Verification of EBU-POM regional climate model using E-OBS and ERA5-Land dataset over Pannonian Basin

Irida Lazic*, Vladimir Djurdjevic, Milica Tosic, Neda Aleksandrov, Darko Savic
University of Belgrade – Faculty of Physics, Institute of Meteorology
*** irida.lazic@ff.bg.ac.rs (corresponding author)**

Introduction

In previous studies, it was noticed that most of EURO-CORDEX Regional Climate Models (RCMs) tend to overestimate the mean near surface air temperature and underestimate the precipitation in the Pannonian Basin (area of interest is shown in fig. 1) during summer, leading to the so-called summer drying problem. Our intention for this study is to check does dry and warm bias is also present in the results of fully coupled atmospheric-ocean RCM EBU-POM and to further investigate possible reasons for warm and dry bias.

Previous studies pointed out an important role of soil moisture in the climate system through complex soil-moisture-atmosphere feedbacks. Therefore, we tested the hypothesis that the biases are related to a false representation of soil properties in this region.

Materials and Methods

To verify EBU-POM model's results, we compared model results with daily data derived from E-OBS gridded dataset for 2-m temperature and precipitation, and ERA-5 Land for soil moisture content with horizontal resolution of 0.11 degrees (approximately 12 km x 12 km).

Model skill for 2000-2010 time period was expressed in term of three verification scores: BIAS, root mean square error (RMSE), spatial correlation coefficient and compared standard deviation with observed data. Finally the calculated scores are averaged over Pannonian valley. The degree of statistical similarity between two climatic fields was determined by the using normalized and non-dimensionalized Taylor diagram (Fig. 5,6 and 7) to provide a concise statistical summary.

In order to test the hypothesis that the biases are related to a false representation of soil properties, we ran two EBU-POM simulations: control simulation (CTL) shown in Fig. 2 with soil type distribution derived from Zobler dataset (1986) and modified simulation (MOD) which is the same as CTL but with clay loam (6) areas instead of loamy sand (1) and sandy loam (4) areas. Soil corrections in MOD simulation have been done according to the observed emphasized biases and to the high-resolution (30 degrees) hybrid STATSGO-FAO soil map.

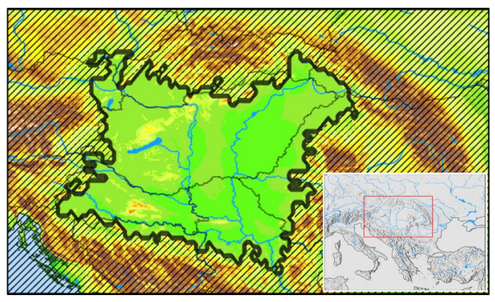
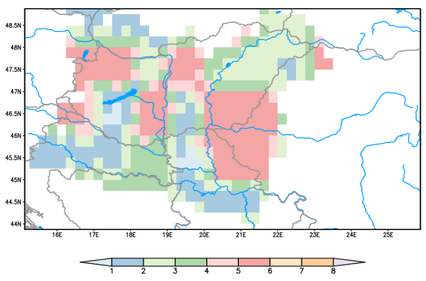


Fig. 1 – The Pannonian Basin - non-hatched area. In the bottom right corner, the wider Southeast Europe region is given with the red rectangle indicating boundaries of main figure.



Soil type	Zobler (1986)	Cosby et al. (1984)
1	COARSE	LOAMY SAND
2	MEDIUM	SILTY CLAY LOAM
3	FINE	LIGHT CLAY
4	COARSE-MEDIUM	SANDY LOAM
5	COARSE-FINE	SANDY CLAY
6	MEDIUM-FINE	CLAY LOAM
7	COARSE-MED-FINE	SANDY CLAY LOAM
8	ORGANIC	LOAM
9	LAND ICE	LOAMY SAND

Fig. 2 – Soil type distribution used in model control simulation (CTL). Numbers of soil types in figure (left) follows numbers of soil types in Table - Zobler dataset 1986 (right).

