

# Assessment of Relative Shortwave Radiometry between S-NPP VIIRS and Aqua MODIS

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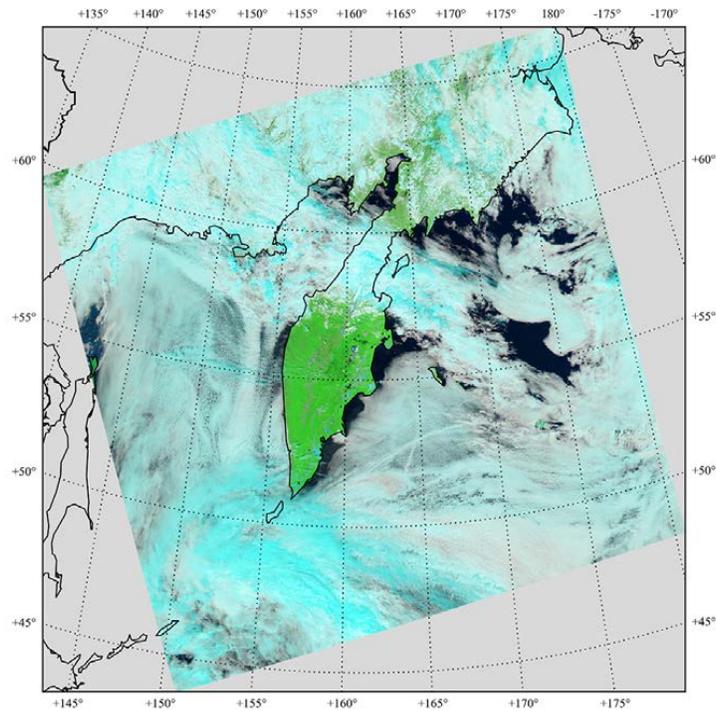
*Robert Holz and the Atmosphere SIPS Team*

# Statement of Need

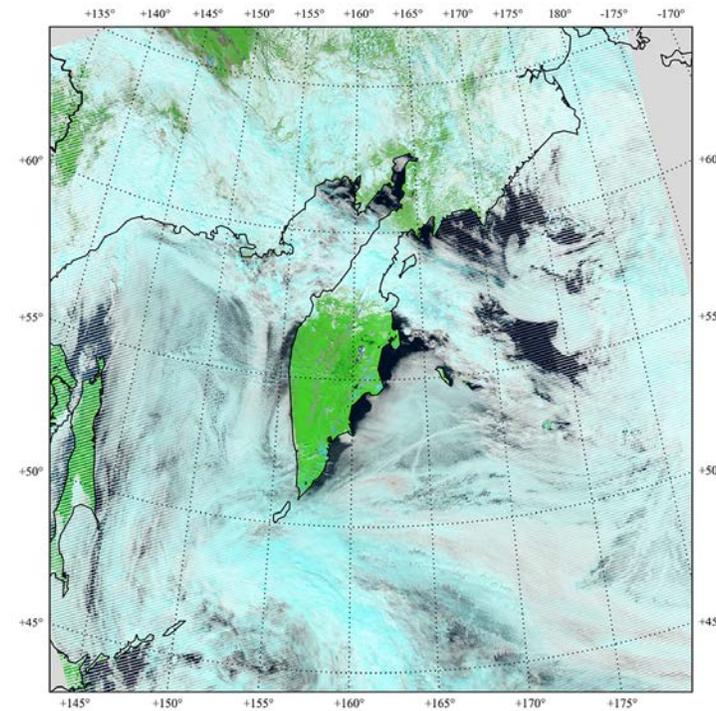
- Long-term climate data records require merging the observational records of multiple instruments (e.g., MODIS/VIIRS)
- Many remote sensing geophysical products are physically based and rely on absolute radiometry
  - E.g., cloud top/optical properties, aerosol optical properties, etc.
- For geophysical product continuity between sensors, relative radiometry (and radiometric stability) is fundamental
  - Much more challenging for solar channels where the absolute reflectance specifications can be greater than the expected climate change signals
- For cloud optical properties, relative radiometric offsets (even those within specified instrument uncertainties) have induced large non-linear inter-sensor retrieval differences

