MODIS PC Bands Optical Leak Characterization Using Lunar Observations

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General References:

X. Xiong, T. Dorman, S. Xiong, K. Chiang, Y. Zhang, B. Guenther, and C. Moeller, "Using the Moon for the On-orbit Determination of MODIS Photoconductive (PC) Bands Optical Leak," CALCON, 2000

W. Li, X. Xiong, K. Chiang, and G. Toller, "Evaluation of Terra MODIS PC Bands Optical Leak Correction Algorithm", SPIE, 2005
X. Xiong X, K. Chiang, A. Wu, W.L. Barnes, B. Guenther, and V. Salomonson, "Multiyear On-orbit Calibration and Performance of Terra MODIS Thermal Emissive Bands," IEEE TGRS, 2008

Background

- **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

36 spectral bands (490 detectors) on four FPAs

Instrument FPA Main Frame Temperature   Cold FPAs: (80. 83, 85k)
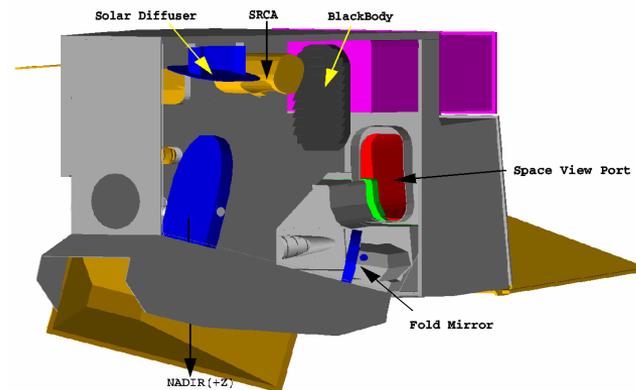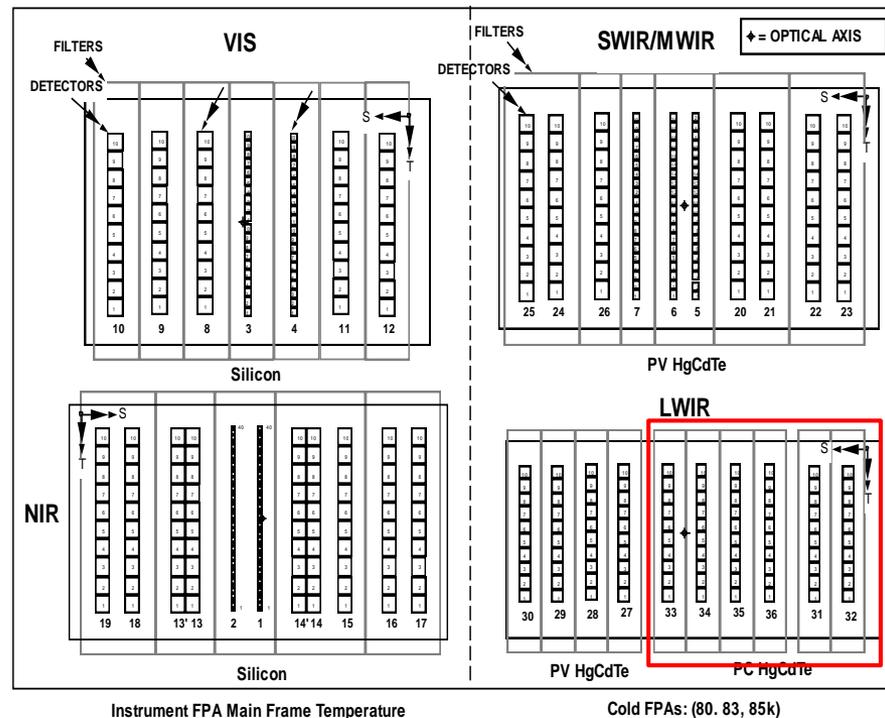
Optical Leak Characterization

