"See The Sea" – new opportunities for distributed collaboration aimed at solution of oceanographic problems using remote sensing

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General description

The "See the Sea" (STS) is an information system developed by the Space Research Institute of the Russian Academy of Sciences (IKI RAS, Moscow, Russia), to study various processes and features in the ocean and sea using diverse satellite data. The STS is the toolkit to work with remote sensing data and to analyze results. Its key advantage is in an ability to perform a complex analysis of data varying in physical character, spatial resolution and units of measurement. The system also provides access to long-term (over 20 years) distributed archives of satellite data for the entire Eurasia from 1995 to the present, including Synthetic Aperture Radar (SAR): Envisat ASAR, ERS-2 SAR, Sentinel-1A, -1B; optical systems: MODIS Terra/Aqua, MERIS Envisat, TM/ETM+/OLI Landsat-5/7/8 satellites series, MSI Sentinel-2A, -2B, OLCI Sentinel-3 and hyperspectral data from Hyperion and HICO systems. Currently, the volume of the archive is over 2 PB and it is updated with real time data daily. In addition, the multi-year weather data are available on-line. The STS is an open system capable to incorporate any required data (such as altimeter data, buoy data, in situ measured data, and other).

The STS capabilities

The main goal of the system is to develop the toolkit for efficient work with diverse data involved into analysis of various processes on the ocean surface. First of all, the STS satellite service allows to perform data transformation and analysis without any preliminary data download, but by accessing the data "on the fly" in the STS archives. It is important that users of the system have no need to install any special software to their PCs. They can also avoid downloading large volume of data for processing, which is especially significant when data processing from new sensors, such as Sentinel 1 & 2 (one MSI Sentinel-2 image may take up to 7 GB). Using the STS is also possible to analyze data provided by the system using a standard Internet browser. The STS automatically downloads complete satellite data as soon as they appear on appropriate servers, for example for Sentinel 1 & 2 data in the Sentinels Scientific Data Hub (SSDH) (https://scihub.copernicus.eu/). The received data are transferred into the UTM/WGS84 projection. From the resulting file, a number of quick view files are generated containing double-thinned georeferenced data with a pyramid of resolutions. These datasets accompanied by metadata are then transferred to the Center for Collective Use of IKI RAS ("IKI Monitoring") archives

where they are stored and from where delivered on request to various information systems. For displaying data in cartographic interfaces of various information systems (including the STS), the online data display unit compiles from the archived data information products (layers) using either the basic resolution or quick look files depending on the scale requested. The required data, so called virtual data products, are actually being prepared on-line when user requests it from the band data stored in the archives. The database stores rules for their formation in a special table structure. The rules allow building of arbitrary band combinations with different normalizations, as well as transformations according to formulas written in a meta-syntax and pixel by pixel transformations. Such approach significantly reduces storage requirements for the set of data products and enables easy addition of new products and modifications of existing ones without extra processing or enlarging physically stored data.

The STS provides a comprehensive toolkit for data processing and analysis; and has capabilities of cartographic web-interface similar to desktop GIS applications. This toolkit is also based on the technology developed by the IKI RAS. Image Algebra, Classification, Image Color Enhancement, Indexing, and some other tools are presently available in the STS. The Image Color Enhancement allows to correct image histograms and improve display characteristics of particular elements. The Image Algebra implements arithmetic, logic and various mathematical transformations according to formulas defined by the user directly via the interface. The Indexing is intended for calculation of various predefined indices. With the Classification one can identify data types and image peculiarities using various supervised and unsupervised classification methods and applying masks. It should be noted, this tool has a high flexibility: it is possible to classify simultaneously data from different sensors, for example, Landsat and Sentinel-2A, taken at different time, data of any bands by user choice, and more.

The STS satellite service provides a powerful toolkit not only for access to satellite data and various information products derived from their processing, but also provides an opportunity for various types of specialized analyses of information. An integrated analysis of data of different physical nature, spatial resolution, dimension and time of acquisition is also available. The STS offers a comprehensive description of different phenomena and processes, their quantitative and qualitative assessment as well as tools to investigate conditions of appearance and development of these phenomena. Studies of spatial and temporal characteristics of distributions of different phenomena are also provided by STS.

Examples of oceanographic tasks solved by means of the STS

1. ***Determination of zones of ecological risk affected by anthropogenic pollution of the sea surface.*** In particular idetification of areas of oil pollutions discharges from ships. For the Black, Baltic and Caspian seas, the main areas of pollution were evaluated and mapped.
2. ***Study of river discharges.*** Terrigenous sediments enter the sea with river plumes of mesoscale structures with sharp boundaries. Not only salinity and temperature in a plume are different from surrounding seawater, but also turbidity in a plume is greater due to increased content of suspended particulates and dissolved organic matter. Every watershed forms a specific individual range of particulate solids. It helps in identifying boundaries of and individual outflow plume. True-color composites of visible satellite data are best suitable for discrimination of sea areas with different optical properties, associated with a concentration of suspended matter. With the Classification tool of the

STS, we have identified and estimated areas with different turbidity. The STS provides methods of a combined analysis of satellite and meteorological data, to reveal an influence of meteorological parameters such as wind and precipitation on formation and distribution of river plumes.

3. ***Study of mesoscale and submesoscale hydrodynamic processes.*** On the basis of long-term series of satellite and meteorological data, hydrodynamic processes of different spatial scales such as vortices, internal waves and fronts were studied. The STS helped to identify areas of their permanent manifestations and mechanisms of their generation. The latest satellite data of high spatial and temporal resolution allow estimating not only spatial but also dynamic characteristics of these processes. The joint analysis of the various satellite data provided in the STS made it possible, for example, to assess the velocity of propagation of these hydrodynamic processes.

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