Short communication

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Spectral bio-optical properties of Lake Baikal (July 2018 and September 2019)

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ABSTRACT. The complex investigations of hydrophysical, biological and spectral bio-optical characteristics have been carried out in Lake Baikal during two scientific cruises in July 2018 and September 2019. The depth-dependent variability of investigated parameters has been analysed.

Keywords: spectral light absorption coefficient, optically active components, phytoplankton, PE-containing species, Lake Baikal

1. Introduction

Operative monitoring of the state of unique ecosystem of Lake Baikal can be realized by remote approach. Correct transformation of the satellite optical scanner data to water quality and productivity indicators is possible with regional bio-optical algorithms.

To develop the regional algorithms the knowledge on regularities of spatial and temporal variability in spectral bio-optical properties, mainly – light absorption by all optically active substances is required.

2. Materials and methods

Variability in spectral bio-optical properties of Lake Baikal were investigated in two scientific cruises carried out in July 2018 and September 2019. Spectral absorption by particles and colored dissolved organic matter were measured in line with the protocol (Boss et al., 2018).

3. Results and discussion

Spatial variability of chlorophyll *a* concentration (Chl-*a*), light absorption coefficient of phytoplankton ($a_{ph}(\lambda)$), non-algal particles ($a_{NAP}(\lambda)$) and colored dissolved organic matter ($a_{CDOM}(\lambda)$) was rather high (in order and higher).

In surface layer values of Chl-*a* varied from 0.58 to 5.3 mg m^{-3} in July 2018 and from 0.90 to 2.7 mg m^{-3} in September 2019. Vertical distribution of Chl-*a* was dependent on hydrophysical characteristics, in particular, on temperature stratification of water column. In situ measured temperature, chlorophyll *a* fluorescence (F) and photosynthetic available radiation (PAR) profiles allowed to analyze Chl-*a* profile types. In case an appearance of the thermocline (TC) within euphotic zone Chl-*a* vertical distribution was characterized by unimodal profile with deep chlorophyll *a* maximum (DCM) in the layer below TC. The DCM was located near the bottom of euphotic zone (at ~1%PAR). At a few stations bimodal Chl-*a* profile was observed: second maximum was appeared in TC layer. Deepening of the TC down to the bottom of euphotic zone resulted in relatively homogeneous Chl-*a* distribution within euphotic layer.

It was shown that water stratification effected on light absorbance capacity of phytoplankton. In the deeper layer of euphotic zone (below the TC) shape of the spectrum has a specific feature - a local maximum at 550-570 nm in comparison to the upper layer. Light absorbance in this spectral band is associated with phycoerythrin (PE). The PE-sign on spectra became more marked at depth with low PAR level (1 - 0.1%). The appearance of the PE-sign reflects relative increasing of PE-containing species in phytoplankton community. The PE-containing species are likely to be cyanobacteria with light absorbance band at ~ 545 nm and eukaryotic algae (class Cryptophyceae) with absorbance at 566 nm (Six et al., 2007; Heidenreich and Richardson, 2020). The revealed significant depth-dependent variability in was associated with changes in phytoplankton species composition caused by adaptation of the phytoplankton

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community to environment, particular to spectral features of downwelling irradiance.

The $a_{NAP}(\lambda)$ and $a_{CDOM}(\lambda)$ spectra were described by exponential function. The $a_{NAP}(\lambda)$ was correlated with $a_{ph}(\lambda)$: the NAP contribution to particulate light absorption at ~440 nm was ~20% on averaged. The NAP spectra slope coefficient (S_{NAP}) was slightly variable and equal to 0.010 nm^{-1} on averaged. The CDOM spectra slope coefficient (S_{CDOM}) was 0.018 nm^{-1} on averaged. The analysis of and S_{CDOM} variability revealed the relationship between them, which described by power function. Parameterization of light absorption by NAP and CDOM revealed no differences between July 2018 and September 2019.

The absorption budget was assessed at the different wavelengths corresponding to satellite scanners spectral bands. At the ~440 nm (corresponding to the blue maximum of phytoplankton light absorption spectra) relative contribution of the phytoplankton pigments, NAP and CDOM to total light absorption varied significantly (up to order) between regions of Lake Baikal. The budget at 440 nm showed that the CDOM was the main optically active component, which provided ~ 50% contribution to total absorption on averaged over Lake Baikal surface. The mean contribution of phytoplankton pigments and NAP to absorption budget at 440 nm was ~38 and ~12 %, correspondingly, without statically reliable difference between years.

4. Conclusions

The obtained new data on variability of spectral light absorption coefficients by phytoplankton, particles and dissolved organic matter, their relation to chlorophyll a concentration will be used for analysis of photosynthetic characteristics of phytoplankton, for development of spectral models of downwelling irradiance and primary production with application for remote sensing.

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