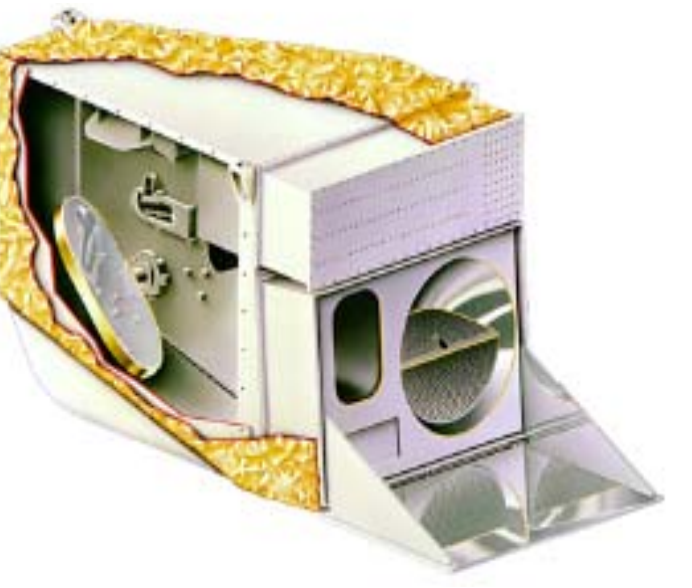




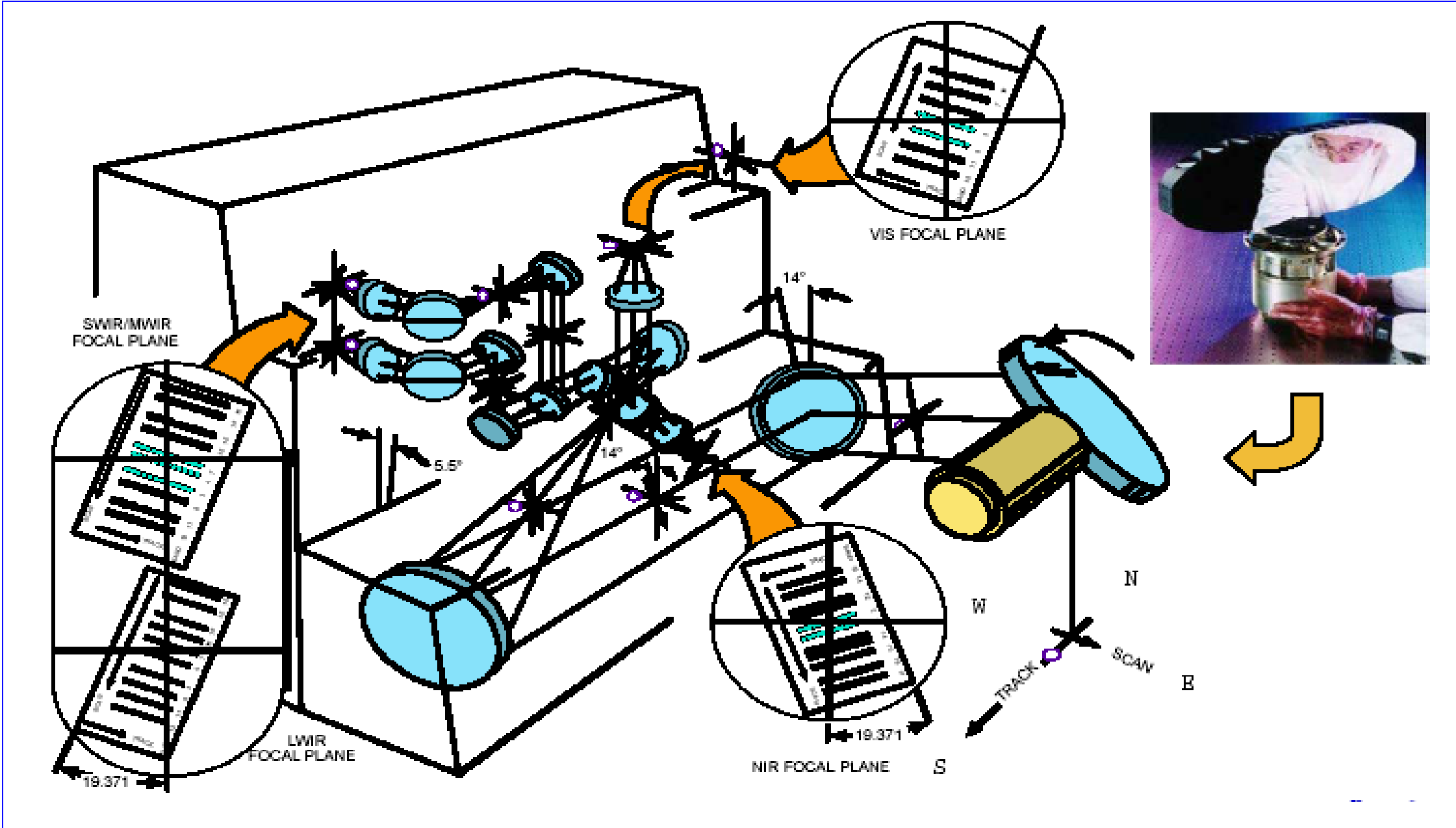
# MODIS Reflective Solar Bands On-orbit Calibration and Performance

