Radiometric evaluation of the MODIS C6.1 reflective solar channels radiances and the need for C7

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Outline

- Introduction
  - Why MODIS calibration important for CERES?
    - Consistent MODIS cloud retrievals and scene identification for the CERES ADM
    - MODIS as reference calibration for to provide consistent cloud retrievals and radiances across GEO imagers
- Evaluation Methodology
  - Tropical DCC calibration
  - Pseudo-invariant Earth sites (Dome-C and Libya-4)
- Terra and Aqua MODIS Results and Discussion
- Conclusions

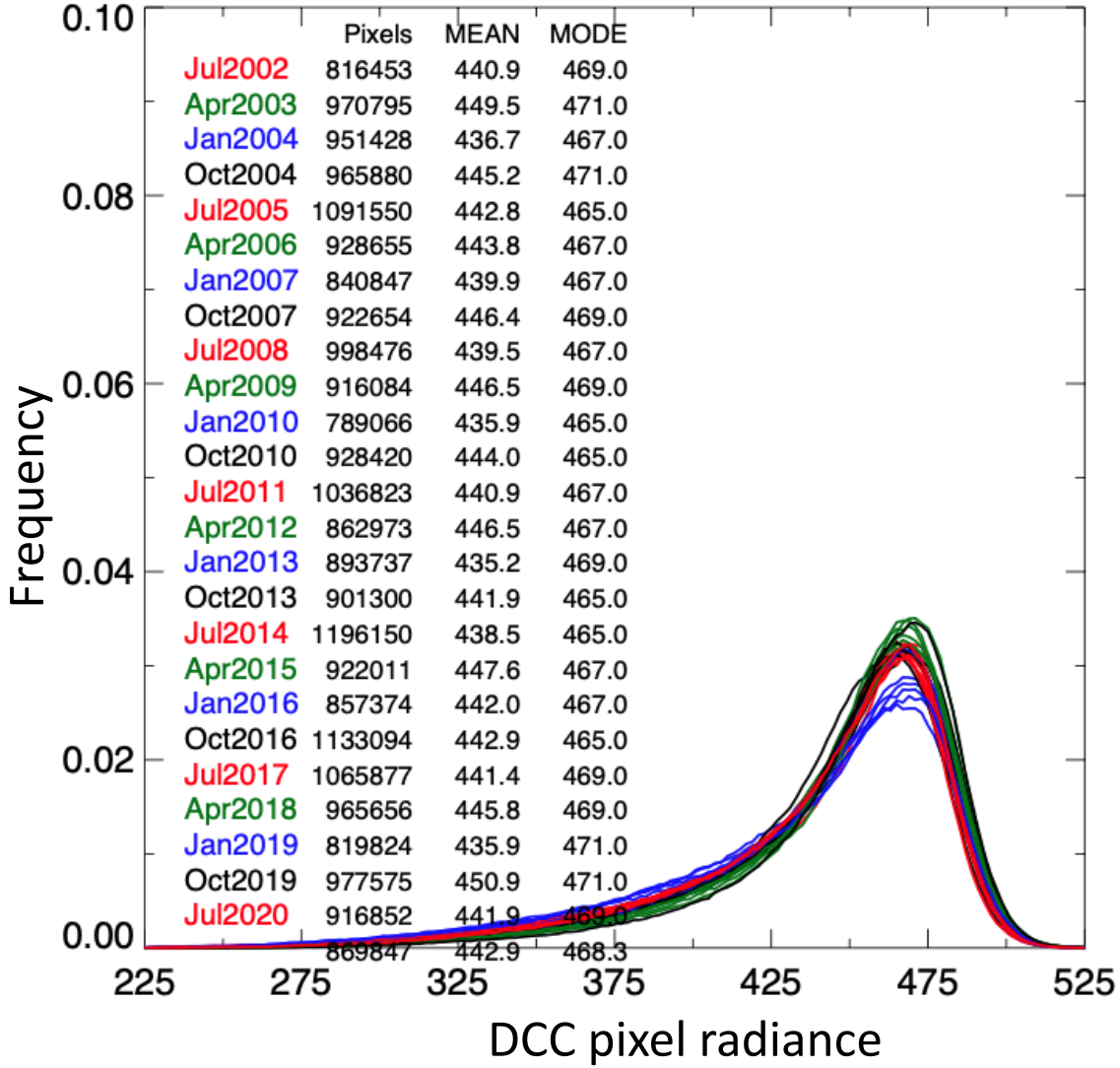
Why MODIS calibration matters to CERES

- Clouds and the Earth's Radiant Energy System (CERES) relies on coincident measurements from onboard imagers (MODIS, VIIRS) for proper scene identification needed to convert CERES radiances into radiative fluxes.
- Consistent retrievals of cloud properties requires the MODIS calibration is temporally stable.
- CERES also utilizes geostationary (GEO) imager radiances to retrieve clouds and derive broadband fluxes that are used to account for the regional diurnal flux variation between the CERES measurements.
- To ensure that the GEO fluxes and cloud properties are consistent across sensors, the GEO radiances are radiometrically scaled to MODIS.
- Any radiometric drift in MODIS manifests itself in both the MODIS and GEO cloud retrievals.
- CERES imager and geostationary calibration group (IGCG) performs an independent calibration assessment of MODIS and VIIRS L1B products using multiple approaches.

