Towards including sub-sea permafrost in the MPI-ESM.

Stiig Wilkenskjeld[1]

Paul Overduin[2], Frederieke Miesner[2], Matteo Puglini[3] and Victor Brovkin[1]

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Max-Planck-Institut für Meteorologie Hamburg

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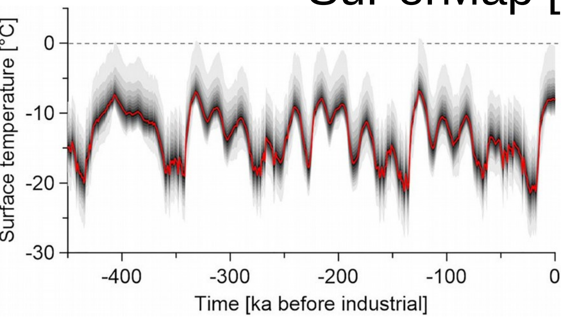
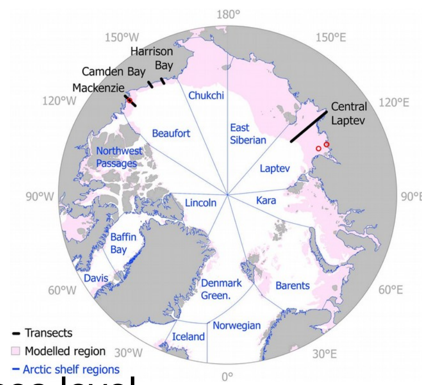
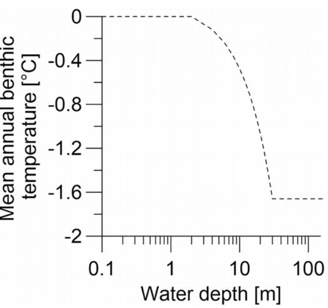
Model Setup

SuPerMap [1]

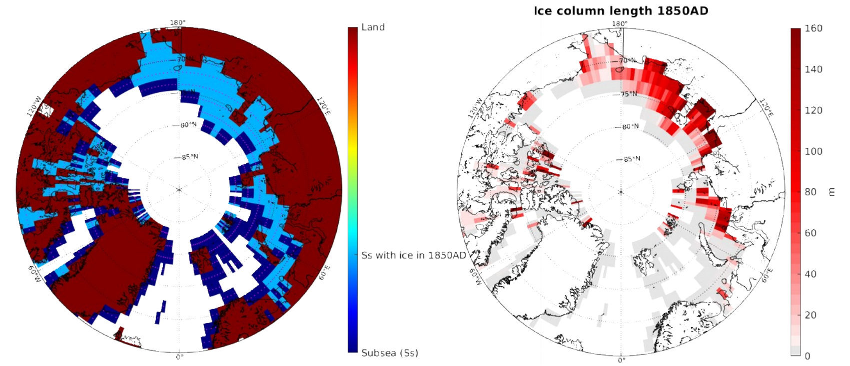




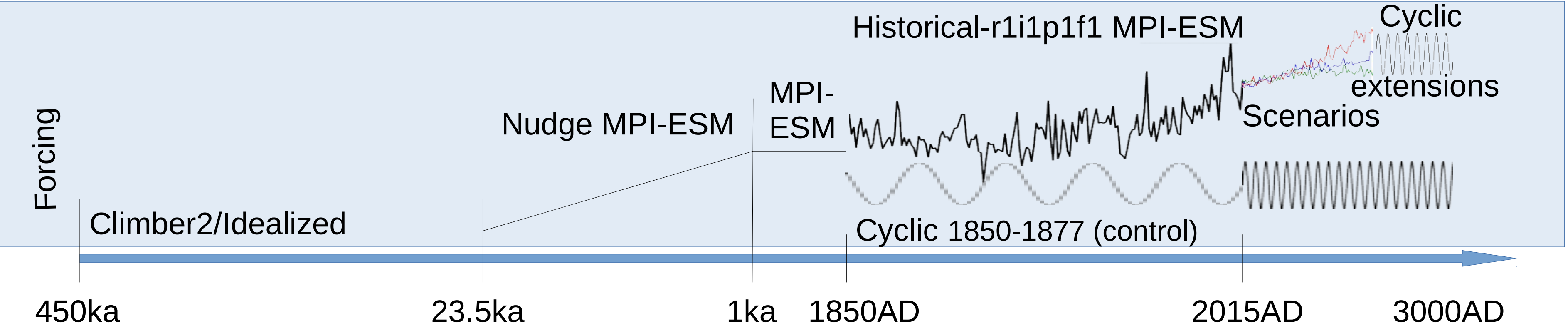


- Changing sea level
- Sedimentation (c_{land}/c_{ocean})
- Const. salinity in ocean sediments
- Forcing: Climber[4] climate (land)/Depth dependent (ocean)
- Geothermal thawing from below
- 12.5 km horizontal resolution
- 2 m thick layers down to 6 km

