Multiple Interacting Pathways Model
Modelling flow and transport in real soils and catchments

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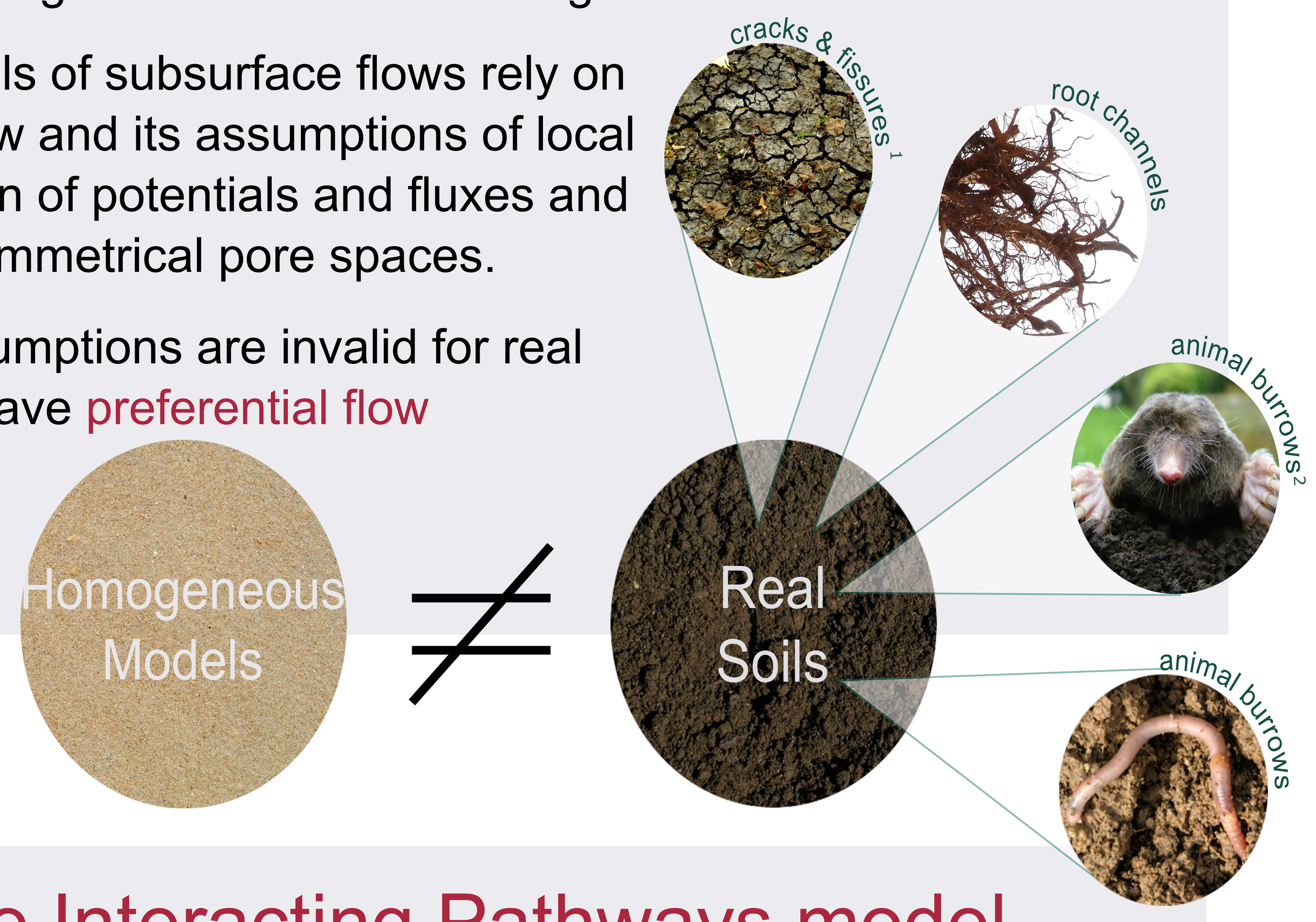
Why develop a new hydrological model?

Advancing understanding of hydrological flow and transport processes is central to understanding pollutant and nutrient fluxes, and predicting streamflow and flooding.

Most models of subsurface flows rely on Darcy's Law and its assumptions of local equilibration of potentials and fluxes and assume symmetrical pore spaces.

These assumptions are invalid for real soils that have preferential flow pathways.



