INFORMATION TECHNOLOGY OF SATELLITE DATA PROCESSING FOR GLOBAL OCEAN SURFACE GRADIENT CHARACTERISTICS CALCULATION

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Abstract. The structural components of information technology and software tools for calculating gradient characteristics of the global ocean surface based on satellite data are considered. The examples of calculation of the global ocean surface gradient fieldsusing information technology and software tools based on satellite data are submitted. A spatial-temporal averaging of gradients in accordance with scales of hydrophysical processes is discussed. The problems of spatial-temporal scaling and averaging of computed regions of the global ocean are considered.

Keywords:global data, format conversion, regional features, gradientfields, frontal zones, spatial averaging, mean seasonal variability.

1 Introduction

Aglobalclimate change problem has led to aneedto find causal relationships between hazardous weather events and dynamic processes in the Global Ocean.Recently, a problem of analyzing manifestations of climate change trends is solved using global data which are results of averaging data from weather stations, ship, buoy and satellite measurements and other sources which are used in re-analysis models [1,2]. Based on these data, global climate change researches are conducted using sea surface temperature (SST) data on large-scale computational grids and a comparison of global differences in sea level pressure (SLP) and surface air temperature (SAT) occurring during El Niño and La Niña [3]. Particular attention is paid to calculating temporal energy spectra of El Nino–South oscillation (ENSO) and global atmospheric oscillation (GAO) indices calculated from observational data and their re-analyzes[3]with relevant characteristics obtained by integrating models CMIP5 [4] in order to identify flaws of modern climate models.

Continuous improvement of global datasets allows working with available measurement data which include interpolation adjustments and averaging of ship and buoy measurements to restore the subsequent period and estimate uncertainty associated with internal parameters of re-analysis. For example, SST demonstrates a significantly more realistic El Niño/La Niña behavior in the early fixation period when data are scarce but provide an improved estimate of long-term variability in zone of internal climate variability [5].

In the global data sets, representation of local SST detailing is improved through overlay SST source data with reference to a degree grid and control of sampling and contact measurements random errors. It provides a unique global analysis of historical data since 1871 [6]. However, these data sets do not have a sufficiently high spatial resolution to study regional characteristics of SSTdynamic switch can be recorded by satellite datawhatmakes it possible to identify local structural features of temperature frontal zones (TFZ) under condition of meandering and vortex formation in interaction system of the cold Labrador Current and the warm Gulf Stream [6, 11].

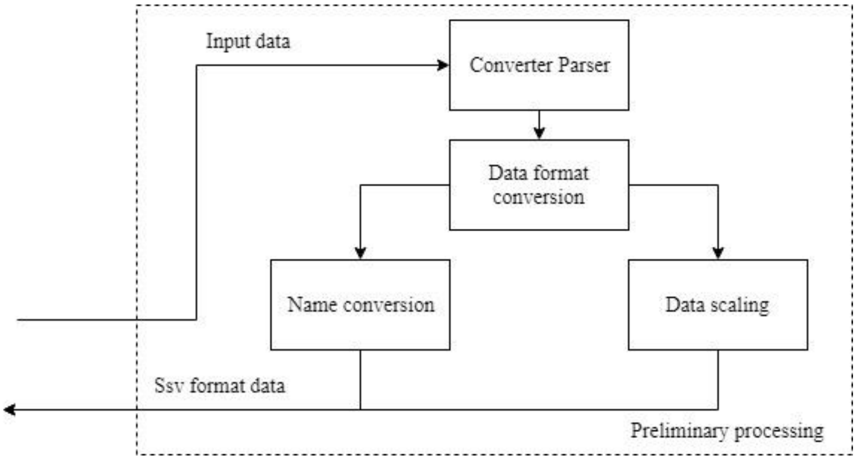
2 Materials and methods

The work uses information technology and software tools to study variability of ocean surface layer TFZ based on satellite data. This information technology consists of two parts: a converter for source data of HDF format and an information system. The basis of the software for calculation and construction of gradient fields of the global ocean surface is a satellite data base, which includes information from PODAAC and Ocean Color data banks [7, 8]:

- satellitedata of temperature of the global ocean surface layer (NOAA) for a period from 1981 to 2002 in HDF format. Spatial scale 18 km/pix - weekly composite;
- satellite data of temperature of the global ocean surface layer (MODISA) for a period from 2002 to 2014 in HDF format. Scale 9 km/pix - monthly average composite.

