National Aeronautics and Space Administration

NASA earth

Radiometric Evaluation of Planet SuperDove Constellation Using RadCalNet

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December 2025

Introduction

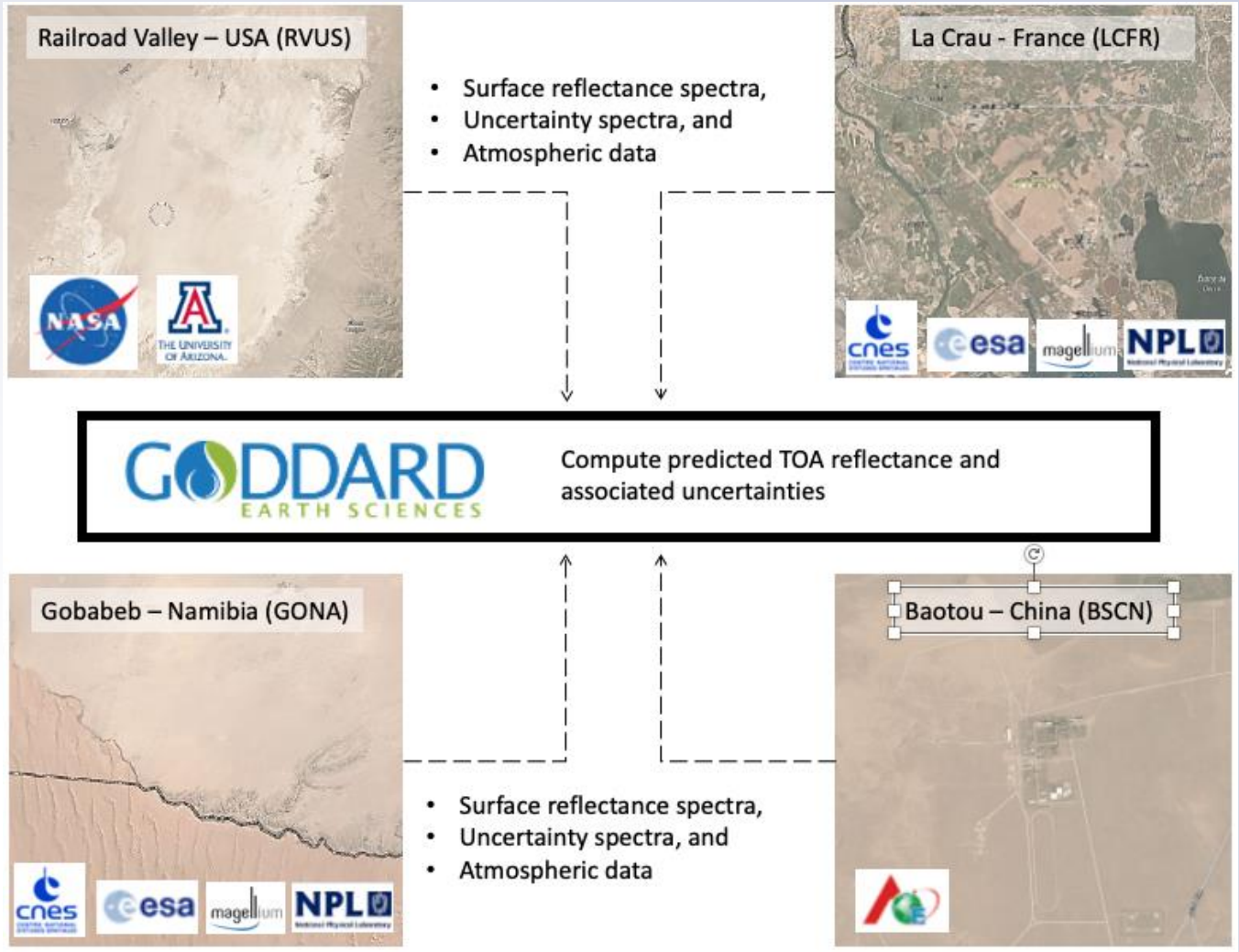
The NASA Commercial Satellite Data Acquisition (CSDA) Program conducted a radiometric quality assessment of SuperDove top-of-atmosphere (TOA) reflectance data provided by Planet Labs Inc. This CSDA report is an independent follow-on evaluation to the previous report on Planet Labs' PlanetScope (Classic, Dove-R, and SuperDove) constellation that was reported back in February 2025.

https://www.earthdata.nasa.gov/s3fs-public/2025-03/CSDA_Planet_Radiometric_Assessment%20February%202025.pdf

The analysis in this report was performed on 2986 SuperDove scenes collected over four RadCalNet sites from January 2021 through December 2024 and includes the eight spectral bands of the SuperDove sensors within the PlanetScope constellation.

