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Internal dynamics of steady and nearly uniform granular avalanches

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We experimentally investigated the internal dynamics of stationary mono- and bidisperse granular avalanches in an inclined conveyor belt flume. We used the refractive index matching technique to visualize and obtain information from within the granular bulk. In combination with particle tracking velocimetry and coarse-graining techniques, we were able to calculate continuum particle distributions and velocity fields. The experimental avalanches had distinct flow regions: (i) a convective-bulged front, (ii) a compact-layered tail, and (iii) a breaking size segregation wave structure, serving as a transition between the former two. To describe the dynamics of these regions, we computed local strain rates in the form of its tensor invariants. The invariants varied notably between regions; while the largest values and non-linear distributions were found at the front, linear distributions were observed in the tail. In general, and although that slip was considerable at the base of the flow, time-averaged velocity profiles were found to be well captured by a Bagnold model. Based on recent developments in particle-size segregation theory, we calculated the segregation flux within the bidisperse avalanches. In those experiments, we found that segregation flux was higher at the front than at the back, a fact that was confirmed by the observed recirculation of large particles at the front. All our experimental data show a strong link between rheology and segregation, a result that will provide grounding for new developments in segregation theory.