JSBACH (Land component of MPI-ESM) [2,3]



- Extended below sea (thermodynamics/ hydrology/carbon, no vegetation)
- Constant sea level, no sedimentation
- Forcing: mpiesm-CMIP6[5] (historical, scenarios)
- Geothermal heat, thawing mainly from above
- T63 resolution (~1.9 deg, 100-200 km)
- Layer thickness 6.5cm (surface) to 300m (1km)



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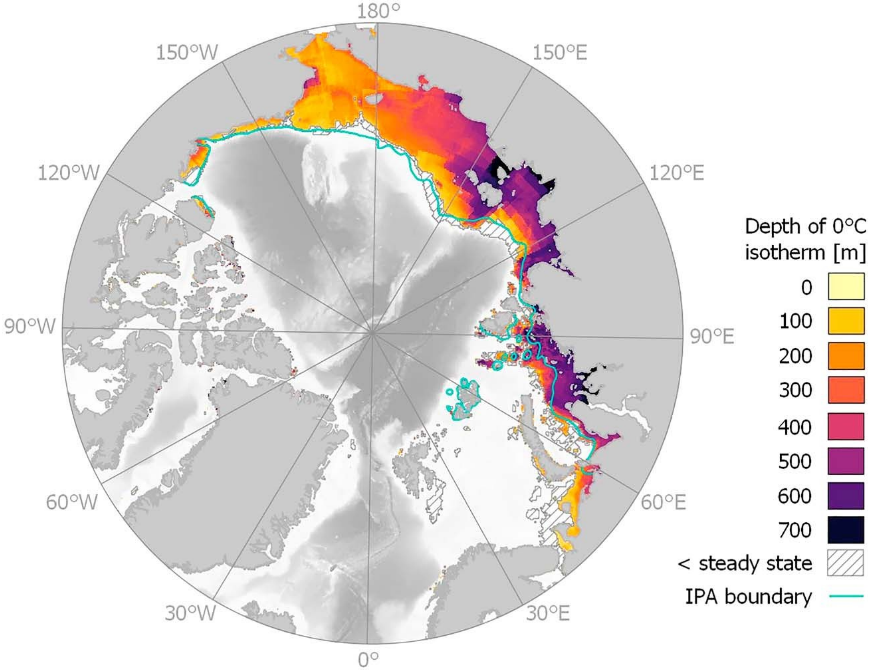
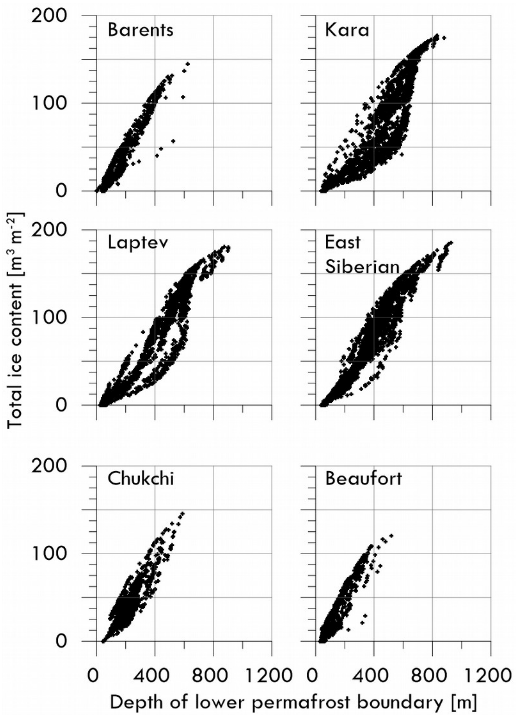
SuPerMap results

Lower permafrost boundary 1850AD[1]



