

# Impact of reflectance calibration on the long-term Terra and Aqua MODIS aerosol products

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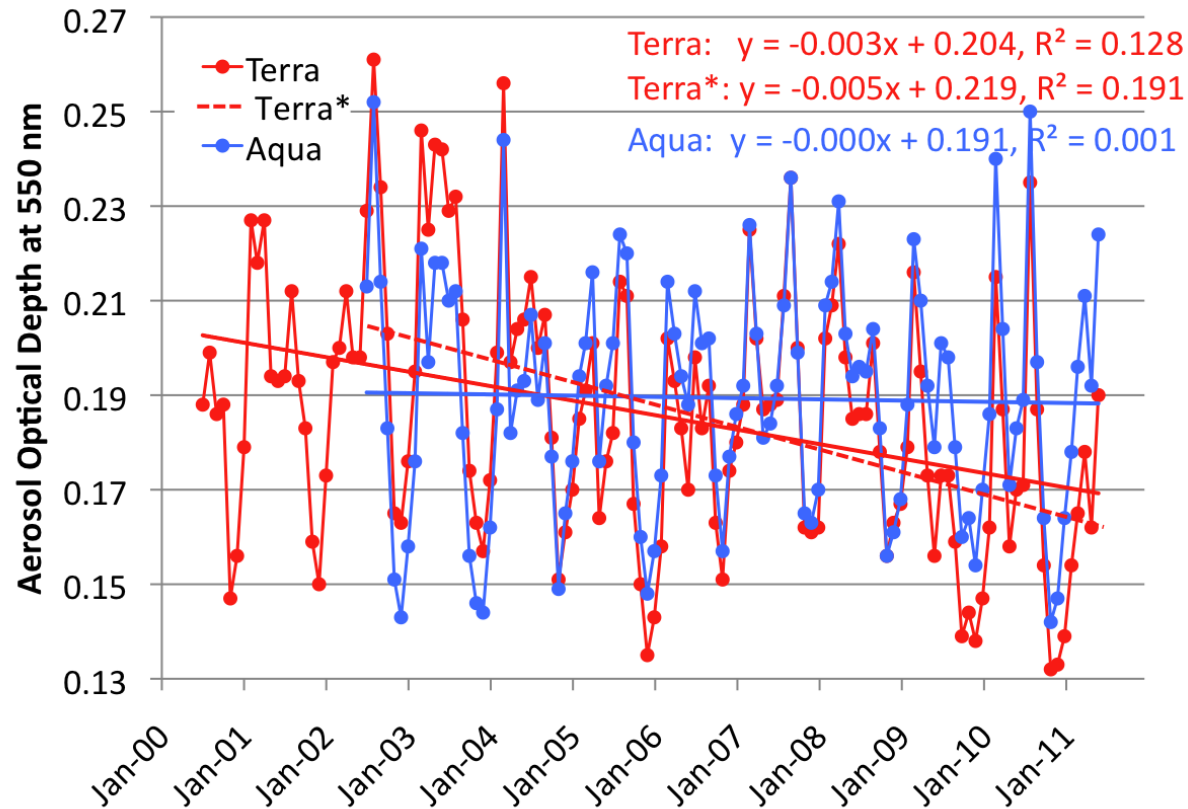


We have validated Collection 5 aerosol products, so...

**Q: Is global aerosol increasing or decreasing?**

# A: A Definite Maybe

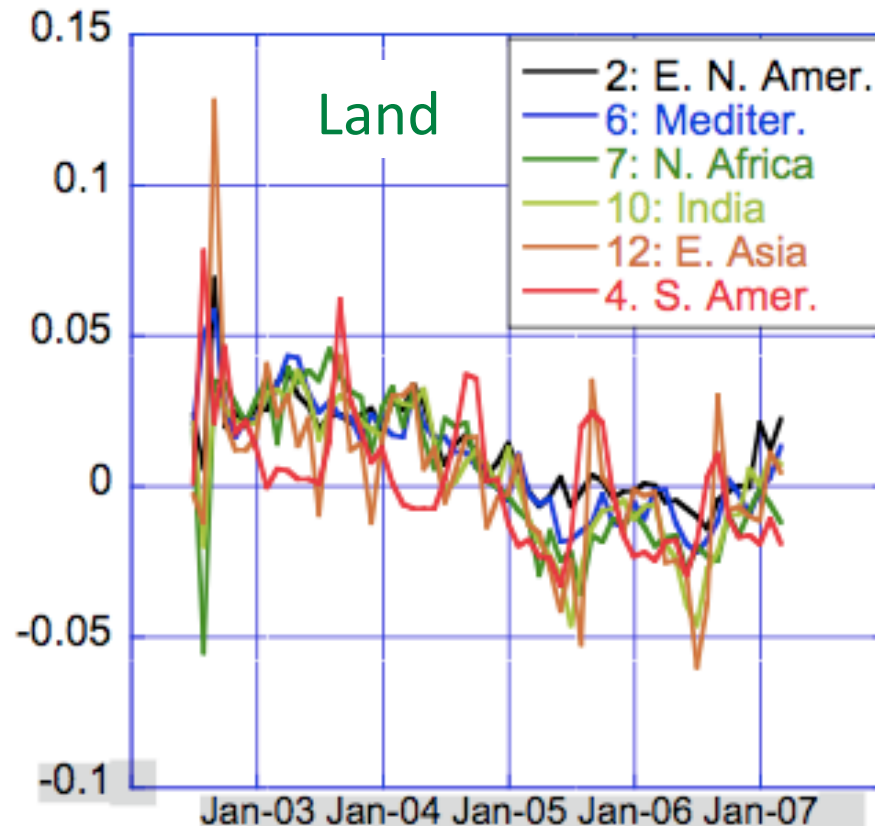
## MODIS AOD Monthly Mean - Land Only



• Over land,

- Terra decreases (-0.004/yr), and is significant at 95% level
- Aqua constant
- (Terra - Aqua) = changes from 0.01 to -0.02!  $\Delta(\text{Terra} - \text{Aqua}) = -0.03$

