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New approaches to space weather forecasting

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We developed several approaches to the problem of real-time space weather indices forecasting using readily available data from ACE and a number of ground stations.

The first one is based on a dynamical-information approach to nonlinear modeling of space plasma [1]. It uses new nonlinear mathematical models of geomagnetic indices and original algorithms for detection of structure and parameters. The identification problem is formulated as a constrained optimization problem. Novel algorithms provide an optimal structure of discrete dynamical system using fuzzy systems modeling.

The second one is based on the regression modeling method [2], which combines the benefits of empirical and statistical approaches. It uses such statistical methods as the linear regression analysis, maximum likelihood method, dispersion analysis and Monte-Carlo simulations to deduce the empirical relationships in the system.

In both cases the typical elapsed time per forecast is about several seconds on an average PC. Such techniques can be easily extended to other indices like AE and Kp. The proposed system can also be useful for investigating of physical phenomena related to interactions between the solar wind and the magnetosphere – it already helped uncovering two new geoeffective parameters.

In addition, we performed the risk analysis of damage to VUV, EUV and X-ray optics due to space weather factors and analyzed the safety of space instruments.

We plan combining short-term and medium-term approaches to accurately predict geomagnetic storms at least 5-10 hours before commencement.

Practical applications of such a system include (but are not limited to):
– spacecraft safety (prediction of radiation threat);
– human health (putting emergency services on alert);
– prevention of technological disasters (power grid failures, major radio blackouts).

1. Cheremnykh O.K., Yatsenko V.A., Semeniv O.V., Shatokhina Yu.V. Nonlinear dynamics and prediction for space weather // Ukr. J. Phys. — 2008. — V. 53, №5. — P. 502-505.
2. Parnowski A.S. Regression modeling method of space weather prediction // Astrophysics & Space Science. — 2009. — V. 323, № 2. — P. 169-180. doi:10.1007/s10509-009-0060-4 [arXiv:0906.3271]