Role of Goddard Earth Sciences in RadCalNet

- RadCalNet is a collaborative international service established under the CEOS Working Group on Calibration and Validation (WGCV) to provide consistent data for the radiometric calibration of optical sensors.
- The RadCalNet sites are independent and provide absolute surface reflectance with SI-traceable uncertainties verified and validated by the RadCalNet Working Group.
- The GSFC RadCalNet calibration team assists in quality control of data from all RadCalNet sites and is responsible for producing the RadCalNet top of atmosphere (TOA) reflectance product.
- The Radiometric Calibration Test Site (RadCaTS) facility in Railroad Valley is the only US-based RadCalNet site as of March 2026. It is operated by the University of Arizona and is partially funded by NASA's Terra/Aqua and Landsat projects.



Data are free and available to download from www.radcalnet.org

Comparing Planet SuperDove and RadCalNet (continued)

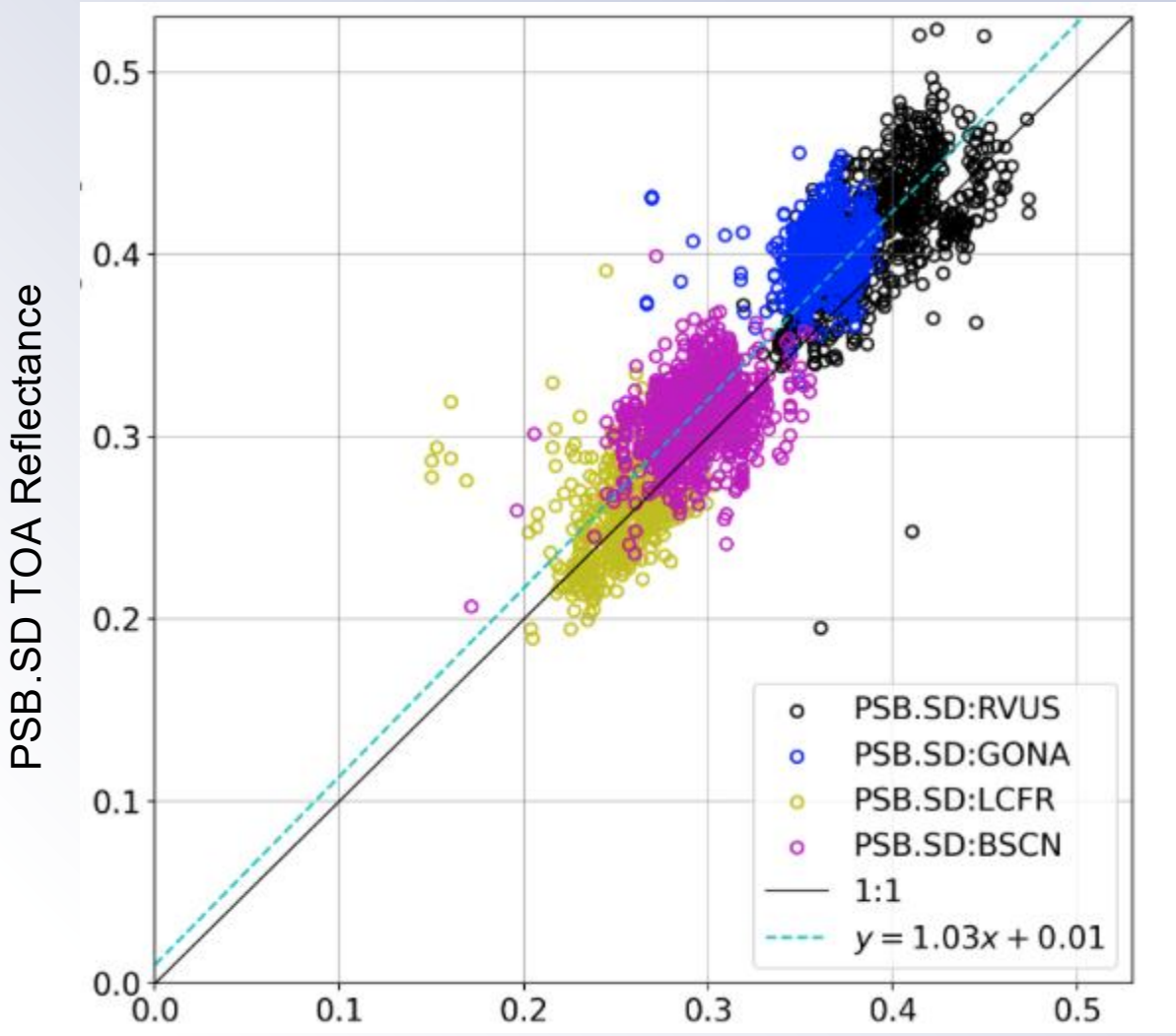
The Planet-provided 2986 SuperDove scenes were filtered by these criteria:

- Image processing filter to ensure the site is visible in the scenes
- A time gap between the RadCalNet data and the Planet scenes is less than 30 min
- Pixel-level screening for: 0% cloud, 0% cloud shadow, 0% Snow

After filtering, the number of scenes for this analysis was reduced from 2986 to 2480.

This plot shows comparison of the top-of-atmosphere (TOA) reflectance of PSB.SD to that of four RadCalNet sites (RVUS, GONA LCFR BSCN) in the NIR band.

The regression line is computed for the combined comparisons from the four RadCalNet sites and indicates a radiometric agreement between the PlanetScope SuperDove constellation data with RadCalNet.



Guide to the Expression of Uncertainty in Measurement

(to help explain the next slide)

Uncertainty of RadCalNet data is smaller than 5%

Uncertainty of SuperDove data is assumed to be 5%

14% expanded combined uncertainty is calculated by $2 \times \sqrt{5\%^2 + 5\%^2} \cong 14\%$ **(k=2)*

Joint Committee for Guides in Metrology (JCGM) 100:2008

- Uncertainty of measurand y characterizes dispersion of values that could be attributed to the measurand based on the measurement
- Each component of uncertainty (assumed to follow a normal distribution) is represented by an estimated standard deviation.
- If we treat uncertainty contributors as orthogonal then we can calculate the net displacement by addition in quadrature.

$$y = f(x_1, x_2, \ldots, x_n)$$

$$u(y) = \begin{bmatrix} u(x_1) & \cdots & u(x_1, x_n) \\ \vdots & \ddots & \vdots \\ u(x_n, x_1) & \cdots & u(x_n) \end{bmatrix}$$

$$u^2(y) = \sum_{i=1}^{n} \left(\frac{\partial f}{\partial x_i}\right)^2 u^2(x_i) + 2 \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \frac{\partial f}{\partial x_i} \frac{\partial f}{\partial x_j} u(x_i, x_j)$$