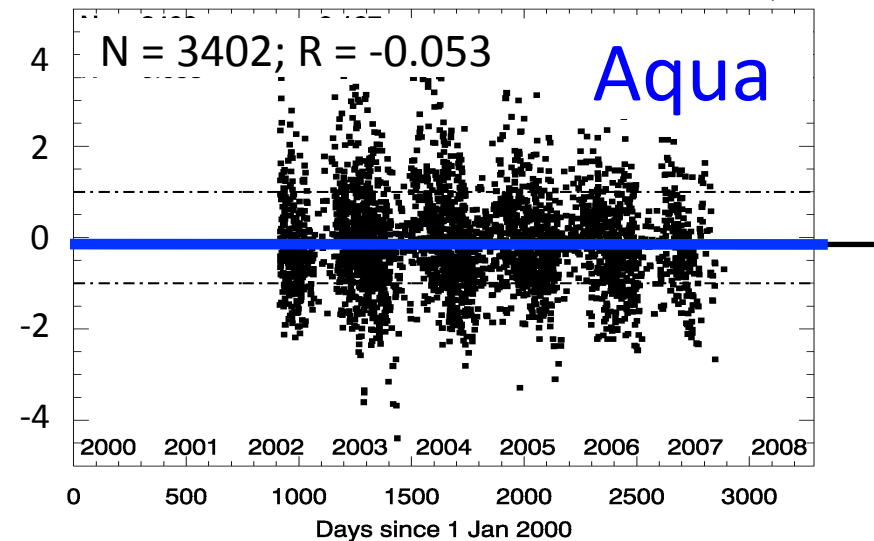
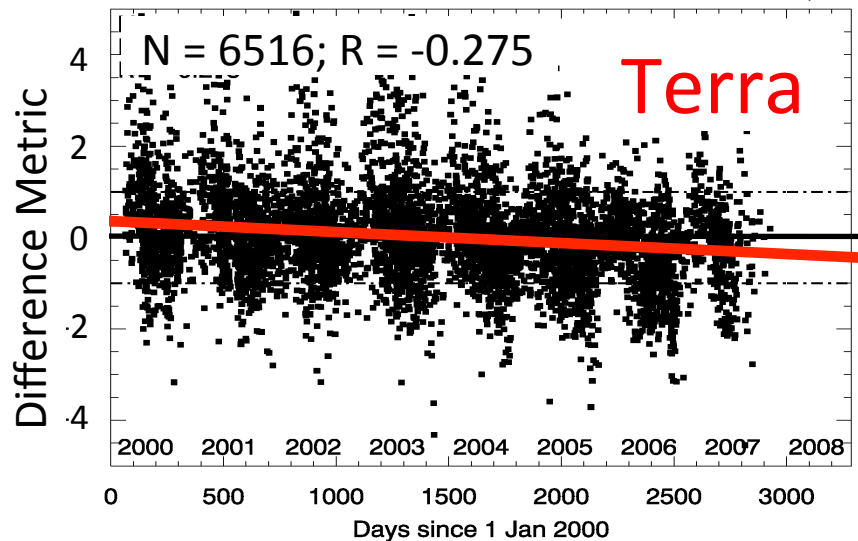
# Terra $\neq$ Aqua



- Terra – Aqua divergence is the same everywhere on the globe!
  - Land: Terra-Aqua changes from +0.02 to -0.01.
- Details of aggregation and sampling are NOT primary driver
- All-regional behavior suggests not local diurnal cycle

# Reprise: Comparing MODIS with AERONET

## Trends of MODIS-AERONET “agreement” over time (land)

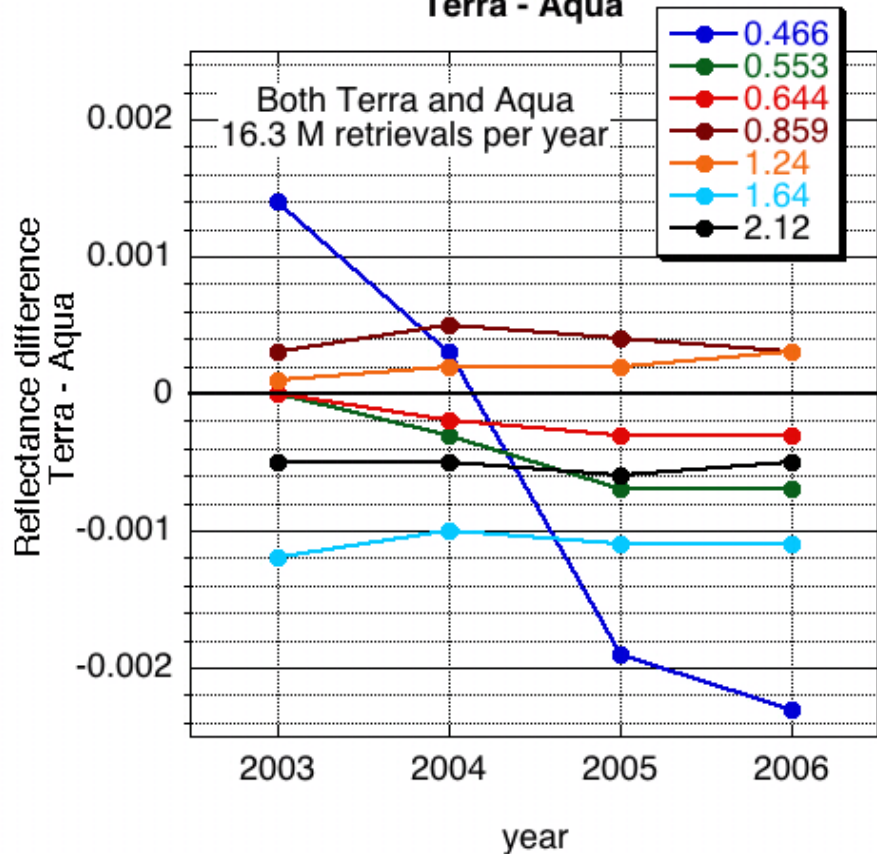


- Over land: 14 AERONET sites with >7 years of data
- Metric *decreases* for **Terra**:
  - Pre-2004, MODIS overestimates AOD
  - Post-2004 MODIS underestimates AOD.
- divergence of Terra - Aqua similar to divergence of Terra – AERONET (-0.03/10 years)

**WHY?**

# AOD differences related to reflectance differences?

Yearly mean L2 spectral reflectance ( $\rho = \pi/\mu_0 * \rho_{L1B}$ )  
used for calculating 10 km aerosol over ocean  
Terra - Aqua



- Assume that statistics of global average reflectance *should* be similar.
- Compute global average reflectance for “valid” AOD retrievals over ocean (16.3 M/yr).
- **Band 3 (466 nm)** is NOT used for over-ocean retrieval
- Pre-2004, Terra > Aqua
- Post-2004, Terra < Aqua
- Over land:

$\Delta\rho$  of 0.003  $\rightarrow$   $\Delta\tau$  of 0.03

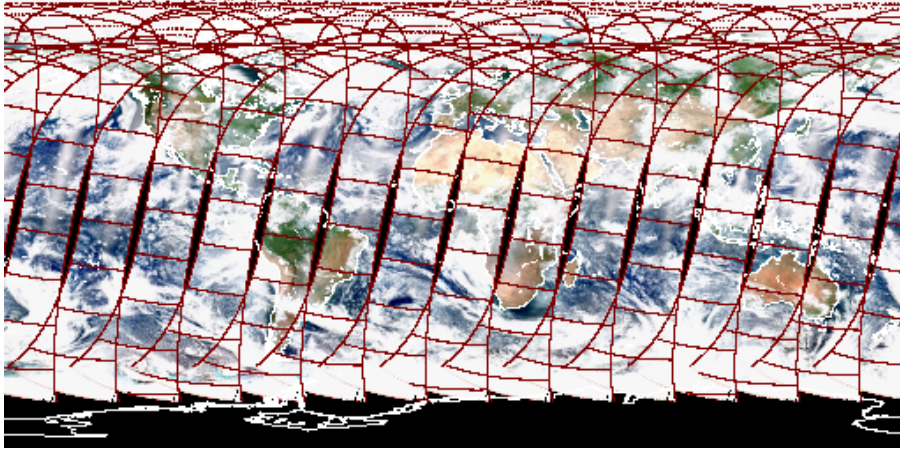
**WHY?**

# Regular meetings with MODIS calibration group

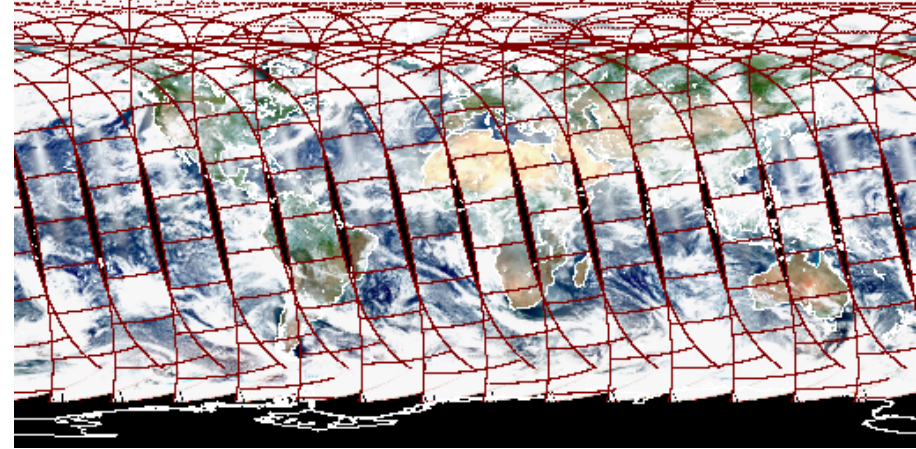
Junqiang Sun, Jack Xiong, etc

# MODIS instruments = “identical twins”

Terra (10:30 Local Time, Descending)



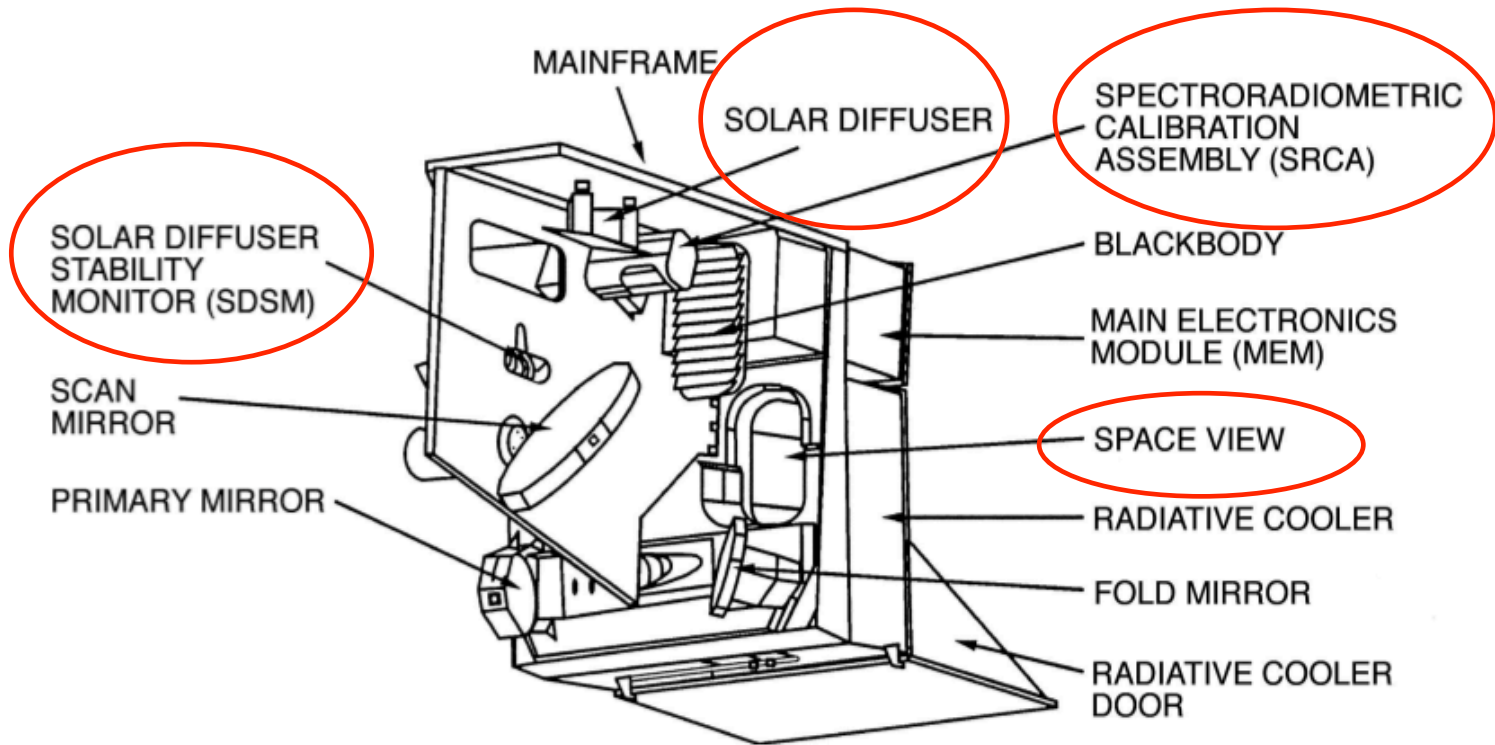
Aqua (13:30 Local Time, Ascending)



Like human twins:

- Each instrument has had a different life experience (pre-launch, during-launch, during orbit)
- Different *aging* patterns (for optics, sensor characteristics, electronics)
- **May have different personalities!!!**

