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Blame it on the Weatherman: How critical is rainfall to geomorphology?

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Three related studies using the CAESAR-Lisflood Landscape Evolution Model (LEM) have shown how critical rainfall data is when modelling sediment transport and landscape evolution.

Differences in how rainfall observations are collected, processed, and applied propagate through the modelling process resulting in similar differences in discharges yet larger and non-linear differences in sediment transport processes.

We attribute this to the 'geomorphic multiplier' (Coulthard et al, 2012) – the physical non-linear response of sediment transport to changes in discharges – which makes the model more sensitive to differences in the rainfall input compared to models of hydraulics alone.

The sensitivity of landscape evolution models to spatial and temporal rainfall resolution
Coulthard, T., and Skinner, C., 2016

The same rainfall was used in all tests but was applied at different spatial and temporal resolutions, from daily – lumped (catchment average) to 15 min – 5 km.

Complete Swale	24 h	12 h	8 h	6 h	4 h	1 h	0.25 h
Lump	0.00	1.19	1.61	1.54	1.68	1.63	1.66
20 km	0.80	1.62	1.90	2.11	2.36	2.53	2.49
10 km	0.74	1.72	2.15	2.38	2.55	2.58	2.61
5 km	0.76	1.96	2.35	2.52	2.68	2.81	2.82

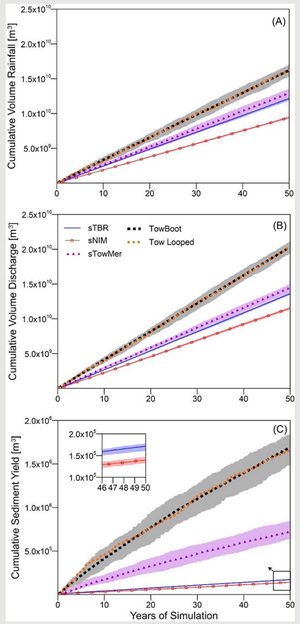
Using the higher resolutions produced slightly higher discharge (~3% between extremes).

Complete Swale	24 h	12 h	8 h	6 h	4 h	1 h	0.25 h
Lump	0.00	44.04	51.96	48.54	53.50	66.50	66.18
20 km	27.78	63.16	72.56	73.12	83.15	91.09	91.74
10 km	30.99	64.85	78.46	72.59	87.91	98.71	100.54
5 km	34.72	67.94	90.64	84.03	101.28	115.00	118.10

But much higher sediment yields (~118% between extremes). Sediment transport is far more sensitive than discharge to rainfall resolution.

The impact of different rainfall products on landscape modelling simulations.
Skinner, C., Peleg, N., Quinn, N., Coulthard, T., Molnar, P., and Freer, J., In Press.

There are no rainfall observation methods that are able to capture all the information about a rainfield, such as point intensities and spatial distribution. Consequently, observations of the same rainfall will vary based on the methods used. These differences propagate through the modelling framework, including into the conditioning of weather generators used to produce longer records for use in landscape evolution studies.



The study conditioned the STREAP weather generator with two observation products with short records – a gauge network (sTBR), and radar (sNIM) – and produced 50-year rainfall records for CAESAR-Lisflood, along with looped and boot-strapped records from a single gauge with a longer observation period (TOWLooped and TowBoot).

The differences in rainfall translated to similar differences in discharge, yet much greater differences in sediment yields.

The longer observation period afforded by the single gauge provided more extreme events, resulting is far higher sediment yields, and greater changes to the basin, than the other records.

Using the best information from each product (sTowMer) it is possible to produce a more realistic representation of rainfall.

Temperature effects on the spatial structure of heavy rainfall modify catchment hydro-morphological response
Peleg, N., Skinner, C., Fatichi, S., and Molnar, P., 2020

Climate change will change rainfall beyond just intensity and volumes. Changes to storm shapes and behaviours will also impact sediment transport processes. The combination of weather generator and LEM allows for investigation of these impacts.

See more at https://presentations.copernicus.org/EGU2020/EGU2020-1563_presentation.pdf

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