

## The Role of the Cryosphere in Earth's Geohydrologic Cycle in Deep Time

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Water is a primary component of climate change, continental weathering, and evolutionary processes. The cryosphere is the second-largest reservoir of water in the near-surface hydrosphere, and the waxing and waning of polar ice influences regional ocean chemistry and marine biological primary production. The amount of water in the cryosphere, as well as the movement of water into and out of the cryosphere, has varied over the past 700 Ma. For example, during Cryogenian low-temperature “snowball-Earth” conditions, the cryosphere enveloped Earth in a shell of ice. Previous workers have investigated “snapshots” of the cryosphere at discrete points in Earth’s history, though none have linked cryosphere-related processes to dynamic variations in the global water cycle throughout deep time.

We have developed a numerical model to assess variations in the amount of water in the cryosphere over the past 700 Ma. The model combines the amount of water in the various geohydrologic cycle reservoirs (atmosphere, the cryosphere, the biosphere, continental surface water, groundwater, and the oceans) with the fluxes of H<sub>2</sub>O between these reservoirs. We examine how the distribution and fluxes of water between reservoirs vary in proportion to environmental changes. For example, precipitation from the atmosphere to the cryosphere varies with changes in global temperature and polar ice surface area. At global average temperatures >3°C, precipitation to the cryosphere is controlled by changes in ice cap surface area; at temperatures <3°C, precipitation to the cryosphere is controlled by changes in global temperature (see Figure). Thus, as global average temperature varies in deep time, the flux of water from the atmosphere to the cryosphere varies accordingly.

