Effects of ATMS SRF Imbalances at G-Band Channels on Brightness Temperature Simulations

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Statement of Problem

- SRF imbalances were found to be present in J1 ATMS double-side water vapor sounding channels (G-band)
- An imbalance in the instrument SRF at side bands could affect the data utilization in NWP if the measured imbalances in SRFs are not taken into account in forward radiative transfer models

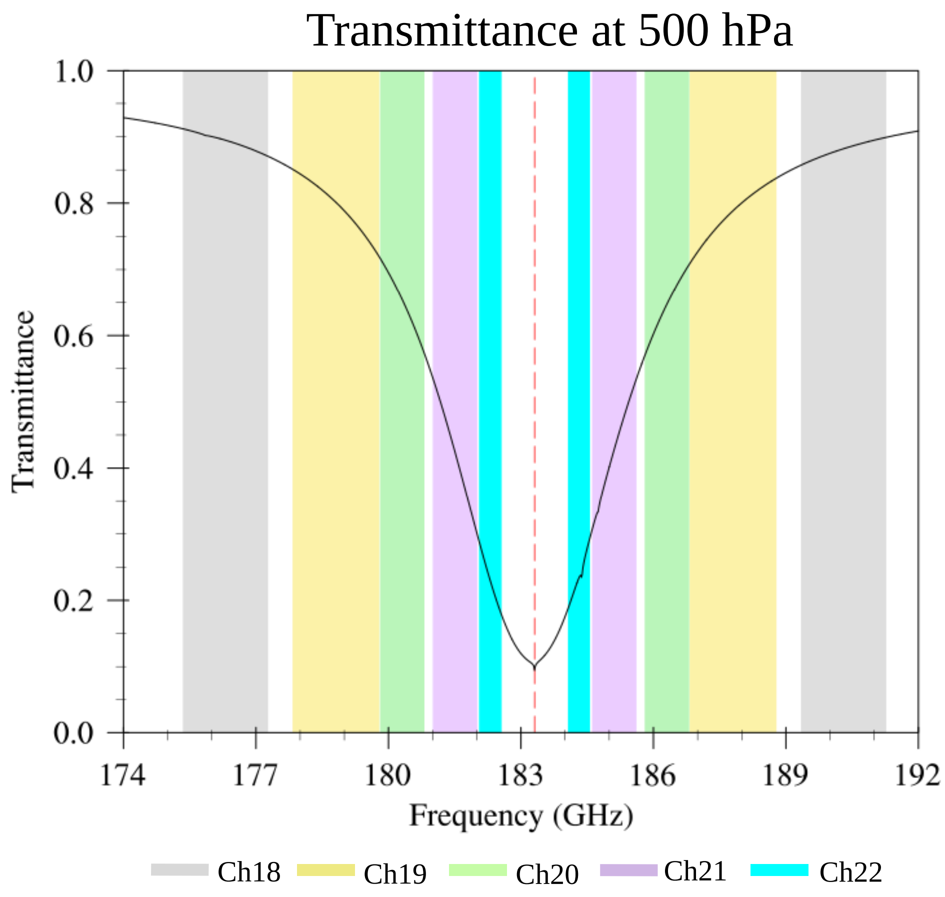
Action

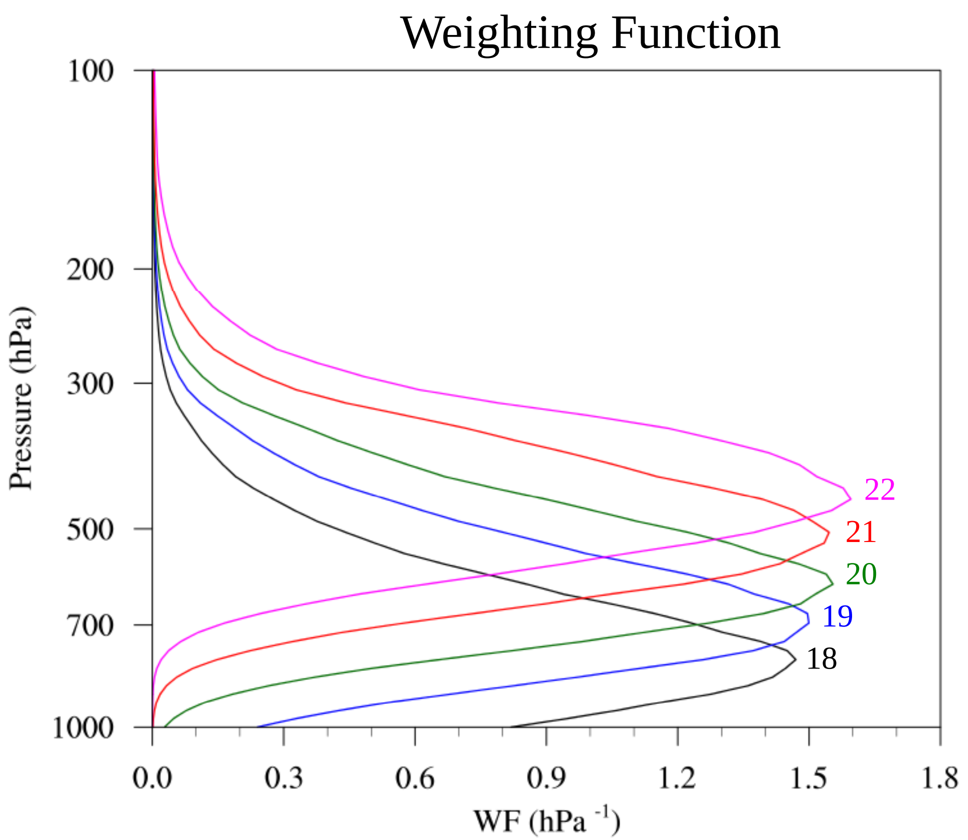
- Quantify impacts of such SRF imbalance on brightness temperature simulations

  — Sensitivity study with four scenarios of SRF distributions

  — Comparison of MonoRTM simulations using J1 ATMS measured SRFs with those from using the boxcar SRF

