Initial Evaluation of TROPICS in the ECMWF Data Assimilation System

All-sky monitoring of Pathfinder radiances

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*April Telecon*

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Background

MW sounders are some of the most impactful sensors for driving skill in global NWP

Small platforms like TROPICS can enable greater utilization of the MW spectrum through greater sampling

- In the current IFS, MW frequencies from 18 to 190 GHz are assimilated in all-sky (from clear to precipitating) conditions

- We've shown that additional sounders continue to add NWP skill (Duncan et al. 2021; https://doi.org/10.1002/qj.4149)

We expect additional MW sounders to deliver a positive impact for global NWP if the sensors are low-noise and possess good calibration stability
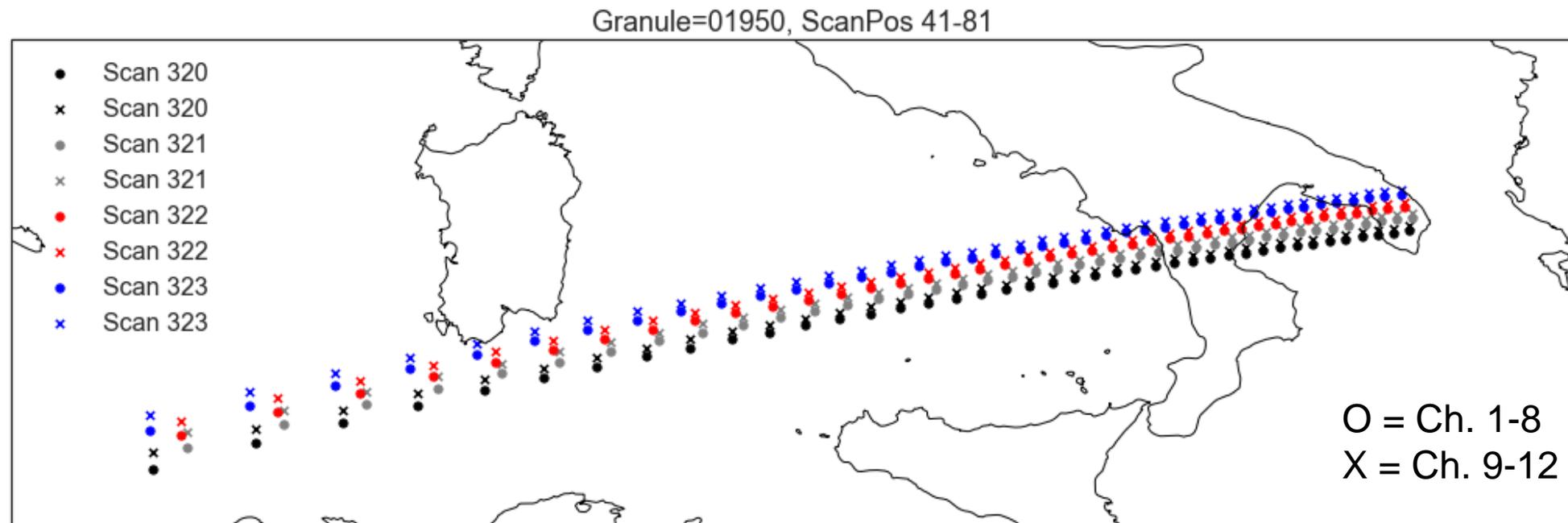
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Duncan et al. (2021)
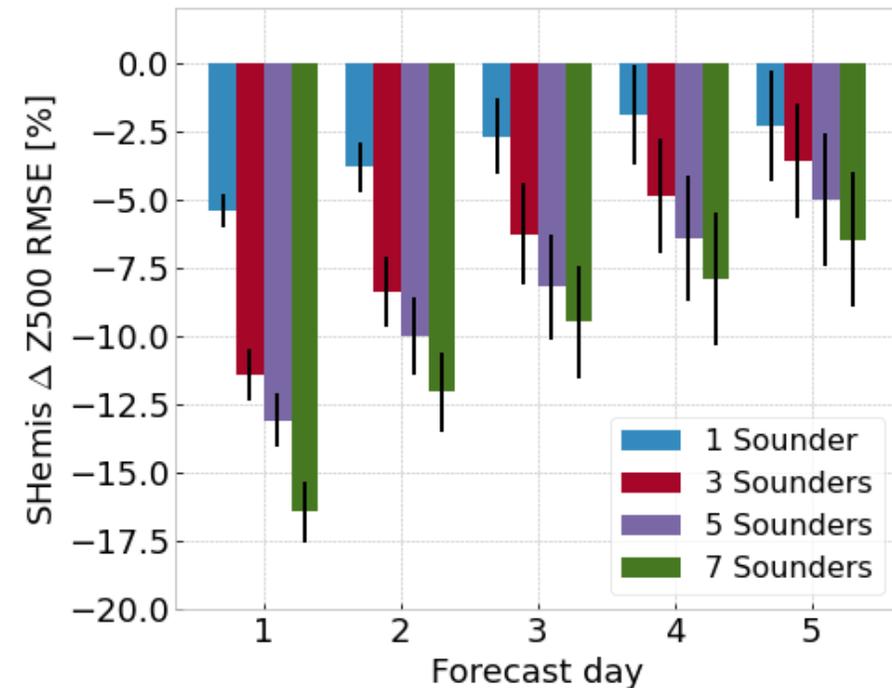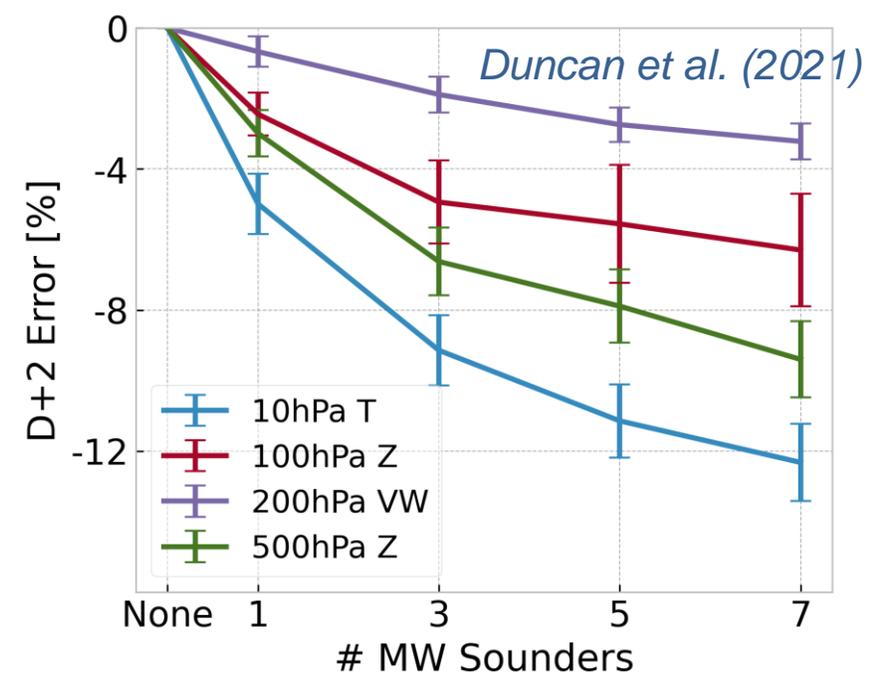
Technical Notes

