GEOINFORMATICS 2020

EAGE

17882

Theory and realization of dynamic correlation method for environmental safety evaluation

V. Okhariev *(Institute of Telecommunications and Global Information Space, NASU)*

SUMMARY

An approach to environmental monitoring data analysis was proposed and substantiated. It builts on introducing the concept of dynamic correlation and the method of calculation its coefficient based on actual techniques of correlation analysis. The method was tested on environmental monitoring statistical data at one of Ukraine regions and was implemented in the developed software. The proposed approach can be used in tasks of operational monitoring and for environmental emergencies forecasting.

Introduction

The current research topics in Institute of Telecommunications and Global Information Space are wide-variety. One of the main areas of research is new information technologies and mathematical modelling methods creation for solving the actual problems of environmental safety. Among them, it is necessary to highlight a research of hazardous processes into geological terrain and soils (Trofimchuk, A.N., 2002; Trofymchuk, O. et al., 2017, particularly landslide problem (Kaliukh, I. and al., 2015; Trofymchuk, O. et al., 2013a). Actual geoformation technologies (GIS) and remote sensing technologies can be used for modelling [(Trofymchuk, O. et al., 2013b; Trysnyuk, V. et al., 2019) and mapping (Baum, R.L. and al., 2014) of landslides. Except geological processes, GIS and remote sensing are using for anthropogenic impact evaluation (Korchenko, O. et al., 2019; Trofymchuk, O. et al., 2019). Aspects of environmental monitoring and management based on modern information technologies were presented in such researches as (Okhariev, V. and Trysnyuk, V., 2019). Also a new method of decision of inverse problem in well logging electrometry was found (Myrontsov, M.L., 2019a; Myrontsov, M.L., 2019b). In this paper author touches on a problem of a factor score in multi-parameter system in area of environmental monitoring.

Method and theory

One of the methods of model status describing is to determine values of some parameters that describe its instantaneous state. However, research of this system status in dynamics needs determination not only instantaneous values of these parameters, but also the dynamic conformities that describe the changes. For example, if the oscillation period of mathematical pendulum does not depend on the mass of the material point and the amplitude of oscillations, it can be described by the height of material point deviation from the equilibrium point and the motion direction. However, these two parameters do not contain information about the further dynamics of the system or qualitative change of its status.

There are a lot of systems with significant negative consequences of qualitatively condition changes. For example, constantly observed quantitative changes in Earth crust fluctuations can take a qualitatively different form and may lead to earthquakes with human casualties, infrastructure destructions and other consequences. Also there are many situations in the area of environmental safety with such specific. Foremost, it is prevention of emergency situations concerned with anthropogenic pollution of environment.

Let's try to research not the mutual relations between the instantaneous values of the system parameters, but the dynamics of their mutual connection. At that, a certain dynamic process changes the degree of mutual connection. Let's introduce a quantitative measure of interconnection degree similarly to Pearson correlation coefficient (Okhariev, V., 2019). It was calculated for several functions and for a limited "window" of observation:

$$DC_m^l(X_1, X_2, \dots X_n) = \frac{\Sigma_{j=m-l}^{m} \Pi_{i=1}^{n} (X_i^j - \Sigma_{k=m-l}^{m} X_i^k)}{\sqrt[2]{\Pi_{i=1}^{n} \Sigma_{j=m-l}^{m} (X_i^j - \Sigma_{k=m-l}^{m} X_i^k)^2}}$$

where x_j – researched function; x^j_i – their instantaneous values at the moment j. Target value is dynamic correlation coefficient (DCC).

Examples

For example, let's use proposed method to analyze statistical information about anthropogenic impact to hydrosphere for a number of ecological features. Test location is a section of Ustia river-bed situated in the area of Rivne city, Ukraine. List of features exist suspended substances, pH, dissolved oxygen, biochemical oxygen content, ammonium nitrogen, nitrate nitrogen, nitrite nitrogen, phosphates, and chlorides.