Atmospheric Transmittance and Weighting Functions of ATMS G-band Channels

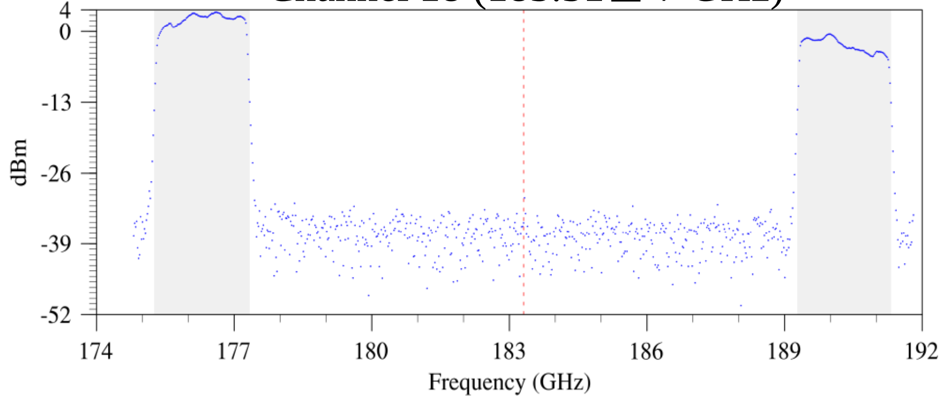




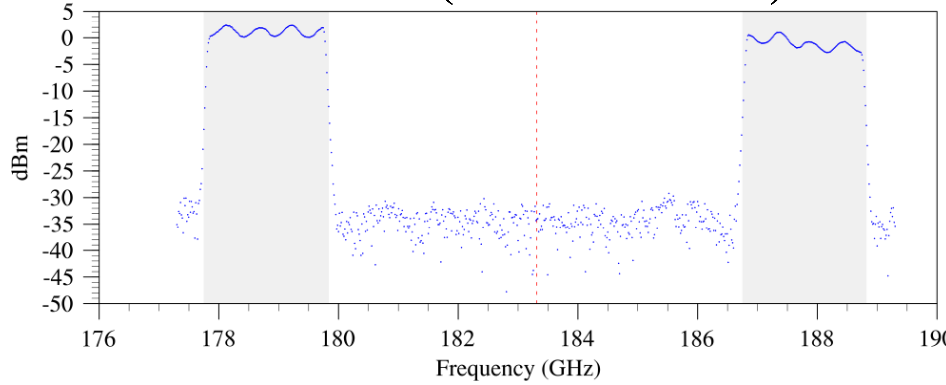
ATMS G-band channels 18-22 are located on a strong H_2O absorption line centered at 183 GHz frequency.

J1 ATMS G-Band SRFs

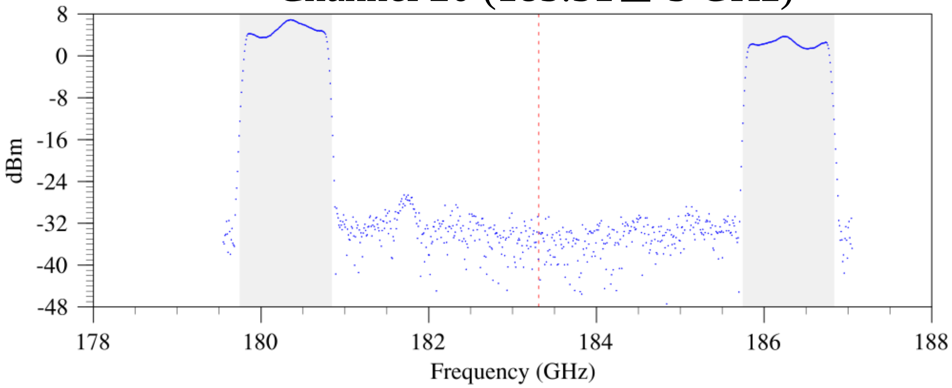
Channel 18 (183.31± 7 GHz)



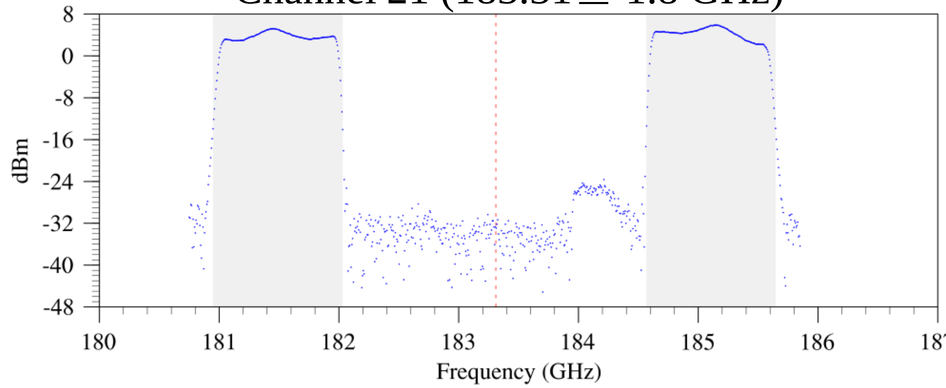
Channel 19 (183.31± 4.5 GHz)



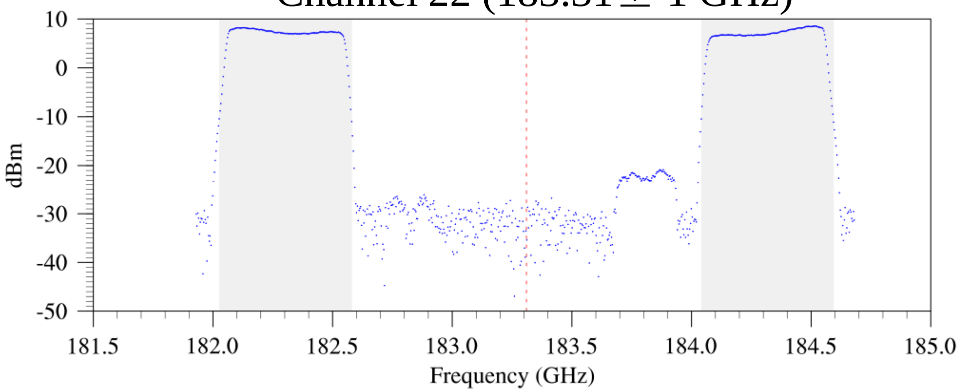
Channel 20 (183.31± 3 GHz)



Channel 21 (183.31± 1.8 GHz)



Channel 22 (183.31± 1 GHz)



Strong SRF imbalances are found for J1 ATMS channels 18-20.

The requirement of the mean gain ratio for the side-band SRF is less than 2 dB.

SRF data obtained at primary local oscillator with baseplate temperature 20°C

Calculation of SRF Imbalance for J1 ATMS Channel 18

Original lab-measured SRF

↓

Truncate the SRF at -20 dB

↓

Compute average gain at each side band

$$\overline{G}_{low\ band} = \frac{\int_{f_1}^{f_2} G(f)\,df}{f_2 - f_1}$$

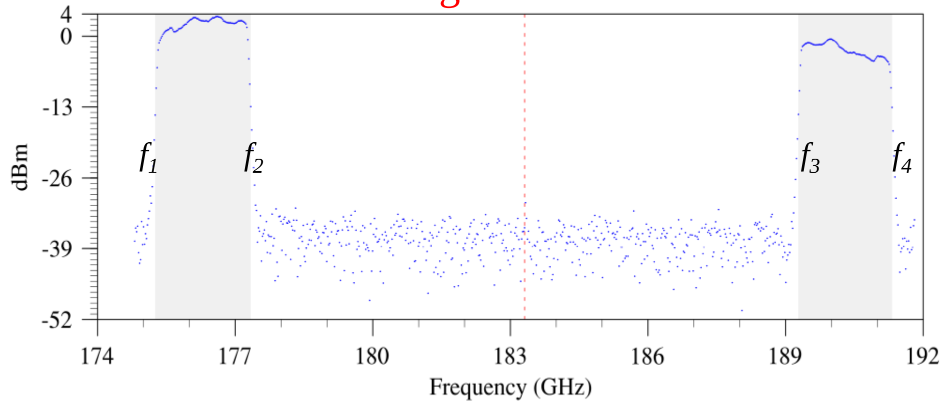
$$\overline{G}_{high\ band} = \frac{\int_{f3}^{f_4} G(f)\,df}{f_4 - f_3}$$

