The CrIS/VIIRS IMG product, and Radiometric Comparisons of CrIS and VIIRS

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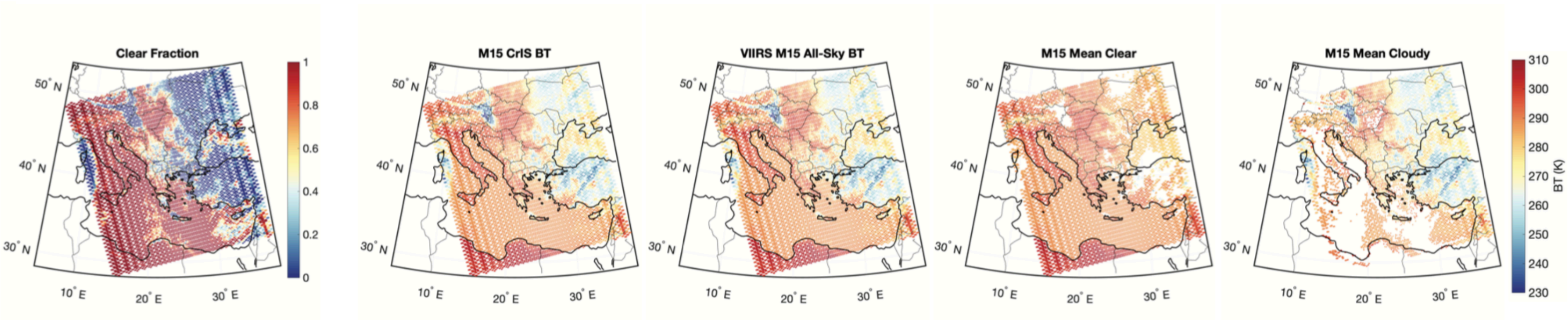
CrIS/VIIRS IMG Product

- A "value added" product, that provides VIIRS to CrIS footprint collocation information in small, easy to use files with common file granulation to the NASA VIIRS and CrIS L1b products
- Collocate CrIS FOVs with VIIRS Cloud Mask and Radiances/Reflectances
- For each CrIS and corresponding VIIRS L1B granule, CrIS/VIIRS collocation is performed, and the indices of VIIRS pixels within each CrIS footprint are written to an imager to sounder collocation file **(IMG_COL, 12-15 MB per file)**
- A corresponding **IMG file** is also produced, containing statistics of the VIIRS (MVCM) cloud mask and VIIRS radiances and reflectances that have been collocated within each CrIS footprint **(IMG, ~6 MB per file)**
- One-to-one relation to the {9 x 30 x 45} CrIS footprints in the L1b files
- Potential future work to create additional collocated fields or files, e.g.
    - VIIRS clouds heights, aerosols, etc
    - Surface temperature, re-analysis fields, carbon tracker, etc.
- SNPP product available at the GES DISC (see Ruth M's presentation). NOAA-20 product to be available when VIIRS cloud mask product is available.



➢ Example applications: Help in interpreting trace gas retrievals; Single footprint cloud clearing

Long term stability

Towards a Traceable Climate Service: Assessment of Quality and Usability of Essential Climate Variables, Zeng et al., 2019

"The climate data and information products (i.e., from satellite, in-situ and reanalysis) shall be fully traceable, adequately documented and uncertainty quantified and can provide sufficient guidance for users to address their specific needs and feedbacks."

Satellite Instrument Calibration for Measuring Global Climate Change. Ohring et al., 2005:

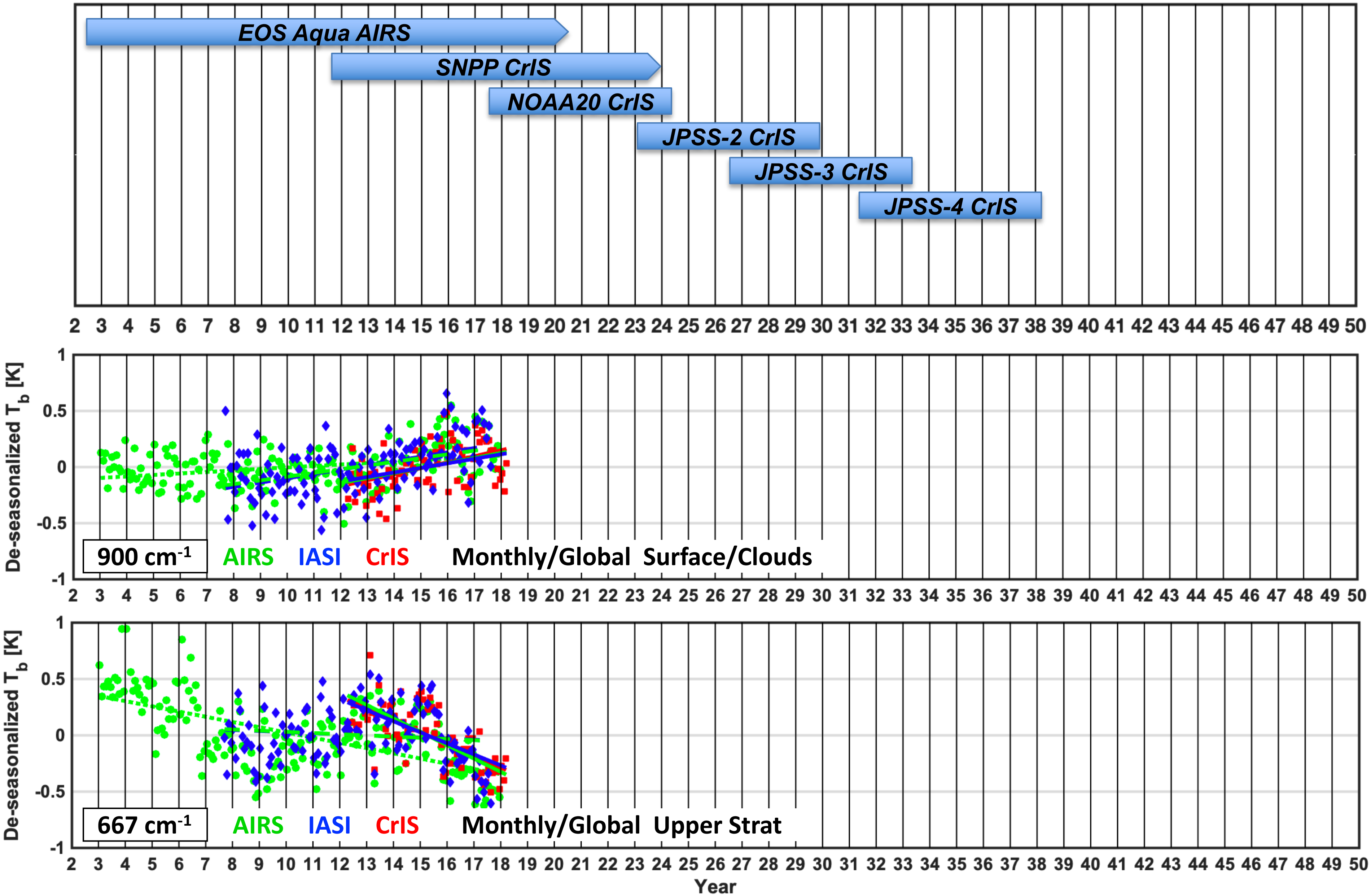
- *Required stability of 0.004 K/Year for temperature soundings for climate studies* — ***40 mK/decade***

