Antarctic-climate multi-millenia coupled simulations under different pCO_2 levels with the iLOVECLIM-GRISLI model

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ANDRA

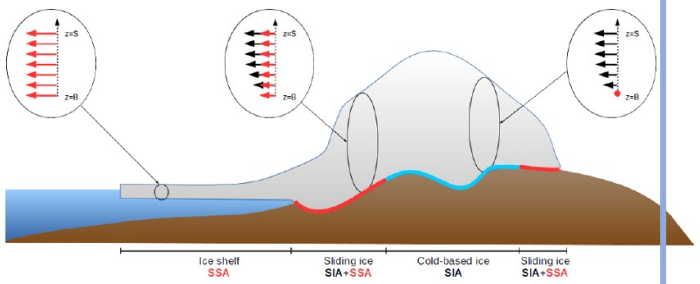
LSCE

iLOVECLIM climate model coupled to the GRISLI ice sheet model

GRISLI

→ Ice sheet model

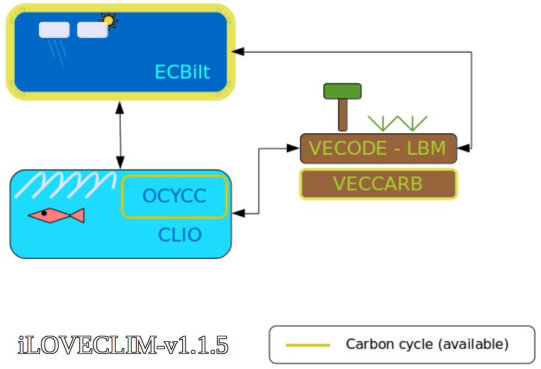
→ Shallow ice + shallow shelf approximation



iLOVECLIM

→ Climate model of intermediate complexity

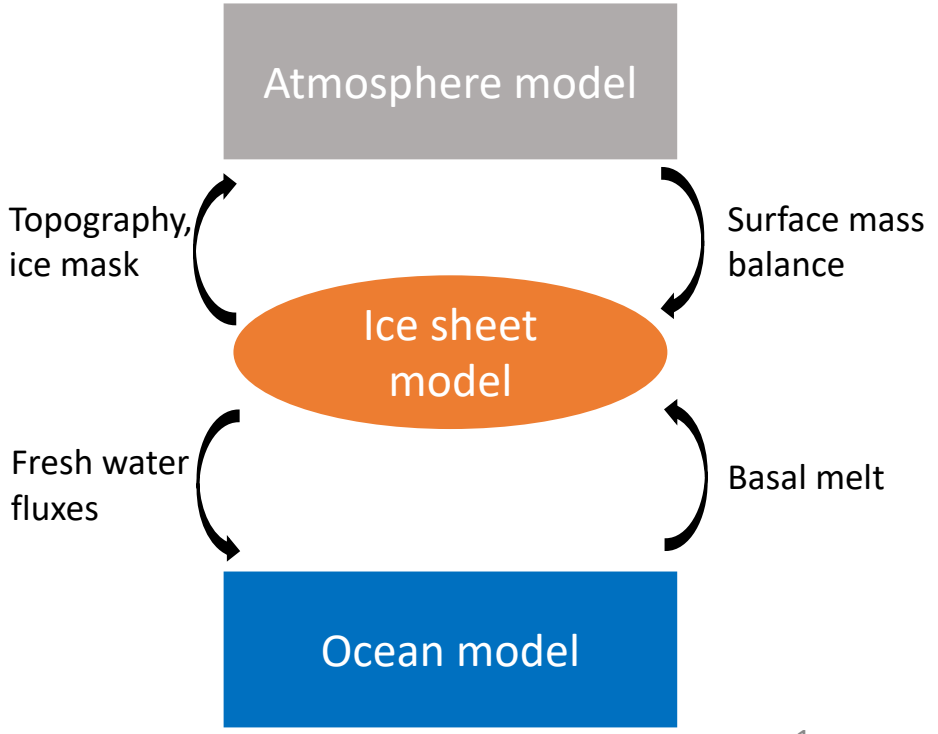
→ representation of the atmosphere, ocean and vegetation



iLOVECLIM – GRISLI coupled

→ Allows to take into account possible **feedbacks** between ice-sheet and the rest of the climate system

