Stability of current Antarctica grounding lines

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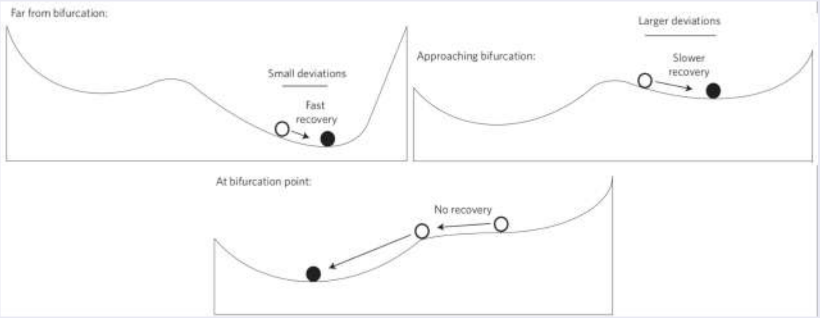
Introduction

Tipping Point

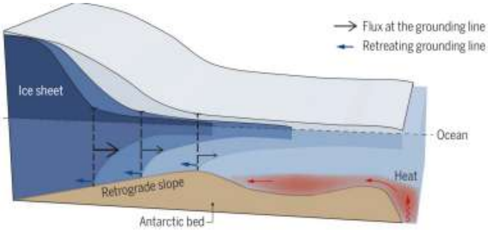


Lenton,2011

Antarctica

Warming context
Increasing of the instability

MISI (Marine Ice-Sheet Instability)



Pattyn, 2020

Conditions :

- retrograde slope of the bedrock
- Circumpolar Deep Water (CDW)

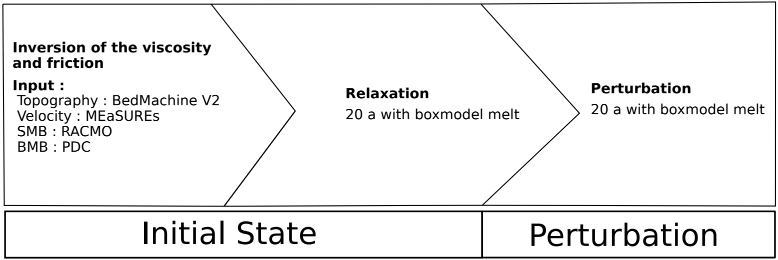
Consequences :

- Increasing the melt under the ice-shelf
- Retreat of the grounding line (boundary between floating and grounding ice)
- Thinning and reduction of the buttressing effect
- Increased flow velocity and flux at the grounding line

Work Package 2 : Ice Modelling

- Use of 3 ice-flow models : PISM, Úa, **Elmer/Ice**
- Define the stability state of the grounding line (GL)
  - Define some initial states
  - Apply melting perturbation under the ice-shelf and define the stability of the GL
  - or an unstable and irreversible retreat of the GL

Framework


Inversion of the viscosity and friction
Input :
Topography : BedMachine V2
Velocity : MEaSUREs
SMB : RACMO
BMB : PDC
Relaxation
20 a with boxmodel melt
Perturbation
20 a with boxmodel melt
Initial State
Perturbation

Creating an initial state

Initial state : reproduce the ice-sheet at define time
Localisation : Antarctica
Parameters to be optimized :

- β for the friction parameter $C = 10^{\beta}$
- η for the viscosity $\bar{\mu} = \eta^2 \times \bar{\mu}_{ini}$

We are using the adjoint method described by MacAyeal (1993)

3 steps for the inversion :

- Mesh
- Initialization of the variables
- Optimisation of the friction and viscosity parameters

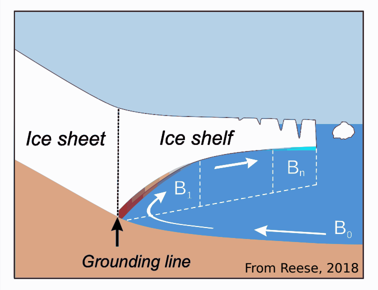
Relaxation

20 a with box model parametrization

Box model parametrization

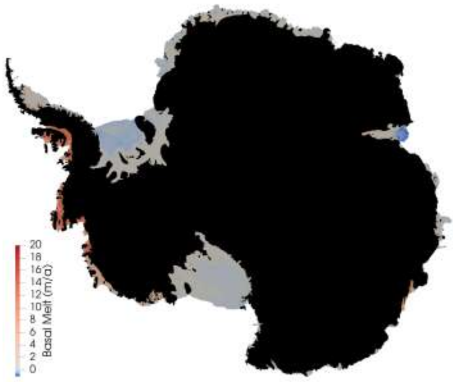
Newly on Elmer/ice

for realistic case



Temperature and salinity are given for each basin.
The parameters of this box model come from the PICO model of Reese, 2018

