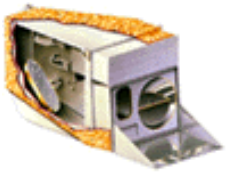


MODIS and VIIRS Calibration Inter-comparison Using Vicarious Approaches

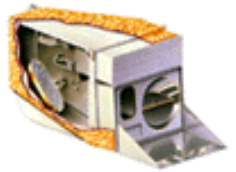
MCST/VCST

Science Systems and Applications, Inc. (SSAI)
NASA Goddard Space Flight Center, Greenbelt, MD 20771

Outline

- Introduction
- Methodology
  - SNO & PICS (desert, DCC, Dome C, ocean buoys)
  - Comparison of reflectance and brightness temp (BT)
- Results
  - Terra & Aqua MODIS
  - SNPP & NOAA20 VIIRS
  - NOAA20 VIIRS & Aqua MODIS
- Summary

VIIRS and MODIS



VIIRS RSB			MODIS RSB		
Band	CW (nm)	BW	Band	CW (nm)	BW
M1	412	20	B8	412	15
M2	445	18	B9	443	10
M3	488	20	B10	488	10
M4	555	20	B4	555	20
M5	672	20	B1	645	50
M6	746	15	B15	748	10
M7	865	39	B2	858	35
M8	1240	20	B5	1240	20
M9	1378	15	B26	1375	30
M10	1610	60	B6	1640	24
M11	2250	50	B7	2130	50
I1	640	80	B1	645	50
I2	865	39	B2	858	35
I3	1610	60	B6	1640	24

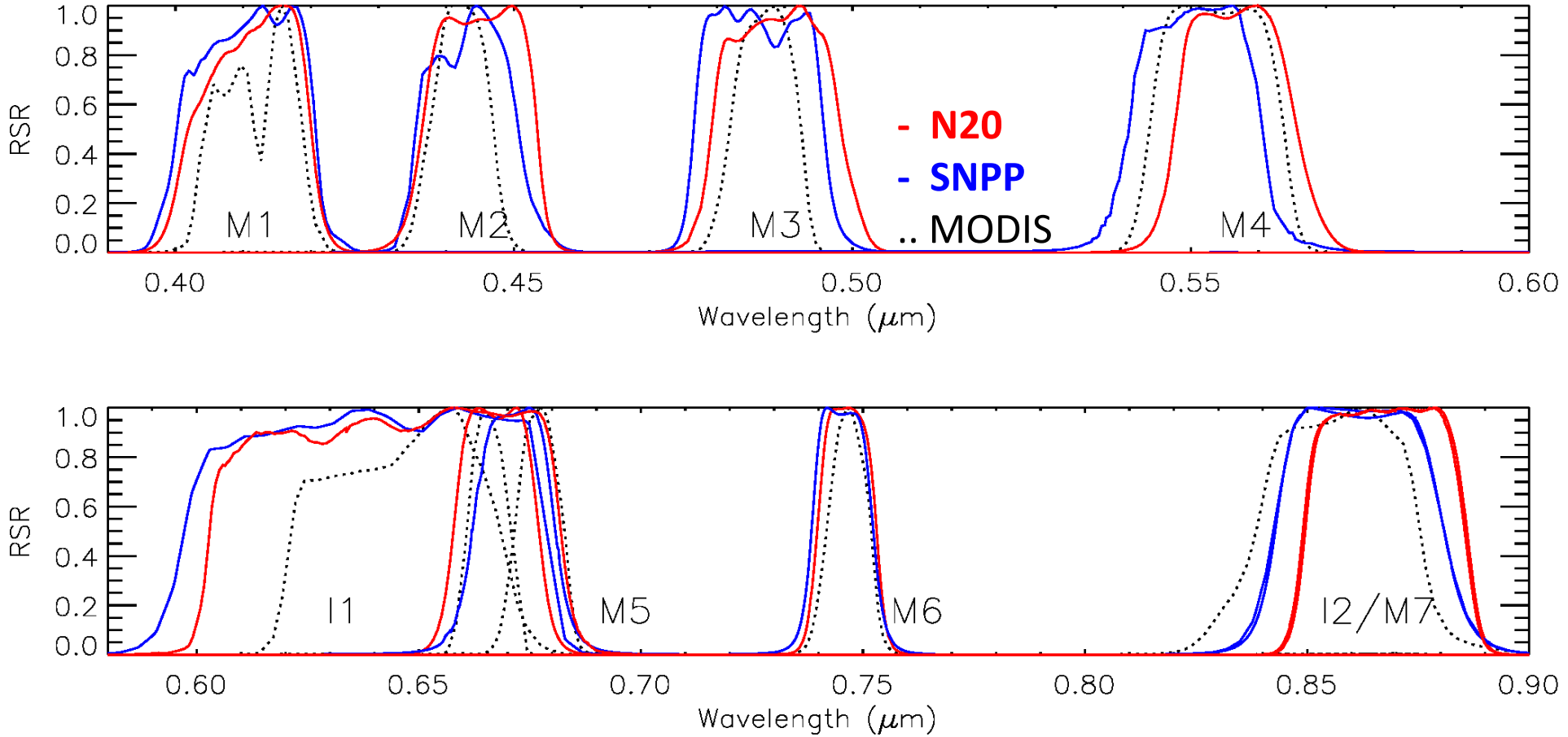
NOAA-20/SNPP VIIRS

- Scanning radiometer
- 22 bands between 0.4 and 12 µm
- Afternoon polar orbit
- Swath distance of 3000 km
- Nadir resolutions: 0.375, 0.750 km
- Launched Nov 18, 2017 & Oct 28, 2011
- Aggregation, dual-gain

