A coupled ice sheet – ice shelf – ocean model with an explicit representation of a variable Filchner-Ronne Ice Shelf (FRIS) cavity has been developed, based on a global implementation of the Finite Element Sea Ice Ocean Model (FESOM) and a regional setup of the Parallel Ice Sheet Model (PISM). At the base of the FRIS, melt rates and boundary layer temperatures from FESOM are applied. PISM returns ice thickness, ice temperatures and the position of the grounding line. Building on the Timmermann & Goeller (2017) infrastructure, we run FESOM with a hybrid vertical coordinate and a horizontal mesh that adjusts to the varying cavity geometry. The ice sheet model uses a horizontal grid with 1 km resolution for an appropriate representation of grounding line processes. Enhancement factors for the approximation of the stress balance become obsolete at such high resolution. Ice stream flow is well captured by polythermal coupling of the ice flow and a Mohr-Coulomb yield stress criterion that accounts for properties of the till material and the effective pressure on the saturated till. We present results from model runs with a 20th-century climate forcing and projections until the end of the 22nd century.

**Overview**

**FESOM**

- **Finite element Sea ice – ice shelf – ocean model**
- **Domain**: global
- **Horizontal resolution**: 1.9 – 250 km
- **Dynamic-thermodynamic sea ice model**: 3-equation model of ice shelf-ocean interaction
- **Projections**: atmospheric forcing from HadCM3 for IPCC scenario A1B

**PISM**

- **Parallel Ice Sheet Model**
- **Domain**: pan-Antarctic
- **Horizontal resolution**: 1 km
- **Vertical resolution**: 401 sigma layers (3 m at base)
- **Ice dynamics**: SIA-SSA hybrid
- **New BedMachine geometry, 900 yr spin-up**
- **Enhancement factors** for the approximation of the stress balance become obsolete at such high resolution
- **Coupling**: ice shelf thickness and grounding line position from PISM
- **Coupling**: ice shelf basal melt rates and boundary layer temperatures from FESOM

**Experiments:**

1. **FESOM-PISM 20C/A1B**: 1950-2200 (“A1B coupled projection”)
2. **FESOM 20C/A1B**: 1950-2200 (“A1B fixed-geometry”)
3. **FESOM-PISM 20C2**: 2000-2200 present-day CTRL, with 20th-century forcing repeated
4. **FESOM 20C2**: 2000-2200 present-day CTRL, with 20th-century forcing repeated

**The next generation:**

We are about to launch a suite of simulations with an enhanced enthalpy coupling. In these experiments, PISM will also provide the varying temperature within the ice to the computation of the heat flux between the ice-shelf boundary layer and the interior ice in the 3-equation system describing ice shelf-ocean interaction. Next to the A1B sensitivity experiments forced with HadCM3/RACMO-A1B data, we will also produce coupling scenarios for the SSPS-8.5 scenario forced with atmosphere data from CESM2/RACMO-2.3. A pan-Antarctic version of the model will be implemented in the TiPACCs project.

**Summary**

- **Coupling of FESOM and high-resolution PISM works efficiently and can be expanded to pan-Antarctic Ice Sheet simulations.**
- **Coupled simulation for the A1B scenario suggests a contribution of 27 mm to sea level rise from the FRIS catchment area until 2165 (not shown here).**
- **Simulations with enhanced enthalpy coupling with and without CESM2/RACMO-2.3 forcing for SSPS-8.5 are under way.**

**References**

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