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# COMPARATIVE ANALYSIS OF GAIA DR3 GSP-SPEC AND GAIA-ESO DR5.1

M. Van der Swaelmen[1], C. Viscasillas Vazquez[2], L. Magrini[1] and A. Recio-Blanco[3]

**Abstract.** Gaia is a gift for the stellar community: it brings us not only the largest catalogue of stars with 3D-velocities but also the largest catalogue of stars with homogeneously-obtained atmospheric parameters, namely the effective temperature, the surface gravity and two global abundances ([M/H] and [alpha/Fe]), as well as some individual abundances of elements probing different nucleosynthetic origins (e.g., Ca, S, Ni, Ce). These chemo-physical quantities are crucial to investigate the chemo-dynamical evolution of stellar populations forming the Milky Way. The Gaia RVS survey relies on space-based spectroscopy at resolution 11500 over a small wavelength range centred on the infrared Ca II triplet. We perform a comparative analysis of the Gaia RVS radial velocities, photospheric parameters and abundances to those obtained by the higher-resolution Gaia-ESO survey. There is an excellent agreement between the radial-velocity scales of these two surveys (given their respective uncertainties). For the Gaia RVS photospheric parameters and abundances, the agreement between the two sets of inferred parameters is good for targets brighter than about G = 11 while there is an increasing scatter for fainter targets. We show that averaged abundances (*e.g.* for clusters) can be used to recover the properties of Milky Way stellar populations. All the results of this study are presented in Van der Swaelmen et al. (2024).

Keywords: Stars: abundances, Stars: evolution, Galaxy: open clusters and associations: general, Galaxy: evolution

## 1 Introduction and data selection

*Gaia*-ESO science operations have ended in July 2023 with the fifth and final public data release (DR5.1 Gilmore et al. 2022; Randich et al. 2022)*. The third *Gaia* data release (DR3 Gaia Collaboration et al. 2023) includes, for the first time, the results of the analysis of RVS spectra, providing spectroscopically derived temperature, surface gravity, metallicity [M/H] and $\alpha$-content [$\alpha$/Fe], but also individual abundances of many elements (Recio-Blanco et al. 2023). The aim of this study is to compare the results of both surveys.

The intersection between the final release – DR5.1 – of the *Gaia*-ESO survey (GES) and the latest release – DR3 – of *Gaia* contains 114 864 stars ($\mathcal{S}_0$). The availability of data used for this study depends on the physical quantity of interest in both samples. The sample $\mathcal{S}_1$ contains 19 636 stars with valid radial velocities in both surveys. The sample $\mathcal{S}_3$ contains 1566 stars with valid stellar parameters $\{T_{\rm eff}, \log g, [{\rm Fe/H}]\}$ in both surveys. Figure 1 compares the magnitude distributions of the parent sample and the two sub-samples $\mathcal{S}_1$ and $\mathcal{S}_3$ under study and it shows the Kiel diagram for $\mathcal{S}_3$.

## 2 Radial velocities

After discarding objects with suspicious or variable radial velocities from the sample $\mathcal{S}_1$, we find an excellent agreement between the GES and *Gaia* radial velocity scales, given their respective uncertainties (Fig. 1). The mean and median difference between the two datasets are respectively 0.07 and $-0.02\,{\rm km\,s^{-1}}$. We cannot explain the disagreement for about 4 % of the analysed stars; the possible reasons might be hidden multiplicity, jitter or underestimated uncertainties.

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[1] INAF – Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125, Firenze, Italy
[2] Institute of Theoretical Physics and Astronomy, Vilnius University, Sauletekio av. 3, 10257 Vilnius, Lithuania
[3] Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS, Laboratoire Lagrange, Bd de l'Observatoire, CS 34229, 06304 Nice Cedex 4, France
*https://www.eso.org/qi/catalog/show/411

