Answer on Anonymous Referee #2

Dear Reviewer,

Thank you for your review. Below we address the comments you made on the paper.

Main points:

- *"How have the landscape positions been validated, the map presented in Figure S6 makes sense at the global scale, but how valid are the results if you look at the landscape scale, where the authors develop their conceptual framework? I assume this can be easily done with global topography data such as SRTM. I would encourage the authors to discuss this a little bit more in detail since the landscape position is a critical part in your analysis."*

The landscape classification was based on the same water table depth dataset used for the correlation calculations. This water table depth map data was produced with global topography data as one of the input datasets. The resulting classification was validated visually against some geological literature on sample regions. As with any classification some locations will be misclassified, but it does pick up on even quite small landscape features, as I will demonstrate in two examples.

Example number one is a closeup of the Netherlands. The bigger landscape units, the 'wetland and open water' class, defines most of the west and north of the Netherlands, the areas with extensive lowland polders (Hartemink and Sonneveld, 2013). Smaller landscape units are visible as well; the coastal dunes in the west of the Netherlands and the individual push moraines in the Veluwe complex (central Netherlands) can be distinguished (for reference see Overmeeren, 1997). Also, smaller units are visible such as the river levees of both the Meuse and Waal (the last part of the Rhine).

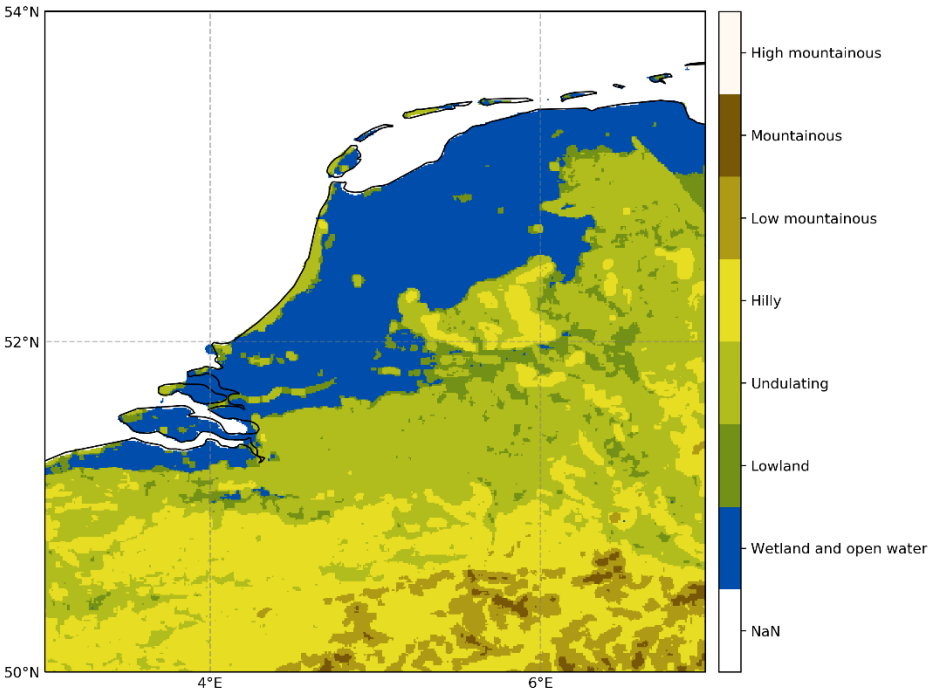

Figure 1: Landscape classification closeup from the Netherlands

The second example shows northern Italy. The Alps show up as the highest locations in this example, with some detail in this mountainous area. The Apennines appear as mountainous but clearly lower than the Alps. In between, the Po valley shows up as low lying area and the delta (close to Venice) shows up as 'wetland and open water'. Smaller units are picked up as well; several lakes appear, most notably Lago di Garda, just under the Alpine region. Just below the Alps, the Euganean Hills – protrusions in the Po valley of volcanic origin – show up as well.

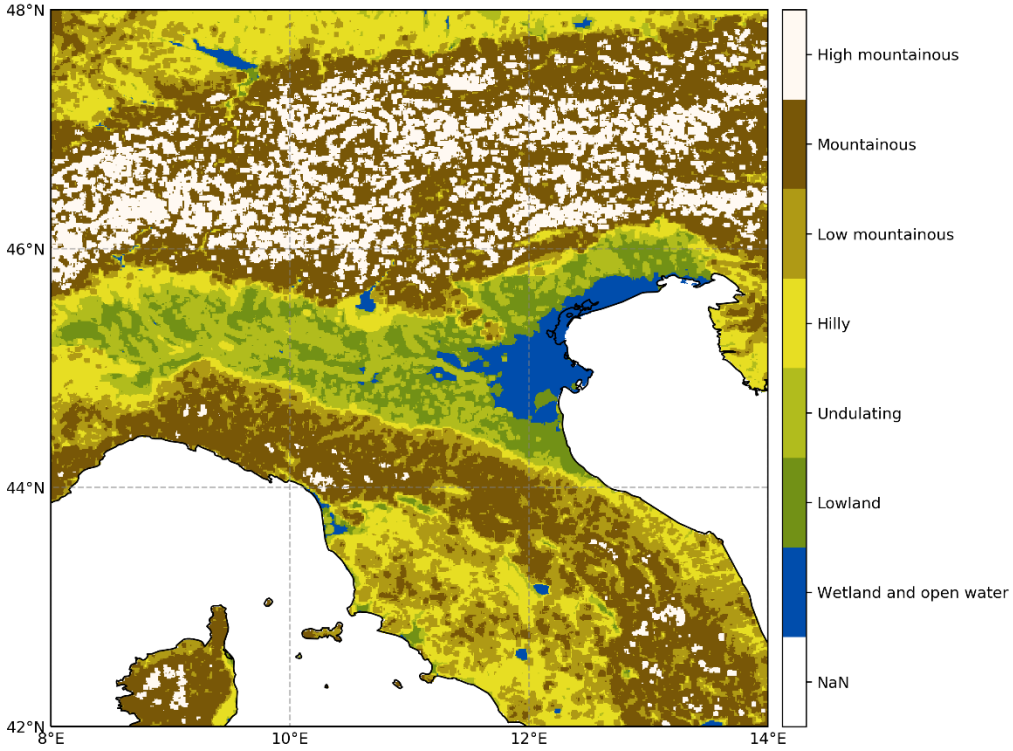

Figure 2: Landscape classification closeup of northern Italy

We decided to not include these visual examples in the paper for brevity. We will add a sentence to the paper describing that the classification has been validated based on visual inspection based on several sample regions.

