First, we would like to thank the reviewers for having carefully read the paper and provided valuable comments which helped us to improve the quality of the manuscript. We have taken into consideration all the comments raised by the reviewers and changed the manuscript accordingly. The details of our changes are highlighted in the main text. The point-by-point answers to Reviewers #1 and #2 are provided in the following and highlighted in red.

RC1:'Comment on hess-2023-214', Anonymous Referee #1, 09 Oct 2023

General Comments

The authors tackle an important topic, namely how to best combine gauge and satellite precipitation estimates for applications. The hydrological validation they pursue is a reasonable way of testing how the various input datasets perform, and this is clearly the strong point of the manuscript. As such, the existing examples and conclusions related to hydrology seem solid.

The other big point of the manuscript, as the title makes clear, is the combination scheme that employs CA interpolation, but here the manuscript falls short. I would expect a step-by-step demonstration that all the extra mathematical complication produces precipitation fields that are physically meaningful and more consistent with the input fields than some simpler scheme. I would consider it mandatory to address this issue.

The manuscript has been revised. A new figure 4 is added to show the physical consistency of the combination scheme that employs CA.

The English is not ready for publication; I have commented on a few word choices that I found confusing or that might escape a general technical editor, but not otherwise. Other issues needing attention are listed below.

If accepted for publication, we will make use of the English editing service of the journal.

Specific Comments

1. ***CA and regularly gridded data:*** *It is not clear to me how CA handles the regularly gridded data. Does it assign each satellite gridbox value to the finer gridbox closest to that satellite gridbox's center? Conventionally, gridded data give you an average value across the entire box, so if you just assign that value to the box's center, doing an interpolation and then averaging that field back to the original resolution will not give you the right average, in general.*

We Thank the reviewer for her/his comment. The technique implemented does not pose any constraint on the final interpolated field (i.e., averaging the output field back to the original resolution will not likely give the initial average value exactly). Indeed, what we did is to redistribute spatially the rain information from multiple sources, namely, rain gauges and satellite retrievals. For the former, the measured precipitation is assigned to the closest grid point in our destination grid and then interpolated over the neighbourhood grid points using Cressman inverse distance interpolator with a ray of influence, for example, of 5 km. From the satellite standpoint, the rainfall values in each Field Of View (FOV) of the satellite are first assigned to the respective FOV center. Secondly, each FOV center is assigned to the closest grind point in the destination grid as done for the rain gauges. Thirdly, each satellite rainfall value thus obtained is interpolated with Cressman inverse distance with a ray of influence equal to the native FOV size. So doing, the areal information from the satellite is spatially redistributed with the inverse distance criteria. Although this can sound a little bit arbitrary because we do not really know how precipitation is distributed within each satellite FOV, the methodology that we implemented has the advantage to treat both rain gauges and satellites equally in terms of the processing applied. In addition, the approach proposed follows a source hierarchy, for MODULAR approach, which means that rain gauges are interpolated first and then the satellite comes into play for gap filling only, and in the NOMODULAR approach, both satellite and rain gauge data are interpolated simultaneously at each time step. Eventually, the Cellular Automa has the role to make the final reconstructed rainfall field spatially consistent. Note that the goal of the manuscript is not to propose a new multi-source merging strategy, but instead to demonstrate how the use of multiple sources can improve the hydrological output.

For a more in-depth description of the technique, in Coppola et al 2007 you find different examples of applying Modular approach sequences with two and three modules where the rain sources utilized in each module are detailed.

Specifically, locally convex-up areas will be underestimated (particularly sharp peaks), concave-up areas will be overestimated, and the boundary of the precipitating region will spread somewhat into the non-raining area. I consider discussion of these issues to be mandatory.

Certainly, locally convex-up areas will be underestimated (particularly sharp peaks), concave-up areas will be overestimated, and the boundary of the precipitating region will spread somewhat into the non-raining area. However, our results indicates that the distribution of input precipitation field with smoothed peaks and minima but with a more homogeneous spread, improves the estimate of the flow discharge and peak timing in the hydrological model output.

2. *What is the model grid spacing:* Section 4.3 seems closest to stating this, but I missed seeing a declarative statement giving the specific value of the grid spacing. If you're really down at "hundreds of meters", it needs to be made clear that the effective resolution of the precipitation data is back at 5, 10, or more km. Finer than that is just

more and more precisely defining smooth variations between the available value locations.

A detailed comment has been inserted on lines L290-293. The hydrological spatial resolution is approximately 900 m, the same as used for the rainfall field. The approach was explained in the previous comment.

3. *Example interpolated precipitation fields:* Given the emphasis on the innovative combination of data sources, I would expect to see a sequence of maps illustrating the process and improvement versus simpler "traditional" schemes. This should happen first, before pointing to the accumulated precipitation in Fig. 5 and the aggregate hydrological results in Fig. 6 (for example). This aspect of the manuscript is where the issues in item 1 need to be addressed.

