EnMAP Moon observations

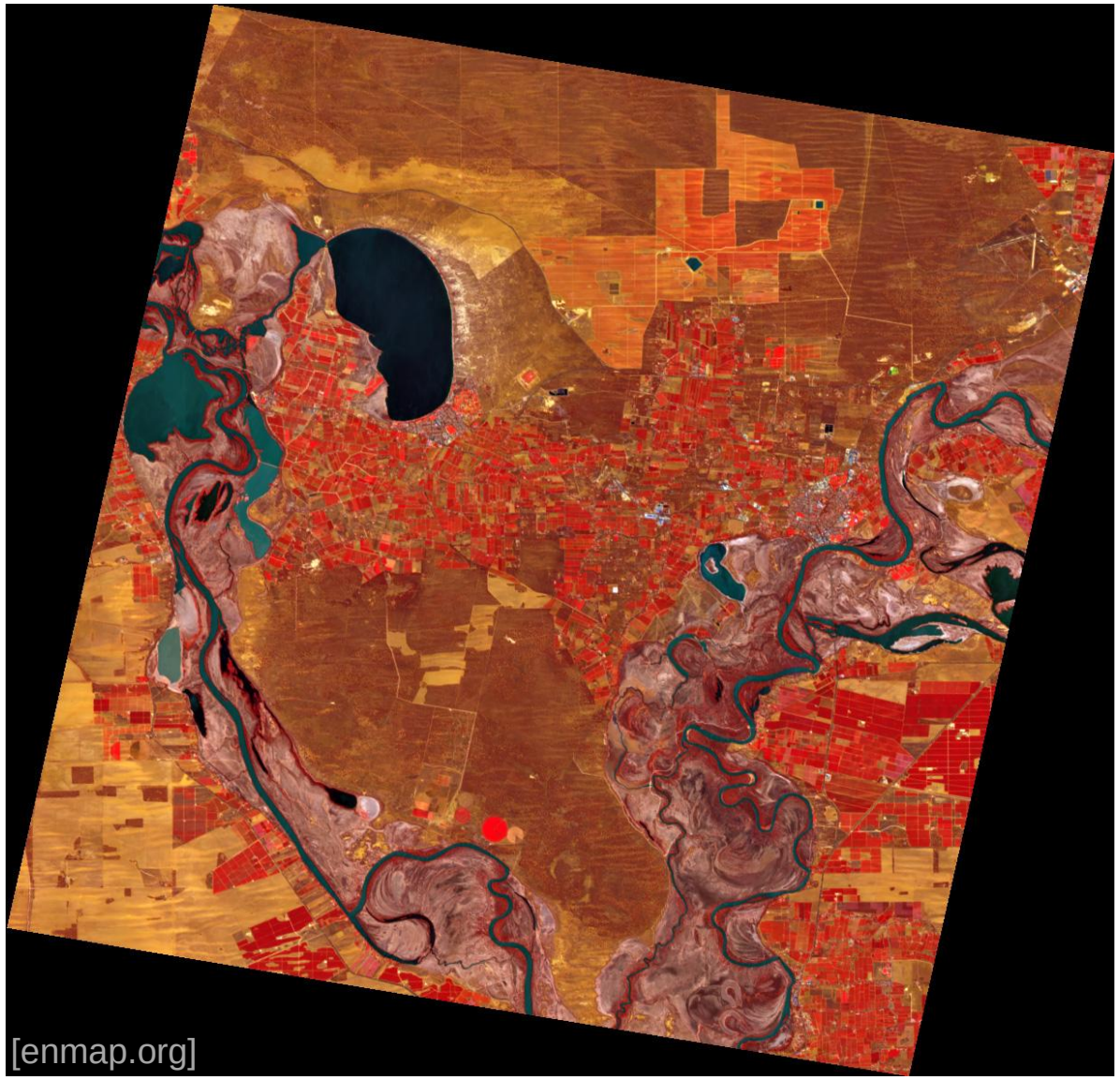
Miguel Pato[1,*] for the EnMAP Mission

GSICS Lunar Calibration Subgroup Webmeeting, 07.10.2026

[1] Remote Sensing Technology Institute, German Aerospace Center (DLR), Oberpfaffenhofen, Germany
* Miguel.FigueiredoVazPato@dlr.de

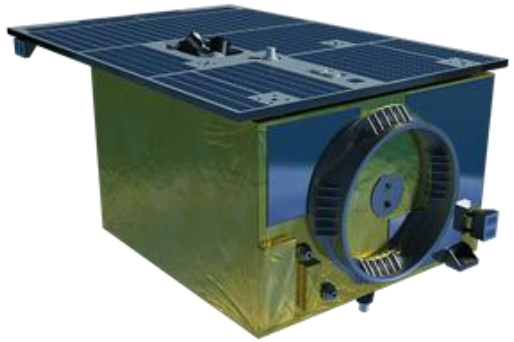
EnMAP mission: in a nutshell

https://www.enmap.org/


[enmap.org]

