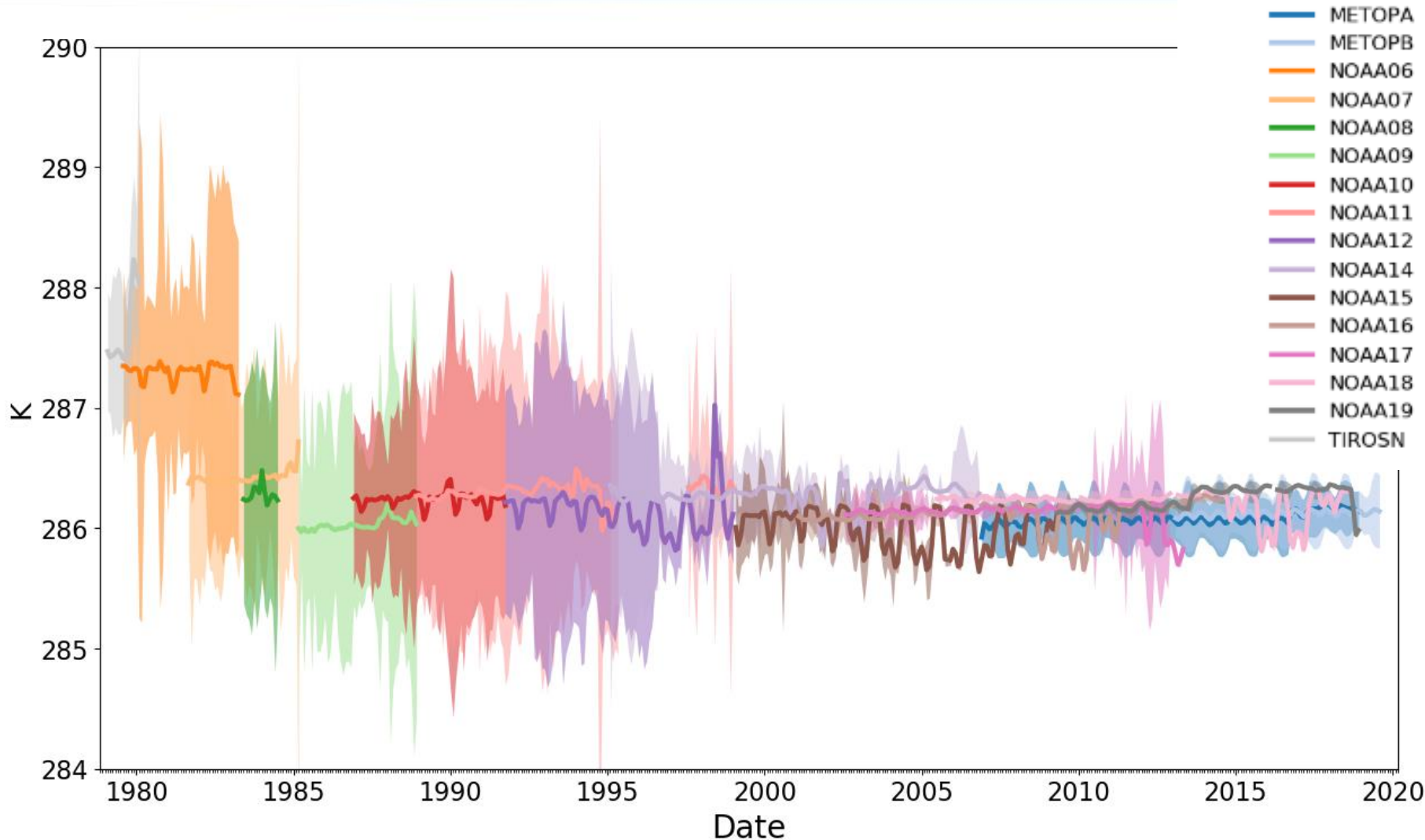Outlier rejection in the calibration counts:

$$|x_i - median(x)| < 100$$

HIRS/2:

- Add capability to HIRS AlgoV4 to process HIRS/2, which has one earth view line less (instead an Internal Cold Target)
- Add coefficients: IWT PRT and telescope conversion coefficients, central waves, band-correction coefficients.

