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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Characteristics and controlling factors of the drought runoff coefficient" *by* Rei Itsukushima

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ãČżGeneral comments This manuscript by Itsukushima clarified that the controlling factors of drought runoff coefficient depend on drought severity. As is mentioned in the manuscript, many researchers have pointed out the importance of the controlling factors introduced in this manuscript, but the quantitative analysis for them is not enough. Especially, the effective factors for the drought have not been clarified theoretically. I believe this manuscript contributes the effective water resource management. However, the following point is not clear for me. In this manuscript, snowfall and rainfall pattern is considered to be the important factor, but the related factors to them are not included in 11 (or 12) controlling factors. What is the relationship between snowfall or rainfall pattern and the selected controlling factors? I hope this point will be elucidated.

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Moreover, hypothesis of the mechanism in 4.2.2, which is about geological condition, is a little bit unclear compared with other sections. I ask you to make discussion more convincing one.

Response: I wish to express my strong appreciation to the reviewer for insightful comments on my paper. I feel the comments have helped me significantly improve the paper. I agree with you and have incorporated this suggestion throughout my paper. As you pointed, precipitation is strongly related to the drought runoff volume. Therefore, I used the indicator of drought runoff coefficient which was calculated from dividing the total river runoff by total rainfall in each area. In addition, I added the explanation of the relationship between geological condition and drought runoff coefficient based on your comments.

ãČżSpecific comments 1. Line 96 “The drought runoff co-efficient of . . . by annual precipitation” How did you deal with the amount of water withdrawal upstream of the stations? I guess the amount of water withdrawal is not negligible during drought season in some rivers.

Response: To avoid the effects of artificial flow equalization, I excluded the observation stations whose watershed was subjected to over 10 % occupancy by a dam watershed. This is explained in Line 76. Further, I checked the discharge-duration curve to confirm the no unnatural and extreme reduction of flow discharge.

2. Line 110 “topographical gradient” How did you calculate this parameter? Explain the definition by showing the difference from the channel slope.

Response: According to the suggestion, I added the calculation method of topographical gradient as follow (Line 112-113).

Topographical gradient was obtained by averaging the slope angles calculated by the average maximum method in the watershed (Burrough, 1998).

Additional Reference Burrough, P. A., McDonell, R. A.: Principles of Geographical In-

formation Systems (Oxford University Press, New York), 190, 1998.

3. Line 122 “Of the 11 indicators” & 129 “10 controlling factors” I might misunderstand, but why are they 11 and 10? I thought you selected 12 factors in addition to the metamorphic rock. Then you excluded topographical gradient from them, right? Moreover, you show 12 controlling factors in Figure 4 while you excluded the topographical gradient. It is confusing.

Response: Initially, I installed 12 indicators as watershed factor. Among the 12 indicators, I delated the indicator of metamorphic rock (composition ratio was less than 5% in all target watersheds) and topographical gradient (strong positive correlation ($r > 0.07$) between it and cropland.). Finally, I used 10 indicators for calculation of NMDS and GLM. Therefore, I corrected the description as follows.

Line 99: I assessed 12 indicators Line 124: Of the indicators Line 131: As the explanatory variables, 10 controlling factors were used,

4. Line 122 “the topographical gradient was excluded” Why did you exclude the gradient instead of cropland? It is reasonable to exclude one of them, but it is necessary to consider the cause of strong correlation. Moreover, in the discussion chapter, it is better to discuss which is the fundamental cause of high or low drought runoff coefficient.

Response: I left the cropland as indicator because cropland is an important parameter that occupies a relatively large area in the target watersheds. In addition, I added the discussion of fundamental cause of drought runoff coefficient as follow (Line 229-233). Further, I added the standard partial regression coefficient of each analysis results in Table 2.

Comparing the standard partial regression coefficient obtained from the GLM according to the occurrence probability, value of MCBF of land use factor was high as that of geological factors in the high-frequency drought. In the drought with occurrence probability of 30 years, the value of land use factor exceeded the geological factor, and

CF was selected as the particularly influential indicator. Further, CS is selected as an important factor in low-frequent drought in addition to CF.

5. Line 151 “CF and SR were . . . of the second axis” Isn’t SR placed in the negative direction of the first axis, too?

Response: As requested, I modified the sentence as follow (Line 153- 154).