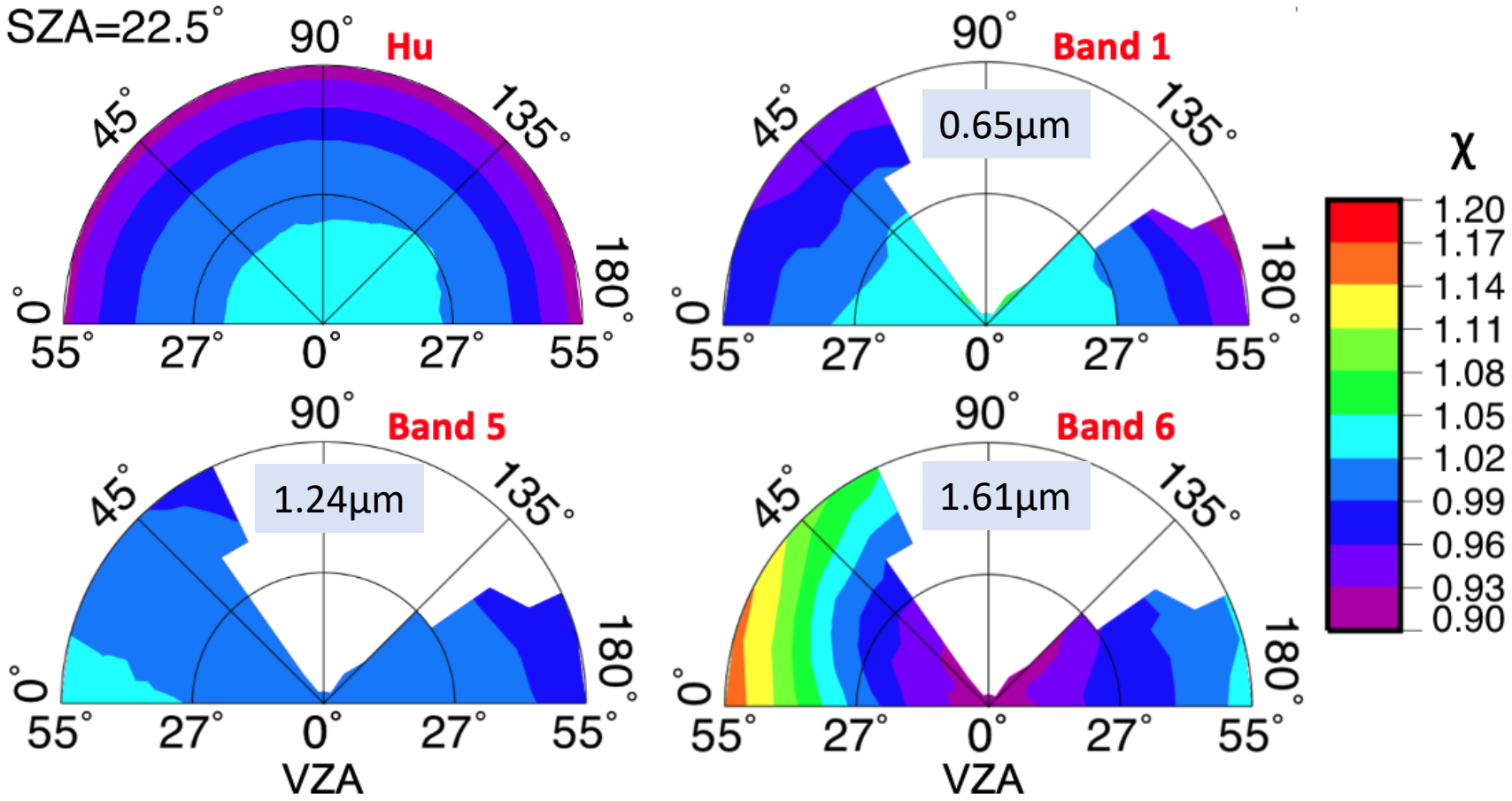
DCC-IT method

- DCC pixel selection criteria:
  - BT11µm < 205.0°K, SZA < 40°, VZA < 40°, 10° < RAA < 170°, σ(BT11µm) < 1.0° K, and σ(VIS) <3%
- DCC pixels are compiled into monthly probability distribution functions (PDFs) and their modes are tracked over time.
- Anisotropic correction
  - Hu ADM for VIS-NIR bands
  - Seasonal BRDFs for SWIR bands
- At SWIR wavelengths,
  - DCC reflectivity is affected by ice particle size
  - larger ice particles are more absorbing
  - results in large seasonal cycles
  - DCC response is highly dependent on the IR BT threshold

