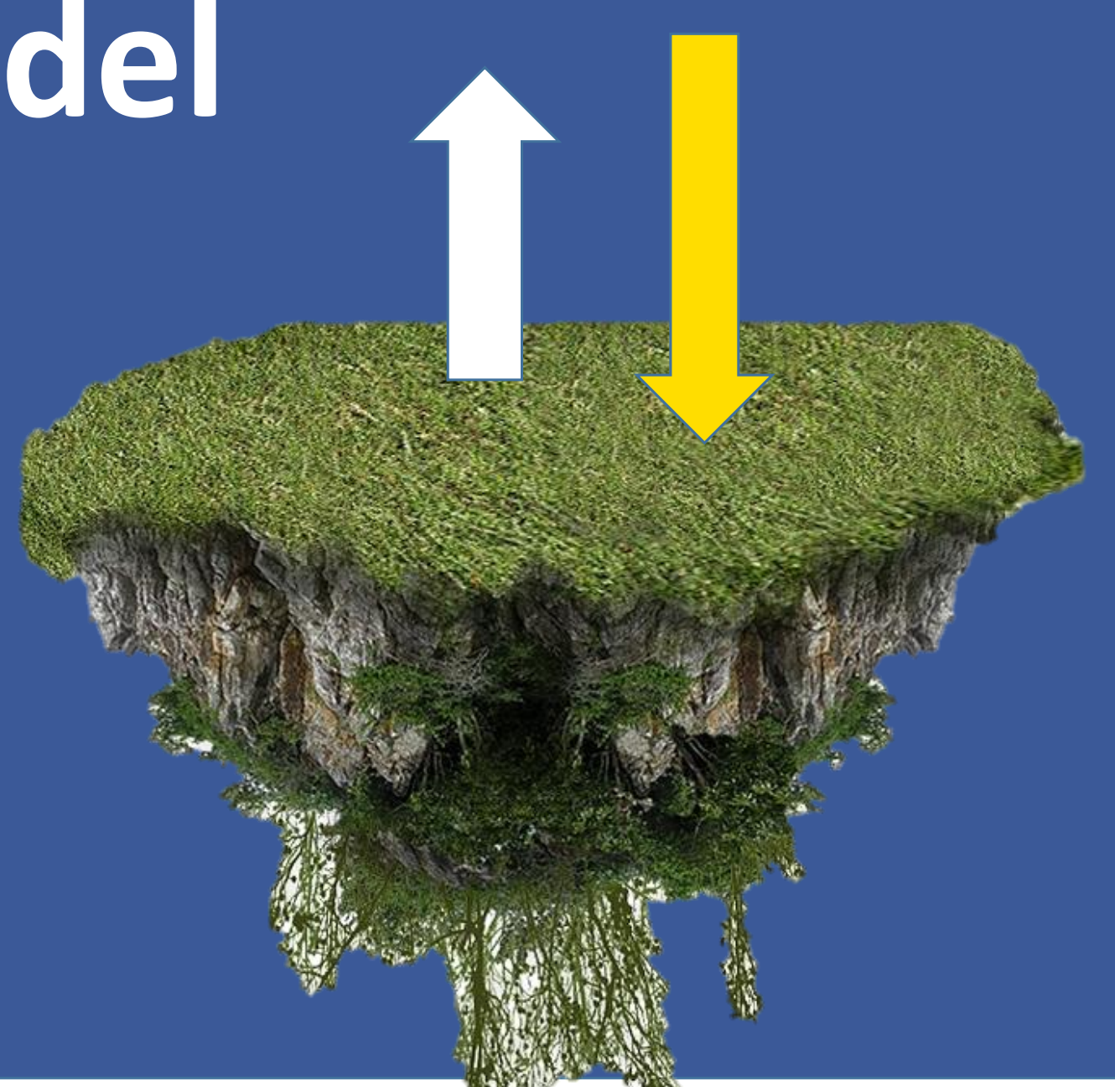
Sensitivity of the simulated regional climate to changes in the prescribed soil type distributions: Insights from Coupled Regional Climate Model EBU-POM



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Introduction

Regional climate models (RCMs) are used as crucial to support decision-making in response to climate change and are still subject to large uncertainties. One of the considerable sources of uncertainty in simulated regional climate is the choice of soil texture database and its soil parameter values. This is crucial because soil hydrophysical properties, influenced by such choices, have an impact on soil moisture and therefore affect the partitioning of surface fluxes. These properties among others play a role in controlling the evolution of soil and air temperature, evapotranspiration, runoff, and precipitation. On the other hand, biases related with land state, variables and fluxes are related with biases in future extreme events projections.

