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Modelling Bioturbational Effects With a Particle Lattice-Automaton Model

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We have developed a new type of model that simulates sediments as a (random) collection of particles on a grid and bioturbators as autonomous programmed entities. Biologically active sediment becomes a collection of solid and water "particles" with individually assigned chemical, biological and physical properties, e.g. food versus inert material. These model particles are not true sediment granules, as that would be numerically onerous, but idealized "grains" of sufficient number to be statistically equivalent. Particles can be added to the model by sedimentation and removed by burial, while compaction guarantees the existence of a sediment-water interface and the slow disintegration of some biologically generated features. The benthic organisms then move through the lattice by displacing or ingesting-defecating particles. Each automaton obeys a set of rules (for movement, feeding, interaction, etc.), both deterministic and stochastic, designed to mimic real deposit-feeder behavior.

Model output shows that the effects of infauna on a sediment are striking, just as they are in nature. An initially random, but statistically smooth, distribution of porosity rapidly develops distinct biologically-induced heterogeneities. Such heterogeneities appear and disappear largely as a function of feeding rate, selectivity, locomotion rates, and population size. Tracers like ^{210}Pb are mixed into the sediment and also display strong local heterogeneities, while laterally averaged distributions resemble classic mixing profiles. The latter results allow calculation of equivalent mixing (bio-diffusion) coefficients and the linkage between specific infaunal activities and this geochemical parameter can be explored. For example, for a typical individual ingestion rate of 3 times body weight of d^{-1}, a single individual will generate a D_B of about 0.05 $cm^2\ yr^{-1}$, and this rate increases linearly to 0.25 $cm^2\ yr^{-1}$ with 8 such individuals. Thus, for the first time, it is possible to explore the link between infaunal activities and values of related geochemical parameters.