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Panamanian gateway closure chilled North America: A dynamical impact of the atmosphere on Northern Hemisphere Glaciation

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The most significant climate transition during the Pliocene was the pronounced intensification of Northern Hemisphere Glaciation around 3 million years ago. Various hypotheses have been proposed to explain the sudden appearance of major ice sheets in the Northern Hemisphere. One hypothesis, which has received much attention, relies on the combined effects of the closure of the Panamanian gateway and favorable orbital forcing.

Here, we study the potential role of the Panamanian gateway closure in Northern Hemisphere Glaciation using the fully coupled climate model CCSM2. The closure of the Panamanian gateway affects the circulation in all ocean basins. In accordance with paleoceanographic data, sea-surface temperatures increase by 1-2 K over large areas of the North Atlantic due to a strengthened Gulf Stream. North Pacific surface waters experience a similar warming. The resulting surface heat-flux anomalies over the northwestern Pacific generate a large-scale dynamical response in the troposphere, which is considered to be a thermally excited stationary Rossby wave train. The associated wind-field anomaly reduces the advection of heat from the Pacific Ocean to northern North America, leading to a winter cooling at the surface by up to 1.5 K in the Alaskan and Canadian Arctic. We surmise that this cooling of the North American continent may have intensified Northern Hemisphere Glaciation via a forest-tundra feedback.