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Multivariate analysis to assess the impact of irrigation on groundwater quality

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Climate change and a growing need for freshwater supply and consumption will impact groundwater resources dramatically. The increased demand is linked with a variety of factors: population increase, pressures for food production, rapid urbanization and increasing uncertainties about water availability and precipitation regimes. Ensuring the global food supply, impacts on water resources are intensified due to increased irrigation with pressure on groundwater quality and quantity. Therefore the evaluation of agricultural irrigation management strategies is essential to minimize negative impacts on groundwater and groundwater dependent ecosystems. Particularly in regions with a tense climatic water balance, water use for agricultural crop production needs to be balanced against the groundwater recharge. Beside there is a strong impact on the geochemical environment of aquifers by groundwater level fluctuations and nutrient loads. Therefore, a valid prediction of the influence of irrigation strategies is a prerequisite especially under the limitations of water availability.
The objective of this project was to develop and adapt a methodical approach that enables the description of the geochemical reaction processes under irrigated fields affecting groundwater quality. Studies were carried out exemplarily in the Fläming region, NE Germany, characterized by intensive agricultural land use and irrigation. The geochemical data was based on a common groundwater monitoring approach. Groundwater monitoring programs provide large data sets that usually cover considerable spatial and temporal pattern. The complexity of these data sets requires sophisticated tools for their processing. Usually, established schemes are followed, including the application of numerical geochemical and hydraulic models as well as chemical graphical interpretation approaches. However, these schemes are too inflexible and vague with respect to analyzing and parameterization of complex features used for identifying operative hydraulic-geochemical processes including intensive hydraulic-geochemical interactions. In this study, an alternative approach is followed. A multivariate Principle Component Analysis (PCA) is used for the interpretation of large multivariate monitored data sets. The PCA subdivided the data set according to different strengths of effects induced by differing geochemical processes under irrigated field sites. Thus a spatial assessment of these processes could be performed as well as a temporal assessment of long-term groundwater quality shifts in the groundwater.
The results can be used to define and allocate local threats to inadequate irrigation measures and to evaluate the sustainability of new approaches for land and water management. Beside, the knowledge of the predominant processes under specific irrigation conditions can improve the uncertainties of geochemical-hydrological model parameterization used as a basis for decision support systems (DSS).