Water table mapping using Bayesian data fusion with auxiliary data

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Water table elevations are usually sampled in space using piezometric measurements, that are unfortunately both expensive to drill and monitor and consequently are thus scarce over space. Most of the time, piezometric data are sparsely distributed over large areas, thus providing limited direct information about the level of the corresponding water table. As a consequence, there is a real need for approaches that are able at the same time to (i) provide spatial predictions at unsampled locations and (ii) enable the user to account in a meaningful way for all potentially available secondary information sources that are in some way related to water table elevations. Advantages of these auxiliary information sources are their cheapest prices and their better spatial coverage, thus allowing the user to improve the quality of subsequent mapping provide that a meaningful way of merging these data is made available.

In this paper, a recently developed Bayesian Data Fusion technique (BDF) is applied to the problem of water table spatial mapping. After a brief presentation of the underlying theory, specific assumptions are made and discussed in order to account for a digital elevation model as well as for the geometry of a corresponding river network. Based on a data set for the Dyle basin in the north part of Belgium, the suggested model is then implemented by accounting for two secondary information sources, i.e., a spatially exhaustive high resolution digital elevation model and a metric allowing us to account for the whole geometry of the river network as auxiliary information.

Results are compared to those of standard spatial mapping techniques like ordinary kriging and cokriging. Respective accuracies and precisions of these estimators are finally evaluated using a leave-one-out cross-validation procedure. They show one one side the obvious benefit of incorporating additional information sources, but more interesting they also emphasize the limitations of traditional multivariate methods (like, e.g., cokriging methods) that fail to efficiently take benefit of these addditional information due to restrictive modeling hypotheses, whereas BDF has no difficulty on that side.

Though the BDF methodology was illustrated here for the integration of only two secondary information sources, the method can also be applied for incorporating an arbitrary number of auxiliary variables. It has also been successfully applied in other fields like remote-sensing and air pollution, thus opening new avenues for the important and general topic of data integration in a spatial mapping context. Extension towards a space-time context for dynamic mapping is also possible.

Keywords—kriging, cokriging, data merging, Digital Elevation Model, river network

References

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