→ Possible to perform multi-millenial simulations



Reference Ice sheet for a coupled PI simulation

Goal : study the effect of **different pCO_2 levels** on the long term (multi millenial) on the Antarctic ice sheet, **starting from a pre-industrial configuration**

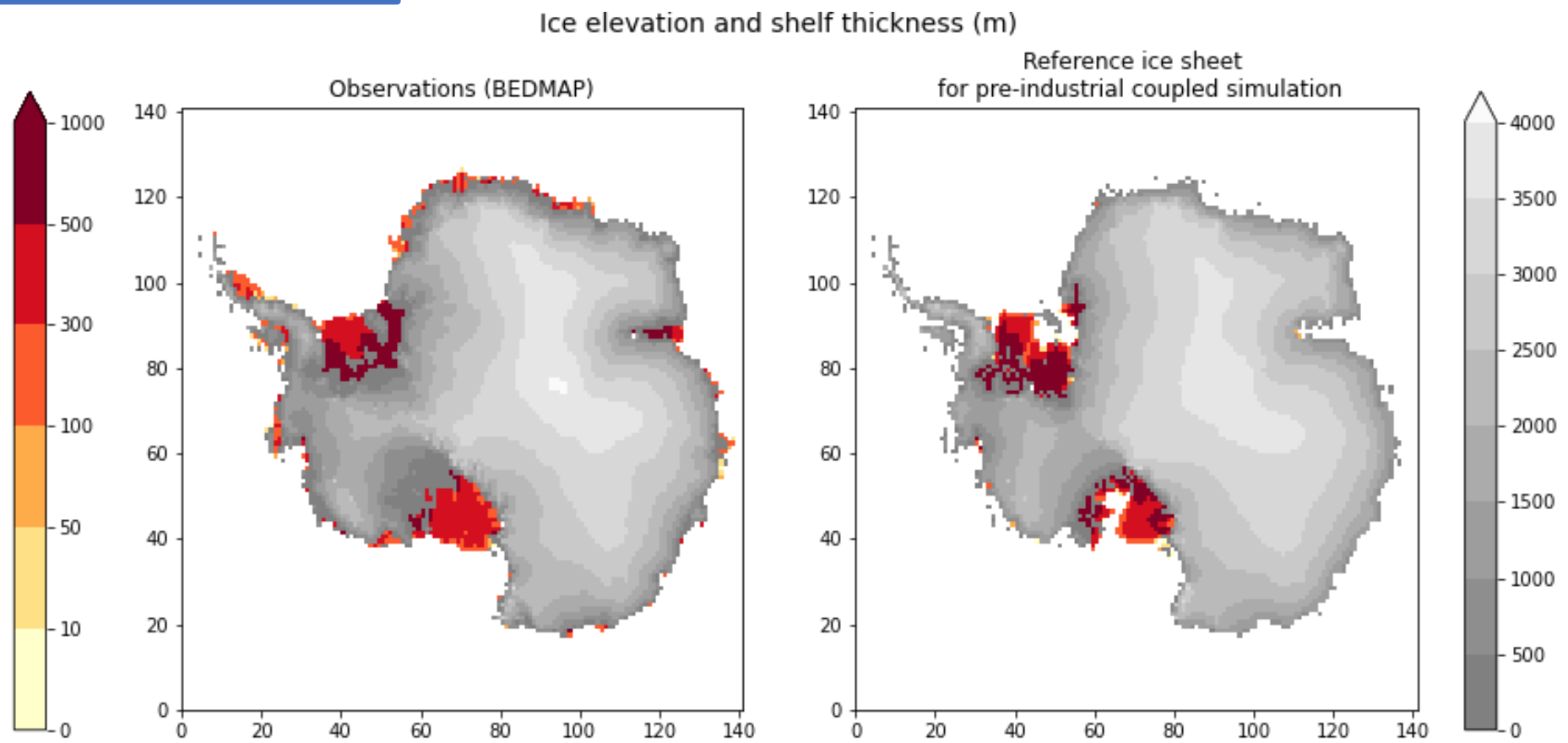
→ Reference pre-industrial ice sheet needed

PI ($1xCO_2$) CO_2 levels

Correction of the atmospheric and oceanic biaises of iLOVECLIM

Grounded part : overestimated
Shelves : underestimated

Reference ice sheet for coupled simulation
→ Starting point for simulations with different pCO_2 levels

