Reviewer 3

The paper deals with an interesting numerical approach to calculate a drought index fitted to clay shrinkage induced subsidence over France. The reviewer asks the authors to give first more attention to the following general remarks in order to correct them.

The authors thank the Anonymous Referee #3 for their constructive feedback on the work.

***COMMENT 3.1**: I'm not really convicted that we can talk about a "new drought index" in this paper and choose it as a title! This can be misleading. The reuse of existing parameter SWI derived from ISBA simulation method, with an extended vegetation representation, is in my opinion not enough to name this parameter new drought index. I suggest to the authors to modify the title according to a "new approach" or an "adaptation" of an existing parameter.*

RESPONSE 3.1: We suggest modifying the title as follows:

> 'A new **approach for a** drought index fitted to clay shrinkage induced subsidence over France: benefits of interactive leaf area index'

***COMMENT 3.2**: Add a legend for Figure 5 and specify the correspondence of each color bar.*

RESPONSE 3.2: Figure 5 was corrected as requested:

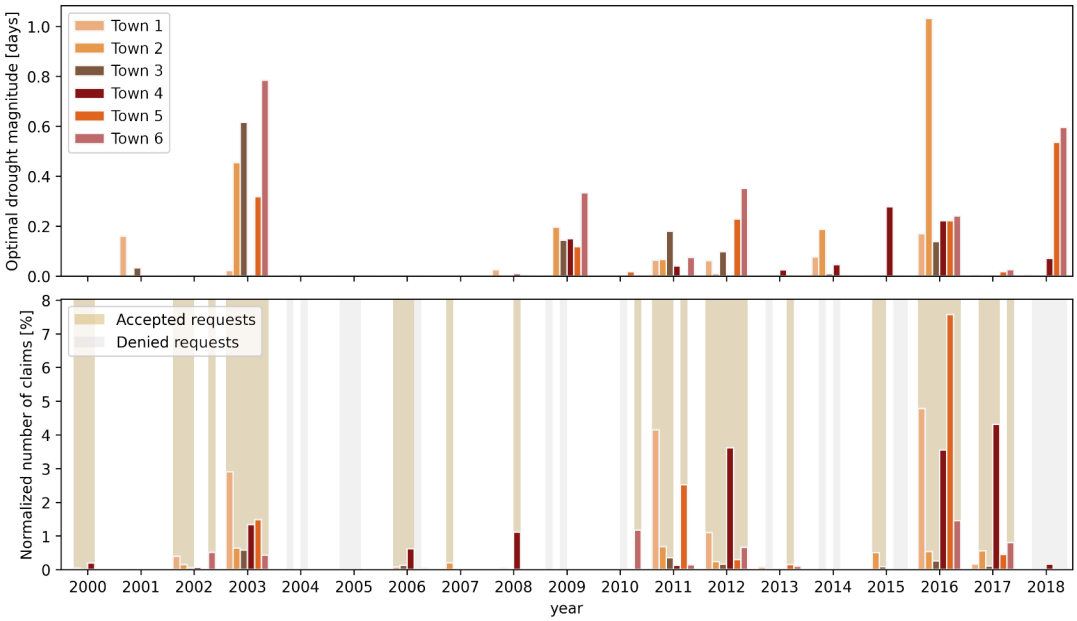


Figure 5: Optimal drought magnitude (top), and normalized number of claims superposed to accepted and denied CatNat requests (bottom), for the six towns of the validation set.

COMMENT 3.3*: page 4 and lines 100-101, moisture variations depend also on the mineralogy of clays and their saturated and unsaturated hydraulic conductivity, the initial soil suction and how water flows depending on its hydromechanical properties. Can the authors give more details on the choice of not taking soil parameters and behaviour into account in this study?*

RESPONSE 3.3: Soil parameters and behavior are accounted for indirectly in this study by the way the ISBA model works. As explained in Decharme et al. (2011), soil hydraulic parameters such as porosity, matric potential at saturation and saturated hydraulic conductivity are related in the model to soil texture through empirical pedotransfer functions (more specifically, Noilhan and Lacarrère (1995) relationships derived from Clapp and Hornberger (1978)).