Data and Methods

Regional climate model **EBU-POM** [1] is employed to test and evaluate the role of soil texture in regional climate. EBU-POM is used for dynamical downscaling and developed at the University of Belgrade, Faculty of Physics. It is **fully coupled regional climate model**. EBU-POM has been previously used in Med-CORDEX simulations and projections. Initial and lateral boundary conditions are based on ERA5 reanalysis data and horizontal resolution was 0.25°. We performed two simulations with EBU-POM with two different prescribed soil type distributions. One simulation used the soil type dataset derived from the **Zobler dataset (CTL)** and in the second simulation, we used **FAO/STATSGO dataset (MOD).** Two 11-year EBU-POM simulations were conducted, spanning the period from 2000 to 2010. These simulations were initiated in 1998, allowing a two-year spin-up time to reduce the impact of initial fields. The area of interest was Central Europe with a focus on **Pannonian Basin** because previous studies indicated pronounced dry and warm biases during summer and autumn in low-lying areas, especially in south-eastern Europe.

Results and Discussion

The main goal of this study is not to inspect the accuracy of the soil texture map but rather to comprehend the impact on modeled surface and near-surface variables when employing one soil texture dataset versus the other (hereafter refered to as MOD-CTL). Our focus was on the **summer season (JJA)**, as it is the season with the strongest land-atmosphere coupling in Europe. Regions with lower latent heat (corresponding to smaller evapotranspiration fraction) coincide with areas exhibiting higher t2m (exceeding +0.4 °C) and drier soils (with soil moisture content less than -60mm). Also, differences in soil moisture content coincide mostly with differences in parameters such as wilting point and diffusivity.

Fig. 6 displays coupling strength for the MOD experiment (first row), which is important for the exchange process between the land surface and the atmosphere, strongly affecting climate and climate extremes. Coupling strength is based on correlations between characteristic variables connected to surface exchange processes, and in this research, it is focused on soil moisture-temperature feedbacks. These measures allow the diagnosis of energy-limited and soil moisture-limited regimes. **Regions with strong coupling are important because small changes and biases in soil moisture profoundly affect the near-surface atmosphere**. A negative correlation between latent and sensible heat (LE-H) marks strong coupling and is only meaningful where evapotranspiration is reasonably large. The LE-H correlation indicates the process of changing flux partitioning at the surface, and the LE-t2m correlation describes the second step of the feedback path into the atmosphere. As we can see, the Mediterranean region, parts of Central Europe, and the Pannonian Basin are regions with strong coupling. Fig. 6 second row displays how different soil texture datasets (MOD-CTL) affect coupling strength (LE-t2m) and therefore have an impact on climate extremes. In the Mediterranean region and Central Europe, areas where LE-t2m becomes more negative (stronger coupling) are areas with a greater 90th percentile of t2m (differing by more than +0.4 °C). This difference is more pronounced when we focus just on the year 2007 with extreme summer weather and a heatwave.

[1] *Djurdjevic, V. and Rajkovic, B. (2010), Development of the EBU-POM coupled regional climate model and results from climate change experiments, In: Advances in Environmental Modeling and Measurements, Editors: T. D. Mihajlovic and Lalic B., Nova Publishers.*

Conclusions

The analysis of the individual contributions of each soil type to climate variable biases reveals that soil properties alone do not dictate surface fluxes; rather, it is the combination of soil properties and soil moisture that influences them.

Furthermore, these experiments highlight the significant role of soil parameters in summer climate dynamics, as they impact coupling strength and consequently influence climate and its extremes. The choice of soil parameters/soil texture datasets has considerable consequences, particularly on climate extremes, as biases and coupling strength can become more pronounced.

Acknowledgement

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1.

