3RD WORKSHOP ON INTERNATIONAL COOPERATION IN SPACEBORNE IMAGING SPECTROSCOPY

CURRENT AND FUTURE RADIOMETRIC CALIBRATION AND VALIDATION OF HYPERSPECTRAL IMAGING SYSTEMS AT CNES

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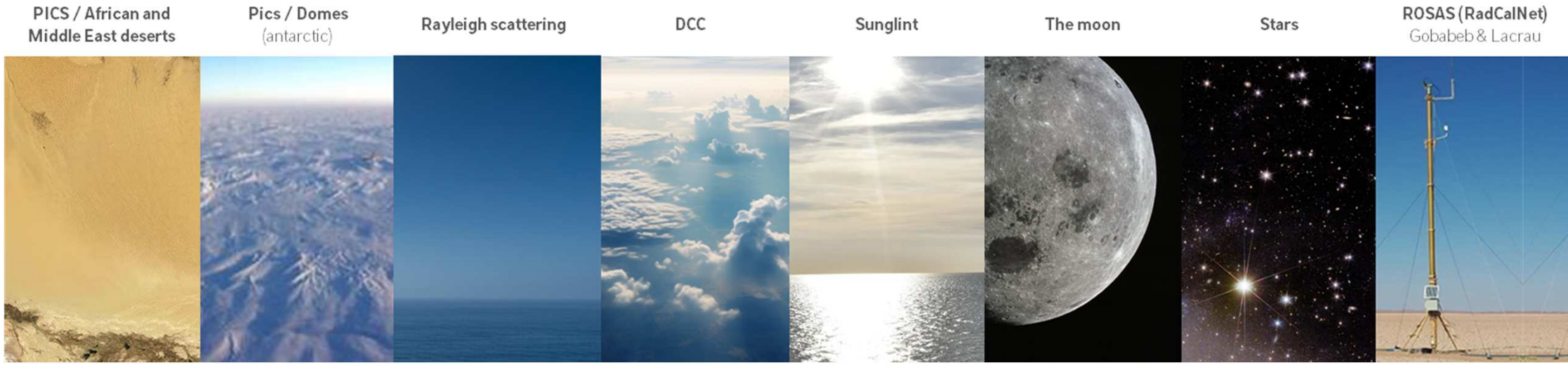
CNES LEGACY ON RADIOMETRIC CAL/VAL ON MULTISPECTRAL SENSORS

Over the last two decades, CNES has calibrated and cross-calibrated a wide range of multispectral imaging systems …

CNES LEGACY ON RADIOMETRIC CAL/VAL ON MULTISPECTRAL SENSORS

… using several vicarious calibration methods



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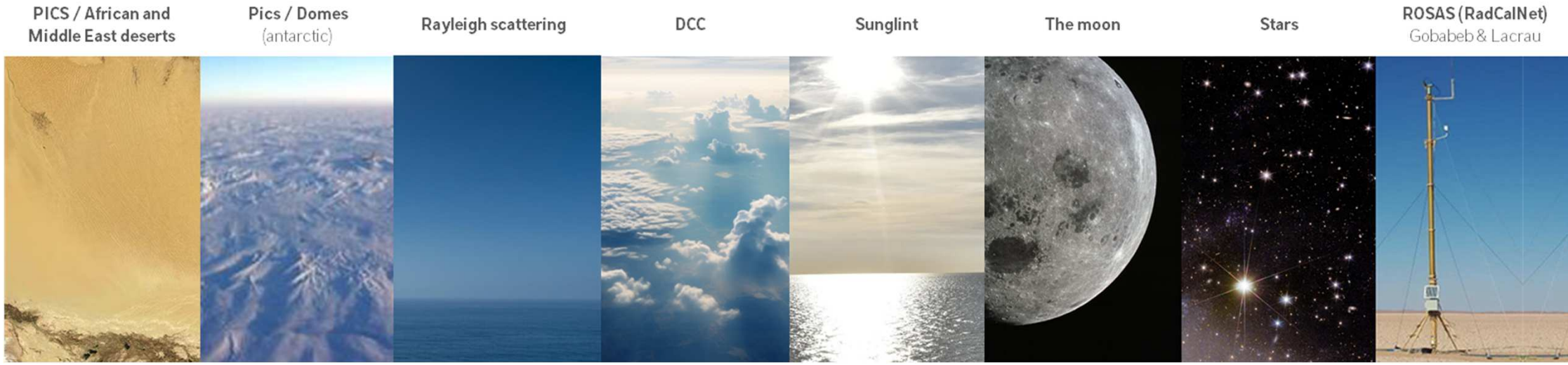