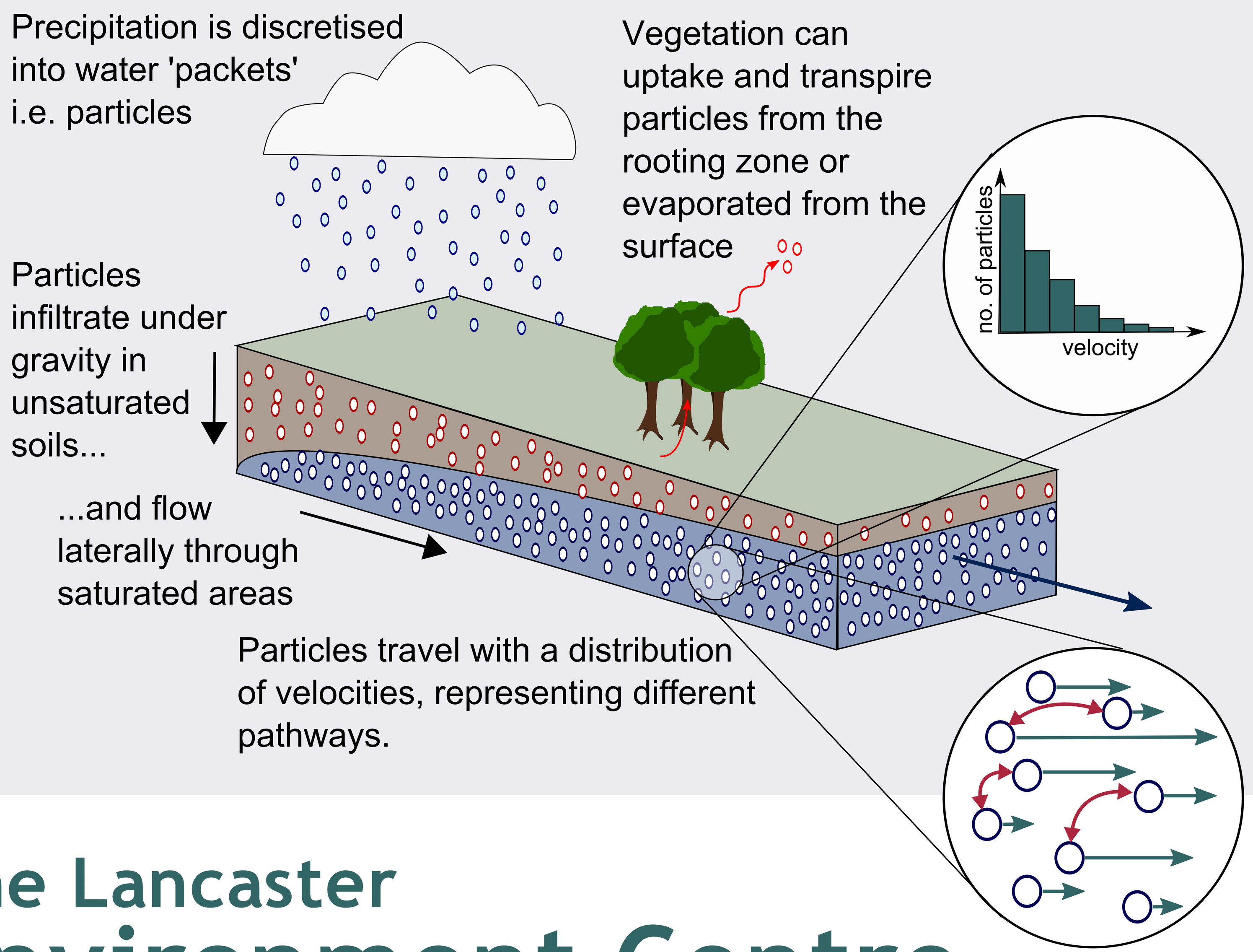
Multiple Interacting Pathways model

The Multiple Interacting Pathways (MIPs) model is a novel modelling concept with 3 main components:

Random particle tracking is used to represent the water in the catchment.

Velocity distributions are applied to the particles, which allows the representation of flow through heterogeneous features.

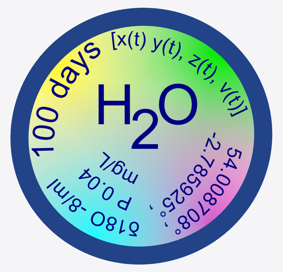
Transition probabilities then define how particles move from one pathway to another.



Current MIPs features

Each particle can be coloured with information such as:

Water age | Spatial history



Chemistry | Water origin

The MIPs model has been successfully applied to simulating a plot scale artificial tracer experiment (Fig. 1) and catchment scale isotope data (Fig. 2).

