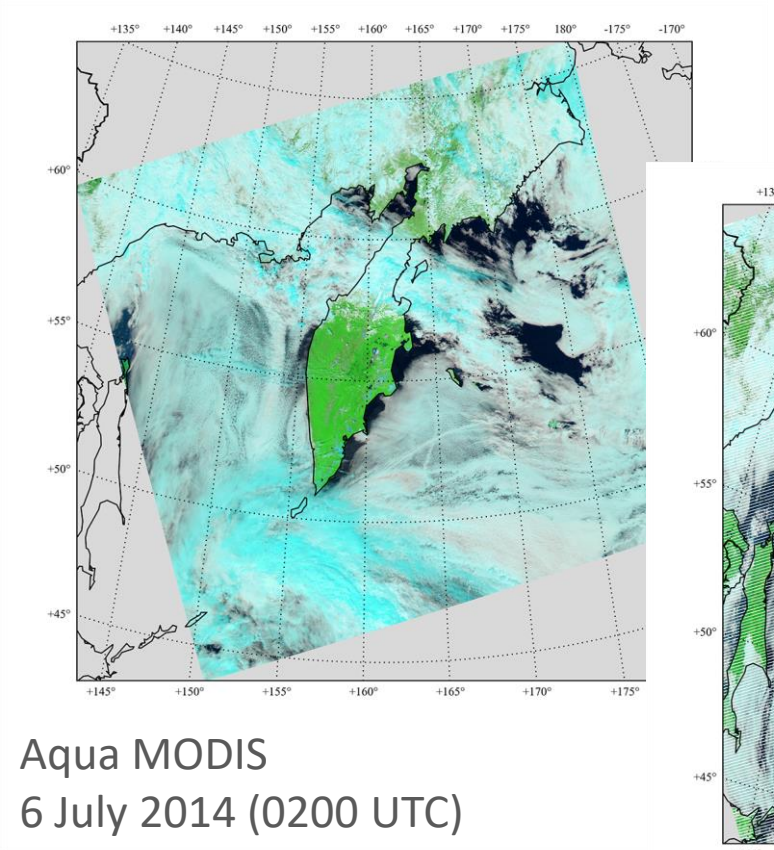
MODIS-VIIRS inter-sensor shortwave radiometric monitoring by the Cloud Product team and the A-SIPS

NASA GSFC: **Kerry Meyer**, Steven Platnick

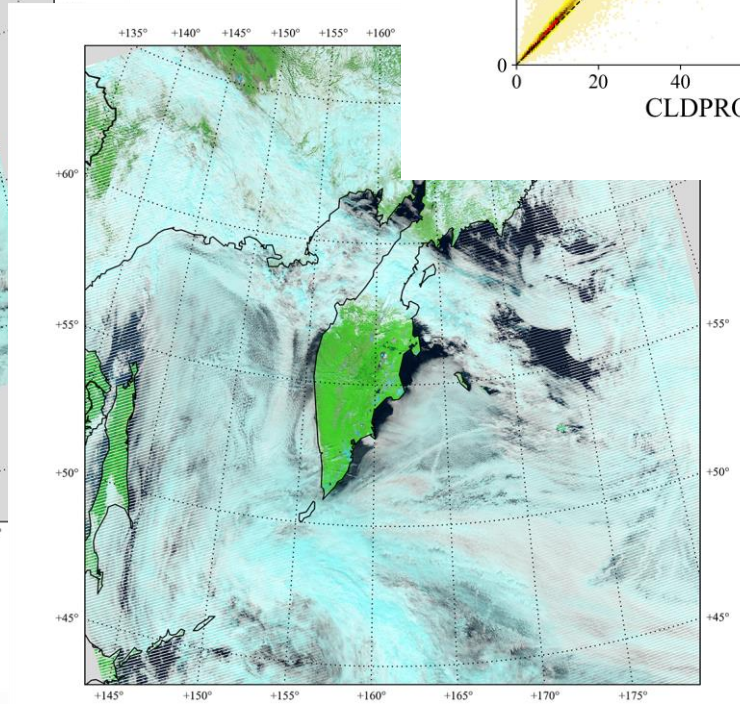
Atmosphere SIPS: **Bob Holz**, Steve Dutcher, Zach Griffith, Greg Quinn