The Reprocessed S-NPP and JPSS Satellite Observations, Zou et al, in press:

- *VIIRS Thermal IR: "… both instruments [Aqua MODIS and SNPP VIIRS] have achieved an absolute radiometric stability within ±0.0016 K per year* — ***16 mK/decade***
- *ATMS: … by comparing with Aqua AMSU-A, Zou et al. (2018) suggest that the reprocessed S-NPP/ATMS instruments have achieved absolute radiometric stability in the measured atmospheric temperatures within 0.004 K per year for the time period between 2012 and 2018 for all analyzed channels.* — ***40 mK/decade***

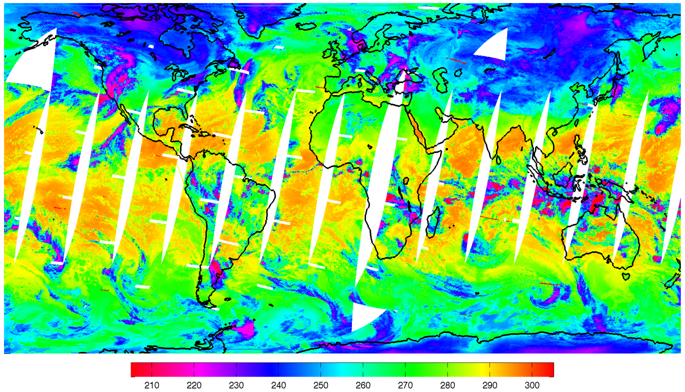
➢ ***For CrIS, comparisons with VIIRS provide one good way to assess long term radiometric stability …***

