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Downscaling near-surface atmospheric fields based on multi-objective Genetic Programming

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The coupling of models for the different components of the Soil-Vegetation-Atmosphere-System is required to investigate component interactions and feedback processes. The Transregional Collaborative Research Center 32 (TR 32) has developed a coupled modeling platform, TerrSysMP, consisting of the atmospheric model COSMO, the land-surface model CLM, and the hydrological model ParFlow. The component models are usually operated at different resolutions in space and time owing to the dominant processes. It is, for instance, not feasible to run a computationally quite expensive atmospheric model at the much higher spatial resolution typically required by hydrological models. Thus up- and downscaling procedures are required at the interface between the atmospheric model and the land-surface/subsurface models. We present an advanced atmospheric downscaling scheme, that creates realistic fine-scale fields (e.g. 400 m resolution) of the near-surface atmospheric state variables from the coarse atmospheric model output (e.g. 2.8 km resolution). We apply Genetic Programming (GP), a machine learning method, to detect downscaling rules from a training data set of high-resolution atmospheric model runs: From a set of functions (arithmetic expressions, IF-statements, etc.) and terminals (constants or variables) GP generates potential solutions to a given problem while minimizing a fitness or cost function. GP offers the advantage that the solutions are human readable and thus can be checked for physical consistency unlike, for instance, the output of artificial neural networks. Further, using the multi-objective Strength Pareto Approach (SPEA) for fitness assignment allows us to consider multiple characteristics of the fine-scale fields during the learning procedure, for instance spatially distributed variances and spatio-temporal correlations. Our preliminary results suggest that realistic fine-scale structures can be retrieved from the coarse scale input, which constitutes an advancement compared to pure interpolations methods.