- **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**
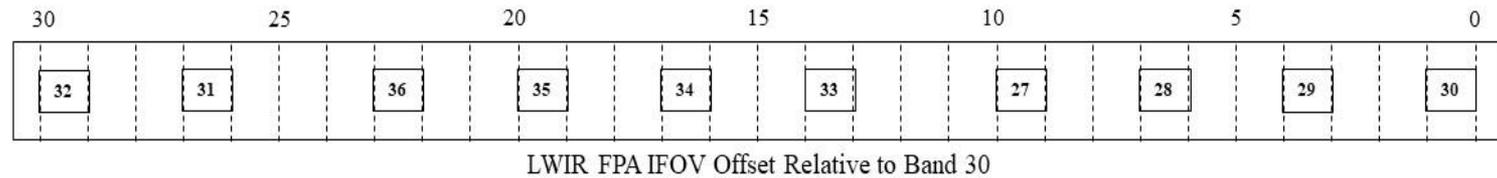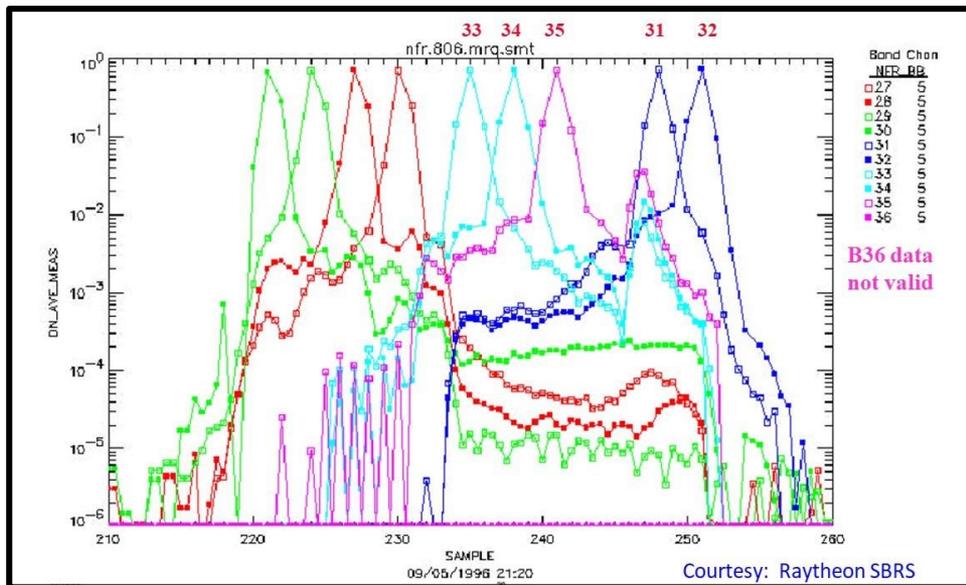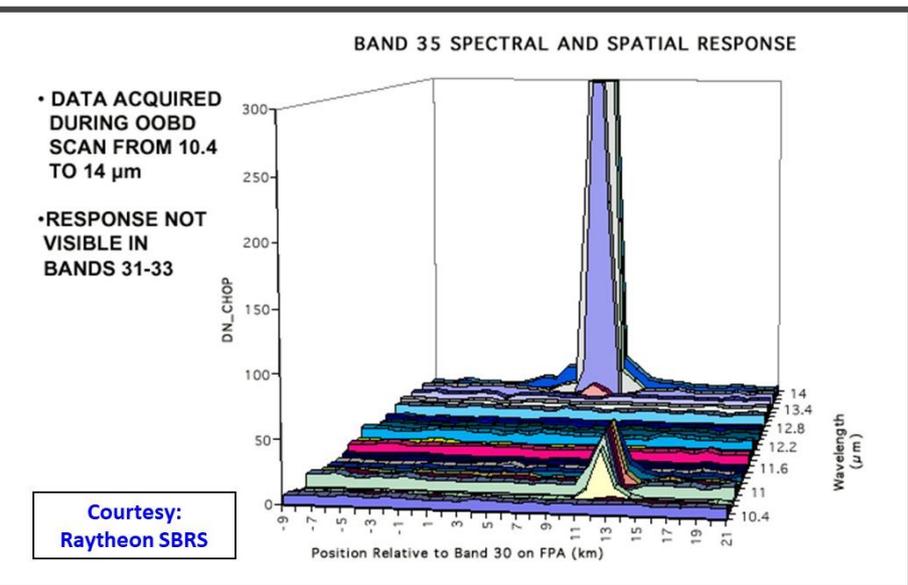
Correction Methodologies

MODIS TEB calibration using a quadratic algorithm

Scene radiance as a function of detector response in digital number (dn)
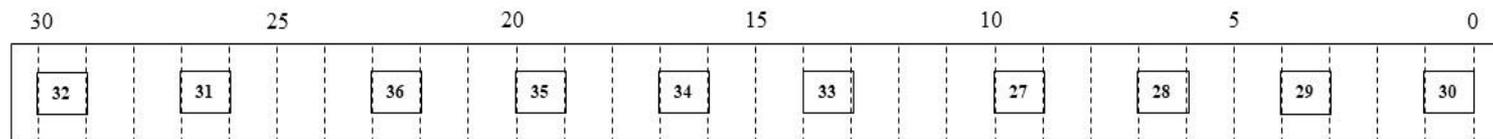
$$L_{Total} = f(dn)$$

Total radiance includes scan mirror contribution

dn is space view background subtracted digital number

Crosstalk correction algorithm (developed pre-launch):

$$dn_{Band\_X}^{True}(FD) = dn_{Band\_X}^{Contaminated}(FD) - Xtalk_{Band\_31->Band\_X} * dn_{Band\_31}(FD + FO_{Band\_31->Band\_X})$$

