# Exploring the use of TROPICS data in the ECMWF system

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## Outline

1. Use of TROPICS data in the ECMWF system
2. Monitoring results and tailored bias corrections
3. Assimilation trials
4. Summary

**ECMWF**

# Monitoring/assimilation of TROPICS in the ECMWF system
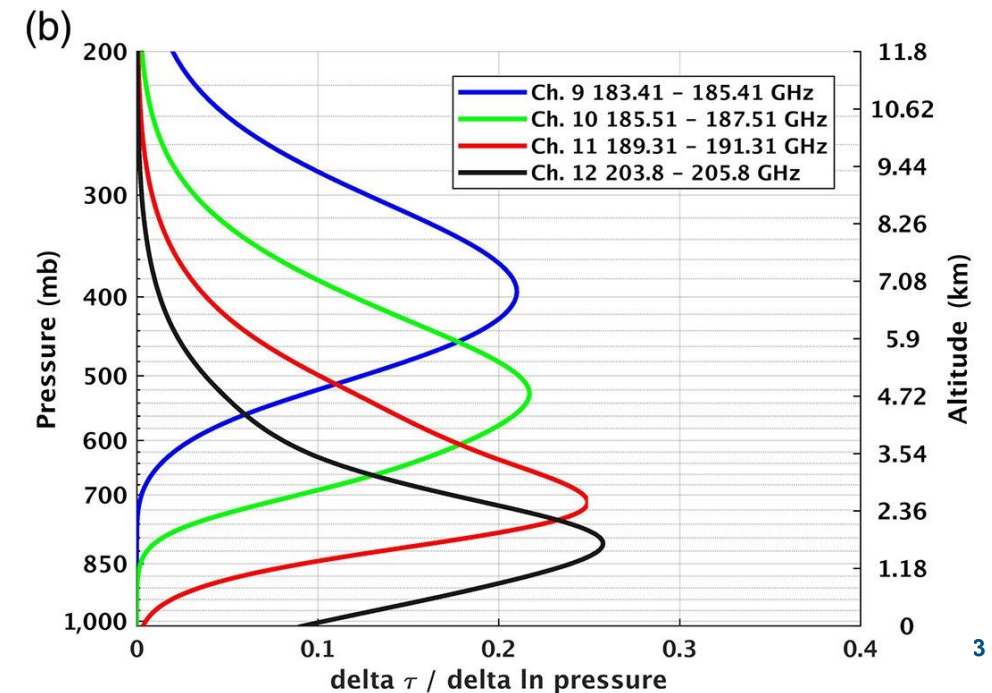
- TROPICS data received in NRT at ECMWF via EUMETSAT

- Data used here: 26 June – 3 October 2024

  – Data from 3 satellites available: TROPICS-3, -5, -6 (-6 only up to 7 August 2024)

TROPICS coverage in a 20 min interval around 15:30 on 17 July 2024
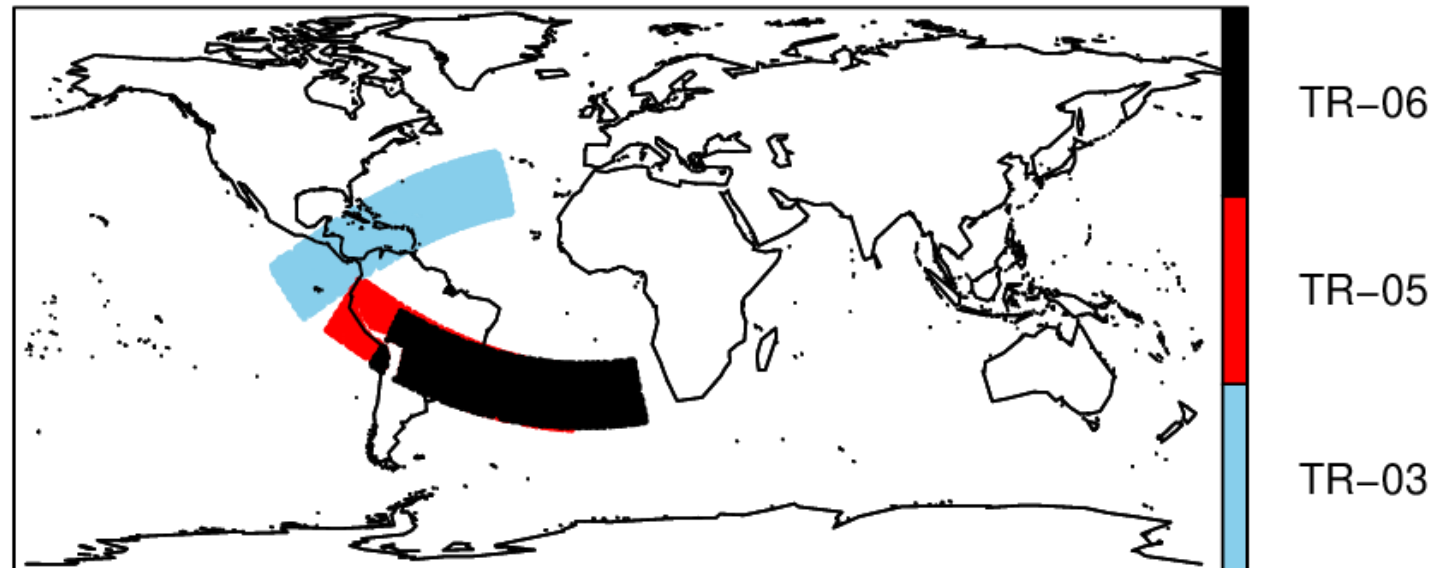
# Monitoring/assimilation of TROPICS in the ECMWF system

- **Here: Consider only 183 GHz channels (ch 9-11)**, due to large orbital biases in the 118 GHz channels

- Treatment of 183 GHz channels follows that of MHS in ECMWF operational system:

    – Super-obbing to N200 gaussian grid (~50 km), "diamond" thinning to ~70 km

    – Geographical screening as for MHS

    – Standard bias correction: 4 atmospheric thickness predictors, polynomial in scan-angle

    – Obs-error model: All-sky error model (Geer and Bauer 2011), with a 91/204 GHz scatter index as cloud indicator

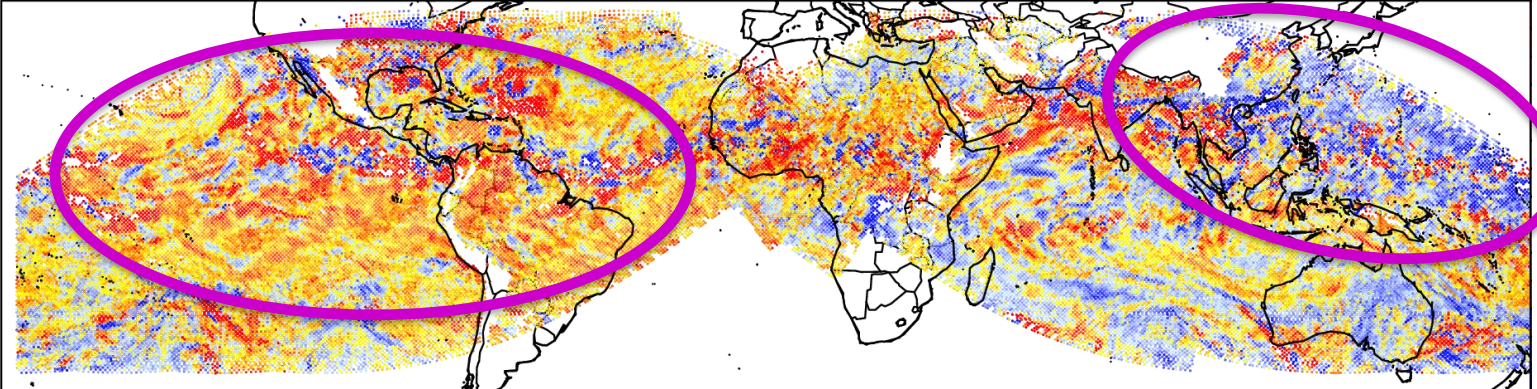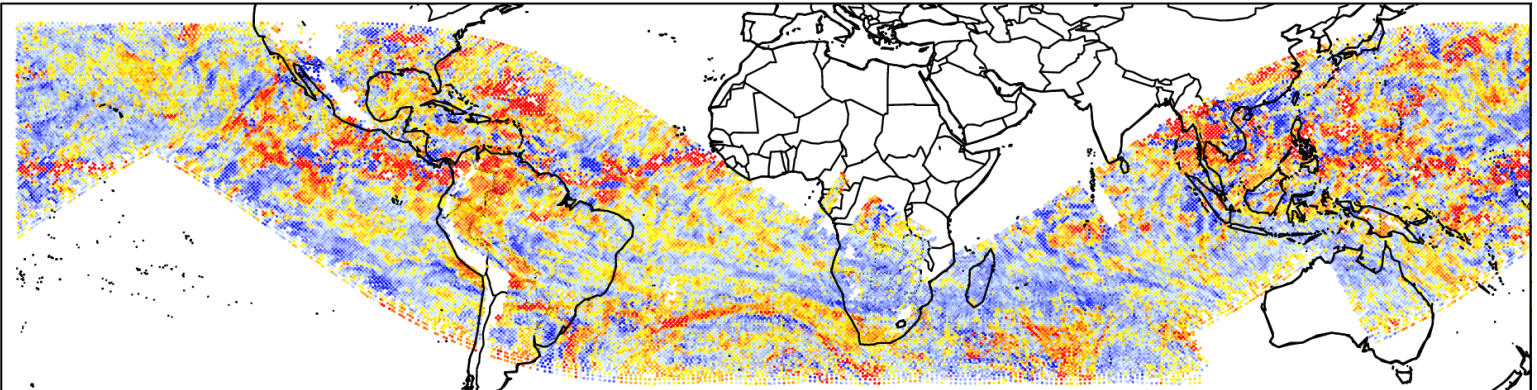- Spatial model resolution: $T_{Co}399$ (~27 km)

