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Optical properties and remote sensing of optically diverse waters in Pomeranian Region (Poland)

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This work presents the large set of empirical examples of upward and downward spectral irradiance fields, along with their associated coefficients of reflectance and transmittance in the waters in Pomeranian Region. On the one hand, the light field prevailing in a water body is one of the main factors governing life in it, affecting as it does a number of processes of great significance for this ecosystem. On the other, it is an important source of information used, among other things, for the remote assessment of the state of structural characteristics, including the composition and concentration of OACs, and the changes taking place in this environment. In this age of remote sensing, be this from on board a satellite or an aircraft, the light field is a highly topical issue. The 235 optical measurements performed in Pomeranian Region enabled a range of characteristic features of the vertical spectral distributions of the downward and upward irradiance, and irradiance transmittance to be defined. Based on these measurements, spectra of the diffusional coefficient of the downward irradiance attenuation in different types of lacustrine waters were determined. The underwater irradiance fields are governed by absorption and scattering, and these processes, in turn, depend on the type and concentration of OACs contained in the water. Later in this work, I show the influence of these constituents on the spatial and spectral characteristics of underwater light fields in trophically and optically diverse waters; I also analyse the possibilities of utilizing this modified light field to determine the OAC concentration in the waters under study here. The magnitude that is used to monitor the state of the water in natural bodies using remote sensing is the reflectance$R(\lambda)$, a function of the reflection of the downward daytime irradiance. Because the spectra of this reflectance differ in shape (the positions and values of their maxima and minima), three types of spectra have been distinguished for Pomeranian lakes. The first type has a broad reflectance peak in the 560 – 580 nm region and is recorded in waters with the lowest absorption of light by CDOM and the lowest levels of chlorophyll a. The second type is characterized by low values right across the whole spectral range as well as two quite pronounced peaks at wavelengths ca 650 and 690 – 710 nm. This type is characteristic of darkly-coloured waters with a very high coefficient of light absorption by CDOM. Finally, the third type always exhibits three peaks: a broad one at 560- 580 nm, a smaller one at ca 650 nm and a distinct one at 690 – 720 nm. Spectra of this kind are typical of lacustrine waters with a high level of chlorophyll a and a lower level of light absorption by CDOM than in the second type. Using the available empirical data base, containing the records obtained in Pomeranian lake waters, I was able to derive a packet of new, original formulas enabling the concentrations $C_a$and C_{SPM} and the coefficient a_{CDOM}(440 nm) to be determined from remote reflectance values for selected wavelengths. Using these new formulas, the above OACs in the waters of Pomeranian lakes can be determined with a far smaller error than the formulas derived by other authors for the waters of other regions. The statistical errors determined for these formulas are: for concentration C_a , $\sigma_+ \approx$36% , for concentration C_{SPM} , $\sigma_+ \approx$56% and for coefficient a_{CDOM}(440nm), $\sigma_+ \approx$46%.

In this work I also discuss the bio-optical properties of Lake Pyszne, a so-called “humus” lake, which contains large amounts of CDOM. My investigations have shown that in most cases the data acquired from measurements made in this lake diverge significantly from those of the other water. Moreover, the data from Lake Pyszne do not fit the trends observed in lakes containing lower levels of CDOM. The characteristically low values of the upward radiation and remote reflectance from such lakes, due to their dark colour, means that their remote sensing is complicated and requires further study. It would appear that different algorithms, relationships and models need to be derived for such lakes in order to take into account their specific properties.