CALIBRATION OF THE MOON'S INFRARED IMAGES FROM GEOSTATIONARY SATELLITE GOMS. S.G.Pugacheva[1], V.V.Shevchenko[1], S.G.Yakovlev [2], V.M.Kibardin [2], (1) Sternberg State Astronomical Institute, Moscow University, Moscow, 119899, Russia, e-mail: pugach@sai.msu.su; (2) Scientific Research Centre for Nature Resources Exploration, Moscow, Russia, 141700, e-mail: adm@ipr.mskw.mecom.ru

The technique of calibrating scan images using the Moon's image can be successfully used for the radiometric calibration of the onboard apparatus of the first Russian geostationary artificial meteorological satellite (GOMS) launched on October 31, 1994, in accordance with the program "Meteorological Service for the Population". Satellite GOMS has television complex, which gives in actual time scale of the digital images of a cloudy, snow and ice cover and measures of radiation temperature of a surface of a ocean, land and high bound of a clouds. The GOMS artificial satellite was launched into a circular equatorial geostationary orbit at an altitude of 35.8 thousand kilometres and the 76^{o}E static attitude. The imaging equipment of the spacecraft is a two-channel television system, which performs optomechanical two-coordinate scanning covering a sector of 18^{o}x18^{o}. This sector can cover the whole Earth's disk visible from the orbit. Taking one image requires 13.5 min. The BTVC optical system has a mirror objective 400-mm in diameter. The instantaneous field of view is 6.3 arcs in the visual spectral range and 22.5 arcs in the infrared range. Photography of the Earth is performed simultaneously in two spectral bands: visual, 0.4-0.7 micron; and infrared, 10.5-12.5 micron. The infrared channel records thermal fluxes from objects with radiation temperatures between 313 and 213 K. The noise level does not exceed 1 K. A method of calibration of infrared images of the Moon from the satellite GOMS was adduced in the articles [1, 2]. The calibration procedure is based on the comparison of the output data of the onboard apparatus of the geostationary satellite GOMS with a photometric database that includes measured values of brightness and temperature for a large number of lunar-surface areas. To this end, an automated database was created, which contains brightness and temperature values for 1954 areas of the lunar surface, measured by the global scanning of the illuminated lunar disk in the visual (0.445 micron) and infrared (10 -12 micron) spectral ranges during a complete lunation. It is known that the emission of the lunar surface in the visual and infrared spectral ranges is stable and constant in space and time and can easily be described analytically. A generalized digital analytical model of the lunar brightness and thermal fields makes it possible to calculate the necessary photometric parameters, surface brightness and temperature for any geometry of the angular parameters of photography and illumination with an accuracy achieved by ground-based photometry. The accuracy of the calibration of the measured brightness and temperature is comparable with the accuracy of the determination of the fundamental lunar constants, which are used in digital models of the thermal and visual emission of the lunar surface. The main criterion for the quality and reliability of the calibration of radiometric observations from space (as in ground-based photometry) is linearity of the signal - brightness and signal - temperature functions together with the scatter in the phase-function points. The software package constructs the thermal and the visual image of the Moon on the computer screen for a given phase, and calculates the brightness and temperature of any area of the lunar surface with an angular resolution of 8″ - 10″. The root-mean-square errors in the determination of the photometry brightness and of the radiation temperature are ±1.5 relative units and ±1.5 K, respectively. Infrared images of the Moon obtained in the working spectral ranges of the GOMS satellite (10.5 -12.5 micron) are presented in Figs. 1, 2, and 3. The size of the image is 160 x 160 pixels. The central light spot has the radiation temperature more 313 K. It is higher than an upper limiting level registration of a heat flow by equipment of the satellite. The radiation temperature decreases up to 300 K to an edge of the lunar disk.

