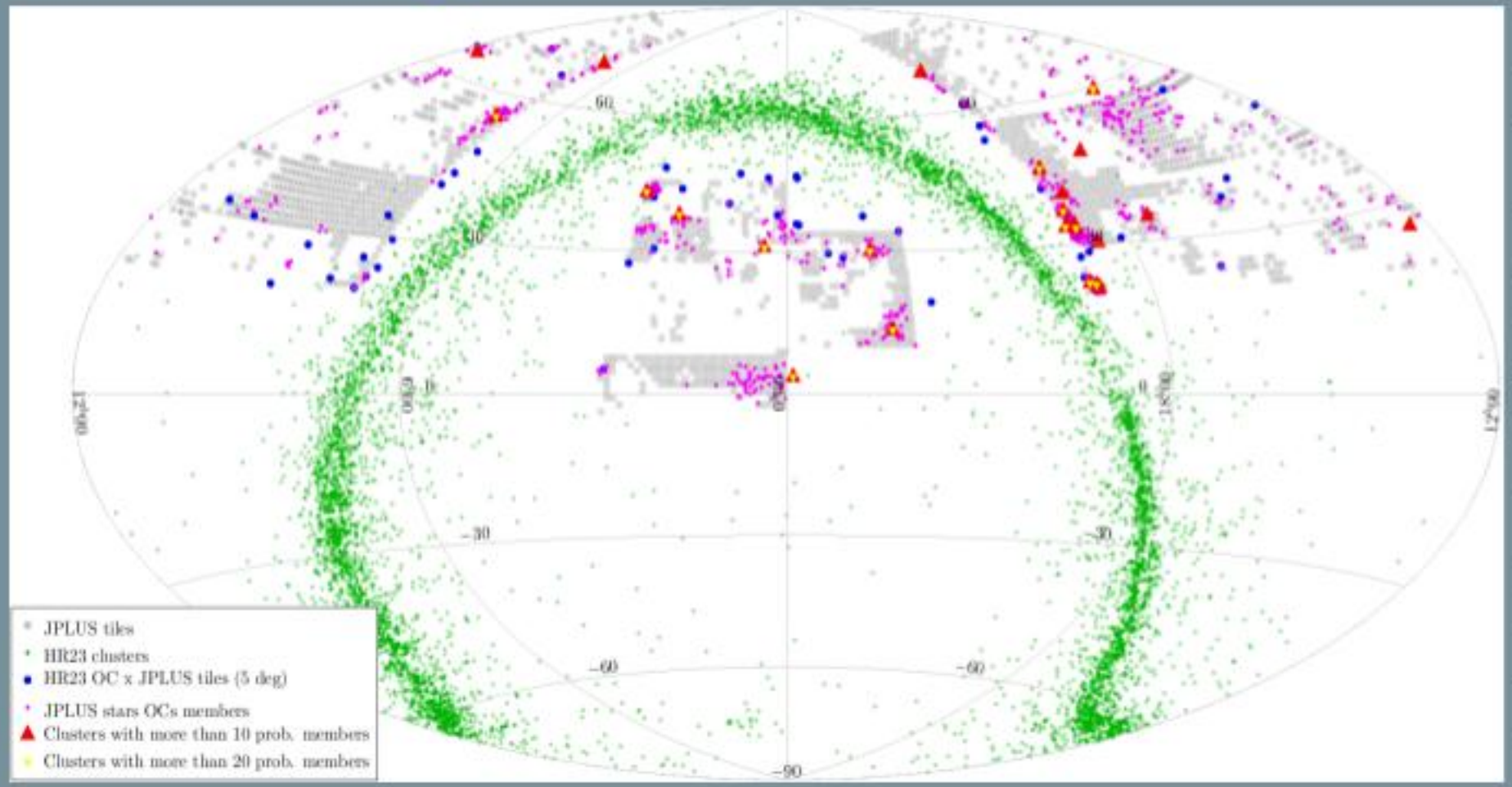
Metallicity determination in open star clusters by exploring Gaia–J-PLUS synergy

