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Geostatistical methodology for assessing the impact of agri-environmental measures on groundwater quality. With application developed for in the State of Baden-Wuertenberg, Germany

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The EU has implemented agri-environmental programs to minimize the negative environmental impacts of agriculture. This study investigates the correlation between the implementation of these measures and the groundwater nitrate concentration in Baden Wurttemberg. Groundwater quality data from the monitoring network was used in a geo-statistical methodology, using two methods, to generate maps of groundwater nitrate distribution from 1990 to 2012. The covered area of each agri- environmental measure that is considered to have a beneficial impact on groundwater quality was attributed to each county in the state for the period of 2000-2012. Using ArcGIS 10.1 and R statistical software, the correlations between the evolutions of these two phenomenon were determined using Spearman's correlation coefficient and the corresponding p value, using three different methods (that incorporate different degrees of additional information such as the evolution of the TUAA and the spatial positioning and extent of agricultural land). Also the evolution of groundwater nitrate concentration was determined for different land use types for the period of 1990-2012.
Variations were visible between the different used methods, however, all of them showed very similar patterns: there were significantly more negative correlations than positive; this was also true for the intensity of the correlations (the value of the correlation coefficient), in some instances negative correlation coefficients went above 0.9 ($p<0.05$) and a relatively large number exceeded 0.8 ($p<0.05$), while in the case of the positive correlations very few even reached 0.8 ($p<0.05$). The counties which showed the highest number of statistically significant correlations were mostly the same counties which showed the most intense correlations (more so in the case of the negative correlations).
Two of the eleven studied measures showed intense and numerous positive correlations and very few and weak negative correlations. Besides the two previously mentioned measures, all had relatively similar negative correlation frequencies and intensities with two measures standing out above the rest, and all performed poorly in terms of positive correlations. The groundwater nitrate concentration remained relatively stable in the study period for the different land use types, with a slight increase in the areas covered by forests and a significant decrease in the areas covered by arable land. Relative to one another the average nitrate concentrations showed the following pattern: arable land > permanent crops > heterogeneous agricultural areas > pastures >= urban fabric >= industrial, commercial and transport units > forests > artificial non-agricultural areas > scrubs and/or herbaceous vegetation.