Modeling and connectivity research. How to use it? How to implement it?

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MODELING AND CONNECTIVITY RESEARCH.
HOW TO USE IT?
HOW TO IMPLEMENT IT ?

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Connectivity research: the basics

Whatever you do, you need:

- To define a **microscopic scale.**
  This is the scale of the individual links/connections.
- To define a **macroscopic scale.**
  This is the scale of your system:
  soil profile, plot, catchment, etc.
- To have **many connections**. Connectivity is about networks.
  10 connections are not enough. 100 are barely sufficient.
  1000 are usually good enough. And the more, the better.
- To define the **state of each connection**.
  On/off is enough. Continuous values (« 69,04 m^3/s »)
  do not necessarily make things better.
- To define a **connectivity index**.
  It measures the overall status of the (many)
  connections

Connectivity modeling: the basics

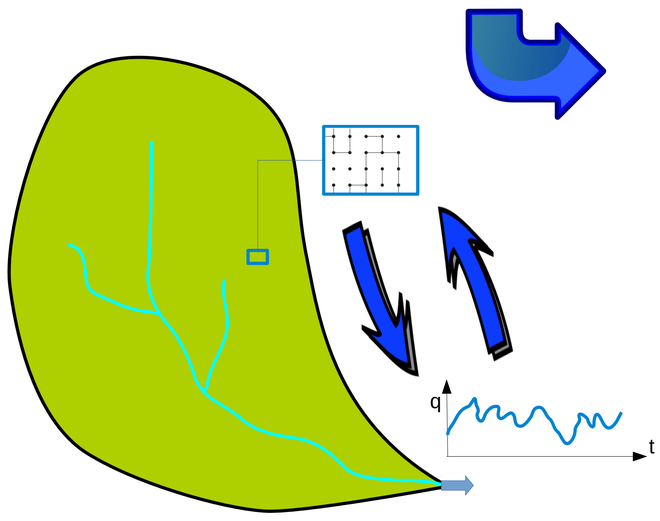
Based on this, we can define the requirements for a suitable model:

- To have the microscopic scale, **you must have a spatially-distributed model** (grid cells, sub-catchments, reaches, etc.).
- To have a **macroscopic scale is not an issue**: virtually all models define an overall output (catchment outflow rate, etc.).
- The model should allow for **sufficient links**/connections.
  Memory issues?
- The model should allow for **saving the state of each connection**:
  Grid, vector map, etc.
- A **connectivity index** can be calculated.
  Define your own, or take it from previous works (ask members of WG4!).

With an existing model,
i.e. not designed for connectivity study

Many existing models allow for a connectivity approach,
even if they were not build with connectivity in mind. Lucky us!

- The model you chose fits the above criteria?
  You have defined the suitable connectivity index?
  So, you are almost set!
- Because your model does not calculate your connectivity index, you have to **post-process the distributed outputs.**
  Which means writing up some kind of script.



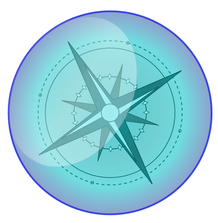
And now
you can apply
the normal research procedure:

What is to be compared? Number of replicates?
Is it statistically significant? Etc.

With a new model,
i.e. designed with connectivity in mind

So, you have decided to brew your own?
Good!

- You can **define the most suitable microscopic scale**.
- You can also **simplify your representation** of the system (modeling is about simplifying, right?). For example, do your river reaches need to be curved? Why straight reaches could not be enough?!?
- Your **connectivity index will be hard-coded** in your model.
  So, no need for post-processing.
- And you have to chose a way to implement all this.
  Which computer language? **Which algorithms?** Which memory structure?
  Well, the normal process of model development.

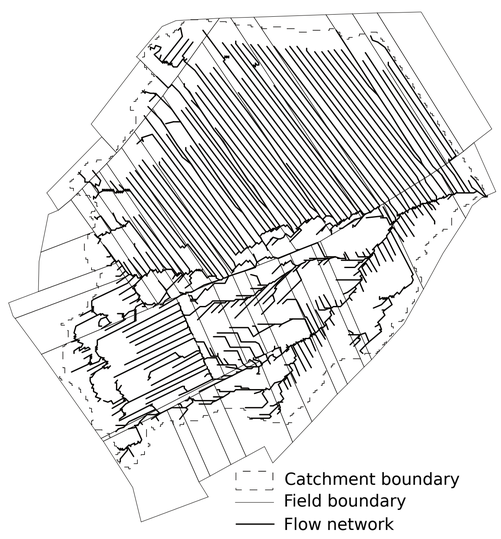


Final thoughts and advices

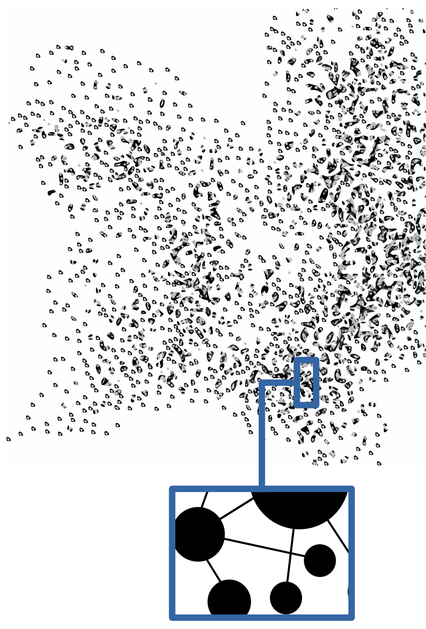
- If you have only one scale, you are **not doing research on connectivity**
  (it can be excellent research, though!).
- Connectivity defines the state of your system at a given time.
  A change through time is not required (although it can be quite interesting).
- They are **theories helping in studying connectivity**
  (percolation theory, graph theory, etc.). Why to ignore them?
- While connectivity can be studied for the sake of it (theoretical development), usually you need a way to **relate the behavior** of the links to the system « outputs ».
- Now that you have a proper model and procedure to measure connectivity, **you need food** for your model (Yeah, data!). **But do you have enough food?**
  This is probably the most common limitation in doing research on connectivity.
  Not enough data? No problem! Simply generate your own; numerically.
  If it sounds weird to you, get a look at these publications (from members of COST Connecteur):

- A. Peñuela, M. Javaux, C. L. Bielders (2015). How do slope and surface roughness affect plot-scale overland flow connectivity? *Journal of Hydrology*, 528:192-205. DOI: 10.1016/j.jhydrol.2015.06.031
- M.-A. Harel, E. Mouche (2013). 1-D steady state runoff production in light of queuing theory: Heterogeneity, connectivity, and scale. *Water Resources Research*, 49: 7973-7991. DOI: 10.1002/2013WR013596
- F. Darboux, C. Gascuel-Odoux, Ph. Davy (2002). Effects of surface water storage by soil roughness on overland-flow generation. *Earth Surface Processes and Landforms*, 27, 223-233. DOI: 10.1002/esp.313

A fully-connected network



A partly connected network



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