



Calibration update of EPS-AVHRR VNIR channels on MetOp-B and MetOp-C

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NOAA AVHRR solar channel calibration

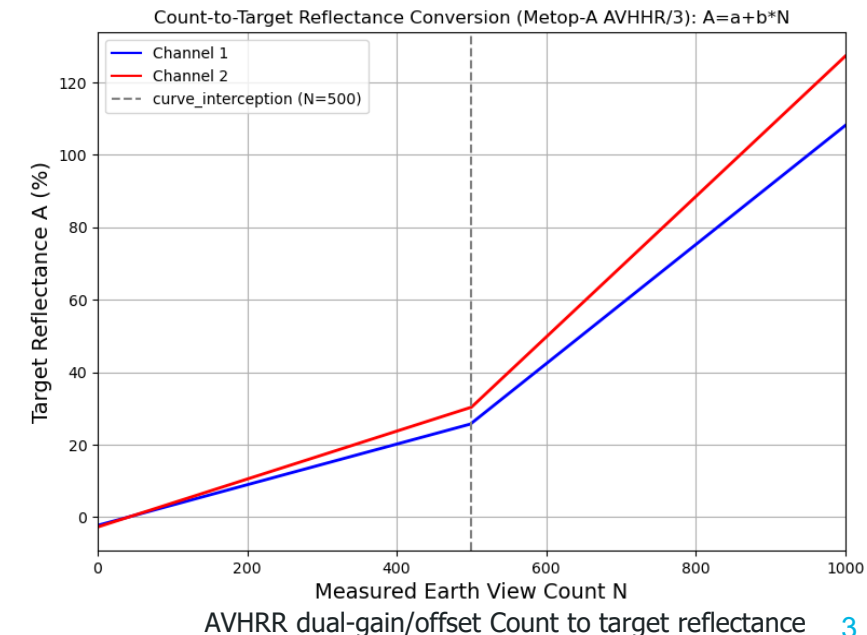
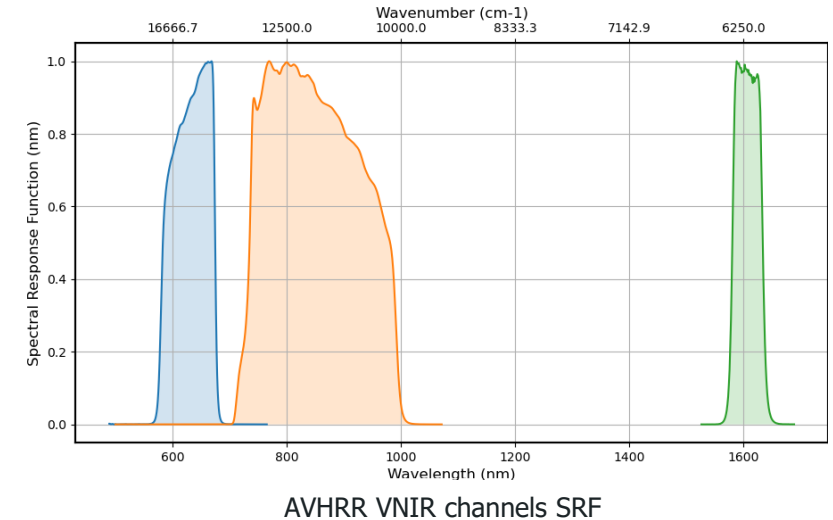
MICMICS

Desert vicarious calibration.

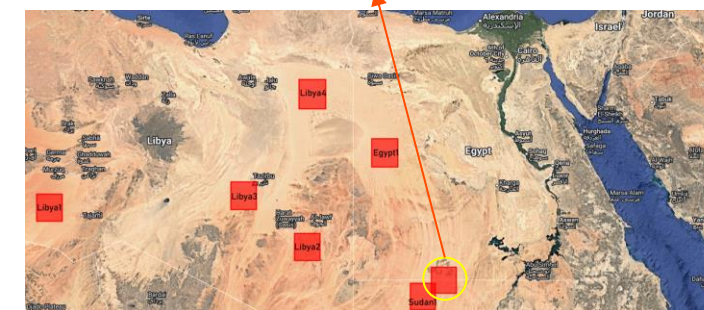
Intercomparison

NOAA, MICMICS and PATMOS-x.