Bands on TROPICS view slightly different paths

- To simplify initial evaluation, assign all bands same geolocation and viewing geometry (set to G-band)

- Any QC flagged radiances are removed in pre-processing

All simulations presented use RTTOV-SCATT v13.0 and IFS Cycle 47r3

Granule=01950, ScanPos 41-81

- Scan 320 (●)
- Scan 320 (×)
- Scan 321 (● grey)
- Scan 321 (× grey)
- Scan 322 (● red)
- Scan 322 (× red)
- Scan 323 (● blue)
- Scan 323 (× blue)

O = Ch. 1-8
X = Ch. 9-12

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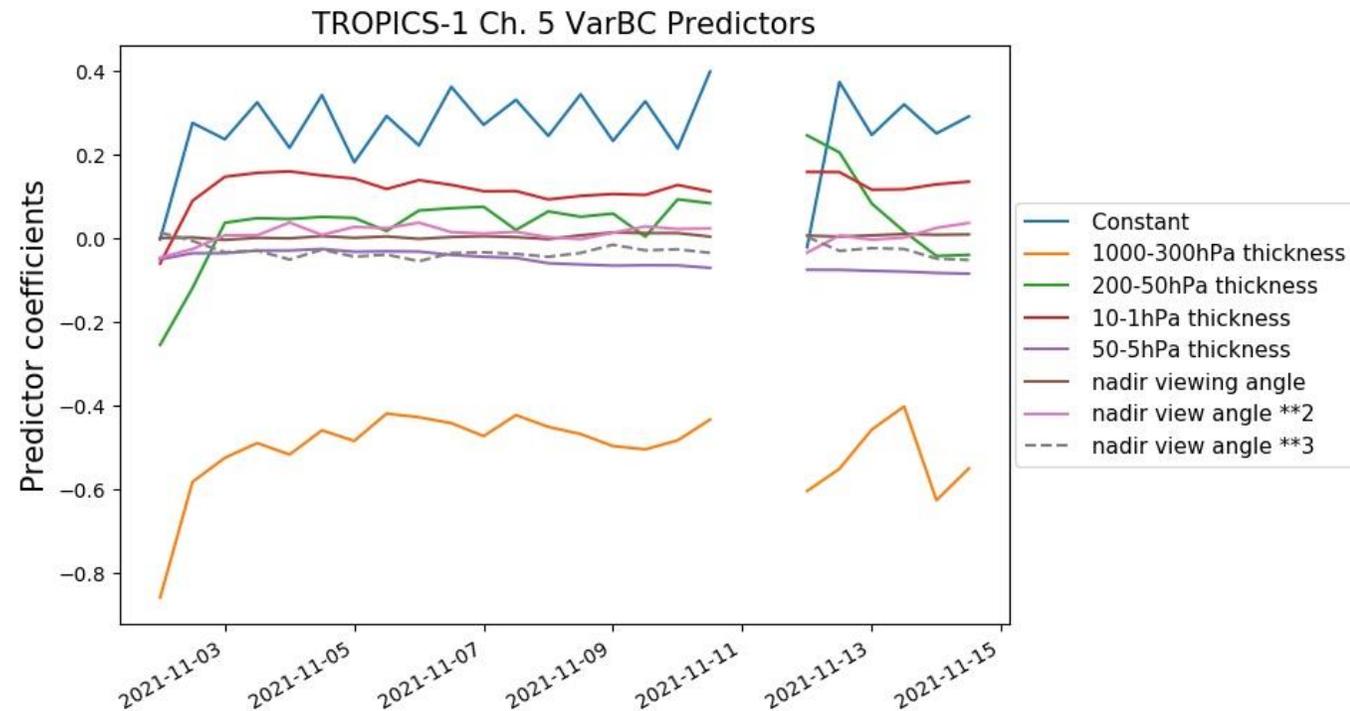# TROPICS Initial Evaluation in the IFS

Stability over time – assess indirectly with VarBC

- Variational bias correction (VarBC) uses a variety of linear predictors to ensure that assimilated observations have a bias near zero

- For radiances, the IFS has a constant predictor (in K), airmass predictors, and third order polynomials for scan angle

- There is some 'memory' in VarBC to avoid abrupt changes on scales shorter than a day or two

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TROPICS Initial Evaluation in the IFS

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- *Jumpiness indicates calibration issue*

- *Struggle for stability following outages*

TROPICS-1 Ch. 5 VarBC Predictors

TROPICS Initial Evaluation in the IFS

**Stability over time – assess indirectly with VarBC**

- Degradation of G-band channels evident in VarBC constant term

- Reasonable stability seen here for F-band channels

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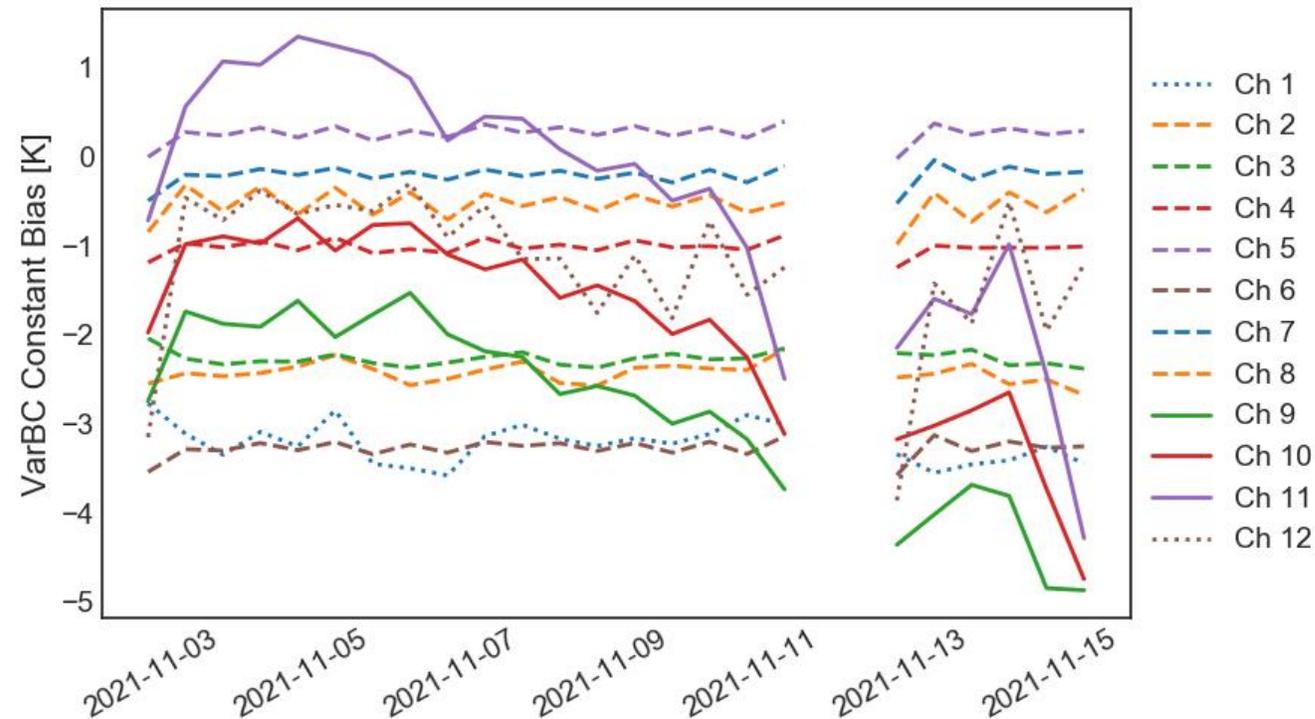
TROPICS Initial Evaluation in the IFS

