Assessment of the sensitivity of the Antarctic ice-sheet to ice-shelf collapse

Yelmo sensitivity to different methods and strategies

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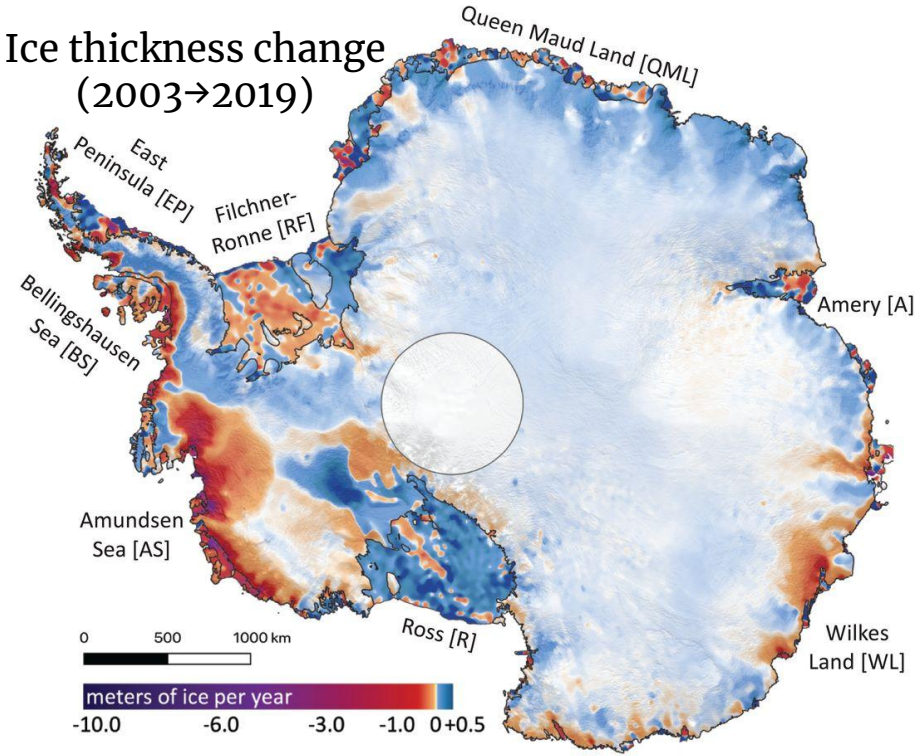
Current state & uncertainties

Ice thickness change (2003→2019)

