BlackBridge
Delivering the World

# ABSOLUTE CALIBRATION OF THE RAPIDEYE CONSTELLATION - PROGRESS AND PLANS


- Andreas Brunn | BlackBridge CalVal

# Outline

- BlackBridge and the RapidEye System
- Absolute Calibration Campaigns
  - Past and Current Campaigns
  - Integrating results
- Outlook
  - Integrating MOBY Buoy
  - First results

# BLACKBRIDGE AND THE RAPIDEYE SYSTEM

# RapidEye Capacity Overview

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**Five-Satellite Constellation**
Enables daily target revisit

**Broad Area Collection**
77-km-wide sensor swath, ideal for large-area monitoring and mapping

**Large Collection Capacity**
More than 5 million km² collected daily

**High Resolution Imaging**
5-meter resolution imagery

**Multispectral Imaging**
5 spectral bands for improved feature discrimination

**Extensive Imagery Archive**
More than 6 billion km² of archived imagery

# The Satellite Constellation

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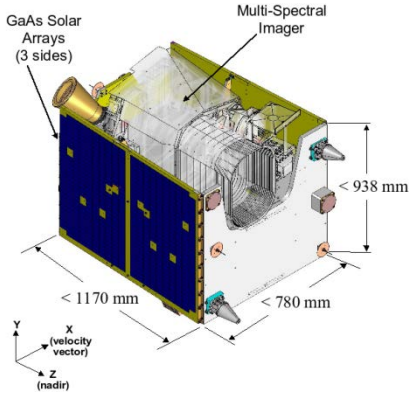
| | |
|---|---|
| **Launch date:** | August 29, 2008 |
| **No. of satellites:** | 5 |
| **Orbit:** | Sun synchronous |
| **Equator crossing time:** | 11:00 |
| **Orbits per day:** | 14.8 per satellite |
| **Nominal altitude:** | 630 km |
| **Swath width:** | 77 km |
| **Imaging capacity:** | max. 1,500 km /orbit |
| **System image capture capacity:** | more than 5 million $km^2$/day |

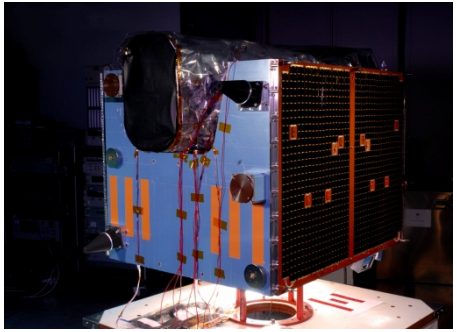
# The Spacecraft

| | |
|---|---|
| **Weight:** | 156.4 kg |
| Bus: | 112.9 kg |
| Payload: | 43.5 kg |