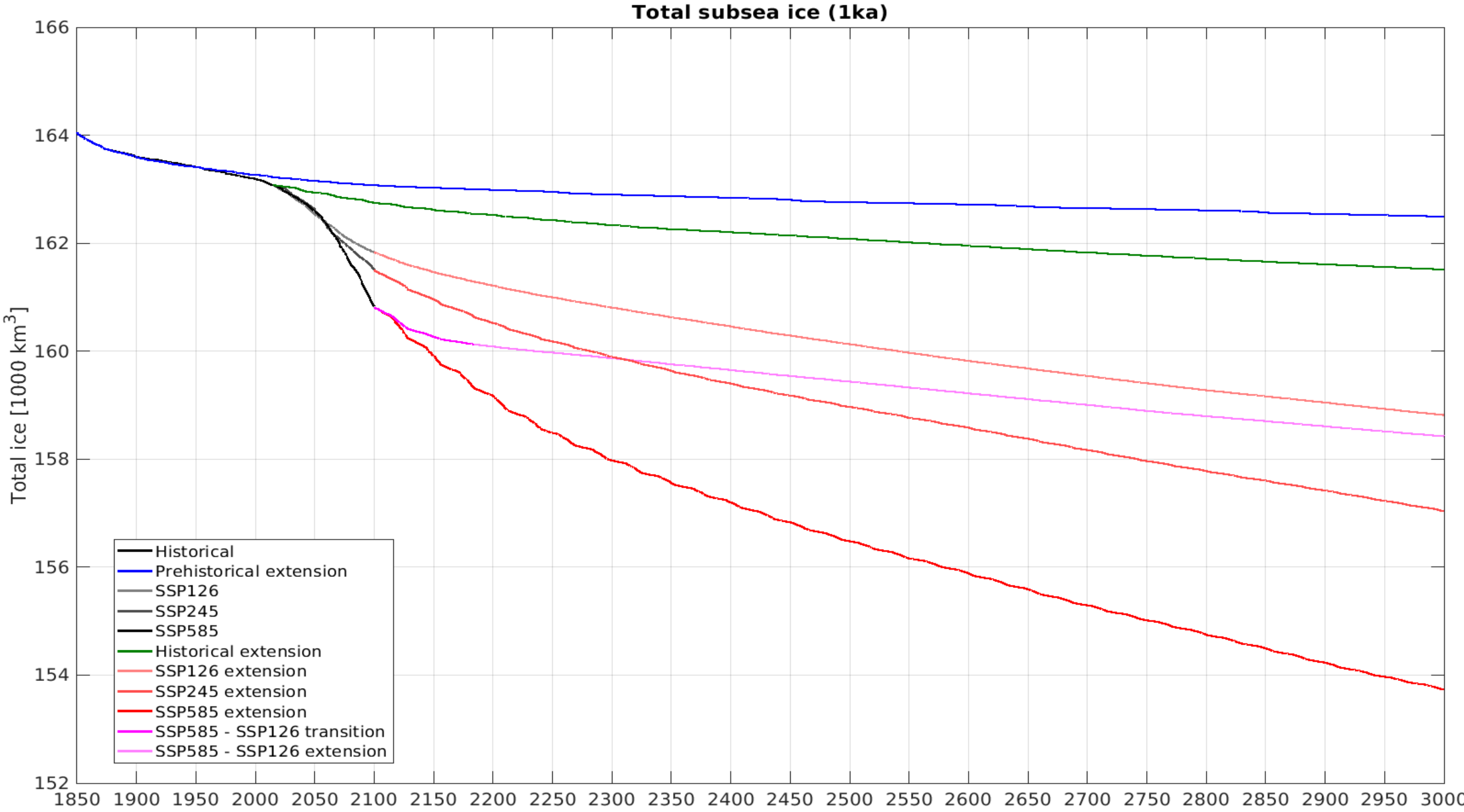


JSBACH experiments

Experiment	Continuation of	Run Years	Forcing	Forcing years
pre-ext (control)		1850-3000	historical	42 x 1850-1877
historical		1850-2014	historical	1850-2014
historical-ext	historical	2015-3000	historical	36 x 1987-2014
ssp126	historical	2015-2099	ssp126	2015-2099
ssp126-ext	ssp126	2100-3000	ssp126	33 x 2072-2099
ssp245	historical	2015-2099	ssp245	2015-2099
ssp245-ext	ssp245	2100-3000	ssp245	33 x 2072-2099
ssp585	historical	2015-2099	ssp585	2015-2099
ssp585-ext	ssp585	2100-3000	ssp585	33 x 2072-2099
ssp585-ssp126	ssp585	2100-2183	ssp585/ssp126	3* x 2072-2099
ssp585-ssp126-ext	ssp585-ssp126	2184-3000	ssp126	30 x 2072-2099

*Linear interpolation between ssp585 and ssp126 forcing over 3 cycles of the 2072-2099 period starting at "pure ssp585" in 2100 ending at "pure ssp126" in 2183.