(b)

Legend:
- Ch. 9 183.41 – 185.41 GHz
- Ch. 10 185.51 – 187.51 GHz
- Ch. 11 189.31 – 191.31 GHz
- Ch. 12 203.8 – 205.8 GHz

Pressure (mb) axis: 200, 300, 400, 500, 600, 700, 850, 1,000

Altitude (km) axis: 11.8, 10.62, 9.44, 8.26, 7.08, 5.9, 4.72, 3.54, 2.36, 1.18, 0

X-axis: delta $\tau$ / delta ln pressure — 0, 0.1, 0.2, 0.3, 0.4

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# Monitoring:
## Background departures, channel 9, after standard bias correction
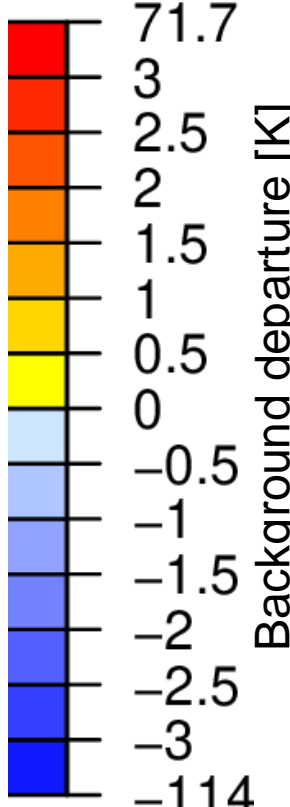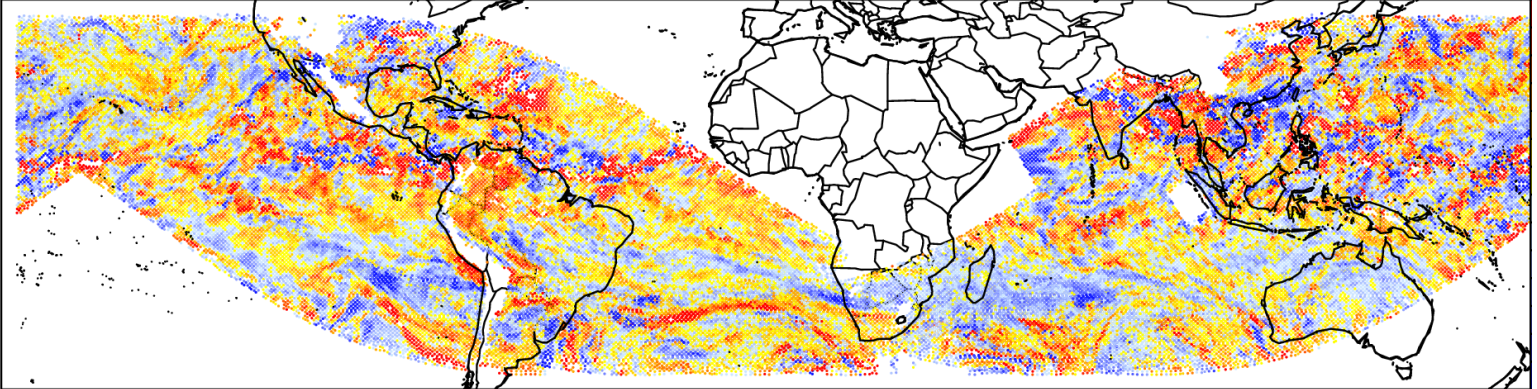
Considerable orbital/ geographical biases

TROPICS-3

TROPICS-5

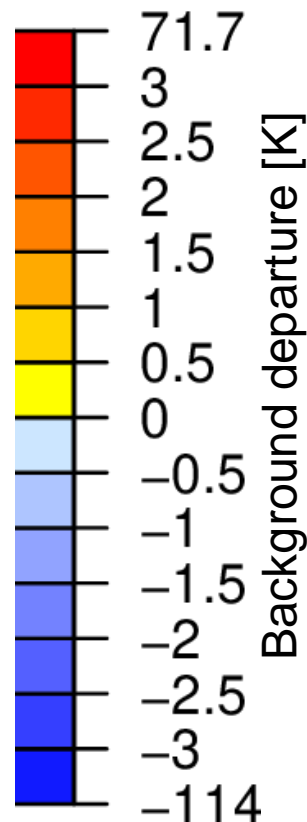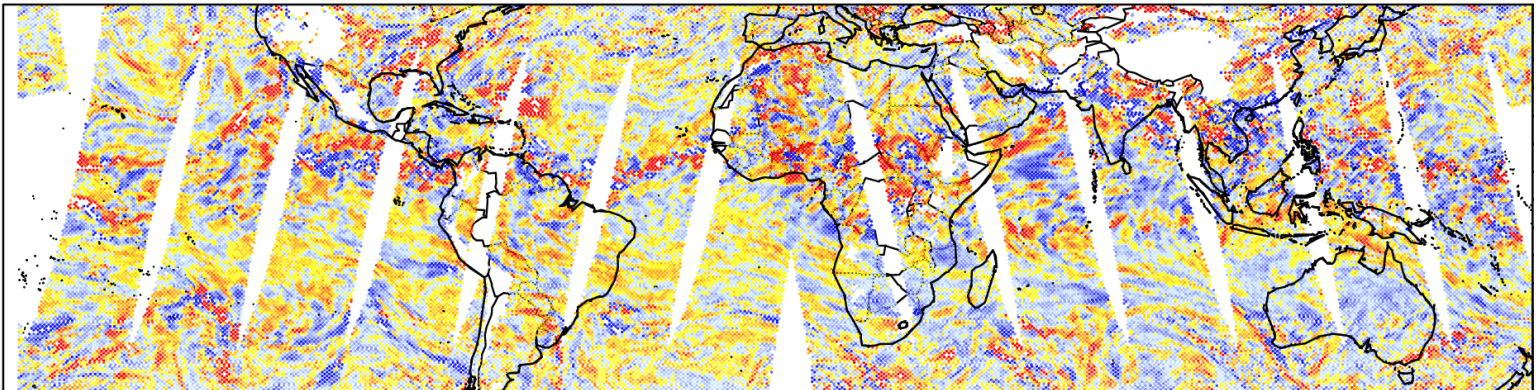TROPICS-6

Background departure [K]

71.7
3
2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
−2
−2.5
−3
−114

17 July 2024, 12Z cycle

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# Monitoring:
## Background departures, channel 9, after standard bias correction

TROPICS-3

TROPICS-5

Metop-B, MHS, Ch 3

Considerable orbital/ geographical biases – larger than for MHS

Background departure [K]

