

An examination of the quality of a new snow parameterization scheme combined with the COSMO's land surface scheme TERRA

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A validation study performed for COSMO's land surface one-dimensional scheme TERRA in stand-alone long-term regime exerted some deficiencies in the representation of snow water-equivalent depth (SWE) when compared with the observational data collected at the meteorological stations in Russia (Valdai, 1966-1983) and Germany (Lindenberg-Falkenberg, 2005-2006). Too high snow melting rates in spring lead to earlier dates of the snow complete ablation compared with observations and as consequence to earlier rise of the surface temperature above freezing point which begins immediately after snow ablation.

A new, more physically based parameterization of snow is suggested and implemented into TERRA. As the main component, this multilayered scheme includes description of the water phase transitions within snowpack. This scheme contains also description of the diffusive heat conduction through snowpack, simple radiative transport (extinction law), percolation of liquid water and semi-empirical parameterization of metamorphosis and compaction of snow.

The results, i.e., SWE and dates of the snow ablation obtained by TERRA with the new snow parameterization scheme are in closer agreement with the measurements then obtained with the control one (see Fig. 1). This effect is especially clear during those springs when there was no precipitation, since snowfall events in spring could mask too fast snowmelt that the default TERRA's more simple snow model shows. These experiments have shown that for the accurate representation of snow cover evolution it is necessarily to account for liquid water within snowpack and the possibility for liquid water to undergo repeated cycles of diurnal melting and night-time refreezing. It is worth to mention that the analytical calculation of snow density in the new scheme instead of its empirical calculation in the reference scheme leads to more realistic values of snow density (see Fig. 2) and, as a consequence, to more accurate values of geometrical snow heights (see Fig. 3).

Additional experiments with the same input data were performed in order to analyze the sensitivity of the TERRA with the control and new snow schemes to other parameterizations, for example to the parameterizations of snow albedo or snow cover fraction. These dependencies are of particular importance since they induce the snow-albedo feedback. The experiments have shown that 1) by means of only replacement of these dependencies it is impossible in many cases to improve the simulation of snow melting rates and 2) more physically based snow scheme reveals more sensitivity to perturbations of the parameters of abovementioned parameterizations.

Snow melting speed in turn determines hydrological outflow regime. Observational runoff data at Valdai shows that the spring flood in most years falls on April. The default snow scheme simulates the spring flood in March and underestimates the amount of it. The new snow scheme essentially improves the simulated runoff and in the experiments with new snow scheme the spring flood falls on April.

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Figure 1. Time series of snow water-equivalent depths at Valdai: observed (green circles) and simulated by TERRA with the reference (blue line) and new (red line) snow scheme.

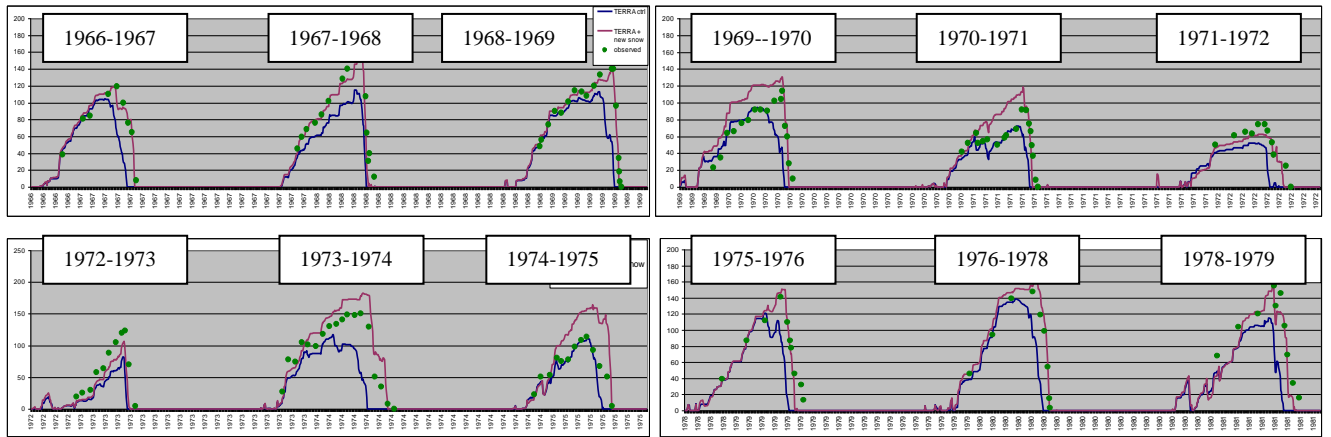


Figure 2. Time series of snow densities at Valdai, 1969-1975: observed (blue circles) and simulated by TERRA with the reference (yellow line) and new (red line) snow scheme.

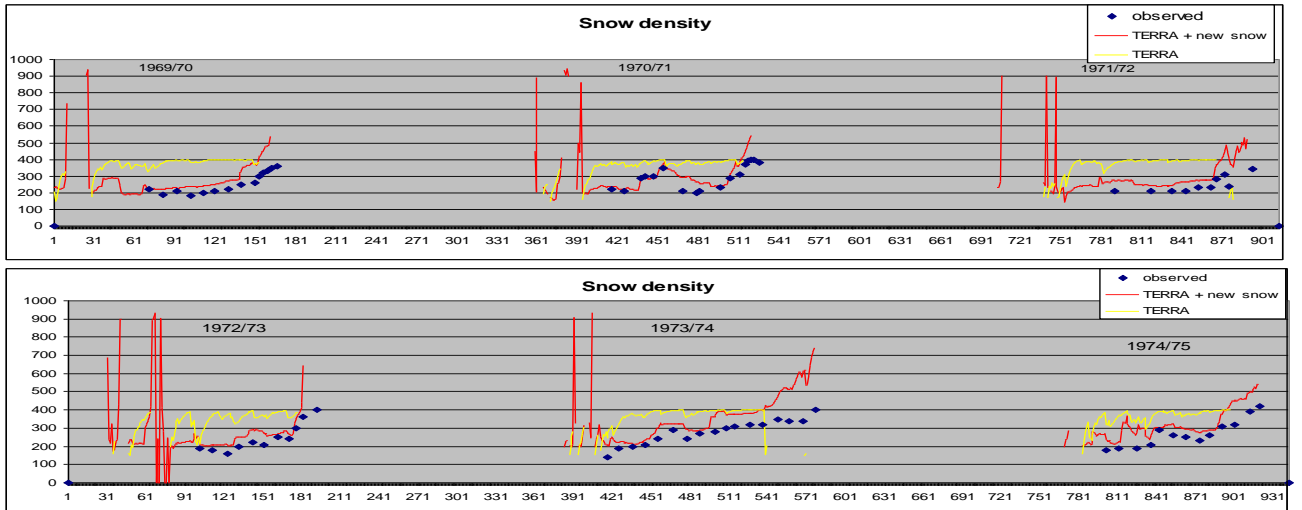


Figure 3. Time series of snow heights at Valdai, 1969-1975: observed (blue circles) and simulated by TERRA with the reference (yellow line) and new (red line) snow scheme.