- Different approaches using very different targets
- The principle of all the methods is to compare a sensor measurement to a simulated one (from a model, a reference spaceborne sensor or in-situ measurements)

ONGOING ADAPTION OF VICARIOUS METHODS TO HYPERSPECTRAL IMAGERS

Adaptation of multispectral vicarious methodology needed for hyperspectral sensors,
at least to manage the number of bands and their spectral resolution (RT models, spectral interpolation,…)

CROSS-CALIBRATION METHOD BASED ON WARM PICS

CNES was precursor in the use of Pseudo Invariant Calibration Sites and, in the 1990s, selected 20 sites in North Africa and Middle East for their temporal stability and spatial homogeneity (cf. figure below).

Among these 20 sites, 6 were afterward **endorsed by CEOS**, the Committee on Earth Observation Satellites: Algeria 3&5, Libya1&4 and Mauritania 1&2.

Purpose:

- Inter-calibration between different sensors operating simultaneously or at different time
- Validation of sensor's temporal stability throughout its entire lifetime

Hypothesis:

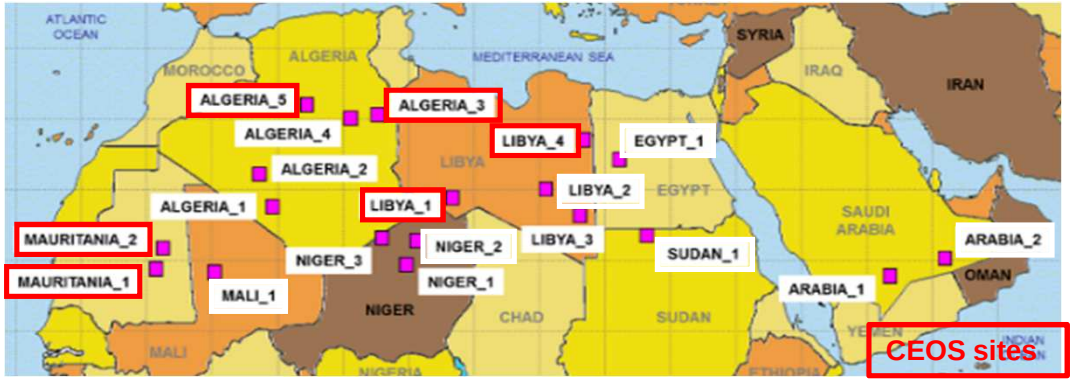
- 20 arid areas (African and Middle East deserts) do not change over time
- **Two images acquired by different instruments, with similar solar and acquisition geometries, over such area can be compared after atmospheric corrections**

Data used:

- Mean reflectance over standard (100 x 100 km²) or small (~ 20 x 20 km²) desert sites
- Exogenous data for the atmosphere

Calibration results:

- Cross-calibration coefficient $\Delta A_k = \frac{\rho_k^{Sensor\_2}}{\rho_k^{ref.sensor}}$

