Grounding line migration as a response to cycles of sliding perturbations and initial geometries in the MISMIP^{3D} experiment

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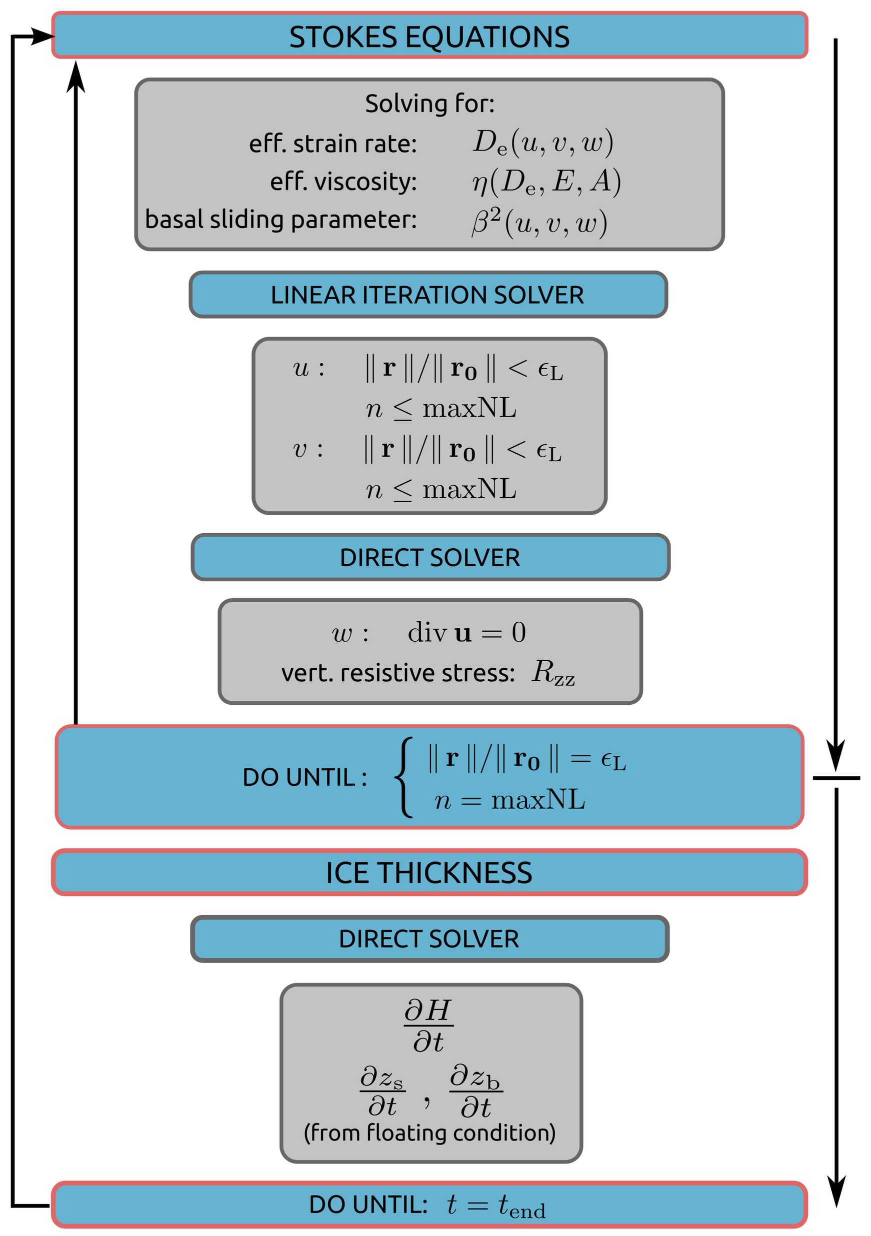
Introduction

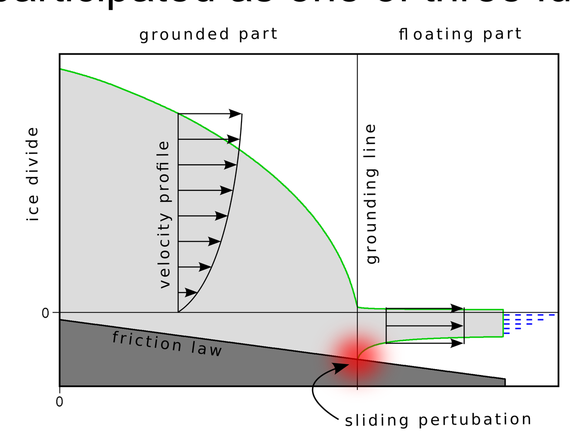
The poster presents results of the response of an artificial ice sheet-ice shelf system to periodic basal sliding perturbations concerning grounding line migration. Modelling grounding line migrations is a crucial component for estimating future behaviour of large ice masses in i.e. Antarctica or Greenland linked to the impact on the sea level rise.