Box model parametrization



Total Melt = 1 464 Gt/yrs

The melting is too high on the West Antarctica => Collapse of WAIS
Tuning of the parameter in progress

Perturbation

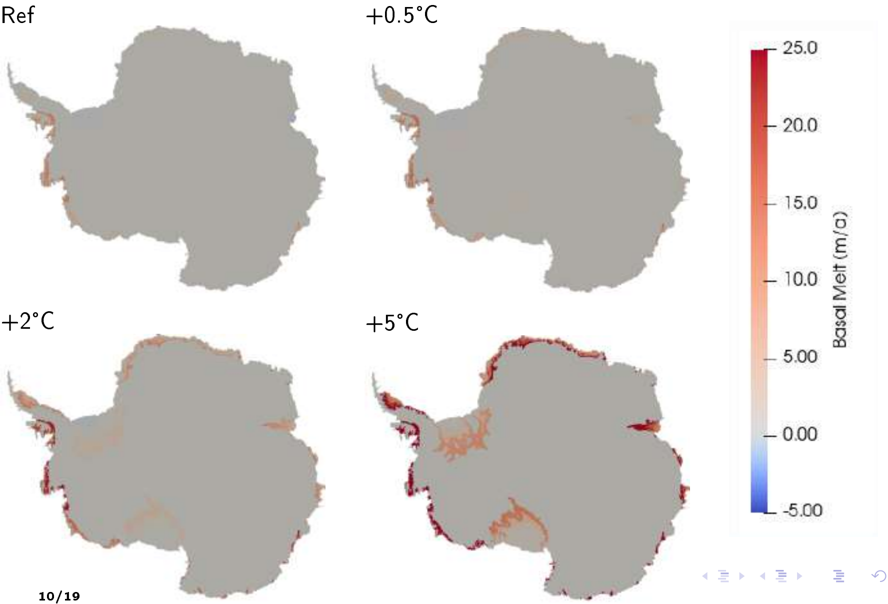
General Perturbation

Applied the same perturbation every where

Goal : Have overview of the ice-shelf reaction

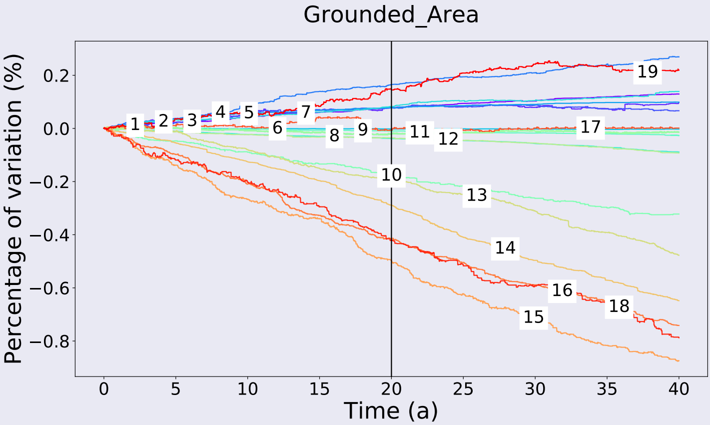
Perturbation on T°under the ice-shelf							
0°C référence	0.1°C	0.3 °	0.5°	1°C	1.5°C	2°C	5°C

Perturbation



What is the basin inital state ?

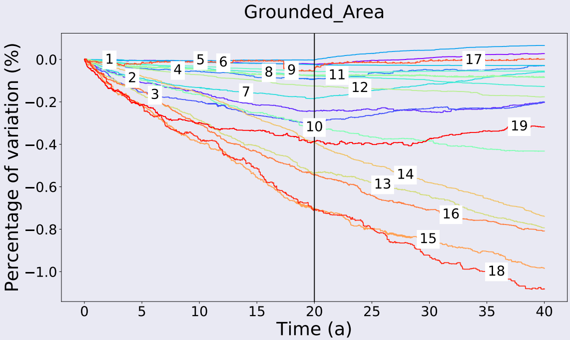
Reference case : No perturbation



Only the warmer cavities have a retreat of the grounding line
(Basin 13 to 16 have a too strong melting)

Which Basin is the most impacted by a small perturbation ?