FD: frame of data; FO: frame offset

30		25		20		15		10		5		0
32	31	36	35	34	33	27	28	29	30

LWIR FPA IFOV Offset Relative to Band 30

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
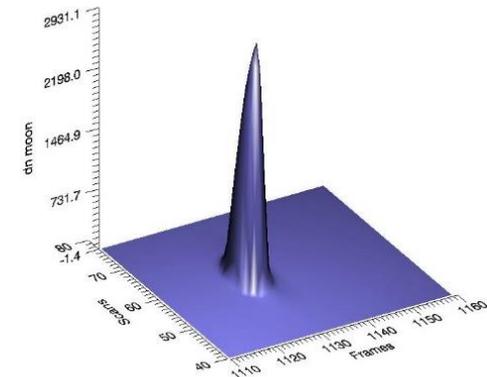
Coefficients Derived and Monitored from Lunar Observations
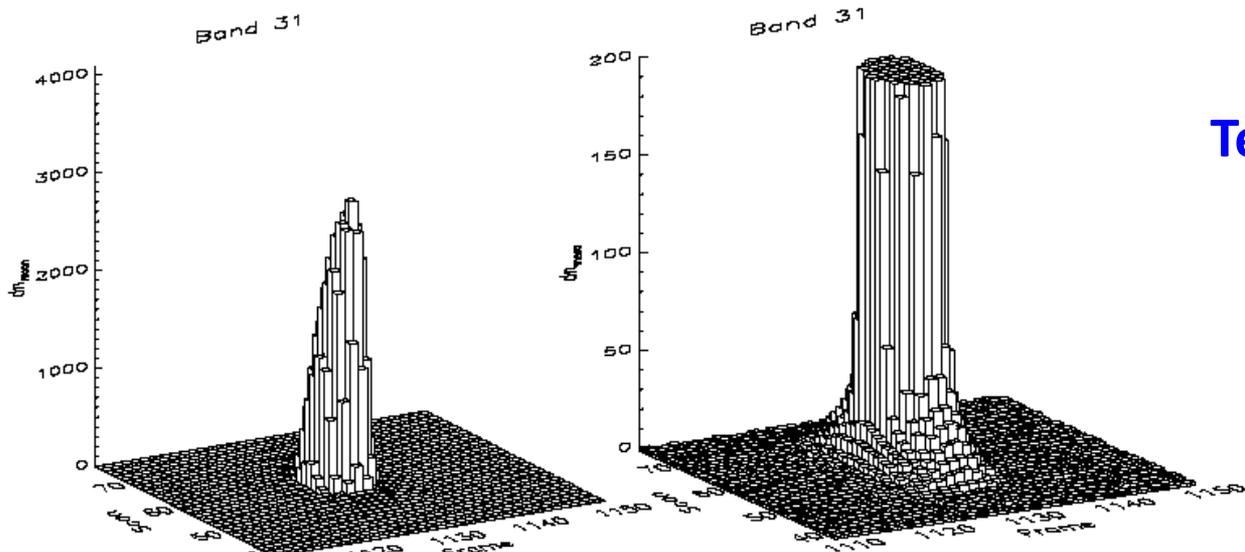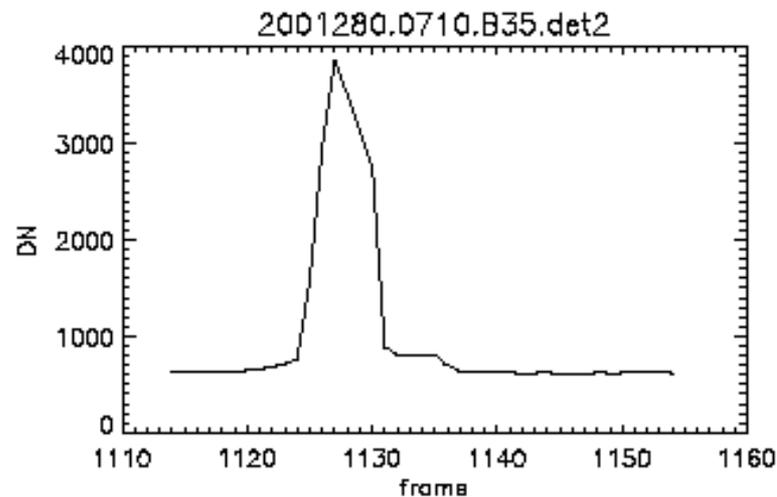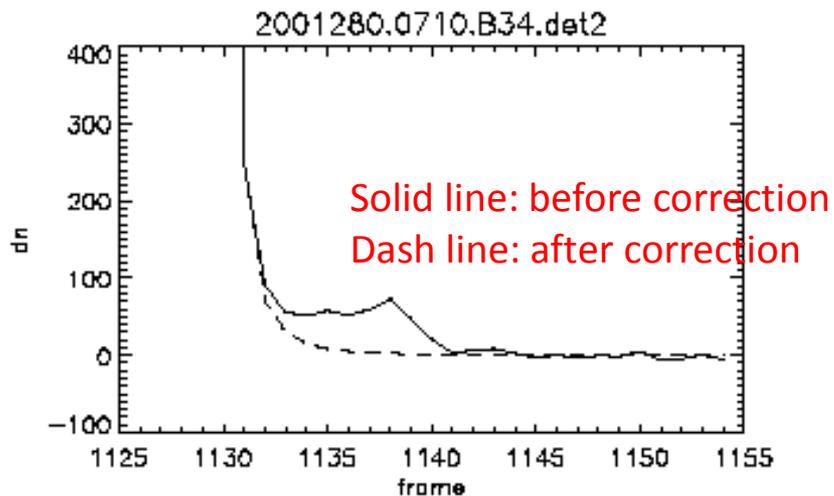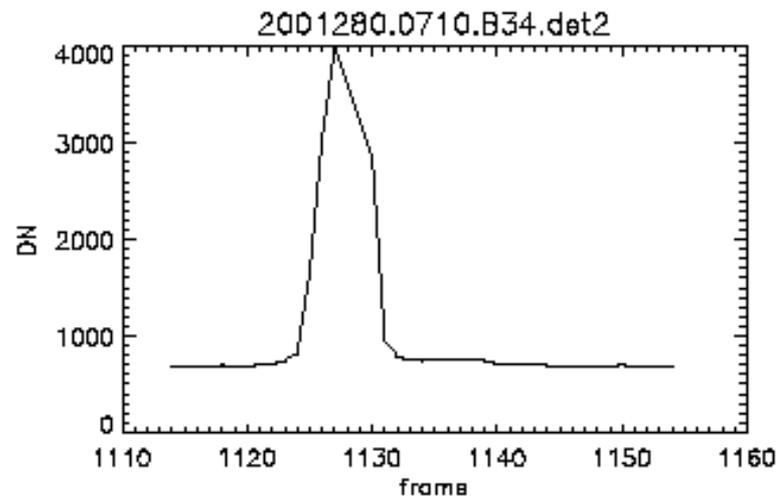

