The ground heat flux simulated by the COSMO land surface scheme TERRA

Jan-Peter Schulz1,2, Gerd Vogel2, Claudia Heret2 and Bodo Ahrens3
1Biodiversity and Climate Research Centre (BIK-F), 2Deutscher Wetterdienst (DWD), 3Goethe University Frankfurt
E-mail: schulz@lau.uni-frankfurt.de

The problem …

- The ground heat flux simulated by the land surface scheme TERRA of the COSMO regional atmospheric model (Steppeler et al. 2003) is systematically overestimated under dry conditions.
- Since this flux is part of the surface energy balance it affects the other components like the turbulent heat fluxes or the surface temperature.
- An overestimation of the ground heat flux during daytime leads to an underestimation of the other surface fluxes and a reduced surface warming.
- During afternoon and night this behaviour is reversed.

Hypothesis

Main reasons for this overestimation:

- Shading effect of the vegetation is not represented
- Soil thermal conductivity is too large (of dry soil)

Methodology

- Focus on thermal conductivity first
- Reduce the soil thermal conductivity and hence the ground heat flux under dry conditions, by introducing its strong dependency on the soil water content

Experiments

The thermal conductivity of water is about a factor of 25 larger than that of air. This means, a wet soil has a much larger thermal conductivity than a dry soil. Experiments on the dependency of the soil thermal conductivity on soil water content in:

- Offline mode: Multi-layer land surface scheme TERRA using atmospheric forcing from DWD observatory Lindenberg (Falkenberg site)
- Climate mode: Climate version of the COSMO model (COSMO-CLM) over Africa

Offline TERRA: Falkenberg July 2010

In TERRA the soil thermal conductivity is constant in time, representing a medium soil wetness (black line). The blue and red curve show two other approaches, relating thermal conductivity to soil water content:

- Johansen (1975)
- McCumber and Pielke (1981)

Curves were computed for mean soil moisture profile for Falkenberg on 1-16 Jul. 2010 in offline TERRA.

Soil temperatures: Grass land

- Diurnal cycle of soil temperature are reduced in the experiment and N better to the observation

- McCumber and Pielke (1981): The diurnal cycles of the soil temperatures are too much reduced in the experiment

Cosmo-CLM over Africa

- CORDEX Africa domain, horizontal resolution: 0.44°
- ERA-interim forcing, simulation period: 2008 – 2010

OBS: Observations of average diurnal 2-m temperature range [°C] (ADTR) by Krähenmann et al. (2013)

REF: COSMO-CLM reference

EXP: COSMO-CLM with Johansen (1975)

Conclusions

- The ground heat flux in the COSMO model is systematically overestimated under dry conditions.
- Affects other components of the surface energy balance like turbulent heat fluxes or surface temperature in terms of phase or amplitude of their diurnal cycles.
- Two approaches by Johansen (1975) and McCumber and Pielke (1981) for a soil thermal conductivity being dependent on soil moisture were tested. The first one leads to better results. Improvements were achieved in offline and climate modes.
- A representation of the shading by vegetation in the model needs further attention.

References

Krähenmann, S., S. Köthe, H.-J. Pantz and B. Ahrens, 2013: Evaluation of daily maximum and minimum 3 m temperatures as simulated with the regional climate model COSMO-CLM over Africa. Submitted to Mic. Z.

The source of one figure in this presentation is the COMET® Website at http://meted.ucar.edu