Bayesian estimates of snow cover characteristics in Eurasia based on simulations with an ensemble of climate models

Arzhanov M.M.[1], Mokhov I.I.[1,2], Parfenova M.R.[1]
[1]*A.M. Obukhov Institute of Atmospheric Physics RAS*
[2]*Lomonosov Moscow State University*
arzhanov@ifaran.ru

The snow cover has a significant impact on the properties of the Earth's surface. A decrease in the albedo of the surface due to a decrease in the snow cover extent leads to an increase in the absorption of solar radiation with an intensification in the positive feedback. An analysis of the changes in the snow cover extent depending on the changes in the surface air temperature in the 21st century based on the simulations with models of global climate shows that the average estimates of the models' ensemble can be much smaller in absolute values than those obtained based on satellite observation data and by the models individually [1]. These results indicate the necessity of considering individual model features when using ensemble model estimates. Particularly, the Bayesian approach is applied to estimate the sensitivity of results to models choice by calculation of individual model weights and subsequent analysis of different variants of the weights [2].

This paper presents estimates of snow cover extent in Eurasia for 2000-2019 based on simulations with global climate models using a Bayesian approach compared to satellite observation data. The global climate models of the CMIP6 project (https://esgf-node.llnl.gov/projects/cmip6/)are used under the historical scenario are the following: (1) BCC-CSM2-MR, (2) CNRM-ESM2-1, (3) CanESM5, (4) FGOALS-f3-L, (5) IPSL-CM6A-LR, (6) MIROC6, (7) MPI-ESM1-2-LR, (8) MRI-ESM2-0, (9) NorESM2-LM. For each model, the weight was calculated based on the likelihood function by comparing it with the reference data - monthly average satellite data CDR (Climate Data Records) for the snow cover extent (https://climate.rutgers.edu/snowcover/) (Fig. 1).

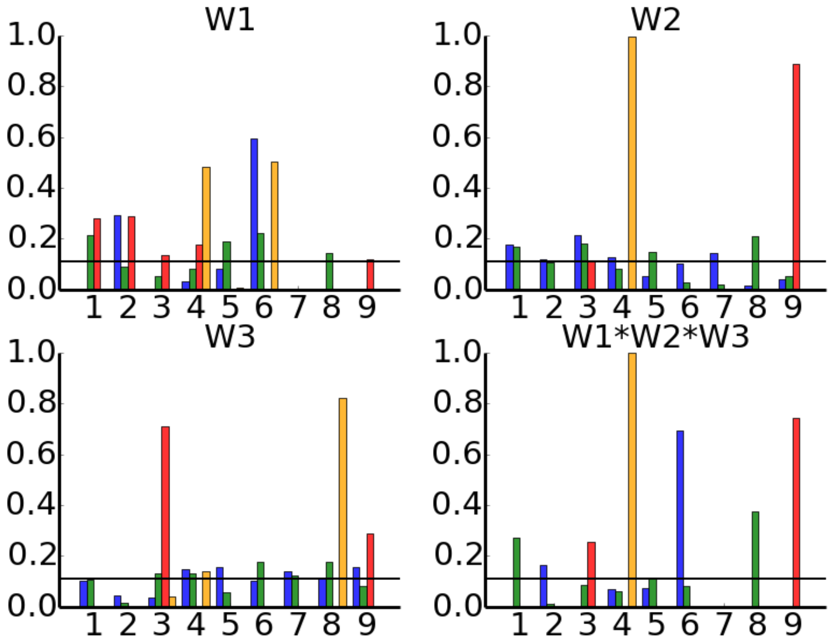

Figure 1. Normalized Bayesian weights for the models ensemble calculated for the snow cover extent in Eurasia in January (blue), April (green), July (red), and October (yellow) for the period 2000-2019. The horizontal line corresponds to the weights W0=1/N, where N=9 is the number of models in the ensemble.

To assess the quality of the models simulations results at different time scales, we calculate the weights for the long-term average (time scale corresponding to the length of the data series) (W1), the linear trend coefficient (interannual time scale) (W2), the standard deviation (interannual time scale) (W3) of the snow cover extent and their product (W4).

The largest intermodel variations are obtained for the summer and fall months for the weights W2 and W3. For winter and spring months, the distribution of weights W2 and W3 is more homogeneous compared to W1 and close to the value W0=1/N, where N=9 is the number of models in the ensemble. The estimates of the snow cover extent calculated with the weights W2 and W3 for the winter and fall seasons are close to the corresponding ensemble averages with the same weights W0 (Fig. 2).

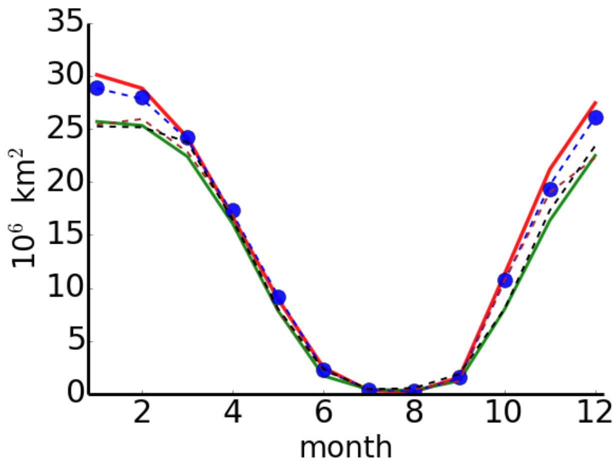

Figure 2. Snow cover extent in Eurasia over the period 2000-2019 based on ensemble of models with Bayesian weights (blue circles) and with W0 weights (green curve) compared to satellite observations (red curve). The dotted lines show the areas for the multiyear average (blue curve), trend (brown curve), and interannual variability (black curve) of the snow cover extent.

The results indicate that the application of the Bayesian approach significantly improves ensemble estimates of snow cover area, including the winter and fall seasons.

This work is supported by Russian Science Foundation project 19-17-00240.

References

[1] Parfenova M.R., Arzhanov M.M., Mokhov I.I. Projected changes in the snow cover extent in the 21st century in Eurasia according to simulations with the CMIP6 ensemble of climate models // Izv. Atmospheric and Oceanic Physics. 2022. Vol. 59. No. 3. P. 255-263.

[2] Parfenova M.R., Eliseev A.V., Mokhov I.I. Changes in the duration of navigation period in Arctic seas along the Northern Sea Route in the 21st century: Bayesian estimates based on calculations with the ensemble of climate models // Doklady Earth Sci. 2022. Vol. 507(1). P. 952-958.