- AVHRR lacks an on-board solar channels calibration (VNIR) device and therefore relies on vicarious calibration to update Level 1 calibration coefficients.
- Updates of VNIR calibration coefficients is performed by NOAA and forwarded to EUMETSAT.
- AVHRR solar channels use a dual-gain design to enhance low-light sensitivity and radiometric resolution, improving clear-sky products like the vegetation index.
- Dual-gain cut-off and nominal calibration are set pre-launch using integrating spheres and calibrated lamps. To account for changes in detector sensitivity, the gain coefficients a , b and the **intersection point** are updated monthly.
- Only high-gain values are directly estimated through vicarious calibration, while low-gain values are derived from pre-launch correlations between high and low gains.



- Top-of-atmosphere (TOA) reflectance simulations of a desert site near Sudan-1 are compared with satellite observations to derive gain and offset values for each solar channel.
- Climatology atmospheric parameters for TOA simulations (e.g., ozone content, aerosol optical thickness).
- Assumes constant surface reflectance and restricts View Zenith Angle ($\sim 8^\circ$) to minimize Bidirectional Reflectance Distribution Function (BRDF) effects.
- Desert reflectance at $0.86 \mu\text{m}$ (channel 2) was found to be incorrect later, however, calibration stability was prioritised over absolute accuracy.
- Calibration relies on a single desert target (near the Sudan-1 target), limiting temporal availability and broader applicability. Sensor drift is estimated from the same desert analysis.
- The approach has some inherent limitations and uncertainties. **Since the orbital drift of Metop-B (late 2023), observations meeting the required $VZA < 8^\circ$ have become unavailable, posing a challenge for its application!**

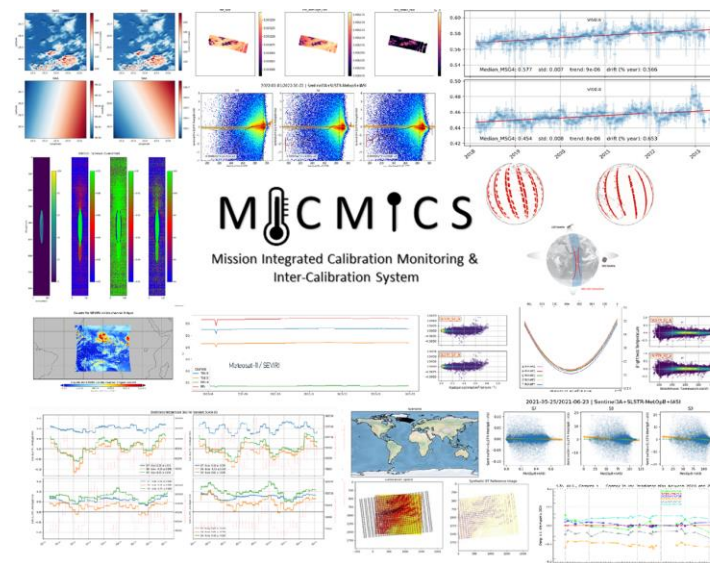


MetopB viewing zenith angle over Sudan-1 target



• MICMICS

- The system has been extensively tested and validated
- Already supporting the EUMETSAT diagnostics on SEVIRI, OLCI & SLSTR, FCI & LI, and EPS-SG commissioning.
- The current dual-gain and offset setup will be retained, producing monthly (or more frequent) updates enabled by MICMICS.

