

250-m resolution lunar gravitational maps from gravity observed by satellites and gravity modelled from topography and 3D crustal density [EGU26-6331]

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What is LGM2026?

LGM2026 are Lunar Gravitational Maps 2026.

- LGM2026 shows the lunar gravitational field at the lunar surface and on its circumscribing sphere
- Depicted are the gravitational potential, vector and tensor at the spatial resolution of 128 pixels per degree (~250 m at the equator)
- The gravitational field is expanded into spherical harmonics up to degree 11,519 (Fig. 1)

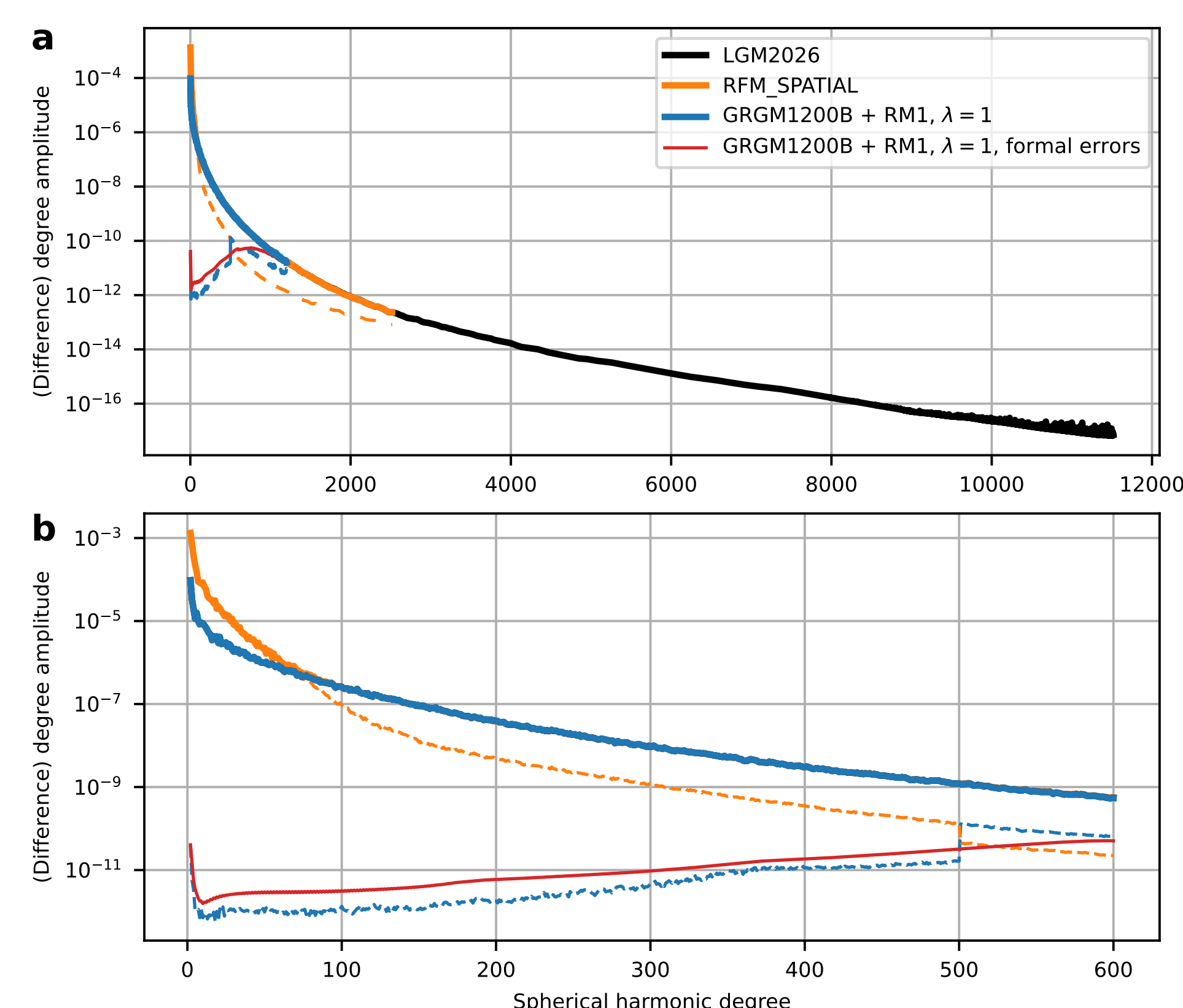


Figure 1. Comparison of LGM2026 with respect to GRGM1200B + RM1, $\lambda = 1$ [1] and RFM_SPATIAL [2]. Harmonic degrees 0 and 1 are omitted for better visualisation.

LGM2026 constituents

- **Long wavelengths** (up to degree 500): Kaula-constrained GRGM1200B [1]
- **Short-scale signals** (beyond degree 500): gravity-forward modelling of topography [3] and 3D crustal density [1] following the residual terrain modelling:
 - Masses up to 10° from evaluation points were gravity-forward modelled by tesserooids with radially variable density
 - Beyond the integration radius of 10° , spherical harmonic technique of [4] was used to gain efficiency