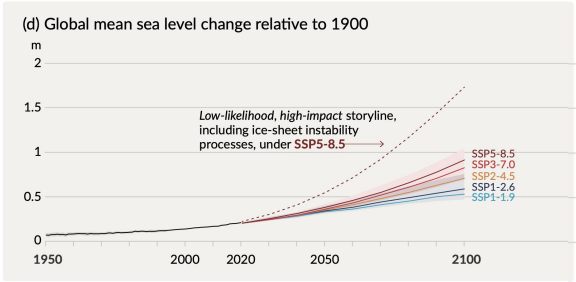


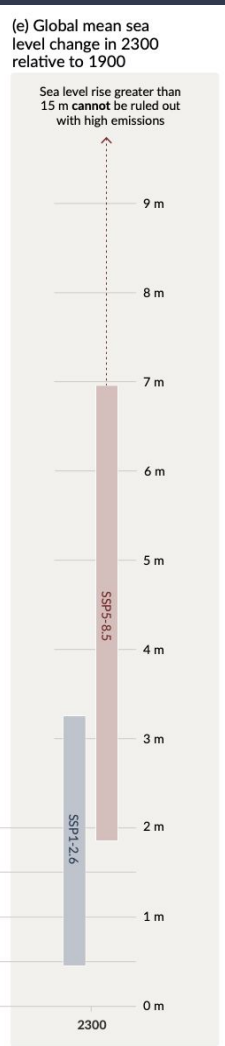
Smith et al., 2020

➔ Climate projections
➔ Observed tendencies

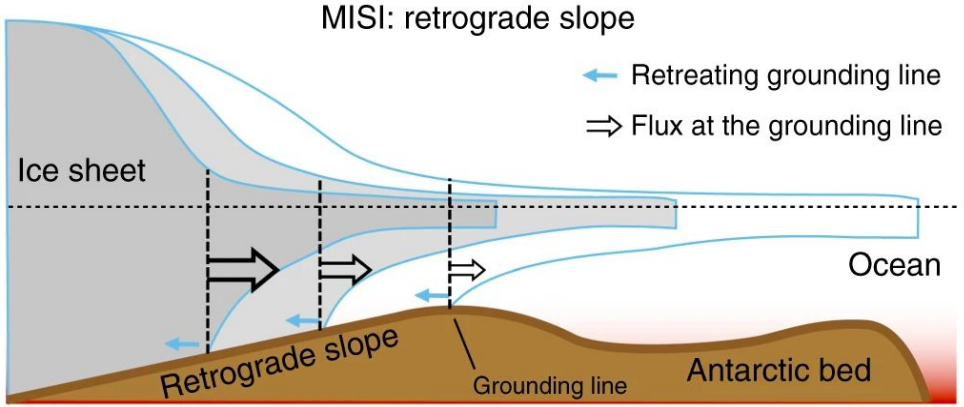
Sea-level projections

IPCC AR6, 2021





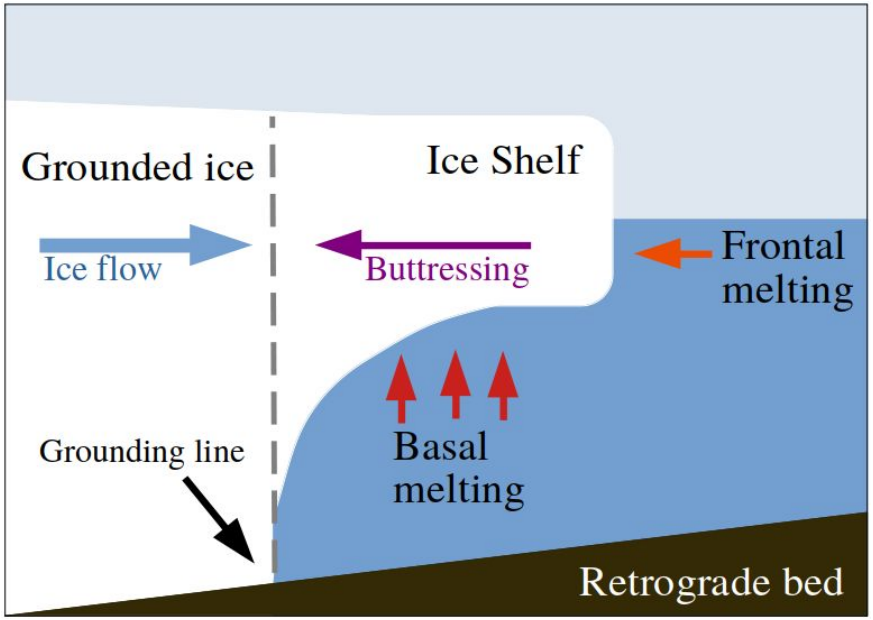
West Antarctic Ice Sheet (WAIS)