**Bus built by:** SSTL (UK)

**Payload built by:** Jena Optronik (Germany)



# Sensors Onboard the Satellites

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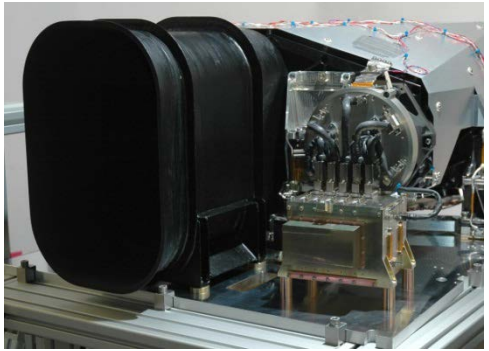
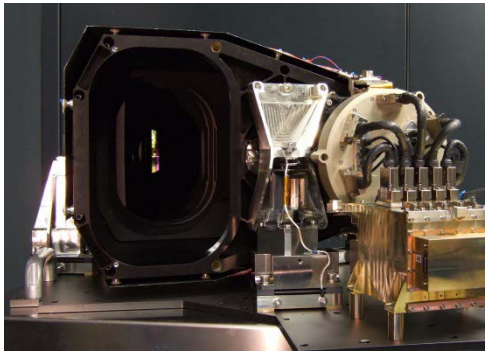
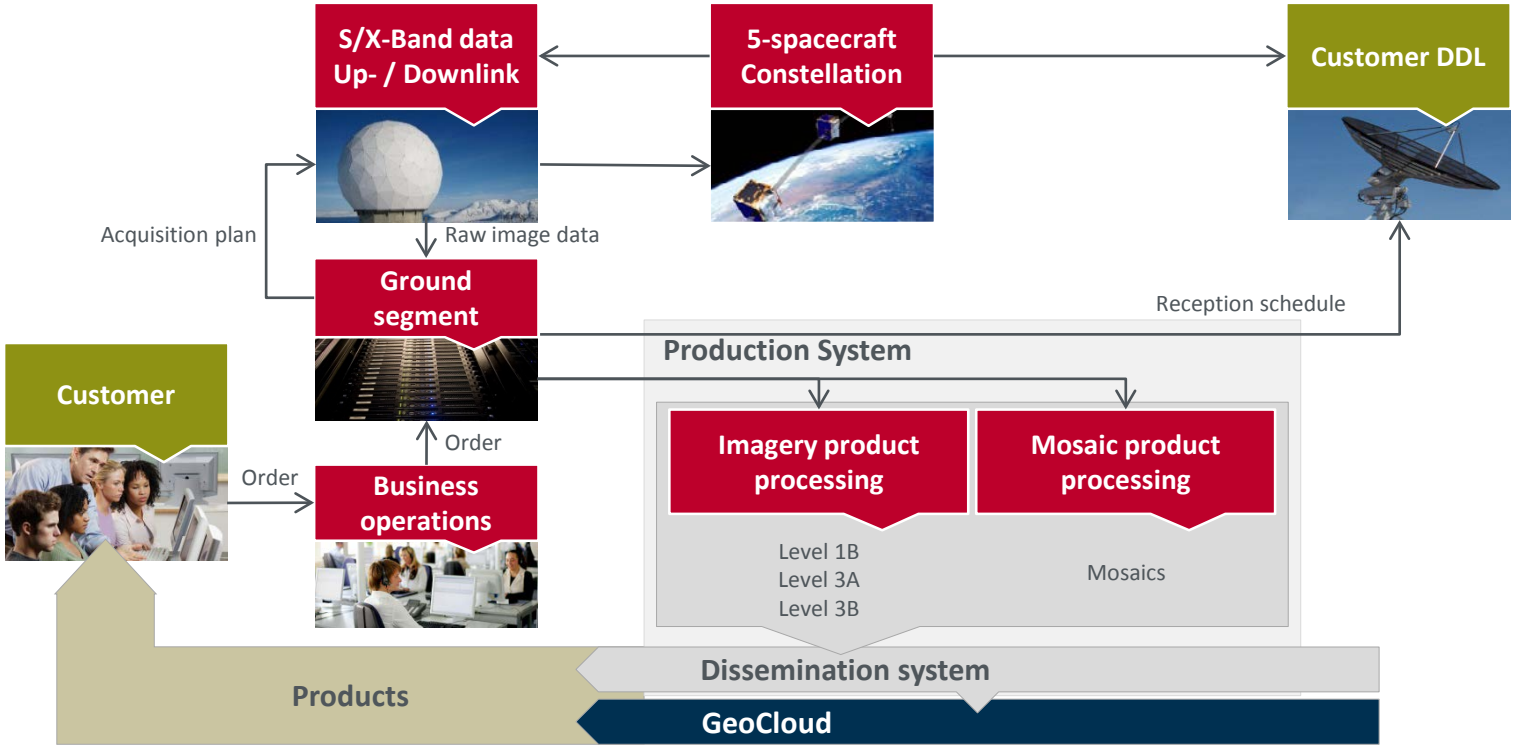
| | |
|---|---|
| **Manufacturer:** | Jena Optronik, Germany |
| **Model:** | JSS56 Spaceborne Scanner |
| **Design:** | TMA (Al mirror) |
| **Eff. focal length:** | 633 mm |
| **Entrance Pupil Ø:** | 147 mm |
| **f-number:** | 4.3 |
| **CCD:** | Atmel (AT71544) |
| **Pixel Size:** | 6.5 m |
| **Pixels per line:** | 12,000 |
| **Camera dynamic range:** | 12-bit |





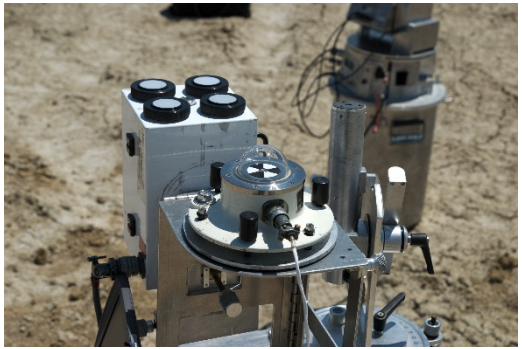
# System Overview



# ABSOLUTE CALIBRATION

# Field Campaigns

- Field Equipment
  - Sun Photometer
  - Line-of-Sight Photometer
  - Wide Angle Photometer
  - Field Spectrometer



# Field Locations

- Railroad Valley
  - Dry Lake Bed
  - Bright
  - Homogeneous
  - High Elevation

# Field Locations

- Brookings
  - Prairie
  - Dark
  - Easily Accessible

# Previous Vicarious Campaigns

- Campaigns have been performed with the University of Arizona and South Dakota State University yearly since 2009.
  - 2009-2010 Railroad Valley and Ivanpah Playa (2 sats., 10 collects)
  - 2011 Railroad Valley (5 sats., 5 collects)
  - 2012 Railroad Valley (5 sats., 25 collects)
  - 2013 Brookings (5 sats., 9 collects)
  - 2013 Railroad Valley (5 sats., 5 collects)
  - 2014 Railroad Valley (5 sats., 10 collects)
  - 2014 Brookings (5 sats., 12 collects)
  - 2015 Continuing …