JSBACH results 1



- Different ssp scenarios essentially identical until ~2070.
- ssp585-ssp126 always have lower thaw rates than the cyclic extension of ssp126.
- No sudden collapse in sight

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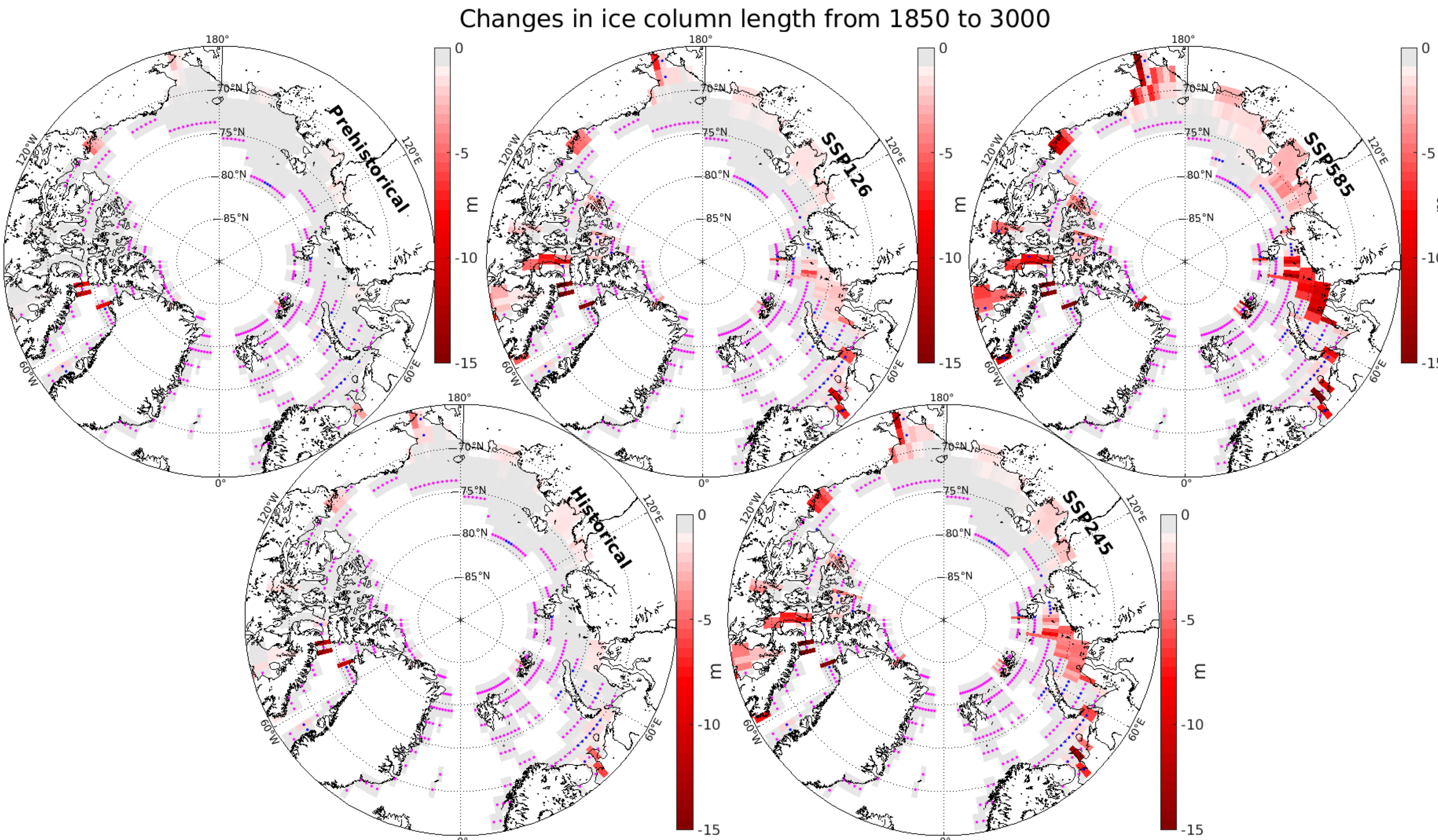
JSBACH results 2



- “Extended” experiment data used for year 3000
- Magenta dots: Points without ice in 1850, Blue dots: Points loosing all ice during runtime
- ssp585-ssp126 is extremely similar to ssp126

Conclusions

- Ice is decreasing in 97% of area with subsea permafrost. [1]
- Ice content always <200 m^3/m^2. [1]
- Ice volume (down to 1 km) decreases by at most 2.0% until 2100, and 6.3% until 3000 compared to 1850.
- Area with frozen sediments decrease by at most 12% until 2100, and 21% until 3000 compared to 1850.
- Ice mainly disappears from Barents and Kara Seas.
- Differences between scenarios does only become visible after 2070.
- Pathway dependency seems weak in the long term.
- Melting from cyclic forcing is questionable, likely underestimating melting (always strongest melting at same geographical location)
- Area with subsea permafrost not comparable between SuPerMap and JSBACH due to different resolutions.

References

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