Example Radiance Trends from Hyperspectral IR Sounders

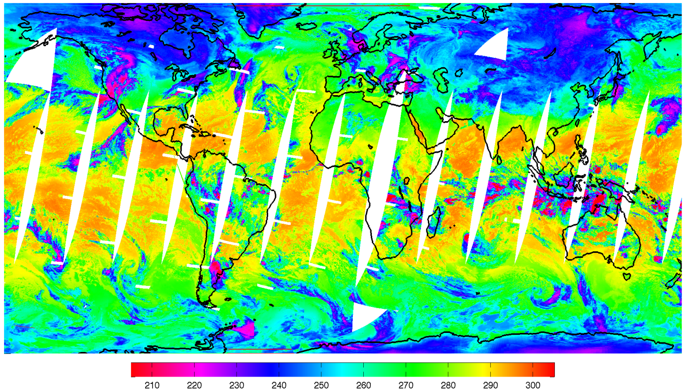


CrIS/VIIRS Comparison Methodology

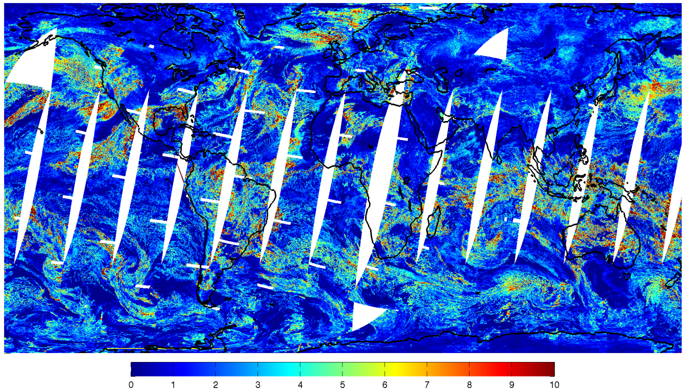
1) CrIS convolved with VIIRS SRF



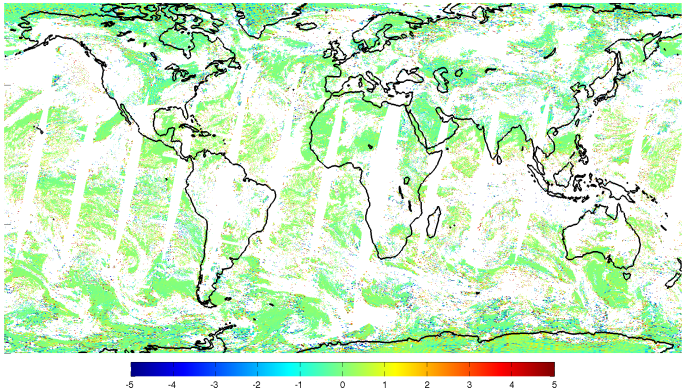
2) VIIRS mean within CrIS footprint

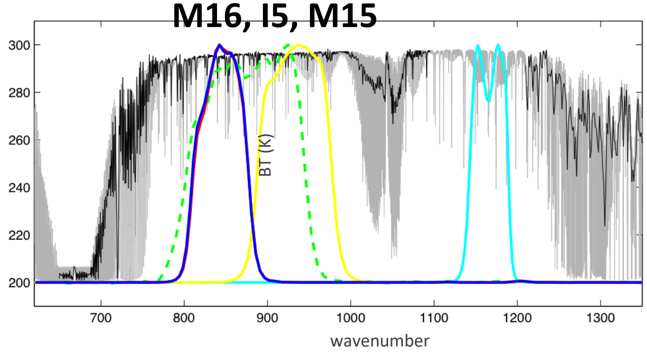


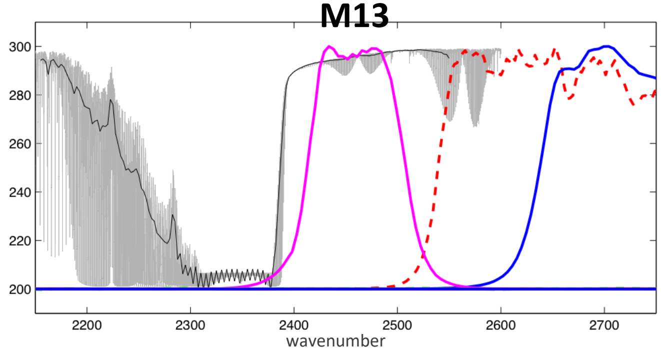
3) VIIRS StdDev within CrIS footprint



4) VIIRS-CrIS differences for homogeneous footprints

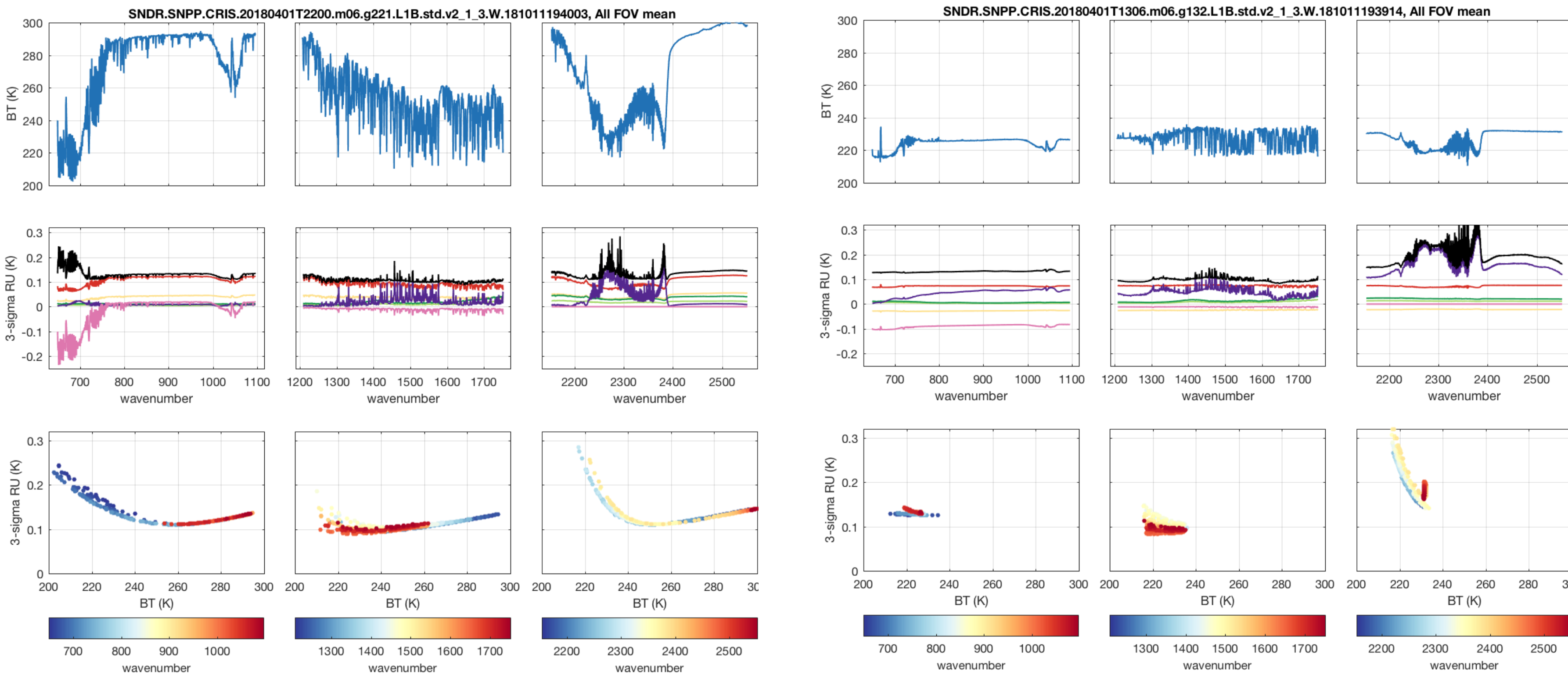


