Answers to referee's report

First of all we would like to apologize for taking such a long time to reply to the referee's report; we wanted to be sure that we had addressed all the points in detail. We would also like to thank the referee very much for his/her thorough report, it helped us to identify a few issues with the article that we had missed.

We have addressed all the corrections/comments/suggestions made by the referee in their original report. Below we address these in the same order they were presented.

Major changes overall:

1. **Section 3.1**: The comparison of our photometry with that of APASS and Gaia was entirely re-done. An offset of ~0.015 mag was found for the (B-V) color.
2. **Section 5.1**: vdBH73 was replaced by vdBH85, which is a much more interesting cluster due to its old age
    - **Figs 4 & 5** (and all equivalent figures) were re-done.
3. **Sect 5.2**: NGC 4349 was re-processed
4. **Sect 5.3**: Ruprecht 87 was re-processed
5. **Sect 6**: we mention the effect that the offset found in the (B-V) color has on the estimated photometric distances.
6. **Appendix**: Ruprecht 85 and vdBH 87 were re-processed.

Major points (11)

1. Section 3.1, par.4

> "Table 4 shows the mean...": Your point is clear here, however the mean differences may mask some colour dependency on the magnitude, for example. A more accurate comparison would be to use APASS stars as standard stars and then compare the coefficients with those obtained from your own calibration. If you do not detect any systematics, only adding a sentence saying so would suffice.

The instrumental to standard system transformation was performed using a colour term as indicated in the set of equations shown in Sect 3.1. No colour dependence of higher order was found. We have added this clarification to the article.

2. Section 4

> "we should see an increase in the star density (not always true)": if this is a limitation of the method, I wonder how sure you can be to confirm that a candidate is indeed not a cluster. Please clarify.

This is not a limitation of the method. We are simply describing the basic features that usually indicate the possible existence of a cluster in a given stellar region. We have modified the previous sentence to make this fact more clear.