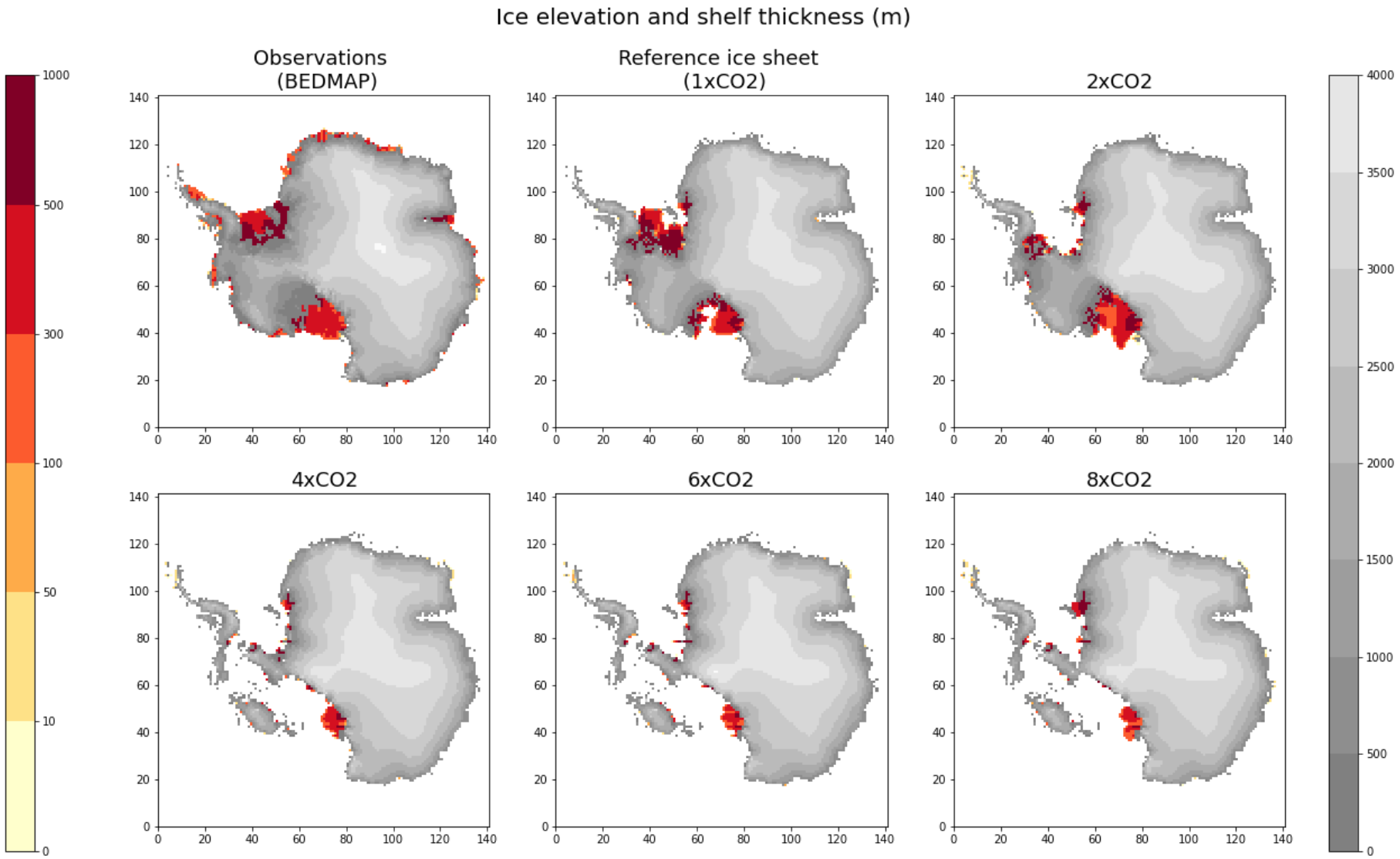


Simulations with different pCO_2 levels

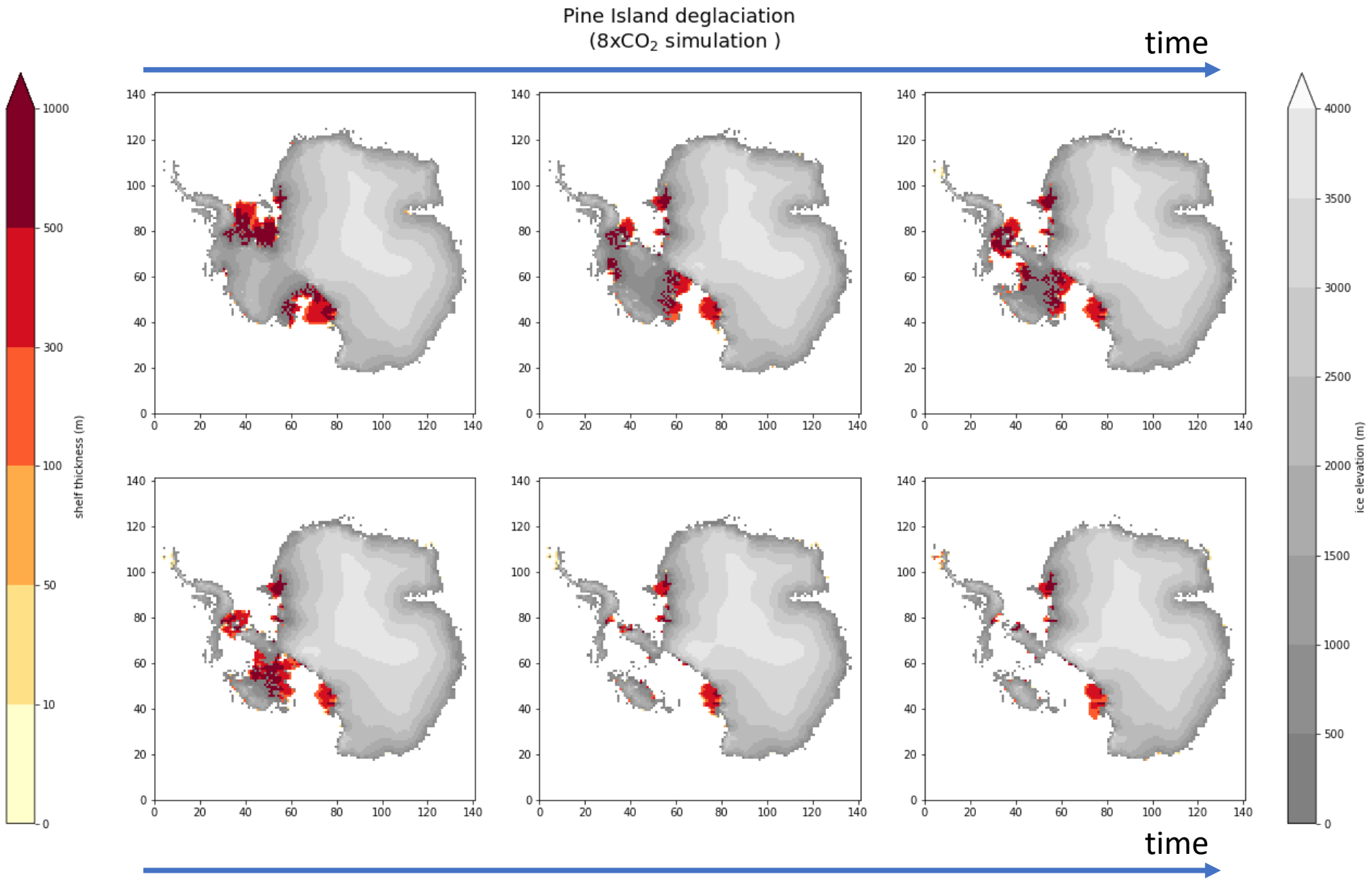
Different CO_2 levels are applied, starting from the reference ice sheet : $2xCO_2$, $4xCO_2$, $6xCO_2$, $8xCO_2$

$2xCO_2$: equilibrium not reached at the end of the simulation

$4xCO_2$, $6xCO_2$, $8xCO_2$ at equilibrium : almost no difference between $4xCO_2$ and $8xCO_2$ forcings



Time evolution ($8xCO_2$)