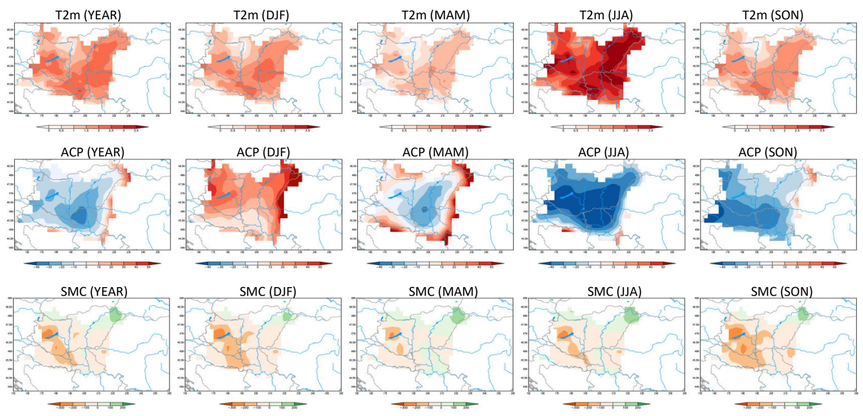


Fig. 3 – Spatial distribution of model's skill term of bias for control simulation (CTL) for: mean 2m-temperature (T2m), precipitation (ACP) and total soil moisture content up to 1m depth (SMC) in annual (YEAR), winter (DJF), spring (MAM), summer (JJA), and autumn (SON) time scales during 2000-2010. Bias units for T2m, ACP and SMC are ℃, % of observations and mm, respectively. Bias is calculated as difference between model's data and observed data.

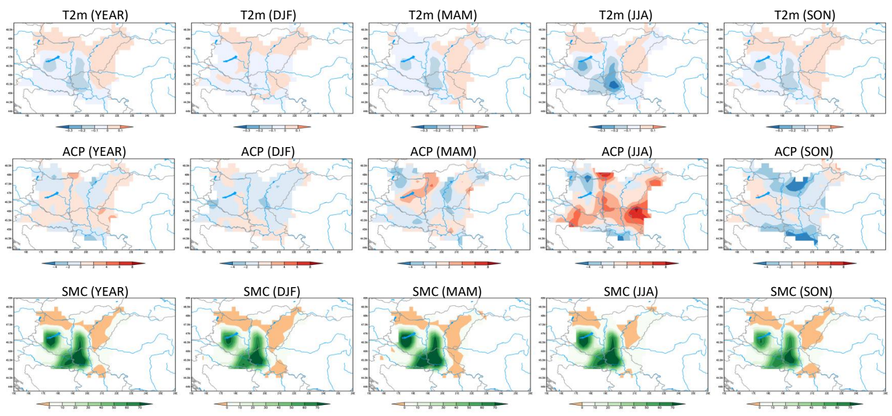


Fig. 4 – Spatial distribution of bias difference between both simulations (MOD-CTL) for: mean 2m-temperature (T2m), precipitation (ACP) and total soil moisture content up to 1m depth (SMC) in annual (YEAR), winter (DJF), spring (MAM), summer (JJA), and autumn (SON) time scales during 2000-2010. Bias units for T2m, ACP and SMC are ℃, % of observations and mm, respectively.

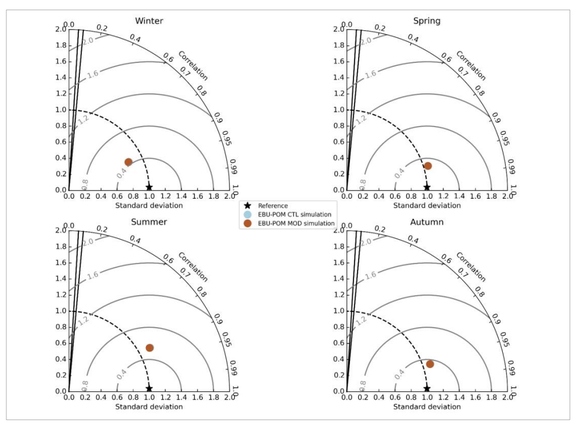


Fig. 5 – Normalized Taylor diagram for monthly mean 2m-temperature in Pannonian Basin during 2000-2010.

