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Glacial sea-ice control of Southern Ocean CO_2 leak

Axel Timmermann (1), Karl Stein (1), and Tobias Friedrich (2)

(1) IBS Center for Climate Physics, Pusan National University, Busan, Korea, Republic Of (timmermann@pusan.ac.kr), (2) Department of Oceanography, University of Hawaii, Honolulu, USA

It is widely recognized that the Southern ocean played a key role in the exchange of carbon between ocean and atmosphere on orbital timescales. To explain why glacial/interglacial CO_2 changes were linked to astronomically-induced changes in incoming solar radiation, it is necessary to understand the Southern Ocean response to orbital-scale forcings and the associated amplifying feedbacks. We use a transient earth system model simulation covering the past eight glacial cycles to elucidate the interplay between glacial forcings , sea-ice export, air-sea gas exchange, deep-ocean stratification and mixing. Cold climates increase sea-ice export and speed up poleward surface flow of carbon-rich waters. According to our model simulations, this acceleration leads to a massive decrease in the atmospheric exposure time of surface waters and would therefore contribute to a reduction of CO_2 outgassing in the Southern Ocean. Moreover, increased brine formation around Antarctica enhances deep ocean stratification and carbon storage. We argue that these orbitally-paced physical processes were the primary drivers for biological and chemical feedbacks, which further contributed to the glacial/interglacial redistribution of carbon between atmosphere and ocean