Review of “Does drought alter hydrological functions in forest soils? An infiltration experiment” hess-2015-255 by K. Gimbel, H. Puhlmann, and M. Weiler

Summary of Changes

First, we would like to thank the referees for the review and the helpful comments to improve the paper. We have addressed all the comments as explained below.

Comments of Anonymous Referee #2

COMMENTS TO AUTHORS:

Properties over longer periods compared to the time frame of more common experiments imposing short but intense dryness. While the experiments seem well executed, I found the presentation to be lacking and the interpretation of the results to be problematic. In some places the conclusions do not follow directly from the results presented. I outline some major issues below.

MAJOR COMMENTS:

1. Description of the dye pattern analysis (section 2.4): this section is tailored for those already familiar with dye pattern analysis. Otherwise, it is difficult to understand the reason the 3 metrics (volume density, surface density, and stained path width) are selected for characterizing flow patterns within the soil column. In addition to referring to previous literature that adopts these metrics, I think the authors should include more descriptions for the advantages of using these metrics and how they relate to physical processes in the soil. In addition, results pertaining to surface density is not presented anywhere in the results section. How does information from surface density complement that from volume density?

Answer: We agree with the referee here and in accordance with referee #1 (comment 14), we changed the section (now section 2.6) and added more information:

“To obtain objective measures to compare the dye patterns of the different profiles and sites, we derived three depth related variables of the binary images: (1) volume density, (2) surface density and (3) stained path width as basis for further delineation of flow processes. The volume density (VD) is similar to the frequently used dye coverage. It is defined as stained volume divided by the reference space and is originating from the methods of stereology, which relates a three-dimensional parameter to two-dimensional measurements (Weibel 1979). Surface density (SD) is defined as surface area of an object divided by the volume of the reference space. Surface density provides information on the size and number of features: a high SD is caused by a large number of small objects, whereas a low SD indicates less but larger objects (Weiler 2001). The stained path width is derived by measuring the width of every stained object at a certain depth. Using the frequency distribution of the SPW of every depth, the dye pattern can be related to distinct flow processes. For example, macropore flow with low interaction can be identified by long and narrow stains, whereas macropore flow with mixed interaction shows a broader distribution of shapes (Weiler and Flühler 2004) .The classification introduced by Weiler and Flühler (2004) was used to distinguish five flow processes: two types of matrix flow ((1) homogeneous and (2) heterogeneous) and three types of macropore flow ((3) low, (4) mixed and (5) high interaction with matrix), where interaction is understood as the lateral water flow from macropores into the surrounding soil matrix (Weiler and Naef 2003). The SPW of every depths were classified into three classes of < 20 mm, 20 – 200 mm, and > 200 mm. Depending on the proportion of stains in each class, a flow type was determined using the classification rules of Weiler and Flühler (2004)."

2. Soil moisture changes (Section 3.1): There are 2 lines delineating the dates of experiments in 2011 and 2013, but the period over which the simulation has been conducted is never indicated. Which year was this? In Figure 4, what does the green line signify? This needs to be explained in the legends. Throughout the manuscript, the authors use qualitative words to describe quantifiable results, such as in page 7698, line 5, "before the experiment in 2013, the soil moisture status of the drought treated plots and the control plots are very similar." I found this to be vague and misleading, and furthermore inadequate to support the main result from this section, which is that "the observed infiltration patterns and changes among the sites are mainly a result of change in soil properties [due to drought]." In fact, differences in trajectories between drought plots and control plots can be observed even prior to the start of experimentation (e.g., coniferous forest in Schwäbische Alb, deciduous forest in Schorfheide-Chorin), sometime to the same extent observed after rainfall-exclusion. The authors need to address these differences, using statistical evidence if possible. In general, this section needs to be overhauled and written to highlight the connection between the main points. Also, if soil measurements have been taken, why not show them on the plots?

Answer: We agree with the referee here and changed the mentioned parts. The soil moisture model and the results thereof were discarded in accordance with reviewer 1 and 3. We now show the results of the soil moisture measurements at all locations. To address the issue of using statistical evidence, we added boxplots of VD values for each 10cm soil depth for better comparison (see also referee #1, comment 29).

