# Impact of ice sheet – ocean interactions on the Southern Ocean using fully coupled models over a circumpolar domain

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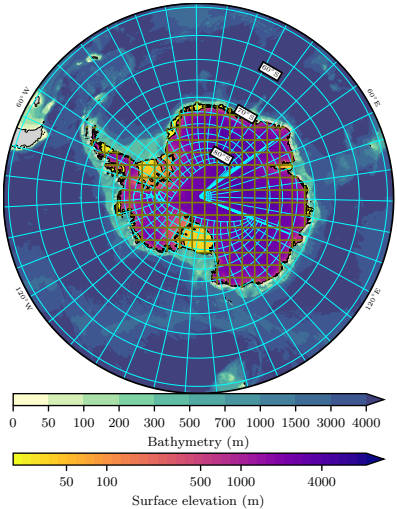
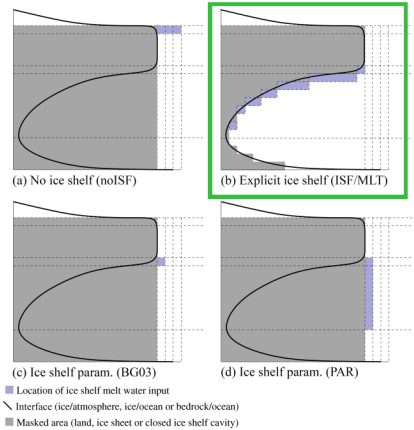
# Project description and model setup



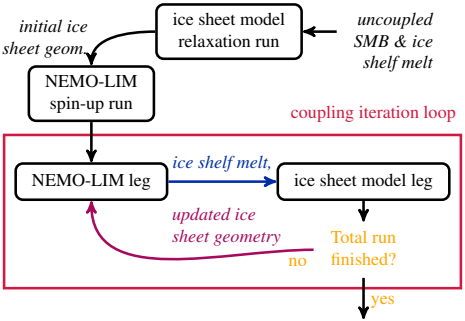

*Domain (cut at 50°S) bathymetry and surface elevation in initial state. Grid imprints: NEMO - blue, f.ETISh - green.*

- **PARAMOUR**: investigating **decadal predictability** in polar regions.
- **Southern circumpolar** configuration at $\approx 0.25°$.
- **Coupled** setup: NEMO3.6 (ocean), LIM3 (sea ice), f.ETISh (ice sheet).
- Includes **fully opened cavities** with melt param. through Jenkins (2010).
- NEMO sends **ice shelf melt rates**, f.ETISh sends **dynamical cavity geometry**.
- **Three 1980 - 2018 experiments** (no coupling, coupling at 1/4yr or 1y freq).
- **Ice sheet initialization** from atm. model melt rates and SMB.

# Interactive ice shelf cavities




*Ice shelf melt water injection strategy (our choice highlighted in green). Adapted from Mathiot* et al. (*GMD 2017*, )

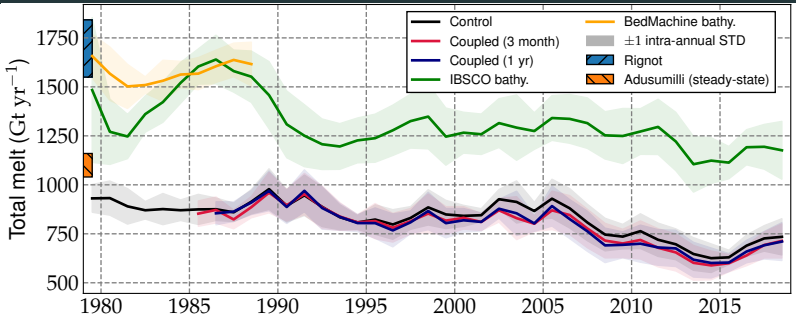



- Cavities **opened to circulation**: interactive melt rates computed from ice - ocean boundary layer **temperature**, **salinity** and **currents** (Jenkins *et al.* 2010).
- **Constraints** on NEMO-perceived cavity geometry (stability).
- Geometry updates: **nearest-neighbor** $T$ and $s$, **no** $\mathbf{u}_h$, **divergence correction** (Smith *et al.*, in prep).

# Impact of relaxed geometry

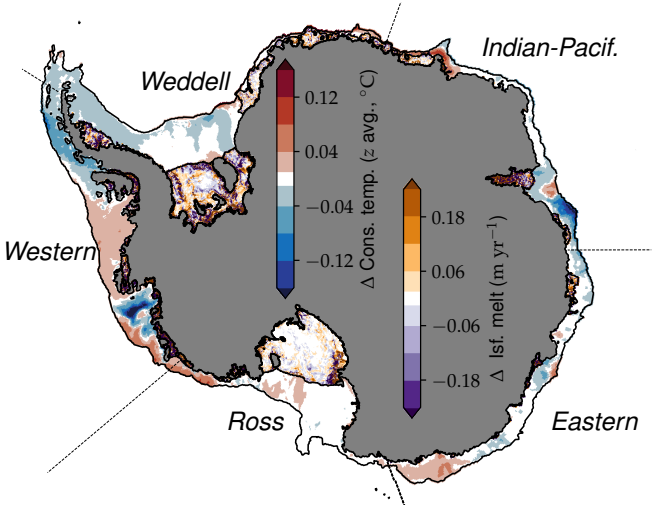
**Initial ice sheet geometry** plays a **crucial role** (at decadal time scales) on melt rates.