HDF is a multi-object file format for generating data in a distributed environment developed in 1992 at National Center for Supercomputing Applications in order to use data by scientists working on the same project but in different scientific field s[9]. The self-describing is a main advantage of the data format. The term “self-describing” means that for each HDF data structure in a file necessary information about location of measurement points and their distribution in the file is contained.This information is indicated as metadata.Access to various pieces of information is carried out through metadata which user sets when creating a file [9]. The presence of metadata in the format complicates processing of information, since structure of metadata in different data banks can differ significantly.Therefore, data are prepared and converted to another format before processing.

To convert to required data format, PARSER converter is developed which is a console application working in tandem with HDFTOBIN utility.The main task of the application is to call HDFTOBIN converter for each file from sample, passing it a file name as an attribute with further post-processing of anany file and forming sample to SSV format. The final stage of sample preparationis formalization of sample during which preliminaryfiles are renamed in accordance with requirements of SSV format. Depending on selected menu item, one or another data processing function is launched. The figure 1 shows a structural diagram of PARSER converter operation.



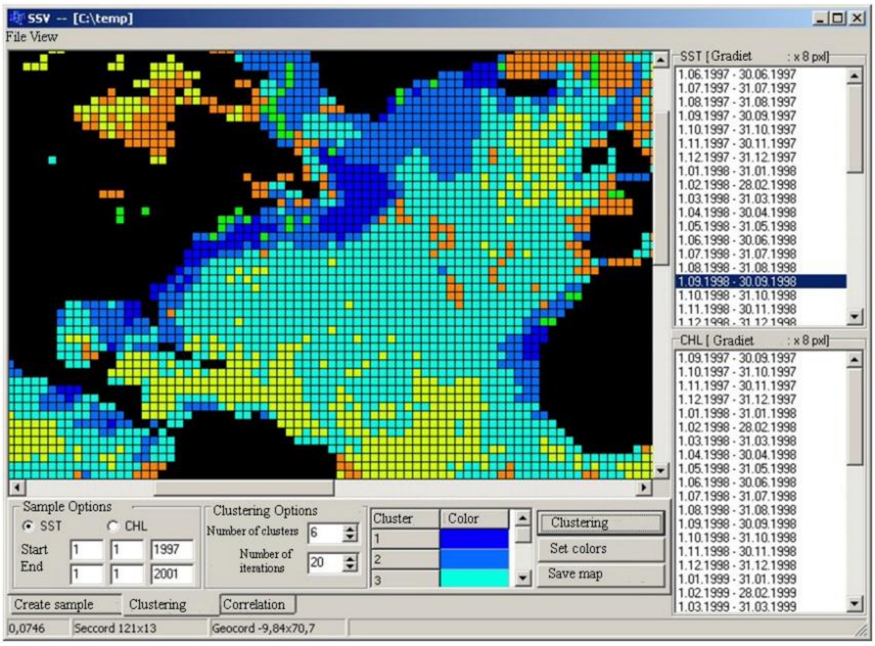


Figure 1. PARSER converter circuit diagram.

Figure 2. An example of information output is “Clustering Panel”.

The SSVOSatD (Sea Surface Variability of Oceanbased on Satellite data) information system (IS) is used as a tool for studying variability of ocean surface structural components, which allows working with data on any media storage, since there is no hard link to directory with input data.

For development of the software, BorlandBuilder C ++ 6.0 Enterprise integrated development environment (IDE) was used. IDE Builder 6.0 is a rapid application development (RAD) system. The problem of input data processing speed was solved by preliminary converting input data into a special SSV format based on presentation of information in binary form.This approach significantly reduces time of information processing [10].

