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From rainfall to rivers: A comparison of modelled and measured stable water isotopes in precipitation and river catchments at a global scale

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Rivers are a crucial link in the global hydrological cycle as they discharge precipitation, groundwater, and water stored in snowpacks and glaciers back to the world oceans. However, there are essential gaps in hydrological data between rainfall, infiltration, and river discharge to the world oceans. Stable water isotopes are used to trace sources of precipitation and river water, unravel hydrological processes, as well as to assess the water balance of watersheds. With the widespread adoption of laser absorption spectroscopy for water isotope analysis, there is growing potential for an improved integration and application of isotope methods, combined with traditional quantitative and qualitative hydrological studies of large rivers.

The Global Network of Isotopes in Rivers (GNIR) has been established a decade ago and aims to fill the informational data gaps between rainfall and river discharge. Here we report the results of a preliminary evaluation of the GNIR data holdings for about 250 river catchments, using measured and modelled stable water isotope compositions. A regionalized, cluster-based precipitation isotope model (RCWIP) was used to compare measured to predicted isotope compositions of riverine catchments. The results help to identify knowledge gaps and to improve the understanding of catchment scale processes of our world river basins.

Our analysis suggests that the global GNIR river stations can be clustered into 6 different groups, as a function of their seasonal variation in stable isotope composition. A sinusoidal function reveals that there are periodic phases within each river grouping, which shows that, despite different catchment effects (e.g. river length, width, or amount of baseflow contribution), direct seasonal run-off (isotopic) patterns are preserved. The periodicity of the isotopic run-off signal, however, is dependent on river catchment latitude and snow or glacier meltwater-contributions. The importance of direct precipitation and run-off to the river discharge is confirmed by the strong co- variation of the isotope composition of precipitation and river water on a global scale. However, as most of the world's rivers are impacted to some degree by natural or man-made reservoirs, mixing processes of different water sources and of precipitation from different seasons are observed. The model predicted isotope composition of rivers correlates well with measured river isotope composition, however, some rivers strongly deviate. These deviations are located in arid regions that experience intense evaporation processes, or watersheds having important contributions from glacier-meltwater or permafrost.