Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte

Band: 63 (1991)

Artikel: Water dynamics and pollution nearby Leningrad dam

Autor: Victorov, Serge

DOI: https://doi.org/10.5169/seals-48506

Water Dynamics and Pollution Nearby Leningrad Dam

Hydrodynamique et pollution près du barrage de Léningrad

Wasserbewegung und - verschmutzung in der Nähe des Leningrader Damms

Serge VICTOROV
Chief of Lab.
State Oceanographic Inst.
Leningrad, USSR

Serge Victorov, born 1941, received his Ph.D. in Physics at A.F. Ioffe Physico-Technical Inst., Leningrad. Since 1977 he has been chief of Laboratory for Satellite Oceanography. His main interests are remote sensing of processes in coastal zones, environmental monitoring of the seas, image processing, geoinformation systems.

SUMMARY

This is a brief review of our papers dealing with remote sensing studies of water dynamics and water pollution monitoring in the eastern part of the Gulf of Finland (Baltic Sea). The results are interpreted in the context of a broad public discussion on the possible negative impact of the construction of the dam across the River Neva Mouth on the state of environment in the Leningrad region.

Hydrodynamique et pollution près du barrage de Léningrad

Résumé

L'article traite des mesures à distance de l'hydrodynamique et de la pollution de l'eau dans la partie orientale du golfe de Finlande (Mer Baltique). Les résultats sont interprêtés dans le cadre d'une large discussion publique sur l'influence éventuellement négative de la construction d'un barrage sur le delta de la Neva, à proximité de Léningrad.

Wasserbewegung und -verschmutzung in der Nähe des Leningrader Damms

Zusammenfassung

In einer Zusammenschau unserer Arbeiten wird über Fernerkundung der Strömungsdynamik und Ueberwachung der Wasserverschmutzung im Finnischen Meerbusen der Ostsee berichtet. Ihre Resultate werden im Rahmen einer breiten öffentlichen Diskussion über den möglichen schlechten Einfluss der Dammkonstruktion in der Newamündung auf den Zustand der Umwelt in der Region Leningrad hin interpretiert.

Fig.1. Satellite image of the River Neva Mouth
9 July 1981

Fig.2. Satellite image of the River Neva Mouth
5 July 1989

Fig.3. Satellite image of the River Neva Mouth
8 September 1989

1. BACKGROUND

The River Neva is one of the most full-flowing in Europe. Freshwater surplus from rivers in the drainage area of the Gulf of Finland is as follows [1, p.II-7]:

River	Drainage area, km^2	Discharge, m^3/s
Kymi (Finland)	37235	517
Neva (USSR)	281000	2463
Luga (USSR)	13200	124
Narva (USSR)	56200	437

Nutrient emissions by rivers (tonnes per year) to the Gulf of Finland is [1,p.II-31]:

	Total N	Total P
USSR	52500	3460
Finland	12000	620

These figures give some idea of the River Neva as the source of pollutants. In the River Neva delta the city of Leningrad is situated, with its five million citizens, and great amount of industrial enterprises with inadequate filtering systems. Thus the problem of spread and spatial distribution of the River Neva pollutants in the Gulf of Finland is obvious. This is not a simple scientific problem and it has not yet been solved. The situation became still more critical when in the vicinity of Leningrad in the River Neva Mouth the construction of dam, protecting the city against the floods, was started in the beginning of the 80's. When the dam was almost built the construction was stopped under the pressure of public opinion.

We recognize the fact that all over the world the public opinion and public actions in the field of environment became a powerful driving force and they should not be neglected. The public opinion may be formed by various manipulations with figures, words and images. Two principle questions: "Has the construction of the dam changed the aquatic environment in the River Neva Mouth and the neighbouring aquatoria?" and "Has the dam influenced the state of environment in the Leningrad region?" are under discussion.

In this paper only one aspect of the problem is considered. Remote sensing satellite and airborne data have been used to monitor the spatial distribution of suspended matter in this region for a number of years.

2. DATA SOURCES AND METHODS USED

In our previous papers [2-4] we discussed possibilities of using satellite imagery of small and medium ground resolution in studies of optical inhomogeneties caused by suspended matters along with reliability of the results obtained. At the initial stage since 1980 multispectral data from "Meteor-30" satellite (MSU-S and MSU-M scanners) were analyzed [2,3], later the information of better quality from satellite "Kosmos-1939" became available: since 1988 - data of medium ground-resolution in visible range 175 m x 200 m from scanner MSU-SK [4]; on summer 1989 high resolution images from MSU-E device (30 m x 45 m) where obtained for the River Neva Mouth.