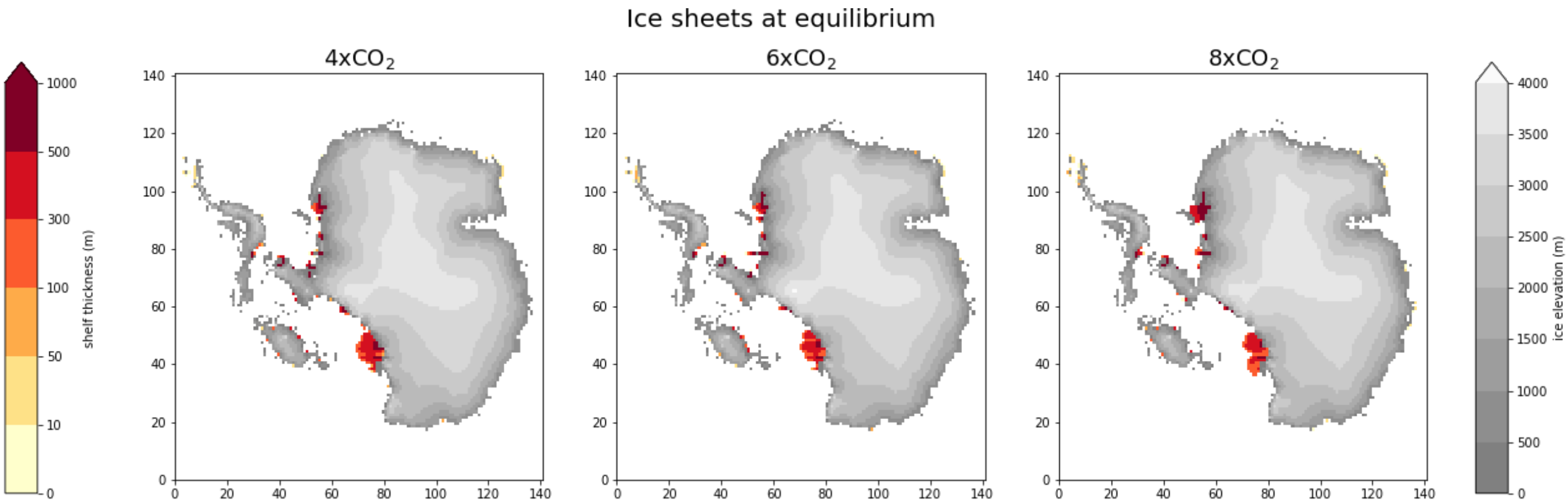
Retreat of West Antarctic Ice sheet via Pine Island

~3.3m SLR equivalent for forcings between $4xCO_2$ and $8xCO_2$

Very limited retreat of the East Antarctic Ice Sheet

Climate sensitivity of the iLOVECLIM model

Low climate sensitivity of the iLOVECLIM model : ~2K



ΔT_{global} = 3.1°C
ΔT_{Ant} = 8.6°C
ΔT_{ocean} = 0.9°C

ΔT_{global} = 3.8°C
ΔT_{Ant} = 10.6°C
ΔT_{ocean} = 1.3°C

ΔT_{global} = 4.2°C
ΔT_{Ant} = 11°C
ΔT_{ocean} = 1.5°C

Limitations and perspectives

Limitations

- **Low climate sensitivity** of the iLOVECLIM model : 8xCO_2 warming corresponds to 2xCO_2 in other models

