Geophysical Research Abstracts
Vol. 17, EGU2015-15814, 2015
EGU General Assembly 2015

Can we measure connectivity?

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Whilst the term 'connectivity' in hydrological and sediment-based research is becoming increasing well-known, it is neither used consistently in the existing literature, nor is it clear from that literature, that the connectivity of a landscape, or part of a landscape can be measured. However, it is argued that understanding how well critical source areas of water or sediment are connected to receiving surface waters, may be an essential step towards improvement of land management to mitigate flooding, soil erosion and water quality problems. The first part of this paper, therefore, explores what is currently meant by the term connectivity; addressing the differences between structural and functional, or process-based connectivity, specifically with reference to the movement of water and sediment through an ecosystem.

We argue that most existing studies do not measure connectivity. Instead, they address only part of the story. Existing work may describe structural change in a landscape, which can perhaps elucidate the potential for connectivity to occur, or indeed the emergent spatial properties of an ecosystem, but it rarely quantifies the connectivity of an ecosystem in a process-based manner through time.

Alternatively, a great deal of work describes fluxes of water and sediment at (sometimes multiple) points in a landscape and infers connectivity of the system via analysis of time series data; from rainfall peak to hydrograph peak or start of sediment flux until peak sediment flux within an event. Such data are doubtless useful to understand catchment function, but alone, they do not provide evidence that quantifies (for example) how well connected sediment sources are to the outlets of the catchments from which they flux.

Finally, there are many examples of water and particularly sediment tracing studies, which attempt to link, either directly or indirectly water or sediment sources with their sinks (which might more usefully be termed temporary stores). Whilst direct tracing techniques have great potential to describe how quickly material travels over measurable distances, and therefore how connected the system may be, such approaches are rarely used to answer this type of question. In addition, indirect tracing techniques, often termed fingerprinting approaches (in the case of sediments), tend to focus on the source apportionment of material that has left a catchment, or field based on 'unique' signatures. Such experiments do not actually elucidate whether the material that is eroded from a source (hillslope, gully or channel bank) has left the catchment, thus not proving whether connectivity has indeed occurred at all.

We conclude that there is great potential to measure, or perhaps more appropriately, quantify connectivity of water and sediment across a wide range of scales and ecosystems. However, we also argue that currently, very few, if any studies actually do this well. We argue that in part, this is because researchers have yet to formulate explicit questions about connectivity at the heart of their research, preferring to experiment within traditional scales of interest; hillslopes, channels and catchments, using measurement techniques that in isolation, do not bridge gaps across scales in a coherent manner.

In the second part of this paper we propose, through the design of three hypothetical (and probably rather costly) experiments, how research might be undertaken to address this problem; resulting in a combination of techniques being applied in parallel to quantify connectivity across scales. It is suggested that workers interested in this area join forces with us, under the banner of WG2 in the EU COST Connecteur project, to realise these experiments and move the discipline closer to a point where we can consistently quantify connectivity of any ecosystem within which we work.