CF was placed in the negative direction of the second axis and SR was placed in the negative direction of the both of first and second axis (Fig. 2).

6. Line 186 Does “Gr” mean “TGr” in Figure 4? Unify the abbreviation. Moreover, didn’t you exclude the topographical gradient from the analysis?

Response: As requested, I modified from TGr to CS (Line 189).

7. “4.1 Difference in drought runoff coefficient between areas” In this section, you analyzed the difference of runoff coefficient by focusing on the snowfall and rainfall pattern. You mentioned Group A corresponds to heavy snow area and Group C corresponds to southwest Japan. However, the relationship between these regional characteristics and 11 controlling factors is unclear. It seems that rainfall or snowfall pattern determine the drought runoff coefficient regardless of 11 controlling factors, but the heavy snow area concentrates in the second and third quadrats where is characterized by low ratios of urban area and plutonic rock as well as high ratios of mixed coniferous-broadleaved forest. Explain the relationship carefully.

Response: In this study, I used the indicator of drought runoff coefficient which was calculated from dividing the total river runoff by total rainfall in each area. However, the drought runoff coefficient was calculated based on the year unit, therefore, the difference tendency of drought runoff coefficient of occurrence probability among groups was caused by the seasonal rainfall pattern with different time scale. Based on your comment, we added the discussion of rainfall pattern as follows (Line 201-206).

In this study, I used the indicator of drought runoff coefficient which was calculated from

dividing the total river runoff by total rainfall in each area. Whereas, the drought runoff coefficient was calculated based on the year unit, therefore, the difference tendency of drought runoff coefficient of occurrence probability among groups was thought to be partly caused by the seasonal rainfall pattern with different time scale. However, it is obvious that the watershed factors have strong influence on the drought runoff coefficient because the characteristic of watershed indicator differs for each classification from the result of NMDS.

8. Line 211 “Group C was composed of watersheds with a high ratio of sedimentary rock (Fig-ure 4).” How about Group A? It may be related to my comment in line 151, but Group A seems to be composed of watersheds with a high ratio of sedimentary rock in Figure 4.

Response: As requested, I added the discussion of comparison with group A as follows (Line 222-224).

Group A is also an area with a large proportion of sedimentary rocks, but it is thought that the difference in geological age and the influence of rainfall patterns are dominant, resulting in a difference in drought outflow rate from Group C.

9. Line 235 “Mushiake et al. (1981) used the average drought value based on a relatively short-term period.” How do you think the average value on a short-term period differs from your values? Introduce the reason why their result is opposite to your result.

Response: In accordance with your suggestions, I added the cause of the difference from the results of Mushiake et al. (1981) as follows. (Line 250-253)

In the steep mountain rivers with a small watershed area, rainfall flows out in a short period, and the ratio of surface and intermediate runoff to drought discharge is thought to be larger. In addition, the influence of local deep percolation in bedrock cracks seem to be remarkable in small watershed. Therefore, a certain degree of basin area is

necessary to evaluate the effect of geological factor to drought runoff coefficient.

10. Line 239 “Therefore, it is necessary for one to consider both geology type and geological age as indicators” Geological age of sedimentary rock and the difference between quanternary and old volcanic rock are the important factor as Mushiake or Yokoo and Oki showed before. But I do not know the study which addressed the geological age of granite. Explain your hypothesis how the geological age affects the runoff process.

Response: As requested, I added the hypothesis of the relationship between the geological age and runoff process. (Line 256-258)

Different geological ages differ in the degree of consolidation and result in the difference of degree of deep percolation. Further, as diagenesis progress, water exchange between aquifer and river less likely to occur. Therefore, geological ages is one of the important factor to characterize the drought runoff coefficient.

ãČżTechnical corrections 1. Figure 2 “CR” in the legend is considered to be “CF”

Response: As you pointed, I modified the legend (Figure 2).

2. Figure 4 & Table 2 Abbreviation of the Roundness is “Ro” in Figure 4 and is “RO” in Table 2. Unify the abbreviation.

Response: As you pointed, I unified the abbreviation as RO (Line 550).

3. Line 191 “FR and CLR : : : were not selected” What is CLR? Isn’t it Ro (RO)?

Response: As you pointed, I modified to RO (Line 194).

Please also note the supplement to this comment:
https://www.hydrol-earth-syst-sci-discuss.net/hess-2019-330/hess-2019-330-AC1-supplement.pdf

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