We propose adding these elements to section 2.1.

COMMENT 3.4*: page 4 and lines 102-103, in the ISBA model, it is considered that texture is homogeneous and represented by some clay, sand and silt contents. This cannot reflect the reality when we know the heterogeneity of clayey soils in France, at the kilometer resolution and including at the same plot of the house. Thus, calculations made and improved based on the ISBA model and derived versions is a tool to have an idea to estimate the top surface soil moisture but it is still complex to deduce any real state of hydromechanical behaviour of clayey soils without considering their mineralogy, heterogeneity and hydromechanical properties such as soil water characteristic curve (SWCC).*

RESPONSE 3.4: As explained in response to Comment 3.3, soil hydraulic parameters are derived from texture in ISBA using empirical pedotransfer functions. As the reviewer correctly points out, it is true that texture averaged at the grid scale is not representative of what can be found on a house plot. Inferring hydromechanical behavior from this information alone would indeed be problematic. It is not the purpose of the drought index we are developing here. We suggest adding this point to the text of the revised manuscript.

COMMENT 3.5*: page 4 and lines 111-113, analysis of this study were based on four model layers until 1.0 m depth. One of the direct consequences of climate change is the propagation of soil desiccation in depth under severe and recurrent drought. This can reach 3.0 m depth and more depending on the close environment configuration. It would be interesting if the authors try to take into account this climate change effect through new calculations.*

RESPONSE 3.5: The reviewer has a good point. In this study we are limited to a maximum depth of 1m, due to the patch continuity requirement. Knowing that the amplitude of soil moisture variations decreases with depth (Ravina, 1983), a drought that reaches deep soil layers will intensively dry out shallow layers. Theoretically, such an event can be detected with surface layer information alone. It should be noted, however, that drying out occurs with a time lag increasing with the depth of the layer. We have verified in this analysis that even for the deepest model layers, the drought observed in a given year never overlaps with the following year, which would distort the index calculations. This assumption may be questioned under future climatic conditions, considering that the frequency and intensity of droughts in France will increase.

We suggest adding this comment to section 2.1.

COMMENT 3.6*: page 5 and line 127, what do the authors mean by "volumetric soil moisture"? Is it possible to explain how simulation can provide this physical property of the soil?*

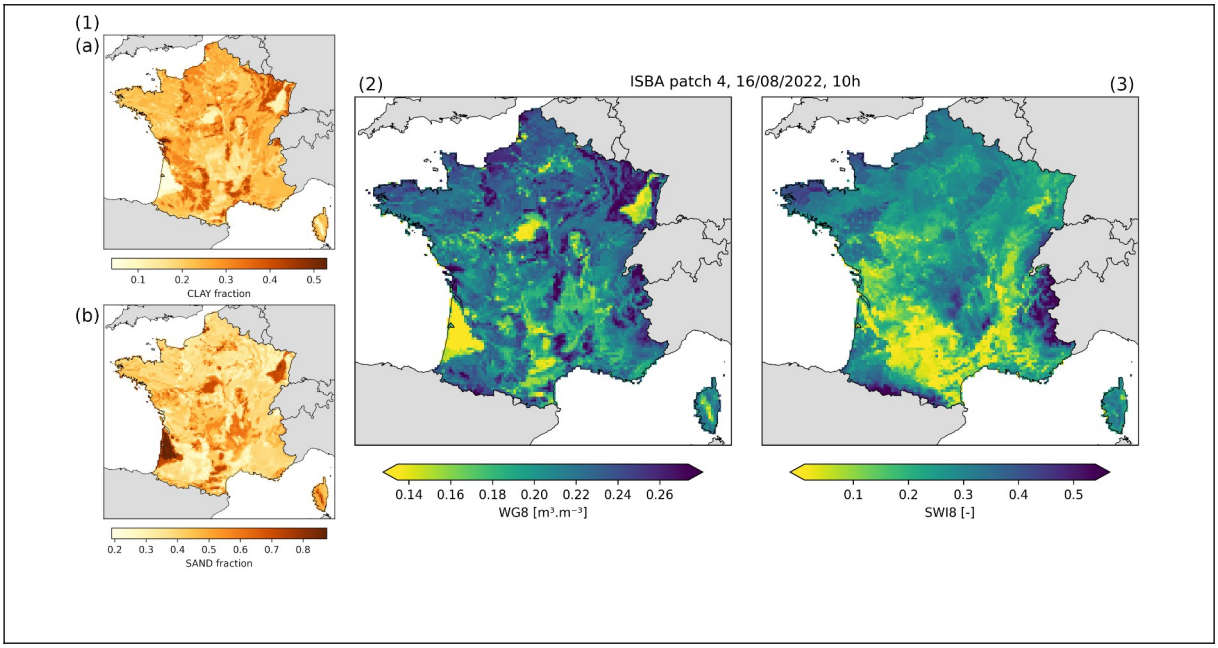
RESPONSE 3.6: Volumetric soil moisture is the water content of the soil, expressed in units of volume of water per unit of volume of soil (m^3/m^3). As explained in the text, ISBA simulates this variable by performing a water balance between precipitation, drainage, evapotranspiration, runoff, and storage. We will add this clarification to section 2.1.