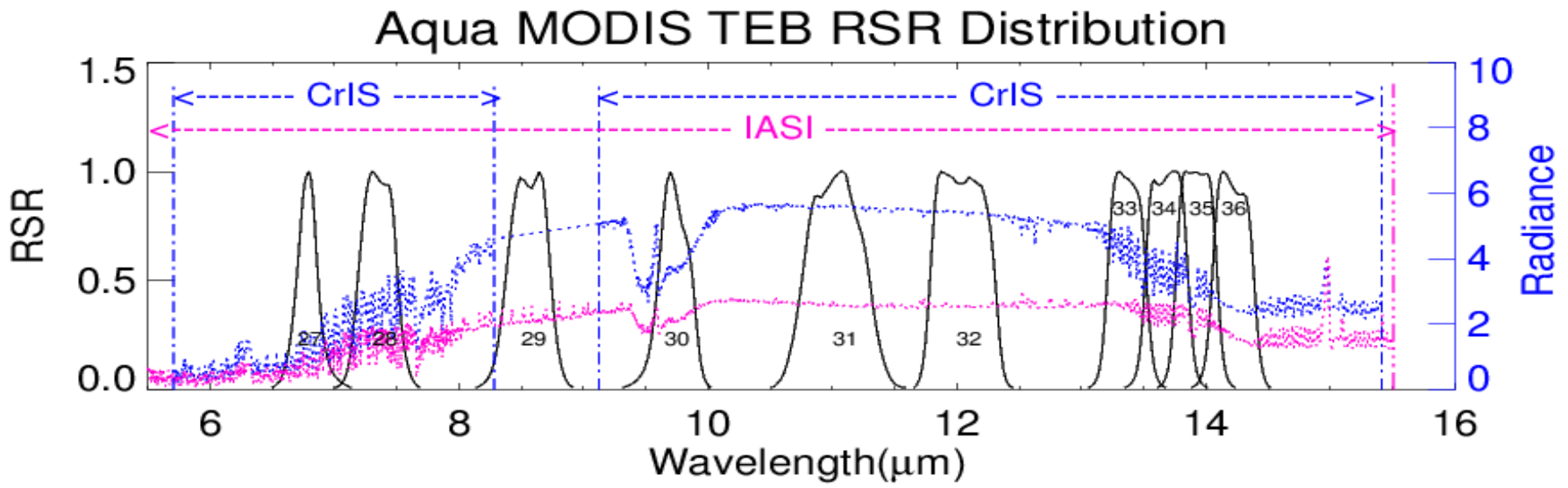
Terra/Aqua MODIS

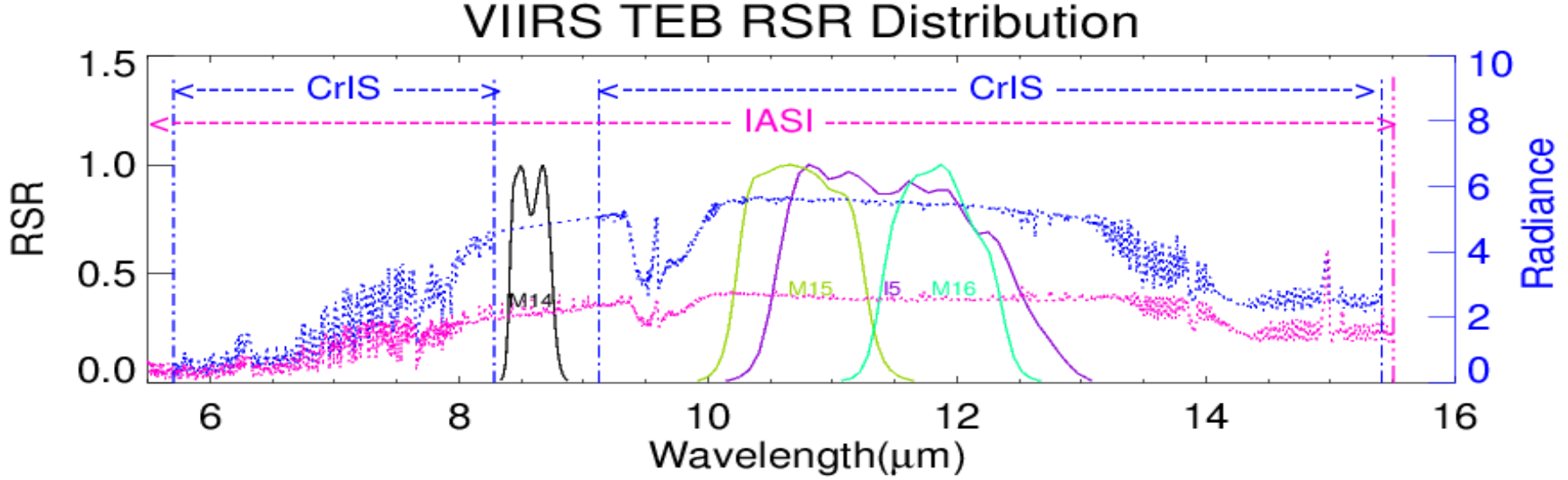
- Scanning radiometer
- 36 bands between 0.4 and 14 µm
- Morning/afternoon polar orbits
- Swath distance of 2330 km
- Nadir resolutions: 0.25, 0.5, 1.0 km
- Launched Dec 18, 1999 & May 4, 2002

Relative Spectral Response (RSR)



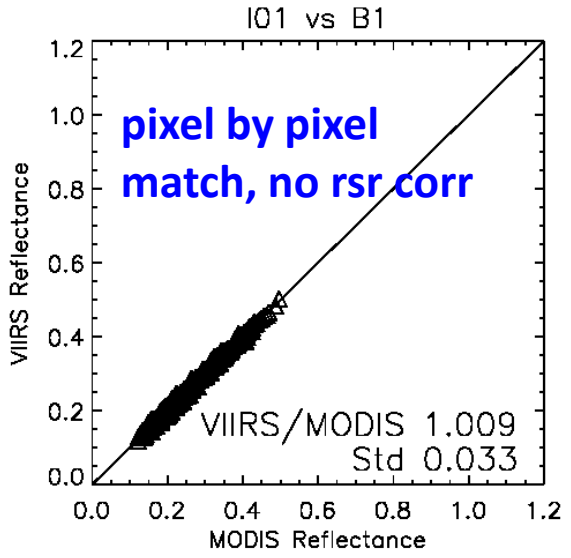
- For RSB inter-comparison, RSR correction is necessary between NOAA20 and SNPP VIIRS and between VIIRS and MODIS.
- Correction is based on historic SCIAMACHY hyper-spectral measurements over typical surfaces (ocean, desert, snow and clouds), provided by the European Space Agency.

