Reply to Editor decision

Comments to the author:

Your revised manuscript was returned to Reviewers 1 and 3, who have now both recommended publication. There is one remaining to issue to address in Section 4.2.2: as noted by Reviewer 3, can you please consider comment regarding horizontal heat transport?

This is the final clarification, after which the manuscript will proceed to publication. Thanks very much for your contribution to The Cryosphere.

Dear editor:

We would like to appreciate the editor and all reviewers for their valuable suggestions and comments on the manuscript. These suggestions and comments have further improved the quality of the manuscript. We have carefully checked all the comments and all point-by-point responses are presented as follows. We have also carefully revised the manuscript based on these comments.

Best regards,

Wei Li and co-authors

Reply to Referee comment 1

Comments:

The manuscript is now much improved and the authors appropriately responded to all my comments. I have only one technical correction to point out. Line 220 of the revised manuscript with track-change: the wording "which pasts" is incorrect, please rephrase.

Reply: Thanks for the positive evaluations. Line 220 of the revised manuscript has been modified as: The + in the figure represents the outlier when calculating the metrics.

Reply to Referee comment 3

General comments:

The authors have responded to most of my questions in a satisfactory way and improved the text accordingly where needed, e.g. the "Methods and Data" Section. After the reading of the revised manuscript, I have only a few minor remarks left, which I'd encourage the authors to consider, in particular the one on the horizontal heat transport, before the paper is published.

Reply: Thanks for the positive evaluations and valuable comments on the manuscript. These comments have further improved the quality of the manuscript. All point-by-point responses are presented as follows and we have carefully revised the manuscript based on these comments. For clarity, all comments are given in the original version, while responses are marked in blue.

Specific comments:

Ln 119 – 129: Not sure what do you mean by "fishnet". Is it not simply a grid with same horizontal resolution of the reforecasts, allowing the conversion from a high resolution binary snow cover information to a low resolution fractional snow cover, as you have described later? Also ln 121-122 could be reworded, to make it clear that the goal of this post-processing steps is to convert a binary higher-resolution information to a lower resolution fractional information.

Reply: Thanks for the comments. Line 119-128 has been modified as: Since IMS snow data was assimilated in the twin analysis experiments, the performance of IMS snow data was evaluated. The IMS snow data used in this study was retrieved from the National Snow and Ice Data Centre (NSIDC) and has a resolution of 4 km. More details about this dataset can be found in https://nsidc.org/data/g02156. In this study, the high resolution binary IMS snow data was post-processed as following steps to get the lower resolution fractional IMS snow cover. Firstly, the raw IMS snow data was resampled to a resolution of 0.005° (1/100 of the resolution of the reforecasts) based on the nearest cell. Secondly, a grid with same horizontal resolution of the reforecasts was produced. In each cell of the grid, there were 10,000 pixels of the IMS snow data as the resolution of the IMS snow data after resampling was one-hundredth of that of the cell. The number of pixels which were covered by snow was counted and then divided by 10,000 to get the ratio of the snow-covered pixels in each cell. Finally, the ratios of the snow-covered pixels in every cell of the grid were calculated to obtain the IMS snow cover fraction with same horizontal resolution of the reforecasts.

Ln 171: It seems that "Fig. R5a" is not the correct figure caption?

Reply: Sorry for the mistake. The figure caption in Line 171 has been corrected as Fig. 3a.

Ln 273: Not sure which "aforementioned model excess in precipitation" studies the authors are referring to here. Maybe for a reader would be better the Section or studies to be explicitly mentioned. On precipitation biases (in reanalyses system), worth mentioning Orsolini et al. 2019.

Reply: Thanks for the comments. Line 272-274 has now been rewritten as: Moreover, the ensemble-mean precipitation of the two reforecasts is much more than GPM precipitation before June 25th, in line with the excess precipitation in reanalyses system and climate and forecast models which has been mentioned in Orsolini et al. (2019) and Su et al. (2013).

References:

Orsolini, Y., Wegmann, M., Dutra, E., Liu, B., Balsamo, G., Yang, K., de Rosnay, P., Zhu, C., Wang, W., Senan, R., and Arduini, G.: Evaluation of snow depth and snow cover over the Tibetan Plateau in global reanalyses using in situ and satellite remote sensing observations, The Cryosphere, 13, 2221-2239, https://doi.org/10.5194/tc-13-2221-2019, 2019.

Su, F., Duan, X., Chen, D., Hao, Z., and Cuo, L.: Evaluation of the Global Climate Models in the CMIP5 over the Tibetan Plateau, Journal of Climate, 26, 3187-3208, https://doi.org/10.1175/jcli-d-12-00321.1, 2013.

Section 4.2.2, ln 253 – 258: I am still not fully convinced about the horizontal heat transport argument as presented by the authors. Bottom row of Fig. 10, Spring panel, shows a quite localised temperature change where the snow DA is most active. If horizontal temperature advection plays a major role, I would have expected a more spatially extended signal, due to the horizontal transport of warmer air from nearby regions. Can just be a local signal in surface temperature, extending throughout the lower troposphere, triggering the convergence and therefore higher wind speed? Also, it might be obvious, but could the author better explain the following sentence "the increases in temperature are also consistent with the increases in wind, as the warmer air is advected with the wind" (ln. 256-257)?

Reply: Following the reviewer's comment, we have modified our interpretation of Fig. 10: the temperature change attributed to the effects of a more realistic, decreased snowpack after snow DA extends throughout the lower troposphere (as seen at 600hPa), implying convergence and ascent, and low pressure. This convergence is consistent with the increase in wind speed. We have modified or deleted relative descriptions throughout the manuscript, especially in Section 4.2.2, Discussions and Conclusions. Because of the modification, Line 256-257 mentioned by the reviewer have now been revised as: Hence, the local signal in surface temperature extends throughout the lower troposphere. The spatial differences in temperature at 600 hPa are similar with those in geopotential height at 600 hPa but reversed, i.e., the temperature increases when the geopotential height decreases. This increase in temperature implies convergence and ascent. The low pressure and convergence are consistent with the increase in horizontal wind speed (Fig 9).

Discussion and Conclusions: An important point that I think is worth mentioning and couldn't really find there is the feedback of the increased snowfall precipitation in the DA-experiment on temperatures. The increase in snowfall before June leads to an increase in snow depth both in the west and east TP (from fig.3). This can partly explain why the two reforecasts ~ converge in the average daily temperature time series after a month or so. If what I am describing is correct, improving the feedback of snow assimilation on precipitation seems crucial to get all the benefits of improved land-surface initial conditions.

Reply: Thanks for the comments. We have added relative discussions in Line 306-308: However, the snowfall of the DA reforecasts is larger than that of the control reforecasts for the ETP and around the boundary of the WTP and ETP in the southern TP, leading to an increase in the time series of snow depth in spring both in the WTP and ETP for the DA experiment, in Line 320-321: The two reforecasts converge in the average daily temperature time series after a month or so, possibly resulting from the additional snowfall and cooling in the DA reforecasts, and in Line 362-364 in Conclusions: Given its feedback on snowfall and snow depth, it appears important for the forecast models to capture the effect of land-atmosphere interaction upon precipitation to get all the benefits of improved land-surface initial conditions.