Implementation and testing of a multi-layer soil model in the NWP models of DWD

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A multi-layer soil model, originally developed for the high resolution limited area model LM of DWD has been implemented in the global forecast model of DWD. The model comprises 7 active soil layers ranging in thickness from 1 cm close to the surface to roughly 5 m for the lowest layer. Below the active soil layers a climate layer with prescribed annual mean temperatures provides boundary conditions for the thermal heat flux computations. The hydrological part of the soil model operates on the same vertical grid and a partial or total freezing of soil water is accounted for in all layers (cf. Heise and Schrodin, 2002).

Since the scheme differs considerably from the currently operational 2 layer scheme, it has to be tested and validated thouroughly before operational implementation, which is scheduled for autumn 2003. This validation exercise included a participation in the ELDAS RhoneAGG model intercomparison experiment (cf. Boone et al., 2001). In the course of this exercise it was revealed that snow melting processes, which were based on the same single snow layer formulation as the previously soil scheme of DWD, were not simulated with sufficient accuracy. The problems were caused by an overestimation of snow density and the fact that ageing of the snow layer with a corresponding decrease of the snow surface albedo for solar radiation was not considered in the original formulation. Adjustment of the snow density to more realistic values and the introduction of an empirical formulation describing the ageing of snow as a function of time since the last significant snow fall solved this problem.

A one year integration based on initial data from January 1st 2002 of the full forecast model was performed in order to study potential bias problems in the evolution of the the soil layers, if, in contrast to the RhoneAGG experiment, where the forcing was prescribed, the soil scheme is forced by upper boundary fluxes provided by the atmospheric model. Since data assimilation schemes in operational NWP models introduce very little information directly into the soil scheme, it is essential that the soil model shows as little drift as possible with regard to prognostic variables. However, since a few W/m**2 imbalance in annual mean surface fluxes is sufficient to cause substantial deviations in the subsoil temperatures from their climatological mean values, the evolution of prognostic soil temperatures and water content, at least for high latitudes, is rather sensitive to the empirial relation describing the snow ageing. This demonstrates the need for a careful tuning of the free parameters of the soil model and a thorough validation of the scheme itself. It also supports the specification of a climatological lower boundary condition rather than a zero-flux condition.

As an example from this integration Fig.1 compares the simulated global distribution of snow for the end of the first month of the integration and the same month in the following year. The good overall agreement is an indicator of a realistic simulation of the evolution of the snow distribution in the course of one year.

Further tests, in particular with regard to the comparison of the new versus the old scheme in operational forecasts and data assimilation will be performed in the near future.

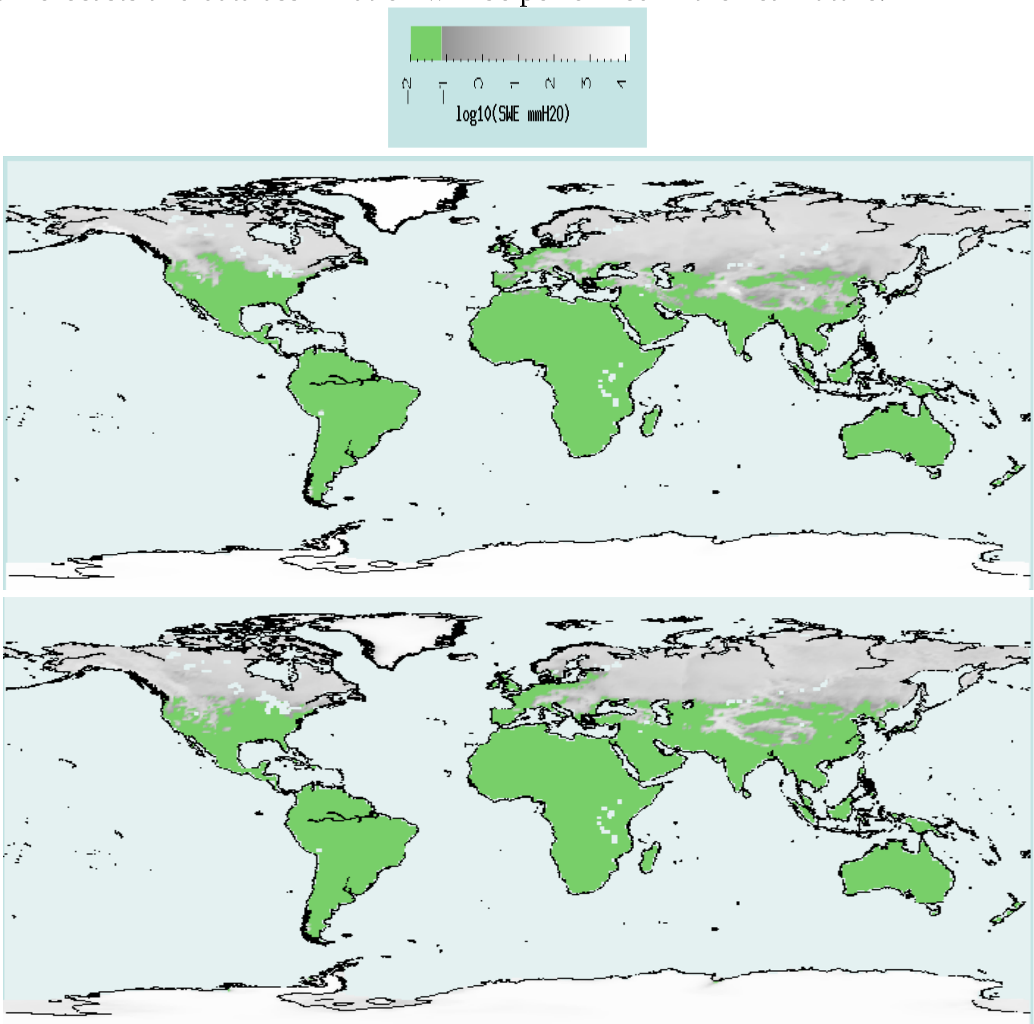

Fig.1: Simulated snow water content at end of first month (top) and one year further (bottom)

References

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