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Status of the Antarctic Ocean “surface isolation” hypothesis for glacial/interglacial carbon dioxide change

DANIEL M SIGMAN[1], FRANCOIS FRIPIAT[2,3], ANJA S STUDER[4], PRESTON COSSLETT KEMENY[5], ALFREDO MARTINEZ-GARCIA[2], MATHIS HAIN[6], XUYUAN (ELLEN) AI[1], XINGCHEN TONY WANG[7] AND GERALD H. HAUG[2]

[1]Princeton University
[2]Max Planck Institute for Chemistry
[3]Université Libre de Bruxelles
[4]University of Basel
[5]California Institute of Technology
[6]University of California - Santa Cruz
[7]Boston College

Presenting Author: sigman@princeton.edu

The Southern Ocean is widely recognized as a potential cause of the lower atmospheric concentration of CO_2 during ice ages, but the mechanisms are debated. In the Subantarctic Zone, the more northern Southern Ocean, data indicate dust-driven iron fertilization of phytoplankton growth during peak ice age conditions. With regard to the Antarctic Zone to the south, after decades of study, there are divergent views of the changes that might have contributed to the lowering of CO_2. In this talk, the evidence will be reviewed for what can be summarized as “isolation” of the Antarctic Zone surface: a reduction in the area-normalized exchange of water between the Antarctic surface and subsurface. As to the physical mechanism, a data-based case will be made for a weakening and/or equatorward shift in the upwelling associated with the southern hemisphere's westerly winds. This would have encouraged declines in both the nutrient content and the formation rate of new deep water, each of which would have contributed to the lowering of atmospheric CO_2. In the context of the processes underlying the modern Southern Ocean’s overturning circulation, this mechanism can explain a range of observations from the ice age ocean, including changes in the ocean’s fixed nitrogen budget.