Geophysical Research Abstracts
Vol. 16, EGU2014-13036, 2014
EGU General Assembly 2014

Methods for space-time scaling of the atmospheric processes and a variational technique for studying the variability of the climatic system and assessing the environmental risks

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To study the dynamics of long-term variability of climatic and ecological systems and to assess the environmental risk due to the impacts of natural and anthropogenic origins, a methodology of modeling is developed. The study is fulfilled on large data sets obtained by observations or modeling. An example of such database is reanalysis data on meteorological fields over a long period of time.

To separate the scales of processes present in these data, some numerical methods are used. They are optimization methods of orthogonal decomposition, principle component analysis and methods of singular value decomposition of matrices in the phase space constructed from these databases. The result is a set of multidimensional orthogonal basis subspaces ranked according to a predetermined criterion of their informativeness [1].

In our approach, variational principles that unite the entire set of models describing the studied processes and all available observed data are essentially exploited. They allow us to design the methods of direct and inverse modeling. The methods of sensitivity theory are among them. They provide the possibility to estimate the behavior of the system under different perturbations in the initial state, in model parameters and sources of impacts. Sensitivity functions provide quantitative estimates of the relative input of variations of all parameters to the given cost functional. This allows one to identify the main origins of disturbances and their scales.

Some typical problems are considered: revealing the centers of action in the climate system, formatting scenarios for solving environmental problems, assessing the possible risk and vulnerability in the organization of environmental policies, etc [2].

Developed mathematical tools have a wide range of practical applications related to the study of nonlinear dynamical systems and space-time scaling of the various characteristics of processes in the atmosphere, ocean and environment.

The work is partially supported by the Programs No 4 of Presidium RAS and No 3 of Mathematical Department of RAS; by RFBR projects No 11-01-00187; by Integrating projects of SD RAS No 8 and 35.

References

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