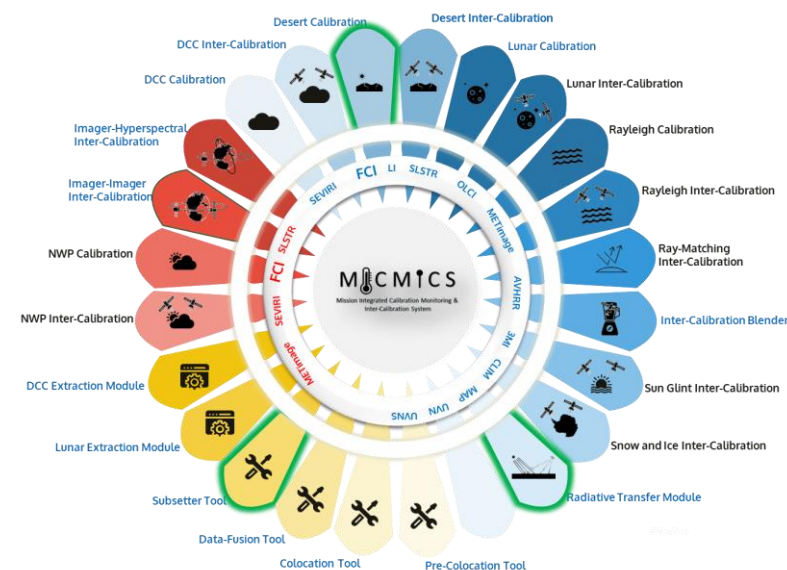


• DESCS

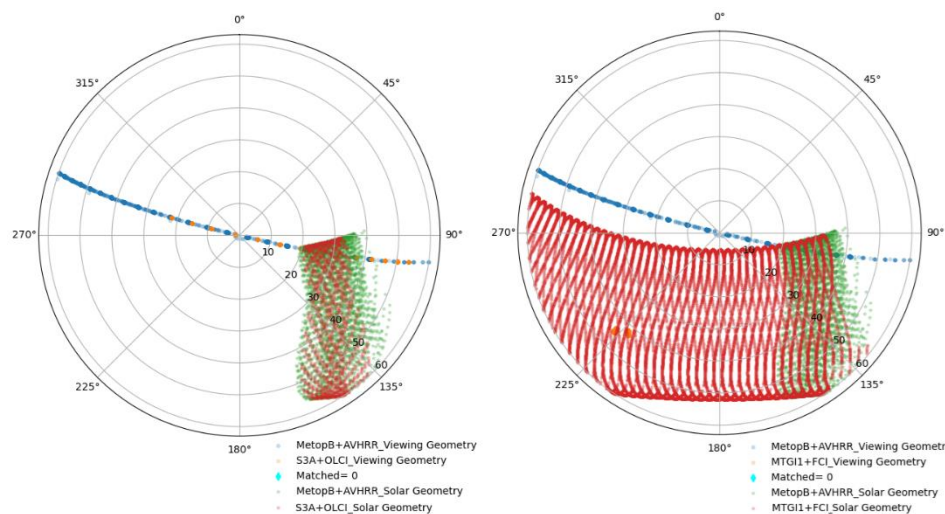
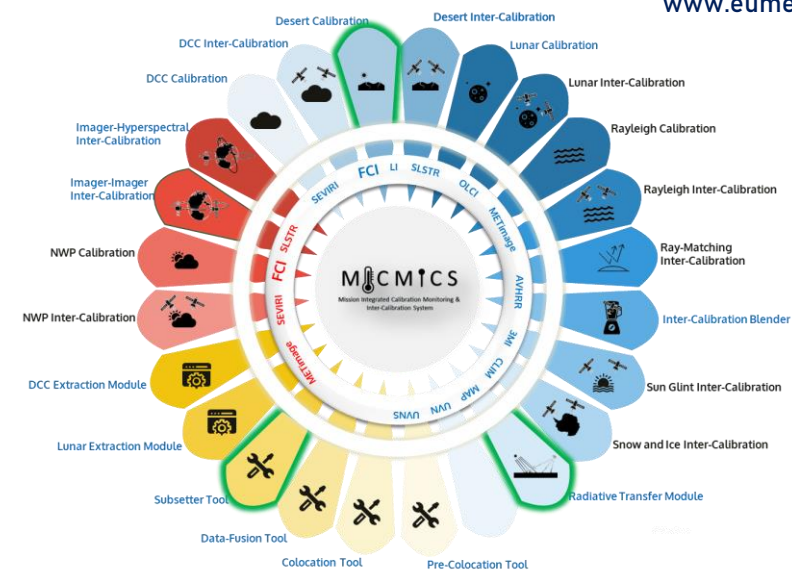
- Use the MICMICS desert module (6 desert targets with advanced BRDF and atmospheric modeling) for primary updates.

• Drift estimation

- Leverage other MICMICS modules to validate results and provide independent drift estimates.



- MICMICS contains several vicarious calibration and intercalibration modules.
- However, for the specific case of AVHRR, Desert absolute calibration is primarily used to derive calibration coefficients and monitor long-term changes.
- Other methods are not applied due to limited suitable observations (e.g. Lunar observations) or mismatches with reference data. Further exploration ongoing.
- Collocation and geometric constraints prevent the use of intercalibration with other instruments over standard calibration targets like desert.
- For instance, AVHRR aboard MetOp-B has no matchups with either OLCI or FCI satisfying the requirements of the desert intercalibration module (Δ zenith angle $< 2^\circ$ and Δ relative azimuth angle $< 5^\circ$).