# Initial MODIS/VIIRS Cloud Optical Property Comparisons

6 July 2014



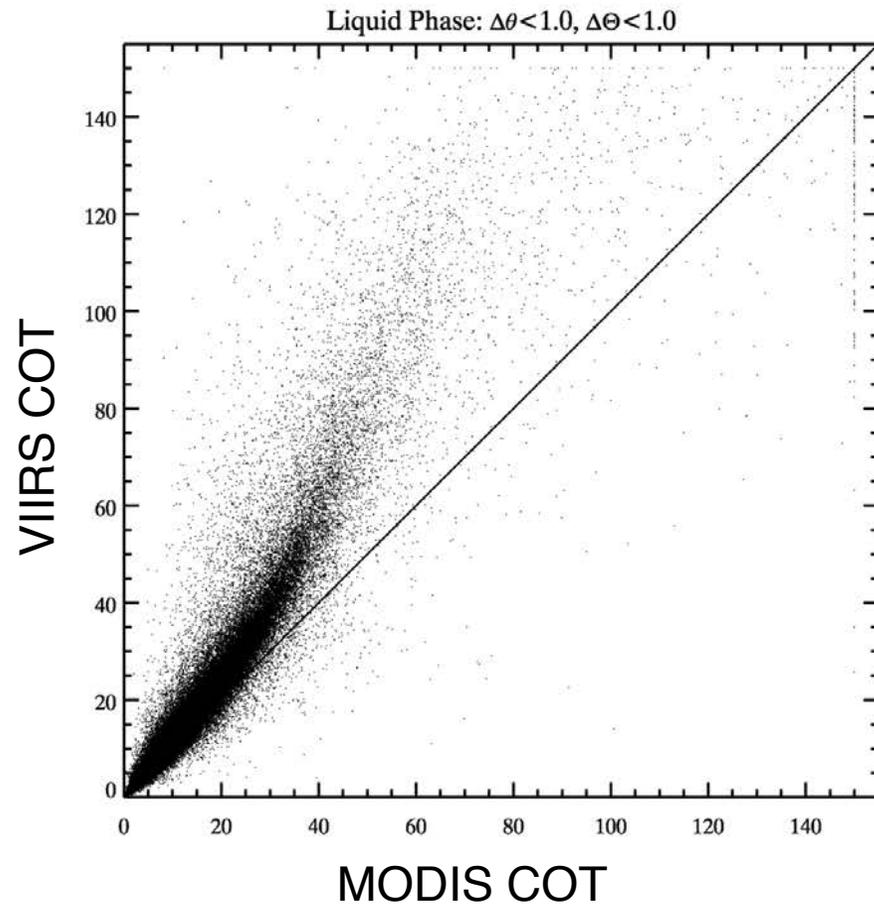
Aqua MODIS (B7-B2-B1)  
0200 UTC



SNPP VIIRS (M11-M7-M5)  
0154, 0200 UTC

# Initial MODIS/VIIRS Cloud Optical Property Comparisons

6 July 2014



COT = Cloud Optical Thickness

# Statement of Problem

- COT retrieval differences strongly imply radiometric offsets between Aqua MODIS and SNPP VIIRS solar reflectance channels
  - Relative radiometric differences can also impact cloud particle size retrievals (CER) and thermodynamic phase determination as well as certain cloud mask tests
- Offsets also found by other Atmosphere algorithm teams (e.g., Aerosol Deep Blue [*Sayer et al., 2017*])

Cloud Optical Property Solar Spectral Channels

MODIS	VIIRS	Primary Retrieval Parameter
0.66 $\mu\text{m}$ (B1)	0.67 $\mu\text{m}$ (M5)	COT over land
0.86 $\mu\text{m}$ (B2)	0.87 $\mu\text{m}$ (M7)	COT over water
1.24 $\mu\text{m}$ (B5)	1.24 $\mu\text{m}$ (M8)	COT over snow/ice
1.64 $\mu\text{m}$ (B6)	1.61 $\mu\text{m}$ (M10)	CER; supplemental COT over snow/ice coupled with 2.13/2.25 $\mu\text{m}$
2.13 $\mu\text{m}$ (B7)	2.25 $\mu\text{m}$ (M11)	CER

# Plan of Action

- **Cloud and Aerosol algorithm team consensus:** *Radiometric adjustment factors to either MODIS or VIIRS are necessary in order to reconcile observed retrieval differences*
- Each algorithm team pursued independent radiometric adjustment analyses, though closely collaborated with each other
  - *Adjustment factors derived by all teams applied to VIIRS since MODIS is the reference record*
- Atmosphere SIPS offered critical support for these efforts via creation of MODIS-VIIRS match files