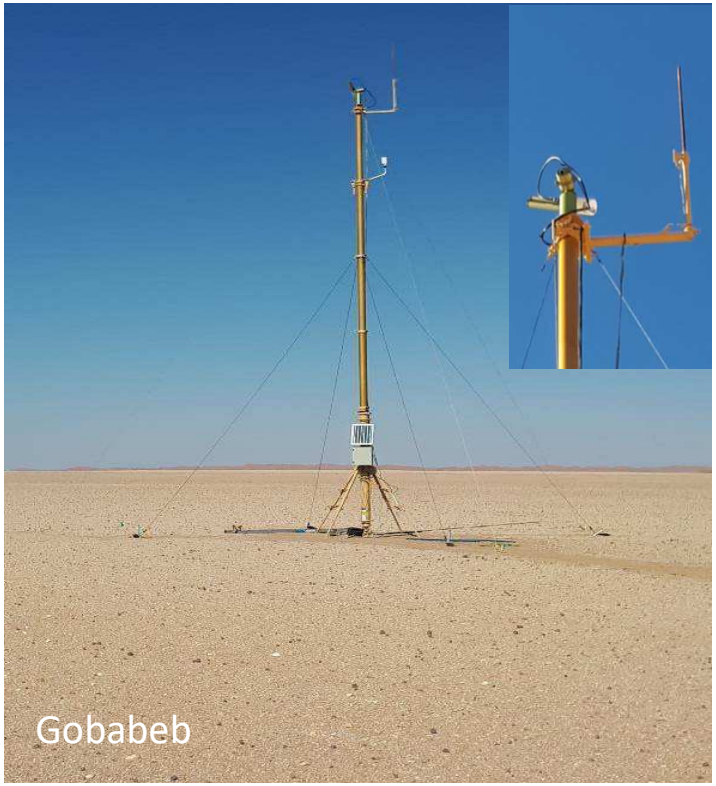


ROSAS (ROBOTIC STATION FOR ATMOSPHERE AND SURFACE)

3 sites with the same instrumentation (CIMEL CE-318 – 12 bands):

Band	1	2	3	4	5	6	7	8	9	10	11	12	13
λ(nm)	414Si	440Si	500Si	550Si	675Si	702Si	740Si	782Si	870Si	937Si	1020Si	1020 InGaAs	1640 InGaAs

La Crau (France), Lamasquère (France) and Gobabeb (Namibia, ESA/CNES cooperation)



Data sent to RadCalNet (CEOS)
for La Crau and Gobabeb

CALIBRATION WITH ROSAS INSTRUMENTED SITES

[6]

Hypothesis:

- The *in situ* measurements are available and representative of the imaged area.

Method and data used:

- Mean reflectance over the LaCrau and Gobabeb sites measured by the spaceborne sensor
- In-situ measurements in **12 bands everyday**: surface reflectance, BRDF and atmosphere
  -> gives us surface reflectance measurements in the **same angular conditions** as the optical sensor to calibrate
  -> These measurements are used to **fit a hyperspectral spectrum** which was measured during a field campaign
- Automatic field instrumentation
- Nadir data accessible to the public via RadCalNet

Calibration results:

- Absolute calibration coefficient $A_k = \frac{\rho_k^{measured}}{\rho_k^{in\ situ}}$

ROSAS STATION UPDATE

Hyperspectral radiometer development on going with CIMEL company for ROSAS station

⇒ Embeds 3 spectro-radiometers:

	VNIR	SWIR 1	SWIR 2
Spectral range	300 – 1050 nm	1000 – 1700 nm	1600 – 2600 nm
Spectral resolution	< 2nm	< 5nm	< 10 nm
Sensor type	Silicium dector	InGaAs detector	InGaAs detector
Taille	150 x 121,5 x 78,5 mm	115 x 52,5 x 52,3 mm	115 x 50 x 87 mm

- Same measurement protocol as today (CE-318) for surface reflectance, BRDF and atmosphere retrieval
- Delivery to CNES at the end of 2024 for characterization
- Deployment at La Crau in Q2 2025
- Starting a comparison phase with the actual multispectral instrument (CE318) for 1 year

