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A two-fluid model for block-and-ash flows and ash-cloud surge for the 1994 eruption of Merapi volcano (Indonesia).

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A new numerical model is presented where the emplacement of both block-and-ash flows and ash-cloud surges of Merapi volcano are simulated. Surges are generated by the surface of the block-and-ash flows. Surge deposition can form either a deposit or secondary dense flows. The model was tested against field data of the 1994 eruption of Merapi volcano and allows reproducing flow directions, deposits thicknesses and flow extension observed in the field. The extension and thickness of block-and-ash flows can be reproduced but the simulation of these dense flows is difficult because of their high sensitivity to meter-scale features of the topography, because the mechanical behaviour of the initial stage of the dome collapse cannot be fully simulated and because the erosion caused by the flows probably changes the topography during the emplacement. All these limitations should be taken into account when numerical simulation is used for hazard assessment. The simulation of the ash-cloud surge with a simple depth-average approach, which assumes no density variation in time and space, can reproduces the velocity, the extension and the deposit thickness of surges. However, the simulation fails to reproduce the final stage of the emplacement, close to the lift-off phase, when the constant density hypothesis is too far from reality. During the 1994 eruption, according to the model, the mass transferred into the surge by the dense flow was of about $1 - 5$ kg/m^2/s on average. The mass lost by the surge by sedimentation was of about $0.5 - 1$ kg/m^2/s.