Communicating landscape hydrology — the water cycle in a box

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[Correction added on 06 December 2016, after first online publication: To ensure a practical file size of the final document each of the embedded videos were replaced by a screenshot of the respective video — the video on the construction of the model (doi: 10.5446/18699) and the video with the visualization of hydrological processes (doi: 10.5446/18823) are freely available (CC-BY-3.0) in the archive of the Leibniz Information Centre For Science And Technology University Library (TIB).]

Abstract

Physical models are a well-established tool in education to strengthen hydrological understanding. They facilitate the straightforward visualization of hydrological processes and allow the communication of hydrological concepts, research and questions of general interest to the public. In order to visualize the water cycle in a landscape of postglacial sediments, in particular the subsurface part, a physical model was constructed. In two videos, (1) a detailed construction manual and (2) visualization examples of hydrological concepts and processes are presented. With our contribution, we like to encourage professionals in the field of hydrology to share methods and tools of knowledge transfer and communication of hydrological concepts. Copyright © 2016 John Wiley & Sons, Ltd.

Key Words science communication; physical model; hydrological process visualization; do-it-yourself (DIY); didactic tool; groundwater surface water interaction

Description

The important of groundwater as a natural resource for water supply, agriculture and ecosystems is pretty obvious to most people and usually highly valued. Nonetheless, it is very striking that the picture of how natural waters are circulating becomes typically rather rough when it comes to the subsurface part (Unterbruner et al., 2016). For many laymen, ‘groundwater’ is something relatively vague. Questions like ‘is groundwater located directly below the surface? Where does it come from? How long has it been in the ground?’, etc. often quickly arise.

To facilitate communication on many of these questions, we built a physical model of the water cycle in a landscape of postglacial sediments. The design of the model was inspired by Harnischmacher (2004) and the physical groundwater model of the hydrogeology group of the Institute of Geological Sciences of the Freie Universität of Berlin. The model comprises both the surface and subsurface part of the water cycle. To our knowledge, most other physical models in hydrology focus on specific parts of the water cycle. This is related to the long tradition in hydrology to use physical models to investigate specific hydrological questions such as the hydraulic properties of substrates (e.g. Darcy, 1856), the groundwater conditions at heterogeneous hillsides (Rulon et al., 1985), the processes in the hyporheic zone (Zhou and Endreny, 2013) or morphological features on Mars (Marra et al., 2014). The experimental focus implies the design of models that work directly on the ‘real world’ scale, e.g. a volume of soil, or models whose results are scalable to the real world (Kleinhans et al., 2010). In contrast to the models designed primarily for experimental purposes, the purpose of our model is to establish a conceptual understanding of how water is circulating through the landscape. Except from communicating hydrological research and facilitating discussions on publicly relevant hydrological questions, the model can also be used as a straightforward pedagogic tool in education. Here again, our model differs from many other...
more process-orientated physical models used for education (e.g. Rodhe, 2012) in so far that it pictures the whole water cycle, but allows at the same time to have a closer look into details.

The model consists of an aquarium in which two layers of a sand–gravel mixture (aquifers) are divided by a layer of loam (aquitard). The two aquifers can be used to simulate different groundwater levels and the origin of confined groundwater. The surface of the landscape in the model and the aquitard are inclined such that water flows from the highlands, where precipitation takes place in the model, towards the lowlands. At the foot of the slope of the highlands, we included a hollow that develops into a groundwater-fed lake, given that the groundwater level rises high enough. If the lake level continues to rise, a stream springs from the lake and dewater into the sea. From there, the water is evaporated (pumped) to the clouds (precipitation tank) and the water cycle is closed. In the lower section of the stream, we included a local aquitard in the form of a loam lense which alters the groundwater level locally.

We presented the model at various events. The audience covered the whole range from primary school children, laymen at the public day of our institute and undergraduate students to the scientific community at the European Geosciences Union General Assembly 2014. Independent of the hydrological background, interesting discussions on the model and the work of our institute developed easily. The materiality of the model – ‘the feeling of what happens’ – (Kleinhans et al., 2010) the intriguing effect of flowing water and the direct visual access to hydrological processes in the ‘familiar setting’ of a miniature landscape seem to encourage people to take a closer look at the model or ask questions. We felt this ice-breaking aspect of our model to be much stronger than, for example, the appeal of an attractive poster. The low inhibition threshold and the ‘familiar setting’ have a self-regulating aspect in it. Questions and discussions evolved naturally on the level of knowledge of the respective audiences. For example, children tend to enjoy the colouring of the water and were curious to follow its subsurface path, maybe dealing the first time consciously with something like ‘groundwater’ and its integration in the water cycle. Professionals, on the other hand, discussed specific details such as the effects of the loam lense on the local groundwater level. The model worked also very well as hands-on reference to introduce hydrological measurement equipment such as water-level metres, piezometers, data loggers or perforated gauging pipes to laymen. Overall, we found the model to be a very effective tool to communicate our work. The feedback was always very positive. That is why we want to share our experiences on the construction and the application of the model with the hydrologic community by means of the two videos presented here.

The first video (doi: 10.5446/18699) is on the construction of the model (Fig. 1). The first chapter shows in a general sketch where the different compartments of the hydrological cycle-like precipitation or subsurface flow are represented in the model. The second chapter consists of a list of components that are needed for the construction of the model. After the two introductory chapters, the viewer is guided step-by-step through the construction of the model, starting from the preparation of an aquarium to the modelling of a landscape. Each construction step consists of three parts: (1) title of the segment of the model that will be constructed, (2) a technical sketch of the next segment in the developing model and (3) a short video sequence that shows the actual construction. The video and a document with an overview of the construction steps in the video and the list of needed components and materials is given as supporting information.

The second video (doi: 10.5446/18823) presents hydrological concepts and processes, which can be visualized with the model (Fig. 2.) The viewer is guided through each scene in four steps: (1) title of the next visualization, (2) the location of the visualization marked with a red rectangle in a photo of the model, (3) a short video sequence of the visualization and (4) a technical sketch of the visualization and its location in the model. The video and a document with a summary of all scenes is given as supporting information.

Figure 1. Screenshot of the final model of the water cycle in a landscape after construction

Figure 2. Screenshot of preferential flow paths in the groundwater as one example of possible visualizations of hydrological processes
We want to emphasize that while the model can be reconstructed according to our documentation, the main purpose of the documentation of our model is to serve as a template that can be adapted to one’s own needs. We hope to inspire you with this work to communicate your own work in the same do-it-yourself spirit and share your experiences with the scientific community.

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SUPPORTING INFORMATION
Additional Supporting Information may be found online in the supporting information tab for this article.