File overlap

Extended file

NSS.HIRX.M1.D15318.S1237.E1332.B1637879.SV.l1c.h5; ch=15, x=2

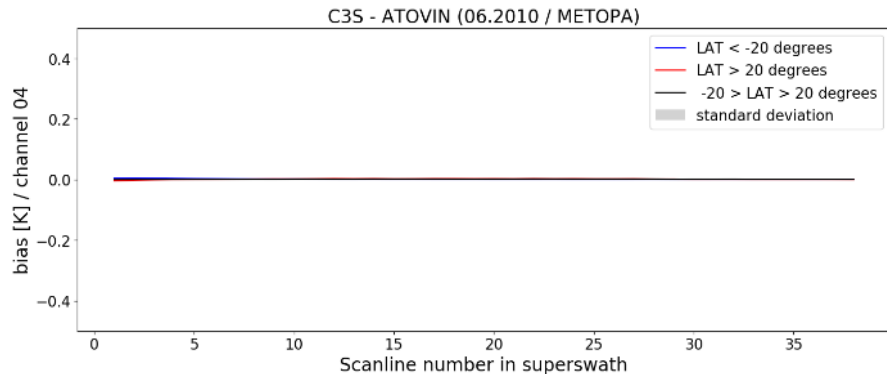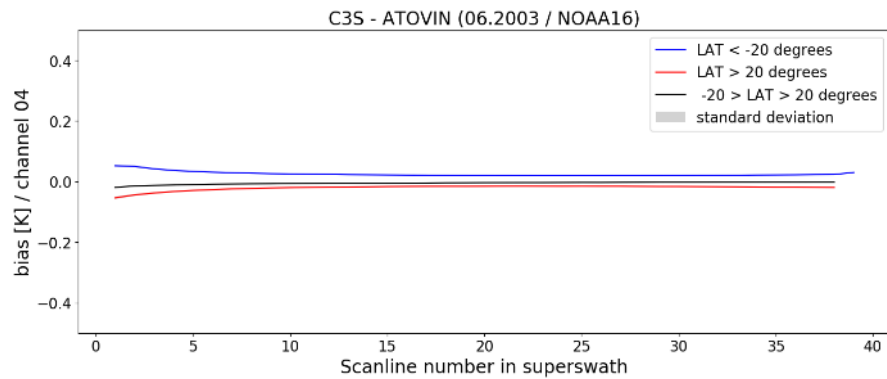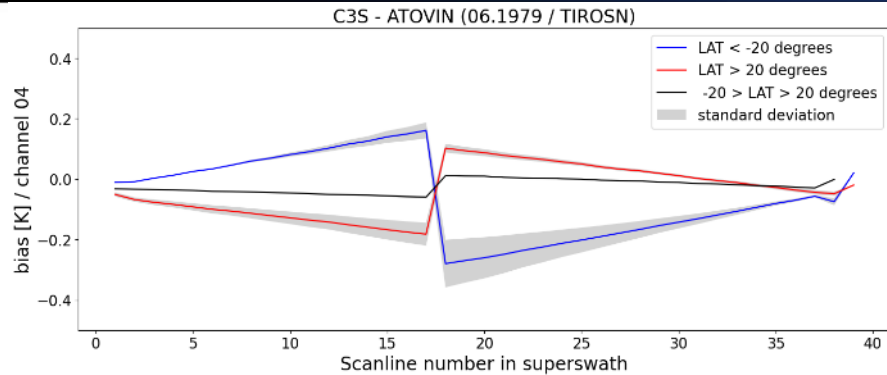EUMETSAT
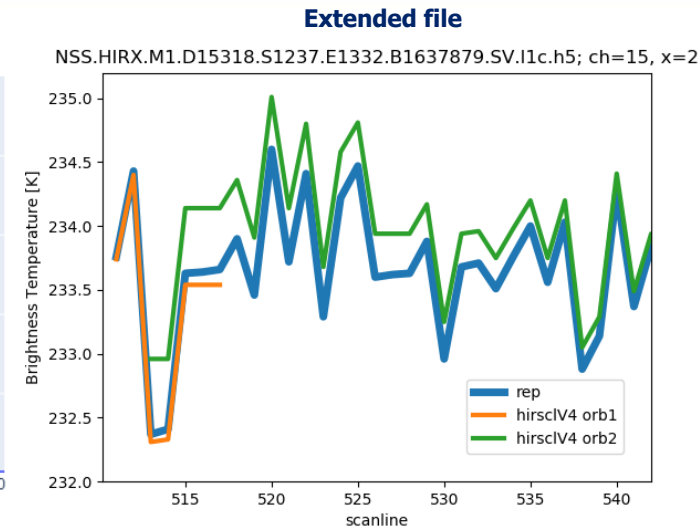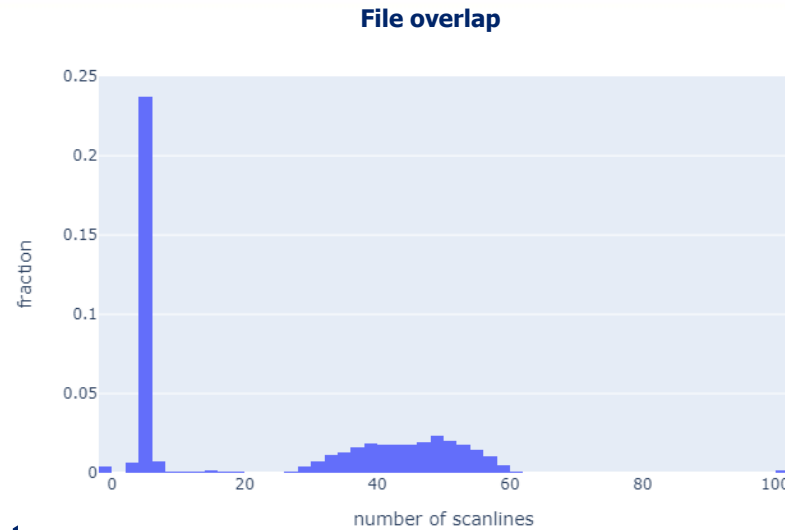
Instrument temperature

