A regional Southern Ocean configuration for investigating polar decadal predictability

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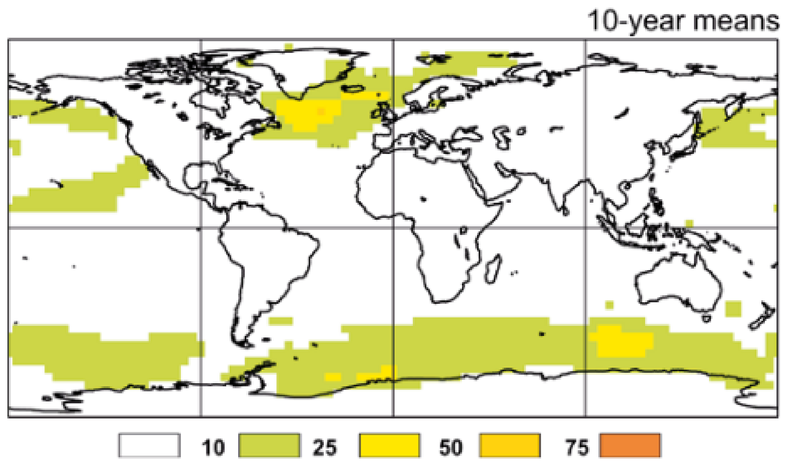
The Southern Ocean (SO) plays a key role in global ocean heat uptake and circulation. In recent years, the polar climate has rapidly evolved in a non-predicted way, which considerably uplifts challenges and constraints on mid and long term global climate predictions. While previous studies have shown that polar regions could withhold predictability on 1 – 10y time scales, further investigations are required for fully understanding the processes accounting to it. We aim at assessing decadal predictability in the Southern Ocean by using a five-component coupled configuration.

Motivations



Boer et et. (2004)

Geographical distribution of the potential predictability fraction for the SST on the 10-year time scale

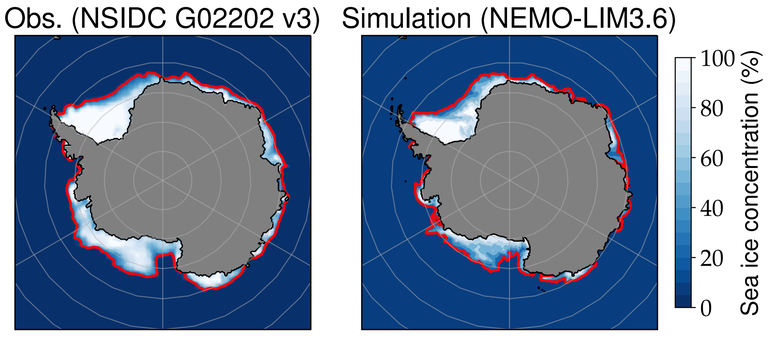
- Polar regions potentially holds significant **predictability** on seasonal to decadal timescales.
- Possibly due to **slower climate components** (e.g., ice sheets) and their interactions with the ocean and atmosphere.
- GCMs typically run at **too coarse resolutions**, and do not include **comprehensive enough coupling mechanisms**.
- In these areas, **measurement-induced constraints** on model are **sparse**.

Establishing cutting-edge coupled configurations is necessary for gaining insight on polar predictability.

Ocean & sea ice model: NEMO-LIM 3.6

- **Energy and mass conservative** numerical schemes.
- Sub-grid-scale sea ice thickness **distribution** and **salinity processes**.
- Custom ice parameterizations for **melt ponds** and **blowing snow**.
- Large **community**.

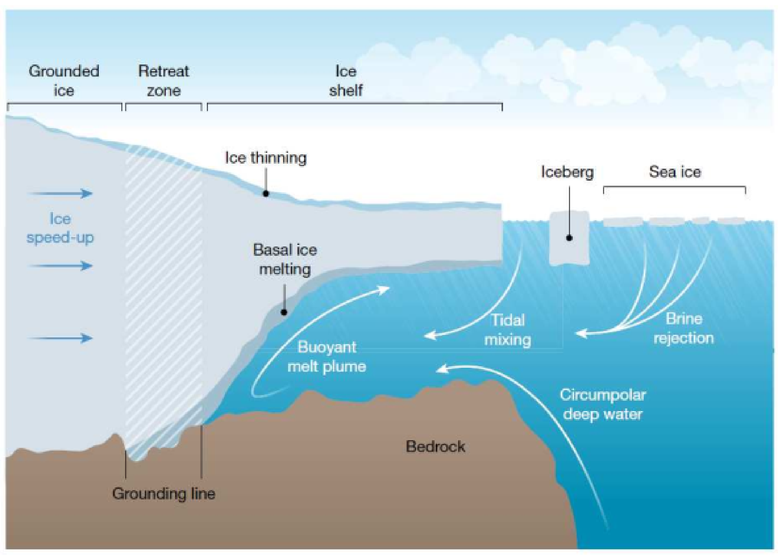
Obs. (NSIDC G02202 v3) Simulation (NEMO-LIM3.6)



Observations and simulated sea ice concentrations and extents in autumn (March 2000).