Eduardo Machado-Pereira[1] (eduardopereira@on.br), Simone Daflon[1], Vinícius Placco[2], Rafael Guerço[1], Guilherme Limberg[3], Francisco Maia[4]
[1]Observatório Nacional, [2]NSF's NOIRLab, [3]IAG-USP, [4]IF-UFRJ

Javalambre-Photometric Local Universe Survey (Cenarro et al. 2019)
12 band filters

Improving the open cluster census. II. An all-sky cluster catalogue with Gaia DR3 (Hunt & Reffert, 2023, HR23)



The goal of this exercise is to look for open clusters (OCs) in the footprint of the Javalambre-Photometric Local Universe Survey (J-PLUS), but also exploring the synergies between this survey and Gaia DR3.

Our first step was to crossmatch JPLUS DR3 tiles with the catalogue provided by Hunt & Reffert (HR23, 2023), which contains over 4000 OCs reliable candidates and is based on data from Gaia DR3.

18 reliable OCs were found, after considering clusters with more than 10 probable stars according to HR23 membership probabilities.

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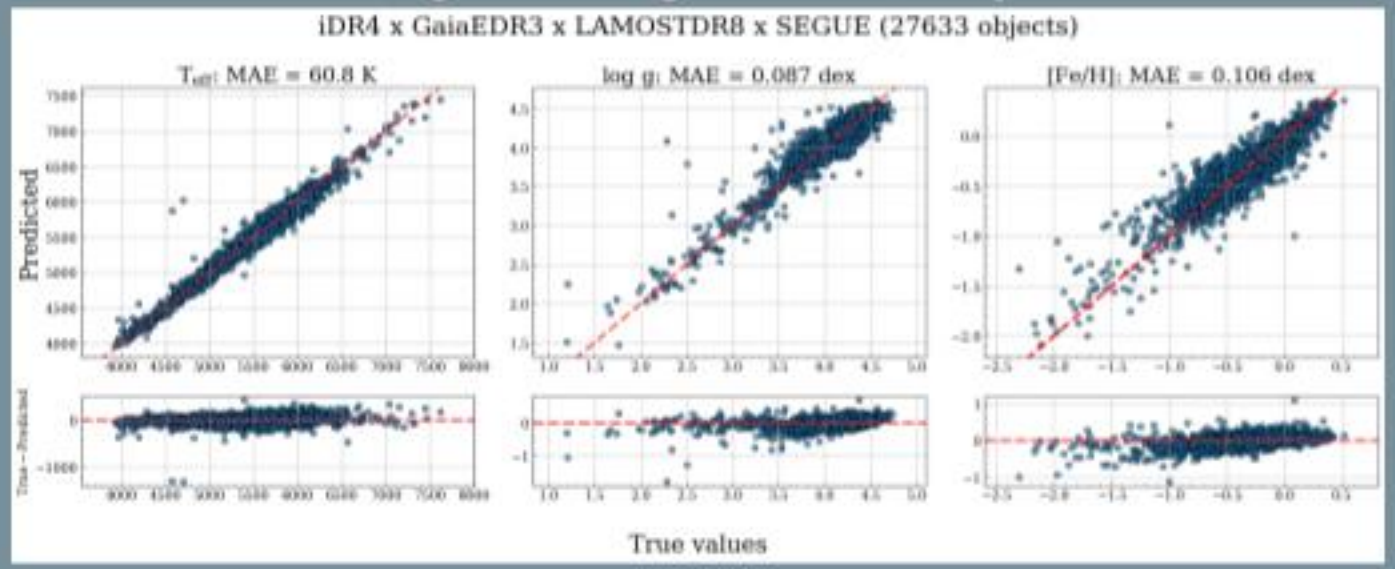
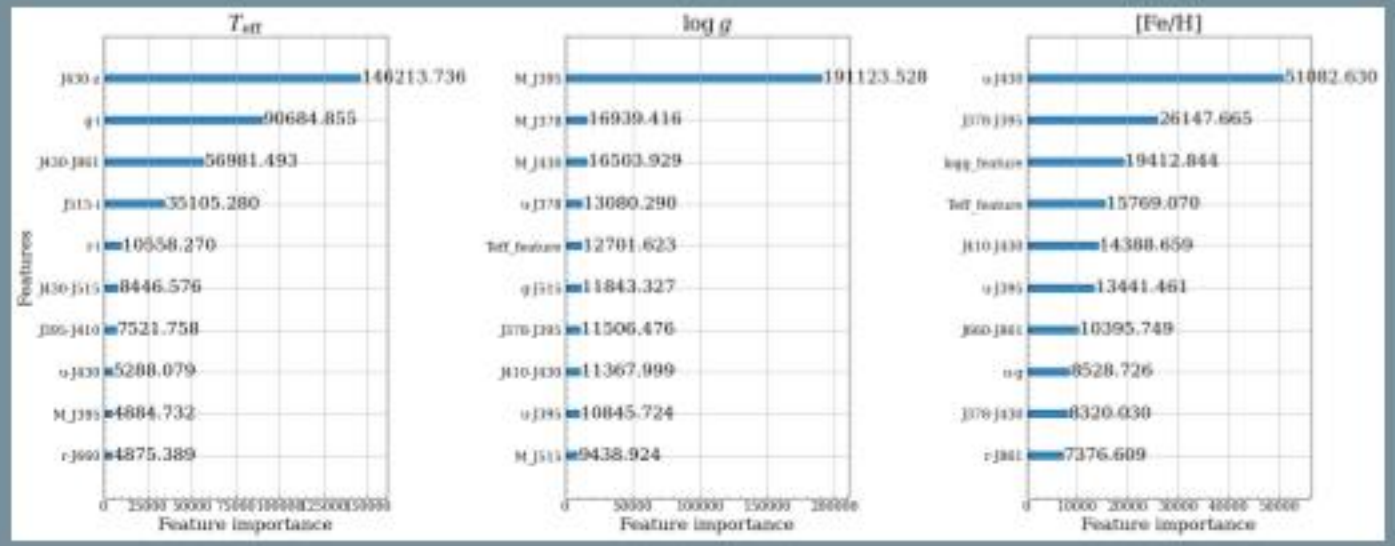
Machine learning: training models for parameters determination





