Usage of Internet-based Oceanographic GIS of the NW Pacific for Joint Analysis of Satellite and sub-Satellite Data

A.V. Golik, V.K. Fischenko, V.A. Dubina, L.M. Mitnik
V.I.Il'ichev Pacific Oceanological Institute, Far Eastern Branch of the Russian Academy of Sciences
43 Baltiyskaya str., Vladivostok 690041, Russia
gis@poi.dvo.ru, fischenko@poi.dvo.ru, dubina@poi.dvo.ru, mitnik@poi.dvo.ru

Abstract: The task of development and usage in a corporate computer network of the Far Eastern Branch of the Russian Academy of Sciences (FEB RAS) of integrated technology of joint use by the scientists of satellite and subsatellite data on a Northwestern Pacific is considered. This integrated technology is realized by embedding of satellite data in the corporate oceanographic GIS of FEB RAS as a new information layer, and also by support of GIS by program techniques for specialized processing of both kinds of the data. As a result of integration the specialists of FEB RAS have an opportunity to carry out coordinated samples of satellite and various oceanographic data as a function of area, time and other important conditions, visualize them together and carry out analytical processing with the usage of the GIS tools. Application of the realized approach to improve the techniques of detection and description of the oceanic phenomena on ERS-1 and ERS-2 SAR images as well as to improve of perspective techniques of the usage the brightness temperatures measured by a microwave radiometers AMSR-E on a board of Aqua (USA) satellites are discussed.

Keywords: GIS, Internet, Intranet, Oceanography, Satellite and sub-Satellite Data, Internal Waves, Sea Surface Temperature, Sea Surface Wind

1. Introduction

Despite of the already achieved essential successes in area of use of the satellite information for support of oceanological researches it is necessary to note, that the opportunities of satellite supervision of ocean while are realized unsufficiently. One of the reasons it is the separation of researches conducted by the specialists in the area of remote sensing of ocean and the "usual" oceanographers. The first specialists frequently simply are not informed on opportunities of satellite supervision, which can be useful at the analysis and interpretation of data, observable directly in sea experiments. The second specialists have no the complete information on features of oceanographical researches and data, received in them, which are rather diverse. Therefore we consider as a very important task the task of development of the integrated informational-analytical multiuser systems, which will give to all specialists both satellite data and traditional oceanological data, and also effective tools for joint visualization and analysis of these data.

One of the most acceptable forms of realization of such systems is the internet-based Geographic Information System (GIS). For the users the work with such GIS looks as usual work in the Internet. But thus the base functionalities inherent in traditional desktop GIS - a storage, retrieval, manipulation, cartographical visualization and analysis of the geographically referenced data are easily realized.

Use of such GIS in a corporate computer network (Intranet) of scientific institute or several institutes conducting complex researches of some area of World ocean is especially perspective. The high-speed connections of workplaces of the scientists in a Intranet provide speed of service of the users queries comparable with speeds at work with usual desktop GIS. In a Intranet it is possible to carry out more free policy of differentiation of access rights to the data and program techniques of their analysis, than in the Internet. The presence in a modern corporate network of the large number of the rather powerful computers, and is possible also of supercomputer systems with parallel architecture allows to use for decision of difficult computer tasks the technology of the distributed and parallel calculations.

In the present work the experience of development and usage in oceanographic researches of technology of joint usage of satellite and usual oceanological data on the basis of corporate FEB RAS GIS of Northwestern Pacific is submitted. Let's note, that we have no the information on realization of the similar corporate projects essentially focused on the joint analysis of the oceanological and satellite data, at least in Russia.

In an initial part of this paper the corporate oceanographic GIS of FEB RAS is described. Further submitted in GIS data of supervision of ocean from satellite also are described. The opportunities of sharing satellite data and coordinated with them on time and space of the data of direct supervision of sea environment - sub-satellite data are demonstrated. In the conclusion the basic results and the prospects of development of the described technology are formulated.