- Large variability for older instruments → unstable temperature sensors / thermal environment

- Thermal environment affects the self-emission of the HIRS instrument

$$R_{target} + R_{self} = R_{detector}$$
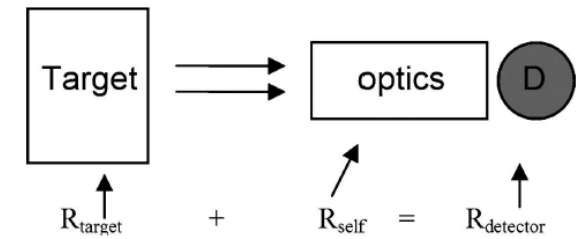
Cao et al (2006)

- Impact of the orbits → NOAA15 moving into twilight

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Comparisons as function of scanline in super swath

- Difference between reprocessed and operational calibration as a function of scanline in a super swath averaged over one month

- Clear change of bias for HIRS/2 → different handling of calibration cycle

- Differences by latitude → impact of self-emission

- Small differences for HIRS/3
- No difference for HIRS/4

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Time series channel 12

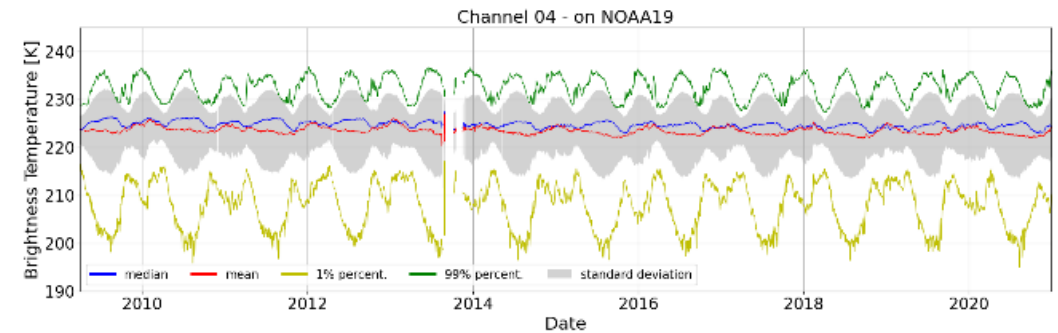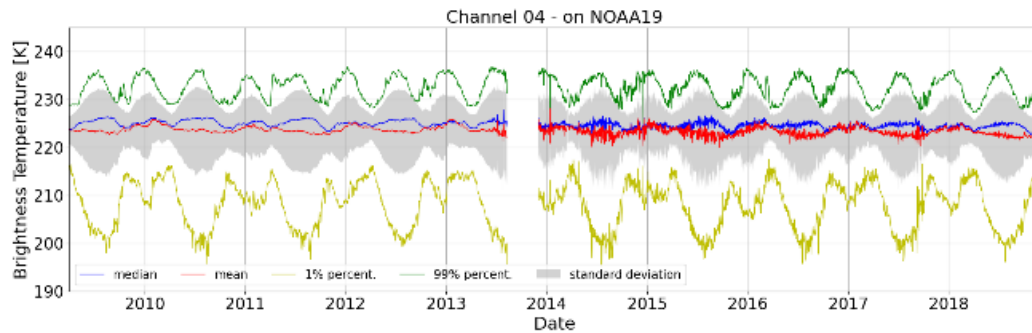
HIRS Channel 12