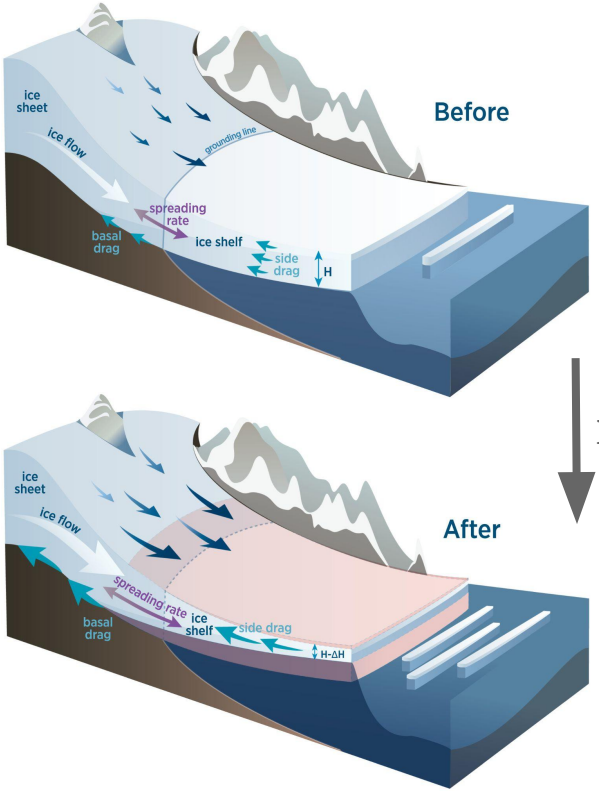


Pattyn et al., 2018

- ➔ Marine nature
- ➔ Retrograde bed
- ➔ Marine Ice-Sheet Instability

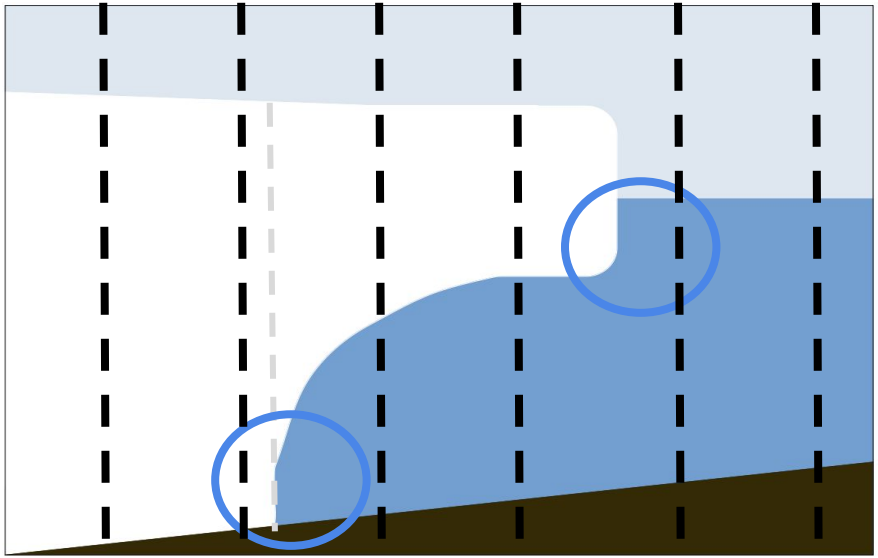
Ice shelves


Grounded ice
Ice Shelf
Ice flow
Buttressing
Frontal melting
Basal melting
Grounding line
Retrograde bed


ice sheet
ice flow
grounding line
Before
spreading rate
basal drag
ice shelf
side drag
H
Debuttressing
ice sheet
ice flow
After
spreading rate
ice shelf
side drag
basal drag
H-ΔH

Simulated world

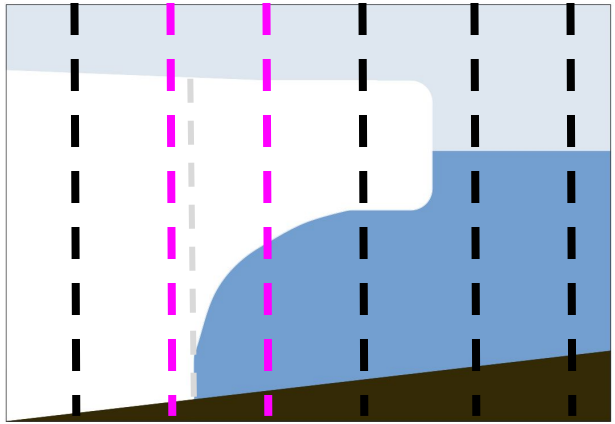
Model's grid



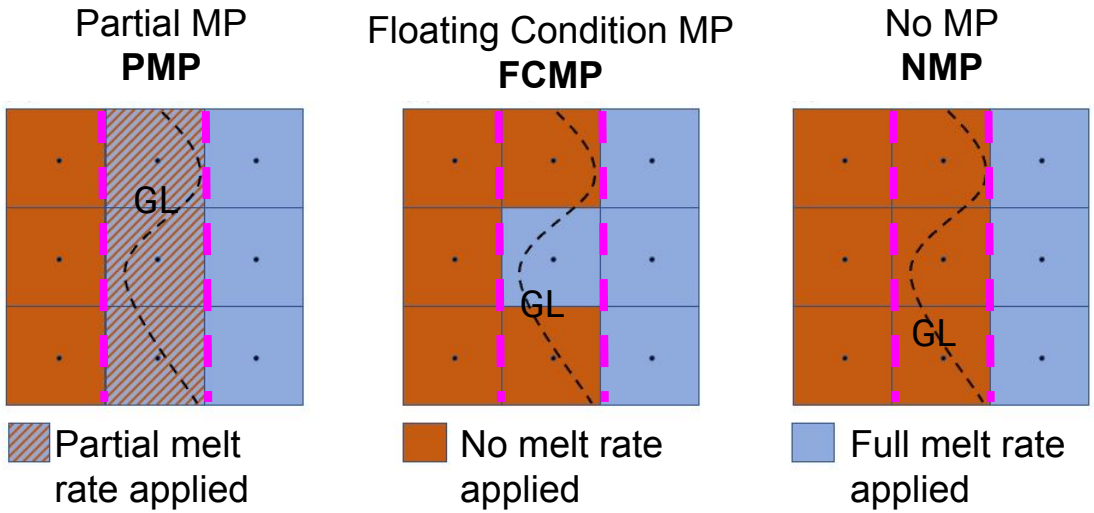
- ➔ Discretization
- ➔ ABUMIP (Sun et al., 2020)
- ➔ Uncertainties in methodology
  - ◆ Melting at the ...
    - Grounding Line
    - Ice-shelves front