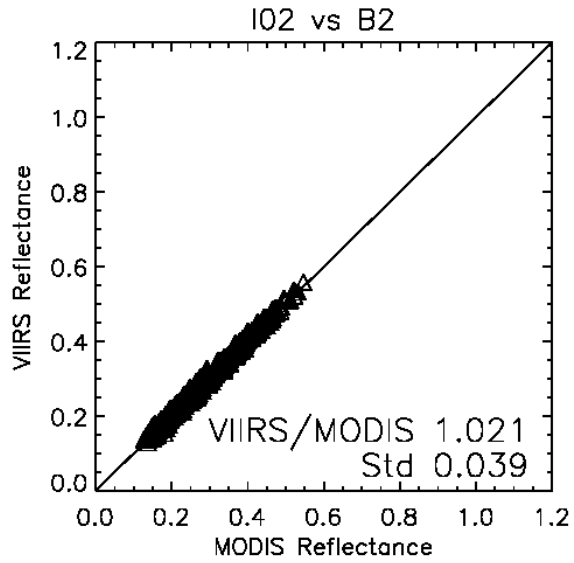


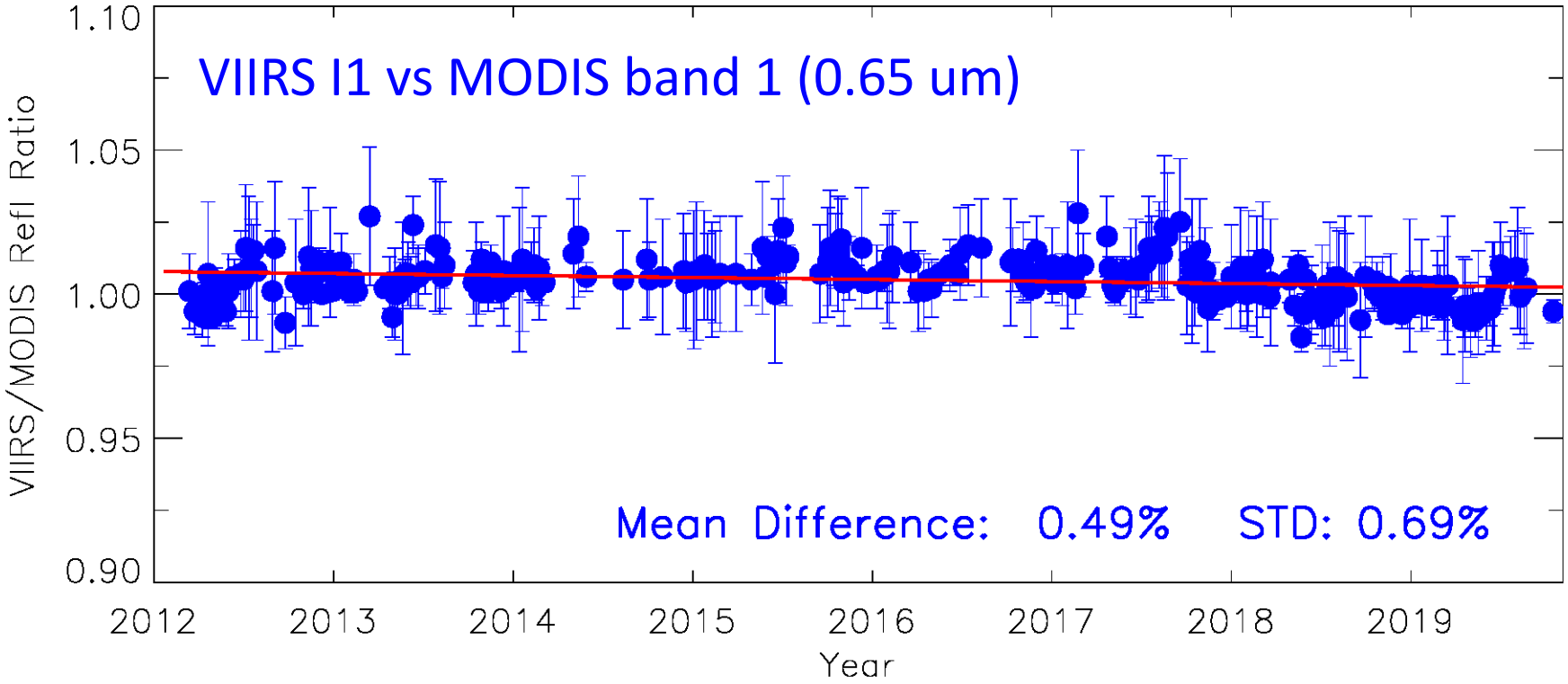


For TEB inter-comparison, high quality RSR correction can be achieved based on IASI and CrIS using SNO

SNO (Simultaneous Nadir Overpasses)

