Reviewer 1

The authors thank the reviewer for their constructive comments.

We have the following answers to the reviewer's comments:

Page 1 – The causes of clay swelling/shrinkage are well established at the micro-scale and mineralogical scale. Actually defining causes at large spatial scales would not be possible since the phenomenon is impacted by very local parameters.

Yes, we agree. We suggest rephrasing the original sentence as follows: **"The causes of clay shrinkage are understood at the micro scale, but the same reasoning cannot be applied at the large spatial scales that are critical for land management because the phenomenon depends on very local parameters."**

Page 3 – Damage models should also incorporate parameters related to the building structure. Mainly light-weighted constructions may be damaged by soil movements. This aspect is not taken into account while it is of major impact.

Yes, we agree that the building structure is crucial for understanding clay shrinkage induced subsidence. However, this information is not widely available for France. We acknowledge that this is a limitation of the present work and we will add these two sentences to Section 4.4: **"The YDMI index is only a proxy for soil moisture conditions and does not integrate soil susceptibility to shrinkage and swelling or building characteristics. Therefore, the relationship between YDMI and damage is not straightforward."** We will also add the following at the end of the Introduction section: "**The aim of this work is to improve the characterization of clay shrinkage occurrence factors and to statistically quantify the global number of insurance claims. The aim here is not to determine a risk of damage for each house.**"

Page 4 – Soil shrinkage and swelling are mainly governed by flow in the unsaturated soils. Are the unsaturated soil parameters somehow considered?

We suggest adding these details to section 2.1.: **"To account for surface conditions, ISBA is based on the Richards equation (Richards, 1931) for modeling water transfer in unsaturated soils. Application of this equation requires knowledge of the matric potential. This variable can be derived from soil moisture through the Soil Water Characteristic Curve (SWCC), for which several equations exist in the literature. In particular, the Campbell (1974) equation used in ISBA requires knowledge of the soil moisture at saturation and the matric potential at saturation. These two properties are derived from the soil texture based on Clapp and Hornberger (1978). Therefore, ISBA simulates water flow in unsaturated soils, but requires values of the parameters at saturation."**

Page 6 – This choice is not clear to the reviewer! What could be the impact of choosing a different soil layer?

Although clay shrinkage and swelling is a relatively superficial phenomenon, it is important to focus on the deepest layer (80-100 cm) because it provides the best explanation for long-term trends, due to filtering by the superficial layers. This is consistent with the slow kinetics of the phenomenon as previously explained in Barthelemy et al. (2024). To illustrate the effect of layer depth in modeling soil moisture variations, we show below the time series corresponding to different layers for a single grid point (situated at lon=43.567, lat=1.397) close to the city of Toulouse, with a deciduous broadleaf vegetation for the year 2022.

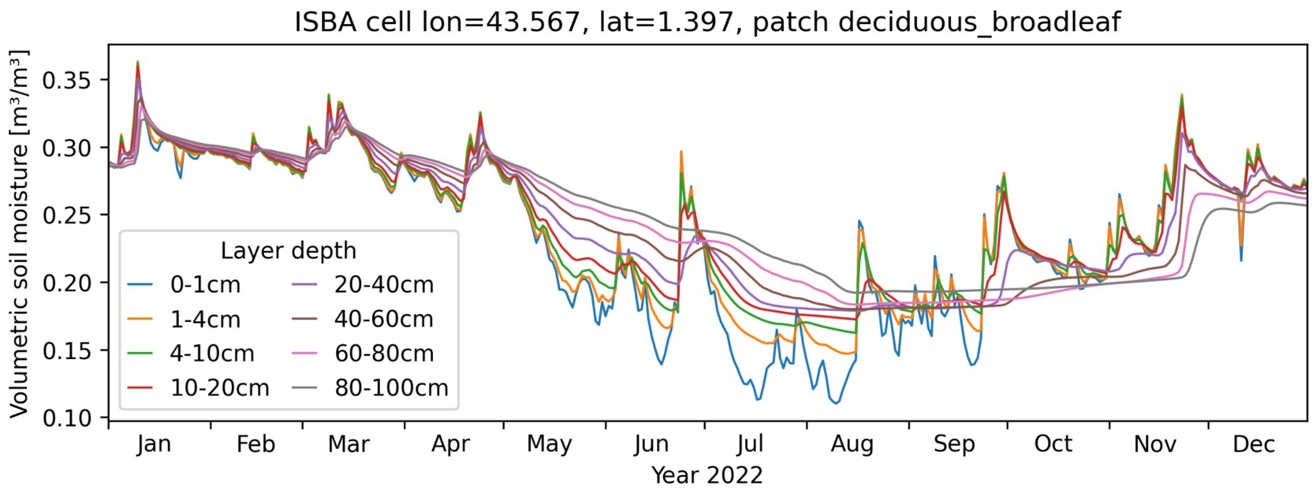

Figure 1: Variations of the volumetric soil moisture over time at the ISBA grid cell located at lon=43.567, lat=1.397, for year 2022, and a broadleaf tree vegetation type. The colors indicate different soil depths, from the soil surface to 1 m.