In accordance with the referee #1 (comment 26 and 29) and referee #3 (comment 3), we rewrote section 3.3.1 and 3.3.2. In addition, we now show boxplots of VD values of the pre-drought, control and drought profiles. The sections now read as follows:

"**3.3.1 Comparison between pre-drought pattern and control pattern**

Differences between pre-drought and control plots (without drought treatment) reflect differences in soil structure, texture and moisture due to a distance of 20 - 40 m between the drought and reference plot, but may also include time dependent changes of the soil characteristics, which are independent from the drought treatment. To ensure validity of the dye pattern analyses, it is necessary to assure comparability among the plots. To exclude time dependent changes as reasons for differences in pre-drought and drought treated dye patterns, the pre-drought pattern were checked against the pattern of the control plots. Figure 6 compares the pre-drought pattern and the control pattern of the deciduous plots. In addition, Figure 7 provides VD boxplots of the pre-drought and the control profiles for direct comparison.

The Schwäbische Alb pre-drought plot (Figure 6, top left) shows high VD in the top 10 cm in all profiles. The 40 mm and 60 mm sprinkling volume profiles show a high SPW in the top 5 to 10 cm. On the control plot (Figure 6, top right) also large areas in the top 10 cm are stained, but the VD and SPW are not as high as in the pre-drought profiles. This is especially evident in the VD boxplots of the upper 10 cm (Figure 7, top). All Schwäbische Alb profiles have high stone contents, in some cases exceeding 50 % of the profile width (Figure 6). Below 10 cm depth, the control plot profiles are almost completely stained. This pattern is similar to the pre-drought profiles. In general, the patterns of the control profiles are similar in VD, SPW values, and distribution to the 20 mm pre-drought profile. The 60 mm control profile is reflecting the high VD and SPW values in top layers, which are characteristic of the 40 mm and 60 mm pre-drought profiles.

The Hainich-Dün pre-drought profiles (Figure 6, center left) show low to medium SPW in all depths. VD values are high in the top 5 cm in all profiles and between 10 cm to 30 cm in the 40 mm and 60 mm sprinkling amount profiles. The 20 mm profile displays only small VD values below 10 cm depth. All profiles have a medium to high stone content (30 – 60 %) below 30 cm depth. The control plot profiles (Figure 6, center right) are very similar in VD and SPW to the pre-drought profile pattern, but with generally lower VD in the 60 mm sprinkling amount profile (Figure 7, center right). Except for the 20 mm profile, which displays no stones, the control plot profiles have a medium to high stone content below 25 cm depth. In all profiles, large areas of the profile stayed unstained. However, although having a low VD in top layer, the 60 mm control plot profile is not following the pronounced drop in VD between 5 cm and 10 cm depths and the subsequent rise between 15 cm and 25 cm, which is characteristic for all other profiles (pre-drought and control). These distinct differences are visible in the boxplots (Figure 7)

In the Schorfheide-Chorin pre-drought profiles (Figure 6, bottom left), high VD and SPW values are present. The highest VD and SPW values can be found in the 60 mm sprinkling amount profile. Below 10 cm depth, the 20 mm pre-drought profile displays only small to medium SPW and – in comparison to the 40 mm and 60 mm profiles – small VD values. The control plot profiles (Figure 6, bottom right), show in general high VD and SPW values, but have lower values in the top 10 cm than the pre-drought profiles (Figure 6 bottom right and Figure 7, bottom). This is more apparent in the 20 mm and 40 mm profiles (Figure 7). In the pre-drought and control plot, infiltration reached down to depths over 70 cm and no stones are present.

To summarize, the comparison between the pre-drought and control plots showed a broad agreement. Differences, that need to be accounted for, are the lower VD in the profile top layers of all sites. These differences might be due to spatial heterogeneities, given the distance between the control and the pre-drought plots (15 m to 30 m). The pre-drought and drought experiment were performed in close vicinity (0.5 m). In the Hainich-Dün, the drop and rise of VD in all profiles points to a soil layer boundary effect on infiltration. This is not time dependent and present in both pre-drought and control profiles, therefore the comparability between the pre-drought and drought pattern is not affected.

3.3.2 Comparison between pre-drought pattern and drought pattern

As can be seen in Figure 8, all plots show marked differences between pre- and after-drought infiltration patterns. The clayey and loamy sites (Schwäbische Alb and Hainich-Dün) develop unstained (= unwetted) areas in the topsoil layers. This is more pronounced in the coniferous plots, where unstained areas are already visible in the pre-drought infiltration pattern. Figure 9 is showing the paired VD boxplot comparisons of the drought and pre-drought profiles.