Background

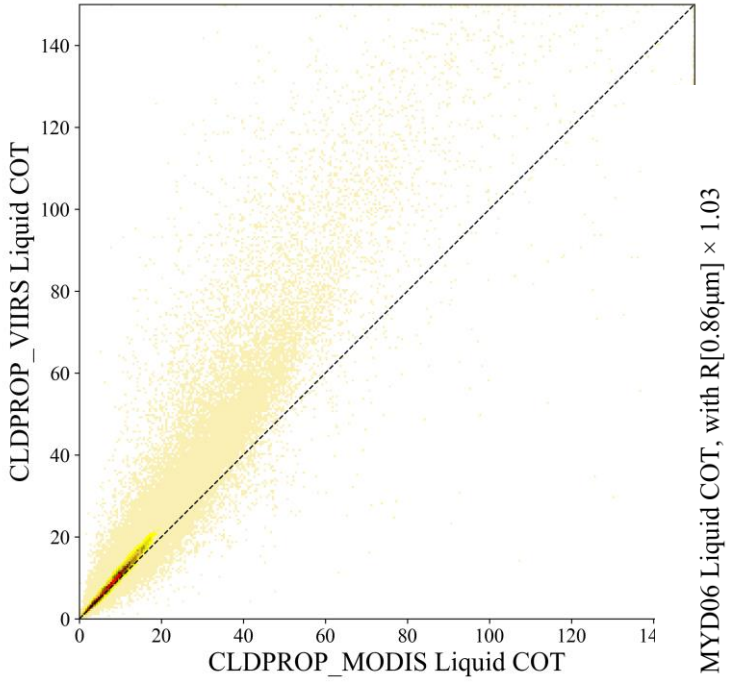
- Initial implementation of continuity cloud optical properties algorithm (CLDPROP) showed large differences between Aqua MODIS and SNPP VIIRS cloud optical thickness (COT) retrievals

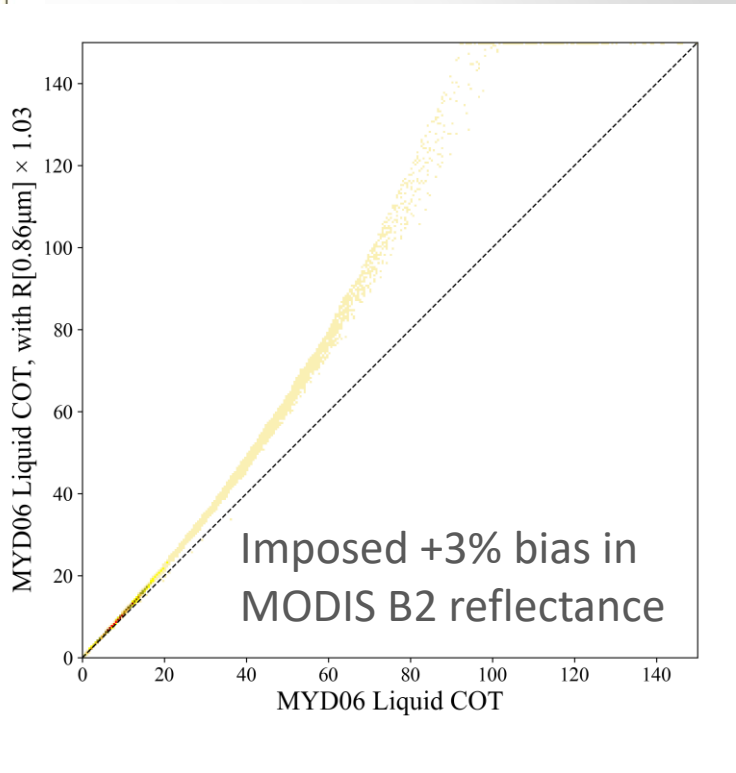


Aqua MODIS
6 July 2014 (0200 UTC)



SNPP VIIRS
6 July 2014 (0154, 0200 UTC)