71.7
3
2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
−2
−2.5
−3
−114

17 July 2024, 12Z cycle

ECMWF
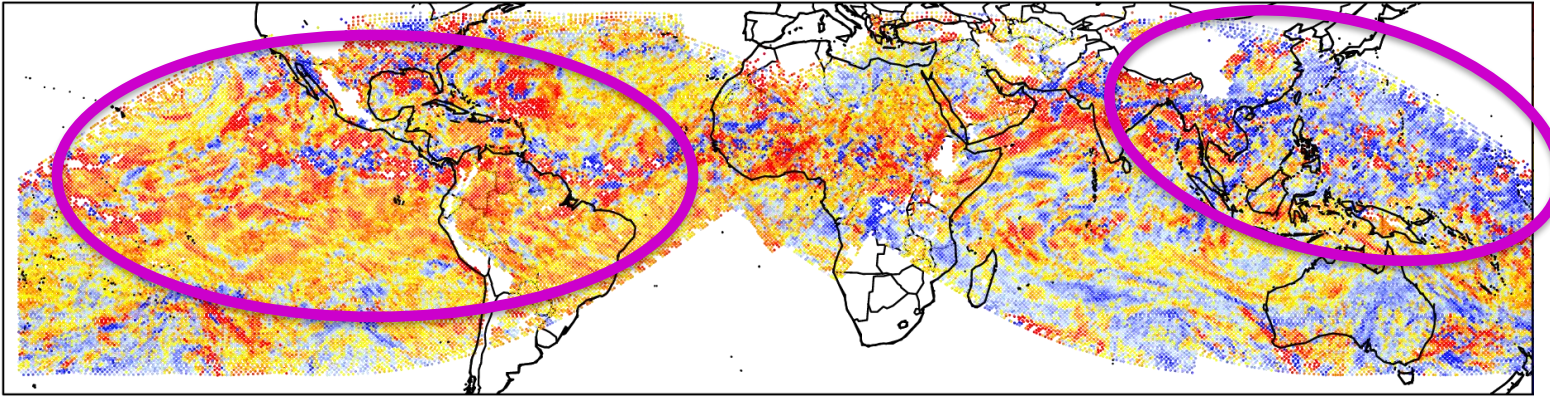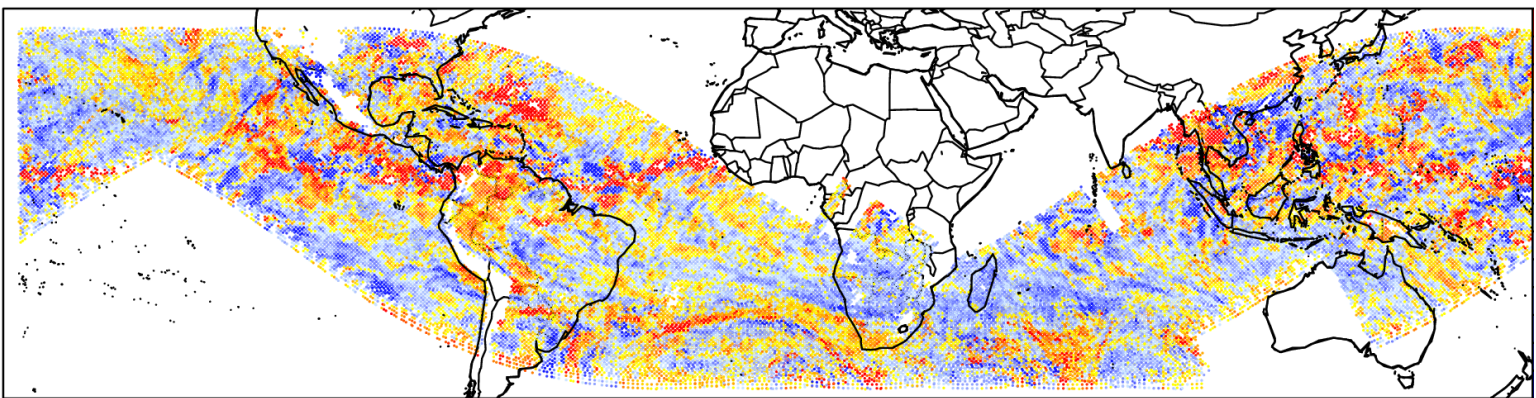
# Correction for orbital biases

## Basis functions/predictors
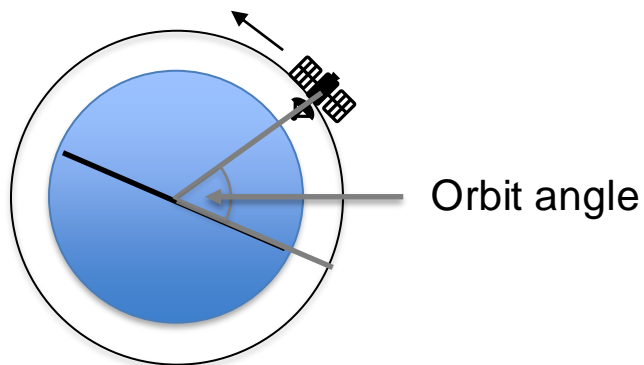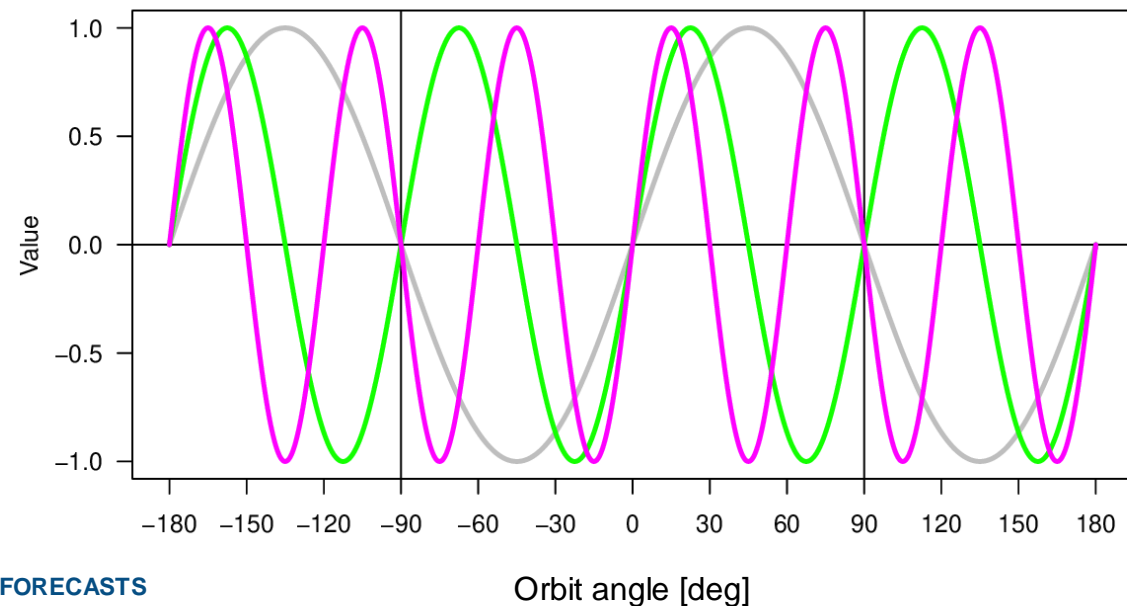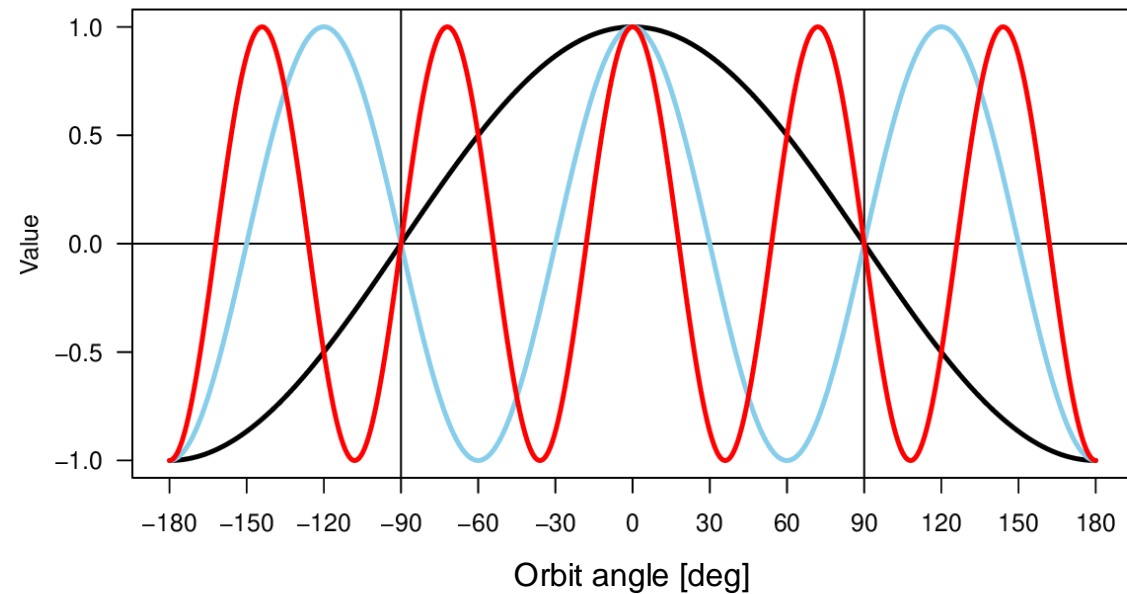
Add terms of a Fourier series in the orbital angle β to the bias correction model ("alternating Fourier series"):

$$f(\beta) = a_1 \cos(\beta) + a_2 \sin(2\beta) + a_3 \cos(3\beta) + a_4 \sin(4\beta) + a_5 \cos(5\beta) + a_6 \sin(6\beta)$$