MODIS Characterization Support Team

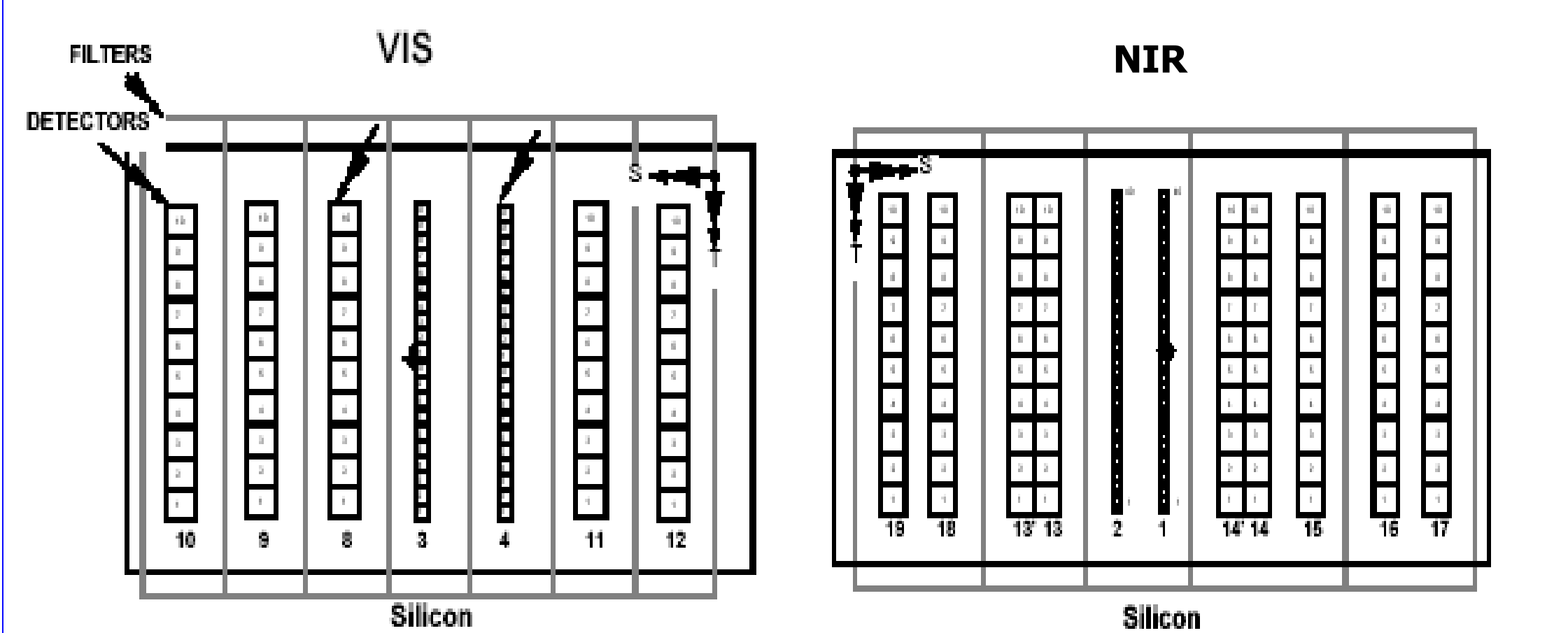


## Introduction

- The MODerate Resolution Imaging Spectroradiometer (MODIS) is a key instrument for NASA's Earth Observing System (EOS). It is onboard both Terra spacecraft (launched on December 18, 1999) and Aqua Spacecraft (launched on May 4, 2002).
- MODIS's 2-sided paddle wheel scan mirror provides a -55 to +55 degree scan of the Earth covering 10 km (at nadir) along track by 2330 km along scan swath.
- MODIS has 36 spectral bands, among which 20 are reflective solar bands (RSBs) ranging from 0.41 to 2.3 microns, with spatial resolution (at nadir) of 250 m (bands 1-2), 500 m (bands 3-7), and 1000 m (bands 8-19,26).
- RSBs are calibrated on-orbit by an onboard Solar Diffuser (SD) panel with SD degradation tracked by a Solar Diffuser Stability Monitor (SDSM)
- Observations from the Moon and that from an onboard Spectro-Radiometric Calibration Assembly (SRCA) are also used for the RSB calibration and characterization



## VIS and NIR Focal Plane Assemblies Layout



## RSB Key Specifications

Band	CW (nm)	BW (nm)	IFOV (m)	Ltyp (W/m <sup>2</sup> /sr/μ × W/m <sup>2</sup> /sr/μ × W/m <sup>2</sup> /sr/μ)	Lmax	Leloud	SNR
1	645	50	250	21.8	685	457	128
2	858	35	250	24.7	285	293	201
3	469	20	500	35.3	593	570	243
4	555	20	500	29.0	518	559	228
5	1240	20	500	5.4	110	138	74
6	1640	24	500	7.3	70	68	275
7	2130	50	500	1.0	22	27	110
8	412	15	1000	44.9	175	573	880
9	443	10	1000	41.9	133	585	838
10	488	10	1000	32.1	101	539	802
11	531	10	1000	27.9	82	538	754
12	551	10	1000	21.0	64	528	750
13L	667	10	1000	9.5	32	471	910
14L	678	10	1000	8.7	31	440	1087
15	748	10	1000	10.2	26	373	586
16	869	15	1000	6.2	16	286	516
17	905	30	1000	10.0	185	252	167
18	936	10	1000	3.6	256	267	57
19	1340	50	1000	15.0	189	244	250
26	1375	30	1000	6.0	90	113	150
13H	667	10	1000	9.5	32	471	910
14H	678	10	1000	8.7	31	440	1087

