BIG DATA PROCESSING ALGORITHMS AND ENVIRONMENTAL INDICATORS IN MULTI – CHANNEL MONITORING SYSTEMS

Ferdenant A. Mkrtchyan, Vladimir Yu. Soldatov

Kotelnikov's Institute of Radioengineering and Electronics, RAS, Fryazino Branch
Fryazino, Russian Federation, E-mail: ferd47@mail.ru

ABSTRACT

In this paper problems connected with the decision making when the natural or anthropogenic processes are studied and assessed basing on the big data clouds delivered by the multi-channel monitoring systems. Decision making tool is developed basing on the classical and sequential analysis procedures. It is supposed that studied process is assessed on the base of specific indicator and a set of its values is formed from different information sources.

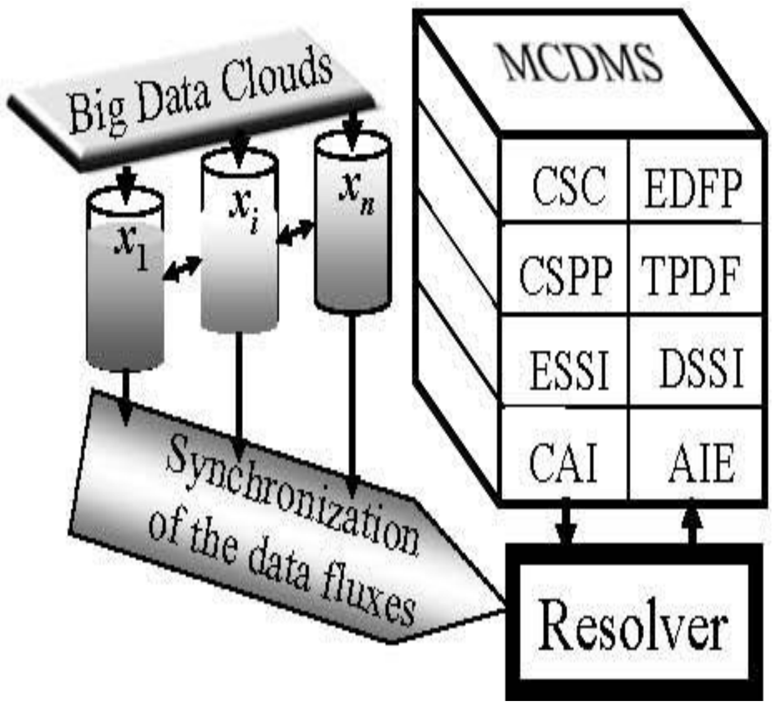
Proposed in this paper multi-channel decision making system (MCDMS) can considered as expert system that automatizes decision making process in different applied areas if the indicator of the studied subject state is defined.

INTRODUCTION

Many problems arising in the climate-nature-society system (CNSS) for their solution need the development of decision making procedures allowing search acceptable strategies for the sustainable development . Sustainable development indicators usually are applied for the assessment of the integral state of studied system or process. As rule, the evaluation of their dynamic characteristics is based on the disembodied data that reflect the endowments of direct and indirect correlations between the processes that act on the studied system. In common case, indicators are used as integral index of the system or process state. A set of indicators is characterized by the variety of their forms and subject orientation. Nevertheless, each indicator is function of many natural and anthropogenic parameters numerical values of which delivered episodically at the time and fragmentary in the space. Under this conditions decision making procedure is to provide the reliable conclusion about the studied system state and to give the recommendations how and what is to be made for the solution of existing problem.

Efficiency of the risk assessment tools depends on the decision making procedure. The most informative decision making procedures are based on the combined use of sequential analysis algorithm and monitoring system. Principal scheme of such algorithm usually is formed from series of the blocks inputs of which receive delivered information and after that this information is assessed in frame work of accepted criterion.

MAIN SCHEME FOR THE MULTI-CHANNEL DECISION MAKING SYSTEM (MCDMS)

