Geophysical Research Abstracts
Vol. 19, EGU2017-18898, 2017
EGU General Assembly 2017

Using high-performance mathematical modelling tools to predict erosion and sediment fluxes in peri-urban catchments

André Pereira (1), Daniel Conde (2), Carla S. S.Ferreira (3), Rory Walsh (4), and Rui M L Ferreira (2)

(1) Instituto Superior Técnico, Universidade de Lisboa, Lisboa, Portugal, (2) CERIS, Instituto Superior Técnico, Universidade de Lisboa, Lisboa, Portugal, (3) CERNAS, Coimbra Agrarian Technical School, Polytechnic Institute of Coimbra, Bencanta, Coimbra, Portugal, (4) Department of Geography, College of Science, Swansea University, Swansea SA2 8PP, United Kingdom

Deforestation and urbanization generally lead to increased soil erosion andthrough the indirect effect of increased overland flow and peak flood discharges. Mathematical modelling tools can be helpful for predicting the spatial distribution of erosion and the morphological changes on the channel network. This is especially useful to predict the impacts of land-use changes in parts of the watershed, namely due to urbanization. However, given the size of the computational domain (normally the watershed itself), the need for high spatial resolution data to model accurately sediment transport processes and possible need to model transcritical flows, the computational cost is high and requires high-performance computing techniques.
The aim of this work is to present the latest developments of the hydrodynamic and morphological model STAV2D and its applicability to predict runoff and erosion at watershed scale.
STAV2D was developed at CEris – Instituto Superior Técnico, Universidade de Lisboa – as a tool particularly appropriated to model strong transient flows in complex and dynamic geometries. It is based on an explicit, first-order 2DH finite-volume discretization scheme for unstructured triangular meshes, in which a flux-splitting technique is paired with a reviewed Roe-Riemann solver, yielding a model applicable to discontinuous flows over time-evolving geometries. STAV2D features solid transport in both Euleran and Lagrangian forms, with the aim of describing the transport of fine natural sediments and then the large individual debris. The model has been validated with theoretical solutions and laboratory experiments (Canelas et al., 2013 & Conde et al., 2015).
STAV-2D now supports fully distributed and heterogeneous simulations where multiple different hardware devices can be used to accelerate computation time within a unified Object-Oriented approach: the source code for CPU and GPU has the same compilation units and requires no device specific branches, like the standard observed in available models. The assembled parallel model is expected to achieve faster than real-time simulations for high resolutions (from meters to sub-meter) in large scaled problems (from cities to watersheds), effectively bridging the gap between detailed and timely simulation results.
The model was validated in Ribeira dos Covões watershed, a peri-urban catchment (6 km2) in the outskirts of the Coimbra city, in central Portugal. Urban land-use has increased from 6% in 1958 to 40% in 2012. The watershed geology comprises a limestone sandstone areas. The soils are generally deep and hydrophobic for part of the year, particularly in the forested areas. Previous research used a sediment fingerprinting approach to establish the relative importance of sediment inputs from different urban areas (Ferreira et al., submitted). The study showed that most of the current catchment erosion is derived from construction sites in the sandstone areas. This was supported by the higher measured discharges and suspended sediment concentrations in storm events from downslope tributaries.
The results of the model are well correlated with field surveys. However, the sever disruption of the channel network by human usage, namely land partition, poses specific modelling challenges, causing the quantitative agreement to be poor. To tackle this problem, it is necessary to introduce as much detail as possible in the specification of the elevation model.

Acknowledgements
This research was partially supported by Portuguese and European funds, within programs COMPETE2020 and PORL-FEDER, through project PTDC/ECM-HID/6387/2014 granted by the National Foundation for Science and Technology (FCT).

References

Canelas, R.; Murillo, J. & Ferreira, R.M.L. (2013), Two-dimensional depth-averaged modelling of dam-break

flows over mobile beds. Journal of Hydraulic Research, 51(4), 392-407.
Conde, D.A.S.; Telhado, M.J.; Viana Baptista, M.A. & Ferreira, R. M. L. (2015) Severity and exposure associated with tsunami actions in urban waterfronts: the case of Lisbon, Portugal. Natural Hazards, Springer, 79
Ferreira, C.S.S.; Walsh, R.P.D., Blake, W.H., Kikuchi, R. Ferreira, A.J.D., Temporal dynamics of sediment sources in an urbanizing Mediterranean catchment. Land Degradation and Development (submitted)