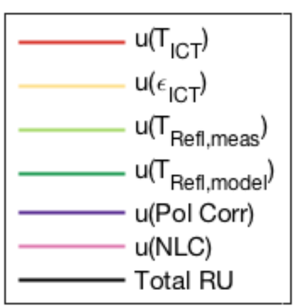




Example CrIS Radiometric Uncertainties

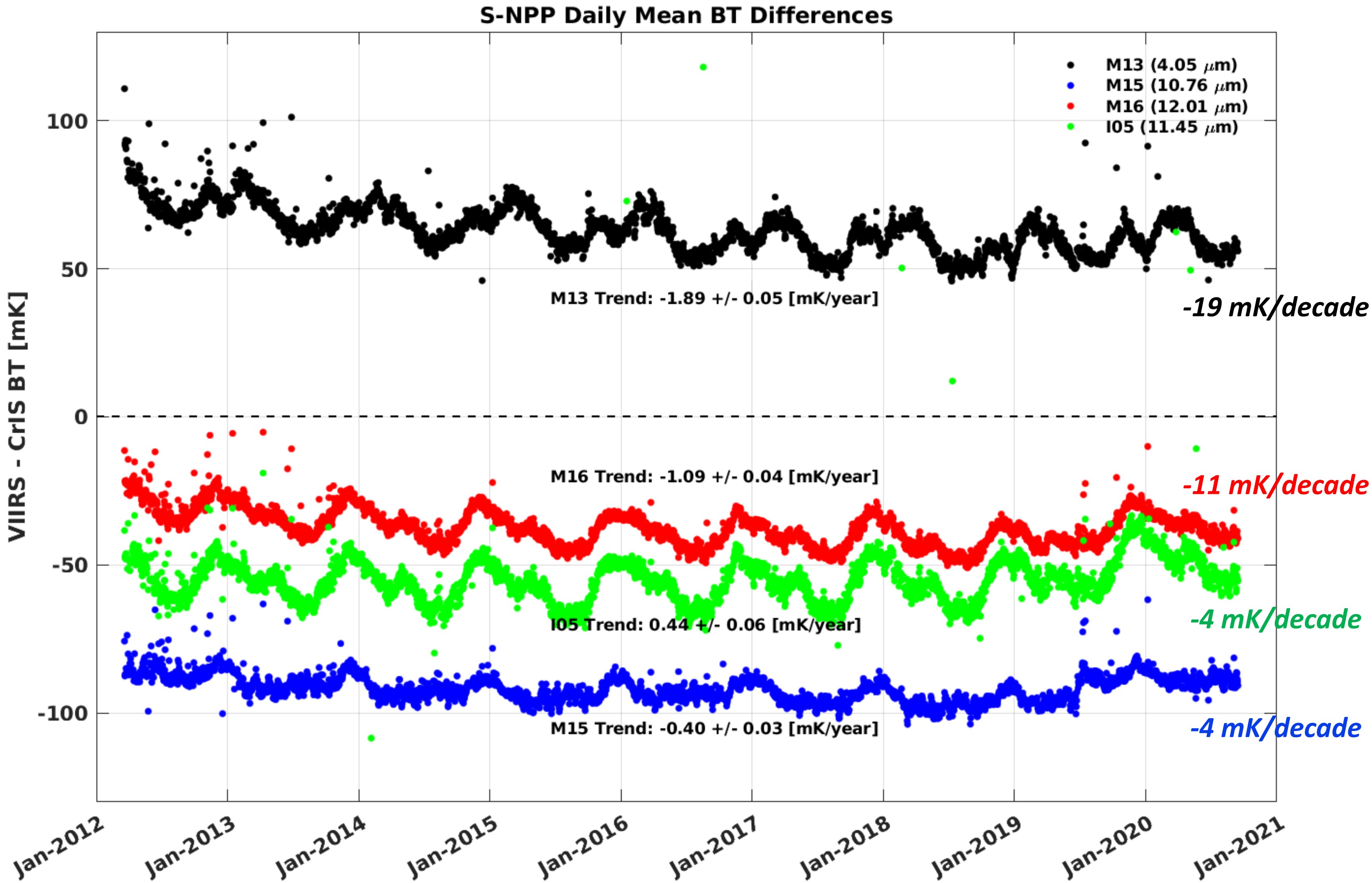
warm clear sky **cold cloudy**





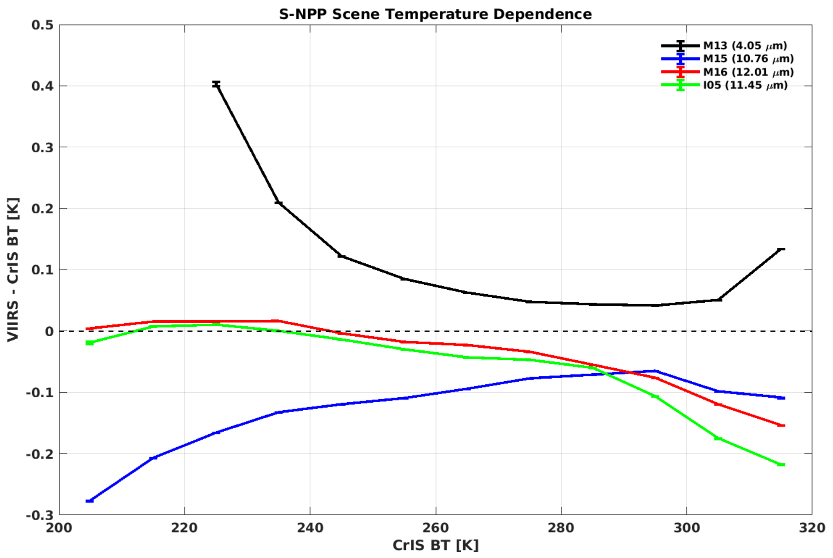
- *CrIS/VIIRS comparisons in LW and SW windows are primarily sensitive to T_{ICT} for warm scenes, T_{ICT}, NLC and PolCorr for cold scenes.*

S-NPP Daily Mean BT Differences

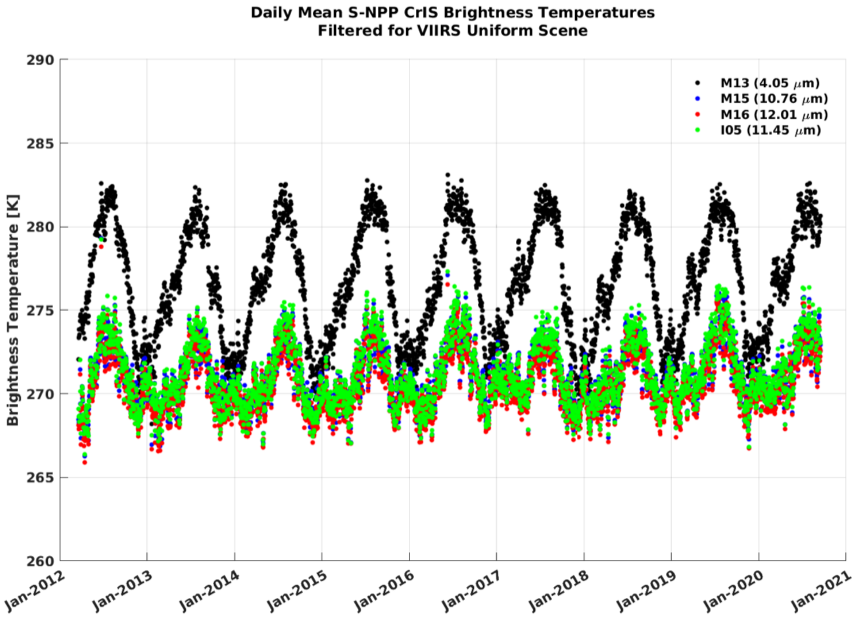


- *Trends of -4 to -19 mK/decade*
- *Curious seasonal variations of order ~20 mK in these all-scene-temp daily mean values*