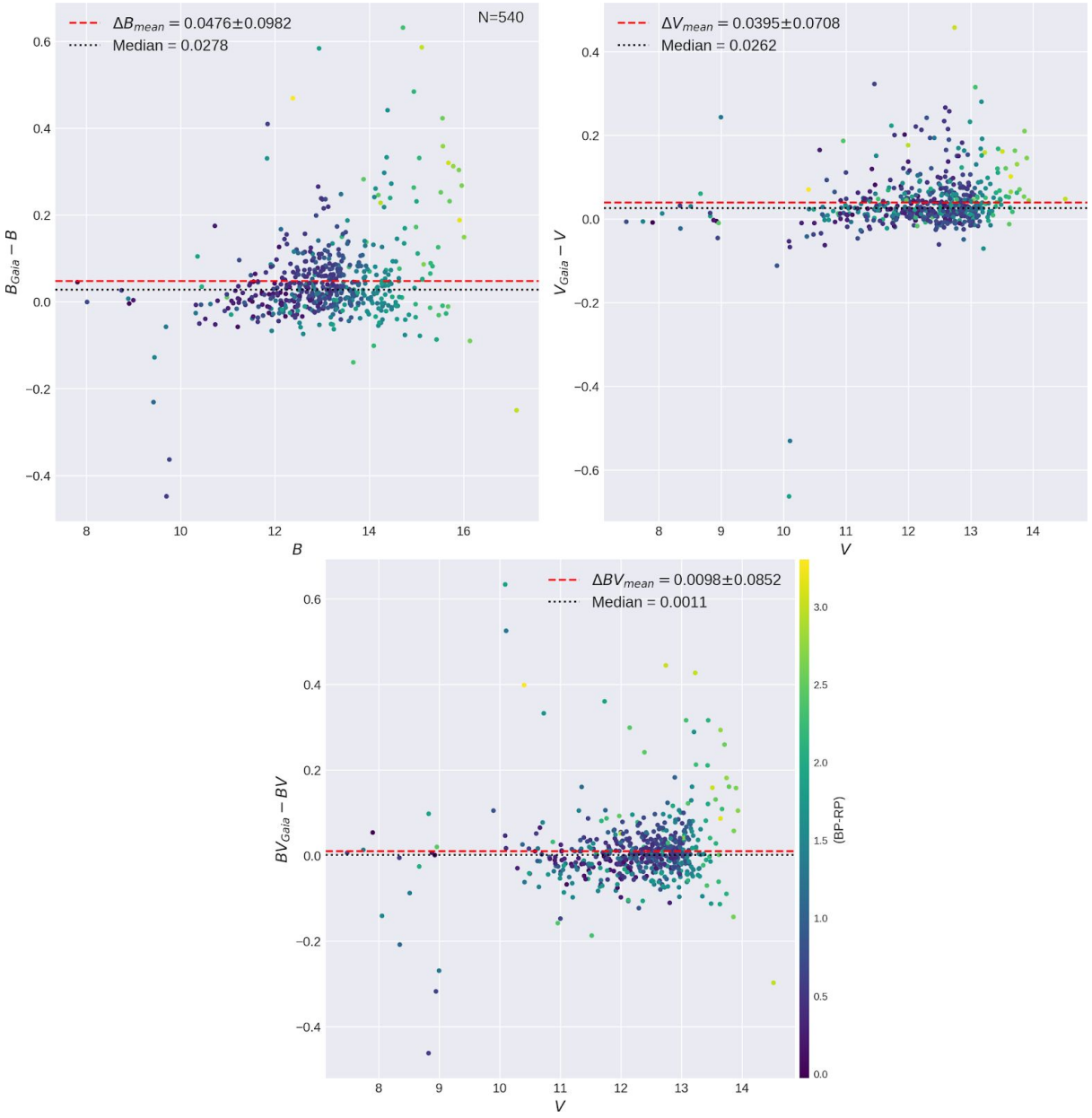
3. Fig.2

> "Right": There is a clear trend in this plot. The differences are very small, maybe of the order of your photometric uncertainties, but this needs to become clear. Otherwise you would need to check for a colour-dependence on the magnitude for example. This seems a detail, but in this paper you discuss systematics on distances obtained with Gaia and ground-based photometry, therefore I recommend verify this trend.

As stated in the first major point addressed above, there is no higher order color dependence on the magnitude. This fact notwithstanding, we carefully re-analyzed the comparison of our photometry with that of APASS DR10 and Gaia DR2. Because of this, a

large portion of Section 3.1 was re-written, Tables 4 & 5 were merged into Table 3 and re-processed to show values obtained applying the same process on both surveys, and Fig 2 was re-done entirely. We believe the comparison of our photometry with these two surveys is now more detailed and clearer. The small ~0.015 mag offset in (B-V) found is mentioned in Section 6 in relation to its effect on the estimated distance modulus.

We believe it is not necessary to include the figure showing the differences between APASS and Gaia (transformed) V, B and (B-V) in the article, so we show it below for the reviewer to see. Differences are in the sense (Gaia - APASS).



4. Section 4.2, par.9

> "The only information...": previously, when the Bayesian approach with 7 dimensions was mentioned, it gave the impression that parameters were set free (presumably with some prior, limiting intervals etc), although not explicitly said. Now, the description says that some parameters are kept fixed in order to determine others. Please discuss the impact on the final parameters, uncertainties and degeneracy if all 7 dimensions are kept free during the fit. If this was done in previous papers, then just a summary and references is fine.

There is a slight confusion here. The Bayesian analysis mentioned in the "second block" is used to assign membership probabilities to stars within the cluster region. This is a completely detached process from the fundamental parameters estimation, which occurs in the "third block". The analysis that takes place in this "second block" can be thought of a general clustering algorithm, where data dimensions (i.e.: photometry, parallax, and proper motions) are used to estimate the probability of each element (star) of belonging to the hypothesized cluster (that one is assuming exists in that region). There are no parameters (fixed or not) involved in this process whatsoever, beyond the single “parameter” of membership probability.
We have modified this section because it contained the description of one of our first runs of the code were we used N=7, not the one finally used here with N=3.

5. Section 5.0, par.2

> footnote 12: vdBH85, RUP85 seems to have a round-ish shape and a reasonable radial density profile. I understand this statement for some clusters, but it is defintely not a general case. Please remove it and leave the discussion to the case by case subsections.

