Geophysical Research Abstracts
Vol. 15, EGU2013-11902, 2013
EGU General Assembly 2013

Predictive uncertainty of groundwater recharges rates caused by climate model chain variability and model simplification

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Accurate knowledge of groundwater recharge is essential for sustainable water resource management. Quantifying the spatial and temporal distribution of this key parameter is difficult, because soil type, vegetation and climate change affect infiltration processes. A wide range of different models, differing in their complexity, are used to estimate groundwater recharge and to quantify the influence of climate change. However, model simplification can introduce a predictive bias due to simpler model structures. The different complexity of these models can even give inconsistent results. Another source of uncertainty is climate change caused by climate model chain variability. The relative importance of both uncertainties was so far not systematically investigated. Therefore, we evaluate how models with various degrees of complexity influence the prediction of recharge and secondly how this uncertainty is compared to the uncertainty originating from the variability among climate model chains.

A highly heterogeneous 2D synthetic model was built to generate recharge data for actual and predicted future weather conditions. Daily values of precipitation and temperature and their changes for future weather conditions based on delta change factors of the A1B emission scenario with 10 model chains are applied. Models of simpler models structure (including physically based 1D and soil water balance models) were calibrated against groundwater recharge outputs of the complex references model. Different calibration periods were applied to prove the significance of different inputs for the calibration. Forward runs with best-calibrated parameters are done subsequently with 11 climatic inputs from the reference model. The corresponding results for each model and climate model chain were compared to the reference model outputs.

Good fits for all models can be achieved through model calibration against the reference recharge period. However, predictive bias occurs by running these models over several years. Applying climate change with more extreme weather conditions increases the resulting bias. The potential for model predictive error tends to rise to the extent to which the climatic forcing function differs from the calibration period. Physically based models are most efficient to predict the “true” change in groundwater recharge rates, whereas the simple models over- or underestimate the future groundwater recharge rate. However, differences in model results in the trend, (increase or decrease of groundwater recharge) cannot be observed. Comparison of both uncertainties, climate change and model simplification, indicate that the highest uncertainty is related to climate change, but model simplification can also introduce a not negligible predictive error.