Predicting Infrared stellar flux densities: teaching WISE to detect like Spitzer

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INTRODUCTION

Astrophysics is an ideal field in which to take advantage of ML due to the great amount of astronomical data and its peculiar characteristics.

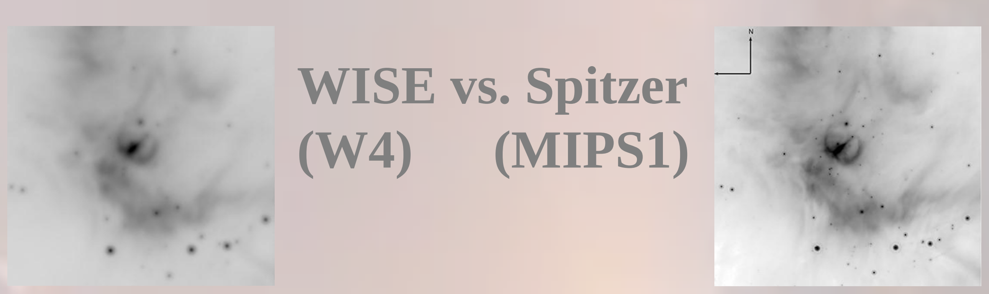
WISE and Spitzer are both satellites that surveyed the same spectral region. WISE is considered the current best infrared all-sky survey in both quality and coverage. In contrast, the space satellite Spitzer, with smaller coverage, has better spatial resolution (3x-2x, depending on the band) and sensitivity.

Some studies have claimed to find some kind of noise or contamination in WISE, resulting in discrepancies when comparing the measurements of both satellites (see blue points in Fig. 3).

These discrepancies can be overcome with the help of ML predicting mid-infrared fluxes at specific Spitzer bands from WISE variables.

METHODS

The problem:



The data:

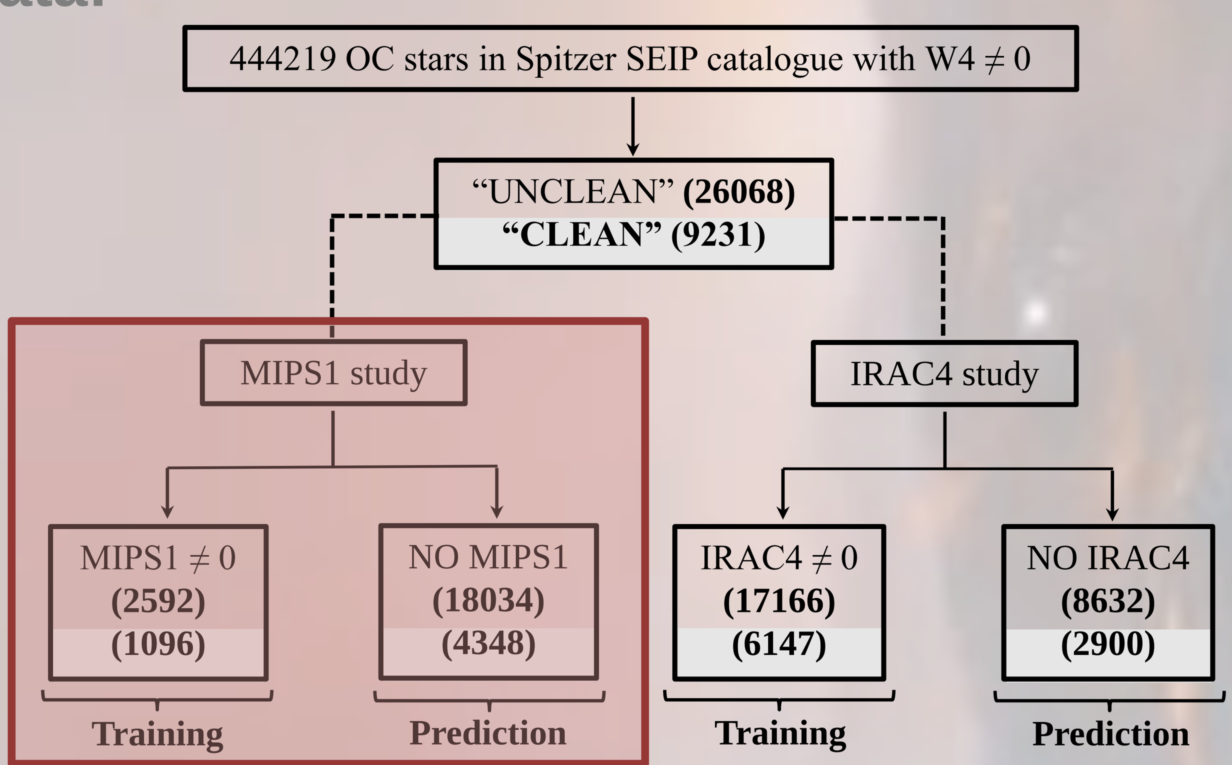


Figure 1. Data structure from this study. OC means open cluster (stars at the same distance, born at the same time). W4 is the WISE "problematic" band, IRAC4 and MIPS1 are Spitzer bands. Our "clean" sample is a higher quality version than the "unclean" one. Here we focus on MIPS1, further information can be found in [1].