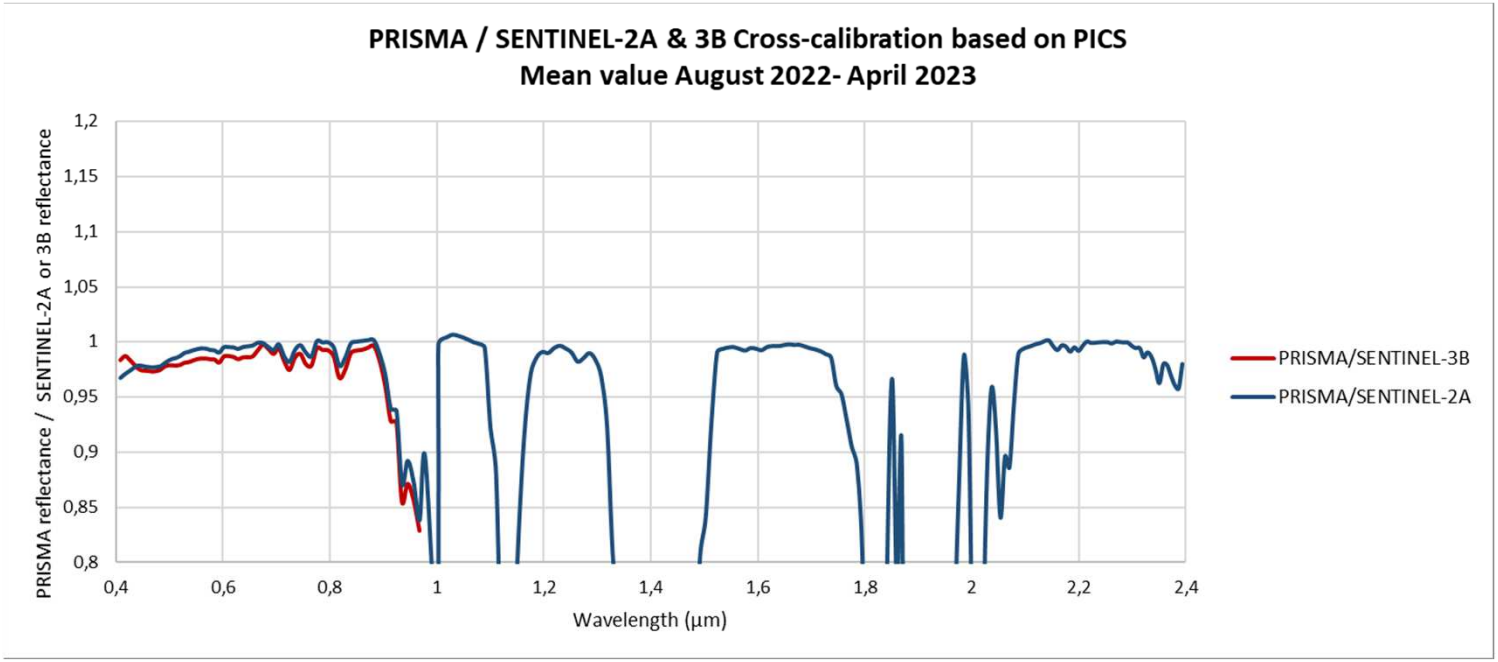
APPLICATION TO PRISMA CALIBRATION AND VALIDATION

- Collaboration with ASI on PRISMA (renewed Agreement)
- Following the 2019 CNES vicarious campaign, PRISMA official absolute gains have integrated the feedbacks from CNES

APPLICATION TO PRISMA CALIBRATION AND VALIDATION

- PRISMA calibration over PICS with Sentinel2A as reference sensor
- PRISMA validation over PICS with Sentinel3B-OLCI as reference sensor (VNIR bands only)
- PRISMA validation with ROSAS in-situ measurements at Gobabeb site

PRISMA CALIBRATION RESULTS OVER PICS



Following the 2019 CNES campaign, PRISMA's absolute gains now include CNES feedback.

-> Gain modification seen by 2023 campaign over PICS with S2A as reference sensor are only due to PRISMA's temporal sensitivity changes.