# INTEGRATION

# Update Of Calibration Factors Early 2015

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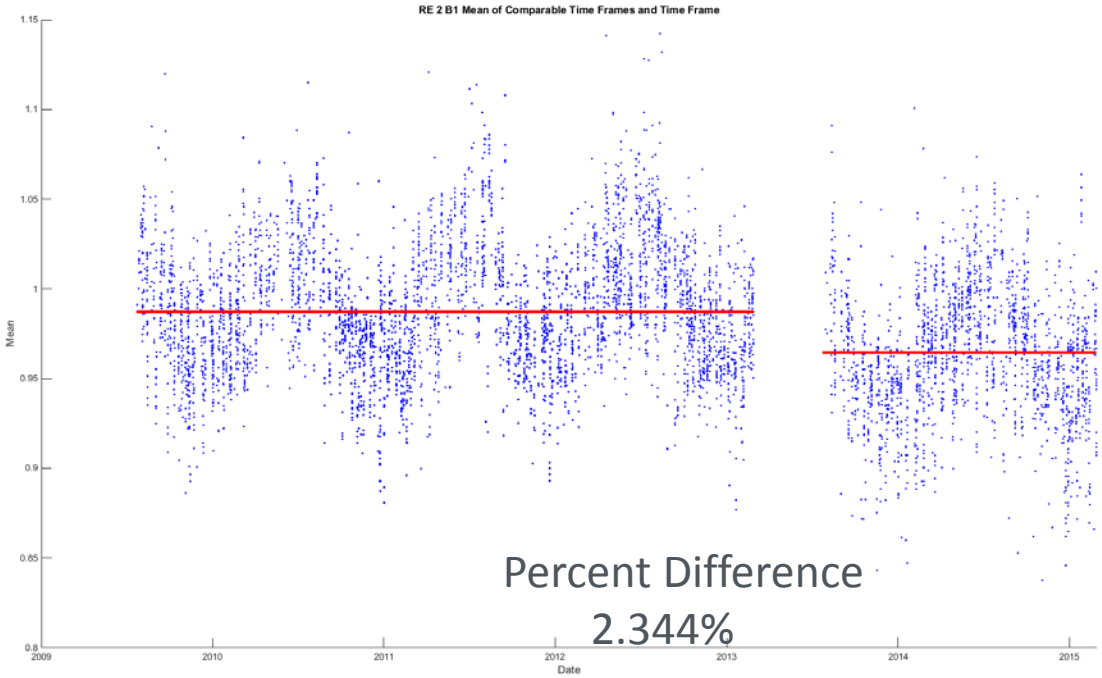
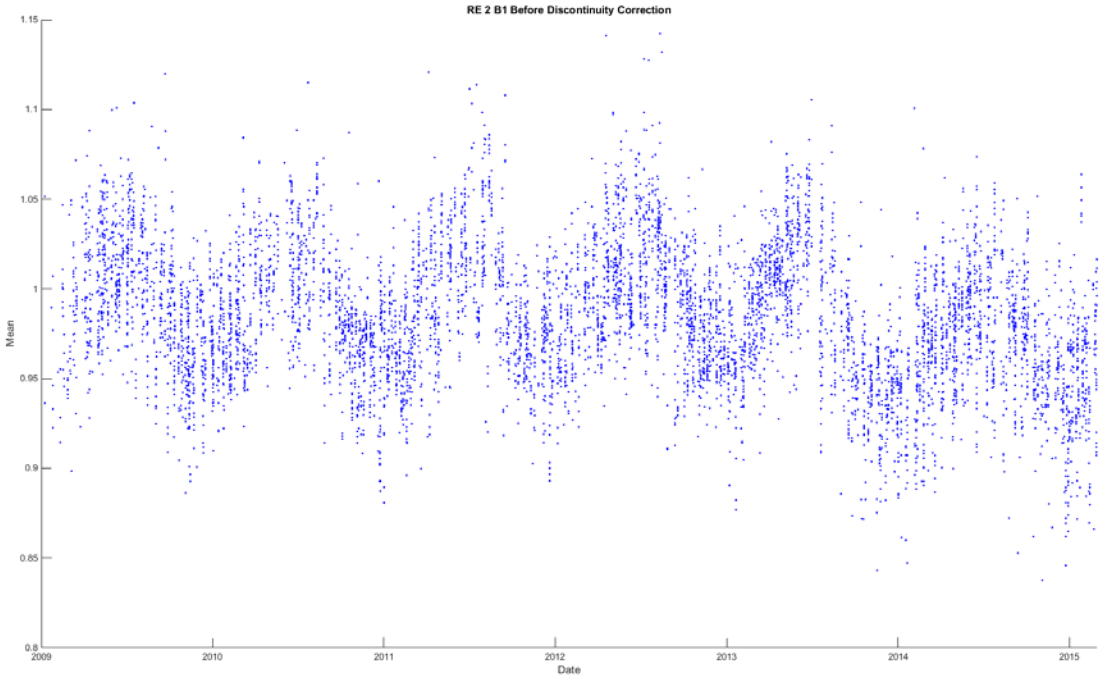
- Involves:
  - Absolute Calibration Results from all 2014 Collects
  - Temporal Calibration Results (incl. discontinuity correction)
  - Spatial Calibration Results from Side Slither and Dark Images