3 Summary and discussion

A basis of satellite data processing technology for calculating gradient characteristics is carried out using the developed information system which implements software procedures and has a number of capabilities.Information system functionality is as follows:

- ensuring averaging of input data on time (monthly, seasonal, annual) and on scale of a computational grid (8, 16, 32, 64, 128), which allows us to distinguish large-scale and long-term hydrophysical processes;
- calculation of gradients and visualization of clusters by gradient values, which implies process of dividing sample into uniform groups with an indication of allocated clusters number and maximum calculation iterations number (allows you to visually identify zones in the ocean with similar changes in gradient values). This displays a visual representation of temperature frontal zonesstructure.Sectors, in which changes in gradient values significantly differ are automatically divided into intervals of gradient values, what leads to formation of a cluster map. An example of clustering is shown in Figure 2.

One of the IS important features is cross-correlation of allocated spatial areas. Calculation of correlation coefficients allows us to identify the presence or absence of a relationship between relevant given variables and is necessary for analyzing dynamics of processes in the global ocean surface layer. The analyzed sectors are selected taking into account several problems: clusters with a close temporal course of gradient variability in latitudinal (zonal), meridional and modulo gradients, which makes it possible to identify energy-active zones, time-space scales of dynamic processes in the global ocean, including determine mechanisms of global circulation.

Additional functionality of the Information System is to display graphs of gradient indicators time course for several selected sectors which reflect dynamics of gradient values. A function of recalculating a correlation coefficient after a temporary “shift” (lag) of gradient values of the second sector relative to the first one is also implemented, which makes it possible to identify a relationship between processes taking into account time delay. An example is shown in Figure 3.

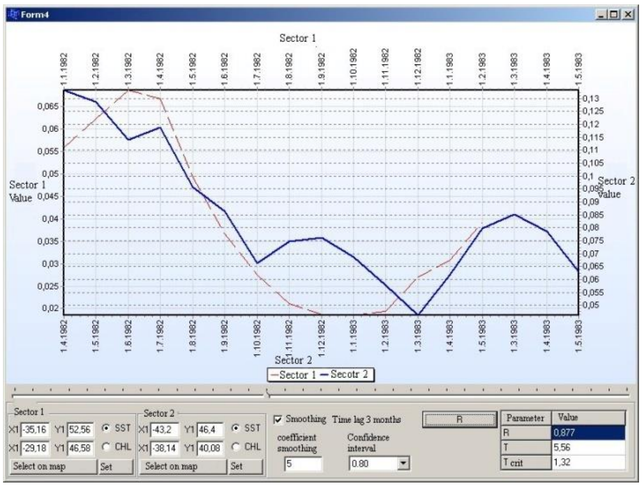


Figure 3. Sector Correlation Window. Ocean Surface Temperature Data(with a lag of 3 months).

Also, the IS provides an ability to output images in form of a correlation table and a correlation map obtained on basis of pair correlationscalculations which display relationships between neighboring sectors (Figure 4).

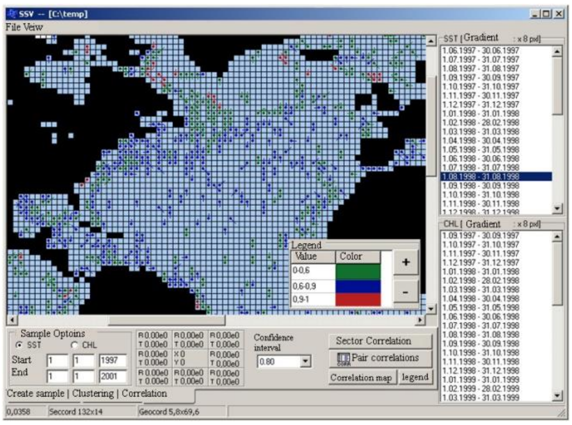


Figure4. An example of information output is the Correlation Map Window.

As an example, a sequence of procedures which must be implemented in order to present calculated characteristics in a form convenient for analysis. Figure 5 shows an algorithm of the Information System.

