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# Variability of active layer thickness prediction from a climate model forced permafrost model

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The climate models of today are not capable of predicting future climate. They rather produce one realization - among infinite possibilities - of climate timeseries that are expected to have the same statistical properties - general trend, decadal scale variation, storm frequency, etc. - as the future climate subject to a given forcing scenario.

Permafrost distribution and temperature regieme is very sensitive to varations in snow cover. A thick snow cover effectively insulates the ground from the cold winter atmosphere resulting in a warmer ground temperature regieme than what would have been, had the snow cover been thinner.

Since a specific climate model realization can only be expected to have the right statistical properties, the actual future development in snow properties could potentially give very different ground temperature developments. Basing active layer thickness predictions at a given points in time on a single climate model realization may therefore be misleading.

It would be better to base predictions on a suite of model realizations and reporting average and standard deviations of the resulting thaw depths. However, since fine scale regional climate models are computationally intensive, several model realizations are often not available.

Instead of using multiple realizations of one climate model calculation, we here investigate the variability in active layer thickness estimations based on permutations of a single climate model realization. After detrending the time series, we produce a large number of alternative realizations based on a permutation of the individual hydrological years. After reaplying the original trend, these alternative timeseries are used to force a permafrost model and produce timeseries of active layer thicknesses. We suggest that reporting average and standard deviation of such active layer thickness prediction suites, provide a more reliable estimate of future thaw depths.

We apply this methodology to a site specific model based on a field site in Ilulissat, West Greenland. The geology at this site consists of fine grained marine sediments, and the model was previously calibrated based on observed ground and air temperatures, precipitation, and laboratory measurements of thermal properties. As future forcing we use a realization of the HIRHAM 4 regional climate model (25 km grid) of the Danish Meteorological Insititute.