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Connecting Ridge - A landing site at the lunar south pole with extended illumination

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Abstract

Illumination conditions of the lunar south pole are investigated using a 20 m/pixel Digital Terrain Model (DTM) derived from tracks of the Lunar Orbiter Laser Altimeter (LOLA). We examined areas near the south pole, in particular a possible landing site residing on a ridge connecting the de Gerlache and Shackleton craters, referred to as Connecting Ridge [1]. Illumination conditions were simulated at surface level but also at the height of a possible solar panel of a rover or lander, specifically we chose heights of 2 m and 10 m above ground. The chosen time period, over which illumination conditions are simulated, is 19 years exceeding the lunar precessional cycle of 18.6 years. Locations receiving sunlight for 92.3% and 95.66% of the time can be identified at heights of 2 m and at 10 m above ground, respectively. The longest continuous periods in darkness are typically only 3-5 days at these locations, which makes the exclusive use of solar panels over long mission durations achievable.

1. Introduction

Due to the low inclination of 1.54° of the lunar rotational axis with respect to the ecliptic, extreme illumination conditions can be observed at the poles. As a result locations in permanent shadow and almost continuous sunlight can be found. Permanently shadowed areas (PSA), usually crater floors, can harbor water-ice and can exist in the immediate vicinity of almost continuously illuminated areas. These locations are of interest for future lunar landing missions due to the extensive illumination conditions and the proximity to potential water-ice reservoirs for scientific exploration. To simulate illumination conditions the so-called horizon method was implemented [2]. An adjusted, south polar LOLA DTM of 20 m resolution serves as the data base for the simulation [3]. In this work an in depth investigation of polar illumination conditions for a study area of 20 x 20 km, especially for the Connecting Ridge (CR1) landing site, is presented (name of landing site was adopted from [1]).

2. Method

The goal is to derive illumination characteristics for polar landing sites at any given moment in time and for any time span. The horizon method places an observer on the DTM and determines the shape of the horizon at this particular location. An horizon is fully described by the location of the observer in combination with the azimuths and corresponding elevation angles. The azimuth is evaluated in steps of 0.5°, coinciding with the angular size of the Sun as seen from the Moon. By repeating this for every pixel within the defined study area, the maximum elevation angles for each location in all azimuthal directions are known. For each azimuth one file is stored containing the maximum elevation angle for each location. The azimuth and elevation of the Sun at any specific time can now easily be compared to the corresponding file created at the same azimuth. Treating the Sun as a disk rather than a point, the comparison of the elevation angles of the horizon to the elevation of the Sun will allow us to consider partial illumination by the solar disk.

3. Results

Accumulated illumination maps revealing the percentage of illumination over a specific time span can be derived by stacking the illumination maps created at each time step. Such an accumulated map showing the illumination at surface level over 20 years and evaluated in 1 h time steps, is displayed in Fig. 1. In Fig. 2a,b

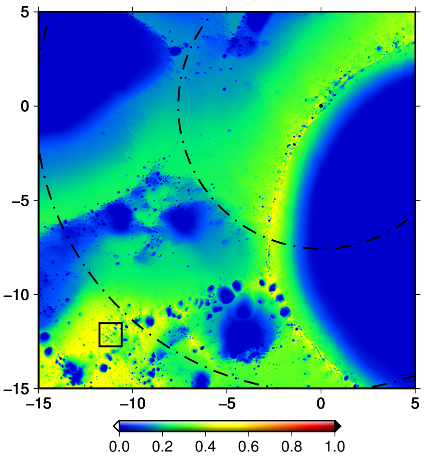

Figure 1: Accumulated illumination over 20 years for the 20 x 20 km study region at the lunar south pole. The CR1 landing site, and parallels every 0.5° are highlighted. Units in km and gnomonic projection.

accumulated illumination maps for CR1, evaluated at 2 m and 10 m above ground, are shown. For spot 1 we find an average of 88.1% illumination when evaluating 2 m above ground. Here, the longest continuous periods in darkness and light are 4.58 and 233.87 days respectively. Further, spot 1 is in light for 92% of the time and consequently only 8% in complete darkness. However, the location exhibiting the shortest accumulated time in darkness is found at spot 2 and amounts to 7.7%. Therefore this location is illuminated for 92.3% of the time. The longest continuous times in darkness and light are 4.62 and 233.87 days respectively with an average illumination of 87.9%. Spot 1 and 2 are next to each other and are displayed in Fig. 2a.
At 10 m above ground we find spot 3, the location with the highest accumulated illumination of 92.5%. This location is 95.6% of the time illuminated and 4.4% in darkness, with the longest continuous times in darkness and light amounting to 3.08 and 262.42 days. Similar to the result at 2 m above ground the location with the longest accumulated period in light does not coincide with the location receiving the highest accumulated illumination. Spot 4 is in light for 95.66% of the time leaving it in darkness for only 4.34%. With an average illumination of 91.9%, the longest continuous period in darkness and light are 3.17 and 262.42 days. Spot 3 and 4 are 90 m apart and are displayed in Fig. 2b.

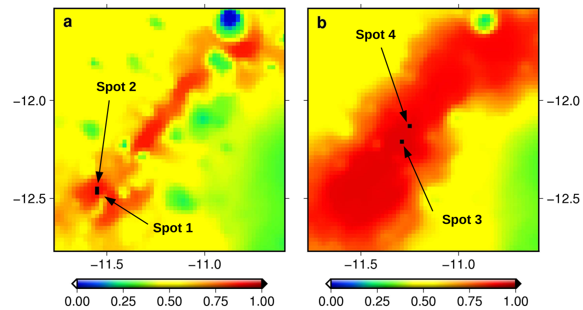

Figure 2: Accumulated illumination over 20 years at the CR1 landing site. (a) Evaluated 2 m above ground. (b) Evaluated 10 m above ground. Units in km and gnomonic projection.

Spot	Coordinates	h [m]	∅ill. [%]
1	89.4395°S, 222.8066°E	2	88.1
2	89.4399°S, 222.8524°E	2	87.9
3	89.4516°S, 222.7581°E	10	92.5
4	89.4544°S, 222.8445°E	10	91.9

4. Summary and Conclusions

In this work we could show that a lander or rover landing at CR1 will benefit from excellent illumination conditions and will only need to survive periods in darkness of less than 5 days. We could also show that elevating a solar panel above ground will significantly raise the hours of received sunlight.

Acknowledgments

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