Project: **169**

Project title: **Gekoppeltes Ozean-Atmosphären-Stratosphärenmodell in Lehre und Studium**

Project lead: **Ingo Kirchner**

Report period: **1.1.2014 - 31.12.2015**

Schwerpunkte des Projekts

Im Rahmen des Projektes wurden Testsimulationen mit dem COSMOS Modell zur Datenassimilation durchgeführt. Das Modellsystem wurde für die Assimilation von Ozeandaten vorbereitet, um das Modell spÃ¤ter auf einem ähnlichen System am Dorodnicyn Computing Centre of Russian Academy of Sciences für Datenassimilationsexperimente einzusetzen. Ein weiterer Teil der Ressourcen wurde in Verbindung mit dem Projekt 884 verwendet.

Part 1: The observation data inclusion for the analysis of dynamic processes in ocean model of circulation (Belyaev K.P., Kirchner I., Tuchkova N.P.)

The variant of adaptation of the MPIESM(ECHAM6/MPIOM/JSBACH/HAMOCC) model is considered. The MPIESM model represents the expanded version of the joint climatic COSMOS (ECHAM/MPIOM)[1,2] model developed in the European scientific professional community of climatic researches and realized in the German computer center of climate of DKRZ. The new data assimilation method with application of the theory of diffusive processes and the stochastic differential equations is offered. Examples of impact of assimilation of data of observations of ocean level on dynamic characteristics of model calculation are given.

The data assimilation of these observations from satellites, in particular, of data on the ocean level and ocean surface temperature is the main direction in the theory and practice now. It is explained by that circumstance that from satellites it is at the same time possible to obtain large volume of the data covering extensive zones of the ocean. Besides, development of mathematical methods of the analysis, modeling and assimilation of these observation, and also increase in speed of modern computing means and communication networks does possible simultaneous parallel calculation of characteristics of the ocean in different areas. In the real work assimilation is carried out along tracks of satellites in the Atlantic Ocean for the anomalies of level of the ocean which are considered as the most significant characteristics for the description of superficial and subsurface dynamics of the ocean.

At assimilation of data of sea level anomaly (SLA), in particular, the generalized Kallman's (EnKF) the filter is used, as a rule. As between model SLA and other variables there is a strong correlation, statistical approach is justified here. The new data assimilation method are developed in this project [3, 4, 5]. The method is based on minimization of the following functional:

$$L(K,\phi) = KQK' + [(I + KH)\Lambda]\phi \quad , \qquad (1)$$

where: *K* – the unknown and subject to definition matrix of dimension *rxn*, *Q* – the covariance matrix of observations of dimension *nxn*, the matrix is supposed known, *H* - the known dimension matrix *nxr*, it means the projection matrix from model space of dimension r to space of observations of dimension *n*, *I* – the identity matrix of dimension *rxr*, *Λ* - the operator of model, of dimension *rx1*, *Φ* - the vector of multipliers of Lagrange, of dimension *1xr*. The stroke at the top of a vector or a matrix designates its transposing. Minimization of functionality (1) makes physical sense of definition of a minimum of the dispersion or diffusion set by a matrix *KQK'* n condition of known or defined from observations of a vector of demolition *(I+KH)Λ* (see illustration on fig.1).

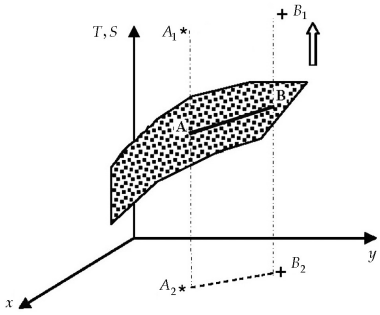

Fig.1. Geometrical illustration of the scheme of assimilation

The geometrical illustration of the scheme (fig. 1) of assimilation using dynamics - stochastic ideology. Let in t_1 timepoint in a point of the coordinate plane measurement of A_2 become, thus value of model is equal in this point to A, and value of measurement is equal to A_1. It is required to correct value of model in B_2 point at the time of t_2 where value of model before correction equally to B, and measurements aren't present. For this purpose it is necessary to know the connection between points of A and B depending on many factors. This dependence can be expressed through the model equations, but the corresponding formulas are, as a rule, almost unsuitable for calculations. In linear approach this connection is defined by covariance function between points of A_2 and B_2 or between A and B values.