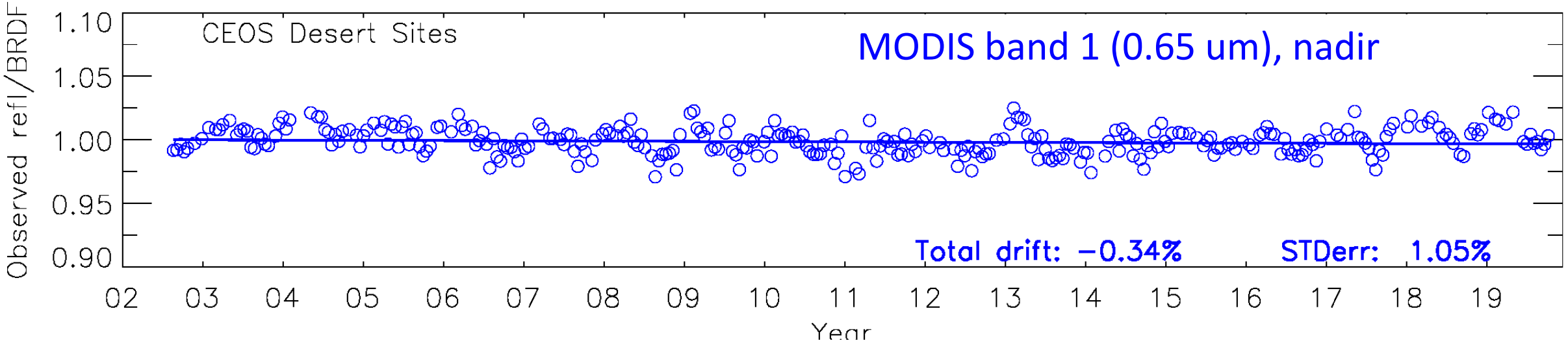




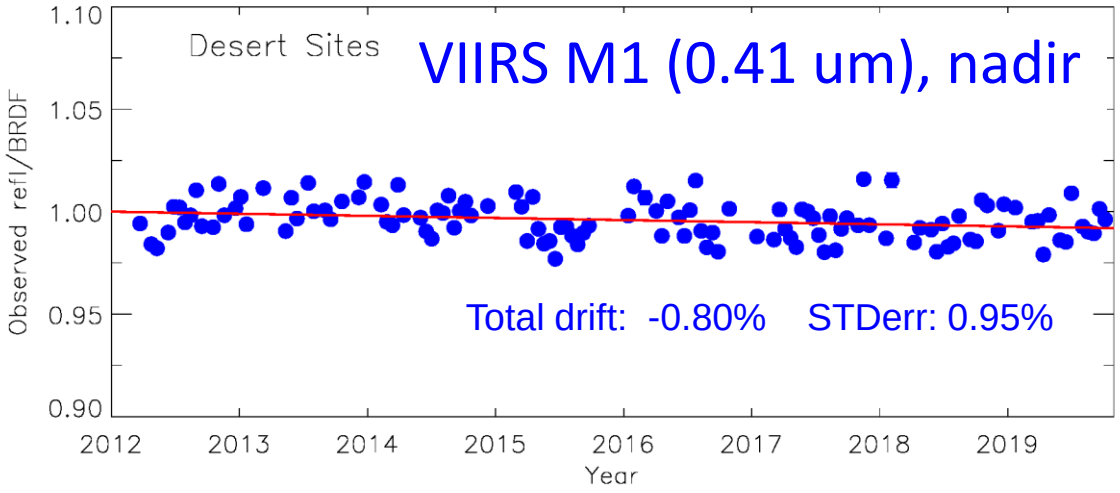


- Ratio approach between two sensors (VIIRS & MODIS)
- Significantly reduces impacts of viewing and illumination angle differences and changing surface (< 30s)
- Different locations in high latitude
- Both RSB & TEB

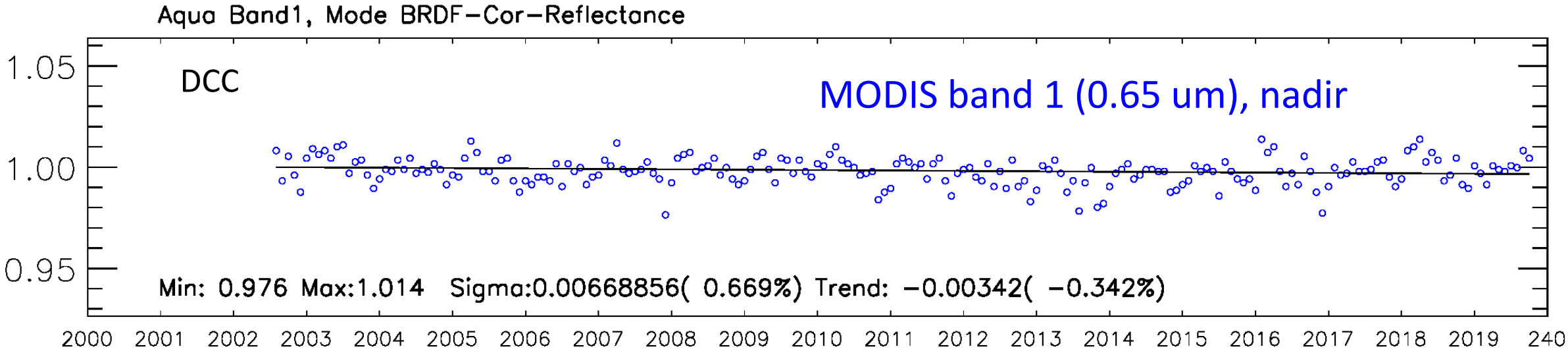
Pseudo Invariant Calibration Sites (PICS) over Desert



- Typical target area of 20 x 20 km
- Excellent radiometric stability for RSB
- Repeatable orbits (every 16 days) maintain constant viewing angles to each site
- Need site-dependent BRDF correction (Roujean et al. 1992) to reduce seasonal fluctuations.

