4B.1 BOUNDARY LAYER PROCESSES OVER DIFFERENT SURFACES SIMULATED BY WRF IN A MOUNTAINOUS REGION SOUTH OF VIENNA, AUSTRIA

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1. INTRODUCTION

The University of Natural Resources and Life Sciences, Vienna, runs a forestry site in a semi-complex terrain south of Vienna used for research and teaching. The Rosalia Lehrforst is 930 hectare large and stretches from 320 m to 725 m. Studies carried out at Rosalia investigate land-surface interactions, hydrological studies such as heavy precipitation events, gas exchange processes, atmospheric processes in the Vienna basin, and many more.

In the past years initiatives took place to bring atmosphere, hydrology, soil, and forestry together. Several ongoing projects build a good baseline for future projects. It was planned to start a meteorological observation and modeling cluster in the forest. Therefore, modeling studies were carried out to study on one hand the effects of differen land-use representations keeping in mind that one would have to implement a new land-use data set to properly represent the region. On the other hand, the impacts of initial and boundary soil moisture conditions was studied as it was planned to also burn down a small patch of the forest to study runoff and drainage.

Here, the WRF model is used to evaluate the effects of different kinds of land-use and soil types, including different soil moisture conditions, on the boundary layer and boundary layer processes within the forest and the southern Vienna basin.

2. MODEL AND SIMULATION SETUP

2.1 *Model*

The Weather Research and Forecasting (WRF) model version 3.2.1 with the ARW dynamical solver (Skamarock et al., 2008) and the WRF Preprocessing System (WPS), version 3.2.1, is used. ERA-Interim data were used as boundary conditions for the episode 1 – 12 September 1999. A four domain setup (Fig. 1a) was chosen with a resolution of 600 m in the innermost domain. Feedback between the nests was enabled and grid nudging was applied on the outermost domain. The innermost domain started 6 hours later, allowing for spin-up of e.g. soil parameters. In the vertical a resolution of 40 full σ levels was used with model top at 50 hPa.

The microphysics scheme of Lin et al. (1983) (Lin et al., 1983; Rutledge and Hobbs, 1984; Tao et al., 1989; Chen and Sun, 2002), the Mellor-Yamada-Nakanishi-Niino (MYNN) 2.5 TKE closure boundary layer scheme (Mellor and Yamada, 1982; Janjić, 2002; Nakanishi and Niino, 2004, 2006), the Noah LSM (Chen and Dudhia, 2001), the RRTM longwave scheme (Mlawer et al., 1997), and Dudhia shortwave radiation scheme (Dudhia, 1989) were used. On the outermost domain, the Betts-Miller-Janjić cumulus scheme (Betts and Miller, 1986; Janjić, 1994) was applied. Fig. 1b) shows the innermost modeling domain.

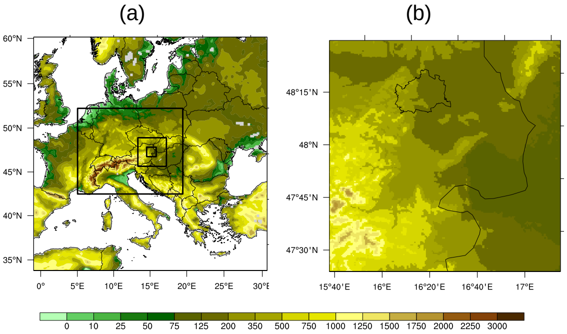

FIG. 1: a) Domain setup used and terrain representation b) domain and terrain representation of the innermost domain using 600 m resolution. The legend is in metre. Black lines denote the Austrian border and in b) the outlines of Vienna.

2.2 *Simulation setup*

Two different experiments were carried out. Experiment one investigates the effects of different land-use data on the local meteorology. A reclassified CORINE data set (CLC06) (EEA, 2007; Schicker and Seibert, 2014), a USGS climate (USGS-clim) version of the USGS data where water bodies were reclassified to grassland, and the MODIS data (MOD) were applied. The reclassified data shows that in some regions, especially for urban and forested areas in the domain, the USGS classification is not up-to-date and also MODIS is not always classified correctly. But also the re-classified data needs careful evaluation and should not be taken without quality control. Experiment two uses a simple dry-normal-wet approach to evaluate the impact of volumetric soil moisture content on the simulation results. For the dry and wet simulation the volumetric soil water content of the ERA-Interim input data were reduced/increased by ± 30%, respectively. In total, five simulations were carried out (Tab. 1).

