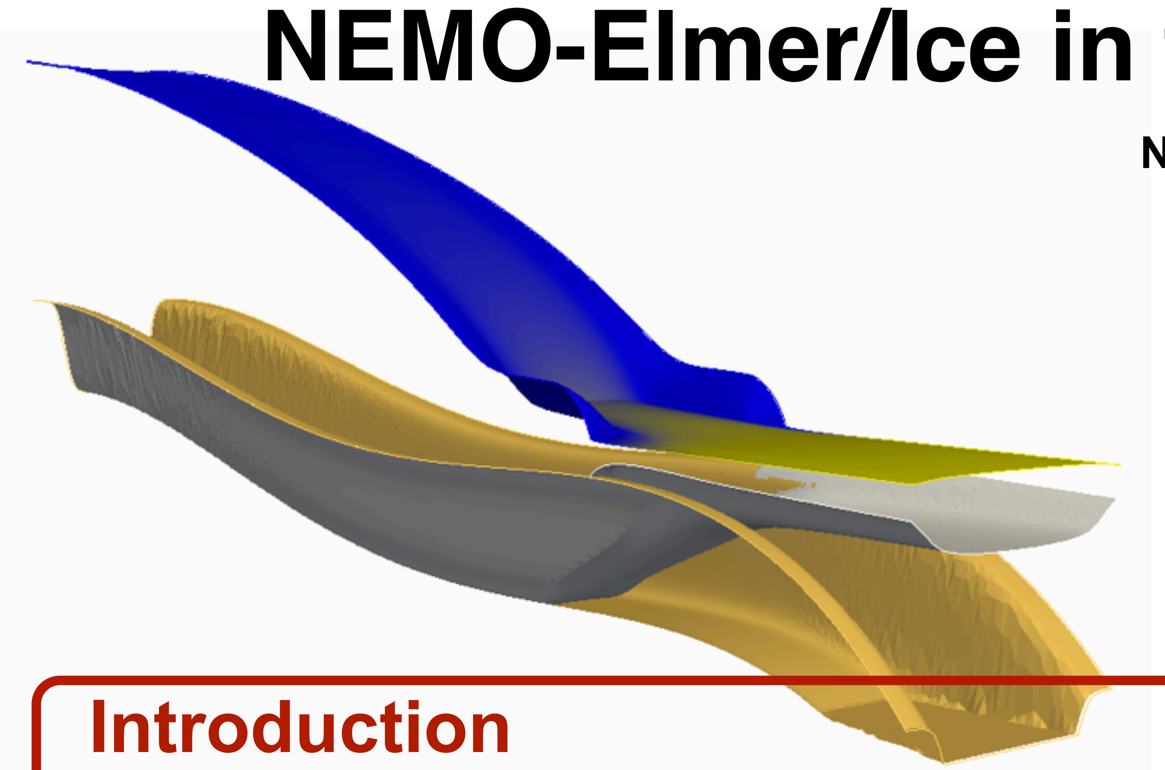
NEMO-Elmer/Ice in the context of MISOMIP tests



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Introduction

West Antarctica, and the Amundsen sector in particular, is the largest potential contributor to sea level rise (SLR) in the next future according to recent climate projections. Most of the glaciers in this region, presenting Marine Ice Sheet instability (MISI), are suggested to be strongly affected by ice-ocean interactions. However, some of those processes are not completely well understood yet and the estimates of the SLR are still very uncertain. The efforts in SLR predictions are recently more focused on the coupling of standalone ice and ocean models and the emergent properties of the new coupled systems. In this context, and following previous model inter-comparison MISMIP and MISMIP3D, a new set of experiments have been designed. This new generation of MIP's, with an idealized geometry based on a typical Amundsen Sea configuration, aim to investigate a number of processes related to the interactions between the two components of the ice-ocean coupled system. Three different MIP's have been proposed: for the ice-sheet model (MISMIP+), the ocean model (ISOMIP+), or for the coupling of both components (MISOMIP). Here we discuss the results a different features concerning the ice-sheet model ElmerIce fof MISMIP+ and the ocean model NEMO for the test for ISOMIP+.

ElmerIce in the context of MISMIP+ at LGGE

Resolution at the grounding line of **500m** with and **0.1 yr** of timestep

Stress Approximation: **SSA** and **SSAStar** (Full Stokes not performed yet).

Friction Law: **Power Law** and **Schoof Law** (parameters by default of the MIP)

Grounding Line: Hydrostatic approximation with sub-element parameterization of the basal friction (SEP3 in [1])

Stabilization: The computation of the advection of the ice in FEM requires a **Petrov-Galerkin formulation** in order to avoid the spurious oscillatory solutions.

Bubbles method is not efficient at the fast part of the glacier with very steep slope.