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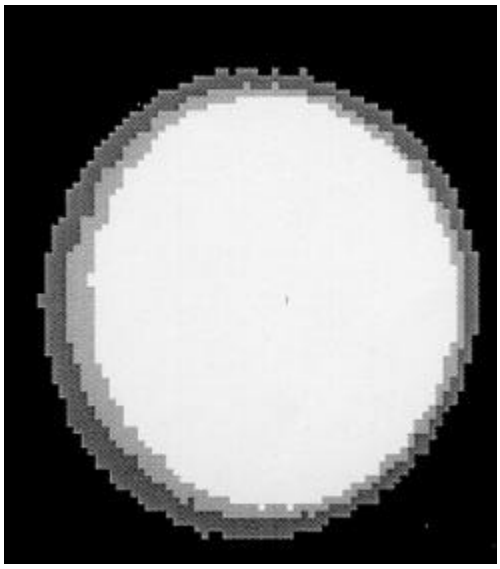

Fig.1. The image of the Moon was transmitted by satellite GOMS on March 3, 1995 in the working infrared range10.5 - 12.5-micron. The phase angle of the Moon is -26.5°. The isotherms for IR radiation temperature of the lunar surface are the system of concentric circles, which has centre in sub solar point (longitude, 21.33E, latitude, 1.13N). The centre of the apparent disk has coordinates: longitude, 5.69W, latitude, 6.29N. The lunar surface has radiation temperature 397.0 K - 261.1 K.

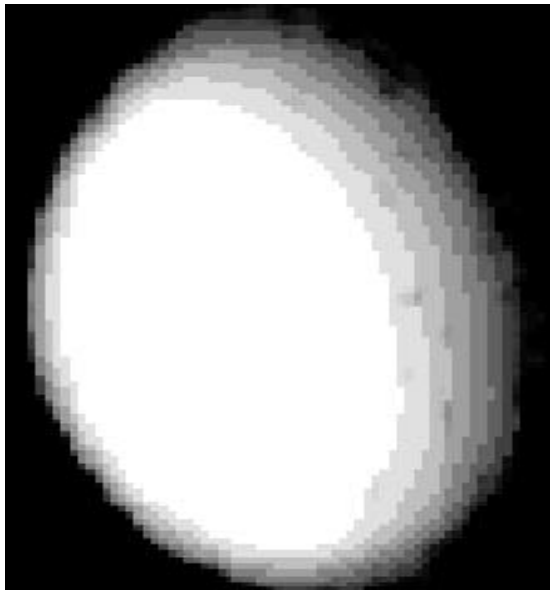

Fig.2. The image of the Moon was transmitted by satellite GOMS on January 9, 1996 in the working infrared range 10.5 - 12.5 micron The phase angle of the Moon is +34.4°. The isotherms for IR radiation temperature of the lunar surface are the system of concentric circles, which has centre in sub solar point (longitude, 38.38W, latitude, 1.59N). The centre of the apparent disk has coordinates: longitude, 4.20W, latitude, 5.71N. The lunar surface has radiation temperature 394.9 K - 250.1 K.

Fig.3. The image of the Moon was transmitted by satellite GOMS on July 15, 1995 in the working infrared range10.5-12.5 micron. The phase angle of the Moon is +35.4°. The isotherms for IR radiation temperature of the lunar surface are the system of concentric circles, which has centre in sub solar point (longitude, 28.90W, latitude, 1.50S). The centre of the apparent disk has coordinates: longitude, 54.20W, latitude, 5.71N. The lunar surface has radiation temperature 394.9 - 250.0 K.

REFERENCES: [1] Pugacheva S.G., Shevchenko V.V., Novikov V.V. etc. Radiometric calibration of observations of the Earth by the Moon's images in the visual and infrared spectral ranges// Astronomical Vest., V.31, N1, page 64-69 (1997). [2] Pugacheva S.G., Shevchenko V.V., Novikov V.V. The Moon as a natural standard for calibration of spectrofotometric under-sputnik observations// Astronomical Vest., v.27, N4, page 47-64 (1993).