Here, we are taking the ratio of TOA reflectance values

$$y = f(\rho_{TOA_{RCN}}, \rho_{TOA_{PSB.SD}})$$

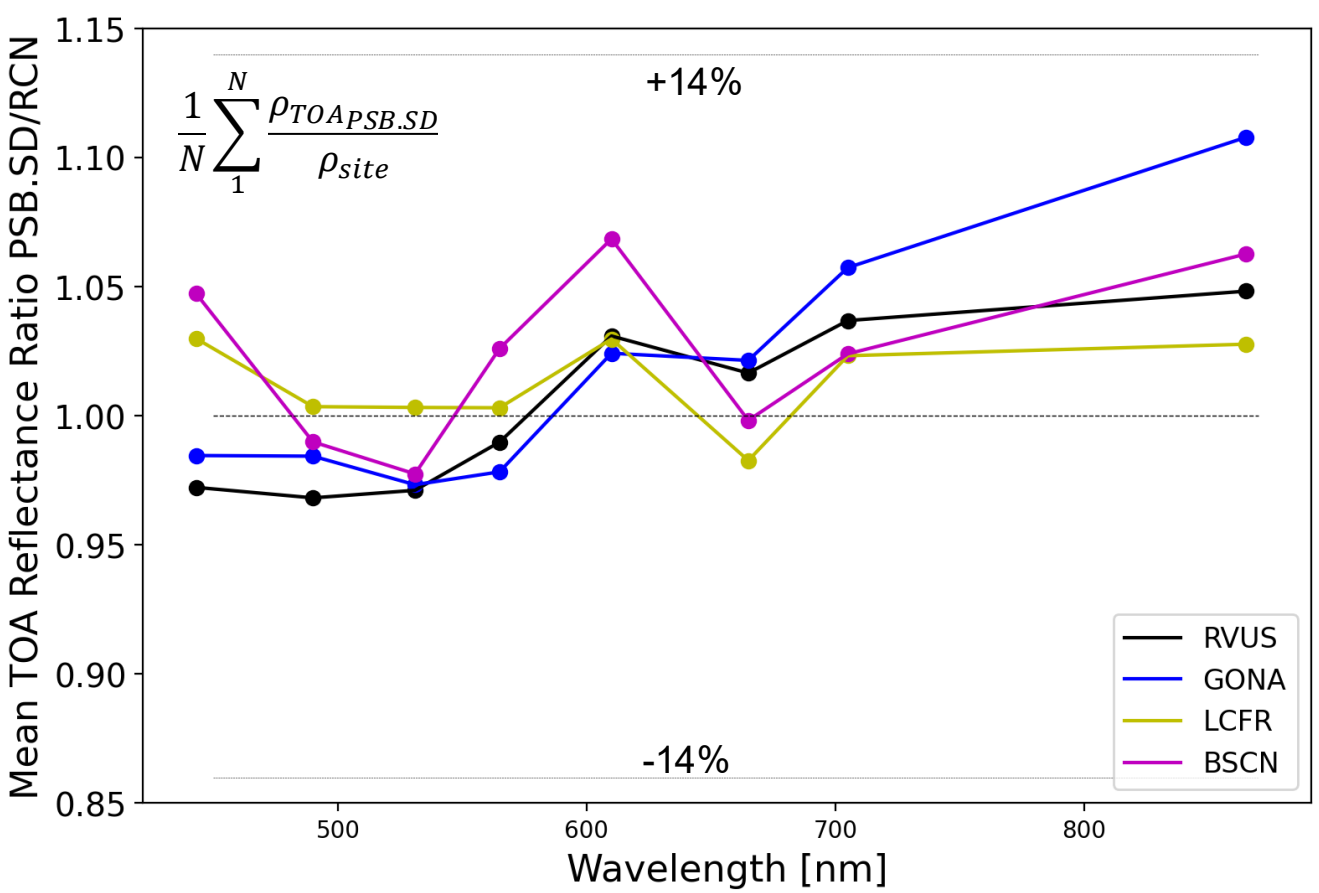
$$u(y) = \sqrt{(u_{RCN})^2 + (u_{PSB.SD})^2} \cong 7$$

Note

- **k is the "coverage factor". For Gaussian distributed data, k is equivalent to the number of standard deviations. See NIST TN 1297: Appendix B. Coverage Factors RadCalNet provides uncertainty for each datum [Wenny et al., 2022]*

Validation of Planet SuperDove with Reference to RadCalNet

- All means are ***within expanded combined uncertainties***
- SuperDove reflectance data are consistently higher in bands 5, 7, and 8
- Noticeable deviations of the SuperDove data from RadCalNet warrants further analysis