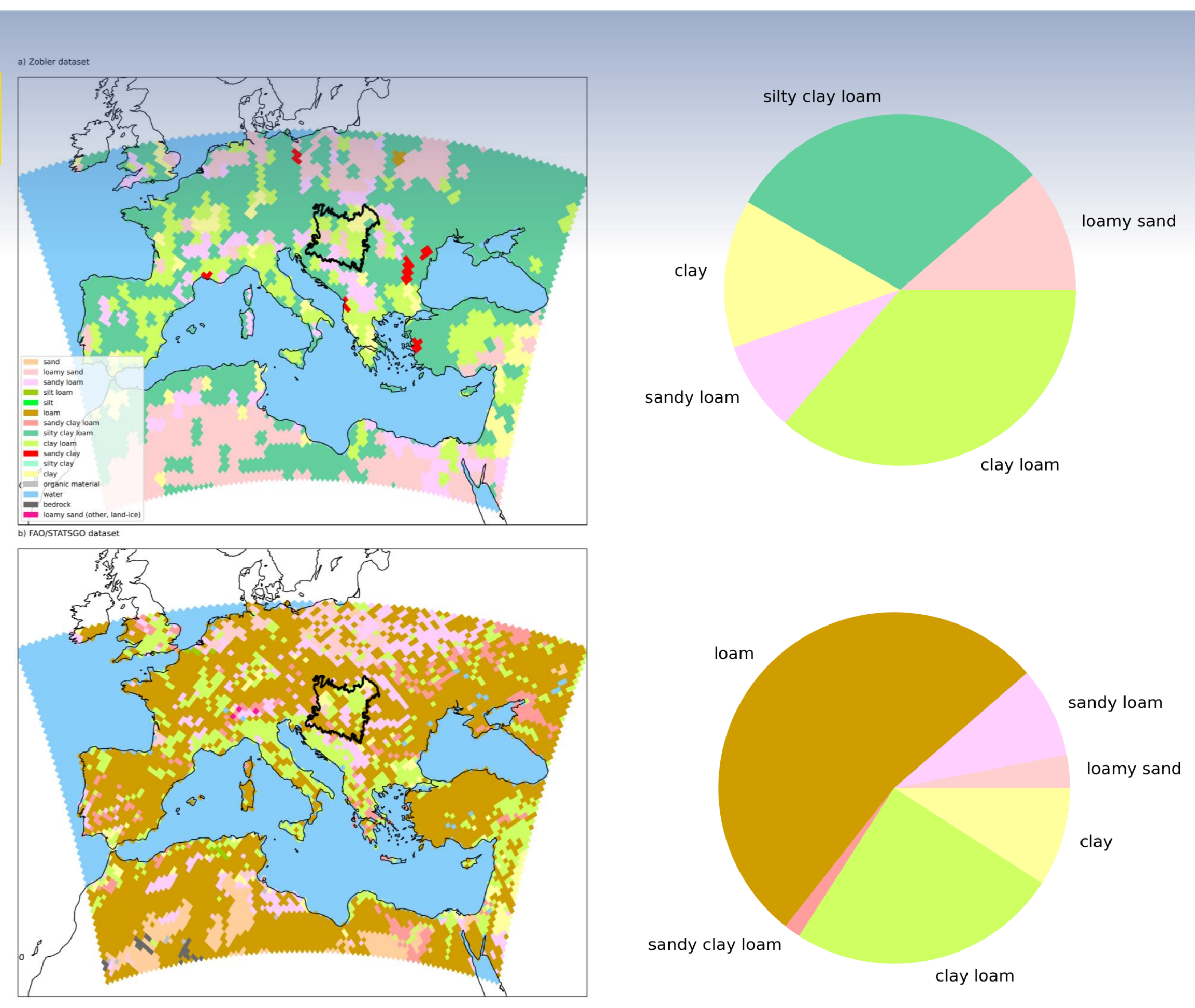