Mean O-B as a function of scan position

- Sample is from clear-sky over sea only

- Bias characteristics show generally negative bias compared to RTTOV-SCATT

- Stronger biases near scan edge

- Ch 1 (91GHz) is an outlier

- Most channels have 0 to -3K bias relative to IFS

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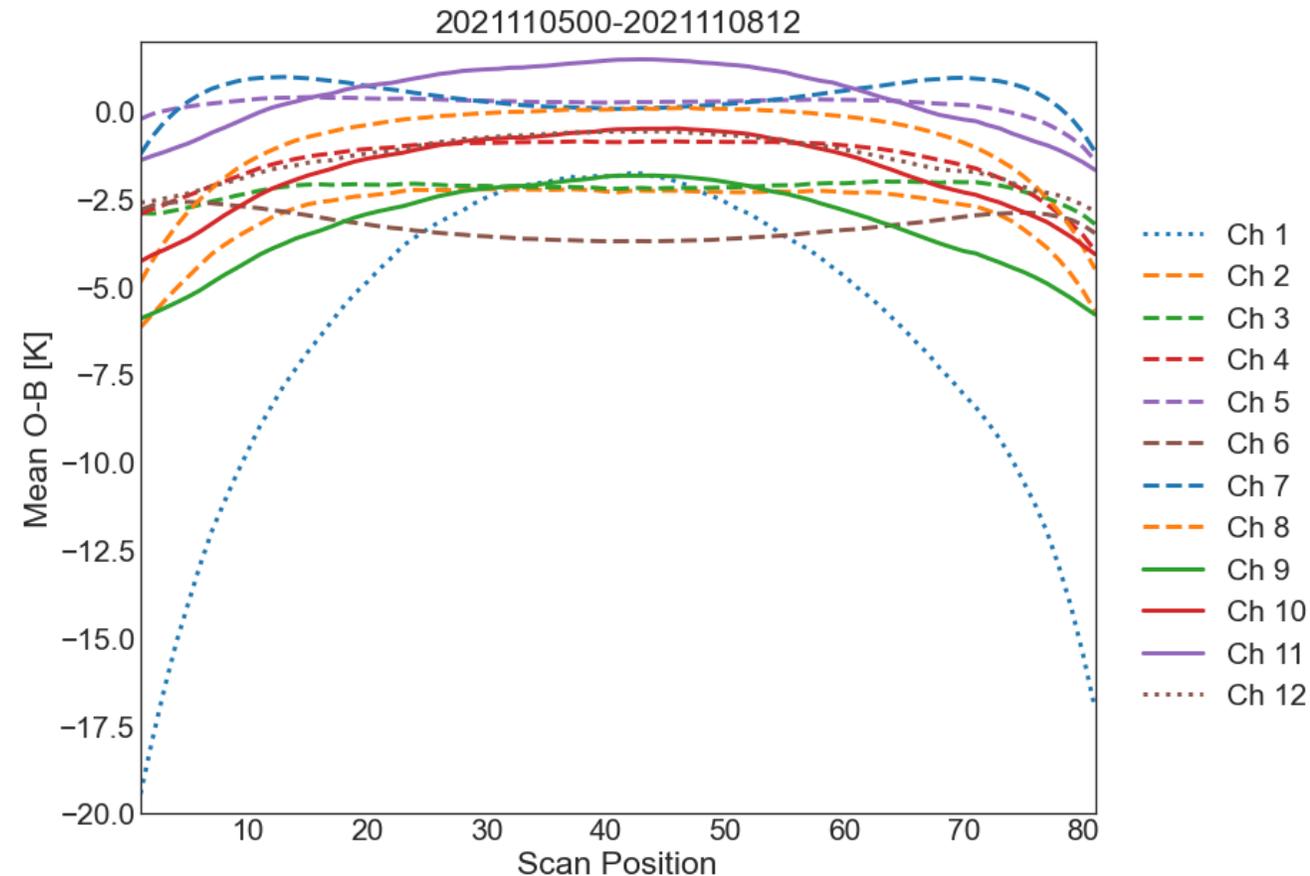
TROPICS Initial Evaluation in the IFS

Mean O-B before and after correction

- VarBC handles largest biases but struggles with some scan biases

- Partly a function of predictors chosen – could be improved
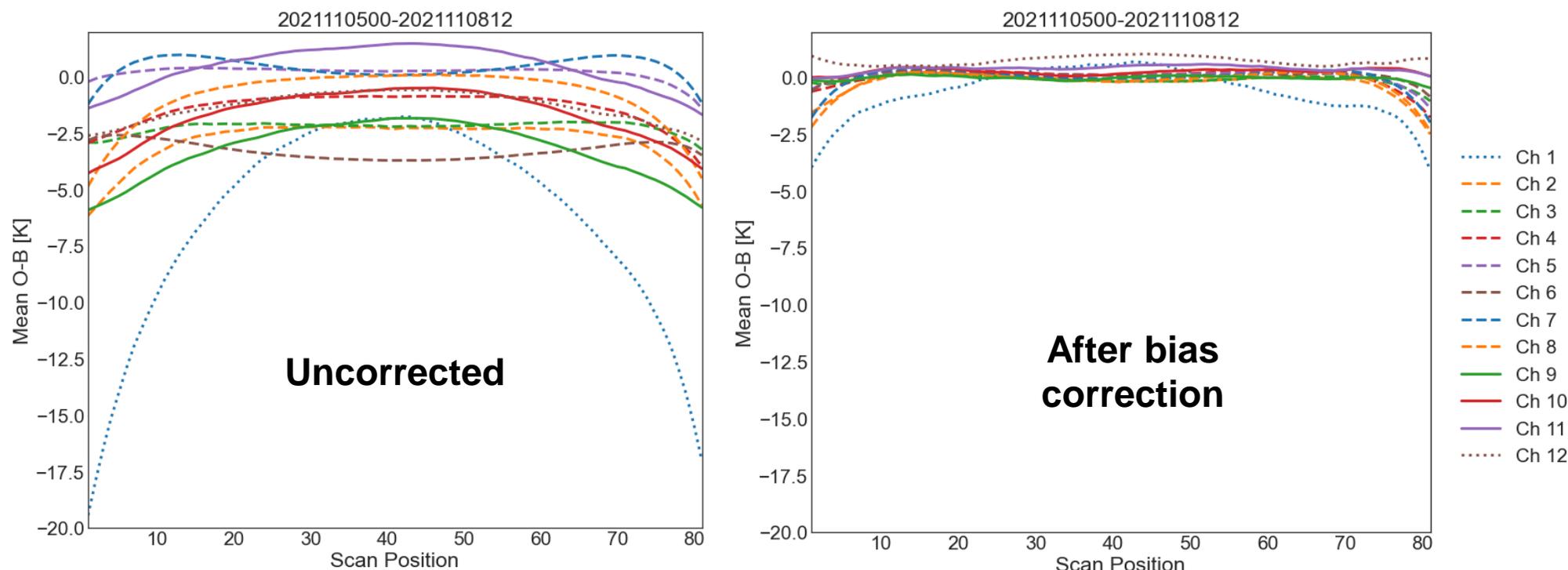
TROPICS Initial Evaluation in the IFS