Terra MODIS Lunar View (2000/084)
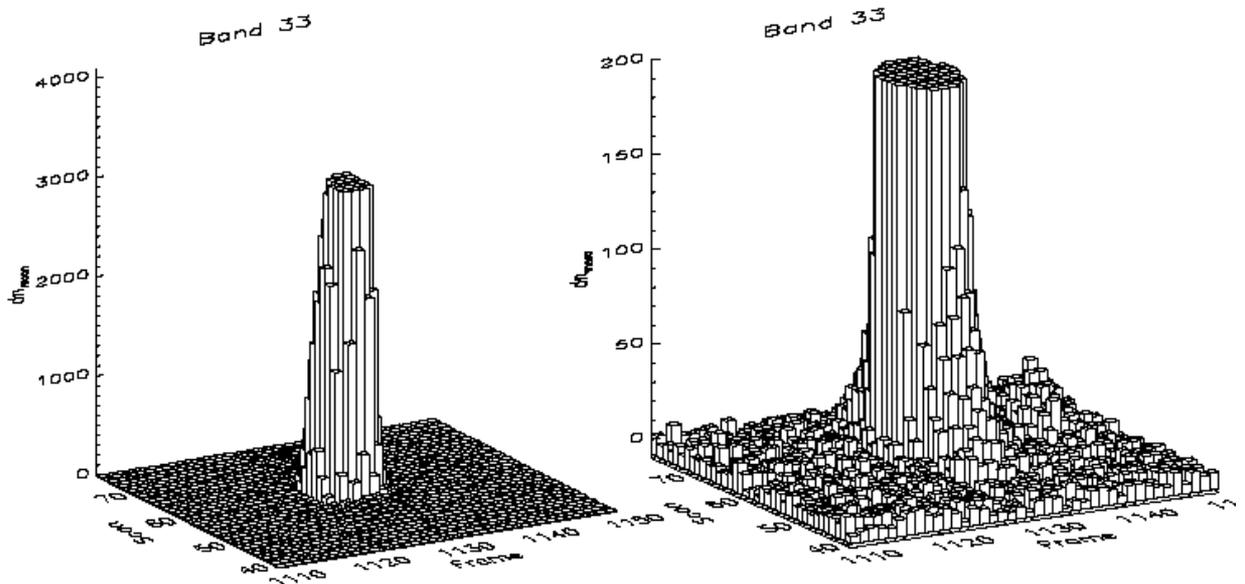
Different bands view the same target at different time, depending on their FO

Output data are co-registered

Bands 32, 33, 34, 35, 36 (mid detector) coefficients: 1.0%, 1.3%, 2.2%, 4.5%, 2.5%

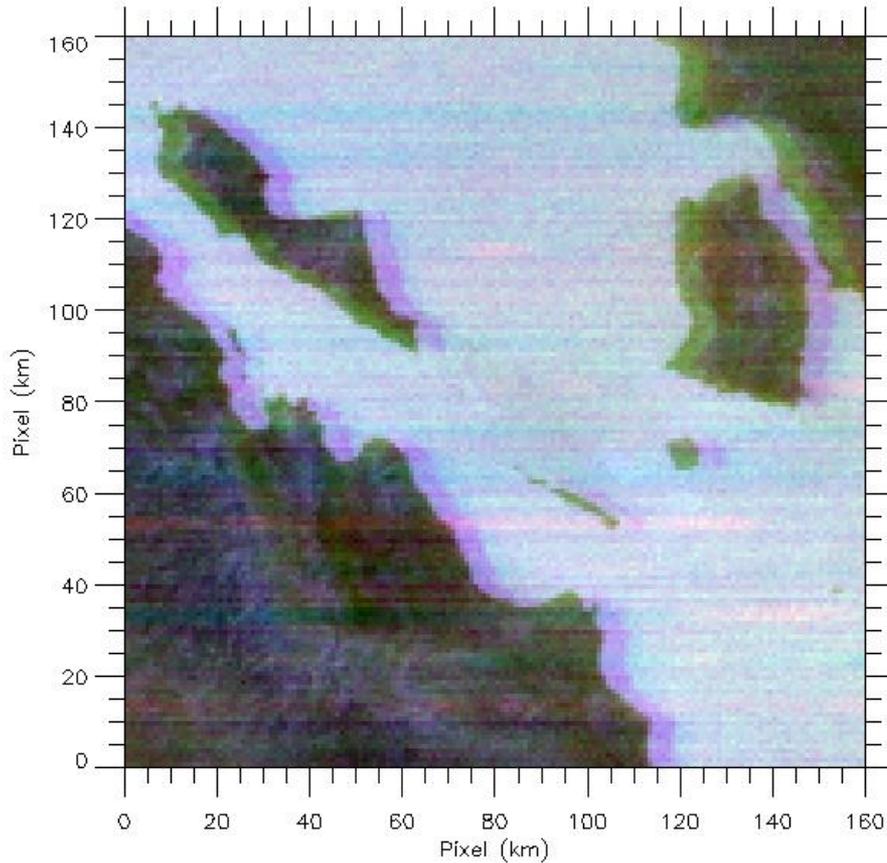# Coefficients Derived and Monitored from Lunar Observations