Footnote was removed

6. Section 5.0, par.2

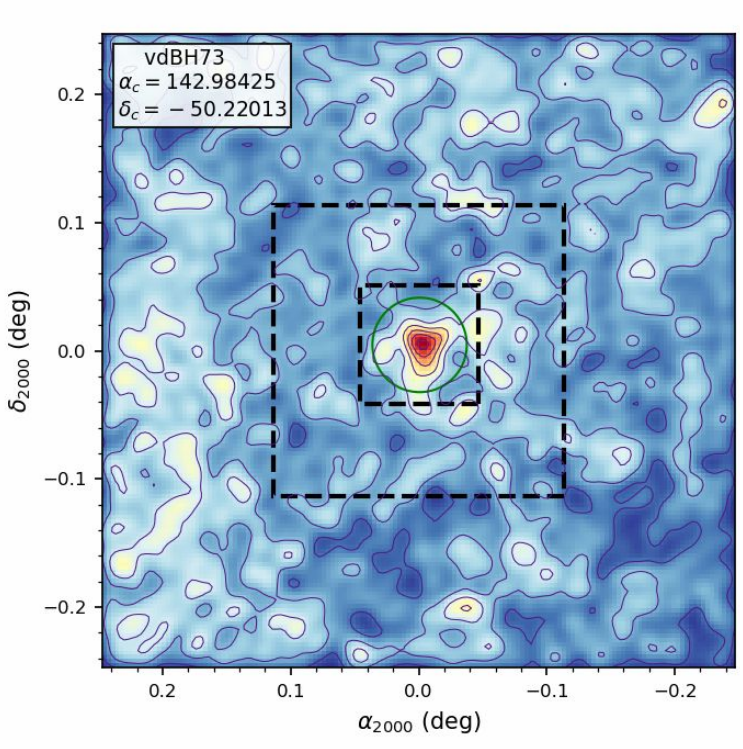
> "show as well the isochrone curves": do you generate isochrones for the exact age and metallicity final values? Or you choose a pre-selected isochrone with approximate values? If the latter, then the age and metallicity differences between the final results and the displayed isochrone will affect the visualisation. Please clarify.

ASteCA employs theoretical isochrones taken from the CMD service, as stated in the article. A grid of [z, log(age)] values is generated from these isochrones with as much resolution as possible. From these fixed values the code then generates new ones (through weighted averaging) corresponding to the exact [z, log(age)] values requested by the genetic algorithm during the maximum likelihood process. Thus, the isochrones displayed correspond to the actual maximum likelihood [z, log(age)] values found for the analyzed cluster. Details were added to Sect 4.2 and 5 to make this more clear.

7. Fig.5

> "estimate the field star properties": Stars outside the larger black square have densities ranging from less than 20 to about 70 stars/arcmin2. Your final estimate for the field density was 16 stars/arcmin2. Please explain how you found this very low value. It does not seem to represent the field density. Also: I find it at least suspicious that the borders of the image have the lowest background. It happens in all cases, for large and compact clusters. I wonder if this is vignetting from the observations or some other artifact not considered. Please verify this and comment on the paper.

The referee is correct, there is a clear inconsistency in these images. This arose from an incorrect px to deg conversion at the time of producing the plots that does not affect the analysis (since radii are manually fixed in pixel space). These, and all the structural analysis images, were re-done and replaced.
About the borders: this is simply a mathematical artifact (namely: infinite support) of the kernel density estimator (KDE) used to plot the density maps. If we lower the bandwidth value of the KDE and increase the grid where it is evaluated this effect tends to disappear, at the cost of the noise in the image increasing considerably, as shown below:



The only two clusters with actual density artifacts in their frames are NGC 4349 and Lynga 15, due to the combination of observations made with two telescopes (as explained in Sect 3). We have added comments about this in their respective sections.

8. Fig.5

> "star number per square min": right panel shows the RDP from 80 stars/arcmin2 down to 16 within 5arcmin. But the left panels shows that the large square has about 11x11 arcmin2 and a minimum density of 35 stars/arcmin2. It does not make sense. Please explain and correct.

All these images were re-done and replaced.

9. Fig.9

> again, as in Fig.5, left and right panels are not consistent with each other. The smaller square on the left panel has 7.5x7.5 arcmin size and the lowest density of about 30 stars/arcmin. In the right panel the density drops from 40 to 20 in less than 2 arcmin. Please correct in all figures and revise all analysis.

All these images were re-done and replaced.

10. Fig.10

> well-defined CMD and CCDs. However, there is a 93% probable star at Gmag ~10.3mag and some main-sequence turnoff stars that are not fitted by the isochrone. I wonder if a slightly younger isochrone would be a better fit. Please revise this analysis.

It is important to remind the referee that the code does not fit isochrones, these are only drawn to give a general idea of where the "best fit" is located. The actual fit involves synthetic clusters which contain much more information than a simple isochrone: binarity, error dispersion, photometric incompleteness, mass distribution. This information can not be conveyed by an isochrone, which is why we point out in the article that isochrones should be regarded only as a way to guide the eye.

It is also important to notice that a single or a few stars with large membership probabilities can eventually be seen scattered in the CMD, but this does not mean that they are **without a doubt** members of the cluster. The membership assigning algorithm is a statistical process and as such is prone to mislabel a few elements.

