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Organization of Operational Processing, Interpretation And Transmission Results of Space Monitoring of Planktonic Algae

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Planktonic algae - phytoplankton, causing algal blooms and affect its quality, especially near the coast where phytoplankton is booming. Coastal area is considered as a special dynamic boundary ecotone structure within the concept of ecotone "water-land". Strong anthropogenic impact on urban and agricultural landscapes and remote coastal waters with a transfer of substances and materials is carried out through the buffer zone - Ecotone, which consists of five blocks. First block is a water block - "Aquatic", where there is an active transformation of land substances, recreational, economic use of the territory and also four land blocks. Basic research has been conducted on Lake Ladoga (N 60.8, E 31.5) and also on Chudskoe (Peipsi) lake by a sharing data of ship and satellite measurements (N 58.4, E 27.6) in August-September 2014.

Earth remote sensing data (RSD) are used to distinguish these blocks and implement a full-scale real-time monitoring of their condition, as well as the distribution of phytoplankton in the waters.

The purpose of this project was to create the operational monitoring of phytoplankton "fields" ("clouds") in Lake Ladoga on the basis of satellite imagery.

Following problems were solved.

1) Determination of the optimal data types for operational detection of phytoplankton (free MODIS data - refresh rate at least 1 image/day. LANDSAT-8 – for further test of the algorithm phytoplankton identify).

2) Determination of the optimal data and places of ground truth measurements (i.e. synchronized with satellite imagery), taking into account the timing of the satellites passage over the place shooting (for experimental part and development of interaction between the monitoring groups).

3) Processing of archival field data 2005 - 2012: field data and them maximum corresponding satellite images (development of an algorithm to identify phytoplankton, its spatial distribution and quantification of the biomass).

4) Training of the operational cooperation scheme for ground truth and satellite groups of monitoring for the transfer of information on: the distribution and biomass of phytoplankton and fronts of dense clouds.

5) Feedback - getting operational monitoring ground truth data: coordinates, date and time of measurements, a qualitative assessment of phytoplankton biomass, a representative sample (i.e. uniform distribution in the range about of 500 m from the place of sampling).

Low-resolution data from AQUA and TERRA satellites - multispectral instrument MODIS, were processed in accordance with the approach to color scanner data processing that is based on assessments of the relationship $\lambda1/\lambda2$ signals - "color index" for wavelengths $\lambda1 \approx 440 \dots 490$ nm and $\lambda2 \approx 520 \dots 560$ nm. This is due to the fact that the first range corresponds to a maximum absorption coefficient of chlorophyll-A, the second - its minimum. Also phytoplankton chlorophyll-A absorbs radiation in the red (about 675 nm) region of the spectrum.

Were selected relationship B10/B12 (and close B9/B11) channel radiometer MODIS, corresponding to the spectral ranges B10 = 483 - 493 nm and B12 = 546 - 556 nm. For LANDSAT-8 data were used 2 spectral channels: 2nd (450 - 515 nm) and 3rd (525 - 600 nm). The color index is calculated as the ratio B2/B3 of the spectral brightness.

Were obtained concurrences of "phytoplankton fields" outlines for processed satellite data different spatial resolution (1000 m/pixel for AQUA/TERRA and 30 m/pixel LANDSAT-8). When generalization (coarsening) images LANDSAT-8 to 1000 m/pixel matching of these outlines increases significantly.

Following the thematic processing of all results and data, including ship measurements were exported into an integrated GIS project "Plankton" for further combined analysis of ground truth and satellite data - Figure 1, Table 1.

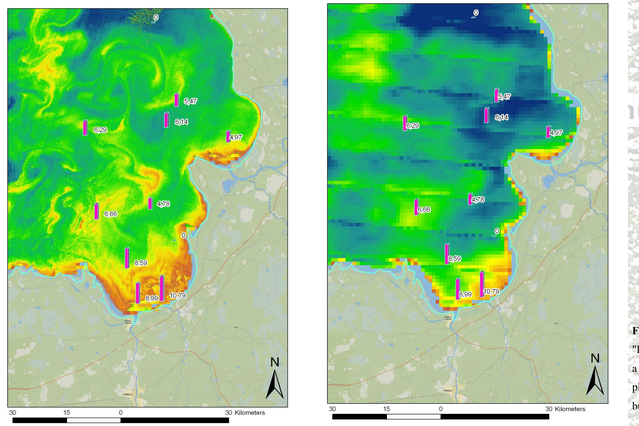


Figure 1. The area of the Ladoga lake, surveyed August 4, (GIS project "Plankton"). Left – LANDSAT-8; right – satellites AQUA / TERRA (substrate a topographic base map). Bar chart of the number and concentration of phytoplankton (Chl-a, mg/m3) according to ground truth measurements. The distribution of phyto- plankton and quanti-

Concentration of phytoplankton (Chl-a, mg/m3) according to ground truth measurements. The distribution of phytoplankton and quantitative parameters Table 1.

Table 1. The results of image processing (MODIS) and in situ measurements according to Ladoga expedition. August 4, – the series ranked in ascending order of the concentration of Chlorophyll-a (Chl-a).