Uses bright desert sites (PICS) to transfer calibration from a reference radiative transfer model to the target sensor

- **Simulations:**

- TOA radiance via customized 6SV2 radiative transfer model

- **Inputs:**

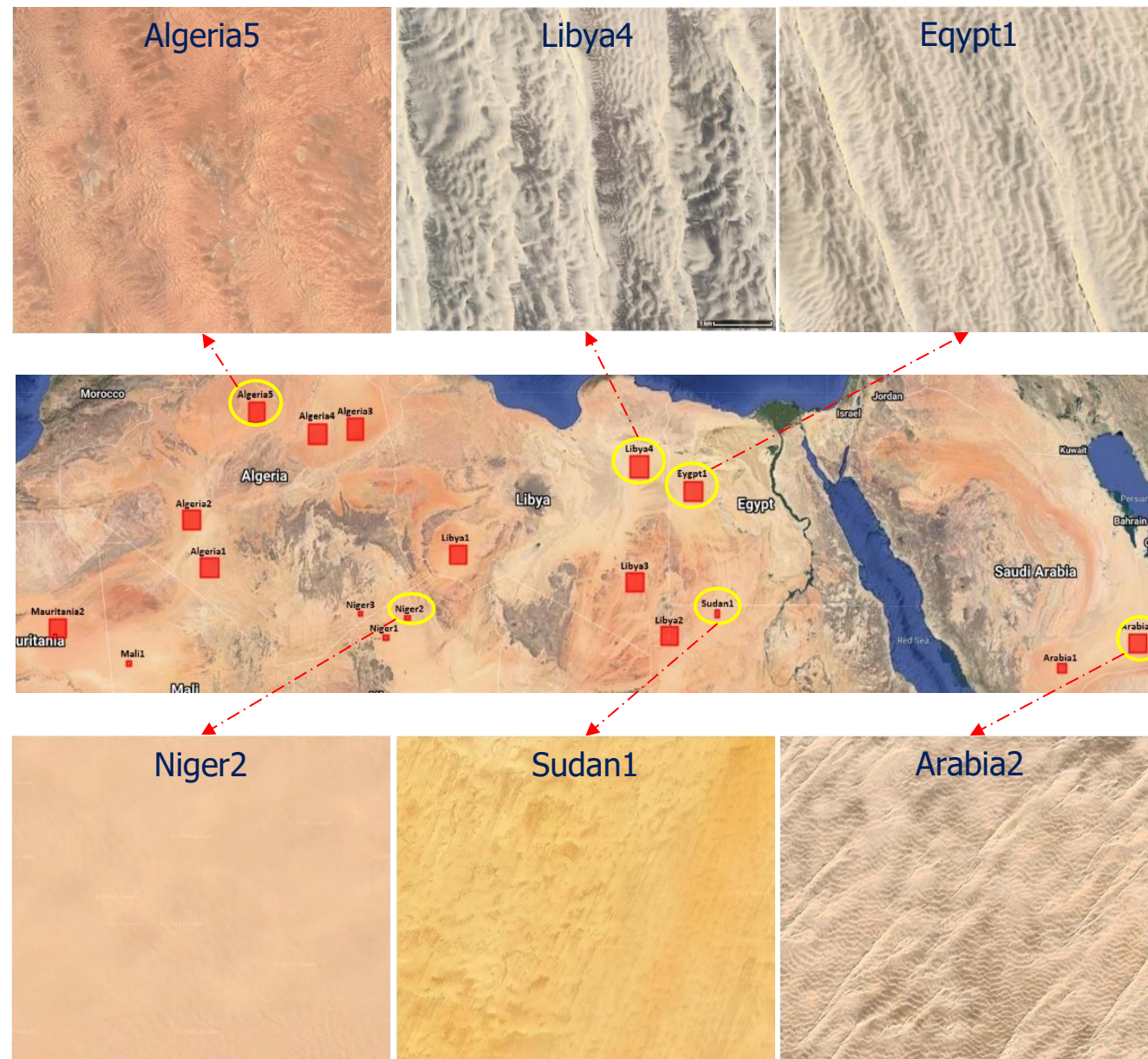
- Surface BRDF four-parameter RPV model
- Tailored desert aerosol model
- ECMWF(WV, O3, Pressure) and CAMS (AOD) atmospheric data
- TSIS solar irradiance

- **Goal:**

- Compare simulated radiance/reflectance vs. measured quantity to assess sensor bias