S-NPP Scene Temperature Dependence

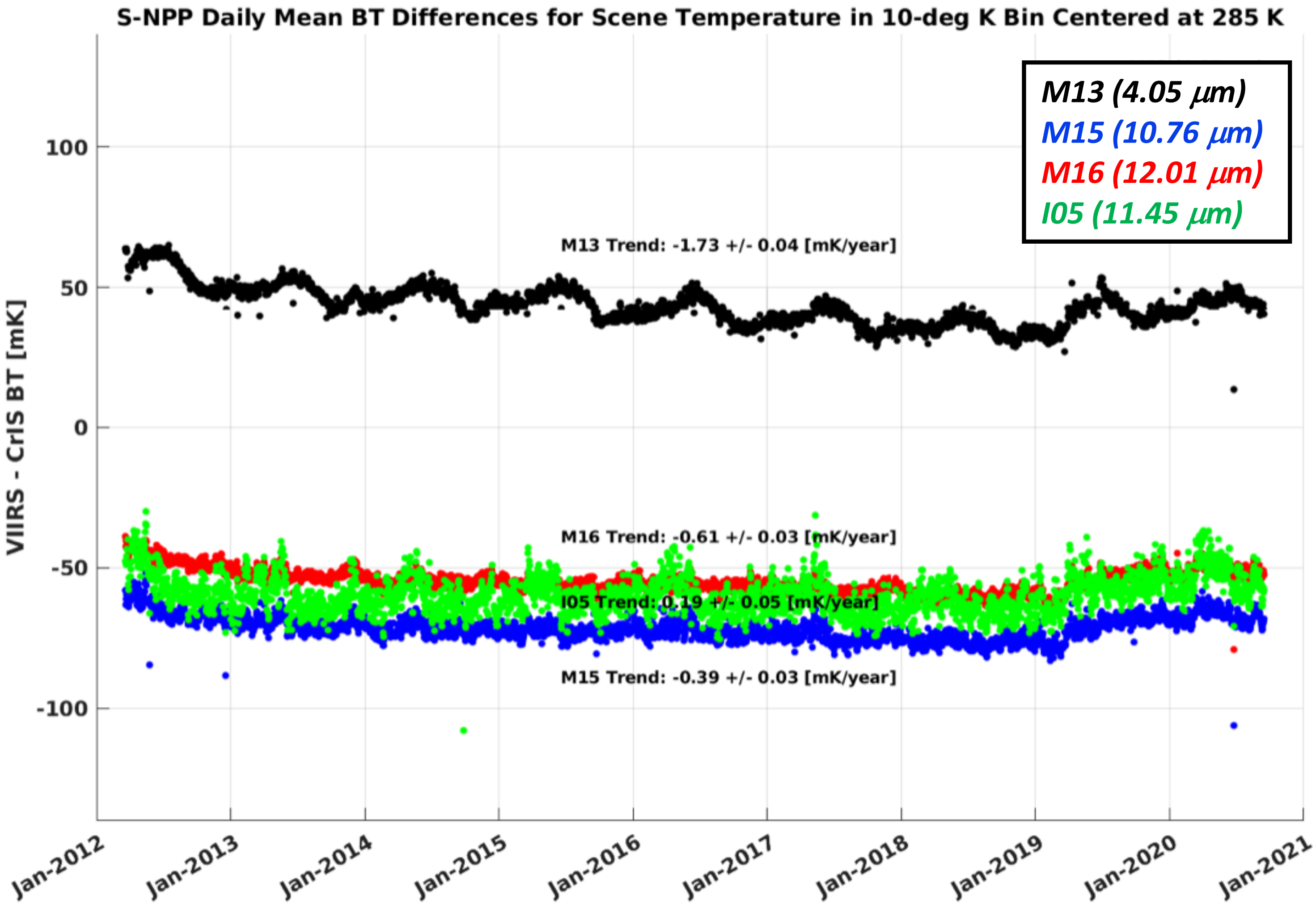


S-NPP Global Daily Mean BTs

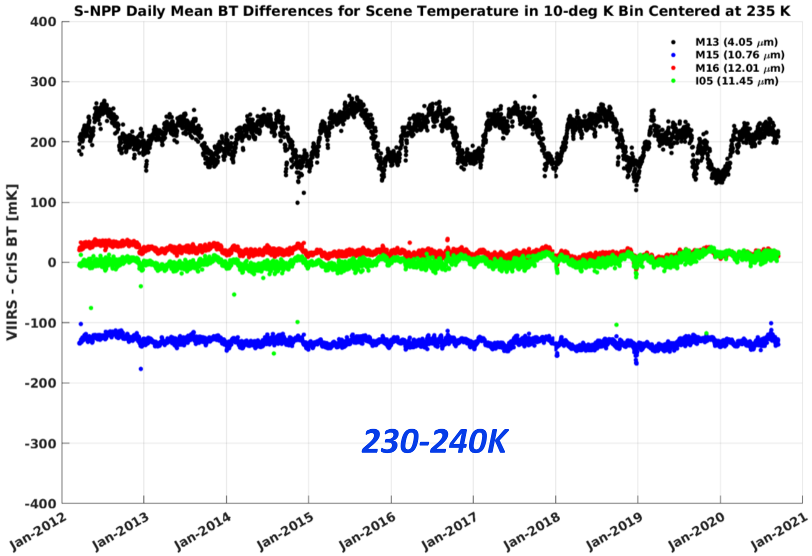


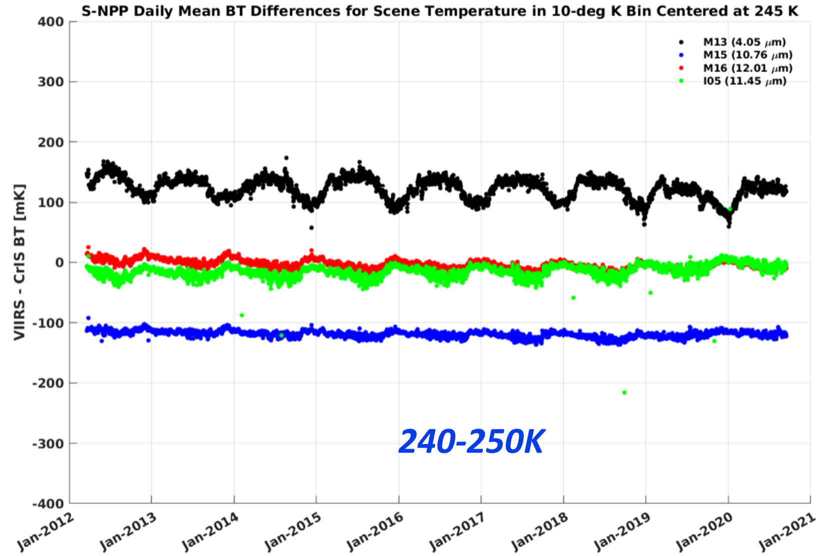
- *Seasonal variation of the Global Mean Daily differences are due to a combination of scene dependence calibration differences (left panel) and seasonal variations of ~8 K (M15,M16,I05) and ~12 K (M13) (right panel)*

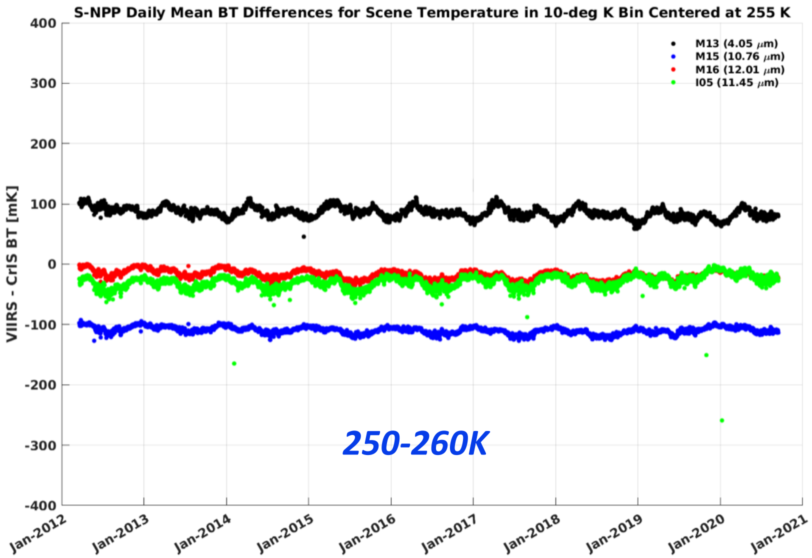
S-NPP Global Daily Mean BTs, with scene BTs of 280 to 290K

