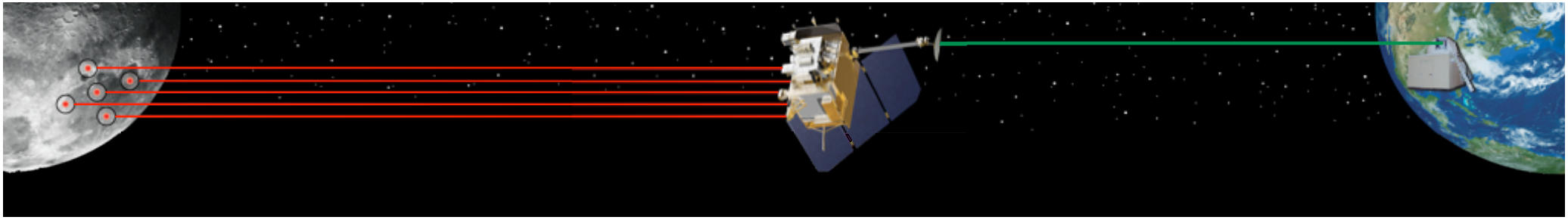

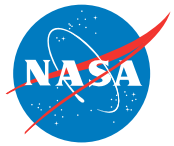

New High-Resolution Polar Topographic models from LRO/LOLA

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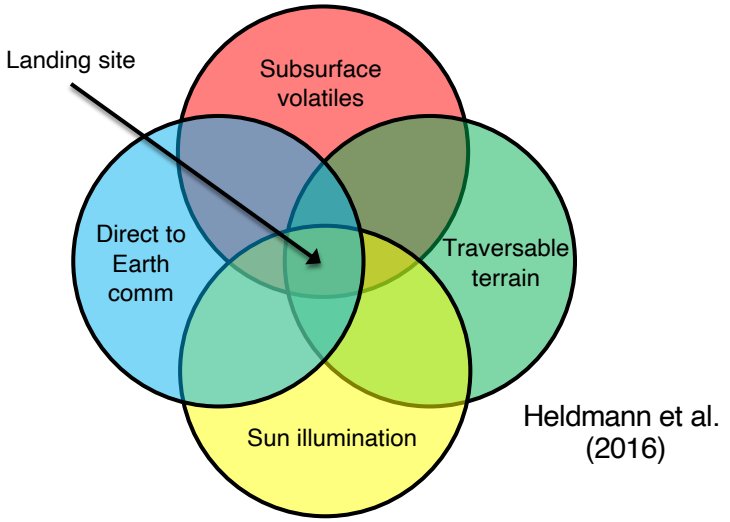
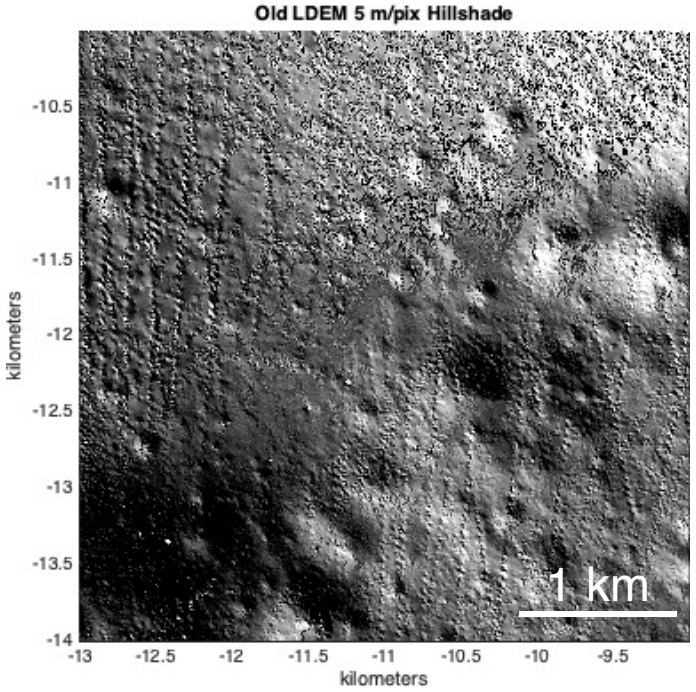
Greg Neumann (GSFC), Dave Smith (MIT), Maria Zuber (MIT)
& the LOLA Science Team

Detailed and accurate topographic maps are critical inputs to mission & site planning.

