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Evaluation of Parametrisation Approaches for the Ground Heat Flux

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The ground heat flux (GHF) is one of the components of the energy balance at the earth's surface and often plays an important role in this context. Especially over bare and/or dry surfaces, it may become a significant part of the energy balance (Heusinkveld et al., 2004). Thus, it is important to determine it correctly.

The first choice to get dependable GHF data is to calculate it from soil measurements (e.g. soil temperature and soil moisture profiles). As it is quite elaborate to measure detailed profiles of all soil parameters in every experiment, experimentators often tend to parametrise the GHF from meteorological data. Unfortunately, there are many parametrisation approaches and yet we lack a comparison between them. In this study, we try to evaluate different parametrisation methods by comparing the results with reference GHF data calculated from soil measurements. Ideally, we would find a way to reliably calculate the GHF from easily accessible meteorological parameters. Then, GHF data could be obtained on numerous sites without detailed soil measurements.

The data set used for this study was recorded during the LITFASS-2003 experiment in Lindenberg, Germany (Beyrich et al., 2004). In the beginning of the campaign (May 2003), the site was bare, but during the four week experiment, maize plants grew up to a height of 60 cm. Our data set comprises detailed soil data (temperature, moisture, density) as well as quality checked radiation and turbulent flux measurements.

The reference GHF data set was calculated from soil temperature and soil moisture profiles using a combination of the gradient approach and calorimetry. In a sensitivity analysis, this method turned out to be the most robust one to measurements errors (Liebethal et al., 2005). Thus, these results can serve as reliable reference values.

Against the reference data set, we evaluated the following GHF parametrisation approaches: - few soil measurements: The same approaches that were used for the detailed GHF analysis were applied to smaller data sets. Instead of complete temperature and moisture profiles, only two or three measurements were used. - GHF from solar or net radiation: There are several approaches to calculate the GHF from radiation measurements, the most simple one assuming a fixed ratio between them. More realistic approaches use a dependency of the GHF/radiation ratio on other parameters (e.g. soil moisture, Cellier et al., 1996). - GHF from turbulent sensible heat flux: The GHF may be parametrised as a portion of the sensible heat flux, because these two fluxes are closely related. As with radiation, the ratio is not fixed but can be correlated with the horizontal wind speed reflecting the efficiency of the turbulent transport (Cellier et al., 1996). - GHF from surface temperature: Wang and Bras (1999) developed an approach to parametrise the GHF from the time series of the surface temperature and the heat diffusivity of the soil. They assume a uniform temperature distribution at t = 0 and a uniform and constant heat diffusivity. With these assumptions, the GHF can easily be derived from the surface temperature.

As we can learn from our analysis, none of the parametrisation methods meets the reference data set perfectly. Though, some of the approaches are better than others, leading to at least realistic estimates of the GHF.

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