A method for predicting hydrogen and oxygen isotope distributions across a region's river network using reach-scale environmental attributes

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Long-term isotope values of river water provide information on hydrological flow pathways and atmospheric exchange and can be used to determine the origins of hydrogen and oxygen stored in animal and plant tissues. However, development of isotope maps for rivers is currently limited by methods to spatially interpolate point measurements to values for entire river networks. Catchment environmental characteristics and structures that affect river water isotope values also affect downstream reaches via flow, but many (such as man-made dams) are no more likely to affect nearby unconnected catchments than distant ones. Hence, distance-based geospatial and statistical interpolation methods used to develop isoscapes for precipitation and terrestrial systems may be less appropriate for river networks. We developed a modified ‘water balance’ river isotope mapping method to consider the effects of reach-scale catchment environmental characteristics and applied it across the entire stream network of New Zealand. This network comprises over 600,000 reaches and over 400,000 kilometres of rivers. The method uses national rainfall precipitation isoscapes, a digital elevation layer, a national river water isotope monitoring dataset (currently over 3 years of monthly sampling at 58 sites) and reach scale environmental attribute databases that cover New Zealand's river network. \( \delta^2 \text{H} \) and \( \delta^{18} \text{O} \) isoscapes produced showed an improved fit to validation data, compared to a model for which residuals between observed and simulated isotope values were applied as a correction factor across the river network using the ordinary kriging method. Hence, we show how a water balance modelling approach can provide an improved representation of long-term river water \( \delta^2 \text{H} \) and \( \delta^{18} \text{O} \) values when combined with a correction for catchment environmental attributes.