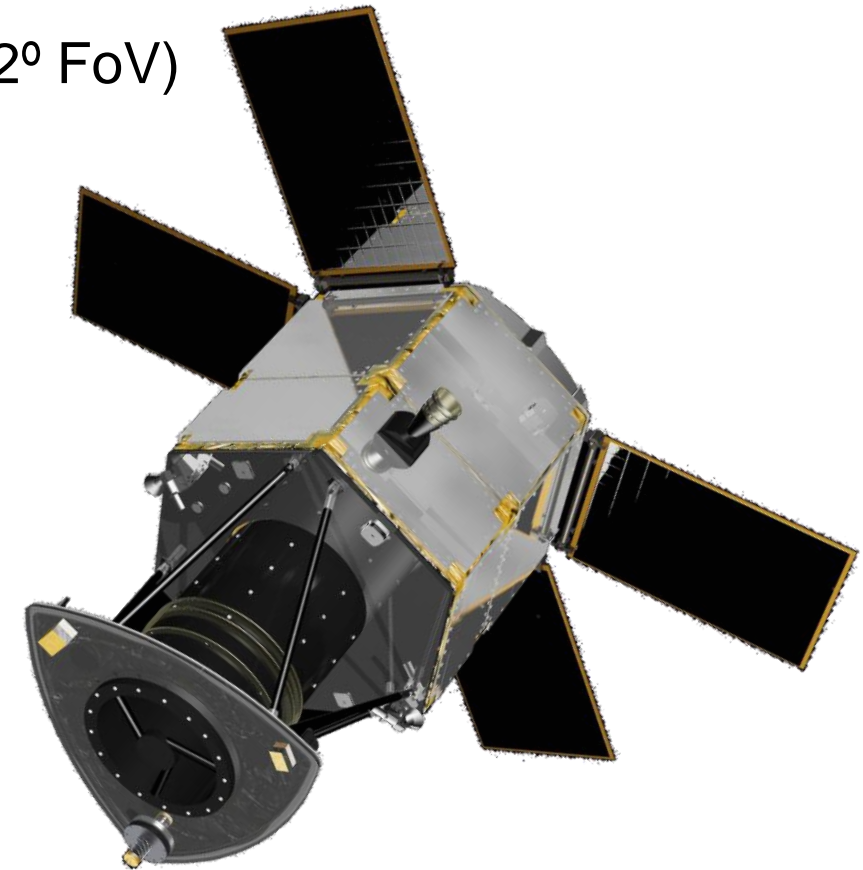# Deimos-2 Post-Launch Radiometric Calibration

Jorge Gil, DEIMOS Imaging

VH-RODA Workshop, ESRIN, 19 November 2019
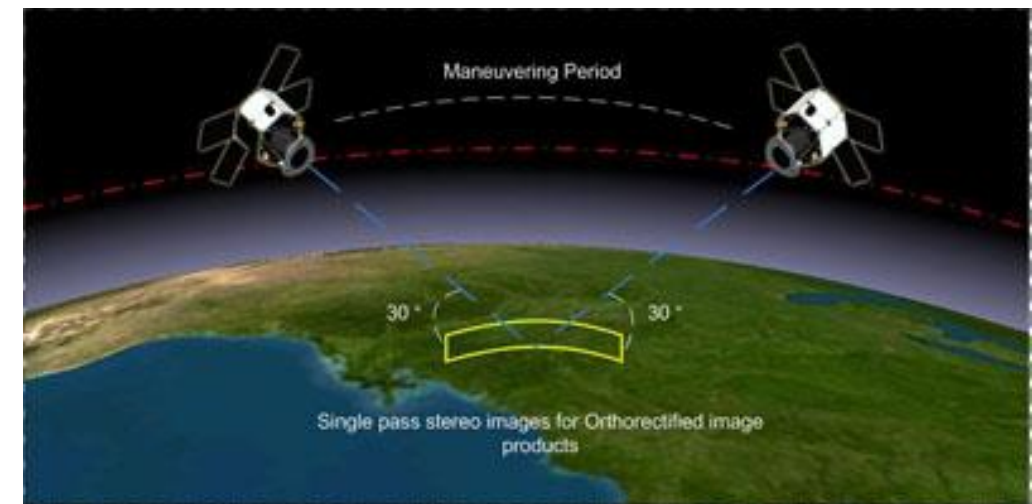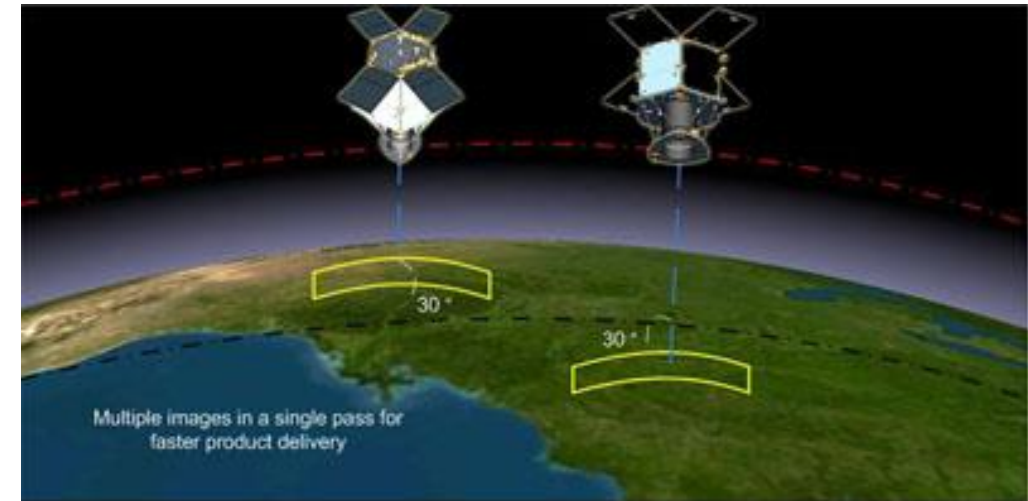
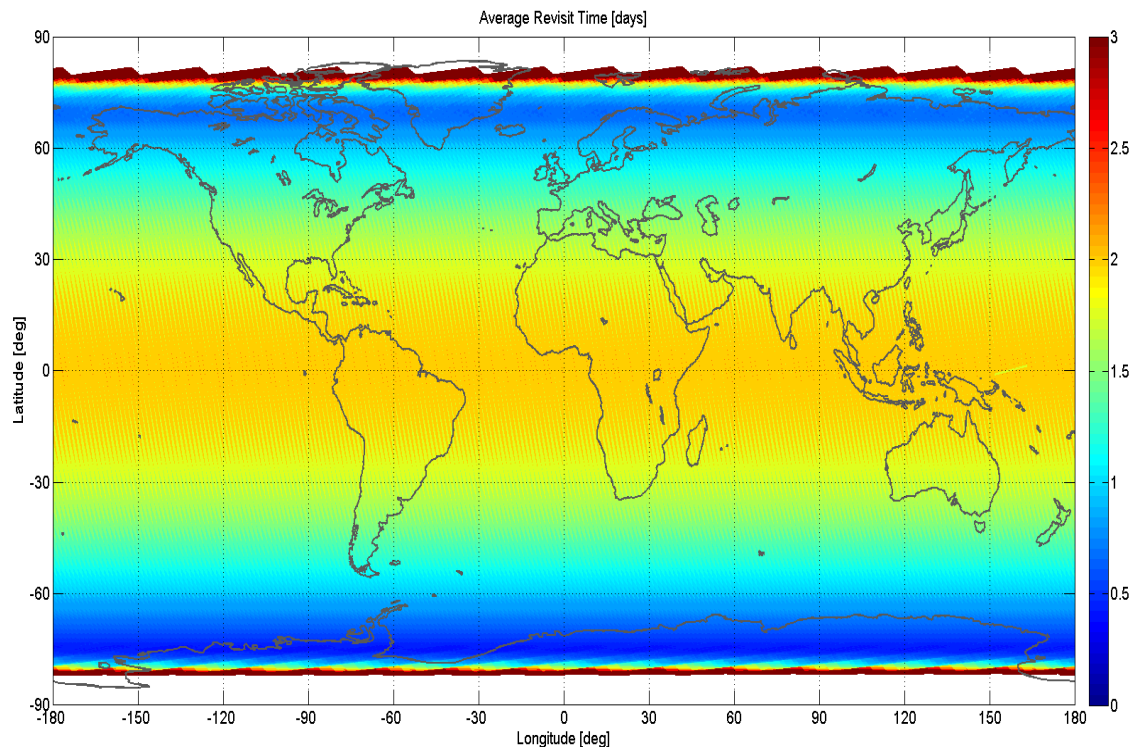deimosimaging
an urthecast company

The DEIMOS-2 Earth Observation System

- Pan and Multispectral high-res camera

- 40 cm Korsch 4-mirror telescope (5.77 m focal length, 1.2⁰ FoV)

- GSD @ Nadir: 1.0m Pan, 4.0m MS

- Pan (450-900 nm) + 4 bands (R,G,B, NIR)

- 12 km swath (24 km in wide area mode)

- Capacity for stereo-pair acquisitions

- Radiometric resolution: 10 bits

- TDI sensor with 4 PAN and 3 MS selectable modes:
  - PAN : 6, 12, 24, 48 steps
  - Blue, Green : 4, 8, 16 steps
  - Red, NIR : 2, 4, 8 steps

The DEIMOS-2 Earth Observation System

- System Capacity: Up to 150,000 km^2/day

- Sun-synchronous, LTAN 10:30, ~620 km orbit

- Image data: 10 bits, lossless compression

Multiple images in a single pass for faster product delivery

Maneuvering Period

Single pass stereo images for Orthorectified image products

Deimos-2 pre-launch radiometric characterization

- Spectral transmissivity profiles
- Dark Signal
- Pixel Response Non Uniformity
- Signal-to-noise ratio
- Pixel saturation levels
- MTF
- Radiometric model development
- Etc.