2. Internet-based oceanographic GIS of the Northwestern Pacific

Internet-based oceanographic GIS is developed at Pacific Oceanological Institute of FEB RAS since 2001. Primary task of project - granting multiple access to all available oceanographic data on region, means of their joint cartographical visualization and the analysis with

use the GIS and Internet - technologies to all interested scientists of institutes of FEB RAS.

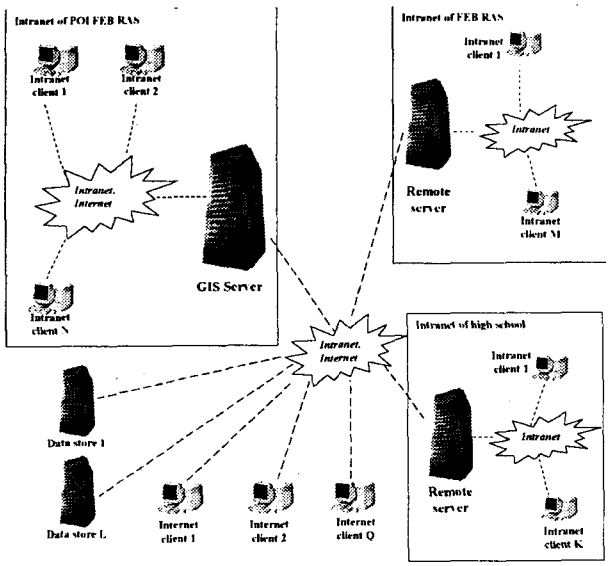


Fig. 1. Architecture of Internet-based oceanographic GIS

On Figure 1 at the upper left the GIS which is locating in Pacific oceanological institute of FEB RAS is submitted. It includes a base GIS-server on which is stored the basic data collection and which provides execution of all GIS functions on serving user queries. Also the scientists having a computer, connected to a local area network of institute are submitted. The segment of GIS including remote data store and users located in other institutes of FEB RAS and the universities of Vladivostok city connected to high-speed computer network of FEB RAS are conditionally submitted on the right. The oceanographic data stores located in the Internet and used GIS are submitted below at the left. Internet users who can use information-analytical resources of GIS, but at essentially smaller speeds and smaller access rights are submitted in the same place.

All work of the user with GIS is conducted in a window of the Internet browser, for example, MS Internet Explorer or Mozilla. Using intuitively understandable interface the user can easily carry out the following functions:

1 - to request the oceanographic data satisfying set of spatially, time and other criteria of selection;

2 - to visualize the requested data in a window of cartographical display with any detail levels, to request the attributive information in tabulated and graphic format on viewed objects in cartographical window;

3 - to take effective analytical processing of requested data by software registered in system of analytical support of GIS.

It is necessary to note, that if necessary processing of complex queries or serving an intensive flow of usual queries, the GIS-server is capable to distribute computing loading between free at present computers of network of FEB RAS. For this purpose used system Condor 6.7.1 established on these computers for support of distributed calculations, freely distributed by university Madison (Wisconsin, USA) [1].

On Figure 1 the typical configuration of information windows is submitted at work of the user with GIS. In this case in a cartographical window is displayed all region of a northwest part of Pacific ocean in the largest scale and layers: monthly average distribution of overcast in September, routes of typhoons in 2002, the additional information on typhoon PHANFONE-02, positions of hydrological stations, vertical distribution of temperature at one of stations.