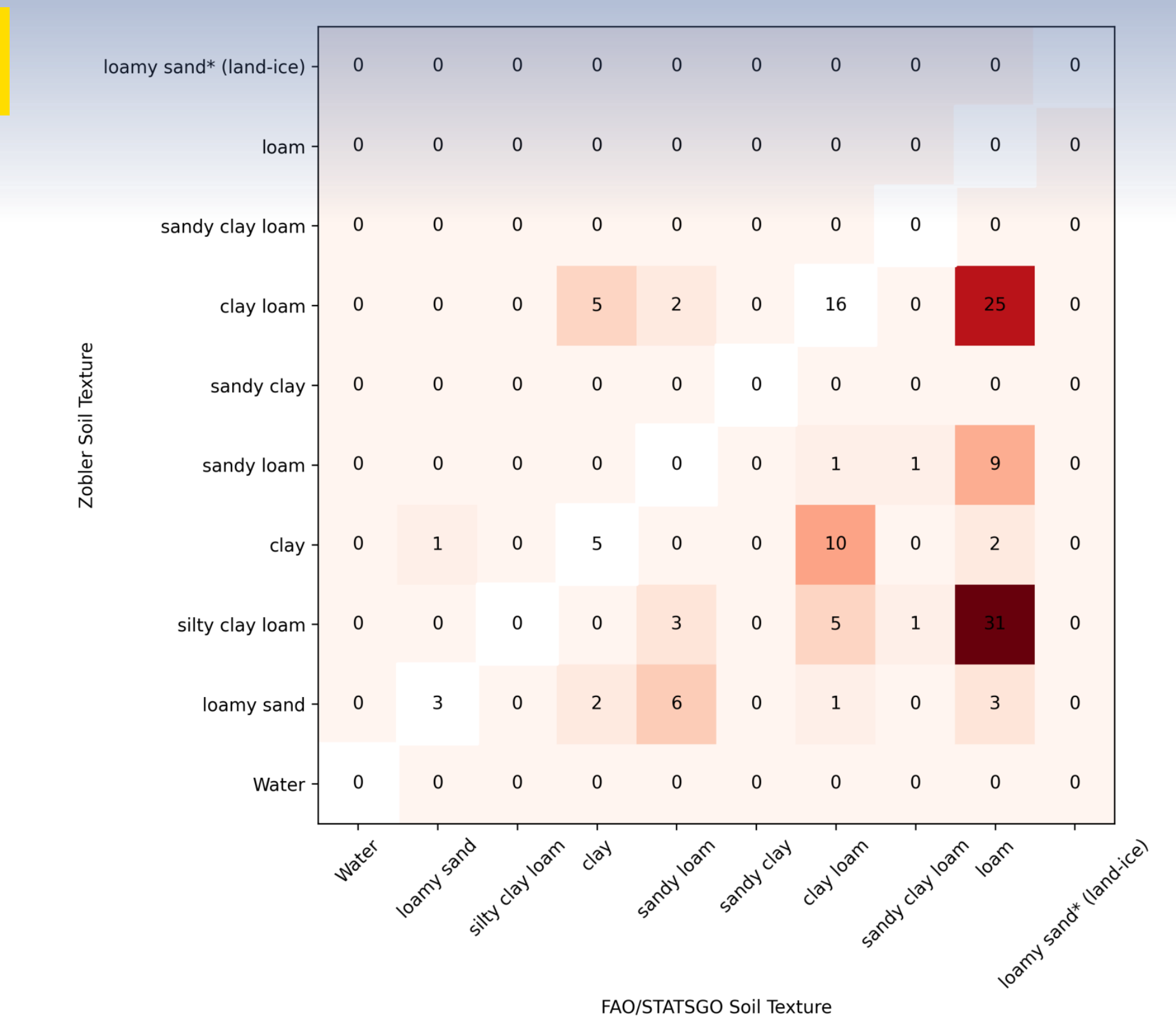