Deimos-2 normalized spectral transmissivity profile
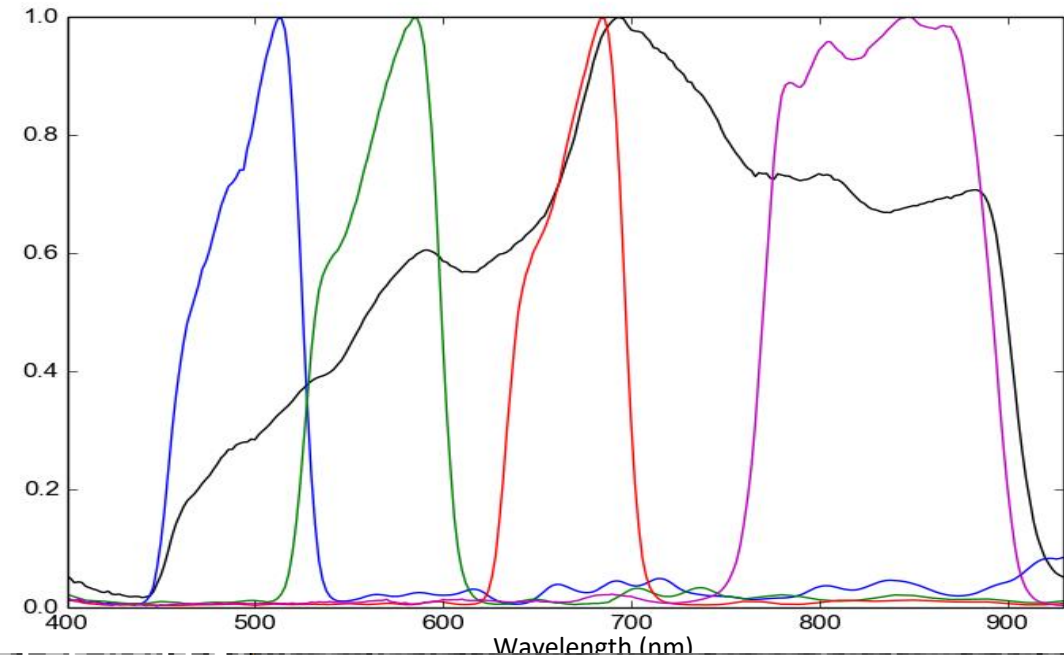
Radiometrically corrected Deimos-2 laboratory PAN image
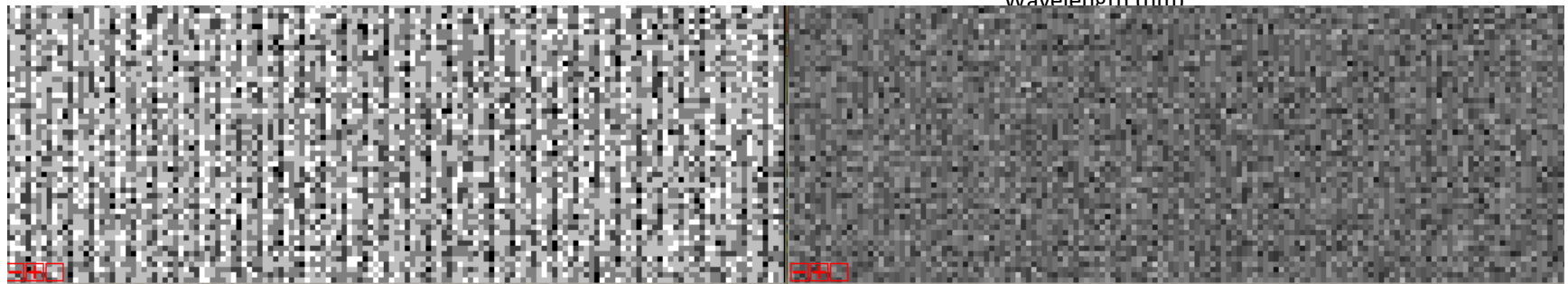
Deimos-2 post-launch calibration

Acquisition Campaigns

DSNU

Acquisitions during eclipse over the North Pacific, where light sources (natural or anthropogenic) are unlikely

PRNU

Greenland (Summer 2014)

Dome-C (Antarctica)

ABSOLUTE

Libya-4 PICS (reference)

Other PICS (validation)

MTF

Stennis Space Flight Centre (USA)

Salon de Provence (France)

Baotou (China)

Deimos-2 post-launch calibration

PRNU - Greenland

Using Landsat-8 OLI's recent data to find suitable target candidates in Greenland
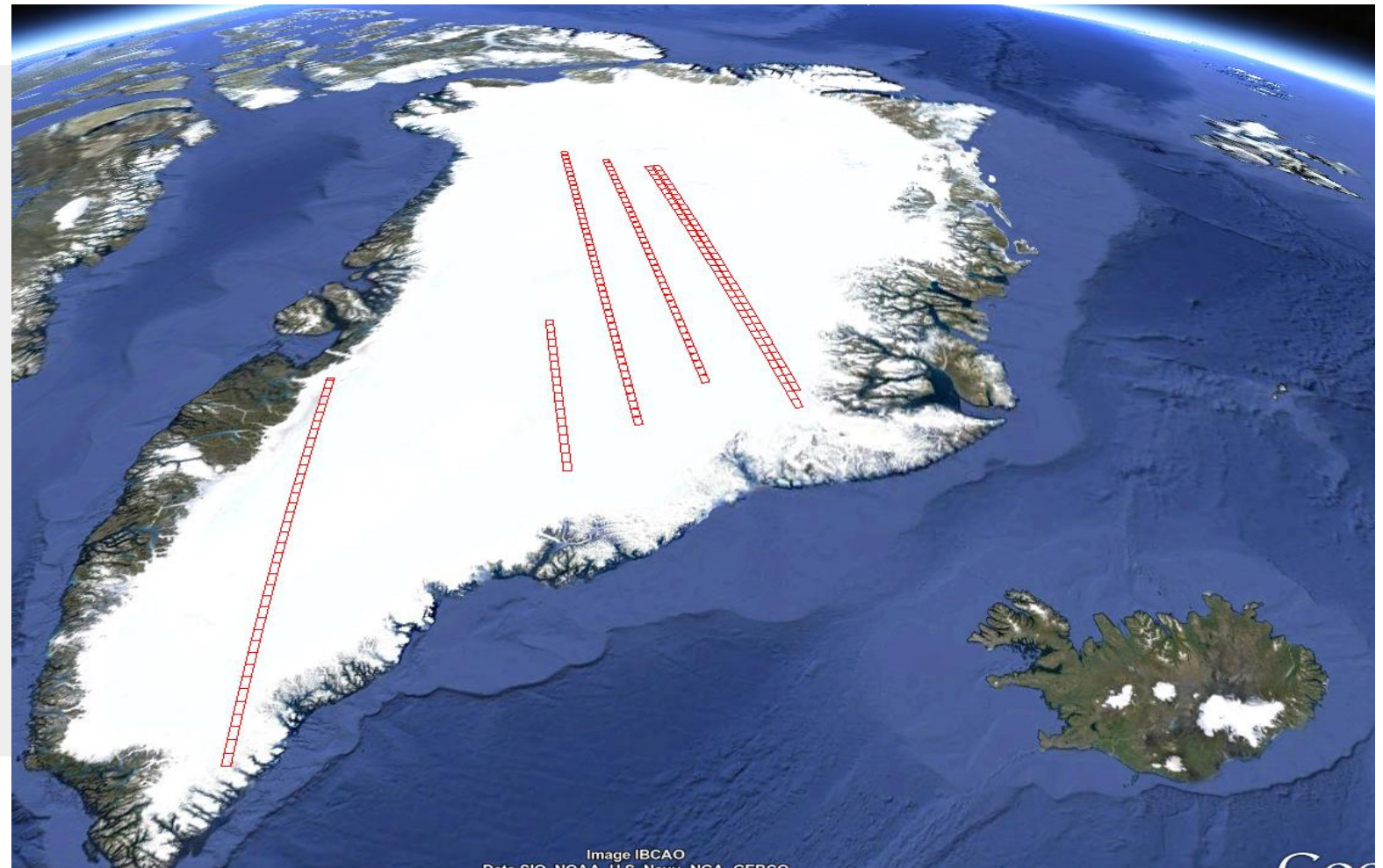
Deimos-2 post-launch calibration

PRNU - Greenland
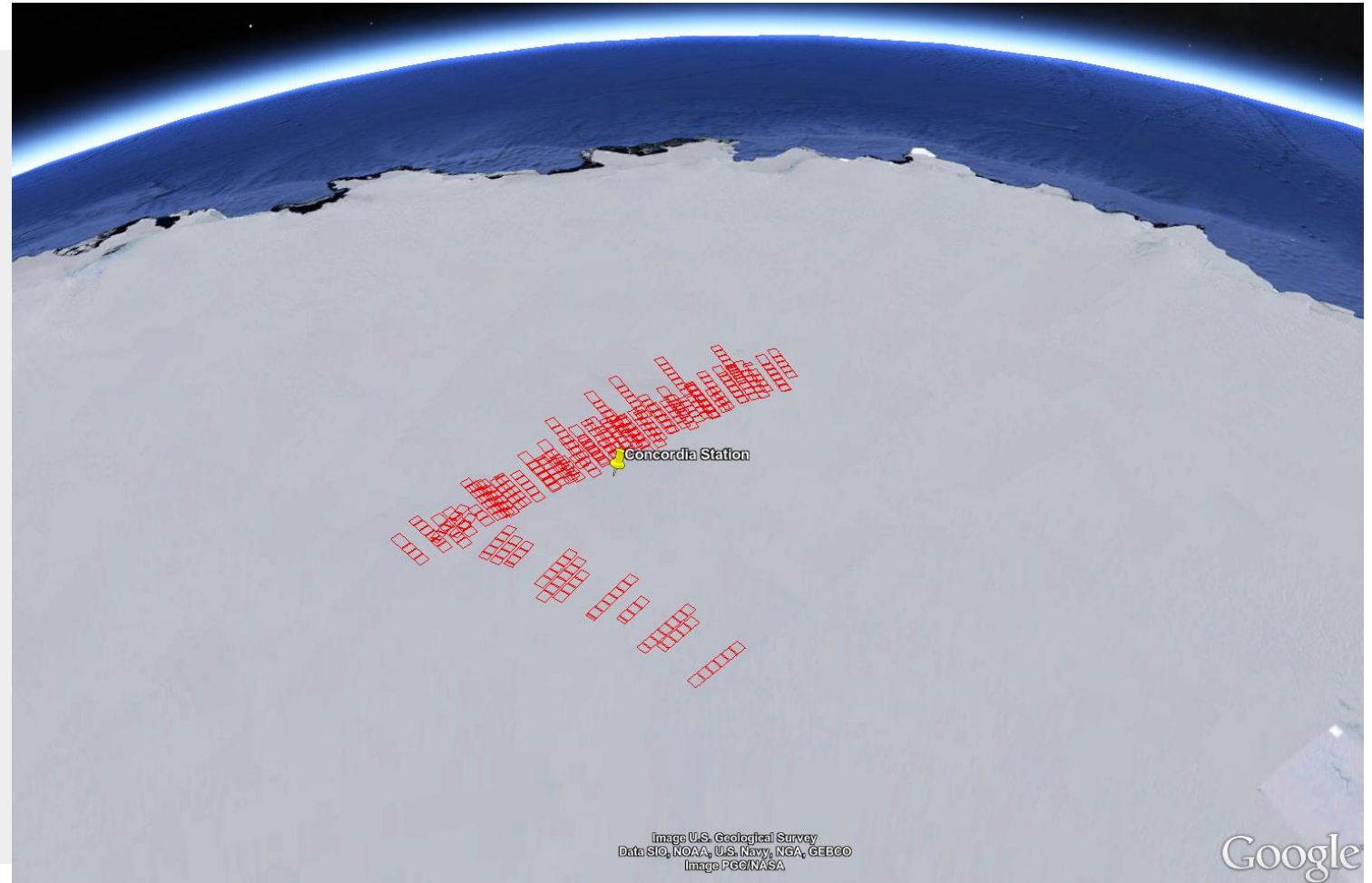
Long acquisitions provided additional data:

- Saturation thresholds

- Sensor behavior under low signal conditions

- Melting snow detection and avoidance
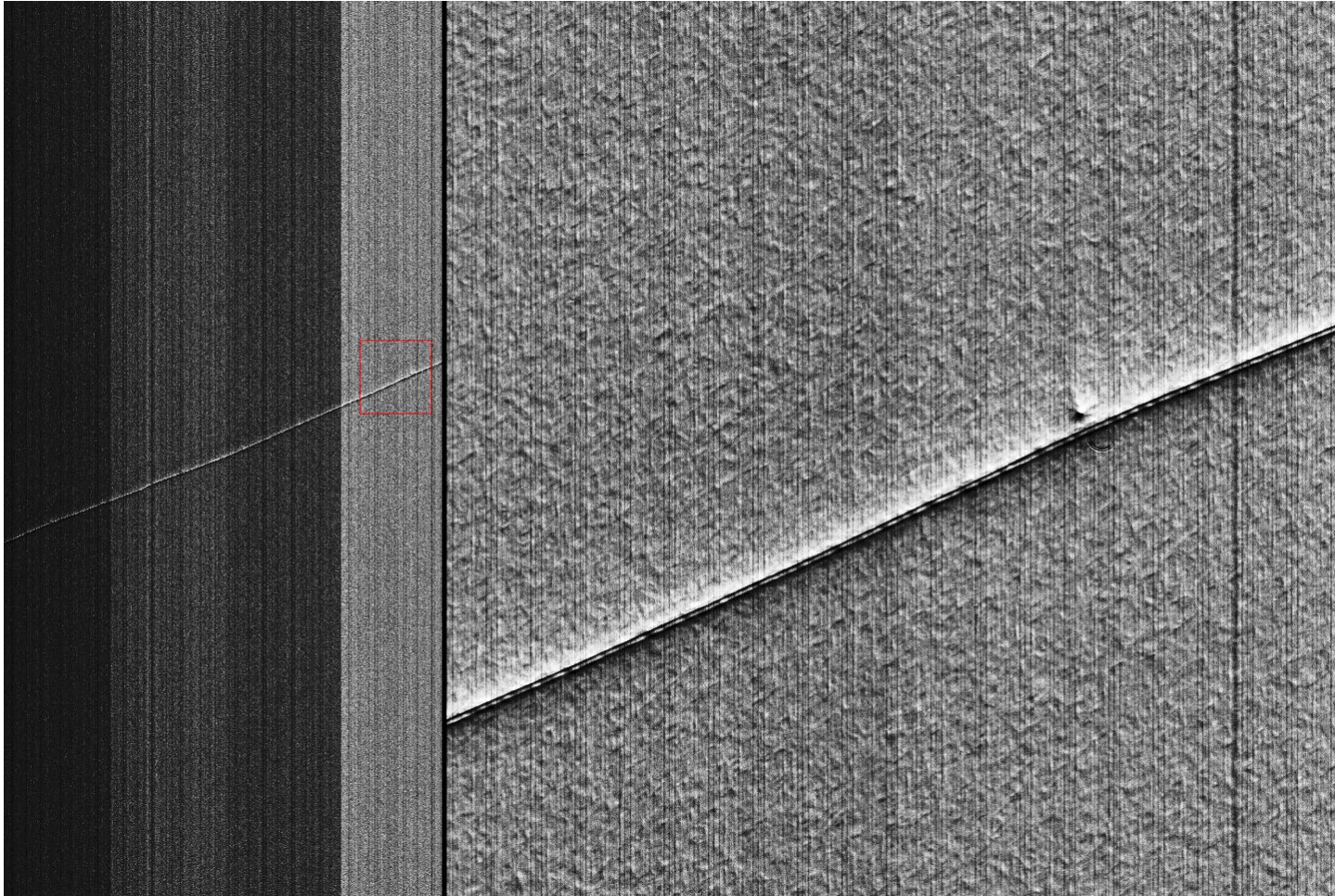
Deimos-2 post-launch calibration

PRNU - Dome-C

- Characterization of the PRNU for all TDI modes

- Check linearity for different signal levels

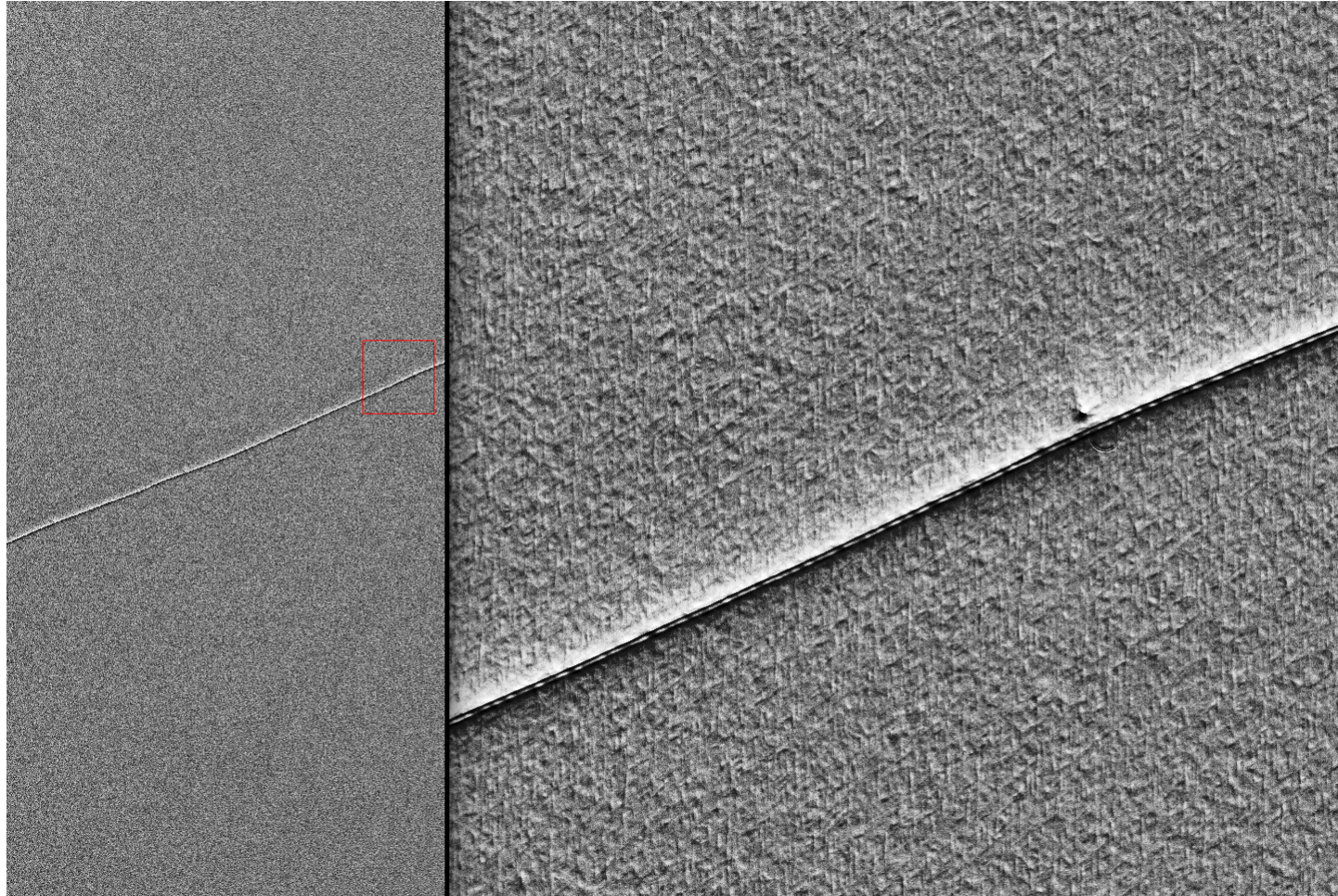- Check model consistency for different sensor parameterizations

