Geophysical Research Abstracts
Vol. 17, EGU2015-5763, 2015
EGU General Assembly 2015

StorAge Selection Functions: a tool for characterizing dispersion processes and catchment-scale solute transport

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Advection-dispersion equations have been extensively used to model flow and transport processes through heterogeneous media like hillslopes and groundwater systems. Therein, the spreading of solute plumes and the shape of the breakthrough curve is known to be controlled by the macrodispersion coefficient, which embeds the underlying heterogeneity of velocities and flowpaths. On a nearly parallel track, the use of travel time distributions (TTDs) has become increasingly widespread in catchment hydrology, to establish a formal linkage between input and output chemographs through suitable transfer functions. Recent theoretical advances and real-world applications have shown that the structure of travel time distributions in time variable flow systems like watersheds is strongly related to the time variability of the water storage and input/output fluxes. The dynamical structure of TTDs has been proved to be effectively parametrized through suitable StorAge Selection (SAS) functions, that express in a spatially integrated fashion how the set of ages available within a control volume are selected and removed by the output fluxes. In this contribution, we analyze the relationship between Advection-Dispersion Models and StorAge Selection Functions, with examples for one-dimensional transport in a finite domain with constant convection and dispersion coefficient. Our results show that when the dispersion is high (say, Pe < 10), the distribution of ages leaving the system through the control plane is similar to the distribution of ages available within the storage, thereby leading to uniform SAS functions (random sampling). Implications for the interpretation and the prediction of the chemical response of rivers are discussed through the application of the SAS functions to model solute circulation in highly monitored watersheds belonging to diverse regions of the world. We suggest that the use of Storage Selection functions in different fields of hydrology may bring important advances to our understanding of pollutant persistence in river basins.