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Probabilistic estimation of entrainment rate in coarse sediment beds

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Many problems in river and coastal engineering depend on sediment transport dynamics induced by turbulent flows over sediment beds. Given the chaotic nature of turbulence and the complex mechanics of granular beds, grain-scale interactions between fluid and sediment are better described using stochastic approaches. A probabilistic model is presented linking entrainment rate to the stochastic properties of the near-bed fluid velocity and the probability distribution of particle elevation. By using a simplified description of the mechanics of grain dislodgement, the distribution of particle waiting time is derived, which is linked to the entrainment rate. The predictive capability of the model and the associated uncertainty are analysed using near-bed flow field and grain motion data obtained from flume experiments at low transport stages. The model predictions are found to be in good agreement with the data. Experimental evidence of distinct entrainment mechanisms is discussed, and flow patterns are identified that cause significant fluctuations in the entrainment rate.