Permafrost response to SRES A2 greenhouse forcing in a climate model of intermediate complexity

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The climate model of intermediate complexity developed at the A.M. Obukhov Insitute of Atmospheric Physics RAS (IAP RAS CM) [4] is extended by modules of soil thaw/freeze cycles [3] and methane cycle [1]. Two simulation with IAP RAS CM are performed which both are forced by the anthropogenic emissions of CO_2 and CH_4 and atmospheric concentration of N_2O. These forcings are changed in accordance to the corresponding historical estimations extended back to 1610 [4] for the 17th–20th centuries and in accordance to scenarios SRES A2 [2] for the 21st century.

The simulated area of the permafost extension changes little till the mid 20th century varying in the range $12.5 - 13.5~mln~km^2$ (Fig. 1). This value is between the estimated areas of the continious ($10.7~mln~km^2$) and total ($22.8~mln~km^2$). permafrost extensions [5]. Geographical distribution of the simulated permafrost looks as a whole realistic if compared with the map from [5]. A notable exception is the region near the Baltic Sea where IAP RAS CM simulates permafrost absent in the observations. This bias as a reflection of the overall model's cold bias in the high latitude continents. In addition, permafrost over the Tibetian plato is not simulated owing to the lack of orography in the model.

In the model, permafrost cover shrinks rapidly in the late 20th–early 21st centuries. In the mid 21st century area of the permafrost extension attains the value $9.0~mln~km^2$ (Fig. 1) and changes little afterwards. Permafrost disappears in the most European regions but remains in Asia and North America. However, over the latter two continents, the annual thaw depth increases substantionally in the late 21st century compared to the earlier periods (Fig. 2).

References

[1] A.V. Eliseev, M.M. Arzhanov, P.F. Demchenko, S.N. Denisov, and I.I. Mokhov. Coupled climate–methane cycle simulation with a climate model of intermediate complexity forced by SRES A2 scenario. 2007. (this issue).

[2] J.T. Houghton, Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson, editors. *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge/New York, 2001.

[3] V.A. Kudryavtsev, L.S. Garagula, K.A. Kondratiyeva, and V.E. Melamed. *Frost Forecasting in Geological Engineering Investigations,.* CRREL, Hanover, NH, 1977.

[4] I.I. Mokhov, V.A. Bezverkhnii, A.V. Eliseev, and A.A. Karpenko. Model estimates of global climatic changes in the 21st century with account for different variation scenarios of solar activity. *Doklady Earth Sci.*, 411(8):1327–1330, 2006.

[5] T. Zhang, R.G. Barry, K. Knowles, J.A. Heginbottom, and J. Brown. Statistics and characteristics of permafrost and ground–ice distribution in the Northern Hemisphere. *Polar Geogr.*, 23(2):132–154, 1999.
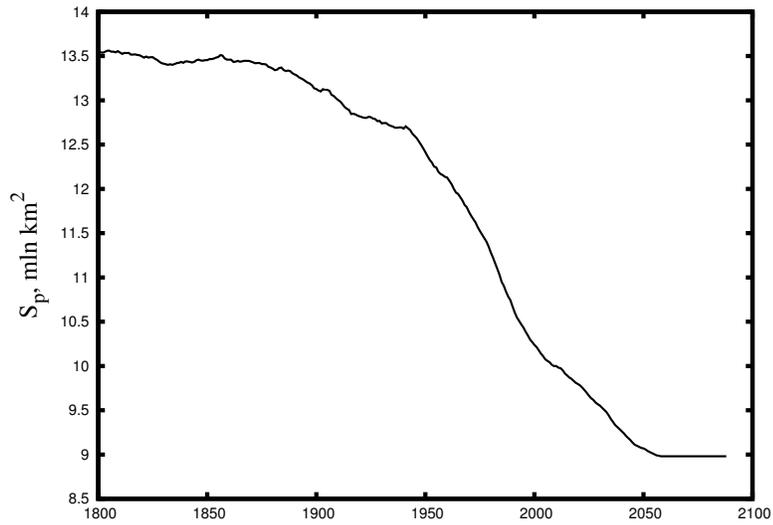
Figure 1: Area of the permafrost extension simulated by IAP RAS CM (a 25–yr moving average is applied).
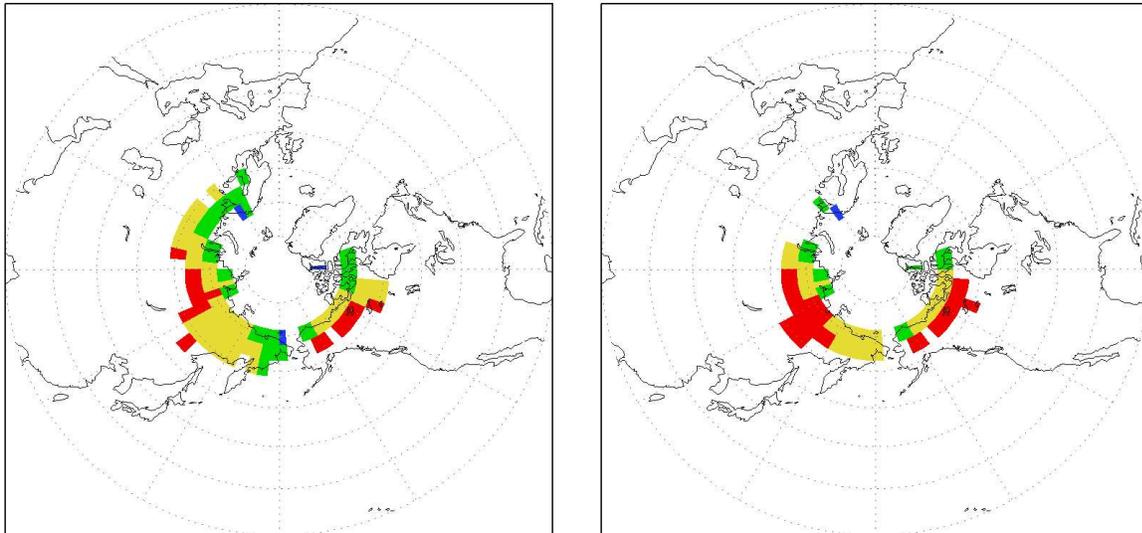
Figure 2: Mean seasonal thaw depth (in meters) simulated by IAP RAS CM for 1961–2000 and 2071–2100 (left and right panels respectively). The colour figures ranges of thaw depth $0.0 - 1.0\ m$ (blue), $1.0 - 1.5\ m$ (green), $1.5 - 2.0\ m$ (yellow), and $2.0 - 2.5\ m$ (red)