Radiometric Calibration of SkySats using Near-Simultaneous Crossovers with Sentinel-2

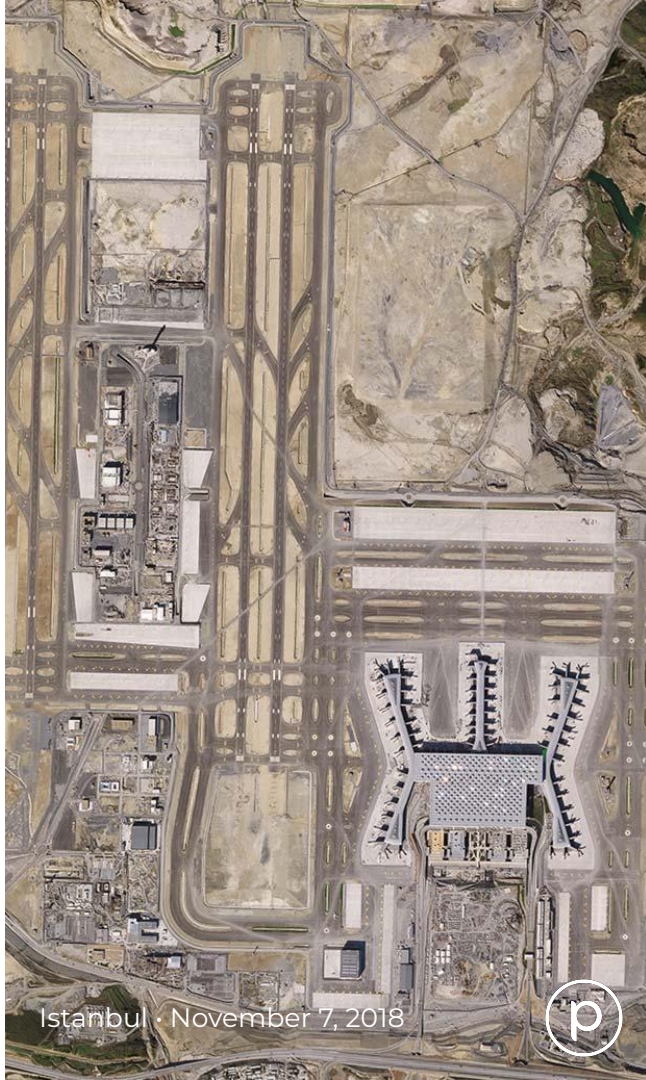
GSICS mini conference 2022

Hannah Bourne, Alan Collison and Arin Jumpasut

Uluru, Australia – December 2, 2015

Agenda

1. Introduction to Planet Payloads
2. Interoperability Challenges
3. Calibration Methodology
4. Calibration Validation
5. Summary



Updates

- 44 additional SuperDoves
- 8 band PSScene product launched
- White paper on the calibration methodology publicly available: https://assets.planet.com/docs/radiometric_calibration_white_paper.pdf
- Currently rolling out SkySat calibration updates to production

Our Speakers

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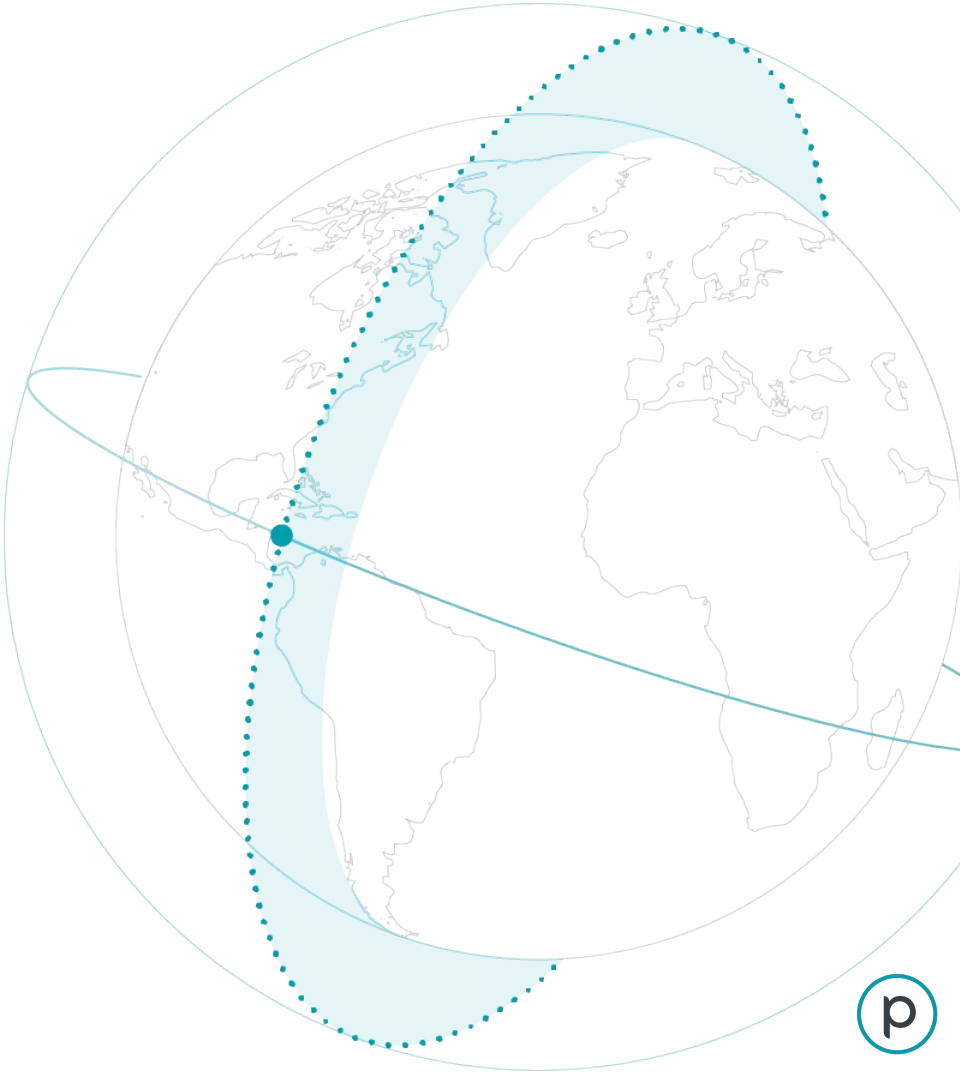
Planet Satellites

