Review comments

Peng et al.'s manuscript provides a valuable estimate of global potential evapotranspiration (PET) and forms the basis for developing the SPEI index. The authors incorporate more realistic vegetation characteristics, such as Leaf Area Index (LAI) and conductance, to enhance PET estimation. However, some sections of the manuscript, particularly the structure and descriptions, could benefit from further clarity. The novel aspects of the PET calculation method should be more distinctly highlighted or enhanced.

1. A more detailed description of the "two-source model" in Section 3.3 would be beneficial. The manuscript does not clearly articulate the relationship between this model, Equation (13), and the improved vegetation characteristics described in Section 3.2. The statement "We adopt the same parameterizations detailed in Zhou et al. (2006)" is too vague. It would be valuable to elaborate on how these parameter improvements are integrated into your PET method.
2. The manuscript estimates PET over 1981–2017. This timeframe should be explicitly mentioned in Sections 2 and 3, such as "PET is estimated over 1981–2017 using [specific methodology]."
3. Clarify whether PET calculations are based on monthly or daily scale meteorological inputs. The application of land surface ancillary data in your equations, such as the usage of "black-sky and white-sky albedo," is not clearly explained. For instance, how is albedo factored into the net radiation calculations in your equations?
4. On L121, you mention obtaining "canopy height data from a global tree height dataset at 1-km for 2005 using spaceborne lidar." It seems not clear how this dataset is used in your study? You also state that "As canopy height and frictional velocity are rarely measured continuously for each grid, we use a simple look-up table approach to provide roughness parameters." These statements seem contradictory and need clarification.
5. Section 3.1 lists different PET methods, most of which are derived from the Penman equation. Including the derivation process in the supplementary material and schematic figures illustrating the differences between these methods (e.g., big leaf models vs. two-

source models) would enhance understanding. This suggestion is optional if it's difficult to implement.

6. In Section 3.3.3, clarify the role of Gstmax in previous PET methods or equations mentioned earlier.
7. While many surface vegetation characteristics are included to improve PET estimations, some easily accessible characteristics are not utilized. Global canopy vegetation height data (https://www.nature.com/articles/s41559-023-02206-6), which could be employed in Ga estimation, is now available. Other datasets like the 1k datasets (https://essd.copernicus.org/preprints/essd-2023-242/) may also be valuable for your study.
8. A recent study "Sun, S., Bi, Z., Xiao, J., et al." (2023) considers comprehensive parameters for improved PET estimation. If detailed consideration of vegetation characteristics is a novelty of your study, please explicitly explain its advantages compared to this study. Alternatively, if your focus is more on comparing different PET methods with limited vegetation considerations, clarify this in your introduction and discussion.
9. Compare your PET estimations with reference datasets, such as Sun et al. (2023).
10. Appendix A contains important information leading to the results in Section 5.1. Mentioning this in your method sections would prevent sudden introduction of these comparisons in the results. Some sentences around L280 could be moved to the method section.
11. Move Figure A1 to the results section. The results section should feature PET estimations before transitioning to SPEI comparisons (starting in Figure 2).
12. Incorporate multiple soil moisture datasets in your comparison to account for the significant uncertainties among different soil moisture data.
13. On L329, introduce the full name 'LC-Kelliher' before its abbreviation. LC is "land cover" as detailed in the table of Figure 3. Please check the manuscript for any potential similar issues.
14. On L61, provide examples of "conventional PET methods" versus non-conventional methods for clearer understanding. Regarding the statement "The vegetation control on transpiration is often neglected," comment on the impact of plant hydraulics on potential transpiration estimation, referencing relevant studies (e.g., https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018MS001500).