Erosion modeling towards, and sediment transport modeling in the unnavigable watercourses in Flanders, Belgium

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Introduction:
In order to develop an effective and efficient policy for sediment control in Flanders, a tool is needed that enables an optimal estimation of soil erosion and sediment supply towards the watercourses, and sedimentation and re-suspension within these watercourses. Therefore, the Flemish Environment Agency (VMM) and the Flemish Department of Environment, Nature and Energy (LNE) have awarded Antea Group and KULeuven a project aimed at the development of a suitable (hydrological) sediment export (soil erosion) and (hydraulic) sediment transport model (SEM and STM, respectively) for the unnavigable watercourses in Flanders.
The SEM needed to be capable of calculating the soil erosion, on-land sedimentation and sediment export on a pixel base ($20x20m^2$), both for an event and on a yearly base. A methodology had to be developed to connect the SEM to the STM, transferring the sediment export from land to watercourses. Sewers, roads, preferential flow paths, etc., had to be taken into account. The STM then had to simulate the sediment transport on an event basis along the watercourses, together with the sedimentation and re-suspension processes per sector of the Flemish Hydrographical Atlas. Moreover, the SEM had to be able to properly implement Erosion Control Measures (ECMs), e.g. grass buffer strips, while the STM needed to be able to deal with watercourse reorganization projects, e.g. sediment traps.
Nine erosion prone river catchments (< 110 km²) were selected as study areas. Furthermore, a simplified version of the SEM and STM had to be developed for the 11 Flemish river basins (ranging from 577 to 1916 km²).

Results and discussion:
A wide range of empirical to physically based models was evaluated in terms of their suitability and applicability as SEM. After a thorough screening, the process based model OpenLISEM and a combination of the empirical, spatially distributed and RUSLE-based WATEM/SEDEM (WS) model (sediment dynamics) with a modified and both spatially and temporally distributed version of the Curve Number (CN) model (runoff generation) were applied for two Flemish erosion prone river catchments on an event base. Both catchments had been extensively studied and sampled in the past. From this evaluation appeared that OpenLISEM suffered from equifinality, overparameterisation and lack of input data. Furthermore, the results with the combined CN/WS model were promising. Therefore, the combined CN/WS model was further modified to take sewers and preferential flows along parcel boundaries into account, to distribute the sediment load (WS) over the runoff hydrogram (CN) resulting in a sedigram, to be able to perform long term simulations (significant rainfall events alternating with relative droughts), to be able to take the implementation of ECMs into account, etc. A GUI was developed for a user-friendly application of the CN/WS model. The model was applied for nine Flemish river catchments for 2 winter and 2 summer rainfall events. This resulted in a general modelled vs. measured runoff ratio of 2.73 and a general modelled vs. measured sediment ratio of 0.95. Taking the uncertainty of event based modelling into account the results were satisfactory, and a number of potential improvements were identified.
Given the availability of hydrodynamic models in Flanders, both InfoWorks River Systems and Integrated Catchment Modelling (ICM) (Innovyze Ltd.) were evaluated as STM. Both models solve the full SWE explicitly in a finite volume scheme and several sediment transport equations are implemented to solve a sediment continuity equation. A thorough evaluation of both models for a Flemish river catchments revealed that IWRS suffers from stability and compatibility problems and is subject to several methodological drawbacks. Therefore, ICM was assigned as the proper software for the STM. This resulted in an ongoing re-developed of the sediment transport module of ICM, based on the requirements analysis conducted in this study. Sediment transport will be modelled in 1D in the river channels and in 2D in floodplains.