Dear Editor,

This document shows a detailed description of all major changes applied to the manuscript and catalogued in two sections. All changes are preceded by "C" and numbered continuously, also indicating the line number of the original manuscript where the change is being included, where additions are colored with **green** and deletions with **red**. Section 1 contains additional changes that all authors considered of highly importance to be added to the manuscript and the justification of why to include it. Section 2 contains all major changes coming from the reply to reviewers without additional modifications from the authors.

Section 1

C1. The authors want to make clear the message that the inclusion of a weathered bedrock in the Community Land Model (CLM 5) is aiming to show the importance of considering the bedrock as an active hydrological component from which vegetation also relay on. We are not claiming improvements on the overestimation of spring transpiration on the drier sites, because it is shown that this issue is linked to the control of a plant water use strategy, where the soil and rock moisture reservoirs are not part of.

Addition in [Line 480]:

> "… Fig. 5). However, the extreme water stress in summer time in the DMC configuration could have resulted from an overestimation of water use during the early season, leading to depleted water reservoirs in summer. Although the DBC and FBC configurations improved the simulated transpiration and water stress experienced by the stem and leaves during summer by increasing the soil water availability, neither of the configurations reduced the transpiration in spring. This could suggest that the reason for the underestimated summer transpiration might not be an underestimated water storage capacity but some other model deficiency that is responsible for both, overestimated transpiration in spring and subsequently underestimated transpiration in summer. "

C2. On the reply to Reviewer #1 (Reply 11), we agreed on modifying Figure 5 to improve the readability but we did not include the modified figure because it took some time to decide the better layout. Now, we are including the new figure and the respective caption:

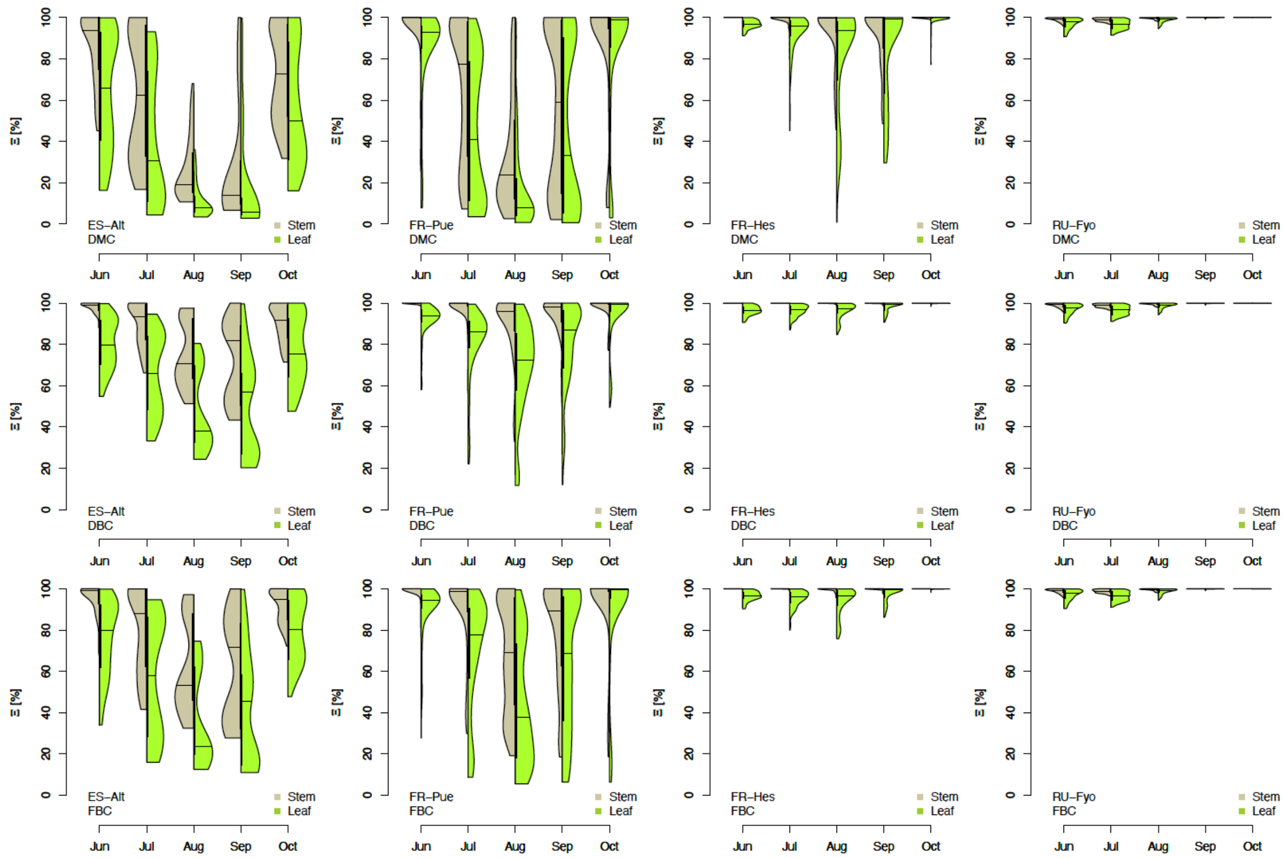

Figure 5. Hydraulic stress experienced by the modeled vegetation per experimental site based on the vulnerability curves of each plant organ (See Fig. A2 to Fig. A5) between June and October. Each plot describes the distribution of the hydraulic stress experienced by stem xylem and leaves xylem expressed as percentage of conductivity (Ξ).