Doves (PlanetScope)

SATELLITES	GSD	CAPACITY
~200	**3.7 m**	**200 M km²**/day 8 band

SkySat

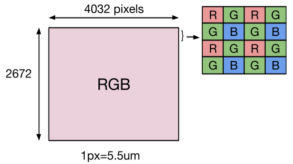
SATELLITES	GSD	CAPACITY
21	**0.65 m**	**600 K km²**/day 5 band

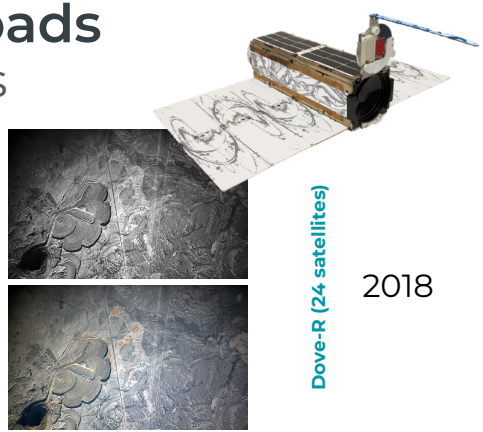


Planet Payloads
Over the Years

Dove Pilot (~50 satellites)

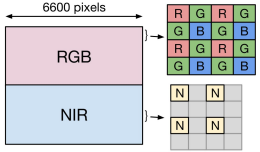
2016

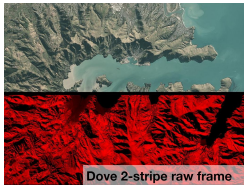




Dove (~150 satellites)

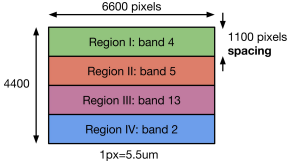
2017

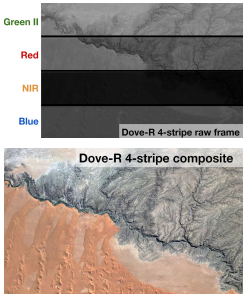




Dove-R (24 satellites)

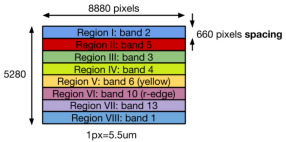
2018

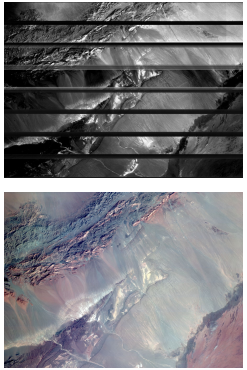




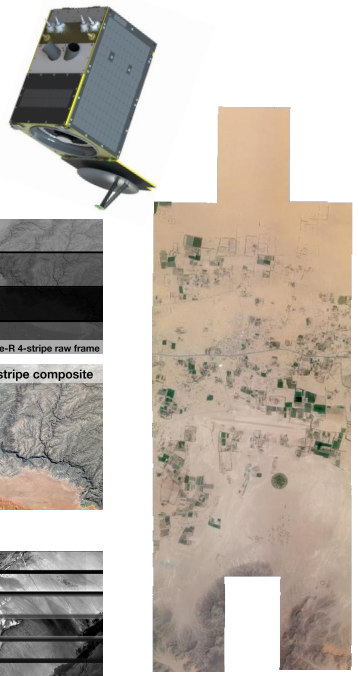
SuperDove (~120 satellites)