All experiments are performed with the full-Stokes ice flow model TIM-FD³ (Kleiner & Humbert, 2014) with a fixed grid implementation. For subsequent cycles of sliding perturbation the abort criterion ε_L is set to $\varepsilon_L = 10^{-6}$ or a maximum number of iterations, *maxNL = 250,* which appeared to be sufficient proved by tests. Horizontal resolutions of the performed experiments reach from 10, 5 to 2.5 and 1.25 km at a maximum.

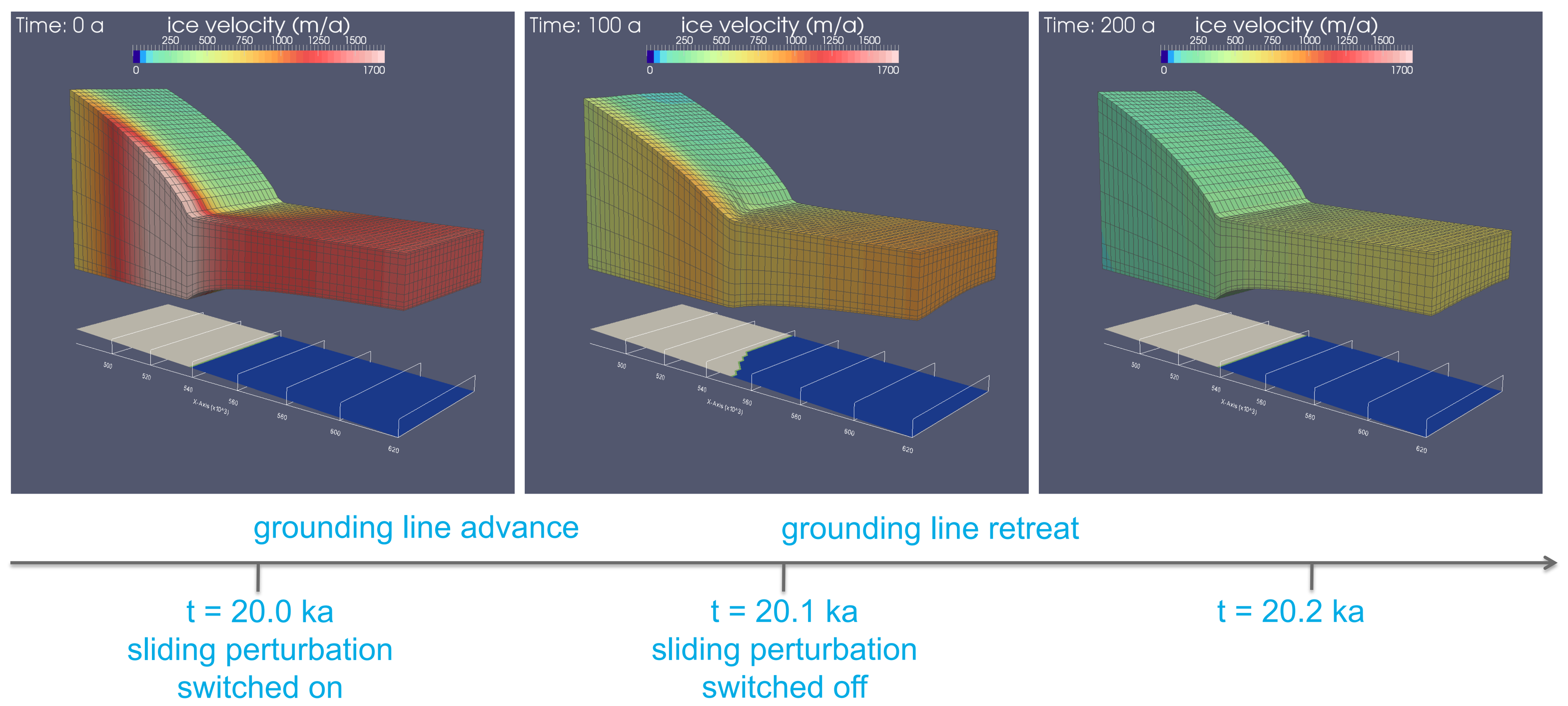


MISMIP^{3D}

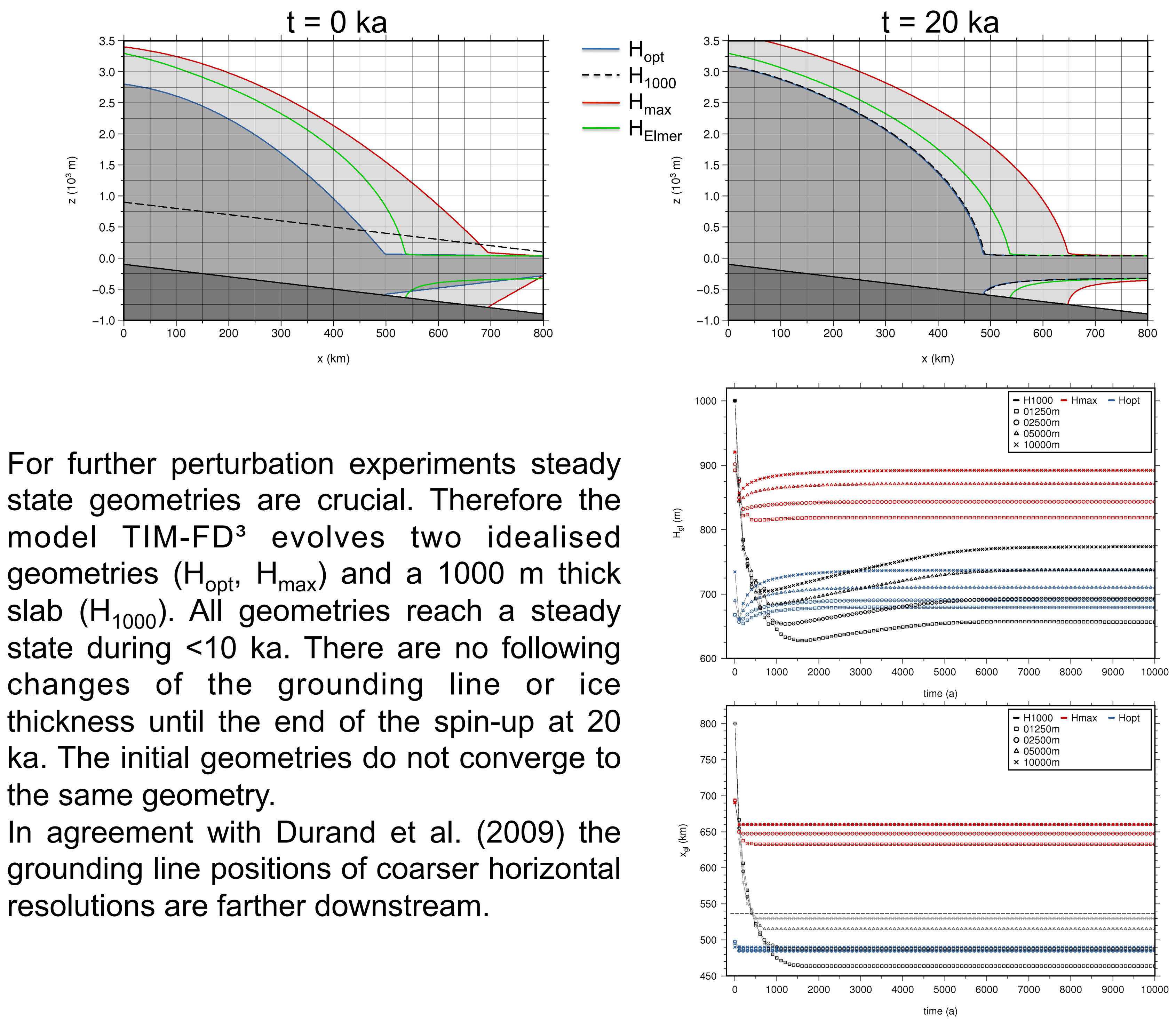
Cycles of sliding perturbations extend the experiments performed for MISMIP^{3D} (Pattyn et al., 2013). The benchmark tested several models concerning the reversibility criterion stated by Schoof (2007) meaning that a basal sliding perturbation of an ice flow resting on a linear sloping bedrock is reversible. TIM-FD³ participated as one of three full-Stokes models.



Experiments of the benchmark used a given geometry obtained with the high-resolution ice model Elmer/Ice. A perturbation C^* is applied for 100 a on an area of x_c=150 km and y_c=10 km at the grounding line on the basal sliding coefficient. The grounding line advances. Afterwards C^* is reset to the initial C. The grounding line retreats until a steady state is reached.



