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Burial effects on bedload tracer transport

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The gradual burial of tracer particles during bedload transport is a recently identified physical source of super-diffusion. It remains unclear, however how exactly this burial effect is related to the possible regimes of anomalous diffusion. In this paper we incorporate the mechanism of tracer burial into the active layer formulation for bedload transport, enabling an analytical treatment of the problem. The deduced equation governing the active layer is shown to be an advection-diffusion equation (ADE) with a sink term, and the increase of tracer concentration in the substrate layer underneath is driven by a corresponding source term which corresponds precisely to the sink term of the active layer. The solution for the variance of the tracer plume is analytically determined by calculating the relevant concentration moments based on the solved concentration distribution. It is shown that when substrate burial is accounted for, there will generally be a normal diffusion regime at very short time scales and a sub-diffusion regime at very large time scales. The appearance and characteristics of a super-diffusion regime during intermediate time scales will depend on relations among particle diffusion coefficient, burial frequency, and the virtual streamwise velocity for the tracer plume. This is in contrast to the single normal diffusion regime obtained for bedload transport when the burial process is not considered.