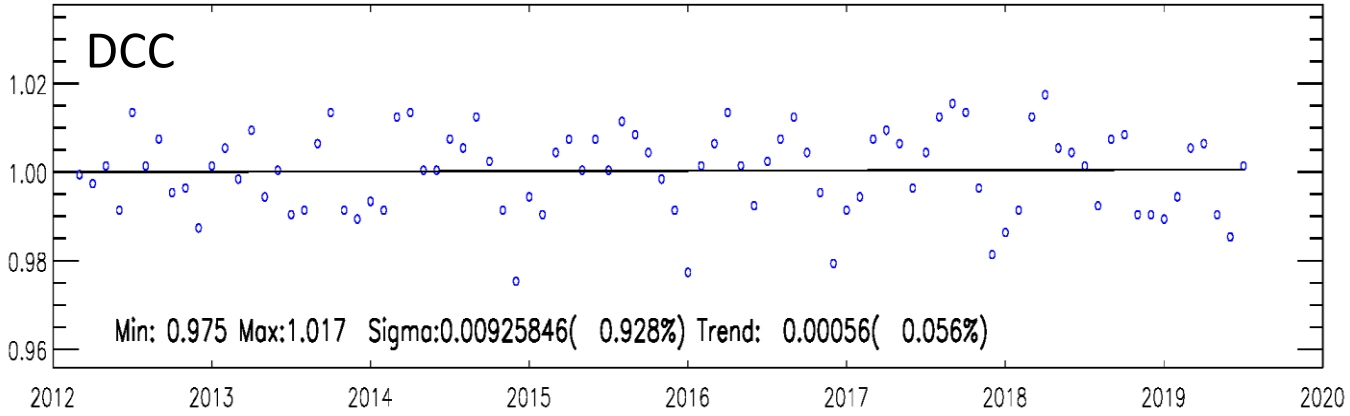


Pseudo Invariant Calibration Sites (PICS) over DCC

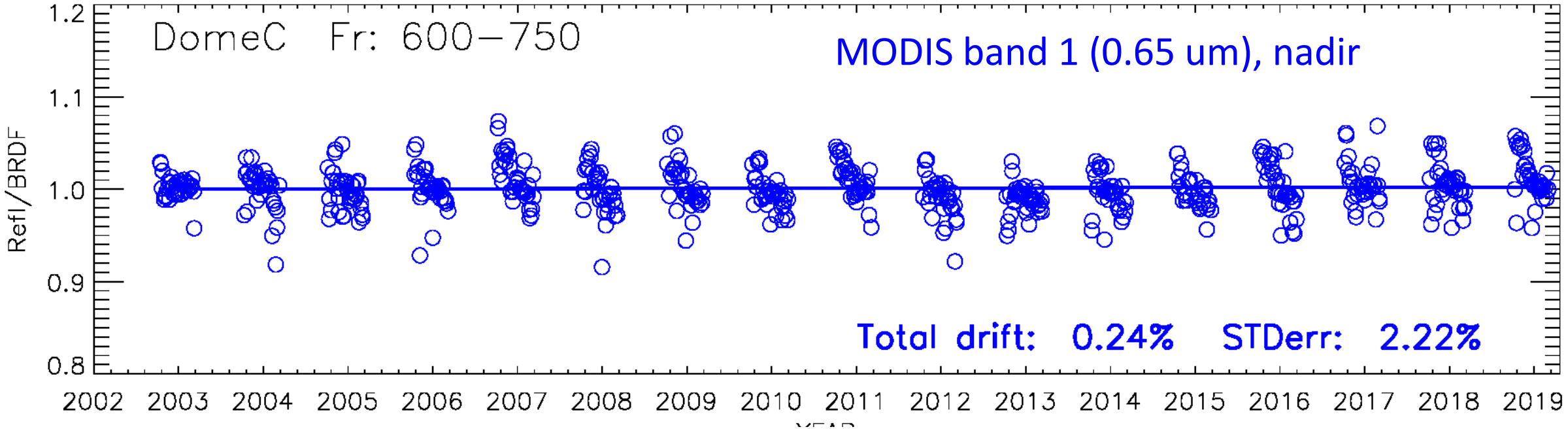


- Variable locations over tropical region
- Brightest EV target with excellent radiometric stability
- Abundant but need monthly PDFs to derive the mean and mode
- Band-dependent BRDF correction to reduce seasonal fluctuations.
- Saturation for some MODIS RSB

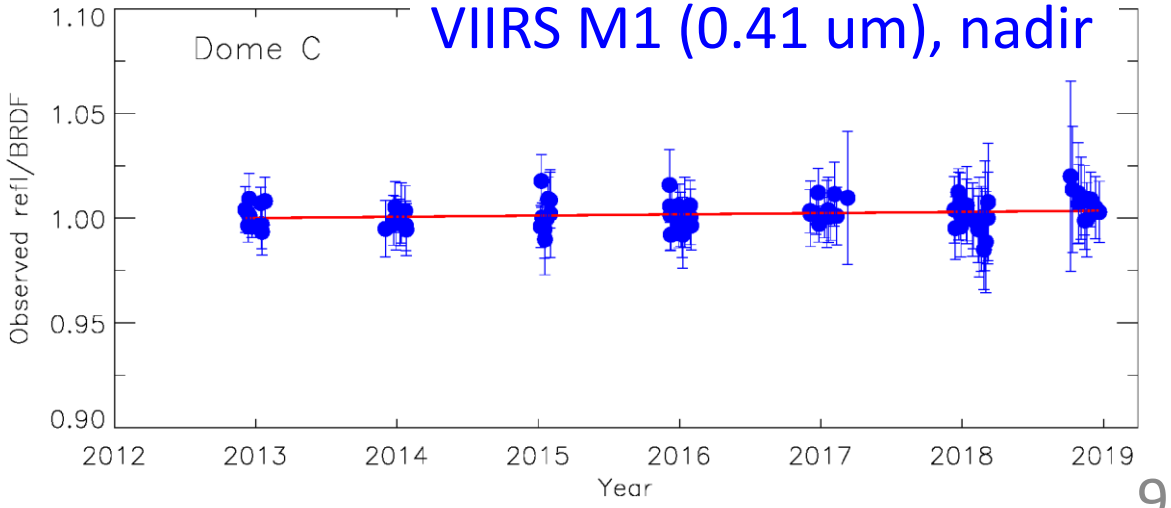
VIIRS M1 (0.41 um), nadir



Pseudo Invariant Calibration Sites (PICS) over Dome C

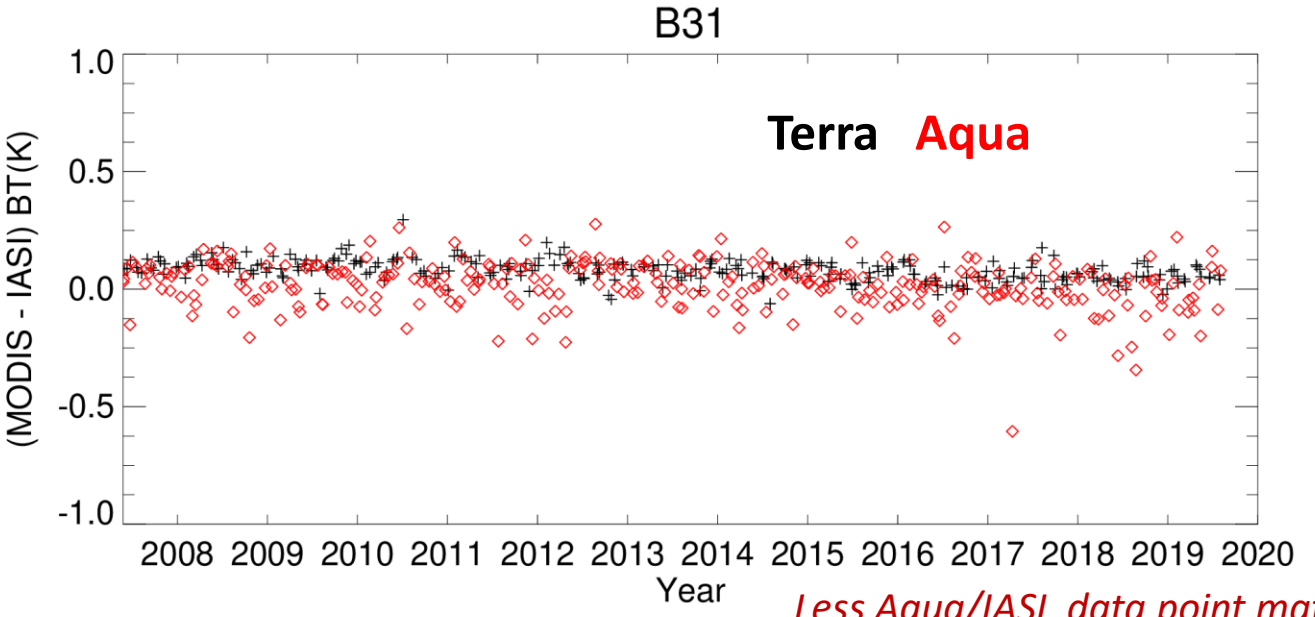


- Typical target area of 20 x 20 km
- Excellent radiometric stability and less atmospheric influence
- RSB data available in Dome C summer
- Large residual after BRDF correction
- Near-surface AWS available for TEB