LGM2026 at the Apollo sites

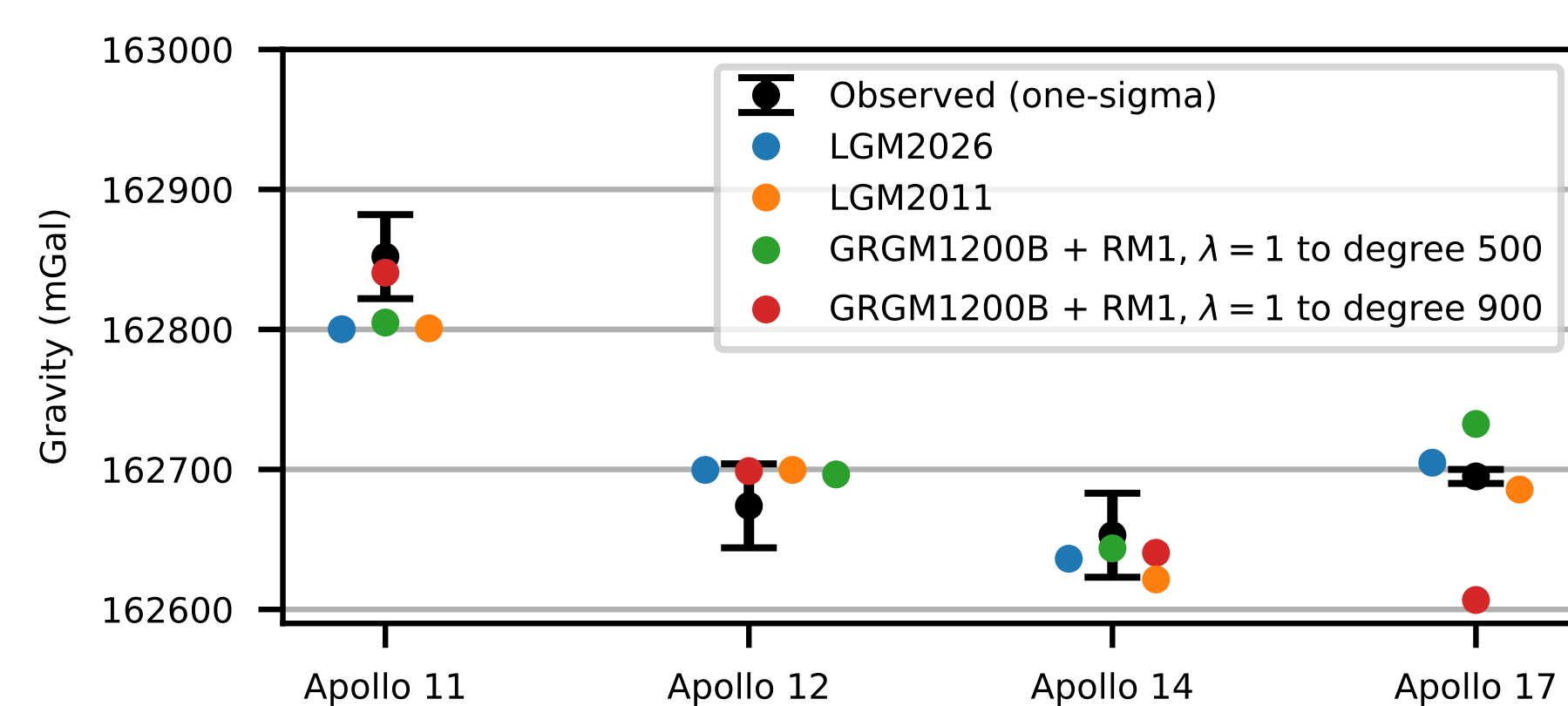


Figure 2. Gravity predictions at the Apollo sites compared to the observed gravity

