Modelling 14C groundwater age: Investigating spatial resolution requirements and impacts of carbon reactions

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Groundwater flow models can potentially be improved by incorporating groundwater flux information, such as is typically derived from ^{14}C observations, as an additional model calibration constraint to potentiometric heads. The groundwater ages estimated from ^{14}C are often "corrected" for reactions in the aquifer prior to comparison with flow model results, using simplifying assumptions regarding the temporal and spatial resolution of both reactions and flow/transport. A recently developed reactive transport modelling framework [1] allows simultaneous assessment of groundwater flow, water quality evolution (including $\delta^{13}C$), and ^{14}C activity. Through application of this framework, simulated ^{14}C can now be compared directly with field observations, however, aquifer residence times of ~1-30ka (and therefore long simulation periods) and grid discretisation requirements provide significant computational challenges. We present the modelling framework and applications to (i) a kilometre-scale 2D model domain, in which reactions of carbonate minerals and organic matter occur, and (ii) a regional scale 3D model for the groundwater system underlying Perth, Western Australia. With these applications we explore the degree to which parameter and process uncertainties in the quantification of ^{14}C concentrations, e.g., due to poorly constrained distribution and reactivity of inorganic and organic carbon, may reduce the overall benefits of direct simulation of ^{14}C concentrations.

[1] Salmon S. U. Prommer H. Park J. Meredith K. T. Turner J. V. McCallum J. L. 2015. A general reactive transport modelling framework for simulating and interpreting groundwater ^{14}C age and $\delta^{13}C$. *Water Resources Research* **51**: 359–376, doi:10.1002/2014WR015779