# Discontinuity Correction




- Both sections are corrected with the same temporal correction gain.
- The second, smaller section is multiplied by a discontinuity correction gain

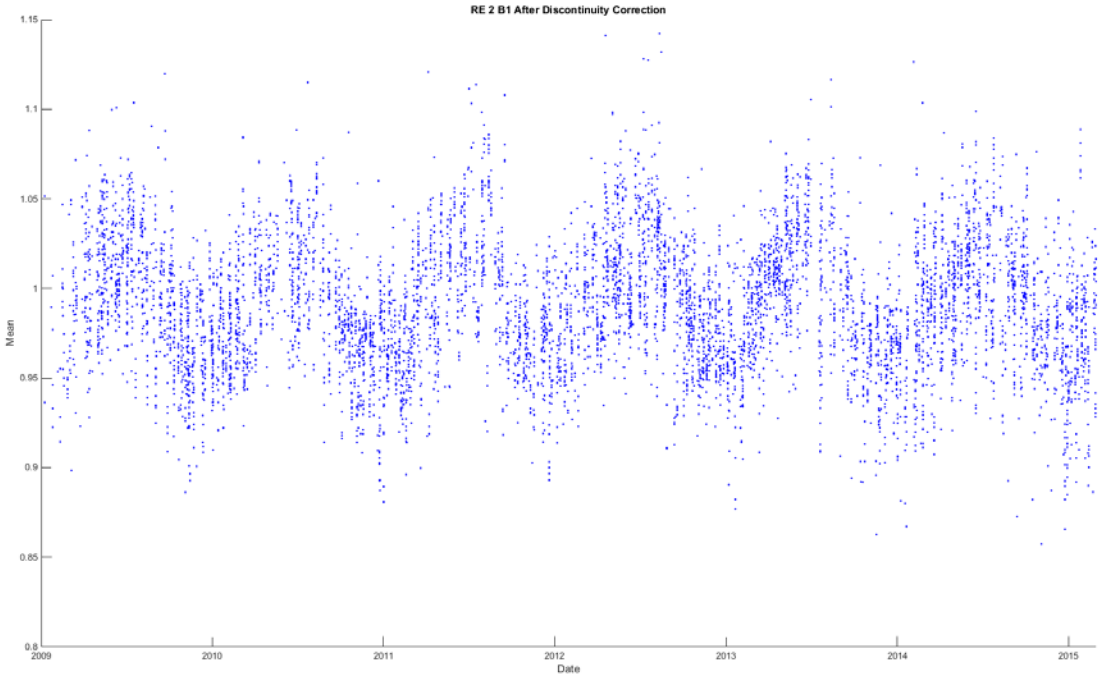
# Discontinuity Correction




Before Discontinuity Correction

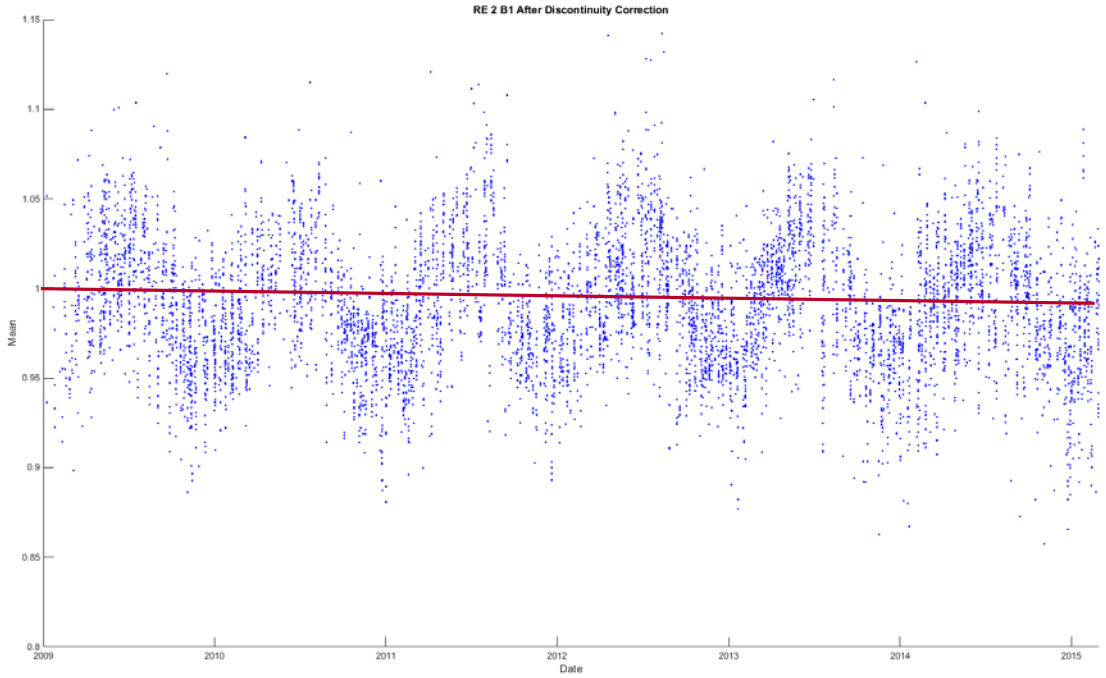
Gaps are filled using mean values of the same time (months) of previous years adjusted using preliminary gains and offsets

