General comment

This study explores the estimation of random error variance in four gridded precipitation datasets sourced from various natural sources using the triangulation method called the Four Cornered Hat (4CH). The investigation focuses on Europe (over the intersection coverage of the precipitation products) and analyses the error variance patterns across different datasets. However, the overall outcome of the study is somewhat modest, resembling more of an experimental report rather than a comprehensive scientific paper. One notable concern is the ambiguity regarding whether the variant of the 3CH, the 4CH, represents an innovative aspect of this study. Furthermore, the introduction of the framework and methodology is brief and suffer from a lack of clarity, and the evaluation of the estimated variances is missing. In my assessment, the paper falls short of the standard expected by the Journal of HESS and would benefit significantly from a major revision. Below, I have listed my comments, which I believe will contribute to the preparation of an improved version of the manuscript.

Major comments

1) The model error hypothesis within the framework of the 3CH should be introduced more effectively. Specifically, the estimation of random error variance assumes additive noise εA (along with some unquantifiable bias bA) in the estimate A concerning the truth t:
$A = t + bA + \varepsilon A$,

While this may seem self-evident, it's worth noting that this is not always the case, especially considering the further extension of triangulation techniques, such as Triple Collocation, where uncertainty estimation is developed for multiplicative error (Alemohammad et al., 2015). I believe this section would benefit from a clear introduction of the formalism utilized by the 3CH, including the notion and notation of the truth t, the estimates A, B, C, and D, as well as their respective errors, before presenting Equation 1.

-Alemohammad, S. H., McColl, K. A., Konings, A. G., Entekhabi, D., and Stoffelen, A.: Characterization of precipitation product errors across the United States using multiplicative triple collocation, Hydrol. Earth Syst. Sci., 19, 3489–3503, https://doi.org/10.5194/hess-19-3489-2015, 2015.

2) From my review, it remains unclear whether the variant 4CH introduced in the submitted manuscript represents a novelty.
a) If indeed it is a novel contribution, it is imperative to underscore this aspect within the manuscript. This could be achieved by delineating the limitations of the 3CH in the methods section, thereby emphasizing the innovation brought forth by the 4CH. Additionally, the title and abstract should be modified to highlight this advancement compared to existing state-of-the-art techniques. It's noteworthy to mention that extensions beyond three datasets have previously been explored within the framework of Triple Collocation (Pan et al., 2015; Gruber et al., 2016; Vogelzang, 2021). Therefore, the authors should reference these prior works while describing the 4CH approach.

b) If the variant 4CH has already been documented in the literature, this information must be explicitly stated, and the relevant references should be cited.

-Gruber, A., Su, C.-H., Crow, W. T., Zwieback, S., Dorigo, W. A., & Wagner, W. (2016a). Estimating error cross-correlations in soil moisture data sets using extended collocation analysis. Journal of Geophysical Research: Atmospheres, 121, 1208–1219. https://doi.org/10.1002/2015JD024027
-Pan, M., Fisher, C. K., Chaney, N. W., Zhan, W., Crow, W. T., Aires, F., et al. (2015). Triple collocation: Beyond three estimates and separation of structural/non-structural errors. Remote Sensing of Environment, 171, 299–310. https://doi.org/10.1016/j.rse.2015.10.028
-Vogelzang, J., & Stoffelen, A. (2021). Quadruple collocation analysis of in-situ, scatterometer, and NWP winds. Journal of Geophysical Research: Oceans, 126, e2021JC017189. https://doi.org/10.1029/2021JC017189

3) The error covariance estimate (as illustrated in Figure A.2) should be incorporated into the main text of the article and deeper analyzed. For example, comparing it with the variance estimates (figure 2) could demonstrate to what extent neglecting these quantities in 3CH methods is accurate. Since these covariance estimates are among the primary outputs of the 4CH method, their inclusion and examination could significantly enhance the understanding and interpretation of the study's findings.

4) 3CH and 4CH method could be compared at least in the appendix or in the main text.

5) The study lacks in terms of evaluation. While I understand that the triangulation technique assumes the unavailability of ground truth, there are strategies that could be employed. For instance, using some gauge stations (not interpolated) from dense networks (over France and Germany) :
a) The author could analyze the impact of adding another dataset (e.g., EOBS) in the estimation of uncertainties (error variance), comparing results from Figure A3 and Figure 2. This comparative analysis would provide valuable insights into the effectiveness of incorporating additional datasets within the 4CH framework.
b) The author could evaluate the error variance pattern of EOBS with respect to the gauge density to investigate how its error variance is link to the interpolation itself.