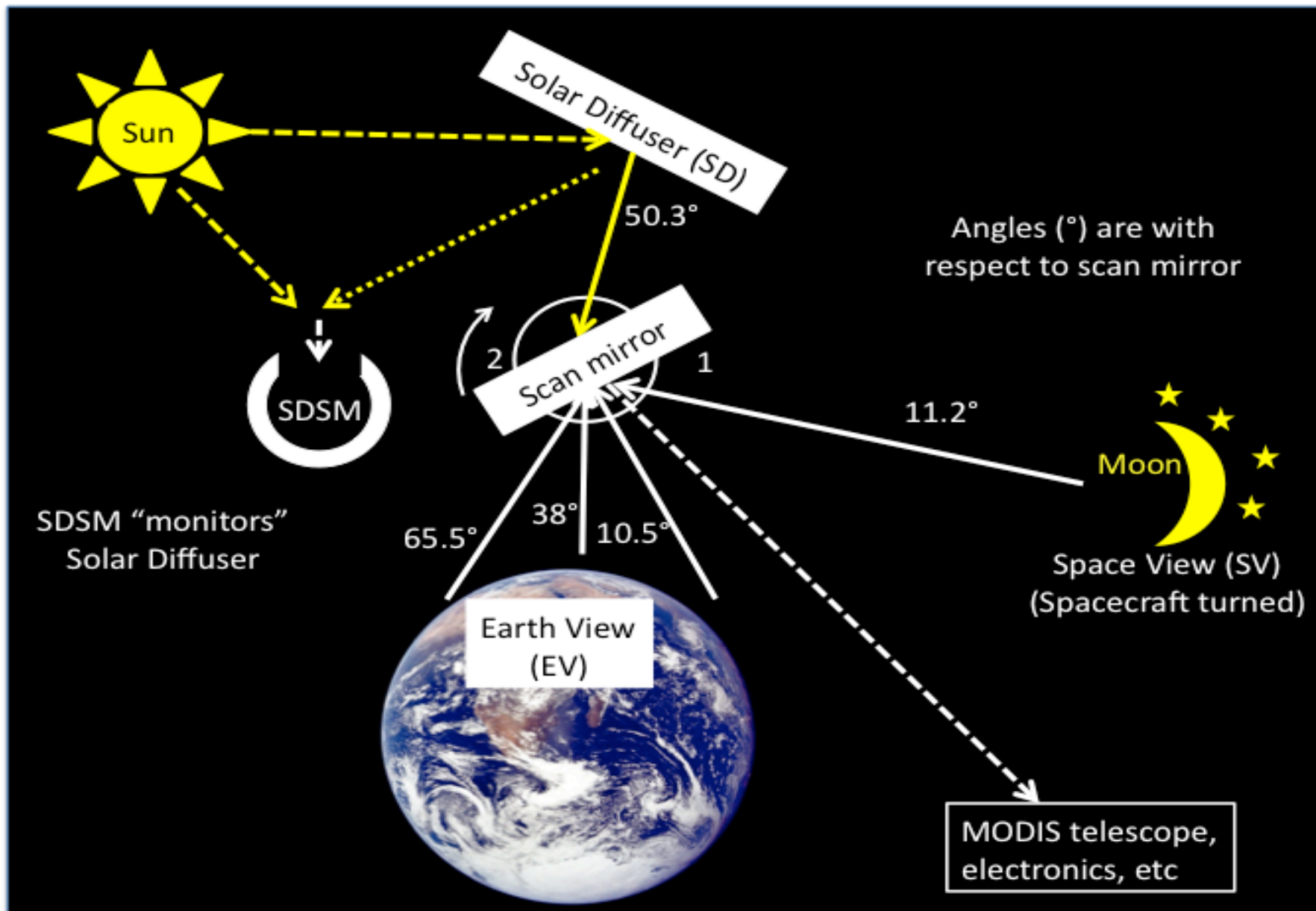




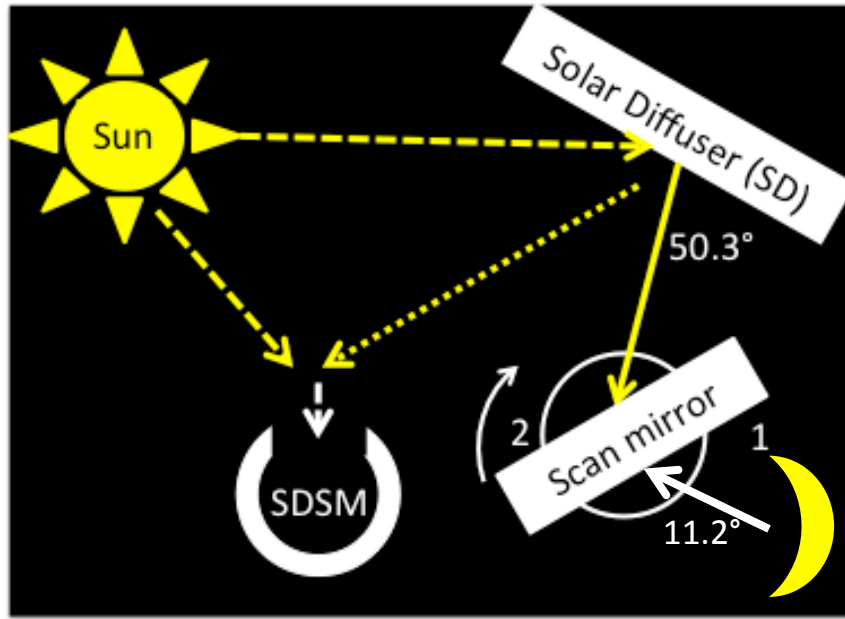
MODIS has many “redundancies” to monitor reflective band calibration

Is something missing?

# Intro to Reflective Band calibration (Geometry): Acronym "soup"



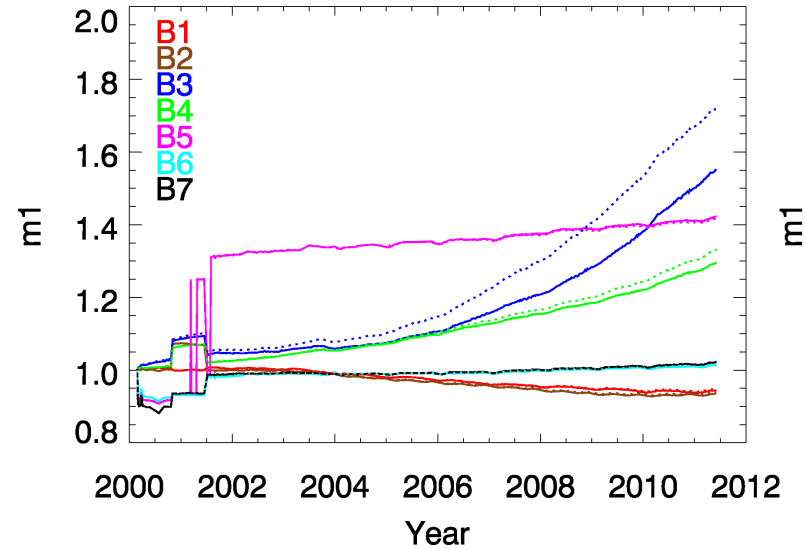
# Instrument calibration tied to Solar Diffuser