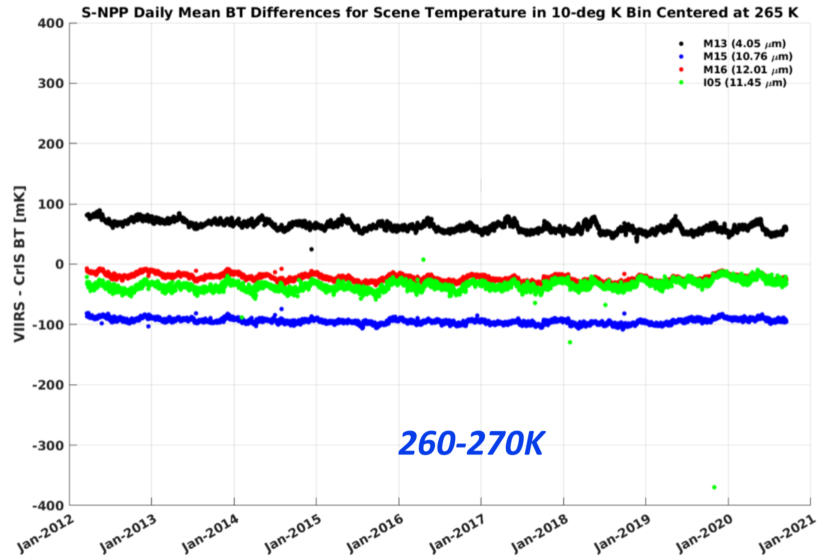


Other scene temperature bins



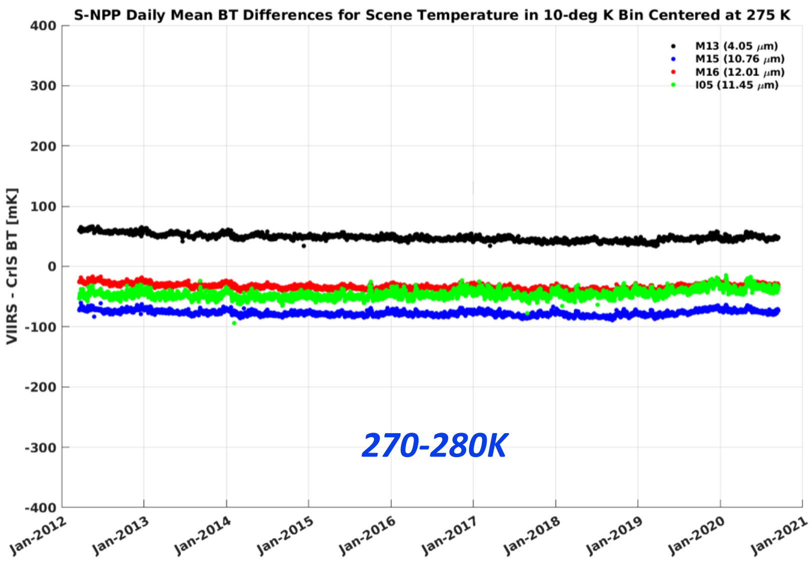


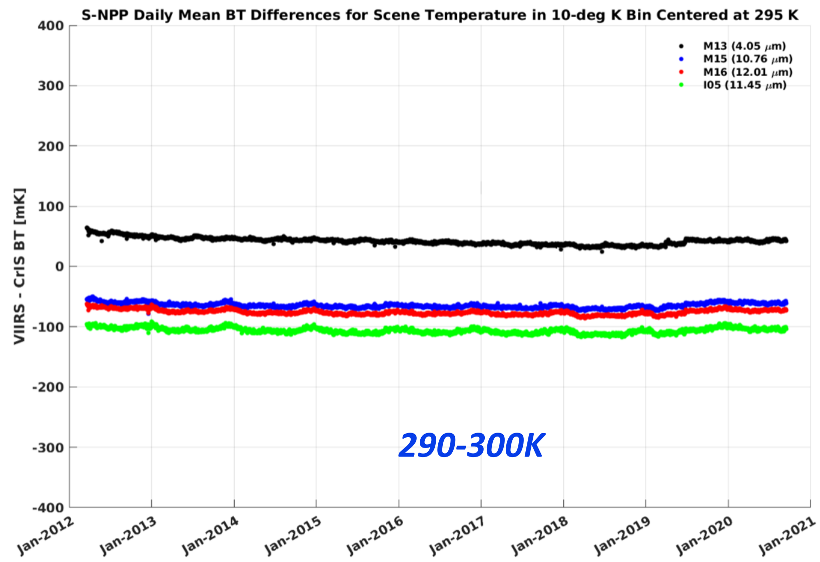


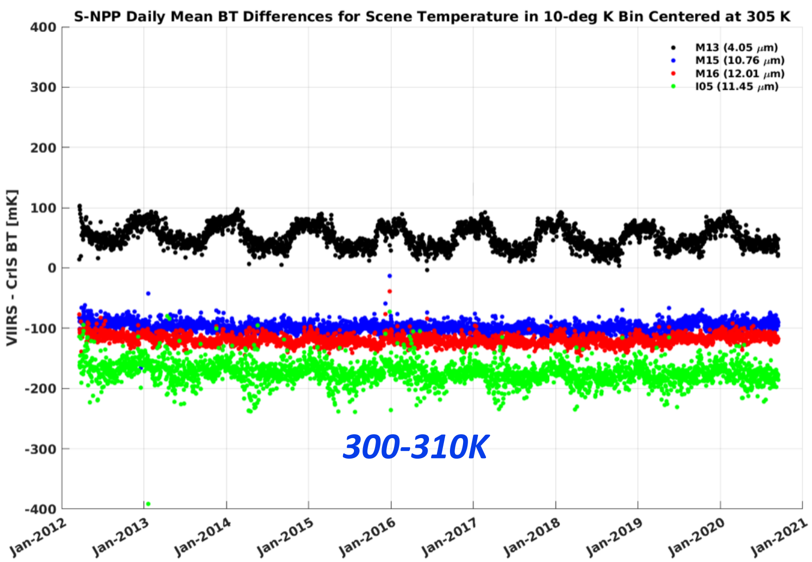


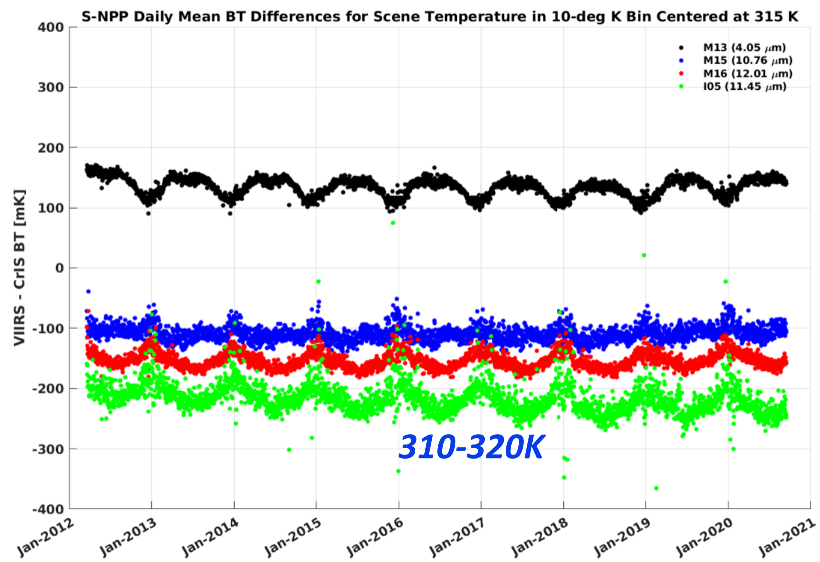
- *Largely flat, but some seasonal variations at extreme BTs for M13*