In order to predict atmospheric parameters for the members of the OCs, we turn to machine learning tools, more specifically the LightGBM framework. The samples for training (70%), validation (20%) and test (10%) were constructed based on features (information to be used in order to reproduce target parameters) from the Southern Photometric Local Universe Survey (S-PLUS) iDR4 and from Gaia, and on targets (parameters to be reproduced using features) from the Sloan Extension for Galactic Understanding and Exploration (SEGUE) and from the Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST) DR8.

We emphasize that S-PLUS is based on filters which are identical to those in J-PLUS, allowing for similar photometry; moreover, absolute magnitudes were calculated using distances provided in Bailer-Jones et. al (2021).

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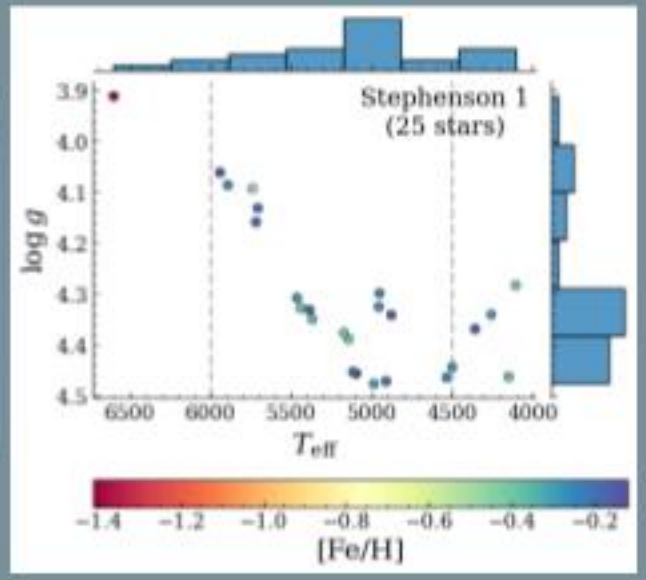
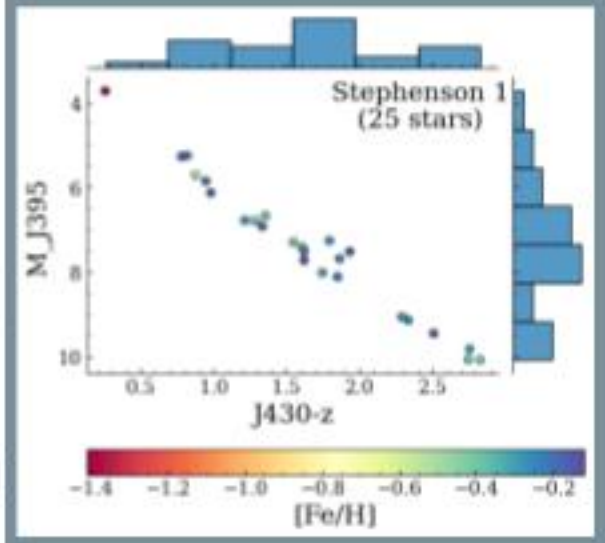
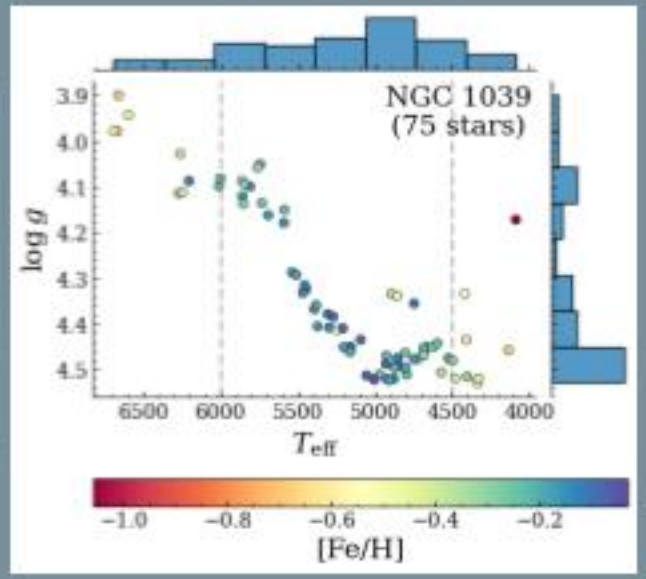
Preliminary results

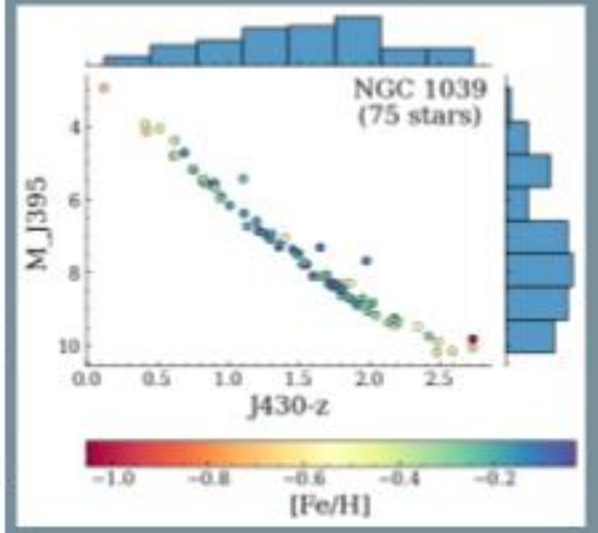
log t: 7.43 (~27 Myr) distance: 355 pc
(Hunt&Reffert, 2023)

log t: 8.09 (~123 Myr) distance: 490 pc
(Hunt&Reffert, 2023)









We obtained preliminary results for members of two clusters in our sample: Stephenson 1 and NGC 1039.

While the Kiel diagrams of these clusters are populated with sparse data points, especially regarding metallicities outside the effective temperature range [4500 K, 6000 K], one can easily notice that the main sequences are reproduced in the color-magnitude diagrams of both clusters.