# Discontinuity Correction



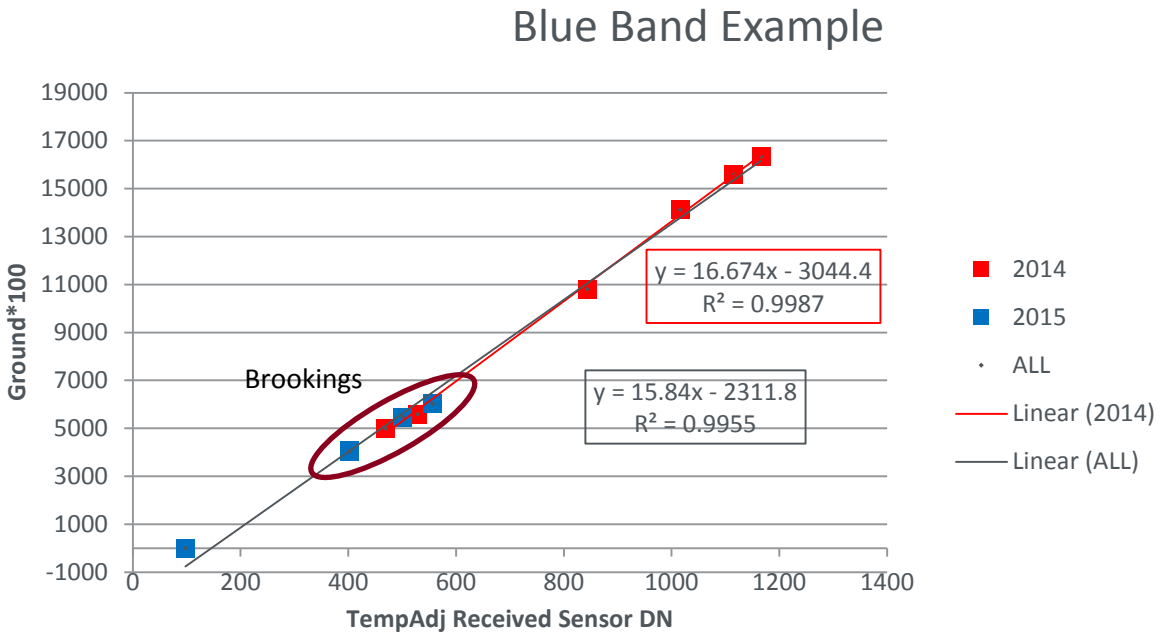

After Discontinuity Correction

# Discontinuity Correction

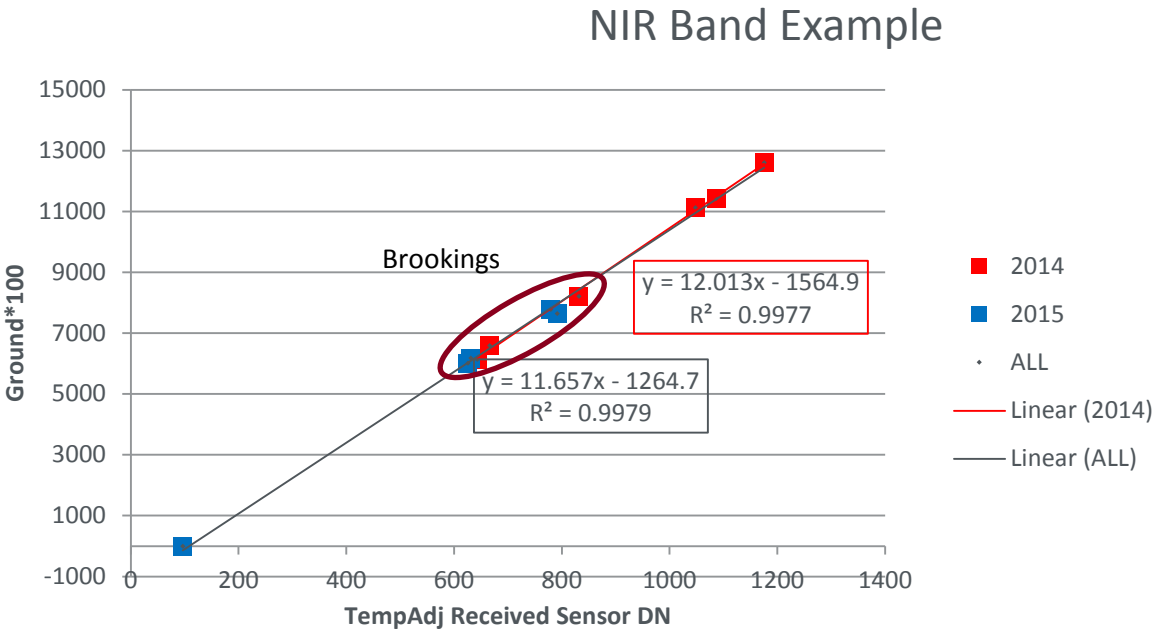



Approx. 2% sensitivity loss over the mission lifetime

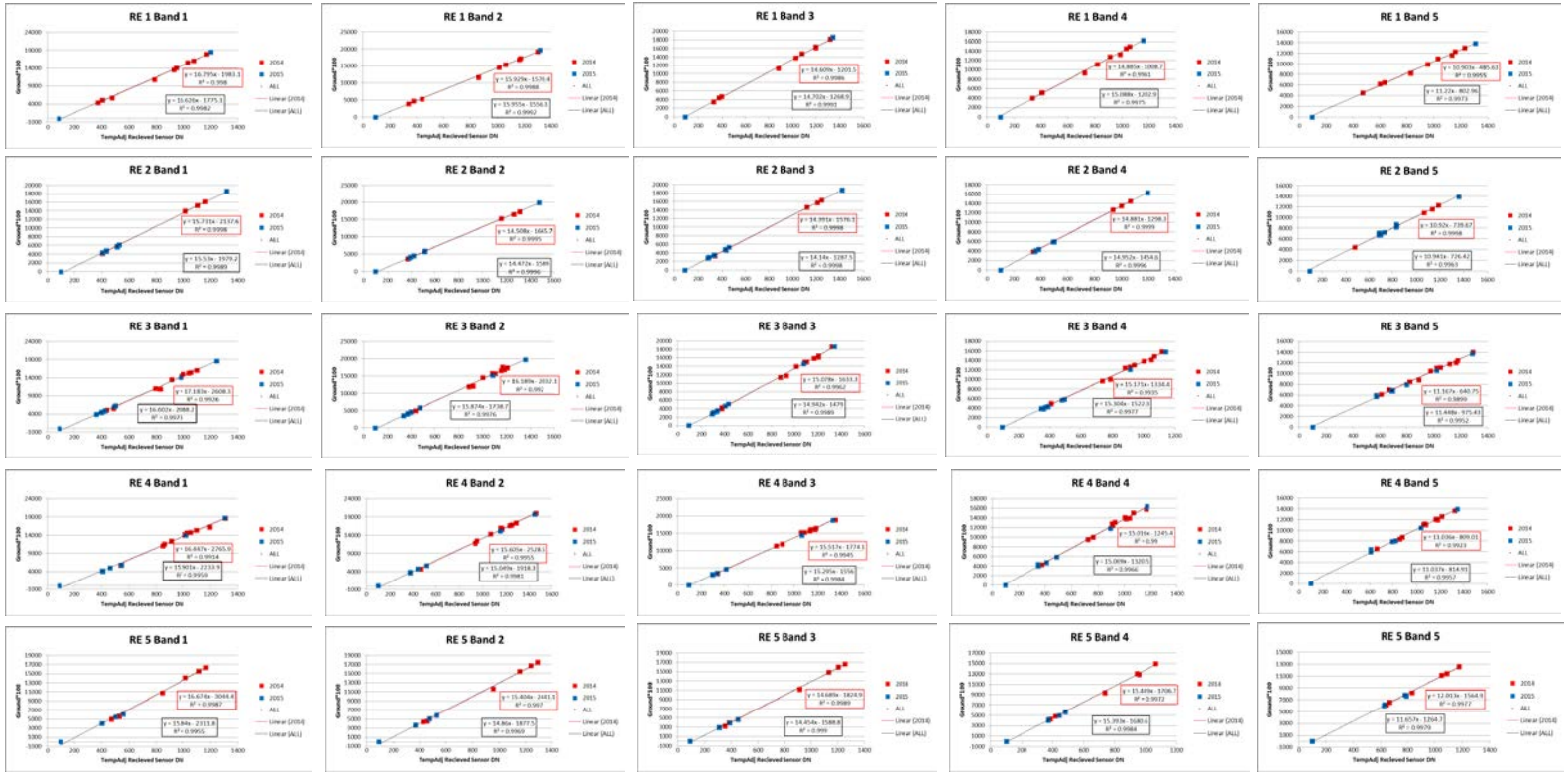
# AbsCal Results



# AbsCal Results



# AbsCal Results




# WHAT‘S NEXT …

# 2015 Absolute Calibration

- Railroad Valley Site
  - Collaboration with University of Arizona
  - 1 image and simultaneous field collect for each spacecraft in 2015
  - Up to 100 Image takes with all satellites and reference data from the automated calibration site between April 2015 and April 2016