MWHS-2 is closest comparison for TROPICS due to similar bands, i.e. 118GHz and 183GHz

- MWHS-2 assimilated in the IFS since 2016 (FY-3C)

- FY-3D MWHS-2 assimilated since Dec. 2019

- These provide good forecast impact primarily through 183GHz

- *Not a perfect comparison* – no 204GHz, 118GHz channels are not using identical bands, different footprint size, FY-3 are large operational satellites, etc.
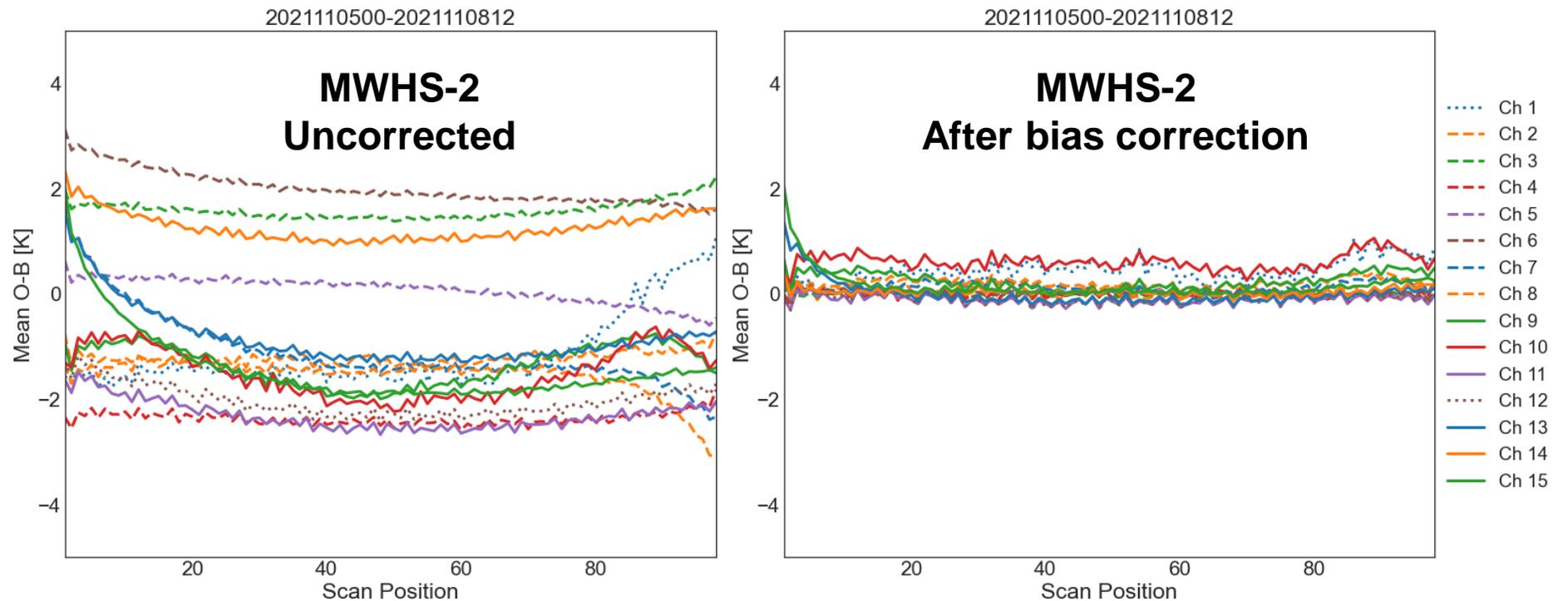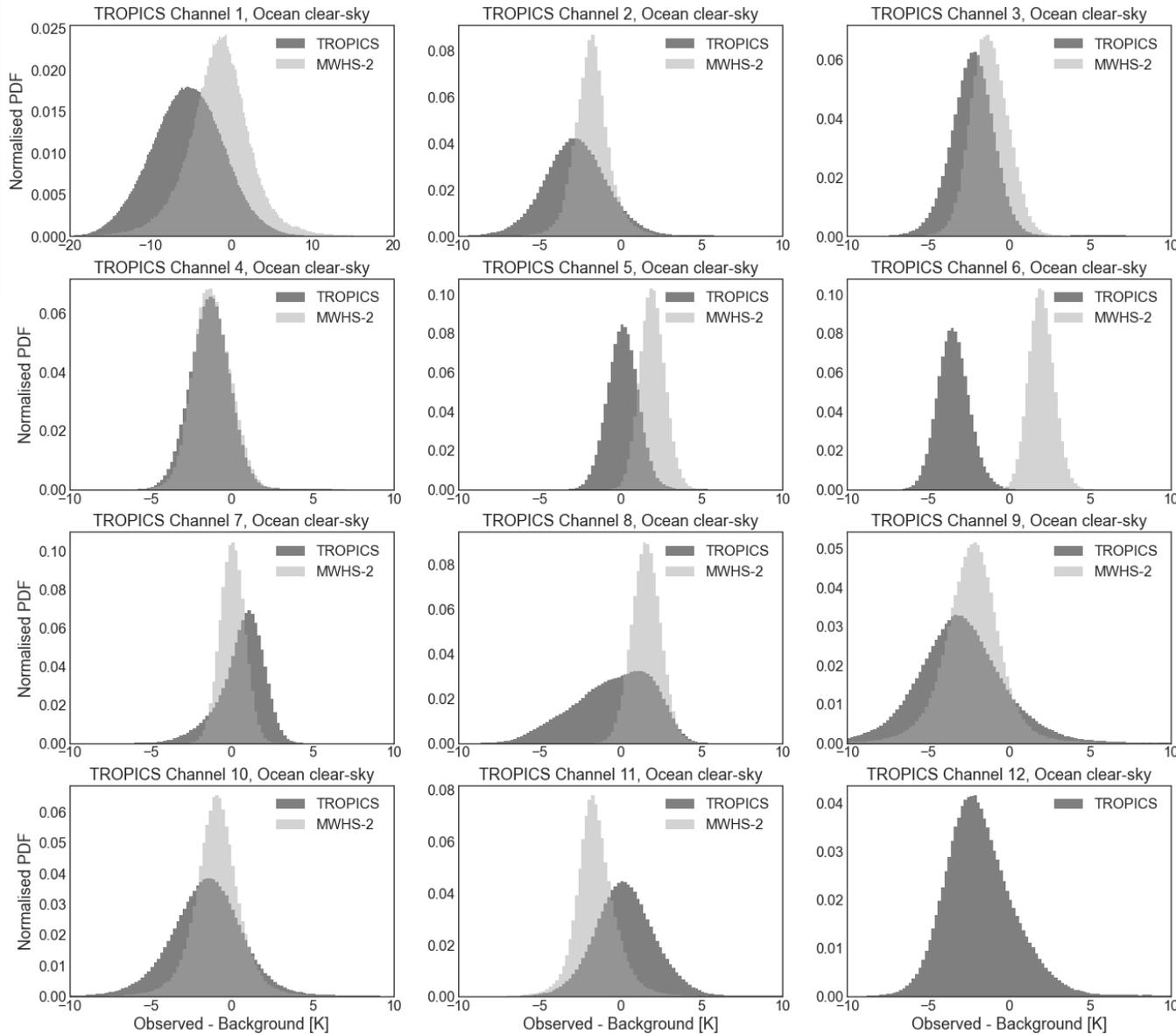

