Preliminary validation of soil moisture based on operational LM predictions

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Proper treatment of soil moisture is important for an accurate modelling of the boundary layer structures during the day - especially in weather situations which are strongly influenced by a physical forcing from the surface. Among the various parameters describing the physical state of the Earth surface the soil moisture is seen to play a crucial role. Soil moisture conditions decide whether the absorbed solar energy is mainly converted into latent heat flux moistening the atmosphere or into sensible heat flux heating the boundary layer. Large deviations of the modelled soil moisture from real conditions often lead, therefore, to prediction errors in boundary layer weather elements. According to model simulations (Xu et al., 2004), extended moisture anomalies may even influence the atmospheric circulation by modifying large-scale precipitation patterns.

The moisture content of a soil layer is roughly determined by the water balance between infiltrated precipitation, vertical water transfer within the soil, withdraw of water due to evaporation and the runoff into the groundwater. In order to reliably simulate the temporal evolution of soil moisture, complex parameterisations of various processes are needed. A further problem arises from the fact that manifold processes closely acting together perform at very different time scales. Therefore, the soil moisture observed at a certain time has to be seen, especially in dry periods, as the accumulated result of quite different meteorological effects integrated over a long time period (some days up to a few years depending on the soil layer depth). Consequently model errors are likely accumulated and stored in the soil moisture.

In order to illustrate the typical behaviour of the soil moisture in the annual cycle and to assess the present day accuracy of local operational LM-predictions a comparison of measure-

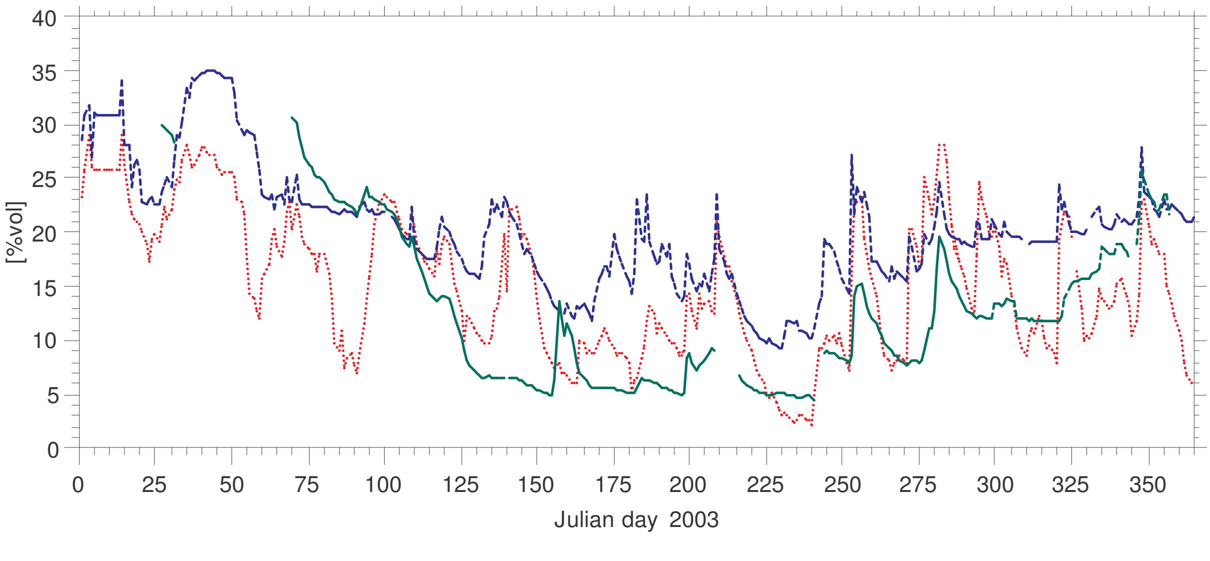

Fig. 1: Annual course of measured and predicted (0-23h) soil moisture within the uppermost soil layer (0-10cm) at Falkenberg site during 2003

ments from the Falkenberg site (Meteorological Observatory Lindenberg) and model values of the uppermost soil layer (0-10cm) is presented in Fig. 1 during 2003. The measurements clearly reflect the typical climate conditions of Central Europe with wet soils in winter and remarkably dryer ones during later spring and summer. This characteristic course isn't well represented in the model over the year. In contrast to nature the model often produces unrealistically low soil moisture values in winter (at the end of March it deviates from the measurements for example by about -18%vol) and doesn't dry up so much in the warmer months. Moreover, a lot of strong moisture peaks arise which do not occur in the measurements and reach up to 15%vol (May 2003). The model results are based here on the soil type 'sand' being comparable that way to the real conditions at the measurement site. Unfortunately, the model deviations are even much stronger in large parts of that model region (federal state Brandenburg) because the soil module is mostly referred to the soil type ‘loam’ producing yet higher moisture levels with different impact on evapotranspiration and, hence, on water input into the atmosphere.

