Impact of climate on river chemistry across the United States

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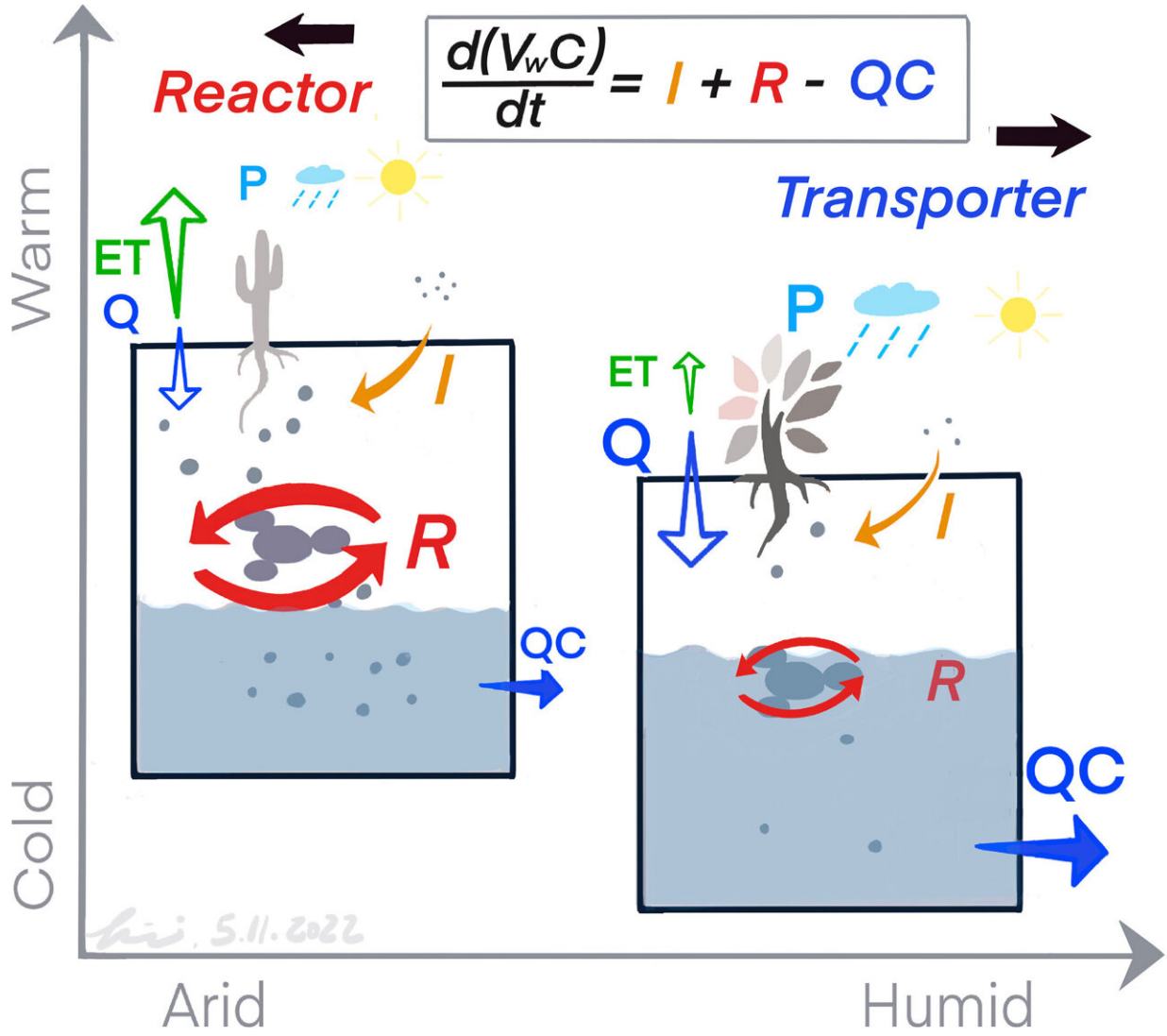

A conceptual model of watershed hydro-biogeochemical reactor under different climates. Water originates from precipitation and travels via subsurface flow paths and river corridors before exiting at river outlets. Along its flow paths,

water mobilizes solutes by interacting with roots, microbe, soil, and rocks. The dynamics of solute concentrations in the stored water (Vw) are therefore regulated primarily by two competing processes: the addition of solutes by external input (I) and production of solutes by reactions (R) in soils, rocks, and streams, and the export of solutes by discharge (QC) (Equation 2). External input can happen but are often insignificant in natural, minimally-impacted watersheds. Under warming climate, some places will become more arid, leading to lower river discharge (Q = P – ET) and solute export (QC); some places will become more humid, resulting in lower solute concentrations but higher solute export fluxes to rivers. Watersheds function primarily as solute-producing reactors in arid, warm climates, and as solute-exporting transporters in humid, cold climates. Credit: *Earth's Future* (2022). DOI: 10.1029/2021EF002603

Rivers flow across many kinds of terrain, interacting with soil, rocks, microbes, and roots. River water therefore carries signatures of everything it interacts with, and its chemistry reflects the response of the critical zone—the region of the planet stretching from the tops of trees to the bottom of groundwater—to changing climate. River chemistry is likely to change with a warming climate, yet most climate-related research studies have focused on changes in river flow.

Now, Li et al. focus on changes in river chemistry and water quality under a changing climate. They investigated the influence of climate on the long-term chemistry of rivers in the contiguous United States, compiling more than 400,000 data points from 506 rivers with minimal human impacts to identify patterns of 16 common river chemistry constituents (solutes).

For all geographic areas of the United States, the team found that concentrations of 16 solutes decrease with increasing mean river discharge, which is the amount of precipitated water (both rainfall and snowfall) that ends up in streams and rivers. This finding contradicts the

common perception that river chemistry is controlled primarily by the abundance of local materials in the critical zone. Instead, river chemistry is controlled first by river discharge, then by the abundance of materials the water interacts with.

Changing climate conditions—including higher temperatures—can influence not only river discharge but also the types of critical zone materials that interact with and dissolve in waters. The authors say that in places that become drier, such as western parts of the United States, mean concentrations are expected to increase, and the magnitude of the increase hinges on the solutes' sensitivity to changes in discharge. In places that become wetter, mean concentrations likely decrease, but the loads, or the rates of solute export leaving rivers, can increase with more water.

As the climate changes, increasing solute concentrations will have implications for water management and treatment efforts and may require renovated or augmented treatment infrastructure. These changes can also have significant impacts on aquatic ecosystem health.

More information: Li Li et al, Climate Controls on River Chemistry, *Earth's Future* (2022). DOI: 10.1029/2021EF002603