- **Accuracy:**

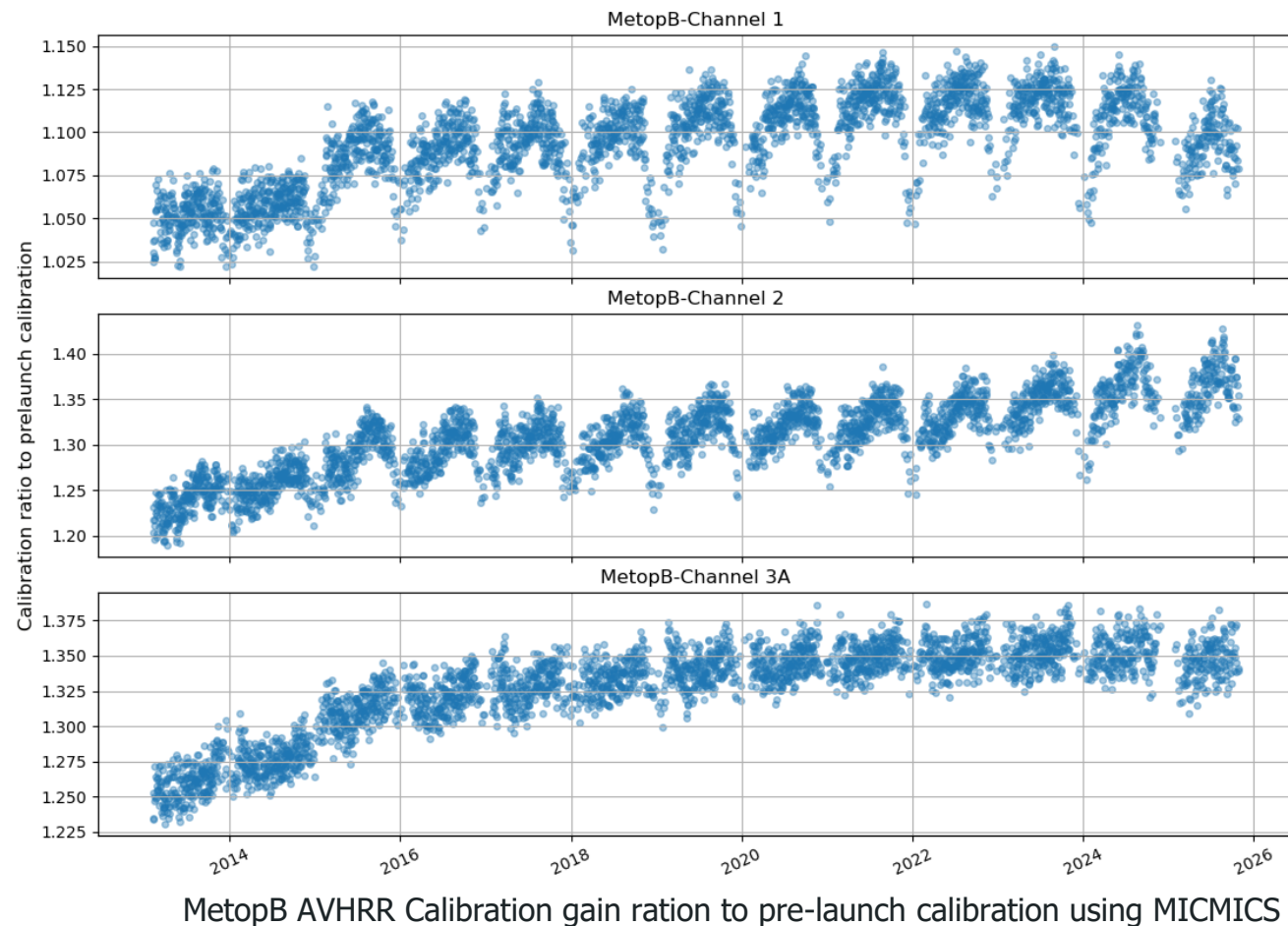
- ~2–3% calibration precision



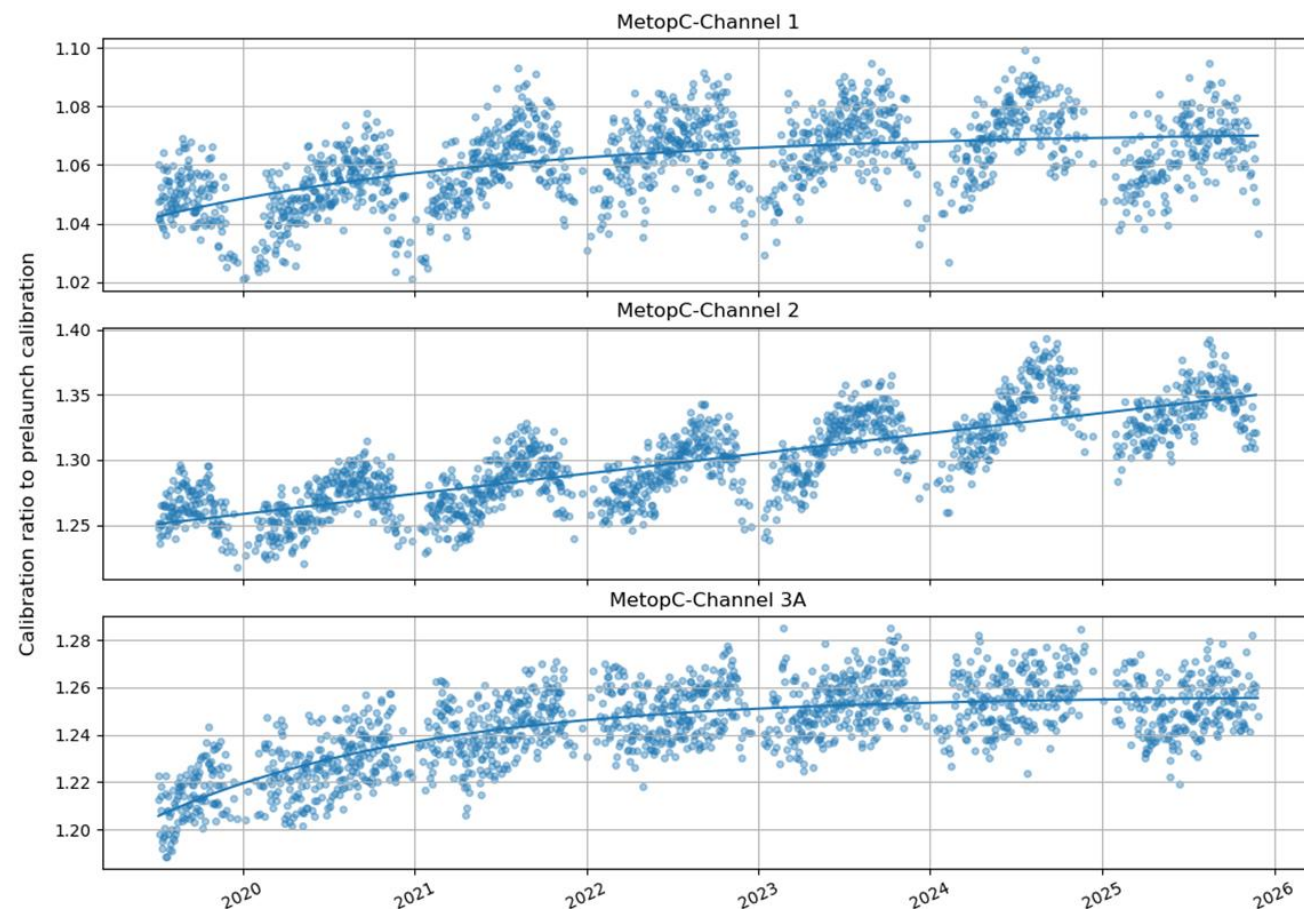


Metop-B AVHRR MICMICS

- The full time series from 2013 to the present shows several distinct regimes, for which a **quadratic fit gives the best** overall description
- However, gain adjustments applied after launch, as well as the orbital drift in late 2023, indicate that these patterns may **not reflect true instrument degradation** or improvement
- Orbital drift has particularly reduced the usefulness of viewing geometry over certain PICS targets, especially when the incidence angle exceeds 60°
- An **asymptotic fit** most effectively captures the instrument's long-term degradation trend, after excluding the period after the start of orbital drift

