Impact of the land surface forcing on land-atmosphere feedback in the convection permitting modeling

J. Milovac(1), K. Goerken(2), J. Fernandez(1), K. Warrach-Sagi(3), J. Ingwersen(1), A. Lavin-Gullon(1), and V. Wulfmeyer(3)

(1)Meteorology Group, Instituto de Física de Cantabria, Santander, Spain; (2)Institute of Bio-and Geosciences (AgroSphere), Research Centre Jülich, Jülich, Germany; (3)Meteorology Group, Dept. of Applied Mathematics and Comp. Sci. (Univ. Cantabria), Santander, Spain; (4)Institute of Physics and Meteorology, University of Hohenheim, Stuttgart, Germany; (5)Institute of Soil Science and Land Evaluation, University of Hohenheim, Stuttgart, Germany

http://www.meteo.unican.es

Contact: milovac@unican.es

1. Motivation and objectives

Predictive skill of an atmospheric model depends on the initial and boundary information that we use for its forcing. Besides the topography, surface texture (ST) and land cover (LC) maps are the two most relevant static information used for the model initialization. In the Weather Research and Forecasting (WRF) model the default LC information are based on the Moderate Resolution Imaging Spectroradiometer (MODIS), and ST on the Food and Agricultural Organization (FAO) data. We created two alternative maps for WRF: A LC map based on the higher resolution and more up-to-date Corine data, for Europe, A ST map based on the Harmonized World Soil Database (HWSD, Milovac et al. 2016) and Bodenüberschneidung (BUK-100; Moravek et al. 2010) top data. LC and ST characterize the land surface and control the hydraulic and physical properties of the soil, which have a strong impact on the energy partitioning at the land surface. The surface heat fluxes – calculated in a land surface model (LSM) or surface layer scheme, depending on the selected model configuration - represent the lower boundary condition for a Planetary Boundary Layer (PBL) scheme.

In the CORDEX Flagship Pilot study CORDEX-IPS initiative on Convective Phenomena over Europe and Mediterranean (Copolla et al. 2018) an ensemble of convective permitting simulations is being produced, where all research groups running WRF use the two alternative (CORINE and HWSD) static maps. For the first time we used the basic validation of the impact of these maps on the model output using FLUXNET2015 data (Pastorello et al. 2017), and we investigate: 1. Sensitivity of WRF to changes in static maps

2. How the model sensitivity in (1) depends on the model configuration

2. Experimental design

• WRF model, version 3.8.1
• 2 model configurations C1 and C2, different in the selection of the PBL schemes and LSMs
• 2 ensembles ES1 and ES2 created for 2 time lines: ES1 for June 2009, ES2 for October
• Each ensemble consists of 8 simulations, where top soil texture, 2 land cover forcing maps and 2 model configurations were combined in 16 simulations.

Results from ES1 presented here.

3. Methodology

• To investigate the impact of the land surface on the PBL evolution we used the mixing diagram approach (Santanello et al. 2009). The diagram is basically a vector representation of the diurnal variation of 2m potential temperature and 2m mixing ratio (we refer from here to 6 to 16 UTC)

• Size of each vector is the quantified impact of the surface (it is a model output or observed) and is taken as the impact from the atmosphere on the PBL evolution. (obtained from the diagram).

4. Validation with FLUXNET2015 data

Fig 4: Mixing diagrams at the locations of 2 FLUXNET2015 stations, DE-Cob and IT-Lav - model comparisons with FLUXNET2015 data. Panel a) shows shortwave surface fluxes (SWRF). Panel b) shows shortwave surface fluxes (SWRF). Panel c) shows shortwave surface fluxes (SWRF). Panel d) shows longwave surface fluxes (LWRF) - black line (compared to observations, black line).

5. Regional averages over dry days

Fig 5: Mixing diagram averaged over grid cells within the Mediterranean (MED) region where LCL (Loam/Cla) and (Loam/Cla) in MODIS is converted to LCL (Loam/Cla) in HWSD.

In the Mediterranean (MED) region 46.9% of Cla-Loam (Cla) grid cells in MODIS are converted to Cla-Loam in HWSD. This change results in an increase of moisture in the boundary layer (BBL) specifically for the C2 (NOAH-MP) configuration.

6. Atmospheric variables: LCL deficit

Fig 6: Mixing diagram averaged over grid cells within the Mid-European (ME) region where Mixed Forest (MF) is converted to European Temperate Forest (ETF) in MODIS. This change increases LCL in C2 (NOAH-MP) simulations, but not in C1 (NOAH-MP) simulations. Influence of the atmospheric drying in the afternoon PBL stronger in C2 than in C1 simulations (Cla) especially in CORINE simulations.

Changes of the static maps have an effect on the PBL height and LCL. Additionally, simulations more sensitive to the changes than the C1 (YSU) simulations. C1 shows a strong diurnal cycle of the LCL deficit for all seasons, with the minimum at midday not evident in C2.

In the ME region changes in C2 enter PBL production higher/lower LCL. This may lead to a conclusion that atmospheric impact on the PBL evolution stronger then the impact from the land surface. 7. Conclusions

• The comparison to the FLUXNET 2015 data shows WRF tendency to be drier and warmer than the observations. Higher variability of MODIS simulations for the moisture variables.

• NOAH-MP LSM and MYNN PBL scheme more sensitive to changes in land top and soil texture maps than NOAH LSM and YSU PBL scheme.

• The changes in the static maps have an impact on the surface variables and the PBL evolution, and the impact of the model configuration and a specific category change.

Acknowledgement

This work is supported by the Spanish Government through the "Plano de Estudios y Formación de Personal de excelencia María de Maeztu” (MME-2017-0706), and FiDiPro programme through INSIGNIA (COLID-2015-79210-F) co-funded by the ERDF/FEDER. The University of Cantabria simulations are carried out on the Alemany supercomputer at the Institute of Physics of Cantabria (IFCA-CSIC), member of the Spanish Supercomputing Network.

Fifty five FLUXNET2015 data are acquired by the FLUXNET community (www.fluxnet.org).

References


• Milovac et al. (2019), Weather Climate Change and Management, vol. 6, pp. 92–100, doi:10.1594/WDCC/WRF NOAH HWSD world TOP_ST v121.


• Milovac et al. (2019), Weather Climate Change and Management, vol. 6, pp. 92–100, doi:10.1594/WDCC/WRF NOAH HWSD world TOP_ST v121.


• Milovac et al. (2019), Weather Climate Change and Management, vol. 6, pp. 92–100, doi:10.1594/WDCC/WRF NOAH HWSD world TOP_ST v121.


• Milovac et al. (2019), Weather Climate Change and Management, vol. 6, pp. 92–100, doi:10.1594/WDCC/WRF NOAH HWSD world TOP_ST v121.