Fig 1. Dominant top-layer soil texture classification in the EBU-POM model domain according to (a) Zobler dataset and (b) FAO/STATSGO dataset. The legend in (a) applies to both maps. Additionally, pie charts are provided to depict the proportion of each soil category in both datasets.. The region enclosed within the solid black line is Pannonian Basin.

2.



Zobler Soil Texture \ FAO/STATSGO Soil Texture	Water	loamy sand	silty clay loam	clay	sandy loam	sandy clay	clay loam	sandy clay loam	loam	loamy sand* (land-ice)
loamy sand* (land-ice)	0	0	0	0	0	0	0	0	0	0
loam	0	0	0	0	0	0	0	0	0	0
sandy clay loam	0	0	0	0	0	0	0	0	0	0
clay loam	0	0	0	5	2	0	16	0	25	0
sandy clay	0	0	0	0	0	0	0	0	0	0
sandy loam	0	0	0	0	0	0	1	1	9	0
clay	0	1	0	5	0	0	10	0	2	0
silty clay loam	0	0	0	0	3	0	5	1	31	0
loamy sand	0	3	0	2	6	0	1	0	3	0
Water	0	0	0	0	0	0	0	0	0	0

Fig 2. Count of grid spaces with given soil texture transitions from the Zobler dataset (vertical axis) to the FAO/STATSGO category (horizontal axis) within Panonnian Basin. White boxes represent areas where both datasets agree on classification; the intensity of color increases with a higher number of transitions.

3.

