

Features of Formation of Remote Sensing and Sea Truth Databases for The Monitoring of Anthropogenic Impact on Ecosystems of Coastal Water Areas

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Abstract - This work presents the main features of creating problem-oriented remote sensing and sea truth databases, for data collected through complex monitoring of anthropogenic impact on the Mamala Bay water area (Oahu Island, Hawaii). Based on the objective of monitoring anthropogenic influence on the Mamala Bay water area coastal ecosystem and on the analysis and systematization of input data, the main requirements for the database are formulated. A technological scheme for the cataloging and archiving of information is developed and a structural diagram for the satellite and sea truth database is proposed.

Special attention is paid to capabilities for providing operative access to and search for necessary information in data analysis and recommendations on decision making when choosing measures for the protection of the environment.

Keywords: databases, ecological monitoring, pollution of seas and oceans, remote sensing.

1. INTRODUCTION

An important field of application for remote sensing methods is the monitoring of anthropogenic impact on littoral water areas (Bondur 1995, 2004; Savin, Bondur, 2000). When carrying out such monitoring, it is necessary to organize sea truth observations of hydrophysical and biological parameters of the marine environment using sensors installed at stationary buoy platforms and onboard ships. These observations have to be performed at times when satellite images are taken. Such an approach was implemented in the monitoring of anthropogenic effects on the Mamala Bay water area (Oahu Island, Hawaii) (Bondur, 2005). Complex monitoring carried out in 2002-2004 enabled to accumulate a great volume of information that includes remote sensing and sea truth data, as well as data obtained through preliminary and thematic processing (Bondur, 2005). It became evident that a specially designed problem-oriented database allowing secure storage and operative data retrieval needed to be organized. This database needed to support the analysis and post-processing of information, as well as the planning of environmental protection measures and development of thematic GIS layers.

The main requirements for such a database, its flow diagram, and the main principles of its development and maintenance are presented below.

2. MONITORING OBJECTIVES AND DATABASE REQUIREMENTS

When carrying out space monitoring of anthropogenic impact on littoral water areas, the following tasks should be performed (Bondur, 2005):

- Study of the possibility of detecting from space, phenomena related to deep outfalls into littoral water areas

based on their manifestations on the ocean surface and in near surface layer;

- Collection of data on marine environment parameters combining remote sensing methods and sea truth measurements in order to develop hydrophysical models of these phenomena and models of anthropogenic influence on ecosystems of littoral waters;

- Complex analysis of ecological state for the investigated water area;

- Forecasting of situations that may occur under the influence of various hydrological and meteorological factors, and are capable of leading to the propagation of wastewaters;

- Development of recommendations concerning measures for environmental protection in the region.

Allowing for the above mentioned items, the following system requirements to the database can be formulated:

- Secure and long-term storage of great volumes of raw space images, sets of sea truth data and results of their processing;

- Capability of storing cartographic data and various kinds of complementary information;

- Capability of distributing data in such a way as to eliminate the storage of redundant information;

- Possibility of complex processing and combined analysis of different kinds of information;

- Open database design allowing its functional enhancement and addition of new data;

- Access to the information for different user communities.

3. DEVELOPMENT OF A DATABASE FOR REMOTE SENSING AND SEA TRUTH DATA

Figures 1 and 2 present a technological chart for the cataloging and archiving of information in the database, and a structure chart of a problem-oriented database for remote sensing and sea truth data during monitoring of coastal water areas.

A large number of satellite images from QuickBird, IKONOS, RADARSAT, ENVISAT, EO-1, TERRA and AQUA satellites were obtained between 2002 and 2004, during experiments carried out in the Mamala Bay water area. The total volume of these images exceeds 150 Gb.

The onboard sensors of these satellites register the spatial structure of sea surface waves, its temperature, hydrooptical heterogeneities of the surface layer and other parameters. To verify remote sensing data obtained with space assets, sea truth observations were organized. This enabled us to collect data on (1) wind conditions at ground stations and in the water area, (2) parameters of surface waves (wave buoys), (3) current fields (ADP sensors and drifters), (4) temperature fields (thermistor strings), (5) variation of temperature and salinity with depth (CTD and XBT sensors), (6) microstructure data (MSS, TOMI), hydrooptical (Secchi disks, AC-9) and hydrobiological (Niskin bathometer) parameters, (7) tidal mode.

