Geophysical Research Abstracts
Vol. 18, EGU2016-1552, 2016
EGU General Assembly 2016

Uncertainty of natural tracer methods for estimating river-aquifer exchange flux in the Heihe River, northwest China

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Reliable estimation of river-aquifer exchange flux is critical to the conjunctive management of surface water and groundwater, especially in the arid and semiarid regions where potential evapotranspiration is much higher than precipitation. A number of natural tracer methods are available to estimate river-aquifer exchange flux at different spatial scales. However, these methods have primarily been applied to rivers with relatively low flow rates (mostly less than 5 m^3 s^{-1}). In this study, several natural tracers including heat, radon-222 and electrical conductivity were used to quantify river-aquifer exchange flux at both point and regional scales in the Heihe River, northwest China with a large flow rate (63 m^3 s^{-1}). These tracers were measured both on vertical riverbed profiles and on longitudinal river samples. Results show that the radon-222 profile method can estimate a narrower range of point-scale river-aquifer flux than the temperature profile method. However, three vertical radon-222 profiles failed to estimate the upper bounds of plausible flux ranges. Results also show that when quantifying regional-scale river-aquifer exchange flux, the river chemistry method constrained the flux (5.20 – 10.39 m^2 d^{-1}) better than the river temperature method (-100 – 100 m^2 d^{-1}). The river chemistry method also identified spatial variation in the flux, whereas the river temperature method did not have sufficient resolution. Overall, for quantifying river-aquifer exchange flux in a large river such as the Heihe River, both the temperature profile method and the radon-222 profile method provide useful complementary information at the point scale to complement each other, whereas the river chemistry method is recommended over the river temperature method at the regional scale.