Report

The Effect of *Gaia* Data Release 2 on the Asteroseismic Target List

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1 Introduction

Originally, the ATL was made with parallaxes from the TGAS catalogue. For a few bright stars with more precise values, parallaxes were instead taken from the XHIP catalogue. Where available, distances were taken from Astraatmadja & Bailer-Jones (2016). TGAS provided the most accurate source of parallaxes for the majority of stars in the ATL.

Recently, a new *Gaia* data release (DR2) has been made available (Lindegren et al., 2018). This promises to provide much more accurate parallaxes than TGAS, for a larger number of stars. In a similar way to Astraatmadja & Bailer-Jones (2016), distances for the DR2 stars have been inferred using Bayesian prior knowledge (Bailer-Jones et al., 2018).

The parallaxes and distances of the ATL stars were changed, and the differences between the target lists were compared. This report discusses those changes (Section 2) and reviews the effects (Section 3). Note that in both the old and new versions of the ATL, parallaxes from the XHIP catalogue have been included to keep the brightest stars in the list.

2 The Potential Consequences

Changing the sources of parallax and distance could affect the data in the following ways:

- Parallax is used to make rudimentary cuts to the catalogues used in the ATL. This removes stars with very uncertain parallaxes (fractional differences >0.5), or negative parallaxes (as these are unphysical). If the parallaxes are incorrect, stars could be cut from the ATL unnecessarily.

- Distance is used to calculate the amount of reddening to apply to magnitudes and colours.

- An incorrect reddening value will lead to incorrect apparent magnitudes. If the apparent magnitude of the stars is incorrect, the wrong amount of shot noise will be added to the signal of each star. This will alter the detection probabilities of the stars.

- The stellar luminosities are calculated with an equation that depends on distance. An incorrect distance will lead to an incorrect luminosity.

- The effective temperatures of the stars use a polynomial with (B-V). If this colour is incorrect (because of incorrect reddening values), the effective temperatures will also be.

- Stellar radius is calculated from the Steffan-Boltzmann law. This uses both luminosity and effective temperature. As discussed, incorrect parallaxes and distances have the potential to perturb both the luminosity and effective temperature. This in turn could lead to poor estimates of the luminosities.

- The global seismic parameter $\nu_{\max}$ is calculated using a scaling relation with both radius and effective temperature. If this is miscalculated, the predicted evolutionary state (and size of the solar-like oscillations) for the ATL stars will be wrong.

- These factors all contribute to the detection probabilities of the stars, P_{mix} .

3 Results for the stellar parameters

Two versions of the ATL were generated; one using TGAS and XHIP parallaxes, and one using DR2 and XHIP parallaxes. These two target lists were compared to each other. The results of the comparison have been shown as a function of the apparent I-band magnitude of the stars.

Figure 1 shows the parallax difference between DR2 and TGAS, for the stars at the top of the ATL (with ranks $< 25,000$). There is a spread of ∼2mas between the catalogues. DR2 measures smaller parallaxes for the majority of the stars, particularly the fainter targets in the ATL.

This spread has consequences for the inferred distances of these stars (Figure 2). The distances are from the Bailer-Jones et al. (2018), where distances are inferred using DR2 parallaxes. As expected, there is more of a discrepancy for fainter stars. For stars with apparent magnitudes of $\sim$ 10mag, there is a difference of up to 200pc.

These differences in distance will manifest themselves in several ways (as discussed in Section 2). One of the consequences of these different differences is in apparent magnitude (Figure 3). Distance

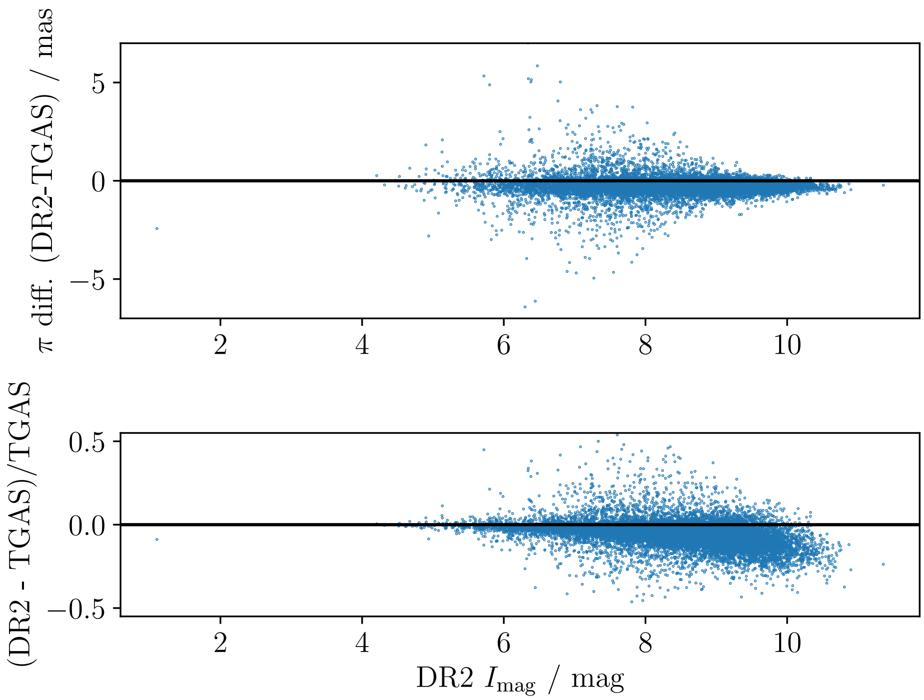

Figure 1: The parallax difference between the DR2 and TGAS catalogues, as a function of I_{mag} .

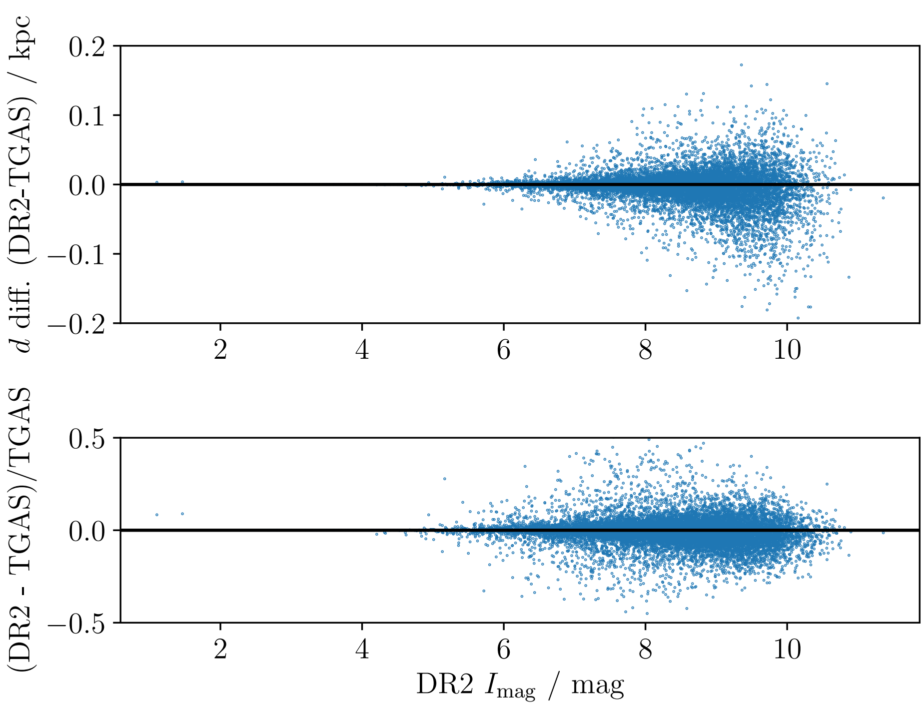

Figure 2: The inferred difference in distance between the DR2 and TGAS catalogues, as a function of I_{mag} .