Melting at the Grounding Line (GL)

Model's grid



Melting parameterizations (MP)



Adapted from: Leguy et al., 2021

Melting at the ice-shelves front

Ice-shelf mass balance

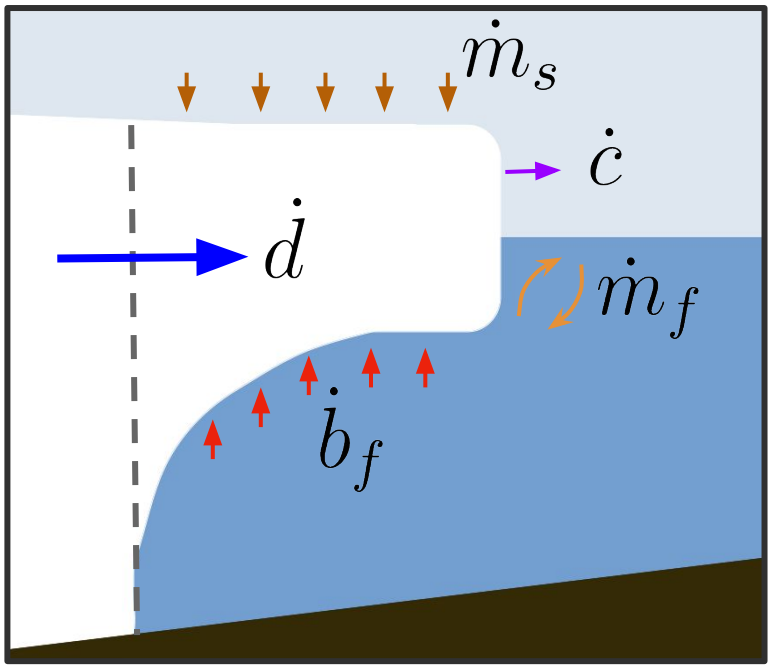
$$\dot{M}_{shlf} = \dot{m}_s + \dot{b}_f - \dot{c} + \dot{d} + \dot{m}_f$$

Frontal mass balance

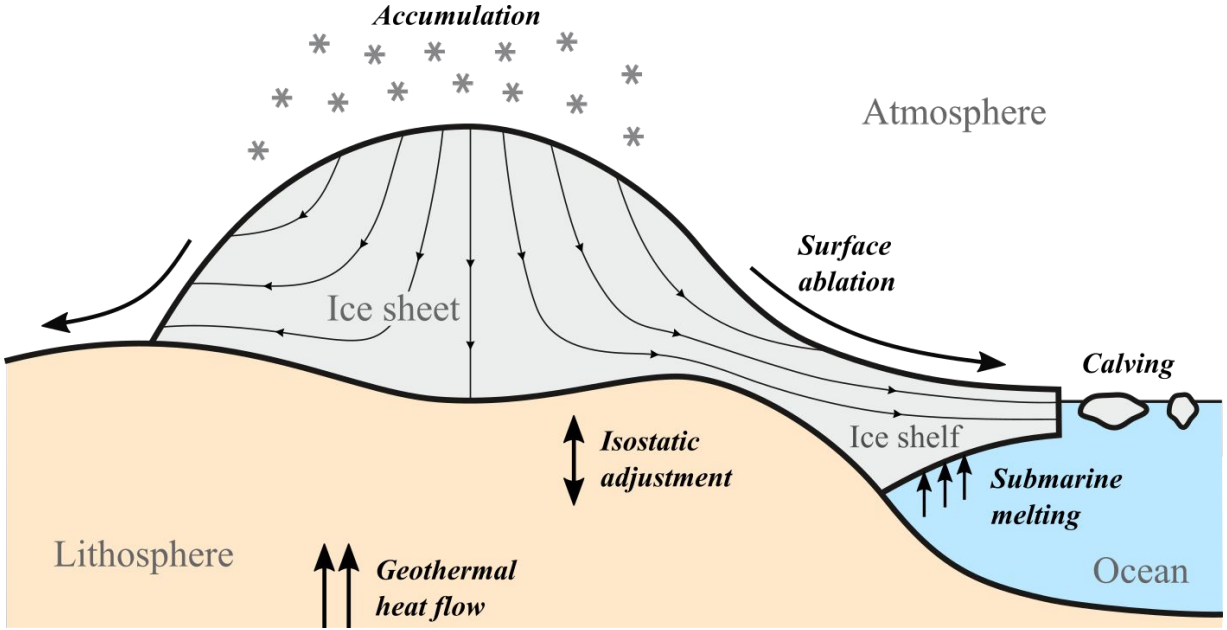
$$\dot{m}_f = \dot{b}_f \cdot \frac{A_f}{A_b} \cdot f_c$$