\*Contact: Xiaoxiong.Xiong-1@nasa.gov

## RSB On-orbit Calibration Algorithms

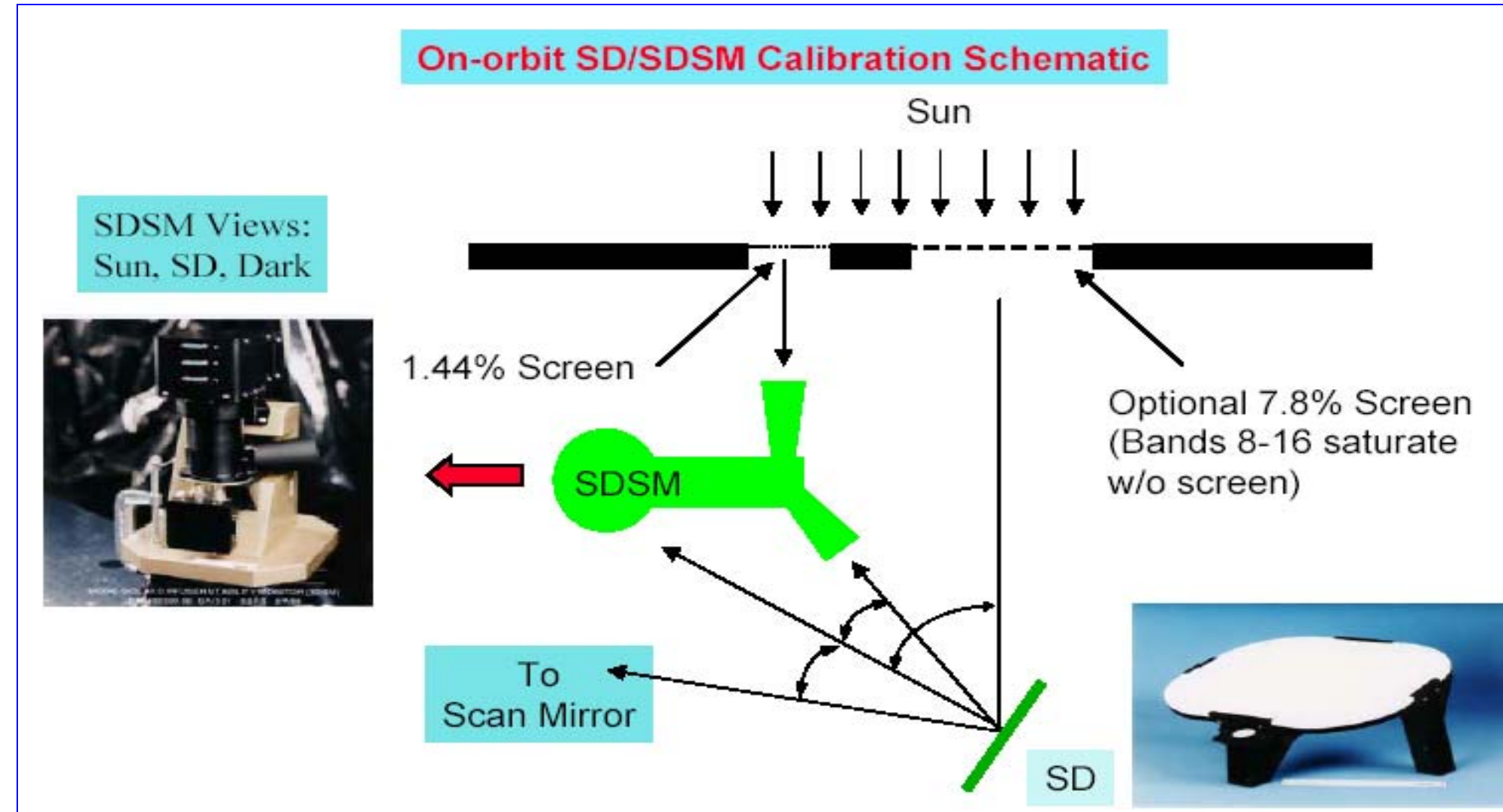
**Retrieval Algorithm**

**Reflectance**  $\rho_{EV} \cdot \cos(\theta_{EV}) = m_1 \cdot dn_{EV}^* \cdot d_{Earth-Sun}^2$

$dn_{EV}^* = dn_{EV} \cdot (1 + k_{INST} \cdot \Delta T_{INST}) / RVS_{EV}$

**Radiance**  $L_{EV} = m_1 \cdot dn_{EV}^* \cdot E_{Sun} / \pi$

$E_{Sun}$ : 0.4-0.8 μm Thuillier et al., 1998; 0.8-1.1 μm Neckel and Labs, 1984; Above 1.1 μm Smith and Gottlieb, 1974



**SD/SDSM Calibration Algorithm**

Scaling factors  $m_1$  from SD

$$m_1 = \frac{pIBRF_{SD} \cdot \cos(\theta_{SD})}{\langle dn_{SD} \rangle \cdot d_{Earth-Sun}^2} \cdot \Gamma_{SD} \cdot \Delta_{SD}$$

$\Delta_{SD} = \frac{dc_{SD}}{dc_{Sun}}$

$\Gamma_{SD}$ : SD screen vignetting function (1 for open mode)