LGM2026 at Artemis IV Candidate Landing Sites

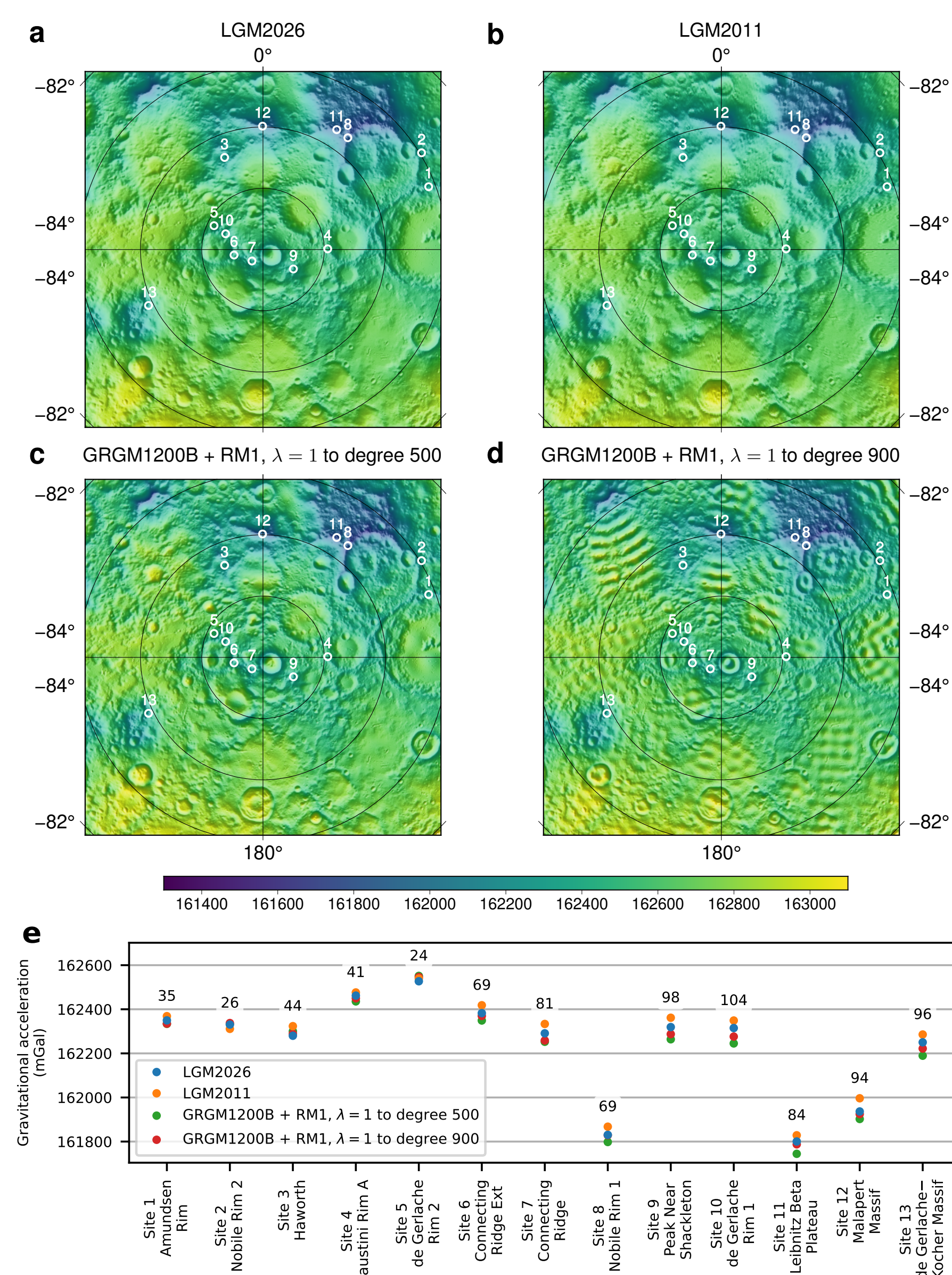


Figure 3. Gravitational acceleration over the south polar region (a to d). The panel (e) shows predictions of the gravitational acceleration at the 13 candidate Artemis sites for possible human landing. The values above the dots show the range of the discrepancies between the predictions. All values in mGal.

LGM2026 vs LGM2011

- New data: GRAIL, LRO, Kaguya, 3D density
- New modelling techniques: 3D density, high- and low-frequency RTM corrections

