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Bayesian surface reconstruction: examples of application and developments

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Interpolation of spatial data in 2D (surface reconstruction) is routinely performed in many fields of geoscience. It allows to construct new data points within the range of a discrete set of known data points (measurements). Classical interpolation schemes suffer of a number of limitations. 1) The level of smoothness in the solution has to be chosen by the user; 2) it is difficult to introduce weights to different data types when multiple datasets are used together and 3) the final solution is represented by a best-fit model without uncertainties.
In this work we explore the capabilities of the probabilistic surface reconstruction tool first developed by Bodin et al. 2012. The Bayesian framework in which is developed allows to overcome the limitations of the conventional methods. The surface is parametrized with Voroni cells. We use a transdimensional and hierarchical scheme in which the total number of cells and the magnitude of the data errors are treated as unknowns in the inversion.
Through synthetic tests, we show how the level of complexity (smoothness) in the reconstructed surface is directly inferred from the data, and how the solution, expressed in terms of probability distributions takes uncertainties into account. We then apply the algorithm to interpolate multiple datasets of Moho depth estimates for the British Isle to build a map of crustal thickness for the region. The retrieved map is compared with previously published results.
Lastly, we adapt the algorithm to the case that the full probability distribution for each data point is known. The assumption of Gaussian distributed errors is overcome by considering each data point as a random variable with known probability distribution. We test this approach by interpolating 1D probability distributions for Vs along a linear array of seismic stations to create a pseudo 2D section.

Bodin, T., M. Salmon, B. L. N. Kennett, and M. Sambridge (2012), Probabilistic surface reconstruction from multiple data sets: An example for the Australian Moho, J. Geophys. Res., 117, B10307, doi:10.1029/2012JB009547