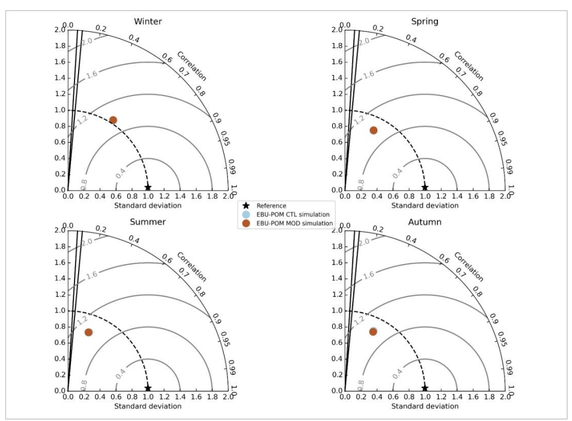


Fig. 6 – Normalized Taylor diagram for monthly precipitation in Pannonian Basin during 2000-2010.

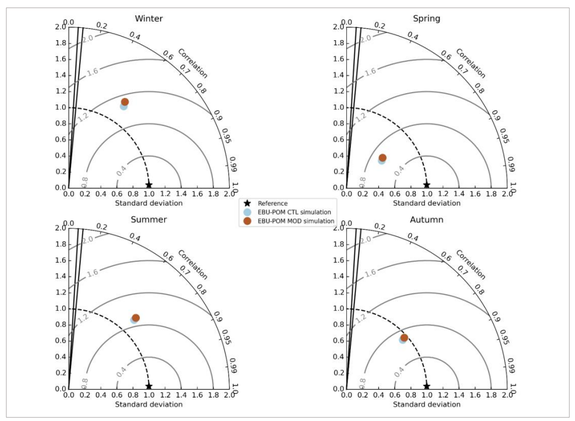


Fig. 7 – Normalized Taylor diagram for monthly mean soil moisture content up to 1m depth in Pannonian Basin during 2000-2010.

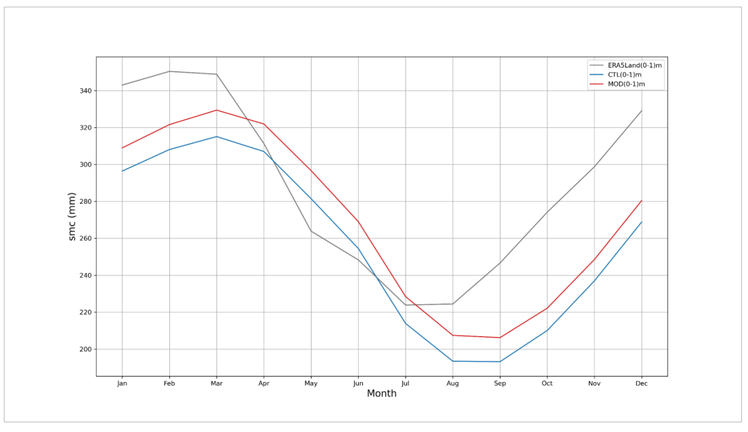


Fig. 8 – Monthly mean soil moisture content up to 1m depth averaged over Pannonian Basin for 2000-2010. The black line depicts the observed dataset (ERA5-Land), the blue line depicts CTL simulation and red line depicts MOD simulation.