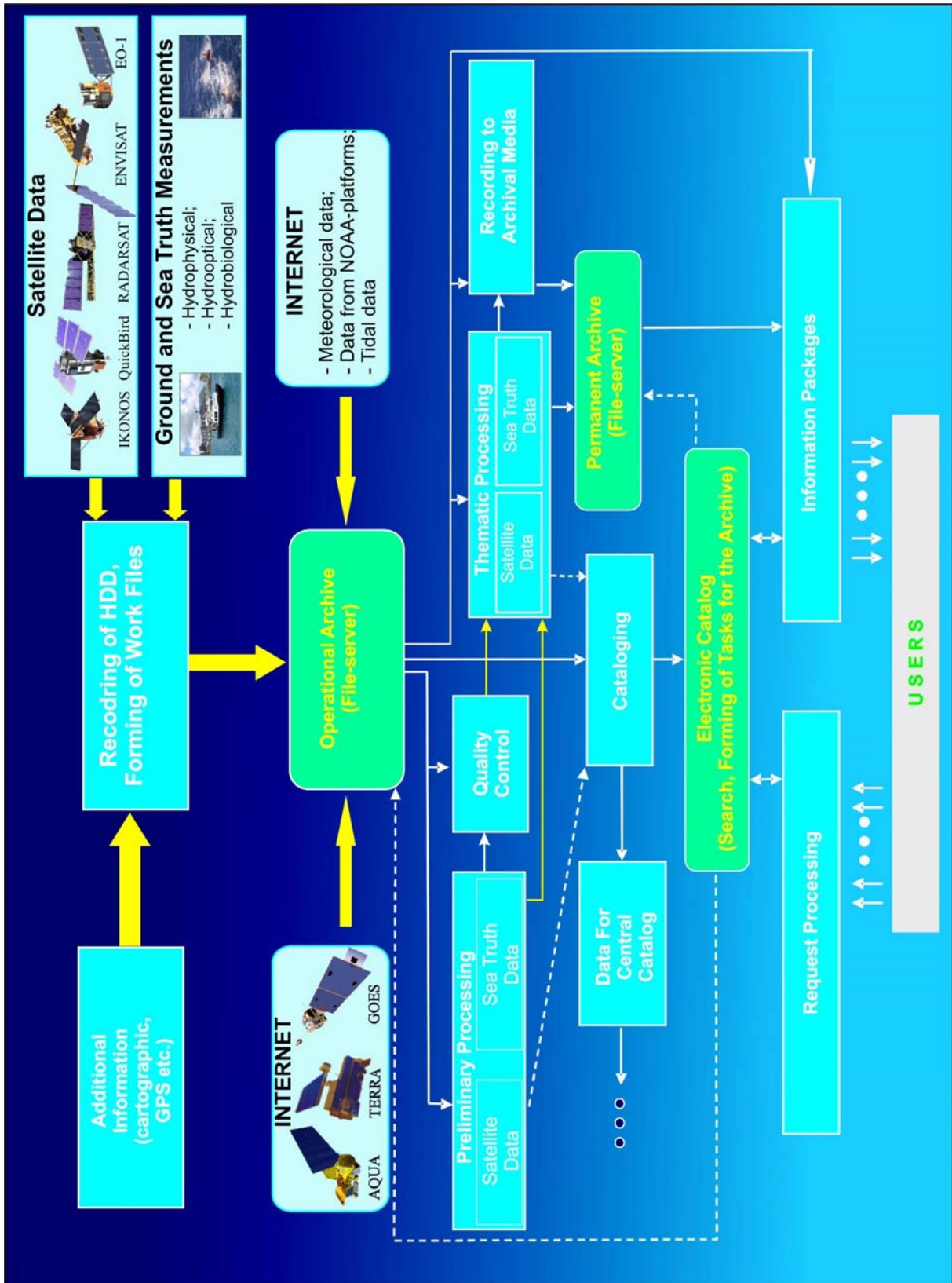


Figure 1. Technological chart for cataloging and archiving of information acquired during monitoring of coastal water areas