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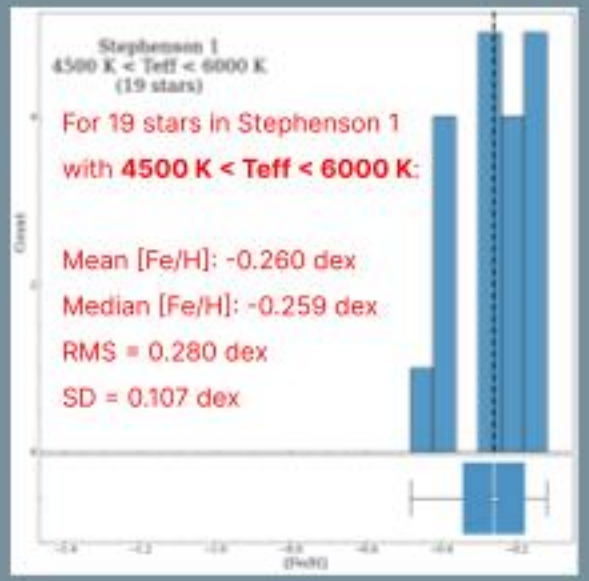

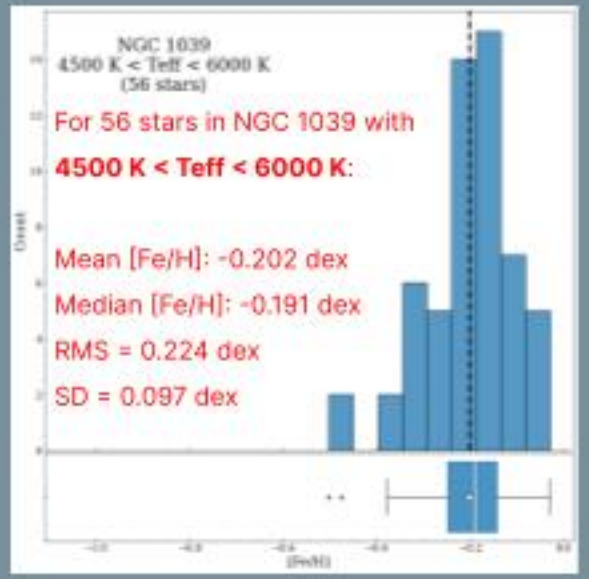

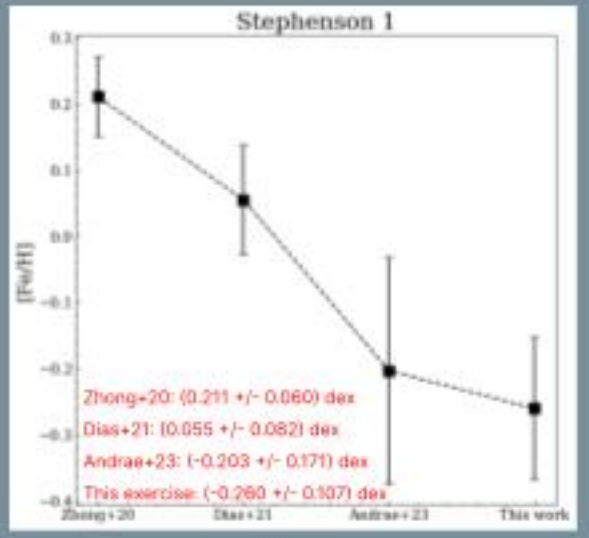

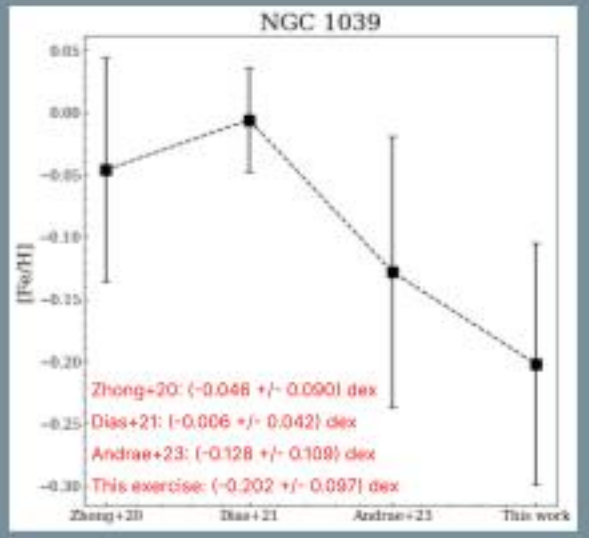

After limiting the Teff range to [4500 K, 6000 K], standard deviation in metallicity drops to ~0.1 dex for both clusters.