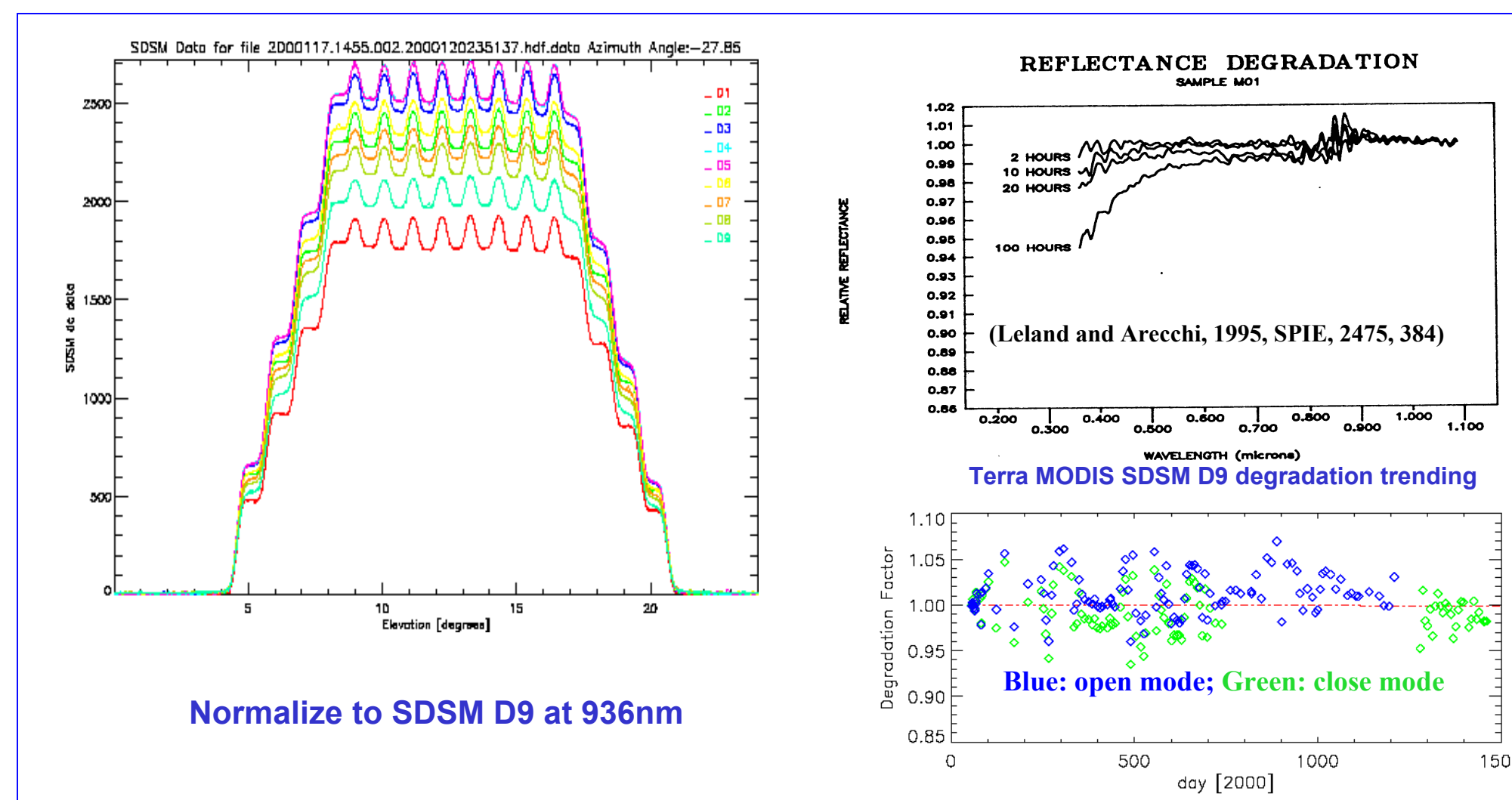
$dn_{SD}^*$ : MODIS detector's "corrected" digital number