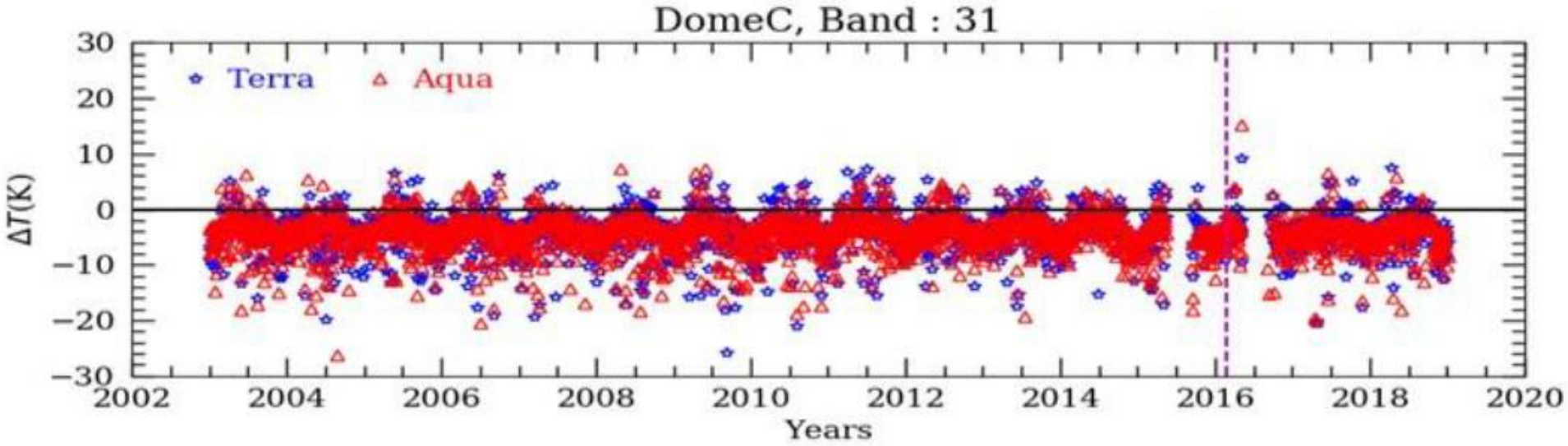


SNO and Dome C (ocean buoys) for TEB

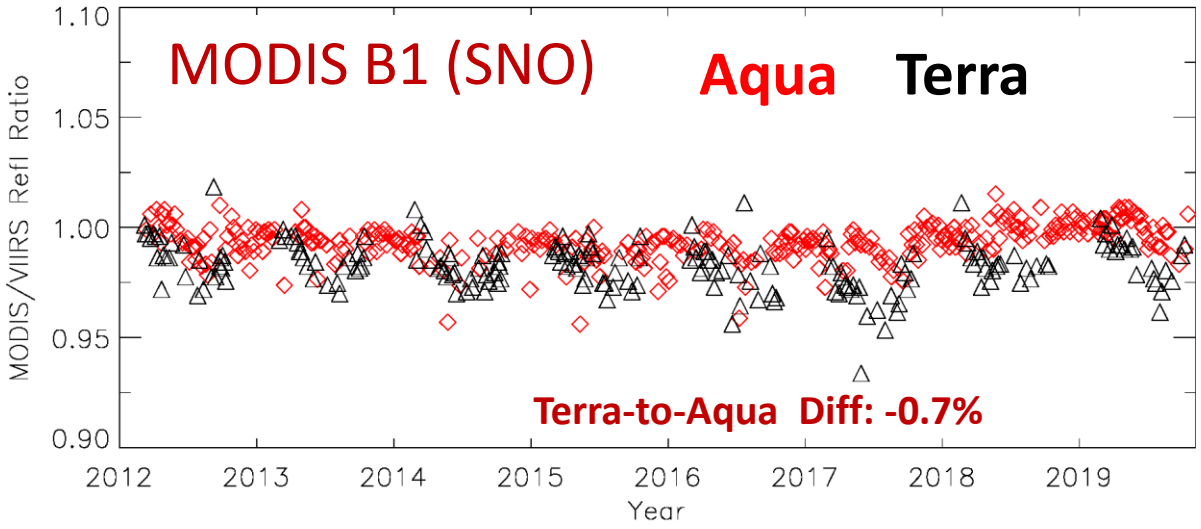
- For SNO, a temperature difference, ΔT, is used by subtracting the simulated T using IASI & CrIs
- For Dome C or ocean buoy sites, a temperature difference, ΔT, is determined by subtracting the measured coincident T at site