MWHS-2
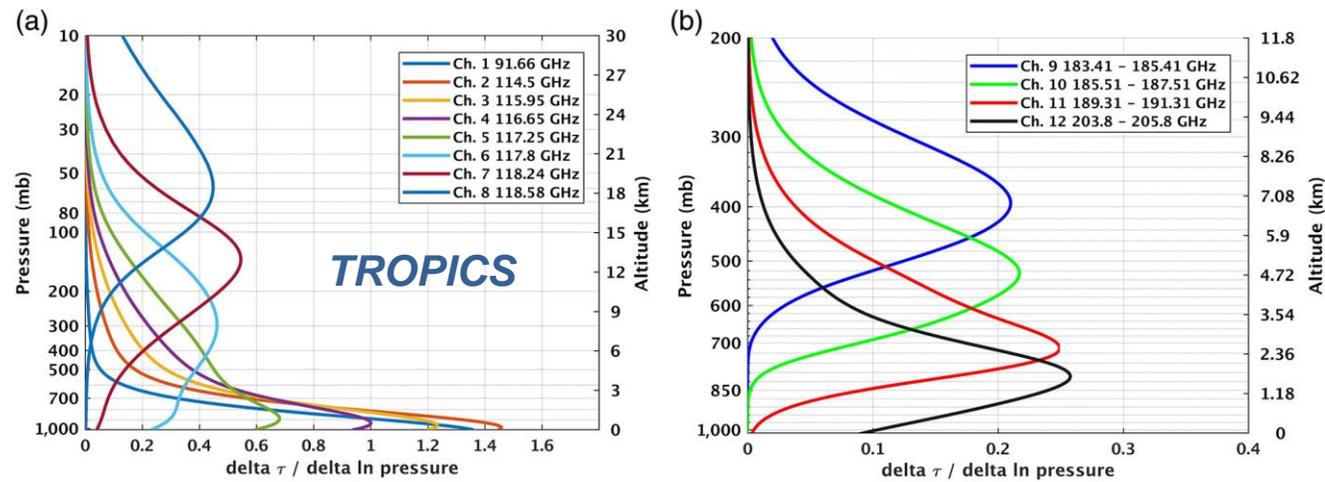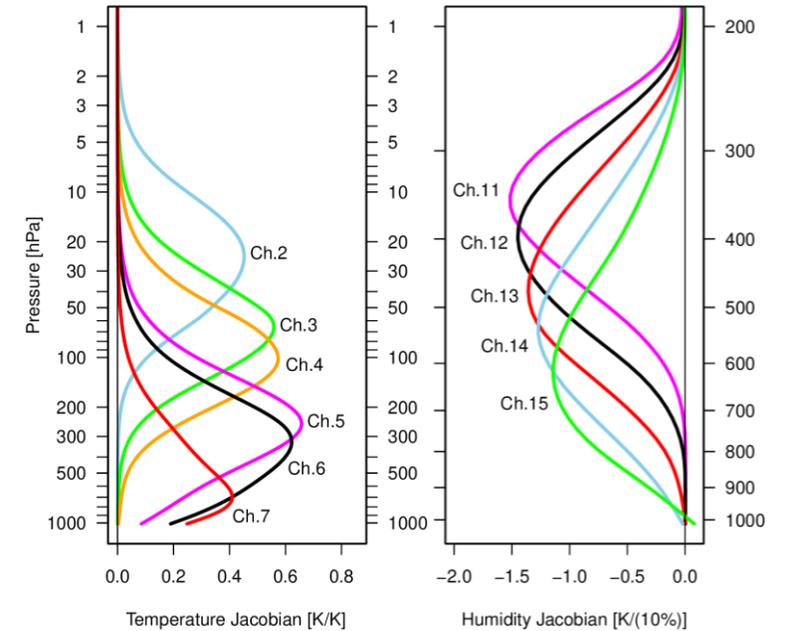
TROPICS

TROPICS Initial Evaluation in the IFS

Comparison to MWHS-2 [Nov 5-8]

- MWHS-2 also has significant biases prior to correction

- VarBC handles most biases well with exception of far scan edge

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TROPICS Initial Evaluation in the IFS

Comparison to MWHS-2 [Nov 5-8]

- Clear-sky data selection over sea

- Before bias correction, several MWHS-2 channels exhibit large biases

- Most TROPICS channels exhibit Gaussian-distributed O-Bs

- Some channels show comparable performance already: 3, 4, 5

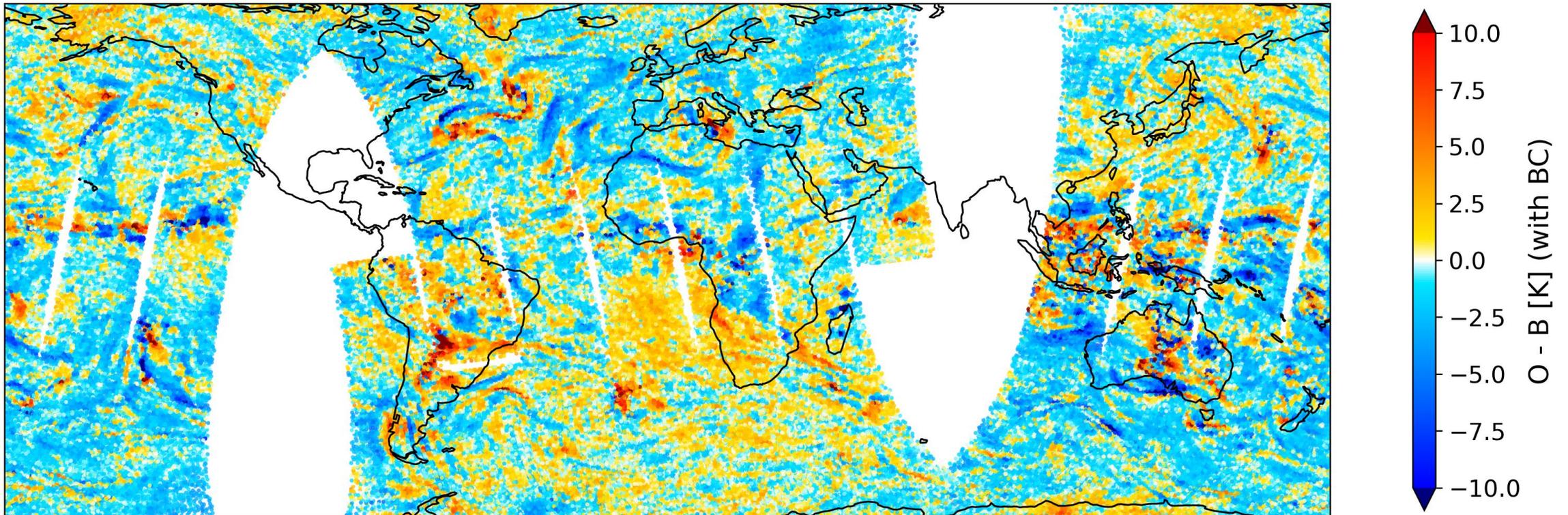- No averaging applied, but will be considered in the future
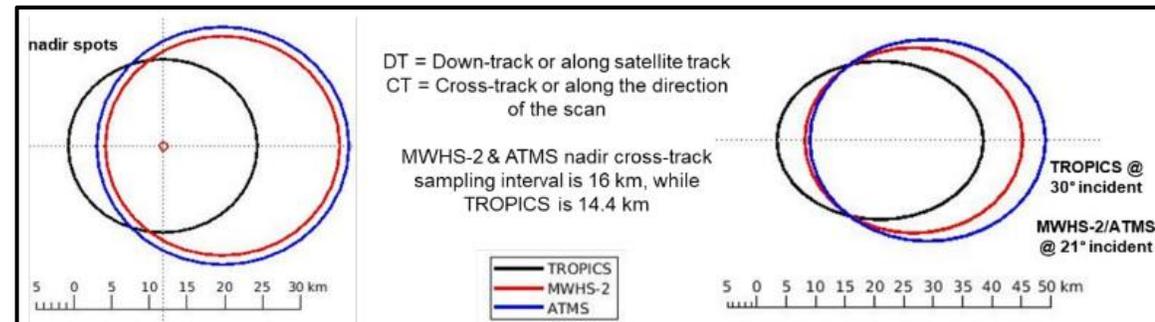
TROPICS Initial Evaluation in the IFS