3. RESULTS

Three meteorological observation sites are operated by BOKU inside the forest, one located at the foothills, one in a small valley, and one close to the BOKU building close to the highest point of the forest (HIER FIG LINK).

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Table 1: Summary of the five simulations.

	land-use	vol. soil moisture content
CTL	CLC06	orig. ERA-Interim
CLIM	USGS-clim	orig. ERA-Interim
MOD	MODIS	orig. ERA-Interim
WET	CLC06	ERA-Interim + 30%
DRY	CLC06	ERA-Interim - 30%

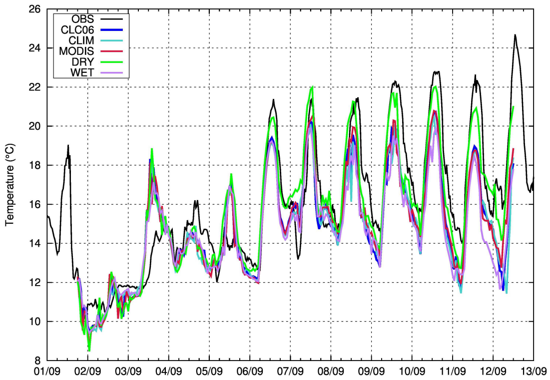
In total, 18 observation site of the ZAMG (Central Institute of Meteorology and Geodynamics) are available for the evaluation of the modeled episode. Additionally, radiosounding observations of Wien Hohe Warte are available twice daily.

Results for the averaged simulated 2 m temperature of grid points corresponding with observation sites (Fig. 2) reveal that between the CTL and the MOD simulation difference are small with a in the bias corrected rmse of 1.53 K and 1.51 K, respectively. The performance of the CLIM simulation is not as good as the other two with a BCRMSE of 1.66 K. Nocturnal temperature of the CLIM simulation are on average 0.5 – 1 K to low compared to observations and the other two land-use simulations. Results of the two soil moisture simulations show that differences between the WET and the land-use simulations are rather small, especially between CLIM and WET. The DRY simulation performs best, the amplitude of the diurnal cycle is represented, especially daily maxima between 9 – 12 September are captured. Compared to single observation sites the DRY run performs best, also with an overall BCRMSE of 1.34 K. This indicates that already the boundary conditions of the land-use simulations, thus the original ERA-Interim fields, are close to the tabulated soil wetness parameters.

Time-averaged soil temperatures show differences due to the land-use representations and also differences between WET and DRY compared to the CTL simulation (Fig. 3). The DRY simulation is generally to warm, by 1 – 1.5 K, whereas the WET simulation is colder than CTL. Visible in the WET simulations are the soil type fields. These fields are currently available only with a coarse resolution of $2'$. Thus, also the tabulated parameters such as field capacity are available on this coarse grid.

Differences in initial and boundary conditions of soil moisture affect also latent and sensible heat flux. Whereas the land-use simulations and the WET simulation do not differ in latent and sensible heat flux the DRY simulation differs by 10 Wm^{-2}. Again, soil texture background data influences the model results and are visible in the spatial representation of average fields. The effect of the drier soil is also visible in the simulated boundary layer height and vertical profiles. Boundary layer heights in the DRY simulation are on average 36 m higher than in the CTL simulation. Also, vertical profiles are modified. Compared to observations of the radiosoundings of Wien Hohe Warte DRY represents the vertical structure better than the other simulations (Fig. 4).

