Project: **1142**

Project title: **Nunataryuk WP8**

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Report period: **2020-01-01 to 2020-12-31**

Model development

During 2020 several technical changes to the JSBACH model was implemented to facilitate sub-sea applications. These include:

A) Including new switches to separate true land (JSBACH core focus) from sea bottom which should – at least from a soil point of perspective also be treated as land.

B) New forcing algorithm which switches off radiative transfer and precipitation for submerged points and these points are subject to benthic (ocean bottom-sediment interface) temperatures from MPI-OM instead of the atmospheric temperatures from ECHAM.

C) Vertically and horizontally dependent freezing point depression in the soil due to intrusion of salinity was included. Presently this is constant in time.

D) Switching off normal JSBACH plant treatment for submerged points.

E) Adaptation of initialization process, including initial reading (of vertical profiles) of soil ice content, temperature, salinity.

Results

The initial data (soil ice content, temperature and salinity) were taken from the multi-ice-age permafrost model SuPerMap (Overduin et al., 2019), where some iterations were needed to minimize initial shocks arising mainly from different forcing of the two models.

During the work it has become obvious how slow the sub-sea processes of interest are. Thus the standard CMIP6 – SSPs - ending at 2100 - turned out to be of less scientific interest. Therefore we changed the focus to longer term runs. This switch was supported by new MPI-ESM coupled runs in the PalMod project (done by T. Kleinen), extending the SSPs further than to year 3000 which could deliver forcing data for our experiments.

Our main result until now, is that the extreme SSP, SSP5-8.5 even compared to the expected radiative forcing causes an disproportional large loss of sub-sea permafrost ice, whereas the more moderate scenarios react more linearly wrt. the radiative forcing. In the extreme case, more than 40% of the sub-sea permafrost will be thawed in year 3000 compared to <6% if we exclude anthropogenic warming.

The main loss of permafrost ice is taking place on the East Siberian Shelf (EAS) and mainly in the shallow coastal waters. This is in line with the expectations and previous studies since EAS presently holds the majority of the sub-sea permafrost and comparatively lately submerged areas (i.e. shallow coastal areas) contain more permafrost close to the sediment top.

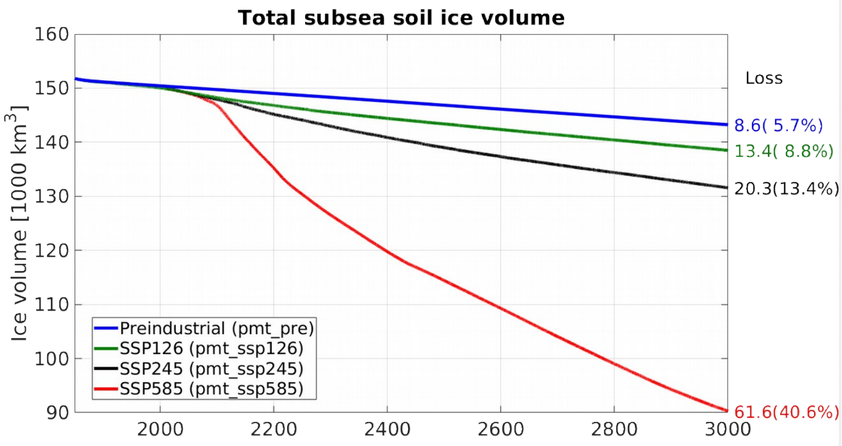

Fig. 1.: Development of total sub-sea permafrost ice from 1850-3000 for different extended SSPs (Wilkenskjeld et prep).

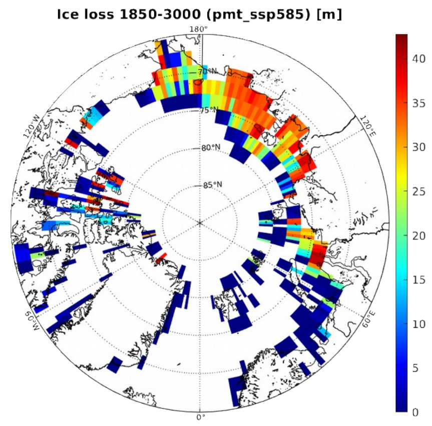

Fig. 2.: Geographic distribution of sub-sea permafrost, in thaw from 1850 to 3000, in extended SSP5-8.5 (Wilkenskjeld et al., in prep).

The planned coupled model system JSBACH -> BRNS (e.g. Puglini et al., 2020, work done a University of Brussel) -> HAMMOC have shown that an “online” coupling is more complicated than anticipated. Therefore the coupling work has been postponed from 2020 to 2021, and focus has moved more from developing the coupled MPI-ESM for sub-sea permafrost purposes to more JSBACH development and sensitivity studies. This in parts explains the smaller Node-hour consumption compared to the application.

Due to the still relatively short running period and the slowness of large scale sedimentation on the ocean bottom, no sedimentation has been implemented.

Effect of Covid-19

The German lockdown from mid-March to June caused the main project investigator (Stiig Wilkenskjeld) to be caught in home-office with two kindergarden kids which could not be externally supervised. Since this situation did not allow for efficient work, this has caused a delay in the project work of about 2 months. This of course is also reflected in the Node-hour consumption.

References

Overduin, P. P., Schneider von Deimling, T., Miesner, F., Grigoriev, M. N., Ruppel, C., Vasiliev, A., Lantuit, H., Juhls, B., and Westermann, S., 2019: *Submarine Permafrost Map in the Arctic Modeled Using 1-D Transient Heat Flux (SuPerMAP)*, https://doi.org/10.1029/2018JC014675

Puglini, M., Brovkin, V., Regnier, P., and Arndt, S., 2020: *Assessing the potential for non-turbulent methane escape from the East Siberian Arctic Shelf*, https://doi.org/10.5194/bg-17-3247-2020.