Schwäbische Alb plots

At the Schwäbische Alb coniferous site, medium to low volume densities (VD) were found on the pre-drought coniferous plot throughout the whole profile for the 20 mm and 40 mm sprinkling depth and high VD for 60 mm sprinkling depth (Figure 8, top left). The drought 40 mm and 60 mm profiles are lower in VD in the top layers (0 – 10 cm), than the pre-drought profiles (Figure 8 and 9, top left); the 40 mm profile is displaying even unstained areas (no VD). The 20 mm pre-drought profile is already very low in VD, therefore the differences to the after drought profile is not distinct (Figure 8, top left). The drought coniferous plot shows a rise of VD culminating around 20 cm depth (Figure 8, top) for all sprinkling amounts (20 mm, 40 mm and 60 mm). Below 20 cm depth, the 20 mm and 40 mm profiles show (Figure 9, top left) higher VD in the after drought profiles than in the pre-drought profiles, whereas the 60 mm profile show the same extent of VD in the drought and in the pre-drought profile.

The stained path ways (SPW) of the Schwäbische Alb coniferous pre-drought profiles are small to medium in the 20 mm and 40 mm profiles and high in the 60 mm profile (Figure 8, top left). After drought, low to medium SPW are dominant in the 20 mm and 60 mm profiles; high SPW values are occurring in the 40 mm profile below 20 cm. The flow processes identified in this depth as matrix flow, are caused by local saturation due to low Ks (Figure 8, top left). The dominating flow types in the pre-drought profiles are identified as macropore flow, with low, mixed and high interaction depending on soil layer and infiltration volume. Dominating flow types in the drought plot are macropore flow with low, medium and high interaction.

The Schwäbische Alb deciduous plot shows in the 40 mm and 60 mm pre-drought profiles high SPW and in all infiltrating volumes high VD in the top layer (0 – 10 cm; Figure 8 and Figure 9, top right). Medium to high VD are maintained throughout the whole 40 mm and 60 mm profiles, and to lesser extend in the 20 mm profile. The drought profiles show lower VD in the top 10 cm, compared to the pre-drought profiles (Figure 9, top right). Below 20 – 25 cm depths, the 20 cm and 40 cm drought profiles show higher VD than the pre-drought profiles. However, the drought profiles are more similar in shape to the VD pattern of the control than to the pre-drought profiles (Figure 6, top). Also, the stone contents in the three pre-drought profiles are higher than in the drought profiles (Figure 8, top right).

The dominating flow types in the Schwäbische Alb deciduous pre-drought profiles are identified as macropore flow with low, mixed, and high interaction, and as matrix flow, depending on soil layer and infiltration volume (Figure 8, top right). The flow processes identified in the top layers of the 40 mm and 60 mm pre-drought profiles as matrix flow are caused by local saturation due to low Ks. The dominating flow types of the drought deciduous profiles are identified as macropore flow with low, mixed, and high interaction, but without matrix flow in the topsoil (Figure 8, top right).

Hainich-Dün plots

The Hainich-Dün coniferous pre-drought profiles show low VD for all sprinkling amounts, especially in the topsoil between 4 cm and 22 cm (Figure 8, center left). The 20 mm and 40 mm pre-drought profiles show unstained areas (no VD). The small VD values are even more pronounced in the drought profiles (Figure 8 and Figure 9, center left), in which all profiles exhibit unstained areas.

Below the unstained layer, the VD rises to a maximum in 15 to 20 cm depth and drops again around 30 cm depth. The 20 mm and 60 mm drought profiles show throughout all depths low VD (Figure 8, center left).

In all Hainich-Dün coniferous pre-drought profiles, no large SPW occur and flow types are classified as macropore flow with low, mixed and high interaction. This applies also for the 20 mm and 60 mm drought profiles. In contrast, the 40 mm drought profile exhibits high SPW between 15 cm and 25 cm depth. Therefore, the flow types in this depths are identified as matrix flow (Figure 8, center left). The main flow types in the coniferous drought profiles are macropore flow with low, mixed and high interaction. The pre-drought profiles are dominated by macropore flow with low and mixed interaction. In both, pre-drought and drought profiles, the stone content is comparable (Figure 8, center left).

