Supplement A: Description of applied CryoGrid stratigraphy classes

Ground stratigraphy classes provide user-defined information about the ground material, which consists of mineral, organic, ice, water and air fractions. If seasonal snow cover should be accounted for, the ground stratigraphy class is coupled to a snow class by using a twin called "CLASSNAME_snow". A detailed description of stratigraphy classes in the CryoGrid community model can be found in Westermann et al. (2022).

GROUND_freezeC_RichardsEq_seb_pressure: This is the new stratigraphy class presented in this study. It is based on the former stratigraphy class *GROUND_freezeC_RichardsEq_seb* as described in Westermann et al. (2022). The stratigraphy class is applied to the upper 9 m of the soil column in all model scenarios. It computes the surface energy balance as an upper boundary condition, the freezing characteristics of Painter and Karra (2014), a water balance based on Richards equation and soil mechanical processes.

GROUND_freezeC_RichardsEqW_seb_pressure_sedimentation: This stratigraphy class includes all functionalities of the stratigraphy class *GROUND_freezeC_RichardsEq_seb_pressure* in addition to user-defined sedimentation.

GROUND_freeW_seb: This is a stratigraphy class presented in Westermann et al. (2022), which is used below 9 m depth in all model scenarios. It includes the surface energy balance, free water freezing characteristics and a bucket scheme water balance.

SNOW_crocus2_bucketW_seb: This is a snow class presented in Westermann et al. (2022), which is applied in all model scenarios. It takes into account the surface energy balance, snow microphysics as well as a bucket scheme snow hydrology. Melt water is pooled up to the snow surface.

Supplement B: Saturation and ground temperatures of the soil column in model scenarios *S-clay*, *S-clay-rain50* and *B-clay*

The following figures show the saturation of the ground column (model scenarios *S-clay* and *S-clay-rain50*) as well as ground temperatures (model scenarios *S-clay* and *B-clay*). The soil water and ground temperature conditions are used for the discussion of the dependency on climatic conditions (chapter 3.3).

While the soil column is predominantly saturated below the permafrost table, the active layer experiences changes in soil water content due to precipitation and evapotranspration. As less rainfall is available in *S-clay-rain50* compared to *S-clay*, the soil water content in the active layer is reduced. With a deepening of the active layer, the soil water content can be decreased also in larger depths, increasing the effective stress and thus causing soil compaction. Temporarily increased soil water contents during future forcing (e.g. 2070 to 2080 in *S-clay*) can result in soil swelling due to the boyancy effect.

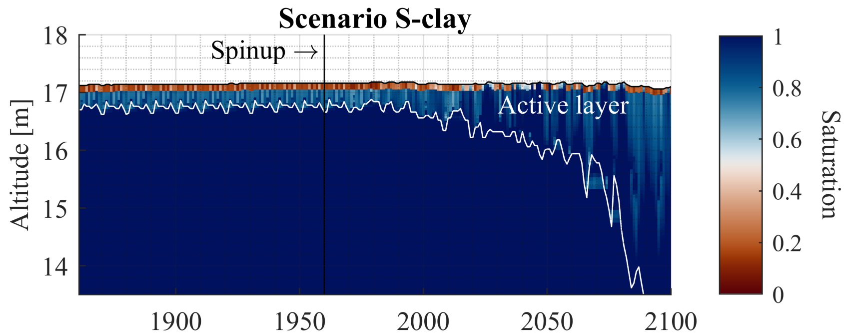

Figure 1. Saturation on the reference date August 31 for the model scenario *S-clay*.

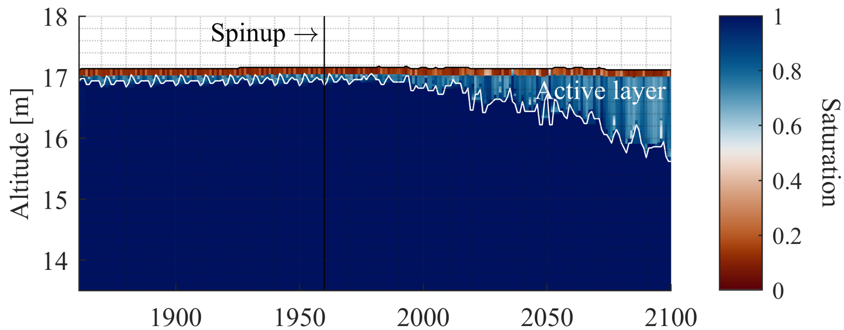

Figure 2. Saturation on the reference date August 31 for the model scenario *S-clay-rain50*.

The forcing data set of Bayelva represents warmer climatic conditions compared to Samoylov and less extreme temperature changes between summer and winter season. Therefore, the vertical gradient in ground temperatures in model scenario *B-clay* is smaller than in *S-clay*.

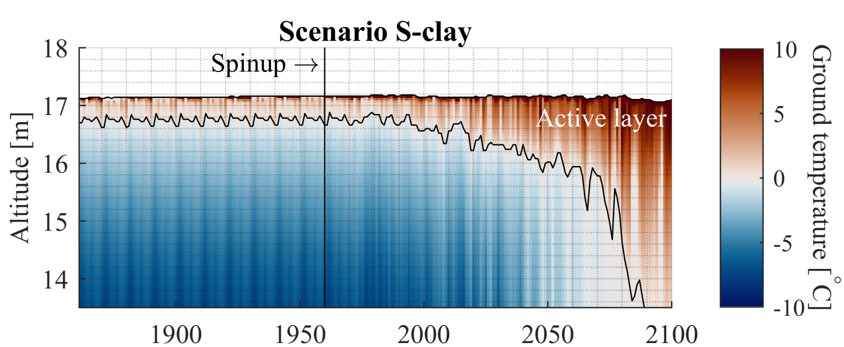

Figure 3. Ground temperatures on the reference date August 31 for the model scenario *S-clay*.