**Why ?**




- Geometry is a(n ice sheet) **model output**..
- ... derived from **modelled** SMB (COSMO) and uncoupled melt rates.
- Typical ice sheet **relaxation times** are much longer than 10yr.
- Bathymetry & draft $\Rightarrow \pm$ **warm water intrusion** $\Rightarrow \pm$ melt rates (especially in Western Antarctica).

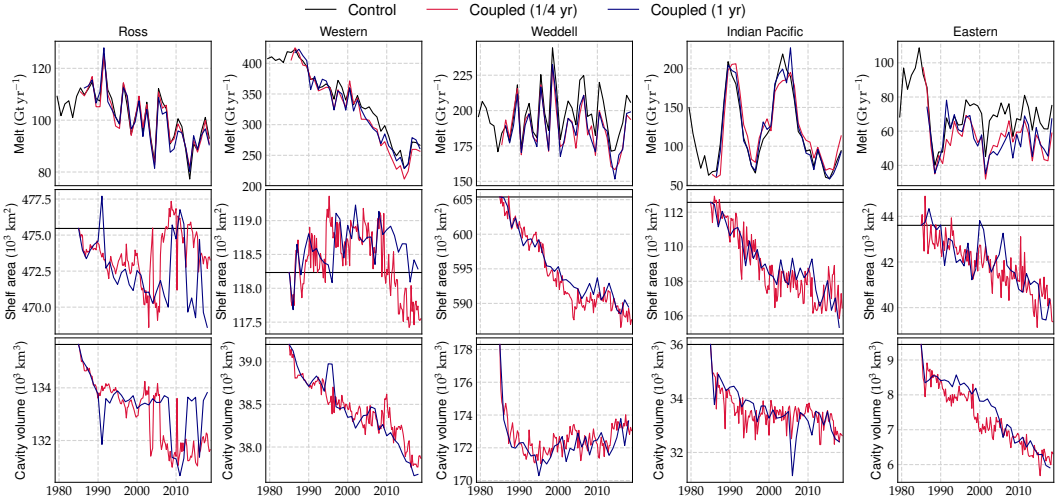
# Impact of coupling on melt rates



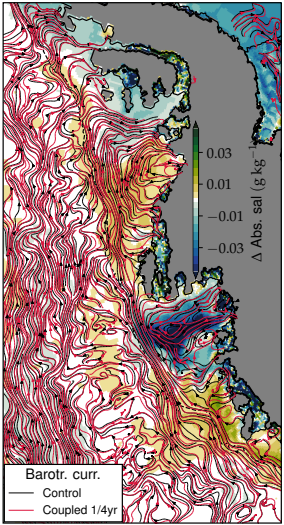

*1999-2018 averaged anomalies (Coupled 1/4yr - uncoupled) in ice-shelf melt rates and depth-averaged continental shelf temperatures*

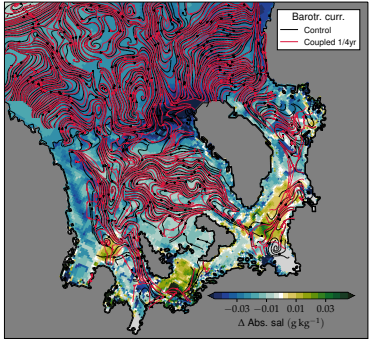
- Limited impact of coupling of melt rates and temperatures.
- Specific areas (e.g. Amundsen, Amery IS) feature stronger coupling signal.
- Impact on spatial melt patterns in large cavities (Ross, Ronne-Filchner), but not on total melt.

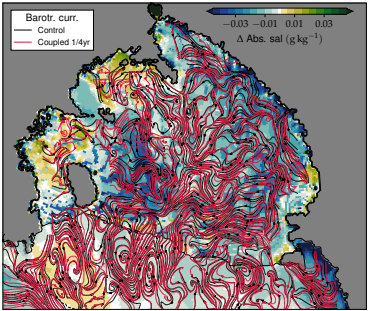
# Impact of coupling (frequency) of total melt and cavity geometry



# A closer look on specific areas




- **Salinity**: coupling has a limited impact, but melt patterns perceivable within largest cavities.
- Intra-cavity **circulation** affected by dynamical mesh, but not in the open-ocean (driven by surface stress).

*Anomalies (Coupled 1/4 yr - control) for absolute salinities over 1999 - 2018 and barotropic flow for Western, Ronne-Filchner and Ross sectors.*

# Take-home messages

- We have a **working coupled ice sheet - ocean setup** over a Southern circumpolar domain at 0.25°, including **explicitly resolved cavities**.
- In terms of melt rates, our setting is extremely sensible to the **initial ice sheet geometry**, which is thus crucial.
- While this tool probably does not allow a proprer representation of the intra-cavity circulation (due to resolution), it offers **insight on what to expect from including dynamical cavities within global climate models**.
- **Ongoing tasks**:
  1. **Fully coupled setup**, including COSMO as an atmosphere model.
  2. Transposing this ice sheet – ocean tool to a local configuration over the **Totten area** at 1/24° with NEMO-LIM and **BISICLES**.