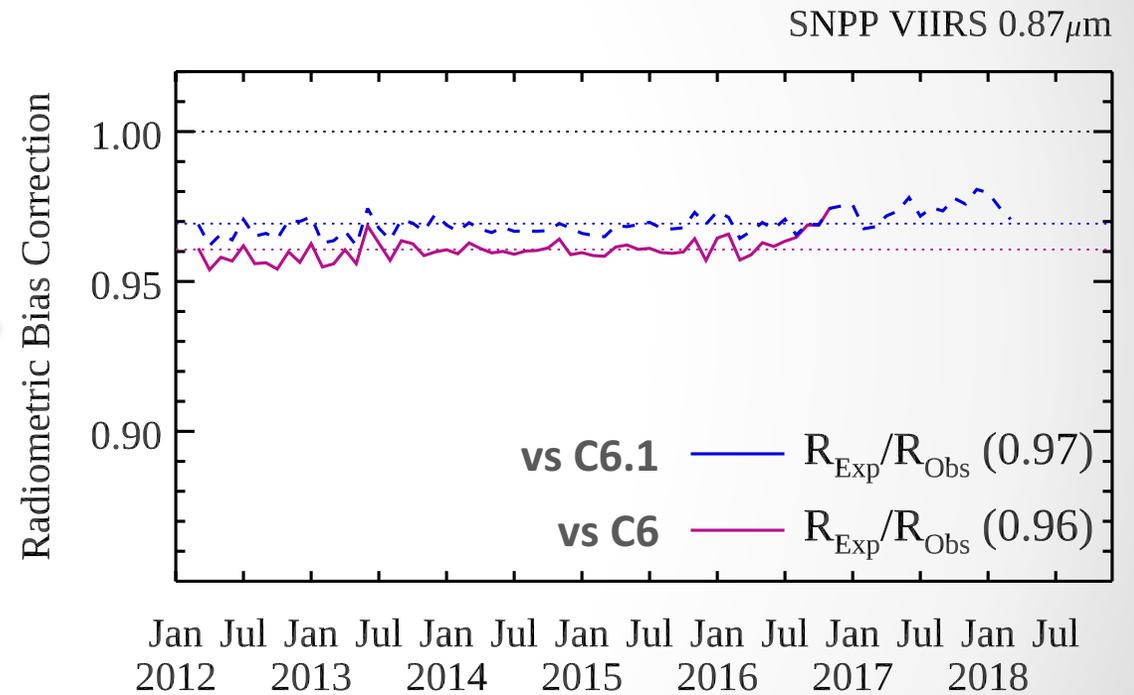
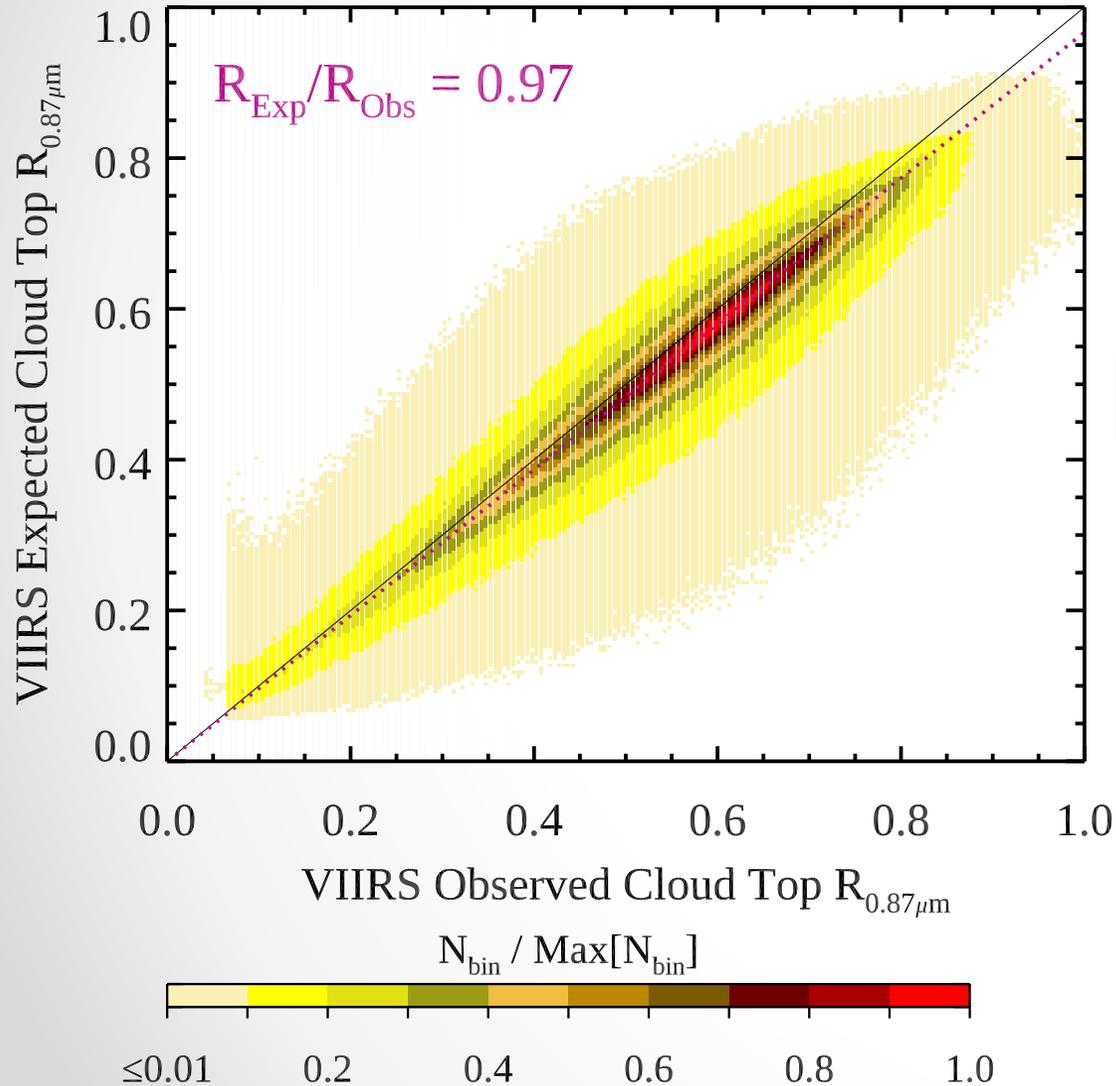
# Starting Point: Atmosphere SIPS Match Files