Earth observation data provided by EnMAP:

- 418–2450 nm, 224 bands, FWHM 6–11 nm
- 30 km x 30 km tiles, 30 m pixel size
- 4–27 days revisit time at 11:00 local time
- L1B: top of atmosphere radiances
- L1C: orthorectified top of atmosphere radiances
- L2A: orthorectified bottom of atmosphere reflectances (land and water)


[enmap.org]

EnMAP mission: in a nutshell

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EnMAP specification	VNIR	SWIR
Spectral range	420 – 1000 nm	900 – 2445 nm
Number of spectral bands	91	133
Spectral sampling distance	6.5 nm	10 nm
Spectral full width at half maximum	6 – 11 nm	7 – 11 nm
Spectral accuracy	0.5 nm	1 nm
Spectral stability	0.5 nm	
Spectral smile	<0.2 pix	
Signal-to-noise ratio	>500 (at 495 nm)	>150 (at 2200 nm)
Radiometric accuracy	<5%	
Radiometric stability	<2.5%	
Geometric accuracy	1 pix (30 m) with GCPs, otherwise 100 m	
VNIR/SWIR co-registration	0.2 pix	
L2A AOT, WV, BOA (land, water)	see Storch et al 2023	
Orbit type, altitude and inclination	Sun-synchronous, 653 km, 97.96°	
Orbit period and repeat cycle	1.6 h, 398 revolutions in 27 days	
Local time descending node	11:00 h ± 18 min	
Revisit time	4 days (±30° off-nadir tilt) 21 days (±5° off-nadir tilt)	
Ground sampling distance	30 m (at nadir; sea level)	
Swath width	30 km (2.63° across track)	
Swath length	1000 km / orbit; 5000 km / day	
Product size	30 km x 30 km	

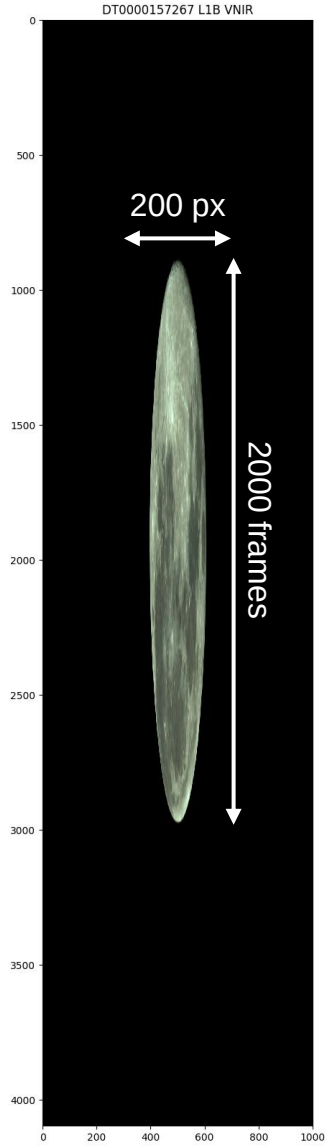
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In-orbit calibration type	Mechanism	Frequency
Relative radiometric (lamp)	white spectralon	1x / fortnight
Absolute radiometric (Sun)	Sun diffuser	1x / 2 months
Spectral	doped spectralon	1x / fortnight
Linearity	focal plane LEDs	1x / month
Deep space	dark sky	1x / month
Dark frames	closed shutter	before/after imaging

EnMAP Moon observations

- EnMAP focus is Earth observation, but the mission is committed to performing regular Moon observations and is collaborating with lunar experts (USGS, CNES, ESS).
- Moon observations are useful for instrument monitoring, radiometric validation and lunar modelling.
- EnMAP Moon imaging capabilities:
  - variable lunar phase angle
  - along-track scan of Moon with 10x oversamping (Moon: 200 px, 2000 frames)
  - Earth observation mode used (spectral gaps at ~1400 nm and ~1800–1900 nm)
  - spectral data: VNIR: 418–993 nm, 91 bands, SSD 5–8 nm, FWHM 6–11 nm
    SWIR: 902–2445 nm, 133 bands, SSD 7.5–12 nm, FWHM 7–11 nm
  - space-based, high-quality and stable radiometric and spectral performance
- Current observation strategy: lunar phase angle ~7° every 2 months. This is well adapted for instrument monitoring and radiometric validation.
- Dedicated Moon observations campaigns with other missions (Pléiades/S2 and JESSC-1 in Jul/Aug 2026) and to scan lunar phase angles (Oct/Nov 2026) underway.



