Changes of seasonal ice area in the Arctic Ocean from model simulations with IPCC SRES scenario

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Analysis of sea ice characteristics such as a thickness and area of seasonal sea ice (or first-year ice) area was performed using simulations with global climate model ECHAM5/MPI-OM (Marsland et al., 2003; Roeckner et al., 2003) with the SRES A1B scenario (Houghton et al., 2001). This scenario reaches 720ppm CO2 levels by 2100 and is one of the middle SRES scenarios used in IPCC runs.

Sea ice concentration and thickness were used for calculating of seasonal sea ice area. Multiyear ice is ice that has survived at least one summer melt season (Zhang and Walsh, 2006). Consequently, we can use the summer minimum sea ice area as an indicator of multiyear ice area. Therefore we define an area of seasonal sea ice as the difference between the largest (April-May) sea ice area and the summer minimum (August-September) sea ice area (Holland et al., 2006) for each year. Sea ice thickness was averaged for areas with ice concentration more than 0.15. The Arctic region (68-90N) has been partitioned to the western (90W; 90E) and eastern (90E; 270E) parts for the regional analysis (ACIA, 2004).

Figure 1 shows March ice thickness (a) and the area of seasonal ice (b) as a function of the March ice thickness for the eastern and western parts of the Arctic basin. Over the run (Figure 1), the ice cover thins from about 2 m to less than 1 m for the western Arctic and from about 4 m to less than 1.5 m for the eastern Arctic. As a result there is increasing of seasonal ice area in the both regions. The strongest (nonlinearly as function of March ice thickness) increase of seasonal ice has been indicated for the eastern Arctic. For the western Arctic model results show weaker increasing of seasonal ice area with decreasing of ice thickness.

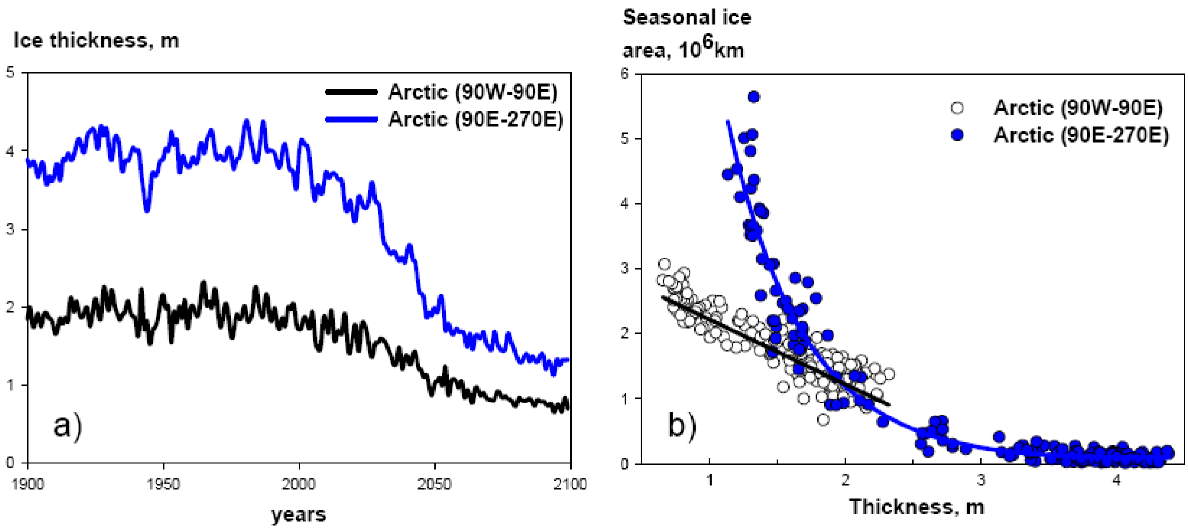

Figure 1. (a) March ice thickness and (b) the seasonal ice area as a function of the March ice thickness for the eastern and western parts of the Arctic basin. The seasonal ice area (or open water formation during melt season) equals the difference between the largest sea ice area and summer minimum sea ice area for each year.