The above notwithstanding in the case of NGC 4349 the referee is correct in suggesting the possibility of a younger fit to the cluster. We realized that the lower portion of the sequence (low mass stars) was interfering with a younger age (and slightly smaller distance) fit. We thus removed the section below G=18 mag in the cluster's sequence and re-processed the cluster. The result now shows a younger age and distance fit. This new distance is smaller by ~200 pc, which makes it more similar to Gaia's parallax distance estimate (which was also run again, given the new cluster sequence processed, see 39. Fig 11).

11. Section 6

> this whole analysis assumes that the photometric distances are accurate. However, as pointed out before in the analysis of the three selected sample clusters, the extinction and isochrone fitting could be improved. Therefore it seems that the photometric distances may (or may not) suffer from biases in the analysis. As a consequence, this analysis could not be used as a reference to define the parallax offset to Gaia results. Although the values agree with previous studies, this is not an argument to prove the quality of the photometric analysis. I strongly recommend revise the analysis with the specifics detailed before.

We have addressed the issues raised by the referee regarding the extinction and "isochrone fitting" (which is actually a synthetic cluster fitting) in detail. They can be summarized as follows:

- The extinction issue was raised in relation to the vdBH 73 cluster. In this case we explained that the (U-B) vs (B-V) diagram (the one that showed the disagreement in the extinction fit) was not used in the analysis, and instead the (B-V) vs (V-I) diagram is now displayed which shows a much better agreement (see 32. Fig.6).
- The "isochrone fitting" issue was raised initially in regards to NGC 4349 in 10. Fig. 10. We re-processed this cluster removing the section of low mass stars (which was disrupting the fit) and found indeed a younger age fit.
- For RUP 87 the referee also questioned the fit because it did not follow the sequence of stars with larger membership probability values. This is a complicated case because of the low number of members associated to this purported cluster. We run the analysis again, taking care to clean the photometric diagram of the cluster region as much as possible without resorting to hand-picking stars (which would bias the process). Even though the fit changed, we are still inclined to label this as a non-cluster given the sum of evidence collected throughout the analysis.

The photometric distances may indeed suffer from a small bias due to the offset in the (B-V) color compared to the transformed Gaia photometry, mentioned in 3. Fig 2. We have taken this offset into account in the analysis, and we now explicitly mention the effect it has on the final photometric distances (and their relation with Gaia distances) in Sect. 6 of the new manuscript. We have also re-processed two clusters (RUP 85 and vdBH 87) that showed slightly off fits.

Minor points (52)

1. Abstract, results

> "young and therefor potential arm tracers": this is highlighted as a good result. Nevertheless, it would be good to connect the results with the aims presented at the beginning of the abstract and hightlight other relevant results.

Done as suggested.

2. Introduction, par.3

> "combining UBVI" --> "combining ground-based UBVI"
> "space based astrometry" --> "space-based astrometry"

Fixed both points.

3. Introduction, par.4

> "absolute coordinates" --> "equatorial coordinates" (change it everywhere it appears in the paper)

Fixed.

4. Section 2

> please explain how these clusters were selected to be analysed here. There are many clusters in this quadrant, do these 16 clusters represent the quadrant somehow, or are they just a subsample?

Done.

5. Section 3, par.1

> YALO: define acronym

Fixed.

6. Section 3, par.4

> "All observations were made under air mass ranges from 1.08 to 1.092 for U, 1.072 for B and 1.077 to 1.164 for V and I."

This information is now included in Table 2.

7. Table 1

> "are indicated using the usual vdBH abbreviation." --> "are indicated by vdBH." --> This information could be moved and completed to Tables 2 and 3 for all clusters and observations.

Fixed the first correction. We comment abbreviations here because this is the first time they appear in the article.

> According to the A&A style, the position of the legend should be on the top of tables, instead of below as in the case of figures. Please check all tables.

Fixed all tables.

> "Note: van den Bergh-Hagen clusters": although it is well-known, please write the full reference, presumably van den Bergh & Hagen (1975, vdBH). Same for the other acronym definitions. Same for the other clusters and acronyms.

Added the references.

8. Table 2-3

> Tables 2 and 3 could be merged. There is repeated information about exposure times that could be summarized. YALO was also at CTIO. Suggestion: one (or more) line per cluster following Table 1, with columns: Date, airmass, DIMM seeing (or image quality), filters, exposure times.

Tables 2 and 3 were merged into Table 2 and the suggested format is now used.

9. Section 3.1, par.2

> after the equation the sentece starting with "where" should be preceded by "\noindent" latex command

Fixed.

> sentence starting with "In each case detector..." should be a new paragraph, as the topic is WCS calibration and astrometry. Please provide more details on this step: was there any distortion correction? What is the precision of the match? This information is useful to endorse your results based on the match between your data and that from Gaia.