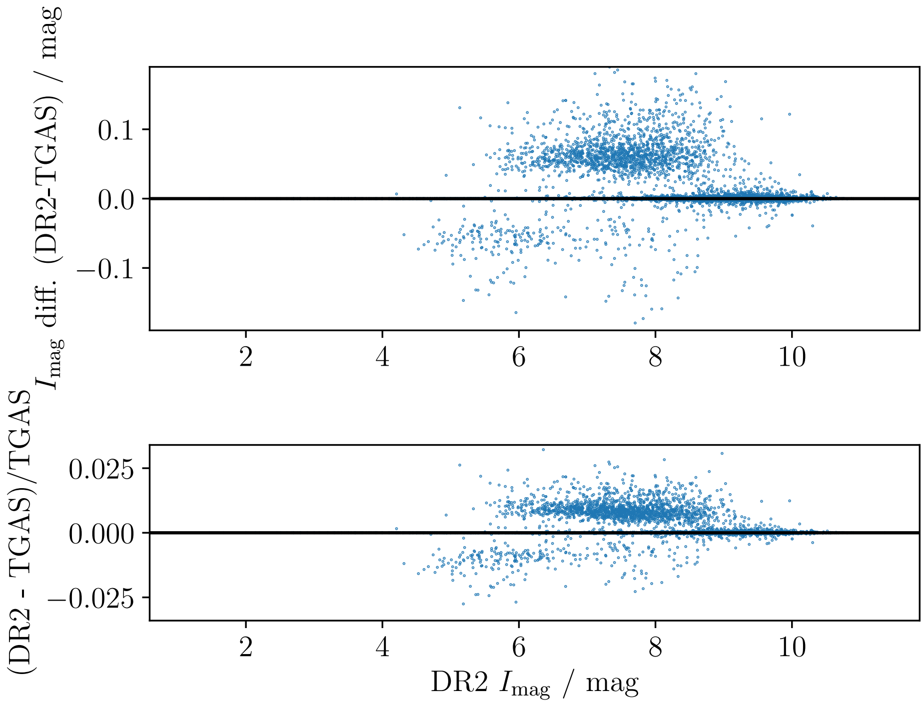

Figure 3: The $I_{\rm mag}$ difference in the ATL using the DR2 and TGAS catalogues, as a function of $I_{\rm mag}$.

affects I-band apparent magnitude through the extinction coefficient $A_{\rm I}$. This extinction has a very small effect on the apparent magnitudes (and therefore the calculated stellar shot noise levels of the stars).

The stellar distances are also used to calculate luminosities. Unlike with $I_{\rm mag}$, using a different source of distances has a large effect (Figure 4). When calculating $I_{\rm mag}$, distances were used indirectly (through an extinction coefficient). When calculating luminosity on the other hand, they are required directly. An incorrect luminosity will lead to misclassified stars; Subgiant Branch stars and Low-Luminosity Red Giant Branch stars could be treated as Main-Sequence stars (or visa versa) by mistake.

Effective temperature is another parameters (like $I_{\rm mag}$) than is only affected by the different sources of parallax and distance indirectly. Using DR2 parallaxes and distances leads to a relatively small difference in the calculated effective temperatures of the stars. In the same way as $I_{\rm mag}$, the effective temperatures in the ATL are slightly different depending on the source of distances. This is due to different extinction coefficients being used, which come from the different distances.

Once both stellar luminosity and effective temperature are calculated for the stars in the ATL,

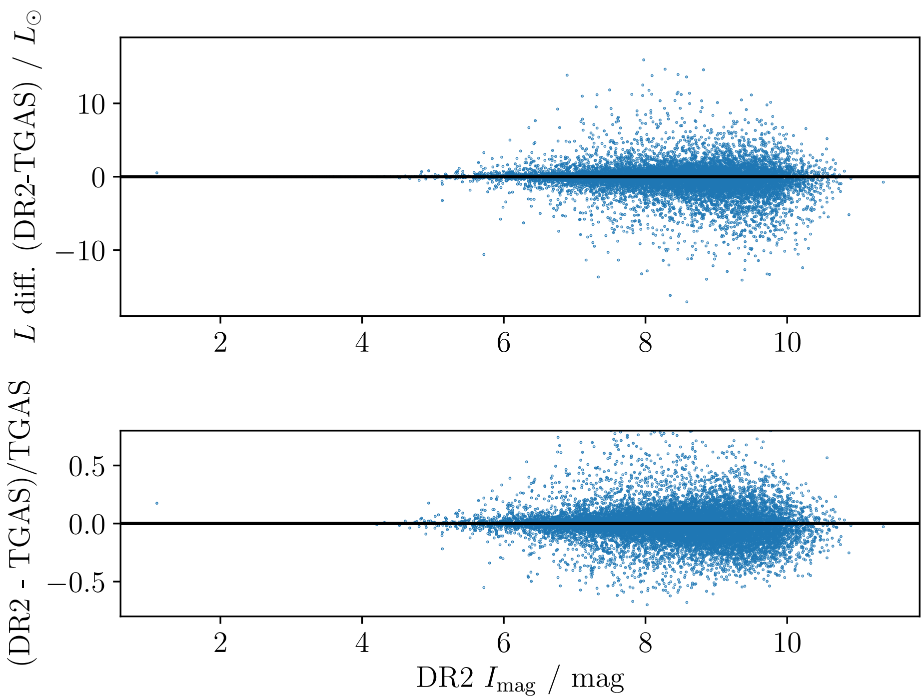

Figure 4: The luminosity difference in the ATL using the DR2 and TGAS catalogues, as a function of I_{mag} .

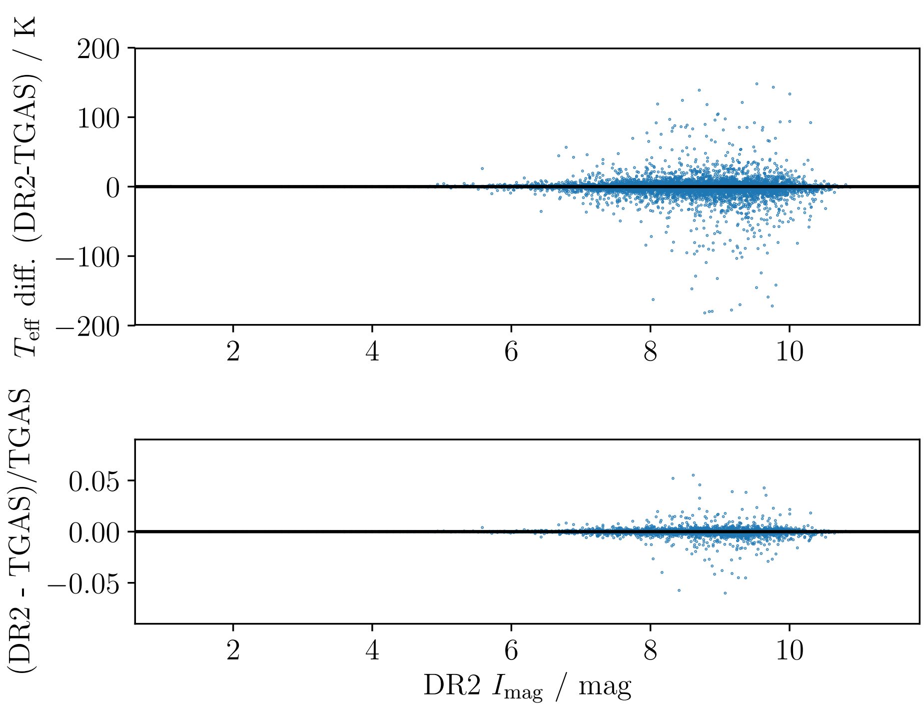

Figure 5: The T_{eff} difference in the ATL using the DR2 and TGAS catalogues, as a function of I_{mag} .

