Climate change projections in the Black Sea region based on CMIP5 model ensemble

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Estimates of the future climate changes in the Black Sea region are of particular importance in light of rapidly developing infrastructure. 2014 Sochi Olympic Games, growing marine transportation, possible gas and oil exploration on the sea shelf: all these require an implemention of the growing factor of the global climate change in building strategies for social-economic development in the region. Previously, data of CMIP3 models have been used for analysis of temperature variability in the Black Sea region [1]. Here, we present some results of the analysis of anthropogenic climate change simulations for the 21st century using CMIP5 (Coupled Model Intercomparison Project, phase 5) model ensemble [2].

Some models were excluded from the analysis because they provide data only untill 2035. Selected models (23 in total) have different spatial resolutions ranging from 0.75°x0.75° to 2.8°x2.8°. Before processing, all models' data were interpolated on the same 1.0°x1.0° grid. Monthly mean data for the 21st century simulations performed under moderate anthropogenic scenario RCP 4.5 (Representative Concentration Pathways, experiment rcp45, implying 4.5W/m2 radiative forcing to the end of the 21st century) [3] were used for the analysis.

Annual and seasonal changes of temperature and precipitation have been analyzed. Due to space limitation, here we present in broad strokes only the annual means. Changes for annual mean surface air temperature (SAT) and precipitation averaged for the selected model ensemble in the Black Sea region (24-48W, 40-50N) for 2006-2100 are shown in Fig. 1. In this region the yearly mean air temperature increase amounts from 1.9° C to 2.5° C. The largest SAT increase by 2.6°C for the selected scenario is obtained in the north-eastern and south-eastern area of this region, whereas relatively moderate increase in temperature (about 1.9-2.2°C) is found in the central part of the Black Sea region (Fig. 1a) presumably due to larger thermal inertia of the Black Sea surface layer.

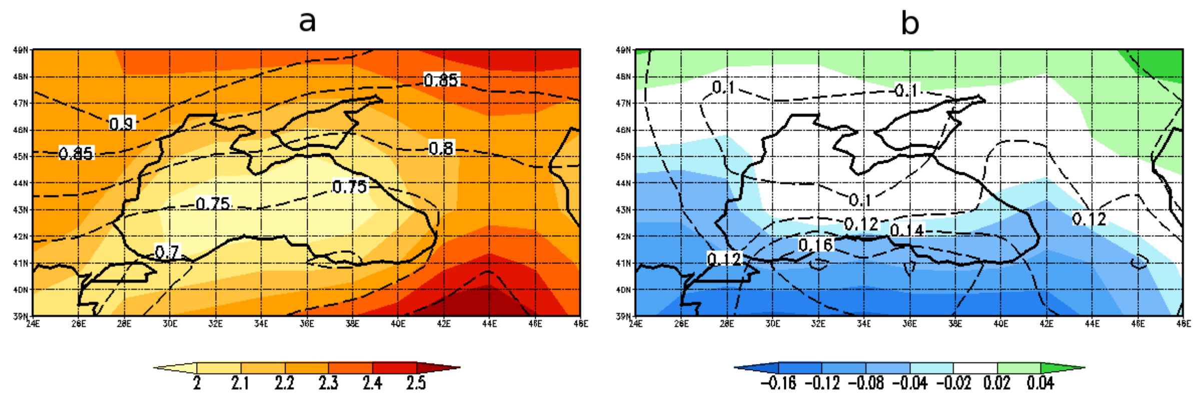

Fig. 1. Ensemble mean changes (shaded) of annual (a) surface air temperature (in °C) and (b) precipitation (in mm/day) for 2006-2100. Contours depict intra-ensemble standard deviation of the trends.

The largest increase in SAT occurs in summer in the first half of the 21st century.

Since 2070s the growth rate of the air temperature decreases. Ensemble mean temperature trends are significantly stronger than the intra-ensemble spread represented by intra-ensemble standard deviation (Fig. 1a) that increases with latitude. Precipitation only slightly changes in the selected region in 21st century (Fig. 1b). A slight increase of precipitation occurs in the northern part of the Black Sea region basically due to changes in winter season. A negative trend of annual precipitation is expected in south-west part of this region in 21st century. The intra-ensemble spread is considerably larger than the ensemble mean trends for precipitation except for the southern part of the region.

Ensemble mean and 95% confidence interval of annual SAT and precipitation for Sochi region (36-40W, 42-46N) are shown in Fig. 2. The average annual SAT increases almost linearly by about 1.5° C from 2006 to 2070 (Fig. 2a). SAT increases for all seasons in the 21st century untill 2070. The largest increase in SAT for Sochi region occurs in summer during 2006-2080 period.

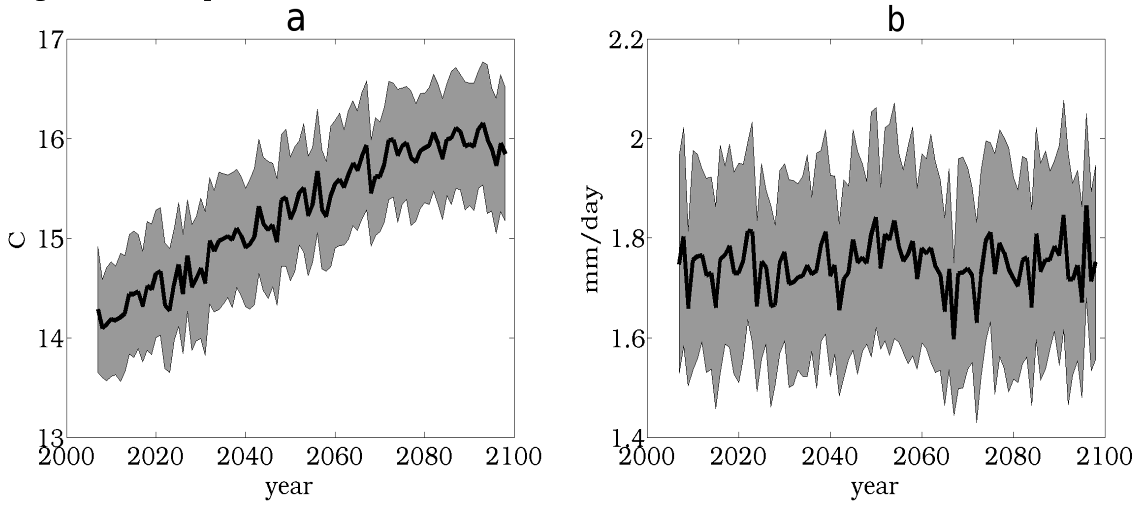

Fig. 2. Ensemble mean annual surface air temperature (a) and precipitation (b) for Sochi region (36-40W, 42-46N). Shading represents 95% confidence interval for intra-ensemble spread.

Precipitation slightly increases (by about 0.2 mm/day) in winter and decreases in summer and autumn seasons during 2006-2050 (not shown). Spring precipitation does not change during the 21st century. Ensemble mean values of annual precipitation also do not exhibit significant trend in the 21st century (Fig. 2b).

This work was supported by the Russian Foundation for Basic Research; the Presidium of the Russian Academy of Sciences (program no. 31); the Ministry for Education and Science of the Russian Federation (state contracts nos. 11.519.11.5006 and 11.G34.31.0007); and the Russian Academy of Sciences (contract no. 74_OK/11_4).

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