- Subsurface volatiles, traversable terrain, sun illumination, direct-to-Earth comm.
- Need to know the topography both *outside* and *within* permanently shadowed regions on lander-relevant scales.
- Imaging-based techniques face challenges in polar regions due to the extreme shadowing.
- LOLA not hindered by shadows, but by gaps between tracks and laser spots which require interpolation to fill in.
- Small errors in the LRO orbit reconstruction (~ few meters horizontally & ~0.5 m vertically) can cause streaky artifacts in a LOLA digital elevation model (DEM) at ~5 m/pix.
- Estimating and mitigating these issues are two of the primary goals of this work.

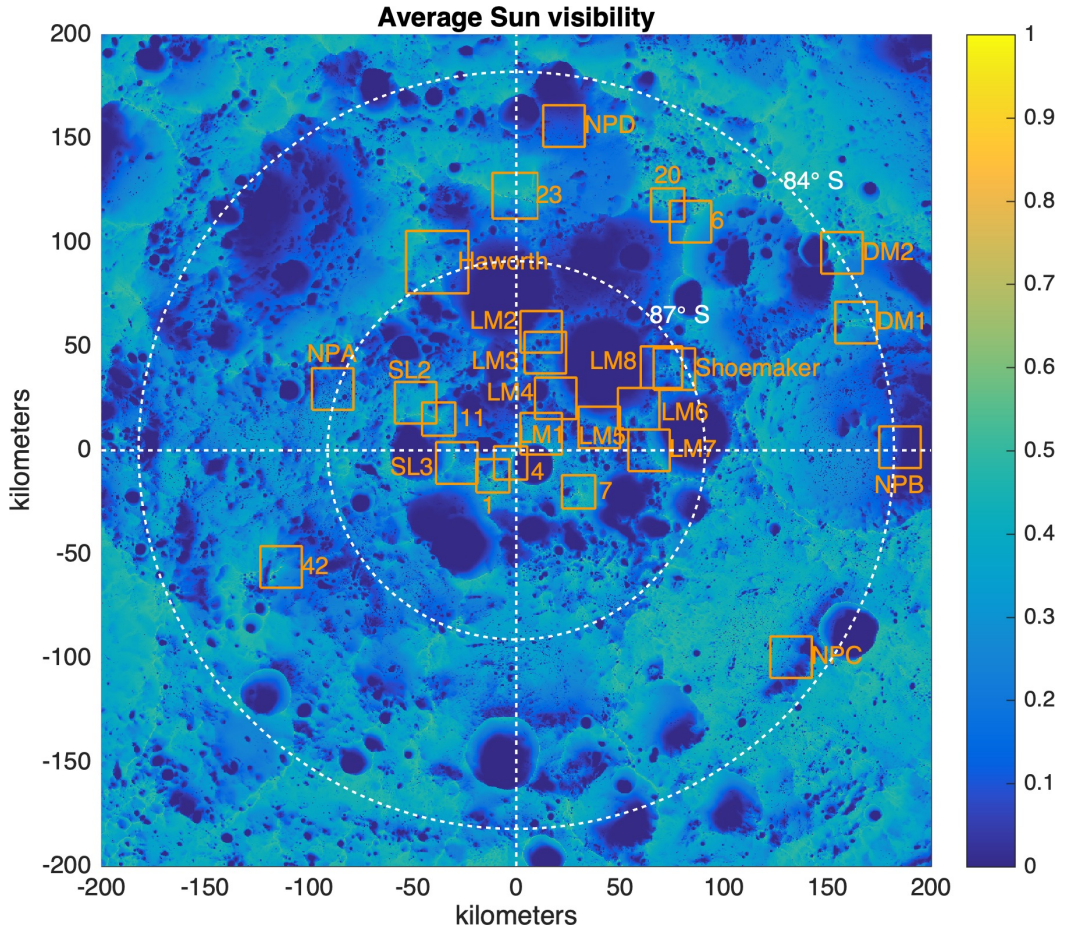


Heldmann et al. (2016)