[Source: DLR]

EnMAP Moon observations

Moon campaign Jul/Aug 2026:

- Five observations at different phases successfully acquired, no problems observed
- Joint observations with Pléiades, S2, GOME-2, PACE, Tanager-1, IPERLITE, GOES and ARCSTONE
- Processing and detailed analysis of data in progress
- Comparison to other missions in collaboration with CNES and ESS in progress

UTC	Lunar phase [deg]	Planned?	In timeline?	Acquired?	Downlinked?	Raw data check?
26.07.2026 21:44	-29.9	Yes	Yes	Yes	Yes	Moon well centered.
29.07.2026 14:52	1.3	Yes	Yes	Yes	Yes	Moon well centered. 1 SWIR SCF lost.
30.07.2026 05:31	7.2	Yes	Yes	Yes	Yes	Moon well centered.
01.08.2026 04:43	29.8	Yes	Yes	Yes	Yes	Moon well centered.
04.08.2026 02:44	65.3	Yes	Yes	Yes	Yes	Moon well centered.

[Source: DLR]

EnMAP Moon observations

Moon campaign Oct/Nov 2026:

- Two blocks of 12 ~daily observations after/before full Moon
- Planning in progress within the Ground Segment

UTC		Lunar phase [deg]
26.10.2026	11:00	6.8
27.10.2026	00:00	12.9
27.10.2026	17:00	22.0
28.10.2026	09:00	30.2
29.10.2026	12:00	45.3
30.10.2026	05:00	54.9
31.10.2026	09:00	70.1
01.11.2026	02:00	79.9
01.11.2026	21:00	90.2
02.11.2026	16:00	99.8
03.11.2026	10:00	109.8
04.11.2026	06:00	119.9
14.11.2026	18:00	-119.8
15.11.2026	15:00	-110.0
16.11.2026	13:00	-99.8
17.11.2026	10:00	-90.1
18.11.2026	08:00	-79.9
19.11.2026	05:00	-70.0
20.11.2026	01:00	-60.3
20.11.2026	20:00	-50.2
21.11.2026	19:00	-38.0
22.11.2026	19:00	-25.1
23.11.2026	18:00	-12.8
24.11.2026	08:00	-7.2

[Source: DLR]

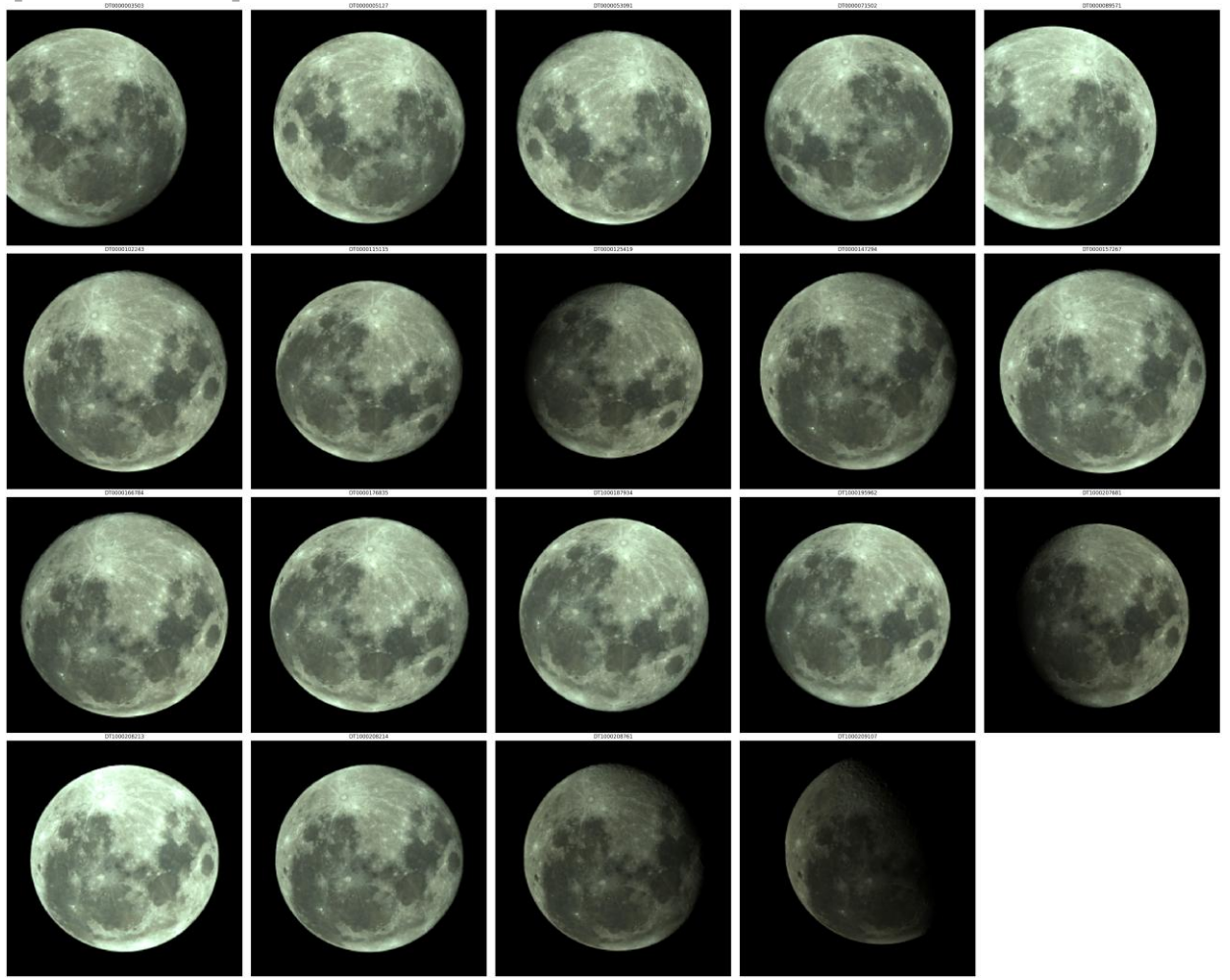
EnMAP Moon observations

[Source: DLR]

