The convergence paradox: are catchment divergent or divergent?

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Catchments are the fundamental spatial units of the land surface, as seen through the hydro-geomorphologists eye. As with all atomic units, they can be broken up into composing elements. In the case of catchments, these are the hillslopes and the channel network.

Because the lateral boundaries of hillslopes are ill-defined, it is tempting to regard the catchment as one wide hillslope, folded around the channel network. The hydrologically relevant question then is: is this hillslope convergent or divergent in nature.

A prior observation is that because catchment are areas draining towards a single point (the outlet), they must be convergent. However, both pixel-based distributions of contour curvature, and flow-path length distribution based hillslope width functions suggest that the total set of hillslopes are overall divergent. This disagreement creates the 'convergence paradox'.

We explain this convergence paradox by investigating the scaling of contour curvature with contributing area. We find that near-divide landscape parts are mainly divergent, and near-channel parts are mainly convergent, with hillslope hollows forming a transition zone. This is in agreement with geomorphic landscape evolution theory, which explains hillslope geometry from diffusive processes, and channel-like forms from advective fluvial erosion. The observed divergence of the hillslope part of the landscape is more than balanced by the areally few, but strongly convergent channel parts, making the catchment as a whole convergent.