The Hainich-Dün deciduous drought profiles exhibit smaller VD in the top 5 cm compared to the pre-drought profiles (Figure 8 and Figure 9, center right). Unstained areas are present in the top 5 – 10 cm of the 20 mm drought profile. The 40 mm and 60 mm pre-drought profiles show high VD values between 10 cm and 25 cm. High VD values are also present in the drought profiles, maintaining high values throughout the whole profile. While no high SPW values are found in the pre-drought profiles, high SPW values can be found in the 40 mm drought profile between 10 cm and 30 cm and in the 60 mm drought profile between 10 cm and 40 cm (Figure 8 and Figure 9, center right). The flow types of the deciduous pre-drought profiles are classified as macropore flow with low, mixed, and high interaction. The drought profiles are also classified as macropore flow with low, mixed, and high interaction and, where high SPW values occur, as matrix flow (homogeneous and heterogeneous) (Figure 8, center right). The stone contents of the pre-drought and drought profiles are increasing with depth below 25 – 30 cm; the drought profiles are exhibiting a slightly higher stone content than the pre-drought profiles (Figure 8).

Schorfheide-Chorin plot

The pre-drought pattern of the Schorfheide-Chorin coniferous site show high SPW and VD in the top layers (0 - 10 cm depth) decreasing with depth (Figure 8, bottom left). While the 20 mm and 40 mm pre-drought profiles show a maximum infiltration depth of about 45 cm and 30 cm, respectively, the 60 mm pre-drought profile is stained below 70 cm, exhibiting medium VD values (Figure 8, bottom left). High SPW values are found in the 20 mm pre-drought profile up to a depth of 15 cm and in the 40 mm and 60 mm profiles up to 10 cm and 30 cm, respectively. The drought profiles of the coniferous plots show far lower VD values in the top layers compared to the pre-drought profiles (Figure 8 and Figure 9, bottom left). The 40 mm drought profile is exhibiting even an unstained layer in about 5 cm depth. High SPW values can be found in the 40 mm and 60 mm drought profile, not in the top layers, but between 20 cm and 25 cm depth (40 mm profile), and between 10 cm and 25 cm depth (60 mm profile) (Figure 8, bottom left). This is reflected in the flow type classification. Whereas matrix flow is dominating the top layers in pre-drought profiles (at least the top 10 cm), matrix flow is occurring below 10 cm depth in the 40 mm and 60 mm drought profiles (Figure 8, bottom left).

The Schorfheide-Chorin deciduous pre-drought and drought patterns do not exhibit much differences in shape and in VD values in the 20 mm and 40 mm profiles (Figure 8, bottom right). The largest differences in VD can be found in the top 10 cm of the 20 mm profiles and in the 60 mm profile (Figure 9, bottom right). In addition, the 20 mm drought profile exhibits an unstained layer around 40 cm depth (Figure 8, bottom right). The difference between pre-drought and drought is more evident in the SPW values: Whereas high SPW values are found in the 40 mm and 60 mm pre-drought profiles in the top and bottom half of the profile, high SPW values are found in the drought profile in the bottom half, plus a small layer of two centimeter of high SPW around 10 cm depth in the 40 mm profile (Figure 8, bottom right). In the Schorfheide-Chorin deciduous pre-drought profiles, flow types of the 40 mm and 60 mm are dominated by matrix flow (Figure 8, bottom right). However, all profiles in the pre-drought plots have, a proportion of macropore flow. In the drought profiles, matrix flow is only occurring in bottom half of the 40 mm and 60 mm profiles.

To summarize, compared with pre-drought infiltration pattern, the drought pattern of all plots show differences in infiltration processes. Clayey and loamy soils behave similarly as they developed hydrophobic soil layers. High SPW values in 20 to 30 cm depth of the drought pattern indicate local saturation. In sandy soils, the change from high SPW values of the pre-drought pattern to medium and low in the drought pattern exhibit a change from front-like to a more scattered infiltration. In general, the effects were more pronounced at the coniferous plots. These findings correspond well with the results of the WDPT tests: In the clayey and loamy soils (except Hainich-Dün deciduous plot), the unstained topsoil layers are coinciding with the high WDPTs (Figure 5). Coniferous plot Hainich-Dün stays unwetted up to a depth of about 15 to 20 cm and Schwäbische Alb plots to a depth of about 10 cm, which is corresponding to the depths where the highest WDPT values were observed (Hainich-Dün: WDPT class 4; Schwäbische Alb: WDPT classes 4 and 3, respectively). In the sandy soils of the Schorfheide-Chorin profiles, low SPW values correspond to high WDPTs (class 2 and 3). Below the water repellent zone, SPW values are increasing again (Figure 5, bottom)."