Datatake ID	Date	Number of tiles*	Lunar phase [°]
3503**	09.09.2022	3	-8.2
5127	07.11.2022	4	-6.1
53091	27.11.2023	12	5.6
71502	24.04.2024	4	6.8
89571**	19.08.2024	4	3.4
102243	16.11.2024	4	7.8
115115	13.02.2025	4	10.7
125419	10.04.2025	4	-23.0
147294	10.08.2025	4	15.4
157267	07.10.2025	4	7.4
166784	04.12.2025	4	-7.5
176835	02.02.2026	4	6.8
1000187934	02.04.2026	4	6.6
1000195962	30.05.2026	4	-7.2

* EnMAP tile = 1024 along-track frames x 1000 across-track pixels
** Pointing innacuracy led to missing part of the Moon disk.

[Source: DLR]



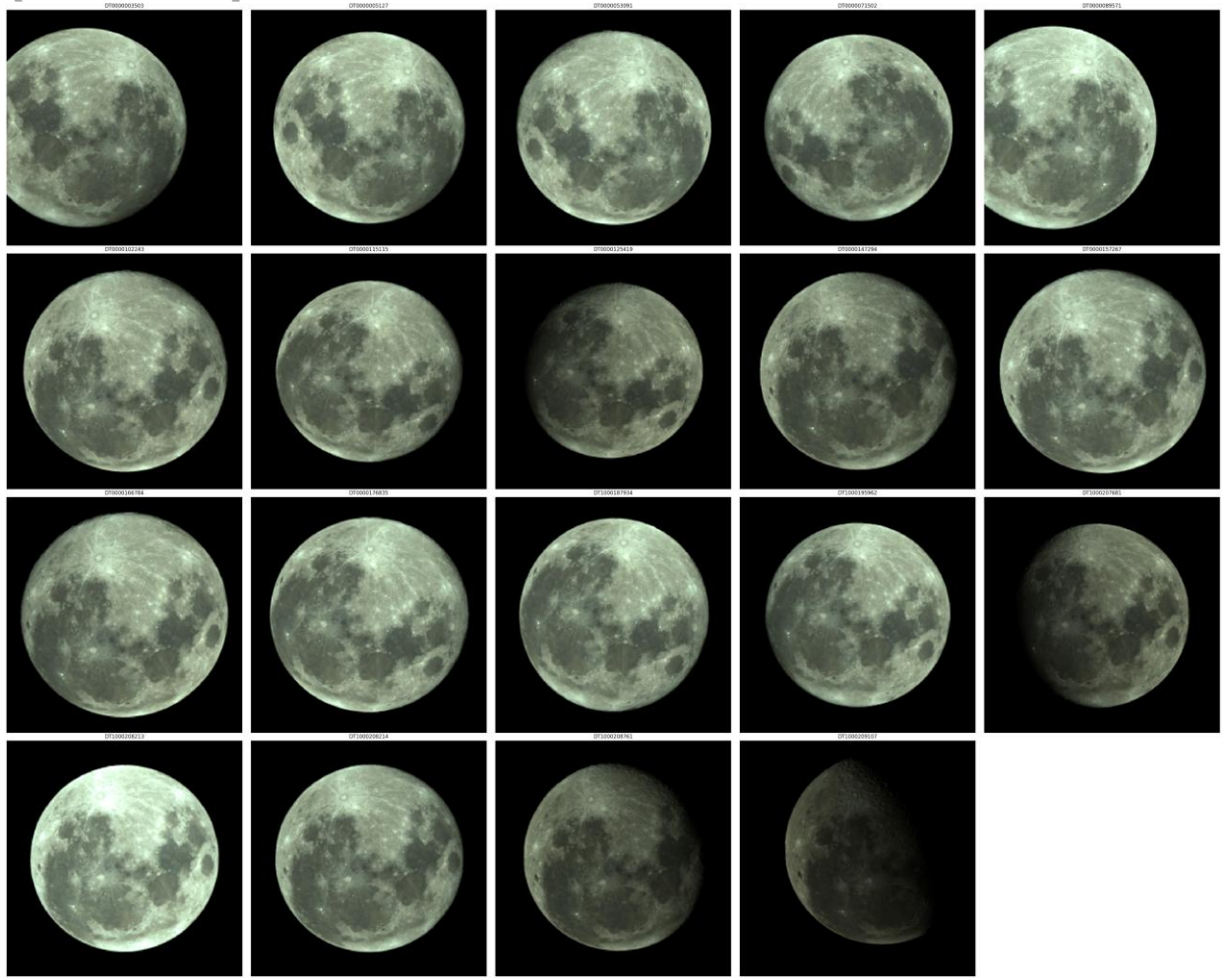
EnMAP Moon observations

[Source: DLR]