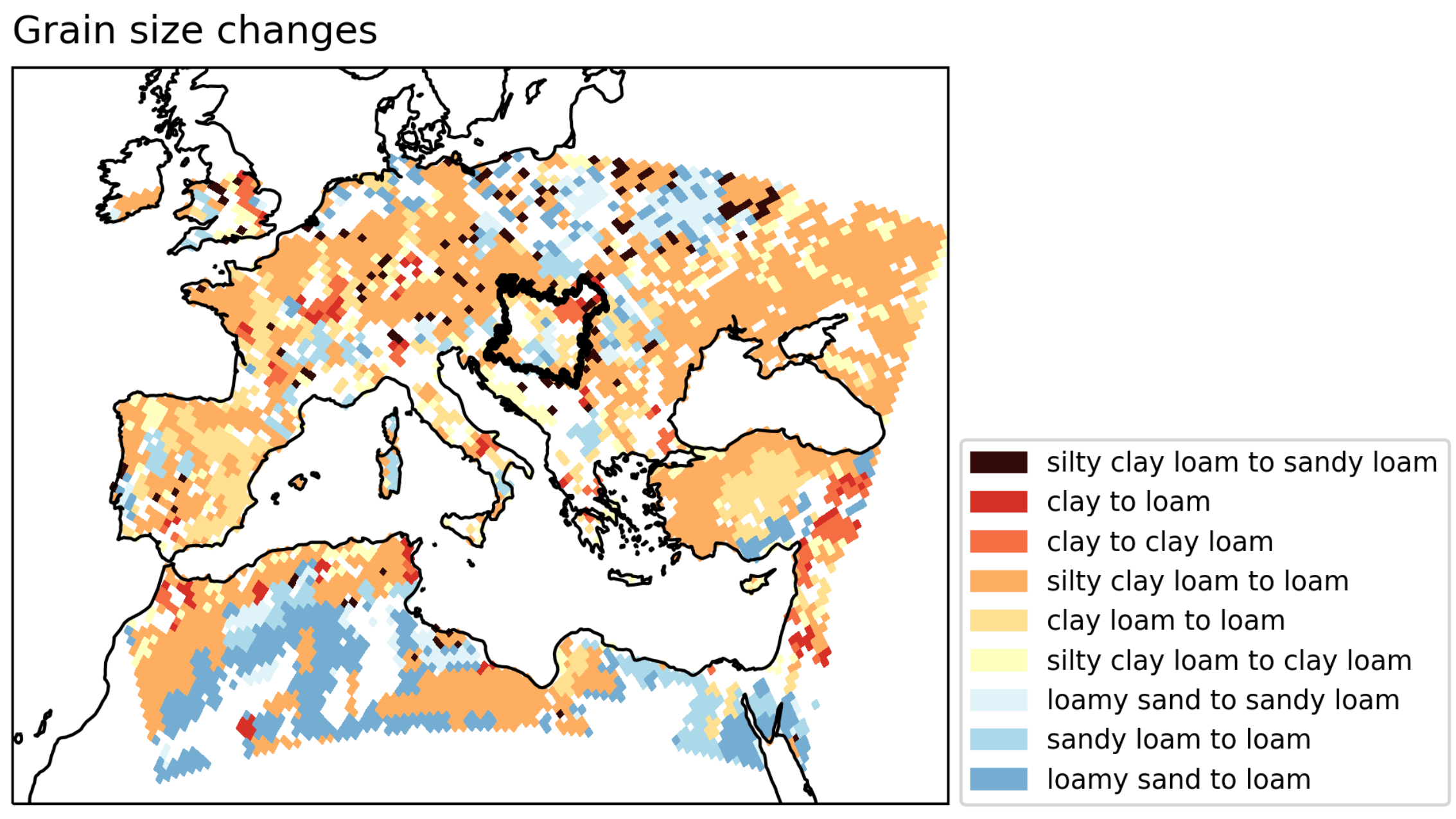


Fig 3. Locations of the nine most common soil texture category transitions from Zobler dataset to FAO/STATSGO dataset for the model domain. Red shades represent increases in average grain size and blue shades represent decreases in average grain size.

4.

Wilting point and field capacity generally increase as grain size decreases, and so the extractable water. Note that for larger grain soils, the matric potential is near zero (little energy is required before evaporation can occur), but for smaller grain soils like clay, the matric potential gets strongly negative (significant energy is required before evaporation can occur). Matric potential is a function of soil texture and soil moisture as well.

