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Imaging analysis of Kaguya Lunar Radar Sounder off nadir echo data

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Abstract

We attempted surface imaging of the Moon using the off nadir echo data of Kaguya Lunar Radar Sounder (LRS). The primary purpose of this attempt is to detect very shallow subsurface signal of geologic structure such as lava tube which would not be discerned in nadir echo analysis due to poor range resolution of the LRS. The LRS range-echo data was mapped (projected) to the lunar surface, considering the lunar surface terrain elevation, to produce a mosaic image of the Moon. Multiple orbit data allows us to resolve the mirror image problem (one cannot discern which side of the orbit the received echo comes from because of the axisymmetric radiation pattern of a dipole antenna). Produced image is carefully checked in comparison with optical surface images. Preliminary analysis proved that LRS can image surface features such as craters, ridge systems and rilles.

1. Introduction

Kaguya LRS is an HF (5 MHz) radar sounder which flew to the Moon to explore subsurface geologic structure [3]. LRS successfully found layering structures in maria but the area where subsurface layering was found was rather limited. In addition, the apparent depth range of the layering structure was limited only to ~1000 meters at the maximum. The rest of LRS data in farther ranges was regarded as off nadir surface echoes. However, the "surface" echo of an HF radar such as LRS and MARSIS contains information of shallow subsurface (near surface) medium [1] [2], which is true not only to nadir echoes but also to off nadir echoes. This fact motivated us to make an attempt to extract subsurface information from off nadir echoes of LRS observation. In this study, we mapped (projected) LRS off nadir echoes to the lunar surface to make mosaic images of off nadir lunar surface, and, by doing so, we pursue shallow subsurface geologic structure.

2. Data mapping (projection)

Provided the nadir surface range being as the reference range, the LRS data in the range of 1000 m to 7000 m was mapped (projected) to the lunar surface which was defined by Kaguya Digital Terrain Model data [4]. Consideration of surface terrain elevation prevent the image from suffering "layover" problem. Gain control was applied so that the echo intensity variation as a function of range is flattened thus the detail feature of produced mosaic image is better recognized at visual inspections. Direction of LRS illumination, i.e. westward/eastward, was considered when the data was projected, and, as results, two images are produced for each imaged area. They should provide useful information concerning surface and shallow subsurface features when the image is interpreted

3. Preliminary result – Aristarchus plateau

Figure 1. shows the LRS projection images of Aristarchus plateau with a Kaguya Terrain Camera (TC) image as the reference. Aristarchus crater and neighboring Herodotus as well as Vallis Schröteri are well recognized in both westward illumination image and the eastward illumination image. Other rille systems and minor craters are also recognized but appears less prominent than major features. It should be noted that those features appear differently depending on the illumination direction of LRS. An interesting observation is that the plateau appears a little darker than surrounding mare plane, which suggests that the plateau surface is less rough in term of the LRS wave length scale (60 m) than surrounding mare surface.

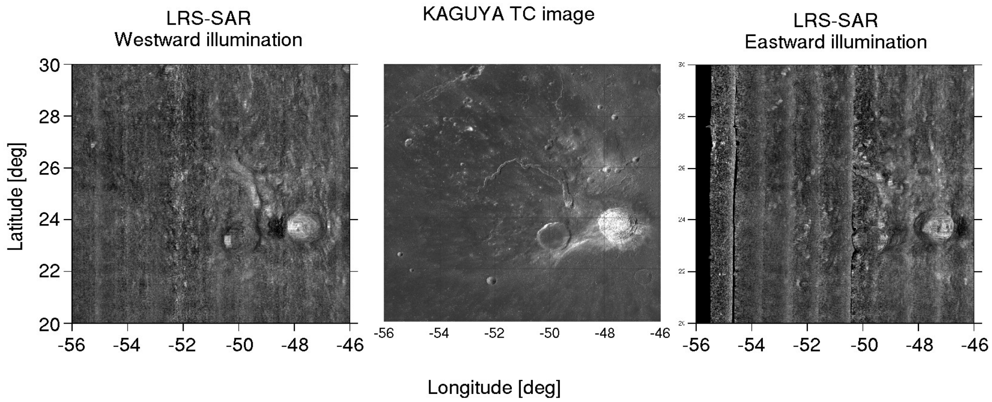

Fig. 1 Aristarchus plateau: LRS projection image of westward illumination (left), Kaguya TC image (center), and LRS projection image of eastward illumination (right).

4. Summary and Conclusions

We have established a procedure of LRS range-echo data mapping (projection) onto the lunar surface. The procedure takes into account the surface terrain elevation based on Kaguya DTM data. Global mapping (projection) work is currently in progress. Establishing a simulation procedure of LRS observation is also in progress so that suspicious features found in the LRS image is examined by simulations. The simulation is designed based on Kirchhoff approximation theory and Kaguya DTM is incorporated.

Acknowledgements

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