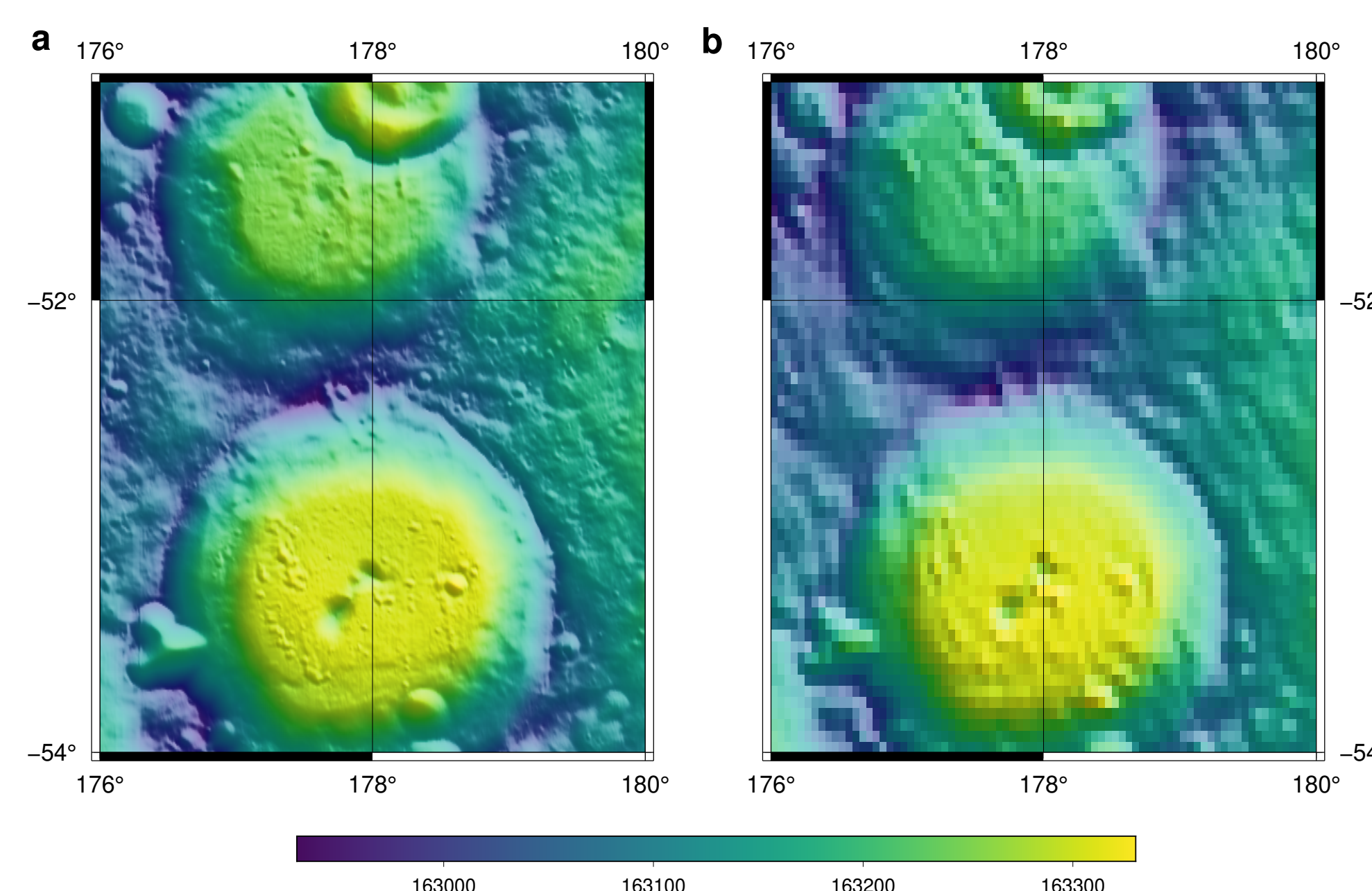


Figure 4. Gravitational acceleration from (a) LGM2026 and (b) LGM2011 [5]. The statistics of the differences over the entire lunar surface are $-220.3/203.2/0.5/22.8$ (min/max/mean/standard deviation). All values in mGal.

Commission errors

Commission errors were estimated based on:

- error propagation for GRGM1200B to degree 500 using 100 GRGM1200B clones,
- error propagation for topography and density (Monte Carlo method) and
- error analysis of gravity-forward modelling techniques.

Commission errors estimates:

- gravitational potential: $13 \text{ m}^2 \text{ s}^{-2}$ (2 to 3 orders of magnitude better for the disturbing potential),
- gravitational vector: 2 mGal,
- gravitational tensor: 250 E for the diagonal elements, a few tens of E for the off-diagonal elements.

Applications

- **Gravitational potential:** physically meaningful height system, study of gravity-driven mass movements and basalt flow direction
- **Gravitational vector:** gravity predictions at prospective landing sites, verification/calibration of accelerometer readings, inertial navigation
- **Gravitational tensor:** autonomous navigation of spacecraft based on gravity gradient measurements, upward/downward continuation of the gravitational potential and vector in mass-free space
- **Spherical harmonic expansion:** spectral-domain analyses at fine spatial scales, study of convergence/divergence of spherical harmonic at the lunar surface

Final Notes

- LGM2026 avoids divergence of spherical harmonics at the lunar surface
- Thanks to the strong correlation between the lunar topography and gravity, LGM2026 realistically models lunar gravity even beyond the GRAIL resolution
- Since short-scale LGM2026 signals come from topography and density, LGM2026 cannot be used for geophysical or geological interpretations at wavelengths shorter than 11 km at the equator
- LGM2026 is available at <https://doi.org/10.5281/zenodo.19365932> under the CC BY 4.0 license
- A new methodology was developed for high-resolution gravity field modelling with 3D variable densities at planetary bodies (applicable also to the Earth)

References

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- [3] G. A. Neumann, "LOLA MOON_PA gridded dataset [Data set]. NASA Goddard Space Flight Center Planetary Geodesy Data Archive," 2024.
- [4] B. Bucha, "Spectral gravity forward modelling of 3D variable densities using an arbitrary integration radius with application to lunar topographic masses," *Journal of Geodesy*, vol. 99, no. 31, 2025.
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