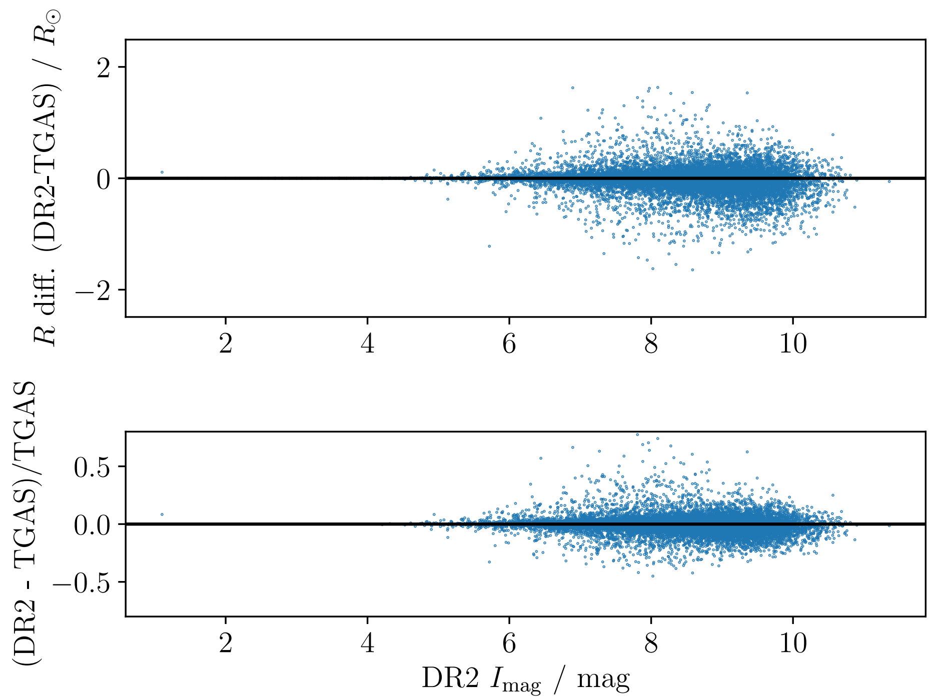

Figure 6: The radius difference in the ATL using the DR2 and TGAS catalogues, as a function of $I_{\rm mag}$.

radius follows from the Steffan-Boltzmann law. If the stellar luminosities and effective temperatures of the stars are different, the radii will also be (Figure 6). The difference in radii increases with $I_{\rm mag}$(as expected). This suggests that this difference in stellar radii is due to more accurate parallaxes (and inferred distances) using DR2, compared to TGAS.

4 The ATL with DR2 parallaxes and an updated mask size

Section 3 showed the change in stellar parameters that comes from using DR2 parallaxes and distances, rather than values from TGAS. Note that in both versions, the same XHIP parallaxes and distances were used alongside the *Gaia* stars. This Section shows the equivalent results on the probability of detection solar-like oscillations ($P_{\rm mix}$) and the ranks of the stars in the ATL.

When updating the target list with better parallaxes and distances, the pixel mask size was also changed. The mask size that is now used is the latest that was published on the TESS Wiki. For the stars fainter than ∼6mag, the new mask size is smaller than before. This will reduce the amount of shot noise in the observations of these stars, so the predicted detection probabilities will increase. This is shown as a function of $I_{\rm mag}$ (Figure 7).

There are a few stars brighter than ∼6mag in the ATL. They will now have larger pixel mask sizes

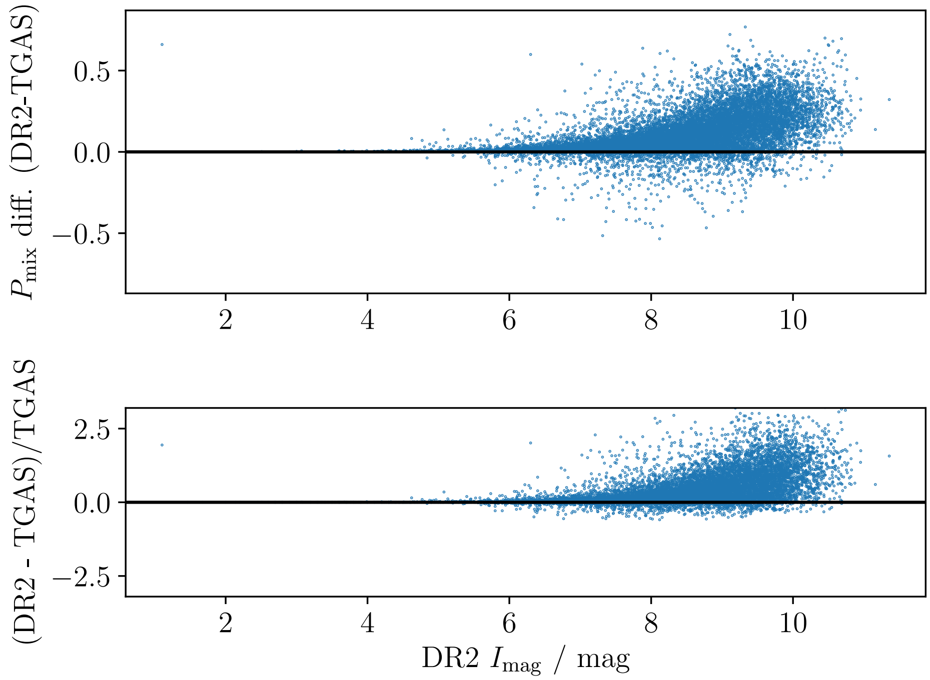

Figure 7: The $P_{\rm mix}$ difference between the ATL with DR2 parallaxes and an updated mask size, and the old ATL. Shown as a function of $I_{\rm mag}$.

(and higher shot noise levels). Since these stars are so bright, they already have very high Signal-to-Noise ratios. This means that their detection probabilities are already saturated at 1. Increasing the pixel mask size of these stars will not make any noticeable difference to their $P_{\rm mix}$ values.

The rank change to the ATL is more complicated. It is shown as a function of $I_{\rm mag}$ (Figure 8), and as a function of the ATL ranks (Figures 9 and 10). The plots show that bright stars are favoured more in the updated ATL than in the previous version.

Figure 11 shows 2000-star subplots of the ATL with updated parallaxes and pixel mask sizes. The highest-ranked 8000 stars of the new ATL (which are all guaranteed to be observed) contain a mixture of Main-Sequence, Red Giant Branch and hotter stars close to the δ-Scuti Instability strip. For comparison, Figure 12 shows subplots of the previous version of the ATL.