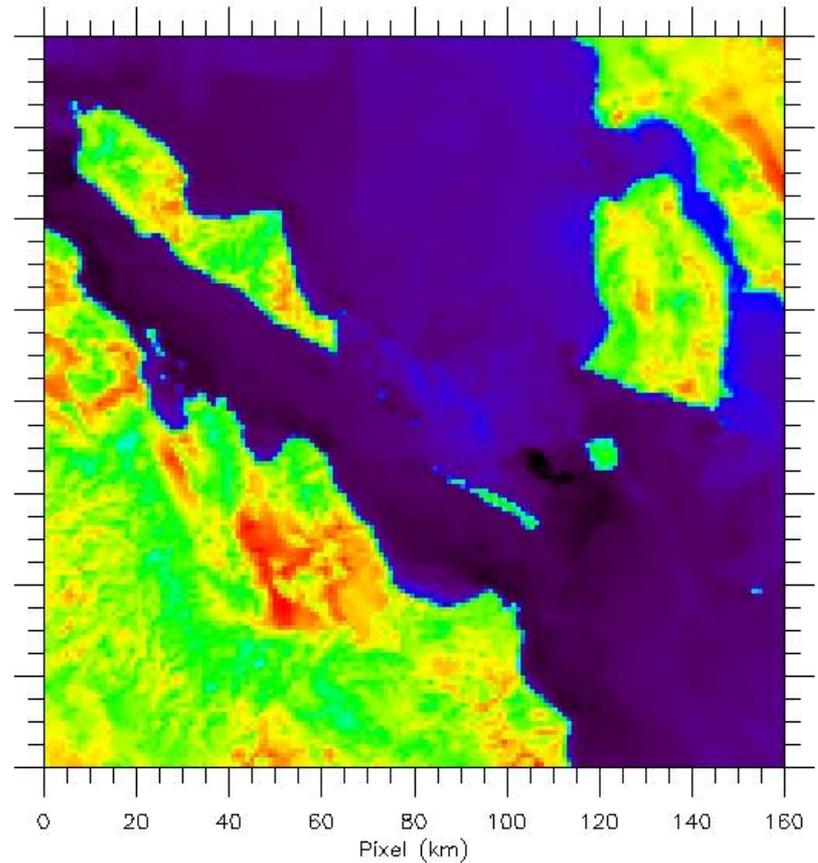A Single Lunar View Along-Scan Profile for Bands 34 and 35 (detector 2)
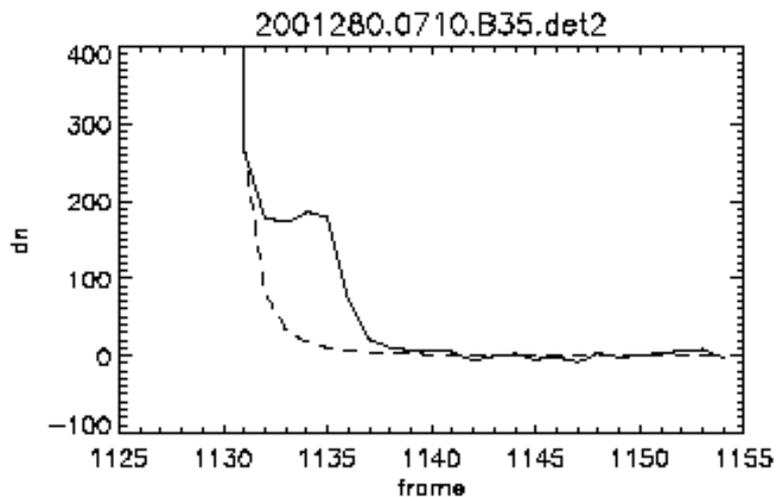
Solid line: before correction
Dash line: after correction