Other scene temperature bins



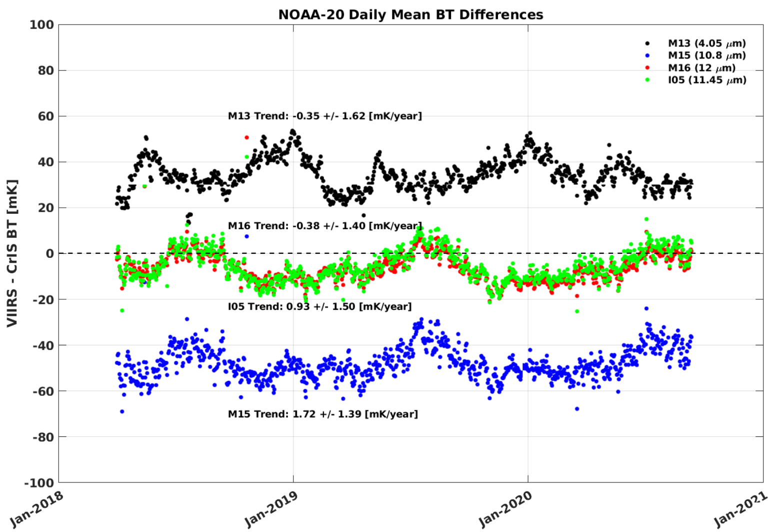


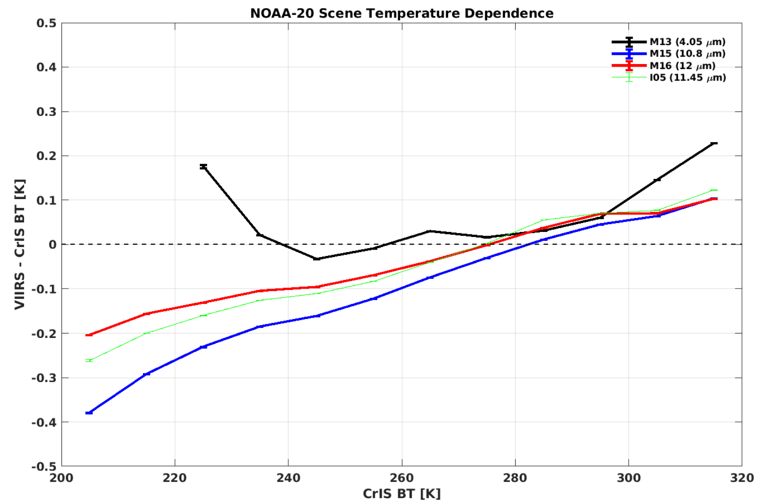


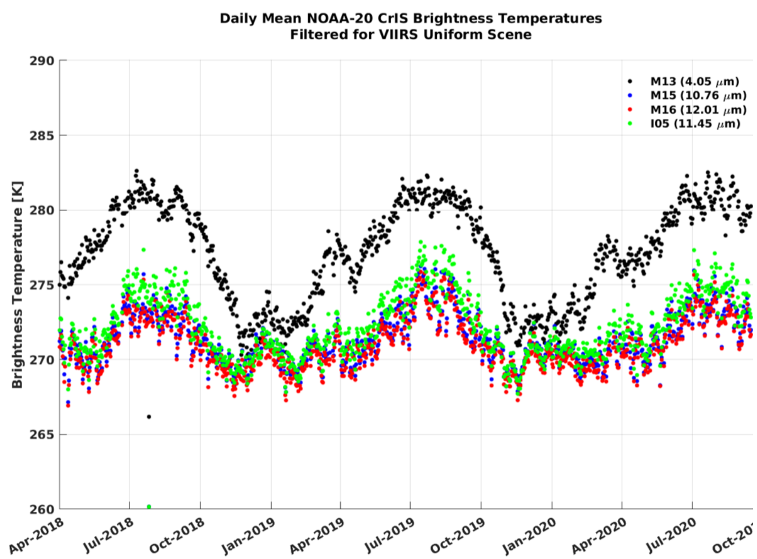


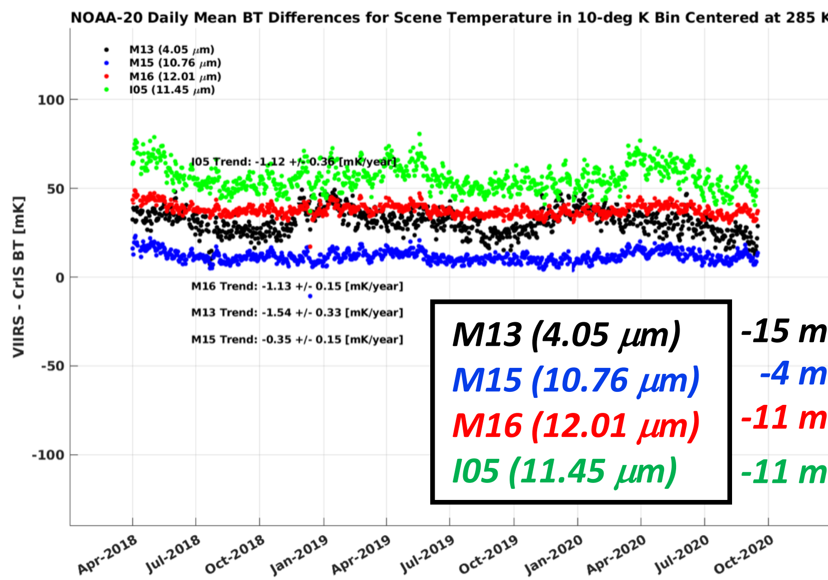
- *Largely flat, but some seasonal variations at extreme BTs*