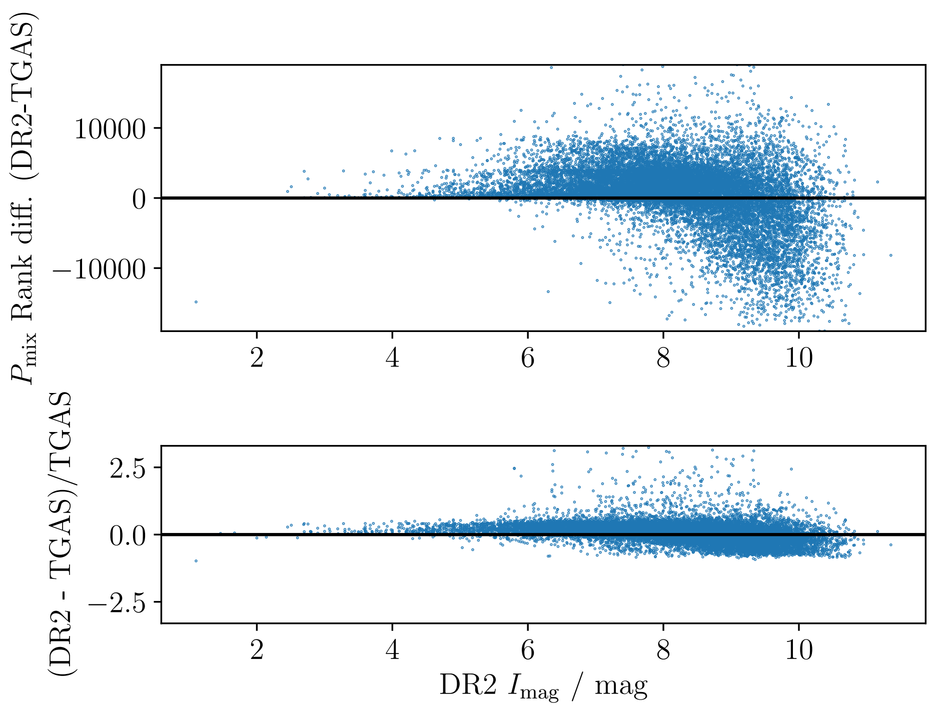

Figure 8: The rank difference between the ATL with DR2 parallaxes and an updated mask size, and the old ATL. Shown as a function of $I_{\rm mag}$.

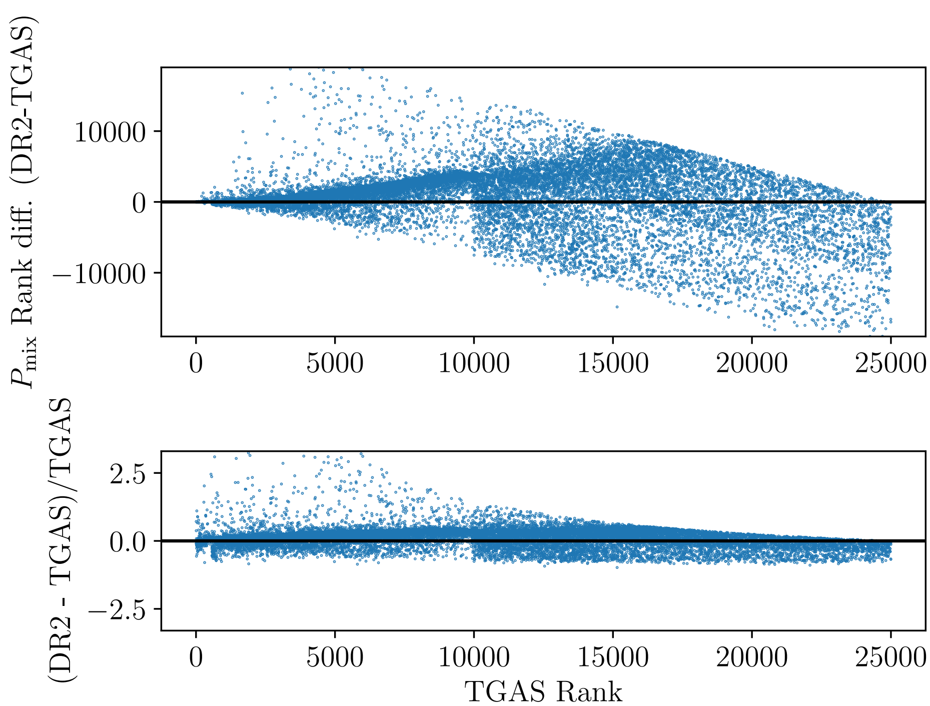

Figure 9: The rank difference between the ATL with DR2 parallaxes and updated mask size, and the old ATL. Shown as a function of the old $P_{\rm mix}$ rank.

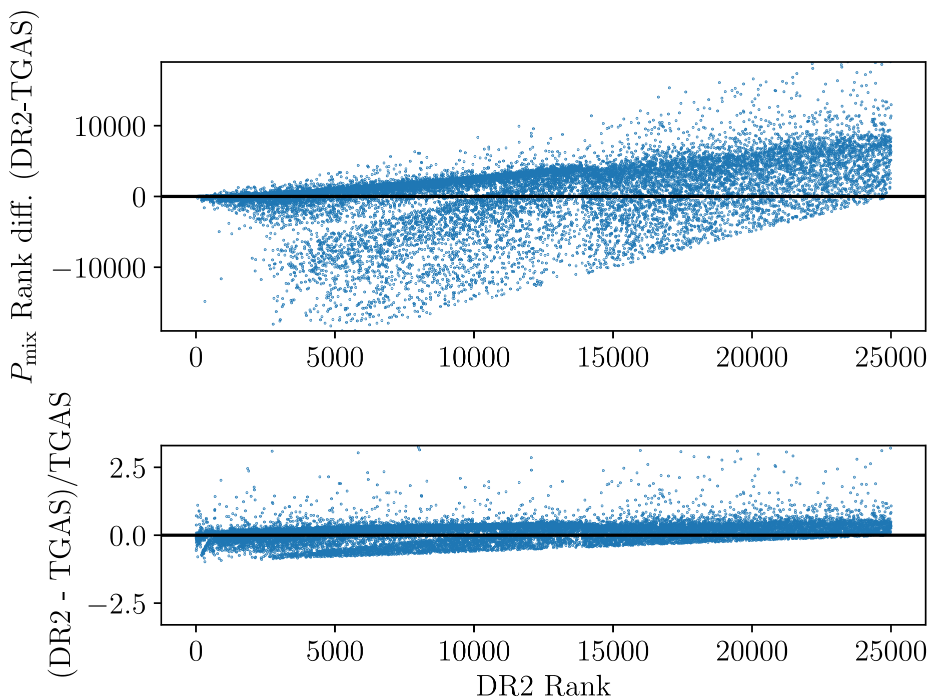

Figure 10: The rank difference between the ATL with DR2 parallaxes and updated mask size, and the old ATL. Shown as a function of the new $P_{\rm mix}$ rank.

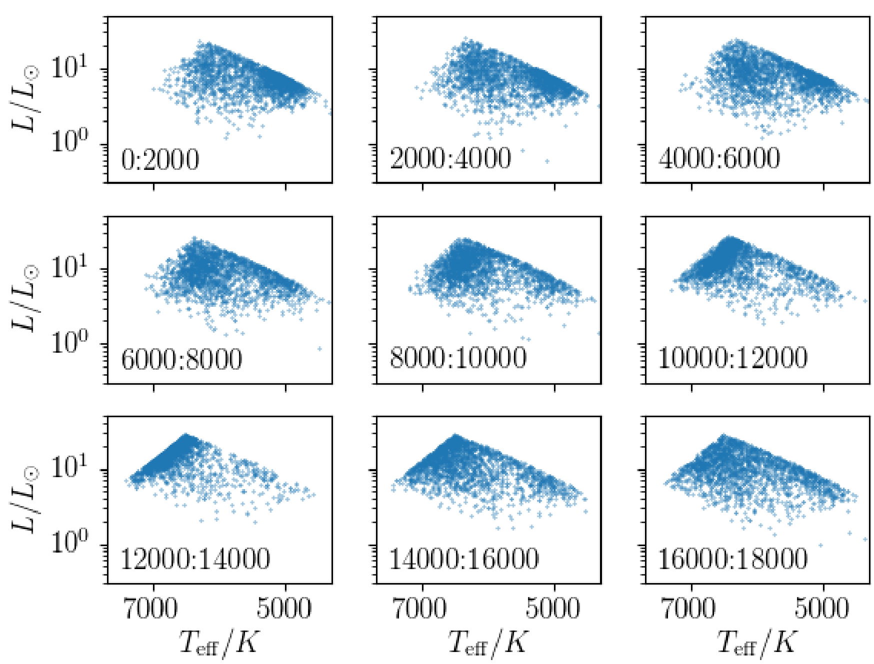

Figure 11: HR subplots of the ATL with DR2 parallaxes and distances, and an updated pixel mask size.