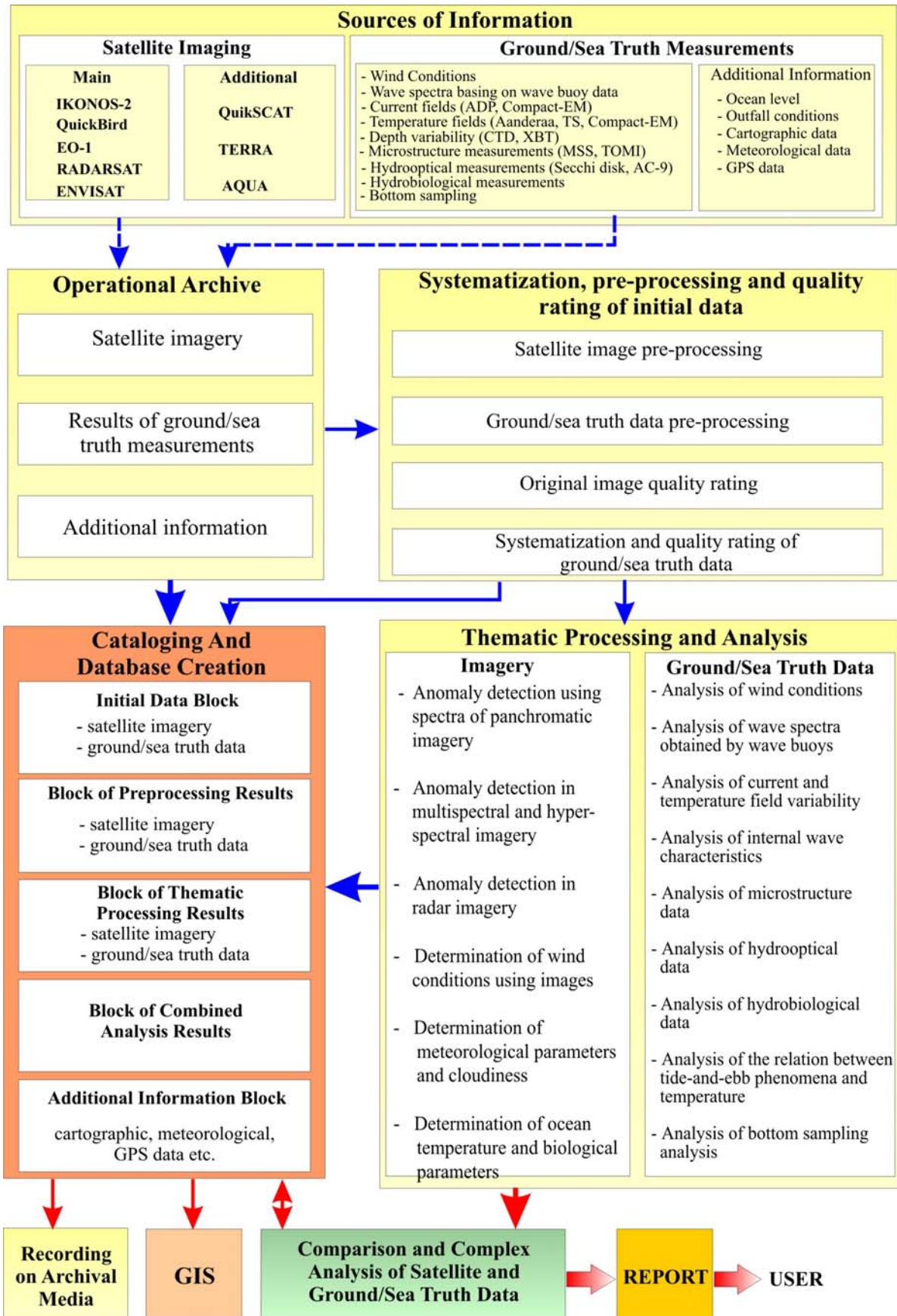


Fig. 2. Structure chart for forming of problem-oriented base of satellite and ground/sea truth data during monitoring of coastal water areas

Original satellite images and sea truth data were recorded to the operative archive (file server). In addition, complementary information (digital maps, meteorological and GPS data, etc.) was also added. Then, preprocessing of data was carried out.