- 6 new bias parameters to estimate per channel
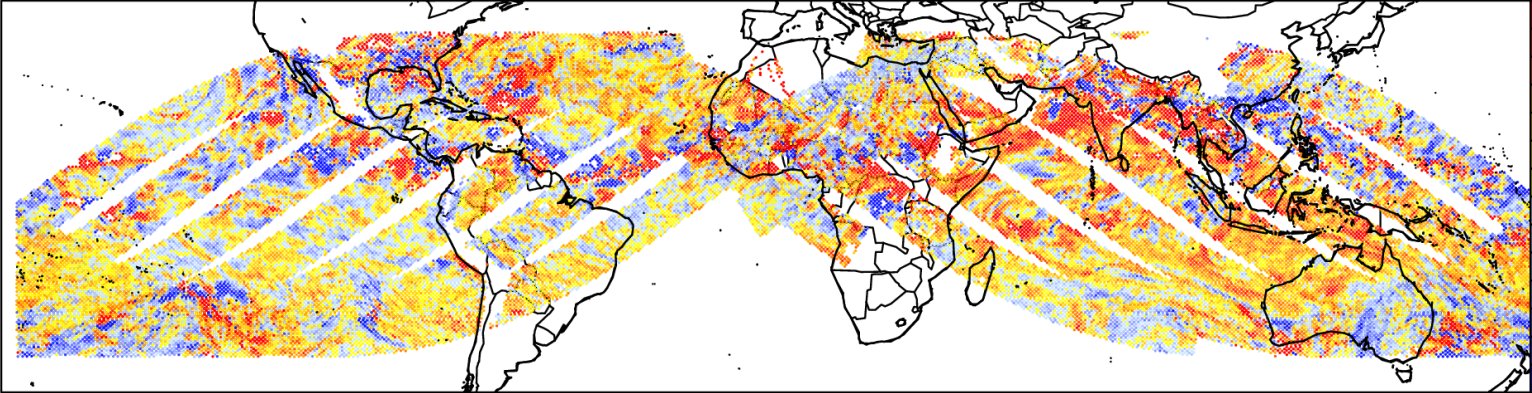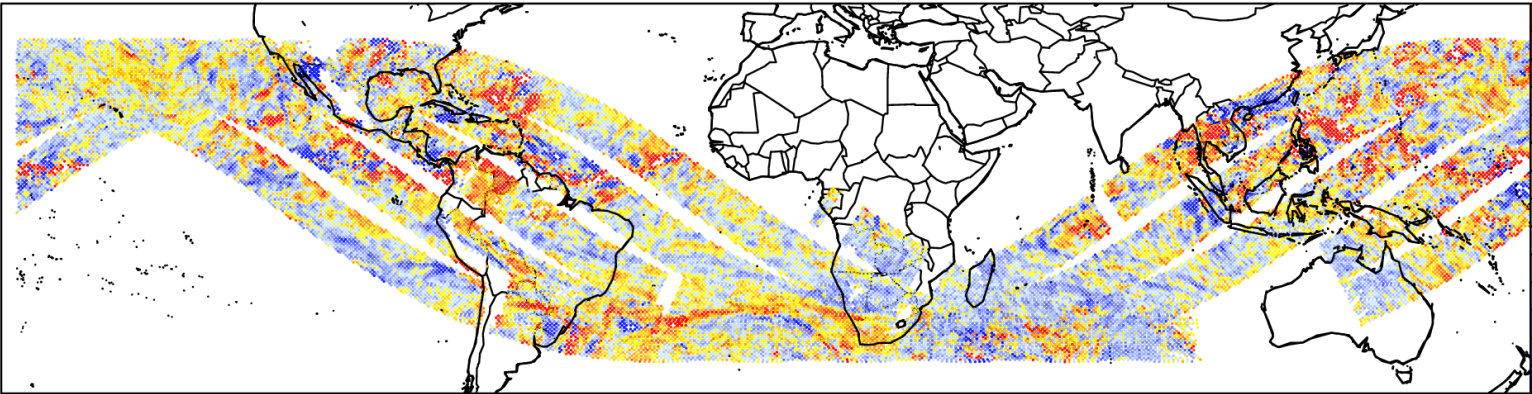
- See Bormann at al (2023), https://doi.org/10.21957/d281dc221a

Orbit angle

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# Background departures, channel 9, with orbital bias correction added for TROPICS



TROPICS-3

TROPICS-5

Metop-B, MHS, Ch 3

Some improvement for orbital/ geographical biases

Background departure [K]

71.7
3
2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
−2
−2.5
−3
−114

17 July 2024, 12Z cycle

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# Temporal evolution of the orbital bias

E.g., channel 9, TROPICS-3

- Orbital biases evolve as orbit precedes
- Orbital bias correction is moderately successful in addressing them



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# Background departures, channel 11,
## with orbital bias correction added for TROPICS

Additional geographical biases remain, not evident in MHS
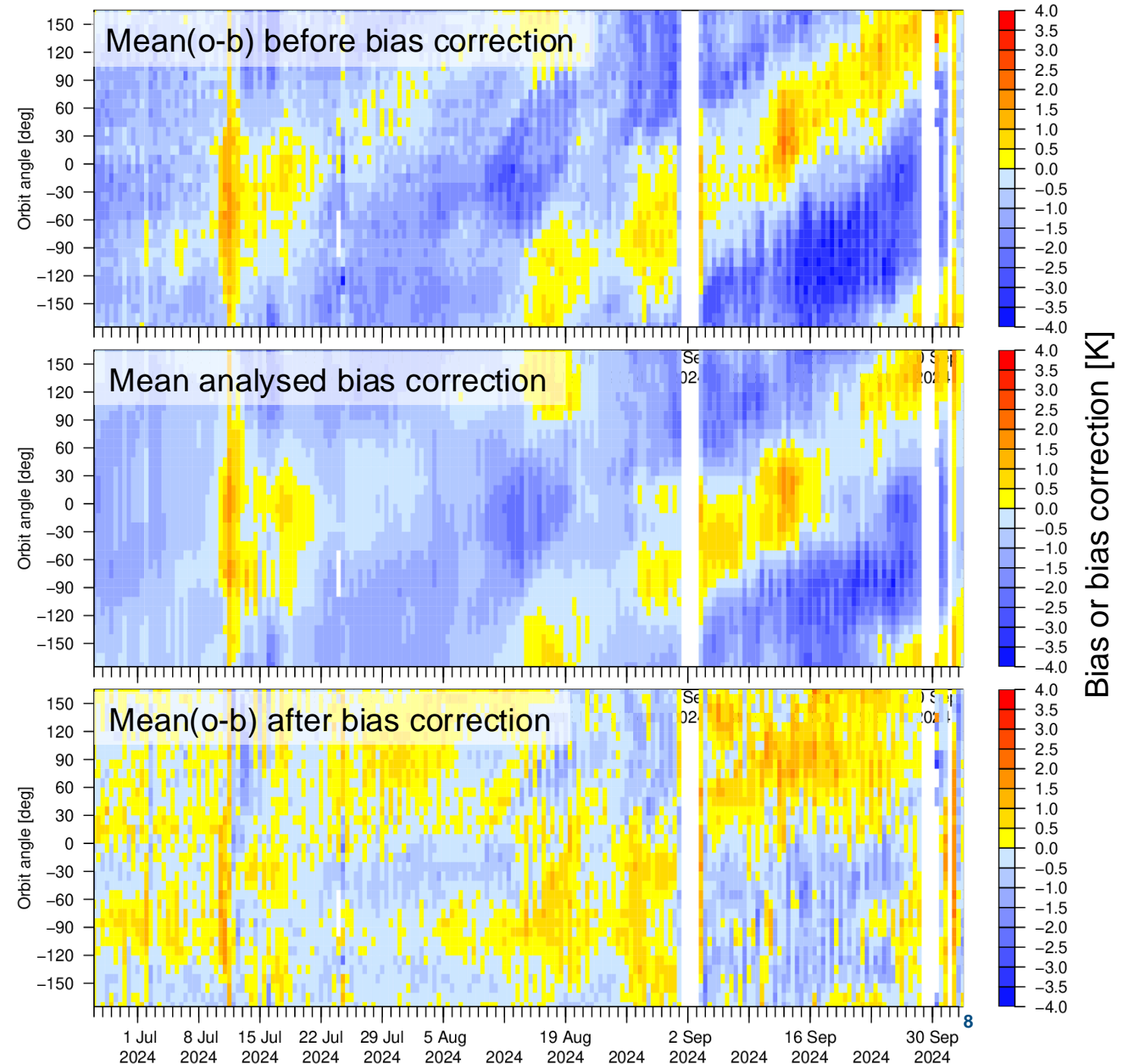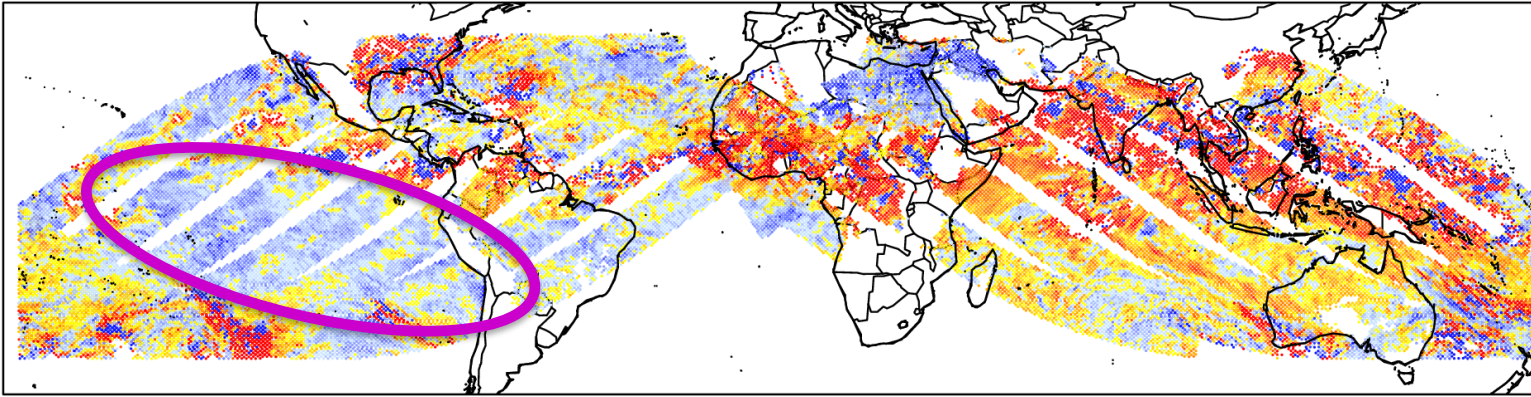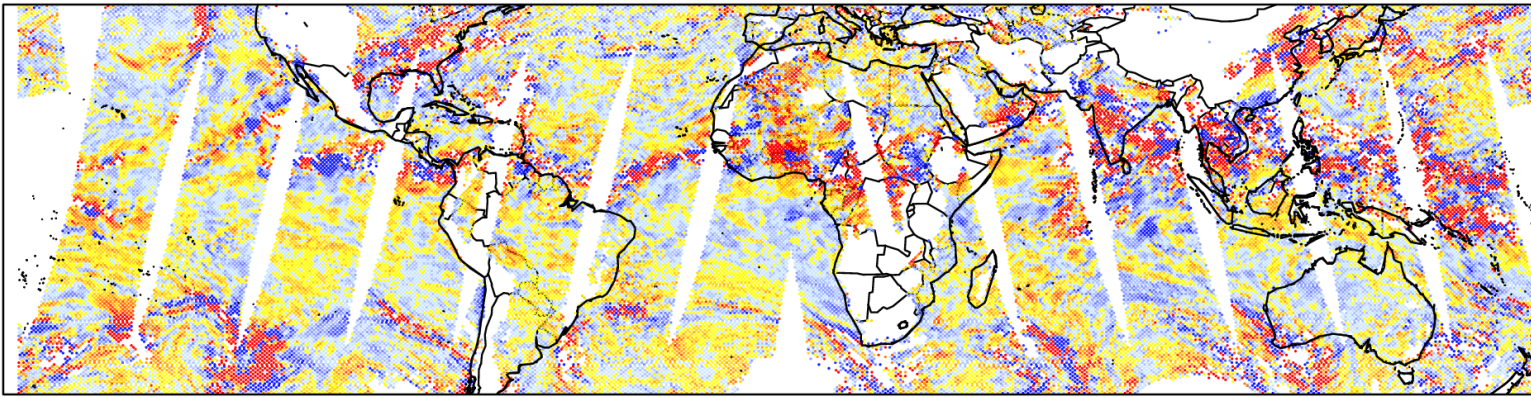
**TROPICS-3**