$dc_{Sun, SD}$ : SDSM detector's digital count

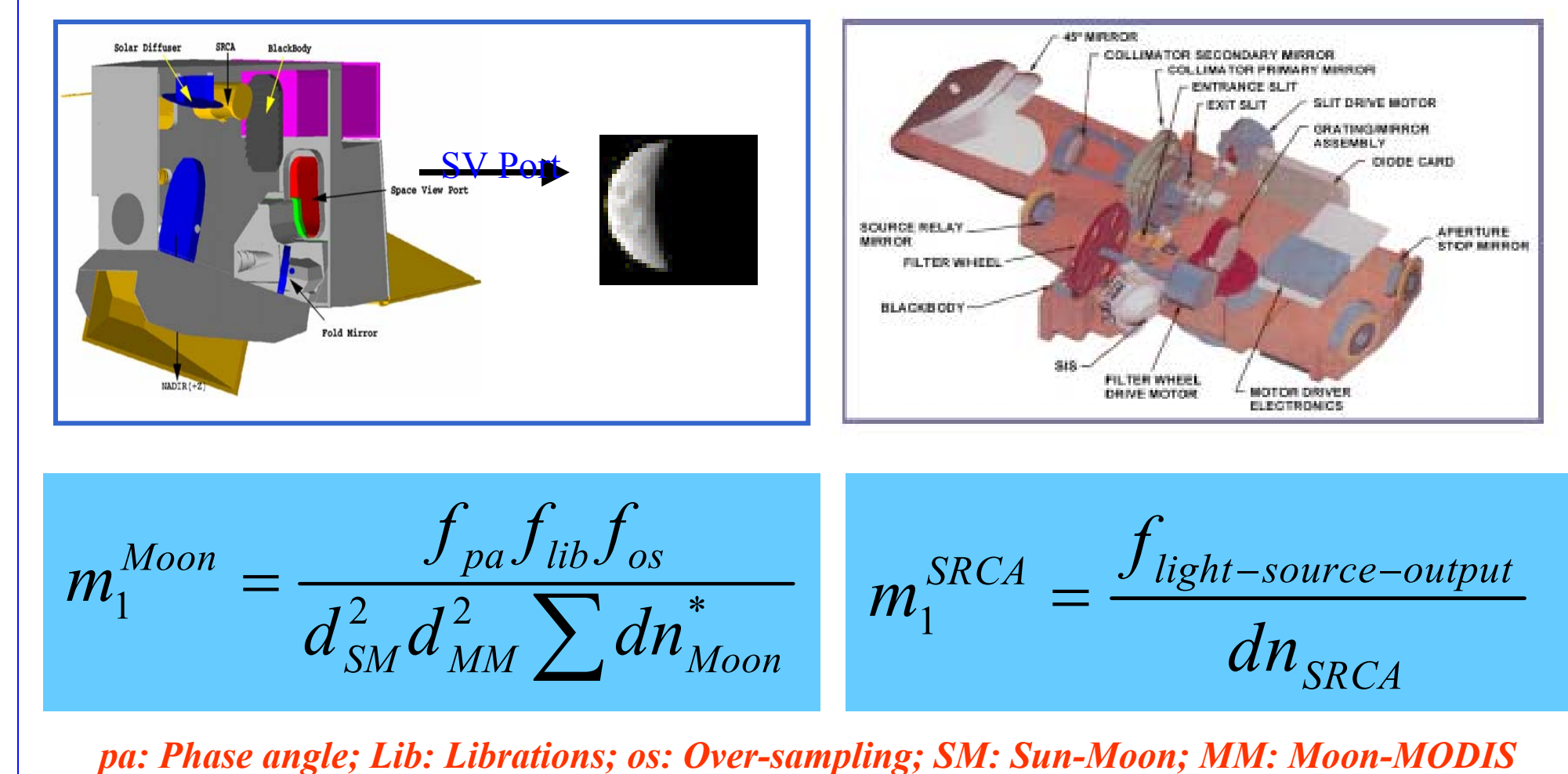
$d_{Earth-Sun}$ : Earth-Sun distance

