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Comment on essd-2022-248

Anonymous Referee #3

Referee comment on "IT-SNOW: a snow reanalysis for Italy blending modeling, in situ data, and satellite observations (2010–2021)" by Francesco Avanzi et al., Earth Syst. Sci. Data Discuss., https://doi.org/10.5194/essd-2022-248-RC3, 2022

Review of "IT-SNOW: a snow reanalysis for Italy blending modeling, in-situ data, and satellite observations (2010-2021)". Avanzi et al.

This article presents a reanalysis of the snowpack conditions over the italian territory between 2011 and 2021. It uses a spatially distributed snowpack model (S3M) forced with gridded in-situ observations from automatic weather stations (AWS) and radar. The simulated snow depth is corrected by the assimilation of snow depth measured at AWS gridded thanks to a multilinear regression model and adjusted by satellite-based snow cover maps. The uncertainty of the reanalysis is estimated with Sentinel-1 derived snow depth (C-SNOW) and in-situ snow depth and SWE measurements.

This high-quality reanalysis will sure be useful for many applications. The article is well-written and seems comprehensive, covering most aspects of this work. The methods and results are well presented. I believe that the following points should be addressed by the authors before publication. Below are smaller suggestions and details to help improve the article.

1. The figures need improvement, especially figures 2 and 3. Each map needs a title. The axes should be labeled, a scale added. The colorbar choice often does not allow a clear reading of the maps. The colorbar legend is often too small and with too few labels. See detailed comments on each figure below.

2. Some data and methods information seems missing. I could not find which digital elevation model is used (what source, what resolution) or if the land cover is taken into account. It would be good to mention if the interaction between the snowpack and the vegetation, such as the forests, are considered.

3. Other reanalysis over the swiss, the austrian and the french Alps (Fiddes et al., 2019, Olefs et al., 2020, Vernay et al., 2021) are mentionned. Although the methods are largely different in each work, it would be interesting to compare the uncertainty of these works.

Minor comments and suggestions

L2 "+" disturbing notation. I suggest using "over", ">" or just give the exact value. To be homogeneized in the text.

L9 "no mean bias" rather than "none"? (L421 as well)

L14 If ever the variability of the peak SWE date is available, it could be interesting to provide it.

L25 "(Serreze et al., 1999; Skiles et al., 2018)" you might want to cite Li et al. (2017) in which the contribution of the snowpack to the runoff is indeed calculated. It seems like Serreze et al. (1999) only compared the solid precipitation amount to the total runoff and Skiles et al. (2018) cites Bardsley et al. (2013) for the 80% number.

How much runoff originates as snow in the western United States, and how will that change in the future? Dongyue Li, Melissa L. Wrzesien, Michael Durand, Jennifer Adam, Dennis P. Lettenmaier. GRL. 2017, https://doi.org/10.1002/2017GL073551

L38 "**l**idar" in Deems et al. (2013), "Lidar measurement of snow depth : a review". To correct everywhere.

L38 "**airborne** lidar"? otherwise the list mixes methods (lidar, optic) and plateform (drone, satellite).

L47 and further in the text: what is a "dynamic model"?

L67 GlobSnow: maybe worth to mention that it is not available in mountain areas?

L91. A bit confusing with S3M, S3M Italy and IT-SNOW. Maybe add "**the reanalysis** IT-SNOW"

L100 "**" => I was disturbed by this notation without letters. Maybe use "hh" instead?

L100 Maybe precise the period covered by the inputs: is it only of the last hour?

L108 RMSE of 1 mm, please provide the typical precipitation observed.

L112 "spatialized" at what resolution?

L115 It would be very useful to provide the distribution of the temperature lapse-rate, even if supplement in necessary. This study from Navaro-Serrano et al. (2018) might help if you need to compare your temperature lapse-rate to similar regions.

Navarro-Serrano, F, López-Moreno, JI, Azorin-Molina, C, *et al.* Estimation of near-surface air temperature lapse rates over continental Spain and its mountain areas. *Int J Climatol*. 2018; 38: 3233– 3249. https://doi.org/10.1002/joc.5497

L118 I would suggest rewording along "A**n** unique estimate of the precision of these data

is not available as the type of sensor installed varies from one region to another. The installation and the maintenance of the sensors..."