Preprocessing of RADARSAT and ENVISAT radar images of the Mamala Bay water area was performed using procedures specially developed to enhance image quality. That was achieved by suppressing the noise and increasing the contrast in order to detect anomalies in backscatter signals produced by sea surface waves. Enhanced radar images were transferred to the database. During this preprocessing, the quality of images and their appropriateness for further thematic processing and analysis were evaluated.

Original images of the Mamala Bay water area reconstructed and enhanced after processing, as well as results from their interpretation with selection of semi-transparent and opaque clouds, shadows of clouds, land areas, as well as ships and their trails in the water area not hidden by clouds, were all entered into the database.

Thematic processing of optic and radar satellite images enabled us to detect zones of water pollution propagation. Remote evaluation of wind speed and direction fields, as well as mapping of temperature fields and some biological components were also carried out (Bondur, 2004, 2005).

Systematization and quality analysis of sea truth data was carried out for all the days of monitoring. To validate space imagery data, a great number of sea truth measurements were carried out. The total volume of this data exceeds 25 Gb. Preprocessing of this information included construction of profiles, rose diagrams and spectra. Evaluation of data quality aimed at identifying data unusable for further processing was also performed, and arrays of input data were composed that were then transferred to the database for further thematic processing.

Results from *in situ* observations performed using buoy stations and dropped and towed sensors enabled us to (1) establish the spectral, space-time and statistical characteristics of different hydrophysical, hydrobiological and hydrooptical parameters of marine environment, including wind conditions at different sites of the water area and at ground stations; (2) build spectra of sea surface waves (based on data collected by wave recorders) and spectra of various current speed components, (3) determine 3D components of current speed vectors and variability of temperature fields in the Mamala Bay water area; (4) obtain spectra of variation for temperature fields; (5) evaluate parameters of internal waves in the water area studied; (6) analyze the correlation between tidal phenomena, temperature changes and oscillations of internal waves; (7) analyze results from MSS-measurements (vertical and horizontal); (8) evaluate the transparency of seawater using results from measurements carried out using a Secchi disk; (9) analyze data collected using hydrobiological measurements and bottom sampling (Bondur, 2005; Bondur, Filatov, 2003).

Based on analysis and systematization of the data collected, a problem-oriented database containing input data and results from thematic processing of space images and sea truth data was created.

4. CONCLUSION

The formulated database provides the capability of complex analysis of state for the investigated littoral water area. This includes:

- Complex analysis of wind conditions using space sensing and sea truth data;
- Comparative analysis of wave spectra built based on results of processing high resolution panchromatic satellite images and data registered by wave recorders;
- Complex analysis of anomalies detected in IKONOS and QuickBird images and hydrophysical and hydrobiological data (fields of current speed, hydrooptical and hydrobiological parameters);
- Analysis of internal wave parameters evaluated using different methods;
- Analysis of results from hyperspectral and multispectral image processing and results from *in situ* measurements (hydro optical and hydrobiological parameters);
- Comparative analysis of results from processing of RADARSAT and ENVISAT radar images and images obtained by the MODIS sensor (TERRA and AQUA satellites);
- Complex analysis of results from processing of RADARSAT and ENVISAT radar images, IKONOS and QuickBird optical images, images taken by the MODIS sensor and results of sea truth measurements;
- Comparison of data on the temperature field of the sea surface collected using *in situ* observations and remote sensing methods;
- Comparative analysis of hydrobiological data and results from processing of images taken by the MODIS sensor (TERRA and AQUA satellites).

The problem-oriented database for space and sea truth measurements also allows developing thematic GIS layers, as well as recommendations for measures that should be taken to protect the ecosystem of the Oahu Island recreational zone (Hawaii).

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