↓

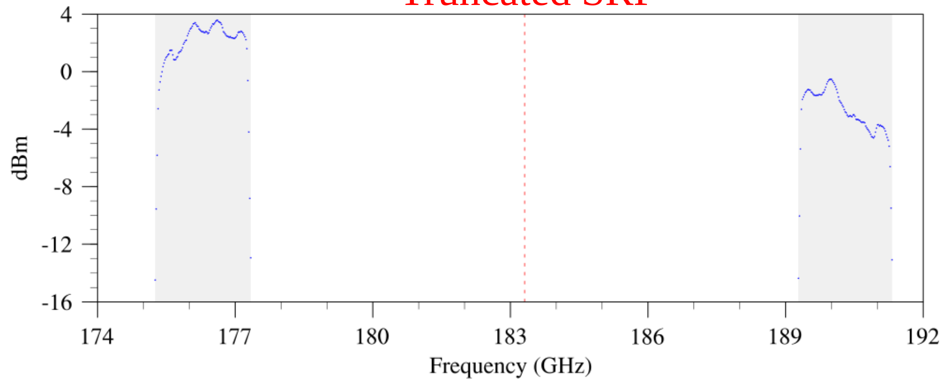
Compute the imbalance (unit: dB)

$$\Delta\overline{G} = \overline{G}_{low\ band} - \overline{G}_{high\ band}$$

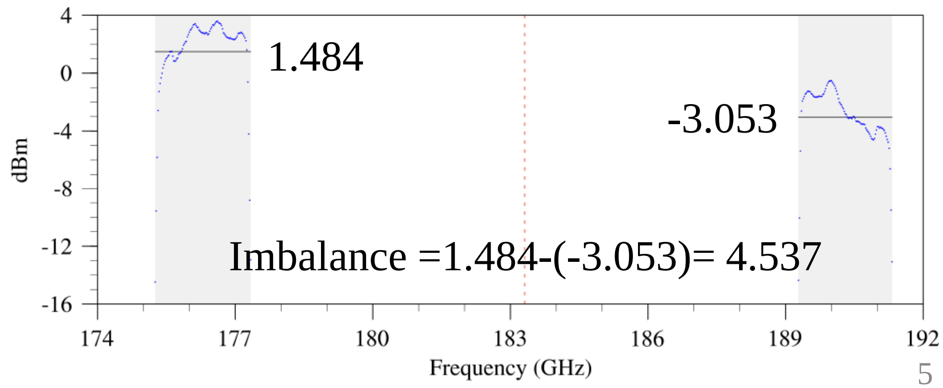
Original lab SRF



Truncated SRF



SRF Imbalance



J1 ATMS SRF Imbalances for G-Band Channels

	G-Band Channels				
	18	19	20	21	22
STAR	4.537	1.997	2.419	-0.482	0.205
NG	4.949	2.228	2.625	-0.607	0.263

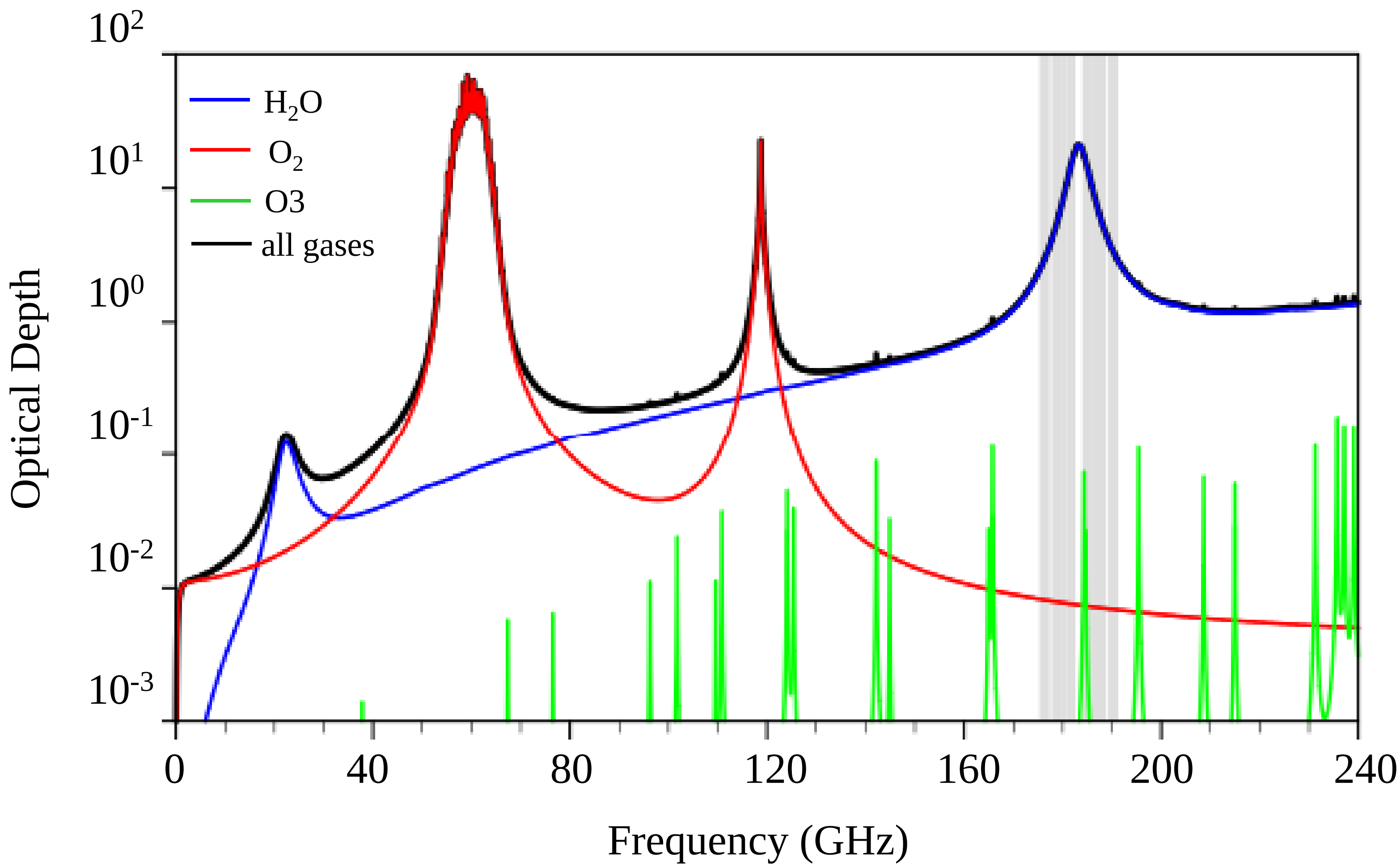
- STAR's imbalance values are close to NG's evaluation
- The SRF imbalances of J1 ATMS channels 18 and 20 are more than 4 dB and 2 dB, respectively. They exceed the specification.

