Lunar Surface Microwave Observations of Brightness Temperature Collected with the Chang’E 2

Yesenia M. Rivera-López1,2; Angel Andino-Prieto2; Yan Su Ph.D.1
1Arecibo Observatory - Universidad Metropolitana - Universidad de Puerto Rico
2Ana G. Mendez University System
3National Astronomical Observatories Chinese Academy of Sciences

Abstract
Chang’E is a series of spacecraft missions to study the Moon surface supported by the China National Space Administration. A multi-channel microwave radiometer on board Chang’E 2 (CE-2) has the purpose of measuring the microwave thermal emissions from the lunar surface [et al. Gong and Jin 2012] with working frequencies of 3.0 GHz, 7.8 GHz, 19.35 GHz and 37.0 GHz. Studying the Moon allows us to expand the scientific knowledge with new discoveries; also Moon’s exploration plays a critical role in understanding our Solar System and the Universe. Obtained observations from the CE-2 microwave radiometer about the lunar surface have been analyzed. Brightness temperature (Tb) is defined as the temperature a blackbody would be in order to produce the radiance perceived by the sensor [see, e.g., Goddard Earth Science Data and Information Services Center website of the National Aeronautics and Space Administration]. By the use of the Interactive Data Language (IDL) the datasets of Tb of each ingested of eight Moon’s periods. The extracted Tb data values were plotted with their coordinate’s points of longitude vs. latitude. To reconstruct the Tb the data points were interpolated in order to generate a mapping plot with distributed colors of the Tb from the lunar surface, known also as a contour plot. The returned values were a two-dimensional floating point array. The 37.0 GHz channel of microwave data reflect better the lunar surface. Afterward, the landing sites ranges of Apollo 11 and Chang’E 3 were used to display a contour plot of the reconstructed Tb.

1. Theoretical Background
A moon is defined as a celestial body that makes an orbit around a planet. Since the first space exploration started, our Moon has been a celestial object to study. It is the only natural satellite, which orbits around Earth in a period of around 27 days. Studying the Moon let us expand the scientific knowledge with new discoveries. Explorations made will definitely benefit life on Earth.

2. Chang’E Missions

2.1. Attempt to the Moon

Russia: Luna 2 (1959)
First spacecraft to visit the Moon.

United States: Apollo 11 (1969)
First manned mission to land on the Moon and made the first steps by humans on another planetary body.

China: Chang E’1 (2007)
First attempt in history to measure the brightness of the lunar surface.

3. Objective

3.1. Analyze observations from the CE-2 microwave radiometer.
3.2. Generate a mapping plot with the distributed colors of Tb from the lunar surface.

Background Information

• Lunar Surface - composed of minerals, rocks, and others.
• Tb - temperature a blackbody would be in order to produce the radiance perceived by the sensor.
• x - longitude
• y - latitude
• z - Tb

4. Implementation
4.1. Data Analysis:
Observations collected in eight periods of the Moon have been analyzed.

<table>
<thead>
<tr>
<th>Night Period</th>
<th>Data Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>610 210</td>
</tr>
<tr>
<td>2</td>
<td>511 959</td>
</tr>
<tr>
<td>3</td>
<td>586 814</td>
</tr>
<tr>
<td>4</td>
<td>557 744</td>
</tr>
<tr>
<td>5</td>
<td>613 200</td>
</tr>
<tr>
<td>6</td>
<td>597 641</td>
</tr>
<tr>
<td>7</td>
<td>508 283</td>
</tr>
<tr>
<td>8</td>
<td>225 477</td>
</tr>
</tbody>
</table>

5. Discussion

• A comparison from my work to previous results of longitude vs. latitude plot.
• An accuracy in the results was found.

6. Results
6.1. Mapping of the Lunar Surface Brightness Temperature

Figure 4. Contour display with distribute colors of Tb

6.2. Whole Moon Mapping

Figure 6. Moon Plot whit all the periods.

7. Conclusions

• Demonstrate of Tb in the night periods of Moon were displayed in multi-color and gray scale.
• 37GHz channel of microwave data reflect better the lunar surface.

8. Further Work

• Conversion from Regular plots images to High Resolution images.
• Conversion of the landing sites missions (Luna, Apollo and CE-3) displaying the whole Moon.

References


Acknowledgments
This work was performed under the auspices of the National Science Foundation, National Astronomical Observatories Chinese Academy of Sciences and Ana G. Mendez University System. Thanks to my mentor: Dr. Yan Su. Special thanks to Angel Andino, Jonathan Freedman, Robert Menging, David Fanning and Jun Cui for all the help and support provide to make me complete this research. Also, thanks to Juan Aratta, Elina Valenzuela and José Candelaria, for encouraging students to achieve goals. Presentation of this work has been supported in part by the NSF Grant CNS 1042341.