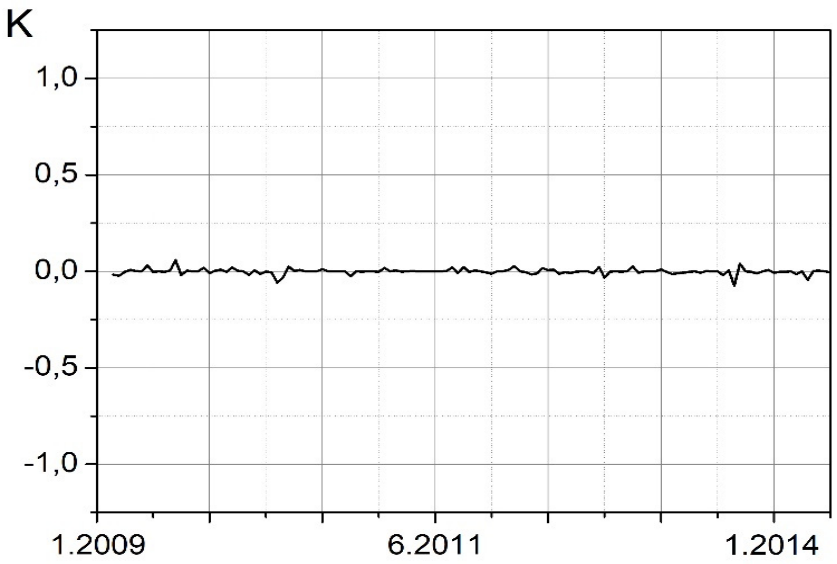

Figure 1 *DCC for all features*

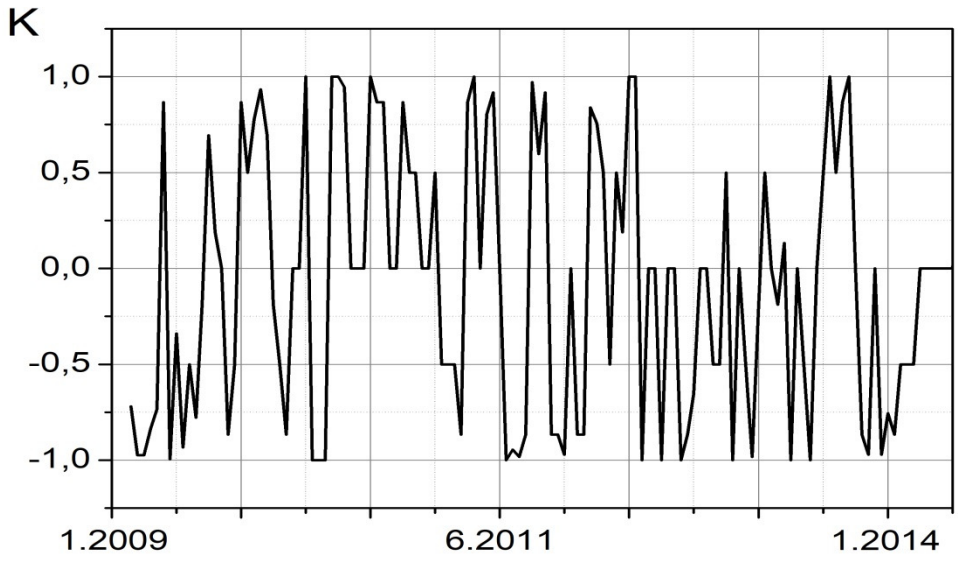

Figure 2 *DCC for suspended substances and pH*

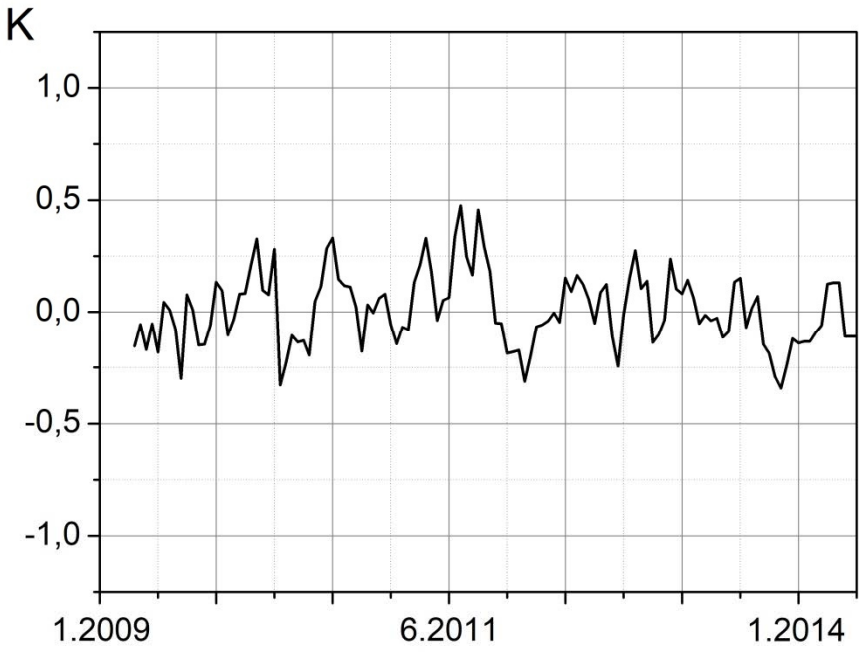

Figure 3 *DCC for suspended substances, pH and dissolved oxygen*

Sudden changes of correlation graphics at particular short moments can show a high probability of pollutants discharge in given period. Also, it can be unauthorized. Consequently, describe approach and software can be used for operational monitoring and prevention of emergency.