The ML pipeline:

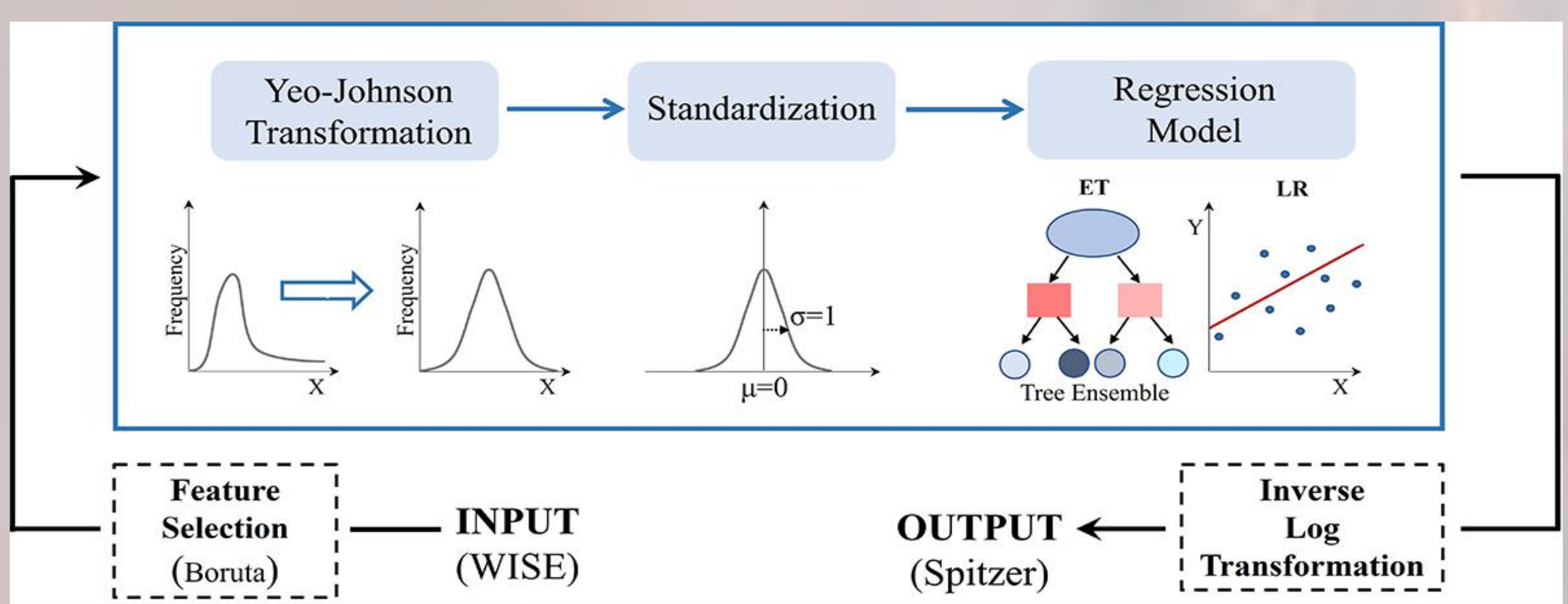


Figure 2. Scheme of the steps involved in the prediction of mid-infrared fluxes from WISE features. ET stands for Extremely Randomized Trees.

RESULTS & DISCUSSON

Predicted vs. observed fluxes:

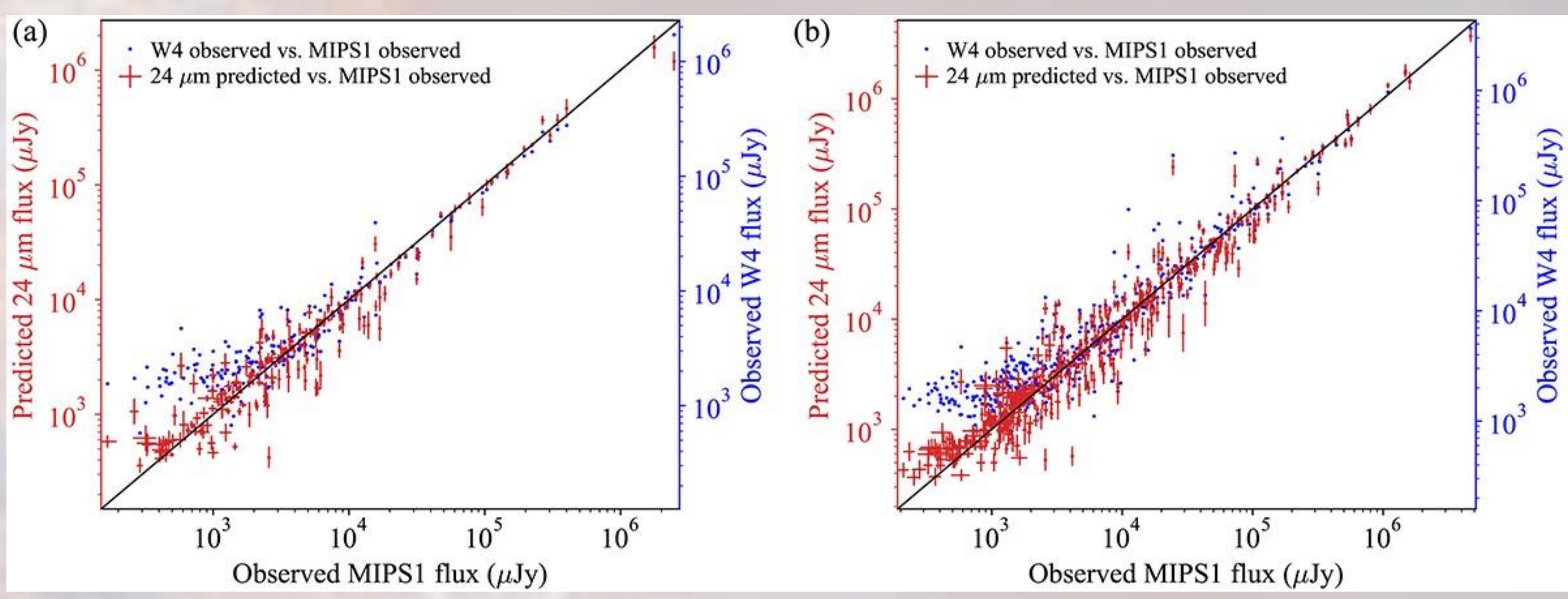


Figure 3. Comparison of the W4 observed fluxes (blue) and predicted at MIPS1 Spitzer band (red) vs. MIPS1 observed ones in the "clean" test set for our ET models. Plots show good correlation even at weak fluxes.

Metric	ML model	MIPS1 clean	MIPS1 unclean
R^2	ET	0.940	0.945
	LR	*0.873*	*0.890*
MAPE	ET	0.031	0.033
	LR	*0.048*	*0.051*

Table 1. Metrics demonstrate the good performance of our ET models for a 10-fold CV step and 1000 configurations in our hyperparameter space.

