Application of laboratory optical measurements to interpretation of the Earth observations data.

Nataliya Zubko[1], Maria Gritsevich[1], Evgenij Zubko[2], Teemu Hakala[1], Jouni Peltoniemi[1;3]

1) Finnish Geospatial Research Institute, Masala, Finland, nataliya.zubko@nls
2) Institute of Astronomy, V.N. Karazin Kharkiv National Univ., Kharkiv, Ukraine
3) Department of Physics, Univ. of Helsinki, Helsinki, Finland

Interpretation of photometric and polarimetric observations of the Earth is often complicated due to direct inaccessibility to the object of interest and lack of the information about it. Laboratory studies are intended to improve understanding and interpretation of the observations. We present results of the laboratory optical measurements of particulate surfaces with various brightness, which are obtained by mixing of two high-contrast materials in different proportions, dark volcanic sand and bright salt. We investigate interrelation between the brightness of the samples and their phase function and polarization characteristics. This study is useful in interpretation of the data obtained from space missions dedicated to terrestrial and astronomical observations. For instance, using satellite observations, e.g. [1], the degree of snow dirtiness can be estimated after volcano eruption. Number of recent studies (e.g. [2], [3] and references therein) focused on the effects caused by the light-absorbing impurities on snow. Our laboratory measurements unambiguously suggest that the mixing ratio of dark and bright component materials can be retrieved using the maximum of positive polarization.

We present photometric and polarimetric measurements, obtained with the FGI field goniospectropolarimeter, FIGIFIGO [4] at phase angle spanning the range from –20˚ to 120˚. Reflectance at phase angle of 6˚ varies from 4% (in pure volcanic sand) up to 86% (in pure salt) as compared to an equivalent Lambertian surface. We found that changing the volume ratio of salt and volcanic sand monotonically affects light-scattering by particulate surface. While samples are getting brighter, their phase function gets more flattened. Relative amount of dark and bright components unambiguously affects angular profile of the degree of linear polarization. This effect is the most apparent at side scattering, where degree of linear polarization acquires maximum value P_{max}, which takes on ~55% in the pure volcanic sand and only ~1% in the pure salt; whereas, in the mixtures it spans intermediate values. Moreover, our samples reveal an inverse correlation between albedo and P_{max} that, in the literature, is referred to as the *Umov effect*. We compare the Umov effect in our samples with what is found in the lunar surface.

References:

[1] https://eo1.usgs.gov/

[2] J. I. Peltoniemi, M. Gritsevich, T. Hakala, P. Dagsson-Waldhauserová, Ó. Arnalds, K. Anttila, H.-R. Hannula, N. Kivekäs, H. Lihavainen, O. Meinander, J. Svensson, A. Virkkula, and G. de Leeuw. Soot on snow experiment: bidirectional reflectance factor measurements of contaminated snow. The Cryosphere Discuss., **9**, 3075–3111, 2015

[3] Meinander, O., Kontu, A., Virkkula, A., Arola, A., Backman, L., Dagsson-Waldhauserová, P., Järvinen, O., Manninen, T., Svensson, J., de Leeuw, G., and Leppäranta, M.: Brief communication: Light-absorbing impurities can reduce the density of melting snow, The Cryosphere, **8**, 991-995, 2014

[4] Peltoniemi J, Hakala T, Suomalainen J, Honkavaara E, Markelin L, Gritsevich M, Eskelinen J, Jaanson P, Ikonen E. Technical notes: A detailed study for the provision of measurement uncertainty and traceability for goniospectrometers. J. Quant. Spectrosc. Radiat. Transf., **146**, 376–90, 2014.