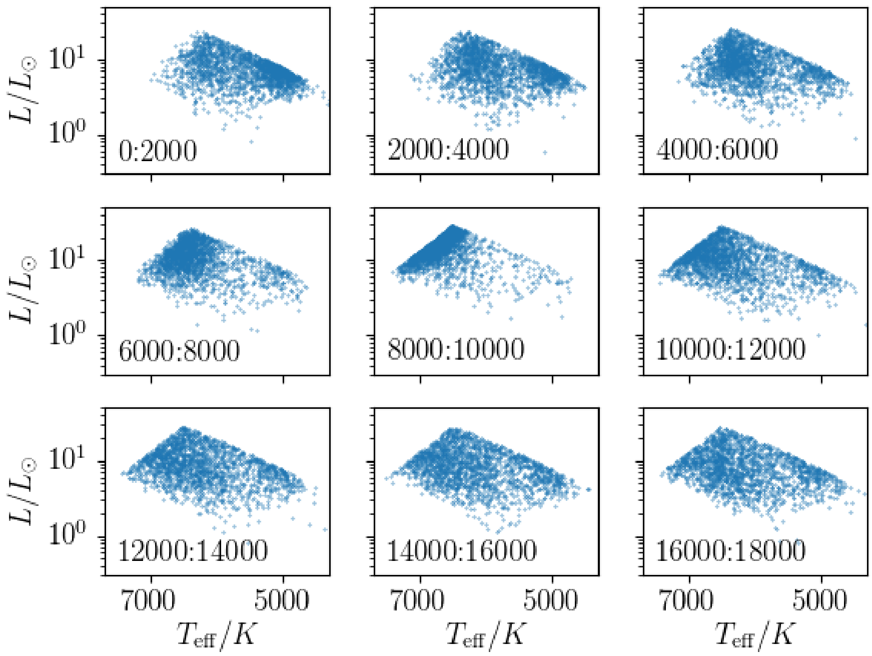

Figure 12: HR subpplots of the ATL with TGAS parallaxes and distances, and the old pixel mask size.

5 Comparing the 'new' ATL to known catalogues

The ATL from Section 4 was compared to catalogues from the literature (Bruntt et al. (2010), Silva Aguirre et al. (2012), Silva Aguirre et al. (2012)). There are no significant changes from the previous results of these comparisons. I am now checking these lists manually to see if any stars are missing from the updated ATL. If there are stars missing, I am investigating the reasons for this.

Radii comparison: Figures 13, 14, 15

$\Delta\nu$ comparison: Figures 16, 17

$\nu_{\rm max}$ comparison: Figures 18, 19

$T_{\rm eff}$ comparison: Figure 20

6 Conclusion

There is a large difference between the parallaxes and inferred distances from DR2, compared to TGAS. This affects most of the properties required by the ATL in order to calculate a probability of detecting solar-like oscillations. If DR2 parallaxes and distances are used alongside an updated pixel mask size, the detection probabilities of almost every star in the ATL will increase. Comparisons

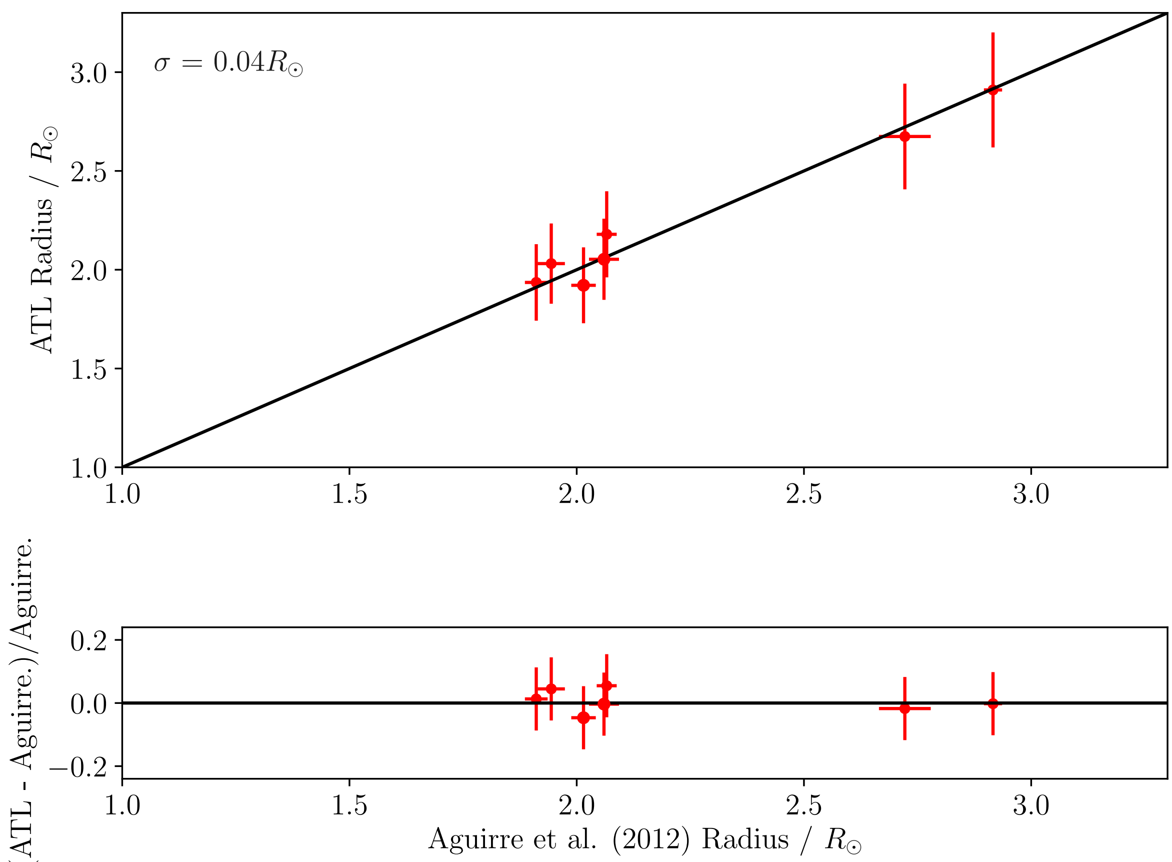

Figure 13: Comparison between the 'new ATL' and radii from Silva Aguirre et al. (2012).

