Spatiotemporal Evaluation of Vertical Dynamics Propagation of Flash Drought and Driving Mechanisms in the Indus Basin in South Asia (1970-2023)

Tahira Khurshid[1], Qiongfang Li[1,2], Chuanhao Wu[2], Akif Rahim[3], Muhammad Shafeeque[4,5,6], Shanshui Yuan[2], Zia Ul Hassan[7], Junliang Jin[2,8,9]

RC2 comments' response:

1) Vertical Dynamics Propagation: The manuscript claims to investigate vertical dynamics propagation of flash drought. However, the current analysis merely compares the frequency and severity of flash drought events across different soil layers. There is no clear assessment of e.g. time-lag relationships or cross-layer dependencies that would explain vertical propagation.

   Response

   Thank you for your valuable comments. In this study, the vertical flash drought propagation process is represented by the downward movement of drying conditions through soil layers. Specifically, moisture deficits in the upper layer during an FD event induce deficits in the middle layer, leading to FD occurrence at that depth. We identified two types of the events i.e., simultaneous ('t') and subsequent ('t+1'), based on the criteria mentioned in section 2.4 (see L187-190). 't' events signify the quicker response of middle layer to upper layer, while in case of 't+1' events, middle layer response was observed at the difference of 1-timestep (i.e., 8-days).

   Following your comments, we will include an analysis of the soil drying relationship between the upper and middle layers to explain the vertical propagation and discuss the underlying mechanisms of vertical flash drought propagation in the revised MS.

2) Limited study domain: The study is limited to the Indus Basin, which limits the generalizability of the findings. While this area provides valuable context, the broader applicability of the results remains unclear. Given that the study used GLDAS, a global dataset, the authors could easily extend their approach across a wider spatial domain.

   Response

   Thank you for your valuable comments. The Indus Basin has a wide range of climate types, with a humid- semi humid climate in the north and a semi-arid to arid climate in the south. Moreover, - this region is one of the most frequent flash drought prone areas in the world (Christian et al., 2021). Therefore, the Indus Basin is a representative area for studying the spatiotemporal evolution of flash drought, which can provide valuable scientific insights for other similar climate regions.

   We fully agree with you that extending the study to a wider spatial domain can better demonstrate the broader applicability of the results. This prompts us to strive to collect more soil moisture data in future research and expand the study to continental or global scales to explore the vertical propagation mechanisms of flash drought under a wider range of climate types and different underlying surface characteristics. Following your comments, we will add more

explanations for choosing the Indus Basin as the research area for flash drought research in the revised MS.

3) Lack of Original Interpretation in the Discussion: The discussion is mostly revised on summarizing previous studies, with limited attention to the novel contributions of this work. The authors should highlight how their findings confirm/contrast, or advance the existing knowledge.

Response

Thank you for your valuable comments. Following your suggestions, we will enhance our discussion section to highlight how our findings confirm or advance the existing knowledge in the field by focusing on the underlying mechanisms of vertical flash drought propagation and the discrepancy in the characteristics of flash drought across different soil layers.

References:

Christian, J. I., Basara, J. B., Hunt, E. D., Otkin, J. A., Furtado, J. C., Mishra, V., ... & Randall, R. M. (2021). Global distribution, trends, and drivers of flash drought occurrence. Nature communications, 12(1), 6330.