Understanding the Impact of J1 ATMS SRF Imbalances on Brightness Temperature Simulations

Model Simulation:

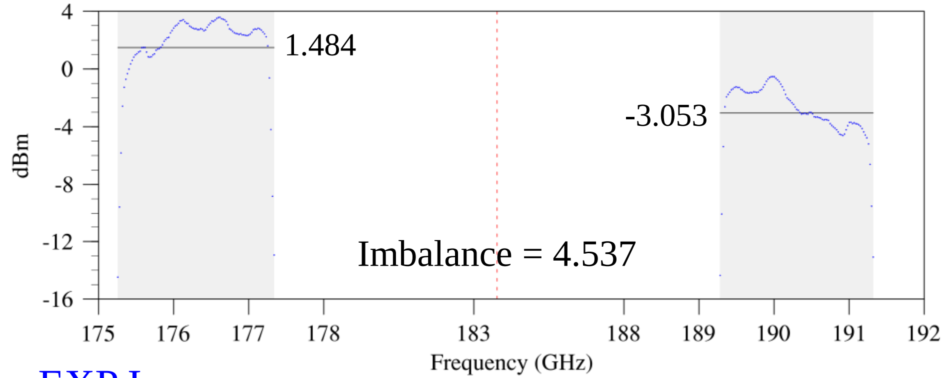
- Monochromatic Radiative Transfer Model (MonoRTM)
  — Accurate atmospheric spectroscopy data base
  — Only gaseous absorption
  — Vertical stratification
- Input to MonoRTM
  — ECMWF analysis
- Cloud detection algorithm
  — Cloud liquid water path (LWP) greater than 0.05 kg m^{-2}

