Virtual research environment for analysis, evaluation and prediction of global climate change impacts on the Northern Eurasia environment

Evgeny P Gordov (gordov@scert.ru), Igor Okladnikov, Alexander Titov, Alexander Fazliev

Institute of Monitoring of Climatic and Ecological Systems SB RAS, Tomsk, Russian Federation; Tomsk State University, Tomsk, Russian Federation; Institute of Atmospheric Optics SB RAS, Tomsk, Russian Federation

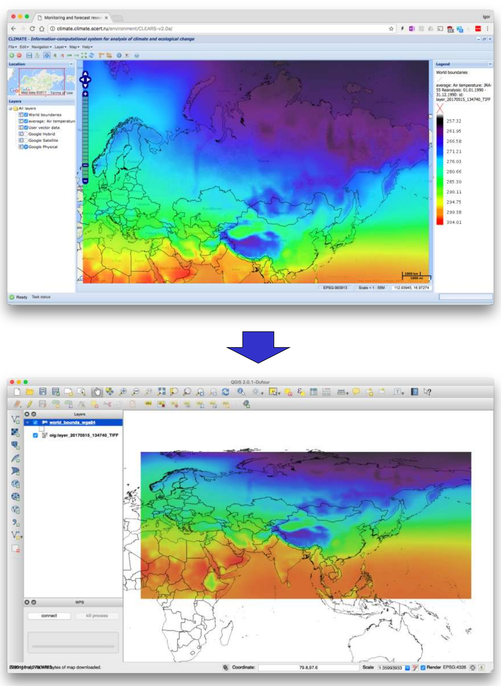
Description and the first results of development of virtual computational information environment for analysis, evaluation and prediction of the impacts of global climate change on the environment and climate of a selected region is presented. The thematic virtual research environment is aimed at development of an Internet-accessible computation and information tools providing specialists, decision-makers and stakeholders with reliable and easy-used tools for in-depth statistical analysis of climatic characteristics, and instruments for detailed analysis, assessment and prediction of impacts of global climate change on the environment and climate of the targeted region. It also provides computational processing services launching to support solving tasks in the area of environmental monitoring, as well as presenting calculation results in the form of downloadable and accessible through WMS/WFS cartographical layers in raster, vector and binary formats. Its usage for solving related to Northern Eurasia climate change research problems is illustrated.

Introduction

Currently the Virtual Research Environment (VRE) prototype integrates various spatial datasets such as WRF and «Planet Simulator» models outputs, global climate reanalysis, and meteorological stationary observations in the framework of a single geoportal. It supports complex statistical analysis of datasets and represents spatial results as georeferenced GIS-layers available for visualization and downloading. This prototype can provide specialists involved into multidisciplinary research projects with reliable and practical instruments for integrated analysis of climate and ecosystems changes on global and regional scales. With its help a user without skills in software development and data handling would be able to process and visualize multidimensional observational and model data in the unified web-interface using common graphical web-browser.

Three steps to process data and create a new product layer are shown below.

Resulted cartographical layers can be downloaded as a raster (GeoTIFF, PNG, JPG), vector (KML, GML, ESRI Shape) or binary (NetCDF) files, or transferred through WMS/WFS into a desktop GIS.



Prototype capabilities

Data handling

Prototype natively supports: NCEP/NCAR Reanalysis II, JMA/CRIEPI JRA-25 Reanalysis, ECMWF ERA-40 Reanalysis, ECMWF ERA Interim Reanalysis, MRI/JMA APHRODITE's Water Resources Project data, DWD Global Precipitation Climatology Centre's data, GMAO Modern Era-Retrospective analysis for Research and Applications (MERRA), reanalysis of Monitoring atmospheric composition and climate (MACC) Collaborated Project, NOAA-CIRES Twentieth Century Global Reanalysis Version II, NCEP Climate Forecast System Reanalysis (CFSR), results of modeling by global and regional climatological and meteorological models. Also meteorological observational data for the territory of the former USSR for the 20th century is stored in PostGIS database. Also new spatial datasets can be easily integrated into the VRE.