$f_c = [0.0, 1.0, 10.0]$

DeConto and Pollard (2016)



Model Yelmo (Robinson et al., 2020)



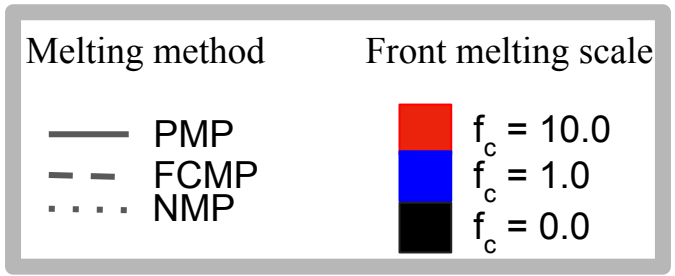
palma-ice.github.io/yelmo-docs
palma-ice/yelmo.git

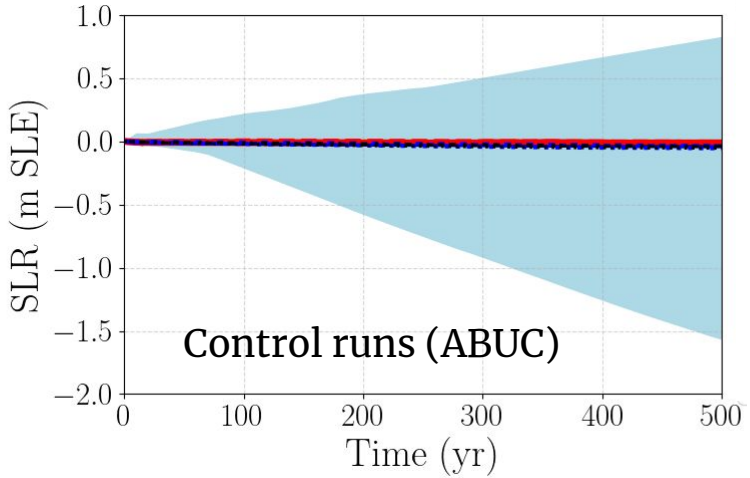
- ➔ Ice-sheet-shelf model
  - DIVA
  - Regularized Coulomb
  - 32 km resolution
- ➔ ABUM (Sun et al., 2020)
  - -400 m/yr
  - 500 yrs

Model performance

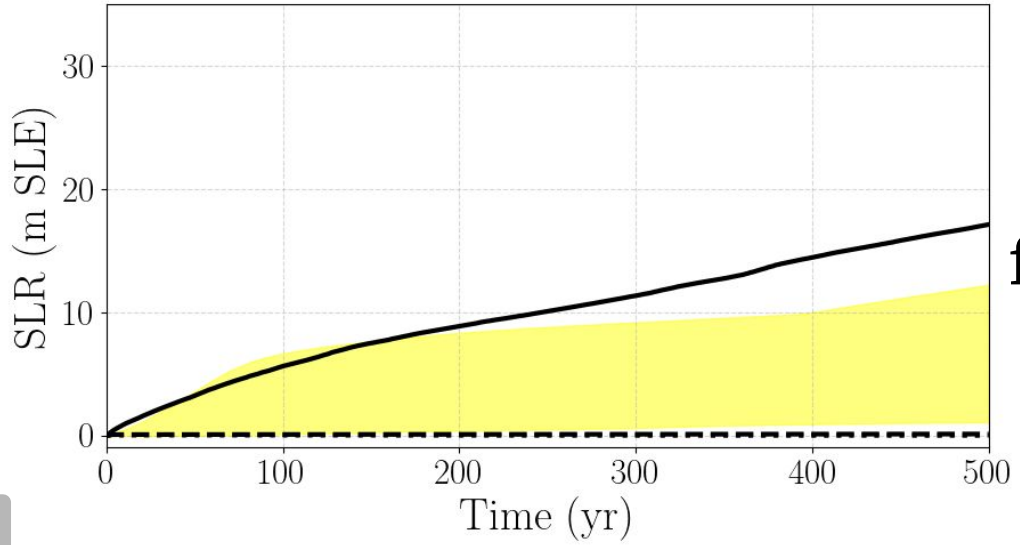
Spin-ups (30 kyrs)	PMP	FCMP	NMP	Mean	Std. dev.
$RMSE_H$ (m)	193.94	163.38	195.18	184	15
$RMSE_{u_s}$ (m/yr)	201.32	200.40	202.79	201.50	0.98
Ice volume (m SLE)	55.99	56.39	57.07	56.48	0.44