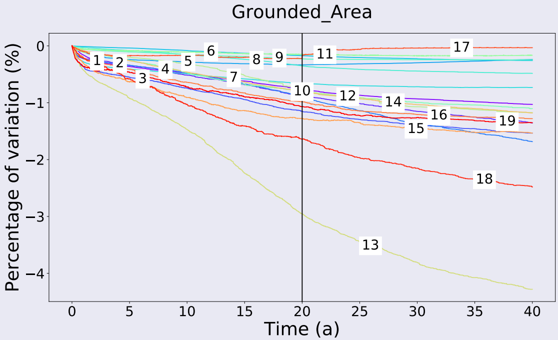
+0.5 °C



Retreat of **most** grounding lines which move forward if we remove the perturbation
(Basin 13 to 16 have a too strong melting)

Which Basin is the most impacted by a strong perturbation ?

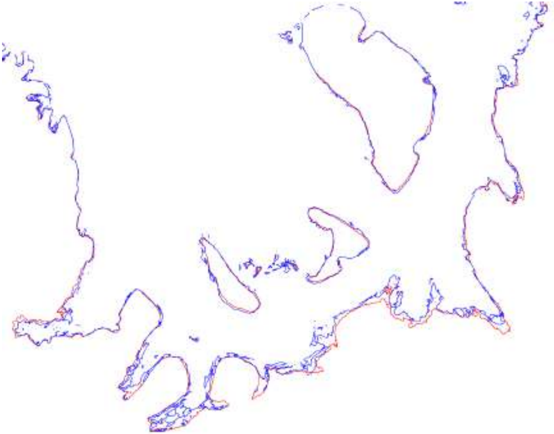
+5 °C



Retreat of all grounding lines. Only few basins stop retreating if we remove the perturbation

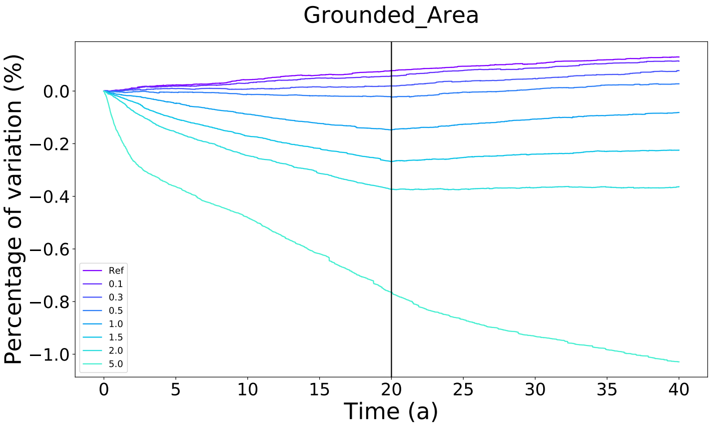
(Basin 13 to 16 have a too strong melting)

The cold cavities case : Ronne-Filchner Basin



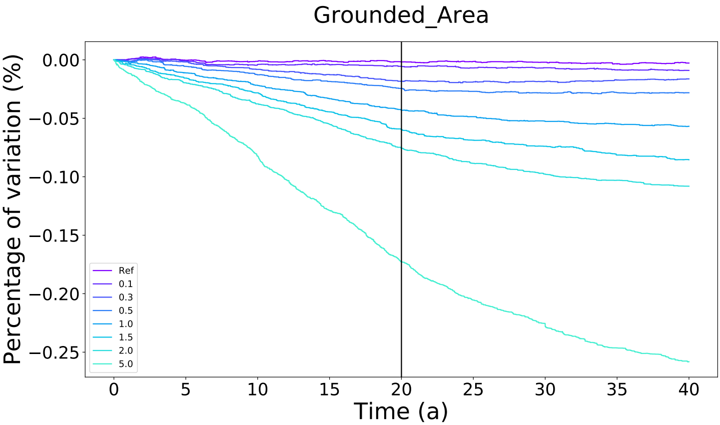
The GL is moving backward with a sufficient perturbation

The cold cavities case : Ronnie-Filcher Basin



Remove the perturbation → advance again (except with +5.0°C)

Aymery Basin



Removing the perturbation don't change the direction of the slope for small perturbation

The retreat seems irreversible

Current work :

- New parameter for the box model
- Change the temperature of the boxmodel (colder cavity on WAIS)
- Continue the work to define the stability state of each basin
- Create longer perturbation (200 a)

Take Away Message

- Cold cavities as Ronne-Filchner are really stable
- Some basins (Aymery) considered as cold cavities seems to be sensible to a small perturbations and an irreversible retreat.
- Huge perturbation (+5°C) seems to be irreversible on all basins

Acknowledgement

All the simulation have been run on the CINES supercomputer.