Information on the cross-match process was added.

10. Section 3.1, par.3

> "All-Sky Survey2)." --> "All-Sky Survey2), that has a magnitude limit of XXX, enough to identify the XXX [upper RGB?] stars in our sample clusters."

Fixed.

> "are for the most part very faint." --> "are mostly very faint."

Fixed.

11. Section 3.1, par.5

> "our photometry" --> "our photometry with that from Gaia DR2"

Fixed.

> "display the median differences": Why table 4 shows the mean and table 5 the median? Please clarify your choices.

Table 3 and Table 4 were merged and they now display equivalent information in their columns.

12. Section 3.1, par.6

> "Coordinates should not be read from images.": Please clarify why not.

These images were re-done now showing coordinates in decimal degrees. The sentence was removed.

13. Fig.2

> Figures read well, but the colour bar between left and central panels may add some confusion. I suggest to move the colour bar to the right of the middle panel instead to make it clear that tha y-axis in both panels are exactly the same.

This figure was re-done entirely. Now, instead of showing the Gaia transformation for a single cluster, we show the differences between our V, B, and (B-V) and APASS DR10, and the transformed V, B, and (B-V) for Gaia DR2, for the **combined** set of clusters. We believe this gives a much clearer picture regarding the quality of our photometry and how it compares with other surveys.

14. Section 4.1, par.2

> "following the advice": please add a few words to mention the advice given.

Added.

> "the model for the cluster": please specify which type of model your are talking about: 3D spatial distribution? colour-magnitude diagram...?

The full model is now specified and described.

> the sentence "Our model marginalizes...decontaminated cluster region" is a bit confusing. Maybe because the definition of the model is missing above. Please consider rephrasing after defining what is the model.

The full model is now specified and described.

> "maximum likelihood estimate": please clarify how this is done and what is compared to obtain the likelihood for the prior.

Explained.

> "shown in a Plx vs G plot for each cluster in Sect 5." --> "be shown in Sect 5."

Fixed.

> "We also show": please add a reference to where this is shown. Presumably on Section 5? If so, please leave the details to Section 5 with the proper reference to the respective figures.

Removed sentence, it is now explained in detail in Section 5.

15. Section 4.1, par.3

> "are indicated": please add reference to where these results are indicated.

Fixed.

16. Section 4.2

> I agree it is important to provide a brief summary on the main points of ASteCA and refer the interested reader to the original papers for more details. Please highlight here any improvements or adaptation on the original code/paper to include more dimensions (e.g. N=7, rather than 4) on the analysis from Gaia (parallax, proper motions).

We have added a paragraph briefly commenting on these changes.

17. Section 4.2, par.3

> "square rings": It is not clear why a square was chosen instead of a circle. This could be the reason why you have outliers, they may come from the corners of the squares. Even though the details of ASteCA are in previous papers, this particular choice needs a sentence to justify.

The “square rings” were used as a method to easily handle the issue of calculating an area when the region reaches the borders of the frame. In this new version of the manuscript we have updated the algorithm to employ the usual “circular rings”, so this clarification is no longer needed. The sentence was changed accordingly.

> ", i.e.:" --> ", i.e.,"

Fixed.

18. Section 4.2, par.7

> isochrones shown: please add reference to where this is shown.

Reference added.

19. Section 4.2, par.8

> "the effects of star loss at large magnitudes": do you mean photometric incompleteness or actual low-mass runaway stars from the clusters? Presumably the former; please rephrase for clarification.

Clarified.

20. Section 4.2, par.10

> "was" --> "is"

Fixed.

> "finally compared to around ~2x10^7 synthetic clusters.": please clarify what this step means. Is a stochastic variation of star positions on the parameters space to derive uncertainties? Are you actually varying parameters from the initial isochrones...?

The maximum likelihood process is applied using a genetic algorithm, as explained in the manuscript. The bootstrap process uses the same algorithm applied on thousands of stochastic variations of the observed cluster, i.e., applying the standard “sample with replacement” method. These two processes use synthetic clusters that are compared (via the likelihood equation, in our case the Poisson rate as presented by Dolphin 2002) to the observed cluster. When we combine the number of synthetic clusters generated by both processes, we arrive at that number. More details have been included in the paragraph.

21. Section 5

> par 1, 4 are OK, but par 2, 3 are confusing to read before presenting the actual results. My suggestion is to dillute this detailed description (par 2,3) into Section 5.1 in the example of the first cluster, to be more objective.

Done as suggested.

