

Dear Referee #2

Thank you for taking the time to evaluate our manuscript. Your comments will lead to a thorough revision of the paper.

Following is our one-to-one response to your concerns. Throughout this letter, your comments are written in blue color and are numbered.

(1) This paper presents research into predicting global terrestrial biomes with a CNN using a correlative climate-vegetation approach. The manuscript is of very high standard w.r.t. introducing the problem and motivation, describing the approach, discussing the results and pointing out the limitations. The authors also correctly state that the presented study is not a ground breaking new innovation, but a demonstration of how existing tools can be used in the context of predicting the future of complex systems.

**Response:**

We greatly appreciate your positive evaluation for our manuscript!

(2) Besides the limitations discussed in section 3.3, a few additional aspects come to mind. Firstly, most climate models have no dynamic vegetation models built in. In addition to what the authors stated regarding the lack of feedback between vegetation and climate, it is also known that large ecosystems create their own climate and therefore changes to the ecosystems - due to whatever factor - may affect the future climate as well.

**Response:**

For addressing this issue, the phrases in lines 261-263 will be divided into two parts and rewritten. The original paragraph will be replaced by the new phrases 1. The new phrases 2 will be inserted into line 228.

Previous phrases (Lines 261-263):

We must also keep in mind that the correlative climate-vegetation approach ignores feedbacks between vegetation and climate, which are known to influence vegetation distribution at equilibrium (Pitman, 2003), as well as present-day species distributions that are not in equilibrium with present-day climates (e.g., Woodward, 1990).

New phrases 1 (will be replaced with the previous phrases):

We must also keep in mind that the correlative climate-vegetation approach ignores feedbacks between vegetation and climate, which are known to influence vegetation distribution at equilibrium (Pitman, 2003). Both Had2GEM-ES and MIROC-ESM explicitly consider climate-vegetation interactions, including dynamic adjustment of biome distribution, and hence its projected climates are the outcomes of such interactions. However, due to the difference in projected distributions of biomes among models, some regions should have mismatched reconstructions of the interactions. Implementing the CNN model with earth system models to dynamically adjust biome distribution to simulated climate distribution would address this issue.

New phrases 2 (will be inserted into line 228):

Even present-day plant species distributions are considered not in equilibrium with present-day climates (e.g., Woodward, 1990).

(3) It is also not clear to me how to separate the human effects that are partly, implicitly included in the model (e.g. human-made landuse changes in the training period) and, more important, the ones that are not included. Recent and future rapid development, sealing of surfaces, large-scale deforestation and irrigation, large-scale relocation of humans due to rising sea levels and temperatures, the development and use of genetic manipulated crops etc. are all factors that may influence future terrestrial biomes. It would be nice to see section 3.3 expanded to include some of this in the discussion and, if possible, to include some suggestions on how to incorporate these complex interactions in a next step.

**Response:**

We will add the following new paragraph at the end of line 263.

-- The CNN model was trained with an observation-based biome map, which is composed of natural vegetation only. However, the impact of human activity on ecosystems is now so prevalent, and hence predicting ecosystem changes without explicit consideration of socio-economic systems would be challenging (Ellis, 2015). Therefore, future research might address how current patterns of human activity interact with projected biome changes to reveal regions where these interactive agents align and amplify one another.

Ellis, E. C. (2015). Ecology in an anthropogenic biosphere. *Ecological Monographs*, 85, 287-331. <https://doi.org/10.1890/14-2274.1>

(4) Lastly, there seem to be a bit of a mixup of present and past tense in section 3.1 that should be made consistent. For example, Line 189-190, "The probability of the most plausible biome tend to be ..." (where it should be tends if it is present tense) versus line 184, "... the allocation disagreement was much larger ...".

**Response:**

Thanks for pointing out the mixup of present and past tense. We check the throughout "Results and Discussion" part. In the expected revised manuscript, all phrases describing results will be uniformed to past tense, while all terms concerning discussion will be uniformed to present tense. Specific changes will be as follows.

Line 172: "shows"      will be "showed"  
Line 187: "have"      will be "had"  
Line 189: "tend"      will be "tended"  
Line 195: "compared" will be "compares"  
Line 244: "shows"      will be "showed"

Best,

Hisashi SATO (on the behalf of all co-authors)