- Files contain co-located MODIS and VIIRS data
  - March 2012 – April 2018
  - MYD02 L1B vs NASA VIIRS L1B v2
    - All spectral channels included (solar + IR)
  - Key MYD35 and MYD06 geophysical parameters (cloud mask, cloud top and optical properties)
  - *Includes only those co-located pixels having similar observations times and sun-satellite view geometries*
- For further details on Atmosphere SIPS match file support – see poster by Greg Quinn.

# Cloud Algorithm Team Analysis

- Stricter co-located pixel filtering:
  - MODIS and VIIRS view zenith and scattering angles match to within  $\pm 1^\circ$
  - Liquid phase clouds over oceans,  $\pm 60^\circ$  latitude, low heterogeneity scenes
- 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**
  - Monthly VIIRS expected vs VIIRS observed spectral top-of-cloud reflectance joint histograms => Monthly VIIRS radiometric adjustment factors
  - Final VIIRS radiometric adjustment factors derived from time series of monthly values

# Example: MODIS B2 vs VIIRS M7



# Final Radiometric Adjustments

## Cloud Team Adjustments

VIIRS Channel		M5 (0.67 $\mu$ m)	M7 (0.87 $\mu$ m)	M8 (1.24 $\mu$ m)	M10 (1.61 $\mu$ m)	M11 (2.25 $\mu$ m)
Radiometric Adjustment (Expected VIIRS TOC/Observed)	vs C6	0.94	0.96	0.98	0.98	0.97
	vs C6.1	<b>0.95</b>	<b>0.97</b>	<b>0.99</b>	<b>0.98</b>	<b>0.97</b>

