MODIS PC Bands Optical Leak Characterization Using Lunar Observations

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General References:
• MODIS Spectral Bands
  – 36 spectral bands (0.41-14.4 μm) on 4 focal plane assemblies (FPAs)
  – **PC bands** 31-36 covering wavelengths from 11-14.4 μm with photo-conductive (PC) HgCdTe

• PC Optical Leak
  – Issues identified during Terra pre-launch calibration and characterization
  – Correction methodologies developed and implemented in MODIS L1B processing (Terra only)
  – Problem fixed for Aqua MODIS based on lessons from Terra MODIS
Optical Leak Characterization

- Extensive Pre-launch Calibration and Characterization
  - Radiometric calibration in ambient and TVAC (3 instrument plateaus, 3 FPA temperatures, A/B electronics configurations)
  - Spectral and spatial characterization, including OOB response and NFR, revealed optical leak in Terra MODIS PC bands

- Lunar Observations for On-orbit Characterization of PC Optical Leak

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**BAND 35 SPECTRAL AND SPATIAL RESPONSE**

- DATA ACQUIRED DURING OOB SCAN FROM 10.4 TO 14 µm
- RESPONSE NOT VISIBLE IN BANDS 31-33

**LWIR FPA IFOV Offset Relative to Band 30**

- Courtesy: Raytheon SBRS

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**B36 data not valid**

- Courtesy: Raytheon SBRS
Correction Methodologies

MODIS TEB calibration using a quadratic algorithm
Scene radiance as a function of detector response in digital number (dn)

\[ L_{Total} = f(dn) \]

Total radiance includes scan mirror contribution
dn is space view background subtracted digital number

Crosstalk correction algorithm (developed pre-launch):

\[ \text{dn}_{\text{Band}_X}^{\text{True}}(FD) = \text{dn}_{\text{Band}_X}^{\text{Contaminated}}(FD) - Xtalk_{\text{Band}_31\rightarrow\text{Band}_X} \times \text{dn}_{\text{Band}_31}(FD + \text{FO}_{\text{Band}_31\rightarrow\text{Band}_X}) \]

FD: frame of data; FO: frame offset
Correction Coefficients

• Assumptions
  – Only B31 to other PC bands (32 - 36) leaks were considered
  – Possible along track crosstalk not included (or separated)

• Coefficients Determination (pre-launch)
  – B31 optical leak led to changes of nonlinearity (NL) for other PC bands
  – Coefficients derived using TVAC data (RC02) with the blackbody calibration source (BCS) operated at different temperatures (170 - 340K)
  – Look-up table (LUT) designed with detector to detector flexibility in L1B code

• Coefficients Determination and Monitoring (on-orbit)
  – Coefficients derived from lunar observations
  – Coefficients slightly adjusted based on science testing
  – Coefficients have been very stable
    • Optical leak (same for different configurations)
    • Stable CFPA temperature
    • Small changes in PC spectral band responses
Coefficients Derived and Monitored from Lunar Observations

Different bands view the same target at different time, depending on their FO

Output data are co-registered

Bands 32, 33, 34, 35, 36 (mid detector) coefficients: 1.0%, 1.3%, 2.2%, 4.5%, 2.5%
Coefficients Derived and Monitored from Lunar Observations

A Single Lunar View Along-Scan Profile for Bands 34 and 35 (detector 2)

Solid line: before correction
Dash line: after correction
Performance

Baja California; March 18, 2000, 18:35
(Terra MODIS 2000078.1835)

Bands 31, 34, and 35

Band 31

No Correction
Performance

Baja California; March 18, 2000, 18:35
(Terra MODIS 2000078.1835)

Bands 31, 34, and 35

No Correction

With Correction
Improvements in Aqua MODIS

Optical leak in Terra MODIS PC bands does not exist in Aqua MODIS

LWIR FPA

Aqua 2002-281

Aqua 2010-086
Summary

• On-orbit lunar observations can be used to characterize sensor optical leak and (electronic) crosstalk

• Terra MODIS PC optical leak has been well-characterized with correction applied in L1B data processing
  – Pre-launch effort
  – Initial on-orbit validation
  – Long-term monitoring

• Lunar observations have also been applied for electronic crosstalk characterization for both Terra and Aqua MODIS
  – See next presentation

• MODIS lessons
  – Support for other sensors/missions