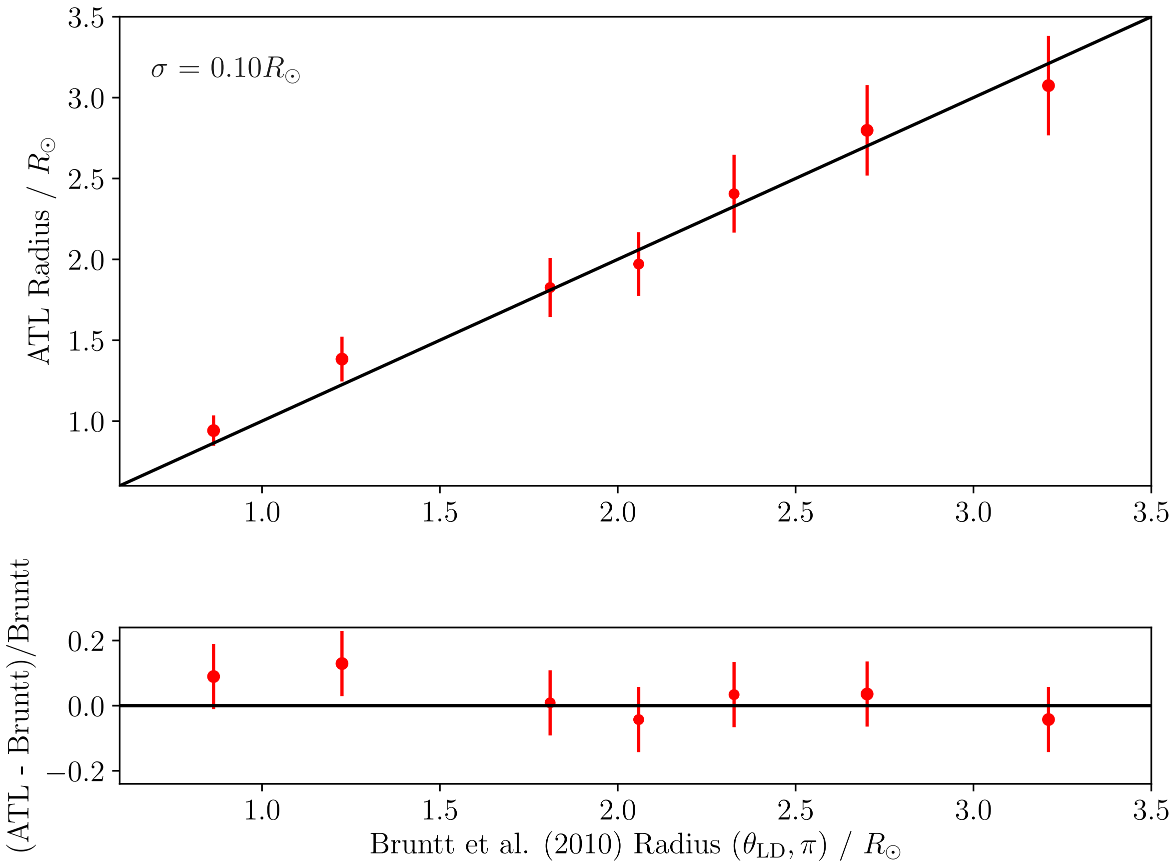

Figure 14: Comparison between the 'new ATL' and radii from the 'limb-darkening' method given in Bruntt et al. (2010).

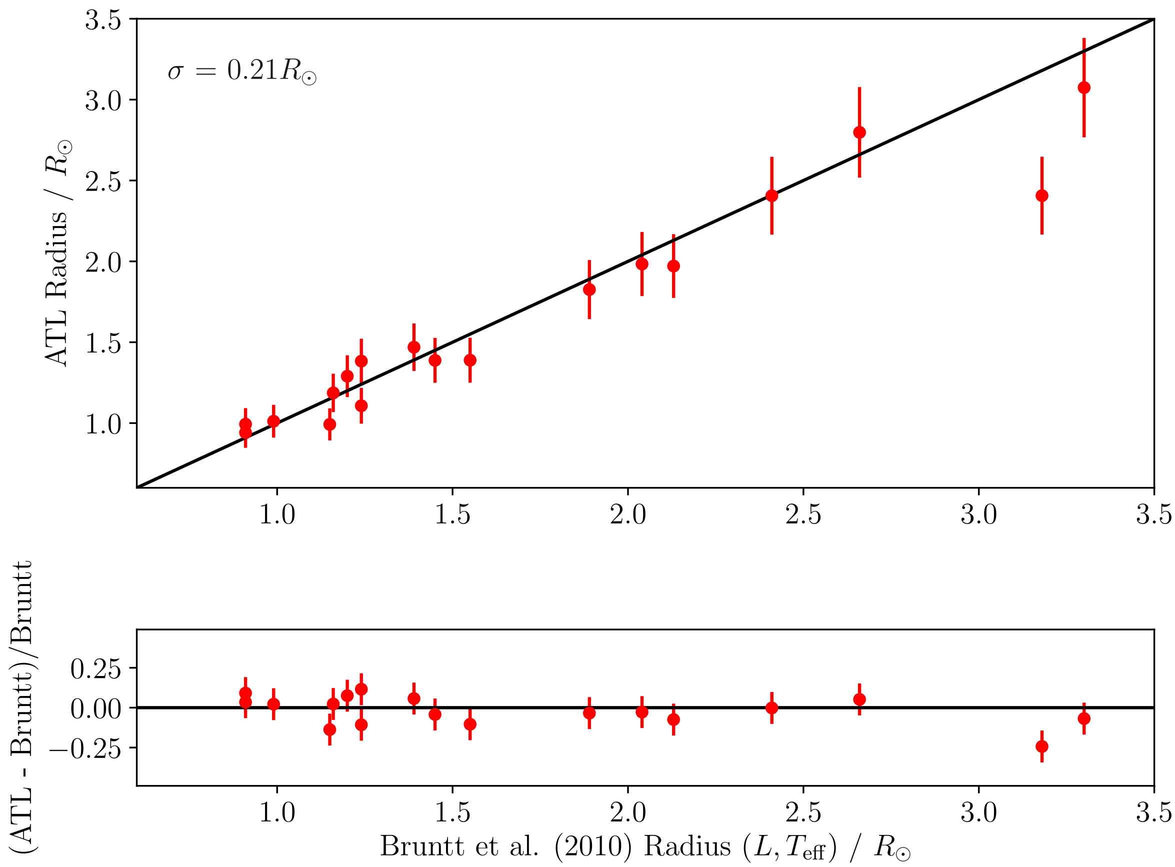

Figure 15: Comparison between the 'new ATL' and radii from the 'direct' method given in Bruntt et al. (2010).