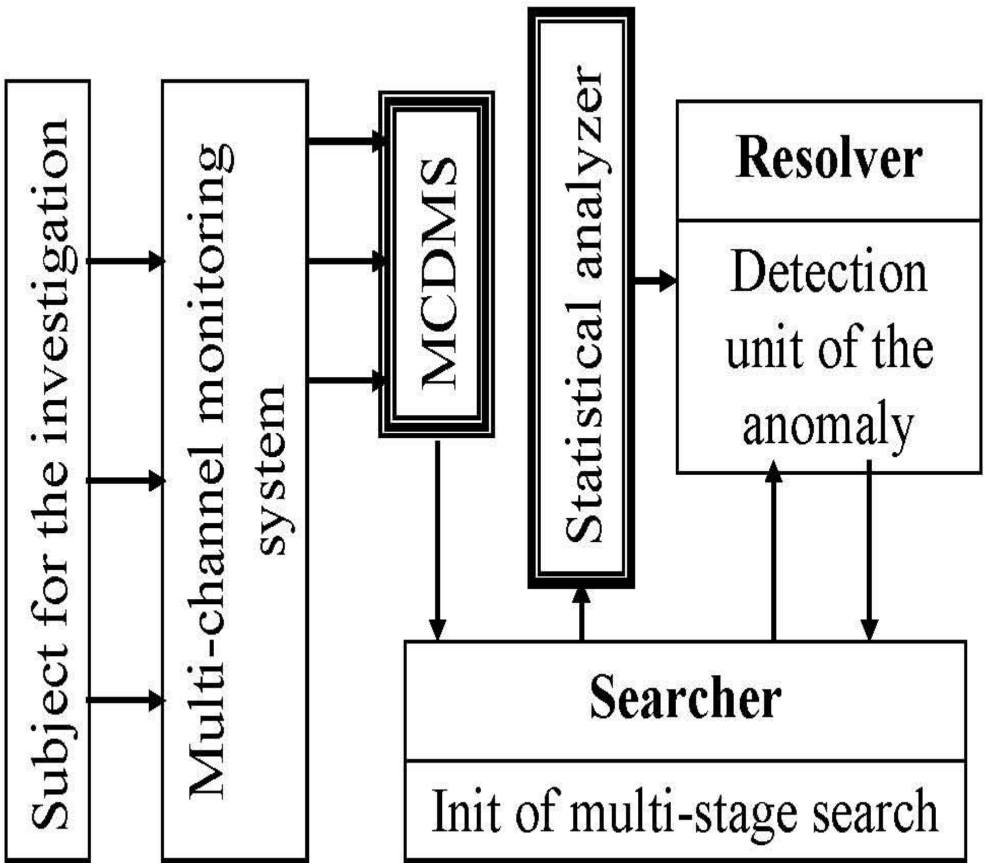


Blocks of the MCDMS

Block	Block function
CSC	Calculation of statistical characteristics.
EDFP	Creation of the empirical distributions of frequency and probability.
TPDF	Creation of theoretical probability distribution function.
CSPP	Calculation of sequential procedure parameters.
DSSI	Definition of the system state Indicators.
ESSI	Evaluation of the system state Indicators.
CAI	Choice of alternative Indicators.
AIE	Analysis of the Indicator evolution.

· **Schematically algorithm for decision making with sequential analysis is represented in Figure. The monitoring data delivered with different channels are characterized different arrival rates, precisions and reliability. Operational decision making is possible when decisions are received basing on the using combination of informational channels.**