Section 2

C3. Addition in [Line: 33]:

> "… et al. 2014). This suggests that rock moisture is likely an important water reservoir supporting dry season water use at sites with shallow soils. Therefore, inclusion of this additional water reservoir in models may be important for correctly simulating vegetation water use, especially under climate change, where seasonal changes in intensity and frequency of precipitation and drought (Hosseinzadehtalaei et al. 2020, Grillakis 2019) are expected to result in extended drought severity and duration. However, due to the …"

C4. Addition in [Line 52]:

> "Land surface models (LSMs) have evolved considerably over the last decades and have been established as useful tools to understand ecosystem responses to water stress conditions and heat waves (Fisher and Koven, 2020). However, these developments have increased the number of parameters exerting control over multiple fluxes, highlighting the need of providing a better way to constrain LSMs simulations (Mu et al., 2021). These constraints are of high importance because they allow assessing the effect of the parameter selection on the model sensitivity and uncertainty (Lawrence et al., 2020). The representation of subsurface processes plays a critical role in the chemical, thermal, and hydrological fluxes simulated by LSMs (Choi et al., 2013, Davison et al., 2015). This representation, which varies quite strongly between LSMs, has been advanced over the recent years (e.g., Felfelani et al., 2021) requiring additional constraints to accurately

estimate water and energy fluxes. For instance, the Joint UK Land Environment Simulator (JULES) LSM has a 10m soil column with 28 soil layers (with 14 layers distributed over the first 3m of soil)."

C5. Addition in [Line: 86]:

"... et al. 2016). Recent studies stressed the importance of the accumulated sediments in weathered bedrock fractures that enhances the water holding capacity beneath the soil (Jian et al. 2020). These sediments allow the woody ecosystems to use the rock moisture at the continental scale across different rock types (McCormick et al. 2021). The widespread use of rock moisture by vegetation is supported by the vast number of studies carried out during the last two decades stressing the importance of adding the weathered bedrock as an additional water reservoir that serves as a buffer water supply during dry conditions (Hubbert et al. 2001, Aranda et al. 2007, Baldocchi et al. 2010, David et al. 2013, Forner et al. 2018, Gil-Pelegrín et al. 2017, Nadezhdina et al. 2008, Penuelas & Filella 2003, Zapater et al. 2011). This reservoir is critical for properly representing transpiration fluxes during dry periods (e.g., summer, drought, heat waves) of vegetation growing in water-limited environments. Consequently, it is necessary to provide a preliminary evaluation of the impact that additional water storage may have on the simulated transpiration fluxes."

C6. Addition in [Line: 115]:

"... and lowlands (RU-Fyo). All the sites lack detailed information concerning the physical properties of the weathered bedrock, such as hydraulic conductivity, water holding capacity, or percentage of fractures. The sites are distributed across an environmental ..."

C7. Addition in [Line: 124]:

"... et al. 2017). The soils are formed from Cretaceous carbonate rocks settled on top of sandy sediments (Carcavilla et al. 2008), showing a poor development (Granda et al. 2012) with maximum soil thickness varying between 25 cm at the top of the slopes, and more than 1.0 m at the bottom (Martín-Moreno et al. 2014). The climate ..."

C8. Addition in [Line: 131]:

"... et al. 2014). *Quercus ilex* trees at this site have the capacity to allocate structural and fine roots down to 8.0 m depth (Penuelas et al. 2003). The plant ..."

C9. Addition in [Line: 137]:

"... et al. 2002). The superficial soil layers have a high soil permeability thanks to the elevated stone fraction of 0.75. On the other hand, soil layers beneath 50 cm have a larger clay content (> 30%) and a stone fraction of more than 0.9 (Limousin et al. 2009, Pita et al. 2013). This location ..."

C10. Addition in [Line: 142]:

"... 2008). This forest stand allocates most of the fine root biomass in the top 50 cm of the soil profile with a small fraction of roots reaching depths down to 4.5 m (Allard et al. 2008). Similarly, to ..."

