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Non depth-averaged continuum models for avalanche motions

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We present a continuum mechanical non depth-averaged model (N-DAM) for rapid motion of granular materials such as snow avalanches, landslides and debris flows. In contrast to the commonly used depth-averaged models (DAM), which are appropriate for smooth changes of flow variables, the motion perpendicular to the topography is taken into account and calculated by the N-DAM. This is important in the initiation and deposition regions and particularly, when the flow hits an obstacle or a defense structure. The primary challenge in modeling a complete three-dimensional flow is to construct an appropriate closure for the stress tensor, and in this talk we present various approaches to relate the stress and the strain-rate tensors. Since advancing from DAM to N-DAM requires fundamental changes in the traditional numerical simulation technique, a numerical method based on the Non Oscillatory Central-Total Variation Diminishing (NOC-TVD), coupled with the Marker And Cell (MAC), is introduced and simulation results are presented.