BLOCK-SCHEME OF THE ALGORITHM TO DETECT THE ANOMALY IN THE SUBJECT DYNAMICS



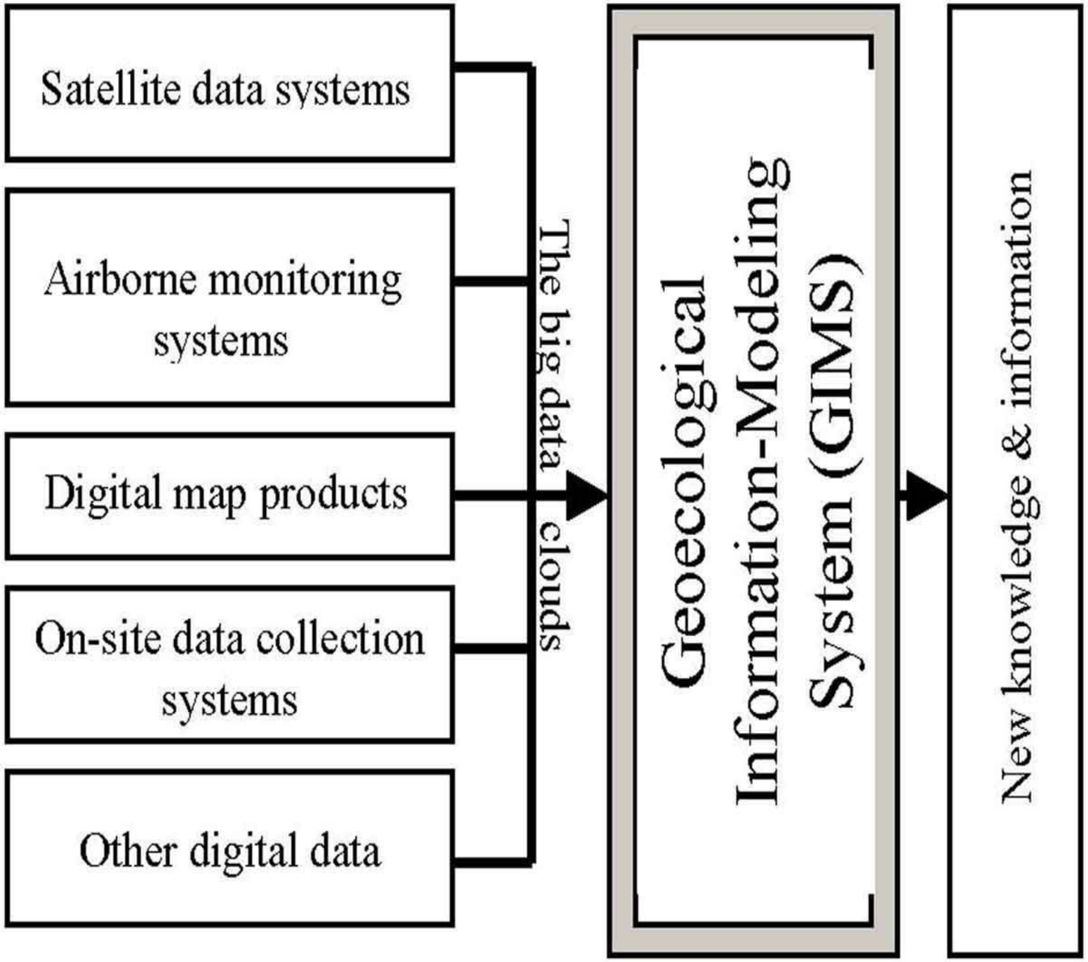
Searcher analyses values of indicator and localizes possible dangerous deviations forming their statistics on the base of which resolver makes a decision about the origin of dangerous changes in the studied system or process.

Real functioning of the MCDMS can has two situations:

- **the MCDMS has time to analyze the $x(t)$ without delay; and**
- **the MCDMS does no have time to analyze the $x(t)$ without delay and makes decision basing on the fragmentary information.**

A big data fluxes in the *i*th channel can have delay by the time of the data deliver and by the restricted volume of the information storage element.

THE GIMS AS BIG DATA APPROACH IMPROVEMENT



Basic GIMS principles are:

•Integration, unification, and coordination of big data fluxes delivered by the existing monitoring resources basing on the unique organizational and science–methodic basis;

•Coordination and compatibility of big data fluxes using the unique coordinate-time system, common system for classification, coding, format, and data structure; and

•Providing the independence of big data fluxes from ecosystem and state boundaries.

In Figure showes the GIMS as tool for integration of big data fluxes delivered by different monitoring systems and other data sources.

DETECTION OF TROPICAL CYCLONE BEGINNING

Develop new indicator for the earlier detection of the tropical cyclone beginning. It is based on the evaluation of instability of the atmosphere/ocean system (AOS). The AOS instability indicator (AOSII) is calculated with the following algorithm:

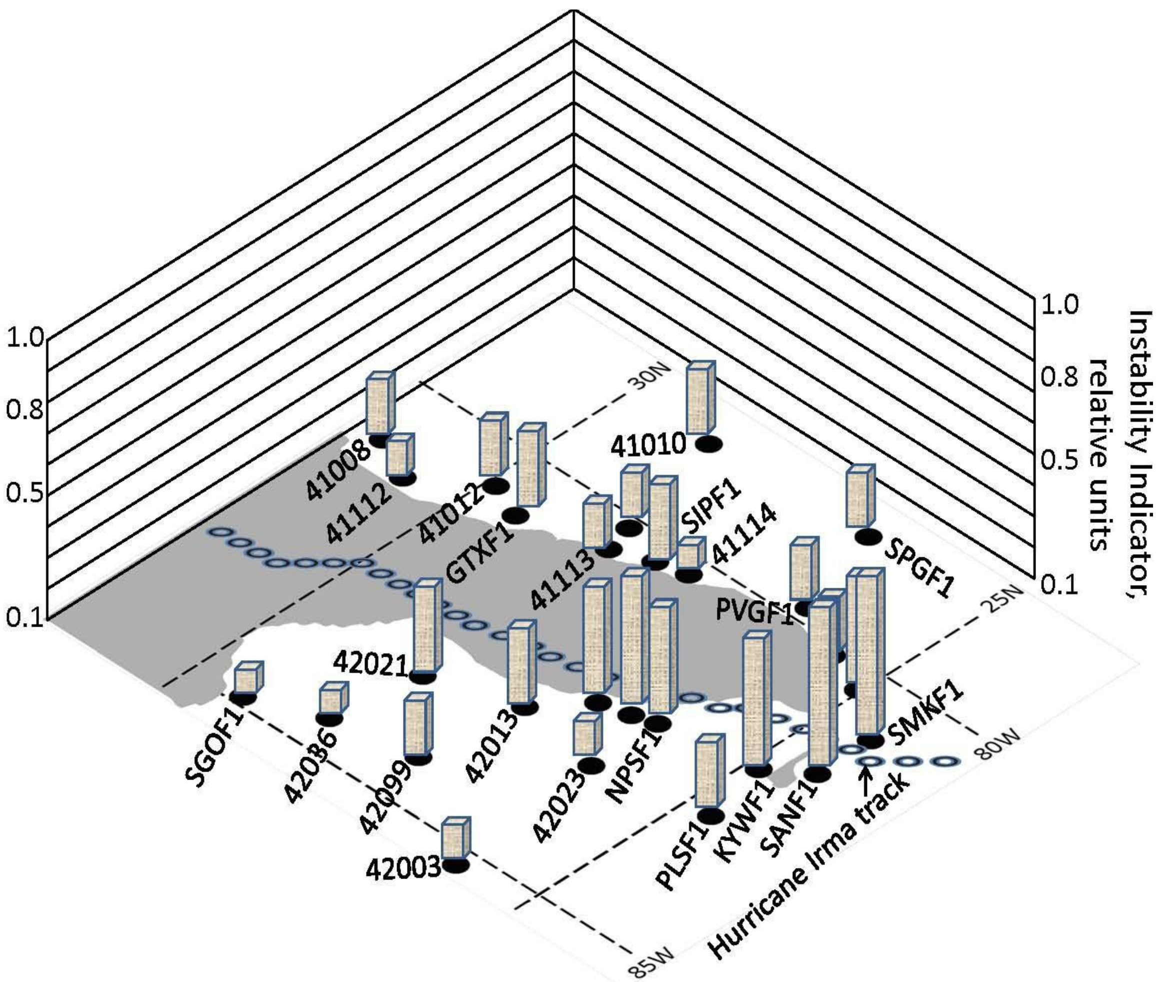
$$I_{AOSII}(x, t_i) = \frac{1}{kn} \sum_{j=i}^{i+n} \sum_{s=1}^{k} Y_s(t_j)$$

where n (=7 hours) is the length of the quasi-stationary period of observations to calculate average values of the ocean-atmosphere system characteristics; k (≤ 17) is the number of registered parameters of the AOS; vector $x(x_1,\dots,x_k)$ represents the values of the AOS characteristics in the geographical coordinates (φ,λ) at the time t_j:

$$Y_s(\varphi, \lambda, t_j) = \begin{cases} 1 \text{ when } \Delta x_s(t_j) \cdot \Delta x_s(t_{j+1}) \leq 0, \\ 0 \text{ when } \Delta x_s(t_j) \cdot \Delta x_s(t_{j+1}) > 0 \end{cases}$$

