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A Bayesian multisensor combination approach to surface water detection

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The measurement of physical quantities often covers a range of scales, from point observations to spatially aggregated satellite observations. The problem of assimilating multiple data sources is complicated by the fact that the data fusion process must include a solution to the scale problem, beyond a combination technique. Some of the most recent techniques that account for spatial variability across many scales are for example: the multi-fractal characterization, the multiplicative random cascade models, the multiscale representation of signals and wavelet transforms and the multi-resolution stochastic processes on dyadic trees. They are effective techniques but their application in an operative context might be difficult. In this sense a promising approach is represented by the techniques based on the so called Rauch-Tung-Striebel (RTS) smoothing algorithm, which support the fusion of data at different resolution, with modest computational loads. An operative example is the algorithm which was applied to the problem of estimating the shape of the ocean surface from satellite altimetry measurements by means of the TOPEX/POSEIDON altimeter.

The paper presents an original Bayesian technique for assimilating data provided on a spatial grid, such as satellite remote sensing data, and point measurements. The Bayesian combination technique is based on the use of Block Kriging, Kalman filter and fixed interval Kalman smoothing (RTS). The problem of the spatial interpolation of point measurements is solved using Block Kriging. In particular, a Maximum Likelihood estimator is used to estimate the semi-variogram parameters in real-time, thus avoiding the typical smoothing in Block Kriging estimates. The Kalman filter combines Block Kriging and Satellite estimates considering real-time updatings of their covariance errors matrixes, while a nontrivial simplification of the Rauch-Tung-

Striebel (RTS) smoothing algorithm is used to solve the downscaling problem.

The proposed technique was applied to rainfall estimates. In particular it was used for combining weather radar, satellite and ground based raingauge data, thus providing rainfall estimates at a spatial scale suitable for hydrologic applications, at a modest computational cost. However, it is not limited to rainfall data assimilation, but it could be used for other applications, as for example the detection of surface water or the problem of estimating the shape of a water surface from satellite altimetry measurements.