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Meridional contrasts in productivity changes driven by the opening of Drake Passage

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The progressive opening of Drake Passage across the Eocene and the Oligocene occurs contemporaneously to the long-term global cooling of the late Eocene, which culminated with the Eocene-Oligocene glaciation of Antarctica. Atmospheric pCO_2 decline during the late Eocene is thought to have played a major role in the climatic shifts of the Eocene-Oligocene boundary, yet reasons behind CO_2 variations remain obscure. Changes in marine productivity affecting the biological oceanic carbon pump represent a possible cause. Here, we explore whether and how the opening of Drake Passage may have affected marine biogeochemistry, and in particular paleoproductivity changes, with the use of a fully coupled atmosphere-ocean-biogeochemical model (IPSL-CM5A). We find that the simulated changes to Drake Passage opening exhibit a uniform decrease in the low latitude marine productivity while the high latitude response is more spatially heterogeneous. Mechanistically, the low latitude productivity decrease is a consequence of the dramatic reorganization of the ocean circulation when Drake Passage opens, as the shift from a well ventilated to a swampier ocean drives nutrient depletion in the low latitudes. In the high latitudes, the onset of the Antarctic Circumpolar Current in the model exerts a strong control both on nutrient availability but also on regions of deep water formation, which results in non-uniform patterns of productivity change in the Southern Ocean. The qualitative agreement between geographically diverse long-term paleoproductivity records and the simulated variations suggests that the opening of Drake Passage may contribute to part of the long-term paleoproductivity signal recorded in the data.