Deimos-2 post-launch calibration

Dome-C sample before radiometric correction
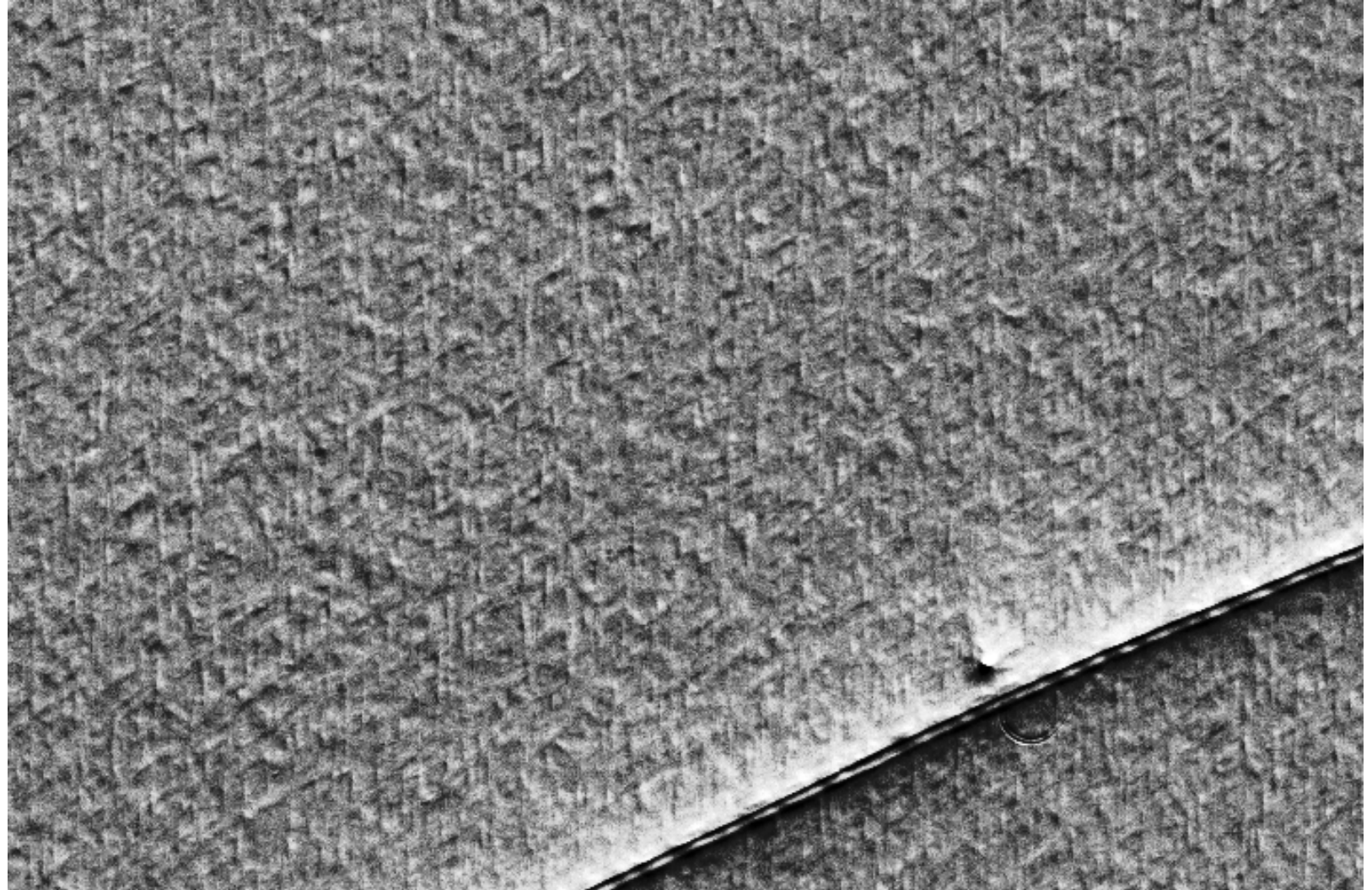
Deimos-2 post-launch calibration

Dome-C sample after radiometric correction

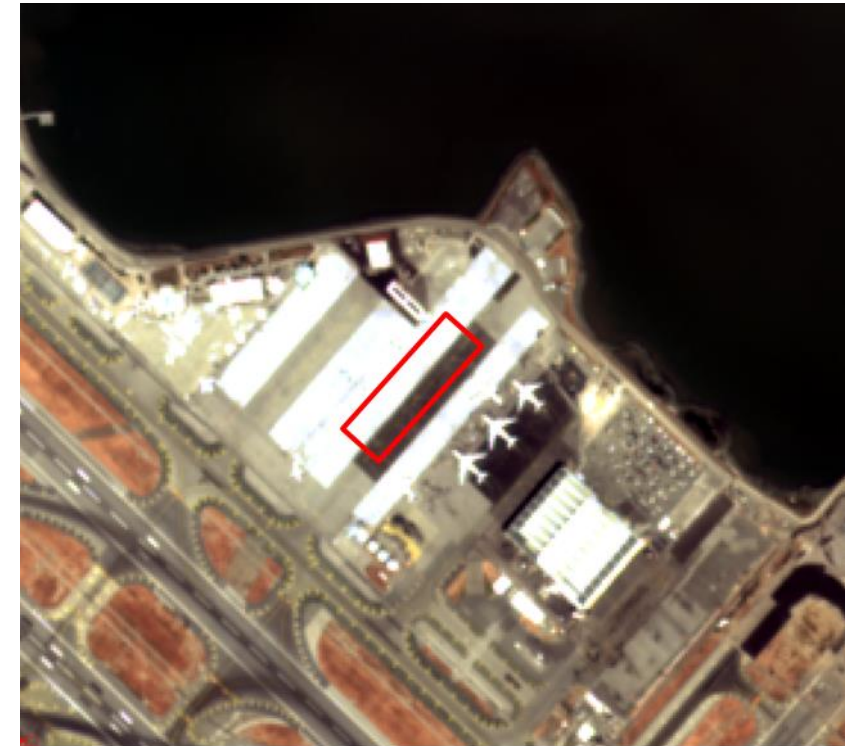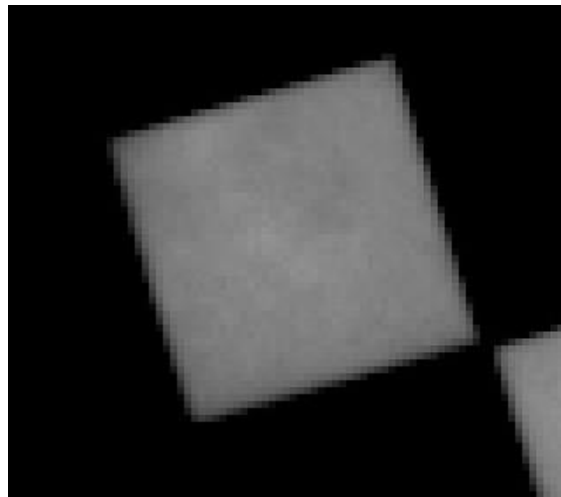# Deimos-2 post-launch calibration
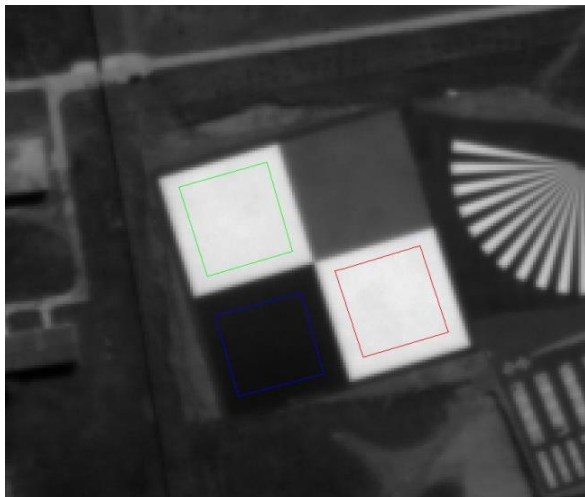
Dome-C Pattern

The vertical pattern is a property of the ground (1m GSD)

Deimos-2 post-launch calibration

MTF

- Stennis Space Center (USA), Salon de Provence (France) and Baotou (China) targets were acquired for the panchromatic band

- Baotou was the best target

- Artificial structures were used for the MS bands

Deimos-2 post-launch calibration

Absolute Calibration

Deimos-2

- No onboard calibration devices

- No reference sensor

We rely on spectral models of PICS created using hyperspectral data

- EO1/Hyperion hyperspectral sensor

- Libya-4 is the primary PICS

- Tuz Golu, Danhuang, Dolan Springs, Frenchman Flat, Ivanpah Playa, Railroad Valley, La Crau, Negev among others CEOS and non-CEOS sites have been to validate the calibration methodology

Deimos-2 post-launch calibration

Absolute Calibration

Methodology

- Keep it as simple as possible

- Build a **spectral model of Libya-4** using a long series of EO1/Hyperion data (~10 years)

  - Assume isotropic BRDF (but…)

  - Include the empirical model of the yearly seasonal trend

  - Assume that the atmosphere causes accidental error (i.e. noise) which is diminished through repeated measurements: No atmospheric correction

  - Model inputs: Wavelength, DoY and time => (seasonal trend status, solar angles)

  - Model outputs: TOA spectral radiance distribution with its corresponding uncertainty