6.73 μm

6.52 μm

HIRS Channel 12
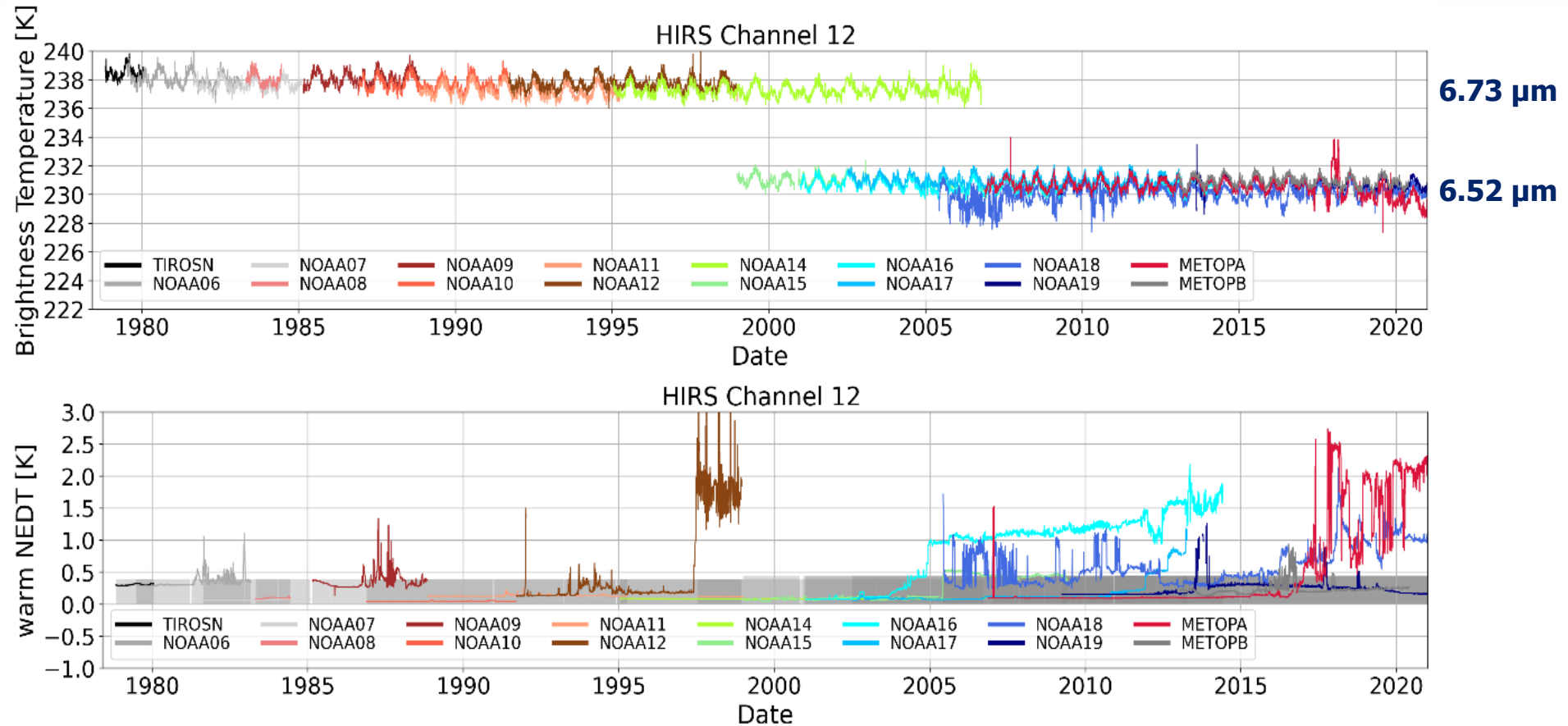
- Stable time series (known problems for a few channels/instruments, e.g. NOAA18)
- NEDT beyond specification reflects higher variability in the brightness temperature