The shading represents **ABUC** results of ABUMIP (Sun et al., 2020)





Melting method effect



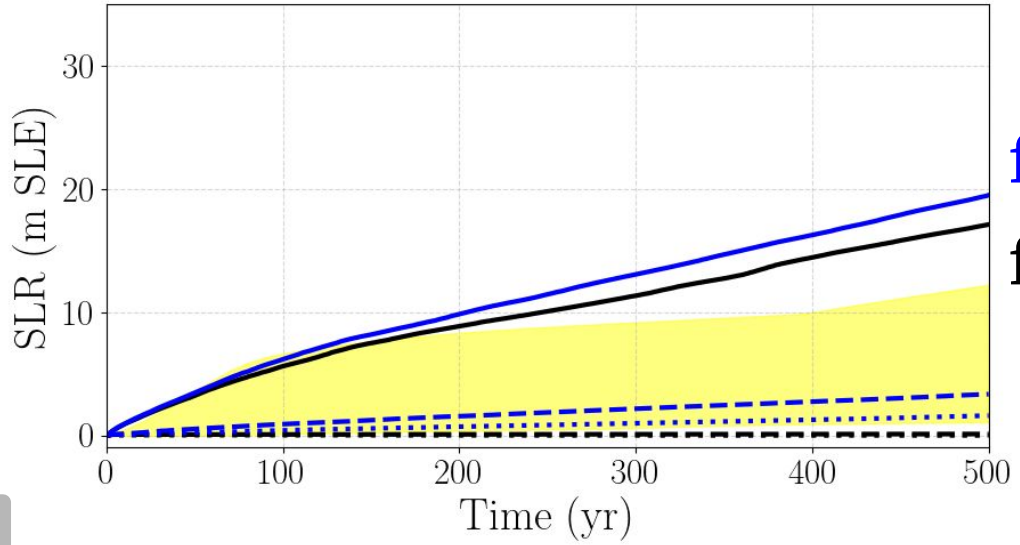
f_c = 0.0

Melting method

PMP
FCMP
NMP

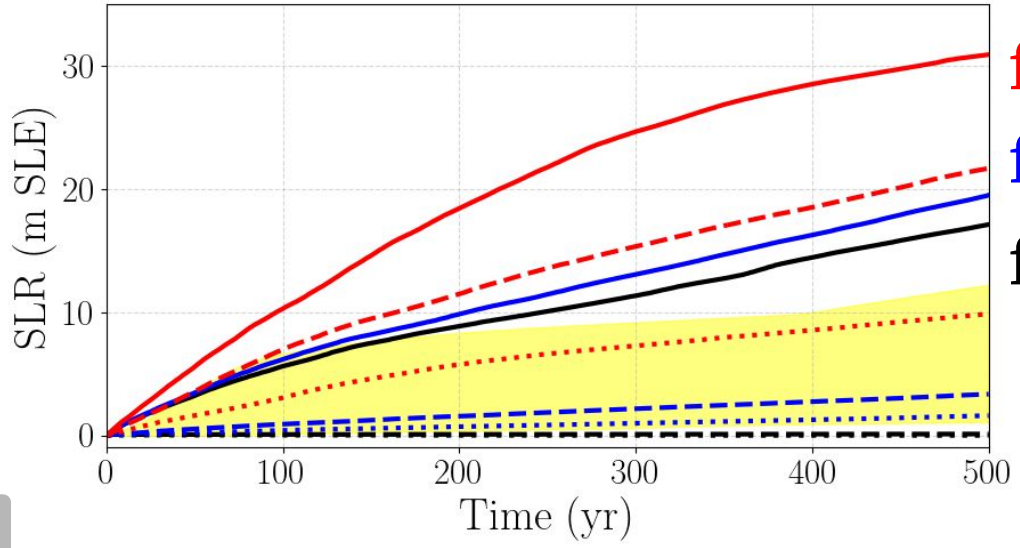
The shading represents **ABUM** results of ABUMIP (Sun et al., 2020)

Melting method effect + Frontal melting



The shading represents **ABUM** results of ABUMIP (Sun et al., 2020)

