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Interactive comment on "Distance in spatial interpolation of daily rain gauge data" *by* B. Ahrens

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Why inverse distance weighting interpolation?

The author appreciates the comment of A. Bardossy and the response from the anonymous referee #1. Both responses were particularly helpful in making obvious that I have to clarify my choice of the inverse distance interpolation method as a prototype spatial interpolation method.

The paper's main idea is to use parsimoniously in spatial precipitation interpolation at daily time-scale the statistical information of observed precipitation time series from a dense station network whose actual observations are not available at the date of interest. The statistical information of a dense rain station network shall be applied in interpolation of a coarser network with available data. It is proposed and successfully applied to replace geographical distance by some statistical distance between station sites in interpolating available observations to unobserved station sites by some standard interpolation method. This is a parsimonious approach of using the historical information of the dense station network. Effectively, this is a densification of the number of available observations or a method for filling in missing data as A. Bardossy noted in his comment. In a precipitation gridding analysis the densification has to be complemented by interpolation of the densified observation network to a spatial interpolation grid by methods like Inverse Distance Weighting (IDW) interpolation or Kriging variants.

The paper applies the IDW in densification for good reasons:

- IDW and its close derivatives are widely used in the scientific community (as the referee 1 noted in his response) and in operational services. In interpolation of Alpine precipitation the IDW method is easy to apply, robust, and with simple modifications competitive with more elaborated methods like Kriging or smoothing spline interpolation as discussed in cited papers.
- It is very easy to apply statistical distances in IDW. It is readily done by replacing the spatial distance matrix with the statistical distance matrix in an already existing IDW implementation.
- The IDW method is an ideal prototype interpolation method since the impact of statistical distance can easier be illustrated than in more elaborated methods like Kriging or multiple linear regression. This will briefly be discussed in the following.

A. Bardossy proposed comparison of statistical IDW with multiple linear regression (MLR). If statistical distance is formulated in terms of linear correlation, then statistical IDW could be thought of as an amputated MLR assuming that all actual observations are independent and all observations have the same time series variance. Therefore, MLR should perform better. But, MLR has some disadvantages: the regression coefficients have to be estimated and algorithmically dealt with for each interpolation site and network topology separately and this is formidable task, the statistical advantages of MLR are questionable in case of a non-normal variate like daily precipitation, it is shown in the paper that a correlation distance is less appropriate than a semi-variance type distance because of systematic effects (of course, this can be dealt with by modification of classical MLR, but a discussion of this would obscure the main aspects of the paper), and it is less often applied.

The referee proposed application of optimal interpolation, a close relative to Kriging, because of the estimation of correlation functions or more general of climatological variograms from historical data. The variate that has to be interpolated in the context of the discussed paper is highly heterogeneous and anisotropic. Therefore, instead of variograms the matrices of site-site semi-variances should be applied as noted by the referee. These matrices have to be estimated for each interpolation site and all possible network topologies. This, again, should improve interpolation results since IDW neglects the statistical inter-relationships between the actually observing stations. The IDW is a sub-optimal version of the more elaborated method, here the Kriging method, but an easier to understand and implement, and more robust method. Optimal interpolation of daily precipitation is applied operationally, for example, in the analysis system SAFRAN by Meteo France (Durand et al. 1993), but the envisaged pixel support is the massif scale ($\sim 500\,\mathrm{km}^2$). At this scale many of the orographic effects making the difference between geographical and statistical distance are smoothed out.

A promising extension of the statistical distance approach that is easy to implement would be re-mapping the station locations in statistical space and interpolation in statistical space instead of in spatial space. This re-mapping could be done by multi-dimensional scaling and would allow interpolation at nether observed sites, for example, by Kriging. I mentioned this in the conclusion section of the paper, but this is a topic for further research since on one hand variogram estimation on a day-by-day basis is not robust and on the other hand climatological variograms shouldn't be applied in statistical space with applying the same historical observations in re-mapping as well as in variogram estimation.

Hopefully I could further motivate the application of the IDW method in the paper as a vehicle for illustrating the idea of statistical distance and some interesting artifacts in interpolation of daily Alpine precipitation.

Reference

Durand, Y., Brun, E., Mérindol, L., Guyomarc'h, G., Lesafre, B,. and Martin, E.: A meteorological estimation of relevant parameters for snow schemes used with atmospheric models. *Ann. of Glaciol.*, **18**, 65-71, 1993.

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