Performance

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

No Correction

Performance

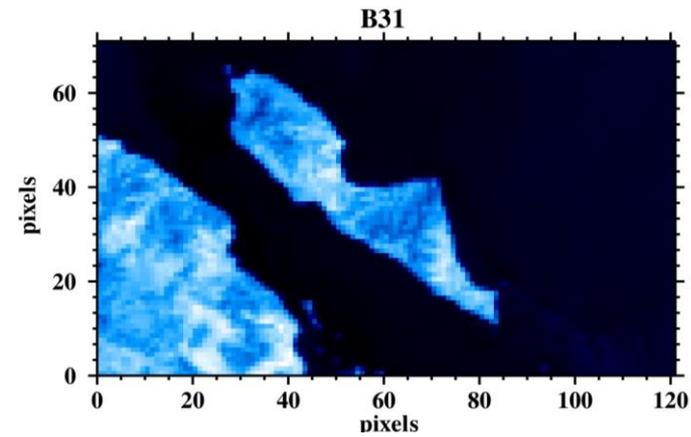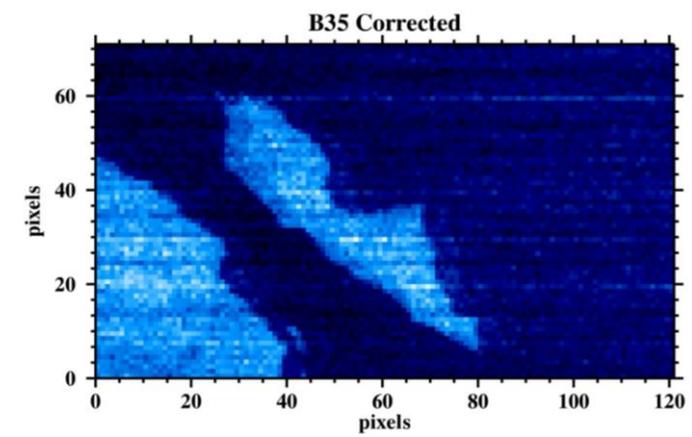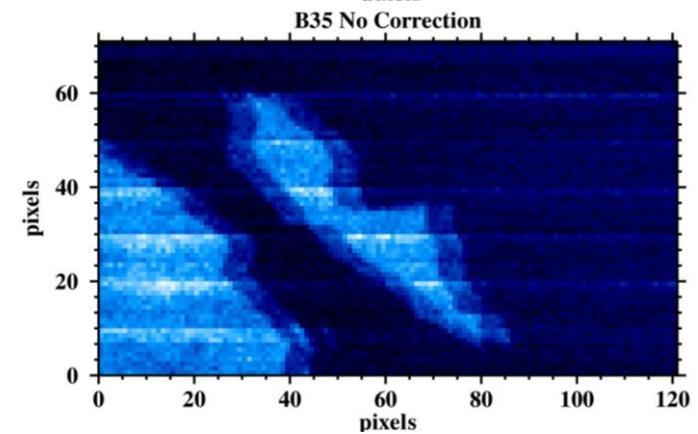Baja California; March 18, 2000, 18:35
(Terra MODIS 2000078.1835)
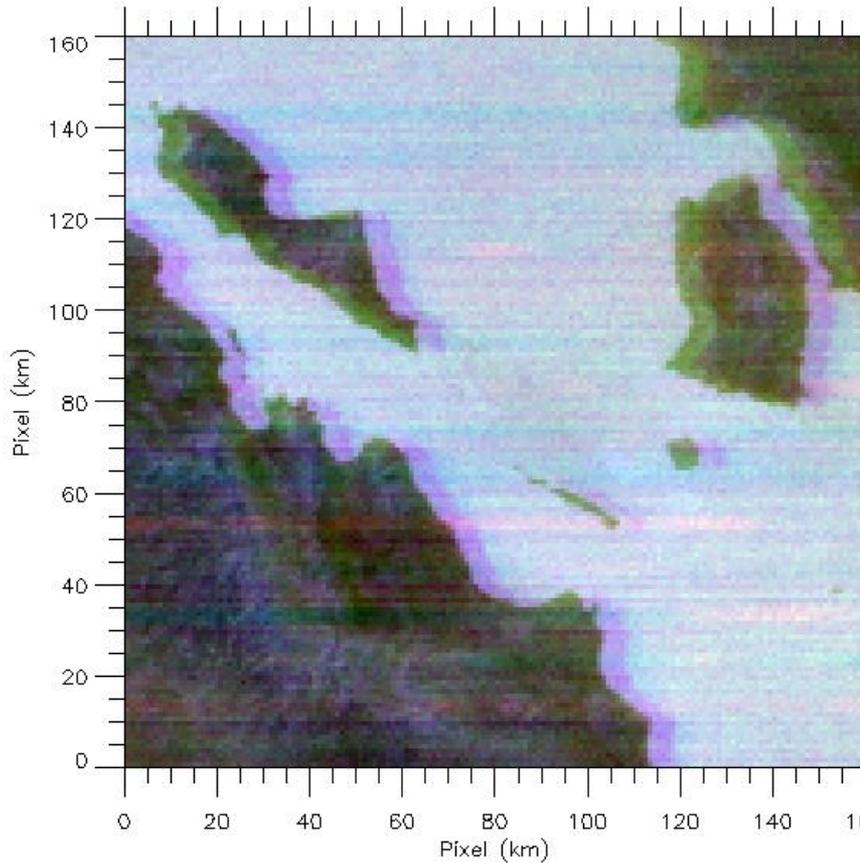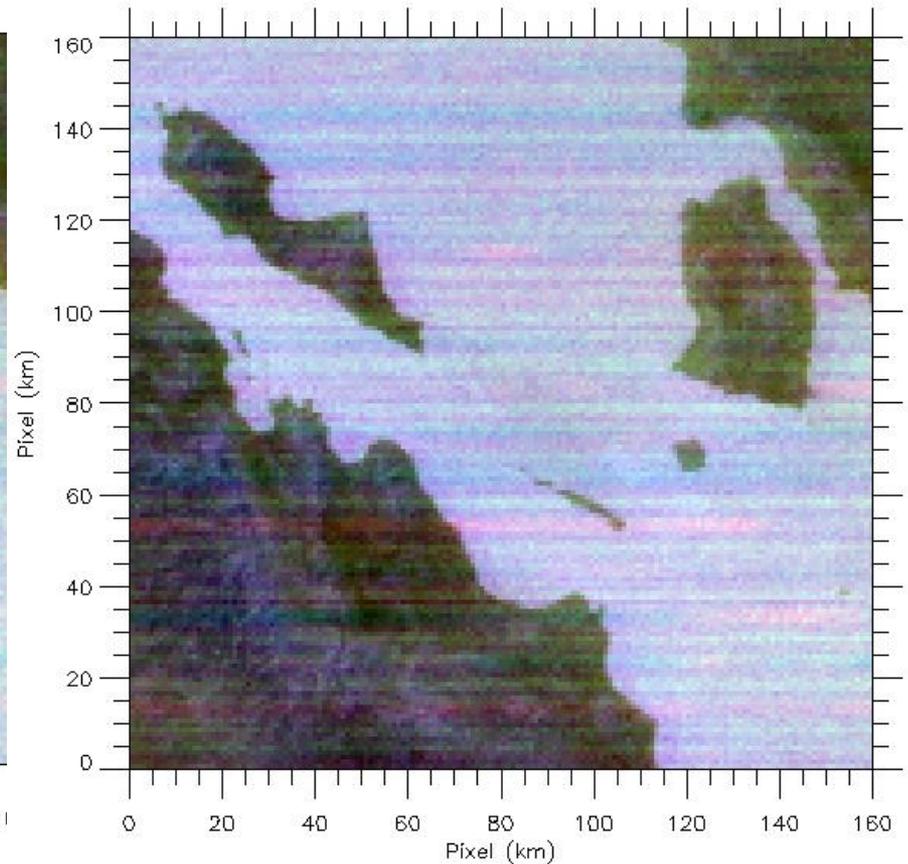