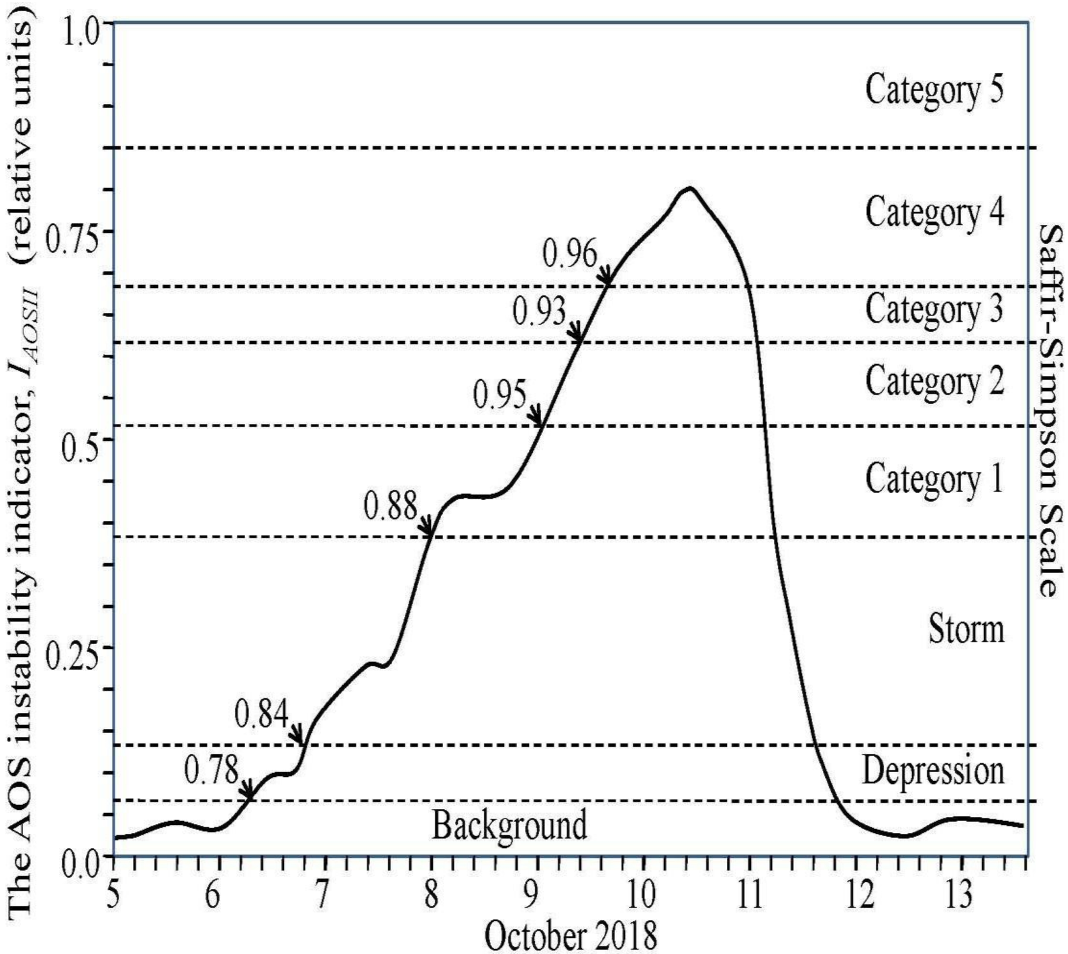
Where $\Delta x_s(t_j) = x_s(t_j) - x_s(t_{j+1})$; $\Delta x_s(t_{j+1}) = x_s(t_j) - x_s(t_{j+2})$

The I_{AOSII} calculated for hurricane Irma (September 11 2017) using meteorological data from NDBC weather stations located in the Florida



The I_{AOSII} reflects the development of destructive processes in the AOS taking into account of instable dynamics of each characteristics assessing weight contribution of every characteristic to the AOS instability development. Spatial distribution of the I_{AOSII} calculated on the base of big data clouds as it is seen from Figure identically showing the cyclone origin coordinates and than tracks of its motion in the space. In the case of the hurricane Matthew (September 28 – October 10 2016, category 5) the spots of the I_{AOSII} moves in direction of its track what allows the detection and prognosis of the hurricane motion direction.

THE AOS INSTABILITY INDICATOR DYNAMICS IN THE CASE OF TROPICAL HURRICANE MICHAEL



Calculation of the I_{AOSII} in coordinates (φ,λ) at time t_i creates the sequence of indicator values and the MCDMS assesses the probability $P\{I_{AOSII}(\varphi,\lambda,t_i)>\Pi\}$ where threshold Π is coordinated with Saffir-Simpson hurricane scale. Figure shows this coordination in the case of hurricane Michael (7-11 October 2018). Probabilities are shown on the curve that reflects the indicator instability dynamics.

CONCLUSION

Co-evolution of climate, biosphere, geosphere, hydrosphere, and human society depends on how the Earth's system generates and maintains thermodynamic imbalance. Understanding and evaluating processes in the climate–nature–society system requires the big data processing algorithms under the exponential growth of them and when using traditional data processing tools eventually become obsolete. Most of the existing climate models and global biospheric models do not provide overall analysis of the processes existent in the Earth system. The GIMS can play the role of the Big Data information-modeling system that at one time can analyze heterogeneous data delivered by different monitoring systems with incongruous scales and un-removable uncertainties. GIMS is as a new Big Data Approach. Moreover, the GIMS possesses the data fusion function when data are delivered from dissimilar sources by irregularly in time and fragmentary by space.