Abstract: Granular materials are omnipresent in our daily life. The same granular material can behave like solid and fluid, which poses a formidable challenge to the constitutive models and numerical methods. Traditionally, constitutive models for the solid- and fluid-like behaviour have been developed for the respective flow regimes in different engineering/scientific disciplines with hardly any intersections. A single constitutive model capable of describing the transient behaviour during phase transitions in both solid-like and fluid-like regimes is a challenging task with enormous application potential. MOTRAN takes on this challenge with a simple yet efficient ansatz by decomposing the stress rate into a frictional and collisional part, which gives rise to an unconventional constitutive model with the 2nd order strain rate similar to the acceleration of motion. It serves as an excellent classifier for steady and transient motions. This constitutive model is then augmented to include a length scale in micropolar continuum for multiscale analysis. Based on the mixture theory, the field equations are established in rate form for the first time and discretised by a multi-layer SPH model. For polydisperse granular flow with individual large particles, the SPH model is coupled with own developed Surface Mesh Represented DEM to simulate particles of arbitrary shapes. Advanced solution techniques are developed based on multi-GPU acceleration for high fidelity simulation of large-scale problems. The constitutive model is calibrated by laboratory experiments on natural granular materials and their transparent surrogate. The numerical model is validated by scaled model tests under elevated acceleration in centrifuge as well as real-world cases of our database. MOTRAN is an exciting endeavour with the potential to create a new paradigm that will revolutionise the way how transient granular flow is to be modelled.

Here is the BOKU Press-release