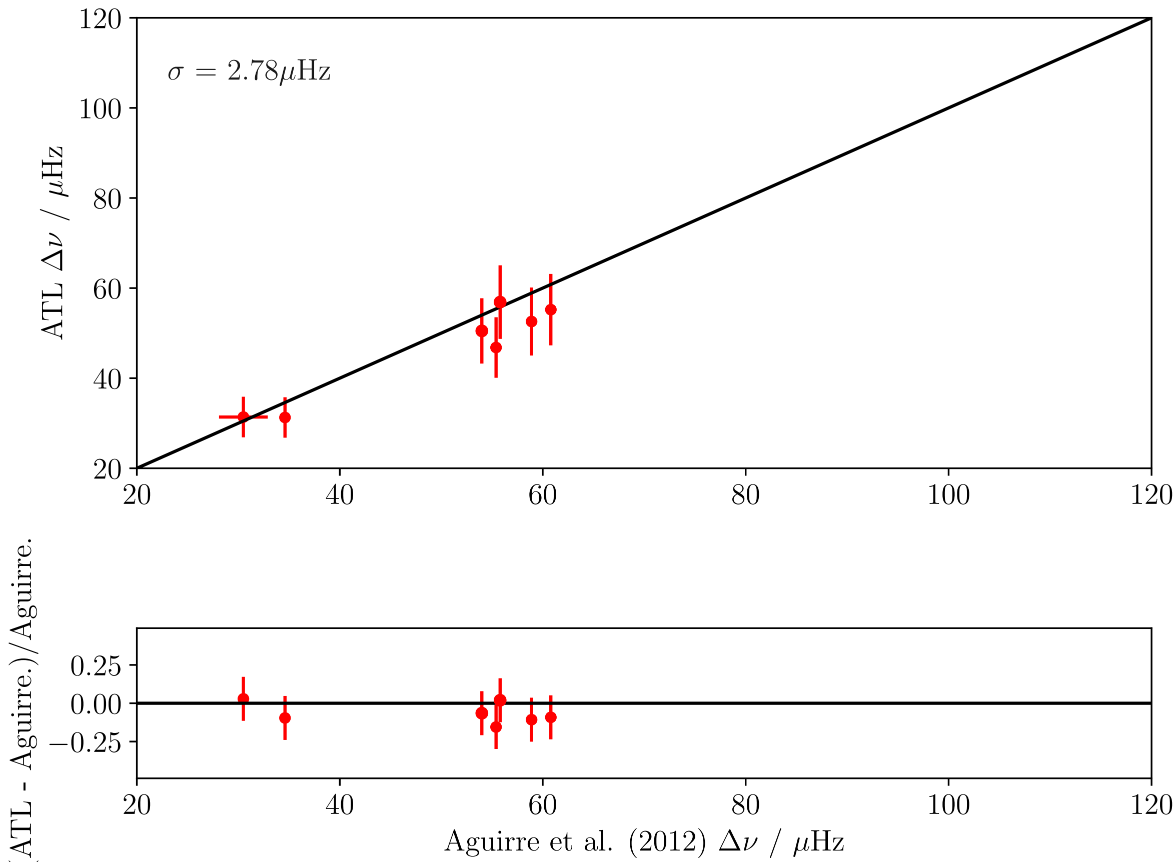

Figure 16: Comparison between the 'new ATL' and $\Delta\nu$ values from Silva Aguirre et al. (2012).

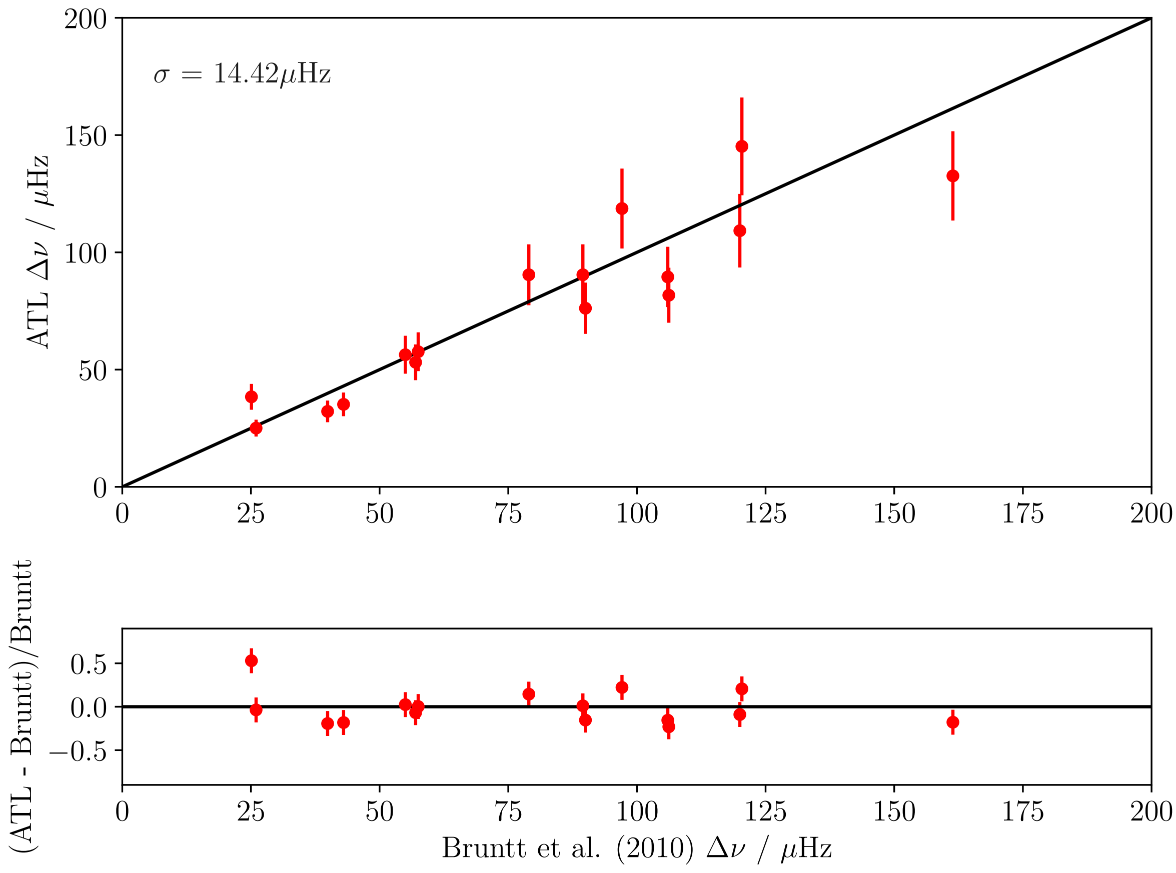

Figure 17: Comparison between the 'new ATL' and $\Delta\nu$ values from Bruntt et al. (2010).

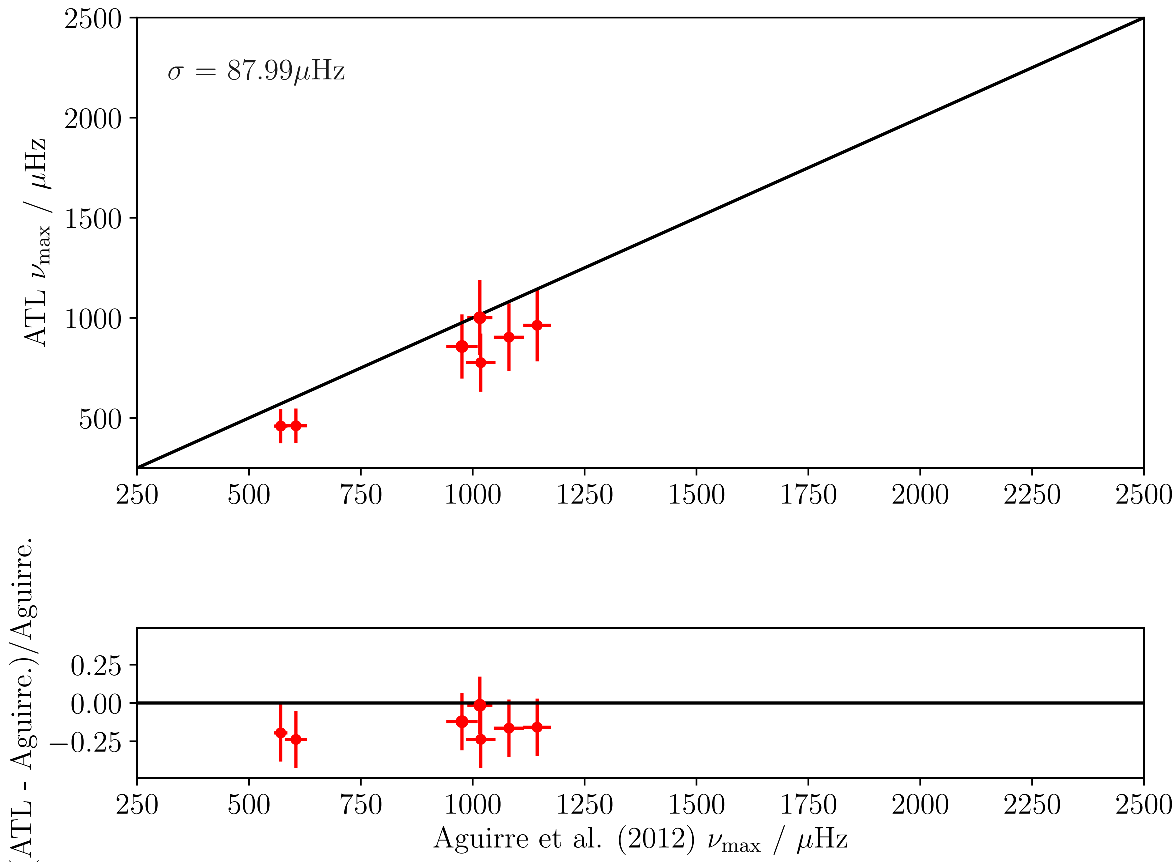

Figure 18: Comparison between the 'new ATL' and $\nu_{\max}$ values from Silva Aguirre et al. (2012).

