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Coupling of terrestrial water and carbon cycles: implications for climate models

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Terrestrial water vapor fluxes represent one of the largest movements of mass and energy in the Earth's outer spheres, yet the relative contributions of abiotic water vapor fluxes and those that are regulated solely by the physiology of plants remain poorly constrained. By interpreting differences in the oxygen-18 and deuterium content of precipitation and river water, a methodology was developed to partition plant transpiration from the evaporative flux that occurs directly from soils and water bodies and plant surfaces. The methodology was applied to fifteen large watersheds in North America, South America, Africa, Australia, and New Guinea, and results indicated that approximately two thirds of the annual water flux from the "water-limited" ecosystems that are typical of higher-latitude regions could be attributed to transpiration. In contrast to "water-limited" watersheds, transpiration in high-rainfall, densely vegetated regions of the tropics represents a smaller proportion of precipitation and is relatively constant, defining a plateau beyond which additional precipitation does not correspond to higher transpiration values. In response to precipitation, transpiration behaves similarly to net primary productivity, suggesting that in conformity with small-scale measurements, the terrestrial water and carbon cycles are inherently coupled via the biosphere. Although these estimates of transpiration are admittedly first-order, they offer a conceptual perspective on the dynamics of energy exchange between terrestrial systems and the atmosphere, where the carbon cycle is essentially driven by solar energy via the water cycle intermediary.