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The Multiple Interacting Pathways model - A scale-independent approach to modelling transport and flow in real soils and catchments

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Whilst classic continuum-based models of hydrological processes are in common usage, their applicability to structured soils at practical scales is questionable. Continuum equations require local equilibration of potentials and fluxes. If complex heterogeneities and preferential pathways that are present in most real soils are to be considered, then this requirement leads to impractically fine grid-scales.

The Multiple Interacting Pathways (MIPs) modelling concept circumvents these issues through use of a discrete methodology. Water in the catchment is represented as a large set of discrete particles, each representing a volume of water that enters the catchment at the same time and spatial locality, and subsequently travels through the same pathways to the outlet. Random particle tracking is used to simulate the particles movement according to mechanistically-based equations. Localised densities of particles, combined with porosity characteristics, determine levels of saturation and soil moisture across the catchment, which in turn dynamically determine whether particles move as saturated or unsaturated flow. However, the particles within these flows do not all move with the same velocity. Instead, a distribution of velocities is applied to the particles, which attempts to represent the range of flow pathways available. Movement between the pathways can also be achieved using pathway exchange probabilities. In this way, the model is able to directly acknowledge the presence of heterogeneities in the soil, in a scale-independent manner. The exchange probabilities can also be used to simulate plant root uptake, evaporation and bedrock losses.

An important feature of this methodology is that there is integrated simulation of flow and transport. Information such as age, origin, and chemistry can be associated with each particle, leading to the ability to analyse input/output/storage residence times and source contributions.

This formulation provides a platform for testing our understanding of catchment processes, however, to identify models of temporally and spatially variable processes, then high frequency data over long periods of time, with possibly multiple observation points is ultimately needed.

In the poster, the capabilities and potential of the MIPs methodology for characterisation of complex, non-stationary, spatially variable run-off generation processes are illustrated and discussed, and data requirements of such a model are also highlighted.