Using multidimensional scaling with Duchon splines for reliable finite area smoothing

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Keywords: spatial smoothing, generalised additive models, within-area distances, splines

Splines are often used to perform smoothing over geographical regions. However when boundary features intrude into the study region, splines may smooth across the features in a way that makes little sense and may be misleading. Other smoothers also suffer form this problem of inappropriately linking parts of the domain (for example either side of a river or peninsula). One view is that the problem is caused by the smoother using of an unsuitable metric to measure the distance between points. A simple substitution of within-region distances in place of Euclidean distances has been proposed previously to combat this problem, with some success, but at the price of some loss of clarity about what the resulting smoothing objective means, and quite high computational cost.

Our new approach takes within-area distances and uses them to project the location data into a new (often high-dimensional) space using multidimensional scaling. Conventional smoothing can then take place in this new space in which the euclidean distances between points now approximates the original within-region distances. We show that Duchon's 1977 generalisation of thin plate splines has particular advantages for smoothing in the MDS space.

As well as finite area smoothing, the new method provides a means for smoothing with respect to general distance measures, and examples of both spatial smoothing and more general distance-based smoothing are given.