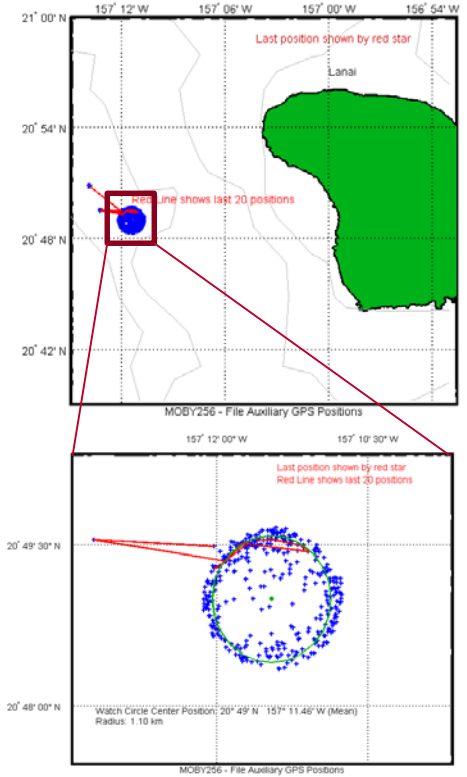
- Brookings
  - Collaboration with South Dakota State University
  - Goal: 2 Image takes per SC with simultaneous field collects until End of October 2015

# 2015 Absolute Calibration

- MOBY Buoy
  - Method to use MOBY data for absolute calibration is currently under development
- Results of campaigns are evaluated as they come in
- Final combined implementation is expected to be done when all reference information is available

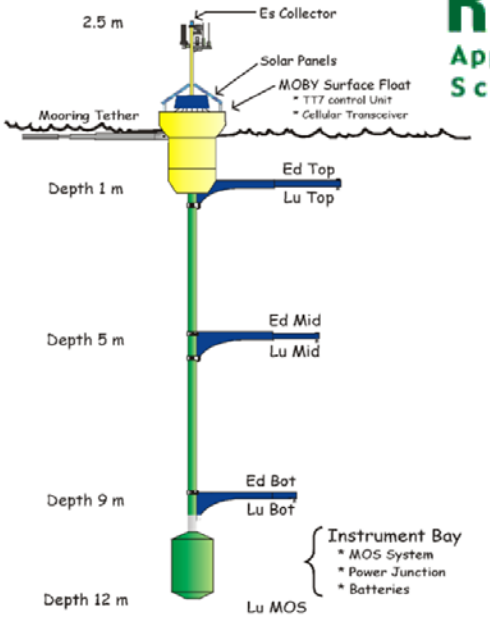
# The MOBY Buoy

- Marine Optical Buoy
  - Located 20 km west Lanai HI
  - 1200 m water depth



# The MOBY Buoy

- Marine Optical Buoy
  - Measures water leaving radiance (-1m)
  - Measures irradiance (+2.5m)
  - NIST calibrated response



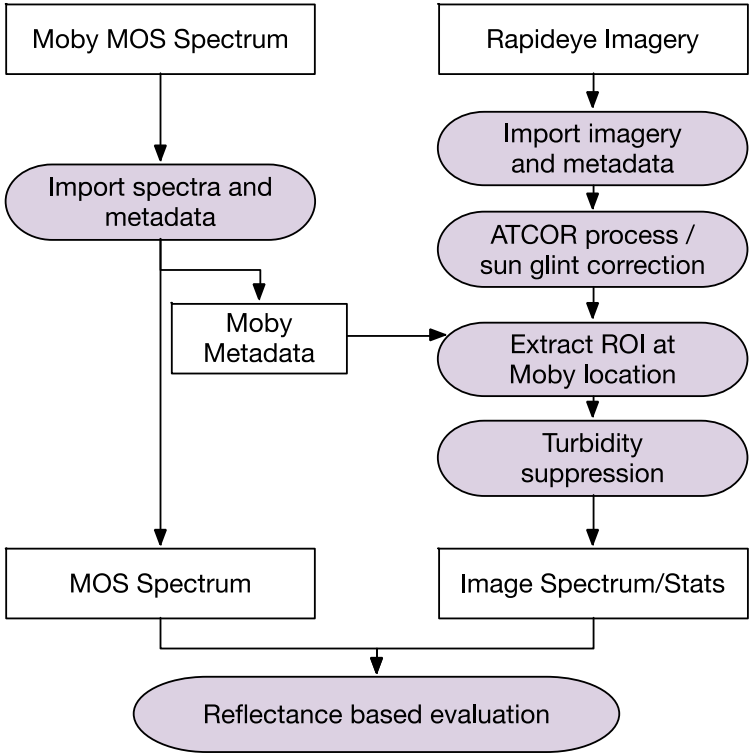

Brown et.al., SPIE 2007

# Integration of the MOBY Site

- Goal: Use MOBY bottom of atmosphere reflectance and irradiance data for validation of RapidEye imagery on the dark end of the brightness range.