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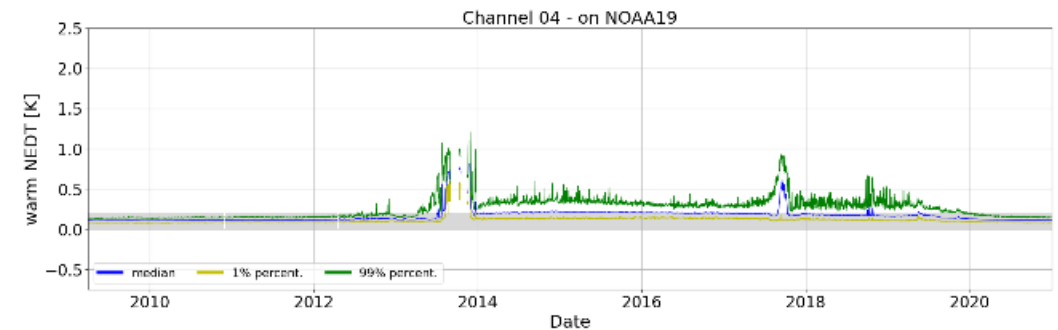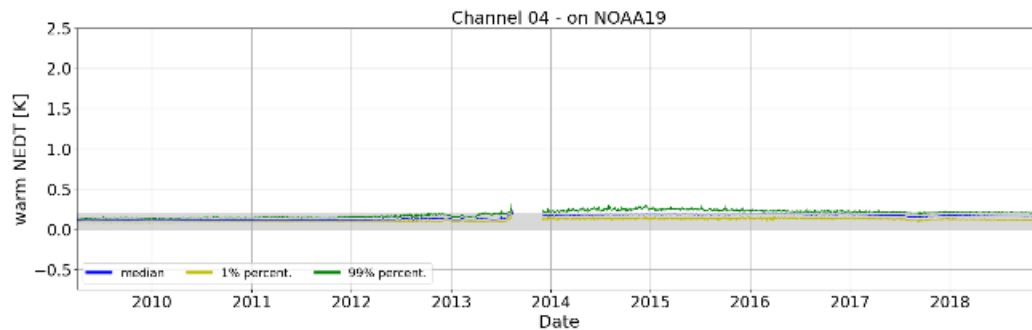# Time series – comparison to operational calibration channel 4 on board of NOAA 19