Same message for NOAA-20 CrIS/VIIRS Comparisons



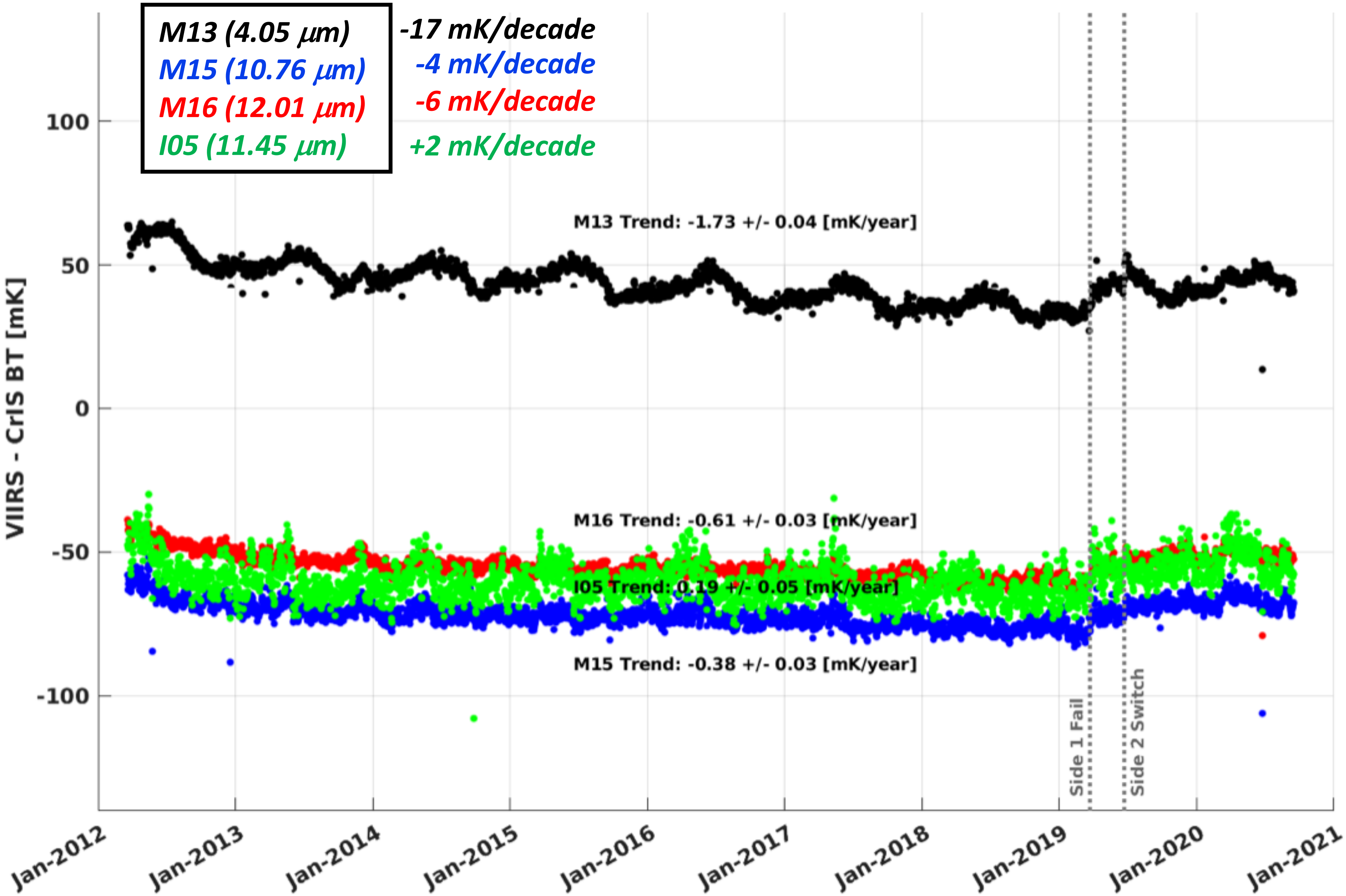






M13 (4.05 μm)	*-15 mK/decade*
M15 (10.76 μm)	*-4 mK/decade*
M16 (12.01 μm)	*-11 mK/decade*
I05 (11.45 μm)	*-11 mK/decade*

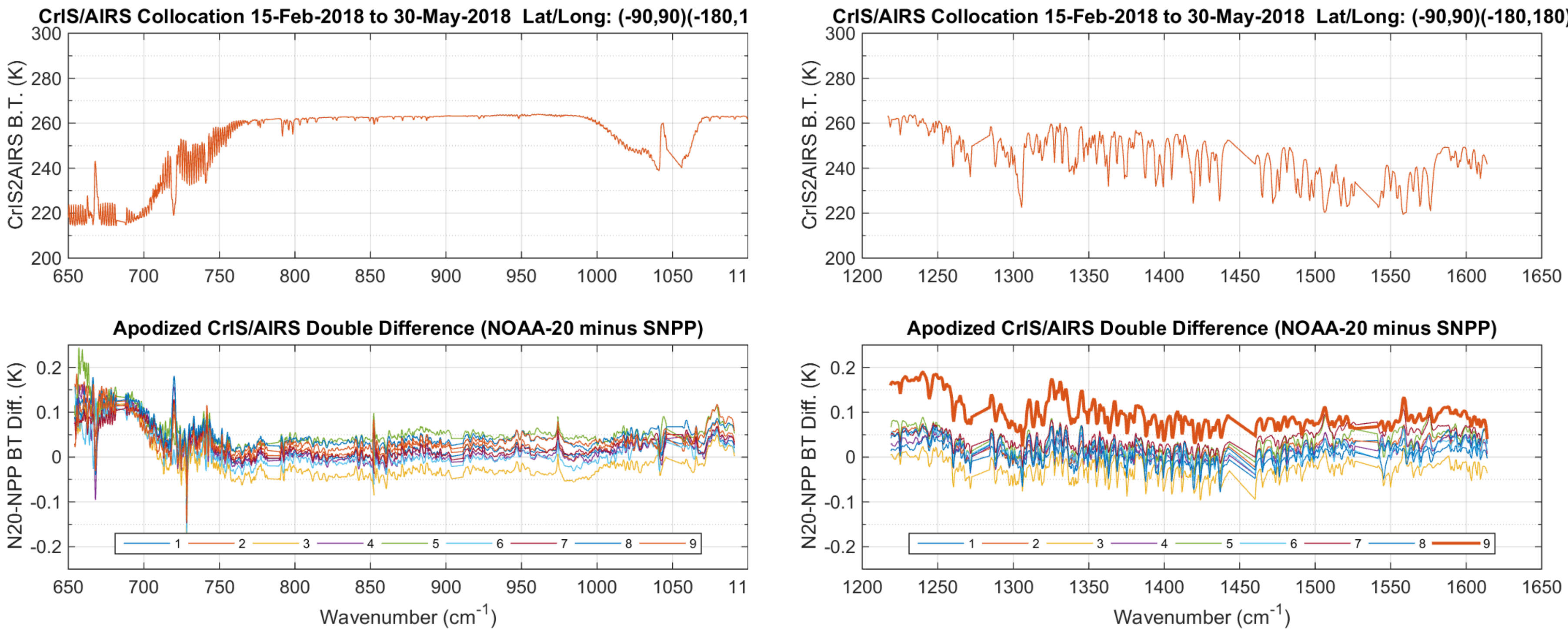
S-NPP CrIS/VIIRS Differences, Global Daily Means for 280-290K Scenes



- Trends of +2, -4, -6, and -17 mK/decade
- Small discontinuities associated with 2019 CrIS electronics side switch

Example differences between NOAA-20 CrIS and S-NPP CrIS

using CrIS/AIRS SNO double differences



- *Differences as large as 100 mK ; FOV9 out-of-family in MW*
- *Consistent with expectations based on individual sensor RU values, but much larger than the estimated stability of the individual records*

➢ *Plan to adjust SNPP a_2 and T_{ICT} , ε_{ICT} values to minimize these differences*

Summary

- IMG and IMG_Col products are available for S-NPP. NOAA-20 soon

- Long term trends in S-NPP VIIRS-CrIS differences are:
  - -17 mK (M13), -4 mK (M15), -6 mK (M16), +2 mK (I05) per decade
    for warm scenes with primary sensitivity to the ICT temperature.
  - Similarly well behaved comparisons and small trends for other temperatures, except for M13 where time-varying, seasonal variations require further investigation.
  - Given the vast differences in sensor designs, components, and optical materials, it is highly unlikely that the two sensors are degrading in a nearly identical fashion. Accordingly the trend agreement with VIIRS allows us to infer radiometric stability at high confidence for both sensors.
  - ~5 mK discontinuities observed for SNPP restart/side-switch in 2019

- When combining subsequent CrISes into a multi-decade radiance record (e.g. CHIRP) physical calibration adjustments below the RU levels will be introduced.