**TROPICS-5**

**Metop-B MHS, Ch 5**

Background departure [K]

71.7
3
2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
−2
−2.5
−3
−114

17 July 2024, 12Z cycle

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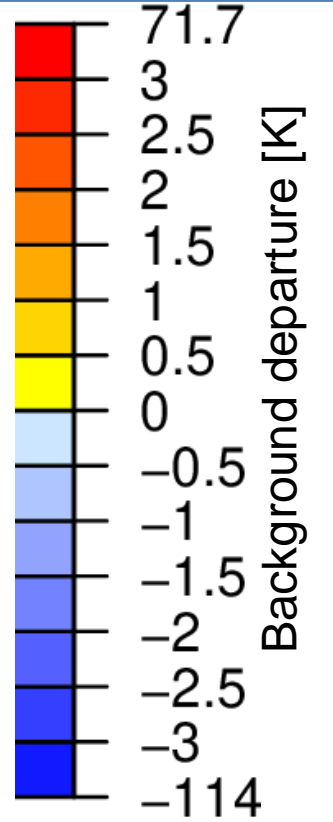
# Scene-dependent biases for TROPICS

**TROPICS-03, channel 11**,
clear data over sea,
o-b after original bias correction

**Metop-B, MHS, channel 5,**
clear data over sea with |lat| < 50,
o-b after bias correction

Data: 26 June – 3 October 2024

# Scene-dependent biases for TROPICS: ad-hoc correction based on linear fit to scene-temperature (outside VarBC)

**TROPICS-03, channel 11,**
clear data over sea,
o-b after original bias correction
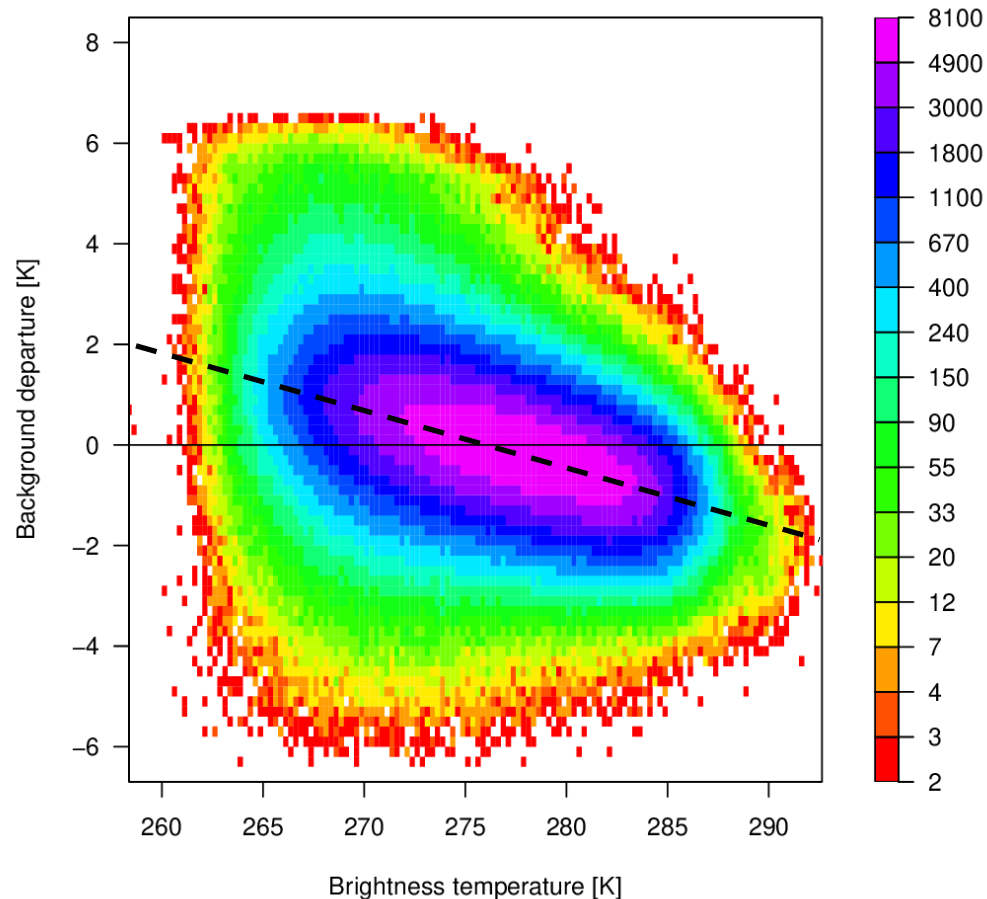
**TROPICS-03, channel 11,
after additional ad-hoc scene-
temperature correction applied**
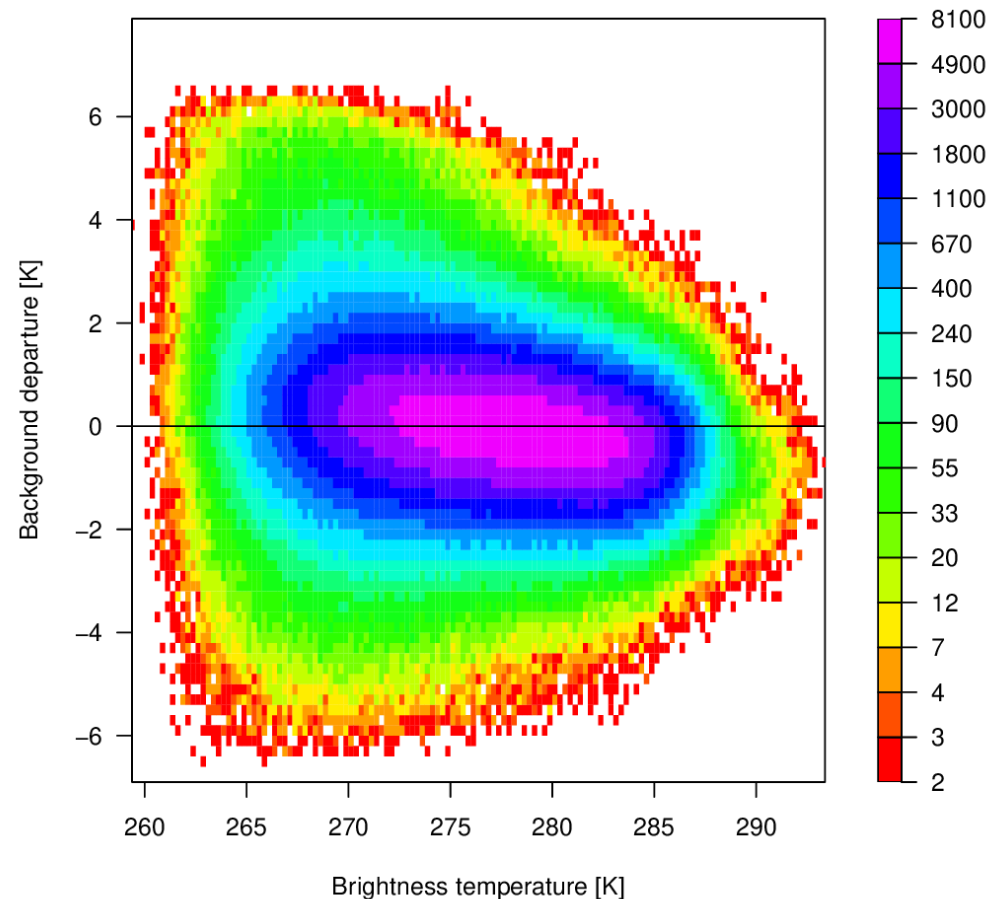
Data: 26 June – 3 October 2024

