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Lunar brightness temperature from Microwave Radiometers data of Chang'E-1 and Chang'E-2

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Abstract

Both of the Chinese lunar orbiter, Chang'E-1 and Chang'E-2 carried Microwave Radiometers (MRM) to obtain the brightness temperature of the Moon. Based on the different characteristics of these two MRMs, modified algorithms of brightness temperature and specific ground calibration parameters were proposed, and the corresponding lunar global brightness temperature maps were made here. In order to analyze the data distributions of these maps, normalization method was applied on the data series. The second channel data with large deviations were rectified, and the reasons of deviations were analyzed in the end.

1. Introduction

Lunar exploration is the current focus of international deep space exploration. China have launched two lunar orbiters- Chang'E-1 on October 24, 2007 and Chang'E-2 on October 1, 2007. They both carried MRMs which were multi-band microwave radiometers with operation frequencies of 3.0GHz, 7.8GHz, 19.35GHz and 37.0GHz. The scientific object of Microwave Radiometers is to survey the radiation brightness temperature of the lunar surface, by which we can retrieve Lunar regolith depth and evaluate the reserve of He-3 and its distribution on the moon. The only difference between these two payloads is the installation angle of the cold horn. The 3GHz channel calibration antenna of Chang'E-2 MRM was set along X axis, 15°away from Z axis, for the reduction of effects from Sun and Earth.

2. Data processing

Chang'E-1 MRM and Chang'E-2 MRM data were received and processed by Ground Research and Application System (GRAS) which is affiliated to the National Astronomical Observatories, Chinese Academy of Sciences (NAOC). The data processing procedure include three stages:

(1) antenna temperature calibration

(2) geometrical positioning

(3) brightness temperature calculation

As the most important stage in the data processing, the antenna temperature calibration consists of algorithms as follows: data filtering, calibration and observation data averaging, sun-cold horn angle checking and flagging, and two-point calibration.

There were some improvements in the antenna temperature calibration of Chang'E-2 MRM from Chang'E-1 MRM, we took nonlinear correction into consideration and flagged the data when the sun was in the view of the cold horn antenna.

After the antenna temperature was calculated, the geographic information such as latitude, longitude and altitude were added into the data by geophysical algorithms. At last, the brightness temperature of the lunar surface was obtained through brightness temperature calculation.

3. Pre-launch calibration

For examining the MRMs' hardware transfer model, pre-launch calibration experiments of the two MRMs were carried out by the Center for Space Science and Applied Research, Chinese Academy of Sciences (CSSAR) ([1]). The calibration experiments were not performed in the vacuum environment but in laboratory at the room temperature. For Chang'E-1 MRM, the instrument temperature was constant,

while Chang'E-2 MRM was tested in different instrument temperature varied from 290K to 315K.

4. Results analysis

Using the processed data, we made the global brightness temperature maps of the moon. After "normalization" of the brightness temperature, we find that there were some differences between the two MRMs data series. In the region of 50°N-50°S on the moon, the night brightness temperature differences between Chang'E-1 MRM and Chang'E-2 MRM were 5-10 k on 3.0GHz channel, 0-5 k on 19.35GHz and 10 k on 37GHz. But on 7.8GHz, the brightness temperature of Chang'E-2 MRM is 25-30k lower than that of Chang'E-1 MRM.

6. Summary and discussion

In this paper, the processing method of the MRM data were described, and the results of Chang'E-1 MRM and Chang'E-2 MRM were compared. It is concluded that the brightness temperature was mostly affected by the illumination, and at the same location, the brightness temperature at daytime is larger than that at night. The brightness temperature at night is linearly related to the time angle. The brightness temperature was reduced at higher latitudes, and the maximum value appears near the equator, while the minimum value appears near polar region.

When processing the CE-2 MRM data, some modifications were applied in pre-launch calibration. The calibration experiments were taken under different temperatures, and the specific systematic nonlinear parameters were calculated. These modifications made the calibration more suitable for CE-2 MRM data.

As the 7.8GHz channel brightness temperature value of CE-2 MRM was much less than expected, it is assumed there are some errors in this channel data, so some statistic methods were adopted to correct these data.

References

[1] Wang Z.-Z., Li, Y., Zhang, X.-H., Jiang, J.-S., Xu, C.-D., Zhang, D.-H., Zhang, W.-G., Calibration and brightness temperature algorithm of CE-1 Lunar Microwave Sounder (CELMS), *Science China Earth Sciences*, vol. 53, pp. 1392-1406, 2010.