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Recent advances in the GPUSPH model for the thermal and rheological evolution of lava flows

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GPUSPH is a fully three-dimensional model for the simulation of the thermal and rheological evolution of lava flows that relies on the Smoothed Particle Hydrodynamics (SPH) numerical method. Thanks to the Lagrangian, meshless nature of SPH, the model incorporates a more complete physical description of the emplacement process and rheology of lava that considers the free surface, the irregular boundaries represented by the topography, the solidification fronts and the non-Newtonian rheology. Because of the very high degree of parallelism, GPUSPH is implemented very efficiently on high-performance graphics processing units (GPUs) employing the Compute Unified Device Architecture (CUDA), a parallel programming language developed by NVIDIA for GPU computing. GPUSPH follows the very general Herschel–Bulkley rheological model, which encompasses Newtonian, power-law and Bingham flow behaviour and can thus be used to explore in detail the impact of rheology on the behaviour of lava flows and on their emplacement. We present here the first validation tests of the GPUSPH model against well known analytical problems, considering the different rheological models, heat exchanges by thermal conduction and radiation, and providing the relative error estimates.