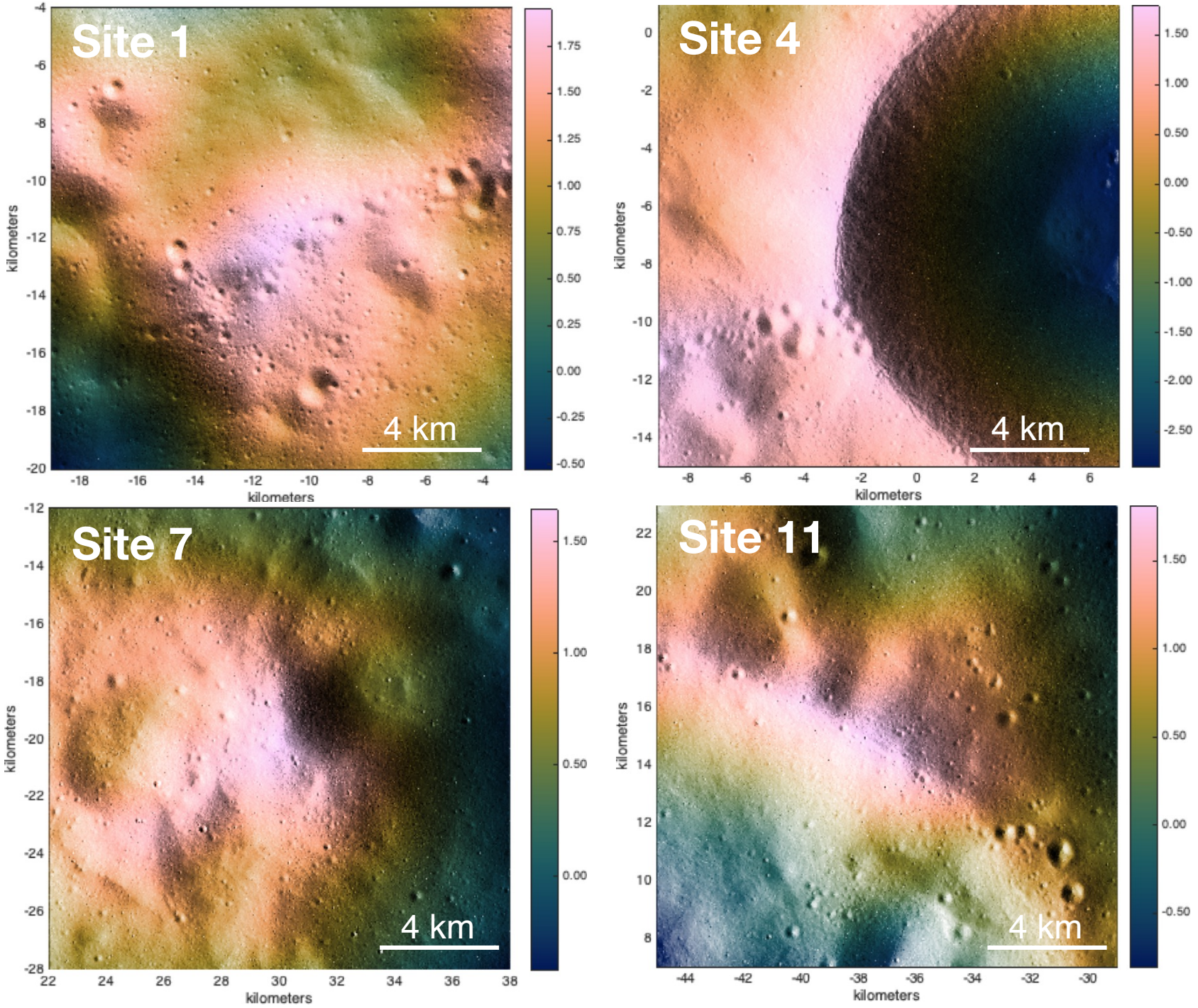


Background

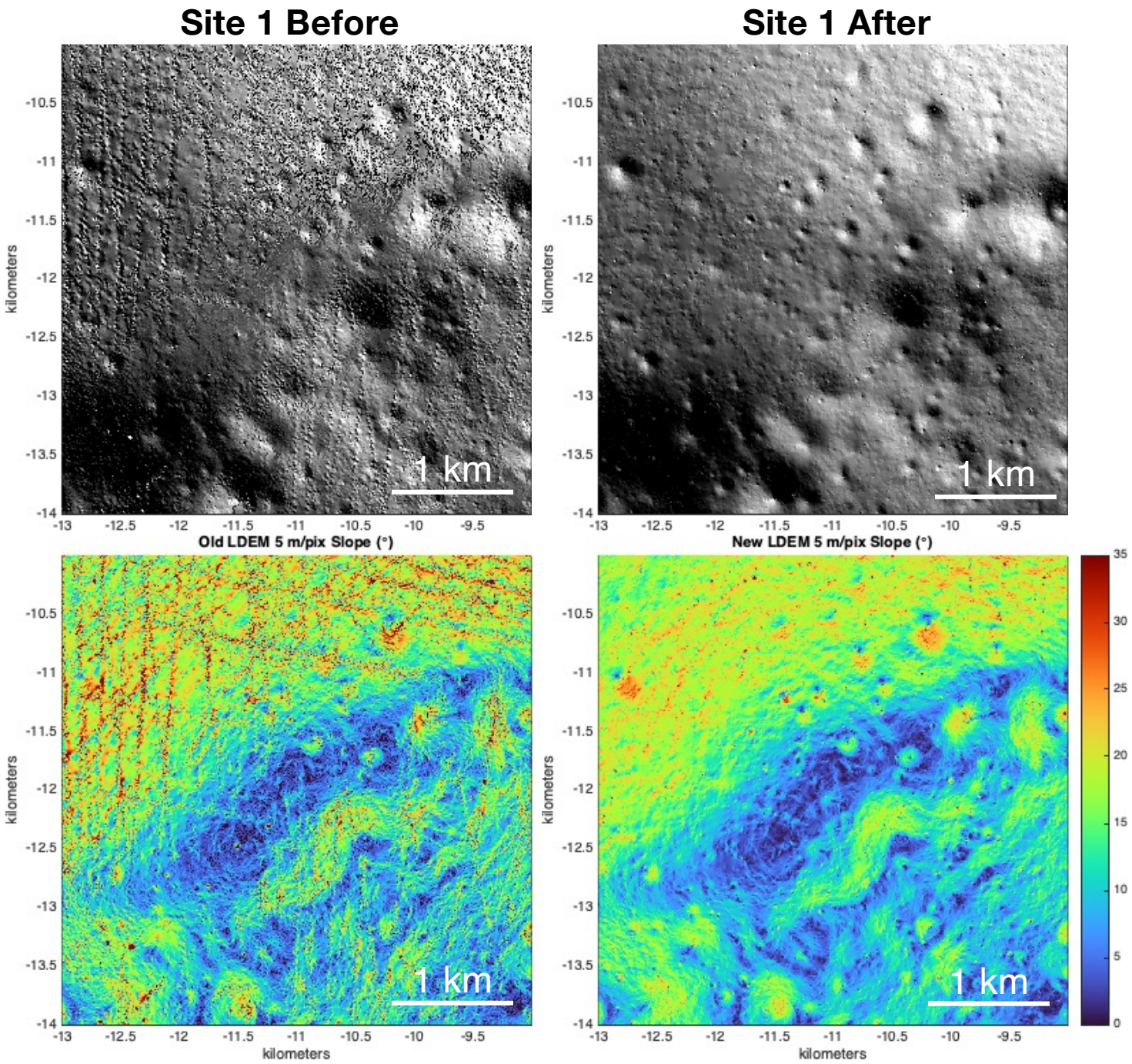
- To support Artemis and CLPS, we are updating the LOLA DEMs and quantifying their uncertainties.
- An updated 5 m/pix LOLA DEM, *with uncertainty estimates*, is more useful to landing site studies and as a constraint to higher-res models.
- The new methodology is applicable to both polar regions, but we currently focus on high-priority south pole sites



