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Catchment chemostasis revisited: water quality responds differently to variations in weather and climate

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Solute concentrations in streamflow typically vary systematically with stream discharge, and the resulting concentration-discharge relationships are important signatures of catchment (bio)geochemical processes. Solutes derived from mineral weathering often exhibit decreasing concentrations with increasing flows, suggesting dilution of a kinetically limited weathering flux by a variable flux of water. However, Godsey et al. (2009) showed that concentration-discharge relationships of weathering-derived solutes in 59 headwater catchments were much flatter than this simple dilution model would predict. Instead, their analysis showed that these catchments behaved almost like chemostats, with rates of solute production and/or mobilization that were nearly proportional to water fluxes, on both event and inter-annual time scales. Here we re-examine these findings using data from roughly 1000 catchments, ranging from $\sim$10 to >1,000,000 km^2 in drainage area, and spanning a wide range of lithologic and climatic settings.

Concentration-discharge relationships among this much larger set of much larger catchments are broadly consistent with the chemostatic behavior described by Godsey et al. (2009). Among these same catchments, however, site-to-site variations in mean concentrations are strongly (negatively) correlated with long-term average precipitation and discharge, suggesting strong dilution of stream concentrations under long-term leaching of the critical zone. The picture that emerges is one in which, on event and inter-annual time scales, stream solute concentrations are chemostatically buffered by groundwater storage and fast chemical reactions (such as ion exchange), but on much longer time scales, the catchment's chemostatic "set point" is determined by climatically driven critical zone evolution. Examples illustrating the different influences of (short-term) weather and (long-term) climate on water quality will be presented, and their implications will be discussed.

Godsey, S.E., J.W. Kirchner and D.W. Clow, Concentration-discharge relationships reflect chemostatic characteristics of US catchments, Hydrological Processes, 23, 1844-1864, 2009.