A simple dynamical systems approach to computationally efficient distributed hydrological modelling

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The simple dynamical systems approach has been applied with satisfactory results to multiple small catchments in various regions (Kirchner, 2009; Teuling et al., 2010; Melsen et al., 2014; Adamovic et al., 2015). All of these catchments were rather small, and the concept was applied in a lumped fashion. Since this approach assumes a quick discharge response to precipitation events, applying the concept lumped to larger catchments is most likely not appropriate. Most distributed hydrological models run on a daily time step, while an hourly time step is better suited for the common pixel size of roughly 1x1km. Therefore, we have modified the simple dynamical systems approach so it can be applied distributed with an hourly time step, where the spatial and temporal scales match the situations in which the concept has already been tested. As a result, it can be applied to bigger catchments. The distributed version has been built with an emphasis on computational performance, ensuring minimal runtimes. The grid cells are connected using a simple routing module, and snow processes can easily be enabled if relevant for the catchment. Running this model with a simulation period of one year and roughly 1700 pixels on an hourly time step takes only two seconds on a normal desktop. These low runtimes and limited number of parameters ensure that experiments with spatially distributed parameters and/or sensitivity and uncertainty analysis are way more feasible than with current models. We will show results of this model when it is applied to catchments in the Swiss Alps and the Belgium Ardennes.

Adamovic, M., Braud, I., Branger, F., & Kirchner, J. W. (2015). Assessing the simple dynamical systems approach in a Mediterranean context: application to the Ardèche catchment (France). Hydrology and Earth System Sciences, 19(5), 2427-2449.

Kirchner, J. W. (2009). Catchments as simple dynamical systems: Catchment characterization, rainfall-runoff modeling, and doing hydrology backward. Water Resources Research, 45(2).

Melsen, L. A., Teuling, A. J., Berkum, S. W., Torfs, P. J. J. F., & Uijlenhoet, R. (2014). Catchments as simple dynamical systems: A case study on methods and data requirements for parameter identification. Water Resources Research, 50(7), 5577-5596.

Teuling, A. J., Lehner, I., Kirchner, J. W., & Seneviratne, S. I. (2010). Catchments as simple dynamical systems: Experience from a Swiss prealpine catchment. Water Resources Research, 46(10).