Aqua-MODIS band 1

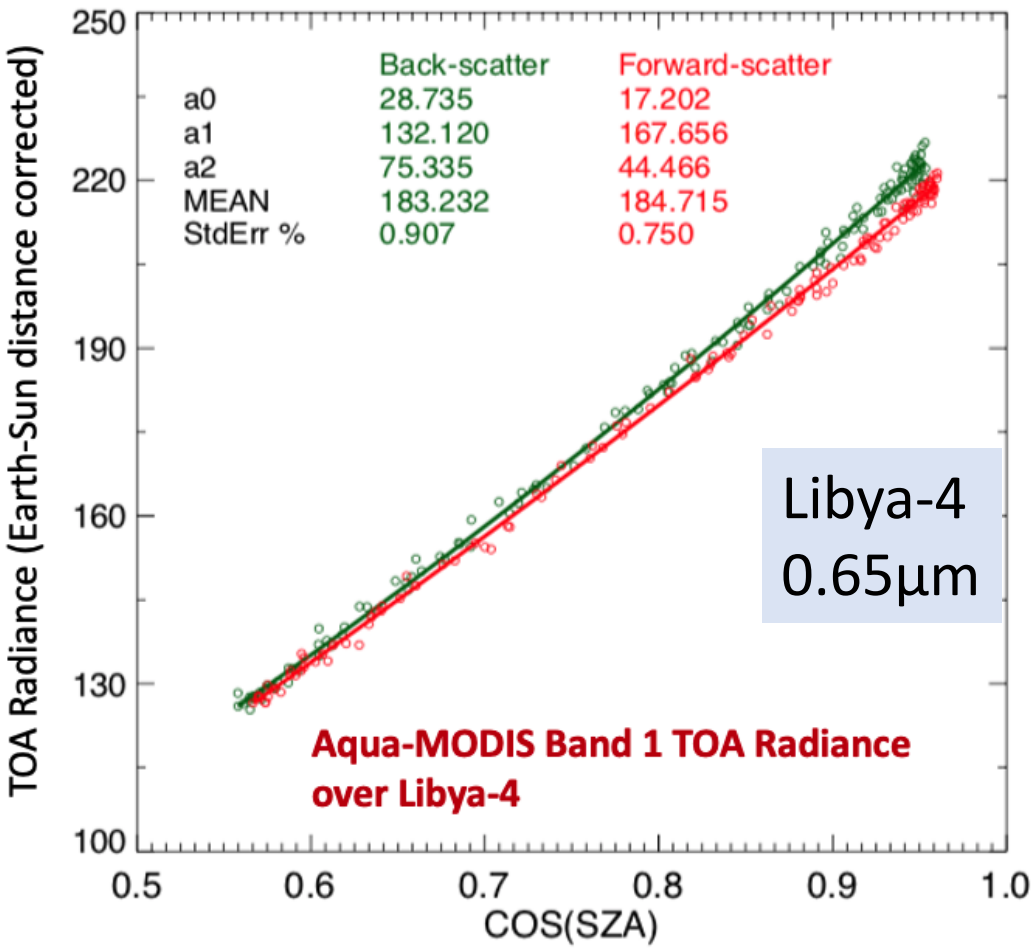


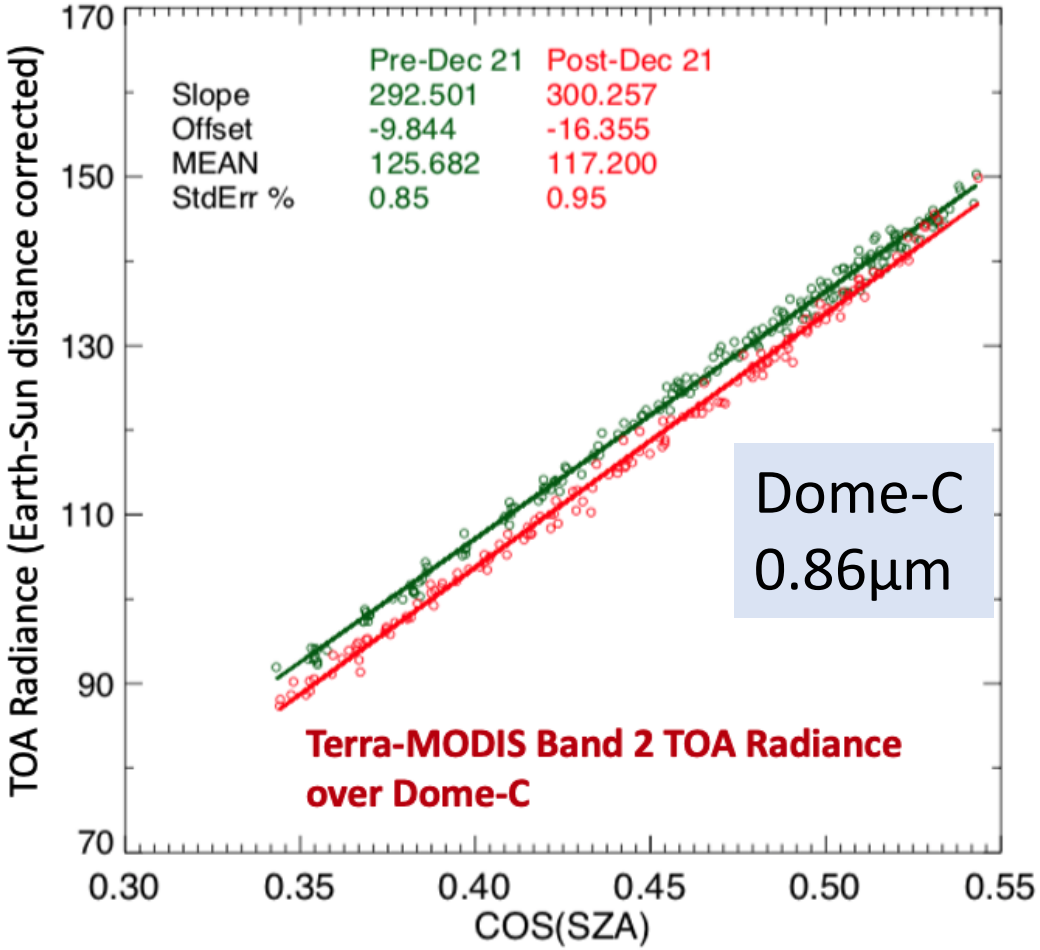
DCC BRDF



- Channel-specific BRDFs are constructed using the first 5-year MODIS record of tropical DCC pixels.
- VIS-NIR BRDFs are similar to Hu model
- BRDF for SWIR bands are channel-specific