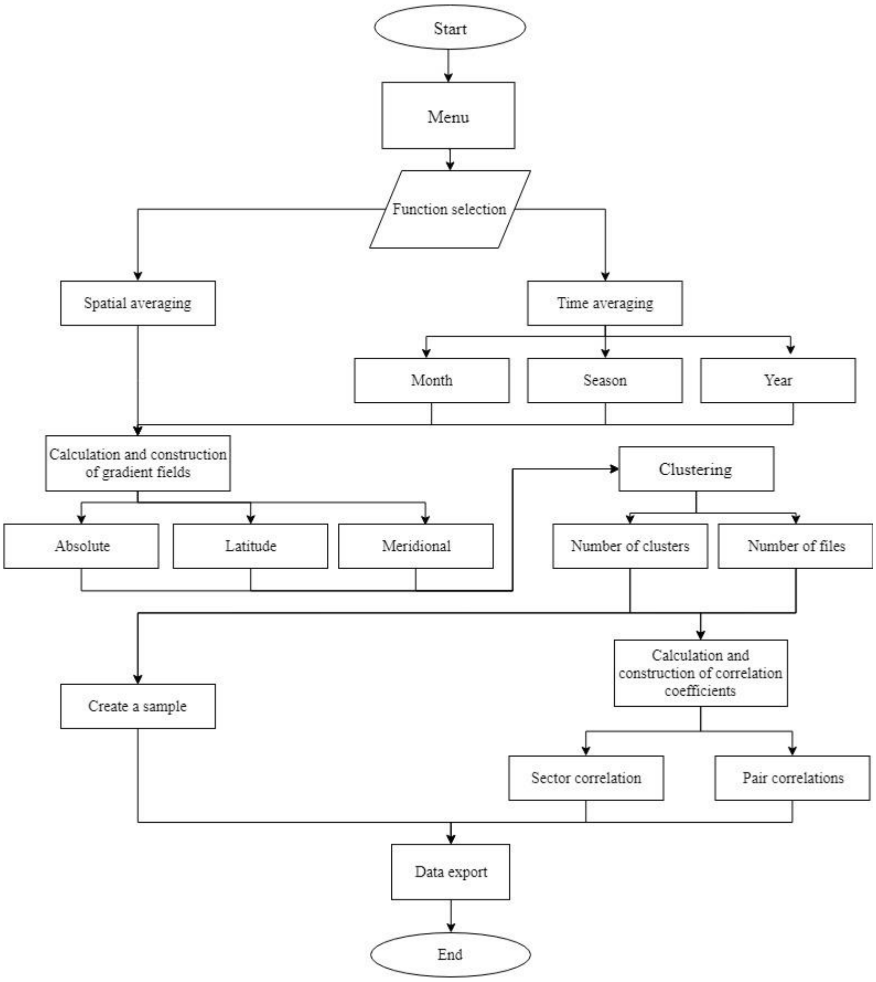


Figure 5. The algorithm implementation of information technology for use satellite data.

3 Conclusion

One of the main conclusions based on results of the work can be formulated as follows: recently, there has been an excessive attention for combining dissimilar measured data on state of the Earth's climate system including contact (in situ) and remote sensing data. The Global warming, Global atmospheric oscillations, Global climate models are used to study fundamental laws of a complex non-linear combination of interaction in an atmosphere-ocean-land system and make it possible to improve predictive estimates of system state. However, one cannot ignore regional features of dynamics of ocean energy-active zones manifestation and structural features of a local interaction of processes in individual ocean regions and heat and moisture fluxes in the troposphere.

The calculations of the global ocean surface gradient characteristics based on satellite data allow us to identify areas with different dynamic activity which play a key role in determining a location of zones with a manifestation of synergism. An analysis of a gradient field magnitude distribution makes it possible to identify heterogeneous and homogeneous zones in an ocean and, with an appropriate averaging period, to obtain a degree of such zone dynamism. This makes it possible to study formation of natural and anomalous structural gradient zones organization processes, an extent of this variability and a vector of dynamic processes development, which can be used in development of mathematical forecast models.

Statistical analysis of gradient indicators makes it possible to obtain a probability of events development degree based on satellite information processing technology and to use data to study global and regional features of natural systems behavior.

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