Correct screen effect

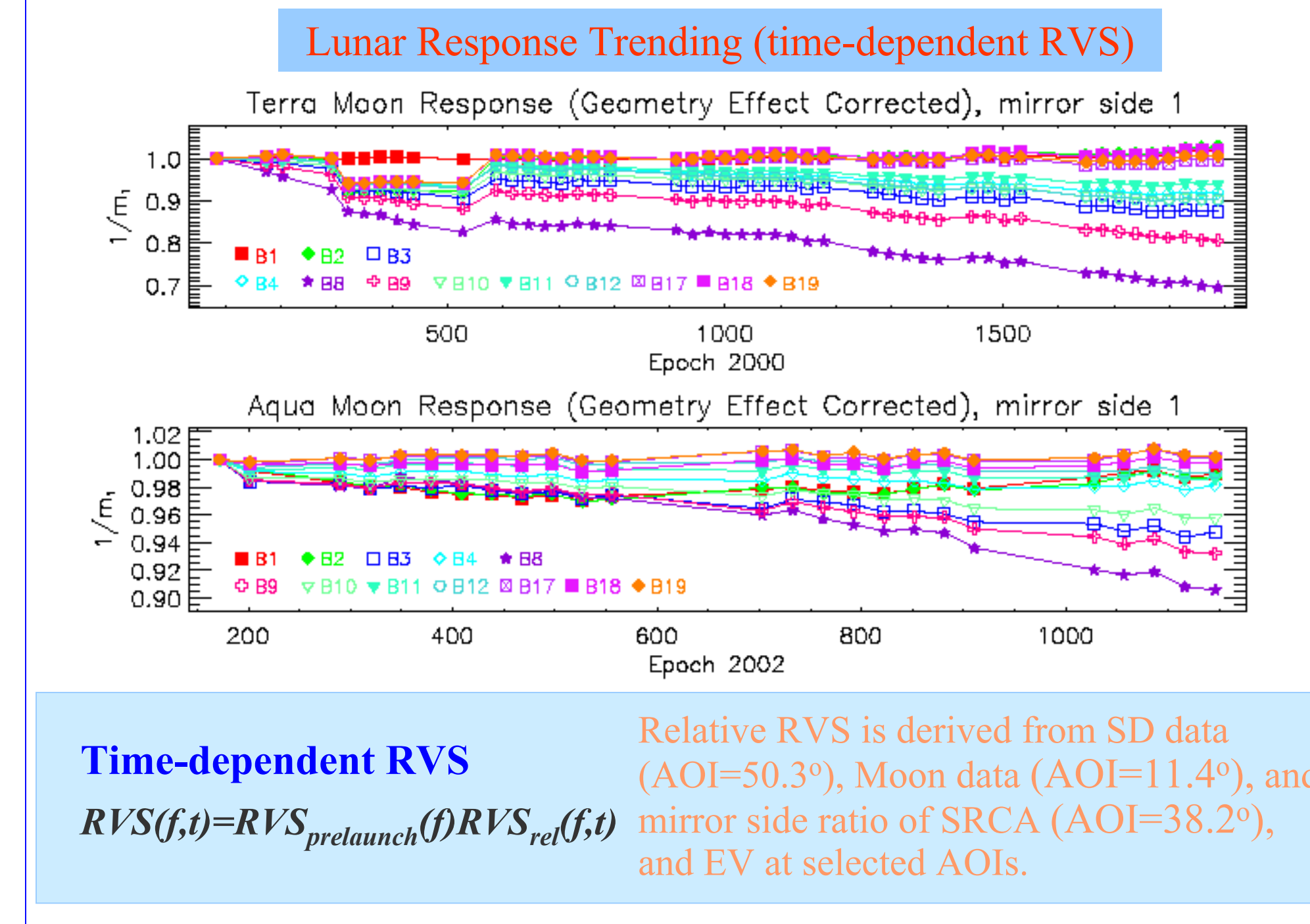
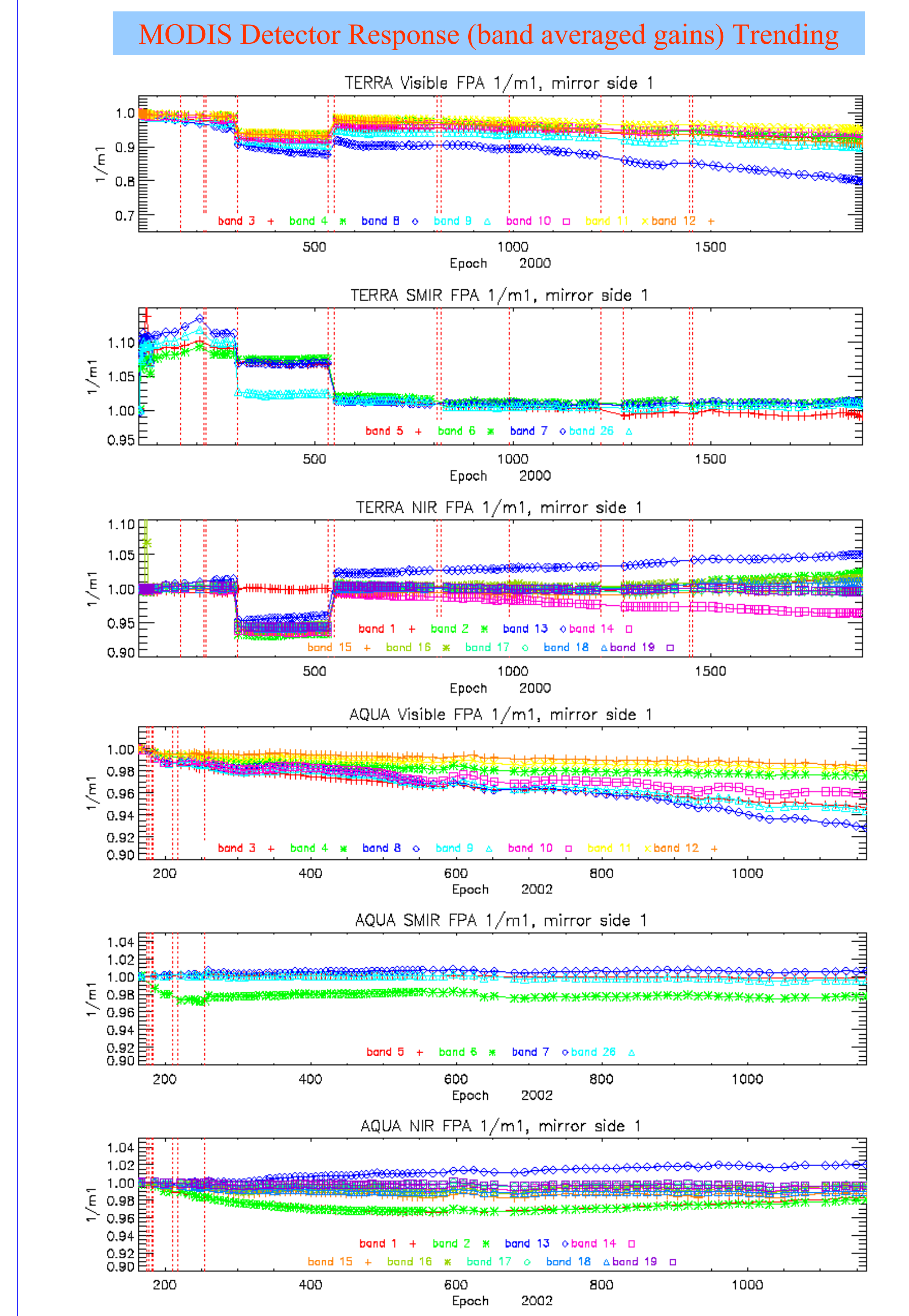