Our paper [4] deals with some problems of environmental satellite monitoring of the Gulf of Finland including the problem of complex studies of water pollution based on satellite imagery in the visible band. We have used satellite images from our database since 1976. Basing on satellite images of the River Neva

Mouth 1980 till 1988, relevant airborne and ship measurements the peculiarities of distribution of suspended matters have been revealed at various hydrometeorological conditions. Our paper [5] deals mainly with analysis of satellite images since July 1988 till September 1989.

In the analysis of satellite imagery we also used the following additional information:

- pilot map of the region,
- mean velocities, general structure and schemes of currents,
- characteristics of suspended matters including size-distribution of suspended particles and sediments,
- data on seston concentration and regression characteristics "transparency-concentration",
- data on the sources of suspended matters,
- historical data on the spatial distribution of suspended matter at various hydrometeorological conditions,
- meteorological situation before, after and at the moment satellite overpass (wind characteristics, atmospheric pressure, horizontal visibility,
- water level position,
- in-situ ground-truth measurements of water transparency, temperature and salinity,
- airborne measurements of sea-surface temperature and optical characteristics of the water upper layer.

The patterns of spread and spatial distribution of suspended matter have been registeredd in satellite imagery of visible and near-IR bands. Suspended particles are used as tracers to visualize flows and currents with their fine structure.

To study the features of fields of suspended matter and the water masses dynamics in the eastern part of the Gulf of Finland satellite images were selected, which fit various hydrological situations, caused by water level changes. We developed a method which enabled us to obtain quantitative estimates of suspended matter concentration limits at each of the zone (cluster) recorded in satellite imagery. (For details see [5]).

Typical values of transparency and concentration of suspended matter for zones determined in satellite imagery of the River Neva Mouth are as follows [5]:

Zone number	Pollution	Transparency, m	Concentration, mg/l
1	"Clean" river water (background level)	>1,0	<10
2	Very small	0.7-1.0	10...15
3	Small	0.5-0.7	15...20
4	Medium	0.4-0.5	20...25
5	High	0.2-0.4	25...60
6	Very high	<0.2	>60

Image processing technique was used to map the distribution of suspended matter with 6-cluster classification with presentation of results in false colors.

3. RESULTS AND DISCUSSION

With respect to characteristics of water level change at least 4 types of hydrological situations can be studied:

- smooth change of level (slow decrease),
- increase of level,
- sharp decrease of level,
- period of change of phase (decrease after durable increase).

For each type of hydrological situation one can see a specific pattern of suspended matter distribution and current field as recorded in satellite imagery. Figs.1-3 show some examples of satellite imagery. In fig.3 the following features can be traced:

- outflow currents in the northern part of the dam,
- quasi-homogenious "mixed" zone at the large area of the mouth to the west of the dam,
- eddy chain along the Morskoj Channel, (the total length of this chain is about 20 km, 10 eddy structures of about 1.5-2.0 km size can be determined),
- reverse currents traced with suspended matter in the northern part of the River Neva Mouth.

For details of other types of patterns see [5].

Complex analysis of sets of satellite images of high resolution and in-situ measurements enables to elucidate a lot of fine features at the frontal zones separating different water masses, in the field of currents, in dynamical structures in the River Neva Mouth and the eastern part of the Gulf of Finland.

One can see that there are two zones with increased amount of suspended matter - along the northern and southern coasts of the River Neva Mouth. They had existed long before the start of construction of the dam. It is worthwhile to note that zones with increased amount of suspended matter have been traced in the satellite imagery even at the periods when no dredging or bottom-deepening operations have been performed. This fact shows the great role of processes of bottom sediments mixing in the shallow waters caused by wind and wave turbulization [4].

Analysis of satellite images stored in our database showed that there is a very high variability of feature characteristics of suspended matter patterns at the synoptic scale according to the above mentioned four types of hydrological situations. It means that for a given time interval (for example, month or year) one can find a certain number of images with "dirty" Mouth (large areas with high concentrations of suspended matter) or "clean" Mouth (small areas). Please, keep it in mind for the future discussion!

As for the seasonal variability, there is a tendency that the total area of zones of suspended matter increases from spring to the end of autumn. One of the reasons may be the increasing activity of dredging and other operations in the summer period plus seasonal grouth of wind and wave activity.

It is difficult to show any tendency in annual variability, no reliable remote sensing data exist which could show changing in general patterns of suspended matter fields before and after the construction of the dam.

Those are the conclusions we came to after having analyzed and thoroughly studied more then 100 of remote sensing images from our database.

