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Determination the optimum number and positions of monitoring stations for proper spatial modeling of mean PM10 concentration in Berlin

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PM10 concentration in Berlin has exceeded from EU limit, therefore the appropriate spatial distribution of PM10 concentration is a prerequisite for management and control of PM10 concentration in Berlin. The key question of this study is "How many PM10 monitoring stations must be installed in Berlin for appropriate spatial distribution modeling of PM10 concentration and where do they have to be installed?" In this study, a geostatistical calculation has been utilized to answer this question. The optimum number of monitoring stations and their positions are determined by minimization of estimation variance. The experimental variogram values of mean PM10 concentration were calculated using the data of 13 existing stations in Berlin and several variogram models were fitted to the experimental variogram data. The results demonstrated that circular model is the best variogram model for mean PM10 concentration and consequently, a circular variogram model was developed. The Berlin urban area was gridded to 500x500m pixels and for each pixel the estimation variance was calculated using the mean PM10 concentration of monitoring stations and the developed circular variogram model. Then, mean estimation variance (σ_E^2) of Berlin was calculated by averaging of the estimation variance of whole pixels.

By adding one virtual station in Berlin, the optimum position for this station was determined using an iterative optimization technique and with the object of minimization of mean estimation variance (σ_E^2). Hence, the position of added station was changed and σ_E^2 was calculated iteratively. The best position for added station is the position that minimizes σ_{E^2} value. Using this method, some stations were added virtually in Berlin one by one and σ_E^2 value was decreased continuously. This iterative technique was performed until the amount of decrease of σ_E^2 per increase of one virtual station goes toward zero ($\frac{|\partial\sigma_E^2|}{|\partial n|} < 0.04$). The relation between the total number of stations (n) (real and virtual) and σ_{E^2} was calculated and a power function was determined [$\sigma_E^2(n) = 10.67n^{-0.44}(R^2 = 0.99)$]. According to this power function, $\frac{|\partial\sigma_E^2|}{|\partial n|}$ is less than 0.04, when $n \leq 28$. Thus 15 further stations should be added in the suggested positions. The presented approach not only is a reliable method for determination of optimum number and positions of air pollution monitoring stations, but also it is applicable for all spatial correlated data such as some of meteorological, land surface, water bodies, groundwater and underground data.