184.41GHz (Ch 9) is a well-characterized upper tropospheric channel

- Some orbital biases visible (after bias correction)

- Encouraging quality considering no averaging applied yet
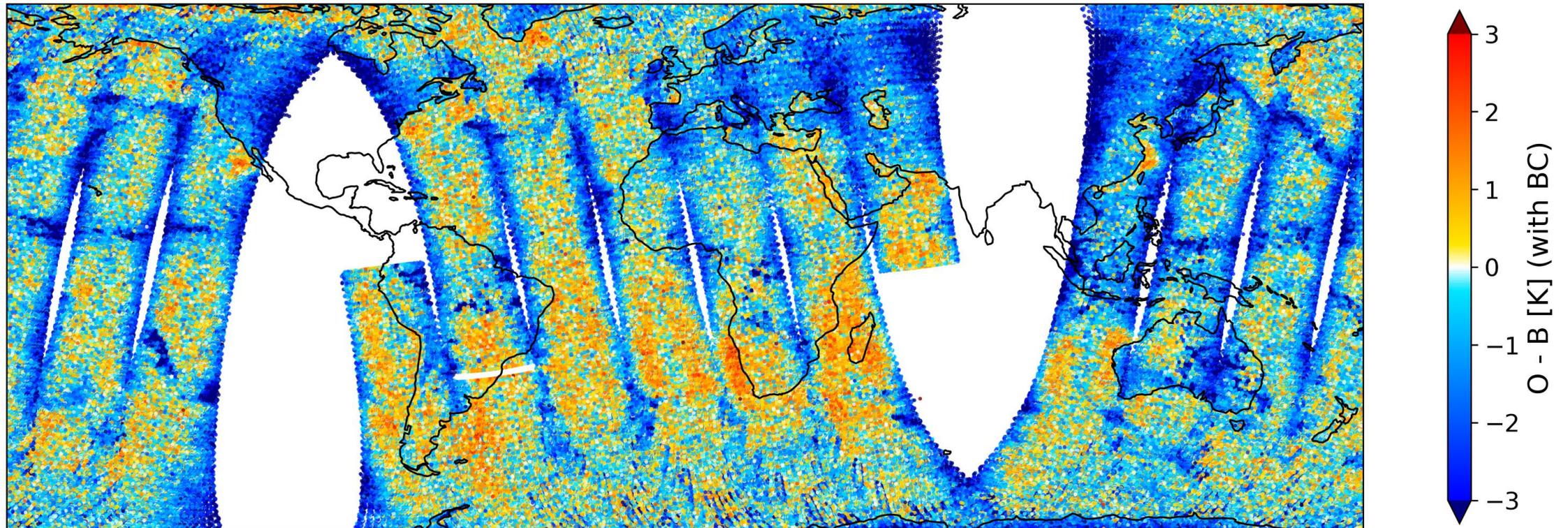
TROPICS Channel 9, 2021111000

TROPICS Initial Evaluation in the IFS

118.24GHz (Ch 7) is an UT/LS temperature channel

- Significant cross-scan biases remain after VarBC correction

- Some land/sea contrast visible
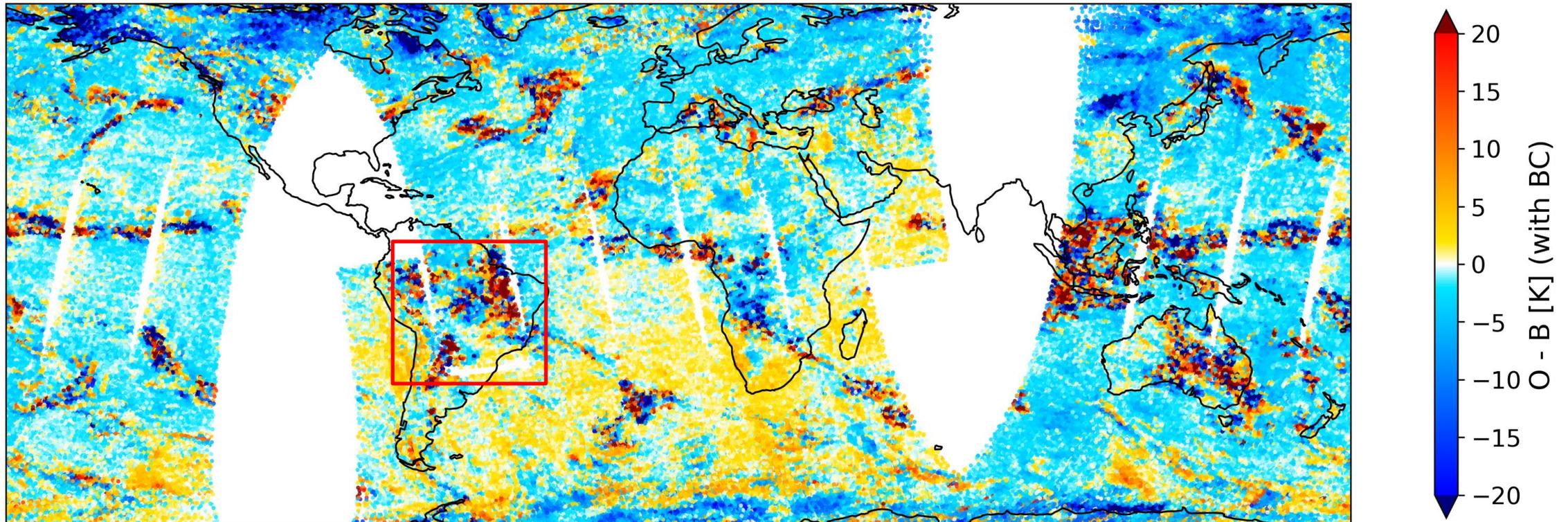
TROPICS Channel 7, 2021111000

