First Results of the ISMIP-HEINO Model Intercomparison Project

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ISMIP HEINO

The ISMIP HEINO project (Ice Sheet Model Intercomparison – Heinrich Event IntercOmparison; see http://www.pik-potsdam.de/~calov/ heino.html) aims at providing a status-quo report on the ability of contemporary ice-sheet models to simulate Heinrich events. Additionally, insight about the underlying model physics and numerics can serve to improve the models.

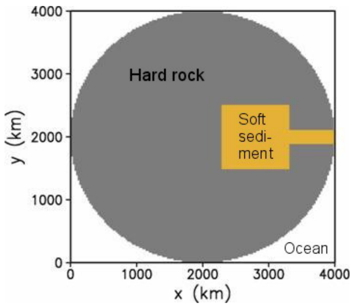


FIG. 1: Model domain of ISMIP HEINO. The sediment area mimics Hudson Bay (square) and Hudson Strait (channel towards the right).

Boundary conditions

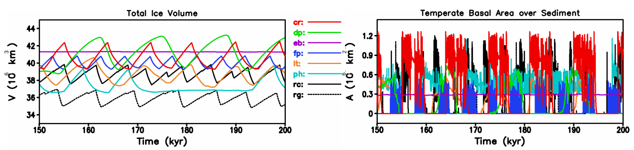
Surface:

- Temporally constant glacial climate.
- Temperature: –40°C (center) ... –20°C (margin).
- Mass balance: 0.15 m/a (center) … 0.3 m/a (margin).

Bedrock:

- Rapid sediment sliding for $T = T_{\mathrm{pmp}}$: $v_{\mathrm{b}} = -C\tau/(\rho g)$, $C_s = 500\ \mathrm{a}^{-1}$.
- Slow hard-rock sliding for $T = T_{\mathrm{pmp}}$.
- No-slip condition for $T < T_{\mathrm{pmp}}$.
- Geothermal heat flux 42 mW m^{-2}.

Simulations



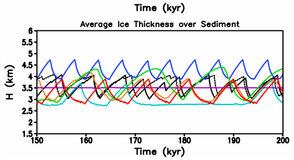


FIG. 2: Time series in the standard run (ST) from the participating ice-sheet models. All models use the shallow ice approximation.

	ST	T_s-10	T_s+10	B×1/2	B×2	C_s×1/5	C_s×2/5	C_s×2
cr	8000	4500	no	-	-	-	-	-
dp	12,000	10,000	no	17,000	no	no	no	11,000
eb	no	12,000*	no	no	no	no	no	no
fp	5000	4500	no	6000	no	no	no	6000[3]
lt	8000 to 13,000	8000 to 16,000	no	17,000	6000[2]	no	no	9000
ph	9000[3]	11,000	no	17,000	no	no	8000[1]	8000
rc	6000	4200	no	10,000	2900	6200	4300	6200
rg	7100	7100	6500	16,000	4500	12,000	7100	9000

Table 1: Preliminary analysis of the time series during the last 50.000 model years of various sensitivity experiments (columns) done with the different ice-sheet models. The rows show the different models indicated by the initials of the participants. The numbers give the approximate duration of HE cycles. Notation: (*) very small amplitude, ([1]) one single cycle, ([2]) two single cycles, ([3]) three single cycles, “no”: very weak non-regular oscillations which are often associated with a permanently more or less expanded warm base on the sediment region, “-”: data not available yet.

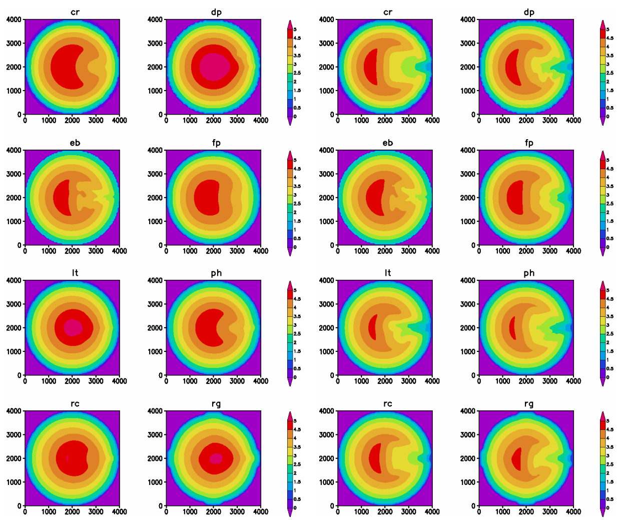


FIG. 3: Ice surface elevation in km for various participants in run ST when the average ice thickness is maximal (left side) and when the average ice thickness is minimal (right side).

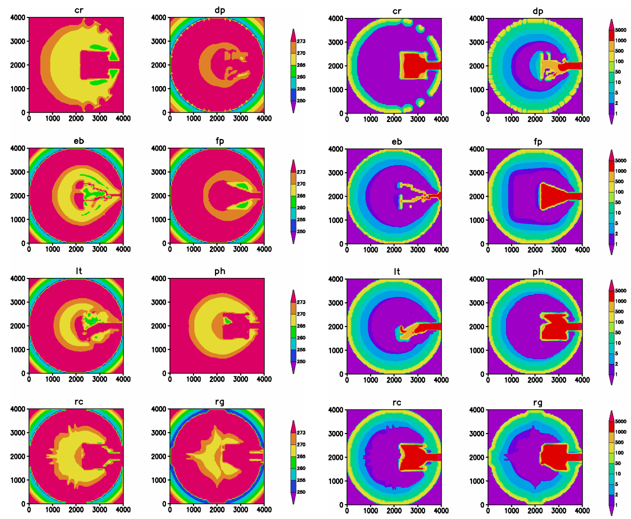


FIG. 4: Basal properties when temperate basal area is maximal for various participants in run ST. Left side: basal temperature (relative to pressure melting) in K. Right side: basal sliding velocity in m/year.

Conclusion

The majority of inspected the models produces full Heinrich cycles within a range of reasonable boundary conditions. In one of the models, parts of the basal ice in the sediment region are permanently on the melting point, and the elevation over the sediment region is therefore always relatively low. In general, the oscillations tend to disappear if the surface temperature is high. Only one model still shows HE cycles for T_s+10(°C). In turn, low surface temperature seems to facilitate the occurrence of HE cycles, because all models show oscillations, although in one case very weak ones. Further, three or possibly four models exhibit threshold behaviour in the sliding parameter, while two models do not show such behaviour. Interestingly, one can distinct between more “noisy” and rather calm models, which can be seen in the time series of the temperate basal area over sediment. Finally, the shape of the basal temperate area in the sediment region during a surge differs considerably among models.

Outlook

A subtle analysis of these model results and its publication is planned for this year. Additionally, a comparison between models in shallow ice approximation and higher order models is desired.