Campaign 2023 shows:

- Cross-calibration with Sentinel-2A as reference sensor :
  - Slow variation for short wavelengths (3% maximum)
  - Good stability for SWIR bands
- Good consistency when SENTINEL-3B/OLCI as a reference for the VNIR part of the spectrum

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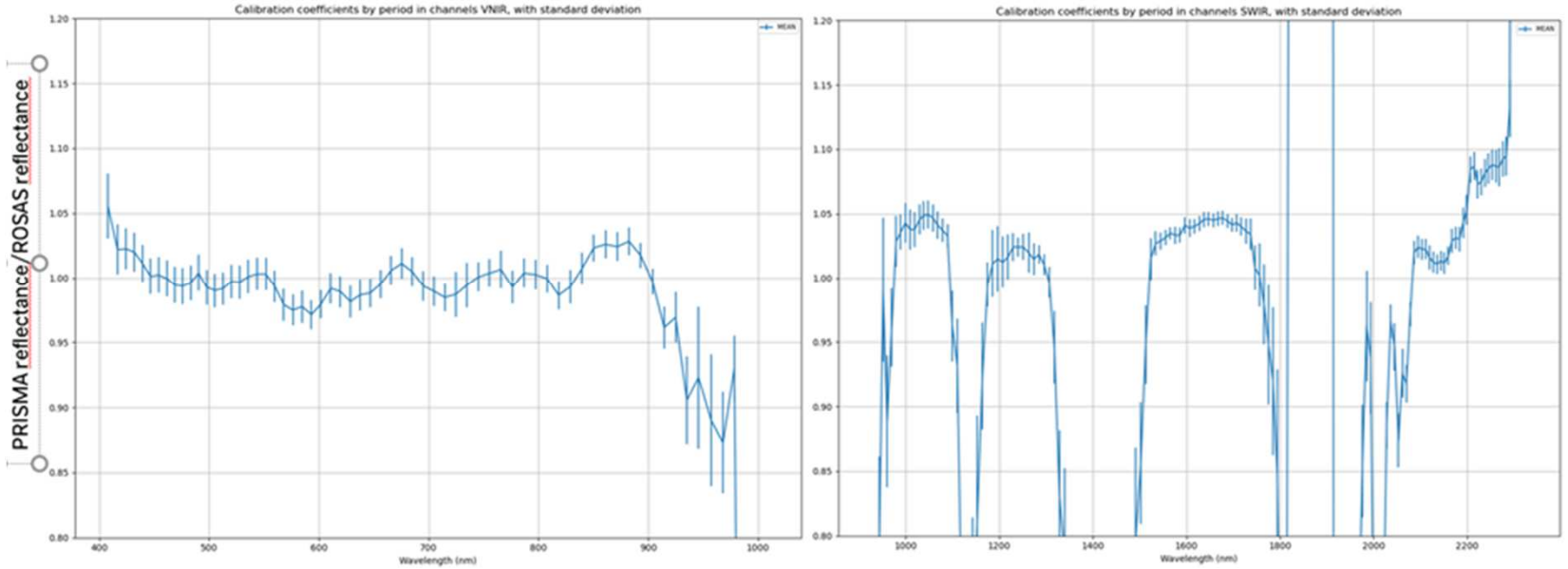
PRISMA ROSAS VALIDATION RESULTS

Between May 2022 and January 2023, 10 Gobabeb products corresponding to full days with clear sky conditions (needed to retrieve the BRDF) were processed



- Good consistency between PRISMA official calibration and ROSAS measurements : 2-3% for VNIR bands and 3-5% for SWIR bands, which is consistent with the instrumented site error budget*
- For SWIR bands we recall that ROSAS has only one band at 1640 nm which is not sufficient to constraint the spectral interpolation of the surface reflectances.

* QA4EO-WGCV-RadCalNet-GONA-U-v2 : RadCalNet site uncertainty statement

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CONCLUSION

- Ongoing adaption of multispectral vicarious methods for hyperspectral imagers

- Development of an hyperspectral instrument to improve in-situ measurements
  (prototype to be deployed in 2025 at La Crau)

- Collaboration with ASI on PRISMA radiometric cal/val activities
  - PRISMA official absolute radiometric calibration is based on CNES PICS using SENTINEL-2A as a reference.
  - This calibration is validated with Gobabeb instrumented sites, and cross-calibration with S3B/OLCI based on PICS.
  - 2024 campaign is currently being processed

- Similar activities ongoing on Desis & EnMAP sensors

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