## Aerosol DB Team Adjustments (vs C6, including trends)

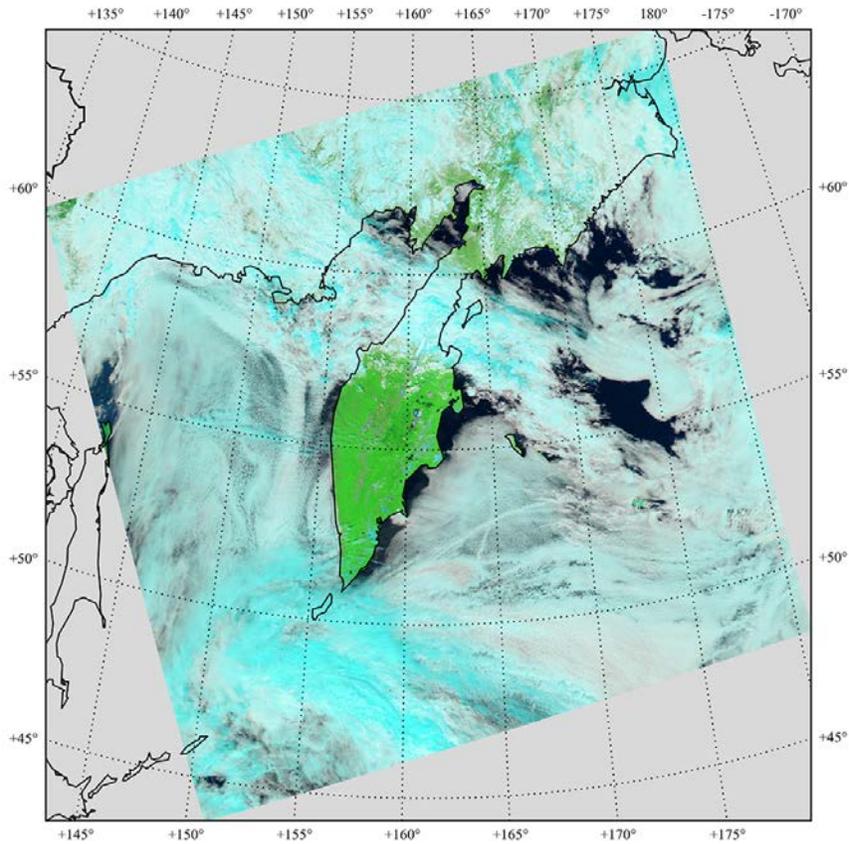
VIIRS band	Gain correction	Linear trend parameters, $a + b t$	
		$a$	$b$
412 nm (M01)	0.995 ( $\pm 0.006$ )	–	–
440 nm (M02)	1.000 ( $\pm 0.004$ )	–	–
490 nm (M03)	0.992 ( $\pm 0.004$ )	–	–
550 nm (M04)	0.956 ( $\pm 0.009$ )	–	–
670 nm (M05)	0.941 ( $\pm 0.008$ )	–	–
745 nm (M06)	0.966 ( $\pm 0.005$ )	–	–
865 nm (M07)	0.963 ( $\pm 0.004$ )	0.9544 ( $\pm 0.0016$ )	0.0018 ( $\pm 0.0003$ )
1240 nm (M08)	1.011 ( $\pm 0.009$ )	1.003 ( $\pm 0.0029$ )	0.0019 ( $\pm 0.0006$ )
1610 nm (M10)	0.981 ( $\pm 0.011$ )	0.9646 ( $\pm 0.0033$ )	0.0035 ( $\pm 0.0007$ )
2250 nm (M11)	0.931 ( $\pm 0.018$ )	–	–

*Sayer et al. [2017]*

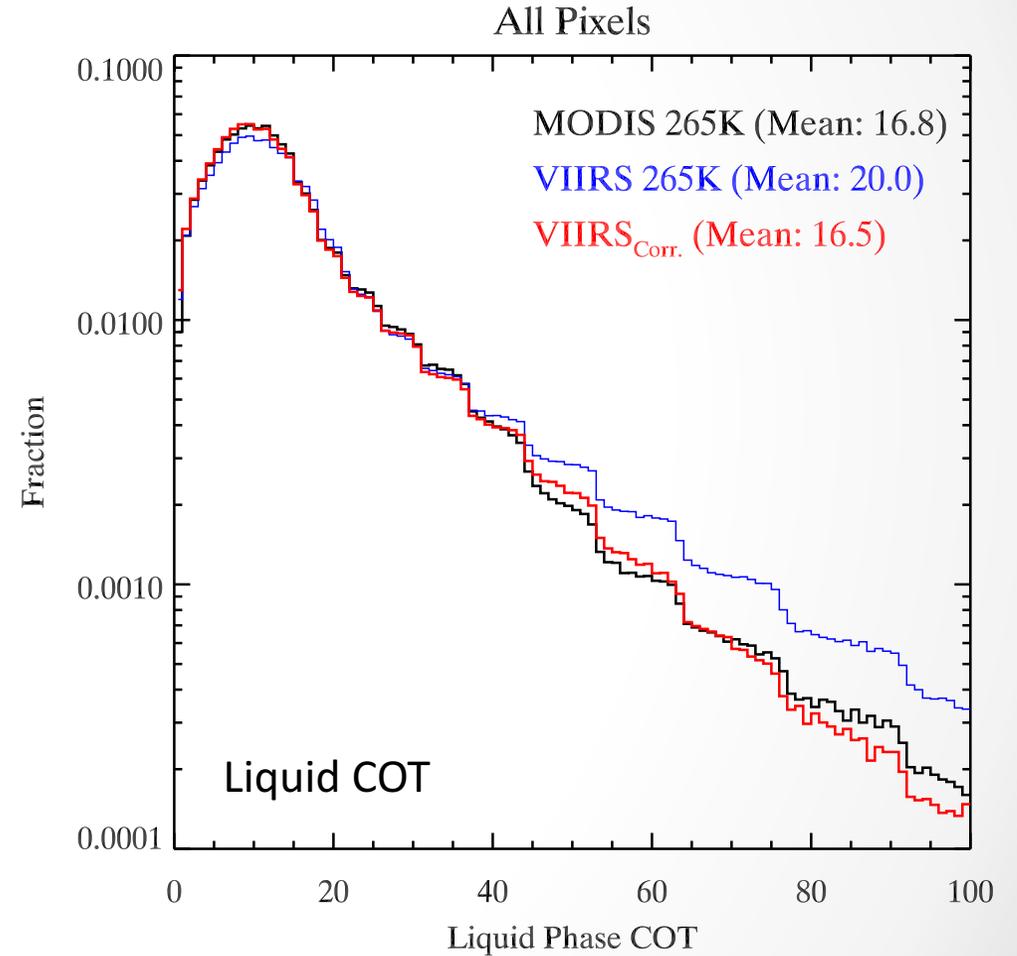
**Radiometric adjustments are applied to VIIRS L1B internally by each algorithm.**

For cloud products, this occurs prior to cloud mask  $\rightarrow$  cloud top  $\rightarrow$  cloud optical property algorithm chain.

