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Evidence for non-local (fractional) diffusive transport on hillslopes

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Hillslopes are shaped by a wide range of processes which can move sediment to large distances in the downslope direction, thus, resulting in a broad-tail in the probability density function (PDF) of the "hopping lengths." Here, we argue that such broad-tailed PDFs call for a non-local computation of the sediment flux, where the sediment flux is not only a function of the local gradient but is an integral flux which takes into account the gradients in an upslope region of influence. We encapsulate this non-local behavior into a simple fractional diffusive model which involves fractional derivatives. We present observations from several hillslopes which carry a signature of the non-local behavior, i.e., power-law relationship between the vertical drop from the ridge-top and horizontal distance downslope with an exponent between 1 and 2. Further, we compare the proposed non-local flux law with the linear and nonlinear local flux laws using data from hillslopes in the Oregon Coast Range.