Reviewer: The grammar needs improvement. Some sentences are cumbersome to read, and commas appear at unexpected places, for instance.

Authors: The grammar will be corrected and checked by a native English-speaking editor

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Reviewer: The title is very brief. Please add what type of models you are using and that you are interested in pore-scale and Darcian-scale processes.

Authors: The title will be modified to "Modelling of water infiltration into water repellent soils with a pore-scale Darcian flow model."

Reviewer: The abstract is strictly qualitative and mentions the models that are used in passing. It also staes results that are rather obvious. It can be made more specific, and why not highlight the more interesting stuff?

Authors: The reviewers is right, the abstract will be modified to give a better highlight to the findings of this this study with some quantitative data.

Reviewer: I missed some relevant literature in the paper. This leads, for instance, to the claim that infiltration into water-repellent soils has not been modeled. See for instance:

Egorov, A.G., R.Z. Dautov, J.L. Nieber, and A.Y. Sheshukov. 2002. Stability analysis of traveling wave solution for gravity-driven flow. *In* S.M. Hassanizadeh et al. (ed.) Computational methods in water resources. Proc. XIVth Int. Conf. (CMWR XIV), Delft, The Netherlands, Vol. 1. 23–28 June 2002. Elsevier, Amsterdam, The Netherlands.

Egorov, A.G. Stability analysis of gravity-driven infiltrating flow. (9). doi:10.1029/2002WR001886.*Water Resour. Res*.2003 39 1266.

Geiger, S.T. Infiltration in homogeneous sands and a mechanistic model of unstable flow. *Soil Sci. Soc. Am. J.* 2000 64 460– 469. https://doi.org/10.2136/sssaj2000.642460x

Raats, P.A.C. Unstable wetting fronts in uniform and nonuniform soils. *Soil Sci. Soc. Am. Proc.* 1973 37 681– 685. https://doi.org/10.2136/sssaj1973.03615995003700050017x

Authors: We agree with the reviewer that the sentence about the lack of modelling of infiltration into water-repellent soils is misleading. We will rephrase it taking into account adequately the references suggested by the reviewer. However, the main topic of our manuscript is not the flow instability in soils as often described in water-repellent soils. Our modelling found that in the case of highly water-repellent soils a superficial ponding pressure is necessary to initiate infiltration and the slight differences in topography could initiate fingering features as a consequence of differential infiltration rate.

Reviewer: Another problem arising from the limited literature review is that no attention is being paid to the temporal dynamics of the contact angle and spatial variation of water repellency. In section 2.1, the dynamics of the contact angle may be of importance, but is not included.

Some (but hardly all) relevant references for this aspect:

Goebel, M.-O., et al., Water potential and aggregate size effects on contact angle and surface energy, Soil Sci. Soc. Am. J. 68, 383-393, 2004.

Leighton-Boyce, G., et al., Temporal dynamics of water repellency and soil moisture in eucalypt plantations, Portugal, Australian J. of Soil Research, 43, 269-280, 2005.

Thwaites, L.A., et al., Near-surface distributions of soil water and water repellency under three effluent irrigation schemes in a blue gum (Eucalyptus globulus) plantation. Agric. Water Managem. 86, 212-219, 2006.

Authors: We agree with the reviewer, that the manuscript does not take into account the importance of the temporal or spatial variation of the contact angle. This important feature in natural soils should indeed be mentioned though it is not the centre point of this study, simply exploring numerically the incidence of different contact angles. Further studies should definitively explore the spatio-temporal evolution of hydrophobicity. This will be mentioned in the new version of the manuscript.

Reviewer: The theoretical analysis of section 2.1 appears to overlap in part with that of Cho et al. (2005), who also invoked the Green-Ampt model. It would be interesting to see how this new analysis compares to this older work.

Cho, H., de Rooij, G.H., and Inoue, M.: The pressure head regime in the induction zone during ubnstable nonponding infiltration: Theory and experiments. Vadose Zone J. 4, 908-914, 2005, https://doi.org/10.2136/vzj2004.0158.

Authors: Indeed we didn't mention this study as the main topic of the manuscript is not the modelling of unstable infiltration flow but rather the effect of increasing contact angle on the Washburn relationship. Nevertheless, the comparison of our model with the Green and Ampt approach developed in this reference is relevant and will be mentioned in the manuscript

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Reviewer: In Section 2.2, include a reference to Fig. 1. In figure 1, include all the terms you used in Section 2.2 to create an solid connection between the text and the figure.

