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Effects of the near-surface soil moisture profile on the assimilation of L-band microwave brightness temperature

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Numerical simulations of atmospheric boundary layer processes require an accurate estimation of soil moisture because the soil water content is a key parameter in the partitioning of available engergy into sensible and latent heat flux. But even in state-of-the-art weather forecast systems modeled soil moisture tends to drift away from reality without regular adjustments. This can be attributed to inaccurate forcing data (precipitation, radiation), the lack of soil texture data, and imperfect parameterizations of soil processes. The assimilation of 2-metre air temperature and humidity is already performed operationally at several weather forecast centers. Another promising observation in this context is L-band microwave brightness temperature because it shows a high sensitivity to surface soil water content and is only weakly affected by the atmosphere and clouds. Satellite observations are not available at present but as of 2007 the launch of the Soil Moisture and Ocean Salinity (SMOS) mission will provide 1.4 GHz brightness temperatures at global scale. In preparation for a possible future operational application of this data a single column assimilation study was carried out with data obtained from the Southern Great Plains (SGP) 1997 Hydrology Experiment. It showed that the assimilation of L-band brightness temperatures in the soil moisture analysis is feasible and leads to promising results. The work presented here makes use of this experiment setup to analyse the effect of systematic and random observation and model errors on the analysed soil moisture and the turbulent atmospheric fluxes. Especially the poor vertical resolution of the soil in land surface models poses a problem, since the penetration depth and weighting function of the low frequency microwaves can not properly taken into account. On the basis of SGP99 soil moisture measurements, which were taken from depths of 0 - 2.5 and 2.5 - 5 cm artificial, high-resolution near-surface water content profiles were created. Sensitivity studies using these profiles showed that modeled brightness temperature can systematically deviate from observations by up to +-5 K. This systematic error is a function of the elapsed time since the last rain event, soil texture and the state of the atmospheric boundary layer. It is shown that a simple systematic error correction of the assimilated brightness temperature can already reduce the rms-error of modeled soil moisture and the turbulent heat fluxes. Therefore, it may not be neccessary to introduce additional soil layers in the land surface model to make optimal use of microwave observations.