Stabilized formulation SUPG gives much smoother results in the fast parts with an advection-dominant limit applied as defined in (2). However, transient simulations needs some extra stabilization in the inflow boundary (very slow ice) where the transient-dominant limit should be preferably applied (see eq. below). Sensitivity tests recommend the use of α=1000 to have a good balanced limit between the two regimes.

$$\tau_{UGN} = \Big(\sum_{a=1}^{nodes} |\vec{v}^h \cdot \vec{\nabla}\vec{N}_a|)^2 + (\frac{2}{\alpha\Delta t})^2\Big)^{-1/2}$$

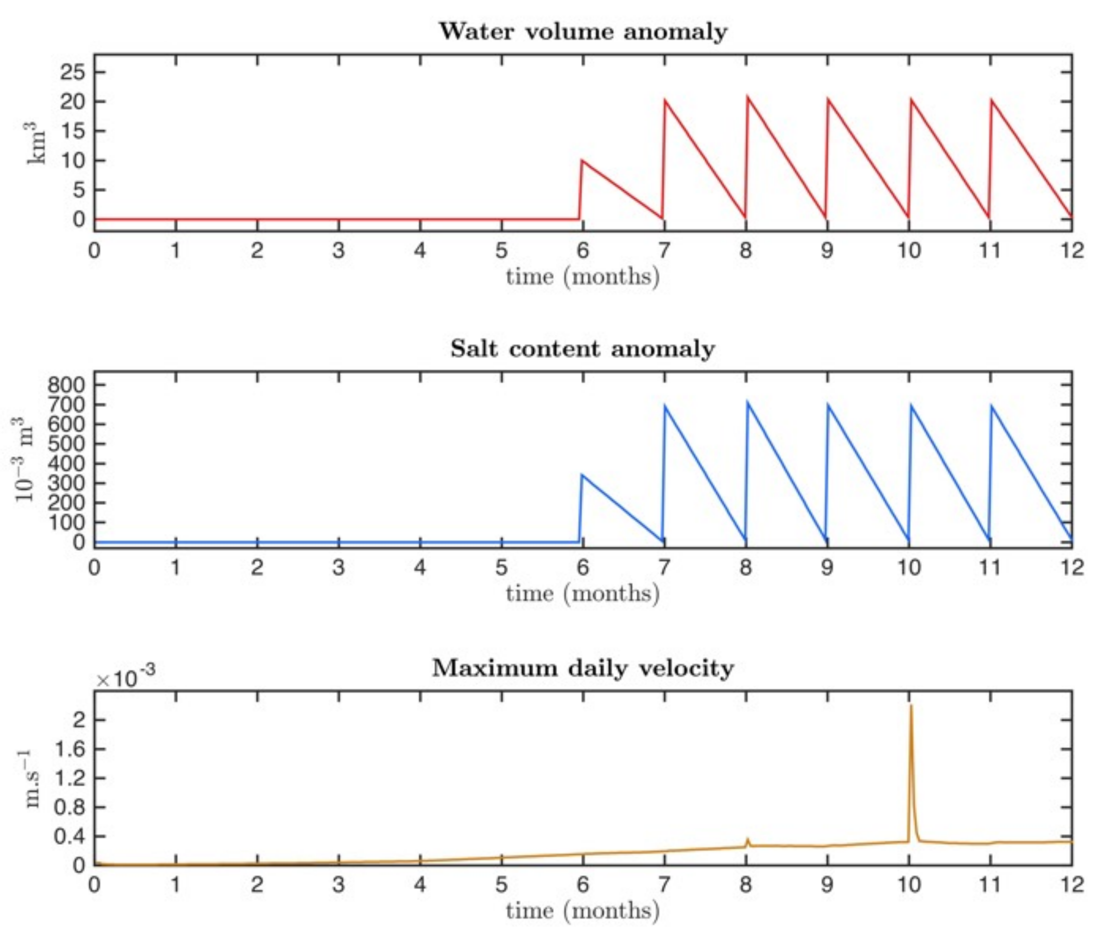
NEMO in the context of ISOMIP+ at LGGE

OCEAN3 test (moving ice draft boundary)

NEMO_3.6/3.7 Z*-coordinate with partial steps

Moving Boundaries:

- Coupling frequency: **6 months**
- T,S in new ice-free cells are extrapolated from closest cell (horizontally if possible)
- U and V in ice-free cells are first set to zero. Then, a barotropic correction of U and V is applied to conserve the barotropic transport.
- If a full water column is open, SSH is interpolated from the closest cells



An alternative conservation method for volume, heat &salt

Specific tests performed:

--No far-field restoring,

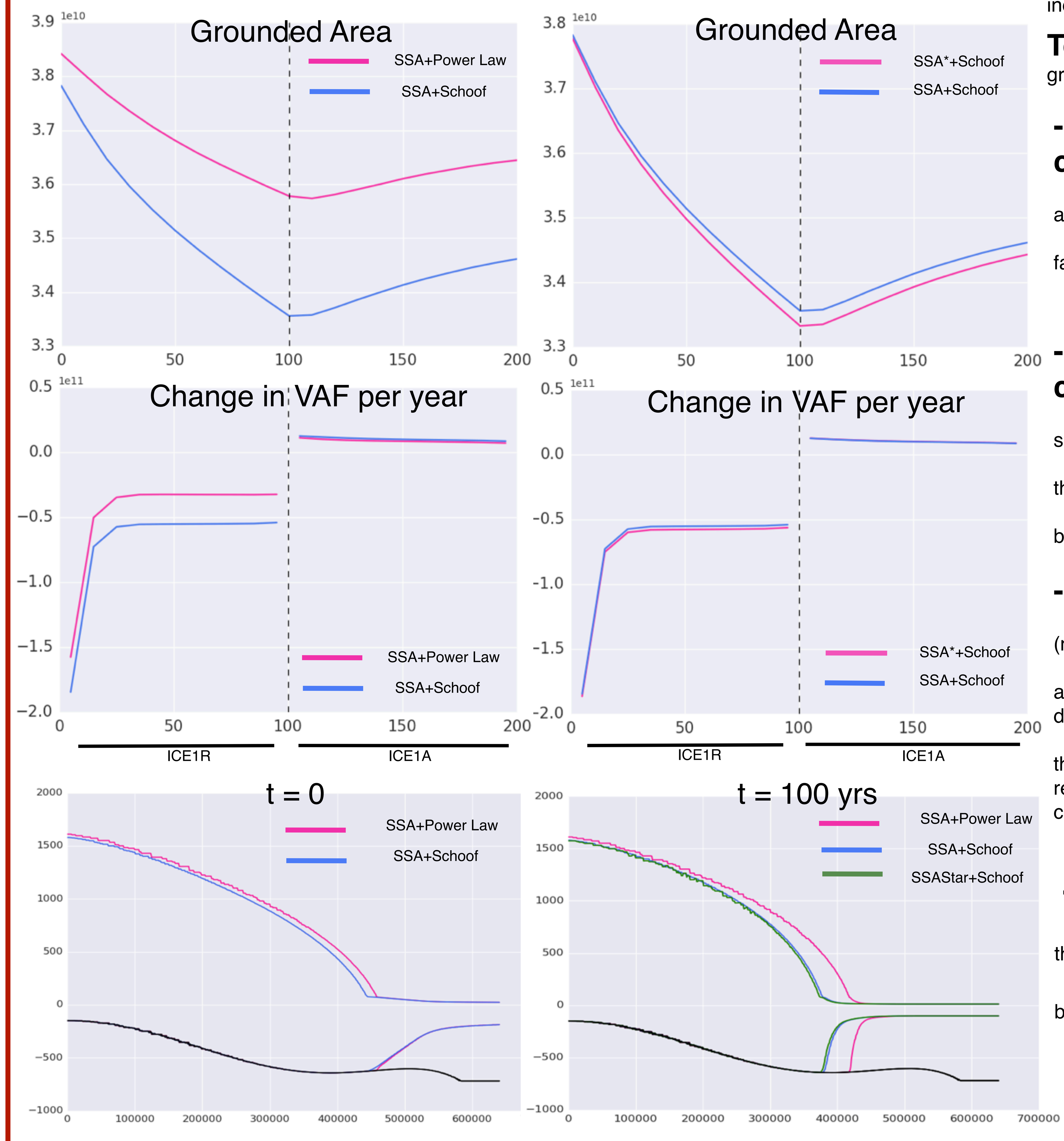
--No melting

--Coupling frequency of 1 month (ice draft interpolated in between)

As shown, there is **conservation in volume and salt.**

Spurious velocities may appear just after coupling. Not clear if related to coupling method or correction method. They remain **small overall** and difficult to detect in presence of melt and stronger circulation

MISMIP+ Results



Test ICE1R: 100 years of melting-induced grounding line retreat.

Test ICE1A: 100 years of grounding line re advance (no melting)

-- Friction Law comparison

- **Power law,** in steady state, gives an upper GL pos. in the retrograde slope
- **Schoof friction law** produces faster retreat than Power law
- **Re-advance** is almost **similar**

-- Stress Approximation comparison

- **SSA** steady state presents an slightly upper GL in the retrograde slope
- **SSA Star** produces faster retreat than SSA
- Re-advance is almost similar in both cases

