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Hydrology and Earth System Sciences Discussions

Interactive comment on "Improved estimation of flood parameters by combining space based SAR data with very high resolution digital elevation data" *by* H. Zwenzner and S. Voigt

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First of all, the authors wish to thank Mr. Schumann for the comprehensive comments, valuable remarks and critique. We try to respond and give our opinion to each individual point of the comment. The initial comment by Guy Schumann is printed in italic and the answer is printed in bold.

*Suggestions to improve: Introduction: *More references should be put in for the verification of models with SAR extent. Although the reference of Bates et al., 2006 is very appropriate here, the authors may want to have a look at: Pappenberger, F., K. Frodsham, K. Beven, R. Romanowicz, and P. Matgen (2007), Fuzzy set approach to*

*calibrating distributed flood inundation models using remote sensing observations, Hydrology and Earth System Sciences, 11, 7398211;752. Also, there is a very nice paper on merging LiDAR with image processing on SAR: Mason, D. C., M. S. Horritt, J. T. Dall8217;Amico, T. R. Scott, and P. D. Bates (2007), Improving river flood extent delineation from Synthetic Aperture Radar using airborne laser altimetry, IEEE Transactions on Geoscience and Remote Sensing, 45, 39328211;3943. *The authors say that image shifting to correct for positional inaccuracies for local level extraction is one of their aims. A near identical procedure has been proposed in other studies: G. Schumann, A. Black, M. Cutler, J. B. Henry, L. Hoffmann, P. Matgen, and L. Pfister, 8220;Hydraulic and event knowledge to reduce the positional uncertainty in SAR flood images for improved flood model calibration and development,8221; in Proc. 7th Int. Symp. Spat. Accuracy Assessment Natural Resources and Environ. Sci., Lisbon, Portugal, Jul. 58211;7, 2006, pp. 6338211;642. Some reference to this work is also given in the paper on line 21 on page 2965. Despite the similarities to this paper, the authors do not give any reference to the studies in their method section!*

The authors wish to thank for the suggestion of the additional references. We think that the work of Pappenberger et al. (2007), Mason et al. (2007) and Schumann et al. (2007) are definitely worth to be cited in the final version of our paper. We will also elaborate on the similarities and differences of our approach with the study of Schumann et al. (2007) in our methodology section. In our opinion, the main difference is that we try to compensate geometric distortions AND thematic classification errors.

*Elbe part: *There is not enough information on the Radarsat image used. Is it VV or HH?*

Radarsat-1 only has C-band HH polarization capability. The incidence angle of the Radarsat-1 scene from 18 August 2002 was 41 degree. We will include this information in the final text version.

HESSD

5, S2028–S2032, 2008

I think the very large disagreement in Figure 3 between the SAR and IKONOS only within 3 hours could be an indication that there is too much distortions from the proximity of the urban areas and thus would indicate that for such a situation traditionally available SAR images do not work well and that there is thus a need for much more appropriate radiometric as well as higher spatial resolutions, such as provided by TerraSAR-X in such situations. This or a similar conclusion could be put at the end of the Elbe case study, as it highlights the need for TerraSAR-X.

This conclusion agrees very much with our opinion. We will describe in greater detail the limitations of the traditional medium resolution SAR systems for such studies and thus highlight the need for modern high resolution SAR satellite systems such as TerraSAR-X.

*Severn part: *The cross sections on Fig. 5 are plotted on two rivers showing a confluence (River Avon in NE and Severn). Which one is plotted in Fig 6. and 7.? Need to be clear, as I would expect to see a divergence in the water surface on the graph at some point along the river if the two rivers were plotted!*

In Figure 7, the longitudinal profile of the River Severn is shown without the tributary (River Avon). This will be clarified in the legend.

Fig. 7 seems to indicate that the reach length is far too short for this topographic gradient (for the River Severn for instance it is only around 60 cm over 7 km. Probably around 20 km would have accounted for some irregularities and as a result you would be very likely to have more of a downward trend too.

Unfortunately, we had only a small subset of the LiDAR DEM (7x7 km) available for this study. We are sure that the consideration of a longer part of the river would confirm your assumption.

The authors claim that the variations in Fig. 7 are due to some classification errors (which ones?) and vegetation height instead of bare ground elevations. Are the au-

HESSD

5, S2028–S2032, 2008

Interactive Comment

thors not using a bare ground DEM from the Env. Agency? If so, why not? If the authors mean remaining very short vegetation (which the LiDAR erosion algorithm did not remove) they should clearly state this. I do not believe that remaining very short vegetation in some local areas could have that much of an effect.

We used the bare ground DEM of the Environmental Agency as the underlying reference on which the flood profiles were fitted and the flood depth was derived. Although we have no particular information on how vegetation and other objects were removed from this LiDAR DEM, automatic methods are generally based on interpolation in order to generate a bare ground elevation model. Although we use the DEM as underlying reference and thus as "'truth"', we have to take into account that minor residual errors in the elevation model may be one possible explanation for the irregularities with the TerraSAR-X flood profiles and the considerable scattering in the elevation of the flood profiles shown in Fig. 7. However, we think that misclassifications due to flooded vegetation or wind may be the very likely source of these irregularities.

**The authors state that possible explanations for the difference within 15 hrs observed in Fig. 6 could be: - the flood situation was recorded between two flood waves or there was a breach. These two possibilities need to be checked in detail - a tidal influence. I think it is quite unlikely that a tidal influence would reach as far as the Tewkesbury location*

Our explanations aimed to describe the depression in the mid-section of the longitudinal profile shown in Fig. 7 rather than the difference between flood levels from TerraSAR-X and orthophotos shown in Fig. 6. It was our intent to discuss possible hydraulic solutions for the increasing water level in downstream direction. We made three theoretical assumptions which we agree have to be checked in detail for this particular flood event. As we mentioned above, we only examined a small reach of about 7 km length and very gentle gradient in flow direction. The observation of a longer reach would give a more comprehensive picture of

HESSD

5, S2028–S2032, 2008

Interactive Comment

the flood situation.

**Generally the part on the River Severn needs to be re-visited by the authors. I believe much can be improved here, which may well show that TerraSAR-X has the potential to support flood management close to or even inside urban areas*

Although we think that TerraSAR-X has the potential to support flood management in urban areas, it was not the objective of our paper to verify this. With this paper we try to give an example how a flood event which is connected to the main river channel can be quickly examined and flood depth can be derived using SAR satellite data, a high resolution DEM and the centreline of a river. This study should be considered as a contribution to the field of crisis mapping and rapid damage assessment and stands in contrast to a number of more complex studies found in the literature using hydraulic modeling approaches for example. In the Severn example it turned out that the flooded urban areas which were not connected to the main flood water body could not be sufficiently represented by the profile method based on the centerline of the main river. Other methods have to be applied and also the higher resolution SpotLight mode of TerraSAR-X should be used to show the potential of the sensor for flood detection in urban areas. However, this was excluded from this study but will be part of another upcoming paper.

We want to thank Mr. Schumann again for the above comments and we will gratefully take them into account for the revision of our paper.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 5, 2951, 2008.