A downscaling approach for atmospheric variables to drive high-resolution soil-vegetation-atmosphere transfer models and hydrological models

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Introduction
To drive high-resolution soil-vegetation-atmosphere transfer (SVAT) models or hydrological models, atmospheric input on a high horizontal resolution is needed. Current atmospheric models usually do not provide data on the resolution needed to force a soil model or hydrological model.

A solution is to downscale the atmospheric forcing data as intermediate step. We developed a stepwise downscaling system for this purpose, which can be used in offline and online simulations.

Application
The mosaic approach is a method to account for sub-grid scale surface heterogeneities in atmospheric models by computing soil properties and the turbulent exchange fluxes on an explicit higher horizontal resolution than the atmosphere, i.e. to have a number of small soil grid boxes per coarse atmospheric grid box.

The downscaling can be employed as interface between the atmospheric model (in our case 2.8 km grid spacing) and the fine-scale soil model (400 m).

Model and training data
The downscaling approach has been developed based on a large data set of output from COSMO-model runs for different weather situations, with 400 m horizontal grid resolution.

The COSMO model is a non-hydrostatic numerical weather-prediction and regional climate model, which is used by several European weather services for daily weather prediction.

Downscaling system
Stepwise downscaling system consisting of three steps:

1) Bi-quadratic spline-interpolation:
First step from coarse to fine grid. The coarse value of each grid box is conserved as average over the corresponding fine pixels.

2) Deterministic downscaling:
Use relationships with surface characteristics, e.g. relief height or surface temperature as predictor in a linear regression, depending on weather situation.

3) Stochastic downscaling:
Establish realistic sub-grid scale variability: Estimate missing sub-grid scale variance and model it as autoregressive noise.

Example:
Stepwise downscaling for longwave net radiation (in W/m²). The anomalies are the small-scale differences with respect to the coarse values. The deterministic anomaly is based on linear regression with the surface temperature.

Problem: Relationships of deterministic downscaling step not valid under all atmospheric conditions.
Example:
→ Rules needed for applicability of relationships depending on atmospheric characteristics, which were derived by an automatic rule-detection system.

Results
Applying downscaling step 1 (spline interpolation) leads to a small reduction of errors compared to using homogeneous forcing (i.e. no downscaling). Downscaling step 2 (deterministic rules) leads, where applicable, to a larger reduction of errors. The third downscaling step increases the errors again, due to the random distribution of the noise.

The sub-grid scale standard deviations (figure on the right) is increased by downscaling steps 1 and 2. After downscaling step 3 the reference sub-grid scale variability is matched closely.

Conclusion
A novel downscaling approach is introduced, which aims not only for estimating the sub-grid values accurately, but also for emulating the realistic sub-grid scale variability. The latter is important if the downscaled fields are used to drive models including nonlinear processes, which is usually the case in SVAT modelling and hydrological modelling.

Acknowledgements
Financial support by the SFB/TR 32 “Pattern in Soil-Vegetation-Atmosphere Systems: Monitoring, Modelling, and Data Assimilation” funded by the Deutsche Forschungsgemeinschaft (DFG).

Further information / contact
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