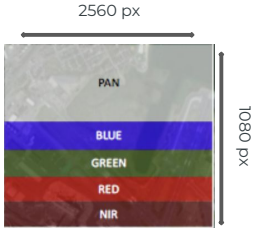
2019
2020
2021
2022



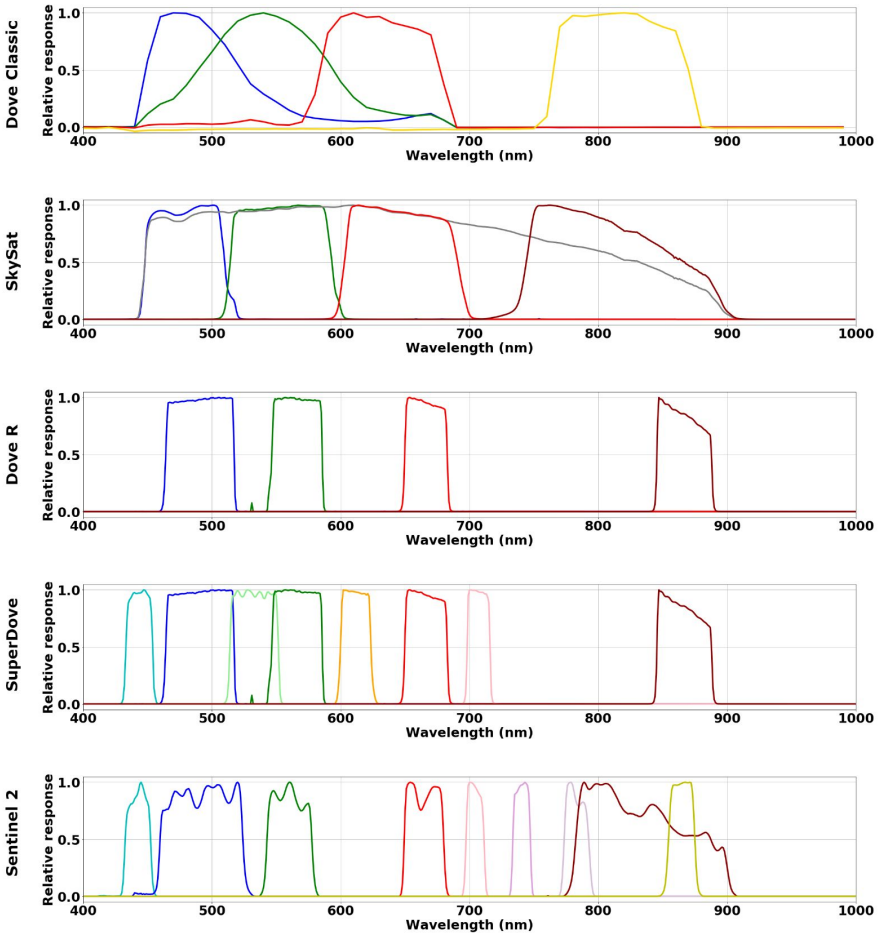


SkySats (21 satellites)