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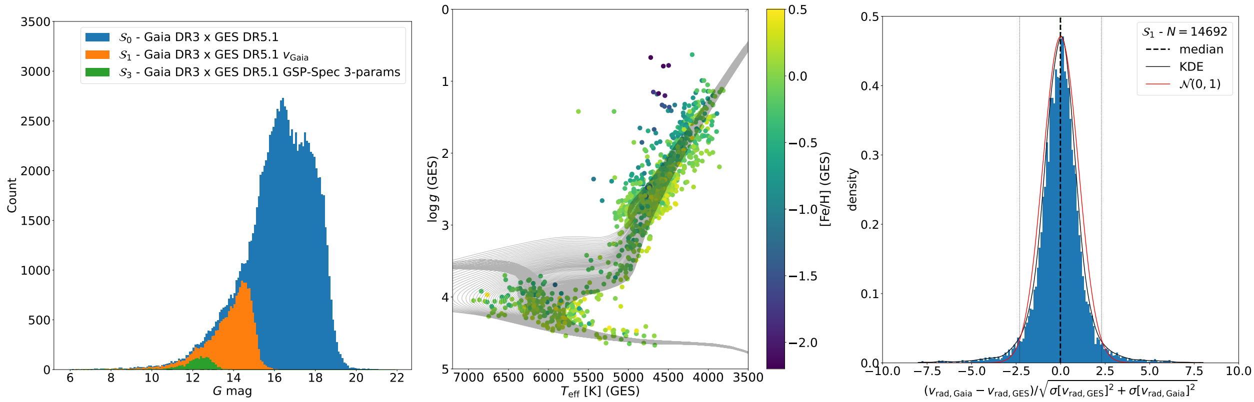


**Fig. 1.** Left: Distributions of the $G$ magnitudes. Middle: Kiel diagram. Right: Probability distribution of the normalised velocity differences.

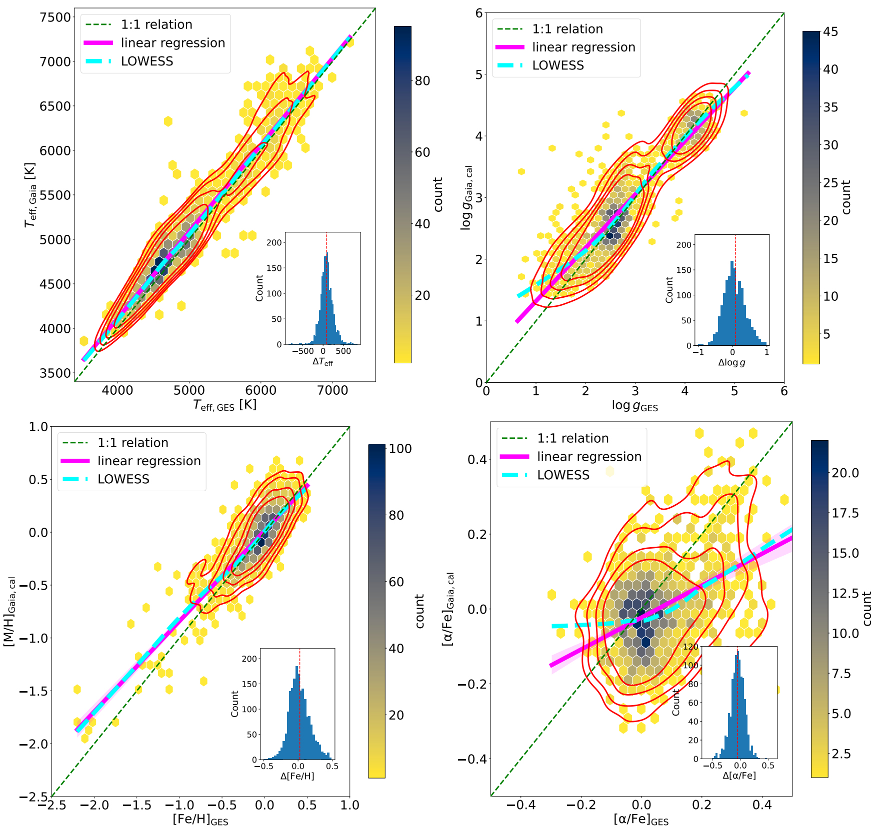


**Fig. 2.** Comparison of *Gaia* GSP-Spec and GES photospheric parameters and abundances. From left to right, top to bottom: $T_{\rm eff}$, $\log g$, [Fe/H] and [$\alpha$/Fe]. For *Gaia*, calibrated $\log g$, [Fe/H] and [$\alpha$/Fe] are used.