→ Might explain why there is almost no retreat in East Antarctica

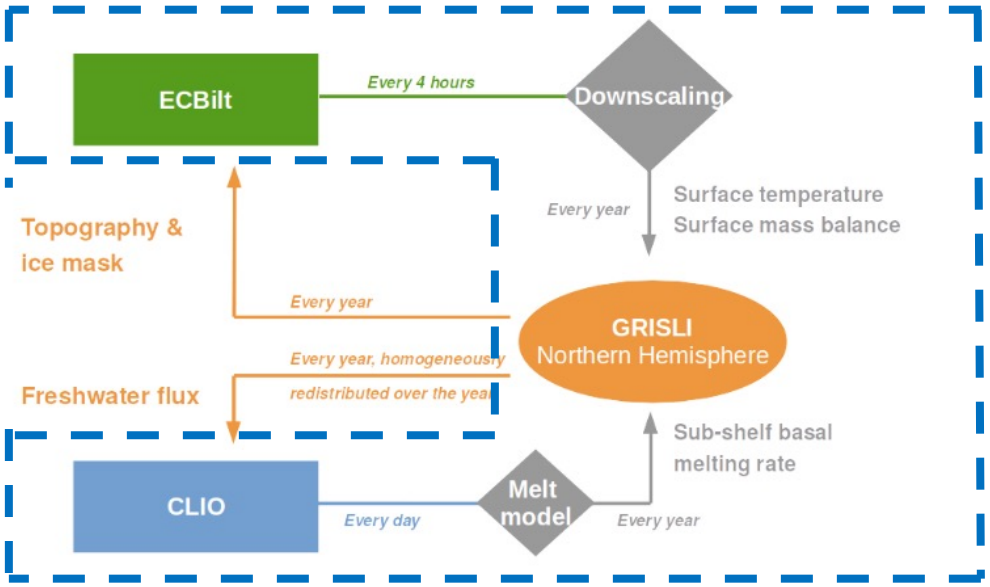
Perspectives

- Simulations with higher CO_2 levels and/or higher climate sensitivity
- Simulations starting without ice sheet to see the ice sheet build up

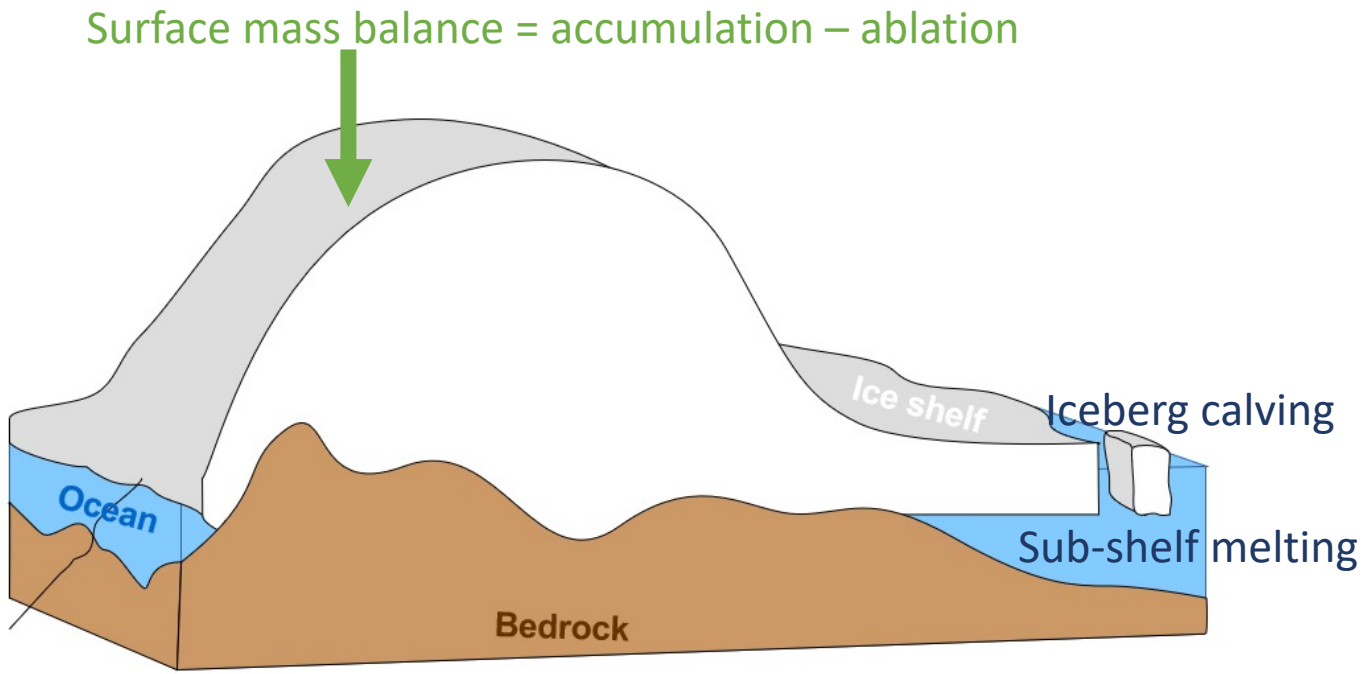
Thank you for your attention !