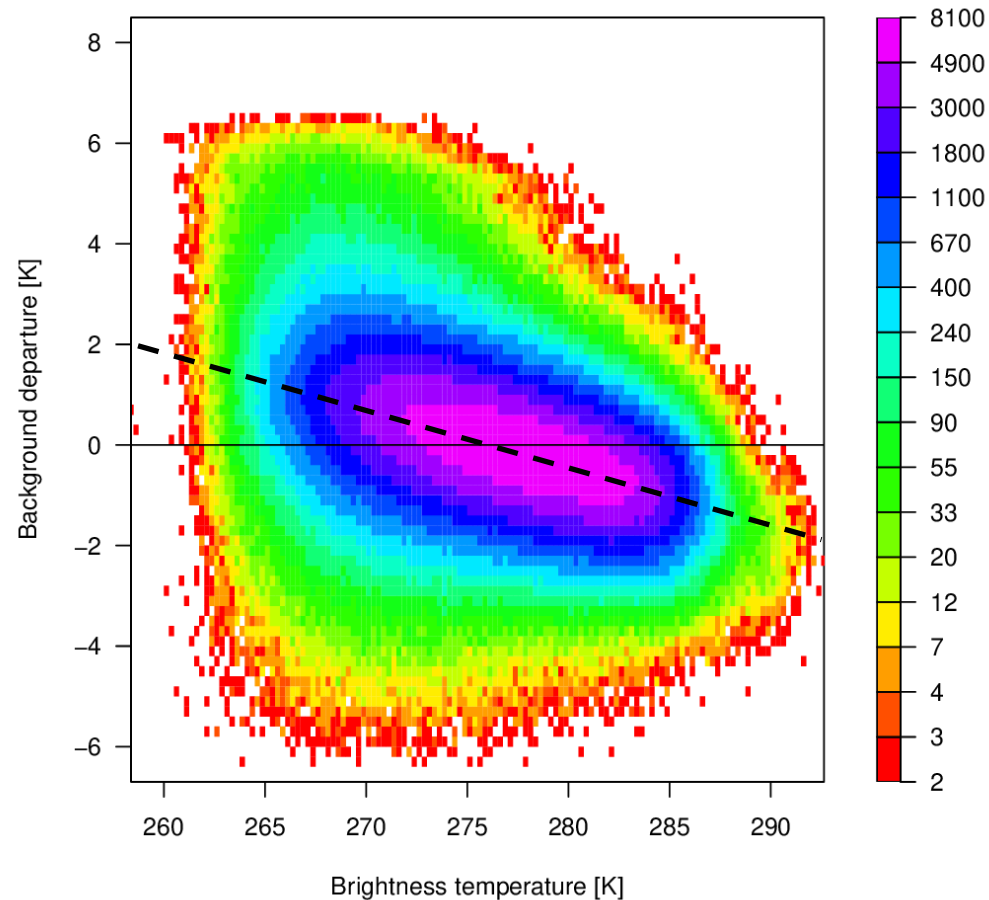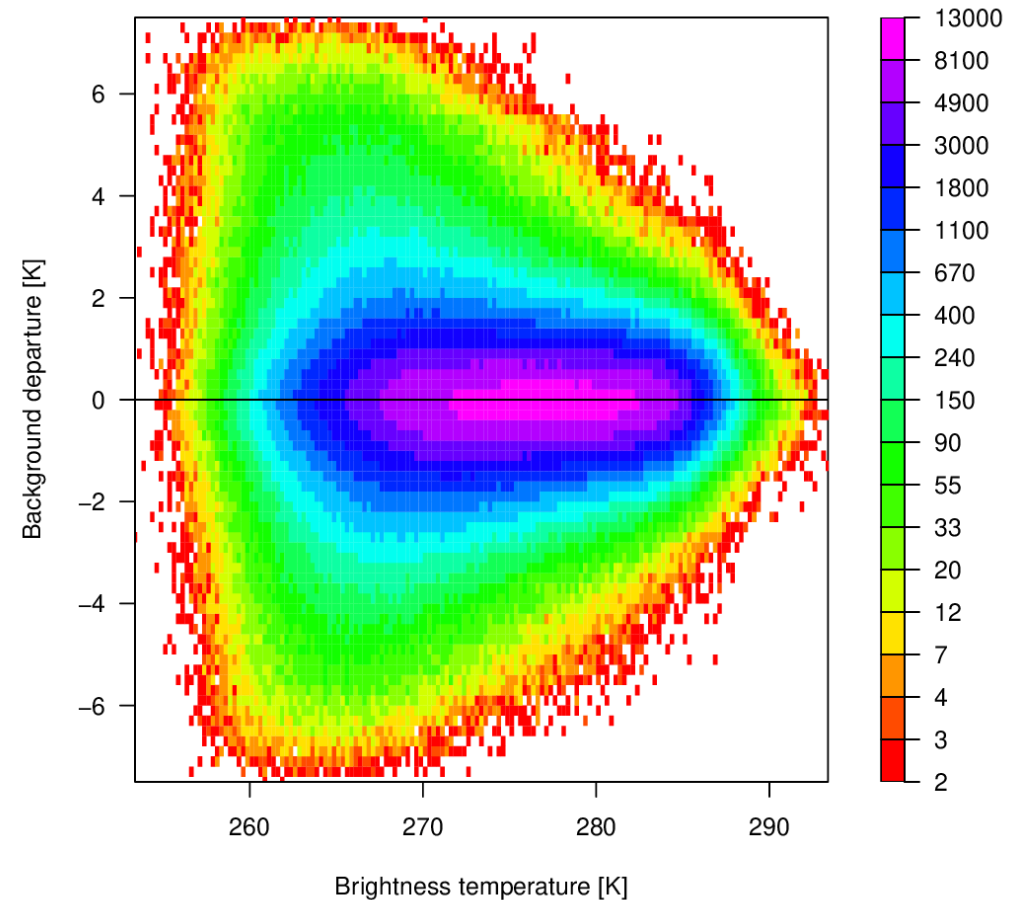# Background departures, channel 11, with orbital and scene bias correction

TROPICS-3

TROPICS-5

Metop-B MHS,
Ch 5

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Background departure [K]

