Modeling and distributed computing of snow transport and delivery

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Human activities in mountain terrain are increasing in scope, as are their impact on the natural environment, such as the effects of artificial snow generation. This PhD thesis describes the working principles, development and validation of a Computational Fluid Dynamics (CFD) computer model of snowfall over a complex orography, with the aim of optimizing ski slope or other installations according to local weather patterns, thus helping the decision-making process. In the first step, the spatial domain is discretized, with the main focus on challenging topography that tends to produce deformed mesh volumes. A novel measure of mesh deformation is then defined and applied to discuss different strategies of mesh optimization with the goal of facilitating parallel computer solutions of the Navier-Stokes fluid transport equations. These strategies are evaluated with regards to their implementation as a parallel computer algorithm. In the second step, a computer model is designed to solve the Navier-Stokes incompressible turbulent fluid equations. Slip- and no-slip boundary layers are considered, modeling surface roughness with the Ks method. The efficiency of the CFD computational toolkit are discussed, as applied within the limits of a small or medium-sized commodity computation cluster using commercially available equipment. Finally, the degree of coupling required between the snow- and air-phases of the fluid during the computer modeling of snowfall is discussed. A two-fluid (Euler-Lagrangian) methodology is implemented. The effects of tangent surface wind speed on primary and secondary snow transport are integrated into the model. An assessment is made of the application of parallel computing to the solution of Lagrangian movement of individual snow parcels. Experimental data is used to verify the suitability of computational techniques. Additionally, real-world applications of such snowfall models are discussed in relation to ski-slope planning and high-altitude road snow clearing. An application of the model to wind energy production planning is presented.

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