- Acquire with Deimos-2

- Calibrate Deimos-2 vs. model TOA spectral radiance
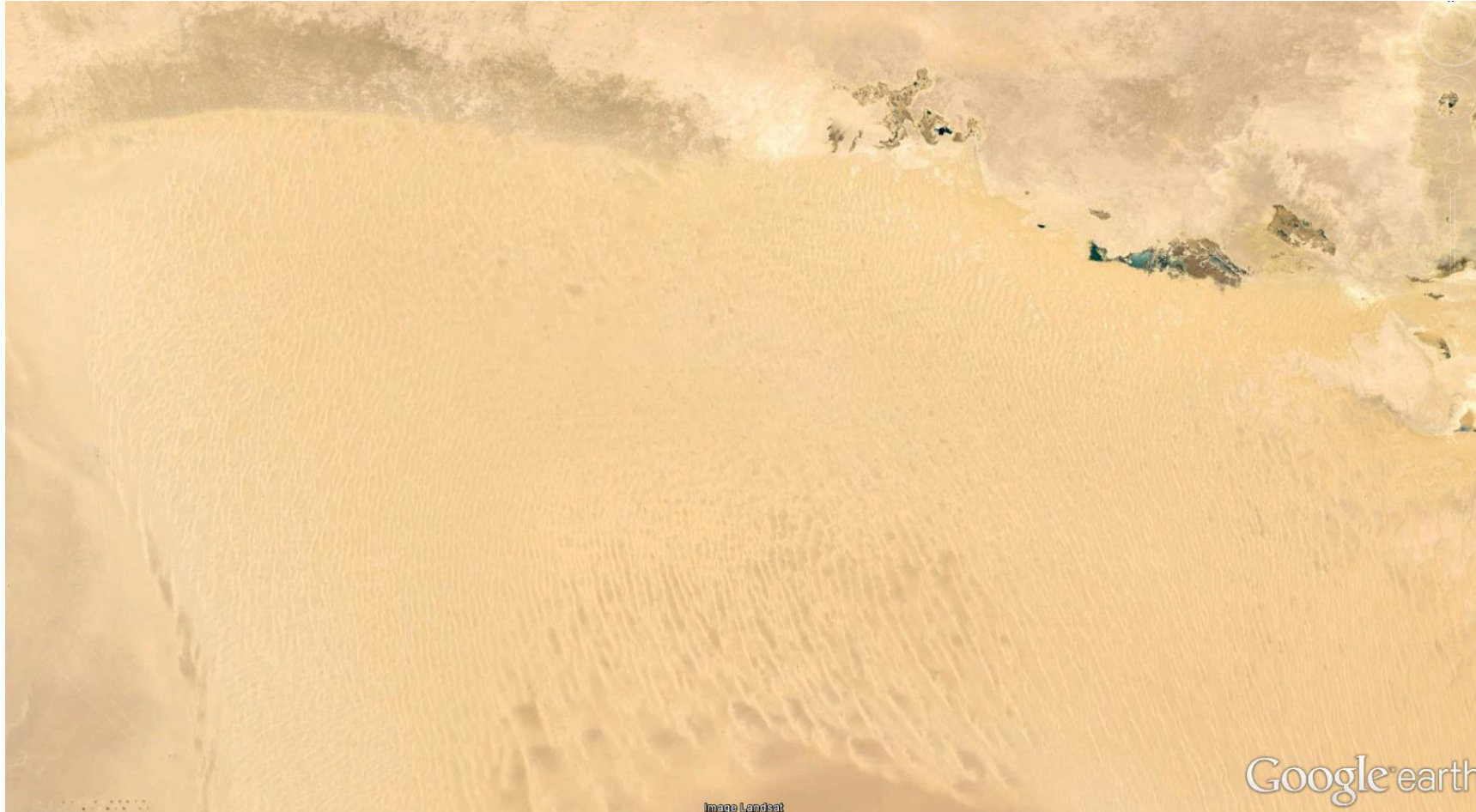
Deimos-2 post-launch calibration

Absolute Calibration

Where is Libya-4?
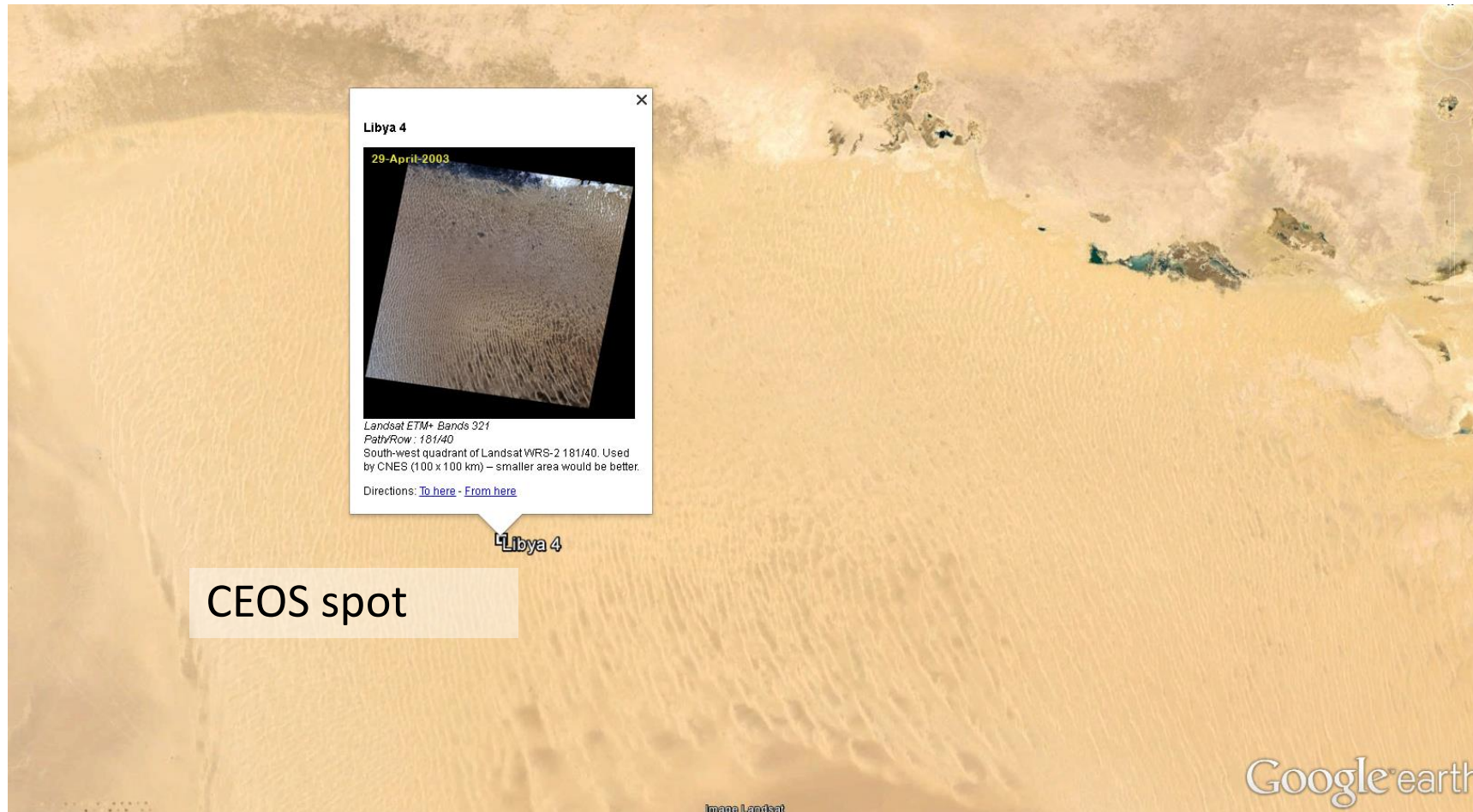
Deimos-2 post-launch calibration

Absolute Calibration

Where is Libya-4?
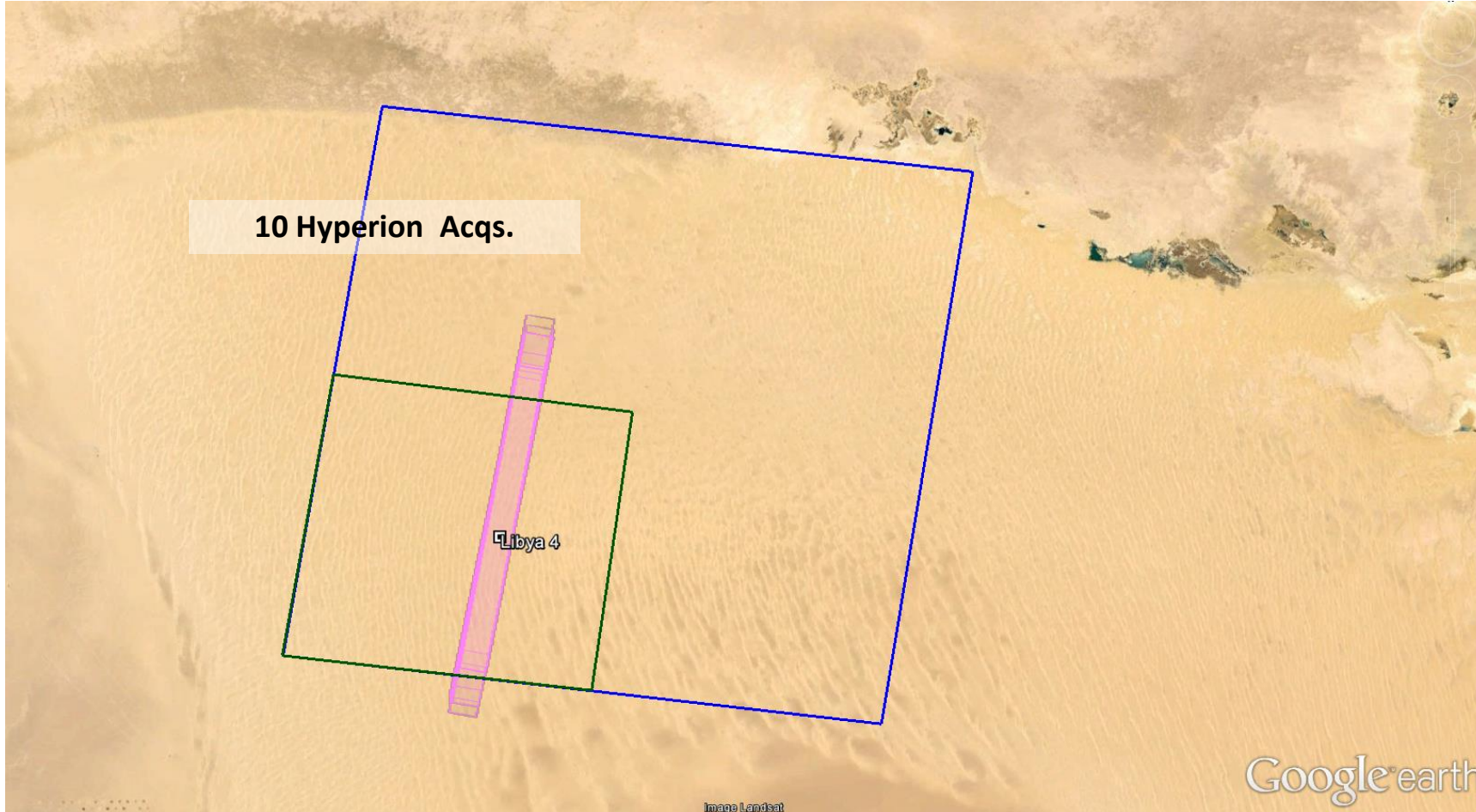
Deimos-2 post-launch calibration

Absolute Calibration

Where is Libya-4?

CEOS spot

Deimos-2 post-launch calibration

Absolute Calibration

Where is Libya-4?

WRS2 181/40	🟦
CEOS AoI	🟩

Deimos-2 post-launch calibration

Absolute Calibration

Where is Libya-4?

