



EGUsphere, author comment AC1
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Reply on RC1

Cynthia Maan et al.

Author comment on "Dynamic root growth in response to depth-varying soil moisture availability: a rhizobox study" by Cynthia Maan et al., EGU sphere,
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Dear reviewer,

Thank you for your constructive comments. Please find our reply to your remarks below

- The reviewer commented that there is still some room to extend the study for real case applications. We agree with the reviewer that there is room for extension to real case applications. However, we think that the results presented here – the parsimonious model with very direct relationships between the two state variables (soil moisture and root density) and the experimental setup for validation (including ‘constant’ and highly controlled flow rates through the drip lines) could already be ready to share with the public.
- The reviewer also notes that our parsimonious model is not new, while other LS models (e.g. NoahMP and STEMMUS-SCOPE model) have a dynamic root growth module.

The authors agree that the proposed model is not the first one considering dynamic root growth. However, only few models take *soilmoisture driven root growth into account*. STEMMUS scope considers the effect of the total root zone soil moisture availability, but does not consider vertical variations in the soil moisture profile. The authors are aware (now) of only the coupled NoahMP/VOM-ROOT that considers the impact of the vertical soil moisture profile on the root growth profile. Last model makes another assumption about the bulk root growth.

Furthermore, the existing dynamic root growth models are unambiguous about first principles. E.g. should the bulk root growth rate be related to the biomass growth rate, as Adiko et al. suggest, to the difference between the water demand and the actual water uptake (Schymanski et al./ NoahMP/VOM-ROOT; growth of the root bulk in case of water shortage), or could it be related to the soil water status directly/only (as proposed here). It generally is a good idea to keep the model as simple as possible, while including the most dominant (proven) relationships. Therefore we propose a very simplified model, which nevertheless includes a dominant functional relationship between root growth and soil moisture.

Unique about this study is the following:

- In the last version of the model we propose to link the (local) root growth rate very

directly to the local soil moisture, with no other (e.g. above ground) dependencies. This is a new proposal/hypothesis.

- In our experiment we maintain the water flow relatively constant. In other studies irrigation is concentrated in short periods of irrigation or rain, which makes it more difficult to distinguish between signals of the forcing and of the response of the plant. By applying constant 'irrigation forcing' it is easier to recognize the adjustment processes to constant irrigation forcing.

Also by simulating a single plant and perform direct measurements on both the soil moisture and root density growth rates simultaneously, i.e. it can give more insight in the direct interactions between the two variables. This information is missing when root densities/weights are measured after the soil moisture measurements. Also we measure both variables (roots densities and soil moisture) directly instead of indirect proxies (like evaporation or temperature) that depend on a translation by more complicated models with more assumptions.

- The reviewer is not clear or the authors did not show how the current approach can be applied elsewhere in the field. Particularly, the most important parameters (e.g., u_2/u_3) are determined via sensitivity analysis, which makes this reviewer wonder how to obtain these parameters in the field, and further at regional/global scale?

We propose two different model-versions for root growth that can be applied in different settings/situations.

The first one is *only the relationship between (vertical varying) soil moisture and root density growth*. This part of the model is easy to couple with a LSM, because the *vertical extension velocity u_1* is a parameter that is already included in LS models with a dynamic root growth module (however not yet including soil moisture driven root growth, like SWAP), and is therefore already estimated/determined for different plants and crops. The most easy way to implement our model in the most basic form (only the impact of vertical varying soil moisture) is to incorporate only equation 1 (possibly in combination with adding a threshold value at the root tip as we also propose), and leave the bulk (depth integrated) root growth of the LSMs intact.

The water extraction rate per centimeter of roots in saturated conditions u_2 was only introduced to make a simple translation between the vertical root profiles and the (measureable) soil moisture. Most existing LSMs contain a much better described and well validated module to calculate water extraction from given root profile and soil moisture profiles. So this part of the model is not meant for incorporation or practical application.

In the second version we propose to link the root growth rate directly to the normalized soil moisture. This is a new proposal/hypothesis. We however fully agree that further measurements and experiments are needed to test this hypothesis, and to determine *the root density growth rate in optimal conditions (saturation) u_3* for different plant types. Note however, that we make use of only one and the same value to simulate the root growth in all time spans and at each level in Figure 8 . In practical applications, to implement this model in LSMs, it will be necessary to maximize the total root growth to (a part of) the total biomass growth.