- DOI: 10.1016/j.pss.2020.105119
- Data: https://pgda.gsfc.nasa.gov

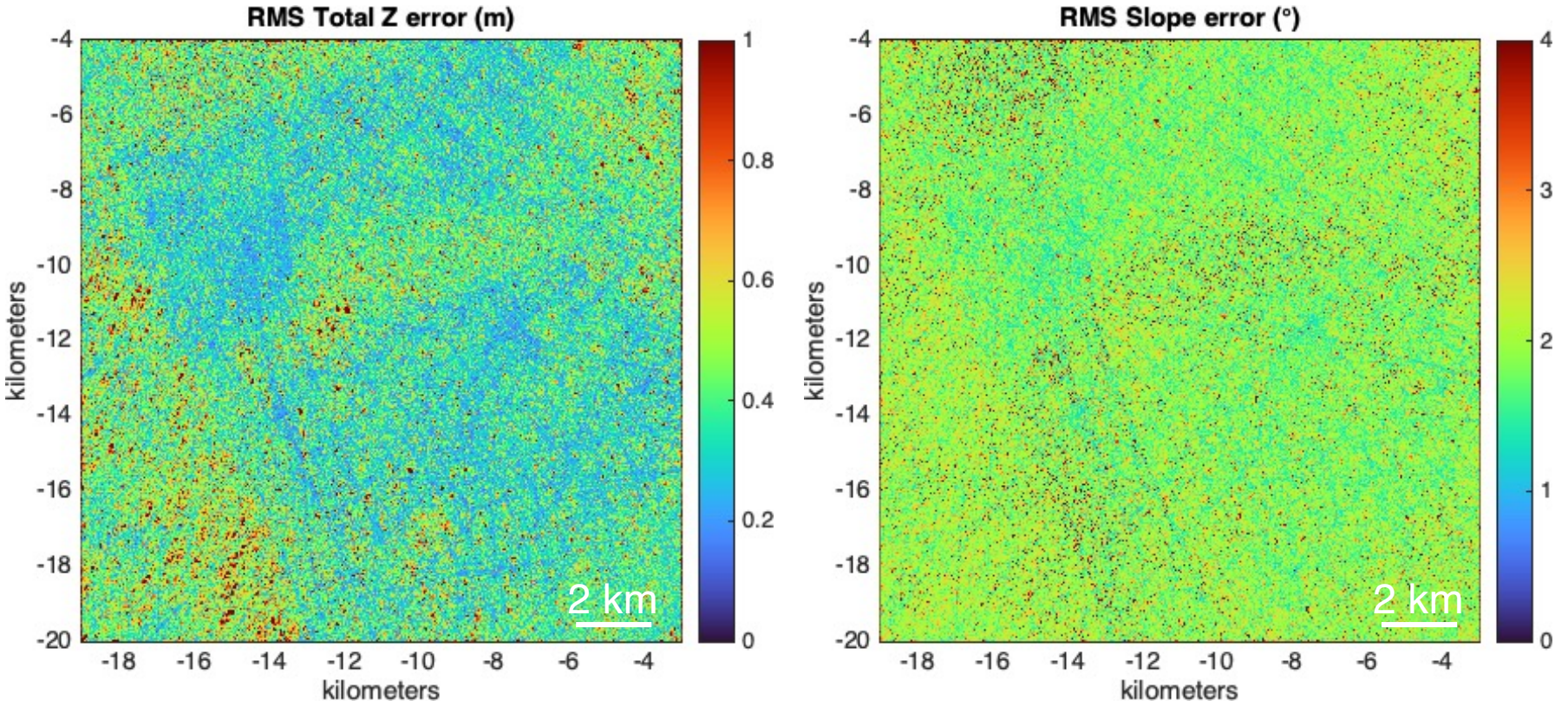

Site 1
4 km
kilometers
kilometers
Site 4
4 km
kilometers
kilometers
Site 7
4 km
kilometers
kilometers
Site 11
4 km
kilometers
kilometers