WRS2 181/40	🟦
CEOS AoI	🟩
CEOS AoI Hyp. Acqs.	🟥

Deimos-2 post-launch calibration
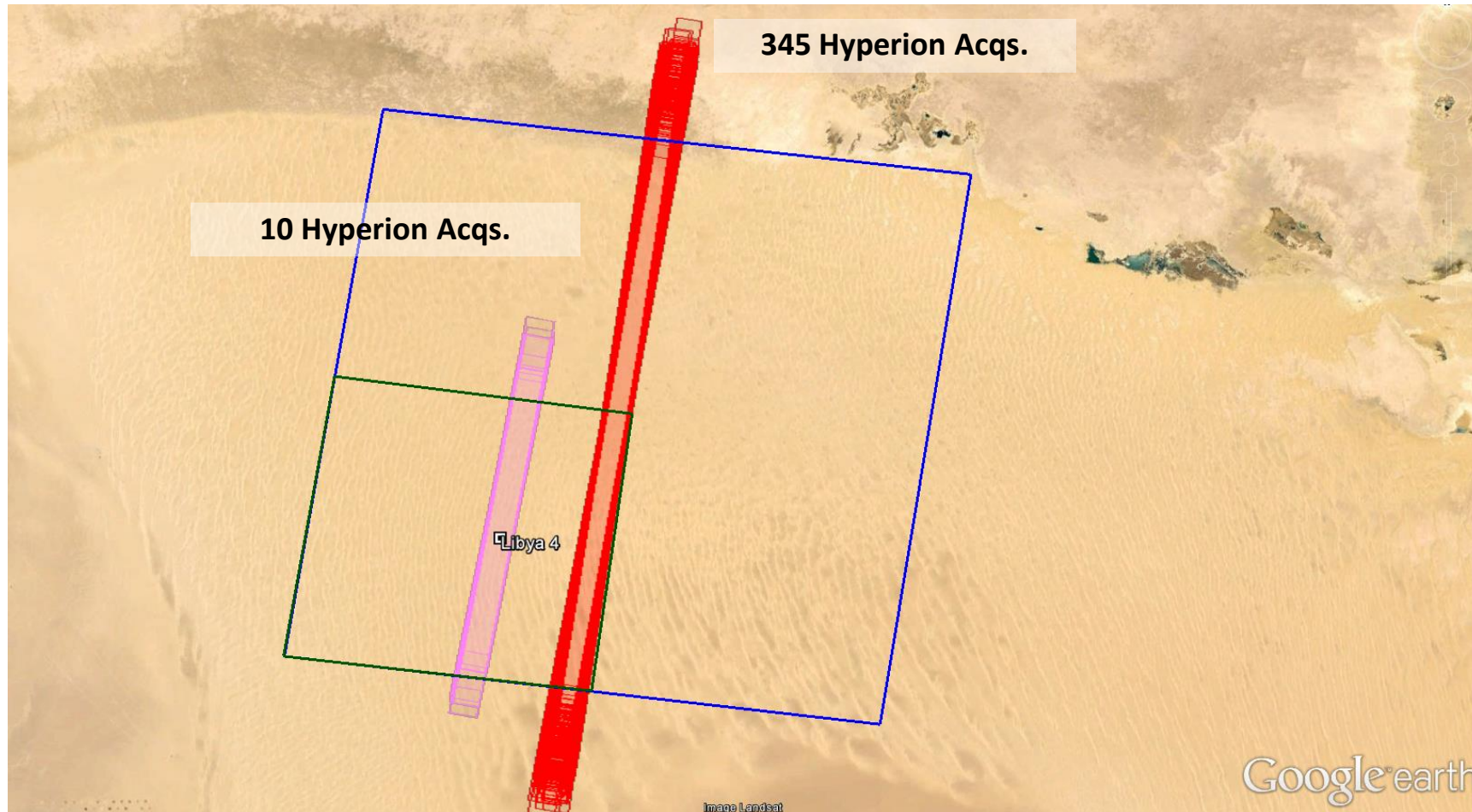
Absolute Calibration

345 Hyperion Acqs.

10 Hyperion Acqs.

Libya 4

Where is Libya-4?

WRS2 181/40	■ (blue)
CEOS AoI	■ (green)
CEOS AoI Hyp. Acqs.	■ (pink)
WRS2 Hyp. Acqs.	■ (red)

Deimos-2 post-launch calibration

Absolute Calibration
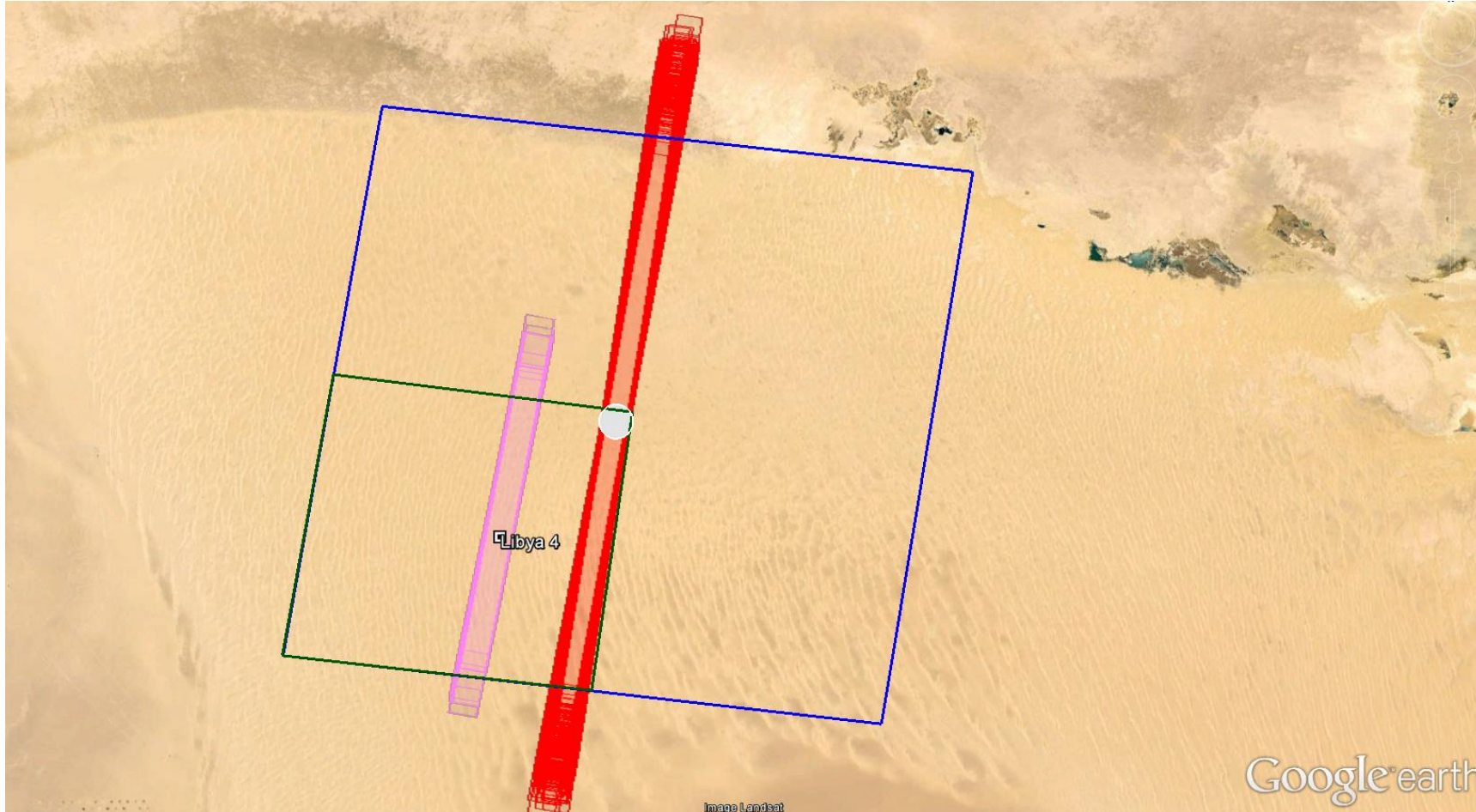
Where is Libya-4?

WRS2 181/40	🟦
CEOS AoI	🟩
CEOS AoI Hyp. Acqs.	🟪
WRS2 Hyp. Acqs.	🟥
Deimos-2 AoI	⬜

Deimos-2 post-launch calibration
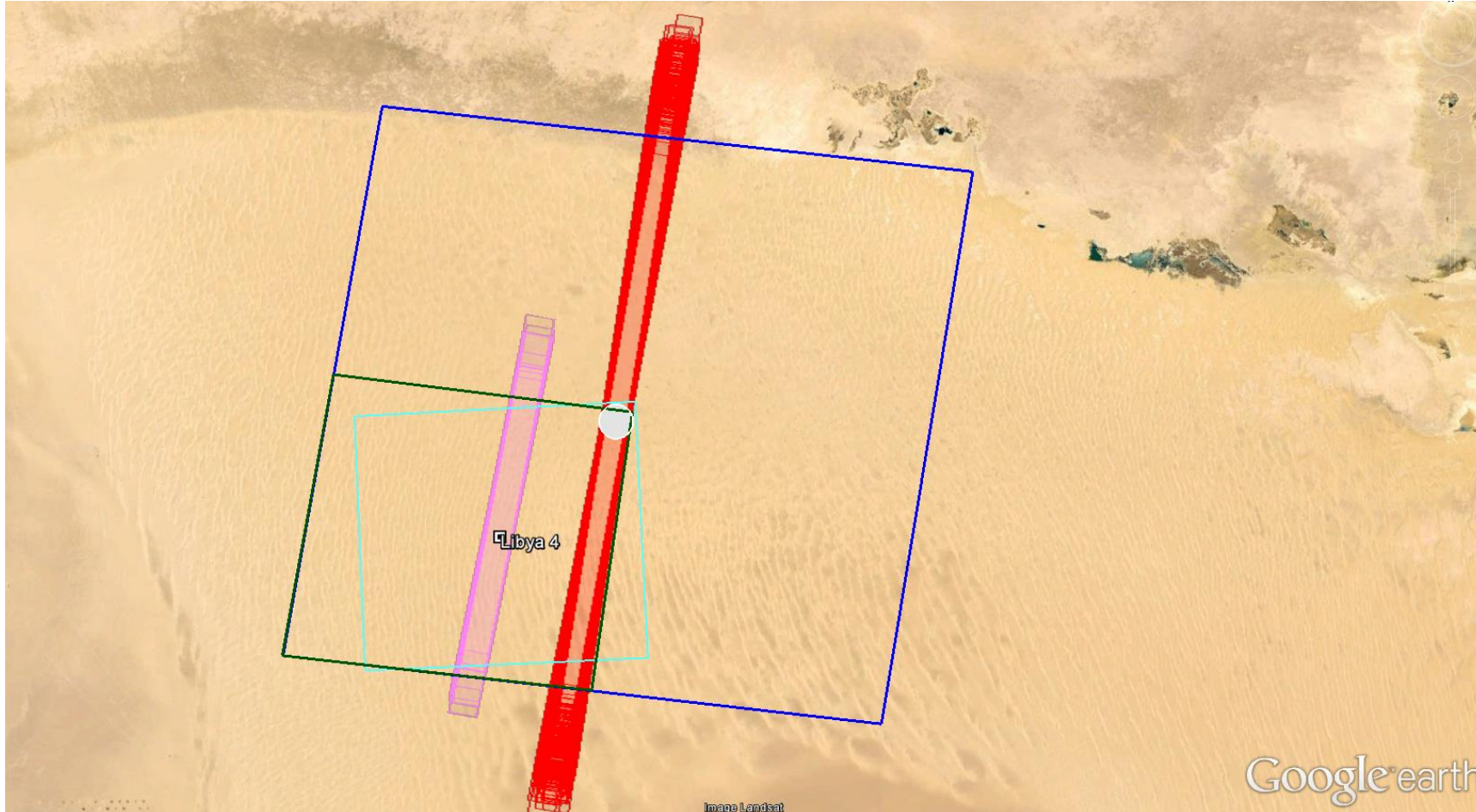
Absolute Calibration