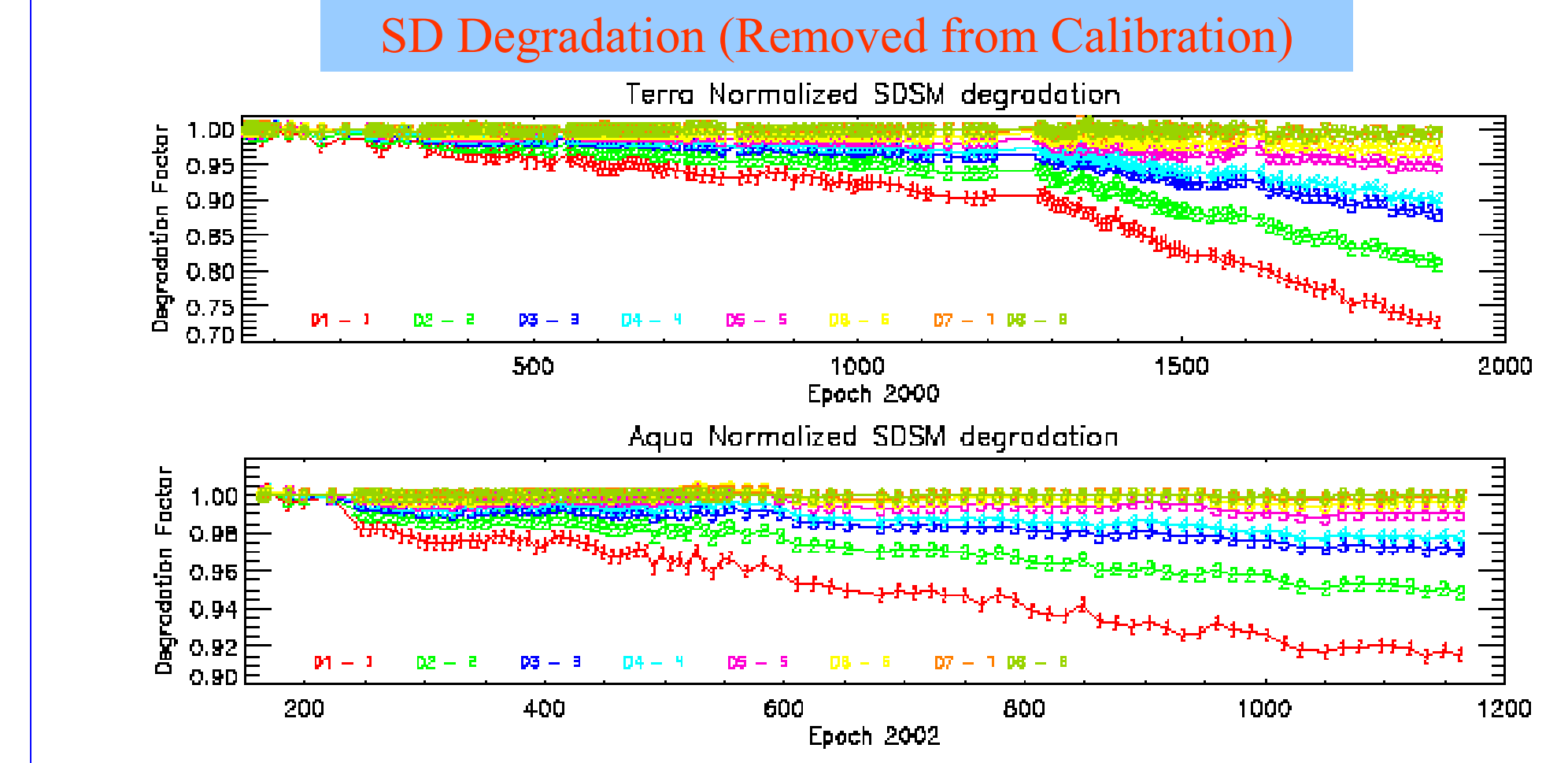
$$\left\{ \frac{dc_{SD\_view}^i / dc_{Sun\_view}^i}{dc_{SD\_view}^j / dc_{Sun\_view}^j} \right\}$$