Figure 1 shows that the closer the layer is to the surface, the more frequently its water content fluctuates. Soil moisture begins to stabilize and shows more inertia below 20 cm. The most superficial layers dampen the fluctuations, and the time lag is explained by the slowness of the water transfer process. Choosing a more superficial layer would result in quantifying instead the short-term variations, that are not relevant to clay shrinkage and swelling. We suggest adding this explanation to the commented paragraph and to the Supplement.

Page 10 – The level of damage highly depends also on the building structure (weight, stiffness, foundations...).

We agree with this comment. We will add the following statement to the commented sentence: **"The level of damage highly depends also on the building structure (weight, stiffness, foundations...)."**

Page 11 (Section 4.2) – Couldn't this be checked by comparing the data?

As a reminder, the projected YDMIs appear to be more pessimistic at the median and more optimistic at the extremes than the historical YDMIs. We stated in the paper that a divergence in climate forcing could explain this discrepancy. As suggested by the reviewer, we compared the precipitation and temperature fields of the SAFRAN reanalysis and the DRIAS-2020 climate models over their common period (2006-2022) to see if this could explain this discrepancy.

The figure below summarizes the differences in daily temperature and precipitation between SAFRAN and DRIAS-2020 simulations over the common period 2006-2022. The details for each model are also given below – they will be added to the supplementary material of the paper.

