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Scaling of stream organic matter stoichiometry across the world's forest biomes

The geographic distribution and climate-dependency of terrestrial organic matter processing across Earth's forest biomes is generally well understood. However, the emergent consequences for the chemistry of streams that permeate these biomes are less clear. As stream chemistry is notoriously variable through time, it is well known that long-term data are essential for characterization of mean field conditions that are critical to evaluation of global change effects. In contrast, bulk soil properties are known to vary greatly through space but remain relatively constant over decades or more. Here, we synthesize stream water chemistry distributed across 250 undisturbed watershed streams in boreal, temperate, and tropical forests worldwide. Most of the >30,000 samples examined were collected regularly over the last four decades or more at Long-term Ecological Research sites. We focused our analyses on dissolved organic C (DOC) and N (DON) cycling and exports. We compare these patterns to an independent global data set on soil chemistry to evaluate the degree of stoichiometric coherency between soils and streams. By examining power-law scaling relationships across space and time we find remarkable coherency within and across biomes in the CN stoichiometry of soils and streams. After normalizing for mass-volume relationships between soils and streams, we derive soil-stream transfer functions and power law scaling between C and N that show increasing relative N enrichment per unit C in soils and streams from boreal to tropical forest watersheds. We demonstrate stoichiometric symmetry between soils and streams made possible via long-term stream chemistry data that reveal the time-integrated averaging effects of watershed ecological and hydrological processing. Our findings offer insight into how stoichiometric pattern emerges at the ecosystem level over space and time.