## On-Orbit Lunar and SRCA Calibration

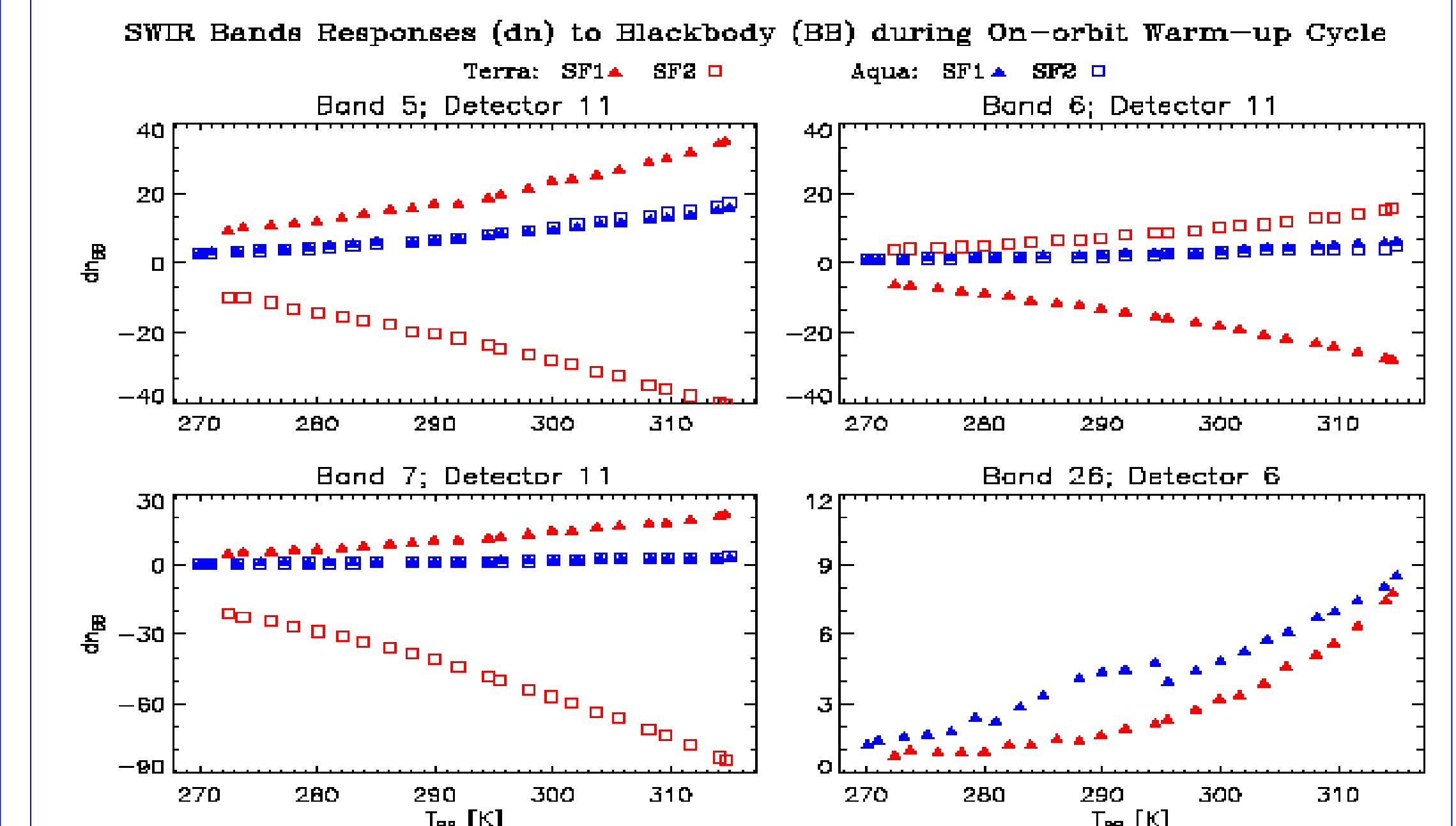


## On-Orbit Performance

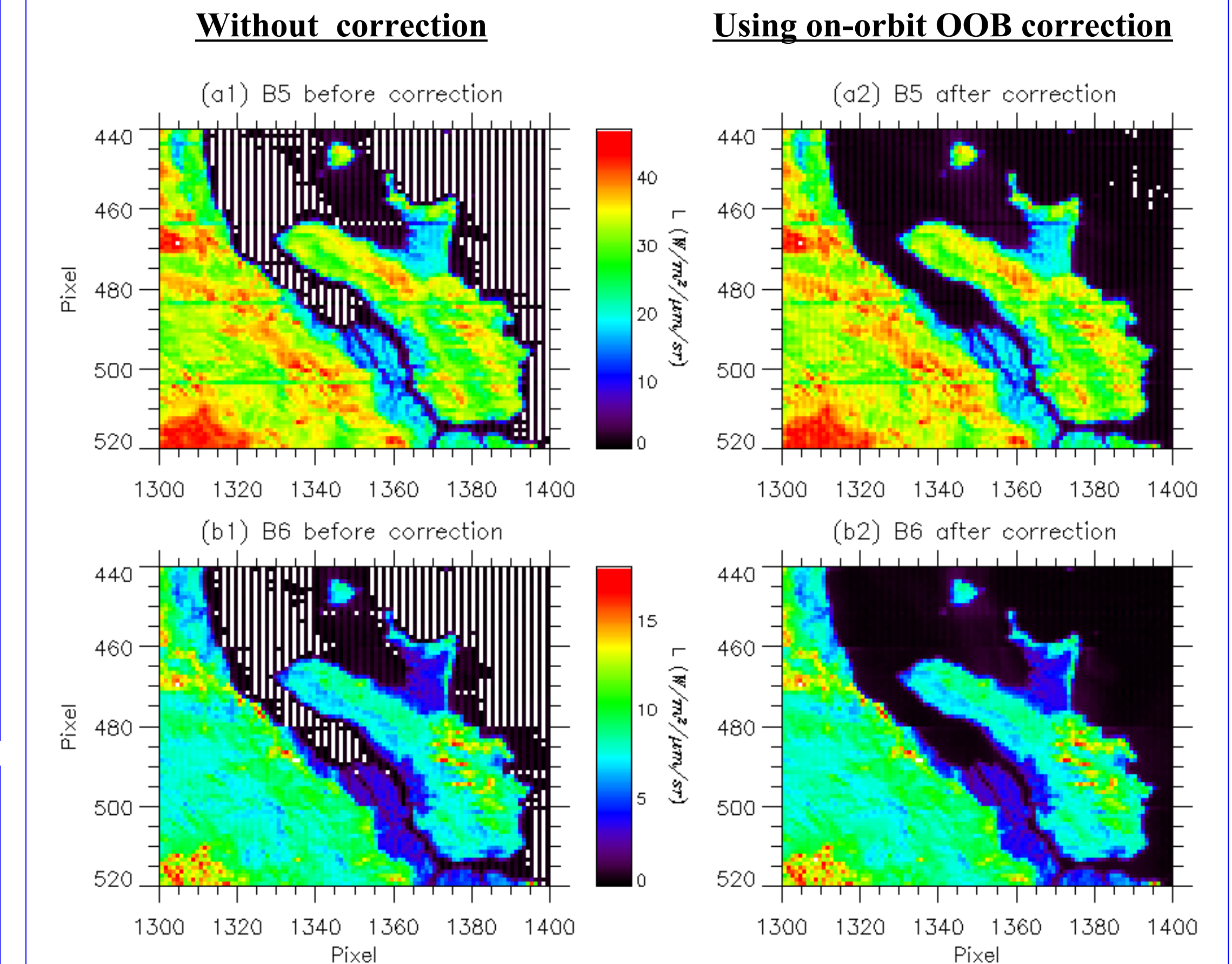


## Special Calibrations and Challenging Issue

- Thermal Leak Correction for SWIR Bands**
- Algorithms:
- Using a linear approach between the SWIR signals
  - $dn'_{EV}(B_{SWIR}) = dn_{EV}(B_{SWIR}) - x_{oob\_1}(B_{SWIR}) \cdot dn_{EV}(B_{Surrogate})$
  - $dn_{EV}$ : uncorrected Earth view signal after background subtraction
  - $dn'_{EV}$ : corrected Earth view signal after OOB correction
  - $x_{oob\_1}$ : linear correction coefficient
  - $B_{Surrogate}$  is B28 for Terra and B25 for Aqua
  - The cross-talk coefficients are derived from Nighttime Day Mode (NTDM) data
  - The correction is also used in the  $m_1$  calculation



## Terra Out-of-band Thermal Leak Correction Example



- Challenging Issues**
- $m_1$  shows small annual oscillation for the Ocean bands
    - 0.5% for B8, 0.4% for B9, and 0.3% or less for other bands
    - This might be true since it was also observed in Moon and SRCA scaling coefficients
  - $m_1$  shows daily oscillation (when measured each orbit)
    - The oscillation is band and detector dependent and can be as large as 0.4% for some bands
  - Accuracy of time-dependent RVS
  - Stripping (noise detectors, non-linearity, calibration bias among detectors?)