71.7
3
2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
−2
−2.5
−3
−114
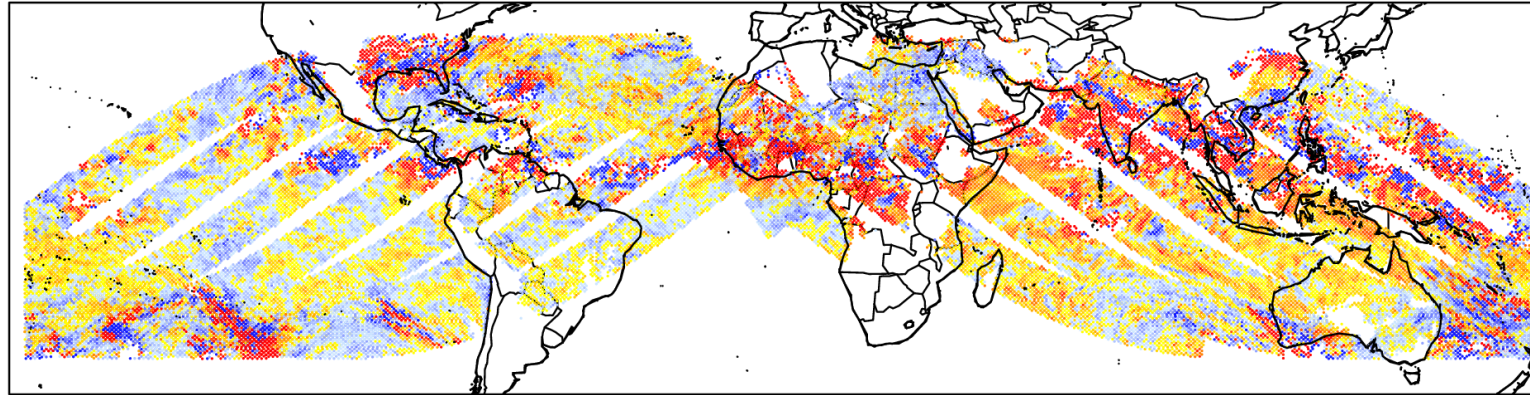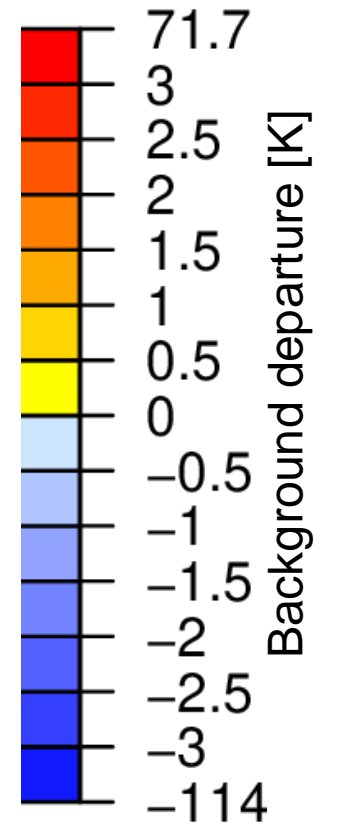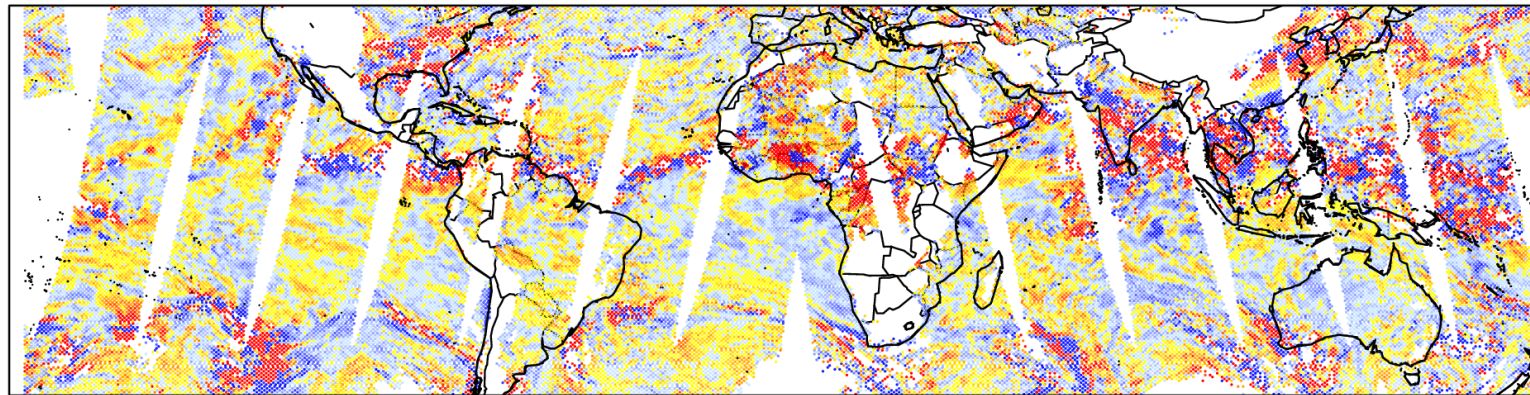
17 July 2024,
12Z cycle

# Assimilation experiments

- **Model resolution:** $T_{Co}399$ (27 km)

- **Period:** 26 June – 3 October 2024

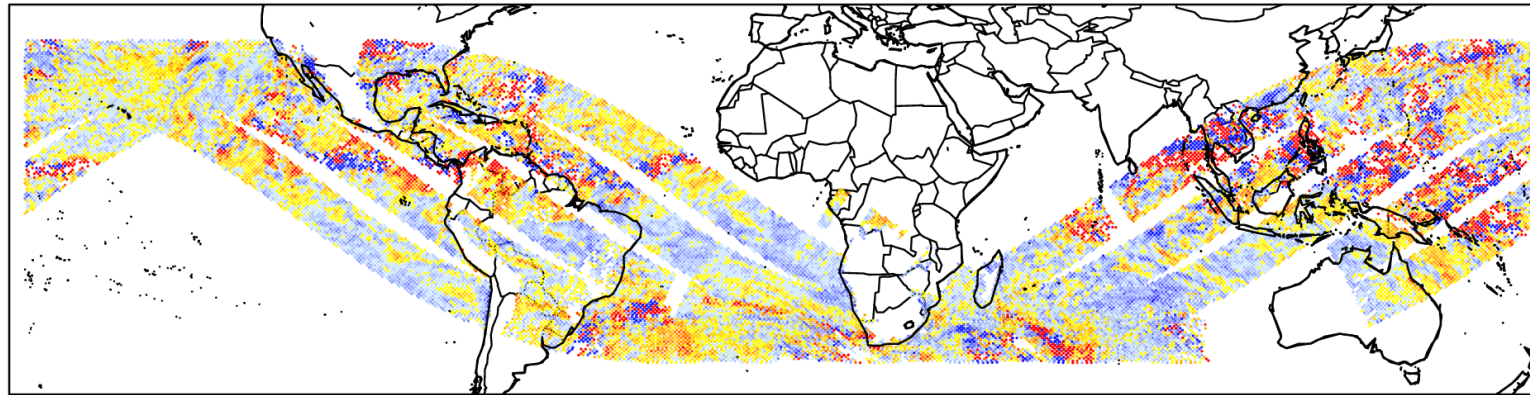- **Experiments:**

  – Control (IFS Cycle 49r1) with full observing system

  – TROPICS 183 GHz channels activated (TR-03/-05/-06), with orbital bias correction

  – TROPICS 183 GHz channels activated (TR-03/-05/-06), with orbital and scene-bias correction

  – FY-3E MWHS-2 denial

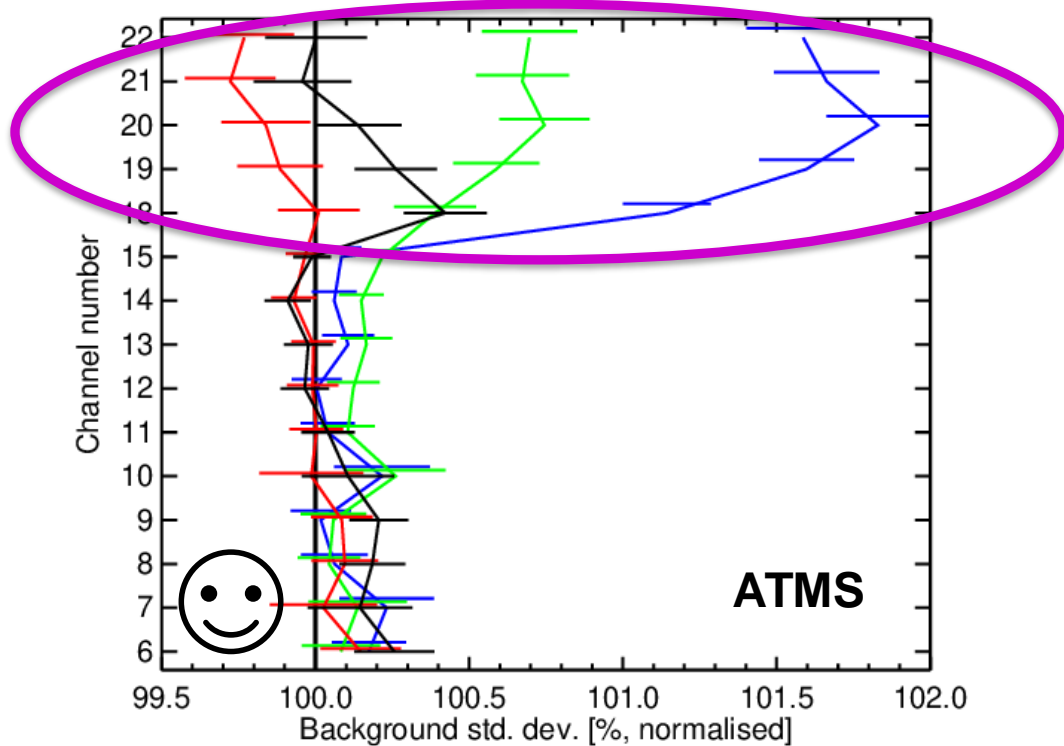  – Denial of all MHS data with |lat| < 40°  (3 MHSs from Metop-B, -C & NOAA-19 – all around 9:30)

  **For context***

* Note:
1) The number of assimilated MHS soundings with |lat| < 40° is similar to that of 3-satellite TROPICS.
2) Slight disadvantage in the experiment set-up for TROPICS, as TROPICS data are added to a fuller observing system than MHS/MWHS-2. But additional experiment shows the effect is small.