Our results do not agree with those found in either Zhong et al. (2020; spectra from LAMOST DR5) or Dias et al. (2021; isochrone fitting), but considering individual members, metallicities estimated by Andrae et al. (2023; gradient boosting) resulted in overall values similar to ours within error bars (standard deviations) for both clusters.

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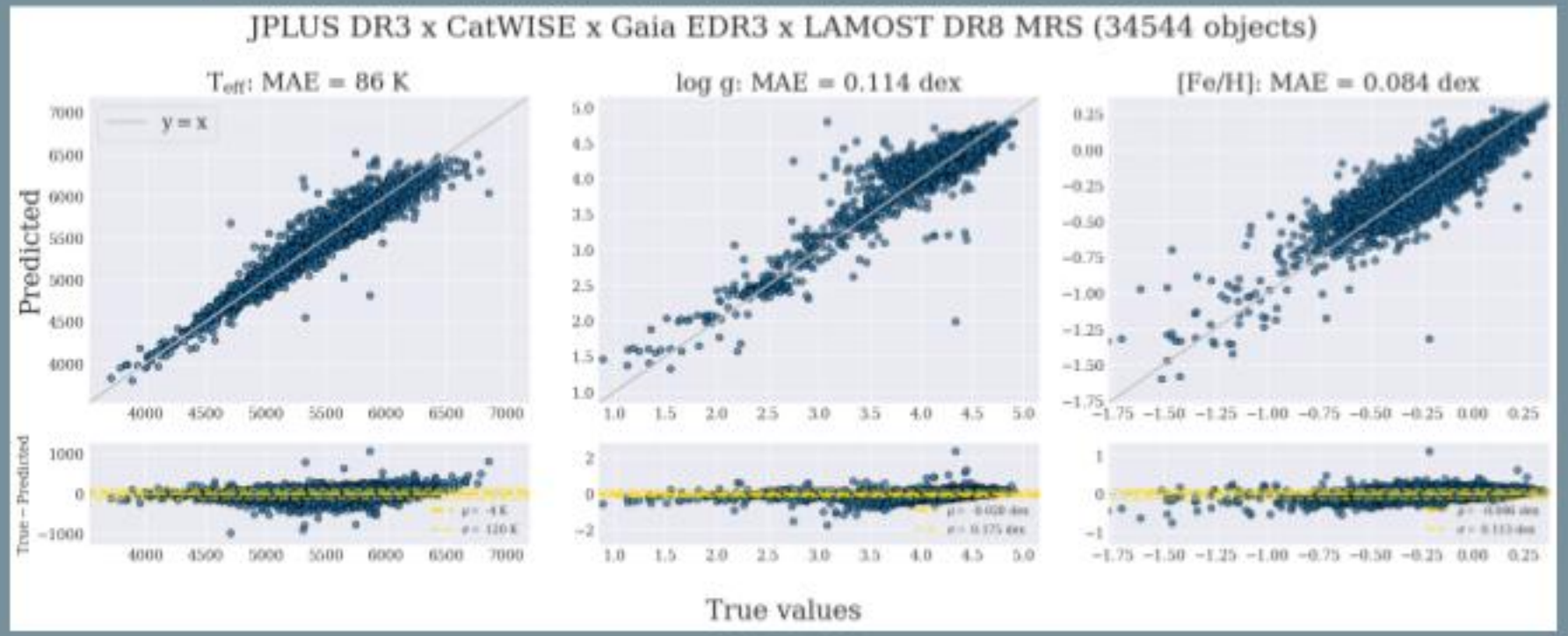
Next steps



- Training sample with J-PLUS DR3 data (in course)
  - define surveys for targets (APOGEE, LAMOST, SEGUE?)
  - include IR photometry (CatWISE)
- Isochrone fitting for clusters parameters determination
- Apply steps for all clusters in sample
- Check Unified Cluster Catalogue (Perren et al., 2023, arXiv:2308.04546v1)

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