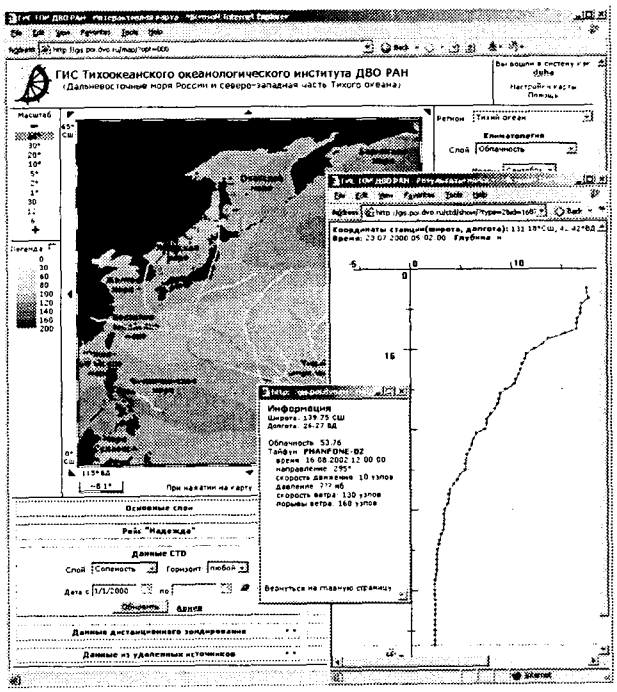


Fig. 2. Typical example of program windows of GIS

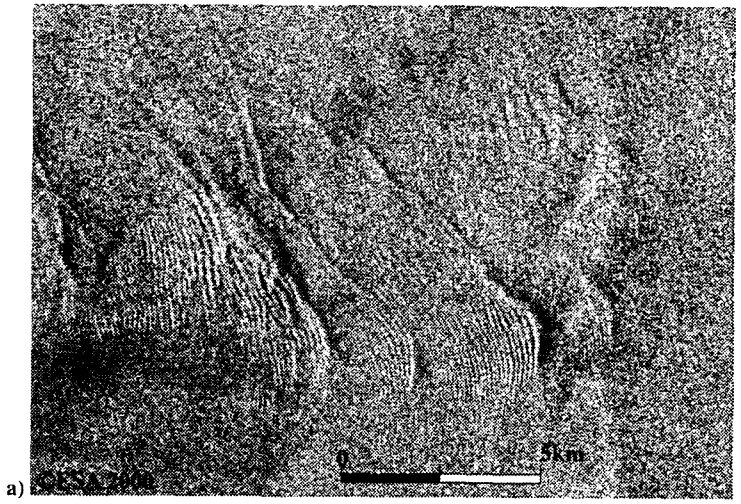
Now the total amount of the oceanographic data stored in GIS more than 100 Gb. The general number of specialists of FEB RAS having access to resources of GIS about 400 person.

3. SAR data in GIS

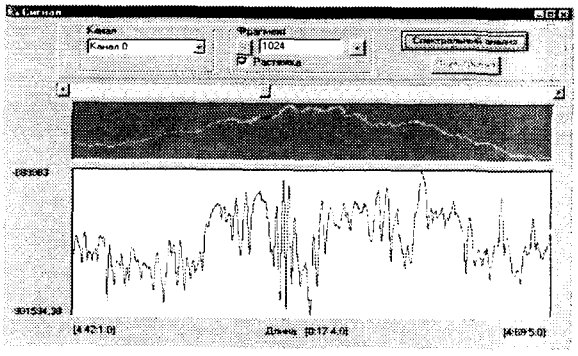
In 2002 the large collection of the synthetic aperture radar (SAR) images from satellites ERS-1 and ERS-2 was integrated into GIS. The important advantage of this type of the satellite data is independence on weather light conditions and capacity to estimate divergence and shift currents. One of the problems solved in POI FEB RAS using SAR-data is development of remote techniques of detection manifested themselves on the SAR-images. For this purpose skilled specialists using GIS and carefully visual analysis compare each image with the natural phenomena shown on it: fronts, internal waves, eddies, oils spills, etc. Subsequently "usual" oceanographers can request for viewing the SAR-image, setting as criterion of selection the fact of presence or absence of some phenomena.