C11. Addition in [Line: 148]:

"... 2007). It is a clear transition between the eluviated horizon and the horizon with high clay accumulation at 50 cm depth (Zapater et al. 2012), leading to a low clay content in the upper soil layers (Granier et al. 2000 a). It has ... "

C12. Addition in [Line: 154]:

"... 2001). *Fagus sylvatica* trees allocate most of the fine roots in the upper 40 cm of soil with some fine roots reaching depths down to 1.5 m (Granier et al. 2000a, Granier et al. 2000b, Zapater et al. 2012, Bestch et al. 2011). The dominant ..."

C13. Addition in [Line: 161]:

"... and still present. The peat layer at this site has an average depth of 50 cm (Arneth et al. 2002), and the glacial deposits result in a loamy texture of the soil beneath it (Novenko et al. 2010, Schulze et al. 2002). The water table at this site is shallow, forcing the trees to allocate most of the fine roots in the top 20 cm of the soil (Milyukova et al. 2002). The climate ..."

C14. Addition in [Line 185]:

"... summary information. Although this data set does not reflect the exact site conditions, the depth to bedrock is closer to measurements reported in previous studies at the experimental sites. The simulations were ..."

C15. Addition in [Line 199]:

"... texture classification. This depth was defined as a fixed parameter across all sites because the thickness and degree of bedrock weathering are difficult to characterize over broad scales (Holbrook et al. 2014), where the interaction between climate, vegetation, and rock type determines the extent and properties of the weathered bedrock (Pawlik et al. 2016). The third configuration ..."

C16. Addition in [Line 204]:

"... clay (Table 1). This approach aims to mimic the hydrological behavior of a fractured bedrock based on two main assumptions: a fractured bedrock should have a high-water conductivity and low water holding capacity. As the sandy soil texture classification can be described by any soil with a combination of more than 85% of sand and less than 10% of clay, we decided to choose the combination of soil fractions that provides a sandy soil texture with a maximum water holding capacity for this textural class. The high sand percentage will mimic the fast water movement through the primary and secondary porosity of the fractured bedrock. At the same time, the low clay content allows having a low water holding capacity for plant water uptake compared with the above soil layers."

C17. Addition in [Line: 309]:

"... configurations.

The soil parametrization used in DMC and DBC agreed with the published data for FR-Hes, FR-Pue, and FR-Hes (Figure A2). These configurations are located within the boundaries of the soil texture classification of each site. In this regard, the agreement of soil water storage capacity, infiltration, and percolation rates agreed with the expected site conditions. Clay content in ES-Alt is similar between model configurations and site conditions, providing a similar water holding capacity. However, the sand content of the model for DMC and DBC configurations represents a lower hydraulic conductivity than the one expected for this site."

C18. Addition in [Line 395]:

"… If geological conditions allow the formation of deep soils (e.g., Amazon Basin, Loess Plateau), the roots will access deep groundwater that will become very important for surviving extended dry periods (Chitra-Tarak et al., 2021; Tao et al., 2021). On the other hand, when soils are shallow and less developed, the trees must thrive by accessing additional water pockets in the weathered bedrock. The heterogeneous nature of weathered bedrock depends on the interaction between climate, vegetation, and rock type (Pawlik et al. 2016). These interactions allow the increment of the water-holding capacity of weathered bedrock by increasing the porosity and mineral surface area (Navarre-Sitchler et al. 2015). This water holding capacity is considered negligible (Novák & Šurda, 2010), but the vertical extent of this layer makes the water reservoir large enough to support deep rooting vegetation during dry spells (Graham et al. 2010, Jones & Graham 1993). As an example, Mediterranean trees are able to uptake water from the deep vadose zone …"

C19. Addition in [Line: 418]:

"… Dietricht, 2018). Oak tree species are known to access deep water storage because of their extensive rooting depths (Gil-Pelegrín et al. 2017). The *Quercus ilex* trees growing at ES-Alt and FR-Pue have shown this feature (Baldocchi et al. 2010, Forner et al. 2018) allowing the trees to transpire during the dry season despite the low soil water potentials. The transpiration signal …"

C20. Addition in [Line: 425]:

"… transpired soil water. *Fagus sylvatica* trees strongly rely on shallow soil water because of their superficial root system (Lüttschwager & Jochheim 2020), a condition documented at FR-Hes by Granier et al. (2000b) and Zapater et al. (2012). Meanwhile, during drought periods, this tree species uses the water stored in the trunk and roots as a reservoir to maintain transpiration until the next rainfall event (Betsch, et al. 2011). However, the limited access of vegetation to …"

C21. Addition in [Line 494]:

"… vegetation types. In addition, plants depending on rock moisture can develop special water access strategies such as dynamic root systems or mycorrhizae growing along the rock cracks and accessing water stored in or dripping from the bedrock (Schwinning 2020). Experimental evidence …"

C22. Addition in [Line: 452]:

5.3 Breaking the bedrock to release the roots

The occurrence and severity of extreme weather conditions like droughts and heat waves (He et al. 2020) highlight the importance of representing the vegetation's mechanisms to avoid or cope with the adverse effects of this new reality. The inclusion of rock moisture stored in the weathered bedrock, which is neither soil water nor groundwater, is necessary to simulate plant transpiration under limited water conditions (Rempe and Dietrich, 2018). The challenge to quantify this rock moisture is linked with the large uncertainty in determining the physical characteristics of this weathered bedrock (Pelletier et al. 2016) and the lack of spatially distributed field information related to the water storage properties of the weathered bedrock. Previous studies have highlighted the importance of groundwater and lateral flow for an improved simulation of transpiration fluxes in LSMs (Maxwell and Condon, 2016, Zeng et al. 2018). In contrast, other studies highlighted the importance of an extended rooting system with the same aim (Fan et al. 2017, Ichii et al. 2009). However, the focus of LSMs on soil water neglects the interaction between these essential components and the weathered bedrock. In this work, we show that allowing the root system to access water stored in the weathered bedrock improves the transpiration and plant water stress estimates during dry periods. The modeling community should address these two issues in a unified approach, eventually improving the water supply at sites with shallow soils and dry conditions. This unified approach, where we allow to break the bedrock and release the root profile, will create a new water reservoir that will refine the vulnerability assessment of forest ecosystems growing in regions with a tendency to experience drier conditions.

C23. In Figure 1, we modified the root profile shape to match the exponential pattern explained along the manuscript. Also, we improve the caption accordingly.

