Relationships of lakes and the ocean to their drainage basins: a plot of hydrologic dominance II

The Plot

Page I of this pair of SFMG pages presented in larger format the plot shown crudely on this page. The plot shows the relationship of two parameters characterizing the extent to which bodies of water dominate their drainage basins or catchments. The parameter on the horizontal axis is the ratio of the area of a body of water to the area of its drainage basin. A large value indicates that a body of water comes close to filling its basin and leaving no dry land, and a small value indicates a body of water that fills comparatively little of its basin.

The parameter on the vertical axis is the ratio of the volume of a body of water to the rate at which water enters that body. That ratio, where volume is divided by volume per unit of time, is the residence time of water in that body. A large value means that the body's volume is large relative to its input, and that water stays in the body a long time, and a small value means that water moves through and out of the body relatively quickly.

The result is a plot that expresses a generalized notion of hydrologic dominance, or the extent to which a body of water dominates its drainage basement in space and time. The gray arrow indicates the direction in which the two parameters increase. The size of circles corresponds to the area of the 15 largest bodies of water. The largest circle represents the oceans, which collectively have an area 1000 times that of the Caspian Sea, which is represented by a circle of intermediate size. The Caspian Sea is in turn 4.5 times larger than Lake Superior, the third largest body. Lake Superior is 4 times larger than Lake Ontario, the 15^{th} largest body, and so the 3^{rd} to 15^{th} are shown with small circles.

Observations

1) The global ocean is far and away the most dominant body of those shown.
2) The Caspian Sea is oceanic by virtue of having some ocean crust (a relic of its origin in the Paratethys Seaway), but on this plot it has the characteristics of a lake.
3) Of the bodies shown here, the four with the greatest residence time are the four deepest. This can be rationalized in terms of the volume at depth in which water is stored for considerable time. However, Great Slave Lake is exceptionally deep and has a smaller residence time.
4) The five Laurentian Great Lakes plot in one region of the diagram. Among them, the deepest has the greatest residence time and the shallowest has the smallest, in keeping with Observation 3.
5) The three hypersaline bodies shown have small values of the parameters plotted. Small residence time can be explained as the result of sufficient evaporation to make the lake saline, and small area relative to catchment may be inevitable because accumulation of water to become large would require dilution.

Sources and Notes

Most of the data for this plot come from LakeNet at www.worldlakes.org. Some residence times are from other sources: Bashitialshaaer et al. (2008, Mixing time for the Dead Sea based on water and salt mass balances: Euromed 2008 conference) for the Dead Sea and Utah Water Research Laboratory (1972, The Great Salt Lake and Utah's water resources: UWRL Reports 37) for the Great Salt Lake. The ocean residence time was calculated from the mass of water in the oceans and rate of river input. The values for the global oceans of the Cretaceous and Ordovicians (times of high sea level) are crude estimates.

Other but smaller lakes of interest include Lake Titicaca, with a residence time of 1343 years, and Crater Lake, with a lake-to-catchment ratio of 0.84 that results from its location in a volcanic caldera. Full consideration of the Laurentian Great Lakes would require inclusion of Lake St. Claire, which is much smaller and for which the residence time is less well established.