--VAF change

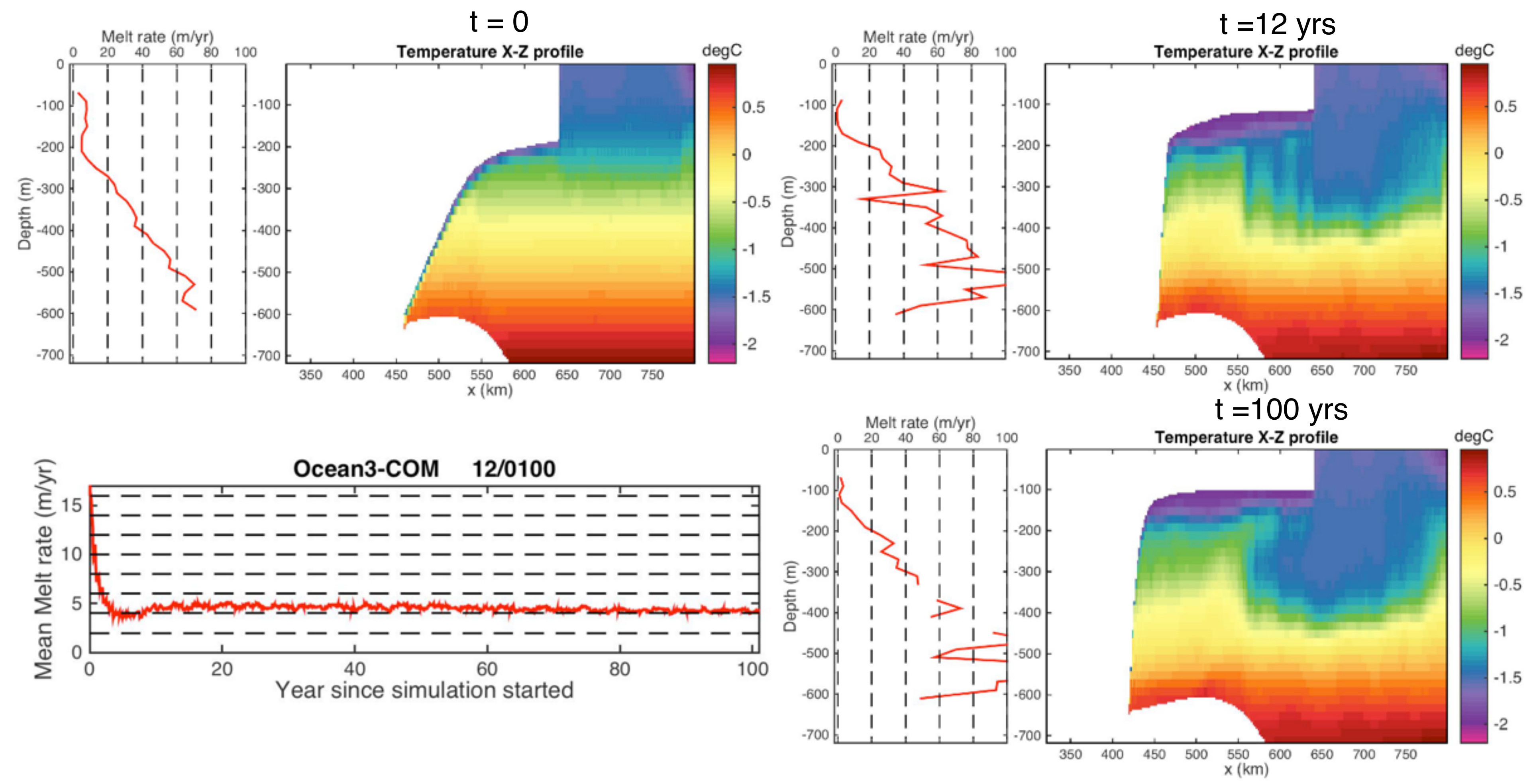
- VAF changes in two linear regimes (not shown).
- **Firstly**: 10 years of strong constant acceleration retreat. Transient cavity draft change.
- **Secondly**: Linear VAF change. At this stage, not sure if related to the reduced bedrock slope or because the constant cavity draft.

--Initial and final drafts:

-- Choice in friction law matters more than in the the stress approximation

-- Ice cavity drafts not very affected by the different choices

ISOMIP+ Results



Test OCEAN3: Moving cavity boundary with a prescribed ice draft

-- Integrated **melt rates** depends on the **cavity draft**

-- **Melt(z)** is **not constant** throughout the experiment, which emphasizes the need for **ice-sheet/ ocean coupling** and the limitation of imposing constant melt functions as in MISMIP+.

References

[1] *H. Seroussi, M. Morlighem, E. Larour, E. Rignot, and A. Khazendar. Hydrostatic grounding line parameterization in ice sheet models. Cryosphere , 8(6), 2014.*

[2] *T. Tezduyar, (2002). .T. Tezduyar, Stabilization parameters and local length scales in SUPG and PSPG formulations. in: Proceedings of the Fifth World Congress on Computational Mechanics.*