## 3 Stellar parameters

The tighter correlation in Fig. 2 is observed for $T_{\rm eff}$ with on average, a bias of nearly 90 K between the two scales. For $\log g$, using the calibrated GSP-Spec values improves the agreement: the mean and standard deviation for $\Delta \log g$ are 0.08 and 0.37 vs. $-0.19$ and 0.39 for the uncalibrated. For [Fe/H] and [$\alpha$/Fe], the use of the calibrated GSP-Spec scales marginally improves the agreement between *Gaia* and GES.

We note a magnitude effect on the agreement between *Gaia* and GES. Fig. 3 shows that the agreement quickly degrades for $G \geq\sim 11$. The median *Gaia* RVS S/N remains below 70 in this faint regime and given

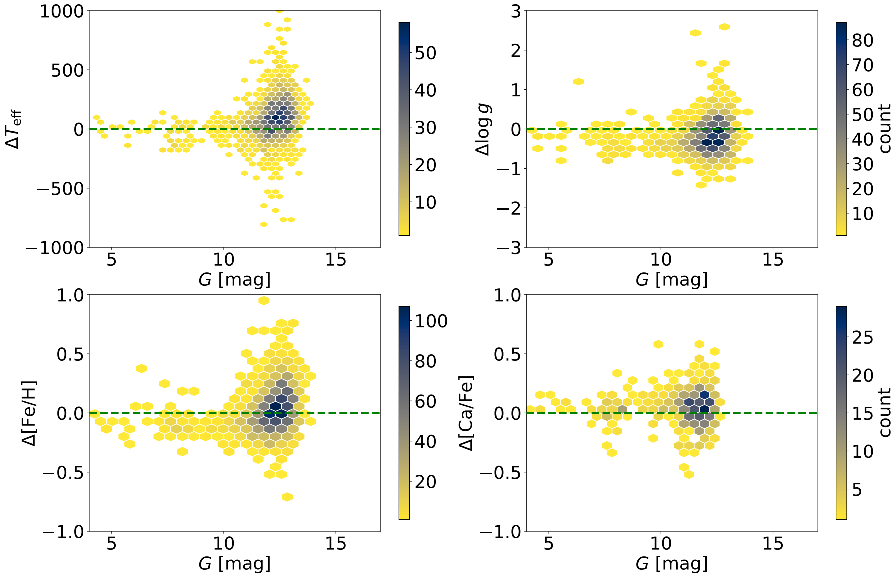


**Fig. 3.** $\Delta\mathcal{P} = \mathcal{P}_{\rm Gaia} - \mathcal{P}_{\rm GES}$ vs. $G$ where $\mathcal{P}$ is $T_{\rm eff}$, $\log g$, [Fe/H] or [$\alpha$/Fe].

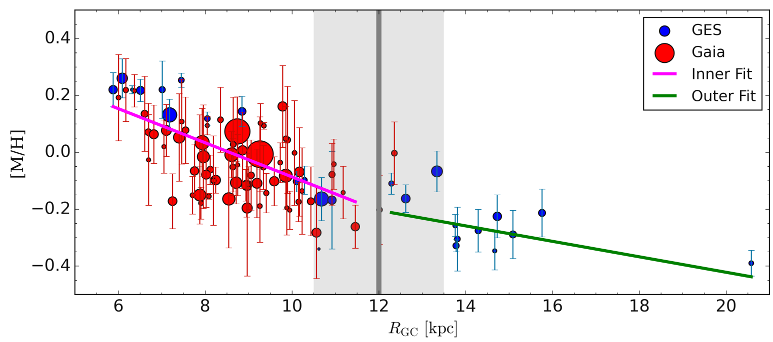


**Fig. 4.** Metallicity gradient for open clusters with symbol size proportional to the number of members used to compute the average values.

the RVS resolution and sampling and the short RVS band, it is not enough to ensure precise estimates of photospheric quantities.

## 4 Science with Gaia and GES: case of open clusters

Averaging abundances counterbalance the somewhat worse quality in the faint regime. It is possible to combine *Gaia* and ground-based spectroscopic surveys such as GES to study the Milky Way stellar populations. Fig. 4 shows the metallicity gradient as seen by the open cluster population. A knee is noticeable around $R_{\rm GC} \sim 11-12$ kpc, in agreement with the literature. The negative metallicity gradient points at an inside-out formation of the Milky Way.

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