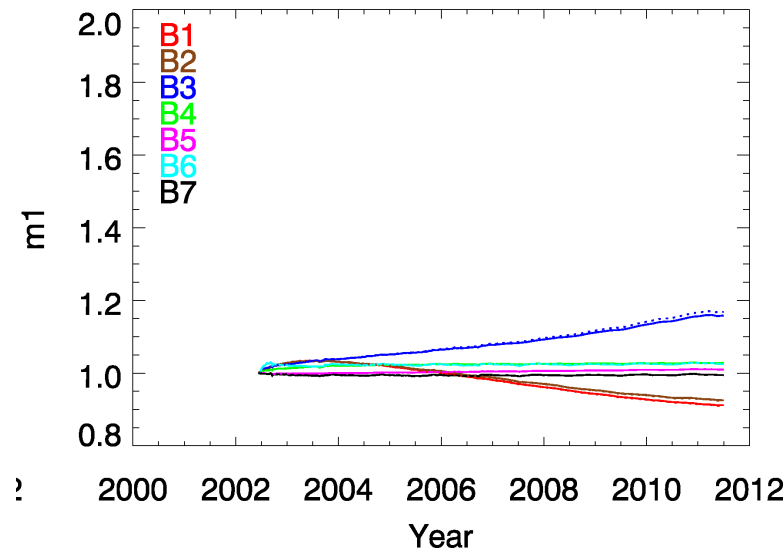
$m_1$  = inverse of instrument gain

- Terra has “degraded” more than Aqua
- **B3**: Terra change by 70%, Aqua by 15%

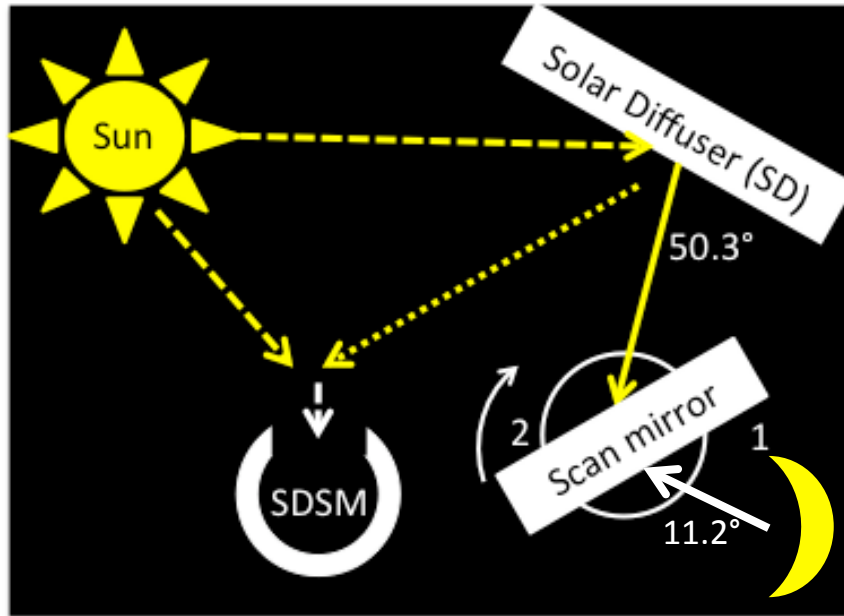
m1 adjustments: terra



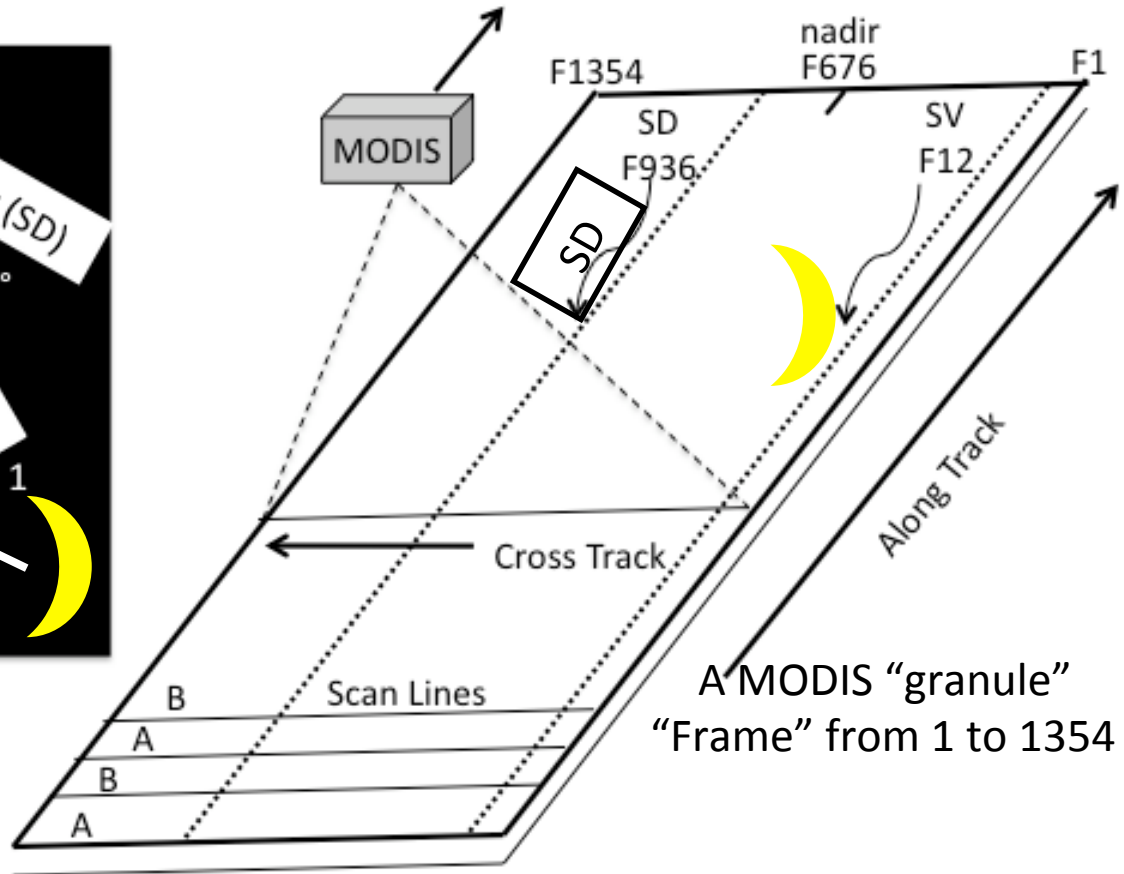
m1 adjustments: aqua



# What if Solar Diffuser is changing?



SD is monitored by SDSM



- AOI of “calibrators” (Solar Diffuser and Space View) correspond to Earth View angles
- Different angles of SD as viewed by SDSM and Scan mirror