This effect can be explained by changes in annual cycle of open water formation for the selected regions of the western (Barents Sea sector) and eastern (Laptev Sea sector) Arctic. Figure 2 shows mean area (in %) of open water in the sector of the Barents (a) and Laptev (b) Seas for the consequent 20-years periods (2001-2020, 2021-2040, 2041-2060, 2061-2080, 2081-2100) of model simulations. For the Barents Sea model results show nearly uniform increase of ice melting for each month. For the Laptev Sea there is strong increase of amplitude (difference between maximum and minimum ice extent) of annual cycle due to strong decrease of sea ice during melt season.

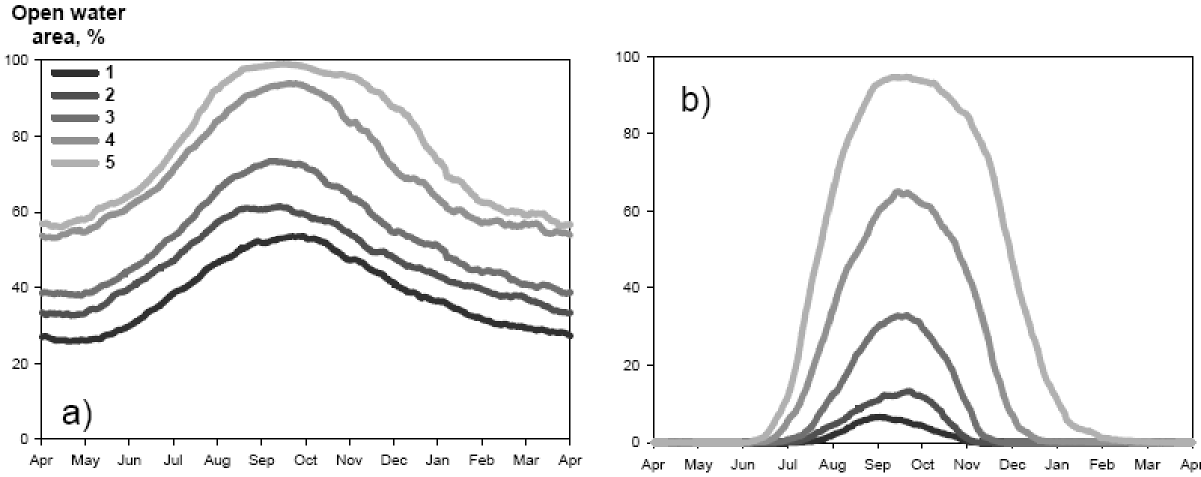

Figure 2. Open water area (%) in the Barents (a) and Laptev (b) Sea sectors according to model simulations for the consequent 20-years periods (1 – [2001-2020], 2 – [2021-2040], 3 – [2041-2060], 4 – [2061-2080], 5 – [2081-2100]).

According to model results an increasing of the open water area in the Barents Sea is connected with earlier ice melting and later ice freezing in the XXI century. For the Laptev Sea model results show the increase for intensity of ice melting (due to strong increasing of seasonal ice area) during warm season with a tendency to later ice freezing in the XXI century.

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References

Houghton, J. T., Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden, X. Dai, K. Maskell, and C. A. Johnson, Eds., 2001: Climate Change 2001: The Scientific Basis. Cambridge University Press, 881 pp.

ACIA, 2004: Arctic Climate Impact Assessment: Scientific Report. Cambridge University Press, 144 pp.

Marsland, S. J., H. Haak, J. H. Jungclaus, M. Latif, and F. Röske, 2003: The Max-Planck-Institute global ocean/sea ice model with orthogonal curvilinear coordinates. Ocean Model., 5, 91–127.

Roeckner E., Bäuml G., Bonaventura L., Brokopf R., Esch M., Giorgetta M., Hagemann S., Kirchner I., Kornblueh L., Manzini E., Rhodin A., Schlese U., Schulzweida U., Tompkins A. The atmospheric general circulation model ECHAM 5. Part I: Model description / MPI Rep. 349, Max Planck Institute for Meteorology, Hamburg. 2003.

Zhang, X., and J. E. Walsh (2006), Toward a seasonally ice-covered Arctic Ocean: Scenarios from the IPCC AR4 model simulations, J. Clim., 19, 1730– 1747.

Holland, M. M., C. M. Bitz, and B. Tremblay (2006), Future abrupt reductions in the summer Arctic sea ice, Geophys. Res. Lett., 33, L23503, doi:10.1029/2006GL028024.