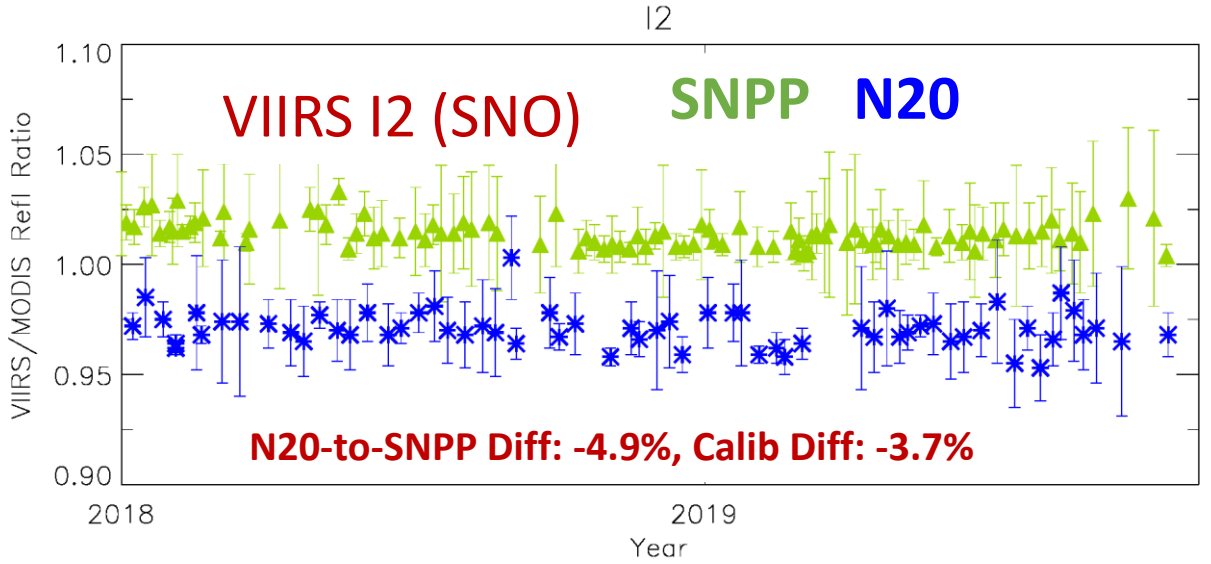


Less Aqua/IASI data point match

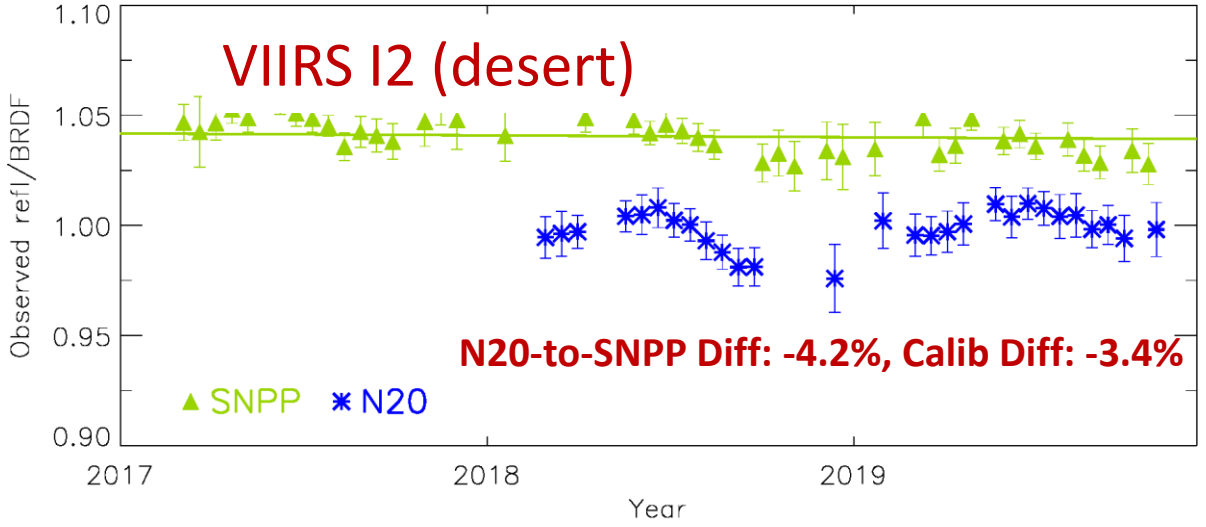


MODIS and VIIRS Inter-Comparison for RSB





- Sensor inter-comparison is based on vicarious approaches (SNO, Desert, no RSR correction)
- SNO approach based on double difference relative to reference sensor (Aqua MODIS or SNPP VIIRS)
- PICS approach based on site-specific BRDF (MODIS or VIIRS)