22. Section 5, par 2

> "four figures": please add explicit reference to which figures you are referring to.

The sentence was removed as this paragraph is now diluted into Section 5.1 as requested.

> " "clean" color-color ": please remove quotes and be more speciifc on what you mean by clean CCD.

Fixed.

> "color-color diagram" --> "CCD"

Fixed

> "In these three panels": it is very confusing to imagine all these figures with this level of details without actually looking at the figures. Please add references to which specific figures you are describing here.

It is clearer now with the new text merged into Sect 5.1.

23. Section 5, par 3

> "is shown": please specify where this is shown.

Indicated.

> "fourth figure": please describe the so-called "fourth figure" in the same paragraph (either the previous or a new one, but avoid splitting the description).

Removed now that this paragraph is included in Section 5.1 as requested.

24. Section 5, par 4

> "of two extreme types of cluster" --> "of three extreme types of cluster"

Fixed.

25. Section 5.1, par 1

> the sentence "However, the inspection ... presence of a cluster there." is misleading. From fig.3 it is clear that there a significantly larger fraction of field stars. If the CMD and CCD are not decontaminated in any sense, naturally you will not see the tiny cluster there. Specially a relatively older cluster. Please rephrase.

Fixed.

> "larger magnitudes the CMDs strongly widen surely due to the presence of increasing visual absorption.": visual absorption does change with the magnitude of the stars... The wider colour distribution for fainter stars is due to photometric errors. Please correct the argument in this paragraph or simply erase it.

Fixed.
> "Even some blue stars": this sentence seems to pass the message of a surprise that blue stars are specially affected by reddening. I do not see why this is a surprise. Consider rephrase the sentence.

Rephrased.

26. Fig.4

> I do not see the point of this figure. The final fit is done with Gaia filters as presented in Fig.6. Showing the polluted CMD and CCD of all stars together without any further info and different filters does not add much to the paper (that already has too many figures). My suggestion is to show CCDs and CMDs that may contain the field stars as background dots and the cluster member stars as foreground points. And display only the combination of filters and colours used to fit the parameters discussed in the paper.

We believe that the photometric distribution of field stars in combination with the defined cluster region in these figures contains valuable information. We have updated all these figures such that they now show stars within the cluster region and the field region stars separately. They now also represent the same combination of filters and colours used to fit the parameters, as shown in Fig 6 (and remaining equivalent figures).

27. Fig.5

> "decimal format": Please be consistent: use the same units/format for RA, DEC in all your figures. Fig.3 displays RA in decimal hours, fig. 5 displays RA in decimal degrees, for example. Update all figures.

All figures now use decimal format.

> "color scale": please also add label in the plot.

Added label.

> "Right panel": what is the magnitude limit of the stars used to draw the RDP? This is important information as it directly affects the fitted parameters.

The maximum observed magnitude is always used, i.e., all the stars in the frame. Mentioned in Sect 4.2.

> "vertical black line": do you account for photometric incompleteness? It makes a lot of difference in the final structural parameters. Please comment about it in the paper.

We do not. We have addressed this in Sect 4.2.

28. Section 5.1, par 3

> "0.38": this is a very specific number. Usually people use a cut in 50%. Please clarify how this number was defined.

This value is not decided by us. It is a part of the automatic decontamination process, i.e., the removal of interlopers. We have added more details in the text.

> "well detached": please be consistent: this cluster was one of three examples selected because it was "poorly defined". Please correct and maybe reconsider the selection of this cluster as the "poorly defined" example.

Fixed.

> "low chance to be confused with the stellar field.": please be consistent: this cluster was listed on Sect.5 as "easy to confuse with the background"

Fixed.

29. Section 5.1, item b

> please provide uncertainties for distance. Fig.6 shows error bars, it is unclear why they are neglected here.

Fixed.

30. Section 5.1, second last par

> please provide uncertainties for Gaia distance.

Fixed.

> "Anderson-Darling test": please discuss the actual results from the test, for example, say explicitly the p-value in the text.

Fixed.

31. Section 5.1, last par

> please provide uncertainties for the age. Fig.6 shows error bars, it is unclear why they are neglected here.

Fixed.

32. Fig.6

> Please be consistent: on fig.5 you write B-V and there Bmag-Vmag. The same for other filters. Correct in all figures.

This issue is related to the latest set of isochrones from the CMD service, where a *'mag*' string was added to the names of all the filters in their respective columns. Since ASteCA takes the theoretical values for the filters from these files, that's how they are read and hence printed. We have corrected all figures removing this extra *'mag*'.

> "(B - V) vs (U - B)": the isochrone doe not fit well the points. Please verify the process. A wrong extinction directly affects the age, distance, metallicity determinations.