MonoRTM Simulated Optical Depths of H_2O, O_2, O_3 and All Gases

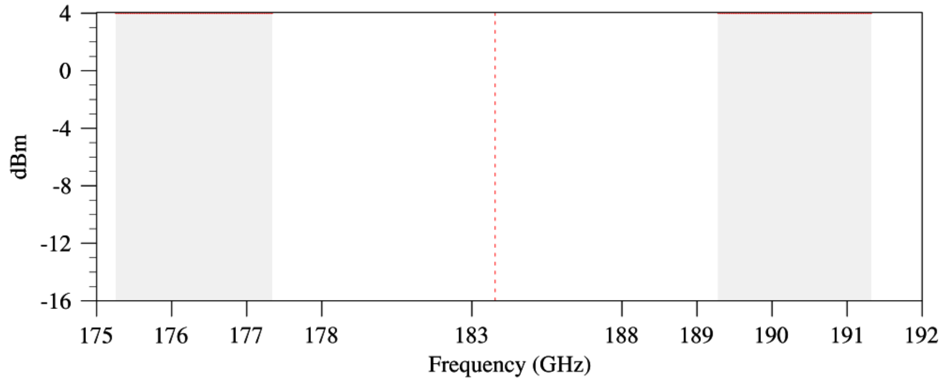


Four Scenarios for Removing SRF Imbalances

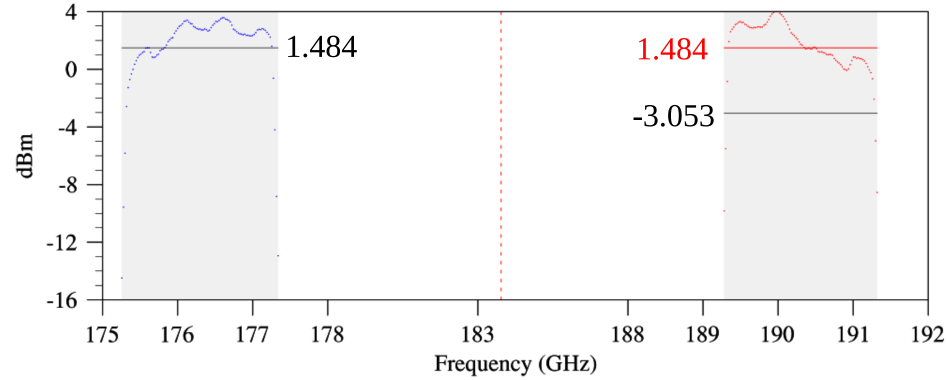
Truncated SRF



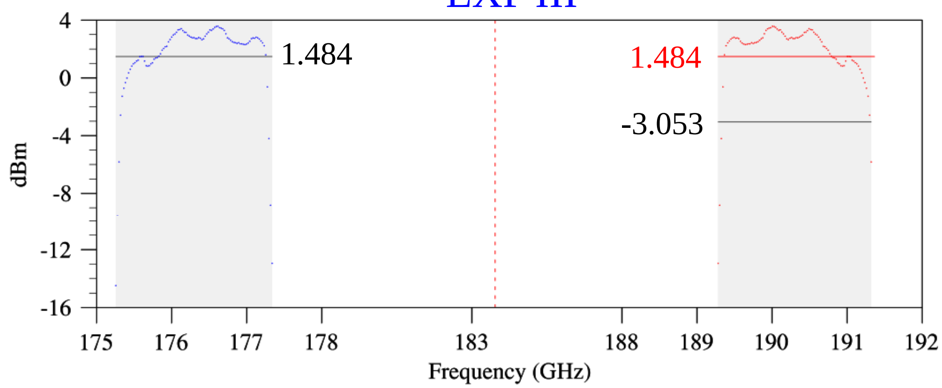