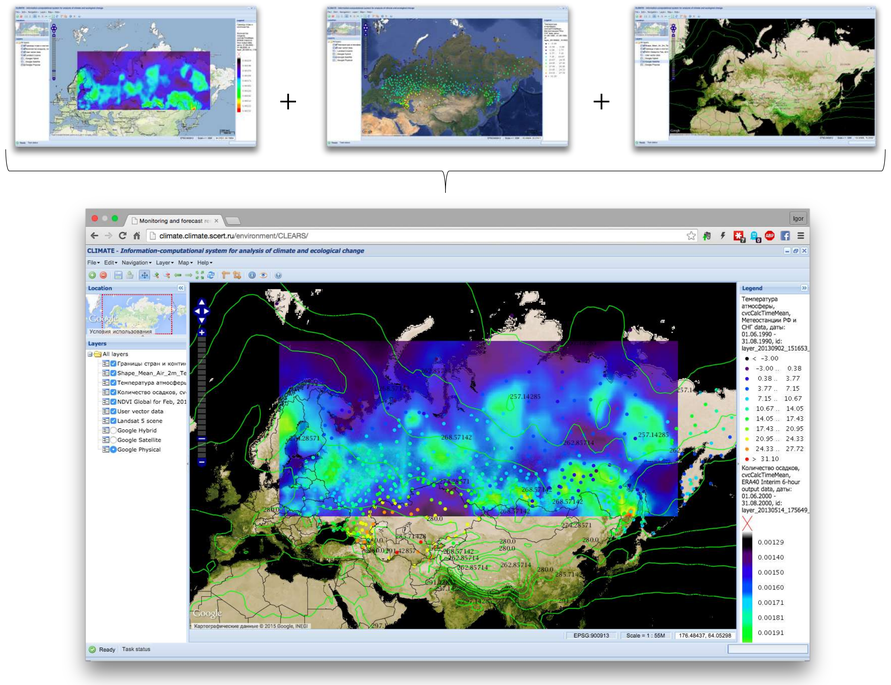
Data processing

Over 20 processing routines are available for spatial datasets analysis including calculation of:

1. Statistical characteristics of meteorological data: sample mean, variance, kurtosis, median, maximum and minimum value, the asymmetry.
2. Derivative climatic indices: length of the growing season, sum of effective temperatures, Selyaninov's Hydrothermal Coefficient.
3. Periodic variations: mean square deviation, norms, deviation from norms, amplitude of diurnal and annual cycle.
4. Non-periodic variations: duration and frequency of occurrences of atmospheric phenomena with parameters above or below specified limits at different time scales.

At present new algorithms for extreme climate events analysis are being integrated into the prototype. New data processing modules can be developed and integrated into the VRE on demand.

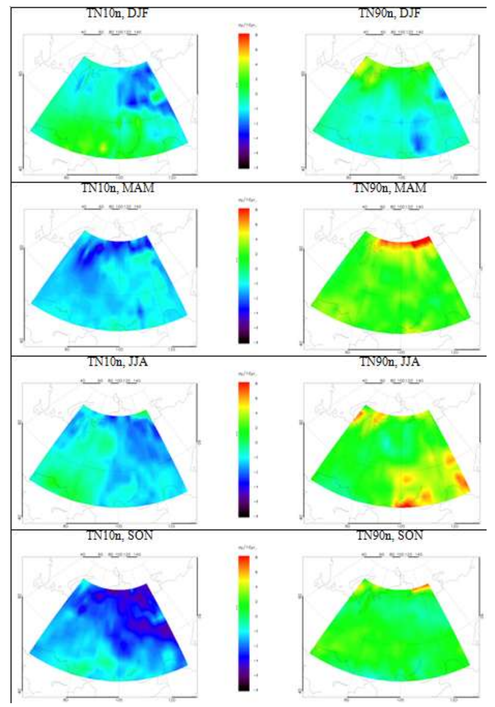
VRE Web GIS data processing results aggregation and visualization



Use-case: Recent temperature extreme changes in Siberia

Temperature changes in Siberia over the time period 1979-2012 have been studied in terms of frequency (n) and intensity (p) of daily minimum (TN) and maximum (TX) temperatures that exceeded 10th and 90th percentile thresholds on the base of the ERA Interim and ERA 40 reanalyses composite using recently added VRE prototype functionality allowing detailed statistical analysis studies of regional climatic extremes. Firstly it was shown that ECMWF ERA Interim Reanalysis data are closest to near surface temperature time series measured at regional meteorological stations in terms of annual means and daily extreme temperature anomalies.

Statistical analysis of ERA Interim daily temperature time series (1979-2012) indicates the asymmetric changes in distribution tails of such extreme indices as warm/cold days/nights. Namely, the intensity of warming during cold nights (TN10p) is higher and more statistically significant than during warm nights (TN90p) especially at high latitudes of the region. Furthermore, a decrease of the number of cold nights is larger than an increase of the number of warm day-time temperatures. Thus, our results show asymmetric warming in the tails of distributions of cold and warm temperatures.



Conclusion

Results of the first stage of the Project implementation are presented. In the framework of this project, approaches of "cloud" processing and analysis of large geospatial datasets will be used. Anticipated results will create a pathway for development and deployment of thematic international virtual research laboratory focused on interdisciplinary environment studies.

This work is supported by the Russian Science Foundation grant No16-19-10257.