Hydrologic balance of Lake Geneva: insights from stable isotope compositions

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With a total surface area of 580 km^2 and water depths reaching 310 m, Lake Geneva is Europes largest freshwater reservoir. Given its Central European position, large size, and long residence time of water (about 11 years; mass balance of volume, fluvial inputs and outlet), the sediments and fossils (e.g. ostracods) in this Lake may represent a unique climatic archive. However, little is known about its water budgets in terms of mixing processes of its distinct sources of water and loss via evaporation, which may have changed in concert with the local climate. Sources include rivers from an Alpine catchment partially fed by glacial meltwaters (Rhone, 72 to 82% of total input), rivers with a catchment in the Jura mountains (e.g., Aubonne or Versoix, totalling 10 to 18%), direct precipitation (about 1 to 5%), as well as groundwater infiltration (volume unknown). To help constrain the water balance, samples from six depth profiles have been analyzed during March and July of 2005 for the hydrogen and oxygen stable isotope compositions of water, and for that of carbon from dissolved inorganic carbon. In February the Lake experienced a rare complete overturn. Furthermore, the isotopic composition of rivers feeding the Lake, its outflow, and local precipitation have been measured periodically.

δD and $\delta^{18}O$ values of the Lake average –90 and –12.4‰, respectively. These values are identical to those measured to depths of 12 m during the 60's [1], which is surprising as the isotopic composition of precipitation and rivers in Switzerland have changed by at least +1‰, related to the changing climate during the last two decades. Because the isotopic composition of the Rhone has changed in parallel with the precipitation, larger amounts of glacial melt water during recent warmer periods cannot account for this constancy. Instead, larger evaporative loss in the past compared to today (from about 4% to 1%), perhaps because of an increase in humidity, may account for this constancy.

Both δD and $\delta^{18}O$ values are higher in winter (–89 and –12.2‰) compared to summer (–90 and –12.6‰), paralleling seasonal variation of the Rhone. Profiles also support a 3-layer model for the Lake: a surface layer (5 to 10 m depth) influenced by evaporation, a middle layer (10 to 90 m) influenced by colder waters of the Rhone and other local rivers, and a deep layer of homogeneous composition.

References

[1] Fontes J.C. and R. Gonfiantini (1969) *EPSL* **7,** 325-339.