MORPHOLOGICAL STUDY OF IMPACT BASINS OF TERRESTRIAL PLANETS BASED ON SPHERICAL HARMONIC ANALYSIS. S. Sun [1], K. Di [1], Z. Yue [1], and J. Ping [2] [1] State Key Laboratory of Remote Sensing Science, Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, Beijing 100101, China; [2] National Astronomical Observations, Chinese Academy of Sciences, Beijing 100012, China

Introduction: Morphological study of impact basins of terrestrial planets is of great significance to reveal the internal structures of the planets, and the spherical harmonic analysis is an important method in the related research. Spherical harmonics is a mathematical tool which can express the spherical functions as the sum of a series of spectral components [1]. It has been widely used in the study of gravity field both in global and regional scale. In this research the localized spherical harmonic analysis [2-5] was used to analyze large scale impact basins of in terrestrial planets, which could also provide information to reveal evolution of solar system.

Data and Method: Spherical harmonic models are used in our study as listed in Table 1. In each planet several impact basins are chosen for analysis.

The localized spherical harmonic analysis method by Wiezcorek and Simons et al. [2-5] was adopted in our study. Spherical harmonics are the natural set of orthogonal basis functions on the surface of the sphere. Any real square-integrable function sphere can be expressed as spherical harmonics. Therefore, the topography *H* of solid planets can be expressed by equation (1) [6]:

$$H(\lambda,\varphi) = \sum_{l=0}^{N} \sum_{m=0}^{l} \overline{P}_{lm}(\cos\varphi)(\overline{C}_{lm}\cos m\lambda + \overline{S}_{lm}\sin m\lambda) \quad (1)$$

where λ and φ is the longitude and latitude of points in planetocentric system, N is the maximum of degree, $\overline{P}_{lm}$ is the associated Legendre functions corresponding to degree l and order m, $\overline{C}_{lm}$ and $\overline{S}_{lm}$ are the normalized coefficients and the unit is m. These coefficients provide information about topography of solid planets.

The relationship between degree l and wavelength ω is reflected in equation (2) :

$$\omega \approx 2\pi r/(l+0.5) \quad (2)$$

where r is the radius of solid planets. ω decreases as l increases, which means that the high degree topography corresponds to small scale features.

The main application of spherical harmonics in topography is to calculate power spectra, which reflects the undulations of topography. The power spectra of a real function f can be calculated according to equation (3):

$$S_{ff}(l) = \sum_{m=0}^{l}(\overline{C}_{lm}^{\,2} + \overline{S}_{lm}^{\,2}) \quad (3)$$

Results: Impact basins formed at around 3.9~4.1 byr on the Moon, Mars and Mercury are compared in Figure 1. It can be seen that the overall trend of power spectra of these impact basins are generally consistent. The power spectra of lunar impact basins generally increase with the wavelengths at less than 30~50 km. After that, the power spectra curve tends mild. The power spectra of the impact basins in Mars and the Moon have the same characteristics, except the turning point occurs at ~40km. The spherical harmonic model of impact basins on Mercury is expanded to 120 degrees and cannot reflect small scale features. Observations from planetary missions have shown that the crustal thickness of the Moon, Mars and Mercury are respectively about 30~50 km [7], 45km [8] and 100~300km [9]. Thus it can be speculated that the deformation of crustal thickness plays important role after impact, and that the thickness of crust determines global and regional characteristics.

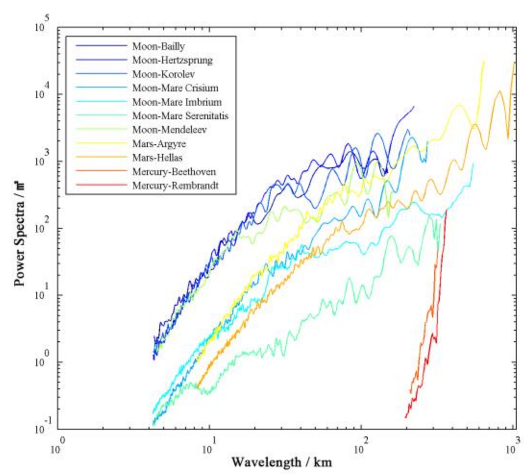

Figure 1. Power spectra of impact basins on the Moon, Mars and Mercury.

The impact basins on the Earth and Venus formed much later than those on the Moon, Mars, and Mercury. Figure 2 is the power spectra of impact basins on the Earth and Venus. Due to the difference of the magnitude of the impact basins on the Earth and Venus, the power spectra of these impact basins overlap at a narrow wavelength of 140~150km. However, the general trend of the power spectra is consistent, revealing the similarity of impact basins on the Earth and Venus.

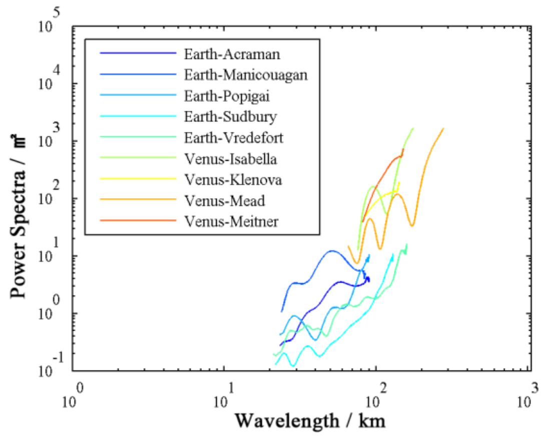

Figure 2. Power spectra of impact basins on Earth and Venus.

Conclusions: Localized spherical harmonic analysis of impact basins on the Moon, Mars, Mercury, Earth and Venus are conducted and results show that the power spectra of all the impact basins decrease with increased degrees. The difference in power spectra reflects the abundance of topographic features at the same scale. Power spectra of impact basins on the Moon and Mars show a turning point at a wavelength corresponding to crustal thickness. It can be speculated that crustal thickness plays a significant role after impact. Power spectra of impact basins on the Earth and Venus are also consistent. These results could provide some clues for revealing the evolution of the terrestrial planets in solar system.

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Table 1. Spherical Harmonic Models of terrestrial planets.

Planet	Spherical harmonic models	Resolution (degree×order）	Release date	Data source
Earth	Earth2012.shape_bathy. SHCto2160	2160×2160	2012	SRTM V4.1/30PLUS merger (7.5 arc seconds), and ETOPO1 (60 arc seconds)
Moon	MoonTopo2600pa.shape	2600×2600	2013.4.1	1/64 °gridded LOLA data (file LDEM_64_PA.IMG）
Mars	MarsTopo2600.shape	2600×2600	2013.4.1	1/32 °gridded MOLA data (file megr90n000fb.img)
Venus	VenusTopo719.shape	719×719	2007	Magellan (GTDR3.2), Pioneer Venus, and Venera 15/16 altimetry
Mercury	gtmes_120v02_sha.tab	120×120	2014.4.1	1/4 °gridded MLA data