- Retrieval differences linked to radiometric differences in analogous Aqua MODIS and SNPP VIIRS spectral channels
  - Above: Liquid COT retrievals from 0.87μm channel (MODIS B2, VIIRS M7)

Starting Point: Radiometric Match Files

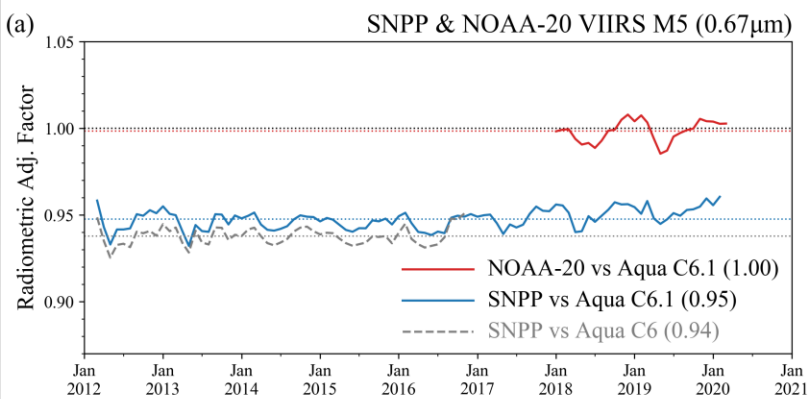
- Developed and processed by Atmosphere SIPS
- Co-located Aqua MODIS and SNPP/NOAA-20 VIIRS data
  - MYD02 L1B vs NASA VIIRS L1B (all M-band spectral channels)
    - **Aqua MODIS C6.1; SNPP VIIRS v2.0.2 ("C1") and NOAA-20 VIIRS v3.0.0 ("C2")**
  - Key MYD35 and MYD06 geophysical datasets (cloud mask, cloud-top/optical)
- Analysis approach
  - Homogeneous liquid phase clouds over oceans, $\pm 60^{o}$ latitude
  - Temporal matching: $\Delta t < 10$min
  - Strict angle matching: view zenith and scattering angle differences $< 1^{o}$
  - **Use Aqua MODIS as the benchmark, i.e., scale VIIRS to match MODIS**

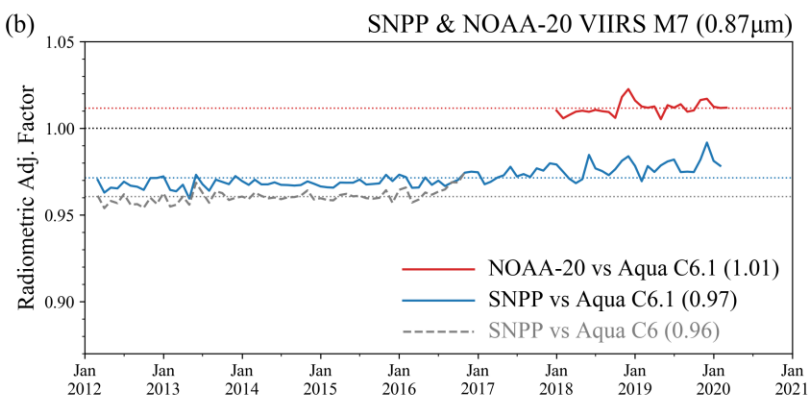
Methodology

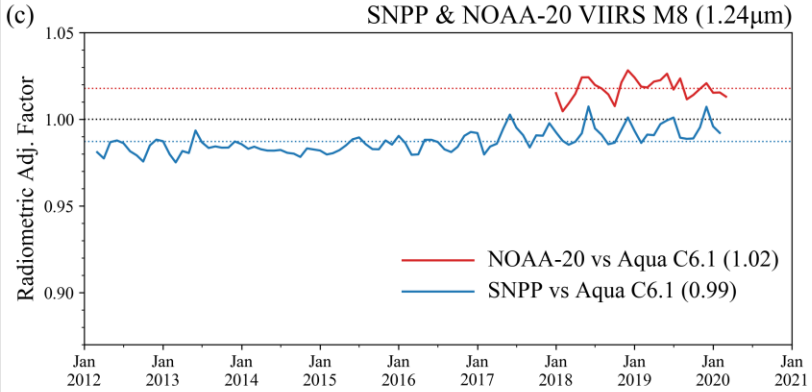
- MODIS COT,CER + VIIRS reflectance LUT => **VIIRS expected top-of-cloud reflectance at pixel level**
- MODIS (MYD06) CTP + VIIRS L1B + atmospheric correction => **VIIRS observed top-of-cloud reflectance at pixel level**
- Aggregate pixel-level expected/observed reflectance into monthly joint histograms => monthly VIIRS radiometric adjustment factors
- Final VIIRS (SNPP or NOAA-20) radiometric adjustment factors derived from time series of monthly values