Authors: A reference to figure 1 in section 2.2. already exists in line 133, but more references will be added to line 141 for example. Caption of Figure 1 will mention explicitly the references to the different radii and heights described in section 2.2

Reviewer: In Section 3, I think the clarity of the figures would benefit from using colour. I had to magnify some of the figures a lot so I could read them.

Authors: Indeed, to improve the clarity of the figures in section 3, colour will be used for the graphs.

Reviewer: At line 187 you state that the observed relationship between the contact angle and the sorptivity was unexpected, but why was it? Although it may be possible to derive such a relationship in the theory section, you did not pursue this there, although it would add an interesting element to the paper. Without a theoretical expression for the sorptivity as a function of the contact angle, I find it hard to see why the relationship you established through the simulations would be unexpected. Indeed, the correction you propose does not seem to be consistent with the rather complicated role of hf in Eq. (10). As it is, the correction proposed in line 188 has no connection with the equations developed earlier in the paper. I therefore think it may be possible to explore this more thoroughly in the theory section. You could do so directly by moving Eqs. (21) and (22) to the theory section, thereby establishing a hypothetical correction of S. The simulations can then be used to test this hypothesis, and you end up with a more neatly organized paper that confirms a theoretically derived hypothesis.

If you decide to do so, as I hope you will, it would be very helpful to modify the theory section so that the sorptivity actually appears in some of the equations.

Authors: We are very thankful for these interesting and valuable comments on this section. Indeed the paper would be clearer by adding equation (21) and (22) to the theoretical section. This will be be modified in the new version of the manuscript.

Moreover as the relationship proposed at line 188 has no theoretical background it would wiser to remove this mention, especially as it has been demonstrated theoretically that:

$$S/S_0 = \sqrt{(\cos(\theta))}$$

Reviewer: Your conclusion in lines 204-206 is nice. Once you think about it it is easy to understand, but I share your view that it is good to mention.

In Fig. 4, does the dashed line in the top panel indicate the 1:1 line and does the same dashing in the bottom panel denote the cylindrical model? That is a bit confusing. Colour could help.

Authors: Colours will be added to these figures in order to avoid this confusion.

Section 3.1.3

Reviewer: I think the effect of time on A reflects the decreasing validity of the two-term approximation of the full series with increasing time. As time progresses the importance of capillarity wanes and that of gravity grows (in Philip's own terminology), which explains why the effect on S is much smaller than that on A.

Authors: We are aware of the problem of the validity of the two-terms Philip equation for long infiltration time and its potential incidence on constant rate parameter A. This is why parameter A was evaluated for infiltration time in figure 5. There's clearly a dependence of parameter A with infiltration but the incidence of contact angle is more important.

In order to assert these results, we could present a table showing the evolution of the 2 terms of Philip equation (1) and the parameters for 3 terms infiltration equation (2):

$$I = S \cdot \sqrt{t} + A \cdot t \qquad (1)$$

$$I = C_1 \cdot \sqrt{t} + C_2 \cdot t + C_3 \cdot \sqrt{t^3} \qquad (2)$$

$\cos(\theta_w)$	$S(m\,.\,s^{-1/2})$	$A(m\,.\,s^{-1})$	$C_1(m\,.\,s^{-1/2})$	$C_2(m\,.\,s^{-1})$	$C_3(m\,.\,s^{-3/2})$
1.000E+00	8.479E-03	7.827E-05	8.499E-03	7.498E-05	1.230E-07
9.848E-01	8.414E-03	7.831E-05	8.435E-03	7.498E-05	1.239E-07
9.397E-01	8.218E-03	7.845E-05	8.239E-03	7.499E-05	1.264E-07
8.660E-01	7.886E-03	7.870E-05	7.909E-03	7.501E-05	1.309E-07
7.660E-01	7.411E-03	7.911E-05	7.438E-03	7.505E-05	1.376E-07
6.428E-01	6.781E-03	7.974E-05	6.813E-03	7.514E-05	1.472E-07
5.000E-01	5.966E-03	8.075E-05	6.008E-03	7.530E-05	1.610E-07
3.420E-01	4.908E-03	8.253E-05	4.966E-03	7.570E-05	1.810E-07
1.736E-01	3.435E-03	8.633E-05	3.529E-03	7.702E-05	2.109E-07
8.716E-02	2.353E-03	9.070E-05	2.481E-03	7.947E-05	2.270E-07
1.745E-02	8.905E-04	1.003E-04	1.034E-03	8.943E-05	1.900E-07