Improved DEM



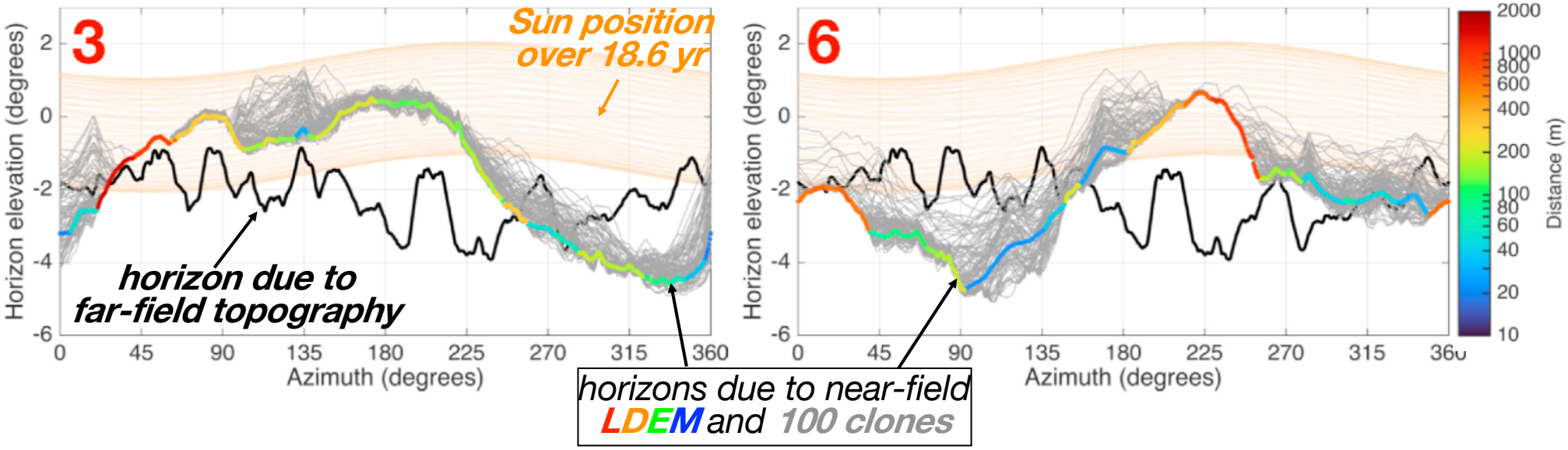
Assessing Uncertainty

- Typical height/slope RMS uncertainties are 0.3-0.5 m / 1.5-2.5°
  - Interpolation and slope error are spatially correlated with gap size (effective resolution) and with slope.
  - Can be used as weight maps when constraining higher-resolution models, solar array height, traverse planning, etc.



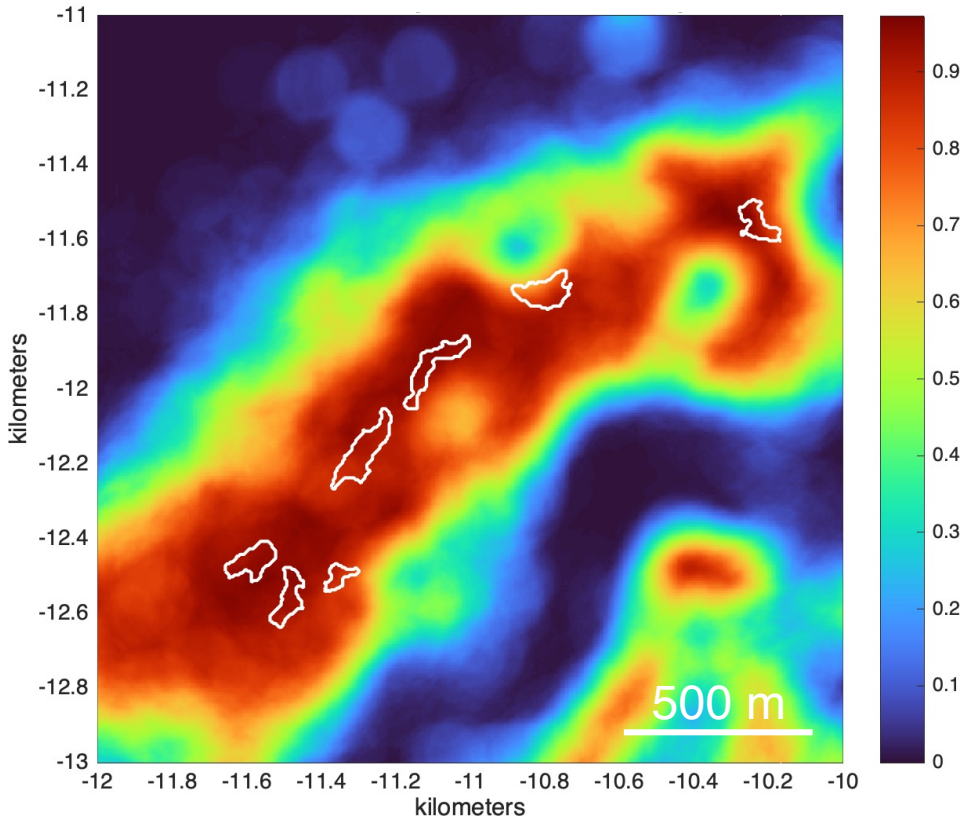
Assessing the Impact of Uncertainty

- We use the nominal DEM and its 100 clones to evaluate statistical spread of illumination condition properties
  - surface height errors translate to near-field horizon elevation errors and variations in illumination conditions.

