Geophysical Research Abstracts
Vol. 16, EGU2014-15318-1, 2014
EGU General Assembly 2014

Calibration of 2D Hydraulic Inundation Models with SAR Imagery in the Floodplain Region of the Lower Tagus River

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Floods account for 40% of all natural hazards worldwide and were responsible for the loss of about 100 thousand human lives and affected more than 1,4 million people in the last decade of the 20th century alone. Floods have been the deadliest natural hazard in Portugal in the last 100 years. In terms of inundated area, the largest floods in Portugal occur in the Lower Tagus (LT) River. On average, the river overflows every 2.5 years, at times blocking roads and causing important agricultural damages. The economical relevance of the area and the high frequency of the relevant flood events make the LT floodplain a good pilot region to conduct a data-driven, systematic calibration work of flood hydraulic models.

This paper focus on the calibration of 2D-horizontal flood simulation models for the floods of 1997, 2001 and 2006 on a 70-km stretch of the LT River, between Tramagal and Omnias, using the software Tuflow. This computational engine provides 2D solutions based on the Stelling finite-difference, alternating direction implicit (ADI) scheme that solves the full 2D free surface shallow-water flow equations and allowed the introduction of structures that constrain water flow.

The models were based on a digital terrain model (DTM) acquired in 2008 by radar techniques (5m of spatial resolution) and on in situ measurements of water elevation in Omnias (downstream boundary condition) and discharge in Tramagal and Zezere (upstream boundary conditions). Due to the relevancy of several dykes on this stretch of the LT River, non-existent on the available DTM, five of them were introduced in the models. All models have the same boundaries and were simulated using steady-state flow initial conditions. The resolution of the 2D grid mesh was 30m. Land cover data for the study area was retrieved from Corine Land Cover 2006 (CO-ordination of INformation on the Environment) with spatial resolution of 100m, and combined with estimated manning coefficients obtained in literature for the different land cover classes.

Flood extent maps, derived from satellite-born Synthetic Aperture Radar (SAR), namely ERS SAR and ENVISAT ASAR imagery, provided the spatially distributed data needed for the calibration of the hydraulic models for the several floods. The flood extent maps obtained for each simulation were then compared with the flood extent maps derived from SAR imagery for each flood and the roughness coefficients changed accordingly. The models were also calibrated in terms of the stage at the gauging station Almourol, located 12km downriver from Tramagal. The combination of the calibration results for the several past floods provided 100 meters resolution Manning coefficient maps of the study area. An application of the obtained calibrated Manning coefficient maps was made for the largest flood of the 20th century (February 1979), for which no SAR imagery was available. In this case validation of the model was made in terms of the stage at the gauging station Almourol and at flood stage marks distributed throughout the floodplain.