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Parameters estimation using Kalman filter with spring discharge measurements

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Kalman filtering is a very popular method for data assimilation in hydrological modelling. In groundwater applications, Kalman filter has been applied in both forward and inverse modelling. In forward modelling, the filter acts to automatically calibrate state variables of incoming time series measurements versus current state estimates, on the basis of their covariances. The use of Kalman filter in inverse modelling can be direct or indirect. In the direct inverse modelling, the filter automatically calibrates the model parameters based on the deviation of the time series measurements from the current state estimates. In the indirect inverse modelling, estimates of the model parameters are obtained by an off-line procedure (an independent optimization algorithm e.g. shuffled complex evolution method) that involves minimization of the difference between actual head measurements and those predicted from the model-Kalman filter framework. This technique combines the robustness of global optimization algorithms with the benefits of data assimilation and for this reason has been used extensively in groundwater applications with hydraulic head measurements. Nevertheless, application of Kalman filter with spring discharge measurements is not straightforward in the sense that spring discharge is not state variable of groundwater models. In this study we suggest taking advantage of spring discharge measurements by preprocessing them using the Darcy equation and deriving hydraulic head time series that corresponds to the modell cell that discharges to the spring. This time series can be considered as measurements of a state variable and can be used in the Kalman filter. This idea was tested in a synthetic case study based on a real world application, which helped also to highlight the advantages and the disadvantages of the Kalman filter indirect inverse modelling method.