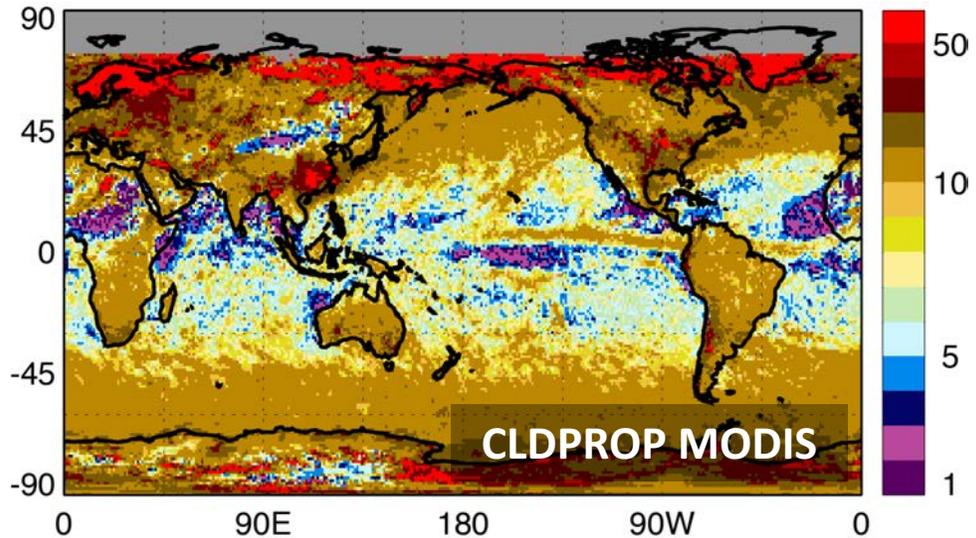
# Impacts of Adjustments



Aqua MODIS (B7-B2-B1)  
0200 UTC



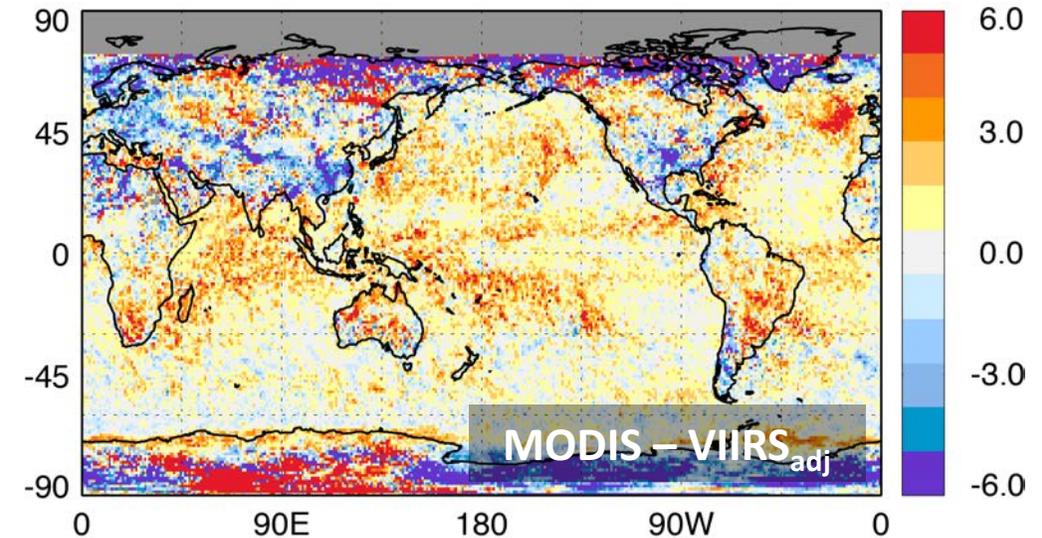
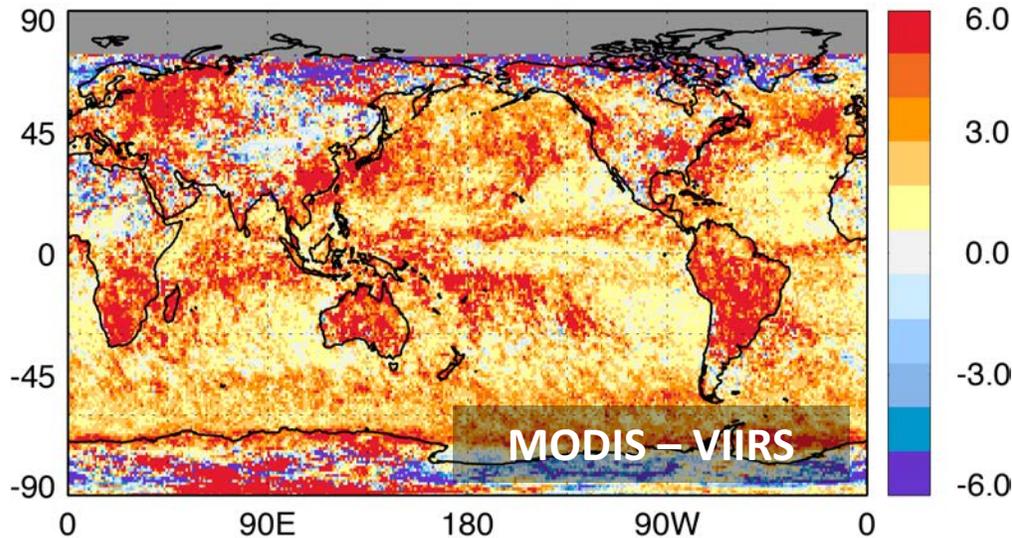
# Impacts of Adjustments



