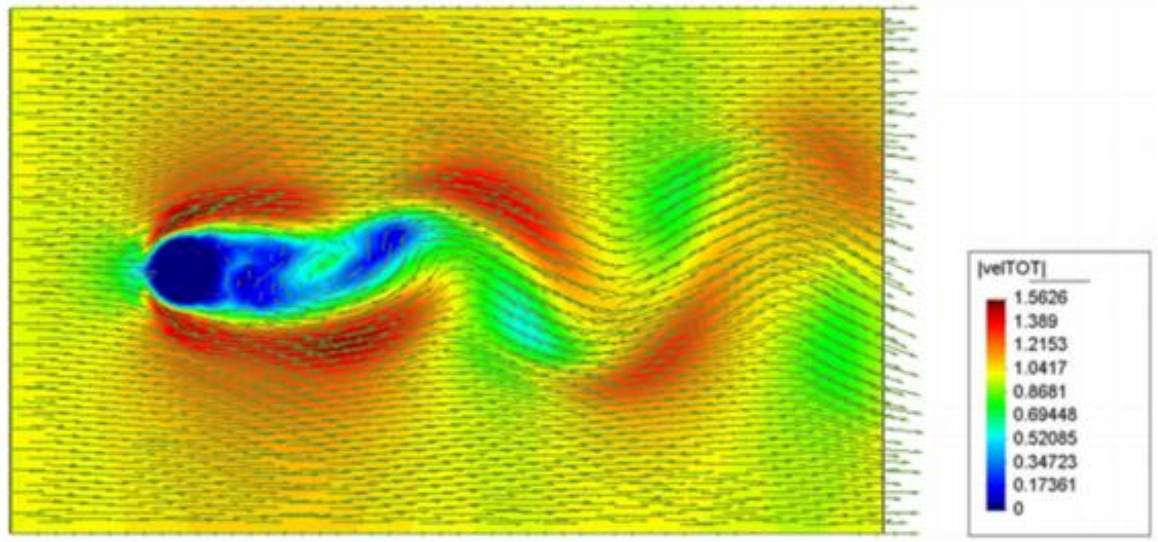
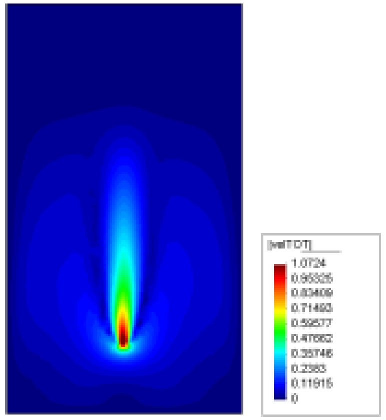
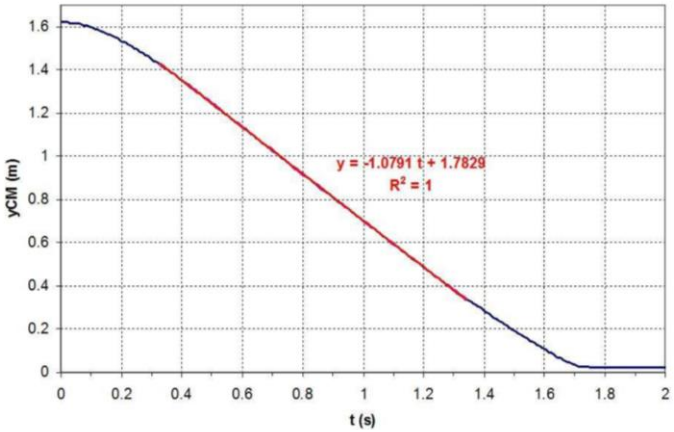
Modelling geological processes in the Solar System: movement of a rigid solid within a multiphase fluid



Flow around a circular cylinder: Velocity vectors for Re=4e5





Settling of a solid particle in a viscous fluid: Velocity contours (left); Evolution in time of the y-coordinate of the solid center of mass and linear regression (right)

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A new approach for the numerical modelling of a rigid solid moving in a multiphase flow is presented. The method is capable to solve the dynamics of the solid and the main features of the fluid at a very low computational cost and with a very high degree of accuracy.

The model is based on the idea of extending the fluid velocity inside the rigid body and solving the flow equations with a penalty term to enforce rigid motion inside the solid. One of the main challenges when dealing with the fluid–solid interaction is the proper modeling of the interface that separates the solid moving mass from the viscous fluid. In this work, the combination of the level set technique and the two-step Taylor–Galerkin algorithm for tracking the fluid–solid interface is proposed. The proposed model has been validated against empirical solutions, experimental data, and numerical simulations found in the literature. In all tested cases, the numerical results have shown to be accurate, proving the potential of the proposed model as a valuable tool for the numerical analysis of the fluid–solid interaction.

Rigid body motion in viscous fluids is a hot issue in engineering (Civil Engineering, Renewable Energy Engineering, Marine Engineering, Aeronautics, etc.) but it is also paramount to understand several natural processes of relevance in Geosciences, Planetary Sciences and Astronomy. The presented model allows the study of geological problems such as impacts, rock avalanches, formation and propagation of tsunamis and the transport and sedimentation of particles in different media.

We hope this work will open the path to a new way of approaching the solid-fluid interaction, without the need for extremely fine meshes and days/weeks of computational time.

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