Multi-scale analysis of the fluxes between terrestrial water storage, groundwater, and stream discharge in the Columbia River Basin

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The temporal relationships between the measurements of terrestrial water storage (TWS), groundwater, and stream discharge were analyzed at three different scales in the Columbia River Basin (CRB) for water years 2004 - 2012. Our nested watershed approach examined the Snake River (182,000 km^2), Upper Columbia (155,000 km^2), and the greater CRB (614,000 km^2). These three watersheds represent distinct climatic and geologic provinces found in the region. TWS (the vertically-integrated sum of snow, soil moisture, surface water, and groundwater) was measured remotely by NASA's Gravity Recovery and Climate Experiment (GRACE). Results show that over the course of a water year, TWS and discharge exhibit a characteristic counter clockwise hysteresis pattern for each of the three regional watersheds. Similarly, in each of the three watersheds groundwater and discharge also exhibit a characteristic hysteresis pattern over the course of a water year—only in a clockwise direction. Our findings provide regional characteristics that quantify and describe the fluxes between snow, groundwater, and discharge, and also identify the out-of-phase relationship between the region's wet winters and groundwater recharge from during the spring. The methods and results presented in this study provide an analytic framework to incorporate remotely-sensed measurements of TWS to better understand how regional watersheds function as an integrated system, and also to identify potential water surplus and scarcity in the CRB and other regional watersheds.