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Temperature dependence of the Northern Hemisphere sea ice extent derived from observations and AR4 models

L. Bobylev (1,2), S. Kuzmina (1), O. M. Johannessen (2,3), and G. Alekseev (4)

(1) Nansen Centre, St. Petersburg, Russian Federation (leonid.bobylev@niersc.spb.ru), (2) Nansen Centre, Bergen, Norway (leonid.bobylev@niersc.spb.ru), (3) Geophysical Institute, University of Bergen, Bergen, Norway (ola.johannessen@nersc.no), (4) Arctic and Antarctic Research Institute, St. Petersburg, Russian Federation (alexgv@aari.nw.ru)

It is estimated how well the modern generation of climate models reproduces interrelated changes in the Northern Hemisphere sea ice extent (SIE) and surface air temperature (SAT) in the 20th century. Generally, comparison of observational data and IPCC AR4 model results showed that the modern climate models reproduce SIE and SAT and their interrelated changes not satisfactory. Thus, most of the models overestimate sea ice extent. In the Barents Sea model mean overestimates sea ice extent during the whole year. For other seas model mean overestimates SIE during summer and early fall and underestimates during other seasons. For sea ice concentration the largest difference between mean model and observed data takes place in the Barents, Kara, Laptev and East-Siberian seas, where it exceeds 80 %. The observed sea ice is decreasing faster than modeled. The absolute magnitude of SIE mean model trends is several times less than that of observed trends except the Barents Sea.
Model mean underestimates SAT not only in the whole Northern Hemisphere but also in mid-latitudes and in the Arctic separately. Such underestimation bears systematical character. In the Arctic it reaches the maximum during December-March – the cold season. The largest difference between mean model and ERA-40 SAT values occurs in the Barents, Kara, Laptev and East-Siberian seas being maximum in the Barents Sea where it amounts about -8 C. SAT mean model trends generally are higher than observed ones from May to January. During February-April observed SAT trends are about equal to or larger than the model mean trends.
Models do not reproduce observed correlation between sea ice extent and air surface temperature. For example, models do not show the June maximum in correlation between observed SIE and SAT. Models also reproduce SIE-SAT sensitivity quite poorly.
Therefore, the projections of sea ice and temperature changes in the Arctic in the 21st century based on IPCC AR4 models can't be reliable. But much better and more reliable projections can be based on the several specially selected models which best match the observational data. The appropriate procedure, performed in this study using approach that models should satisfy to some criteria of matching observational data, allowed to select five best models. They are: UKMO-HadCM3, UKMO-HadGEM1, CNRM-CM3, ECHAM5/MPI-OM and MIROC3.2(medres). These models demonstrate the largest sum of positive air temperatures among considered AR4 models and also closer to the observed sensitivity of September SIE to variations of summer SAT. These models indicate also$\sim$20 % larger SIE trend in the 21st century, than ensemble mean of all AR4 models, what follows better extrapolation of observed SIE time-series. Particularly, selected model mean shows that to the end of the 21st century (about 2080) the Arctic Ocean may be almost ice-free in summer This is not indicated by the model mean of all AR4 models.
Significant disagreement between observed and modelled sea ice parameters and surface air temperature as well as their interrelated changes indicates the necessity of further significant improvement of existing climate models.