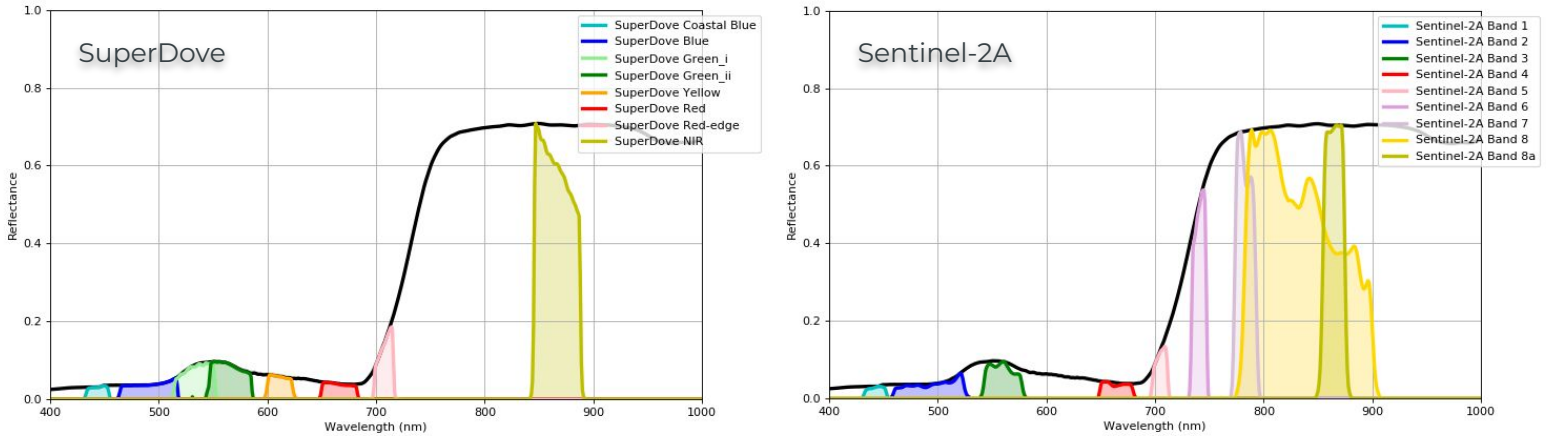
Planet Payloads
Over the Years



Effects of Differing Responses

SuperDove

A lawn grass spectrum from a spectral library

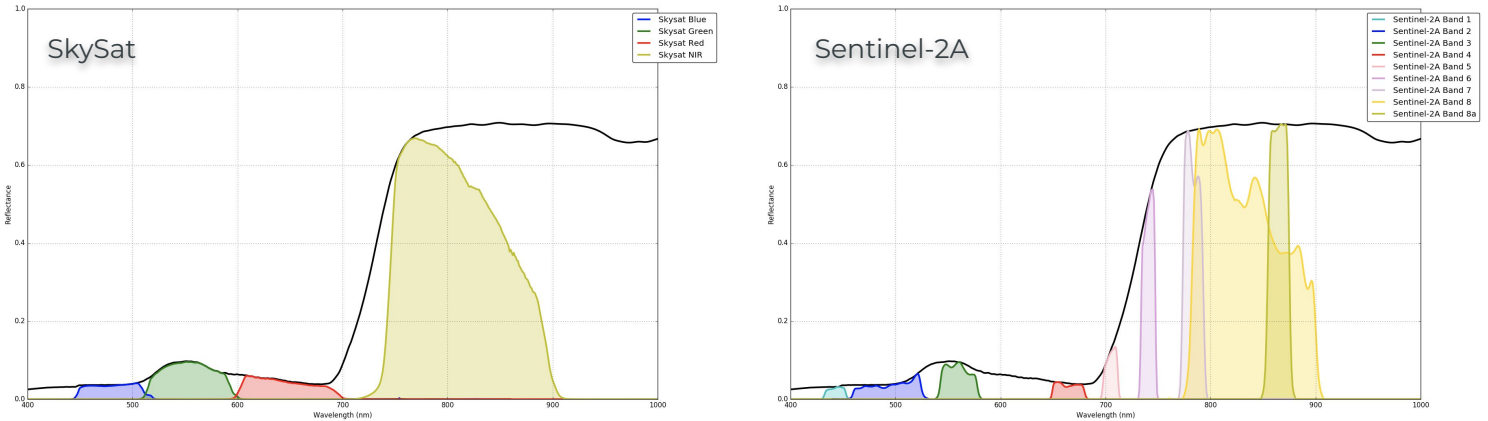


SBAF Corrections *SuperDove → Sentinel-2*	Coastal Blue to Band 1	Blue to Band 2	Green_ii to Band 3	Red to Band 4	Red-edge to Band 5	NIR to Band 8a
	0.992	1.019	1.053	0.9524	0.846	1.000

Effects of Differing Responses

SkySat

A lawn grass spectrum from a spectral library



SBAF Corrections *SkySat → Sentinel-2*	Blue to Band 2	Green to Band 3	Red to Band 4	NIR to Band 8
	1.12	1.11	0.84	1.03

Calibration Methodology

TRANSPORTER-1 · SLC-40, Cape Canaveral, Florida · January 20, 2021

Overview

Original SkySat Calibration Methodology

Calibrations based on gathering a dataset of **RadCalNet** site crossovers.

$$Rad = \frac{DN}{IntTime} \cdot gain + offset$$

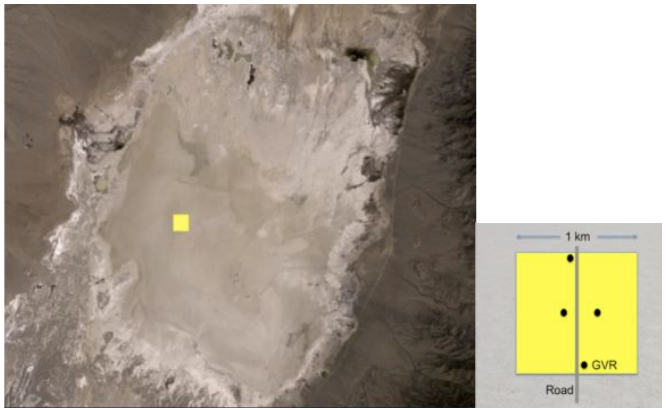
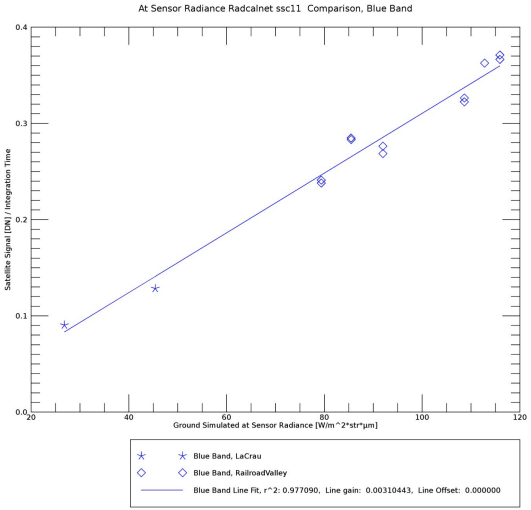


Figure from radcalnet.org



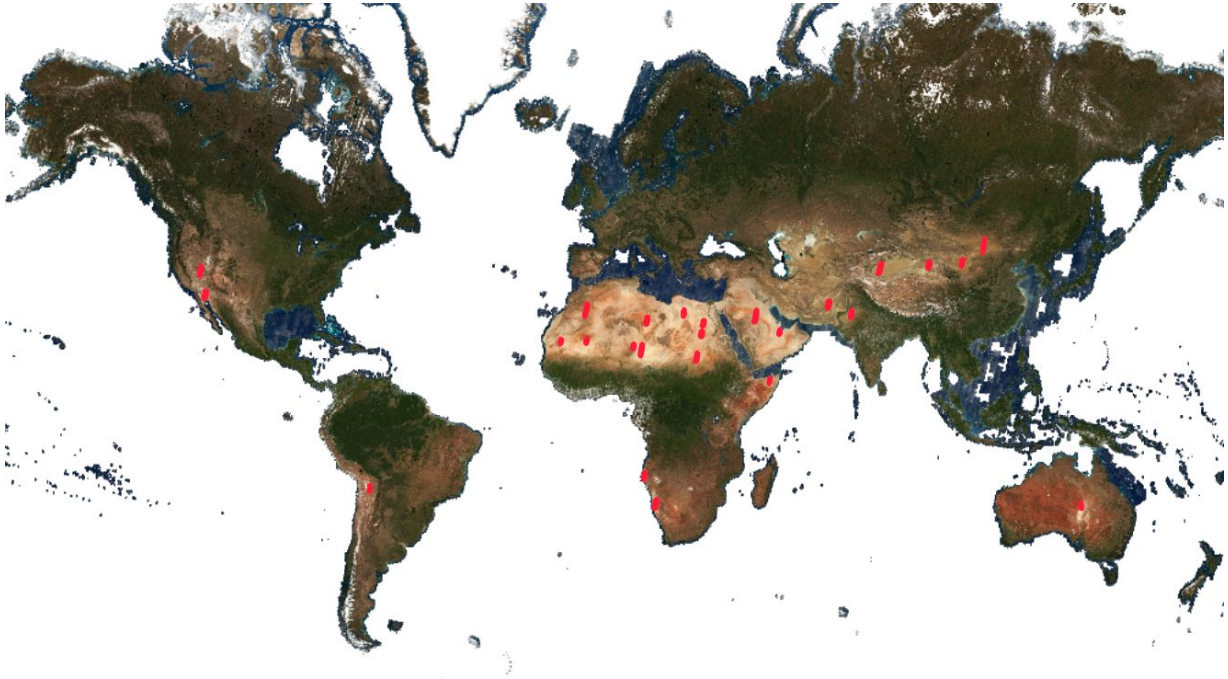
S111 September 2020 Calibration
Blue Band

