IMPROVING AVALANCHE FORECASTS BY EXTRACTING BOUNDARY CONDITIONS FROM MEASURED WIND DATA AND LOCAL WEATHER MODELS FOR SNOW DRIFT SIMULATION IN ALPINE AREAS

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AIMS:

Due to increasing development of Alpine environments by transport and tourism the forecasting of avalanche danger becomes more and more important. The protection of civil facilities and human lives is one major aim of avalanche forecasting. The accuracy of avalanche forecasting depends mainly on the precision of the provided initial conditions. Results close to reality can only be obtained by introducing real weather data. On the one hand these data can be extruded from local weather models such as Inca. Extra computational effort is needed to calculate boundary conditions based on this data. Comparison to calculation with constant average wind shall point out whether the implementation of the weather data provided by Inca is worth the extra costs or not. On the other hand weather data can be provided from station measurements by solving the open boundary conditions problem. In irrespective of the chosen methods, the operation has to happen fast enough to fulfill the requirements for the long-term objective, the forecast of avalanche danger.

METHODS

The forecast is done by using Computational Fluid Dynamics (CFD) with an implemented formulation of the physical concept of drifting and blowing sand, adapted to suit the needs of simulating snow transport.

To understand how wind contributes to snow drift, we have to understand the basic physics behind these phenomena. If the wind shear exceeds a certain *threshold* grains will be entrained and set in motion. The so called *fluid threshold* (for reference see Bagnold 1941) is given by

$$\tau_{c_e} = (A_e)^2 (\rho_P - \rho_a) g d_P .$$

ρ_P and ρ_a are the densities of the snow particles and air. Furthermore g denotes the standard acceleration due to gravity, d_P the snow particle diameter and A_e a dimensionless empirical

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parameter, which is a function of the particle shape and particle cohesion. Following Bagnold Anderson and Haff (Anderson and Haff 1991) estimated that the number of entrained grains per unit time and unit area depends linearly on the excess shear stress

$$\frac{\partial N_e}{\partial t} = \xi\left(\tau_a - \tau_{c_e}\right),$$

where τ_a denotes the air induced shear stress. ξ is an empirical constant with the dimensions of (force x time)$^{-1}$. If the wind shear is below a second *threshold*, the *impact threshold*, snow will be accumulated

$$\tau_{c_i} = \left(A_i\right)^2\left(\rho_P - \rho_a\right) g\, d_P.$$

Grains whose motion is directed towards the snow pack are deposited.

RESULTS

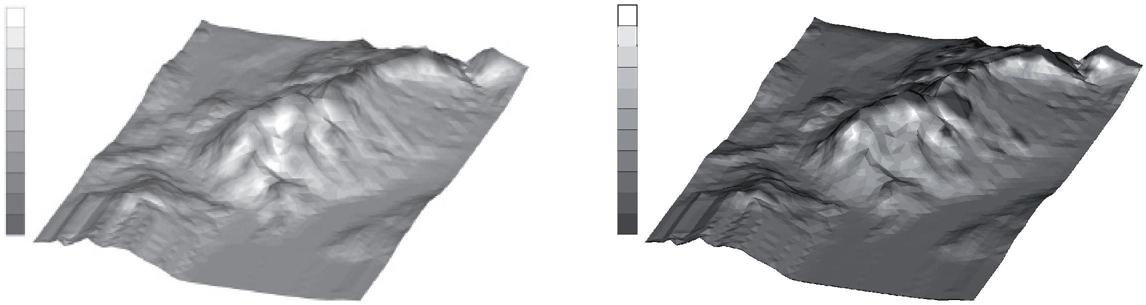

Fig 1 Comparison of the snow distribution on mount Grimming after a 6h drifting period using a time varying wind field provided by Inca (left) and a averaged wind field (right). The arrow indicates the average wind direction. White corresponds to additional snow loads due to snow drift and dark gray to erosion zones.

CONCLUSIONS

The results of the snow drift simulations show the applicability of the novel simulation methods for whole mountain ridges. Therefore, snow drift simulations provide important information for the prediction of avalanche danger. The results demonstrate that it is necessary to apply measured wind data as boundary conditions, because of the high sensitivity of snow drift patterns to different wind conditions, which was clearly demonstrated on the mount Grimming example. Compared to punctual snow depth measurement the numerical simulation provides an area-wide distribution of the snow depth. Additionally, the result of snow drift simulations can be used as improved initial conditions for avalanche simulations.

REFERENCES

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