Figure 3 shows the example of the using of the SAR-data for interpretation of the microseismic fluctuations of the Earth data [2]. This experiment was carried out with the precision laser interferometer established on marine research station of POI FEB RAS «Cape Schultza». On registered in experiment signals of microdeformations of Earth's crust at coast of ocean besides the processes proceeding in depth of the Earth, render essentially influences the oceanic phenomena – tides waves, surface waves, internal waves, seiches, storms, etc. It gives the basis in the long term to hope for creation of essentially new systems of remote research of ocean on the basis of the analysis of field of microseismic fluctuations of the Earth in a coastal zone. Therefore digital signals of microdeformation also are loaded in databases of oceanographic GIS, and the program of processing and the analysis of the multichannel digital signals is integrated in system of analytical support, capable to process these data.

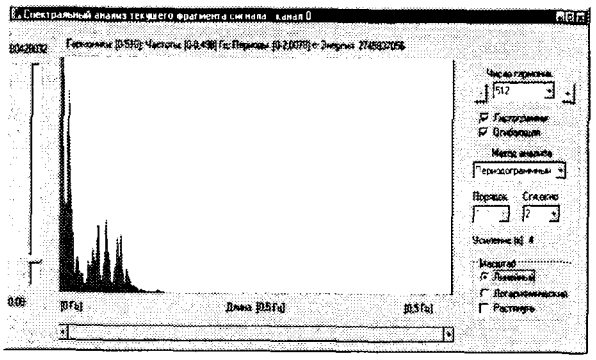
Figure 3b shows the fragment of microdeformation signal, Figure 3c shows the Fourier spectrum of this signal. There are periods of 12, 18 and 22 seconds in the spectrum. This high-frequency components can be caused by the surface waves. Low-frequency component (15-20 minutes) can be explain by the influence of the internal waves. SAR-image (Figure 3a) of the coastal water near Cape Schultza received at the approximately same time shows the periodic structure caused by surface manifestation of the internal waves with the similar frequency characteristics.



a)



b)



c)

Fig. 3. Internal waves on the remote sensing data: a) SAR-image with visually distinct system of internal waves; b) fragment of signal of t he Earth's microdeformations in a coastal zone; c) Fourier spectrum of this signal

4. AMSR-E data in GIS

The large data collection of satellite remote sensing received by the microwave radiometers AMSR-E (satellite Aqua) and AMSR (satellite ADEOS-II) has been loaded in GIS in 2003. The data represent global fields of brightness temperatures (BT) of leaving radiation of the Earth on 6 (AMSR-E) or 8 (AMSR) frequencies n, coordinates of pixels and values of the calibration parameters for the each scan line [3]. Measurements BT(n) are conducted on vertical and horizontal polarizations in a strip width of 1600 km. POI has the data due to the agreement with Japanese Space Agency JAXA. The further work will be in the following directions:

- development and testing of the algorithms of the retrieval of the sea surface temperature (SST) and sea surface wind (SSW);
- development of technology of construction of the composite SST fields.