Overview
Current Methodology

- Calibrations are based on gathering a dataset of near **simultaneous crossovers with a reference satellite**
  - A simultaneous crossover is when there is **less than two hours difference** (three hours for SkySats) between a reference image and a Planet image for the same point
  - Same reference satellite for all: **Sentinel-2**
- **Dove Classic/SkySat**
  - Standard set of calibration sites, “homogeneous” sample regions
  - **Hyperion spectra** for characterizing the surface reflectance to calculate SBAFs
- **SuperDove/Dove-R**
  - **Global** simultaneous crossovers with Sentinel-2
- **Lunar collects used for:**
  - per-satellite trending of calibration gains to check satellite health
  - Intra-flock consistency adjustments
- **6-month update interval chosen**
  - Long enough to allow sufficient crossovers
  - Short enough to allow needed updates

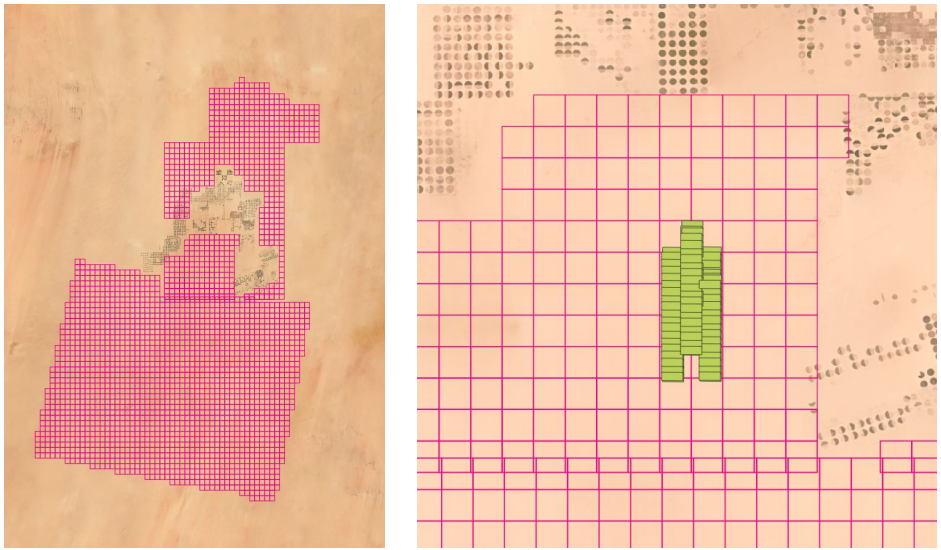
Calibration Sites

Locations of Pseudo-Invariant Calibration (PIC) sites and RapidEye Calibration sites



