Development of a soil moisture analysis by parameterisation of the relation between screen level temperature and soil moisture content.

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At DWD a daily soil moisture analysis runs operational for the limited area model LME. The gradient of the cost function in the 2D variational approach is calculated by two additional 15 hour forecast runs with slightly changed initial soil moisture content. To overcome this computational costly and organisational extensive approach in a global soil moisture analysis a parameterisation of the functional dependence between screen level temperature and initial soil moisture content is developed to calculate the gradient of the cost function directly.

The soil moisture analysis is based on the fact, that under clear conditions, when the temporal evolution of the boundary layer is dominated by the effect from surface heating, screen level parameter as T2m and Rh2m carry information on the soil wetness that mainly controls the partitioning of the available energy input into latent and sensible heat fluxes. As direct measurements of soil moisture are sparse and hardly representative for a whole grid point, and quantitative information on soil water input from precipitation radars not available for a global domain, indirect information is used to prevent the soil moisture state from drifting permanently into unrealistic states.
The processes that determine the actual evaporation rate at every grid point in a NWP model, and hence the effect of changes in soil moisture at the initial time of the forecast, usually 0:00 UTC on screen level parameter at observation times e.g. at noon are generally too complex to be parameterized in detail without running a full land surface scheme. The feedback processes from the surface layer or the planetary boundary layer on the fluxes may distort the initial conditions that analytic solutions to the problem fail. However under ideal conditions a linearization of the dependence of the sensitivity of 2m temperature on soil moisture around the initial background state can be done if case distinctions are applied to account for different land surface properties and atmospheric conditions.
The parameterisation task covers two main issues: First to find a simplified relation for the functional dependence of the sensitivity of 2m temperature on variations in soil moisture (dT2m/dwb) in the different soil layers. Secondly to determine criteria for the characterization of the individual conditions at every grid point to get an estimate on the confidence of the analysis. Given the basic assumptions that surface cooling is linear correlated with latent heat flux, and variations in latent heat flux with soil moisture content are linear correlated with latent heat flux itself, a linear relation between variations in surface temperature and change of initial soil moisture is derived. Assuming further linearity between surface and screen level parameter in case of moderate surface fluxes the sensitivity dT2m/dwb can be approximated by a linear fit.
A series of model experiments is outlined to investigate the sensitivity of 2m temperature on soil moisture with respect to incoming net radiation, soil type, evaporation in the previous hour before observation time and initial soil moisture content itself. It is found that the parameterisation can be applied during strong radiation conditions but it has to be carefully distinguished between different cases of the abovementioned parameter.