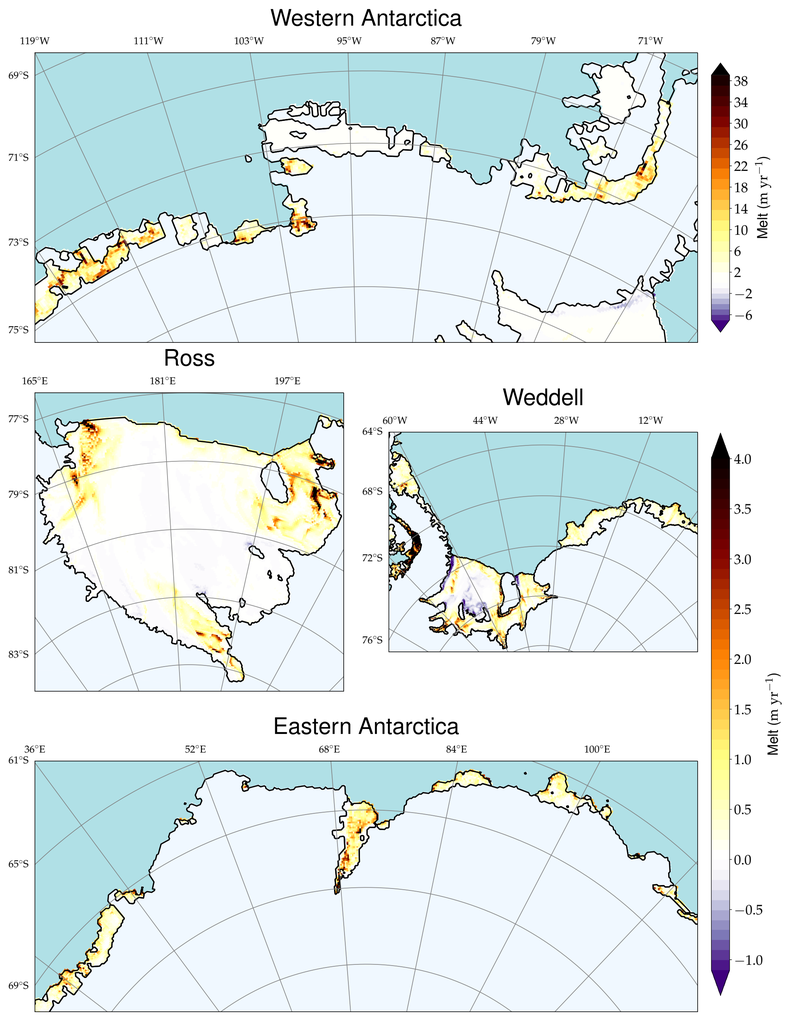
Marine ice shelf representation

Marine ice sheet (MIS) melting is a major **freshwater source** in the SO.



Shepherd et al. (2018)

Process: melt due to **warm circumpolar water upwelling** towards the Antarctic continental shelf.
Modelling: **represent ocean ice shelf cavity** circulation and subsequently compute ocean state dependent melt rates.

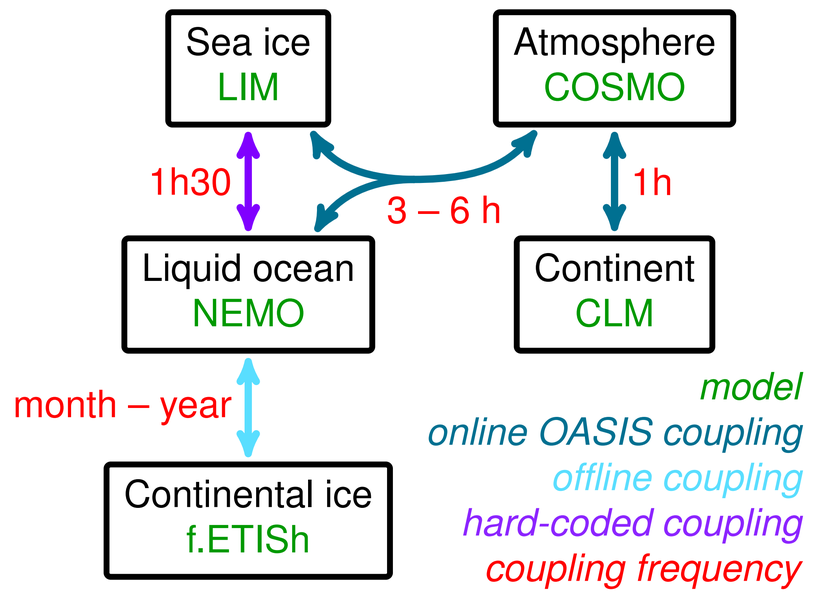


Simulated 2004 - 2018 average ice shelf melt rate.