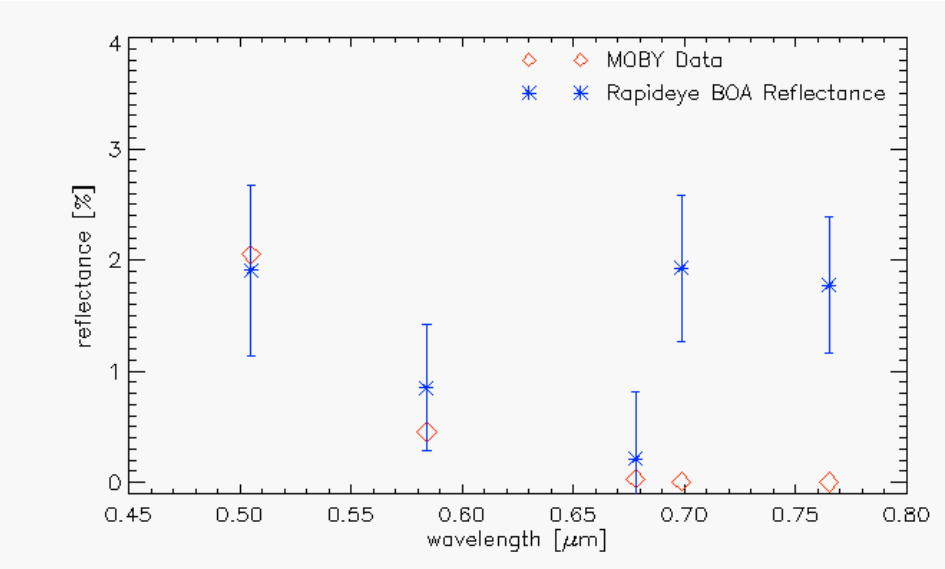
- Conditions:
  - The station is moving
  - Water turbidity is large
  - Reflectance based method is limited by the wave registration on the satellite imagery

# Reflectance Based Validation



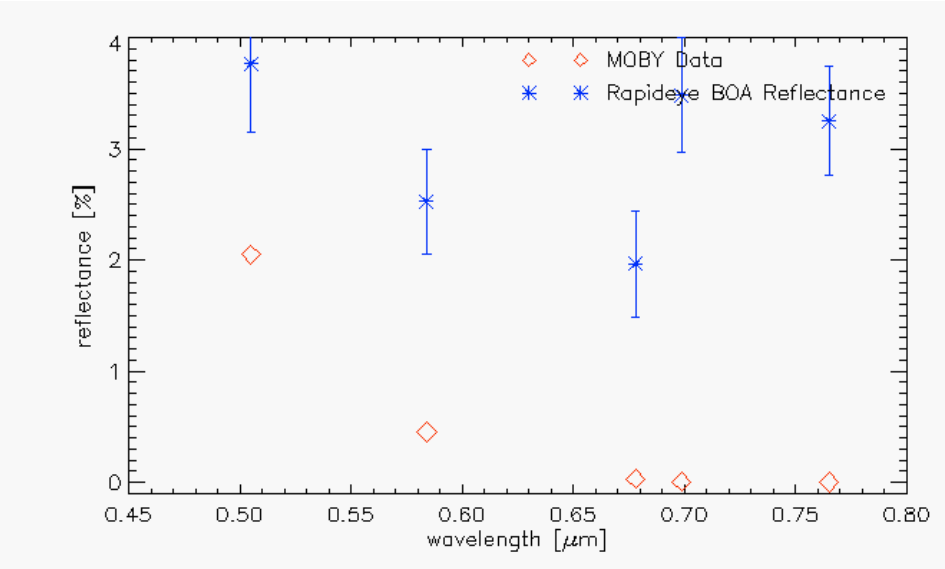
# First Results

- ATCOR processing with 10km visibility:



# Aerosol Influence

- ATCOR processing with 15km visibility:




It is crucial to find the right atmospheric conditions for the right results.

# MOBY Status and Outlook

- RGB bands may be processed to reasonable values using high aerosol contents
- NIR bands show consistently too high values
- water turbidity impede unlimited use of MOBY data for RapidEye validation and calibration

Further steps:

- implement at-sensor radiation based validation
- check sunglint correction approaches

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