Where is Libya-4?

WRS2 181/40	🟦
CEOS AoI	🟩
CEOS AoI Hyp. Acqs.	🟪
WRS2 Hyp. Acqs.	🟥
Deimos-2 AoI	⬜
Deimos-1 AoI	🟦

Deimos-2 post-launch calibration

Absolute Calibration
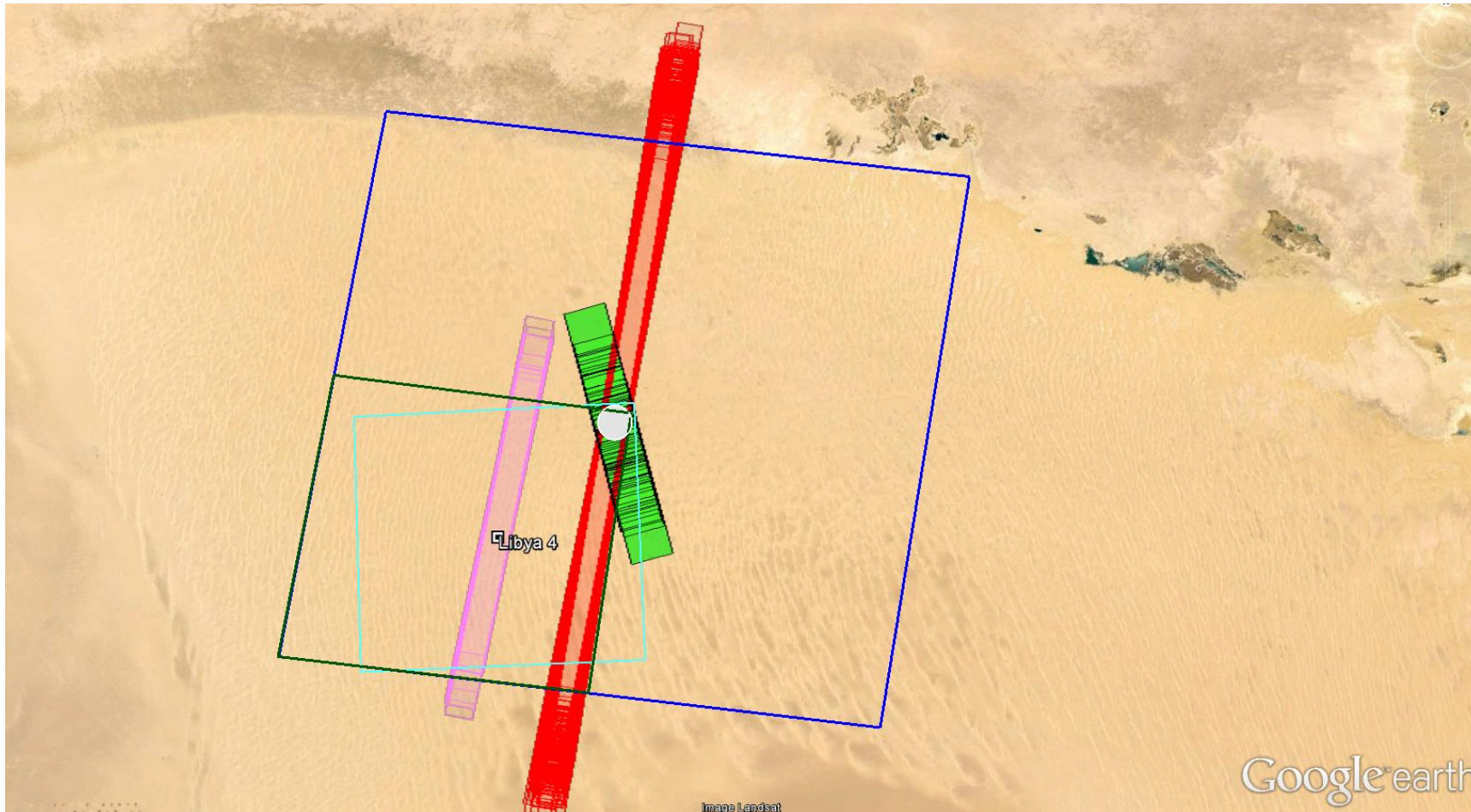
Where is Libya-4?

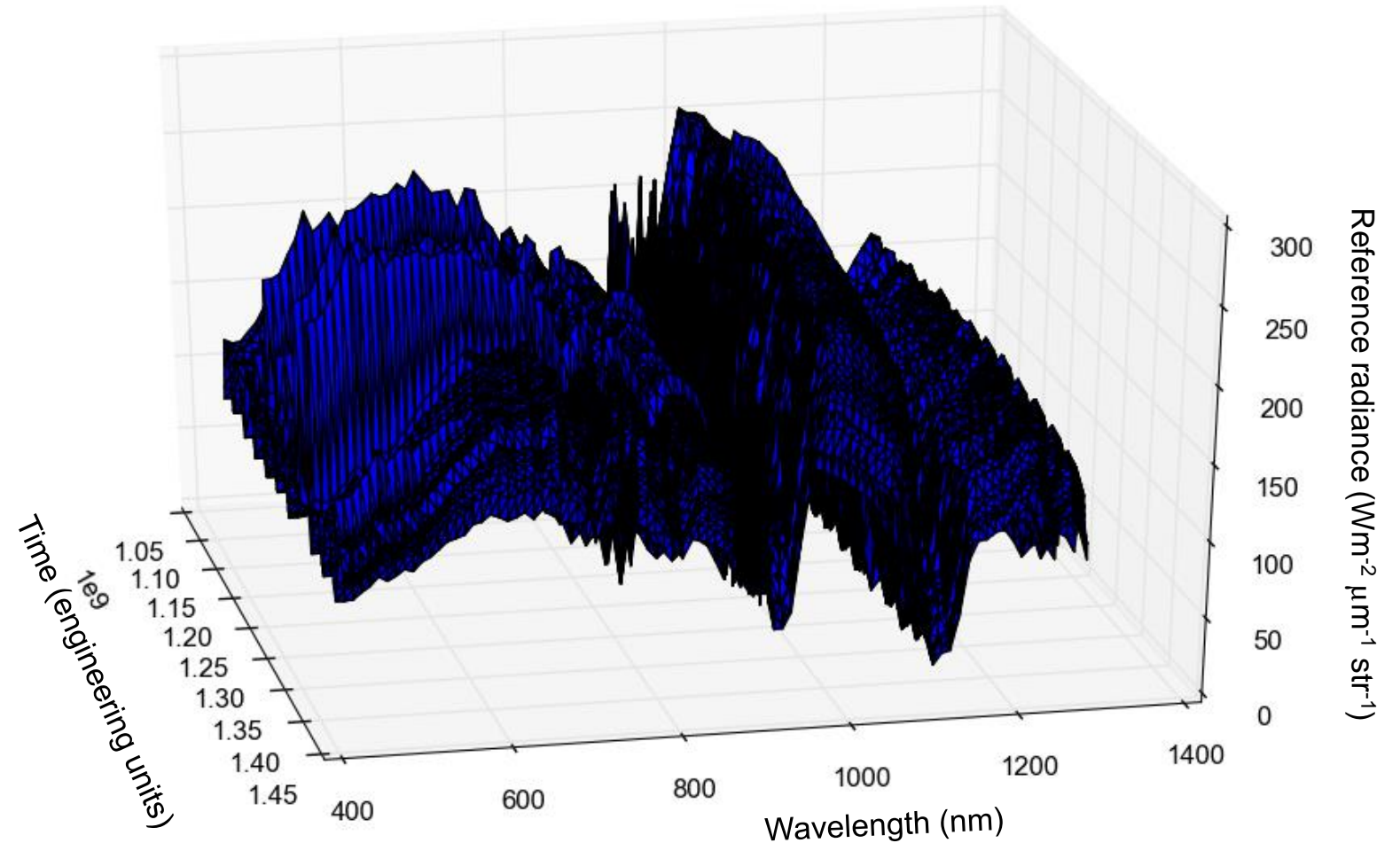|	
WRS2 181/40	🟦
CEOS AoI	🟩
CEOS AoI Hyp. Acqs.	🟪
WRS2 Hyp. Acqs.	🟥
Deimos-2 AoI	⬜
Deimos-1 AoI	🟦
Deimos-2 Acqs.	🟩

