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A framework for using connectivity to measure and model water and sediment fluxes

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For many years, scientists have tried to understand, describe and quantify water and sediment fluxes at multiple scales (Cerdà et al., 2013; Parsons et al., 2015; Poeppl et al., 2016; Masselink et al., 2016a; Rodrigo Comino et al., 2016). In the past two decades, a new concept called connectivity has been used by Earth Scientists as a means to describe and quantify the influences on the fluxes of water and sediment on different scales: aggregate, pedon, location on the slope, slope, watershed, and basin (Baartman et al., 2013; Parsons et al., 2015; López-Vicente et al., 2015; 2016; Masselink 2016b; Marchamalo et al., 2016; Mekonnen et al., 2016). A better understanding of connectivity can enhance our comprehension of landscape processes and provide a basis for the development of better measurement and modelling approaches, further leading to a better potential for implementing this concept as a management tool. Our research provides a short review of the State-of-the-Art of the connectivity concept, from which we conclude that scientists have been struggling to find a way to quantify connectivity so far. We adapt the knowledge of connectivity to better understand and quantify water and sediment transfers in catchment systems. First, we introduce a new approach to the concept of connectivity to study water and sediment transfers. In this approach water and sediment dynamics are divided in two parts: the system consists of phases and fluxes, each being separately measurable. This approach enables us to: i) better conceptualize our understanding of system dynamics at different timescales, including long timescales; ii) identify the main parameters driving system dynamics, and devise monitoring strategies which capture them; and, iii) build models with a holistic approach to simulate system dynamics without excessive complexity. Secondly, we discuss the role of system boundaries in designing measurement schemes and models. Natural systems have boundaries within which sediment connectivity varies between phases; in (semi-)arid regions these boundaries can be far apart in time due to extreme events. External disturbances (eg. climate change, changed land management) can change these boundaries. It is therefore important to consider the system state as a whole, including its boundaries and internal dynamics, when designing and implementing comprehensive monitoring and modelling approaches.
Keywords: Connectivity, catchment systems, measuring and modelling approaches, co-evolution, management, boundary conditions, fire effects.

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