Variations in the simulation of climate change impact indices due to different land surface schemes over the Mediterranean, Middle East and Northern Africa

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The Eastern Mediterranean (EM) and the Middle East and North Africa (MENA) are projected to be exposed to extreme climatic conditions in the 21st century, which will likely induce adverse impacts in various sectors (Lelieveld, 2012; Zittis, 2016; Constantinidou, 2016). Relevant climate change impact assessments utilise data from climate model projections and process-based impact models or simpler, index-based approaches.

In this study, we explore the implied uncertainty from variations of climate change impact-related indices as induced by the modelled climate (Weather Research Forecast (WRF) regional climate model (RCM)) from different land surface schemes (Noah(Tewari,2004), NoahMP (Niu, 2011), CLM (Oleson, 2010) and RUC (Benjamin, 2004)). The three climate change impact-related indicators examined here are the Radiative Index of Dryness (RID (Budyko, 1974), the Fuel Dryness Index (Fd) (Snyder, 2006) and the Water-limited Yield (Yw) (Constantinidou, 2016).

The aforementioned indices are calculated using the output of six simulations performed by WRF RCM using the above stated four different LSSs in a total of six sensitivity experiments, as presented in Table 1, for the period of 2000–2010 over the MENA-CORDEX domain at a 50-km horizontal resolution.

Table 1. Description of the six performed experiments

Experiment No.	Land Surface Scheme	Number of soil layers
run 1	Noah	4
run 2	NoahMP Dynamic vegetation = OFF	4
run 3	NoahMP Dynamic vegetation = ON	4
run 4	CLM	10
run 5	RUC	6
run 6	RUC	9

Our findings indicate that Noah simulates the highest values for both RID and Fd, while CLM gives the highest estimations for winter wheat Yw. The “relative dispersion”, used in this word as an indicator of the uncertainty, in the three indices derived by the different land schemes is not negligible, amounting, for the overall geographical domain of 25% for RID and Fd, and 10% for Yw. The dispersion is even larger for specific sub-regions, which the domain is divided into and are shown in figure 1. The highest relative dispersion for RID is over 100% in the region of eastern Mediterranean and for Fd and Yw, Mesopotamia has the largest 40% and 35% respectively.

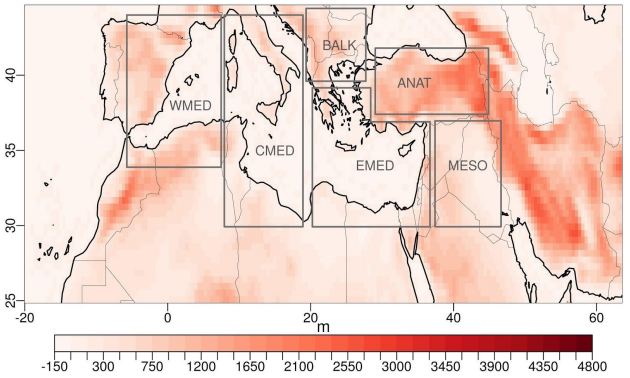

Figure 1. Orography of the MENA domain used in the analysis, with the 6 sub-regions (Anatolia, Balkans, western, central & eastern Mediterranean and Mesopotamia).

References:

Lelieveld, J.; Hadjinicolaou, P.; Kostopoulou, E.; Chenoweth, J.; El Maayar, M.; Giannakopoulos, C.; Hannides, C.; Lange, M.A.; Tanarhte, M.; Tyrlis, E.; et al. Climate change and impacts in the eastern Mediterranean and the Middle East. Clim. Chang. 2012, 114, 667–687.

Zittis, G.; Hadjinicolaou, P.; Fnais, M.; Lelieveld, J. Projected changes in heat wave characteristics in the eastern Mediterranean and the Middle East. Reg. Environ. Chang. 2016, 16, 1863–1876.

Lelieveld, J.; Proestos, Y.; Hadjinicolaou, P.; Tanarhte, M.; Tyrlis, E.; Zittis, G. Strongly increasing heat extremes in the Middle East and North Africa (MENA) in the 21st century. Clim. Chang. 2016, 137, 245–260.

Constantinidou, K.; Hadjinicolaou, P.; Zittis, G.; Lelieveld, J. Effects of climate change on the yield of winter wheat in the eastern Mediterranean and Middle East. Clim. Res. 2016, 69, 129–141.

Tewari, M.; Chen, F.; Wang, W.; Dudhia, J.; LeMone, M.A.; Mitchell, K.; Ek, M.; Gayno, G.; Wegiel, J.; Cuenca, R.H. Implementation and verification of the unified NOAH land surface model in the WRF model. In Proceedings of the 20th Conference on Weather Analysis and Forecasting, Seattle, WA, USA, 12–16 January 2004; In Proceedings of the 16th Conference on Numerical Weather Prediction, Seattle, WA, USA, 12–16 January 2004; pp. 11–15.

Niu, G.Y.; Yang, Z.L.; Mitchell, K.E.; Chen, F.; Ek, M.B.; Barlage, M.; Kumar, A.; Manning, K.; Niyogi, D.; Rosero, E.; et al. The community Noah land surface model with multiparameterization options (Noah-MP): 1. Model description and evaluation with local—Scale measurements. J. Geophys. Res. 2011, 116, D12109.

Oleson, K.W.; Lawrence, D.M.; Gordon, B.; Flanner, M.G.; Kluzek, E.; Peter, J.; Levis, S.; Swenson, S.C.; Thornton, E.; Feddema, J.; et al. Technical Description of Version 4 of the Community Land Model (CLM); NCAR
Tech. Note NCAR/TN–478+STR; National Center for Atmospheric Research: Boulder, CO, USA, 2010; 266p.

Benjamin, S.G.; Grell, G.A.; Brown, J.M.; Smirnova, T.G.; Bleck, R. Mesoscale weather prediction with the RUC hybrid isentropic-terrain-following coordinate model. Mon. Weather Rev. 2004, 132, 473–494.

Budyko, M.I. Chapter VI: Climatic factors of geographic zonality. Geophys. J. Int. 1974, 18, 317–370.

Snyder, R.L.; Spano, D.; Duce, P.; Baldocchi, D.; Xu, L. A fuel dryness index for grassland fire-danger assessment. Agric. For. Meteorol. 2006, 139, 1–11.