Melting method effect + Amplification factor



f_c = 10.0

f_c = 1.0

f_c = 0.0

Melting method

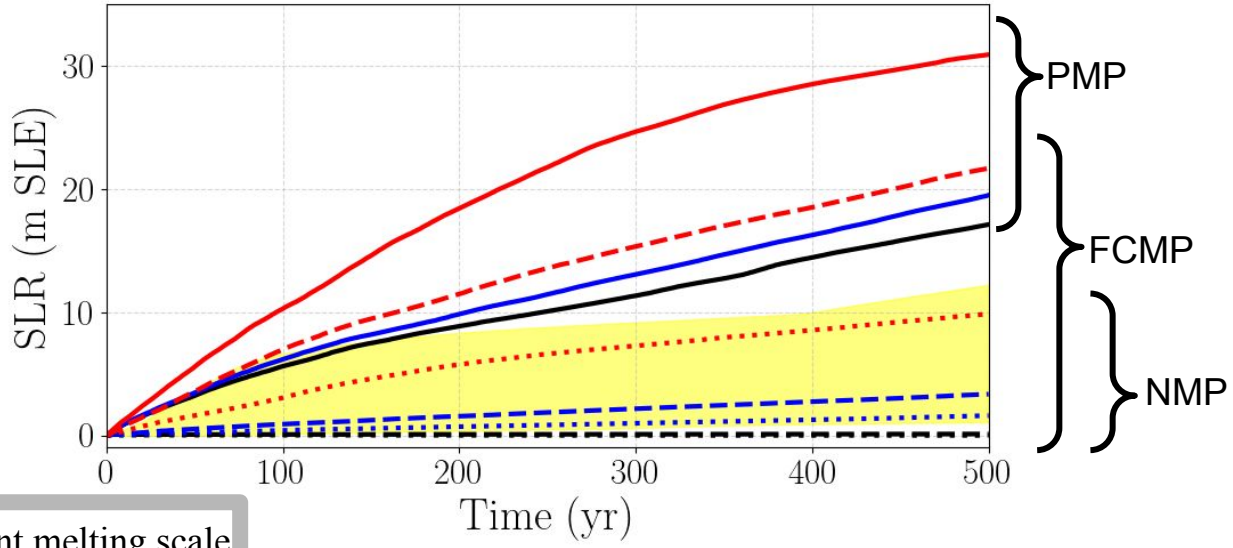
PMP

FCMP

NMP

The shading represents **ABUM** results of ABUMIP (Sun et al., 2020)