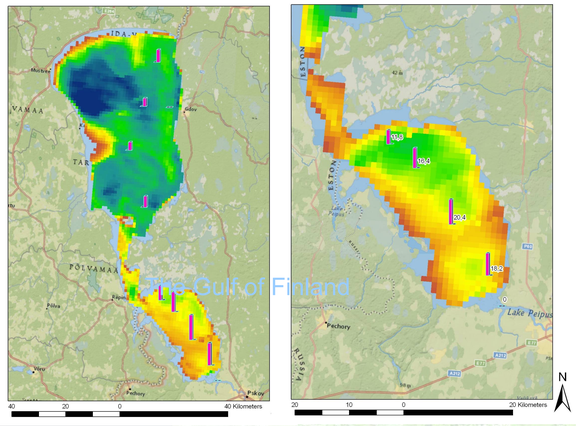
Chl-a, mg/m3	Brightness	No. station	Correlation
4,78	*63*	*4*	
5,47	31	2	
6,14	*20*	*1*	
6,29	76	5	0,876
6,66	131	7	
8,59	120	6	
8,99	151	8	
10,79	201	9	

Comparison results of the quantification method with ground truth data showed that requires consideration of several points.

1. Satellite image makes it possible to identify fields of phytoplankton distribution at the time of the shooting only.

2. Coarsening of satellite images can lead to a spatial shift in pixels for "phytoplankton fields".

3. You should specifically consider and handle various anomalies (e.g., bandwidth inversion) in the image because of hardware or other failures.



Research vessel
http://sea-transport.ru/nauchno-isledovatelskie-suda/1087-

Figure 2. Pskov-Peipsi lake system (left) and the Lake Pskov (right). Images satellites AQUA/TERRA (substrate a topographic base map). An example of the distribution of phytoplankton and quantitative parameters (bar chart) on

The results of processing similar data on the Pskov-Peipsi lake system is presented below - table 2, ranked by the column of "Brightness". The calculation of the correlation coefficient between the calculated brightness and the data of ship measurements (Chl-a) were carried out in standard mathematical package LibreOffice Calc (also MS Excel) - Table 2.

Table 2. The data series on the results of satellite images (MODIS - am and PM shot) and ground measurements and the coefficient of correlation (13.09.2013). Dashes - no ship measurements at this lake.

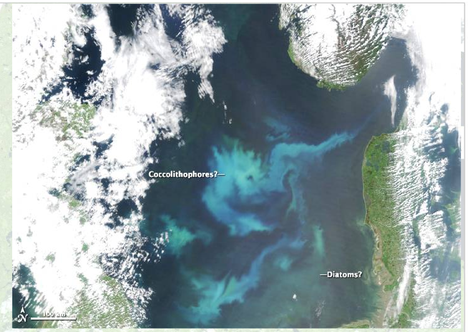
NN stations	Latitude, degrees	Longitude, degrees	09-13H Chl_a, mg/	15-17h Chl_a, mg/	Brightness	Coefficient of correlation
1a	57,85898	28,15036	-	0,0	5	
2a	58,75	27,55278	-	6,7	21	
3a	58,6	27,48333	-	6,7	57	
4a	58,9	27,61667	-	10,3	77	
5a	58,41561	27,60925	-	9,0	78	0,950
6a	58,11217	27,76756	11,8	-	143	
7a	58,07631	27,85528	16,4	-	161	
8a	57,90883	28,10489	18,2	-	168	
9a	57,98833	27,97933	20,4	-	175	

The correlation coefficient for these two data sets is very large - about 1 ($r = 0.965608$ and $r = 0.949613$ accordingly) - high accuracy quantitative evaluation of concentration of phytoplankton, in good weather conditions for satellite imagery. Interpretation of the correlation coefficient r: $0.7 < r <= 0.9$ is a strong correlation, $0.9 <r <=1$ - very strong correlation.

Conclusion

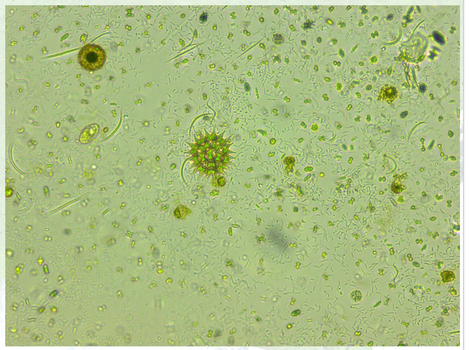
The results of available data processing show a high correlation of satellite data of high and low resolution, which proves the ability to use it in the daily monitoring of phytoplankton. Development of proposals for the organization of operational data monitoring shows a fairly high level of accuracy quantify with ground truth (ship) and satellite data (the concentration and spatial distribution of phytoplankton). Thus, the proposals being developed by the operational system of remote monitoring can significantly reduce the need to contact (ship) measurements within acceptable weather conditions for satellite monitoring.

Results quantification and analyze the spatial distribution, allow largely replaced traditional ship measurements and, simultaneously, to increase the amount of the definitions these water environmental parameters.



Phytoplankton “clouds” in Baltic sea/.
http://eoimages.gsfc.nasa.gov/images/imagerecords/86000/86176/northsea_tmo_2015157_lrg.jpg

Ship measure the concentration of phytoplankton “cloud”, lake Onega 2013.



Phytoplankton under the microscope
http://phys.org/news/2015-12-phytoplankton-hot-boosts-biodiversity-photosynthesis.html