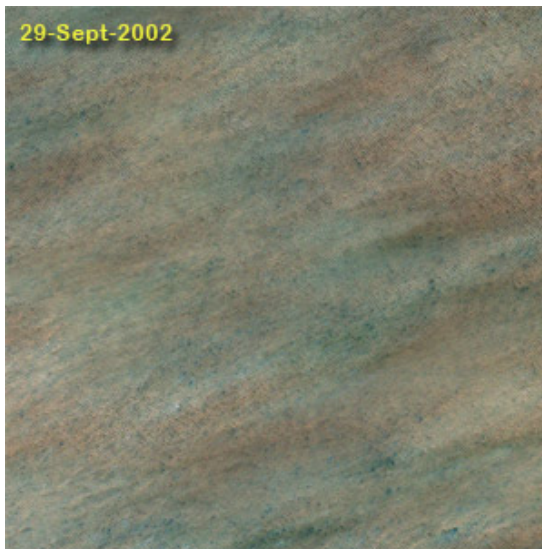
What if... in addition to gain changes,

The BRDF of the SD has changed? And cannot be sufficiently monitored by SDSM?

How could this impact calibration? How could this impact data?



# MODIS reflectance trends over desert sites

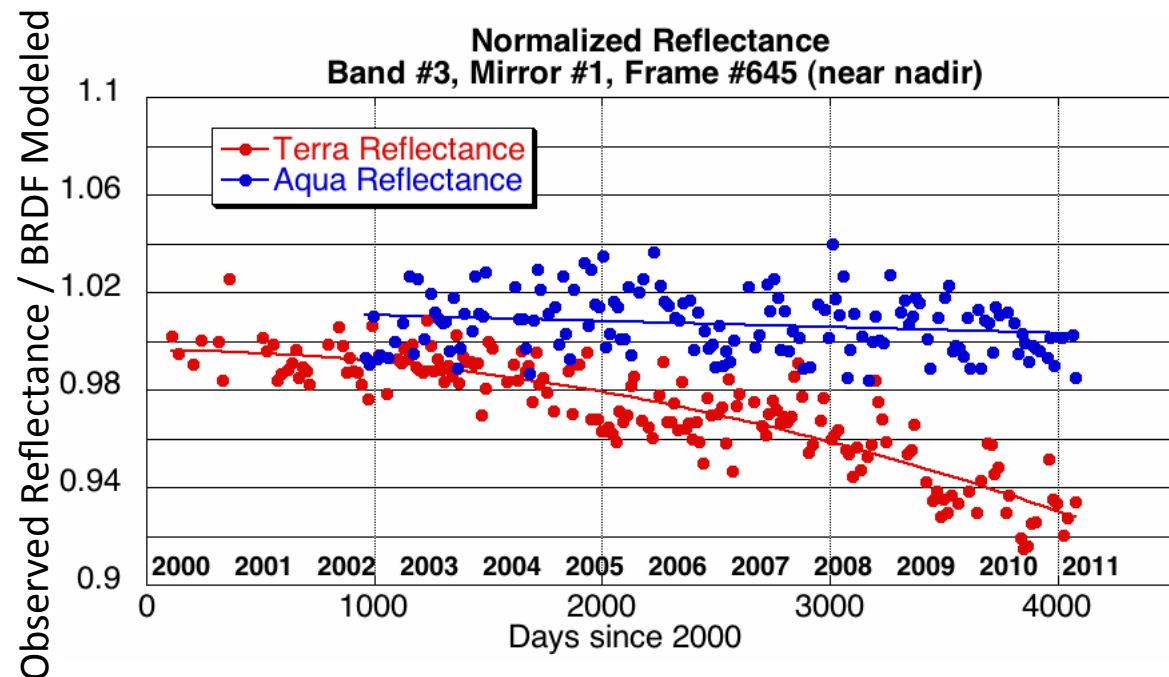


desert test sites



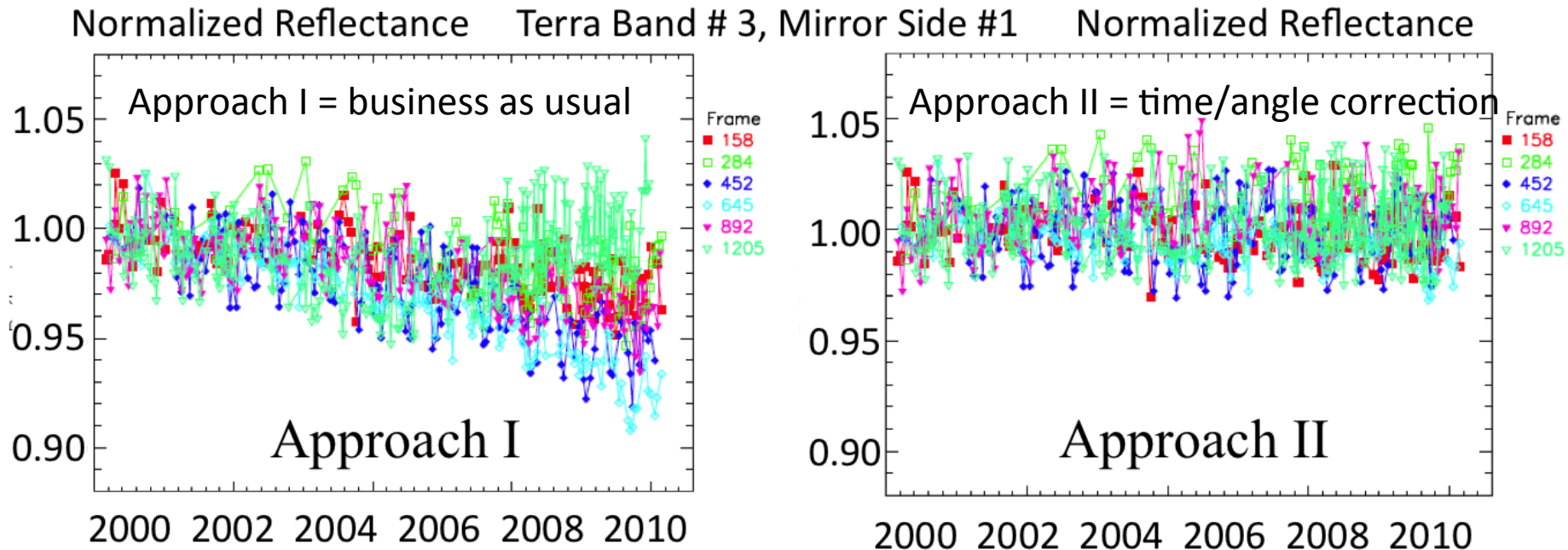
- (1) Collect clear-sky MODIS data over desert sites
- (2) Develop site-specific BRDF from first 3 years of mission
- (3) Over time, compare “observed” reflectance with BRDF modeled reflectance, for different view angles

