RESOLUTION ISSUES OF ELEVATION DATA DURING INUNDATION MODELING OF RIVER FLOODS

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During the last decade, many countries have suffered from severe river floods. Meanwhile, politicians, public authorities, organizations, etc. have realized that river flooding is not some improbable event, only happening to others. Also, a global climate change is expected to occur which may further increase the frequency and magnitudes of heavy storm events. Therefore, it is not a question of if rivers will be flooded, it is question of when and how much. This puts a big responsibility on physical planners, etc. to make sure that new areas are not planned at places which may be flooded, or that already existing areas can be managed to minimize the effects of floods. One way to be better prepared for river flooding events is to produce inundation maps of different flood magnitudes, which can be used either when storm events are expected, or for use in physical planning. In this paper a case study of the Eskilstuna River in Sweden is presented. This study, as well as an earlier study of river flooding in Eskilstuna, is carried out within the project KRIS-GIS®, a Swedish initiative of handling crisis situations, including flooding. The earlier flooding studies have been carried out by Yang et al. (2001) and the Swedish Meteorological and Hydrological Institute (SMHI, 2001). Yang et al. (2001) used MIKE 21 as hydraulic modeling software and SMHI (2001) used MIKE 11. The results from these studies have been criticized for being too uncertain, because the inundation maps are based on elevation models (DEM) of 2500 m^2 (50×50 m) grid-cell sizes. The purpose now is to show how different resolutions in input elevation data affect the resulting inundation maps.

For this study an airborne laser scanner survey was conducted, generating 41 million data points, i.e. approximately 2 points per square meter. A terrain model was constructed in ArcView GIS as a triangulated irregular network (TIN), which served as the base for all later modeling. The hydraulic modeling was done as one-dimensional steady flow in HEC-RAS flow routing software (Hydrologic Engineering Center, 2002). The input to the model was cross sections derived from the GIS and four different water discharges: 23.7 $m^3\ s^{-1}$ is the mean water discharge, 70 $m^3\ s^{-1}$ is the annual flood, 123 $m^3\ s^{-1}$ is the 100-year flood, and 198 $m^3\ s^{-1}$ is the calculated highest flow possible (not related to any frequency). After running the HEC-RAS model for different water discharges, the resulting water-surface elevations for all cross sections were imported back to ArcView and inundation polygons were created. Inundated areas were calculated for the different water discharges, for different resolutions of the rasters, as well as for different friction values, i.e. Manning's n. See e.g. Tate et al. (2002) for comprehensive descriptions on the methods when using ArcView and HEC-RAS.

The results of the hydraulic modeling and following inundation analysis can be seen in Fig 1. Not surprisingly, using high-resolution elevation data leads to better inundation results than do low-resolution elevation data.

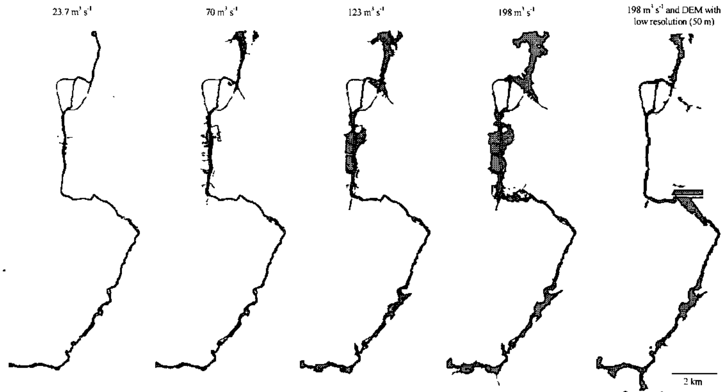

Fig. 1 Different inundation scenarios. From left to right: 23.7 m^3 s^{-1} is mean water discharge, 70 m^3 s^{-1} is annual flood, 123 m^3 s^{-1} is 100-year flood, and 198 m^3 s^{-1} is maximum probable flood. The last map shows inundation based on a low-resolution DEM.

Several different flooding scenarios have been modeled. Results, based on different ground elevation resolution, have been exported to a GIS and mapped as inundation areas. The better the ground resolution, the better and more exactly the inundated areas can be determined. It is also shown that by using ground-elevation data of poorer resolution, the resulting inundated areas will differ so much, that usage of the results is affected. E.g., incorporation of accurate flooded areas in detailed physical planning will be limited.

To be able to model small narrow rivers, high-resolution data is necessary. Otherwise, the river may be totally invisible in the results. For larger wider rivers, high-resolution data may not seem to be necessary, but if delineation of the flooded areas needs to be correct, high-resolution is needed. If high-resolution data are used, then determination of Manning's n will be the limiting factor for correct inundation results. Therefore, differentiation of n depending on landuse is of importance.

A weakness in inundation modeling is to know which water discharge to use. For example, should statistical data be used, such as the 100-year flood? Should a maximum probable flow be used, or are there any other factors that need to be considered?

Keywords: Digital elevation models; Scale; Floods; Inundation; GIS; HEC-RAS; Hydraulic modeling; Airborne laser altimetry

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