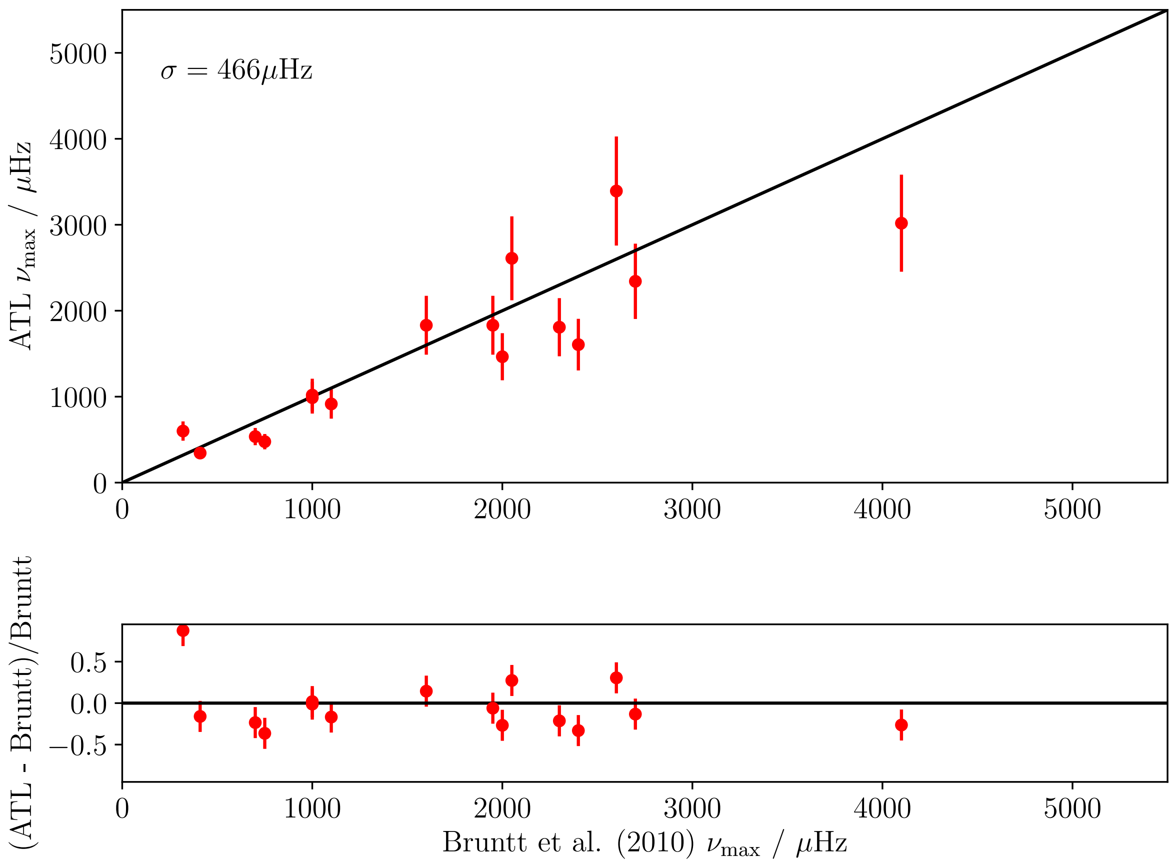

Figure 19: Comparison between the 'new ATL' and $\nu_{\max}$ values given in Bruntt et al. (2010).

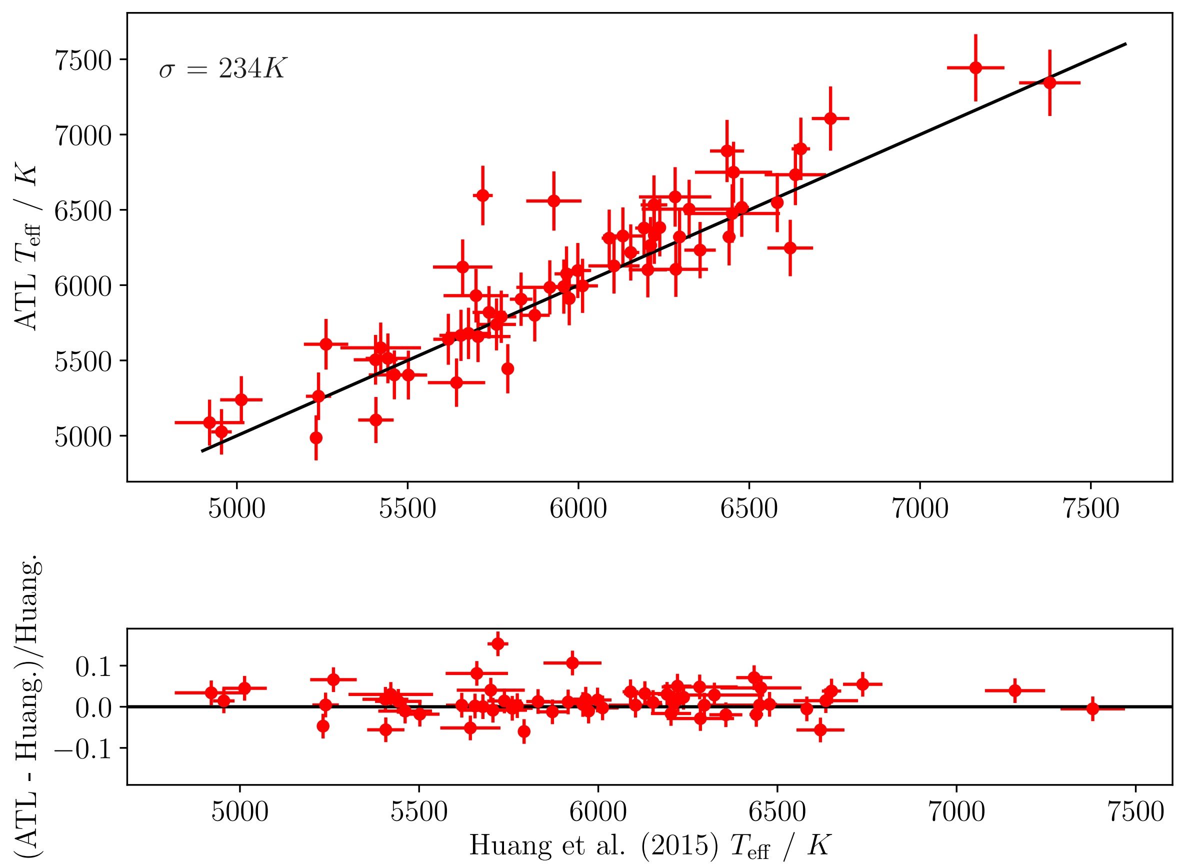

Figure 20: Comparison between the 'new ATL' and $T_{\rm eff}$ values given in Huang et al. (2015).

with pre-existing catalogues do not reveal any systematic biases.

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