Section 3.2

Reviewer: The word 'sorptivity' conveys the tendency of a soil to absorb water. If the contact angle exceeds 90 degrees, this tendency is zero. Reporting positive sorptivities for such soils sounds contradictory.

Authors: We understand that the use of sorptivity for hydrophobic conditions sounds contradictory. However, we use "sorptivity" to refer to the first parameter S in the Philip equation, as it is usually used.

Reviewer: The caption and legend of Fig. 7 do not explain r and the contact angles. For A/A0 I cannot see to which radius a curve belongs.

Authors: Indeed r and contact angle are not mentioned in the caption and will be mentioned in the new version. Nevertheless, r is already mentioned for S/S0 but doesn't appear clearly for A/A0 as the curves coincide.

Reviewer: Particularly in strongly hydrophobic soils, which are the focus of this section, the tendency of the contact angle to decrease when the soil is exposed to water has dramatic effects on infiltration and the formation of preferential flow paths. Although this is a long section, this aspect is not addressed at all, in fact, it is not even mentioned. I can follow the analysis and its internal logic, but nevertheless it seems beside the point because it ignores the most important factor governing infiltration in such soils, which is the persistence of hydrophobicity under wet conditions.

Authors: We understand the point of view of the reviewer. Though the model presented here does not pretend to explain all the mechanisms involved in water infiltration into water-repellent soils, we will mention references describing the increase of wettability with increasing water content, to cite this phenomenon.

Reviewer: Figure 12 c incorrectly represents a finger. As soon as a slight instability develops (termed a proto-finger in some of the references mentioned above), the pressure head near the proto-finger tip will be slightly larger than at the rest of the wetting front, accelerating the infiltration rate at that finger tip. This creates a positive feedback loop that lets the 'winning' protofingers grow while the 'losers' stop advancing. In the shallow wet layer of the top soil, flow will be directed horizontally towards the growing fingers. Because these take all the water, the wetting front stagnates everywhere else. The wet lobe to the left of the finger that is shown in the figure therefore will not develop. Some podzolic soils show evidence of very long persistence of preferential flow paths in the pattern of the brown organic matter band that is leached from the A horizon and deposited in the B horizon. I have never seen such a lobe next to a finger in the literature.

Authors: We agree with the reviewer, that the flow instability described by the above-mentioned references has not been taken into account in the manuscript, because it does not derive from the development of the model presented here. The results deriving from the use of this model, show that slight differences in ponding pressure at the soil surface will develop important differences in infiltration rate and therefore prepare the occurrence of fingers or proto-fingers. Therefore we will mention what is described is not strictly speaking a fingering feature due to flow instability, with the according references.

Reviewer: All in all, the theoretical analysis is interesting and offers some new insights. It needs to be better embedded in the literature because there are previous uncited analyses available that are not compared with the work reported here.

Authors: The references suggested by the reviewer will be integrated into the text to illustrate the findings in this study.

Reviewer: As indicated above, I think there is potential for a more thorough analysis of the relation between the sorptivity and the contact angle that, to my knowledge, has not been explored before. The inclusion of results obtained with a Richards solver (Hydrus-1D) is interesting, but it can be better clarified in the text that these simulations either apply to the very early stage of infiltration when the induction zone (terminology adopted from the references above) is formed and preferential flow paths have not yet developed, or to flow in a single preferential flow path without interaction with the dry soil surrounding it.

Authors: The relationship between sorptivity and contact angle will be developed in the new manuscript especially based on the theoretical development of the Washburn equation and its connection with the Philip equation as well as developing the connection with the Green and Ampt equation. We will add some supplemental information to section 3.1.4. about the determination of van Genuchten parameters, to specify the conditions for the use of these parameters.

Reviewer: Some minor comments were made directly in the text.

Authors: The comments and corrections will be introduced in the new version of the manuscript.