3. Interpretation of results: As mentioned before, the authors have a tendency to make broad stroke generalizations on the results that should otherwise be addressed with more nuance to accommodate for other explanations. On page 7698, line 20, "In general, coniferous plots under drought had higher WDPTs than deciduous plots." By looking at Figure 5 it is clear that this is the case for 2 out of 3 sites and far from a general observation. This tendency continues throughout the manuscript: "in general, the patterns of the control profiles are similar in vd, SPW… (page 7699, line 24)" and "The comparison… showed no differences which can be addressed to other reasons than small scale heterogeneities of soil properties… All control plot profiles can be assumed to be comparable to the pre-drought plot profiles (page 7703, line 23)." I would dispute the accuracy of those statements. This becomes extremely disconcerting in Section 3.3, when the authors dismiss "time dependent changes of the soil characteristics" by equating control profiles to pre-drought profiles and attributes observed differences between pre- and post-drought profiles to the effects of rainfall-exclusion. However, by looking at Figure 6 and 7, it is not apparent to me the degree that the differences can be attributed to either the pre-drought and control pair or pre- and post-drought pair. In some cases, the difference between post-drought and control profiles seem much less than pre-drought and control profiles (Schwäbische Alb, coniferous, 60mm), which would invalidate the authors' premise. These differences are brushed aside, which to me raises red flags about the validity of the ensuing arguments. The authors should strive to clarify this section a bit more. It would help, for example, to reorganize Figures 6 and 7 to highlight the similarity and differences between the 3 classes of observations (control, pre, post) and include the flow processes bands in Figure 6.

Answer: Concerning the sentence on page 7698, line 20 "in general, coniferous….": We do not agree with the referee here, the exception is given directly in the sentence afterwards. Nevertheless, we changed the sentences in question to avoid future misapprehensions to:

"The coniferous plots under drought of Hainich-Dün and Schwäbische Alb showed higher WDPTs than the deciduous plots. This is valid for both mean and maximum values. The Schorfheide-Chorin deciduous plot showed higher water repellency than the coniferous plot."

To improve the comparability between the pre-drought, control and drought pattern, we show now boxplots of the VD values. In addition, the sections 3.3.1 and 3.3.2 were completely rewritten (see comment above and see also referee #1, comment 30 and referee #3, comment 7) and the first paragraph of section 4 improved (see also referee #3 comment7).

OTHER COMMENTS, QUESTIONS AND LINE EDITS:

1. Page 7690, line 15: "WDPT tests" This is the first time this acronym appears in the paper and needs to be written out.

Answer: We agree with the referee and changed the sentence; the sentence reads now as follows:

"This was 15 confirmed by water drop penetration time (WDPT) tests, which revealed, in all except one plot, moderate to severe water repellency."

2. Page 7691, line 15: "these shrinkage cracks foster bypassing of the soil matrix" This is done through preferential flows? The sentence as it stands now does not make much sense and needs to be expanded.

Answer: We agree with the referee and changed the sentence; the sentence reads now as follows:

"These soil shrinkage cracks channel the infiltrating water, and by that foster the bypassing of the soil matrix (Hendrickx and Flury, 2001; Ritsema et al., 1997) and therefore alter the infiltration patterns in soil."

3. Page 7692, line 13: "in respect to the expectable behavior" needs to be changed to "expected behavior"

Answer: We agree with the referee and changed the sentence; the sentence reads now as follows:

"By introducing these extreme events, the question of transferability of the results to natural systems in respect to the expected behavior under predicted future drought conditions arises."

4. Page 7692, line 15, "avoiding tentativeness due to an overreaction to…" needs to be rephrased.

Answer: We agree with the referee and changed the sentence; the new sentences read now as follows:

"Therefore, this study employs a moderate rainfall reduction equivalent to an annual drought with a 40-year return period, which is in accordance with climate predictions. Thereby we avoid an unnatural extreme drought resulting in system overreaction (Gimbel et al., 2015)."