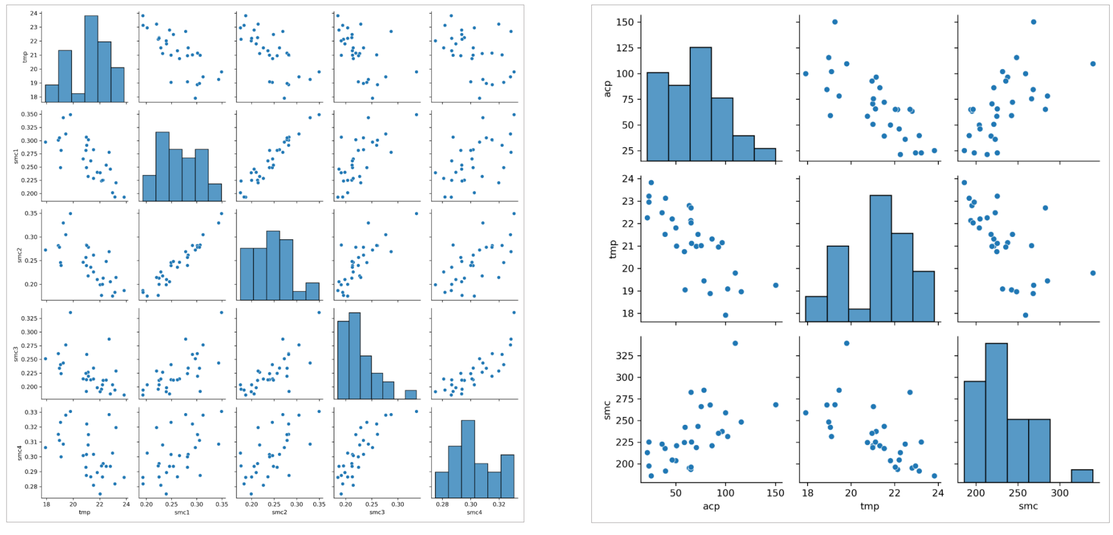


Fig. 9 – Pairwise observed E-OBS dataset relationships between mean monthly 2m-temperature and monthly volumetric soil water layers (left) and between monthly precipitation, mean monthly 2m-temperature and monthly soil moisture content up to 1m depth (right) averaged over Pannonian Basin for summer season (JJA) during 2000-2010.

Results and Discussion

According to the bias distribution, the most prominent feature in Fig. 3 is mostly widespread warm and dry bias during summer in Pannonian Basin. The 2m-temperature bias distribution is positive everywhere and up to 3.5 ℃ and the precipitation bias distribution is negative everywhere and up to -40 % during summer season. Note that the E-OBS reference dataset errors are larger in the summer season for precipitation field since summer precipitation is mainly convective rather than frontal. Hence, we assume that summer precipitation underestimation over Pannonian Basin is even more pronounced because, according to the previous studies, E-OBS underestimates summer precipitation. The bias distribution of soil moisture content up to 1m in depth is mainly negative everywhere, and we have mainly model underestimation for all seasons (shown in Fig. 3 and 8).

Since we have observed emphasized biases in some areas related to specific soil types, we ran as well MOD experiment and calculated the spatial distribution of bias difference between both simulations (MOD - CTL) shown in Fig. 4. The most pronounced modification was during summer in places where we changed soil type. As we can see in Fig. 4, we decreased all the biases related to 2m-temperature, precipitation, and soil moisture content through a modified experiment (MOD). The presented results agreed with previous studies which pointed out that soil moisture-climate interactions and feedbacks are manifested through impacts on temperature and precipitation and especially are pronounced in the summer season.

From Figures 5-7, we notice that for the summer season, the presented scores show the highest spatial variability, the highest normalized RMSE, and the lowest spatial correlation coefficient in comparison to the other three seasons for all examined fields.

Pairwise observed dataset relationships between tmp, acp, and smc presented in Fig. 9 showed patterns of positive and negative relationships observed in the summer season while it is not the case with other seasons (not shown).

Conclusions

Dry and warm biases over Pannonian Basin have been observed during the summer.

Bias of 2m-temperature,precipitation, and soil moisture content decreased in modified simulation and it is the most prominent during the summer season. Soil types are based on soil parameters with fixed definitions such as porosity, heat capacitu, etc., which strongly influence the soil moisture conditions and surface fluxes, and therefore air temperature and precipitation through complex land-atmosphere coupling and feedbacks.

Acknowledgement
This study was supported by the Serbian Ministry of Science and Education.