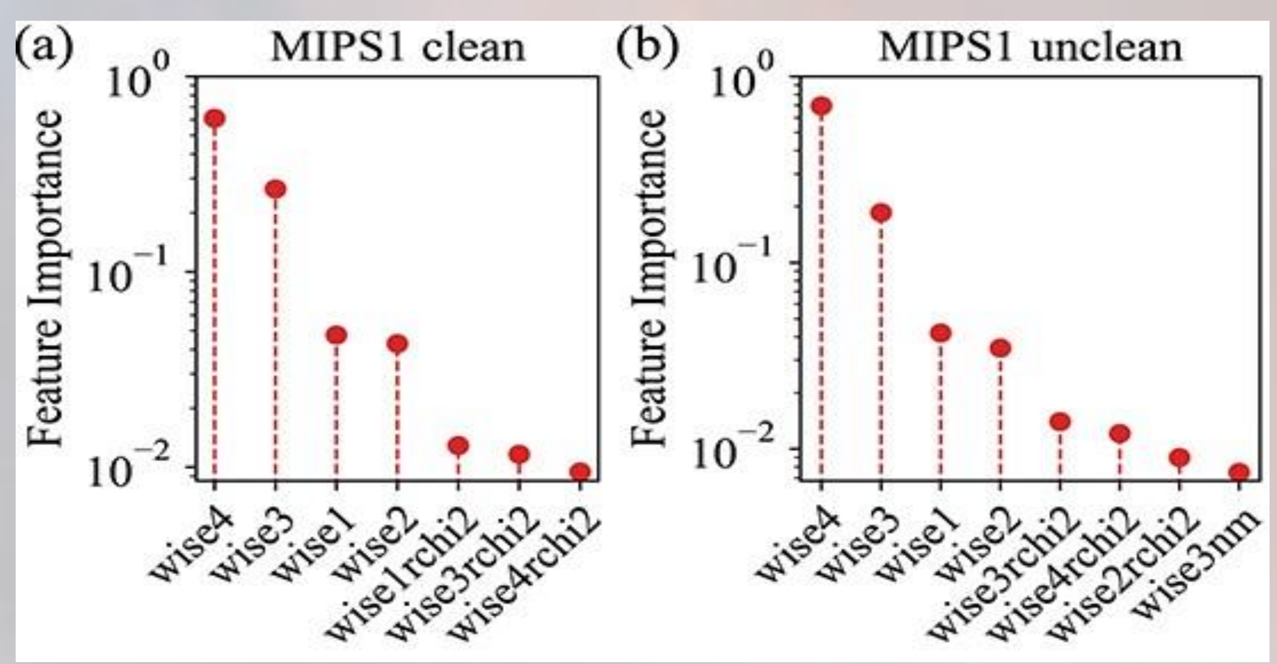


Figure 4. WISE features selected by the Boruta algorithm and their importance as estimated by the ET models: fluxes at different WISE bands (more important) and quality flags (less important).

A case study:

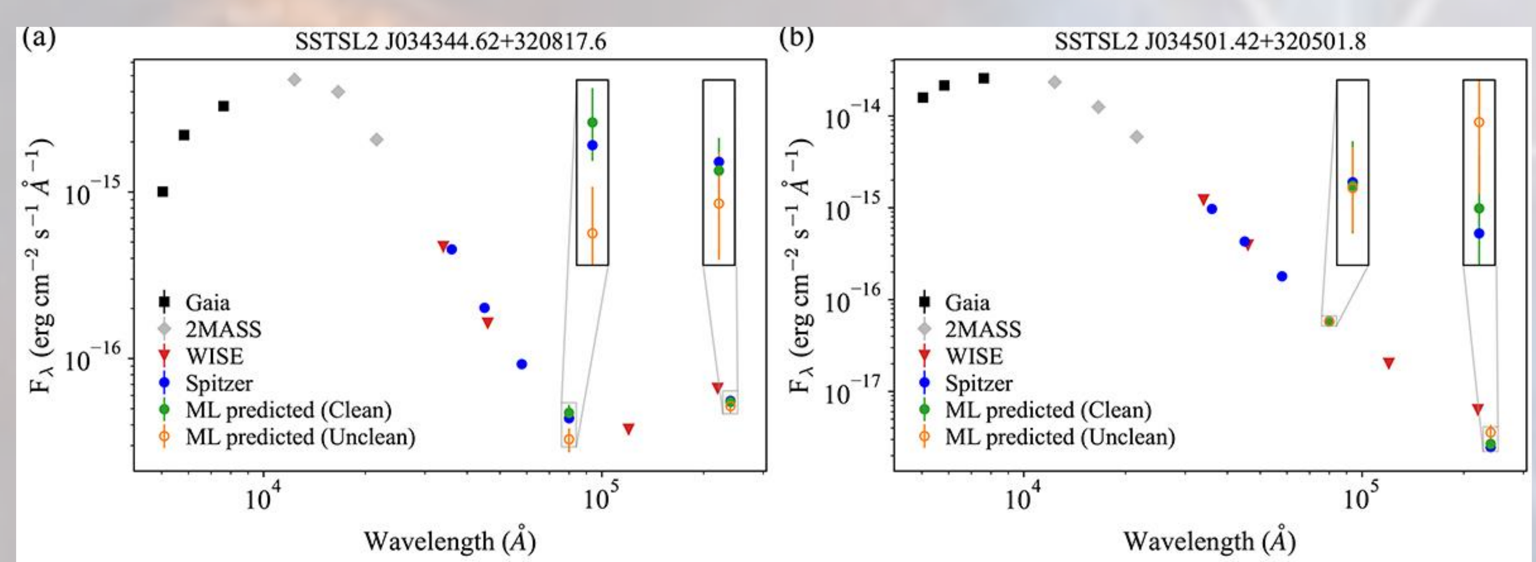


Figure 3. Emission of two stars in the OC IC 348 at different bands from optical to mid-infrared showing the better behaviour of the predicted values compared to the observed WISE ones (and the clean compared to the unclean fluxes).

CONCLUSION

- The use of ML allows us to bring the best characteristics of both satellites together without the loss of data that other approaches could cause.
- A similar strategy could be useful in other studies when dealing with similar discrepancies.

FUTURE WORK

- Evolutionary study of the stars in different open clusters using the predicted fluxes (ongoing).
- Update of the study with a bigger sample or/and improved data (updated versions of the used catalogues).

References:

[1] Fonseca-Bonilla et al. 2024, Astronomy & Astrophysics, 691, A271.