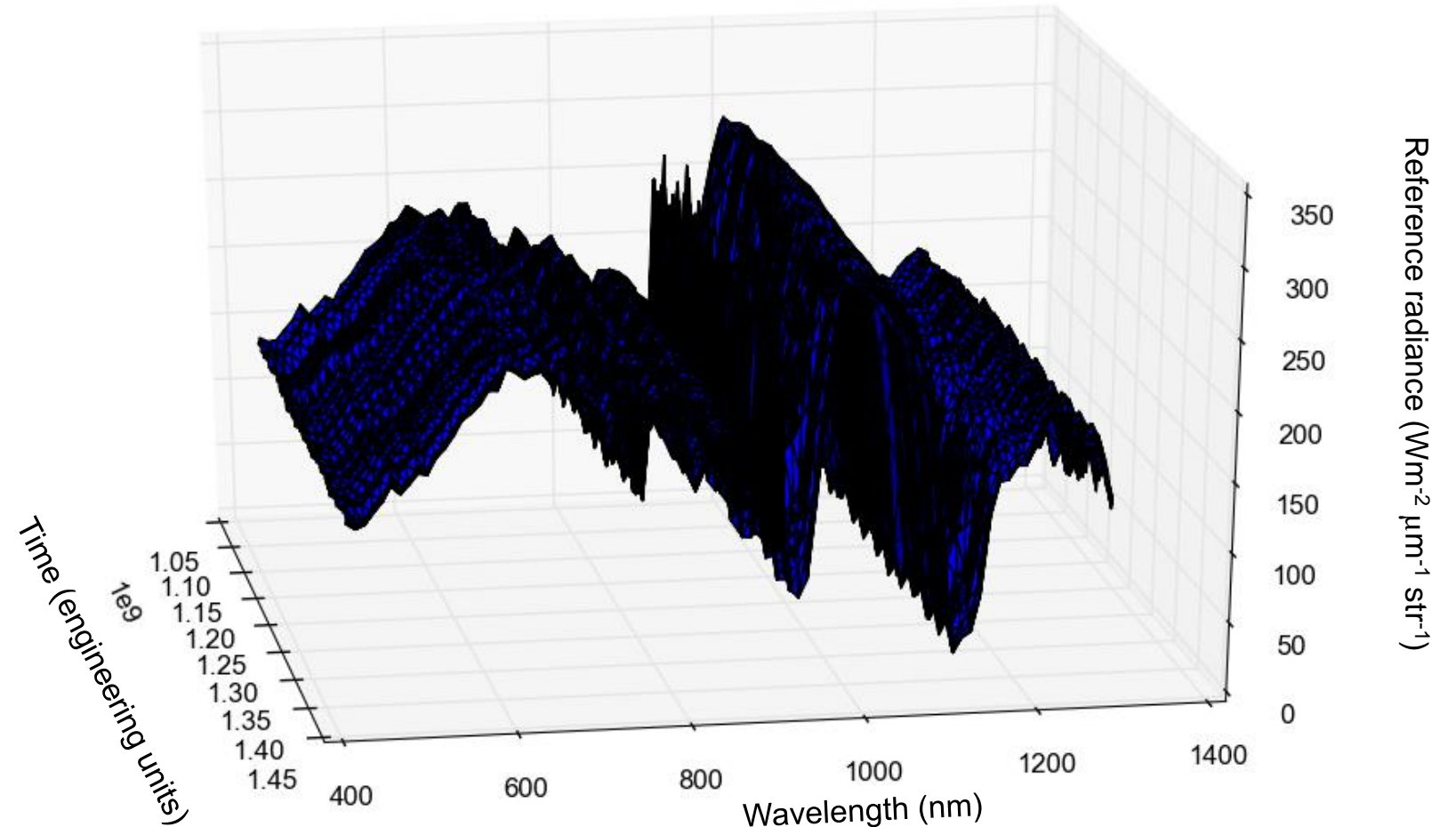# Deimos-2 post-launch calibration

Absolute Calibration

Hyperion data before filtering and correction

Deimos-2 post-launch calibration
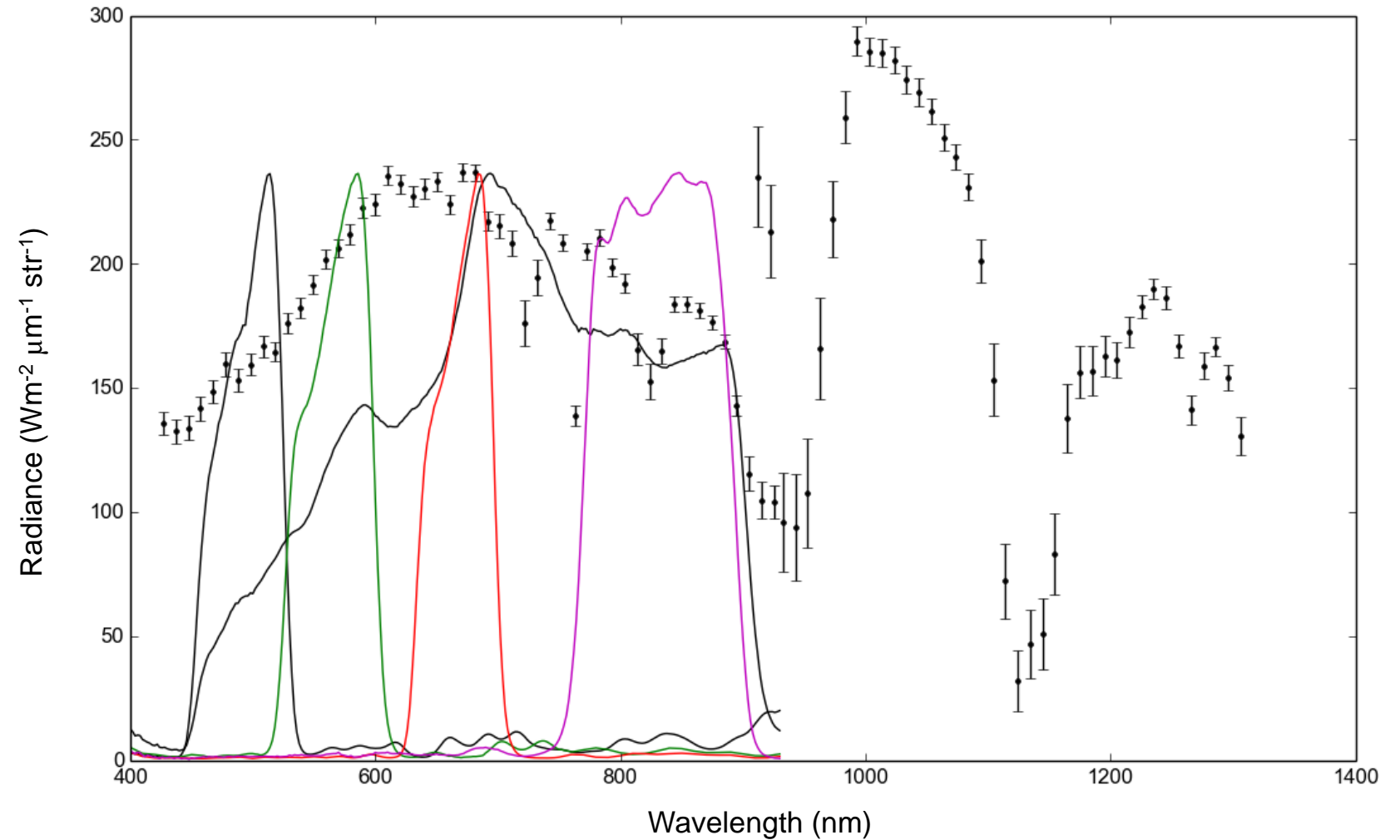
Absolute Calibration

Hyperion data **after** filtering and correction

Deimos-2 post-launch calibration

Absolute Calibration

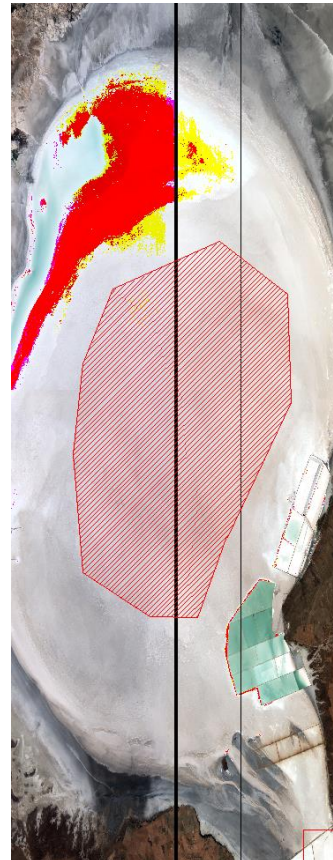Libya-4 spectral model and Deimos-2 relative spectral response

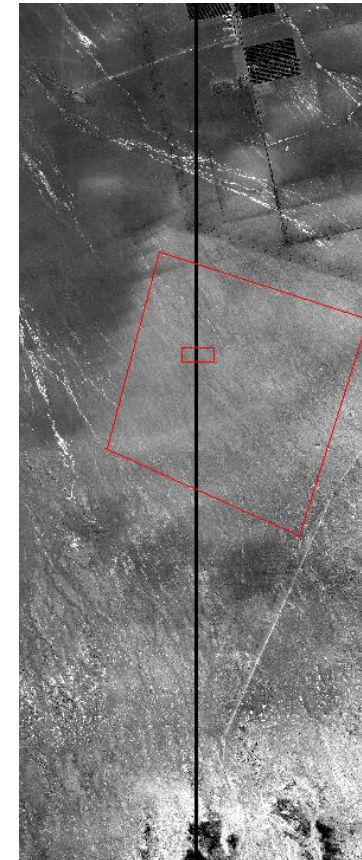# Deimos-2 post-launch calibration

Absolute Calibration

The absolute calibration has been assessed by using a less thorough version of the same procedure in the following targets:

Tuz Golu

Danhuang

Dolan Springs

Frenchman Flat

Ivanpah Playa

La Crau

Negev

Railroad Valley

Tuz Golu

Danhuang

Deimos-2 post-launch calibration

Results Summary

Quality indicator	Calibration results
Radiometric correction	OK
Absolute calibration uncertainty	< 5.4% MS, ~7.4% PAN
SNR	~112:1 PAN, > 90:1 MS
MTF	~9.1% PAN, > 31% MS @Nyquist

THANK YOU!