Unfortunately the sore subject of dam construction gave rise to some sweeping statements made as a rule by non-professional opponents of the dam and based on no scientific data. They

agitated the public anxiety appealing not to reason but to emotions. Thus people having no idea of the peculiarities of hydrological regime of the aquatoria using a few random remote sensing images tried to present to the public the "awful" picture of the dam impact on the aquatoria. The images they showed were ones taken at different hydrometeorological situations, different seasons, and with different number and location of dredging and bottom-deepening machines. More often than not those ignorent "experts" have a very vague idea of what is recorded in remote sensing images of different spectral bands; all the optical non-homogeneties in their interpretation are called "mud". We shall discuss this situation later.
The results obtained have once more proved the validity of operative (transmitte via radio links) satellite data in regional ecosystem studies and the hard necessity of development of these studies according to suggestions listed in [4]. The gained experience can be used also in the analysis of photographic satellite data [5].

4. THE DAM LESSONS

4.1. Some lessons in the field of scientific research.

- adequate observation of the aquatoria requires regular satellite monitoring providing high-resolution images once in 3-4 days and medium-resolution images - daily,
- specific spectrometric remote sensing measurements should be performed along with the existing broad band satellite images,
- location of regular in-situ observation stations must be specified in accordance with current system and spatial distribution of suspended matter,
- prior to construction of Major Engineering Structures (MES) and in the process of it storage of homogenious time-series of remote-sensing and relevant in-situ data is necessary,
- those data should be accumulated in integrated Geographical Information Systems (GIS) of the type suggested in [6],
- further analysis of satellite imagery demands the efforts of specialists in hydrodynamical modelling who could use satellite data to obtain the new or to specify the already known initial and boundary conditions and some parameters in numerical models. These models for the River Neva Mouth should account for 2-dimensional sources of pollution,
- "zero-solution approach" suggested for the Great Belt Link is a good example to follow in future MES projects.

4.2. Some lessons in the field of public relations.

- for MES that could possibly affect a great number of citizens or a large aquatoria, or cause trans-generational effects international examination of the project is recommended,
- scientists should not ignore public discussions. Sometimes scientists simply ignore non-specialists opinions. Very soon a large amount of non-professional opinions expressed in letters, published in news-papers or appeared in TV-programmes becomes so large that it is almost impossible to dissuade the public,
- try to avoid manipulating with terms: pollution, mud, clean, dirty, - all these terms should be defined strictly before you start discussion with lay men,

- it should be clarified that two environmental events occuring at the same time interval or one after another might not necessarily be caused by one another. Even this very simple thought has to be explained to many people over and over again,
- experts in public relations in the field of environment should have good knowledge of modern sociology, psychology, mass-media, communicative theory, etc.,
- first ideas of ecology and environment must come to people at a very early age, may be, in their childhood (see my concept of ECOLOGIUM in [6]).

Acknowledgements
It's my pleasure to express my gratitude to L.L.Sukhacheva for helpful discussions and to M.D.Demina for preparation of the manuscript.

REFERENCES

1. Environmental Statistics in North America and Europe. Part II. The Baltic Sea. Experimental Compendium. UN Economic Comission for Europe.
2. VICTOROV S.V., KAZMIN A.S., et al. Studies of water masses with various optical characteristics. Determination of fields of plankton and suspended matter. / In: "Earth's Nature from Space" (in Russian), Leningrad, Gidrometeoizdat, 1984, pp.118-124.
3. SUKHACHEVA L.L. Using satellite data for determination of optical inhomogeneties in the upper layer of the sea. / In: Instructions manual for complex usage of satellite data in studies of the seas. (in Russian), Leningrad, Gidrometeoizdat, 1987, pp.49-58.
4. VICTOROV S.V., BYCHKOVA I.A., et al. Problems of satellite environmental monitoring of the Gulf of Finland. / In: Oceanography from Space (in Russian), USSR Academy of Sciences, Express-information, N.4-89, Leningrad, 1989, pp.13-26.
5. VICTOROV S.V., LOBANOV V.Yu., SUKHACHEVA L.L. et al. Elements of water dynamics in the eastern part of the Gulf of Finland as recorded in high-resolution satellite imagery. Paper presented at 17th Conference of the Baltic Oceangraphers (Stockholm, 3-7 September 1990).
6. VICTOROV S.V. International Project in Regional Environmental Geoinformatics "Baltic Europe". Paper presented at the Conference of European Statisticians (Stockholm session, 23-24 Oct.1990)

Leere Seite
Blank page
Page vide