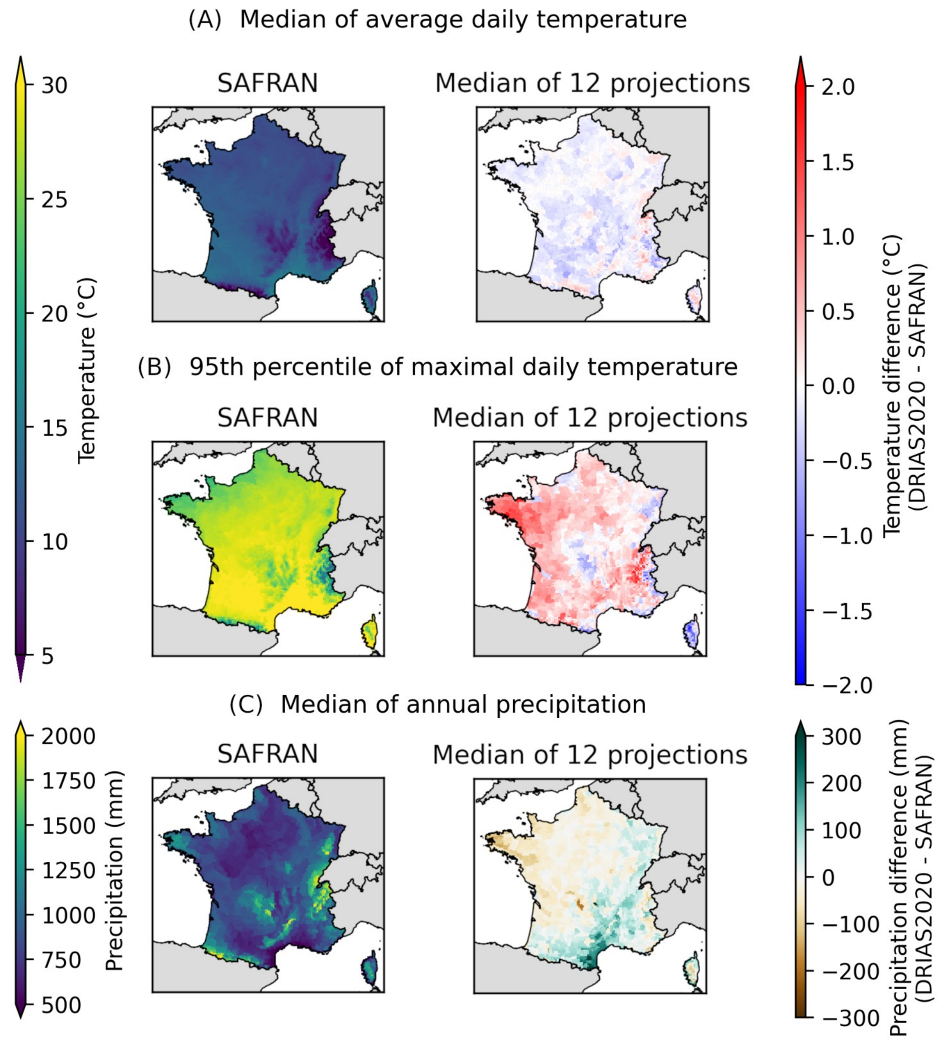

Figure 2: Climate forcing of SAFRAN (left) and projected minus historical differences over their common period 2006-2022 (right). The median of the 12 projected simulations is used. (A) Median of average daily temperature, (B) 95th percentile of maximum daily temperature and (C) median of annual precipitation.

Figures 3 and 4 shows that DRIAS simulations tend to underestimate by less than 1°C the median daily mean temperatures, and overestimate by more than 1°C the higher daily maximum temperatures, respectively. The majority of models agree on these two points. The analysis of precipitation in Figure 5 shows that annual precipitation is underestimated in the northwest and overestimated in the southeast of France. Interestingly, all models are affected by this bias.

In view of this result, differences in climate forcing could indeed contribute to the explanation of the discrepancy between historical and projected YDMI. We suggest adding this result to the article.

Differences for each model:

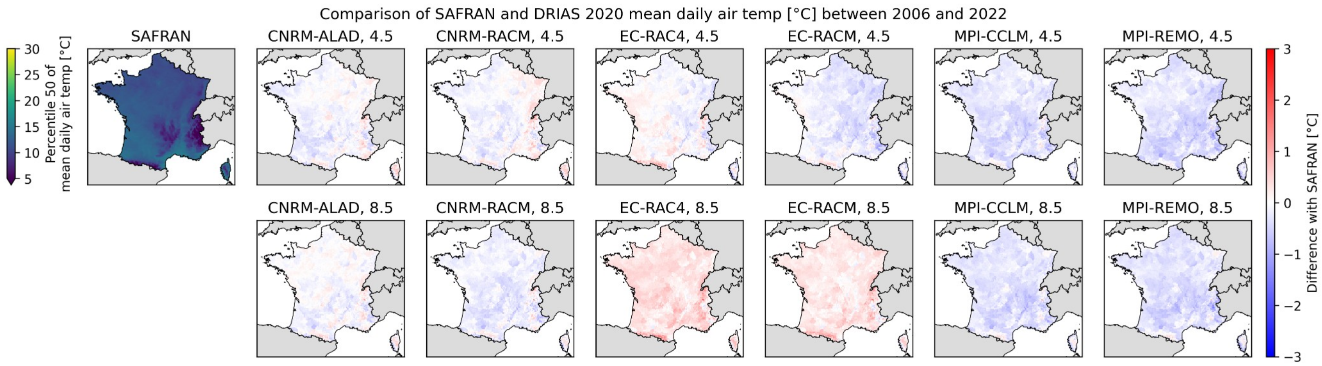

Figure 3: Comparison of the median of the average daily air temperature of SAFRAN and of the the 12 projected simulations over their common period 2006-2022.

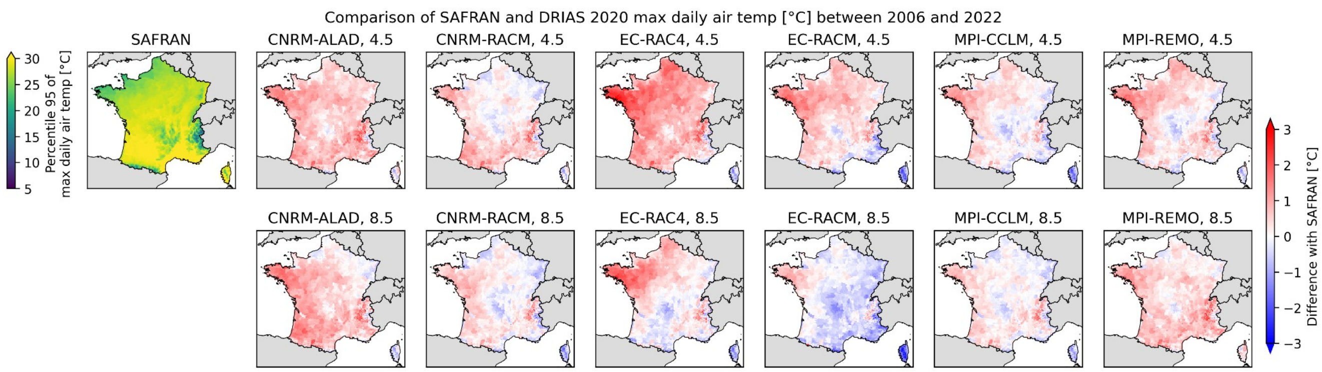

Figure 4: Comparison of the 95th percentile of the maximum daily air temperature of SAFRAN and of the 12 projected simulations over their common period 2006-2022.