Operational / atovin
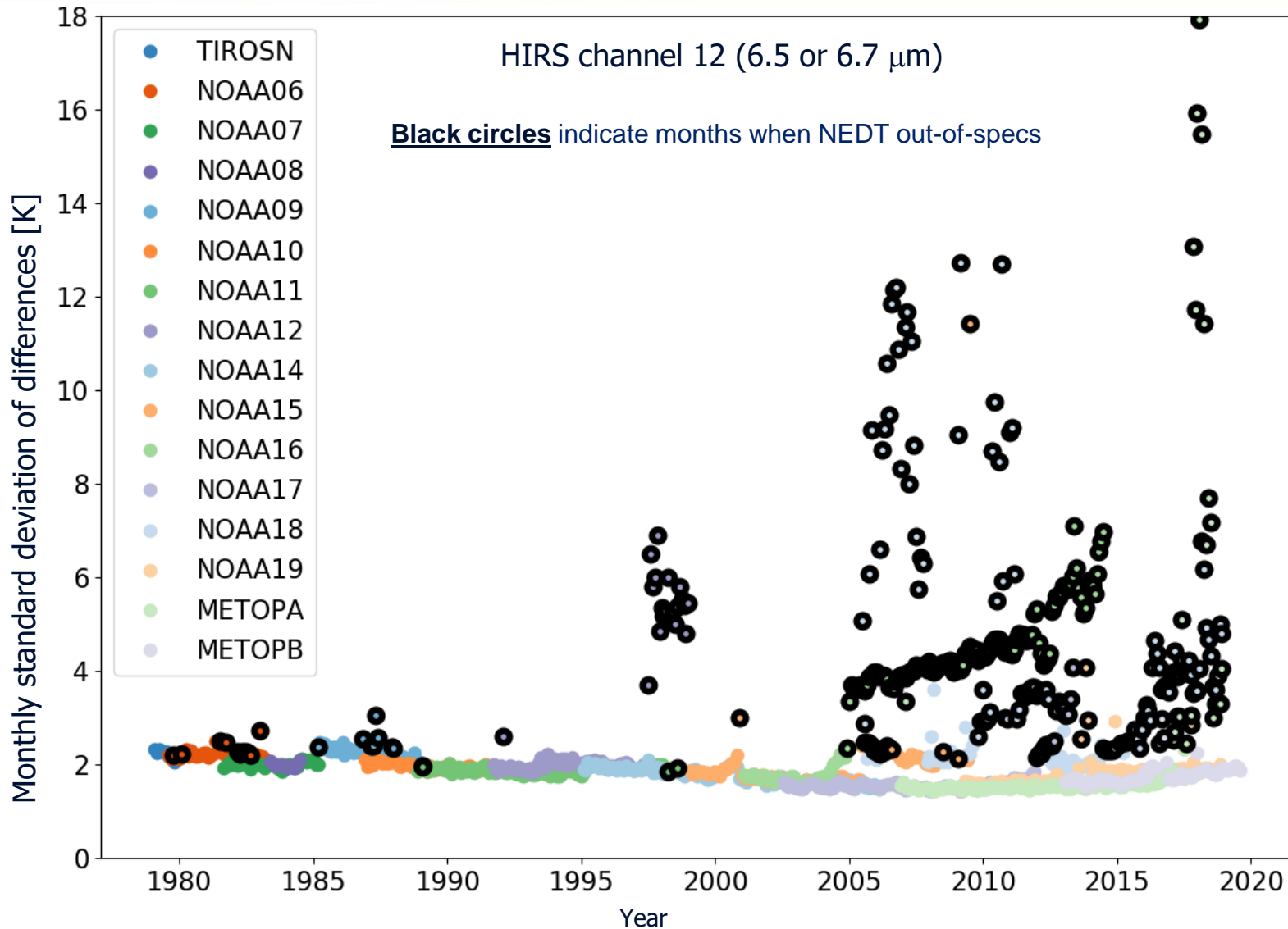
Reprocessed data

BT

NEDT

- Less data gaps and less noise in the BT time series
- Comparable median NEDT (blue line), but higher 99 percentile of the NEDT (green line)
  - Pixels with large noise can be filtered out by the user

Comparison to simulations

- Simulations with the NWPSAF radiance simulator RTTOV v12.3, ERA-Interim atmospheric profiles of temperature, humidity, and ozone, plus prescribed time-varying global CO_2.

- Excluded from statistics of (obs minus calc):
  - Scenes believed to be affected by clouds (screening based on channel 8 differences with simulations).
  - Scenes flagged by reprocessing QC.

- Longwave sounding channels ordered from highest peaking altitude to lowest
  - Temperature sounding (47)
  - Water vapour sounding (12-10)

- Clear inter-sensor bias remains

- Sensors show almost no trend
  Channels 4, 5, 11, and 12 show a small decreasing trend
  → we attribute this to ERA-Interim