- Trends in **Terra** Band #3 ( $0.47 \mu\text{m}$ ). No trend for **Aqua**
- Trend varies with Scan Angle (or Frame #)



## Approach II:

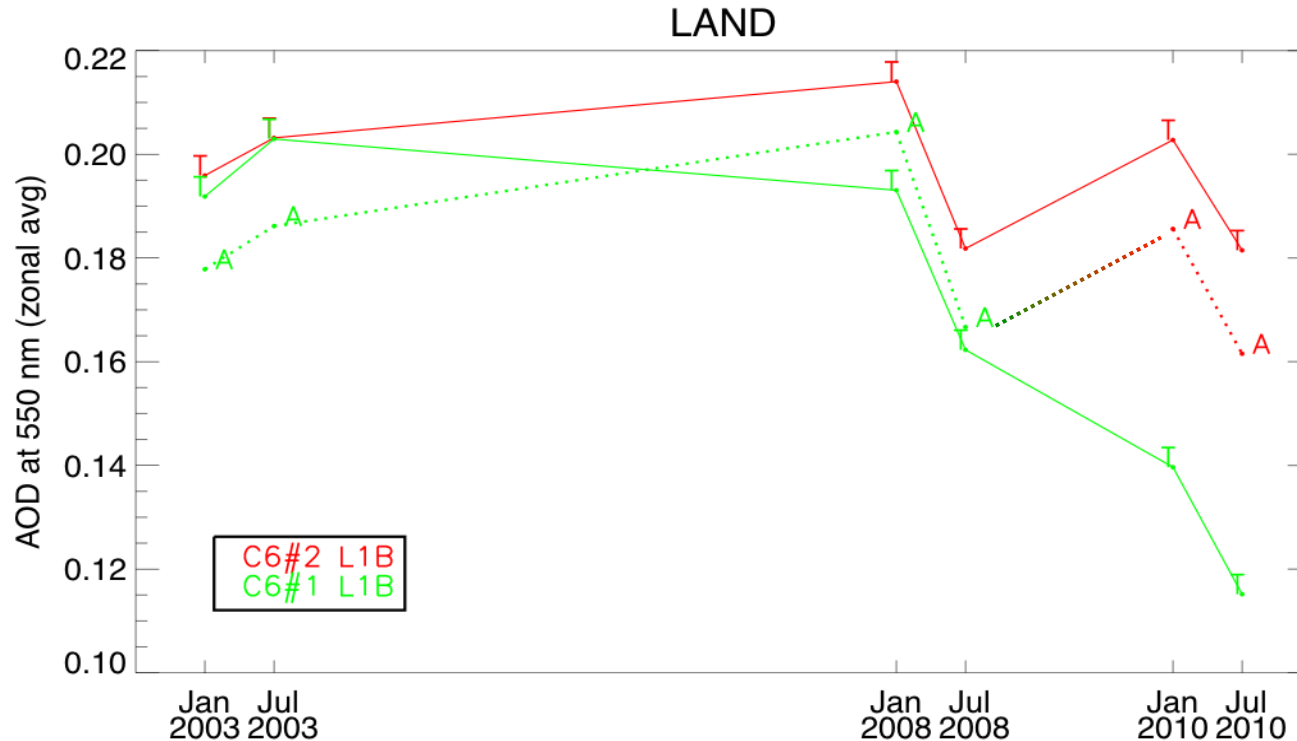
Removes the temporal/angular reflectance trends



- **B3 (466 nm)**
  - 7% decrease near nadir
  - 0% change on right (near Moon)
  - 3% increase on left
- **B1 & B2 (not shown)**
  - 3% decrease for all angles

# Approach II: Impact on AOD time series

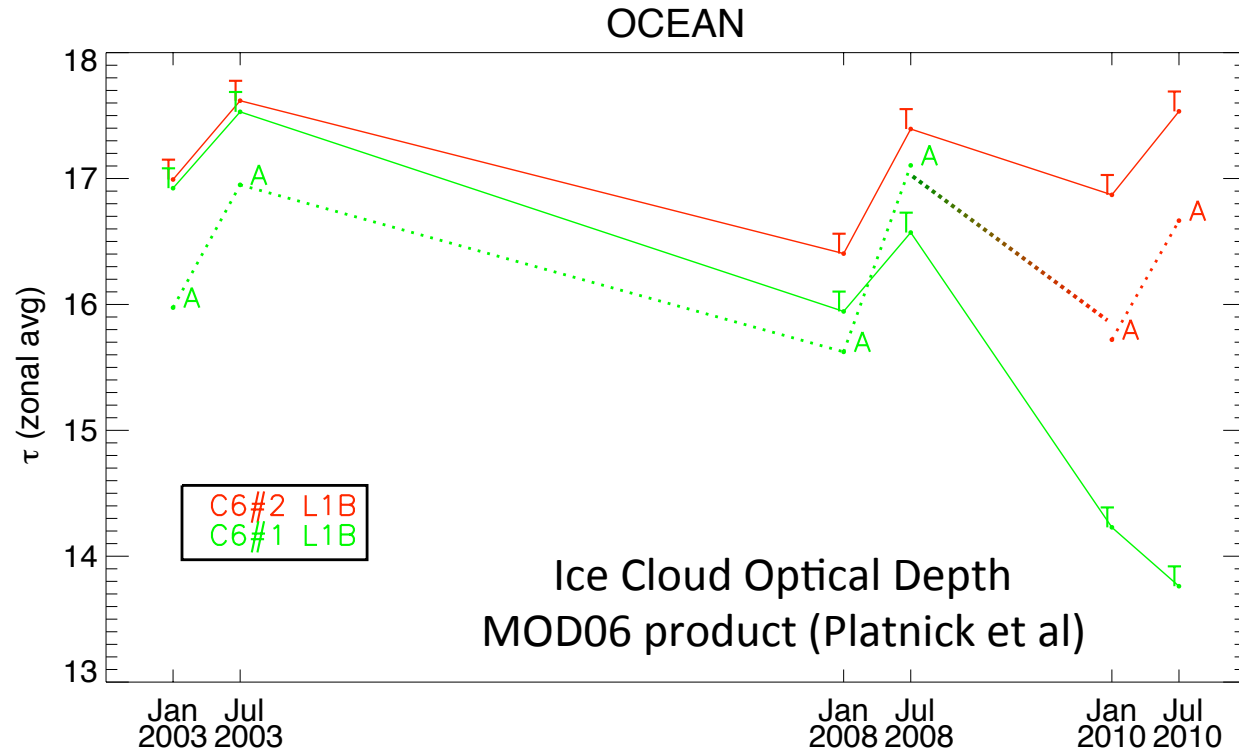
# Two calibration Approaches: One AOD algorithm