Such an evaluation, albeit limited, would enhance the robustness of the proposed analysis.

6) In Figure 5, the quality issues observed for the OPERA dataset, as seen previously in Figure 2, almost disappeared in the winter/summer stratification. The author suggests that a plausible explanation for this phenomenon is the presence of outliers that are only present on certain days of April or October (therefore excluded in both composites), which exert a strong influence on the overall result. I recommend that the author thoroughly investigate this point and, if necessary, consider filtering out these outliers before estimating the error variance.

7) In Figures 4, 5, and A3, the gray area representing negative variance for one dataset should be masked for all the other three datasets in the figures. Furthermore, this discrepancy should be thoroughly discussed in the text as it underscores potential shortcomings in the 4CH approach.

Other comments

)Title: The title should introduce the notion of "variant 4CH" rather than the classical 3CH.

2)In the article structure, Section 3.3 Method could be separated from Section 3.1 Data to balance the length of each section.

3) Notation used in different equations should be harmonized.

4)Figures 2, 5, A2, and A3 show the boundaries of Europe and Africa outside the frame of the figures when the PDF is read locally.

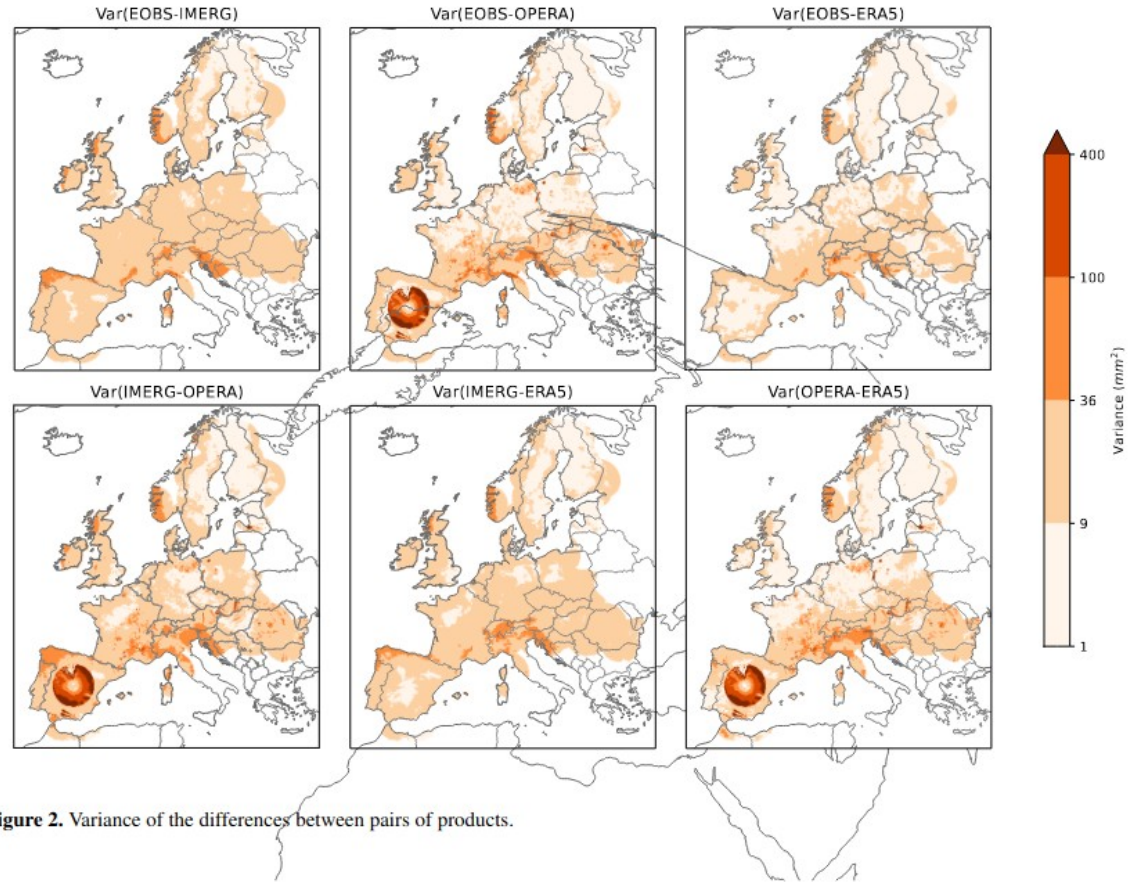

Figure 2. Variance of the differences between pairs of products.

6) L112: “In particular, the OPERA radar data has been interpolated from a finer grid using a conservative interpolation”. Please add the interpolation scheme that has been used here?