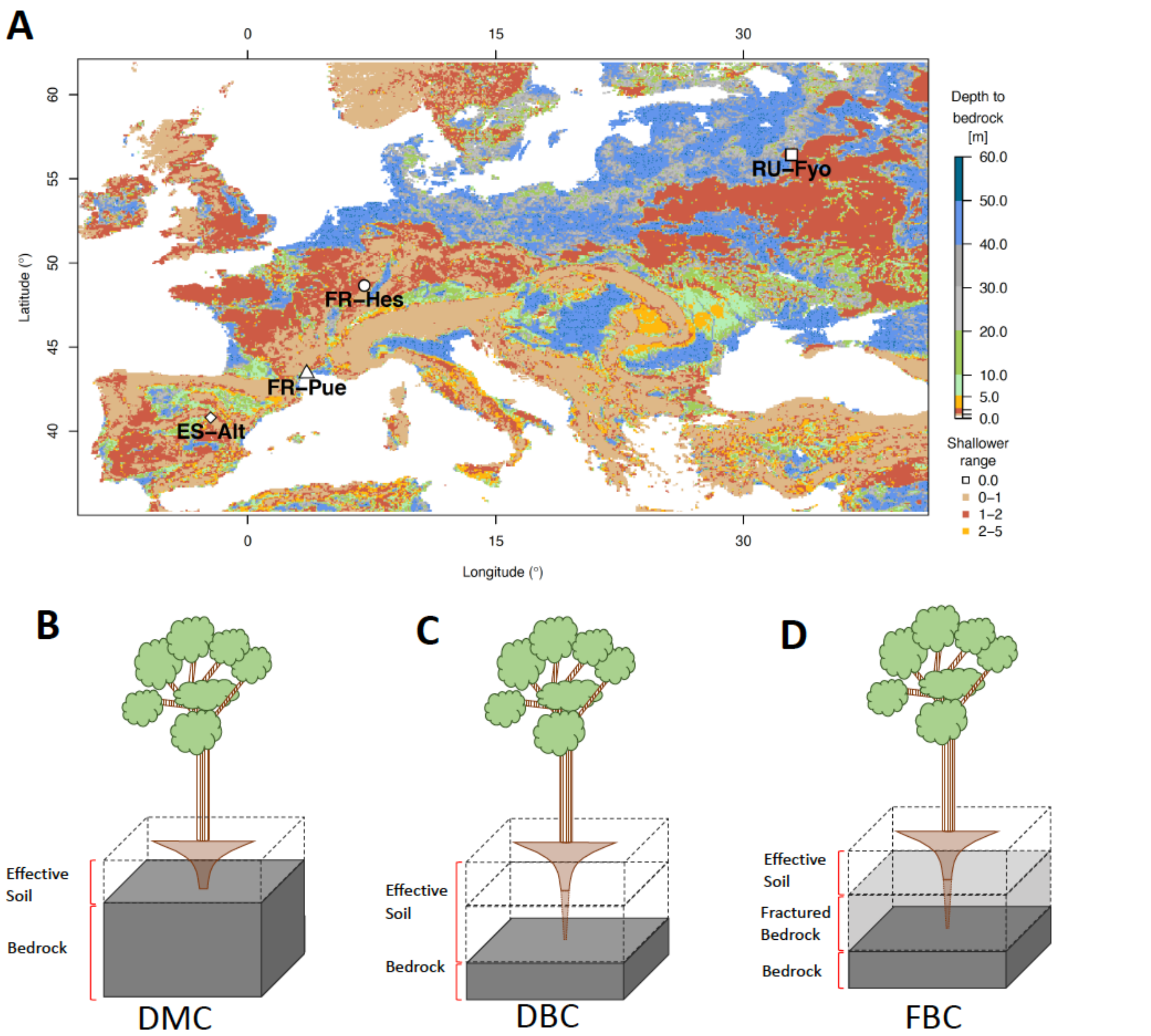

Figure 1. Geographical location of the experimental sites and spatial distribution of the depth to bedrock across Europe (A) based on Pelletier et al. (2016). The graphics below the map are the schematic of the three model configurations used in this work: default model configuration, DMC (B); deeper bedrock configuration, DBC (C); and fractured bedrock configuration, FBC (D). The block with dashed lines represents the soil profile, the solid grey block represents the impermeable bedrock layer as it is assumed by CLM 5, and the translucid grey block represents the mimicked fractured bedrock layer."

C24. We improved the legend of Figure 2 as follows:

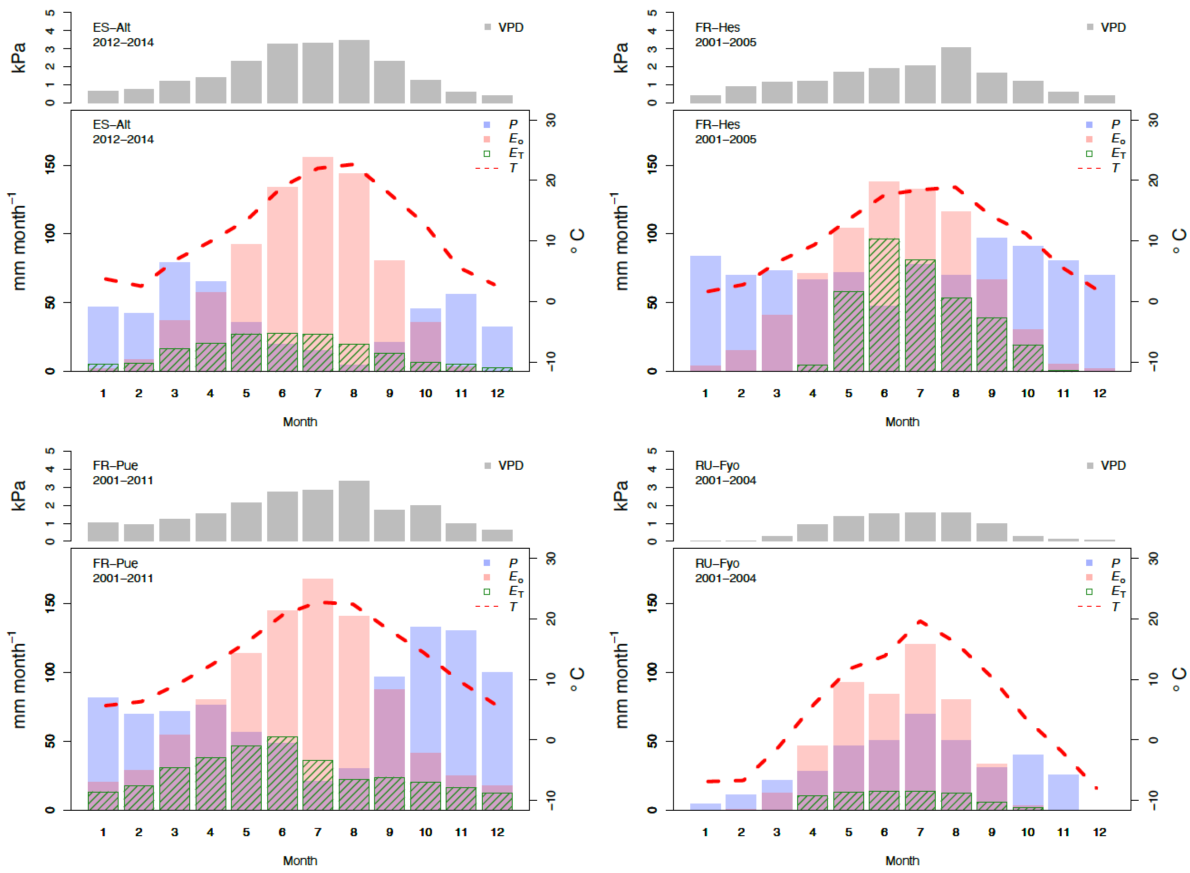

Figure 2. Monthly variation of maximum vapor pressure deficit (VPD), precipitation (*P*), potential evaporation (E_o), measured transpiration (E_t) and air temperature (*T*) for the selected experimental sites across Europe. Monthly averages are based on the different sampling periods for each site.

C25. We improved Figure 3 to guarantee the readability of the image. We decided to show only the median value for each day of the year per site and model configuration, updating the caption as well.

