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Using MM5-derived wind fields for the modelling of snow transport processes

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Abstract

In the last years different research groups emphasized the importance of wind-induced snow transport on the variability of the snow cover. Knowledge about the causing processes saltation is important for determining the temporal dynamics of the snowmelt runoff. Furthermore interception losses induced by snow transport can have reasonable effects on the water balance. In addition wind induced snow transport can lead to a reasonable avalanche risk in deposition areas.

For accurate modelling of the snow pack preferably good climatologic parameters are alienable. There are two major factors which influence the quality of these input data a) the closeness and the temporal resolution of the meteorological network and b) the suitability of the parameters to be interpolated over a given area. It is a known problem that in high-alpine terrain wind fields can not be provided by a simple interpolation of station recordings. Therefore we use a modified version of the PSU/NCAR Mesoscale Model MM5 with a multiple nesting approach to derive wind fields for a 24 x 19 km area at a target resolution of 200 m. The wind fields are validated by station data. In a last step the modelled wind fields are used as an input for a snow model bond (PROMET and SNOWTRAN3D). The modelled snow cover will then be compared with measurements made in the National Park of Berchtesgaden and with remotely sensed data.

Keywords

Snow transport, MM5, wind field catalogue, modelling

Project aims

The superior goal of the project is to investigate how snow transport processes influence the hydrology of alpine catchments. All processes which are relevant for the description of a snow cover shall be assimilated into a model assembly. For doing so we use different approved model schemes like MM5, PROMET and SNOWTRAN3D.

Study area

The test sites are located within the National Park of Berchtesgaden. Founded in 1978 the park is the only one in Germany providing high alpine terrain. A benefit of the park is the dense met-stations network which is owned by the Lawinenwarndienst Bayern (LWD, the Bavarian avalanche forecasting service), and by the National Park. Special attention is given to the areas around the meteorological stations of Kühroint and Reiteralm. Kühroint is located near the centre of the national park (4572386E, 5270606N) at an elevation of 1416 m a.s.l and was installed in winter 2004/2005. Reiteralm is located in the north western part of the biosphere reservation (4560495E, 5279439N). This site contains three stations which were installed by the avalanche forecasting service of Bavaria especially for reconstructing blowing snow events. The stations lie between 1615 and 1755 m a.s.l. Stations at both sites measure wind speed, wind direction, air temperature, humidity, snow surface temperature, snow height and the snow temperature in four depths. Kühroint also provides a snow pillow which enables us to measure the snow water equivalent.

Method

Caused by the fact that MM5 would be to slow for being an operational part of our modelling network we run it separately. So as a preparatory work we made statistical studies of historical DWD (German weather service) Local Model reanalysis data for the Alpine region. By doing so we were able to figure out the most relevant synoptic situations. For these situations we run MM5 in order to derive wind speed and direction for each raster element. For the intended snow modelling

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a library of wind fields was composed on a LINUX cluster computer resulting in 226 data files.

The criteria for the extraction of the wind field to be used for the current snow-model time step are mean wind speed and direction in the 700 hPa level derived from DWD (German Weather Service) Local Model data. This data comes with a / has a temporal resolution of one hour and is then compared to the corresponding mean wind speed and direction of the appropriate MM5 nesting area. From this comparison we can decide which library file represents the best fit. Verification is conducted by comparison of historical station measurements with corresponding downscaled simulation results.

Results

It could be shown that MM5 can reproduce the wind speed on a daily basis very well. Here we found a coefficient of determination of 0.7 between station data and simulated wind fields for the years 2000 2003. On an hourly basis the coefficient is decreasing to a value of 0.5 for the same period. We have also seen that we are underestimating the wind directions. Our values are about 40-50 degrees lower than the values at the station but the time-dependence is pretty good.

Discussion

The presented scheme shows that available mesoscale atmospheric models can be effectively used to provide valuable wind fields even in areas of a larger scale. So one can provide wind speed and direction for a variety of applications such as the modelling of snow transport processes. The application of the wind fields as an input for our snow model will be the next work package. Finally one can say that the National Park provides ideal conditions for such a work. The dense network of meteorological stations allows us to find a better understanding of the meteorological processes within alpine terrain. Another advantage are the constant boundary conditions within the park. These constancy makes the data and results comparable over several years.

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