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Forecasting the weather
- ensemble techniques
in probabilistic weather prediction

Exploring the role of process-oriented GIS in advancing the scientific knowledge in applied meteorology and climatology

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Many scientific studies require collection, analysis and visualization of meteorological data characterizing spatially distributed processes and phenomena. This paper is focused on GIS applications in meteorology and environmental impacts of meteorological factors and addresses a new type of systems that combine the conventional GIS functions with the elements of the process-oriented modelling. One of the examples of such a new system is given by the GIS developed in the Russian State Hydrological Institute in association with the research of the environmental impacts of meteorological factors.

The "computational information system" COMINSY is focused on Russia, and addresses meteorological and agroclimatic parameters, zonation of vegetation, as well as the processes associated with permafrost. It combines many of the conventional GIS features with the process-oriented models and databases necessary to drive them. The COMINSY meteorological data base includes temperature and precipitation data from more than 1600 Russian weather stations with monthly and 3-hourly resolution, and unique daily data on the forms of atmospheric circulation (in classification by Vangengeim and Girs), characterized by three major circulation forms, W, E, and C. These forms are defined on the basis of the 3-dimensional analysis of the sea-level pressure field and generally correspond to dominating westerlies over European part of the continent and most of Siberia (form W), and presence and location of the atmospheric blockings (forms E and C). The data base also includes soil properties, ground temperatures, vegetation, and several GCM-based climate projections scaled to Russia. COMINSY includes several environmental models, i.e. statistical vegetation model, and comprehensive permafrost models of different complexity. The system functions as (a) a relational database; (b) an analytical tool and predictive (through embedded models) instrument; and (c) a cartographic system with scaling capabilities.

The COMINSY was used to study the regional trends of air temperature and precipitation in Russia and to rank the GCM-based climatic projections according to their consistency with the observed regional trends; to calculate changes in the demand for heating energy in the northern lands and agroclimatic potential characterized by the length of the warm period and growing temperature sums (temperatures above +5 C); to calculate the distribution of vegetation zones under current and projected for the future conditions; to predict the distribution, temperature, and depth of seasonal thawing of permafrost under several scenarios of climatic change, and to evaluate the potential hazards to infrastructure built upon permafrost due to warming and thawing of the frozen ground and extreme meteorological conditions. The overall general conclusion that could be made from these studies is that the design of such a combined data assimilation system adds the scientific value of the up-to-date process-oriented mathematical models to the power of the conventional GIS tools ultimately facilitating their use by the broad scientific community, planers, environmental managers and decision makers.

Elements of COMINSY as well as publications devoted to specific applications of this system are presented on a dedicated web portal http://permafrost.su/.