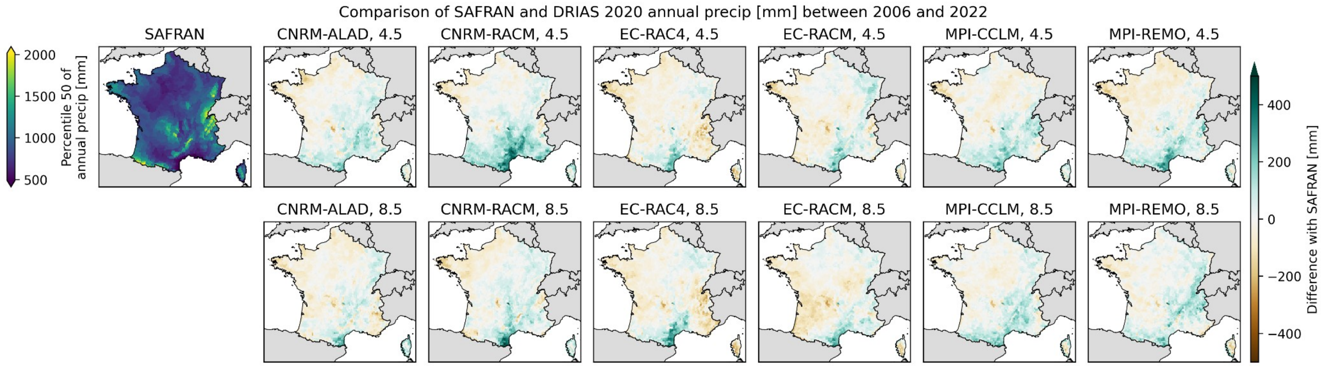

Figure 5: Comparison of the median annual precipitation of SAFRAN and of the 12 projected simulations over their common period 2006-2022.

Page 11 – The RCPs are intended to indicate a kind of warming levels, so this comment is not clear to the reviewer.

We suggest replacing
"The climate modeling framework adopted here involves feeding the same CO_2 evolution into a set of models and assessing their response over time. However, it is not stated that all models warm at the same rate. Other approaches exist that take this element into account. For instance, Samaniego et al. (2018) analyze drought as a function of warming instead of time. This choice enhances model consistency and reduces uncertainty."
by
"The climate modeling framework adopted here involves feeding the same CO_2 evolution into a set of models and assessing their response over time. RCPs consist of projections of greenhouse gas concentrations, whose increase causes the atmosphere to warm. However, models can warm at different rates depending on the modeling choices, resulting in different temperature increases for the same time horizon. For this reason, it could be suggested characterizing the conditions that trigger clay shrinkage as a function of warming rather than time. This is the approach developed by Samaniego et al. (2018)."

RCPs consist of projections of greenhouse gas concentrations, whose increase causes the atmosphere to warm. However, models can warm at different rates depending on the modeling choices, resulting in different temperature increases for the same time horizon. For this reason, one might suggest characterizing the conditions that trigger clay shrinkage as a function of warming rather than time. This is the approach developed by Samaniego et al. (2018).

Page 14 – The link is missing?

We apologize, the link was forgotten. The data is available at:
https://figshare.com/s/61c73ec14ed0b876641e
This is a private link that is only valid for the review process. Once the paper is accepted, it will be replaced by a DOI.

References

Barthelemy, S. *et al.* (2024) 'A new approach for drought index adjustment to clay-shrinkage-induced subsidence over France: advantages of the interactive leaf area index', *Nat. Hazards Earth Syst. Sci.* [Preprint]. Available at: https://doi.org/10.5194/nhess-24-999-2024.

Campbell, G.S. (1974) 'A simple method for determining unsaturated conductivity from moisture retention data', *Soil Science*, 117(6), pp. 311–314. Available at: https://doi.org/10.1097/00010694-197406000-00001.

Clapp, R.B. and Hornberger, G.M. (1978) 'Empirical equations for some soil hydraulic properties', *Water Resources Research*, 14(4), pp. 601–604. Available at: https://doi.org/10.1029/WR014i004p00601.

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Samaniego, L. *et al.* (2018) 'Anthropogenic warming exacerbates European soil moisture droughts', *Nature Climate Change*, 8(5), pp. 421–426. Available at: https://doi.org/10.1038/s41558-018-0138-5.