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Use of a digital elevation model, satellite images and geophysical data to improve the groundwater modelling in the Kavimba (Botswana) region

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Compared to groundwater models in the humid zone, groundwater models in semi-arid regions of the developing world have to deal with additional problems. First, frequently over large areas only very few data are available, and means to collect more data are virtually non-existent. Second, recharge normally only takes place in some limited zones and there episodically with the intensity showing a considerable variability in space and time. In general, model predictions are much more uncertain.

The limited amount of data on hydraulic conductivity, hydraulic heads, and recharge rates makes it necessary to find alternative data sources that give information with regard to the groundwater flow. These alternative data sources are used together with hydraulic conductivity data and hydraulic head data in a stochastic inverse modelling procedure, where a large number of alternative solutions, each of them consistent with all the information available, is calculated. The first alternative data source in this study is information from satellite images that leads to an estimate of the average yearly water balance including information about the recharge pattern. The latter can be correlated to chloride measurements on the ground. The sequential self-calibrated method for the stochastic inverse modelling of groundwater flow was extended to allow conditioning on such pattern information. The second alternative data source is a digital elevation model that has an additional value in the inverse groundwater flow modelling in areas where no hydraulic head data are available, as in a phreatic or sub-artesian aquifer heads cannot reach above ground surface. The third alternative data source are geophysical images from high-resolution airborne geomagnetic surveys

that have been used to detect fault and dike structures in the area, which are also introduced in the inverse modelling.

The results illustrate that all three types of information help to improve the model predictions and reduce their uncertainty. The value of the different data sources can be quantified by its potential to decrease the variance of the solution ensemble. Conclusions can be drawn on how to incorporate these data sources in a direct deterministic simulation.