Temporal evolution of the hydrologic cycle during the Phanerozoic

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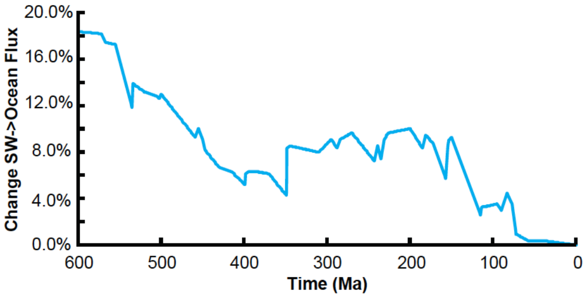
Water plays a major role in virtually all critical zone processes, including climate change, continental weathering, and the sustainability of life. The distribution of water on Earth and the movement of water between near-surface (exosphere) reservoirs have varied during the past 600 Ma in response to changing physical, chemical and biological conditions. For example, the amount of water in the continental biosphere has increased from essentially zero at the beginning of the Phanerozoic to ~$3.2x10^{15}$ kg [1]. Previous workers have investigated variations in individual hydrologic reservoirs and processes over relatively short time scales (ka-Ma), but none have linked those investigations to variations in the whole-Earth hydrologic cycle.

We describe a numerical model to assess variations in the hydrologic cycle over the past 600 Ma. This model describes the amount of H_2O in the exospheric water reservoirs (atmosphere, biosphere, glacial and polar ice, surface water, groundwater, and oceans) and the fluxes of H_2O between them [1]. Starting from modern values, we examine how the amount of H_2O in a given reservoir or a flux of H_2O between any two reservoirs varies with respect to some environmental change, e.g., global average temperature, or polar ice surface area. For example, the growth in continental biomass during the Phanerozoic has led to an ~18% decrease in the flux of water between the continents and the oceans via runoff (see Figure), and also has led to an ~1.7% decrease in the flux of water between the oceans and atmosphere. Thus, the growth of the continental biosphere has had a relatively small impact on the overall water cycle.



[1] Bodnar *et al*. (2013). *Geol. Soc. Am. Sp. Paper* **500**.