A Voyage through Scales - Water in terrestrial systems

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Terrestrial systems – a conglomerate that includes sediments, soils, and vegetation – are the third large compartment of our environment, besides the fluid systems atmosphere and ocean. All of them exhibit structures with a range of spatial and temporal scales that cover at least 9 orders of magnitude. There is a fundamental difference, however. For the fluid systems, structures and flow are one, with structures generated by the nonlinear nature of the flow and manifest in it. In contrast, the structures of terrestrial systems are predominantly formed by processes whose time scales are many orders of magnitude larger than those of the flow and transport within them.

During our voyage, we will first consider the role of terrestrial systems in Earth's environmental machinery, will then stroll through their intricate multiscale architecture that covers some 14 orders of magnitude in space, and indeed also in time, have a short glimpse at the nature of the processes, predominantly the flow of water with just a nod to transport and interactions, and will finally formulate a key question: "Is an effective representation of processes in terrestrial systems possible, at a chosen scale of interest, and if so, how can it be gained?" There is no straight answer to this and we will visit several of its aspects – dissipative processes, representative and maximal averaging volumes, and time-scales –, will look at successes and failures, and will finally glance over to the working crews that attempt to blaze a way forward by dense observation networks, data assimilation, and high-performance computing.

This voyage will be through Earth's terrestrial systems, with a focus on soils and porous media. It should also be informative for all who are facing nonlinear processes in hierarchically heterogeneous architectures.