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Modelling heterogeneity of land surface waters in the permafrost region

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When considering high latitude regions, one of the striking characteristics is the abundance of surface water in comparison to lower latitudes. This difference is not just limited to the total area covered by surface water, but it also extends to the size distribution of water bodies: While surface water in lower latitudes most often occurs in the form of larger lakes or rivers, high latitude regions often display a wide variety of surface water features, ranging from small puddles to huge lakes. Considering the climatic and carbon cycle consequences of lower latitude large water bodies in land models is relatively straightforward – they can be considered static, be prescribed from observations, and described using dedicated submodels. However, considering surface water in the high latitudes comprehensively is substantially more challenging, as a much larger range of sizes needs to be considered, parts of which will not be available from observations. Furthermore, due to the dynamics of permafrost, these cannot be considered static any more and need to be treated dynamically.

To better represent high latitude regions in the ICON-Land land surface model, part of the ICON-ESM Earth System Modelling framework, we are developing a representation of multiple scales of water bodies, ranging from large lakes to small puddles, as well as areas of water-saturated soil. The smaller-scale features are of particular interest, as they do not just affect the exchange of water and energy between surface and atmosphere, but also have large impacts on the carbon cycle and methane emissions. To do this, we employ a statistical distribution function of water body sizes, allowing us to obtain energy, water, carbon and methane fluxes for water features of all sizes.

We will present our novel modelling framework and show first results covering selected Arctic locations.