## CLDPROP Liquid Phase COT

February 2014

(Data from initial C6-based adjustment factor test)

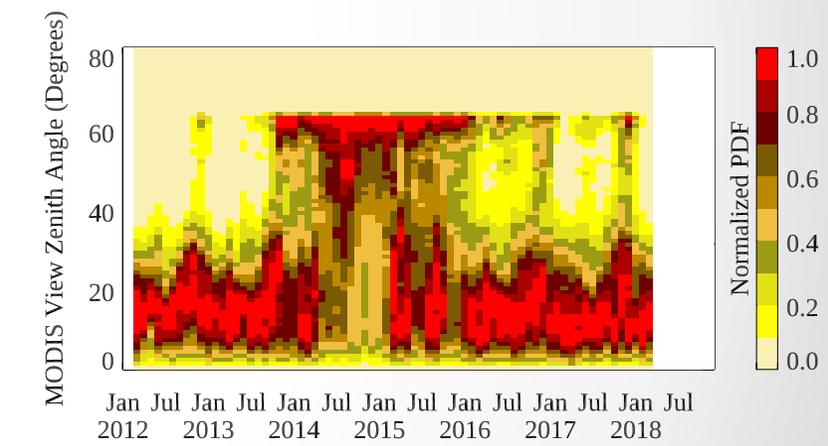
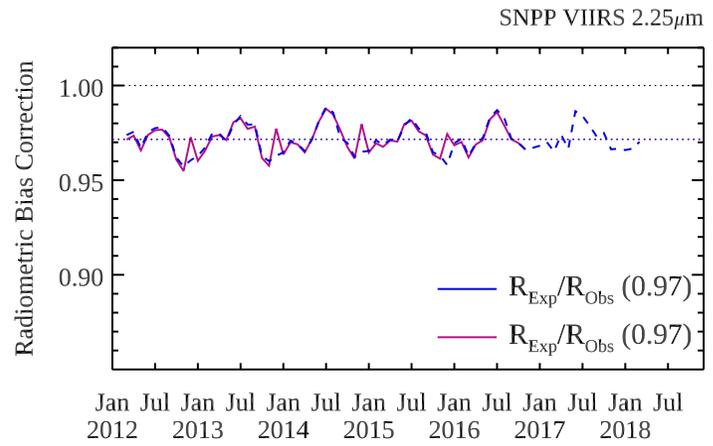
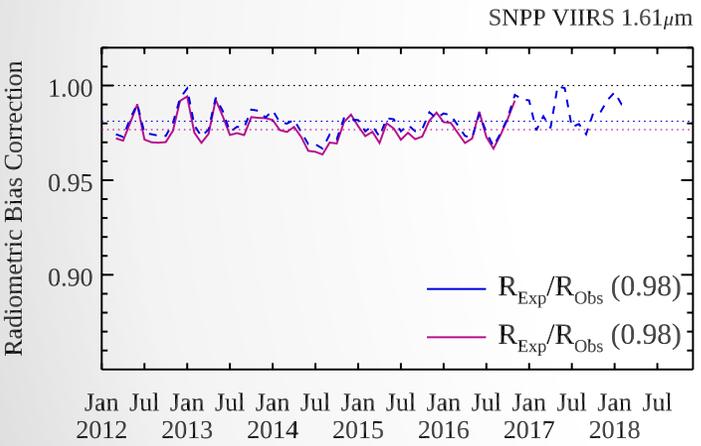
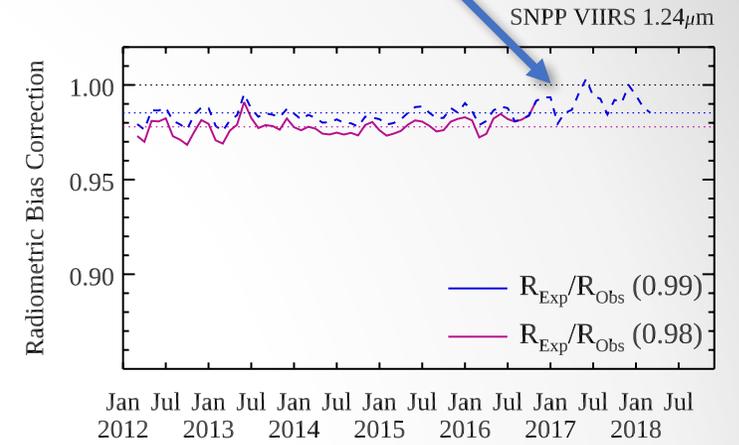
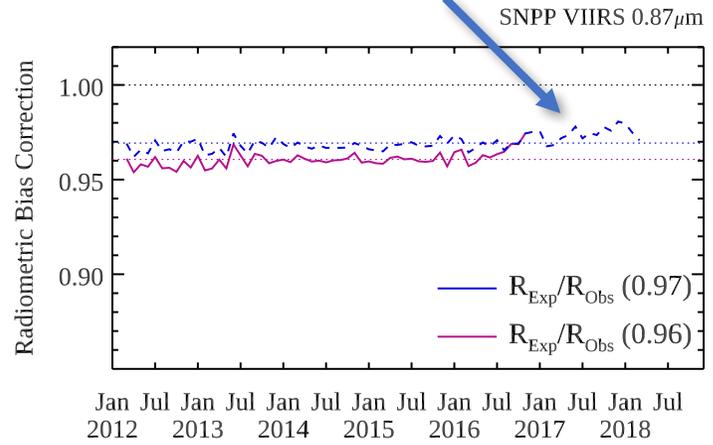
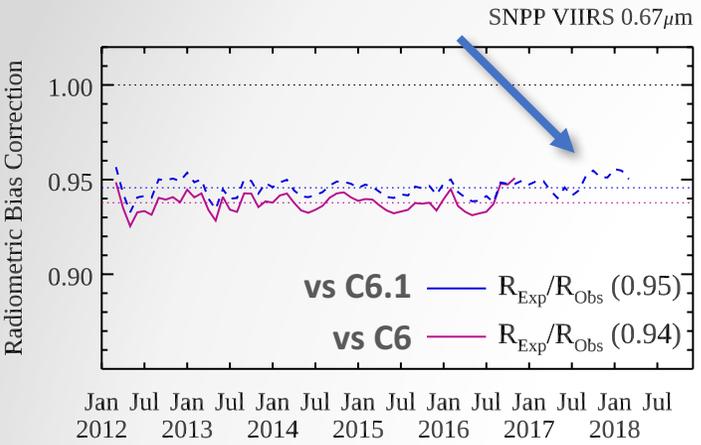


# Summary

- Radiometric adjustment factors to key solar reflectance channels necessary to reconcile observed retrieval differences
  - Important to note that both instruments can be within their absolute calibration specifications yet still exhibit a radiometric offset that can impact inter-sensor geophysical product continuity
- Cloud Team derived VIIRS adjustment factors using Atmosphere SIPS-produced match files
  - Adjustments generally consistent with Aerosol DB team for overlapping channels
  - Applied to VIIRS since MODIS is the reference record
- Improvement seen in COT retrieval continuity, though other factors continue to confound
  - See Steve Platnick's talk this afternoon for additional CLDPROP details

# Challenges Moving Forward

- Potential disconnects between different L2 algorithm teams who are applying independent radiometric adjustments
- MODIS and VIIRS stability cannot be assessed independently, as changes to one or both instruments can adversely affect product continuity
  - Updates to relative radiometric adjustments should be derived and applied as necessary.
  - Note: We're also tracking absolute sensor stability via independent L1B aggregations (see Starry Manoharan's poster).
- For the cloud products, processing paradigm may need rethinking
  - Forward processing near real-time (NRT) only, climate archive processing replacing NRT following periodic radiometric assessments?



**Ongoing Challenge: Accounting for temporal radiometric drifts in one or both instruments.**

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