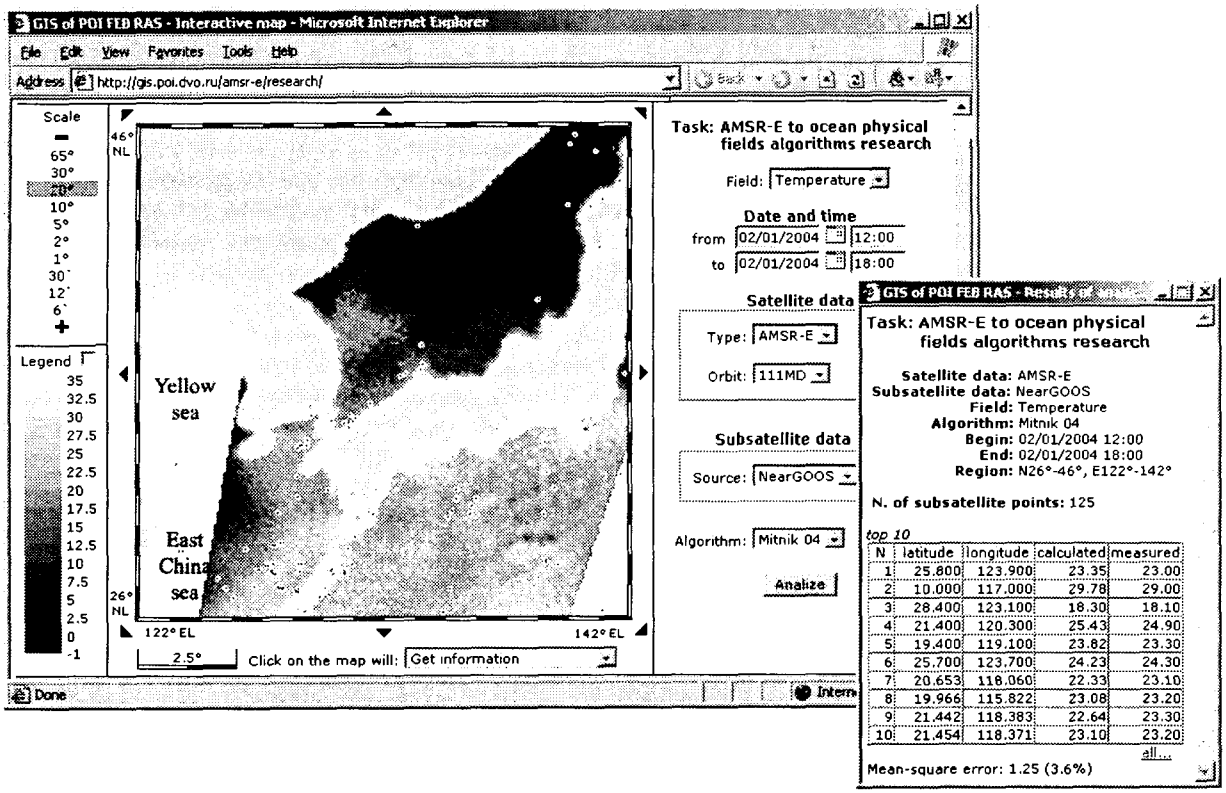


Fig. 4. Validation of the SST retrieval algorithm

Figure 4 shows procedure of the validation of the SST retrieval algorithm. A user specifies type geophysical field (SST, SSW, etc.), sources of the satellite and sub-satellite data, time of data acquisition and validating algorithm. Then the GIS finds suitable satellite and sub-satellite data, calculate required geophysical field using specified algorithm. The calculated field is displayed in cartographical window together with the points where there are data of sub-satellite observation. The list of all sub-satellite points with the observed and calculated values as well as integrated rate of the mismatch calculated and real values is depicted in additional information window.

5. Conclusions

The article describes the experience of corporate oceanographic GIS of FEB RAS application for the joint analysis of the satellite and *in situ* oceanographic data. The system has shown the efficiency and usefulness for remote sensing specialists as well as for oceanographers. The further development of system is supposed to be spent in the following directions:

- updating GIS with the new kinds of the satellite and oceanographic data;
- development and integration in the system new techniques of the satellite data utilization;
- development of technology of use of supercomputer resources of FEB RAS corporate network.

Acknowledgement

The work was done with support of the RFBR (grant № 02-07-90354) and INTAS (grant № 03-51-4987).

References

[1] **URL:** The Condor Project. Available at: http://www.cs.wisc.edu/condor/

[2] Dolgikh G.I. Low-frequency Lithosphere Deformations in the Shelf Zone of the East/Japan Sea, induced by Internal Gravitational Wave // Izvestiya. Physics of the Solid Earth. 1999 V.35, N 11, P.976-981

[3] Parkinson C.L. Aqua: An Earth-Observing satellite mission to examine water and other climate variables // IEEE Trans. Geosci. Remote Sensing. 2003. V.41. N2. P.173-183.