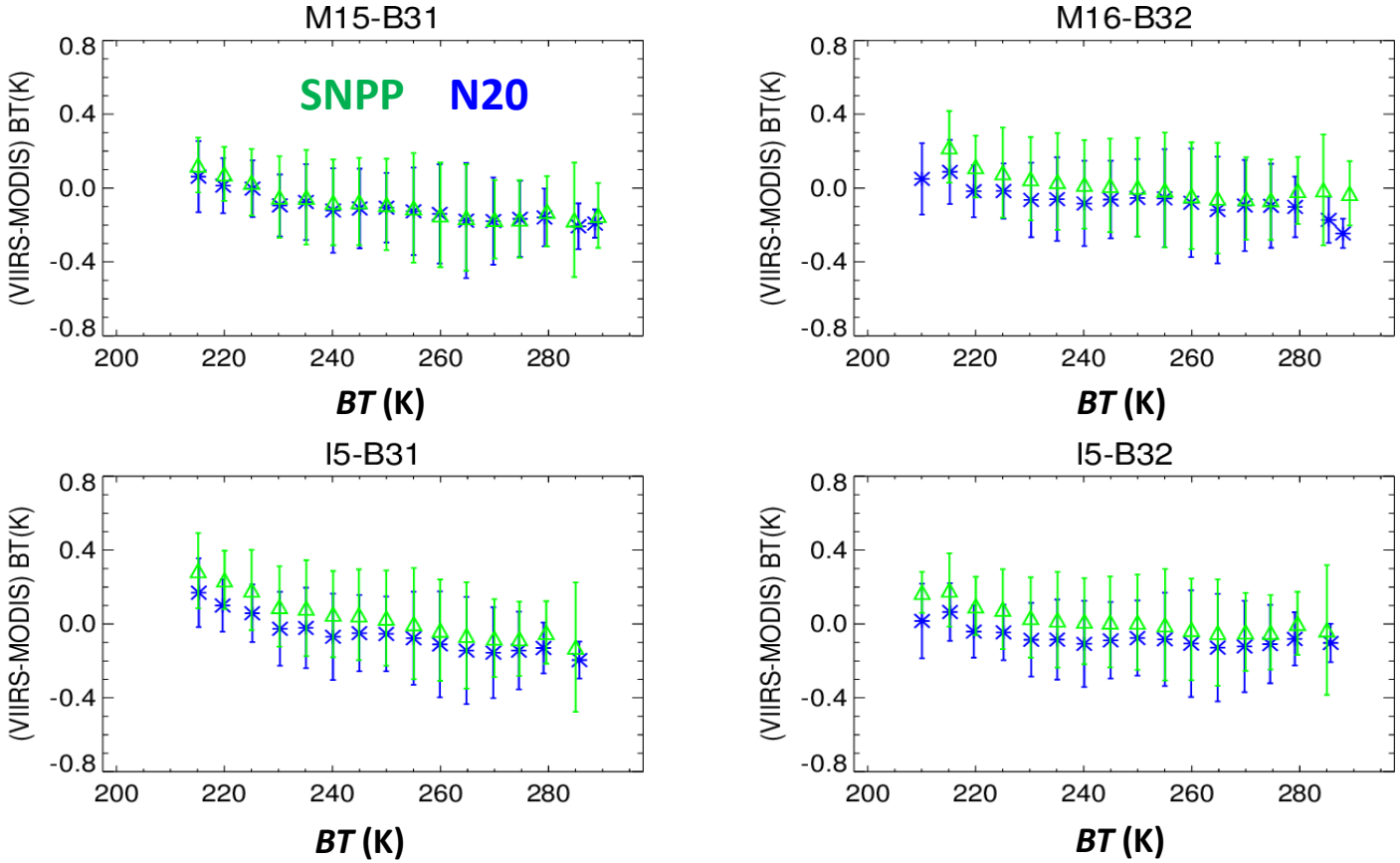


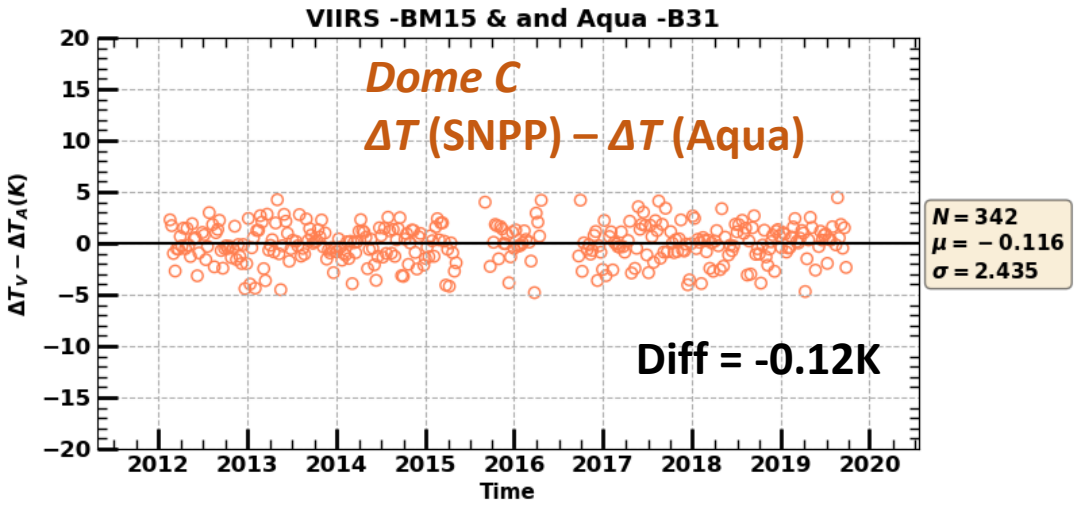
Close *F* factors for I2 between SIPS and IDPS

MODIS and VIIRS Inter-Comparison for TEB

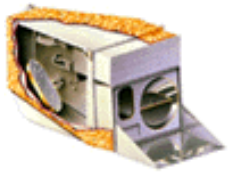
- Sensor Inter-comparison is based a double difference in ΔT
- For TEB, the differences are dependent on radiance level

VIIRS and IASI SNO





Terra and Aqua MODIS RSB and TEB Inter-Comparison

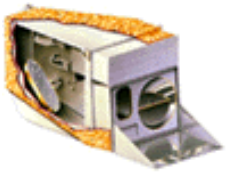


	RSB (%)							TEB (K)				
Method	**B1**	**B2**	**B3**	**B4**	**B8**	**B9**	**B12**	**B20**	**B29**	**B31**	**B32**	**B35**
SNO	**-1.1**	**-0.7**	**2.2**	**-0.8**	**0.5**	**1.0**	**-1.4**	**0.11**	**-0.03**	**0.10**	**0.11**	**0.20**
Desert	**-0.7**	**0.8**	**0.9**	**-0.2**	**0.1**	**-0.4**						
Dome C	**-0.8**	**0.6**	**0.8**	**-0.1**				**0.96**	**0.24**	**0.21**	**0.26**	**-0.14**
Ocean								**0.11**	**-0.08**	**-0.09**	**0.00**	**1.36**

**Results are provided in percentage difference (Terra – Aqua) (%) for RSB and in Kelvin (K) for TEB, mainly L1B data after 2012.*

RSR correction in SNO is based on IASI for TEB and no RSR correction is applied for RSB

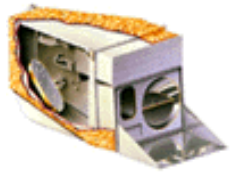
NOAA20 and SNPP VIIRS TEB Inter-Comparison



	TEB (K)				
Method	M13	M14	M15	M16	I5
SNO	-0.12		-0.02	-0.10	-0.10
Dome C	0.15	-0.23	-0.70	-0.64	
Ocean	-0.01	-0.60	-0.11	0.07	

**Results are provided in percentage difference (NOAA20 – SNPP) in Kelvin (K) for TEB*
RSR correction is based on CrIs/IASI for TEB in SNO

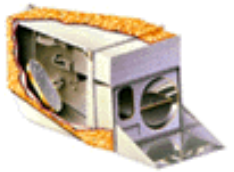
NOAA20 VIIRS and Aqua MODIS RSB Inter-Comparison



	RSB (%)					
Method	**M1 B8**	**M2 B9**	**M4 B4**	**M7 B2**	**I1 B1**	**I2 B2**
SNO	**-2.6 ± 1.3**	**-3.5 ± 1.1**	**-2.6 ± 0.5**	**-3.1 ± 0.9**	**-2.8 ± 0.6**	**-3.1 ± 0.9**
Desert	**-4.8 ± 0.7**	**-5.7 ± 0.6**	**-2.5 ± 0.9**	**-0.7 ± 0.5**	**-3.5 ± 0.6**	**-0.8 ± 0.5**
Dome C	**-4.6 ± 0.6**		**-1.6 ± 2.3**	**-0.4 ± 1.8**	**-1.9 ± 2.1**	**-0.9 ± 1.9**

**Results are provided in percentage difference (NOAA20 – Aqua) (%) for RSB*
RSR correction is based on SCIAMACHY for RSB

Summary



- This study provides assessment of MODIS and VIIRS calibration inter-comparison for both RSB and TEB using various vicarious approaches (SNO, desert, Dome C and ocean buoys)
- For VIS/NIR bands, Terra and Aqua MODIS are consistent within 1.5%. In the case between NOAA-20/SNPP and Aqua, Aqua is between NOAA-20 and SNPP, and NOAA-20 is 1.0~3.0% lower depending on wavelength. For SNPP, additional differences up to 3.0% exist between IDPS and SIPS L1B product.
- For atmospheric window bands, agreement among Terra/Aqua MODIS and SNPP VIIRS is within 0.10 K (typical scenes). Small negative biases (~0.10K) are observed for NOAA20 compared with SNPP using IASI or CrIS.