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Deep oean circulation and climate during the Miocene: Data vs. modelling

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A series of configurations for Neogene ocean circulation sensitivity experiments, i.e. different stages in the shoaling of the Central American Isthmus and of the eastern Tethys as well as different sea-ice coverage scenarios were used as input for a marine carbon cycle model (HAMOCC2s). Using d13C and sedimentary carbonate as model output variables, the geochemical experiments provided a new framework to interpret Neogene paleoenvironmental data.

Assuming the Isthmus of Panama to be open and no sea-ice coverage in the southern hemisphere, deep water is formed in the North Atlantic as well as in the sub-Antarctic realm, in agreement with Neogene carbon isotope pattern. However, the formation rate of NADW is reduced by about 75% compared to the control experiment, consistent with very low d13C gradients between the North Atlantic and Southern Ocean. The sill depth greater than 1000 m allows for the passage of NADW into the Pacific ocean, forming a deep boundary current along the western Pacific margin. The export of NADW is compensated by an influx of low-salinity Pacific Intermediate water, which enters the Caribbean with a maximum strength of 3 Sv at a depth of about 500 m. Forming of sea-ice related to the Middle Miocene build-up of a permanent Antarctic ice sheet intensifies the sub-Antarctic deep water production while NADW formation is suppressed. This scenario is corroborated by the convergence of Atlantic and Pacific benthic d13C values between 15 and 11 Ma. Finally, the re-establishment of the formation of NADW in the late Miocene and the evolution of the modern ocean conveyor is predicted in the model experiments assuming further shoaling of the Central American Isthmus and evolution of sea-ice in the Artic Ocean.