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Streamwater ages derived from tritium show power law variation with discharge like silica concentrations

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Understanding runoff generation is important for management of freshwater systems. Determining transit time distributions of streamwaters and how they change with discharge gives information on the flowpaths and recharge sources of streams - vital information for determining the responses of streams to stressors such as pollution, landuse change, or climate change. This work takes a first look at unique information on how transit time distributions change with discharge in some New Zealand catchments.

Transit time distributions of streamwaters have been determined from tritium measurements on single samples in this work. This allows changes with stream discharge to be observed, in contrast to previous isotope studies which have given averaged transit time distributions based on series of samples. In addition, tritium reveals the wide spectrum of ages present in streams whereas oxygen-18 or chloride variations only show the younger ages (Stewart et al., 2010). It was found that the mean transit time (MTT) data could be reasonably represented by straight lines in log-log plots, indicating power law relationships between MTT and discharge. Similar power law behaviour has been observed for the rock forming elements such as silica in streamwaters (Godsey et al., 2009).

Case studies are presented for two New Zealand catchments, both with volcanic ash substrates. Toenepi is a dairy catchment near Hamilton, which shows well-constrained power law relationships between MTT and discharge, and between silica concentration and discharge (Morgenstern et al., 2010). Baseflow MTTs vary from 2.5 to 157 years. Tutaeuaua is a pastoral farming catchment near Taupo. Results for nested catchments along the stream also show power law relationships for both MTT and silica with discharge. Streamwater MTTs vary from 1 to 11 years. The results indicate that (1) relatively old waters dominate many streams, (2) streamwater ages vary with discharge, and (3) age, like silica, varies according to power law relationships with stream discharge.

References: Godsey, S.E., Kirchner, J.W., Clow, D.W. Hydrological Processes 23, 1844-1864, 2009. Morgenstern, U., Stewart M. K., Stenger, R. Hydrology and Earth System Sciences 14, 2289-2301, 2010. Stewart, M.K., Morgenstern, U., McDonnell, J.J. Hydrological Processes 24(12), 1646-1659, 2010.