The SNOWMIP project : validation of albedo and short wave radiation budget simulated by several snow models.

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Introduction

Over the last thirty years, many snow models have been developed and have been used for various applications such as hydrology, global circulation models, snow monitoring, snow physics and avalanche forecasting. The degree of complexity of these models is highly variable, from simple index methods to multi-layer models simulating snow cover stratigraphy and texture.

In the project SnowMIP (www.cnrm.meteo.fr/snowmip/), four sites were chosen for the comparison of the snow models. As albedo and snow surface temperature measurement are not available for all of them, only the Col de Porte (CDP) and Weissfluhjoch (WFJ) data are used in this paper. The Col de Porte is a middle elevation site located in the French Alps (1340 m). Weissfluhjoch is a more mountainous site that lies at an altitude of 2500 m in the Swiss Alps.

Albedo parametrization

The incoming short wave radiation is the same for all the models and the short wave radiation budget simulation depends on the fraction of the radiation which is reflected by the snowpack, i.e. the snow albedo. The albedo parametrizations of the 23 models are based on temperature (6 models), snow types and/or grain size (6 models), or age (13 models). Four models use either no albedo or a fixed albedo (index based, or a constant albedo, or an albedo depending only on vegetation fraction or shading). Some models use two parameterisations, e.g. age can account for all the aging processes of snow or can be used in conjunction with a parameterisation based on snow grain size or type.

The albedo increases are generally determined by snowfalls. The albedo decreases are more complex because they depend on the snow micro-structure and grain types. As stated above, the decrease of albedo is generally calculated by the models as a function of the snow age, surface temperature, grain size and other parameters provided by the model itself. These parametrizations play a major role in the model performances because albedo is a key factor for calculating the snowmelt. Thus, it appears interesting to examine the accuracy of parametrizations for some particular periods. These selected periods cover at least eight days and do not include snow fall events (table 1). The three CDP periods correspond to snowmelt events and the albedo decrease (-1.63×10^{-2} per day on average) is due to the appearance of liquid water in the snowpack. At WFJ, the decrease is 5 times weaker (-3.17×10^{-3} per day on average) because it is due to dry snow evolution (without melting or rain). The quality of each simulation is estimated by comparing the change in observed and simulated albedos between the beginning and end of each period. The albedo decrease averaged for all models is pretty accurate for all the episodes (table 1), but the extreme values show that some models are far from the reality. For the 6 episodes, the rms error of the albedo variation ranges from 0.07 to 0.13, but average results are very different for the two sites.

	Site	Period	Number of days	Observed albedo (beginning and end)	Observed albedo variation (per day)	Simulated albedo variations: average (per day)	Simulated albedo variations: min-max (per day)
Episode 1	CDP9697	28/02/97-14/03/97	15	0.63-0.5	-0.0087	-0.01	-0.02/0.005
Episode 2	CDP9798	24/01/98-20/02/98	28	0.77-0.59	-0.0064	-0.006	-0.01/0.001
Episode 3	CDP9798	19/04/98-26/04/98	8	0.8-0.53	-0.0338	-0.015	-0.03/0.00
Episode 4	WFJ	13/12/92-02/01/93	21	0.9-0.86	-0.0019	-0.005	-0.01/0.005
Episode 5	WFJ	29/01/03-14/02/93	17	0.91-0.8	-0.0065	-0.008	-0.02/0.00
Episode 6	WFJ	21/04/93-29/04/93	9	0.75-0.74	-0.0011	-0.009	-0.03/0.009

Table 1 : The six periods selected to validate albedo decreases. No precipitation occurred during these episodes. The two last columns contain the average for all models and the minimum/maximum values of the simulated albedo variations.

Particular episodes

The rms error is generally larger for the CDP site (0.08 to 0.16) than for the WFJ site (0.03 to 0.11). The performance of a given model depends a lot on its albedo parametrization. For the CDP site, the best models use parametrizations based on the snow age and/or the snow type. As the albedo regularly decreases during the episodes, the age parametrization is adequate to correctly simulate this evolution. This is illustrated by figure 1, where the daily simulated and observed albedos are plotted for episode 3 (CDP9798): many models properly reproduce the albedo decrease from 0.8 to 0.65. Most of these models use a parametrization based on the snow grain size or the snow age. On the contrary, the less accurate models generally include a parametrization using the snow surface temperature. As this parameter does not vary a lot during the melting period, this is not an accurate predictor for the albedo decrease. Finally, if one considers the whole set of episodes, three of the four best models use albedo parametrizations based on snow grain characteristics and snow age. They are able to simulate both the slow albedo decrease in winter and the fast decrease during the melting period. The other models are generally able to simulate properly the albedo for one type of episode but not the other. Only one model using a parametrization based only on the snow age and surface temperature succeeds in simulating the different albedo evolutions.

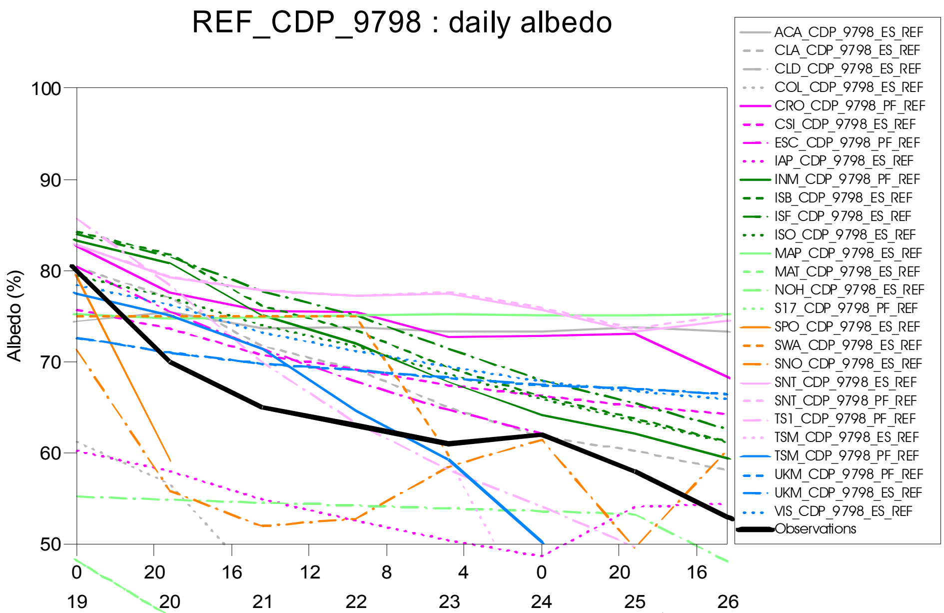

Figure 1 : daily albedo observed (large black line) for episode 3 (CDP site, from 19 to 25 April 1998) The other coloured lines correspond to the 26 albedo simulations.