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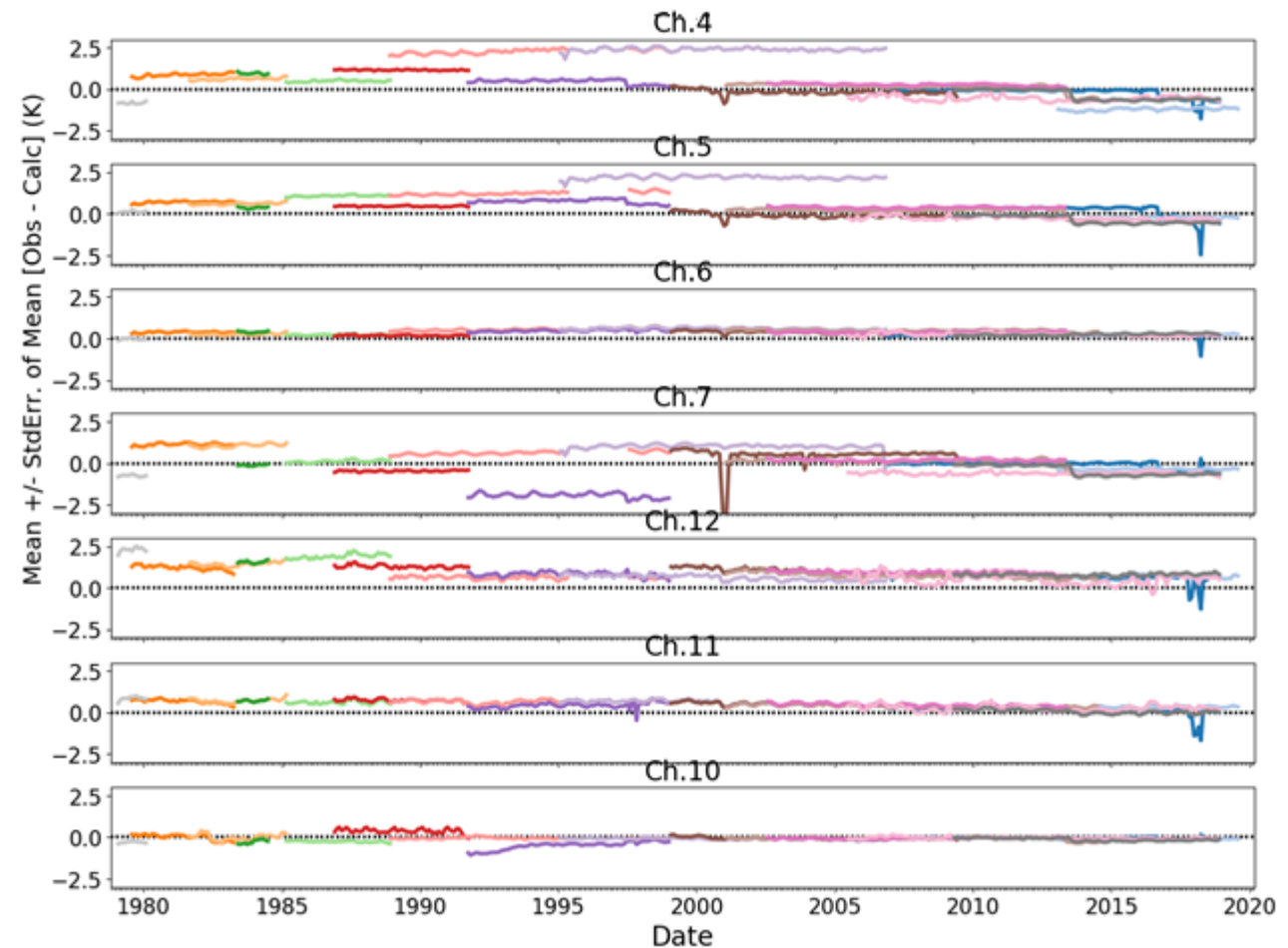
Comparison with simulations

HIRS channel 12 (6.5 or 6.7 μm)

Black circles indicate months when NEDT out-of-specs

NEDT out-of-specifications correlates with large standard deviations for obs-calc

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Summary

- Full reprocessing of HIRS data from 1978 to 2020

- Updates in the calibration algorithm have been applied to all data

- The results show an increased quality compared to the operationally calibrated data

- The availability of the NEDT for all data will improve the usage of HIRS data for any application

- The data record will be released this year

- Modifications to the calibration algorithm will be provided to the NWP-SAF for inclusion into AAPP

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