TROPICS Initial Evaluation in the IFS

204.8 GHz (Ch 12) is an exciting new channel

- Window channel sees more scattering from frozen hydrometeors than any sensor flown before – a preview of e.g. MWS (229 GHz)

- Good test of scattering and continuum absorption for RTTOV-SCATT
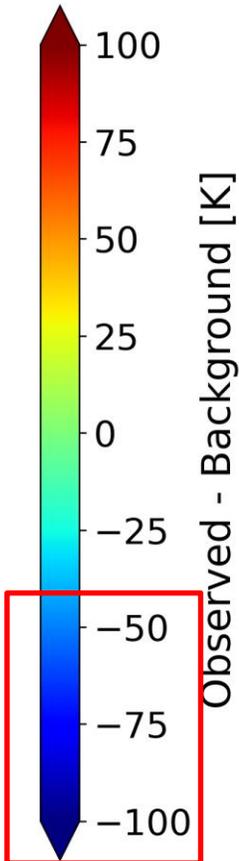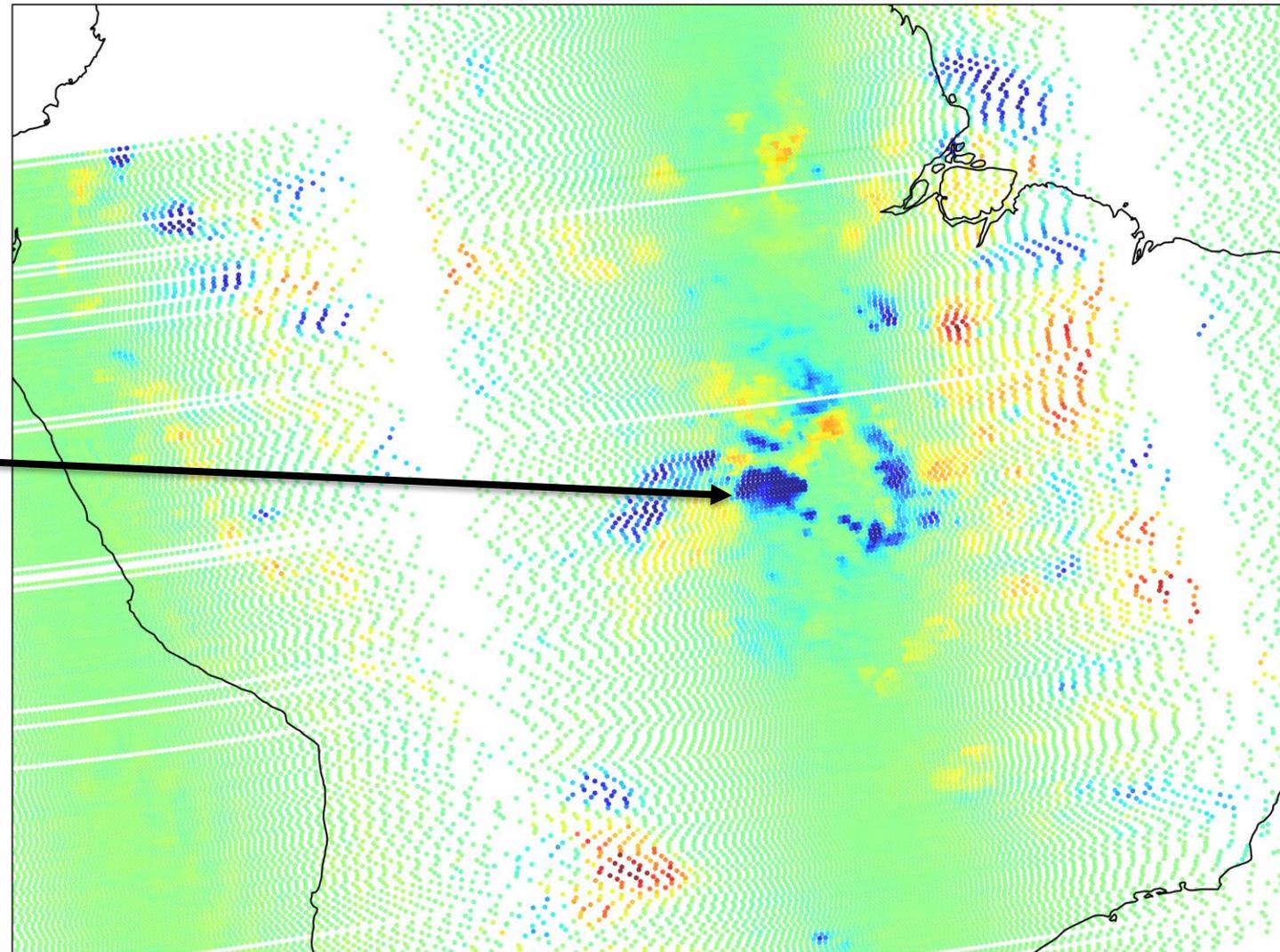
TROPICS Channel 12, 2021111000

TROPICS Initial Evaluation in the IFS

204.8 GHz (Ch 12) zoomed in

- Very large cloud signals

- Fine resolution (no averaging)

- 100K+ scattering (!)

TROPICS Channel 12, 2021111000

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TROPICS Initial Evaluation in the IFS