   Thanks for this tip, this is a great idea for future work. Note that the priority of this study is to demonstrate how the use of combined data improves the hydrological model's output. Probably, this can be achieved even using "traditional" data merging schemes. This is the reason why comparisons with other assimilation techniques are not implemented. Figures ~~5~~6 and ~~6~~7 are useful to demonstrate that the different data sources give different rainfall fields to the point of improving or worsening the results of the hydrological simulation.

4. *Boundary bias:* This phrase comes up several times, but it was never quite defined as to what boundary was being discussed. It is stated that data outside the basin is used, which presumably should solve a problem at the basin boundary. Perhaps the problem is along the southwest side of the basin, where no additional gauges are shown in Fig. 1. The statement in L.417-418 should appear a lot sooner in the text and be more explicit about how this works.

   In general, boundary bias denotes a systematic error or distortion occurring in data or models near the periphery of a study area or dataset. This bias often arises due to differing conditions or factors at the edges of the study area compared to its interior. The presence of boundary bias can impact the accuracy and reliability of analyses and interpretations, underscoring the importance of acknowledging and addressing this bias when working with spatial data or models to ensure more precise and meaningful outcomes.

   In the specific context of this study, boundary bias manifests as a discontinuity associated with the absence of observed data beyond the confines of the basin. To mitigate this potential issue, whenever feasible, all available data across the entire domain is utilized. Nevertheless, a discontinuity persists since no observed data beyond the Italian border are accessible. This aspect will be further discussed later in the paper.

   To further elucidate this concept, the following sentence was incorporated into lines L229-234: "Furthermore, a strategy used by the work to avoid boundary effects is to extend the spatial domain well beyond the studied basin: this strategy is useful for a better reconstruction of the precipitation field (Figure 1). Many data used, although redundant, lead to a better reconstruction of the rain field. A smaller amount of this data would probably be enough, but the work uses everything that the national rain gauge network has available. Future studies could lead to identifying, given their distribution, enough rain gauges outside the basin deemed useful to overcome the boundary effect."

5. *Fig. 1: I question whether all those gauges outside the basin are really useful and therefore worth depicting. I would suggest that as you move outside the boundary you can stop after you pass about 3 gauges (which of course varies with coverage). Was it really not possible to obtain gauge data to the southwest of the basin? This introduces the boundary effects the manuscript discusses (right?).*

   The aim of this work is to demonstrate how to validate an operational chain for civil protection monitoring and forecast purposes. The rain gauge network that was used is the official national one. Using all the data at our disposal, beyond a defined number (3 or 4) outside the basin for example, helps the model to better distribute the rainfall field, it is certainly not a limit, but rather an added value. A possible future work could be to estimate the optimal number of rain gauges, based on their distribution.

   So, the idea is to use all the rain gauge data available for a possible operational activity, which does not include those outside the national border. These limitations help our validation: despite the many critical issues the model seems to respond very well.

6. *Fig. 7 caption:* The statements after the first sentence are interpretation and belong in the text.
   The sentence has been deleted.

Technical Corrections

1. *L.180, 720:* "O" is actually that author's last name; "Sungmin" is her first name. Done. Thanks for your suggestions.
2. *Nine occurrences:* "IMERG" is mis-stated as "IMERGE". Done. Thanks for your suggestions.
3. *L.52:* Not sure "captative" is the right word. Done. Thanks for your suggestions.
4. *L.88-89:* Awkward phrasing, including that "peculiarity" is probably something like "availability". Done. Thanks for your suggestions.
5. *L.168 and 3 other locations:* I'm not sure what "rain bandwidth" means.

Shi et al. (2020): “any region has an effective influence (ERI) radius for any rainfall event, which reflects the influence of a rain bandwidth, and such an EIR is not larger than a certain distance”. The reference to L269 is wrong.

6. *L.186:* Should this be “...that are usually not instrumented.”? Done. Thanks for your suggestions.
7. *L.193:* Fig. 2 refers to a “workflow”, not “rationale”, which seems better. Done. Thanks for your suggestions.
8. *L.193:* Fig. 2 says three tasks, not four. Done. Thanks for your suggestions.
9. *L.202*: Unclear phrasing; are you saying something like “the model is not calibrated specifically for this study’s cases”? The reviewer is right; this sentence is misleading. It was meant that the model was calibrated in past studies on the Po basin of which the Tanaro River is a tributary (Coppola et al 2014) and not for this study. To avoid confusion, it has been deleted from the text.
10. *L.428:* I think “intuitive” could better be “subjective”. Done. Now Line 446
11. *Fig. 1:* a) What are the blue lines? b) The hydrometers are nearly invisible; maybe they should be plotted in white? Done. The description of the blue lines has been added in the caption. The figure has been replaced.
12. *Fig. 2 caption:* The phrasing is awkward, perhaps something like “... workflow, consisting of three main tasks:” Done. Thanks for your suggestions.
13. *Fig. 3*: The mostly-dark colors make it really hard to distinguish the basin and gauge coverages. I’d say the Google Earth background and the basin’s blue need to be much lighter. Done. A new figure is available.