Project: **1347**
Project title: **RESCUE: Ice sheet simulations representing Greenland and Antarctica**
Principal investigator: **Christian Rodehacke**
Report period: **2022-11-01 to 2023-10-31**

The project RESCUE ("Ice sheet simulations representing Greenland and Antarctica," ba1347) contributes to the European project of the same name, where AWI performs ice sheet simulations with the Parallel Ice Sheet Model (PISM) representing Antarctica. The balance between ice mass gain and loss controls the evolution of an ice sheet. Snow accumulation across Antarctic increases the ice mass, while losses occur via basal melting in floating ice selves cavities and calving of icebergs along Antarctica's margins.

The project RESCUE has suffered from a workforce shortage since the start of the project. As initially planned, I have not been able to work as much as anticipated because, in a neighboring project, former colleagues have left academia, which forced me to work less on RESCUE and more on other time-critical tasks, while funding to hire is not sufficient. In addition, our Danish collaborators have found a severe problem with iceberg calving (Issues 521). All these circumstances have forced us to pause our work. Therefore, we have been able to reduce the workload on Levante during the energy crises last year, as requested.

Despite the described workforce shortage, we have started to perform studies to detect the influence of temporal variable forcing on former low-resolution spin-up states. As part of this effort, we could verify the errors reported by our Danish colleagues. In addition, we have detected further issues, although the abovementioned issue has been fixed. As part of this work, we will apply temporal varying atmosphere and ocean forcing provided by RESCUE collaborators in the future. Therefore, we use a former initial state and apply temporal evolving atmosphere and ocean forcing at the initial resolution of 16km. However, we could verify that a higher resolution is needed to resolve sufficiently ice streams through gaps in the Transantarctic Mountain Range (TAMR, Figure 1). The poorly represented ice streams at 16km prevent the recovery of opened holes in ice shelves once temporal forcing is applied.

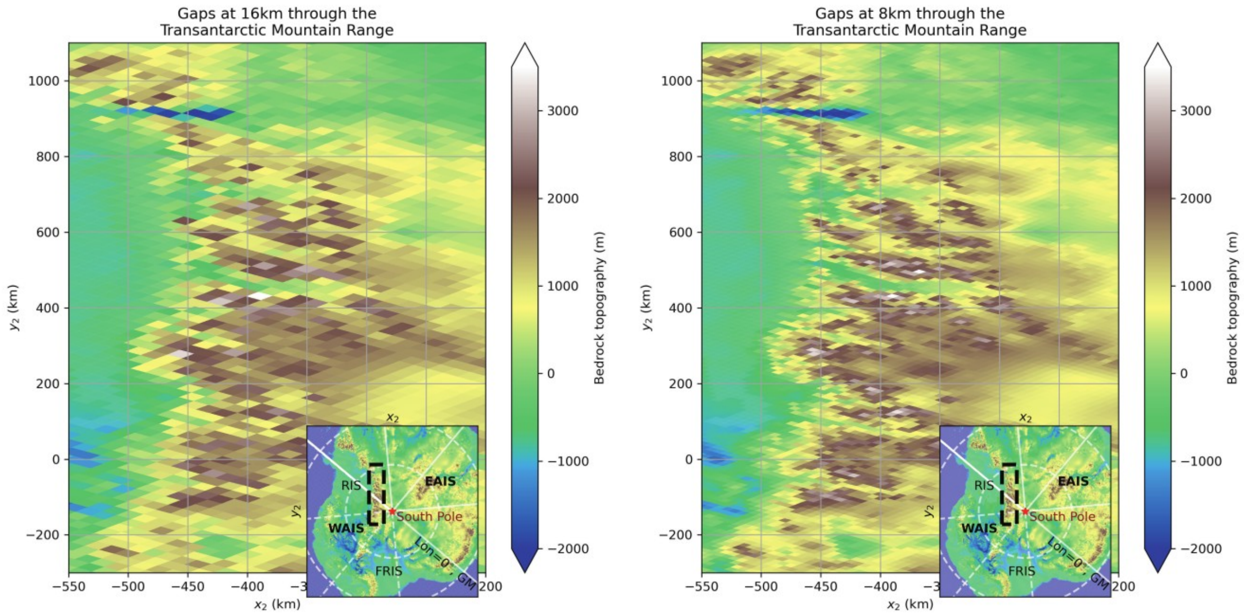

Figure 1: Bedrock topography at 16 km (left) and 8 km (right) along the Transantarctic Mountain Range (lower left figure for location). EAIS: East Antarctic Ice Sheet; WAIS: West Antarctic Ice Sheet; FRIS: Filchner-Ronne Ice Sheet, RIS: Ross Ice Sheet

Therefore, we rebuilt for a test case a setup with a higher resolution of 8km, which led to more vibrant ice streams across the TAMR. To avoid ice shelves extending until the domain edges, we mask an area where iceberg calving is enforced. The masked area covers the abyssal sea because ice shelves generally do not occur there. The mask follows the current continental shelf break (approx. 1500 depth contour line). This mask has worked well and led to adequate results of the ice sheet and ice shelf extents in setups before all the issues described above have been fixed.