The Fig. 1 also presents analogous results of the Swiss operational weather prediction model aLMo (Meteoswiss). They clearly overestimate the reference values all over the year and reveal in the months from May until October only a fairly unimportant reduction being comparable to that seen in the LM. In winter, however, strong drying up phases don't occur. In order to initialise the soil moisture in the LM a Soil Moisture Analysis is applied, which tunes the soil moisture values to predict reasonable 2m-temperatures. In the aLMo an interpolation technique is used which derives the initial values from soil moisture fields of the driving host model (ECMWF predictions) based on a different hydrology. Further studies reveal that initial values (model start at 0 UTC) provides by both techniques have a marked positive bias up to 15 %vol especially in case of low soil moistures, whereas correct initial values are rather seldom. The initialisation error often exceeds the effects of precipitation and radiation errors on soil moisture during the day. Therefore, the present procedures are fairly insufficient for the given task and should be urgently improved.

Following a proposal by Heise (2004) the soil moisture fields should be continuously simulated by an appropriate soil model which is exclusively driven by measurements (or at least by measured precipitation and radiation) at all grid boxes within the LM or LMK domain. In order to keep nevertheless the accuracy of the 2m-temperature prediction, the temperature parameterisation itself should rather be corrected (Ament & Simmer, 2005) instead to tune the soil moisture.

In a first step towards that aim an appropriate soil model should be made available. For consistency reasons it would be desirable that the LM soil module TERRA might be used for this task. A long-term accuracy check of the TERRA soil module will provide important insights into the model behaviour. For that purpose a stand-alone two-layer version has been exclusively driven by measurements (like radiation, precipitation, wind) from the Falkenberg site during 2003. Furthermore, the external and soil parameters have been adapted if possible to the real site conditions.

A comparison of measured and simulated data in Fig. 2 reveals that the stand-alone version meets the measurements fairly well in the cooler seasons. But it seems to be very sensitive to precipitation during summer by producing often large moisture peaks not found in nature. These findings are supported by a comparison with an AMBAV-simulation [basic information about the model available from Löpmeier (1983)], which matches more precisely with the measurements just in summer. Especially, the precipitation rates are, however, quite comparable in that time although this operational model is driven by SYNOP data from the Meteoro-

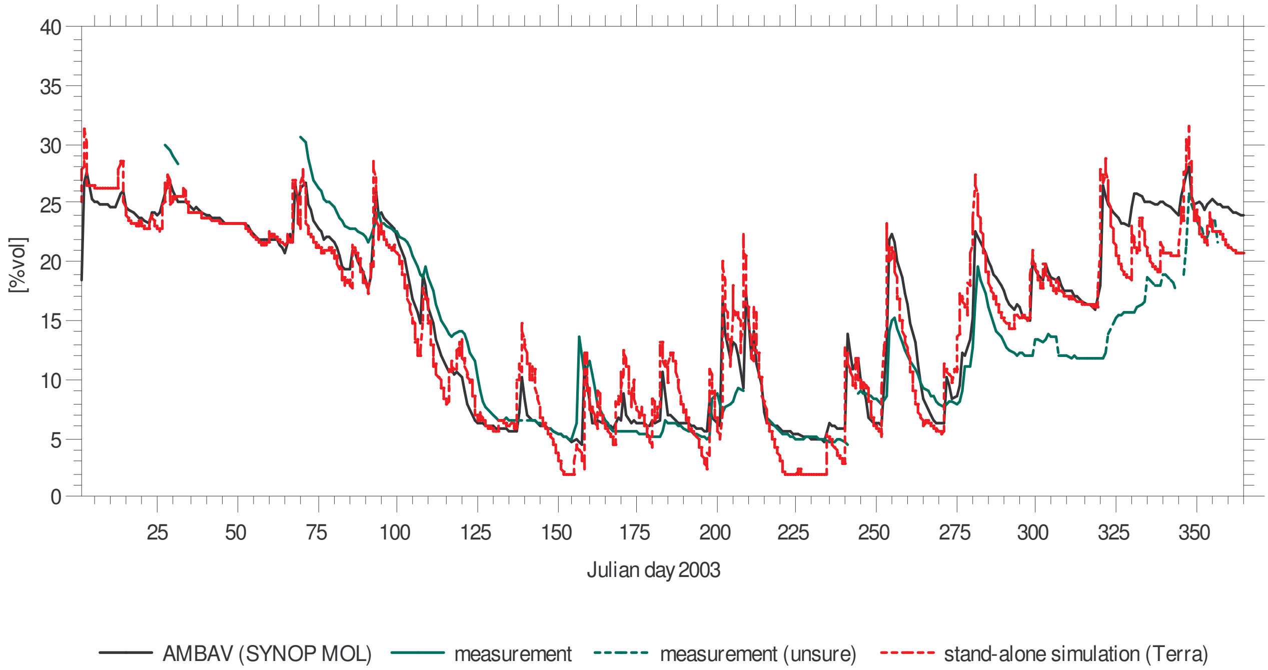

Fig. 2: Annual course of measured and simulated soil moisture within the uppermost soil layer (0-10cm) at Falkenberg site during 2003.

logical Observatory situated in a distance of about 5 km. Therefore, the relevant soil processes (like e.g. infiltration, interception or surface runoff) should be intercompared as well as the manner, in which they are realised in both models to better understand the problem. But despite these remaining deficiencies the real data forcing already yields to a remarkably improved soil moisture course in the annual cycle.

For a more comprehensive assessment of the module performance the studies should be also extended to deeper soil layers. In case of an operational application of the mentioned procedure within the whole model domain the implementation activities should not be restricted to organise an effective data supply and module handling. In view of the importance of realistic external and soil parameters it is, moreover, needed to also update the widely used map of soil types taking advantage of improved soil information nowadays available.

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