PICS directional models

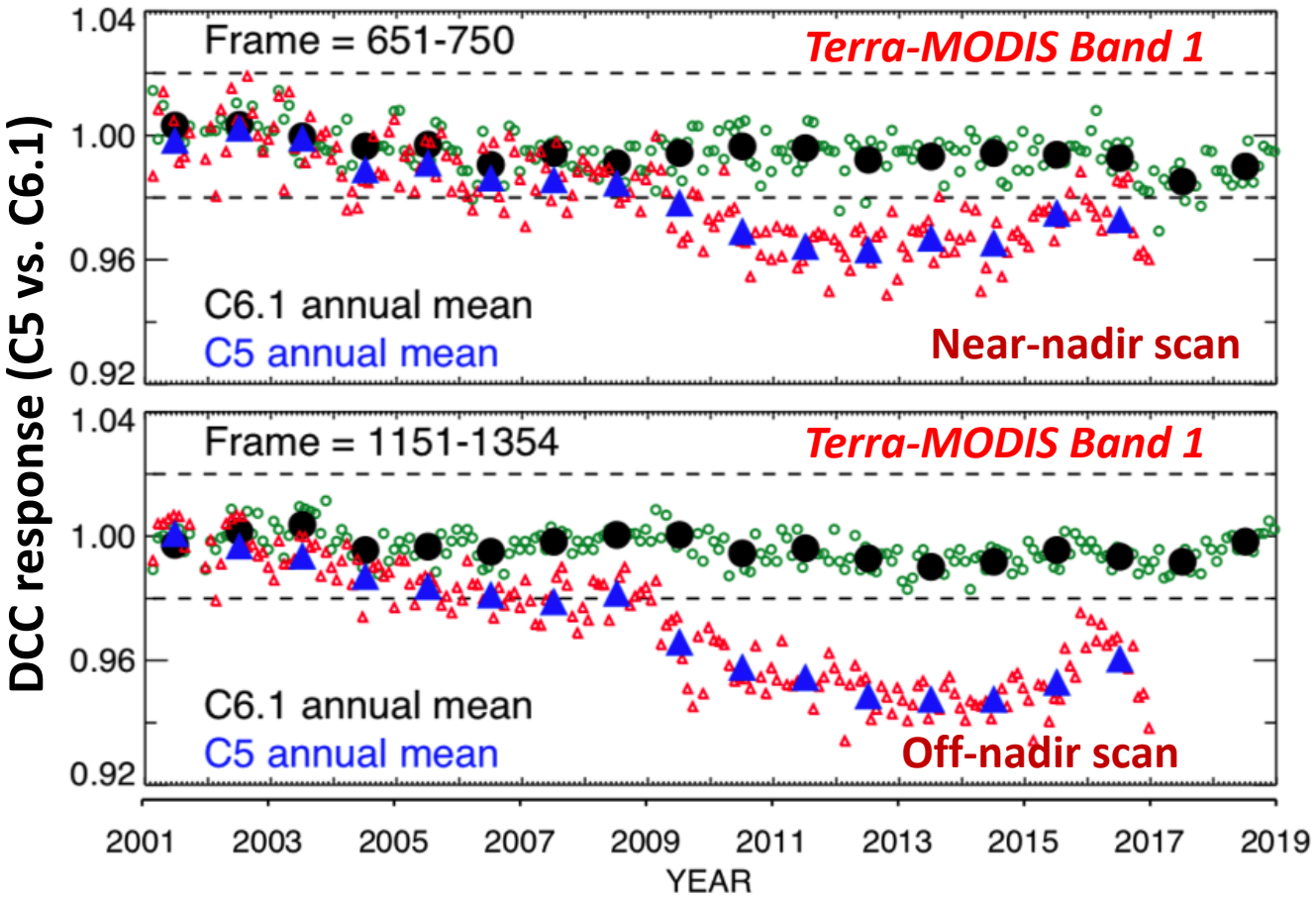




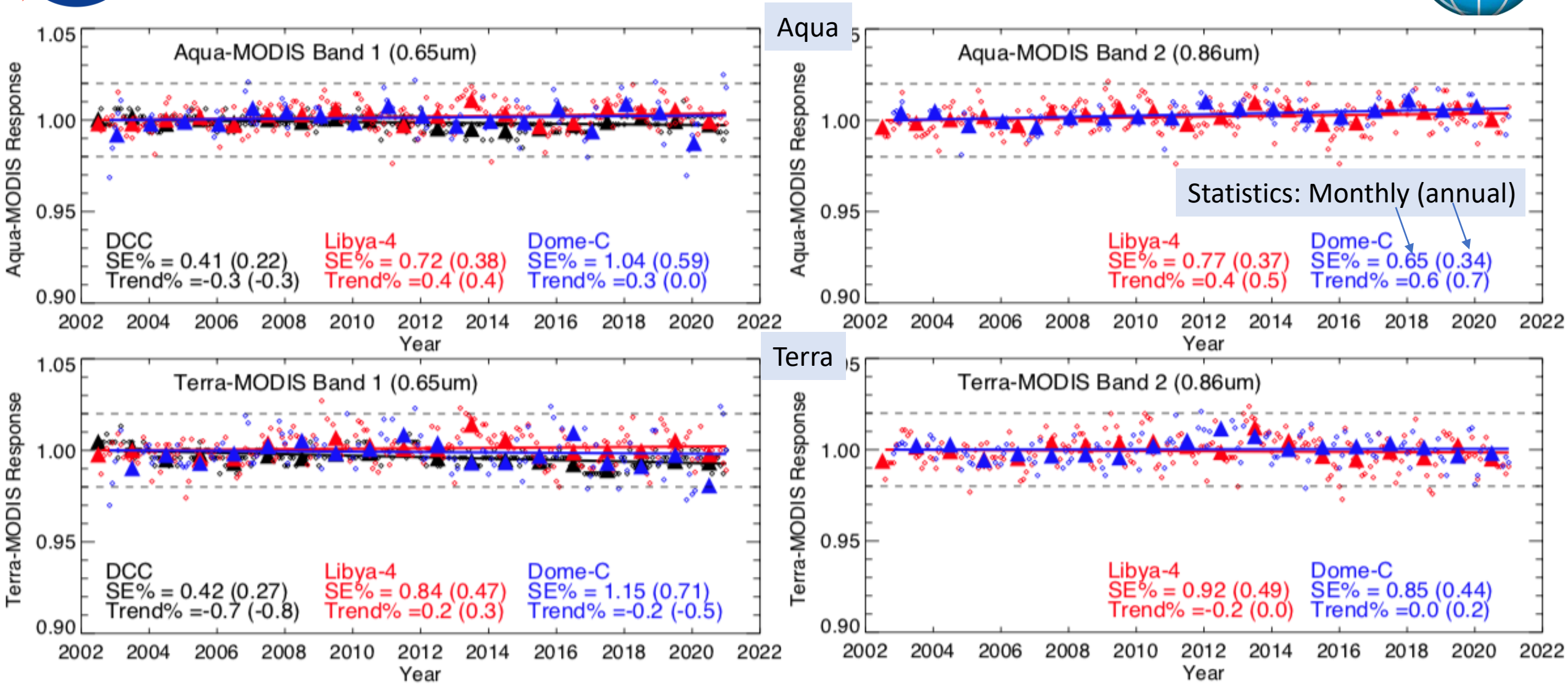
- Near nadir TOA radiance measurements are modeled as a function of Cosine of SZA
- **Forward**/**backward** scattering directional models (DM) over Libya-4
- **Pre** and **post** solstice DM over Dome-C
- Construct DMs from the most stable part of the MODIS record (first 6 years)