EXP I



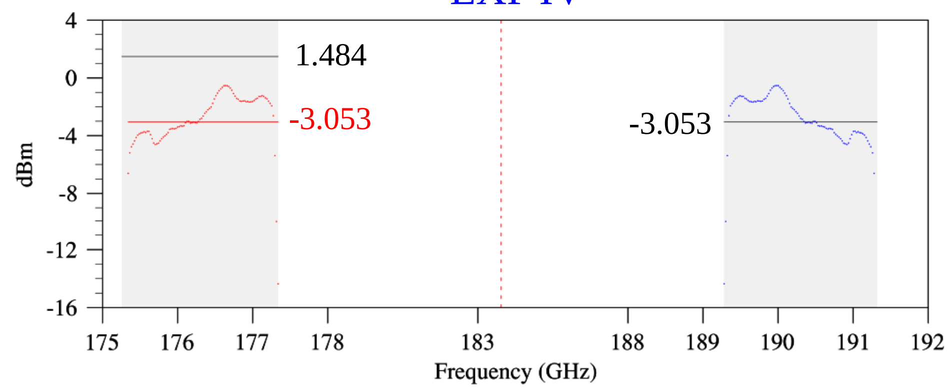
EXP II



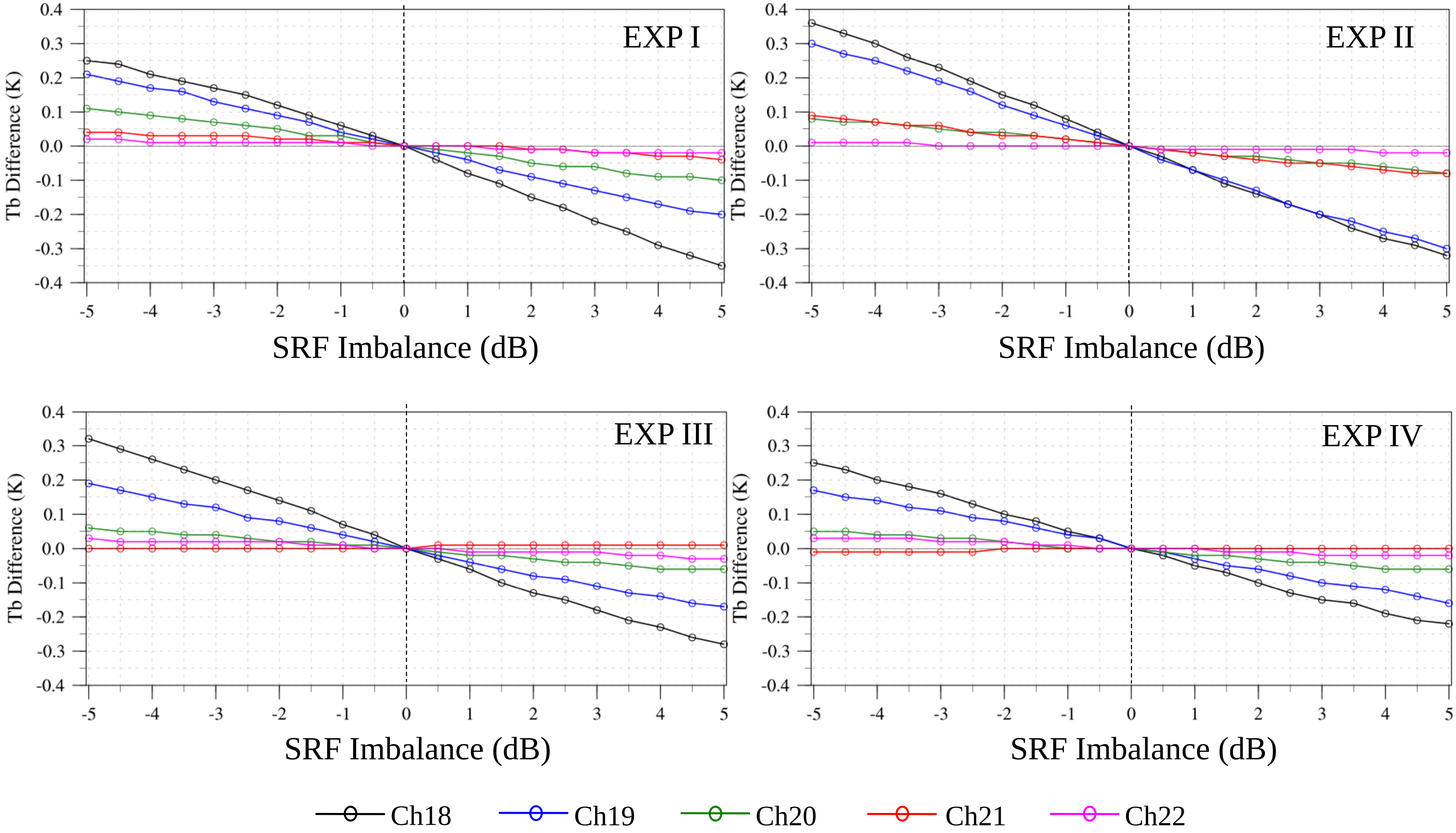
EXP III



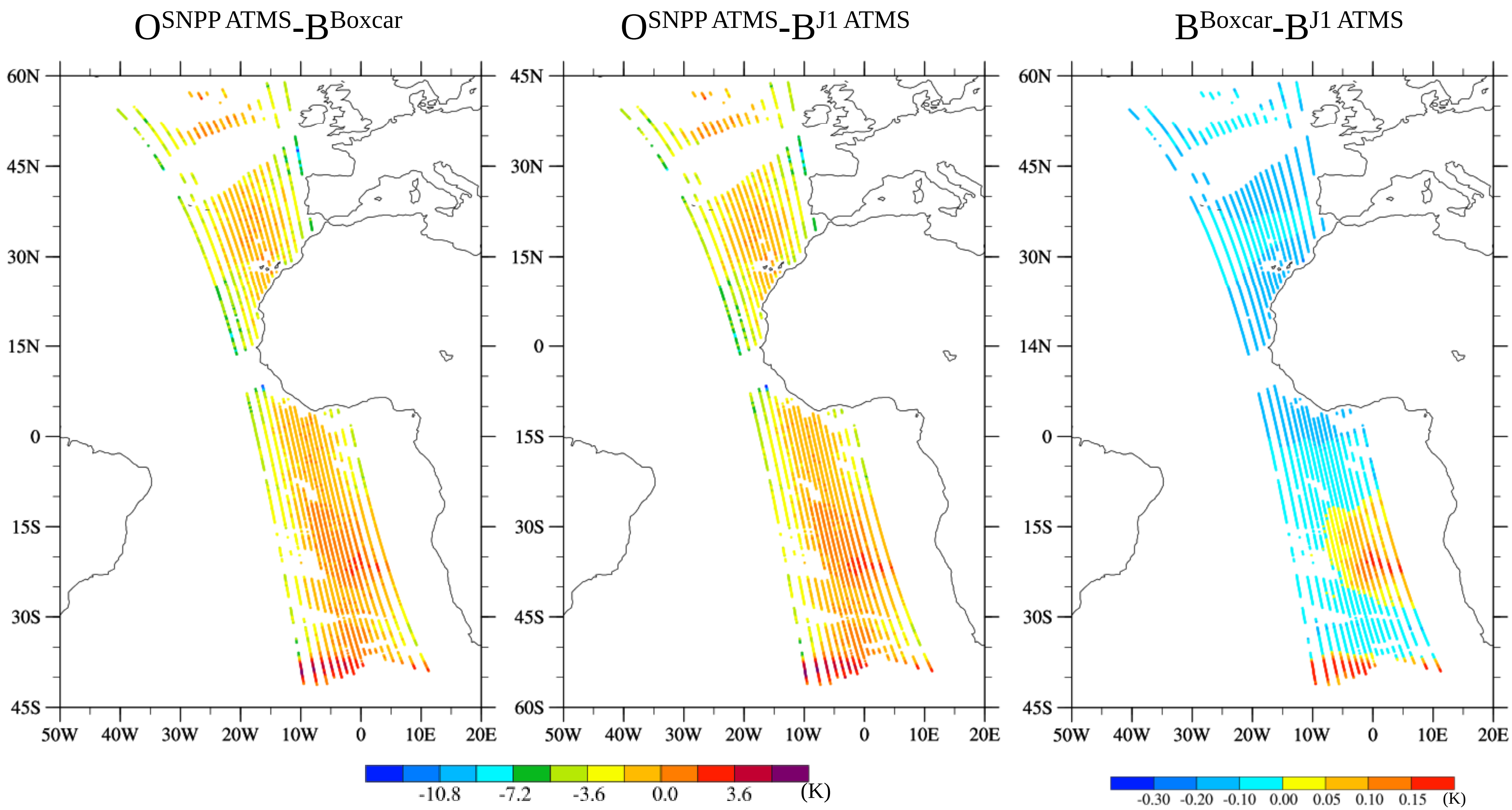
EXP IV



Sensitivity of TB to SRF Imbalances in Four Experiments

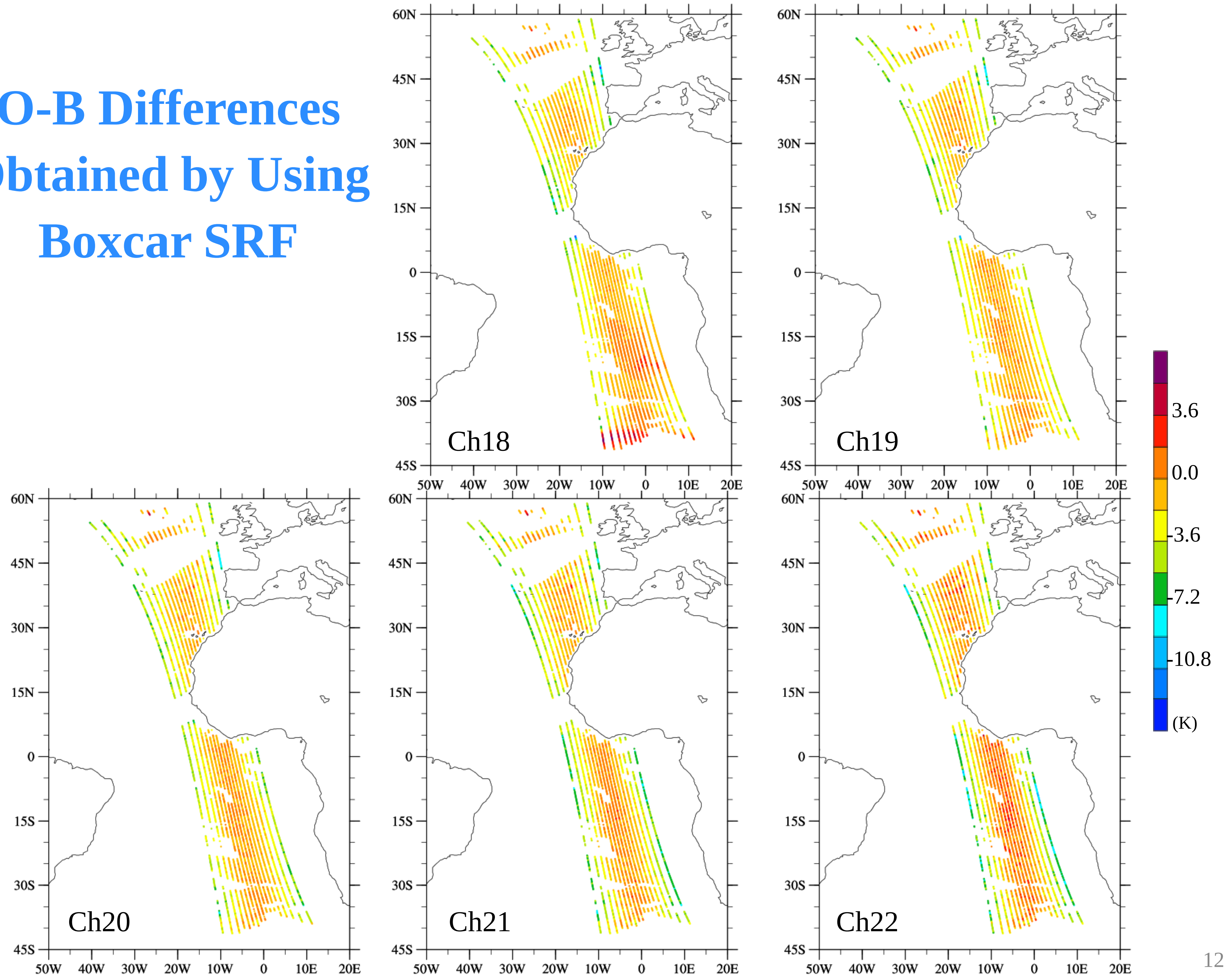


