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Flow regimes, grain mobility and size segregation in stationary bi-disperse granular flows

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We studied granular flows of glass beads on an inclined conveyor channel. An upward-moving belt conveyed particles that flowed down the channel under the action of gravity, thus creating a stationary flow. To visualize the internal dynamics of the bulk, we relied on the refractive index matching technique. Under fixed slope and belt velocity, we ran mono- and bi-disperse experiments to characterize spatially and temporally the dynamics and concentration fields of these granular flows. Mono-disperse experiments were done using 6 and 8 mm beads on slopes of 10, 12, 15 and 18° and 3 different belt velocities. Beads of 14 mm were added in concentrations of 10, 20, 30 and 40% for the bi-disperse experiments. The rear part of the flow exhibited well-arranged particle layers that moved relatively between them. This particle arrangement ended with a sharp transition to the front of the flow and a dilated convective front. Bi-disperse experiments with low concentrations of large particles conserved the same layered-convective regime with the few added large beads confined to the convective front, a result of size segregation. When the concentration of large beads was increased to 30%, the described regime disappeared. Large grains were frequently dragged back by the belt, thus disrupting the arrangement of particle layers. A quasi-stationary behavior was observed in these experiments, small particles migrated to the front of the flow in pulses that after a while were dragged back, repeating the cycle. We observed that particle concentration fields, on average, were consistent with the structures observed for the breaking size-segregation wave phenomenon. The effective basal friction, local concentrations and dilation, among other variables, are responsible for these phenomena.