The cold Antarctic freshwater sources

by

Hartmut H. Hellmer

In February 1841 the Antarctic explorer, *James Clark Ross* (1800-1862), encountered on his search for the south magnetic pole what he named Victoria Barrier, today's Ross Ice Shelf. Demotivated by its size he wrote: „We might with equal chance of success try to sail through the cliffs of Dover, as to penetrate such a mass (of ice)". He did not know that one of the biggest melting Antarctic „refrigerators“ with a cavern volume of ca. 100 000 km^3 was blocking his way to the south. Like today, this ice shelf certainly modified continental shelf waters to contribute significantly to the formation of deep and bottom waters and the ventilation of the global abyss. Ice shelf melting is roughly balanced by the steady flow of ice from the Antarctic ice sheet.

The central mechanism controlling the complex cavern processes is called the „ice pump“. Due to its inaccessibility, researches are forced to use numerical models to study the sensitivity and natural variability of the sub-ice shelf environment. At the Alfred Wegener Institute we use a coupled ice-ocean model with a circumpolar resolution high enough to resolve major Antarctic ice shelves (Fig. 1). Model results show that the freshwater flux on the continental shelf due to melting at deep ice shelf bases amounts to 28 mSv (1 mSv = $1x10^3$ m^3 s^{-1}). This is a huge value considering that most freshwater from iceberg melting (70 mSv) is released to the ocean away from the continent within the Antarctic Circumpolar Current.

The importance of the freshwater from the caverns is documented by comparing the results of two contrasting model configurations, *with* and *without* ice shelf caverns. A discontinuation of the freshwater causes a thinning of the ice cover for most of the continental shelf combined with a salinization of its water masses (Fig. 1) and an increase in dense water transport to the north which enhances the ventilation of the global abyss. These consequences are related to the brine released during sea ice formation which destabalizes the weakly stratified water column causing deep convection. The latter transports cold surface waters to great depth forming dense shelf waters and warm deep waters to the surface thinning the sea ice.

Cavern processes influence the Southern Ocean deep water export and, therefore, are of global importance. Today both hemispheres host deep water sources of equal strength. However, small disturbances in the freshwater fluxes due to changes in Antarctica's ice shelf configuration might shake this balance with global consequences.

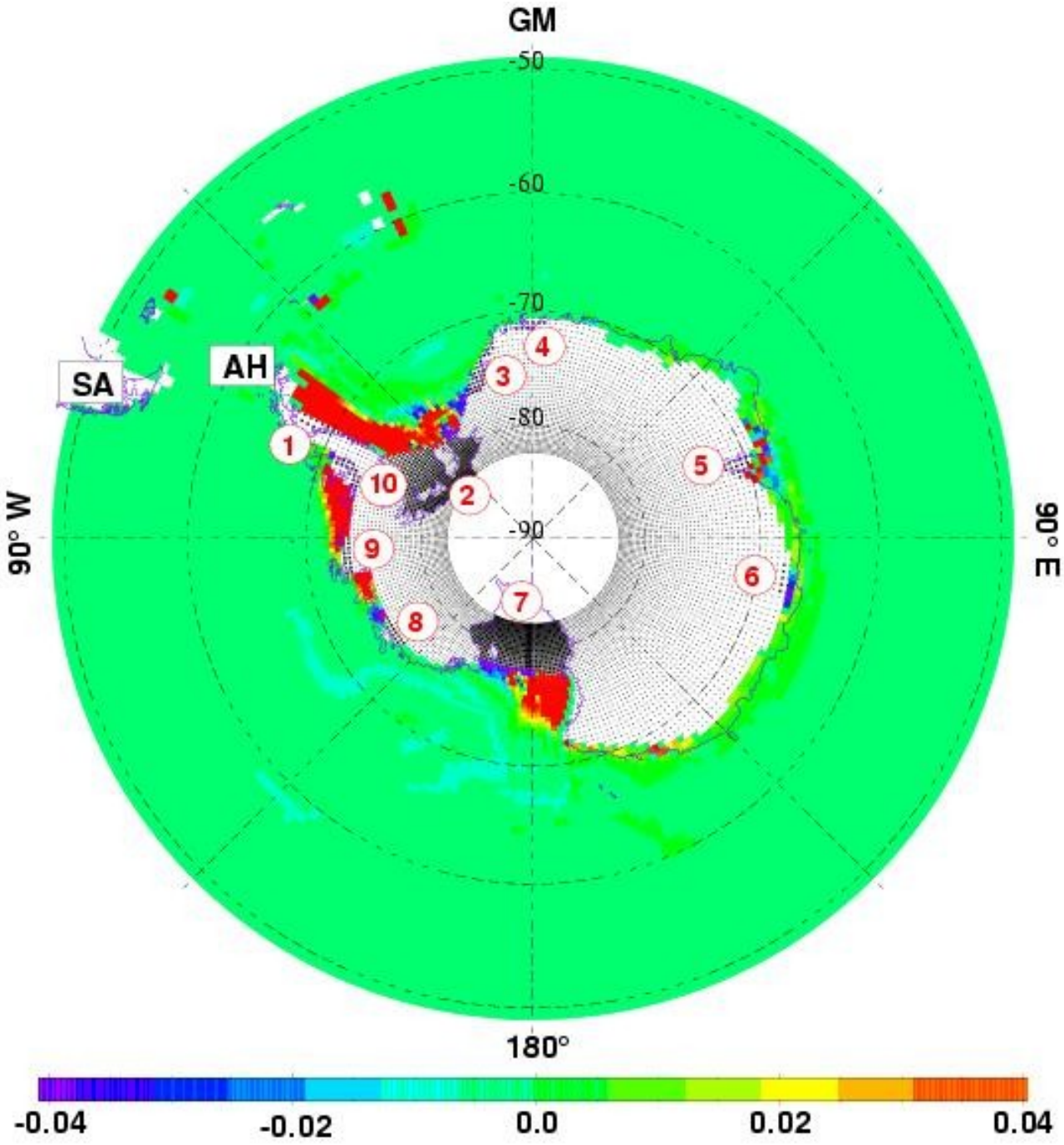

Figure 1: Salinity difference in the bottom layer of the Southern Ocean for September of the 20th model year between configurations *without* minus *with* ice shelf caverns. Circled numbers mark the location of the ice shelves considered in the model: 1-Larsen, 2-Filchner-Ronne, 3-Eastern Weddell Sea, 4-Fimbulisen, 5-Amery, 6-Shackelton, 7-Ross, 8-Getz, 9-Abbot, 10-George VI. SA-South Amerika, AH-Antarctic Peninsula.