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Freeze/thaw processes in complex permafrost landscapes of northern Siberia simulated using the TEM ecosystem model: impact of thermokarst ponds and lakes

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Abstract. Freeze/thaw (F/T) processes can be quite different under the various land surface types found in the complex tundra of the Arctic, such as polygonal tundra (wet center and dry rims), ponds, and thermokarst lakes. Proper simulation of these different processes is essential for accurate prediction of the release of greenhouse gases under a warming climate scenario. In this study we have incorporated the water layer into a dynamic organic soil version of the Terrestrial Ecosystem Model (DOS-TEM), having first verified and validated the model. Results showed that (1) the DOS-TEM was very efficient and its results compared well with analytical solutions for idealized cases, and (2) despite a number of limitations and uncertainties in the modeling, the simulations compared reasonably well with in situ measurements from polygon rims, polygon centers (with and without water), and lakes on Samoylov Island, Siberia, indicating the suitability of the DOS-TEM for simulating the various F/T processes. Sensitivity tests were performed on the effects of water depth and our results indicated that both water and snow cover are very important in the simulated thermal processes, for both polygon centers and lakes. We therefore concluded that the polygon rims and polygon centers (with various maximum water depths) should be considered separately, and that the dynamics of water depth in both polygons and lakes should be taken into account when simulating thermal processes for methane emission studies.

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