Tasking Calibration Sites

Tasking Pseudo-Invariant Calibration (PIC) sites and RapidEye Calibration sites

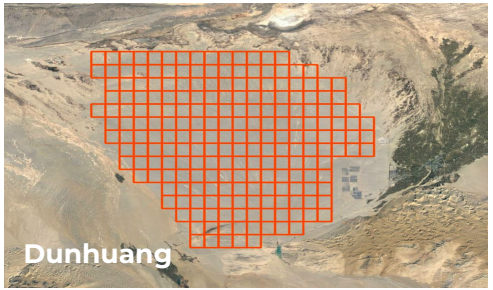


Sample Areas / Details

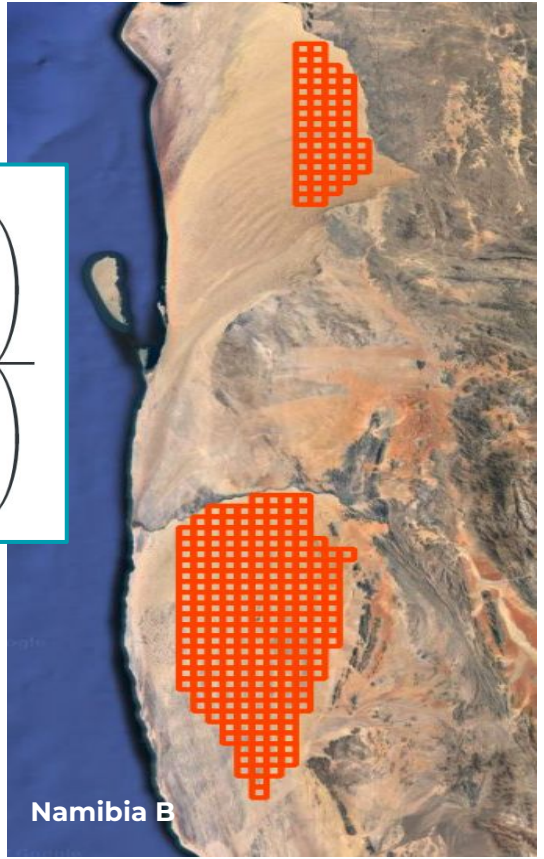
Dove Classic & SkySat

- Sample size is 1000 x 1000 Pixels (~3.5 km resolution)
- Sampling in spectrally homogenous locations within calibration site
- Spectra is characterized using Hyperion Imagery

$$SBAF_{B\rightarrow A} = \frac{\bar{\rho}_{\lambda(A)}}{\bar{\rho}_{\lambda(B)}} = \frac{\left(\frac{\int \rho_\lambda RSR_{\lambda(A)} d\lambda}{\int RSR_{\lambda(A)} d\lambda}\right)}{\left(\frac{\int \rho_\lambda RSR_{\lambda(B)} d\lambda}{\int RSR_{\lambda(B)} d\lambda}\right)}$$