- Take advantage of MODAPS' testing capabilities
- 6 months processed with same dark-target aerosol algorithms
- Terra (T) Approach II now "in sync" with Aqua (A) time series
- Note that Approach II is calibrated using bright targets
- (Terra-Aqua) offset remains 0.01 (ocean) and 0.015 (land)



# Two calibration Approaches: One COD algorithm



- Approach II may also help to remove Terra-Aqua divergence for cloud optical properties; cloud algorithms use Band 1 and Band 2.
- Seems to work for liquid clouds over land and water clouds over ocean, but not for liquid over ocean or ice over land.

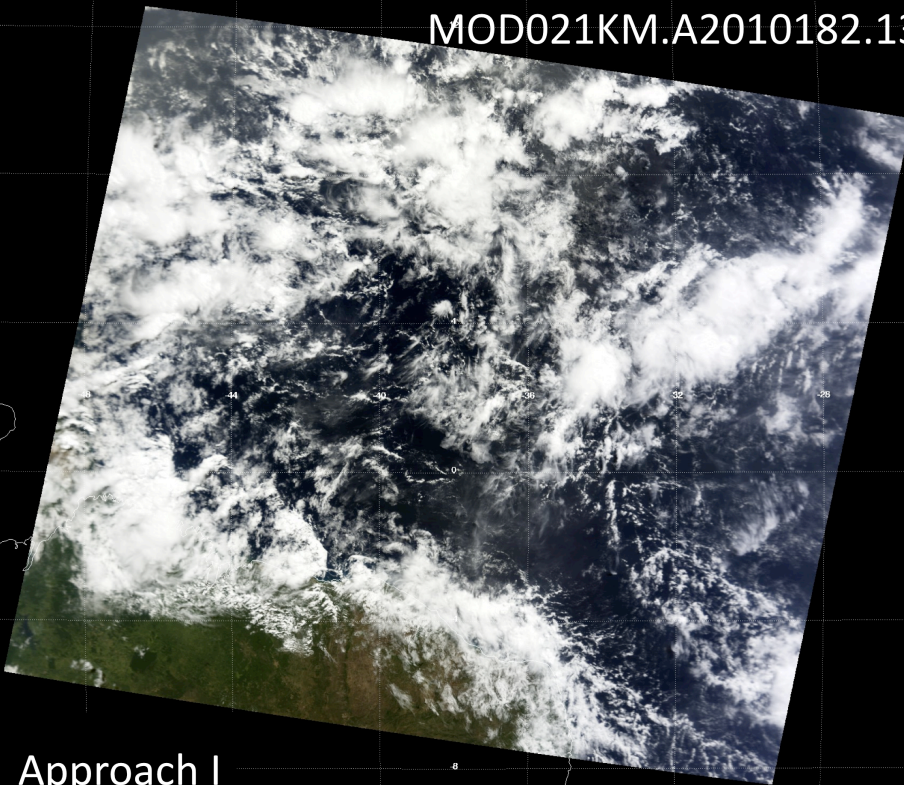
# Conclusion

- MODIS Dark target algorithms and products are validated and identical for Terra and Aqua
- For C5, we found trend in Terra AOD
- AOD trend over land consistent with trends in Band #3
- If standard calibration (e.g. Approach I) is used for C6 calibration, then trend will remain for C6.
- If alternative calibration (e.g. Approach II) is used for C6 calibration, then Terra trend might be removed.
- Cloud optical property retrieval may also be improved with Approach II.
- With Approach II, Terra is biased high compared to Aqua.
- More testing is necessary.
  
- C6 delay: All product teams need to be happy: dark target aerosol, deep blue, Platnick's cloud product, Eric Vermote's land product, etc, etc..

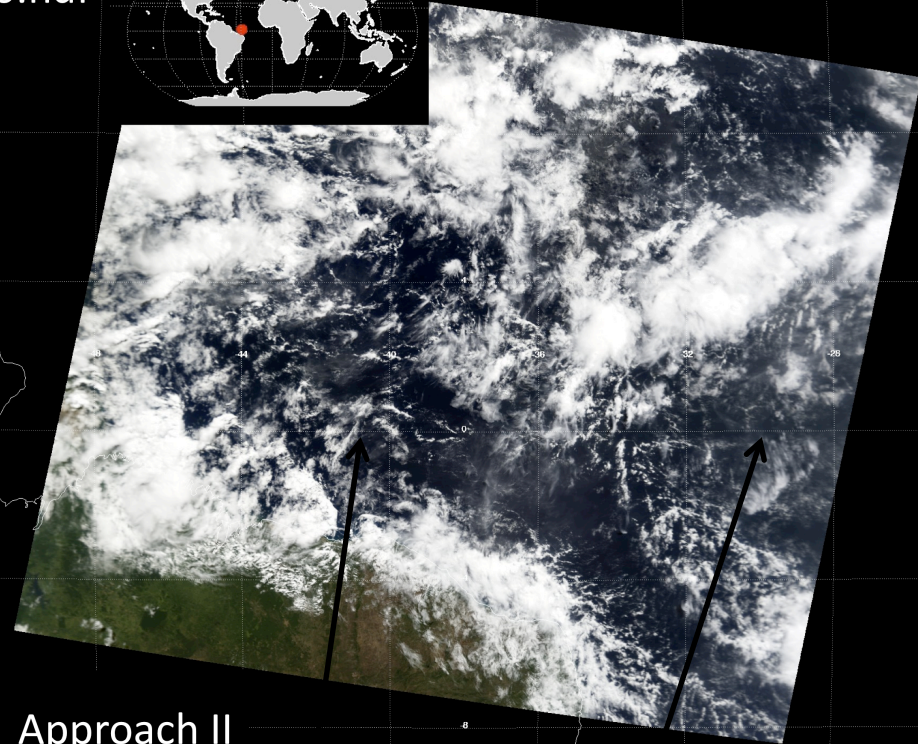
Thank you

... and removes “bluing” of RGB visible images

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Approach I



Approach II

More “bluing”

Less “bluing”