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Evaluating the influence of hetrerogeneity length scale on long profile landscape signals

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Our current understanding is that non-local sediment transport in geomorphic systems arises as a result of the presence of system heterogeneity with a power law distribution of length scales. In theoretical models of nonlocal transport, the implicit assumption is that the length scale of the largest heterogeneity is of an order equal-to or greater-than the domain size (DOM). In some natural systems, e.g., ground water flow, this is a reasonable assumption since it is known that the heterogeneity in preferential flow paths extends across many decades, up to lengths on the order of several km. In geomorphic systems, however, due to length scales of fluvial features and particle transport lengths, we expect that there might be an upper size-limit on the heterogeneity ($maxH$). Here we ask the following questions: (i) What kind of landscape signal is created in systems with a characteristic domain larger than the upper-limit of the transport heterogeneity ($DOM > maxH$) ? (ii) As the ratio $R = \frac{maxH}{DOM}$ decreases below a value of 1, how rapidly do we recover a local landscape signal? (iii) What experiments can be constructed that would be able to determine the value of $maxH$ for a given system?

To answer these questions we use a standard and proven theoretical diffusion-like model for describing non-local sediment transport in geomorphic systems. The key feature in this model is that the sediment flux at a point on the surface, in a long profile of the landscape, is expressed as a weighted sum of gradients – *at*, *up*, and *down*–stream of the point of interest. In general, the weight is largest at the point of interest and decreases in a power-law fashion as we move up or down stream. To investigate the influence of the ratio $R = \frac{maxH}{DOM}$ we construct models of relatively simple erosional and depositional systems and study how the predicted steady state land surface profile is modified as the value of R falls below unity.

Within the limitations of the simple models we observed that as the value of R decreases below unity, the signal of non-locality is restricted to regions in the proximity of domain boundaries. Further, the proportion of the domain over which the non-local signal occurs, appears to be directly related to the value of R. Finally, as the value of R approaches values 0.1, indicating that the length scale of the non locality ($maxH$) is $1/10th$ of the domain size DOM, we essentially recover a local behavior.