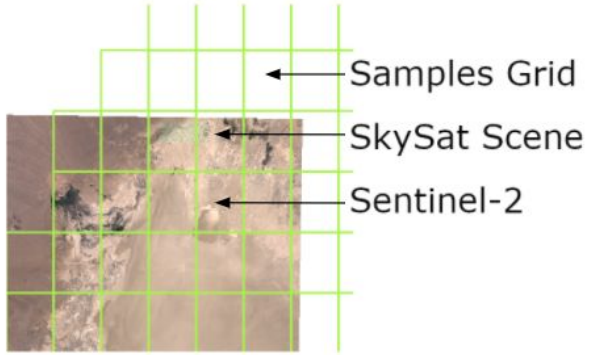
Example Calibration Site sample grids

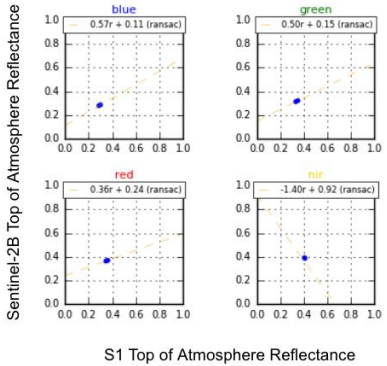


Crossover Analysis / Details

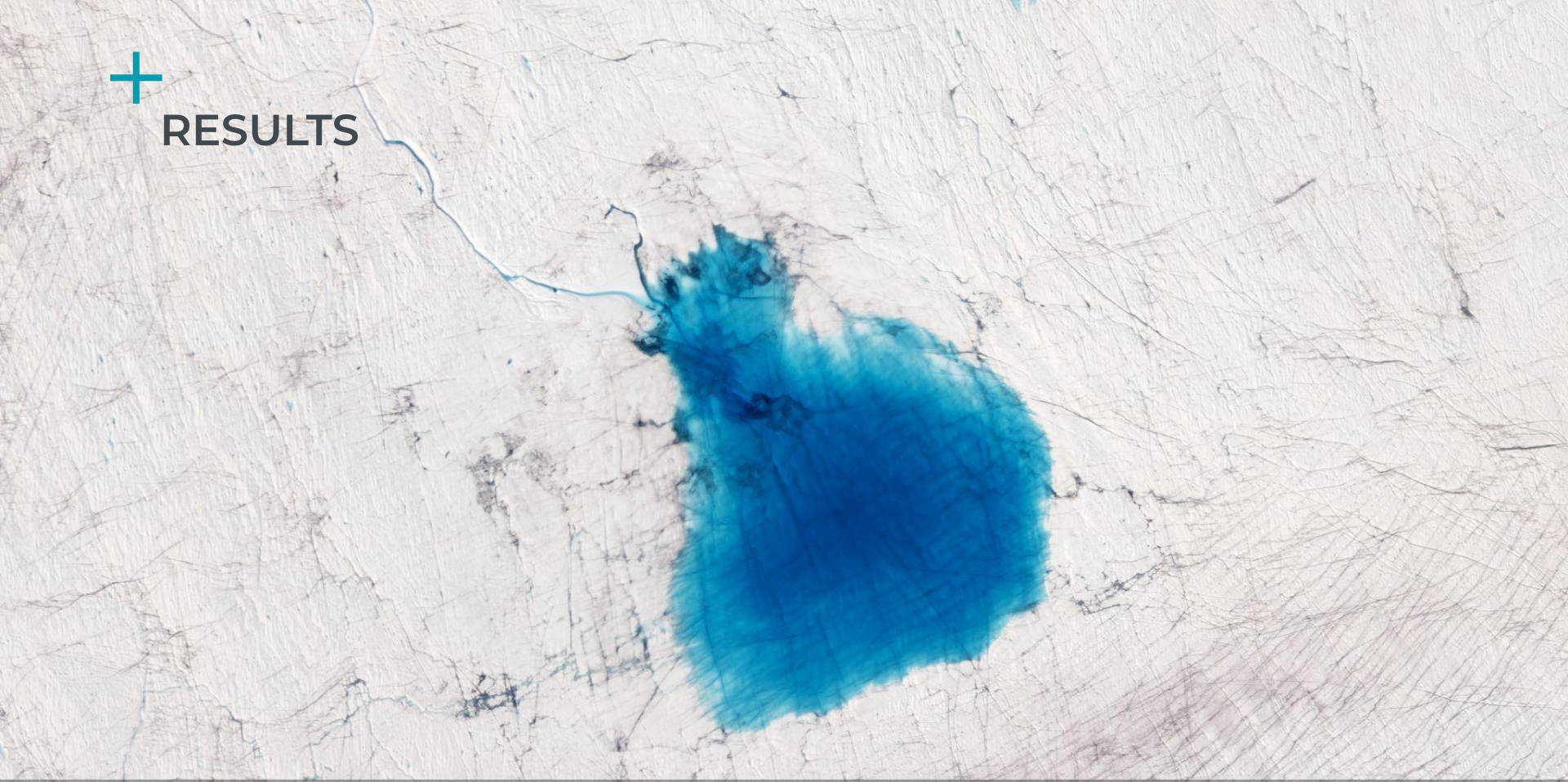
SkySat

- Statistics are gathered and recorded for each crossover, in particular the **median** of the sample reflectance for both the SkySat and Sentinel collects.