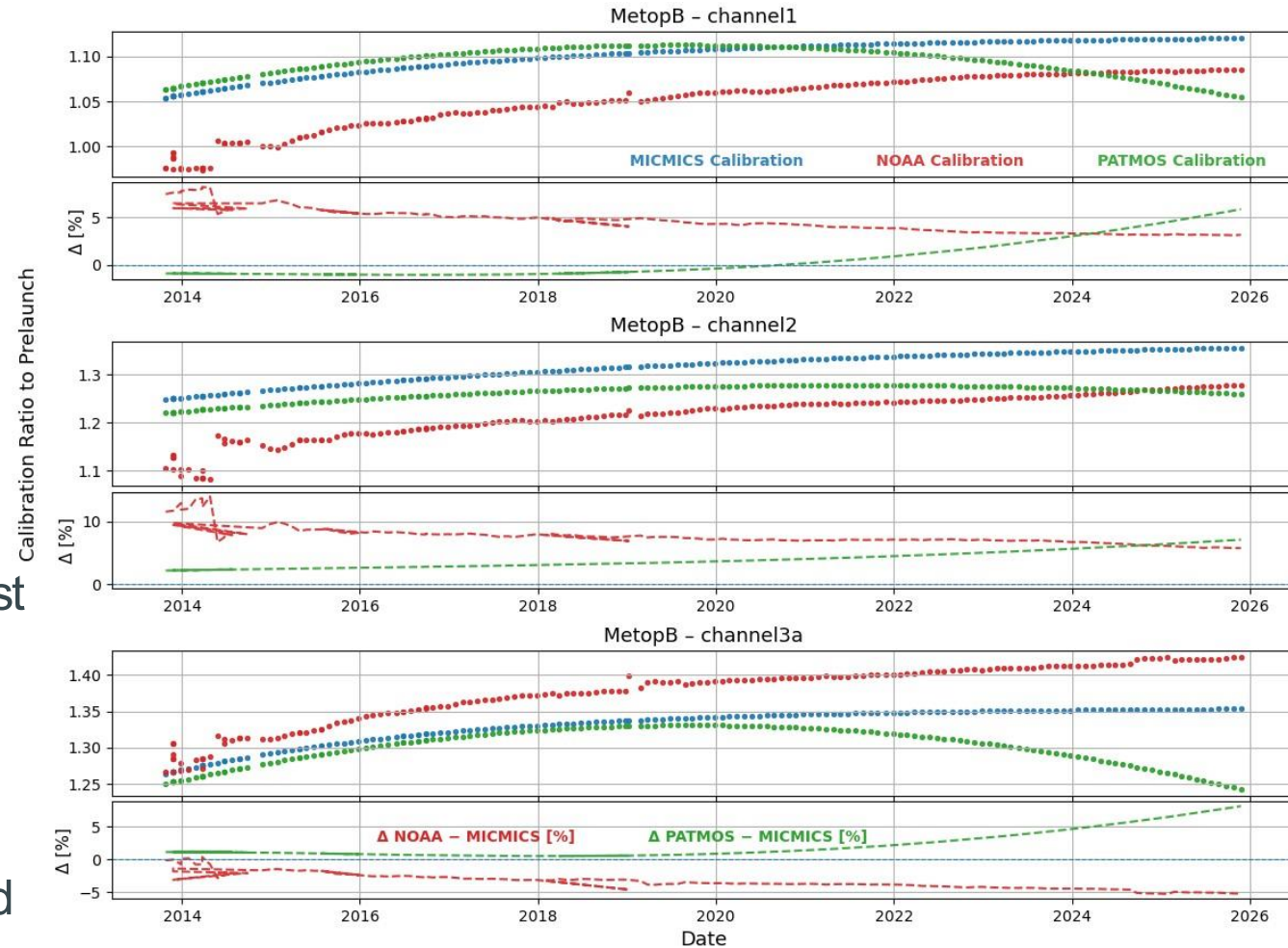


- The full time series from 2019 to the present exhibits more stable behaviour compared to Metop-B
- Clear seasonality is observed (and corrected) across all channels, driven by BRDF effects in the observations
- As with Metop-B, an **asymptotic** fit appears to best represent instrument degradation over time for Metop-C



MetopC AVHRR Calibration gain ratio to pre-launch calibration using MICMICS

- The ratio of current gains to pre-launch gains is compared among MICMICS, NOAA, and PATMOS-x (NOAA Climate Data Record, CDR) for MetopB.
- NOAA calibration results show noticeable channel-dependent differences relative to MICMICS:
 - Channel 1: approximately -3%
 - Channel 2: approximately -6%
 - Channel 3A: approximately +5%
- PATMOS-x calibrations show close agreement with MICMICS up to 2023 (the last year included in the latest release), but diverge thereafter due to the use of a quadratic fit to model the degradation.
- NOAA calibration for Channel 2 shows the largest and relatively stable fixed difference with MICMICS, likely attributed to an incorrect surface reflectance value used in the NOAA calibration.

