Perpetual Motion: The Fatal Flaw in Glaciology

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Gravitational forcing in glaciers is linked to the product of ice thickness and ice surface slope in the glaciological literature. For glaciers such as continental ice sheets that enter the sea and become afloat, gravitational forcing for the floating part is linked to the height of ice floating above water. This is a consequence of basal buoyancy. Glacial flow in ice sheets begins as slow sheet flow spreading from interior ice domes, with most of that flow converging to become fast stream flow that ends as fast shelf flow when the ice streams become afloat. Therefore, stream flow is transitional between sheet flow and shelf flow, and gravitational forcing in ice streams should be represented by a combination of ice surface slope and height of ice above sea level for a given ice thickness. Failure to do this, and relying only on surface slope to provide gravitational forcing, produces flow that becomes faster as "gravitational forcing" becomes weaker and even vanishes when the surface slope approaches zero. This is the defining characteristic of a perpetual motion machine. It is a fatal flaw in glaciology that makes ice sheets only passive components of Earth's climate machine, when in fact the geological record of Pleistocene ice sheets shows they are dynamic components. That flaw vanishes when both sources of gravitational forcing are included in computer models that simulate the flow of ice sheets. When full gravitational forcing is included in these models, they will be able to simulate rapid changes in the size and shape of ice sheets that are large enough to trigger abrupt climate change.