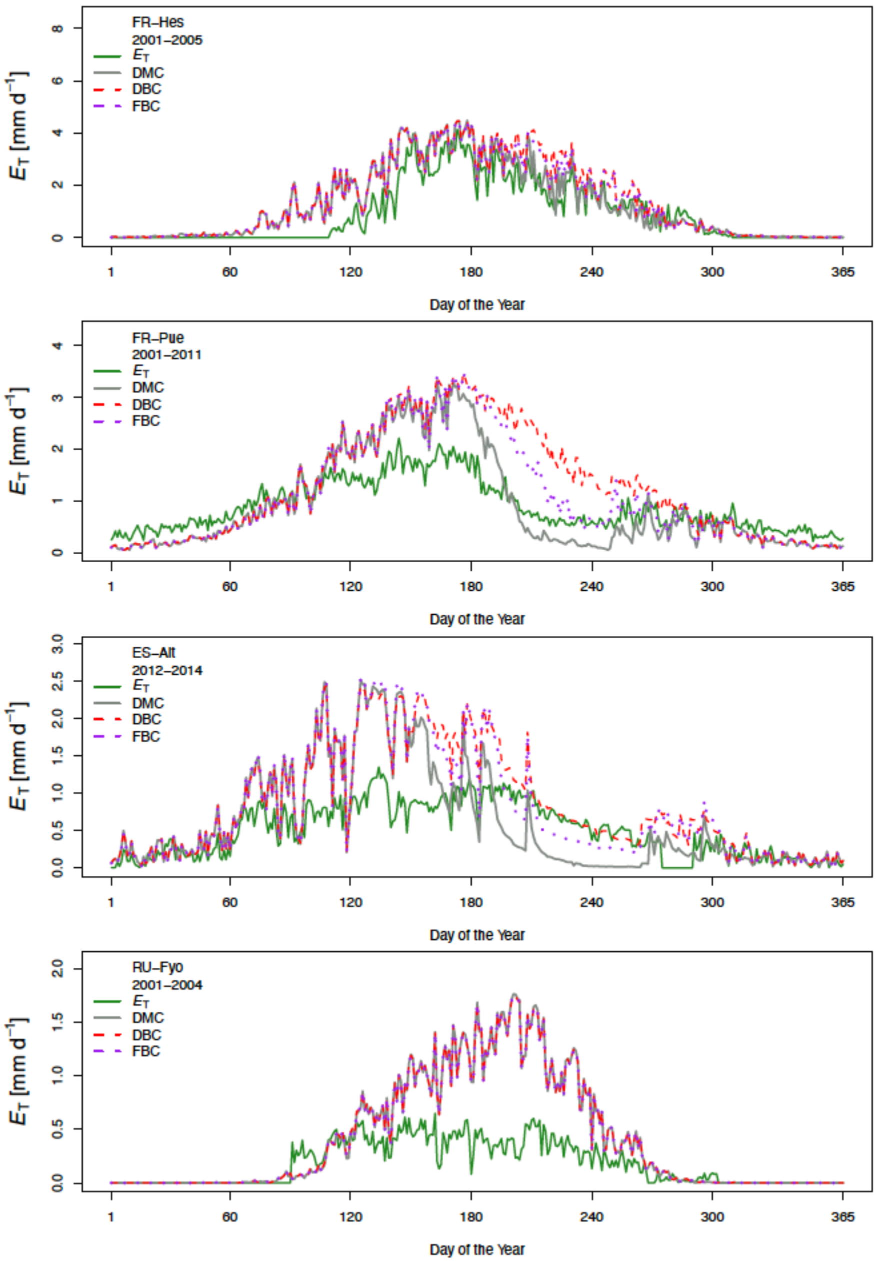

Figure 3. Median of the measured and modeled daily transpiration rates for the different model configurations at each experimental site.

C26. We simplified Figure 4 in accordance with the reviewers' recommendation. We changed the complex circular construction towards a more visual friendly representation. We also upgraded the caption accordingly with the figure changes.