Datatake ID	Date	Number of tiles*	Lunar phase [°]
1000207681	26.07.2026	4	-30.3
1000208213	29.07.2026	4	1.3
1000208214	30.07.2026	4	7.3
1000208761	01.08.2026	4	30.1
1000209107	04.08.2026	4	65.4

* EnMAP tile = 1024 along-track frames x 1000 across-track pixels
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[Source: DLR]

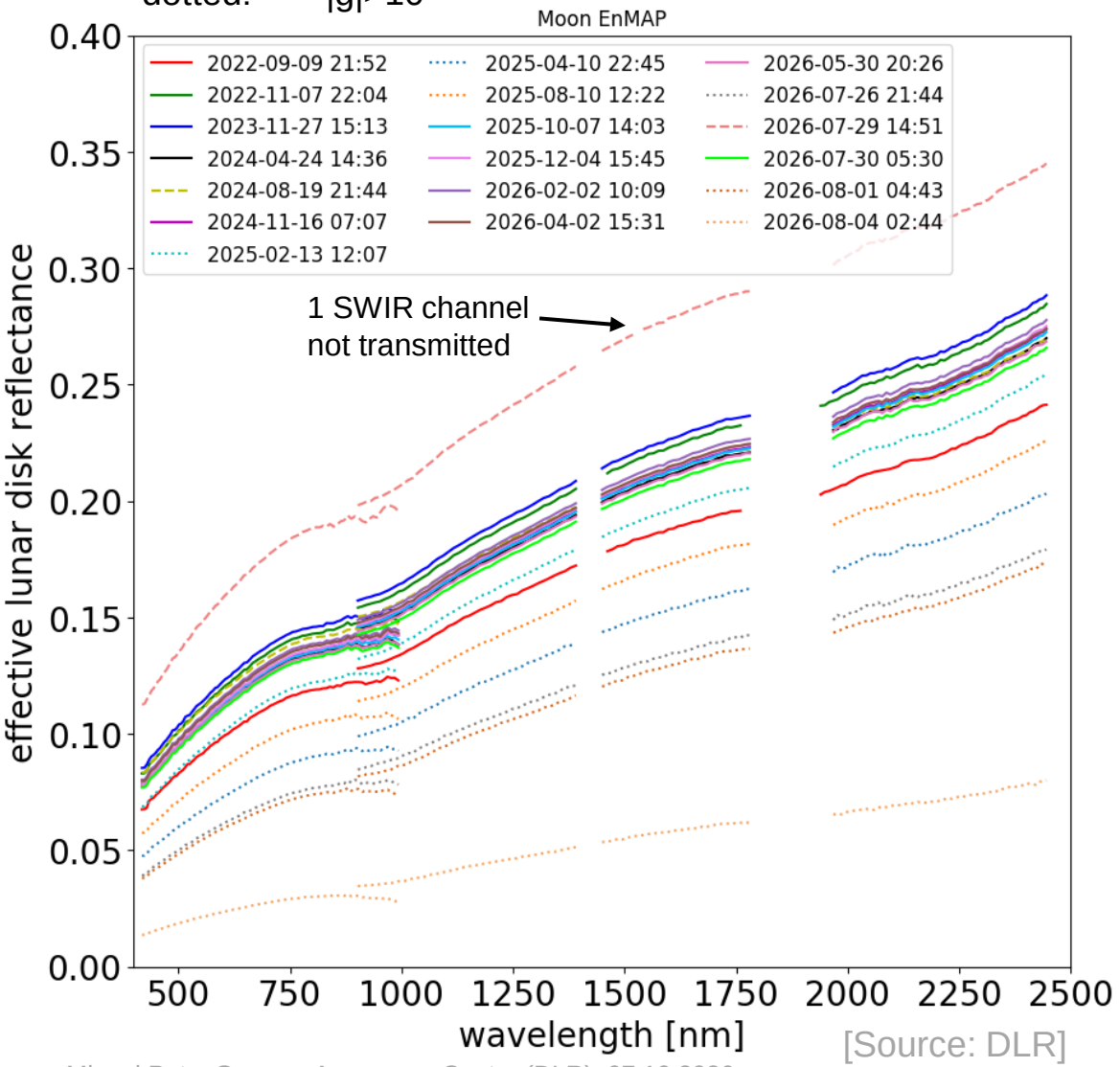


EnMAP Moon data and models

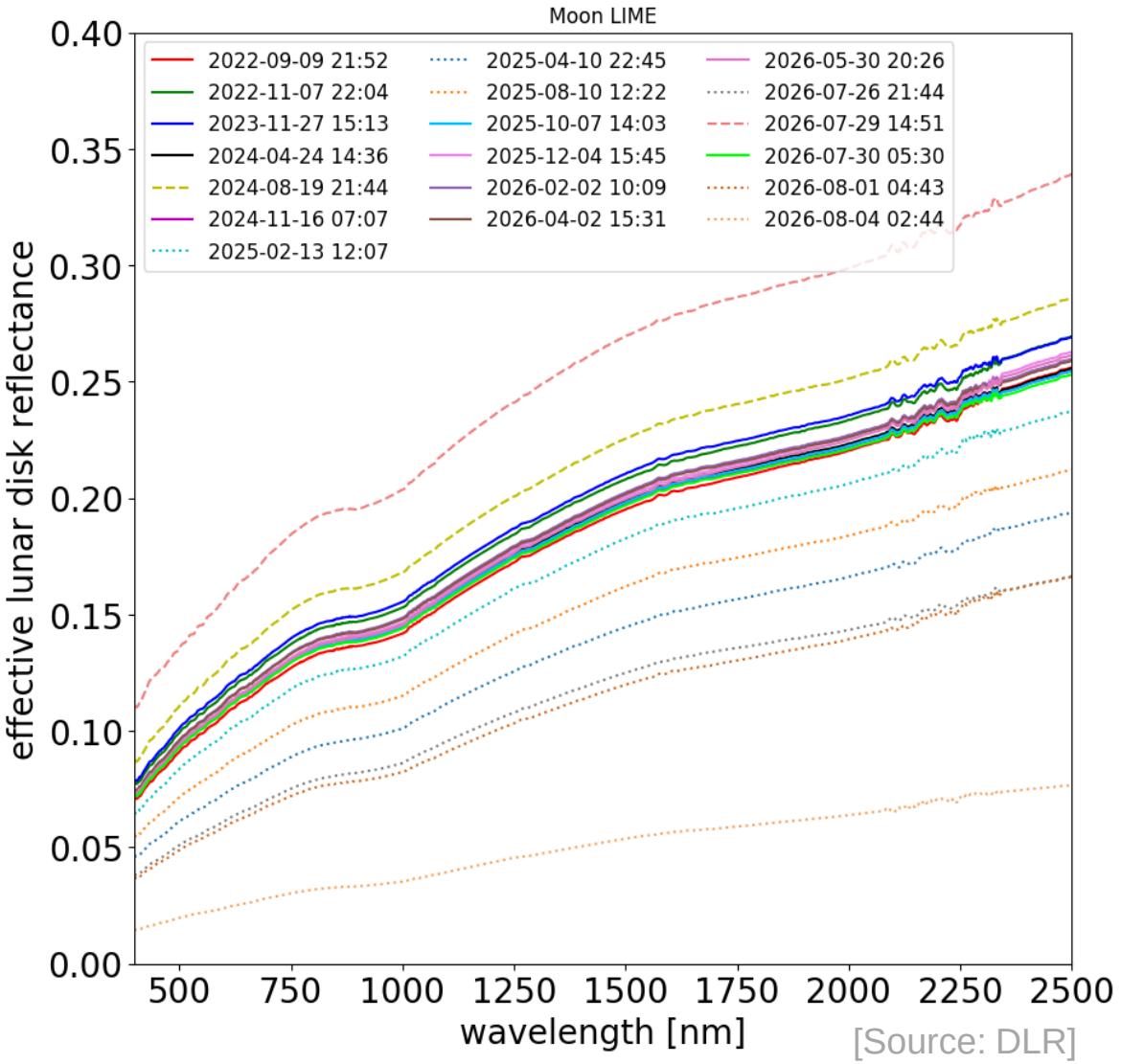
Processor V010601
LIME 1.4.1 (Nov 2025)

PRELIMINARY

dashed: |g|<5°
dotted: |g|>10°



[Source: DLR]



