EGU21-5004, updated on 23 Jan 2022
https://doi.org/10.5194/egusphere-egu21-5004
EGU General Assembly 2021

Surface runoff connectivity across scales: revisiting three simulation studies

Daniel Caviedes-Voullième[1], Ilhan Özgen-Xian[2], and Christoph Hinz[3]
[1]Forschungszentrum Jülich, SimLab Terrestrial Systems, Jülich, Germany (d.caviedes.voullieme@fz-juelich.de)
[2]Lawrence Berkeley National Laboratory, Earth and Environmental Sciences, Berkeley, USA (iozgen@lbl.gov)
[3]Brandenburg University of Technology, Chair of Hydrology, Cottbus, Germany (christoph.hinz@b-tu.de)

Surface runoff (dis)connectivity manifests across scales, spawning from different spatial flow patterns, which are dominated by both topography (structural connectivity) and hydrodynamics (dynamic connectivity). How the connectivity builds and evolves throughout rainfall events is integrated into observable hydrological signatures (namely, hydrographs and water balance).

In this contribution we explore the connectivity properties of runoff generation processes across spatial scales. We revisit three case studies of runoff generation during rainfall, numerically simulated by solving shallow-water equations. This approach provides a full description of the hydrodynamic flow fields, allowing to study both the connectivity properties, as well as the domain-integrated hydrological signatures (namely, hydrographs) that build up in response to flow phenomena.

We discuss and link the runoff generation processes arising from (i) runoff generation at the plot scale (20 m2 at cm resolution) with explicit microtopographies, (ii) runoff generation at the hillslope or first-order catchment scale with overland and (ephemeral) rill flows in the Hühnerwasser experimental catchment (4000 m2 at m resolution), and (iii) runoff generation at the catchment scale in the Lower Triangle catchment (15 km2 at m resolution).

The detailed study of runoff generation dynamics highlights the needs to use time-evolving connectivity metrics, which are particularly useful to understand spatiotemporal model output. We computed the number of disconnected flooded clusters (and Euler characteristic) as the main connectivity metric.

The results of the three different systems suggest similar qualitative behaviours of connectivity across scales, from plot to catchment scales, and therefore also offer the possible use of connectivity to understand how fluxes are re-scaled across the landscape, and as a multiscale indicator of hydrological function. The relationship between the connectivity response at a given scale (e.g., plot) and the hydrological signature observed at the next larger scale (e.g., hillslope) may lead into a hierarchical relationship of connectivities and signatures, in which the time-continuous nature of the connectivity signal may give rise to non-linear and threshold behaviours in the larger scale signature.

Additionally, in the context of assessing model quality, connectivity is a feature of the natural system which models (and modellers) should strive to ensure. In this sense, we argue that model formulations, meshing (including resolution/topology and preprocessing/smoothing of the terrain model) and parameterisations should be evaluated not only using integrated signatures (e.g., water balance, hydrographs) or point data (water depth, velocities) but also using (dis)connectivity metrics. In this way, it is possible to evaluate to which extent a model and its setup can simulate natural flow paths and landscape functions.