Clustering



Melting method

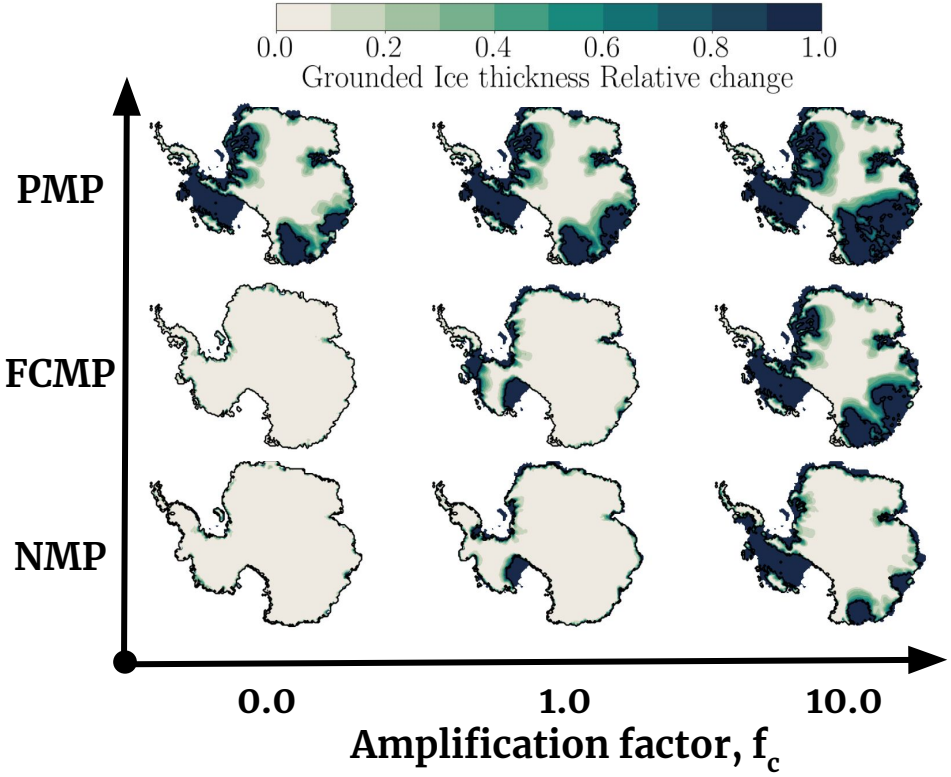
PMP
FCMP
NMP

Front melting scale

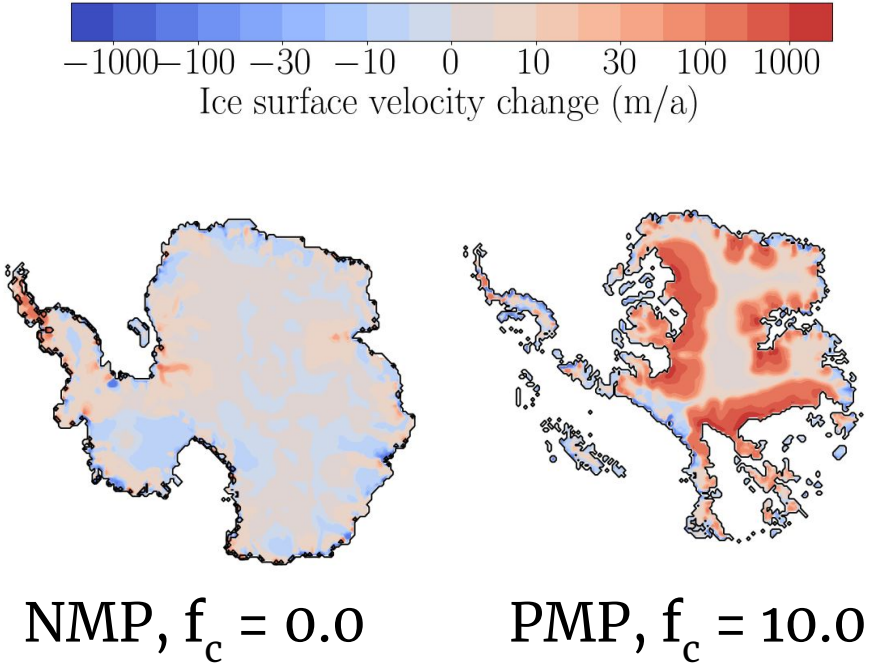
f_c = 10.0
f_c = 1.0
f_c = 0.0

The shading represents **ABUM** results of ABUMIP (Sun et al., 2020)

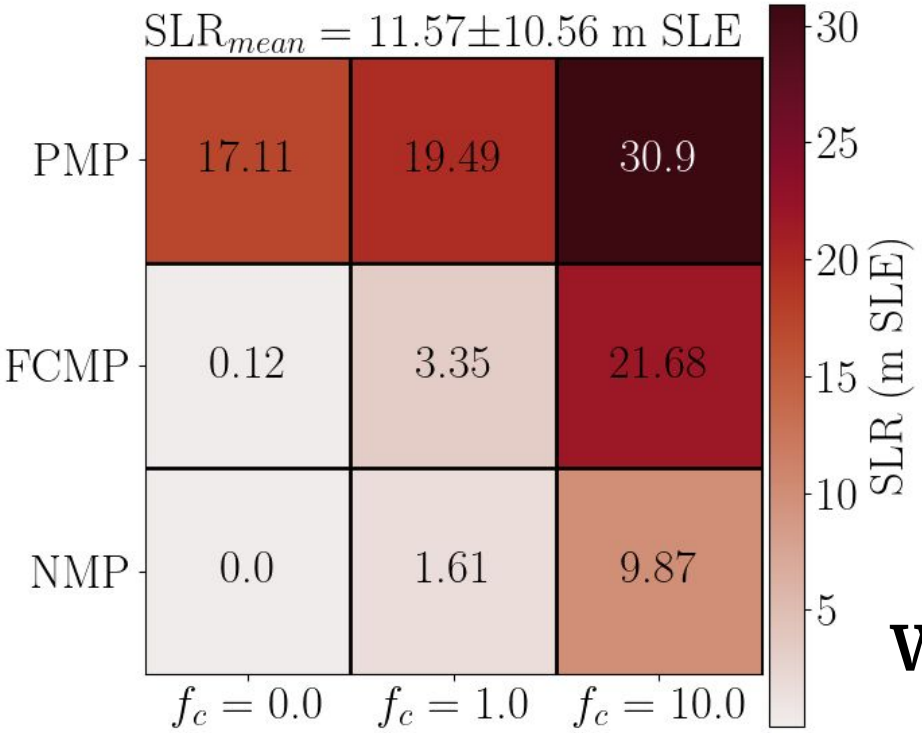
Retreat distribution



Debuttressing effect



Take home messages



- ➔ Melting at the
  - ◆ Grounding line
  - ◆ Ice-shelves front
- ➔ Great spread
- ➔ Sensitivity to methodology

Which combination is realistic?

Future work

Open questions

- ➔ Dependency on scenario?
- ➔ Model Geometry?
- ➔ Model Numerics?

Possible pathways

- ➔ Paleoclimatic constraints
- ➔ More comprehensive models
- ➔ Numerics and statistics

Thank you!

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