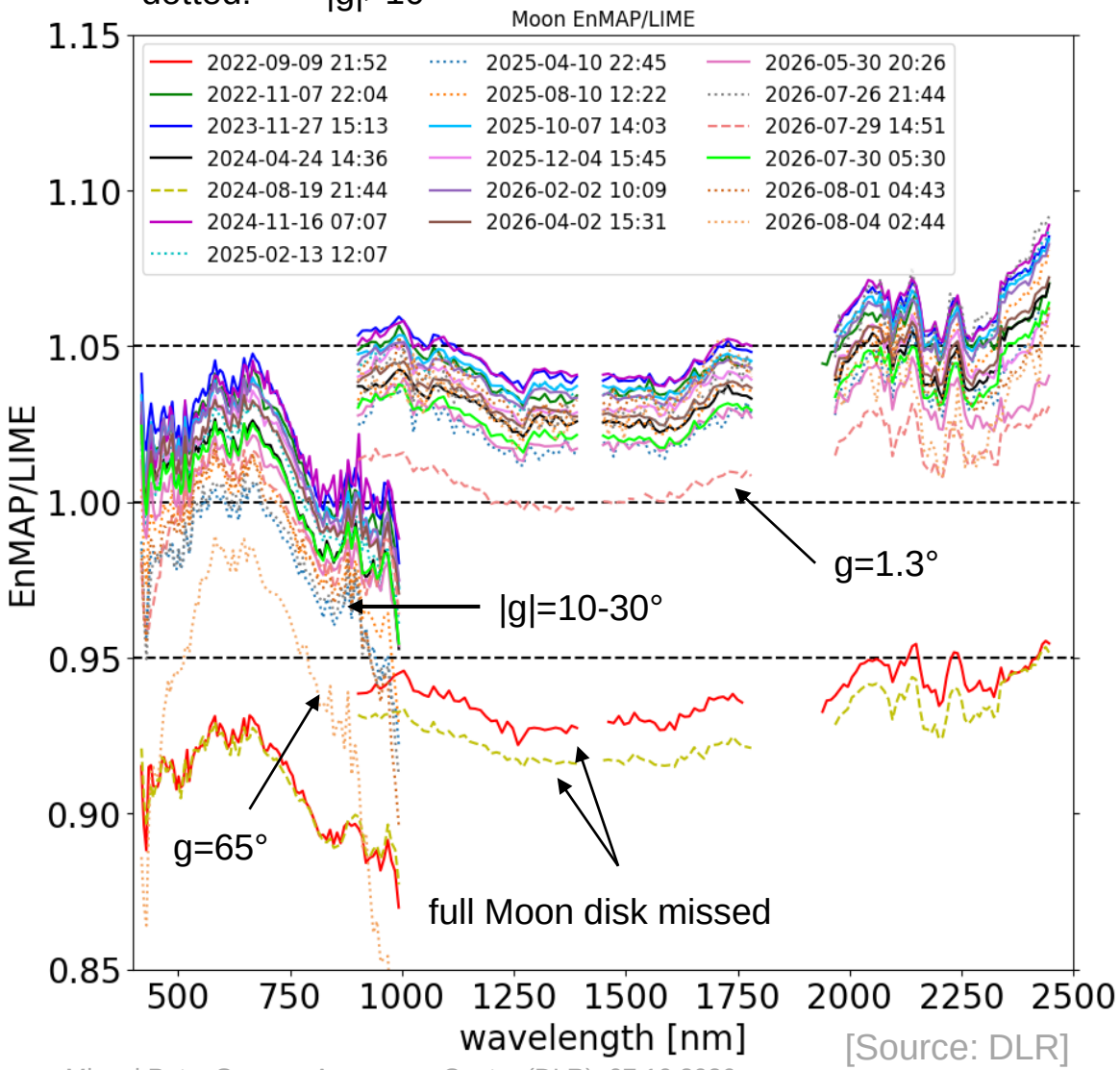
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EnMAP Moon data and models

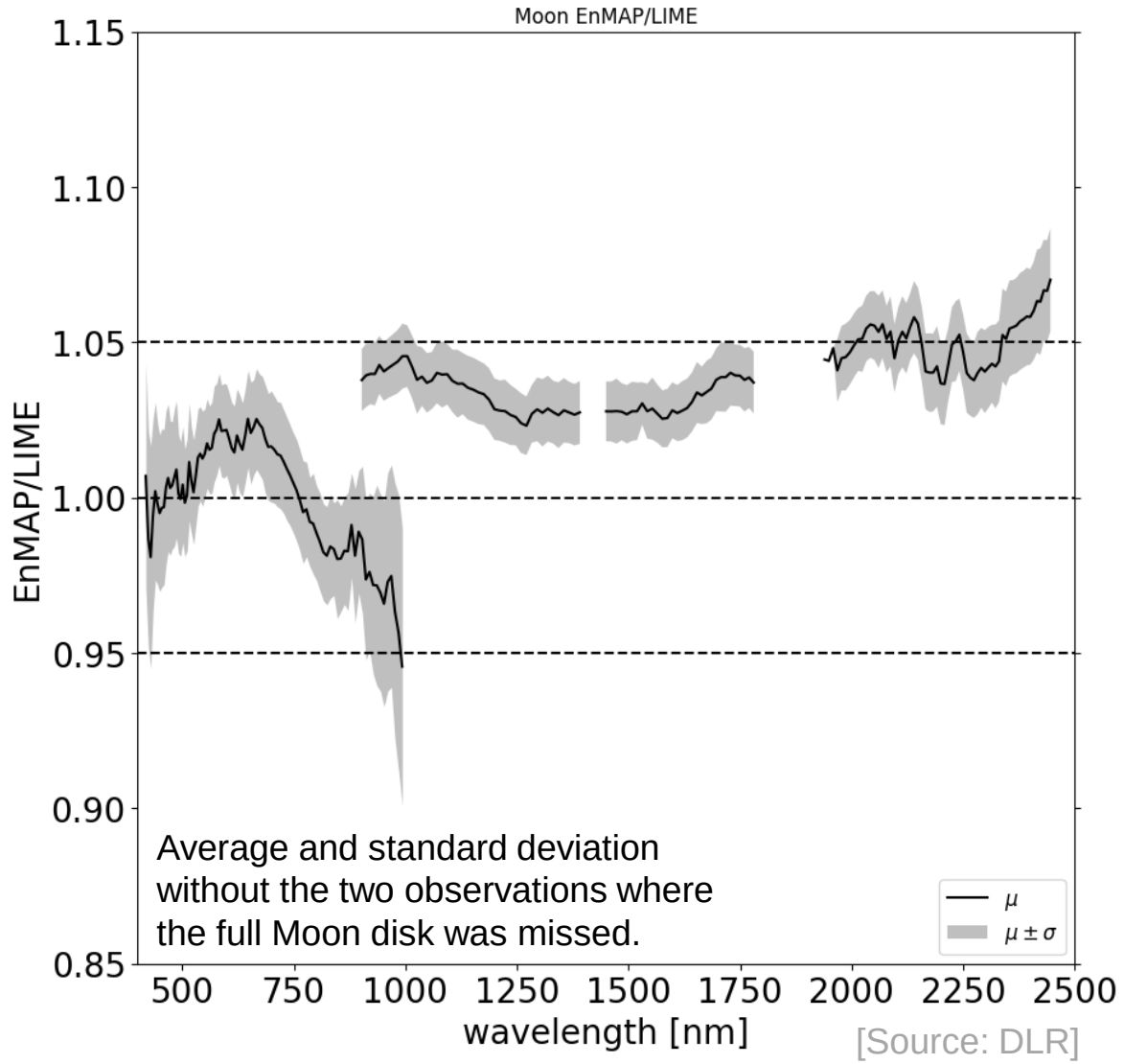
Processor V010601
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PRELIMINARY