Geometry spin-up



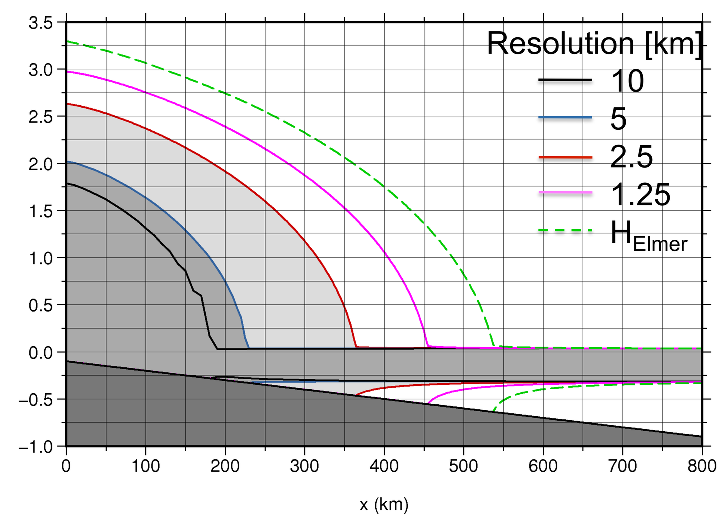
For further perturbation experiments steady state geometries are crucial. Therefore the model TIM-FD³ evolves two idealised geometries (H_{opt}, H_{max}) and a 1000 m thick slab (H_{1000}). All geometries reach a steady state during <10 ka. There are no following changes of the grounding line or ice thickness until the end of the spin-up at 20 ka. The initial geometries do not converge to the same geometry.

In agreement with Durand et al. (2009) the grounding line positions of coarser horizontal resolutions are farther downstream.

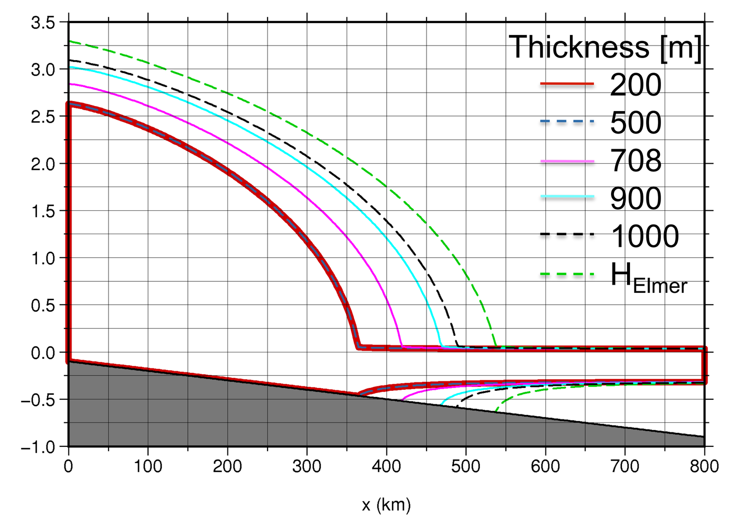
Dependency on initial geometry

Results of the geometry spin-up show an inverted resolution dependency compared to the set of the 1 km thick slab and the two idealised geometries (see above).