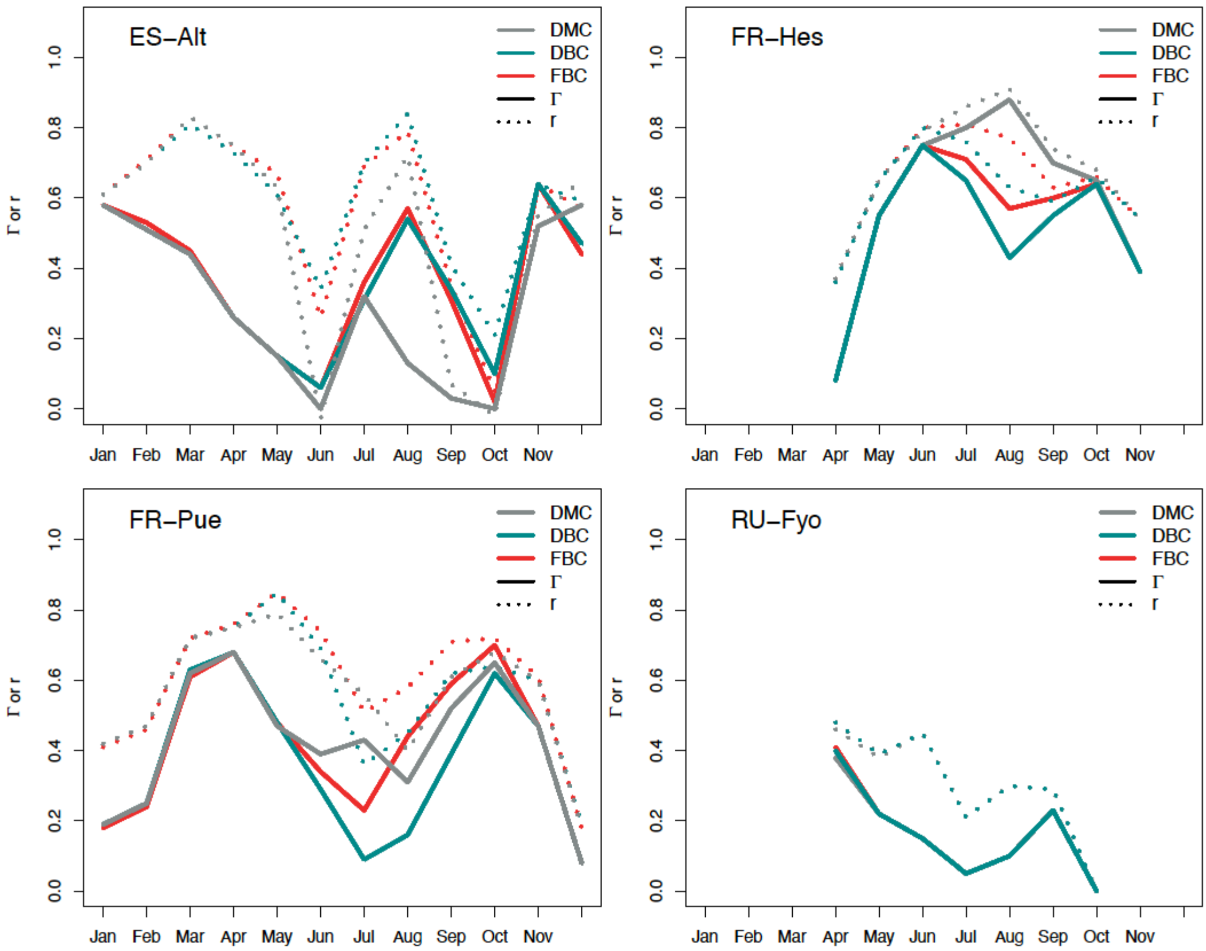

Figure 4. Multi-annual monthly variation of the Pearson correlation coefficient (r) and the index of agreement (Γ) for the default model configuration (DMC), deeper bedrock configuration (DBC), and fractured bedrock configuration (FBC).

C27. We are including an additional table with detailed information about the subsurface conditions for each experimental site.

Table A1. Summary of the main sub-surface characteristics of each experimental site.

Main Site Characteristics	**ES-Alt**	**FR-Pue**	**FR-Hes**	**RU-Fyo**
Rooting Depth (m)	8.0	4.5	> 1.5	0.2
Peat Layer Depth (cm)	None	None	None	50
Soil Depth (cm)	20-40 | 100	50	145	N.A.
Soil Texture: % Clay	25.9	39	25	N.A.
Soil Texture: % Sand	57.3	26	N.A.	N.A.
Soil Texture: % Silt	16.8	35	N.A.	N.A.
Soil Type	Sandy Clay Loam	Silty Clay Loam	Clay Loam	Loam
Soil Permeability	N.A.	High	N.A.	N.A.

Superficial Stone Fraction	N.A.	0.75 (0-50cm)	N.A.	N.A.
Deep Stone Fraction	N.A.	0.90 (>50 cm)	N.A.	N.A.
Bedrock Type	Cretaceous carbonate	Jurassic Limestone	Sandstone	Glacial deposits
Water Table Depth	Deep	Deep	Deep	Superficial
Plant Water	Soil Water, Weathered Bedrock, Groundwater	Soil Water, Weathered Bedrock, Groundwater	Soil Water	Non-Saturated Substratum
Hydraulic Lift	Present	N.A.	Present	N.A.
References	Grossiord et al. (2015) Penuelas et al. (2003) Forner et al. (2018) Martin-Duque et al. (2008)	Allard et al. (2008) Pita et al. (2013) Limousin et al. (2009)	Granier et al. (2007) Granier et al. (2000a) Granier et al. (2000b) Le Goff et al. (2001) Zapater et al. (2012) Betsch et al. (2011)	Schulze et al. (2002) Vigodskaya et al. (2002) Novenko et al. (2010) Arneth et al. (2002) Kurbatova et al. (2002) Milyukova et al. (2002)

C28. We improved the caption of Figure A1 as follows:

"Figure A1. Multi-annual daily boxplots for potential evaporation (E_o), stand transpiration (E_T), and vapor pressure deficit (Λ) of the selected experimental sites across Europe. The boxplot represents the data contained between the first and third quartiles, the central line is the median, the whiskers represent a predefined distance from the median (1.5 x inter-quartile range), and the dots are the outliers."