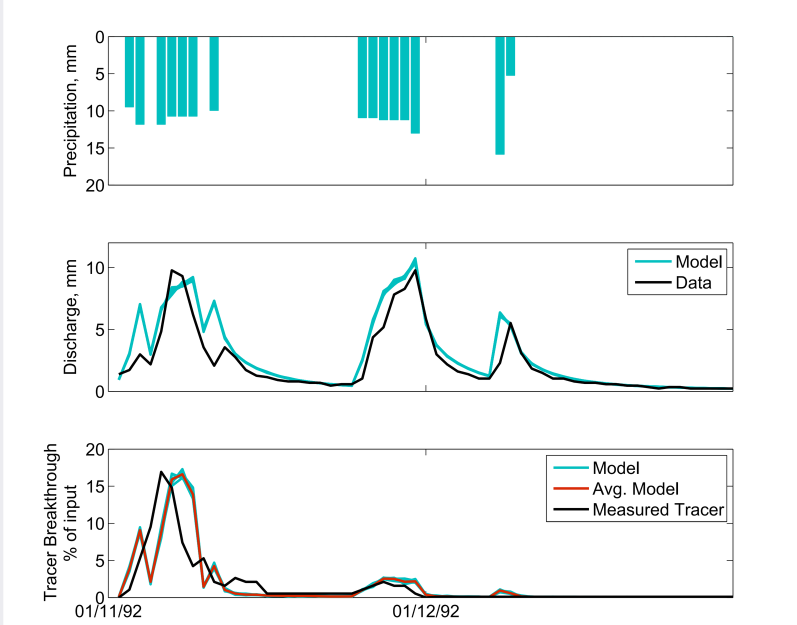


Fig. 1 Tracer Experiment Modelling

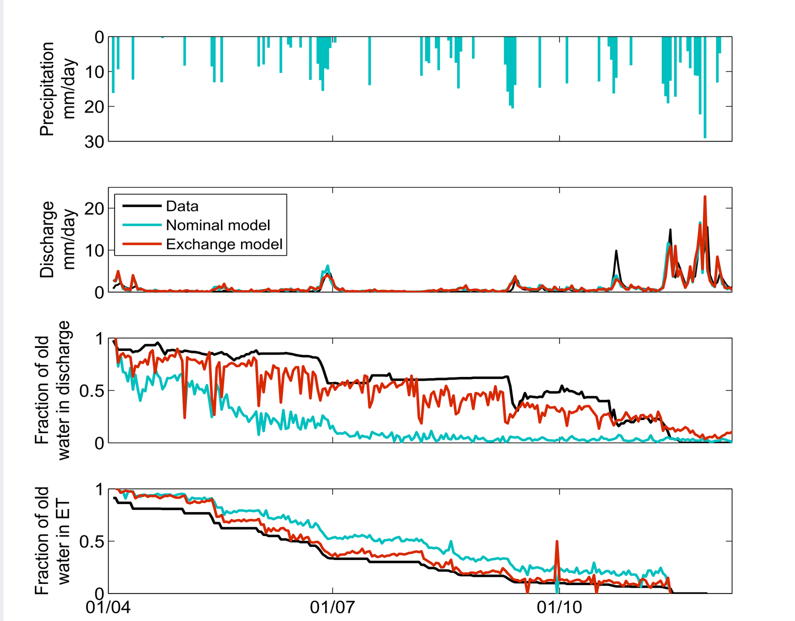
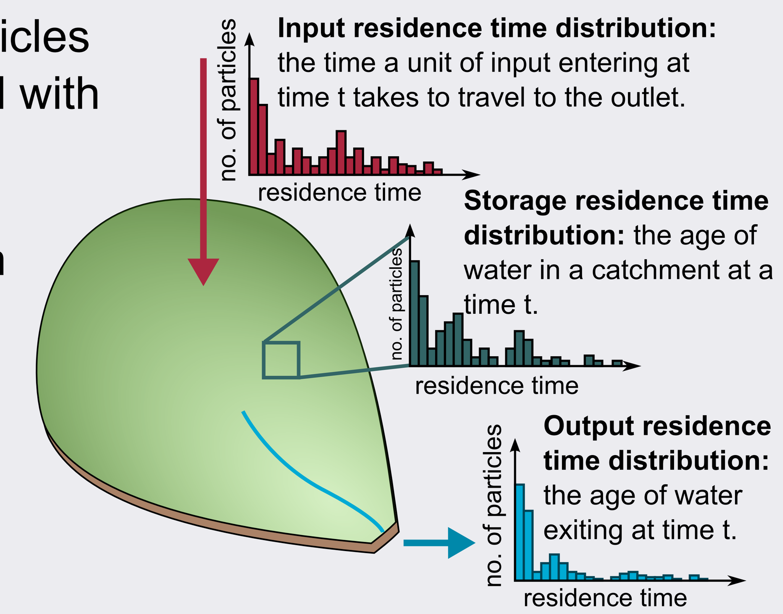


Fig. 2 Isotope Data Modelling

Discharge is derived from counting exiting particles at the outlet and tracer breakthrough simulated with 'tracer' labelled particles.