- *"In the description of the Ecohydrological classes in section 2.3 I would stronger present the effects of temperature on forest growth in the higher landscape positions to avoid misinterpretations. Since this class is mostly present in the higher landscape classes of the temperate regions."*

Temperature plays indeed an important role in this story, especially in the mountainous areas. As mentioned by the reviewer the class "composite" is often found in these areas. In the class descriptions we explain this temperature effect; vegetation grows better in lower landscape positions. This can be attributed not only to water being more available in the lower lying areas, also temperature, soil depth and nutrient availability are more favorable for tree growth in these lower landscape positions. As this class is linked to many different factors we decided to call it 'composite'. We believe this addressed the issue of misinterpretation, but will put some more emphasis on temperature in the descriptions of the classes.

Minor points

- *"statement line 12 to 14 In my mind this statement is only true for water limited areas. For more humid, energy limited environments like the temperate and boreal zones I am not sure whether water availability determines whether vegetation grows or not especially when it comes to trees. I would argue that in the colder climates and higher mountainous areas plant growth an especially Tree growth is also limited by temperature which can be clearly also seen by the tree line distribution in the high mountain areas in the temperate regions as well as in the northern climates."*

Although we definitely agree with the more nuanced picture the reviewer describes, the point we wanted to make with this sentence is that by looking globally at the vegetation distribution water availability is key in understanding the patterns. If insufficient water is present, vegetation does not grow. On the other hand, if enough water is present it does not mean that vegetation definitely does have to grow. Besides temperature, also soil depth, stability and toxicity might be other factors preventing plants to grow at all. To avoid ambiguity, we will change the sentence to

"Water availability is a prerequisite for vegetation growth, while plants influence the local hydrological situation through interception of precipitation and transpiration of water absorbed in the root zone."

- *" Statement line 16 to 20 This statement might be true on large continental scale, however as experiences of the drought years 2018 and 2019 in Europe have shown that forests mainly consisting of species trees species with shallow roots such as spruces suffered serious damages during the droughts."*

This is indeed a good point. This statement is meant to address the point that trees have deeper roots than other vegetation and because they are long lived species they need to be adapted to the local climate and hydrological conditions. This makes them more resilient to weather anomalies (on an ecosystem level) but extremes can still be deadly, especially for varieties (or relatively young forests) with shallower root systems. The drought of 2018 and 2019 was quite extreme for the European climate. We will change the sentence to the following:

"Because they can take up water from considerable depth with their extensive root systems, trees are highly adapted to the local climate and hydrologic regime, making them *more* resilient to weather anomalies, such as prolonged periods of drought"

- *" Statement line 45 to 47 Rooting depth also depends soil properties like the existence of a layer of higher density in the soil profile. This is for instance very often the case in landscapes which have developed after the glaciation period or have been influenced by glaciation (e.g. in North America, Central Europa, Northern Part of Asia)."*

Thank you for the nuance, we will add the following statement to the manuscript:

“Exceptions can occur for various reasons, such as slope instability, insufficient soil depth and the presence of hardpans in the soil.”

- *“Figure 6: I would have expected a stronger temperature effect on forest growth also in the lower landscape classes like low mountain areas and hilly landscapes. How can this be explained?”*

The effect of temperature in these areas is most likely present, but the effect of increased precipitation at the highest locations seems to be dominant. For the tropical climate (Af) this region in classified as ‘Convergence dominated’. One component explaining higher growth in lower lying areas is most likely related to the access to the groundwater, but also temperature might play a role in this trend.

- *“Figure 7: For the boreal and temperate regions the figure indicates a deep and unchanging rooting depth from low mountainous, mountainous and high mountainous regions. This is misleading. In fact in these areas the rooting depth decreases with elevation. In the higher elevations only shallow soils over bedrock can be found. So the development of the rooting depth should be similar as presented in the arid region.*

Good point, we will adjust the figure

- *“Legend Figure 1 change contrained to constrained”*

We will change this

- *“ Figure 7 the color codes of the arrows and lines need to be explained, either in the legend or the figure caption”*

The colors are directly linked to the colors of figure 1, we will accentuate this link in the caption. The direction of the arrows corresponds to the correlation between WTD and fPAR, as obtained from figure 1, we will also clarify this.

- *“Figure S20 the figure caption mentions relationship between fAPAR and climate and landscape positions but the legend says WTD, please clarify.”*

Thank you for spotting the mistake, we will change to caption.

References

Hartemink, A. E., & Sonneveld, M. P. W. (2013). Soil maps of The Netherlands. *Geoderma*, *204–205*, 1–9. https://doi.org/10.1016/j.geoderma.2013.03.022

Van Overmeeren, R. A. (1998). Radar facies of unconsolidated sediments in The Netherlands: A radar stratigraphy interpretation method for hydrogeology. *Journal of Applied Geophysics*, *40*(1–3), 1–18. https://doi.org/10.1016/S0926-9851(97)00033-5