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Spectral diffuse reflectance of Dead Sea

L. Sokoletsky, **A. Kokhanovsky**

(1) Department of Environmental Sciences and Energy Research, Weizmann Institute of Science, 76100 Rehovot, Israel; e-mail: leo@bezeqint.net ; (2)Institute of Environmental Physics, University of Bremen, Otto Hahn Alee 1, D-28334 Bremen, Germany; e-mail:alexk@iup.physik.uni-bremen.de

We developed a novel method for estimation of diffuse reflectance (DR) both just below and just above the water-air interface. DR is characterized by the directional (for instance, from the laser or Sun) or/and diffuse (for instance, from the lamp or sky) illumination and diffuse observation conditions. The idea of the method is the replacement of the hemispherical reflectance (direct illumination and diffuse observation) by the spherical reflectance (diffuse illumination and observation) in main equations. Such replacement can be performed using simple polynomials depending on single-scattering albedo, backscattering probability and asymmetry factor. In turn, polynomial fitting was obtained from the exact solution of radiative transfer equation adapted for 7 different phase functions. A numerical analysis shows a high precision of the method under development, especially in the range of relatively small incidence angles. For example, at angles less than 45 degrees (for natural water conditions this corresponds to the solar zenith angles in air less than 70 degrees) a mean root-mean-squared error calculated for all phase functions is estimated as 3 percent, although relative errors can vary from -15 to 24 percent. A method proposed has also been verified experimentally for the extremely anisotropic light scattering natural environment - Dead Sea (Israel), the saltiest lake in the world (a salinity is about 30 percent). Input parameters for the model were spectral values of absorption and extinction coefficients (measured by ac-9 instrument, courtesy of E. Boss), and the volume scattering function (measured by ECO-VSF instrument, courtesy of E. Boss) at 660 nm at 3 angles (100, 125, and 150 degrees). Additionally, the reflectance factor in the range of 350 to 2500 nm was measured by ASD instrument. Observations have been made in 5 different places throughout the lake on near to (depths are up to 25 m) and far from (depths are up to 300 m) the coast lake stations. The comparison of calculated and

measured DR has been perfomed. We find that the developed theory can be used to describe experimental curves. Thus, the method developed gives a tool for the further studies, including the development of remote-sensing methods for the continuous lake monitoring using satellite or airborne sensors.