COMPARISON BETWEEN KAGUYA (SELENE) ALTIMETRY DATA AND LUNAR TOPOGRAPHY RETRIEVED FROM PHOTOCLINOMETRY. V. V. Korokhin, Yu. I. Velikodsky, Yu. G. Shkuratov, V. G. Kaydash, S. Yu. Gerasimenko, and N. V. Opanasenko, Institute of Astronomy, Kharkiv National University, Sumskaya Street, 35, Kharkiv, 61022, Ukraine, dslpp@astron.kharkov.ua .

Introduction: A new technique to map the zonal component (in the East-West direction) of the lunar topography slopes using telescopic photometry imagery and to correct photometric data for the topography influence has been proposed in our previous paper [1]. In November 2, 2009, the Japan Aerospace Exploration Agency released global altimetry data obtained during the nominal operation phase (December 21, 2007 - October 31, 2008) from the lunar explorer Kaguya (Selene) [2]. We compare our map with the Kaguya laser altimetry (LALT) data.

New photoclinometry approach: The gist of our method is using a series of lunar photometric images acquired at different phase angles. The images should be absolutely calibrated to find the phase dependence of reflectivity for each pixel. These dependences are symmetrized with bringing all points to the same photometric conditions of the crosspoint of the mirror photometric meridian and photometric equator. This procedure allows us to determine for each surface point the phase dependence of the so-called equigonal albedo $A_{eq}(\alpha) = A(\alpha,\beta,\gamma)/D(\alpha,\beta,\gamma)$, where $A(\alpha,\beta,\gamma)$ is the observed brightness distribution, $D(\alpha,\beta,\gamma)$ is the disk function describing the global brightness trend from the limb to terminator and from the equator to poles, α is the phase angle, β and γ are the photometric coordinates, latitude and longitude, respectively [1]. At zero libration and rather large phase angles these coordinates are close to the selenographic ones.

For flat lunar areas the phase function $A_{eq}(\alpha)$ in restricted phase angle ranges can be approximated as $A_0 \cdot \exp(-\mu\alpha)$, where A_0 is a normalizing coefficient and μ is the parameter of the phase curve steepness. When a surface element has a resolved slope, the approximation $A_0 \cdot \exp(-\mu\alpha)$ is not held and, then, we may correct the element brightness minimizing the standard deviation of the observed $A_{eq}(\alpha)$ from values calculated with the model function $A_0 \cdot \exp(-\mu\alpha)$ [1]. This allows us to estimate the topography slopes in the direction of solar illumination, i.e. along the photometric latitude.

We used imagery data of absolute photometry of the Moon acquired in 2006 at the Maidanak observatory (Uzbekistan) with a 15-cm refractor at $\lambda = 603$ nm [3] (12 maps of reflectivity obtained at α = 12.2° … 21.0° before full-moon and α = 12.3° … 21.7° after full-moon). The small range of α (12° - 22°) allows the approximation $A_0 \cdot \exp(-\mu\alpha)$. As the maximal α is 22°, almost full visible disk of the Moon is covered.

Figure 1 shows how the algorithm can minimize the influence of resolved topography on phase-angle-ratio images that are very useful to study the lunar surface structure [e.g., 4]. Distribution of the zonal component of slope over the lunar disk demonstrates realistic values on the basis 3.2 km (Fig. 2).

Processing the LALT data: Before comparison we processed the LALT data. We transformed the data array to put the point with zero selenographic coordinates in the center of the image. Then, we re-sampled the LALT map on the resolution of our observations (~ 3.2 km/pix). The next step was calculations of the zonal component of the surface slopes from heights. Then, we transformed the LALT map from cylindrical into orthographic projection. Finally, the image was smoothed by a Gaussian filter with $\sigma = 0.8$ pix to make resolution of LALT and our maps similar.

Comparison between the LALT and photoclinometry maps: Both the maps show a very similar distribution of the slopes over the lunar disk (Fig. 3), including the maximal value of the slope -22° in the point with selenographic coordinates $l = 0.2°$, $b = 21.6°$ (Montes Apenninus). However, more detailed analysis reveals differences. For instance, our map demonstrates a residual influence from albedo (see Copernicus ray system) and worsening resolution to the limb.

The LALT map exhibits many artifacts. Figure 4 shows central portion of the lunar disk (~ 50° x 50°) in cylindrical projection. The most typical artifacts are displaying some craters as hills (see, e.g., marks 1-3, 7-9 in Fig. 4) or disappearance of craters (marks 4-6 in Fig. 4). Moreover, the LALT map reveals non-existent peaks (see marks 10 and 11 in Fig. 4). The most probable reasons of these artifacts are errors of interpolation at mosaicing. We note also the presence of zonal modulation caused by spacecraft orbital motion (it can be seen in high-contrast images of slopes map). Thus, the considered version of the LALT map should be used with caution. Our map can be used for an independent control of the LALT data.

