

## ***Interactive comment on “Can canopy interception and biomass be inferred from cosmic-ray neutron intensity? Results from neutron transport modeling” by M. Andreasen et al.***

**Anonymous Referee #3**

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General Comments:

In this paper the authors use a model to investigate how different model conceptualizations and different model parameters influence both thermal and epithermal neutron intensities from the ground surface up to a height of 35 m. They want to find out whether it is possible to use combined measurements of thermal and epithermal neutrons at ground level to determine both aboveground vegetation biomass (quasi-statically) and canopy interception (dynamically). In order to do that they need to assess whether there are factors other than aboveground biomass and interception that alter the ratio of thermal to epithermal neutron intensity.

I like the approach. It is novel to measure neutron intensities at different heights in

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a forest and it is novel to try to use the ratio of thermal to epithermal neutrons for biomass determination. Therefore the topic is interesting and the paper is well-suited for publication in HESS.

Still, there is room for improvement. In the end as a reader I felt a little lost on what are the actual outcomes from the study. It seems as if equifinality is a very big problem. Many of the investigated model setups and parameters seem to influence the detected neutron intensity profiles and therefore it is unclear which setup represents reality best. Unfortunately, the discussion section often lacks more detailed interpretations of the comparison of model results and measurements. Therefore the full potential of the study is not yet explored.

So my main point is that a refocus of the discussion section (away from just describing towards interpreting) would definitely improve the manuscript and the value for the reader.

Specific Comments:

p. 1, l. 1: Title: Since canopy interception only plays a minor role in the paper, I would suggest removing it from the title. You are investigating so many more things, like forest canopy representation, complexity of soil matrix chemistry, litter, soil bulk density. A more obvious choice for the title might be going along the line of forest canopy representation (since this part appears most prominently and novel when reading the manuscript). Also, posing a question in the title is not ideal, especially when you answer one part of it with no and the other part with yes.

p. 1, l. 31: It would be good to insert an explicit concluding statement into the abstract that answers the question you were posing in the title. ('Therefore we conclude that while there is potential to infer biomass from cosmic... canopy interception cannot be inferred.')

p. 2, l. 2: '...relativeLY high concentration CLOSE TO THE LAND SURFACE,...'

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p. 2, l. 2-10: I would reorder this paragraph. Start with the role of soil moisture and the difficulties of its detection. Then introduce cosmic-ray neutrons and the detector before mentioning its footprint in line 7.

p. 2, l. 13: In Table 1 you use the word 'transient', here you say 'dynamically'.

p. 2, l. 13-14: Try to categorize this list. 'Hydrogen is stored statically in water in soil minerals and buildings/roads, quasi-statically in...'

p. 2, l. 31: 'HOWEVER, the spatial scale of measurement...'

p. 3, l. 27: '...we PERFORM a sensitivity analysis...'

p. 3, l. 28: Only to look at their effect on MODELED thermal and epithermal neutron intensity? Or also to make statements about their effect on ACTUAL thermal and epithermal neutron intensity?

p. 4, l. 16: Could you shortly introduce what this 'root-to-shoot ratio' is?

p. 4, l. 16: Information? Be more specific.

p. 5, l. 2: Why random soil samples? A composite sample representing mean soil properties would have been much more representative of the soils within the footprint of the sensor given small-scale variability.

p. 5, l. 24: What do you mean by: '...is observed VISUALLY...?'

p. 5, l. 26: Do you mean that the hardpan-layer hinders percolation to deeper depths?

p. 6, l. 12: represent might not be the right word here. Maybe 'detect' or 'be sensitive to'?

p. 6, l. 13: What do you want to express when you write: 'Despite this fact...?'

p. 7, l. 5: The term 'epithermal' includes 'fast', no? So you don't need to say '...fast and epithermal...'

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p. 7, l. 7: Why do you believe in this minor effect on your results?

p. 7, l. 19-20: What are these correction factor models, when exactly where they applied and how did the output of these models look compared to the cadmium-difference model?

p. 7, l. 32-34: The fact that the environmental conditions at the field sites are fairly homogeneous is no explanation for your assumption that the neutron intensities measured by the two different detectors can be compared. Please elaborate.

p. 9, l. 5-32: What about the sub-canopy structure of real forests? With a lot of the leaves and branch biomass a couple of meters above the ground and only the trunks with a lot of air in between near the ground surface. Would you expect the same outcome? How could this impact your results? It would be good to discuss this somewhere.

p. 10, l. 20-21: Rephrase. Maybe something like: 'The thermal and epithermal neutron intensity is both a product of hydrogen abundance as well as elemental composition...'

p. 12, l. 30: From here on I will ask the question 'Why?' whenever I would like to see a more detailed discussion of one of your results/observations. Throughout the discussion section there are instances where you observe and describe your results without giving a proper (attempt of) interpretation. For example here you state that '...the neutron intensity profiles of the simpler forest canopy conceptualization ... is less steep and is the only model providing an epithermal neutron intensity profile within the daily ranges of the time-series measurements...'. Still there is no explanation on why this could be the case.

p. 13, l. 19: Why?

p. 14, l. 17: Why?

p. 14, l. 19: How can the mineral soil act as a producer of epithermal neutrons? Thermal neutrons would have to be accelerated to become epithermal. How does this

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happen?

p. 15, l. 7: Move ‘...from the calculation in the previous section...’ to the beginning or the end of the sentence.

p. 15, l. 31-32: Why?

p. 16, l. 5-6: Why?

p. 16, l. 26-27: Why?

p. 17, l. 7-17: So would you say that this model representation is better than the more complex one? It certainly fits better to your observed data. What does it mean that the average conditions (without separate trunk, foliage, air) perform better? It should be the other way around, no?

p. 17, l. 22: Do you maybe mean ‘...prevailING at the field site.’

p. 17, l. 31-32: Why?

p. 18, l. 7-12: Is that an indication that this more complex model is a more realistic representation of the forest environment? How is this observation compatible with the previous observation that shows the better fit of the less complex model when comparing the differences between ground and canopy level thermal and epithermal neutron intensity?

p. 18, l. 13-20: How would each of these 3 factors influence the modeled ratios?

p. 19, l. 3: Should the amount of biomass not be slightly larger for the Heathland site compared to the non-vegetated Gludsted plantation?

p. 19, l. 6: It would be helpful to introduce an abbreviation for the term ‘thermal-to-epithermal ratio’ somewhere at the beginning (Rt/e) and use it throughout the manuscript.

Figures & Tables:

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Figure 1: Provide a map that zooms in onto your study area with a little more detail and move the current overview map of Denmark into one of the corners of the new map.

Figure 3-10, 12-13: Remove the line in the legend in front of ‘Canopy surface model’. I was looking for it but it is not in the actual figure, is it? Maybe just call it ‘Modeled’ in comparison to ‘Measured’.

Technical Corrections:

p. 1, l. 25: ‘minor’ is no adverb. Maybe use ‘insignificantly’.

p. 1, l. 27: siteS

p. 4, l. 5: ‘...within THE Skjern River...’.

References:

A couple of references are listed but not referenced in the text:

Bogena et al. 2013

Heidbüchel et al. 2016

Rivera Villareyes et al. 2013

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2016-226, 2016.

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