(a) Rosalia Kuhwald



(b) Overall

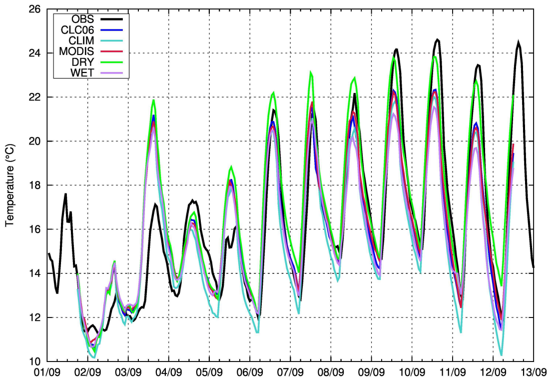


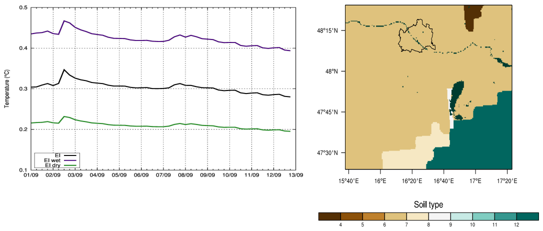
FIG. 2: Height corrected simulated 2 m temperatures at grid points corresponding to observation sites for a) Rosalia bottom site, b) Vienna city centre, c) Rax, a mountain plateau site, and d) averaged over all available observation sites.

Average precipitation results differ especially between WET and DRY, the land-use simulations results are between the two soil moisture simulations. Spatial differences between the five simulations are more pronounced, especially in the Vienna basin along the southeasterly slopes of the mountains ranging from Schneeberg to Vienna.

4. DISCUSSION AND CONCLUSION

Results of the three simulations using different land-use data sets show that the CLIM simulation 2 m temperatures are generally too cold although the amplitude of the diurnal temperature is represented. The CTL and MOD simulations represent the conditions better and differences between the two are only small compared to differences to the observations. Differences in the PBL height, vertical profiles, and latent and sensible heat flux are more pronounced. Overall results show that MOD and CTL differ only slightly but a more detailed evaluation shows that this is not true for every grid point. One has to carefully check both, the in-built MODIS data set and the re-classification routine if land-use is correct in the region of interest.

The two soil moisture simulations show that WET does not differ that much from the land-use simulations and does not improve simulations. The DRY simula-



(a) Vol. soil m. c. (b) Soil texture field

(c) Differences EXP - CTL

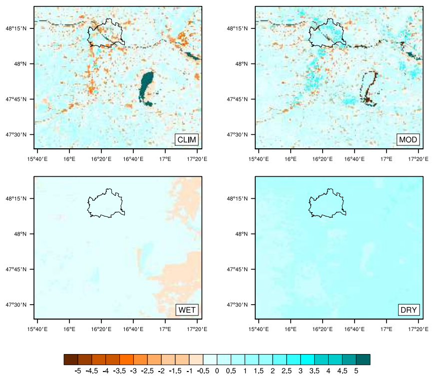
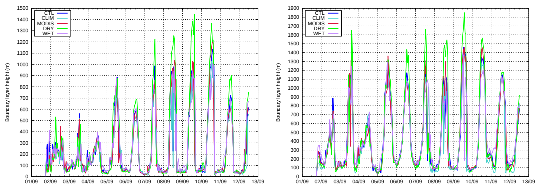


FIG. 3: a) ERA-Interim volumetric soil water content for the grid box covering most of the domain of the dry, wet and original simulation. b) soil texture field in the innermost domain, and c) differences of the CTL and the four other experiments in K.



(a) Rosalia Kuhwald (b) Wien Hohe Warte

(c) Sounding CTL (d) Sounding DRY

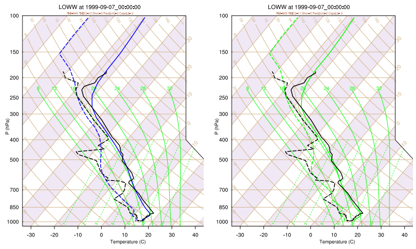


FIG. 4: Top) simulated PBL heights at two observation sites, a) Rosalia and b) Wien Hohe Warte and bottom) observed radiosoundings and simulated vertical profiles for CTL and DRY simulation.

tion, though, has an significant impact on temperature, PBLH, and surface fluxes. Also, vertical profiles reproduce the observations better.

Impacts of the updated land-use data are masked by other effects. One reason could be the too wet initialised soil moisture. Another reason influencing modeling results is the background soil type and related soil capacity effects.

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