L122 "remapped" quite vague. Cropped?

L124 "each region to tailor" unclear. What is the exact meaning of "region" here? What is tailoring S3M?

L128 "Sentinel**-**2"

L129 How do you manage the overlapping images? Putting on top the most recent?

L137. "Not shown". Could be added in supplement maybe?

L146 Please provide the number of snow depth sensor

L151 "remapped"? unclear.

L159. "For each time instant" not clear. Could be deleted.

L163 What happends if snow in SCA observation but not in S3M? "preserving" is a bit unclear, maybe use "leaving without snow..."?

L170 "**The** duration"?

L171 "1.3 h" give it in h and min.

L172 "AM" a.m.?

L184 Given the resolution, it seems like at least the last "57" can be dropped.

L194 Some precisions about C-SNOW product would be welcome. First, it is only available for dry snow, that is accumulation period, isn't it? Second, some part of Italy seems not covered by C-SNOW (grey area in Fig. 1 of Lievens et al., 2019). Finally, is C-SNOW completely independant from IT-SNOW? C-SNOW was calibrated on snow depth from AWS.

L211 "ASL" a.s.l.?

L232 Is it not possible to make it "3.2 Results" and then sub-sections (3.2.n) for the different data sources?

L235 how did you compute the RMSE? Between time-series at each pixel? Please write the MAD from Lievens et al. (2019).

L243 Please provide values for the bias. A table summing all the statistics evaluation would be really helpful.

L248 Then there is little information brought by the comparison of IT-SNOW density with station density since the density is derived from snow depth and SWE and snow depth and SWE are also compared to IT-SNOW.

L253 Please provide bias values.

L284 "102 **gauge** stations"?

L294 "Again**,..."**

L306 "evalution results"=> "**the** results"

L307-309 Cut this long sentence int two.

L313 "peripheral"? geographicaly peripheral? The Alps are on the periphery of Italy but

the station density is high...not clear.

L317 not clear if talking about the SCA of the Sentinel-2/MODIS product or from IT-SNOW.

L331-334 sentence is too long. To be cut.

L334 "apriori appear"? please rephrase.

L336 "Thus, quantifying this uncertainty in still elusive at this stage." I dont understand where this conclusion stems from.

L336: "in"=>is

L337 To move earlier in the description of the data or method.

L344 "basic science"? Please reformulate.

L348 I like the catchy quesions. However, "what is it doing?" is not so clear and it does not appear in the conclusion. Could it be deleted? I also suggest more detailed formulation "How much is accumulated in total? Where/how is it spatially distributed?"

L353 1**st**

L353 "(this finding is in agreement with a recent reconsideration of this conventional date, see Montoya et al., 2014)" get this sentence out of the brackets

L364 "anecdotal data" unclear if they are data from IT-SNOW or non-scientific data.

L366 "150+ cm of fresh snow in 24 hours" give the date of this event.

Figure 2. Provide title in the figure for each subplot, next to (a,b,c). Provide more values for the colorbar of b and c. In a, is there no station with several type of measurements? Or are they hidden because points overlapp?

Make b colorbar symetric so that 0° is linked to the yellow color. In b, keep the same precision (14,**8**//-16,**77**) and meaningful values (-10,0,10…).

In the legend: "by S3M Italy and thus the IT-SNOW reanalysis" => "by S3M Italy to produce IT-SNOW." Confusing otherwise.

Scale is missing as well as xlabel and ylabel.

If you find a way to make all subplots fits in only one line, it would make better use of the space.

Figure 3 See comments for Figure 2 that can be applied here. For b, why is there a transparent area without data which is not of the colour of the NaN provided in the legend.

Figure 4 This figure is much more readable. Add xlabel, ylabel to the maps and make sure color scale is symetric centered on 0. Improve the colorbar (see above).

Figure 5 Suggestion for future figures: b and c would be better plotted with a heat-map or at least some transparency of the points.

Figure 8 Make the color scale continuous, it is really hard to read the map otherwise.