O-B Differences with B Simulated by Using Boxcar or J1 ATMS SRF for Channel 18



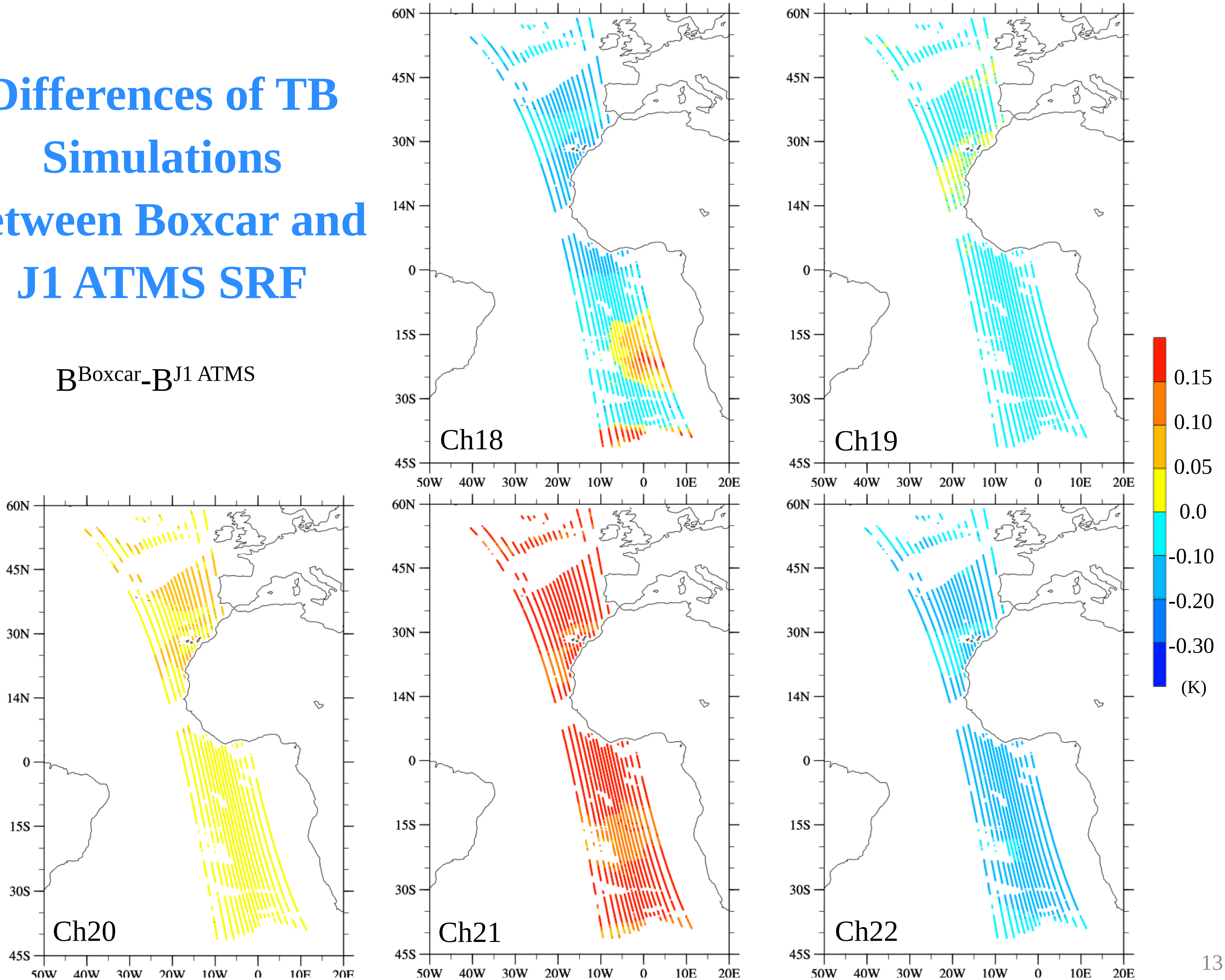
An ATMS swath over ocean in clear-sky conditions at the Suomi NPP ascending node during 1345-1418 UTC 20 July 2016