For this cluster as well as Ruprecht 88, including the (U-B) color resulted in not having enough stars in the photometric diagrams for its analysis to be of use. For these clusters we thus avoided the initial extinction estimation described in Sect 4.2 performed using the (U-B) color, and instead relied in the Schlafly & Finkbeiner (2011) ranges for the region.

We forgot to exchange the (U-B) vs (B-V) diagram for the (V-I) vs (B-V) diagram in these two cases, which we have now corrected. We apologize for the confusion.

> "color bar": add label to the color bar "memb. prob." or something to identify its meaning.

Label 'MP' was added to all the plots and commented in the caption.

> "Insert" --> "Inset"

Fixed.

33. Fig.7

> "see text": The text that refers to this Fig.7 is Sect.5.1, and it does not explain these fits. Please define them briefly here in the figure caption to ease the reading of the figure. Further discussions on the implications of the different fits can be left to the text.

These descriptions are now included in Section 5.1. Nevertheless, we have added a brief description in the caption too.

34. Section 5.2, par.1

> "Fig.8": same comment as in sect.5.1 for fig.4. NGC4349 is younger and therefore the upper main sequence stands-out, but it does not mean much in Fig.8 if there is no information on membership probability, or at least distance from the cluster center. Consider remove or merge fig.8 with fig.10. similarly for all clusters as suggested before.

Addressed in 26. Fig 4.

35. Section 5.2, par.2

> "(say above 0.8": avoid informal language writting.

Fixed.

36. Section 5.2, item a

> "one concludes that": if this conclusion is true, then you would see the cluster well detached from the background field stars in the CCD, but it does not seem to be the case. It could be the window used by S&F2011, or the fit. Please verify.

To see a cluster well detached from the background depends on many factors. The referee makes a probable reference to the presence of a dark or dense cloud behind the cluster in which case one can expect to see cluster stars framed in a more or less weak background. But the case of NGC 4349 is different since it is projected against a dense stellar field that shows similar photometric properties and, moreover, is a slightly old object easy to be confused with a stellar field dominated by stars later than A-types. Finally, S&F2011 values are the result of integrating absorbing material from the Sun to infinity.

37. Section 5.2, par. 3

> "marginally lower": please write down the Gaia distance explicitly. Avoid subjective comparisons.

Fixed.

38. Section 5.2, par. 5

> "around ~0.51x10^9 years old": please add uncertainties

Added.

> "reporting log(t) = 8:32 equivalent to ~ 0.21x10^9 yrs." --> "reporting log(t) = 8:32 equivalent to ~ 0.21x10^9 yrs."

No changes?

39. Fig.11

> the fits seem to be at lower Plx with respect to the distribution of redder points. Please check.

The Bayesian parallax distance estimation involves **all** the stars considered to be probable members within the cluster region, not just the ones with larger probabilities. Restricting this analysis to just a sub-group of stars with large probabilities would involve the (arbitrary) decision of where to make the “probability cut”, i.e., what minimum probability value to accept. This would introduce a new source of uncertainty, as different cuts would result in slightly different final distance values.

We thus include in the Bayesian parallax estimation all the stars that were previously considered to be probable members by the membership algorithm, and also used in the photometric analysis process by ASteCA. It is important to notice that this makes the final parallax distance estimation **directly comparable** to the photometric distance estimation, since both analysis are thus performed over the **exact same** set of stars.

Since the photometric analysis for this cluster was re-done with a cut on G=18 mag, we re-process this cluster’s parallax values using the same selection of stars. As can be seen in the new figure, the fit changes slightly from 2120 pc (original) to 2080 pc (new), a difference that is well within the estimated error of the fit.

40. Section 5.3, par. 1

> boring": avoid subjective adjectives.

Fixed.

> "respective color color magnitude resemble": correct and rephrase

Fixed.

41. Section 5.3, par. 2

> "obviously seen in Fig.13": ... and strong hints in figs. 14, 15 by eye looking at the redder points with higher membership probability. I wonder if this is an actual cluster and the code was not able to find it for some unknown reason for me. Please check again the analysis.

Please see the final comment in this point.

> "we decide to focus the attention in the region encircled by a green line.": it is unclear what it was done here. ASteCA did not look around the circle and squares defined in fig.13? Please clarify.

We meant to say that we decided to define the cluster region as the green circle, after not being able to find a clear overdensity in the density maps. The code indeed used the entire frame in the analysis. We have clarified this.

> "significant portion of those may also belong to the surrounding field.": true. Also true: a significant portion belongs to the cluster. Please rethink the analysis selecting the stars with a larger membership probability.