dashed: |g|<5°
dotted: |g|>10°



[Source: DLR]



[Source: DLR]

Conclusion

Summary:

- EnMAP Moon data have proven very useful for instrument monitoring and radiometric validation, hopefully they will also become useful for lunar modelling in the future.
- EnMAP is within 5% of lunar models (ROLO/CNES, LESSRv3, LIME) with small intrinsic noise.
- Consistent deviations in VNIR (<600 nm, >900 nm) and SWIR (overall) also observed in Earth data and will be mitigated by on-going major calibration update (stay tuned!).

Outlook:

- After more than 4 years in space, EnMAP is in a mature phase with in-orbit calibration facilities working nominally and both VNIR and SWIR instruments stable.
- Five-year mission extension (Oct 2027 – Sep 2032) currently being considered.
- Moon observations routinely performed and it is planned to share the data in the near future (for EnMAP users with limited support).
- We expect to operate EnMAP for many years and continue providing high-quality data!

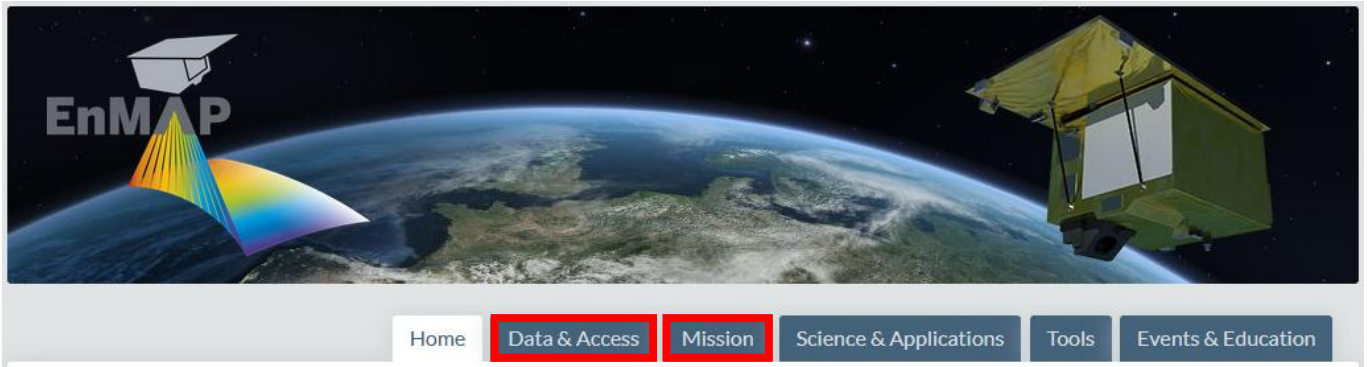
Acknowledgements

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Useful links:

- Tasking orders and catalog browsing:
  https://planning.enmap.org/
- Mission quarterly reports:
  https://www.enmap.org/mission/
- ICDs, ATBDs, FAQ, change log:
  https://www.enmap.org/data_access/

https://www.enmap.org/



Imprint

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