The best ensembles of RCMs for climate change projections in Ukraine

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Application of climate models ensembles instead of individual ones became very useful and prominent technique in modern climate change research. But methodology of models' selection to the ensemble should be different in dependence of the purposes of its application and be based on certain criteria. The proposed research aimed to obtain the best ensembles for climate change projections in Ukraine in the 21st century for two key climatic characteristics: air temperature and precipitation amount. With this purpose 14 RCMs from the European project FP-6 ENSEMBLES scenario SRES A1B and their various ensembles were verified for the periods 1961-1990 and 1991-2010 against the data from the E-Obs database in every 25x25 km grid box and averaged over the territory of the country.

The main criteria for RCM selection to the ensembles for monthly air temperature were following statistical characteristics: multi-year annual mean and its standard deviation as amplitude of the annual variation, root mean squared differences (RMSD) and absolute maximum and minimum errors. Coefficients of correlation were calculated too, but they are rather not indicative for model successfulness in this case since almost all RCMs have the coefficients higher than 0.99 demonstrating that annual course of temperature is perfectly simulated by them. Based on the above criteria 4 RCMs were excluded from the ensemble due to very high max and min absolute errors (over $\pm4^{o}$C) in both control periods. Therefore the ensemble of 10 RCMs has been defined as optimal for air temperature projections in Ukraine.

One more method was applied for RCMs ensembles selection and verification. The main idea is to use the same methodology as proposed for climate projection obtaining. Specifically to build a projection for period 1991-2010 from 1961-1990 based on the same RCM ensembles and compare with data of E-Obs for this modern time. The criteria of "successfulness" were the same as above and for the defined optimal ensemble of 10RCMs all errors were minimal specifically an average areal absolute error was only -0.07^{o}C.

The same methodology was applied for multi-year monthly precipitation amount. But in this case correlation coefficients should be one of the most decisive parameters. Another two are RMSD and standard deviation, and Taylor diagrams are most useful for precipitation verification in this case. Unfortunately just 8 RCMs in the period 1961-1990 and 5 RCMs in period 1991-2010 had positive correlation coefficients and just 4 RCMs had them higher than 0.65. That is why possibility to combine an ensemble was much limited than for temperature. Nevertheless the same methodology as for temperature to build projections for precipitation from past to modern period was applied for the ensemble of 4 RCMs. And an obtained mean areal correlation coefficient between precipitation projection of 4RCMs ensemble and E-Obs data for period 1991-2010 was 0.69, but for averaged over territory of Ukraine multi-year monthly precipitation annual course as high as 0.87 and RMSD was just 6.7 mm that is indeed good result. Thus the ensemble of 4 RCMs has been defined as optimal for precipitation projections in Ukraine.

And the last conclusion from the RCMs verification is that RCM REMO (MPI-M, Hamburg) had the best statistical characteristics both for temperature and precipitation in Ukraine. Therefore this RCM could be recommended as the best one for those investigations where application of ensemble is impossible or useless and daily data are needed (hydrological, agricultural or other applications).