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Bayesian attribution of uncertainty in isotope hydrograph separation

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The stable isotopes of water can provide useful insights into catchment water sources and flow paths. As such, they are commonly used to separate hydrographs into (at least) two components: 1) stored catchment water which is mobilised during an event (pre-event water), and 2) Water derived directly from the event precipitation without significant storage delays (event water). This method of hydrograph separation typically employs a linear mixing model to partition the hydrograph components using end member source contributions or simple transfer functions. Whichever the case, the resulting components are usually defined with precise boundaries, with no attribution of uncertainty derived from the end members, the model, or other sources. Here, we use a Bayesian mixture model to prescribe the pre-event and event hydrograph components, and their uncertainty, from stable isotope samples collected during a large flood event in eastern Australia. Given the spatial and temporal variability of any rainfall and storage inputs during an event, the prior distribution for the hydrograph components is necessarily poorly defined, leaving the uncertainty estimates to be 'data driven' by the isotope samples throughout the event. When the model is constructed this way, the uncertainties become very large (up to 100%) and the hydrograph components are unconstrained. This is because a single isotope sample in time does not provide sufficient information on component partitioning given the poorly defined prior distribution. As a conceptual exercise, we artificially generated large populations within the range of neighbouring isotope samples, and then sub sampled from this range at different sampling densities. Interestingly, we find that 5 – 10 samples collected within a very short time frame are sufficient to considerably reduce the hydrograph component uncertainty so that each is now realistically constrained. These results demonstrate that the lack of uncertainty provided by traditional isotope hydrograph separation techniques masks the possibility that the 'pre-event' and 'event' components may in fact be very poorly constrained. The good news however, is that this can be easily improved through increased sampling replication at each point in time.