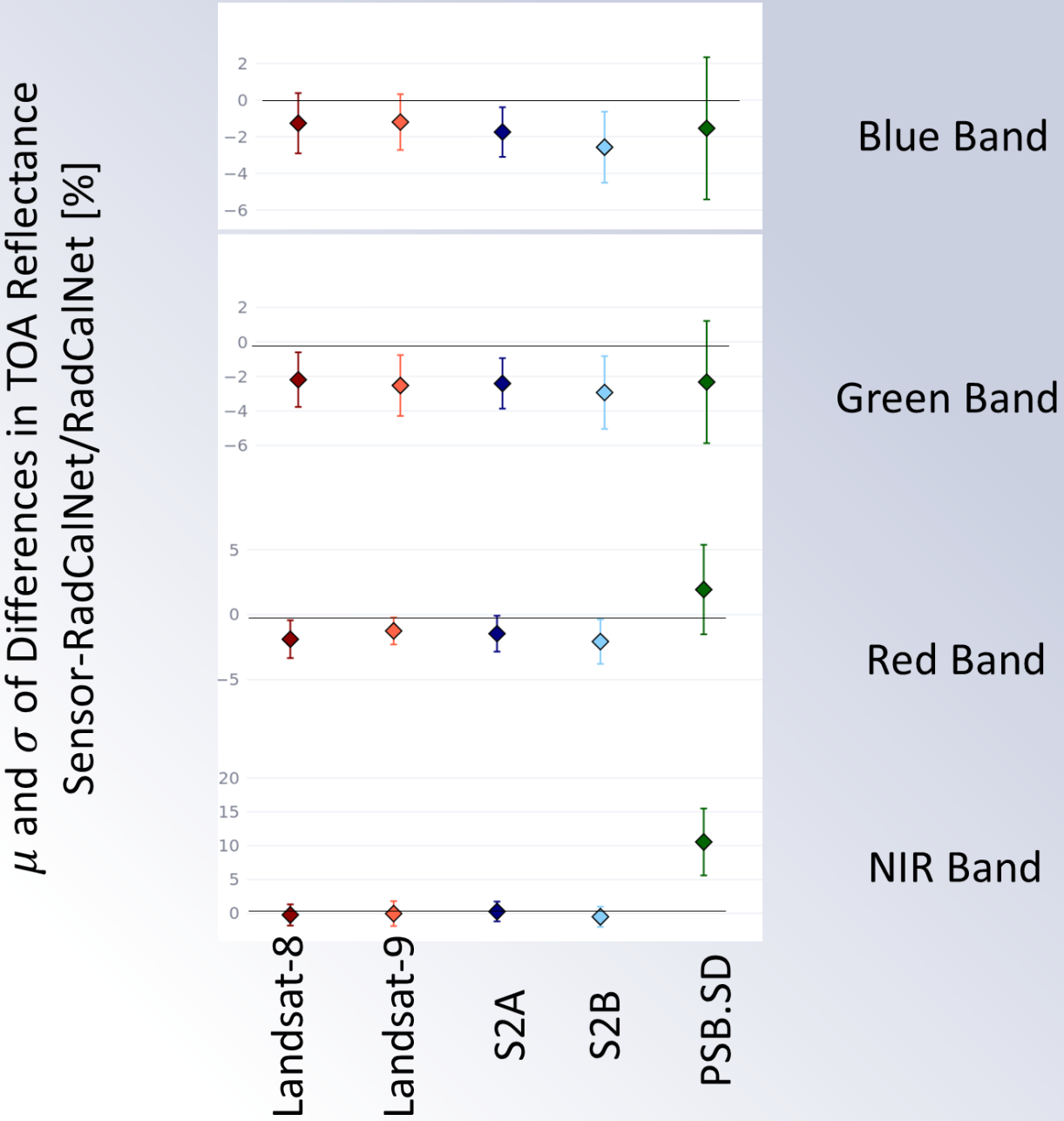
Number of scenes from each site:

393 scenes of Railroad Valley
706 scenes of Gobabeb
411 scenes of La Crau
970 scenes of Baotou

