Initial Evaluation of TROPICS Radiances in the IFS

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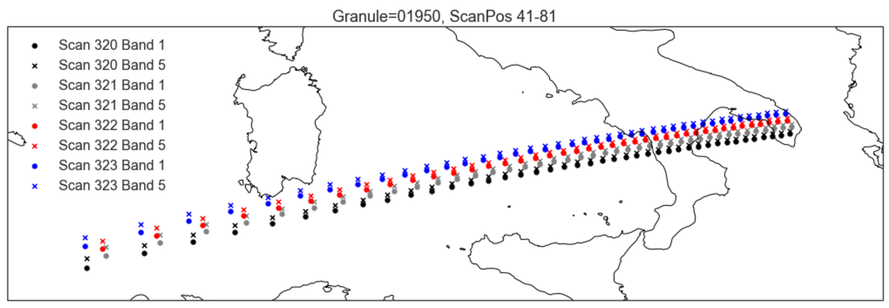
Abstract

One of the first small satellite constellations with an eye to operational NWP, the NASA TROPICS mission launched a pathfinder in summer 2021. The TROPICS payload is a microwave sounder (TMS) with a channel suite like MWHS-2, a sensor currently assimilated in the IFS (Integrated Forecasting System), but significantly smaller. Given the great interest in small satellite constellations at several space agencies, we evaluated TROPICS pathfinder data in the IFS to better understand issues that may arise from future small-satellite sensors.

The evaluation showed that TROPICS radiances were of reasonable quality at most channels, but some orbital biases related to instrument temperature were evident. Antenna pattern issues also may require attention for later constellation sensors to be suitable for assimilation. Longer-term calibration stability was not assessed. The unique geometry and channel suite of TROPICS provide some technical challenges for assimilation, and further long-term monitoring of the constellation will be required to establish whether operational assimilation is feasible.

Technical Implementation

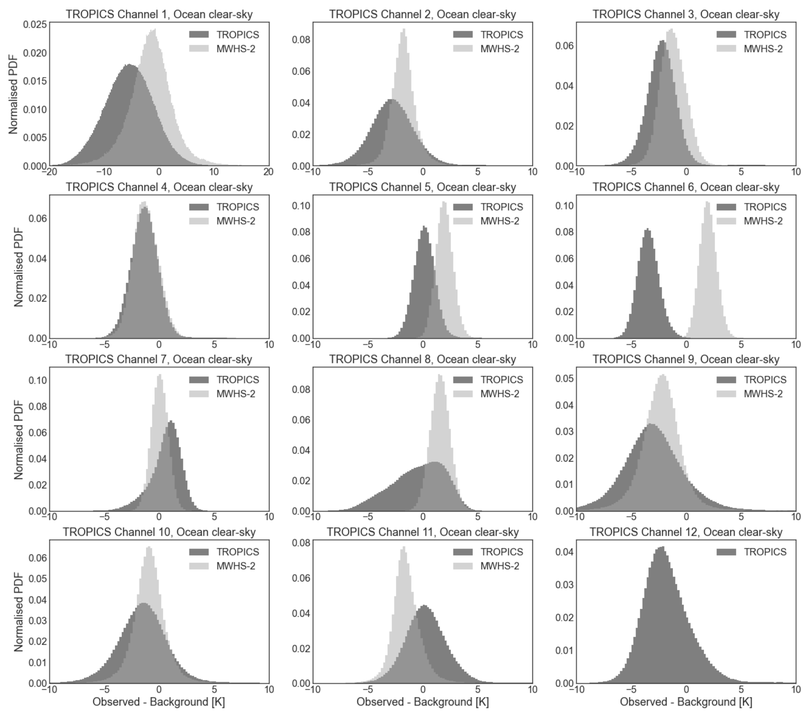
- Analysis uses 'provisional' TROPICS L1 data and RTTOV coefficients with original polarisations (now superseded by 'validated' L1 data and updated polarisation information)
- Tested in current operational version of the IFS – Cycle 47r3
- Evaluated in all-sky system, i.e. including clouds and precipitation
- Radiances simulated using RTTOV-SCATT v13.0 with improved representation of ice scattering (Geer et al. 2021)
- To simplify initial evaluation, assume all channels have same geolocation and viewing geometry (see below); TROPICS has 5 bands with two co-locations
- Any QC-flagged radiances in L1 data are removed in pre-processing
- Use scattering index (SI) for observation error model – a difference of 91GHz and 205 GHz channels



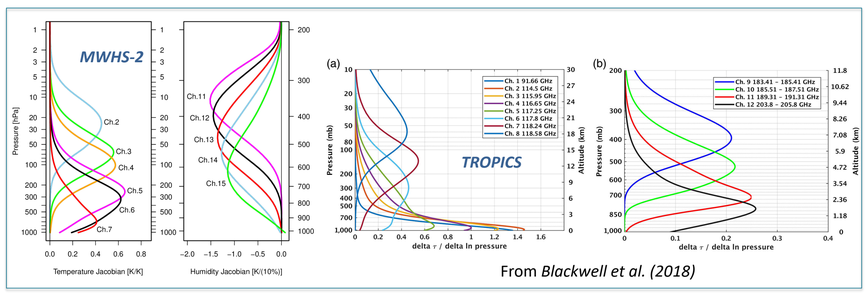
Four half scans from TROPICS over the Mediterranean. Geolocations of two bands are shown to demonstrate that channels are not co-located and there is variability in geolocation between scans for a given scan position.