Old Slide results of C5 and C6.1

- We use DCC to look at MODIS stability as function of frame intervals.
- Terra-MODIS C5 band 1 (0.65 µm) RVS were inconsistent
- MCST improved the RVS for this channel between C5 and C6.1
- We independently verified the improvement of C6.1
- The rest of the presentation will look at the C6.1 stability

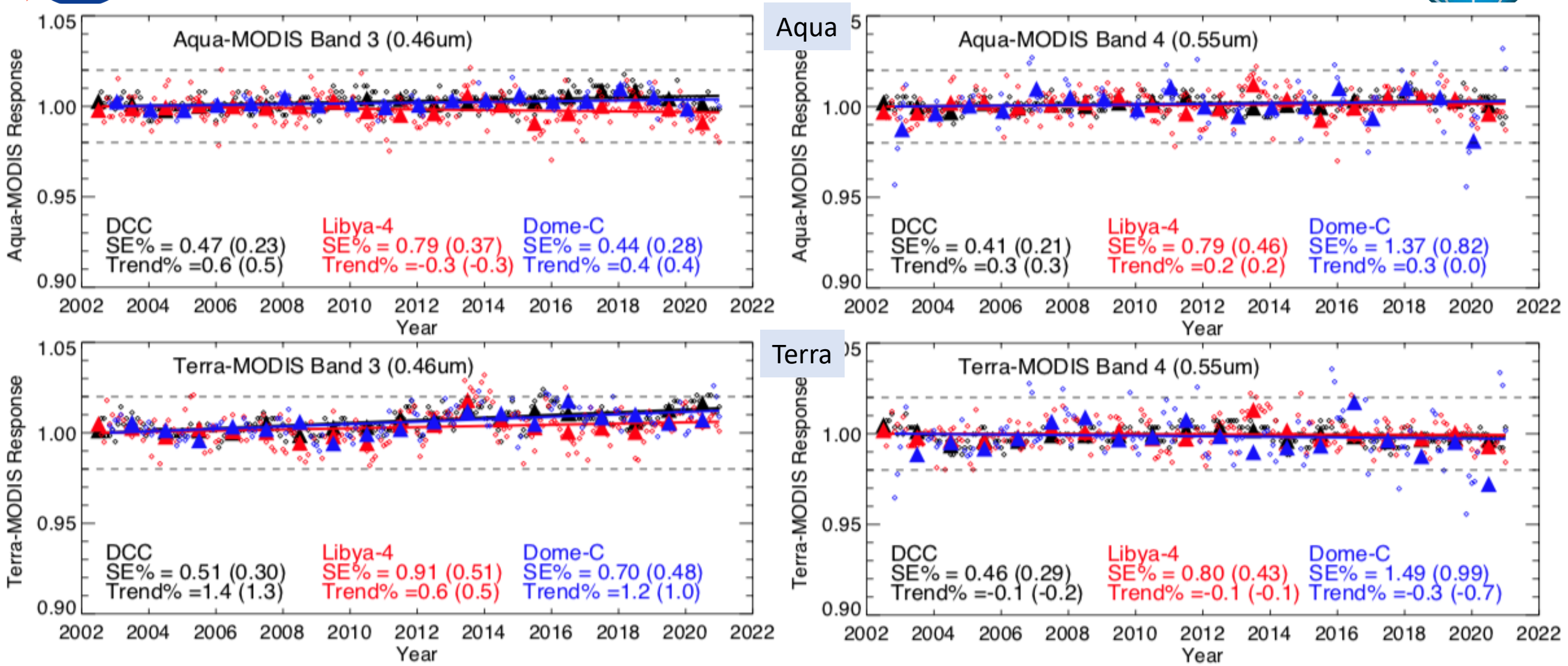


Results, Band 1 (0.65µm) and 2 (0.86µm)



