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PyCatch: catchment modelling in the PCRaster framework

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PCRaster is an open source software framework for the construction and execution of stochastic, spatio-temporal, forward, models. It provides a large number of spatial operations on raster maps, with an emphasis on operations that are capable of transporting material (water, sediment) over a drainage network. These operations have been written in C++ and are provided to the model builder as Python functions. Models are constructed by combining these functions in a Python script. To ease implementation of models that use time steps and Monte Carlo iterations, the software comes with a Python framework providing control flow for temporal modelling and Monte Carlo simulation, including options for Bayesian data assimilation (Ensemble Kalman Filter, Particle Filter). A sophisticated visualization tool is provided capable of visualizing, animating, and exploring stochastic, spatio-temporal input or model output data. PCRaster is used for construction of for instance hydrological models (hillslope to global scale), land use change models, and geomorphological models. It is still being improved upon, for instance by adding under the hood functionality for executing models on multiple CPU cores, and by adding components for agent-based and network simulation. The software runs in MS Windows and Linux and is available at http://www.pcraster.eu. We provide an extensive set of online course materials (partly available free of charge).

Using the PCRaster software framework, we recently developed the PyCatch model components for hydrological modelling and land degradation modelling at catchment scale. The PyCatch components run at time steps of seconds to weeks, and grid cell sizes of approximately 1-100 m, which can be selected depending on the case study for which PyCatch is used. Hydrological components currently implemented include classes for simulation of incoming solar radiation, evapotranspiration (Penman-Monteith), surface storage, infiltration (Green and Ampt), subsurface flow and surface water flow (kinematic wave). A number of components for modelling of water erosion have been implemented, providing capability to model water erosion largely following Modified Morgan-Morgan-Finney model equations (Morgan and Duzant 2008), soil creep, and bedrock weathering. PyCatch is built in a modular way, which makes it relatively easy to swap model components, for instance to compare different process representations, or to add new model components, for instance for modelling pollution transport or vegetation growth. By combining hydrological and land degradation components it can be used for landscape evolution modelling at geological time scales. It comes with all functionality offered by PCRaster and thus is capable of Monte Carlo simulation to calculate error propagation in models and Bayesian data assimilation. We would like to invite the modelling community to contribute to further development of PCRaster and PyCatch.

References

Morgan, R. P. C., and J. H. Duzant. 2008. Modified MMF (Morgan-Morgan-Finney) model for evaluating effects of crops and vegetation cover on soil erosion. Earth Surface Processes and Landforms 33:90–106.