Climate ice sheet interactions in iLOVECLIM - GRISLI

Rest of the climate system to Ice sheet



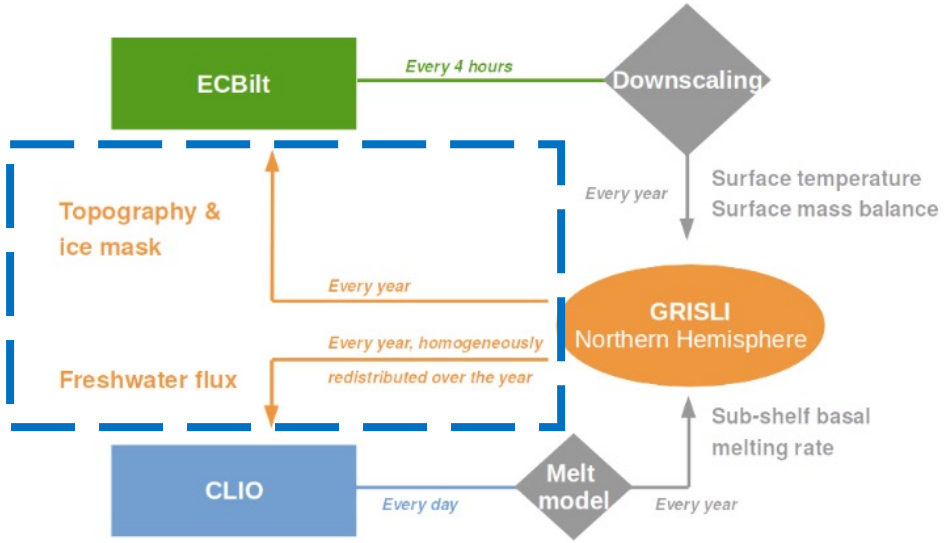
Quiquet et al 2021



For the atmosphere : downscaling procedure to have the fields at the ice sheet model resolution