No Correction　　　　**With Correction**
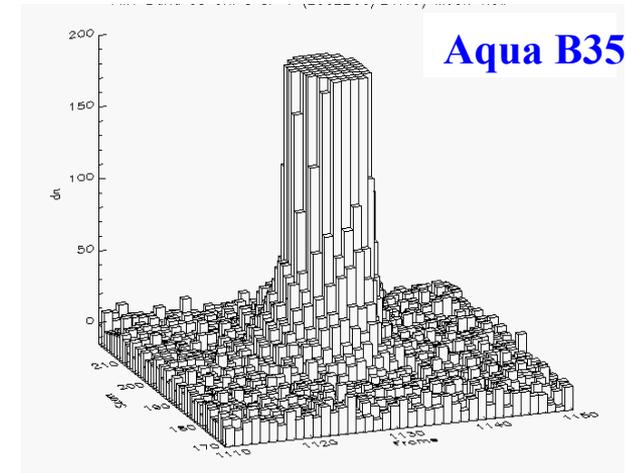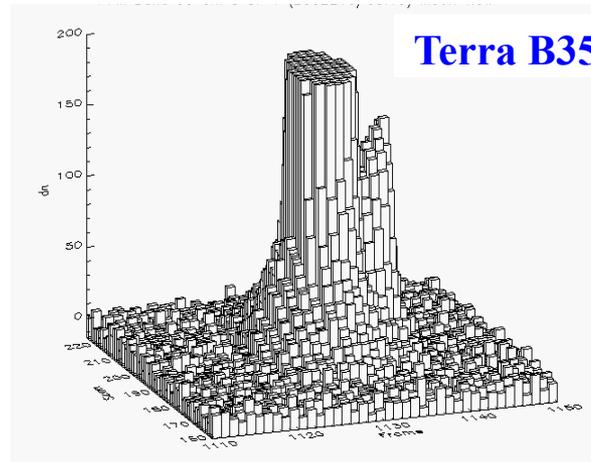
2000-078
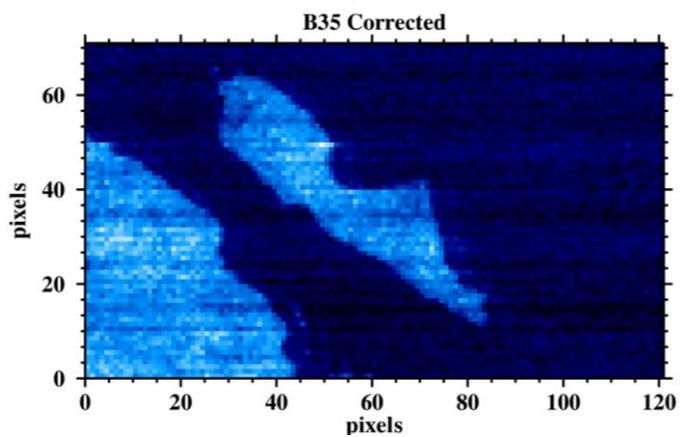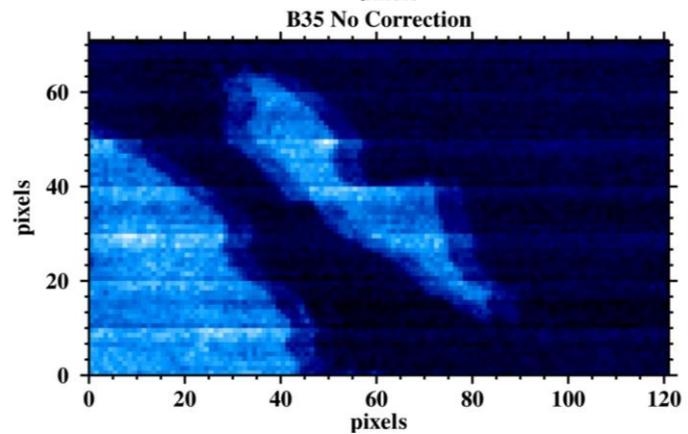
2010-146
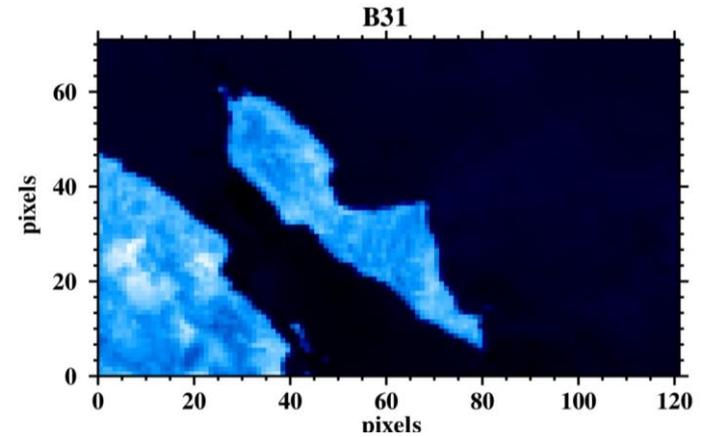
Improvements in Aqua MODIS