2480 scenes in total

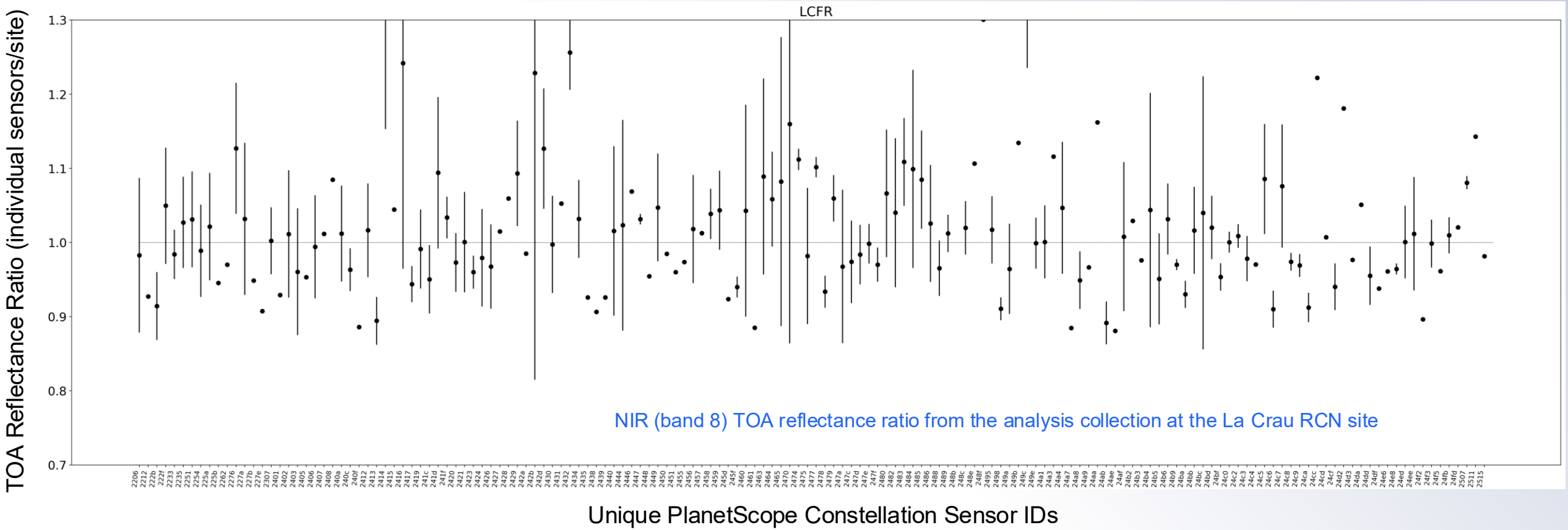
Juxtapose of RadCalNet-based Radiometric Evaluations for Planet Lab Inc., NASA, and ESA Missions

- RadCalNet validates the radiometric accuracy of SuperDove data from 2021 – 2024 in the same way that it validates the radiometric accuracy of the shown NASA (Landsat) and ESA (Sentinel 2A and 2B) missions.
- Planet Lab's radiometric data deviates more from the combined radiometric scale of RadCalNet compared to NASA and ESA mission data, particularly in the longer wavelengths.
  - **Our recommendation to users**: Be cautious when using the Planet SuperDove beyond 700 nm due to the differences shown in radiometric quality
- Planet Lab's radiometric data also shows a large spread compared to NASA and ESA mission data.



SuperDove Constellation Variability

The plot below demonstrates the variability within Planet's SuperDove constellation. Each point on the plot represents the mean ratio from a different SuperDove sensor in the PlanetScope constellation. The x-axis is not ordered by date, but by the constellation sensor ID. The spread is the standard deviation of the ratio, if there were multiple acquisitions in the dataset for this site collected by the same sensor, otherwise there is just a point.



Summary and Take-Away

Findings

This reports validates Planet SuperDove constellation's radiometric accuracy using RadCalNet

- SuperDove and RadCalNet TOA Reflectance agrees within k=2.
- The SuperDove at-sensor reflectance is noticeably higher than the RadCalNet sites in the longer wavelengths.

Recommendations for Data Users

- Users of the SuperDove data should exercise caution when using SuperDove Band 8 (NIR) because of the noted disagreements when compared to absolute ground-based measurements (see Slide 6).
- Do not assume that all SuperDove constellation sensors are in agreement, we found statistically significant variations between individual sensors (see Slide 8), as well as some extreme outliers.

Considerations for CSDA Program

- A comprehensive sensitivity analysis before using PSB.SD data products.
- If resources allow, calibrate SuperDove using RadCalNet and provide users with coefficients to apply to the SuperDove data.

References

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Questions?

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