Comparing channels 11 & 12: 190 vs. 204 GHz

- Greater potential scattering signals at 204GHz – perhaps 10-20K
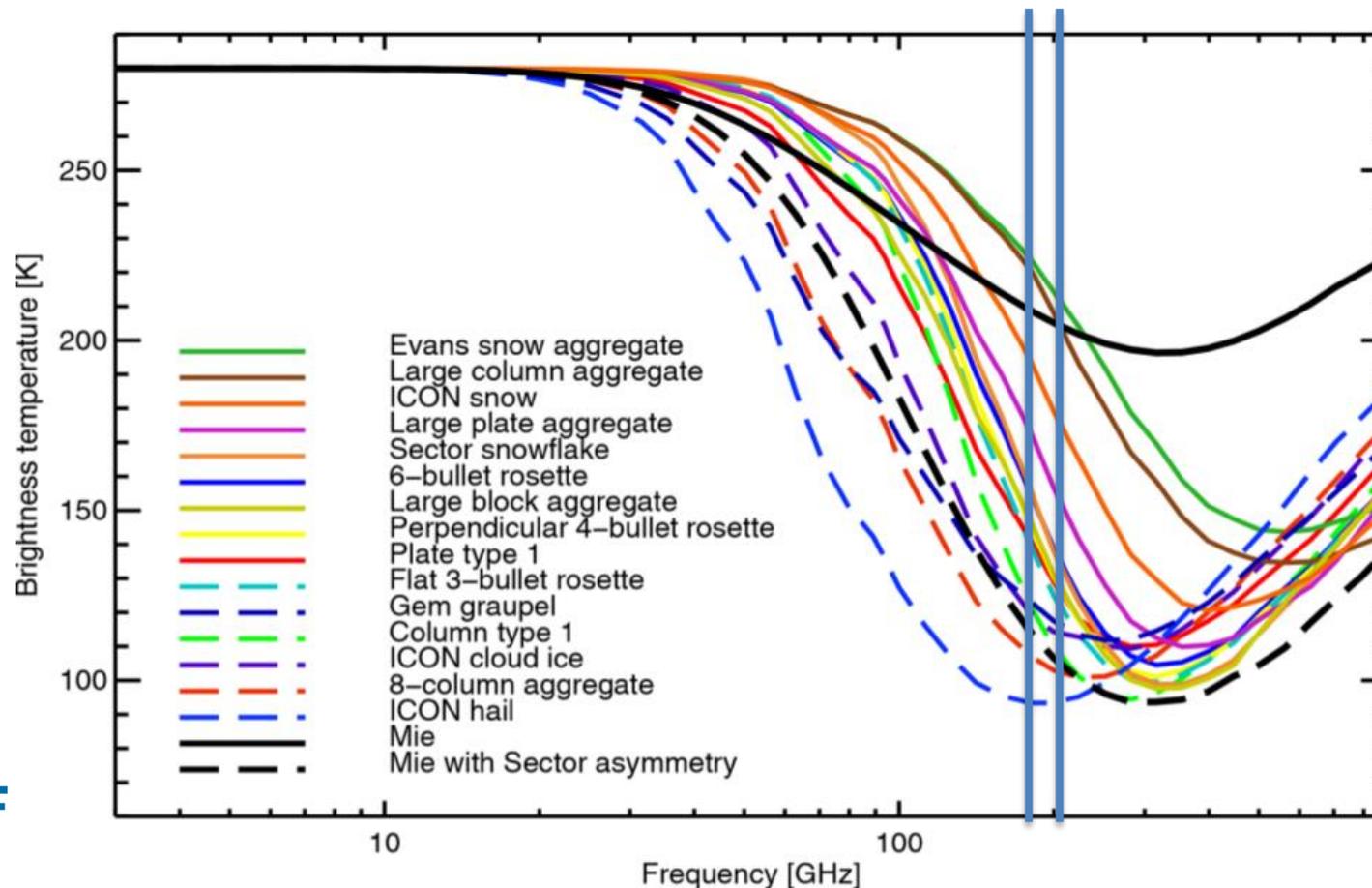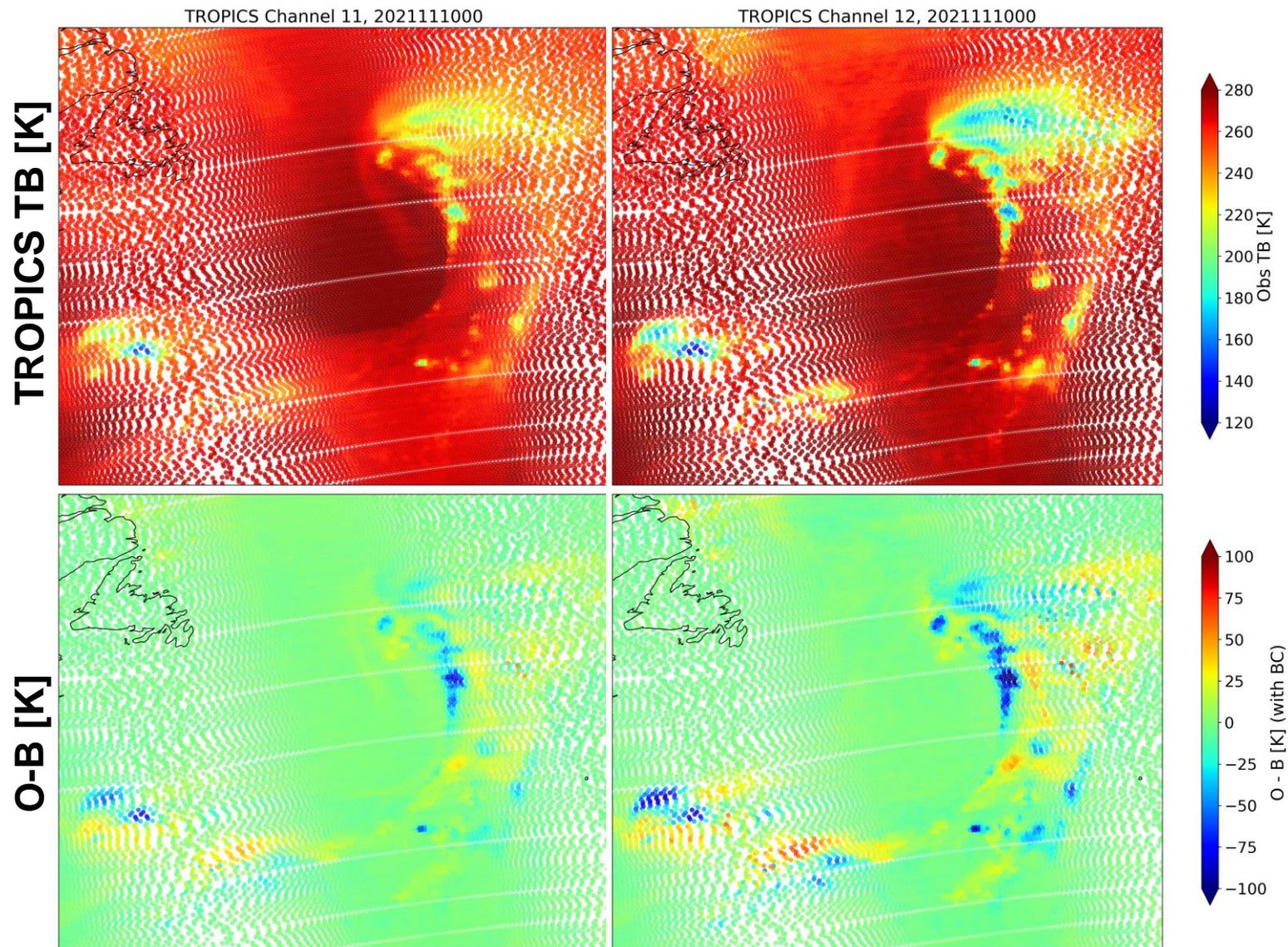
TROPICS Initial Evaluation in the IFS

Comparing channels 11 & 12

- North Atlantic extratropical cyclone in November

- Greater scattering signals seen for Ch 12

- Evidence of systematic bias in frontal cloud

- Both channels could help 4D-Var with misplaced cloud

- Extra information on ice/snow microphysics

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BUFR

BUFR data format is necessary for NWP assimilation

- ECMWF has volunteered to create a WMO-compliant BUFR template for TROPICS

- This needs to be approved by WMO to permit adoption 6 months later

- Opportunity for fast-track proposal to be heard in May

  - *Time is very tight to get a BUFR template proposed for use by November 2022*

- **A draft template will be circulated for comment to users who previously indicated interest in BUFR data**

  - **See**: https://github.com/wmo-im/BUFR4/issues/117

  - **Very quick feedback will be needed to meet the May-meeting deadline!**

- **Please comment to myself or Niels Bormann with any thoughts/concerns ASAP**

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Conclusions

Preliminary evaluation of Pathfinder data in the IFS

- TROPICS offers reasonable quality radiances that could be suitable for assimilation
  - Current QC appears adequate in later period examined

- Antenna pattern correction and mitigation of orbital biases should be priorities
  - Residual biases may require testing alternative VarBC predictors

- Calibration stability over longer timescales remains to be seen

- 204.8GHz offers unique hydrometeor information—more investigation needed

- G-band (183GHz) channels are crucial for measurable NWP impact

We look forward to receiving constellation data later this year

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