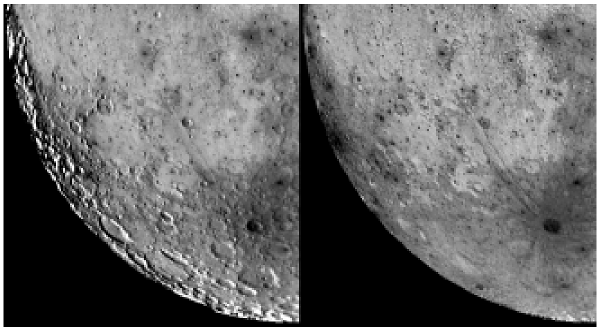

Fig. 1. Phase ratio 2°/21° without (left) and after (right) relief correction

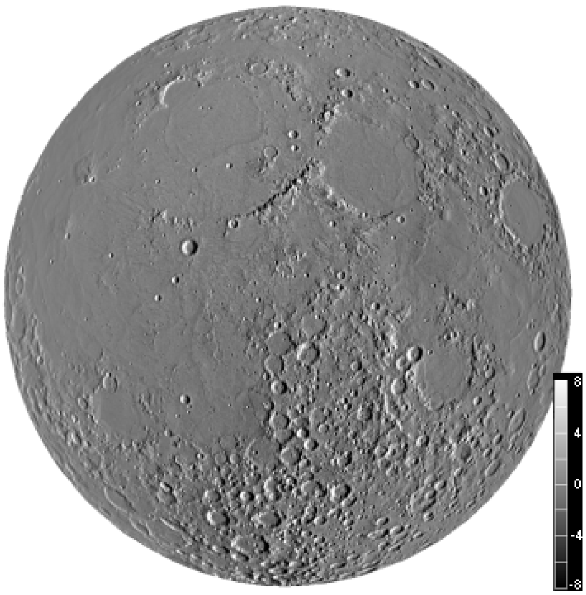

Fig. 2. Photometrically retrieved map of zonal component of slopes on the base 3.2 km. Scale is -8°...+8°.

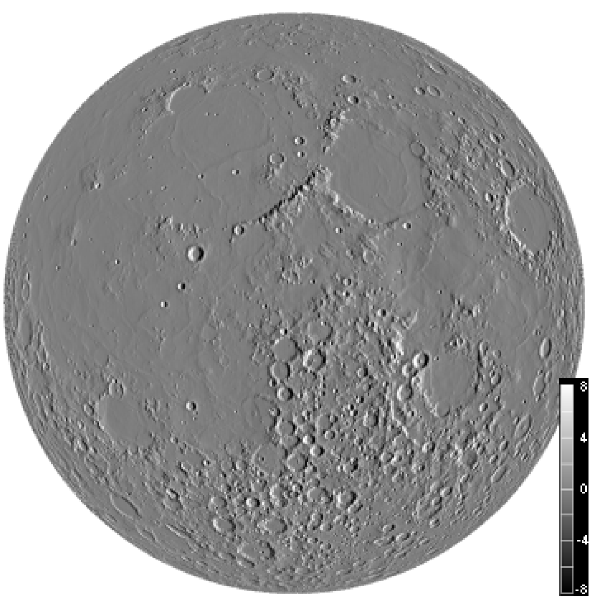

Fig. 3. Map of zonal component of slopes on the base 3.2 km, calculated with LALT data. Scale is -8°… +8°.

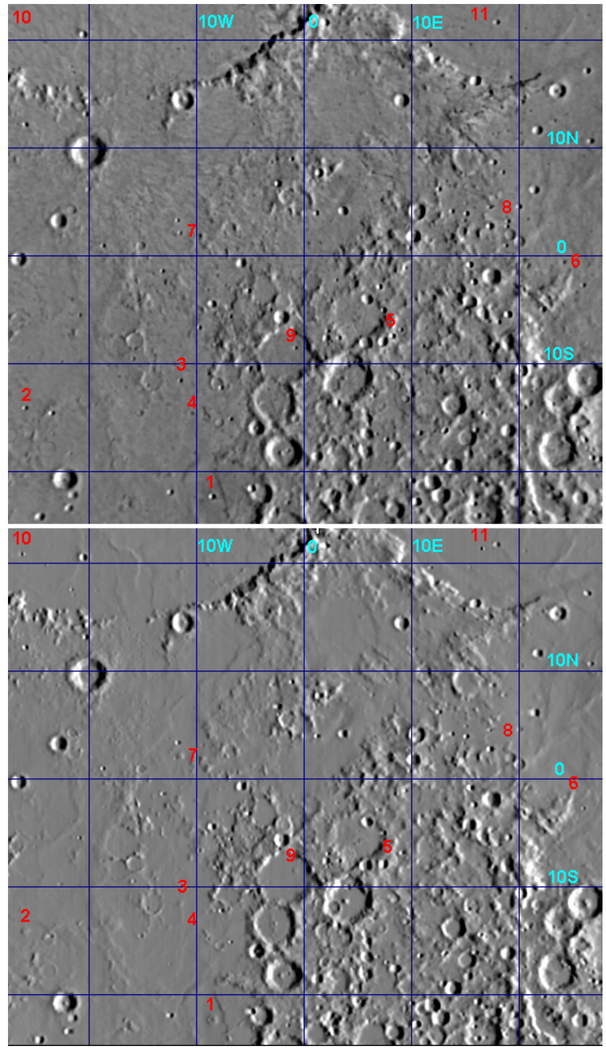

Fig. 4. Comparison of maps of zonal component of slopes retrieved from photometric observations (upper) and the LALT data (bottom).

Conclusion: (1) the map of the zonal component of the relief slopes retrieved from a telescopic imagery of the Moon is very similar to the analogous map reconstructed from the LALT data; (2) our map shows a residual influence of albedo; (3) the LALT map contains many artifacts, a part of them can be detected with our map.

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References: [1] Korokhin V., et al. (2009) http://www.planetology.ru/txt/korokhin_et_al_20090903_91823.pdf.
[2] https://www.soac.selene.isas.jaxa.jp/archive/index.html.en. [3] Velikodsky Yu. et al. (2009) *this issue*. [4] Kreslavsky M. and Shkuratov Yu. (2003) *JGR 108(E3)*, 1-1–1-13.