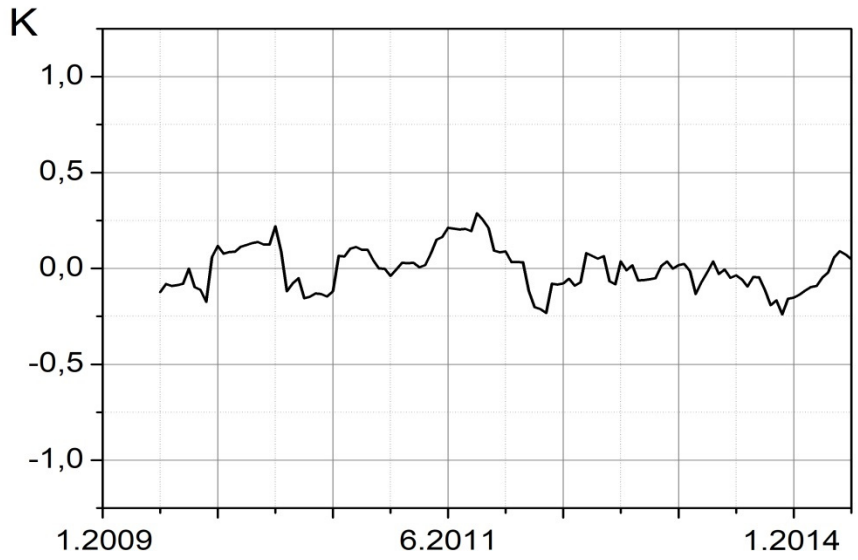

Figure 4. *DCC for suspended substances and dissolved oxygen*

Conclusions

Based on the above, we can draw the following conclusions. Proposed approach to environmental safety evaluation based on dynamic correlation coefficient (DCC) calculation provide high efficiency upon condition of actual, multi-parameter and correct data occurrence. The main result is the method justification, algorithm development and implementation of specific software.

References

Baum, R.L., Miyagi, T., Lee, S., Trofymchuk, O.M. [2014] Introduction: Hazard mapping. Landslide Science for a Safer Geoenvironment: Volume 2: Methods of Landslide Studies, Springer, Cham. 395-396.

Kaliukh, I., Senatorov, V., Marienkov, N., Trofymchuk, O., Silchenko, K., Kalyukh, T. [2015] Arrangement of deep foundation pit in restricted conditions of city build-up in landslide territory with considering of seismic loads of 8 points. *Geotechnical Engineering for Infrastructure and Development – Proceedings of the XVI European Conference on Soil Mechanics and Geotechnical Engineering, ECSMGE.* **3**, 955-959.

Korchenko, O., Pohrebennyk, V., Kreta, D., Klymenko, V., Anpilova, Y. [2019] GIS and remote sensing as important tools for assessment of environmental pollution. *19th International Multidisciplinary Scientific GeoConference SGEM 2019,* Extended Abstracts, **19**, (2.1), 297-304.

Myrontsov, M.L. [2019a] The method to solve the inverse problem of lateral logging sounding and lateral logging. *XIII International Scientific Conference "Monitoring of Geological Processes and Ecological Condition of the Environment"*, Extended Abstracts

Myrontsov, M.L. [2019b] The problem of equivalence in inverse electrometry problems of oil and gas wells. *18th International Conference Geoinformatics – Theoretical and Applied Aspects*, Extended Abstracts

Okhariev, V., Trysnyuk,V. [2019] Environmental aspects of Ukrainian energy sector in connection with transition to low-carbon development. *International Conference on Monitoring of Geological Processes and Ecological Condition*, Extended Abstracts.

Okhariev, V. [2019] Improvement of statistical method for environmental monitoring datasets interpretation. *International Scientific Conference Monitoring 12–15 Nov 2019*, Extended Abstracts

Trofimchuk, A.N. [2002] Unsteady oscillations of a liquid-saturated poroelastic soil layer. *International Journal of Fluid Mechanics Research*. **29,** (1), 124-133.

Trofymchuk, O., Kaliukh, I., Klymenkov, O. [2017] TXT-tool 2.380-1.1: Monitoring and early warning system of the building constructions of the livadia palace, Ukraine (Book Chapter). *Landslide Dynamics: ISDR-ICL Landslide Interactive Teaching Tools: Volume 1: Fundamentals, Mapping and Monitoring*

Trofymchuk, O., Kalyukh, Y., Hlebchuk, H. [2013] Mathematical and GIS-modeling of landslides in kharkiv region of Ukraine. *Landslide Science and Practice: Spatial Analysis and Modelling*

Trofymchuk, O., Kalyukh, Yu., Trofimova, I., Hlebchuk, H. [2013] Modelling of Landslide Hazards in Kharkov Region of Ukraine Using GIS. Landslides: Global Risk Preparedness. Springer, Berlin, Heidelberg. 267-276.

Trofymchuk, O., Yakovliev, Y., Klymenko, V., Anpilova, Y. [2019] Geomodeling and monitoring of pollution of waters and soils by the Earth remote sensing. *19th International Multidisciplinary Scientific GeoConference SGEM 2019*, Extended Abstracts, **19**, (1.4), 197-204.

Trysnyuk, V., Okhariev, V., Trysnyuk, T., Zorina, O., Kurylo, A., Radlowska, K. [2019] Improving the algorithm of satellite images landscape interpretation. *18th International Conference Geoinformatics – Theoretical and Applied Aspects,* Extended Abstracts.