Strategies for resilient and sustainable integrated catchment management

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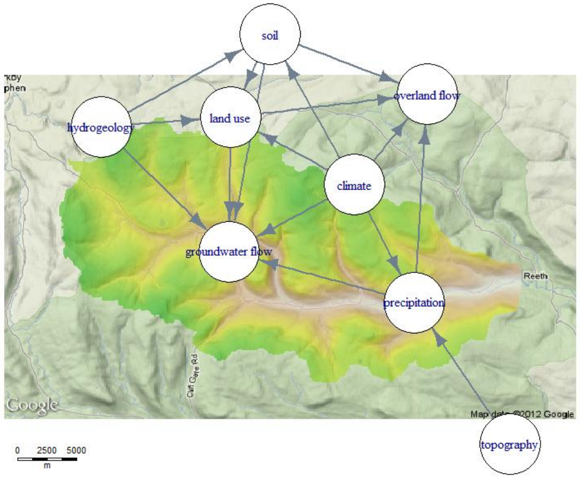
Aims and environmental and economic benefits

- Identify ICM issues – diffuse pollution, water quality, flooding
- Integrated models to predict and plan for changing climate
- Effects of changes in infrastructure, land use and hydrology
- EU WFD requires River Basin Management Plans
- Improved ecosystem services
- Reduced flood damage cost
- Reduced water treatment costs (CO_2)



Payoff between availability / quality of data and model complexity

- Lumped, time-integrated models (e.g. SIMCAT) lack detail to inform on significant events e.g. Don Fish Kill
- Significant uncertainty in data
- Fully-distributed physical models (e.g. MIKE-SHE) difficult to calibrate at RBD scale?

Need for medium complexity models to bridge this gap

Simple catchment connectivity model

Initial approach to catchment transport model

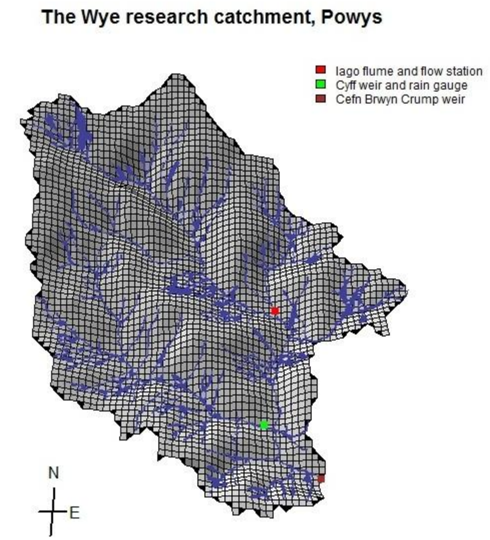
- Minimal physical assumptions and data requirements, e.g. regular gridded catchment DEM

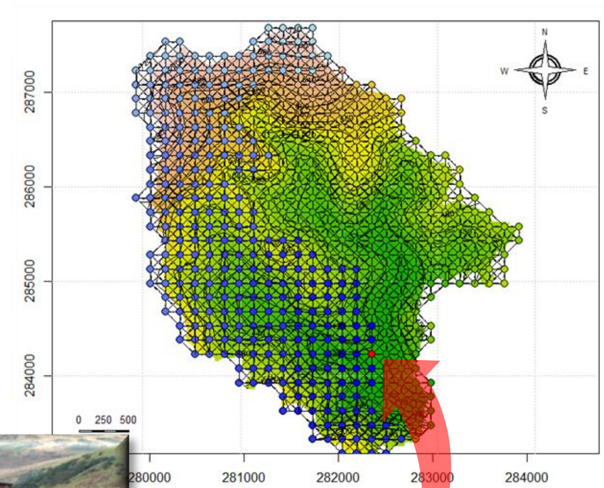
Represent grid elements by node (vertices) indirected, weighted graph structure

- Vertices connected to downslope elements
- Edge weights proportional to local slope
- Rapid evaluation of hydrological connectivity

Use to estimate travel times and transport pathways?

- Other edge metrics - soil type etc



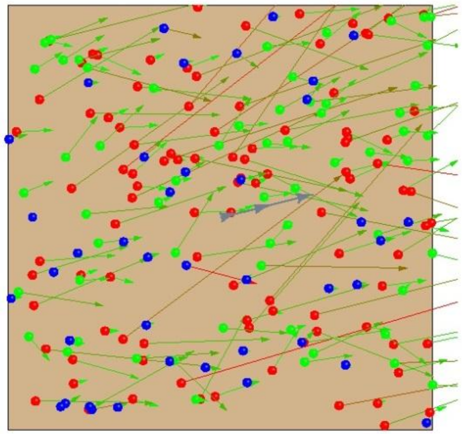


Digital River Network, catchment boundaries and DEM: Brandt,, Robinson, Finch, (2004) (downloaded from CEH Information Gateway www.ceh.ac.uk). Photography: CEH