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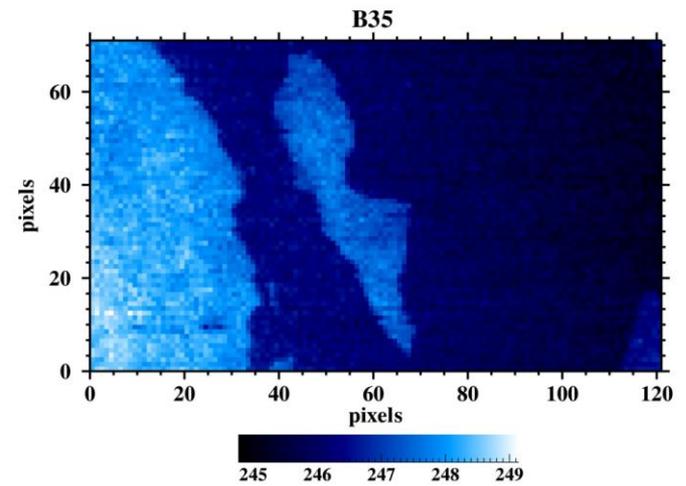

LWIR FPA

Terra B35

Aqua B35
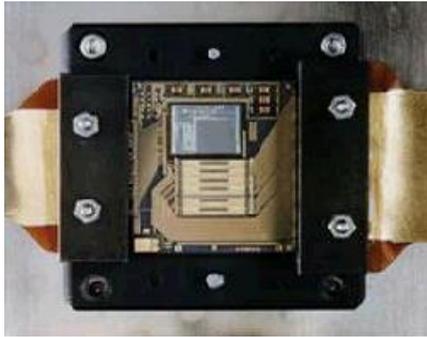
Aqua 2002-281
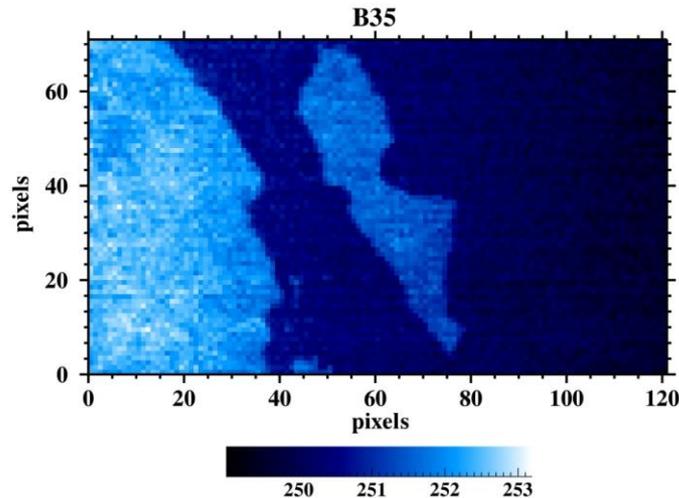
Aqua 2010-086

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