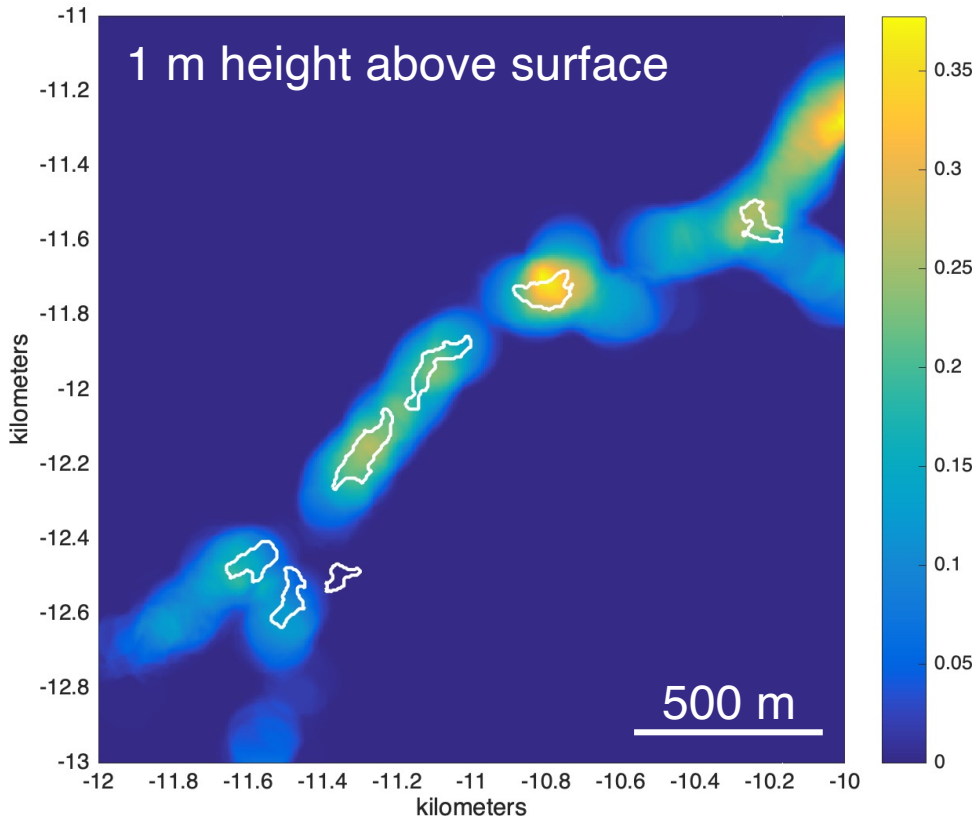


- We do that for the whole map at 2 heights above the surface
- Figures of Merit: Average illumination, Longest day, Longest night

Uncertainties can be incorporated into trades (e.g. slope, longest night, landing ellipse, etc.)



Minimum fraction of pixels within 100 m with slope < 8°



Minimum fraction of pixels within 100 m with longest night < 14 days in 2024 – 2025

Summary

- New high-resolution topographic maps of high-priority lunar south pole landing sites based exclusively on LOLA data.
- These DEMs have accurate geodetic control and are unaffected by shadows.
- Most of the 5-m pixels are interpolated due to LOLA's cross-track and inter-spot spacing, but the interpolation errors are quantifiable.
- Height uncertainties propagate to variations in horizon elevation and thus the predicted illumination conditions.
- Error characterization can inform landing site studies and figures of merit.
- For small-scale detailed site studies, we recommend using all available datasets together (LOLA, images, image-based DEMs)

Paper: https://doi.org/10.1016/j.pss.2020.105119

Data: https://pgda.gsfc.nasa.gov

The End