The data assimilation block which was realized on DKRZ platform is consist of the following parts:

- modelling results database (for the statistical analysis for data assimilation)
- the interface programs for extraction and data transmission in model for continuation of integration (ext and nc output and input files processing)
- programs of formation of data files with assimilation of observation (include the analysis and a filtration of data, work with coordinate grids and also numerical algorithm of the method given above)

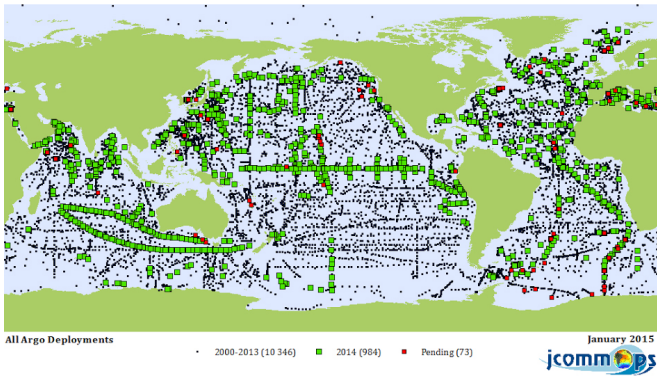

Fig. 2. Map of ARGO drifters

Joining of the MPIESM model and the data assimilation method, experiments in the project with assimilation of these observation from satellites (level of the ocean and superficial water temperature), and also the ARGO (see fig. 2) drifters (http://www.argo.net/), and the analysis of results of these experiments is provided. Besides, comparison of author's methods and models with researches of other authors is provided.

References:

1. Haak H. Simulation of Low-Frequency Climate Variability in the North Atlantic Ocean and the Arctic, Volume 1. Max Planck Institute for Meteorology, 2004.

2. Wetzel P., Haak H., Jungclaus J., Maier-Reimer E. The Max-Planck-Institute Global Ocean/Sea-Ice. Model
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3. Belyaev K.P., Kirchner I., Tuchkova N.P. The method of correction of model calculations for data of measurements based on diffusive approach, and its applications for the analysis of hydrophysical characteristics // Mathematical modelling, 2009. V. 21. No. 3. P. 53-68 (in Russian).

4. Belyaev K.P., Tuchkova N.P., Cubasch U. A reaction of the couple “ocean–ice–atmosphere” model on data assimilation in the tropical zone of Pacific ocean // Oceanology, 2010, V. 50. No. 3. P. 334-344.

5. *Belyaev K.P., Tuchkova N.P. On a limit distribution of characteristics in stationary regime for the linear assimilation problem // Informatics and Applications, 2015. V. 9. Issue. 2. P. 50-55.*

Part 2: Regional simulations for CORDEX-East-Asia (Hunag, Bo)

This work is strong collaboration with project 884 “**Dynamical downscaling in CORDEX-East Asia using the high resolution Regional Climate Model COSMO-CLM**”. Following the CORDEX-East Asia Phase I framework, COSMO-CLM regional climate model simulations have been carried out with a horizontal resolution of 0.44º. The simulating time period is 1989-2008 and forcing data is ERA-Interim. Then, the simulation results have been inter-compared with other 4 RCMs which are contributed to CORDEX-East Asia. The inter-comparison work is focus on the precipitation climatology which include (1) an extreme rainfall event, (2) seasonal climatology, (3) annual cycles and inter-annual variability and (4) the monsoon characteristics. Based upon the model performance, the present set of RCMs from CORDEX can be used to provide useful information on climate projections over East Asia. All these work are contributed to the CORDEX-East Asia project, and has been published on the Journal of Climate Research (Huang et al., 2015).

References

Huang B, Polanski S and Cubasch U (2015) Assessment of precipitation climatology in an ensemble of CORDEX-East Asia regional climate simulations. Clim Res 64: 141–158