# Short-range forecast impact in the Tropics



Instrument(s): NOAA–20,21; NPP – ATMS – TB     Area(s): Tropics
From 00Z 26–Jun–2024 to 12Z 3–Oct–2024

Instrument(s): GOES–16,18; HIMAWARI–9; METEOSAT–10,9 – GEOS – TB
Area(s): Tropics
From 00Z 26–Jun–2024 to 12Z 3–Oct–2024

ATMS

Geostationary radiances
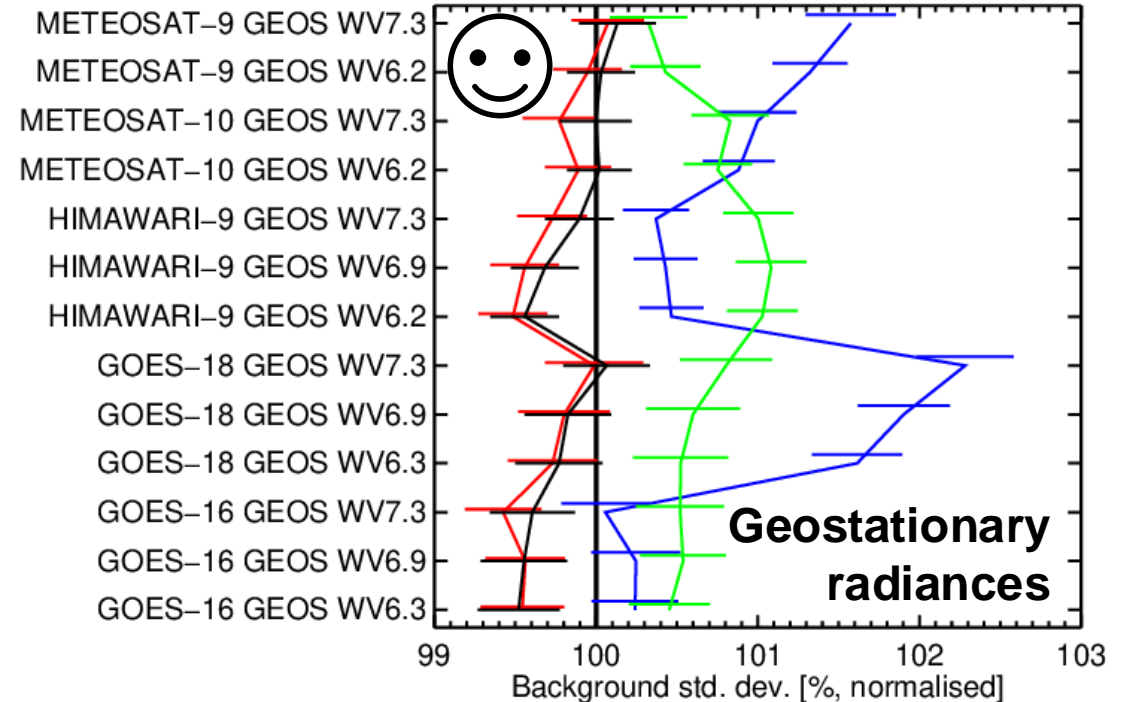
- TROPICS 183GHz OrbitVarBC
- TROPICS 183GHz OrbitVarBC+SceneCorrect
- No FY–3E
- No MHS |lat|<40
- 100% = Control

- Some benefit (reduced stdev(o-b)) from TROPICS for humidity with orbit+scene bias correction, otherwise neutral
- Impact much smaller than the increase in stdev(o-b) from denying low-latitude MHS
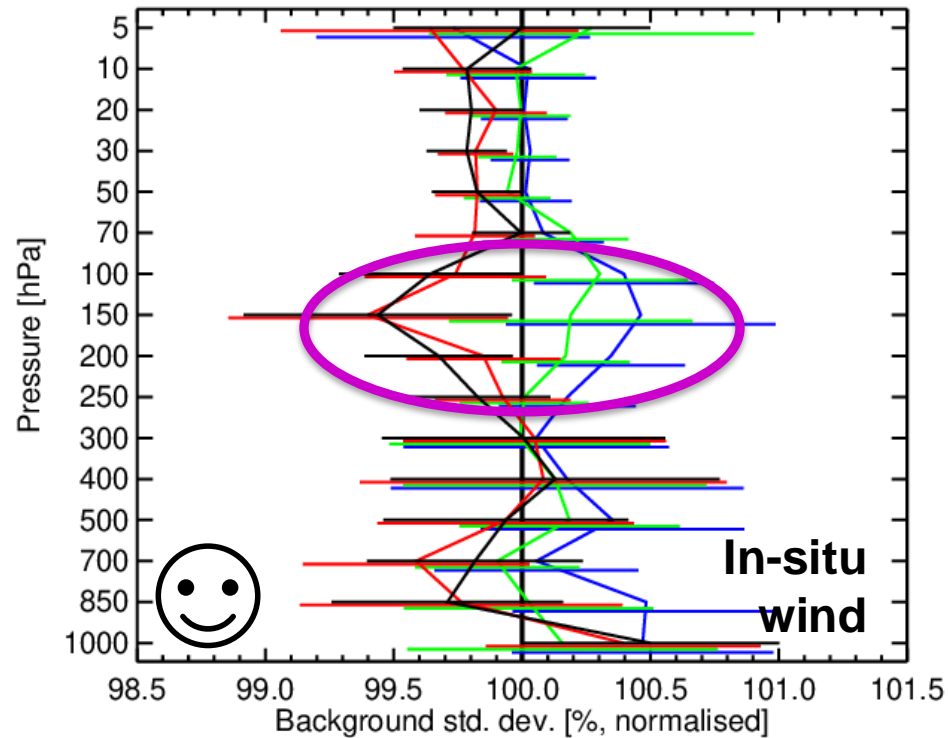
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# Short-range impact in the Tropics: wind



Instrument(s): AMDAR DROP MODE−S PILOT PROF TEMP − U V    Area(s): Tropics
From 00Z 26−Jun−2024 to 12Z 3−Oct−2024

In-situ wind

TROPICS 183GHz OrbitVarBC
TROPICS 183GHz ObrbitVarBC+SceneCorrect
No FY−3E
No MHS |lat|<40
100% =    Control

Instrument(s): SATOB − U V    Area(s): Tropics
From 00Z 26−Jun−2024 to 12Z 3−Oct−2024

AMVs

TROPICS 183GHz OrbitVarBC
TROPICS 183GHz ObrbitVarBC+SceneCorrect
No FY−3E
No MHS |lat|<40
100% =    Control

- Some small benefit for wind around 150-200 hPa

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# Summary

- **Evaluated TROPICS data from the near-real-time stream, 26 June – 3 October 2024**

- **The 183 GHz channels look most promising for assimilation:**

  - Stdev(o-b) broadly in line with MHS

  - But **considerable orbital biases and scene-temperature-dependent biases** were found

    - Biases addressed here (partially) through a Fourier-series-based orbital bias correction in VarBC, and an ad-hoc scene-bias correction.

    - This is a pragmatic choice until a better correction of root-source can be found. Highlights importance of calibration.

    - Residual biases in background departures after these bias corrections are still larger than for, say, MHS.

- **With these additional corrections, there is some small benefit from TROPICS for short-range forecasts of humidity and wind over the low latitudes**

  - But the impact is much smaller than that of low-latitude MHS data, possibly due to the residual biases.

- Medium-range forecast impact is neutral (not shown)

# Stability of departure statistics, e.g., channel 9

Global,
Used data



**Stdev(o−b), after bias correction, chan=9**

**Mean(o−b), chan=9**

After bcor

Before bcor

**Number of observations, chan=9**