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Evaluation of different parameterizations for land surface schemes over drying terrain in West Africa

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It is widely established, that the parameterization of land surface processes, in particular the way energy is partitioned at the earth's surface, appears to significantly affect the performance of regional weather and climate models. Through the last decades various parameterization have been developed and improved continuously. During recent years there is a growing interest in the study of semiarid ecosystems to enhance the overall model performance in those areas. In semiarid ecosystems, strong feedback mechanisms exist between vegetation patterns and soil water availability. These mechanisms make semiarid ecosystems a challenging task for further parameterization evaluation. In this study different parameterizations for land surface schemes currently used in meteorological models at ECMWF and NCEP are evaluated for a semi-arid region in Ghana, West Africa. All parameterizations have been run offline for a seasonal cycle in 2002/2003 using observations as forcings at two test sites. The two locations are in the humid tropical southern region and in the dryer northern region. For the purpose of forcing and evaluation a new data set is utilized including surface fluxes obtained by scintillometry. This robust method yields area-averaged fluxes over complex terrain, which are required, when evaluating models with different subgrid surface fractions. Moreover the use of scintillometry over semi-arid vegetation types is novel. The measurements include the rapid wet-to-dry transition after the wet season at both sites. The first land surface model (LSM) employed in this study is the present ECMWF land surface scheme (TESSEL). The second LSM is the Noah model from NCEP (version 2.7.1). The two models were selected because they are updated regularly and differ in physical aspects and the degree of complexity with which land surface processes are parameterized. Both models utilize the Jarvis-Stewart approach to calculate canopy conductance as the critical variable for partitioning the available energy into sensible and latent heat flux. Additionally an approach within Noah is tested to calculate canopy conductance based on plant physiology (A-gs method), where the photosynthetic assimilation is coupled to the leaf stomatal conductance. It has the advantage that it is more physically based and less parameter are needed compared to the more standard Jarvis-Stewart approach. One additional advantage is the ability to calculate carbon dioxide fluxes based on common atmospheric variables. As a general trend it is found that during the wet part of the season available energy is described well by all parameterizations. During the drying up the errors in modeled available energy increases for both sites. This feeds back into larger errors for the sensible heat flux, whereas for latent heat flux the results are steady. Simple adjustments for reducing available energy during the dry part of the season are proposed. Furthermore the differences in the simulations provide deeper insights into individual parameterizations characteristics. It is found that TESSEL appears to simulate surface fluxes physically more realistically compared to Noah. The results for the A-gs method are more comparable to those from TESSEL. Additionally the role of soil moisture for the different parameterizations is explored because of the direct feedback to latent heat flux. It is concluded that it might be useful to utilize more physically based parameterizations in regions with pronounced wet and dry seasons during the year.