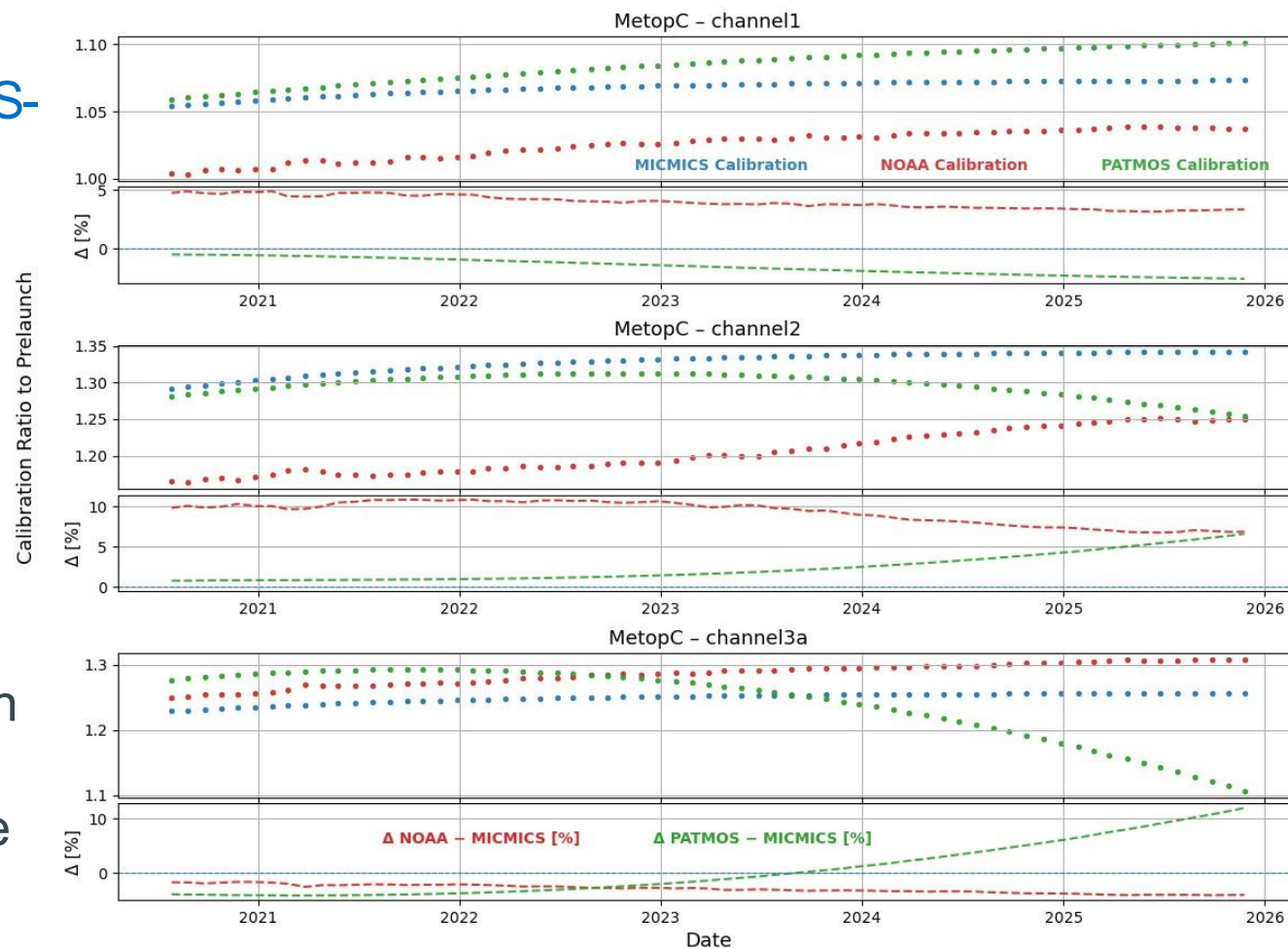


Calibration sources:

NOAA: https://www.star.nesdis.noaa.gov/smcd/spb/fwu/homepage/AVHRR/Op_Cal_AVHRR/Op_Cal_AVHRR.html

PATMOS-x: <https://cimss.ssec.wisc.edu/patmosx/calibration/>

- The ratio of current gains to pre-launch gains is compared among MICMICS, NOAA, and PATMOS-x for MetopC
- NOAA calibration results show noticeable channel-dependent differences relative to MICMICS:
 - Channel 1: approximately -3%
 - Channel 2: approximately -7%
 - Channel 3A: approximately +4%
- PATMOS-x calibrations show close agreement with MICMICS up to 2023 (the last year included in the latest release), but diverge thereafter due to the use of a quadratic fit to model the degradation



Calibration sources:

NOAA: https://www.star.nesdis.noaa.gov/smcd/spb/fwu/homepage/AVHRR/Op_Cal_AVHRR/Op_Cal_AVHRR.html

PATMOS-x: <https://cimss.ssec.wisc.edu/patmosx/calibration/>

- MICMICS-derived calibration coefficients are expected to improve the accuracy of AVHRR VNIR calibration through a validated, multi-target approach with channel-specific adjustments of a few percent.
- Systematic, channel-dependent differences are observed between NOAA calibration gains and MICMICS-based gains.

Satellite	Channel 1	Channel 2	Channel 3A
Metop-B	-3%	-6%	+5%
Metop-C	-3%	-7%	+4%

- The most notable difference occurs at $0.86\ \mu\text{m}$ (channel 2) with approximately 6-7% and stable over time, likely attributed to the inaccurate surface reflectance used in the NOAA calibration.
- EUMETSAT will publish a technical report detailing the MICMICS calibration analysis, findings, and planned coefficient updates in February 2026.
- MICMICS gains will be deployed operationally in the AVHRR Level 1 calibration in March 2026.



Thank you!
Questions are welcome.