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How does the Southern Annular Mode impact ice-shelf basal melt around Antarctica?

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The climate of the polar regions is characterized by large fluctuations and has experienced dramatic changes over the past decades. In particular, the patterns of changes in sea ice and ice sheet mass are complex in the Southern Hemisphere. The Antarctic Ice Sheet has also lost mass in the past decades, especially in Western Antarctica, with a spectacular thinning and weakening of ice shelves, i.e., the floating extensions of the grounded ice sheet. Despite recent advances in observing and modelling the Antarctic climate, the mechanisms behind this long-term mass loss remain poorly understood because of the limited amount of observations and the large biases of climate models in polar regions, in concert with the large internal variability prevailing in the Antarctic. Among all the processes involved in the mass variability, changes in the general atmospheric circulation of the Southern Hemisphere may have played a substantial role. One of the most important atmospheric modes of climate variability in the Southern Ocean is the Southern Annular Mode (SAM), which represents the position and the strength of the westerly winds. During years with a positive SAM index, lower sea level pressure at high latitudes and higher sea level pressure at low latitudes occur, resulting in a stronger pressure gradient and intensified Westerlies. However, the current knowledge of the impact of these fluctuations of the Westerlies on the Antarctic cryosphere is still limited. Over the past few years, some efforts investigated the impact of the SAM on the Antarctic sea ice and the surface mass balance of the ice sheet from an atmosphere-only perspective. Recently, a few oceanic studies have focused on the local impact of SAM-related fluctuations on the ice-shelf basal melt in specific regions of Antarctica, particularly Western Antarctica. However, to our knowledge, there is no such study at the scale of the whole Antarctic continent. In this study, we performed idealized experiments with a pan-Antarctic regional ice-shelf cavity-resolving ocean - sea-ice model for different phases of the SAM. We show that positive (negative) phases lead to increased (decreased) upwelling and subsurface ocean temperature and salinity close to ice shelves. A one-standard-deviation increase of the SAM leads to a net basal mass loss of 40 Gt yr^{-1}, with strong regional contrasts: increased melt in the Western Pacific and Amundsen-Bellingshausen sectors and the opposite response in the Ross sector. Taking these as a baseline sensitivity, we estimate last millennium and

end-of-21st-century ice-shelf basal melt changes due to SAM of -60.7 Gt yr^{-1} and 1.8 to 26.8 Gt yr^{-1} (depending on the emission scenario considered), respectively, compared to the present.