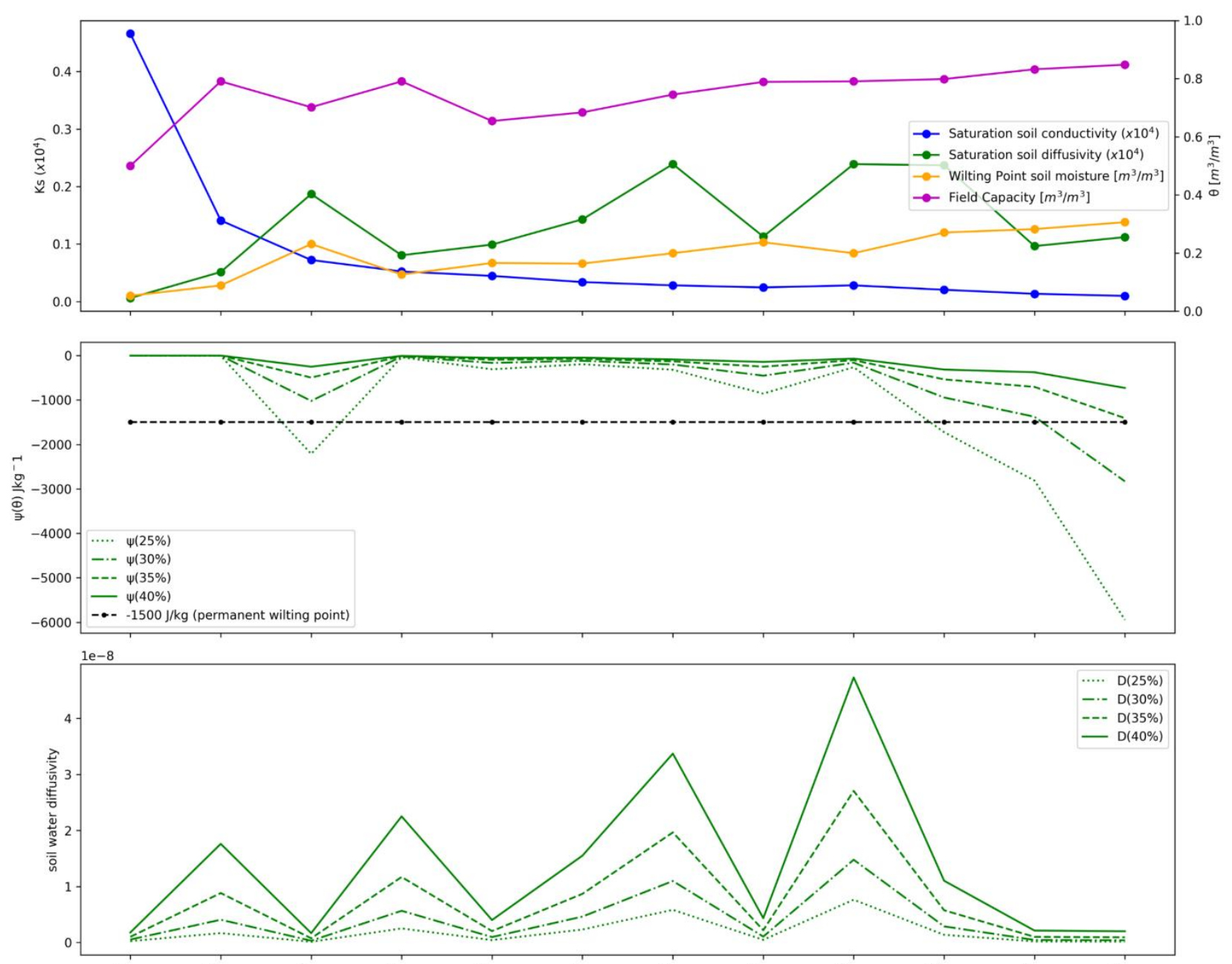


Fig 4. Prescribed parameter values for each soil texture in Zobler dataset. Second graph represent matric potential and third graph represent soil water diffusivity and they are calculated according to a percentage of the extractable water range.

5.

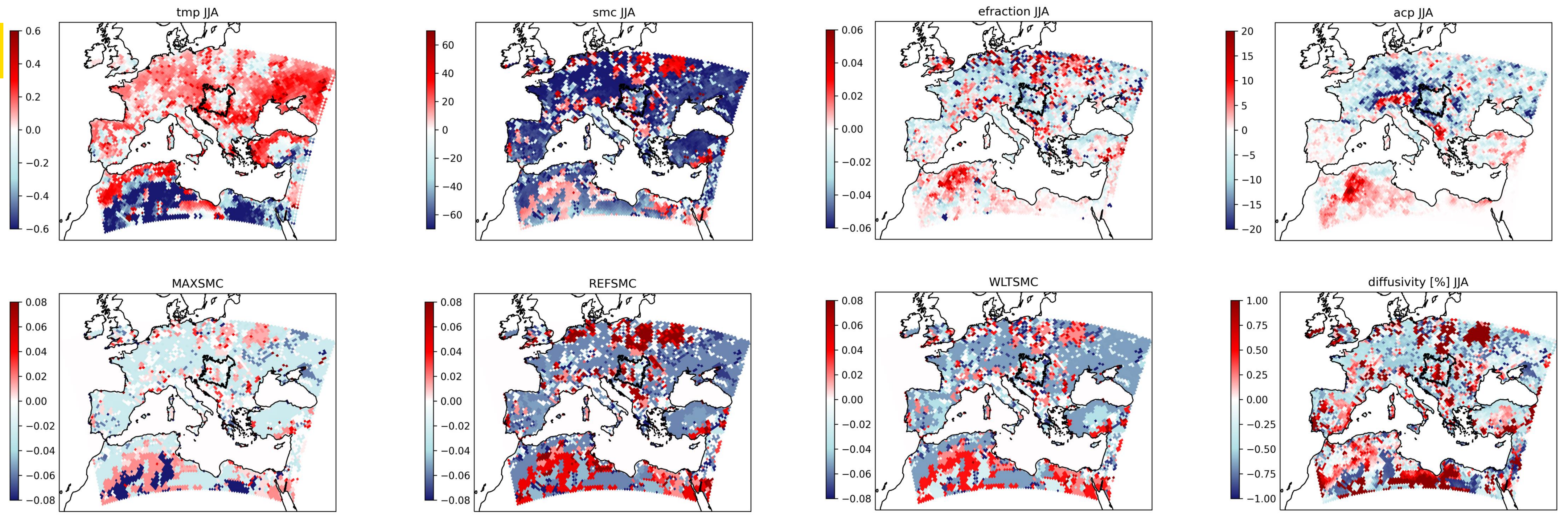


Fig 5. Eleven-years averaged (2000-2010) summer season (JJA) model simulation differences (FAO/STATSGO minus Zobler) of (first row) t2m (tmp) [°C], water content in 1m soil depth (smc) [mm], evaporative fraction (efraction) [-], total precipitation (acp) [%], and (second row) saturation soil moisture content (MAXSMC) $[\frac{m^3}{m^3}]$, field capacity (REFSMC) $[\frac{m^3}{m^3}]$, wilting point soil moisture (WLTSMC) $[\frac{m^3}{m^3}]$ and soil water diffusivity [%] based on equation (1). Precipitation and soil water diffusivity are calculated according to formula $\frac{FAO - ZOBLER}{ZOBLER}$*100.