We have re-processed this cluster taking care in the selection of probable members to be analyzed. A very detailed description is now presented in Sect 5.3 of the new manuscript.

42. Fig.12

> same comments as for Fig.4 and all similar others.

Addressed in 26. Fig 4

43. Fig.14

> the isochrones are significantly off the redder point distribution. Does ASteCA consider the membership probability as weight to the fit? Please check.

ASteCA does take into account the probabilities during the fit: they are averaged and added as weights to each bin in the photometric diagrams. This has nonetheless only a marginal effect in the fit. In this particular case the fit is being disturbed by the large contamination in the diagrams, combined with the very low number of probable members.
Addressed in 41. Section 5.3, par. 2.

44. Fig.15

> the fitted Plx are significantly off the well defined sequence of redder points. Based on figs.3, 14, 15, it could be a low-mass older cluster, but the photometry is not deep enough to see it. Please check the analysis again.

The analysis of this cluster was re-done entirely and Sect 5.3 now includes all the modifications in detail.

45. Sect.6, par.2

> "~2195 pc vs. 2115 pc": please add uncertainties, the same presented as error bars in fig.16.

Added.

> "means that its sequence is not only": presumably main sequence?

Indeed. Fixed.

46. Sect.6, par.4

> the sentence "If we add to the parallax data ... worsens, as shown in Fig. 17." is redundant. Fig.16 and the obtained offset was 0.025. Therefore the previous paragraph together with Fig.16 are clear enough, no need to make another figure. Consider removing fig.17.

Fig 17 was removed. The comparison with the Lindegren bias was added to Fig 16 and the section was slightly re-arranged.

We also mention here the effect that the ~0.015 mag offset in our (B-V) color (compared to the Gaia photometry; mentioned in the point 3. Fig 2) has in the estimated photometric distances.

> "In the case of vdBH85 we use the individual distance estimates obtained in Bailer-Jones et al. (2018).": it is unclear why the analysis of Bailer-Jones was used. They basically perform a similar analysis as it is done here, but applying an offset of 0.029mas to the Gaia parallaxes. Here you perform this analysis and find an offset of 0.025mas. You may only reduce this paragraph to a sentence saying that using a similar analysis with a similar offset, Bailer-Jones found similar distances as you.

There is a slight confusion here. In the article we first apply a **Bayesian inference method** developed by Bailer-Jones in Luri et al. (2018), and then we use **data** estimated by the same author in Bailer-Jones et al. (2018).
The **Bayesian inference method** presented in Luri et al. (2018) estimates the distance to a stellar cluster, using the model shown in Eq. 3 as described in Section 4.1 This method combines the **parallaxes for all the stars considered to be probable members**, and returns a single cluster distance. For vdBH85 the method fails because its members are stars with very low magnitudes at a considerable distance (almost 5 Kpc). Hence its parallax values are affected by very large errors and the method fails.

Because of this, we turn to the **data** presented in Bailer-jones et al. (2018). Here the authors apply Bayesian inference to estimate **individual distances in parsec** for every single star in Gaia DR2, after affecting their parallaxes by the Lindegren et al. bias. We take this individual distances for the probable members of vdBH85, and approximate its distance through a simple weighted mean.

These are two very different processes. The first process combines the cluster members' parallaxes to derive a single parameter, i.e., the cluster's distance. The second method works on a per-star basis to transform single parallaxes to distances measured in parsec (which are affected by large uncertainties).

We have added a footnote warning the reader to not confuse these two processes.

47. Sect.6, par.5

> "The mean...": attach this paragraph to the end of the paragraph starting with "A number of..."

Fixed.

48. Sect.6, par.6

> the sentence "This analysis points to ... given by Lindegren et al." is redundant. It was already stated when first discussing fig.16. Consider removing.

This paragraph was shortened and it now serves as the opening statement to introduce the effect of the ~0.015 mag offset in the (B-V) color on our estimated distance moduli.

49. Sect. 7, par1

> "inconvenient": presumably inconvenience?

Indeed. Fixed.

50. Sect. 7, par3

> "billions" --> "billion years"

Fixed.

> "case of vdBH 85": if true, this result should be highlighted. It is very interesting finding to have an open cluster this old.

This is addressed in Section 5.1 now that vdBH73 was replaced by this cluster.

51. Fig.17

> this figure does not add much to the discussion. Fig.16 plus the discussion in the text is enough.

Fig 17 has been removed.

52. Fig.18

> draw also the Perseus arm as it was mentioned in Section 3, for reference.

Fixed.