Compare to MWHS-2 on FY-3D

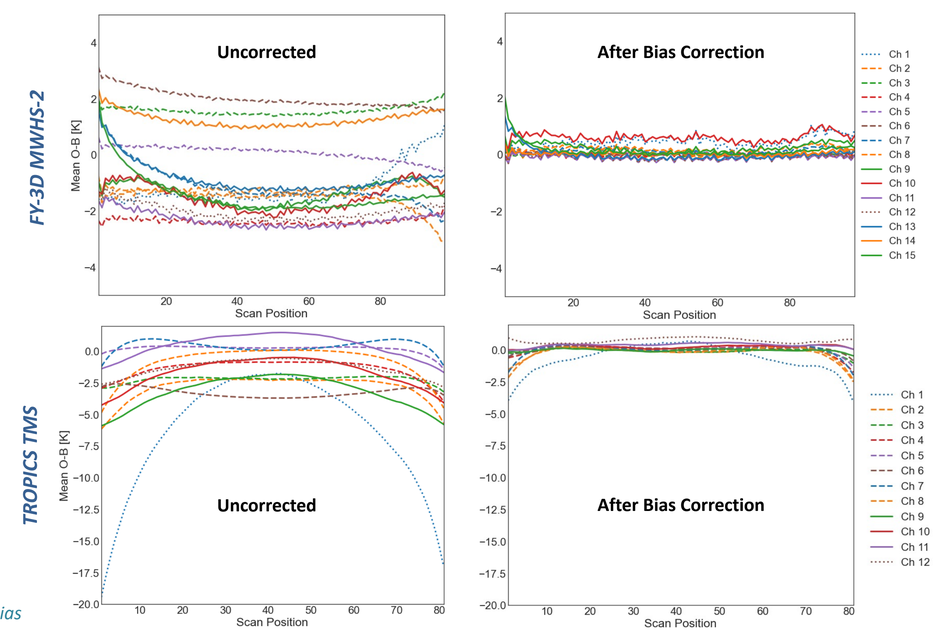
MWHS-2 on FY-3D is an operationally assimilated, cross-track sounder with similar 118 & 183 GHz channel suites



Normalised PDFs of O-B for clear-sky scenes over ocean. Data from November 2021, assessed prior to bias correction. The nearest MWHS-2 channel is matched up.
MWHS-2 FOV at nadir is 16km vs. 14.4km for TMS; integration time is 18ms for MWHS-2 and 8.3ms for TMS.



From *Blackwell et al. (2018)*



Assess global O-B statistics for clear-sky sample from TROPICS and MWHS-2
→ Clear-sky defined by SI<5K
→ Data from early Nov 2021

- PDFs show greater sample noise for 183 GHz channels (9-11) on TMS
- 118GHz channels are mixed—some show comparable performance to MWHS-2
- High-peaking 118GHz channels (7 & 8) exhibit non-Gaussian PDFs that indicate significant bias structures
- Most mean biases relative to the background are 0 to -4 K for TMS channels
- Many TMS channels exhibit scan position biases that may indicate deficiencies in the antenna pattern corrections
- A 3rd order polynomial in the viewing angle is able to correct most of the scan-bias in VarBC, but edge of scan remains problematic

Departures after bias correction

Assess bias structures after spinup of VarBC

Scan edge bias dominant; Land/sea contrast; Some striping

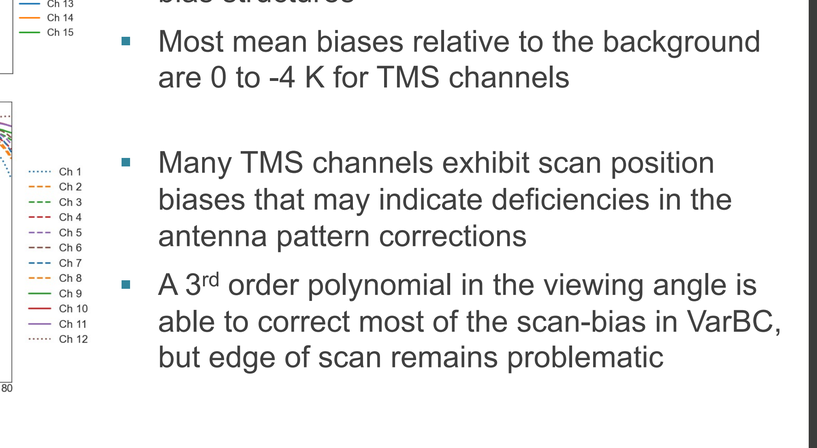
Generally good quality; Orbital bias visible

Orbital bias; Emissivity signal over snow; Large cloud signals for all-sky

Comparing channels 11 & 12

Novel 205GHz channel provides greater scattering sensitivity for all-sky

- North Atlantic extratropical cyclone in November
- Greater scattering signals seen for Ch 12 at 205 GHz
- Evidence of systematic bias in frontal cloud
- Both channels could help 4D-Var with misplaced cloud
- Extra information on ice/snow microphysics



References

Blackwell, W. J., and coauthors (2018), An overview of the TROPICS NASA earth venture mission, *QJRMS*, https://doi.org/10.1002/qj.3290

Geer, A. J., and coauthors (2021). Bulk hydrometeor optical properties for microwave and sub-millimetre radiative transfer in RTTOV-SCATT v13.0. *Geosci. Model Dev.*, https://gmd.copernicus.org/articles/14/7497/2021/