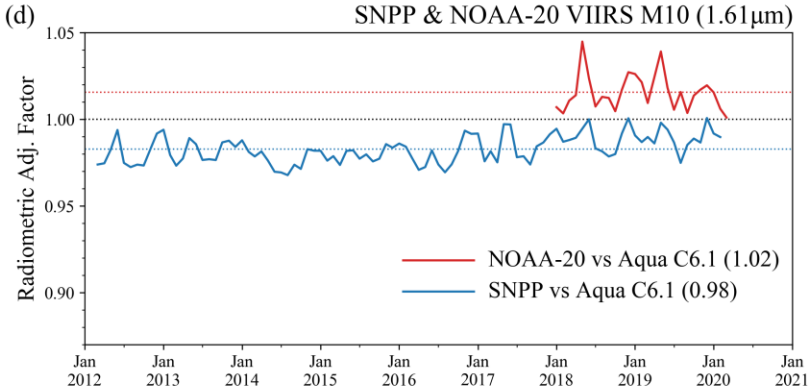
$$\boldsymbol{VIIRS\ Radiometric\ Adjustment(\lambda) = \frac{VIIRS\ Expected\ TOC\ Refl.(\lambda)}{VIIRS\ Observed\ TOC\ Refl.(\lambda)}}$$

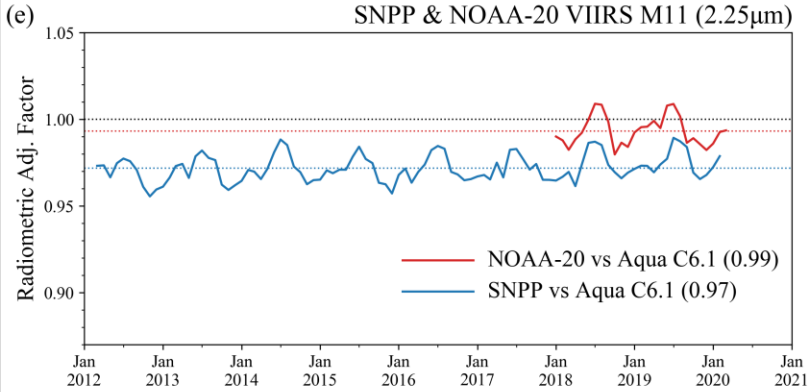
$$\boldsymbol{\lambda = [0.67\mu m\ (M5), 0.87\mu m\ (M7), 1.24\mu m\ (M8), 1.61\mu m\ (M10), 2.25\mu m\ (M11)]}$$











- Radiometric adjustments applied to VIIRS L1B prior to ingestion into CLDMSK and CLDPROP algorithms.
  - Both SNPP and NOAA-20
  - Defined as time series (left) means
- Values are reported in CLDPROP L2 global metadata

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Derivation of Shortwave Radiometric Adjustments for SNPP and NOAA-20 VIIRS for the NASA MODIS-VIIRS Continuity Cloud Products

by Kerry Meyer [1,*], Steven Platnick [1], Robert Holz [2], Steve Dutcher [2], Greg Quinn [2] and Fred Nagle [2]

[1] Earth Sciences Division, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA
[2] Space Science and Engineering Center, University of Wisconsin, Madison, WI 53706, USA
[*] Author to whom correspondence should be addressed.