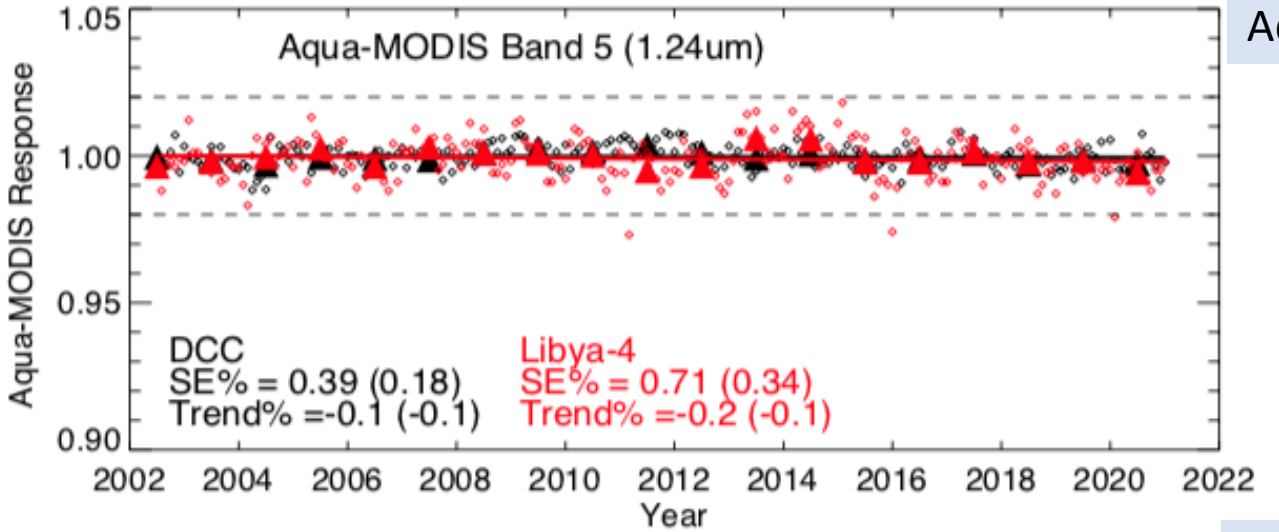
- MODIS bands 1 and 2 are stable within 1%

Results, Band 3 (0.46µm) and 4 (0.55µm)

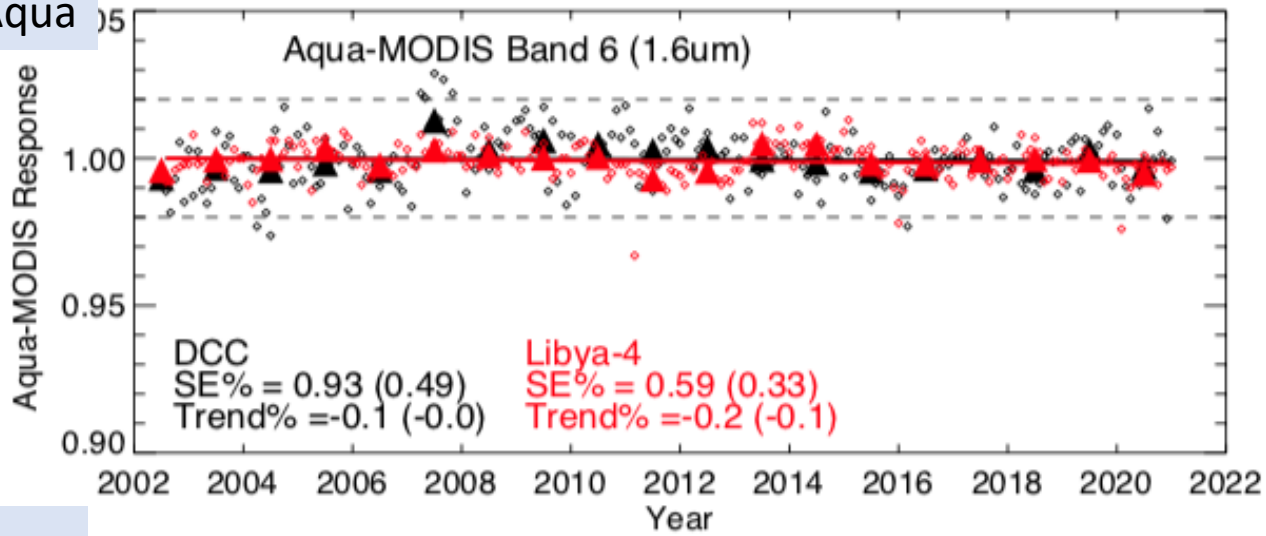


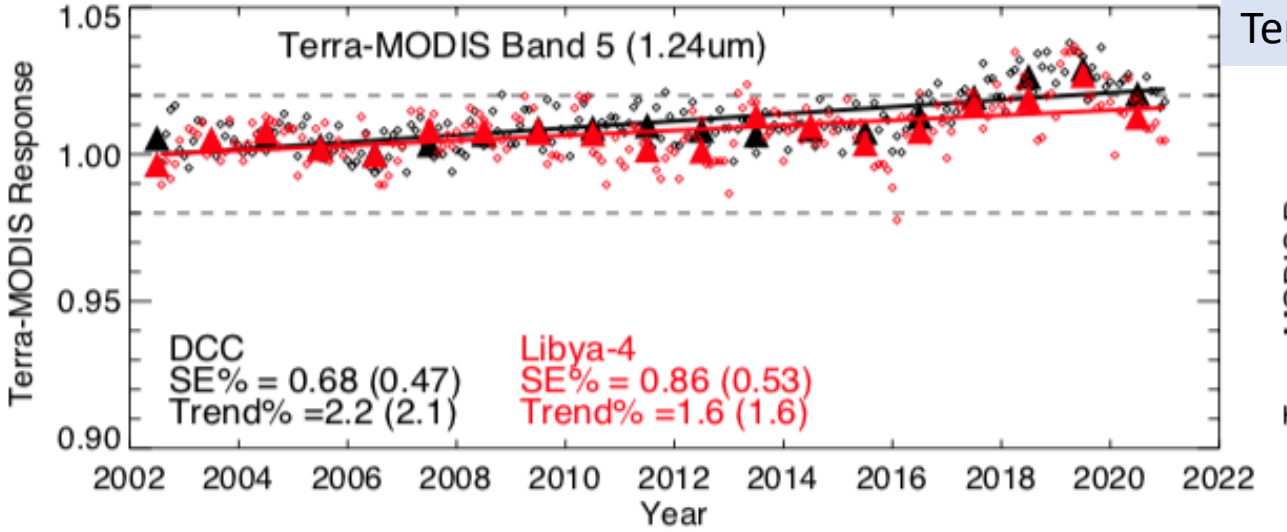
- A positive trend (~1%) is shown by DCC and PICS time series in Terra-MODIS band 3.

