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TTLEM – an implicit-explicit (IMEX) scheme for modelling landscape evolution in MATLAB

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Landscape evolution models (LEM) are essential to unravel interdependent earth surface processes. They are proven very useful to bridge several temporal and spatial timescales and have been successfully used to integrate existing empirical datasets. There is a growing consensus that landscapes evolve at least as much in the horizontal as in the vertical direction urging for an efficient implementation of dynamic drainage networks.
Here we present a spatially explicit LEM, which is based on the object-oriented function library TopoToolbox 2 (Schwanghart and Scherler, 2014). Similar to other LEMs, rivers are considered to be the main drivers for simulated landscape evolution as they transmit pulses of tectonic perturbations and set the base level of surrounding hillslopes. Highly performant graph algorithms facilitate efficient updates of the flow directions to account for planform changes in the river network and the calculation of flow-related terrain attributes.
We implement the model using an implicit-explicit (IMEX) scheme, i.e. different integrators are used for different terms in the diffusion-incision equation. While linear diffusion is solved using an implicit scheme, we calculate incision explicitly. Contrary to previously published LEMS, however, river incision is solved using a total volume method which is total variation diminishing in order to prevent numerical diffusion when solving the stream power law (Campforts and Govers, 2015). We show that the use of this updated numerical scheme alters both landscape topography and catchment wide erosion rates at a geological time scale.
Finally, the availability of a graphical user interface facilitates user interaction, making the tool very useful both for research and didactical purposes.

References

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