Subsurface hydrology

Interactions of different solutes with soil matrix

- Pollutants may have differing retardation and sorbing characteristics e.g Cl nil sorbing
- Non-stationary fluxes? $\frac{\partial C}{\partial t} = -kC + \varepsilon(x,t)$

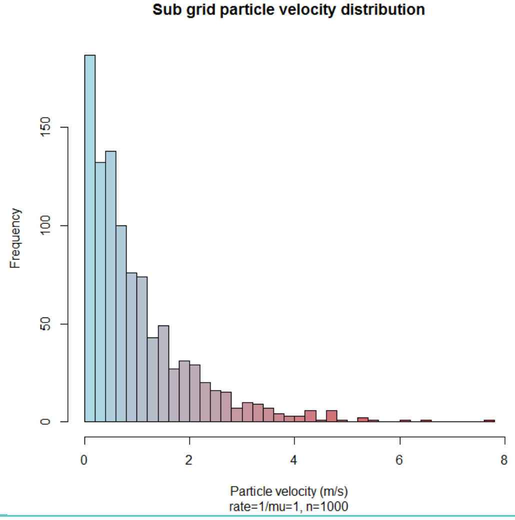


More detail needed at sub-grid level

- Robust scaling e.g. subcatchment -> RBD

Pollutant transport pathways may differ

- Macropores: fast but turbulent? Fine sediment (colloids) and FIO restricted to this path?
- Soil matrix: solutes - slower but less turbulent?



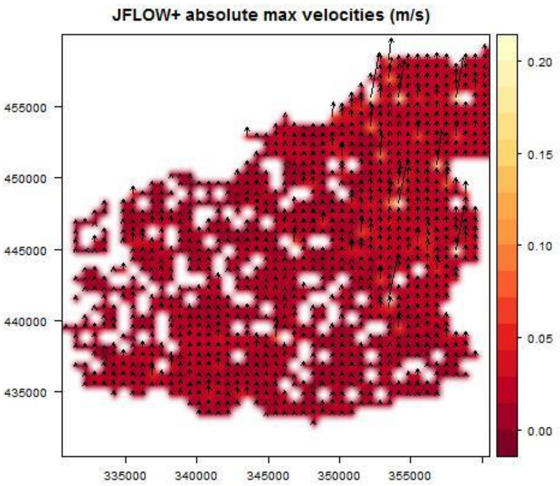
Velocity distribution for each solute and pathway

Dual Path Particle Tracking

Development

- Add temporally-distributed velocities from JFLOW+ runs

- Persistent particle paths – collect particles as they intersect DRN – gives travel times and pollutant fluxes

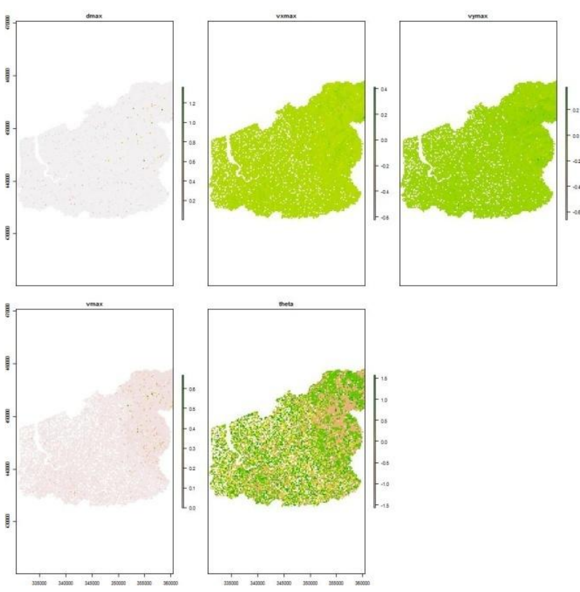


Applications to FaCeR

- Integrate particle fluxes to inform time fluxes. Ability to model concentrations in river reaches at varying spatial / temporal resolutions – multi scale

- Apply different attenuation rates to solutes and colloids. Apply fuzzy rules e.g sandiness index

- Attenuation rates applied to surface pathways for some pollutants e.g. FIO



Thank you – questions?

References

Fitts, C. R. and R. F. Charles (2002). Groundwater science. London, London : Academic Press.
CRAN. (2012). "The Comprehensive R Archive Network." from http://cran.r-project.org/.
Csardi G, Nepusz T: The igraph software package for complex network research, InterJournal, Complex Systems 1695. 2006. http://igraph.sf.net
Hijmans, Robert J.,van Etten, Jacob (2012). R raster package: “Geographic analysis and modeling with raster data”. Downloaded 5/2012 from http://raster.r-forge.r-project.org/
Roberts, P. V., M. N. Goltz, and D. M. Mackay (1986), A natural gradient experiment on solute transport in a sand aquifer: 3. Retardation estimates and mass balances for organic solutes, Water Resour. Res., 22(13), 2047–2058