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Modelling dispersive pressure, fluidization and density variations in mixed flowing/powder snow avalanches

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In this presentation we will derive a system of depth-averaged partial differential equations to model snow avalanche flow with granular turbulence and density variations. The primary application of the model is to simulate mixed flowing/powder snow avalanches exhibiting highly fluidized flow at the avalanche front. These avalanches are characterized by snow mass in the form of snow granules and ice particles which visibly undergo strong, explosive-like slope perpendicular movements. Sudden transitions from a collisional to a frictional flow regime can occur after the front passage depending on the rate of turbulent energy production, which is responsible for maintaining fluidization of the flow body. Fluidization cannot occur without the interaction of the turbulent kinetic energy with the basal boundary, which expands the avalanche flow volume. We capture this effect by solving a third-order energy/momentum equation for the vertical velocities, vertical accelerations and time rate of change of the accelerations. Avalanche mass will work against these vertical movements which produces strong gradients in density depending on the overburden pressure. Thus, we are able to model not only the dispersive pressure induced by the particle interactions of the basal boundary but also the rate of change of dispersive pressure which is responsible for the collisional/frictional flow regime transitions and longitudinal density variations. We no longer assume a hydrostatic pressure distribution. We apply the model to several observed avalanches at the Vallée de la Sionne test site, demonstrating how we can model measured front velocities, front arrival times, flow heights and impact pressures.