

Multisensor monitoring of Peter the Great Bay

Leonid Mitnik, Vyacheslav Dubina, Oleg Konstantinov and Vitaly Fischenko

V.I. Il'ichev Pacific Oceanological Institute FEB RAS

43 Baltiyskaya St. 690041 Vladivostok, Russia

Tel: 7-4232-312-854, Fax: 7-4232-312-573

E-mail: mitnik@poi.dvo.ru

1. Introduction

Peter the Great Bay is the largest bay of the Japan/East Sea (JES). Seasonal changes of oceanic conditions in the bay are expressed very clearly. In winter a significant part of the bay is covered by ice, thickness of which can reach 50-70 cm. In summer the sea surface temperature increases till 22-25°C. Chlorophyll-a concentration is also very variable in time and in space. The highest values are observed in the coastal zone in spring and in autumn and in the open sea they are in several times less. Anthropogenic load is very large near Vladivostok and decreases in the open sea. Oil spills caused by illegal discharge of waste waters by ships and rivers are numerous. Sea ice surface collect dust and litter and transfer them in spring to the south that pollutes waters and the coast in the Marine Reserve area. Oceanic conditions in Peter the Great Bay are determined by water exchange with the JES, atmospheric influence (wind patterns, cloudiness), river discharge and orography. Monitoring of environmental conditions in the bay should consists of measurements of physical parameters (water temperature and salinity, currents, sea surface roughness, sea ice characteristics, air temperature and humidity, wind speed and direction, etc), biological parameters (chl-*a* concentration, turbidity, etc.), pollution (oil spills, litter). Simultaneously it is necessary to trace fishery and transport activity. Monitoring can be realized by combination of satellite, ship, buoy and coastal observations carried out by various sensors operating at different spectral bands and having different spatial resolution. The main attention in a paper will be given to:

- consideration of multisensor satellite monitoring of phenomena and processes in the bay,
- description of the developed optical polarization systems for measurements of physical parameters and for continuous monitoring of the sea surface and
- short description of system of operational monitoring which is under construction at POI.

2. Multisensor satellite monitoring

The advantage of satellite data is well known. It provides at any scale, up to date, inexpensive information on digital form. Many tools, which allow to extract environmental data from satellite imagery, have been developed. With the rapid development of remote sensing technologies, such as the development of the new generation imaging sensors, leading to enhanced performance at a cheaper price, multisensor systems have become a reality in a growing quantity of applications. Larger and spectrally more independent sensor arrays provide for increased spatial resolution and better spectral discrimination of the image data available for these applications. However, implementation of such sensor arrays has resulted in a significant increase in the raw amount of image data which needs to be processed.

Monitoring of the mesoscale (50 m - 20 km) oceanic phenomena is the most important for such bays as Peter the Great Bay. These phenomena were revealed by analysis of multisensor satellite datasets. The datasets consist of ERS-1/2 SAR, Envisat ASAR and ALOS PALSAR images, Landsat TM and ETM+, NOAA AVHRR and Terra and Aqua MODIS visible and infrared images, QuikSCAT-derived sea surface winds and ocean color data (SeaWiFS, MODIS), as well as of the weather maps, ship surveys and ground truth data acquired in 1991-2008. Spatial resolution of SAR images is in the range of 10 -150 m and a swath width changes from about 70 till 400 km. This combination is unique and allows revealing the synoptic-scale, mesoscale and fine-scale features of the surface circulation, oceanic dynamic phenomena, wind field and oil spills independently on sun illumination and cloudiness. Measurements of the SST and wind speed and direction were carried out at POI Marine Stations and at several coastal points during the ASAR and SAR data acquisitions. Characteristics of the sea surface roughness were determined by processing of time series of images of a system of small floats and thin disc floats of various sizes as well as by analysis of images of the sea recorded by a polarization video system.

The surface manifestations of the current fronts, eddies of different sizes, internal waves and other oceanic phenomena were revealed on the SAR images. Spiral eddies of different scales were detected in the Bay both in warm and in cold seasons. The signatures of the Tumen, Razdolnaya and Partizanskaya river plums were detected on true color MODIS images with spatial resolution of 250 m. Velocity of internal waves propagation, surface currents and ice drift was estimated from displacement of radar signatures on SAR images taken by ERS-2 and Envisat images with 30 min delay and visible signatures on Terra and Aqua MODIS images with time delay of 100 min. In a cold season, the grease ice, pancake ice and other forms of sea ice were reliably detected on SAR images of Peter the Great Bay.

3. Optical polarization complex

Complex was developed at POI FEB RAS to study the sea surface roughness characteristics, slicks, internal waves and other oceanic dynamic phenomena/processes and carry out ground truth measurements. Characteristics of the sea surface roughness and their spatial variations determine the spatial variations of the SAR image brightness (Normalized Radar Cross Section σ°). Measurements of the sea surface slope distribution and the mean-square slope (MSS) during field experiments are required for interpretation of the radar signatures. Techniques based on light reflection ('shape from reflection') turn out to be most suitable to take wave slope images. The results obtained earlier show that the measurements of the water surface shape are accurate enough to compute two-dimensional wave number spectra. The original optical devices (video cameras, polarization spectrophotometer, etc.) and techniques were developed and used to derive the characteristics of gravity and gravity-capillary waves under variable environmental conditions in particular during Envisat ASAR and ALOS PALSAR sensing.

The characteristics of the sea surface roughness were estimated from displacements of a light float and a system of light floats. They were also retrieved from the brightness variations of the sea surface images which were recorded at three polarizations with frequency of 6-50 Hz. Original software was developed for processing of the time series of these polarization images. Calibration was suggested to eliminate the random fluctuations of viewing direction of optical devices. Results of measurements and their interpretation will be presented.

Another optical system consisting of three rotating video cameras mounted on a common

base carries out panoramic images of the sea surface around Cape Shults at three polarizations every 30 sec. Analysis of time series of panoramic images allows to trace movement of the contrast features (slicks, oil spills, internal waves, etc.), estimate their velocities and evolution. Animation will be presented demonstrating evolution of oil spill and propagation of a packet of internal waves from the open sea to Vityaz' Bay.

4. Operational monitoring of Peter the Great Bay

Since 2005 POI began to develop a system for operational monitoring of Peter the Great Bay. The system should provide information from the coast, buoys and ships and its transfer in real time to the coastal centers of data storage and processing. Telecommunication infrastructure was created with the usage of fiber-optic, wire and radio connections to solve this task. Several Marine experimental stations and Institutes of FEB RAS in Vladivostok are combined into the structure. A subsystem of video monitoring of the sea surface is an important component of the system. The subsystem will use IP- video cameras which is planned to install on coastal hills. Remote control of camera operation will be realized. This subsystem will allow to get and accumulate the information on environmental conditions in the various parts of the bay. These data can be useful for validation of satellite-based algorithms of geophysical parameter retrieval.

Pilot project of the video monitoring system is tested now at Marine Station Cape Shults. Apart of polarization video cameras, there is another video camera FCS-1040 which transmit the images from Cape Shults to the FEB RAS Institutes. Camera has 10-fold optical magnification and allows to remote control magnification and angle of observations. The static panoramic images of the sea surface around Cape Shults are retained in data bases of oceanic informative-analytical system of FEB RAS.

This work is partly supported by RFBR project 06-05-96076-p_vostok_a and FEB RAS project 07-III-B-07-064.