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VIIRS Wavelength (Band Designation)			0.67 μm (M5)	0.87 μm (M7)	1.24 μm (M8)	1.61 μm (M10)	2.25 μm (M11)
Radiometric Adjustment Factor	NOAA-20	vs MODIS C6.1	1.0	1.01	1.02	1.02	0.99
	SNPP	vs MODIS C6.1	0.95	0.97	0.99	0.98	0.97
		vs MODIS C6	0.94	0.96	0.98	0.98	0.97
		Deep Blue Gain Factors	*0.941*	*0.963*	*1.011*	*0.981*	*0.931*

How do these adjustments compare with the MCST/VCST SNO comparisons shown yesterday?

VIIRS Wavelength (Band Designation)		M5	M7	M8	M10
Cloud Team Radiometric Adjustment Differences	Aqua MODIS – NOAA-20	0.0	1.0	2.0	-1.0
	SNPP – NOAA-20	5.0	4.0	3.0	4.0
MCST/VCST SNO Radiometric Differences	Aqua MODIS – NOAA-20	5.1	2.8	-0.5	1.2
	SNPP – NOAA-20	4.7	2.9	2.7	2.6

Notes: MCST/VCST differences are from Aisheng Wu's slides yesterday. Cloud Team radiometric adjustment differences are simple arithmetic calculations from the adjustment factor table on the previous slide – exact magnitude may be off slightly.

Upshot: The SNPP – NOAA-20 differences generally agree, but the Aqua MODIS – NOAA-20 differences do not.

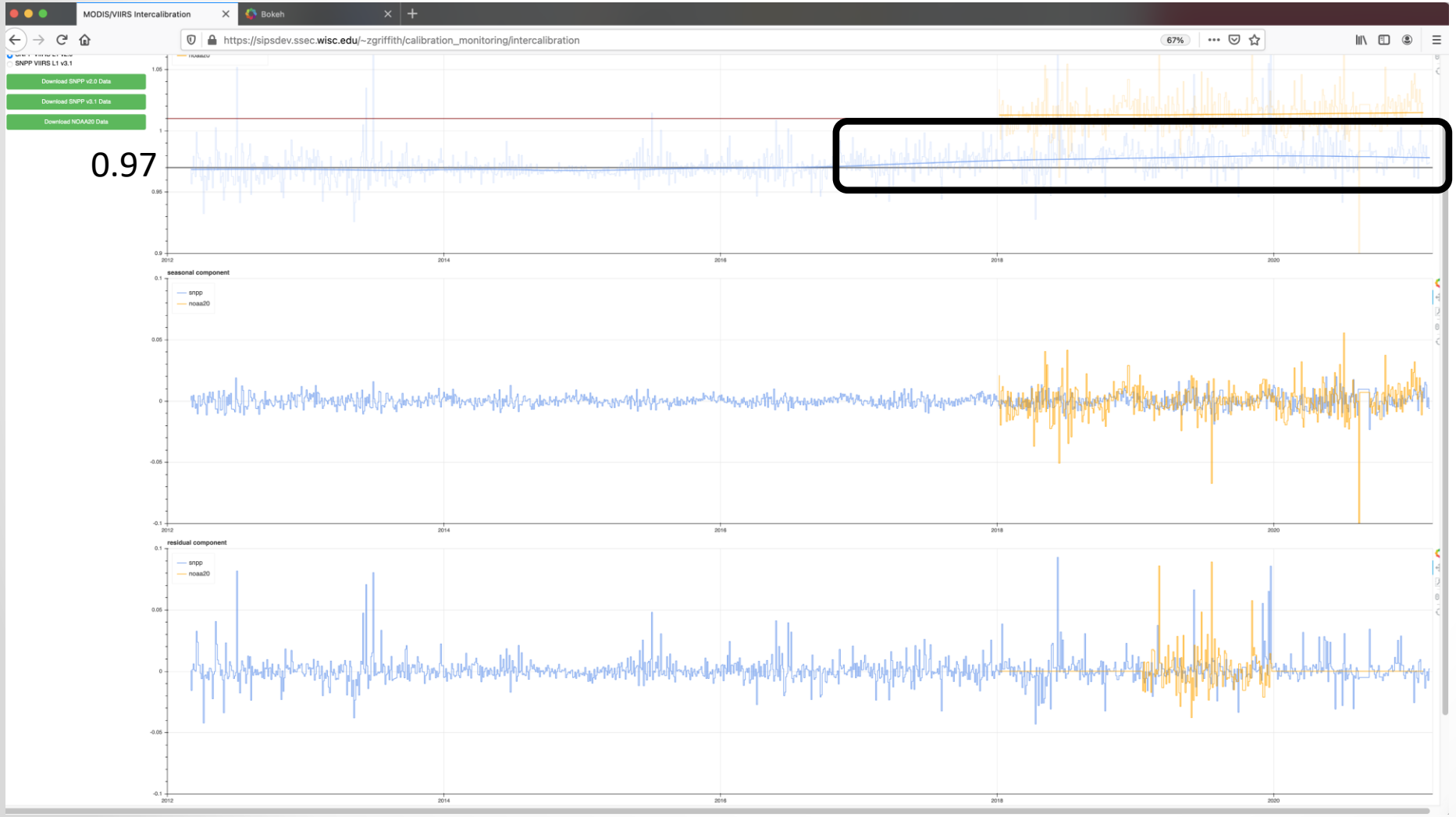
Caveat: Need to verify consistency in VIIRS L1B versions used by the two teams.