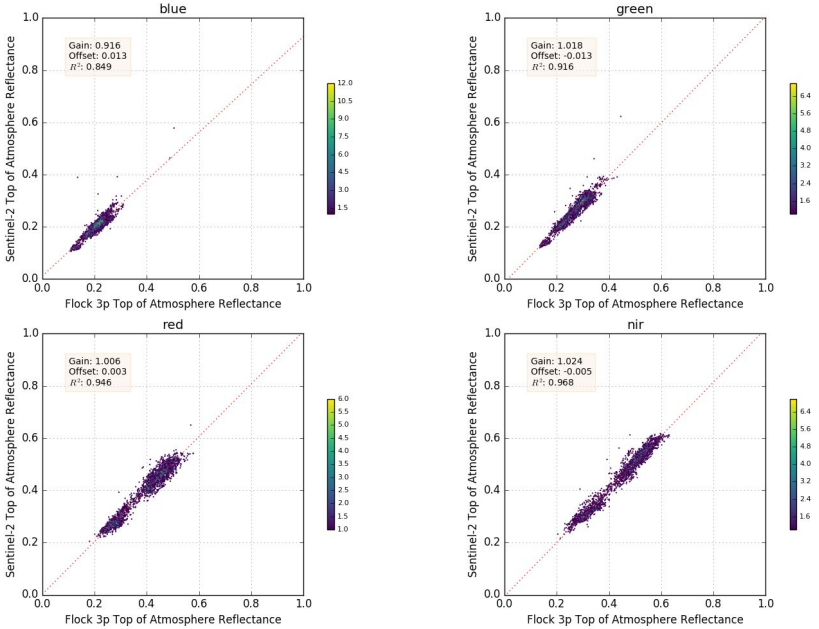


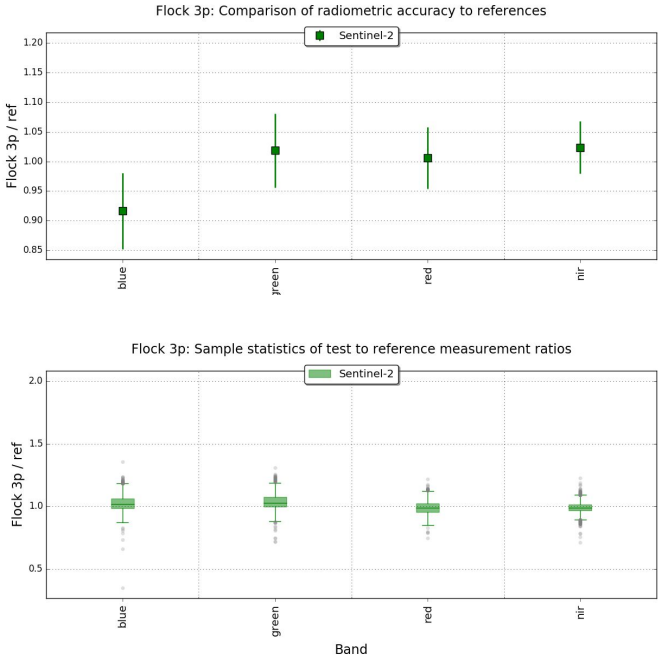
RESULTS



LAKE NIELS · Greenland Ice Sheet · July 29, 2019

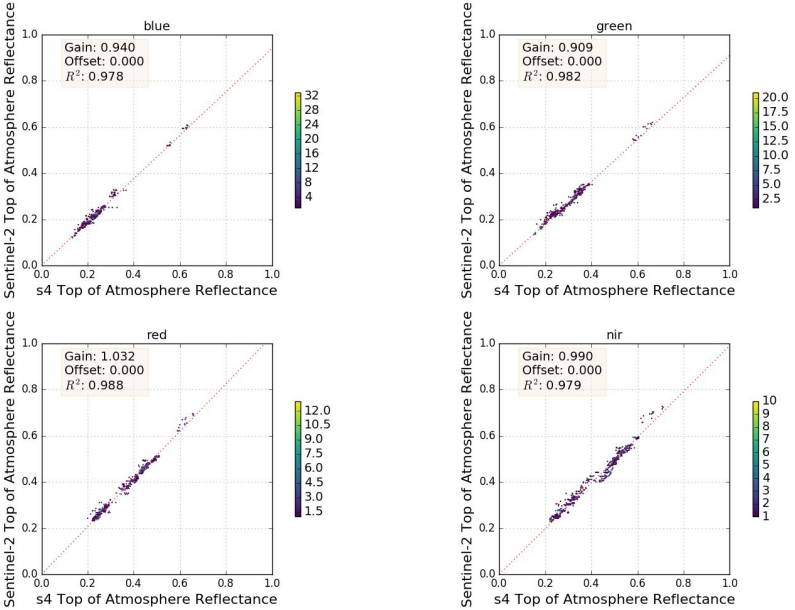
Dove Classic
FLOCK 3P

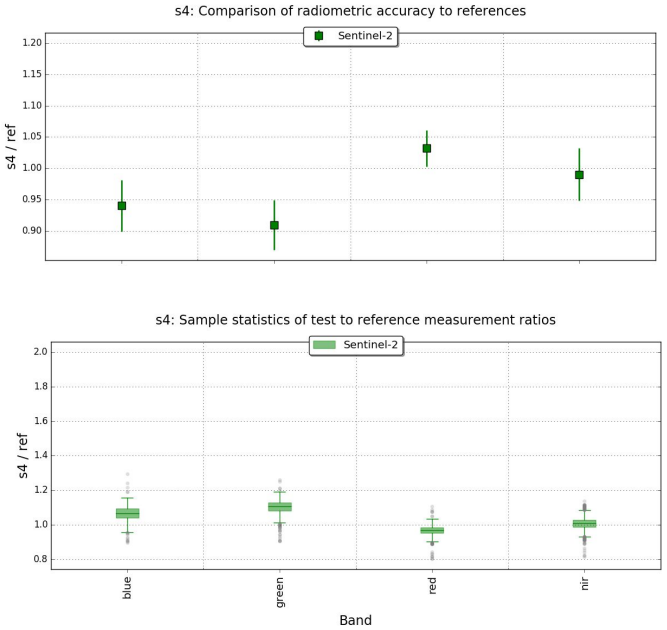




SkySat

s4





*preliminary calibration

RADCALNET VERIFICATION

FAGRADALSFJALL VOLCANO • RGB · Iceland · March 26, 2021

RadCalNet Verification

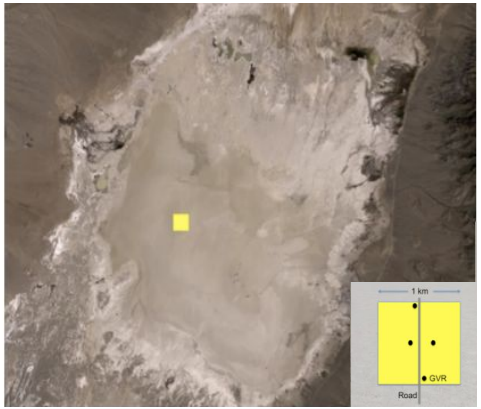
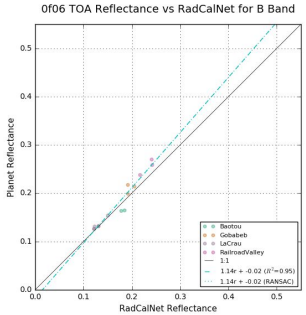
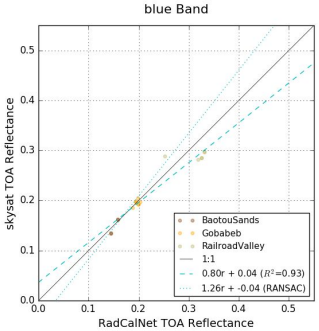


Image of Railroad Valley Site From radcalnet.org

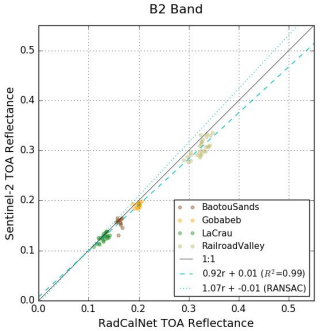
Dove Classic



SkySat s4



Sentinel-2



CONCLUSIONS

Calibration Process

Process	Dove Classic	Dove-R	SuperDove	SkySat*
Simultaneous crossovers for on orbit calibration	With Sentinel-2 over calibration sites	With Sentinel-2 globally	With Sentinel-2 globally	With Sentinel-2 over calibration sites
Lunar Monitoring	Since late 2016	Since late 2018	Since late 2019	None
Reported Validation**	Comparison with RadCalNet data	Comparison with RadCalNet data	Comparison with RadCalNet data	Comparison with RadCalNet data

* Updated radiometric calibration in progress
** For L1 Image Quality reports from Q3 2021 onwards

Sentinel-2 as Reference

Original and post Sentinel-2

Summary

- Update methodology throughout Planet's fleet to use Sentinel-2 as our calibration reference
- New SkySat calibrations in release process
- Calibration verification uses RadCalNet sites
- White paper publicly available: https://assets.planet.com/docs/radiometric_calibration_white_paper.pdf

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