5. Page 7692, line 19, "because they reflect integrally…" needs to be changed to something like "they reflect the integrated changes in soil hydrological functions…"

Answer: We agree with the referee and changed the sentence to:

"Infiltration patterns were chosen because they reflect the integrated changes of soil hydrological functions and directly show how water moves in the soil under altered conditions."

6. Page 7694, line 8, "The incoming precipitation was reduced… to the level equivalent to an annual drought with a return period of 40 years" This would imply different levels of reduction for each of the sites. The basis for this choice was puzzling to me. The authors clearly points to projected climate change with increasing dryness in Europe (Page 7691, line 10) and thus a drought level with a return period of 40 years calculated using historical data would contain little meaning when applied to future, nonstationary conditions. In theory 40-year droughts would become increasingly likely in the future, but the frequency with which it happens would depend on each site. What is the advantage of using this instead of a uniform reduction cross each site? Additionally, the actual amount that was reduced should have been listed somewhere in the paper.

Answer: We agree with the referee: using historical data/a drought with a 40-year return period to forecast future droughts in nonstationary conditions is not advisable. The aim was not to forecast drought levels, but to use the 2.5 %-percentile of the historical annual precipitation inputs (drought with 40-year return period) to make water inputs comparable between the plots: The plots observed in this study range in mean annual precipitation between 533 mm and 940 mm. A annual drought with a return period of 40 years represents a comparative drought event in all of the examined plots and corresponds with the projections of the A1F1 scenario.

Applying a uniform reduction (e.g. -40% rainfall) to all of the plots would result in rather harsh drought conditions for the plots with lower precipitation and rather mild drought conditions for the plots with the highest mean annual precipitation, and therefore make comparisons of the results more difficult.

In accordance with referee #3 (comment 1), we inserted following information:

"The incoming precipitation was reduced between March and November to the level equivalent to an annual drought with a return period of 40 years. The resulting annual targeted precipitation inputs under the roofs were 700 mm (26 % reduction) for Schwäbische Alb, 355 mm (33 % reduction) at the Hainich-Dün, and 395 mm (27 % reduction) at the Schorfheide-Chorin site."

7. Page 7694, line 17: "experimental area was kept shaded and sheltered" how does shaded differ from sheltered?

Answer: Shaded = protected from sunlight; sheltered = protected from rain and other external influences. But we agree with the referee here, the sentence may be confusing. Therefore, we changed the sentence to:

"The experimental area was kept shaded and sheltered from rain in all weather conditions to minimize evaporation and uncontrolled water input during the experiments."

8. Page 7699, line 12: “By comparing the pre-drought pattern and the pattern for the control plots…” This sentence is convoluted and needs to be rephrased for clarity.

Answer: We agree with the referee and split the sentence; the new sentences read now as follows:

“To exclude time dependent changes as reasons for differences in pre-drought and drought treated dye patterns, the pre-drought pattern were checked against the pattern of the control plots.”

9. In general the paper needs to be rewritten with an eye on clarity of the sentences and the organization of the paragraphs (to emphasize a few main points).

Answer: In accordance with referee #1, we rearranged the Materials and Method section. To harmonize the order of the subsections of the Materials and Methods section with the Results section, the new order is as follows: 2.1 Study sites, 2.2 Soil moisture measurements, 2.3 soil water repellency, 2.4 Dye tracer experiments, 2.5 Image processing and data analysis, and 2.6 Dye pattern analysis. We aslo reorganized the paragraphs in order to make the paper more clear.

10. Figure 6: The black and grey regions are not properly explained. They indicate the vd of stones but what differentiates between them?

Answer: The VD of stones following the same logic as the VD of stains: Whereas the VD sums up of the different SPWs (< 20mm, 20 – 200 mm, > 200 mm), the VD of stones sums up of the stone widths (< 20mm, 20 – 200 mm, > 200 mm). To make this clearer, we inserted following explanation in section 2.6:

“…The stained path width (SPW) is derived by measuring the width of every stained object at a certain depth. The SPW of every depth were classified into three classes of < 20 mm, 20 – 200 mm, and > 200 mm (Weiler and Flühler 2004). The sum of the three SPW classes per depth corresponds to the VD of the regarding depth. …”