O-B Differences Obtained by Using Boxcar SRF



Differences of TB Simulations between Boxcar and J1 ATMS SRF

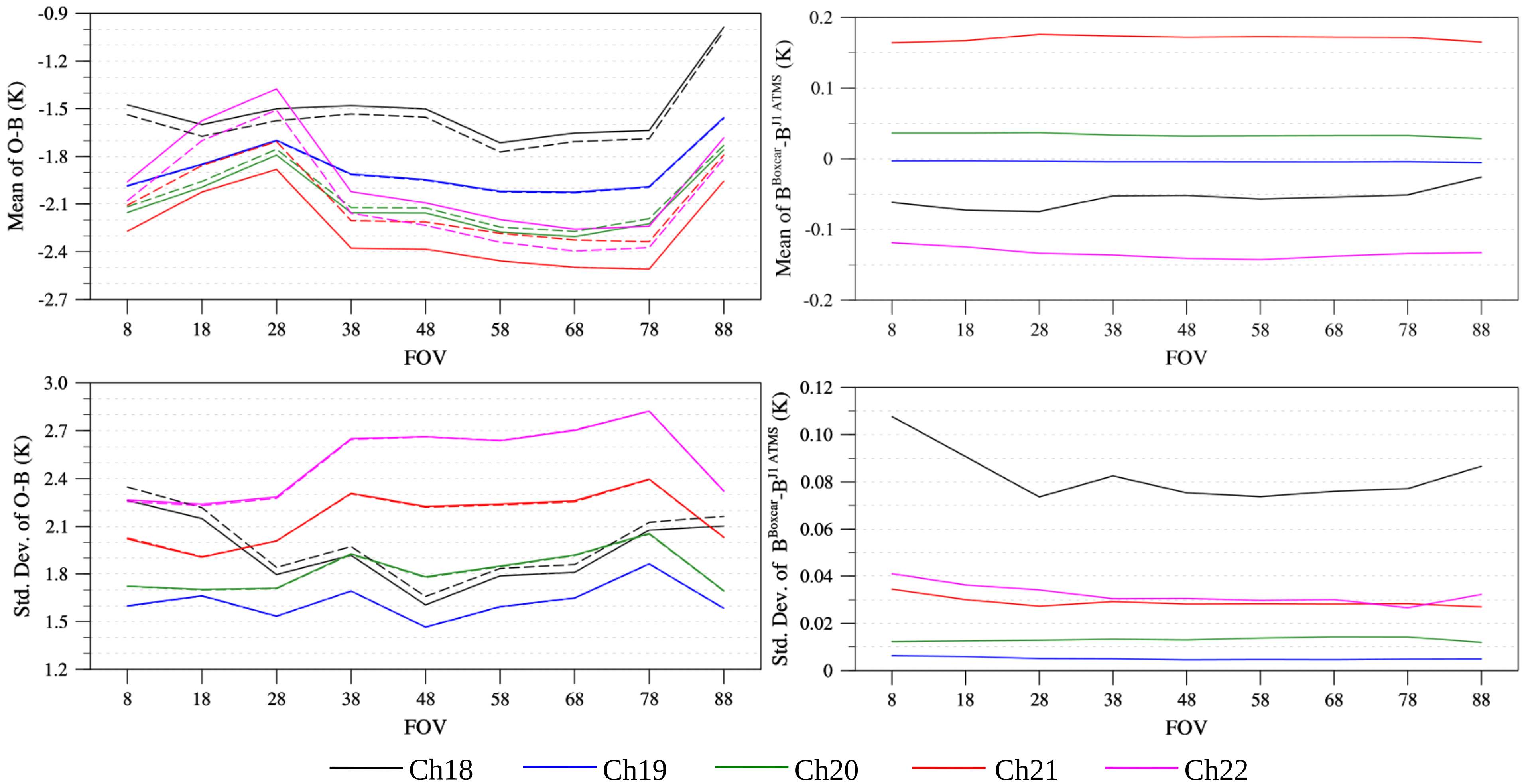
$B^{Boxcar}-B^{J1\ ATMS}$



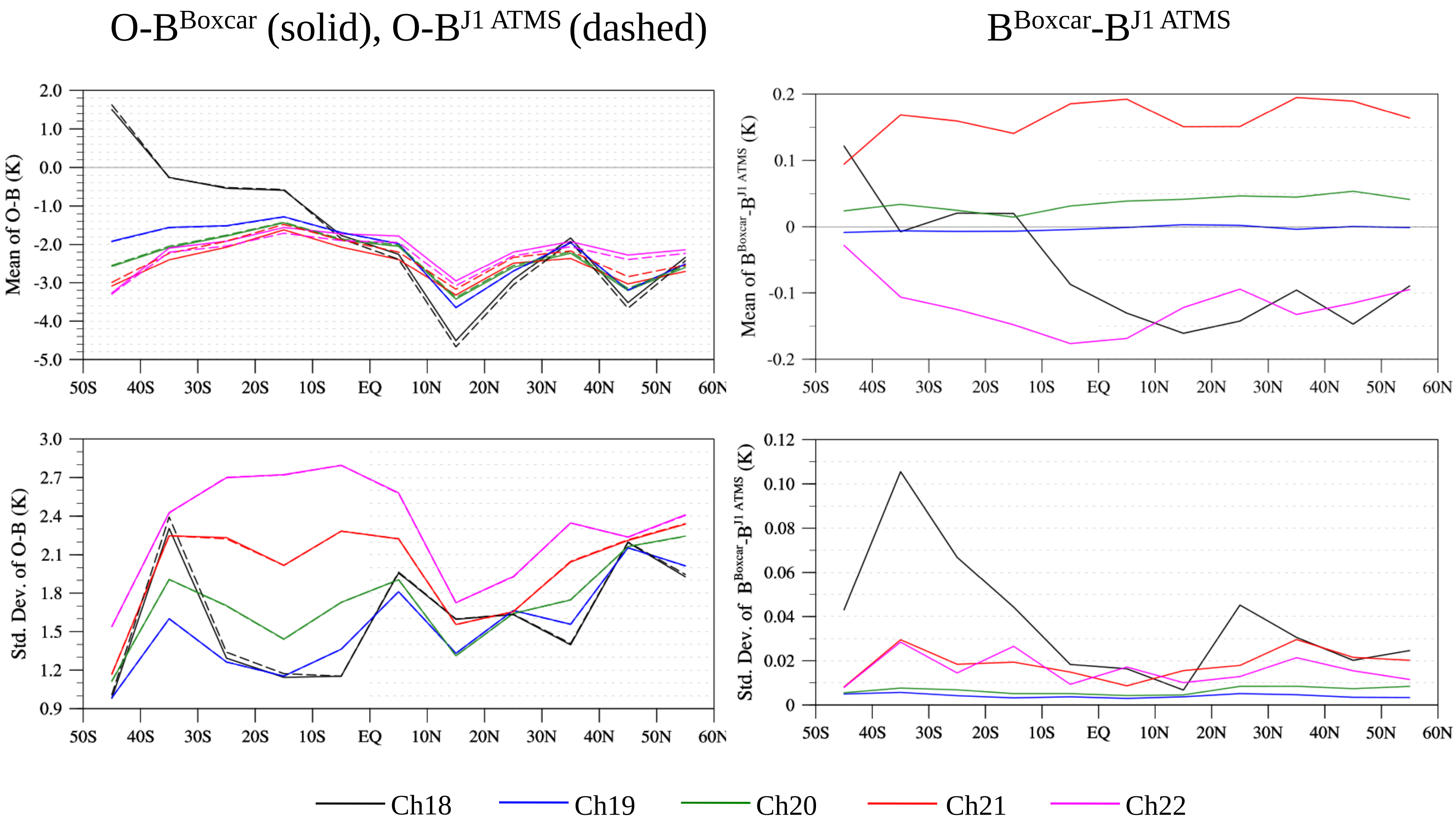
Scan Angle Dependence of O-B Using Boxcar or J1 ATMS SRF

O-B$^{\mathrm{Boxcar}}$ (solid), O-B$^{\mathrm{J1\ ATMS}}$ (dashed)

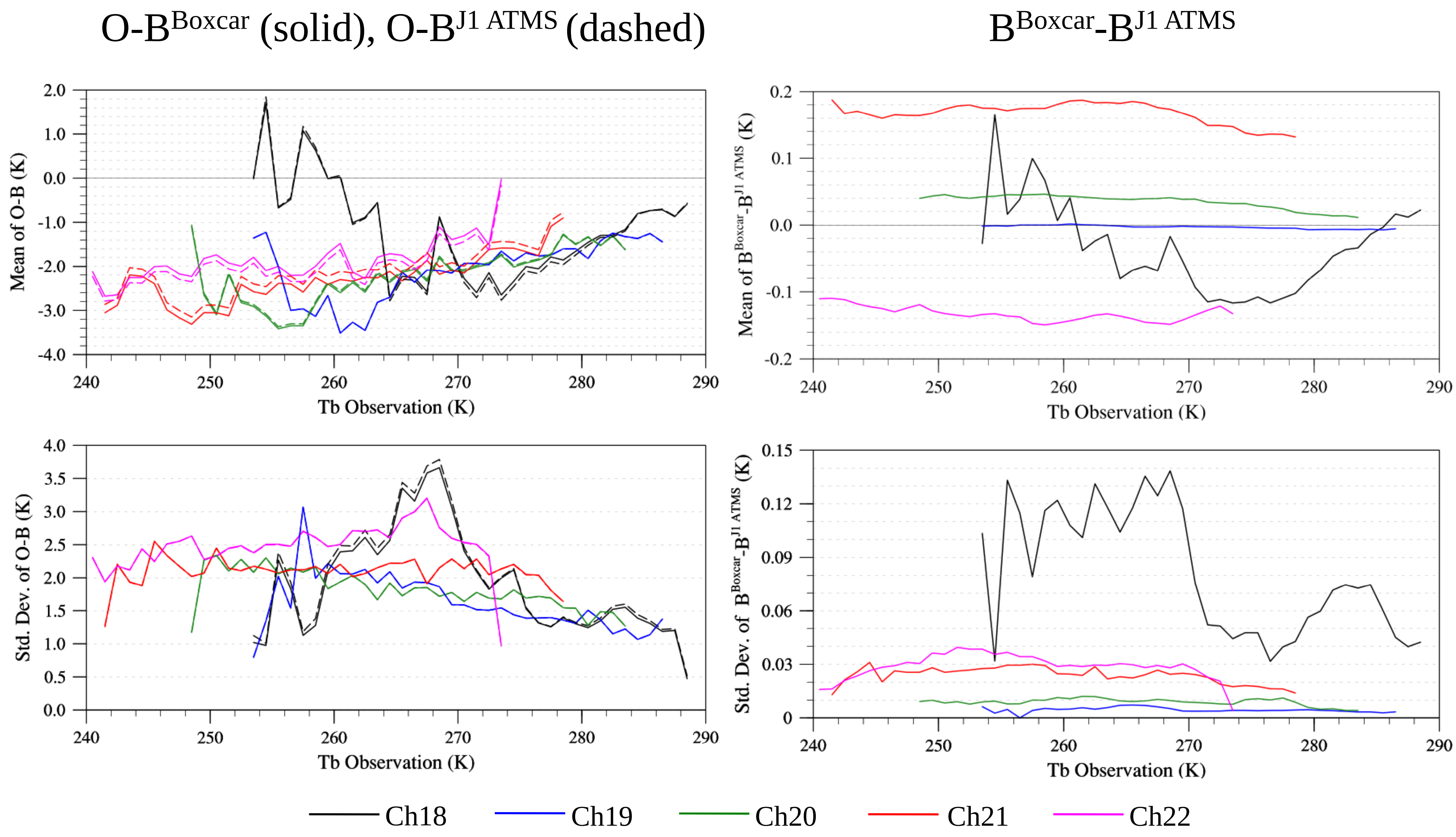
B$^{\mathrm{Boxcar}}$-B$^{\mathrm{J1\ ATMS}}$



Latitudinal Dependence of O-B Using Boxcar or J1 ATMS SRF



Scene Dependence of O-B Using Boxcar or J1 ATMS SRF



Summary and Conclusions

- The SRF imbalance for J1 ATMS channel 18 and 20 exceed the 2 dB specification for the side-band SRF.
- A sensitivity study showed that the TB can be different by more than 0.1 K when the SRF imbalance varies between 2 dB and 5 dB.
- The impacts of J1 SRF vs. Boxcar on simulations of G-band brightness temperatures were evaluated using MonoRTM. The mean difference is ~ 0.15 K for channels 21 and 22.
- This study suggests a necessity of providing the actual SRFs from all the sidebands carefully measured by the instrument vendor to numerical weather prediction (NWP) users to build an accurate fast RTM for satellite data assimilation in NWP models.