- Mathiot, P. et al. (2017). Explicit representation and parametrised impacts of under ice shelf seas in the z^* coordinate ocean model NEMO 3.6. *Geosci. Model Dev.*
- Pattyn, F. (2017). Sea-level response to melting of Antarctic ice shelves on multi-centennial timescales with the fast Elementary Thermomechanical Ice Sheet model (f.ETISh v1.0). *Cryosphere.*
- Rousset, C. et al. (2015). The Louvain-La-Neuve sea ice model LIM3.6: global and regional capabilities. *Geosci. Model Dev.*
- Souverijns, N. et al. (2019). A New Regional Climate Model for POLAR-CORDEX: Evaluation of a 30-Year Hindcast with COSMO-CLM2 Over Antarctica. *J Geophys Res Atmos.*

Coupling implementation

Five subcomponents, four coupling mechanisms.



COSMO ↔ NEMO-LIM3.6

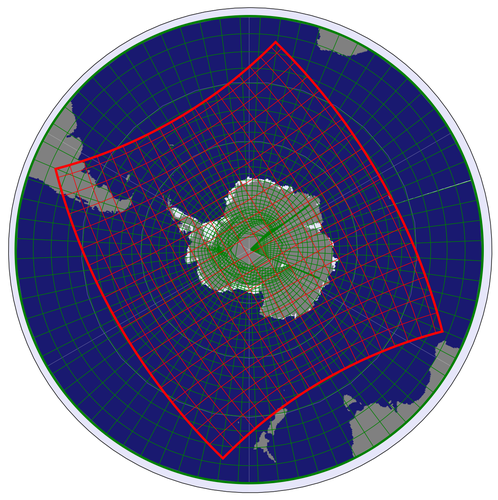
- **COSMO** computes air-sea turbulent fluxes (TKE surface-layer scheme).
- COSMO computing **real-time fluxes**; NEMO receiving 3 – 6h **delayed** ones.
- Flux **tile distribution** over land, ocean and sea ice categories.

NEMO-LIM3.6 ↔ f.ETISH

- NEMO sends the **melt rate** to f.ETISh.
- f.ETISh provides NEMO an updated **cavity geometry**.

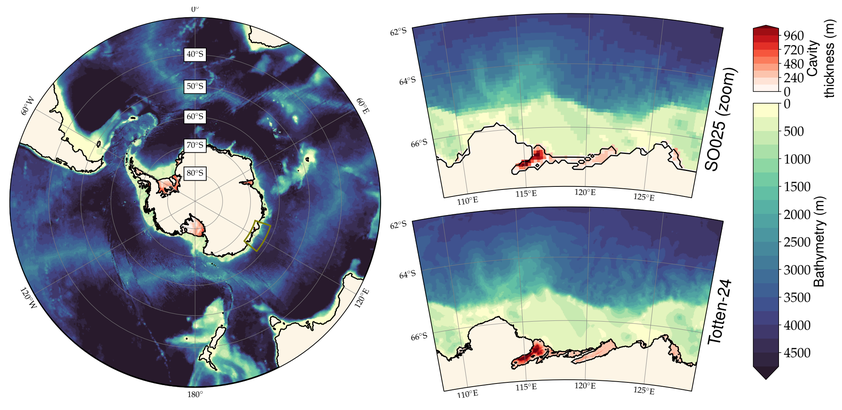
Ocean configuration specifications

- eORCA025 grid (1/4°, 75 levels) cut at 30° S ;
- 15min time step;
- z^*-ISF coordinate;
- GO7 (UK Met. Off.) based climatology;
- ORAS5 reanalyses on lateral boundaries;
- ERA5 reanalysis on non-overlapping area;
- BedMachine2 & ETOPO1 bathymetry.



COSMO and NEMO grids (resp. red and green, boundaries in bold); 1 out of 20 cells represented.

\+ Nested configuration: **Totten glacier** at 1/24°.



Both configurations' bathymetric datasets.

Emphasis on smaller-scale processes (e.g. **land-fastened sea ice**).

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