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Estimating uncertainty associated with water stages from a single SAR image using a stepped GLUE approach

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It is the goal of remote sensing to infer information about objects or a natural process from a remote location. This invokes that uncertainty in measurement should be viewed as central to remote sensing. Estimating the magnitude of uncertainty of some estimate is needed to (a) associate some level of accuracy with that estimate with some degree of certainty, (b) better understand the way such estimate is derived, and (c) use that quantification to some meaningful ends. In this study, the uncertainty associated with water stages derived from a single SAR image for the Alzette (G.D. of Luxembourg) 2003 flood is assessed using a stepped Generalised Likelihood Uncertainty Estimation (GLUE) procedure. Main uncertain input factors to the SAR processing chain for estimating water stages include geolocation accuracy, spatial filter window size, image thresholding value, DEM vertical precision and the number of river cross sections. Initial results show that even with plausible parameter values uncertainty in water stages over the entire river reach is very large. Adding spatially distributed field water stages to the GLUE analysis following a one-at-a-time approach helps to considerably reduce SAR water stage uncertainty thereby identifying appropriate value ranges for each uncertain SAR water stage processing factor. For the GLUE analysis a Nash-like efficiency criterion adapted to spatial data is proposed whereby acceptable SAR model simulations are required to outperform a simpler hydraulic model based on the field-surveyed average river bed gradient. Weighted cumulative distribution functions (CDFs) for all factors based on the proposed efficiency criterion allows

the generation of reliable uncertainty quantile ranges and 2D maps that show the total uncertainty associated with SAR-derived water stages. The stepped GLUE procedure demonstrated that different field data locations have different uncertainty constraining power and that not all field data collected are necessary to achieve maximum constraining. A possible efficient way to decide on relevant locations at which to sample in the field is proposed. It is also suggested that the resulting uncertainty ranges and flood extent or depth maps may be used to evaluate 1D or 2D flood inundation models in terms of water stages, depths or extents. For this, the extended GLUE approach, which copes with the presence of uncertainty in the observed data, may be adopted.