A-SIPS L1B Inter-Instrument Calibration Support

- The co-location and matchfile software are also being leveraged by the aerosol teams (e.g., Sayer et al. 2016) who are focused on dark scenes.
  - Some consistency is seen between the the aerosol team and cloud team approaches, but unresolved differences remain, particularly for the 1.24µm (M8) and 2.25µm (M11) channels (forward models?).
- The cloud team's inter-calibration software is processed in near-real time and continually monitored by the A-SIPS for both SNPP and NOAA-20.
- The co-location and match software are designed to support future instruments including JPSS-2 and advanced GEO (AHI/ABI/AMI)
  - Note: The cloud and aerosol teams are funded to develop GEO products

VIIRS SNPP/NOAA 20 UW A-SIPS Monitoring Tool

- The cloud team's Aqua MODIS – VIIRS (SNPP and NOAA-20) radiometric analysis code is implemented at A-SIPS and running in NRT
- Web "dashboard" developed by A-SIPS (Z. Griffith) to facilitate monitoring by team
  - "Per cycle" (64 hrs) and rolling (~monthly) means
  - seasonal decomposition for trends

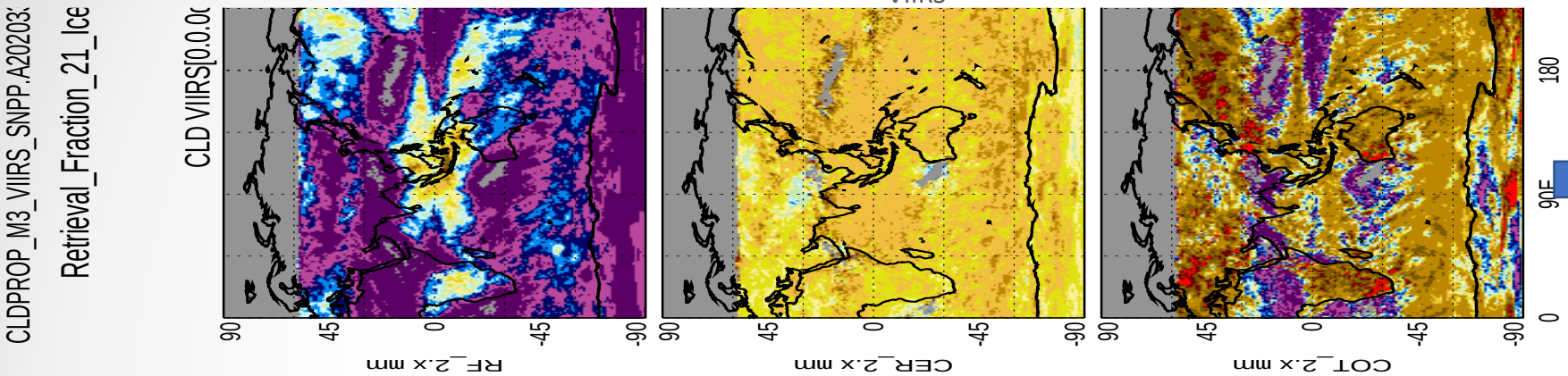


SNPP (Blue)
NOAA-20 (Orange)

