Warm Deep Ocean in Cool Climates: The Southern Connection

Dan Seidov[1] (814-865-1921; dseidov@essc.psu.edu)
Eric Barron[1] (814-865-1073; ebarron@essc.psu.edu)
Bernd J. Haupt[1] (814-865-8188; bjhaupt@essc.psu.edu)

[1]Pennsylvania State University, Earth System Science Center , University Park, PA 16802-2711, United States

Warm abyssal oceans are associated largely with warm periods in the earth's history. This abyssal warmth is usually explained as a response to high latitudinal sea surface warming or a dominant subtropical deepwater source. However, these conclusions have not benefited from substantial experimentation with ocean general circulation models that incorporate the role of both Northern and Southern Hemisphere deepwater sources. Based on a series of numerical experiments, we show that warm high-latitudinal sea surface in both hemispheres or subtropical deepwater production is not a necessary precondition for a substantial abyssal warming. Instead, haline conditions at the sea surface are a significant control, and the two hemispheres can play quite different roles in governing the deep ocean. For the present-day geometry and sea surface conditions, freshening of the Southern Ocean can lead to a strong restructuring of the global thermohaline conveyor and result in substantial abyssal warming. Hypothesized freshening of the high latitudes around Antarctica may result from different events linked to global climate warming (reduced brine rejection due to reduced sea-ice formation, melting of the sea ice and sea-based ice shelves, or melting of the West Antarctic Ice Sheet). A meltwater event in the Southern Hemisphere affects the rate of Antarctic Bottom Water (AABW) production. However, counter-intuitively, the cause of the deep-water warming is not the reduction of AABW but the increase of North Atlantic Deep Water (NABW) production. Meltwater events in the North Atlantic lead to warming at intermediate depths but cooling of the deep ocean due to increased AABW incursion. Hence, the teleconnections between AABW and NADW are the key element in governing the thermal character of the deep ocean. A warming of abyssal waters by as much as 10 degrees results in experiments with a prescribed reduction of sea surface salinity around Antarctica of 1 psu (relatively small change in the view of the southern ice reserve). Warming occurred without any change of the prescribed sea surface temperature, and is the result of strong northward cross-equatorial heat transport during the southern meltwater episodes. Associated sea level rise due to warming of the deep ocean can be tens of centimeters to 1 m or more, without any additional water input from melting ice sheets. The results shed new light on the Warm Saline Bottom Water problem, and the importance of freshwater fluxes and associated thermal impacts in any climate.

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3. (a) Dan Seidov
   Pennsylvania State University,
   Earth System Science Center
   University Park, PA 16802-2711
   United States
   (b) 814-865-1921
   (c) 814-865-3191
   (d) dseidov@essc.psu.edu
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