COMMENT 3.7*: page 5 and lines 129-131, can the authors clarify better the "conversion" of the volumetric soil moisture to soil wetness indices (SWI) to justify considering a single definition of drought?*

RESPONSE 3.7: The Soil Wetness Index SWI consists of the soil moisture normalized between the field capacity W_{fc} and the wilting point W_{wilt}, as expressed in the equation below. The latter two hydraulic parameters are derived from the texture using pedotransfer equations.

$$SWI = \frac{WG - W_{wilt}}{W_{fc} - W_{wilt}}$$

To justify our approach, we propose to include the following figure in the supplementary material of the paper. The maps show (1) the soil texture defined in the model as (a) clay and (b) sand fractions, and (2) the volumetric soil moisture WG and (3) the soil wetness index SWI of layer 8 of patch 4, at the same time (16/08/2022, 10h). Volumetric soil moisture is highly dependent on texture (lower moisture content in sand than clay), making it impossible to use a single definition of drought for the whole country. Switching to SWI allows us to remove the influence of texture and characterize only temporal variations.



COMMENT 3.8*: page 6 and lines 179-181, it appears that this study is mainly based on SWI outputs of the ISBA model. I'm not convicted that these calculations are the most reliable tools for studying soil moisture variations as mentioned.*

RESPONSE 3.8: Land Surface Models that simulate soil moisture variables are reliable tools for evaluating changes on a large scale. As explained in response to Comment 3.7, the conversion to SWI enables to solely focus on variations by removing the dependence on soil texture.

Although the conversion is useful for unifying the information on a national scale, it does not affect the magnitude calculations. In fact, the calculations are based on thresholds defined by percentiles of the daily soil moisture, the distribution of which is unchanged by the linear transformation that is the conversion to SWI.

COMMENT 3.9*: page 6 and lines 189-190, I'm not sure that it is possible to assume that results based on in situ observations in the USA and Canada can be applicable to France especially under climate change context. Many assumptions are considered in this study, which show the complexity to approach the soil water content and its variations without taking into account its hydromechanical properties at a given initial state.*

RESPONSE 3.9: We agree with the reviewer's comment. We are conscious that the hypothesis of a stable daily soil moisture distribution is questionable under a climate change context. We propose stating this in the discussion part dealing with uncertainties, section 4.4.3:

> [L434] 'Nevertheless, there is an advantage to using daily **instead of annual** soil moisture data: the SWI distribution is **expected to be** more robust over a 19-year period**, due to the high number of observations.** This is especially important in the context of a changing climate. **The hypothesis of a stable daily soil moisture distribution remains a source of uncertainty inherent to this work.**'

Additional references

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