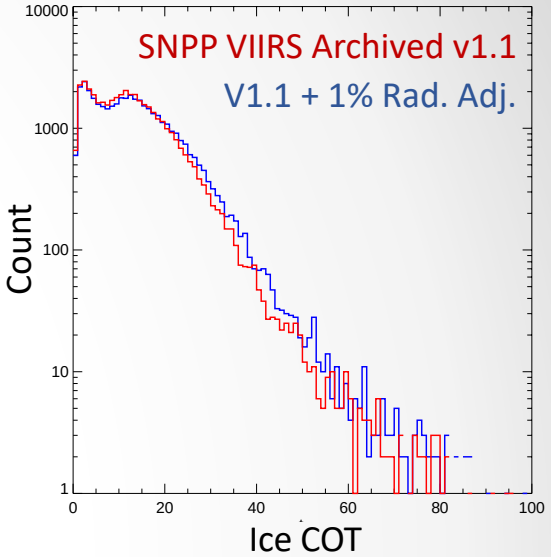
MODIS/SNPP VIIRS calibration ratio for the 0.87µm channel begins to increase starting in 2016, to ~0.98 in Dec 2020

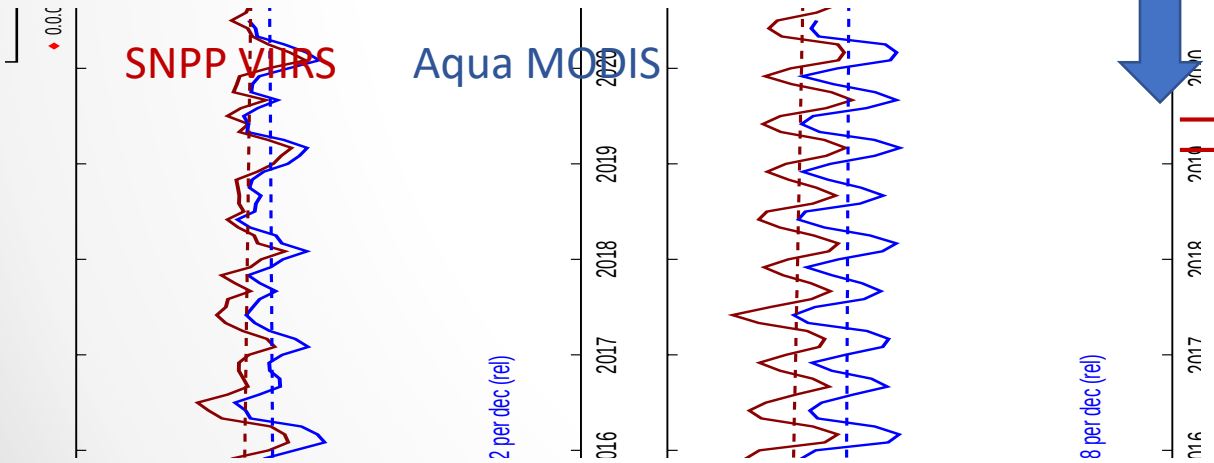
Is this ~1% drift in 0.87µm relative radiometry important?

SNPP VIIRS Ice COT, Dec 2020



ΔCOT_{VIIRS} after 1% adjustment to 0.87µm (M7)





ΔCOT_{VIIRS} (Dec 2020)

Cloud Team Perspective on Inter-Instrument Calibration

- A unified L1B data record, consistent across instruments and tied to a single reference imager with offsets/scaling derived from a consensus approach, is indeed a highly desired goal.
- That said, in practice this may be difficult to achieve given the various, at times divergent, needs of the algorithm and science teams.
  - E.g., bright scenes for clouds vs dark scenes for aerosols
- While MCST/VCST should continue pushing towards the ideal (unless prioritization requires otherwise), the L2 algorithm teams still need to monitor inter-sensor radiometry and apply adjustments as they see fit.
  - Complicating factor: Atmosphere is no longer in the “Collection” paradigm, so team-wide activities, adoption of L1B updates, etc., are less coordinated.