C29. We added Figure A2 as appendix to clarify the soil characterization used in the model and its relationship with the conditions showed by the sites.

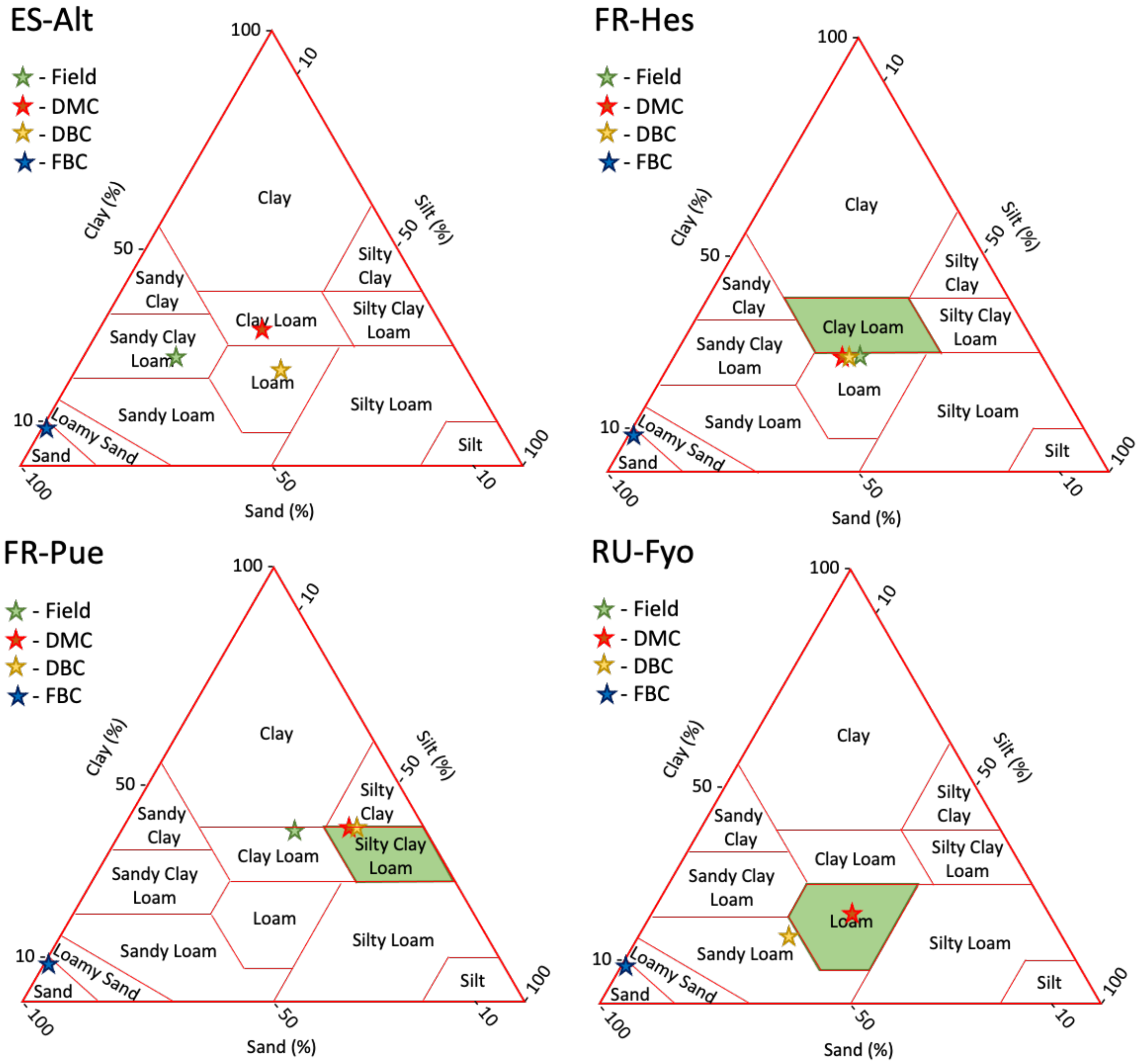

Figure A2. Soil texture classification of each experimental site and model configuration. The green star and polygons highlight the experimental site classification according to the literature (the classification may differ between authors). Red, yellow, and blue stars represent the substrata classification according to the default, deeper bedrock, and fracture bedrock configurations, respectively.

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