(1) Equation

soil water diffusivity $D = D_{\theta s}\left(\frac{\theta}{\theta_s}\right)^{b+2}$

where $D_{\theta s}$, θ_s and b are saturation soil diffusivity, saturation soil moisture content and empirically-derived exponent b, respectively. They are parameters related with soil class and derived from soil texture databases. θ is actual volumetric water content (VWC), and in this research we used VWC in 1m soil depth.

6.

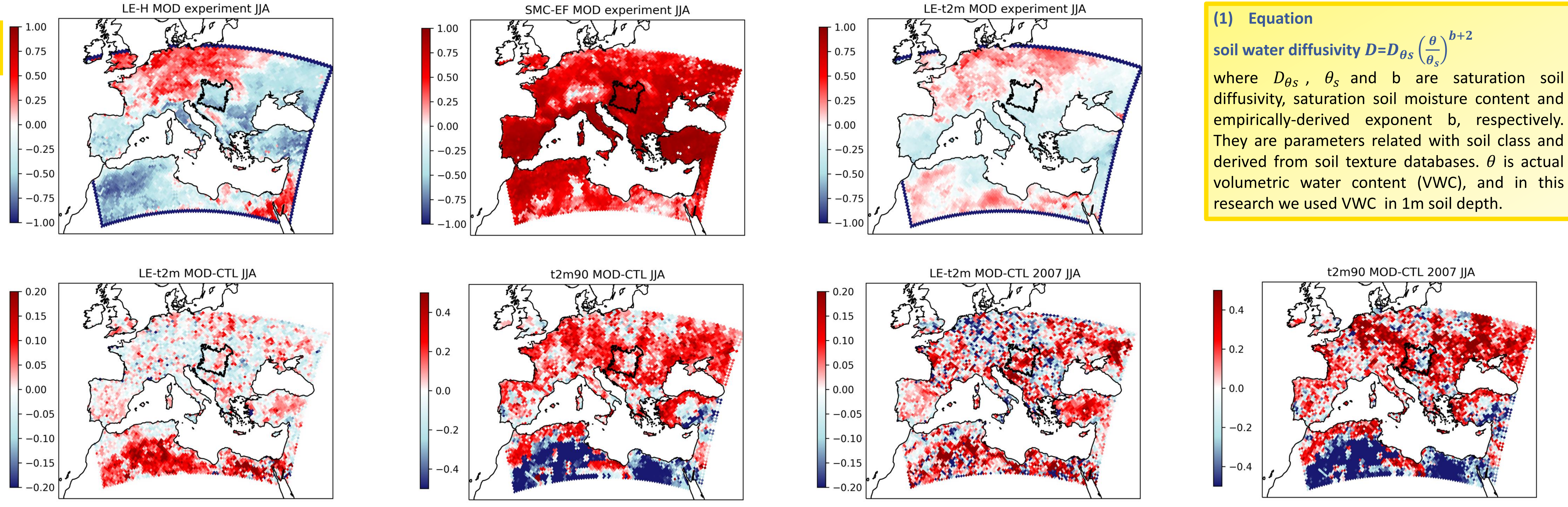


Fig 6. Correlation of summer (JJA) non-overlapping 10-day averages for the years 2000-2010 (first row) for FAO/STATSGO experimenet (i.e. MOD) of latent and sensible heat flux (LE-H), water content in 1m soil depth and evaporative fraction (SMC-EF), latent heat flux and t2m (LE-t2m), and (second row) model simulation differences (FAO/STATSGO minus Zobler i.e. MOD-CTL) for correlation of latent heat and t2m, t2m 90th percentile [°C], and correlation differences of latent heat and t2m for year 2007, and t2m 90th percentile [°C] for year 2007.

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Poster Abstract
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