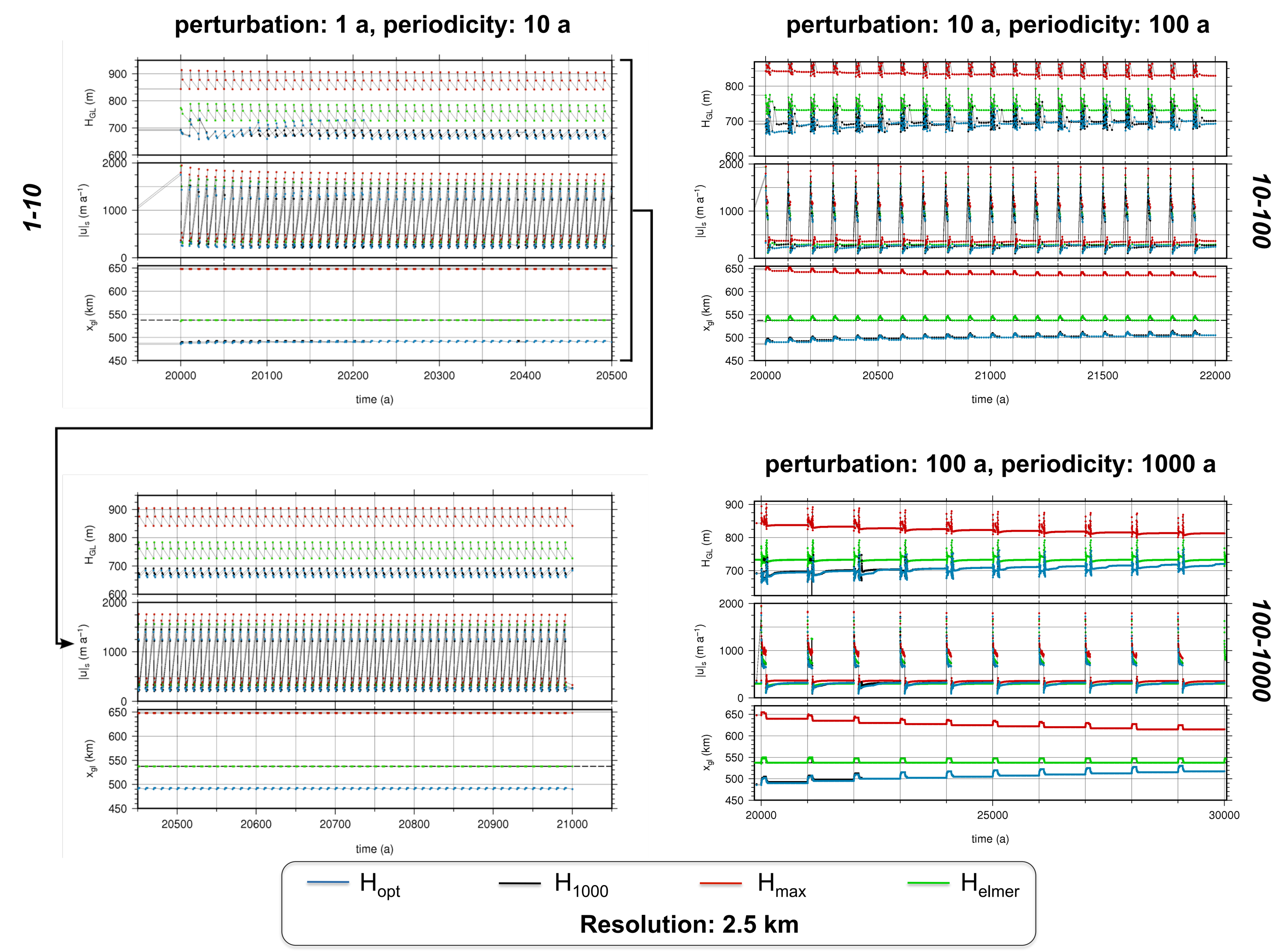
Furthermore, it stays in contrast to Durand et al. (2009) and the thesis that a coarser resolution leads to a grounding line farther downstream. Like in MISMIP^{3D} the initial geometry is a 200 m thick slab.



Steady state geometries after 20 ka of different initial slabs thicknesses (200, 500, 708, 900, 1000 m, Elmer). H_{708} has its initial grounding line at *t = 0* a at the position of H_{Elmer}. The solutions do not converge to the same steady state geometry linked to different grounding line positions. Only H_{200} and H_{500} end up on an identical geometry.



Cycles of sliding perturbations



Results of periodic basal sliding perturbations show different characteristica. Due to the geometry spin-up H_{opt} and H_{1000} are always close to each other. In all experimental setups H_{Elmer} is reversible. The perturbation duration of the 100-1000 setting is identical to MISMIP^{3D}. H_{opt} and H_{1000} show a slight advance, while H_{max} retreats. The 10-100 setting reveals the same trend although some perturbation cycles are reversible. The 1-10 setting does not show any retreat of advance. All perturbations of only 1 year every 10 years are reversible.

Experiments with H_{max} and H_{opt} over >25 ka obtaining MISMIP^{3D}-conditions that advances or retreats of the grounding line cannot be extrapolated linearly as the progression is asymptotically.

Conclusion

- The simulations show that basal sliding perturbations on a small time scale (1-10 experiments) appear to be reversible. Perturbations on longer time scales indicate irreversible changes of the grounding line position.
- Which parameter initiates the migration is still unclear.
- It is necessary to investigate the influence of initial conditions on the grounding line position, as results of the geometry spin-up show a strong dependency on the initial slab thickness and the horizontal model resolution.
- The initial slab thickness or geometry in general appears to have a strong impact on the obtained steady state geometry.

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