Climate ice sheet interactions in iLOVECLIM - GRISLI

Ice sheet to rest of the climate system



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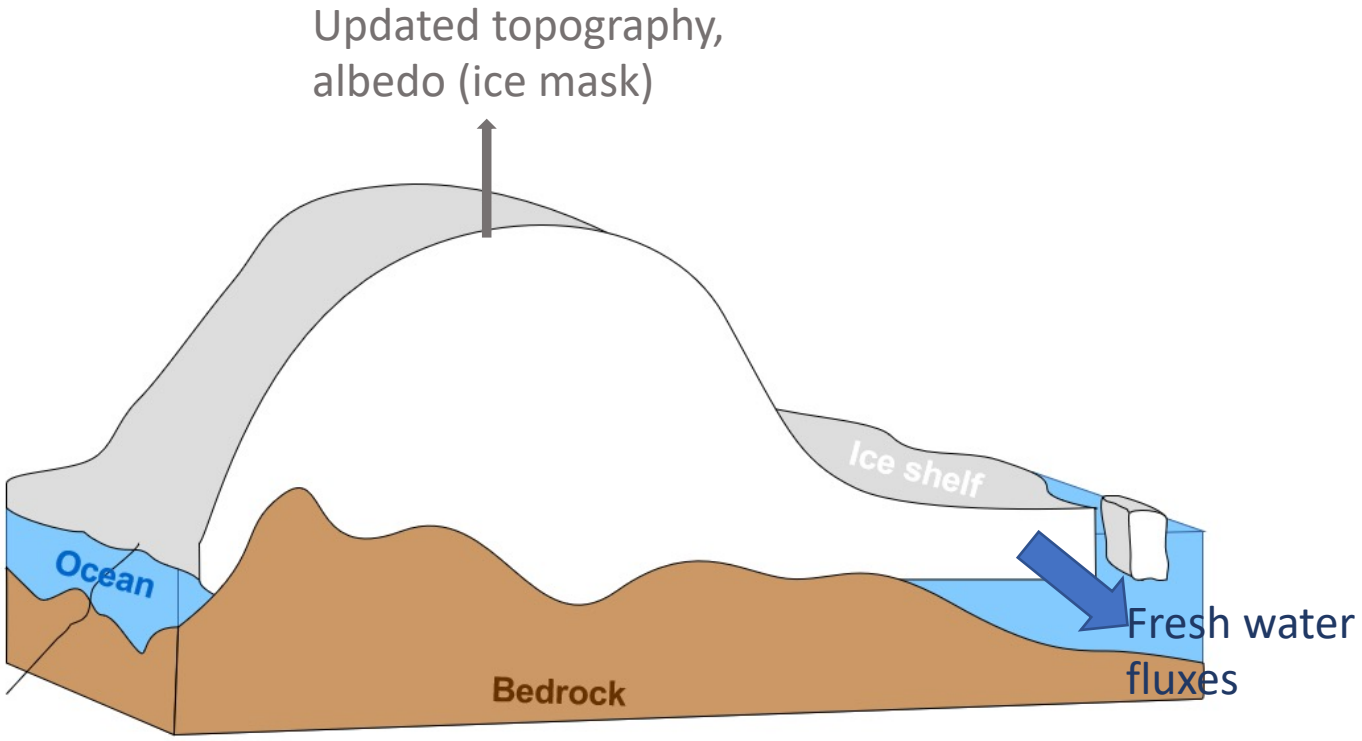
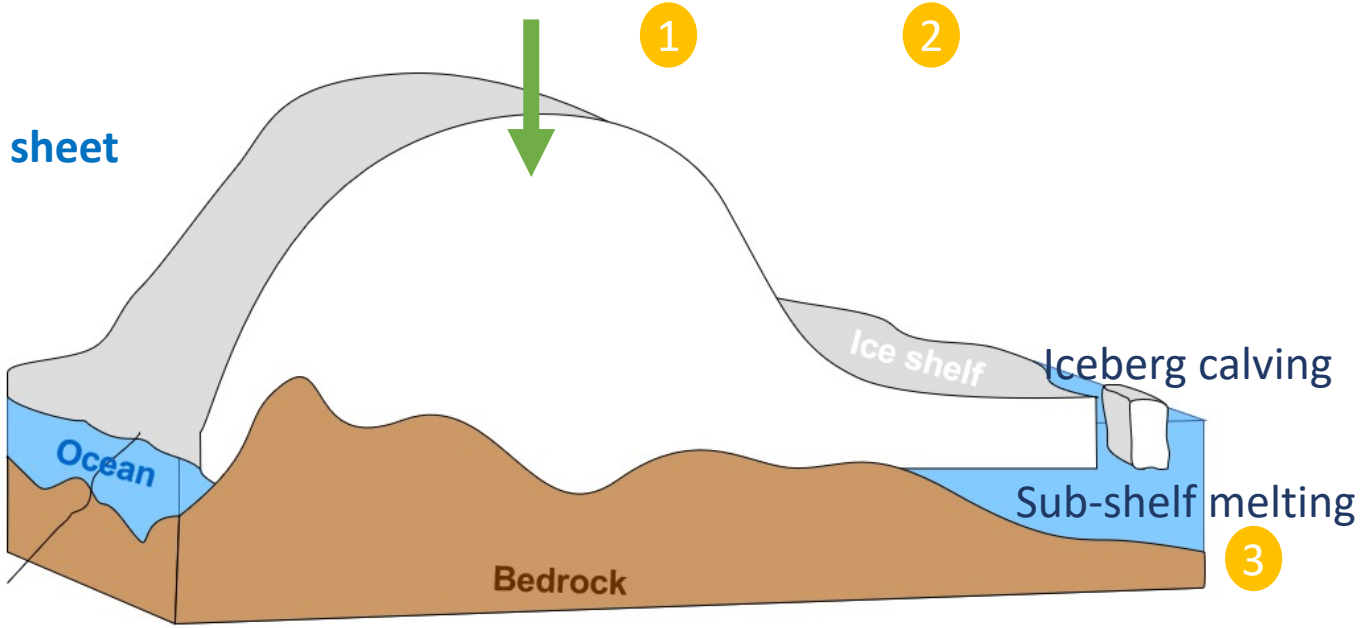


Climate ice sheet interactions in iLOVECLIM - GRISLI

Surface mass balance = accumulation – ablation

Rest of the climate system to Ice sheet



Surface mass balance

1. Accumulation = snow from iLOVECLIM → Depends on atmospheric conditions
2. Surface ablation = melt, parametrized with the Insolation Temperature Melt (ITM) method → Depends on SW flux and temperature
3. Sub shelf melting, proportional to thermal forcing → Depends on oceanic temperature and salinity

$$M_{\text{shelf}}(z) = \frac{\rho_w c_p \gamma_T F_g \text{TF}(z)}{\rho_i L_m}$$

Reference Ice sheet for a coupled PI simulation