Geophysical Research Abstracts, Vol. 9, 09727, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-09727

Using AI to enhance the estimation of flood water levels by merging DTM and satellite imagery

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Some studies have demonstrated the potential of merging DTM and flood imagery for estimating water levels. These estimations are spatially non-uniform over the plain and are often of poor quality, i.e. estimations remain rather uncertain: for instance, Brackenridge et al. (1998) obtain intervals of remotely sensed water levels varying between 1 and 3m from ERS images. To obtain an accuracy acceptable for hydraulic modelling, our methodology builds on two main ideas: (1) a definition of a merging procedure for DTMs and flood imagery to obtain a confidence interval of estimates, and (2) reduction of estimation uncertainties by an AI constraining procedure. For the merging procedure, relevant locations are selected, and provide an adequate interval of water levels (Min, Max). It is worth noting that the accuracy expressed as the range of plausible values varies according to location. In areas with no information available from the flood imagery, a large interval is provided. The aim is to obtain an envelop of estimates that may be very large but certainly brackets the 'true' value. The constraining procedure generates a constraining in uncertainties. It is based on simple hydraulic laws, applied on a flow scheme over the flood plain. Successive water levels are to decrease with flow direction. These rules are translated into a system of numerical constraints that is solved by AI techniques. The results show both a strong decrease in the Min Max interval width and bring a complementation in the distribution of the flood depth estimates over the flood plain.

This procedure has been applied to the Mosel River (France) with aerial photographs for the flood of 05/1983, with Radarsat imagery for the flood of 02/1997, and for the Alzette River (Luxembourg) with ENVISAT imagery for the flood of 01/2003. Without application of the constraining procedure, the mean values for the envelop of esti-

mates (Min Max intervals) range from 0.80 m for aerial photography to 1.60 m from satellite radar images. After application, the mean interval decreases to respectively 0.40 and 0.80 m. Note that this interval is larger than the ‘real’ accuracy: it represents the envelop that includes the ‘true’ value of water levels. To approach the real accuracy, we have considered the mean value (Min+Max /2) as the best possible estimate: the validation conducted on the Alzette River with field-recorded flood levels provides a RMS of 0.13 m, which seems acceptable for hydraulic needs.