Old and new water fractions can be found from particle ages (Fig. 2).

Or full residence time distributions can be analysed for the storage in any area, the input or output at any point in time.



The MIPs model allows analysis of discharge by source area (Fig. 3), and stored water age both temporally and spatially (Fig. 4).

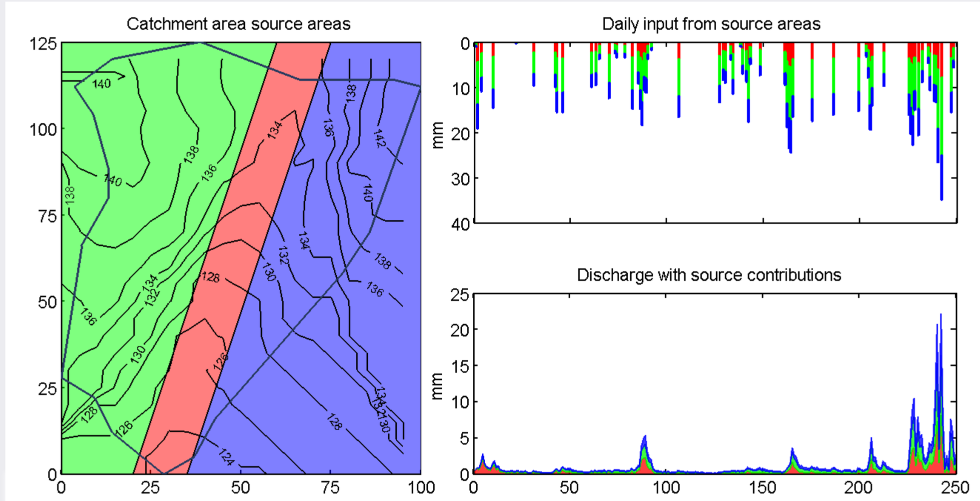


Fig. 3 Discharge by source area.

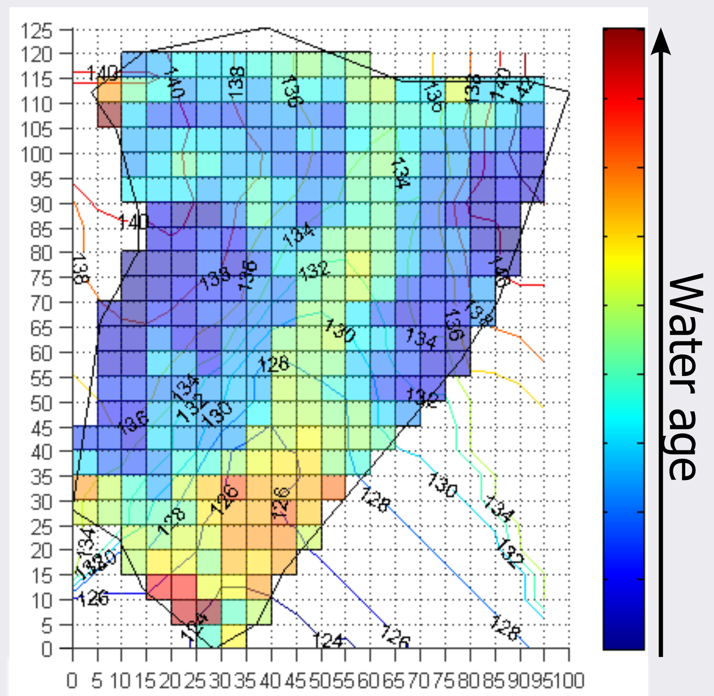


Fig. 4 Storage age over a catchment.

Future MIPs

More flow and transport data/experiments - more MIPs applications on new data sets with different catchment characteristics need to be made.

Pollutant and nutrient flux modelling - particles in the MIPs model can carry pollutants or nutrients allowing simulation and prediction of their transport with more realistic hydrological forcings, having implications for management of these issues.

Sediment transport - it may be possible to represent sedimentary movement in a particle-based framework, integrating with the hydrology expressed by MIPs.

Biogeochemistry - biological and geological weathering processes are inextricably linked to hydrology, and MIPs can be extended to include this chemistry.

Conclusions

The MIPs model is a new methodology for exploring flow and transport processes, which directly acknowledges the structural complexities of real soils in a scalable framework.

The model has been successfully applied to artificial tracer data at plot scale and environmental tracers at catchment scale.

There are many exciting further applications for the model such as water chemistry, sediment transport processes and contaminant modelling.

References

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