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Downscaling scheme to drive soil-vegetation-atmosphere transfer models

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The earth's surface is characterized by heterogeneity at a broad range of scales. Weather forecast models and climate models are not able to resolve this heterogeneity at the smaller scales. Many processes in the soil or at the surface, however, are highly nonlinear. This holds, for example, for evaporation processes, where stomata or aerodynamic resistances are nonlinear functions of the local micro-climate. Other examples are threshold dependent processes, e.g., the generation of runoff or the melting of snow. It has been shown that using averaged parameters in the computation of these processes leads to errors and especially biases, due to the involved nonlinearities. Thus it is necessary to account for the sub-grid scale surface heterogeneities in atmospheric modeling.

One approach to take the variability of the earth's surface into account is the mosaic approach. Here the soil-vegetation-atmosphere transfer (SVAT) model is run on an explicit higher resolution than the atmospheric part of a coupled model, which is feasible due to generally lower computational costs of a SVAT model compared to the atmospheric part. The question arises how to deal with the scale differences at the interface between the two resolutions. Usually the assumption of a homogeneous forcing for all sub-pixels is made. However, over a heterogeneous surface, usually the boundary layer is also heterogeneous. Thus, by assuming a constant atmospheric forcing again biases in the turbulent heat fluxes may occur due to neglected atmospheric forcing variability.

Therefore we have developed and tested a downscaling scheme to disaggregate the atmospheric variables of the lower atmosphere that are used as input to force a SVAT model. Our downscaling scheme consists of three steps: 1) a bi-quadratic spline interpolation of the coarse-resolution field; 2) a „deterministic" part, where relationships between surface and near-surface variables are exploited; and 3) a noise-generation step, in which the still missing, not explained, variance is added as noise.

The scheme has been developed and tested based on high-resolution (400 m) model output of the weather forecast (and regional climate) COSMO model. Downscaling steps 1 and 2 reduce the error made by the homogeneous assumption considerably, whereas the third step leads to close agreement of the sub-grid scale variance with the reference. This is, however, achieved at the cost of higher root mean square errors. Thus, before applying the downscaling system to atmospheric data a decision should be made whether the lowest possible errors (apply only downscaling step 1 and 2) or a most realistic sub-grid scale variability (apply also step 3) is desired.

This downscaling scheme is currently being implemented into the COSMO model, where it will be used in combination with the mosaic approach. However, this downscaling scheme can also be applied to drive stand-alone SVAT models or hydrological models, which usually also need high-resolution atmospheric forcing data.