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Reducing spatial uncertainty in climatic maps through geostatistical analysis

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Climatic maps from meteorological stations and geographical co-variables can be obtained through correlative models (Ninyerola et al., 2000)*. Nevertheless, the spatial uncertainty of the resulting maps could be reduced. The present work is a new stage over those approaches aiming to study how to obtain better results while characterizing spatial uncertainty.

The study area is Catalonia (32000 km2), a region with highly variable relief (0 to 3143 m). We have used 217 stations (321 to 1244 mm) to model the annual precipitation in two steps: 1/ multiple regression using geographical variables (elevation, distance to the coast, latitude, etc) and 2/ refinement of the results by adding the spatial interpolation of the regression residuals with inverse distance weighting (IDW), regularized splines with tension (SPT) or ordinary kriging (OK). Spatial uncertainty analysis is based on an independent subsample (test set), randomly selected in previous works. The main contribution of this work is the analysis of this test set as well as the search for an optimal process of division (split) of the stations in two sets, one used to perform the multiple regression and residuals interpolation (fit set), and another used to compute the quality (test set); optimal division should reduce spatial uncertainty and improve the overall quality.

Two methods have been evaluated against classical methods: (random selection RS and leave-one-out cross-validation LOOCV): selection by Euclidian 2D-distance, and selection by anisotropic 2D-distance combined with a 3D-contribution (suitable weighted) from the most representative independent variable. Both methods define a minimum threshold distance, obtained by variogram analysis, between samples.

Main preliminary results for LOOCV, RS (average from 10 executions), Euclidian criterion (EU), and for anisotropic criterion (with 1.1 value, UTMY coordinate has a bit more weight than UTMX) combined with 3D criteria (A3D) (1000 factor for elevation), applying different interpolation methods/parameters are shown:

RMS (mm) error values obtained from the independent test set (20 % of the samples) follow, according to this order: IDW (exponent=1.5, 2, 2.5, 3) / SPT (tension=100, 125, 150, 175, 200) / OK.

LOOCV: 92.5; 80.2; 74.2; 72.3 / 181.6; 90.6; 75.7; 71.1; 69.4; 68.8

RS: 101.2; 89.6; 83.9; 81.9 / 115.1; 92.4; 84.0; 81.4; 80.9; 81.1 / 81.1

EU: 57.4; 51.3; 53.1; 55.5 / 59.1; 57.1; 55.9; 55.0; 54.3 / 51.8

A3D: 48.3; 49.8; 52.5; 62.2 / 57.1; 54.4; 52.5; 51.2; 50.2 / 49.7

To study these results, a geostatistical analysis of uncertainty has been done. Main results: variogram analysis of the error (using the test set) shows that the total sill is reduced (50% EU, 60% A3D) when using the two new approaches, while the spatialized standard deviation model calculated from the OK shows significantly lower values when compared to the RS.

In conclusion, A3D and EU highly improve LOOCV and RS, whereas A3D slightly improves EU. Also, LOOCV only shows slightly better results than RS, suggesting that non-random-split increases the power of both fitting-test steps.

* Ninyerola, Pons, Roure. A methodological approach of climatological modelling of air temperature and precipitation through GIS techniques. IJC, 2000; 20:1823-1841.