Results, Band 5 (1.24µm) and 6 (1.6µm)

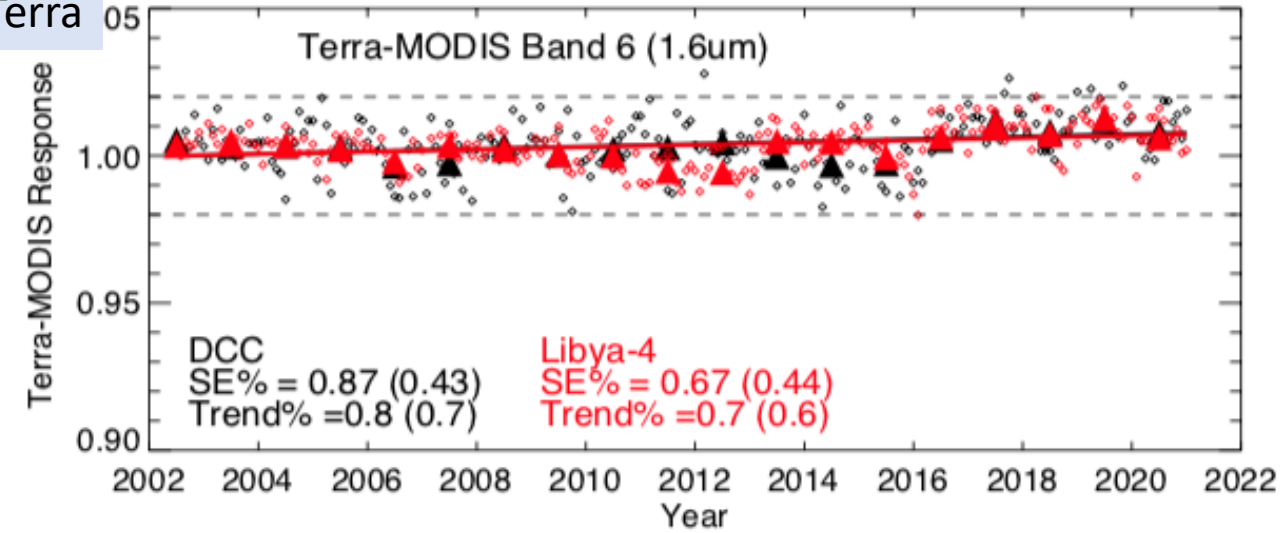


Aqua



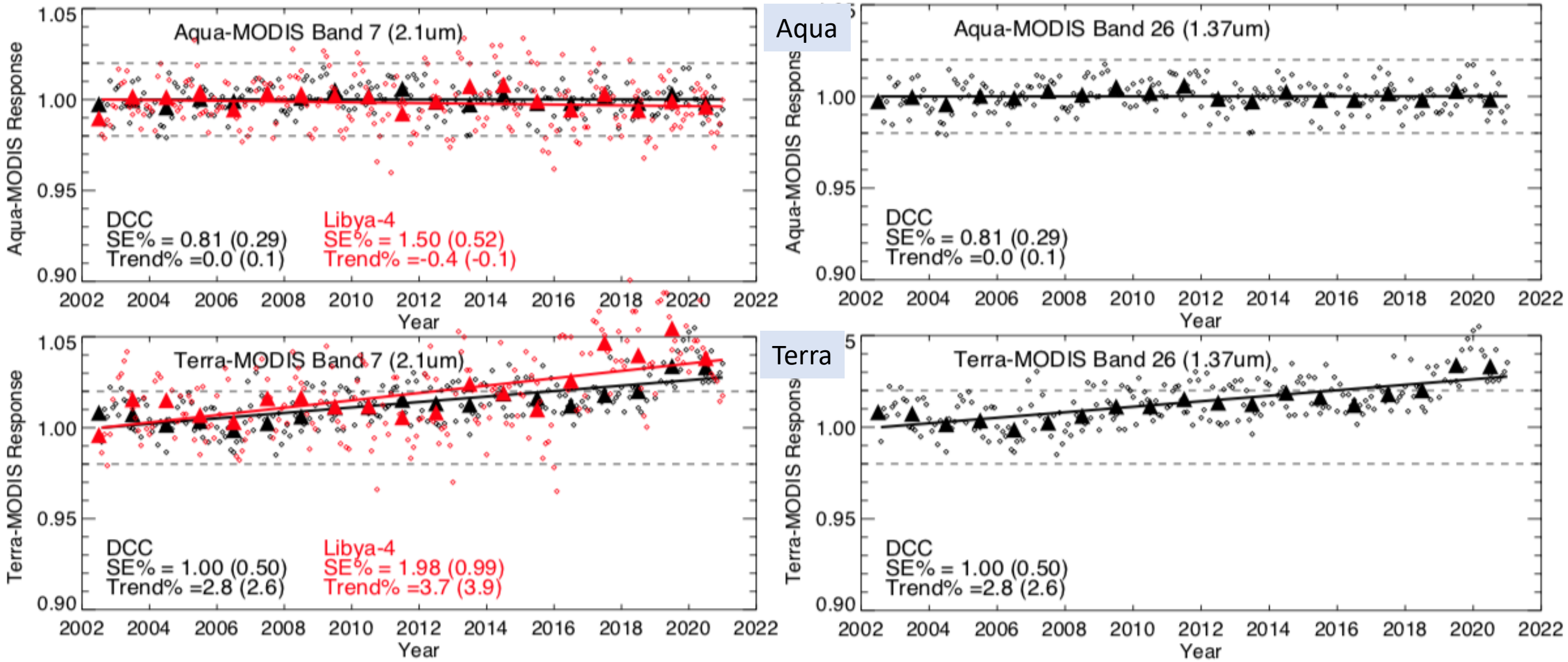


Terra



- Aqua-MODIS SWIR bands are stable within 1%
- Terra-MODIS band 5 response shows an upward drift after the 2016 safe mode incident.

Results, Band 7 (2.1µm) and 26 (1.37µm)



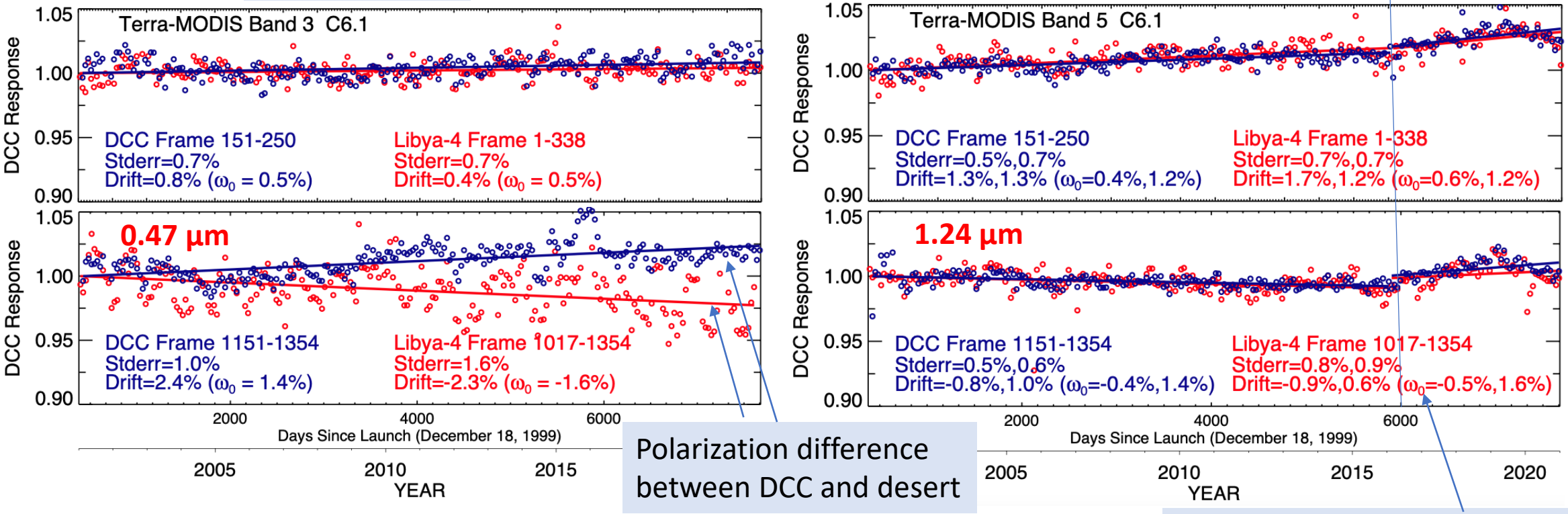
- Both bands 7 and 26 in Terra-MODIS C6.1 show upward trends.

Residual RVS in Terra-MODIS C6.1

Band 3 0.47µm

Band 5 1.24µm

Terra-anomaly



Polarization difference between DCC and desert

ω_0 is the trend significance threshold

- Terra-MODIS C6.1 exhibits some residual RVS dependencies.
- Band 3 RVS is due to a change in the polarization sensitivity of the scan-mirror over time. DCC and desert trends disagree in the right side of the scan.
- Band 5: DCC and PICS approach show an upward trend in the left-side frames and a downward trend in the right-side frames from 2001 through safe-mode incident in 2016.

Future Activities

- We have received the Terra and Aqua MODIS C6.1 to C7 conversion coefficients from MCST.
- We will redo the previous slides after applying the conversion coefficients.
  - Since they are mirror side and frame dependent all of the datasets will need to be rerun
- CERES will be migrating from Aqua to N20 in the future, when Aqua starts drifting outside of 15 minutes
  - Need to develop Aqua-MODIS to N20-VIIRS analogous channel radiometric scaling factors to provide consistent cloud properties

Conclusions

- CERES IGCG works closely with MCST/VCST in providing an independent evaluation of the radiometric quality of MODIS and VIIRS L1B products.
- Aqua-MODIS C6.1 calibration is stable within 1% for all RSB
- Terra-MODIS C6.1 calibration is stable within ~1% for bands 1 (0.65 µm), 2 (0.86 µm), and 4 (0.55 µm)
- Terra-MODIS band 3 (0.46 µm) suffers polarization sensitivity change over time, primarily affecting the response in the right side of the scan. The effect is scene specific.
- Terra-MODIS bands 5 (1.24 µm), 6 (1.6 µm), 7 (2.1 µm), and 26 (1.37 µm) exhibit noticeable calibration drifts (1-3%), especially after the 2016 Terra safe mode incident.
- Observed calibration anomalies in Terra-MODIS C6.1 may potentially influence cloud properties, particularly after 2016.