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Optimization of floodplain monitoring sensors through an entropy approach

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To support the decision making processes of flood risk management and long term floodplain planning, a significant issue is the availability of data to build appropriate and reliable models. Often the required data for model building, calibration and validation are not sufficient or available. A unique opportunity is offered nowadays by the globally available data, which can be freely downloaded from internet. However, there remains the question of what is the real potential of those global remote sensing data, characterized by different accuracies, for global inundation monitoring and how to integrate them with inundation models.
In order to monitor a reach of the River Dee (UK), a network of cheap wireless sensors (GridStix) was deployed both in the channel and in the floodplain. These sensors measure the water depth, supplying the input data for flood mapping. Besides their accuracy and reliability, their location represents a big issue, having the purpose of providing as much information as possible and at the same time as low redundancy as possible. In order to update their layout, the initial number of six sensors has been increased up to create a redundant network over the area. Through an entropy approach, the most informative and the least redundant sensors have been chosen among all.
First, a simple raster-based inundation model (LISFLOOD-FP) is used to generate a synthetic GridStix data set of water stages. The Digital Elevation Model (DEM) used for hydraulic model building is the globally and freely available SRTM DEM.
Second, the information content of each sensor has been compared by evaluating their marginal entropy. Those with a low marginal entropy are excluded from the process because of their low capability to provide information. Then the number of sensors has been optimized considering a Multi-Objective Optimization Problem (MOOP) with two objectives, namely maximization of the joint entropy (a measure of the information content) and minimization of total correlation (a measure of redundancy). From analysis of the Pareto optimal solutions, the optimal number of sensors is evaluated.
Finally the LISFLOOD-FP model is calibrated considering both the whole sensor network, and the set of sensors chosen by the genetic non sorted algorithm (NSGA-II) that solved the MOOP. In the absence of a suitable observed data set, the calibration is performed using by treating results provided by a physically based 2D hydrodynamic model (TELEMAC 2D) as ‘truth’ in order to evaluate the potential value of the model based on the coarse resolution DEM (SRTM).