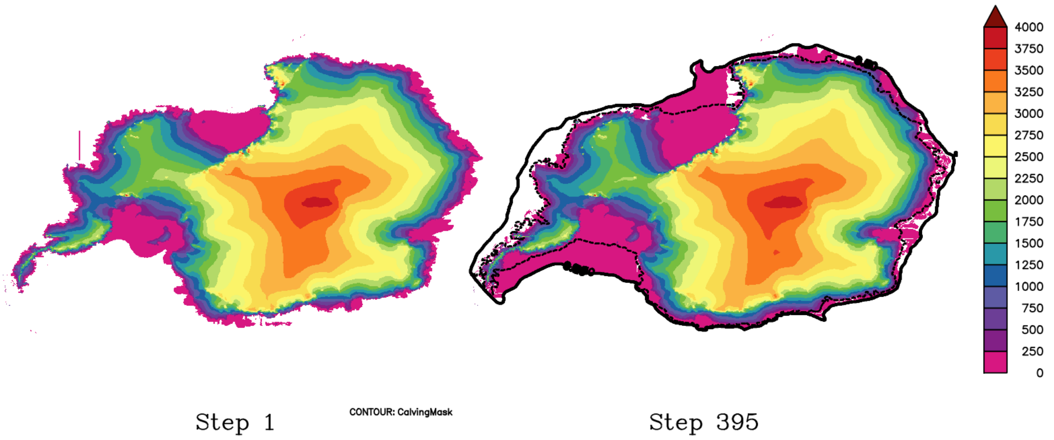

Figure 2: Ice sheet thickness (meter); Simulations starting from the left conditions for 3950 year (1 step = 10 years) with a wide enforced calving mask (thick black line). Dashed black line follows the contemporary extent.

An additional iceberg calving-related issue surfaces once we apply temporal varying atmosphere and ocean forcing and explore the above-described wide mask enforcing ice shelf calving. Under these circumstances, the continental shelf in the southern Weddell Sea is unrealistically filled with floating ice shelves (Figure 2).

Therefore, we performed additional simulations, where the mask follows the contemporary outer ice extent. Under those conditions, we lose the Ross Ice Shelf after some hundred years altogether, while the grounding line of the former Ross Ice Shelf retreats unbraked. Ultimately, the West Antarctic Ice Sheet disintegrates (Figure 3), which is unexpected and unwanted for temporal evolving forcing under otherwise unchanged conditions.

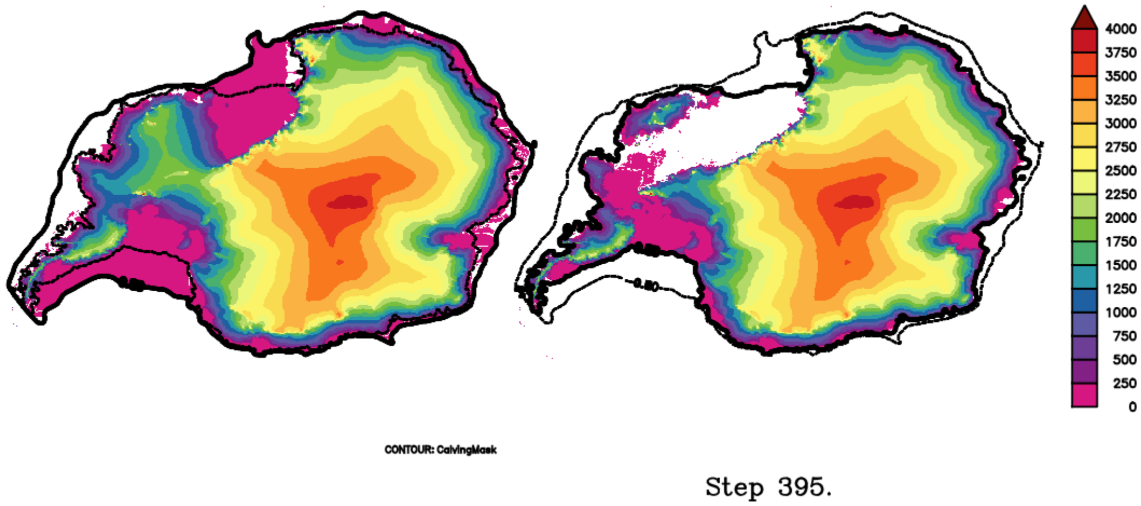

Figure 3: Simulations for 3950 years (1 step = 10 years) for an wide enforced calving mask (left) and narrow calving mask (right). In each subplot the thick black line follows the applied forcing mask, while the thin dash line is the other mask for comparision.

Most recent efforts go to find the right balance of the mask, leading to not too-unrealistic ice shelf geometries while still allowing for a high degree of freedom in the computation of the ice shelf extension.