

Reply to Refree#2 by P. Allen

In glacier basins, linear reservoirs have often been employed in modeling outflow (Gurnell, 1993). In several studies, up to four linear reservoirs have been linked in series to aid in translating estimates of ice and snowmelt and groundwater from different locations in the basin. This becomes problematic because recharge may occur in one or more of the reservoirs at different times. Another alternative is to employ one non linear reservoir (Gurnell, 1993).

Isotopic work by Cable et. al. (2008) in mountainous glacial terrain indicates the recharge to the baseflow system is a mixture of water derived from a combination of glacial, rain, and snow melt as the water moves down the valley. Seepage of this water to a lower aquifer appears to be a major element in baseflow recharge. Recent work in the Himalayan rivers by Andermann et al. (2012), illustrate the importance of a fractured basement aquifer which is the source of baseflow to the area streams. They estimate that in Nepal, the volume of water flowing through this aquifer is approximately six times higher than the contribution of glacial and snow melt to river discharge. Unfortunately, one of the principal problems in dealing with models in the Himalayan area is the lack a dense guage network, and lack of knowledge of the basement aquifer, its physical properties and relationship to the tectonic structures. These unknowns inhibit further understanding of the deep groundwater resources and their contribution to baseflow in the Himalayas. Recent work by Smerdon et al. (2009) indicates the complexity of groundwater recharge in mountainous areas even with abundant well data but similarly show its importance to overall river

discharge. In the case of the proposed model, the addition of a two-reservoir system which links the second reservoir to the deeper aquifer appears to be the best compromise between data availability and current knowledge of the geohydrologic system operating in this area.

Cable, J. M., K. Ogle, D. G. Williams, and S. Bachman, 2008. The contribution of glacier meltwater to stream flow in the Wind River Range, WY. *Eos Trans. AGU*, 89(53), Fall Meet. Suppl., C23A-0597.

Smerdon, B. D., D. M. Allen, S. E. Grasby, and M. A. Berg, 2009. An approach for predicting groundwater recharge in mountainous watersheds. *Journal of Hydrology*, P156-172.

Andermann, C., L. Longuevergne, S. Bonnet, A. Crave, P. Davy, and R. Gloaguen, 2012. Impact of transient groundwater storage on the discharge of Himalayan rivers. *Nature Geoscience*, Vol 5, P127-132.

Gurnell, A. M., 1993. How many reservoirs? An analysis of flow recessions from a glacier basin. *Journal of glaciology*. Vol 39, No. 132, P409-414.