Classification of variable stars observed in multiple filters with MeerLICHT and BlackGEM”

Princy Ranaivomanana

PhD candidate

Radboud University

princy.ranaivomanana@ru.nl

Radboud Universiteit

IN·DEI·NOMINE·FELICITER

June 06, 2023

KU LEUVEN

Outlines

1) MeerLICHT and BLackGEM
2) Motivation
3) Steps towards our goals
4) Results
5) Conclusion

MeerLICHT and BlackGEM

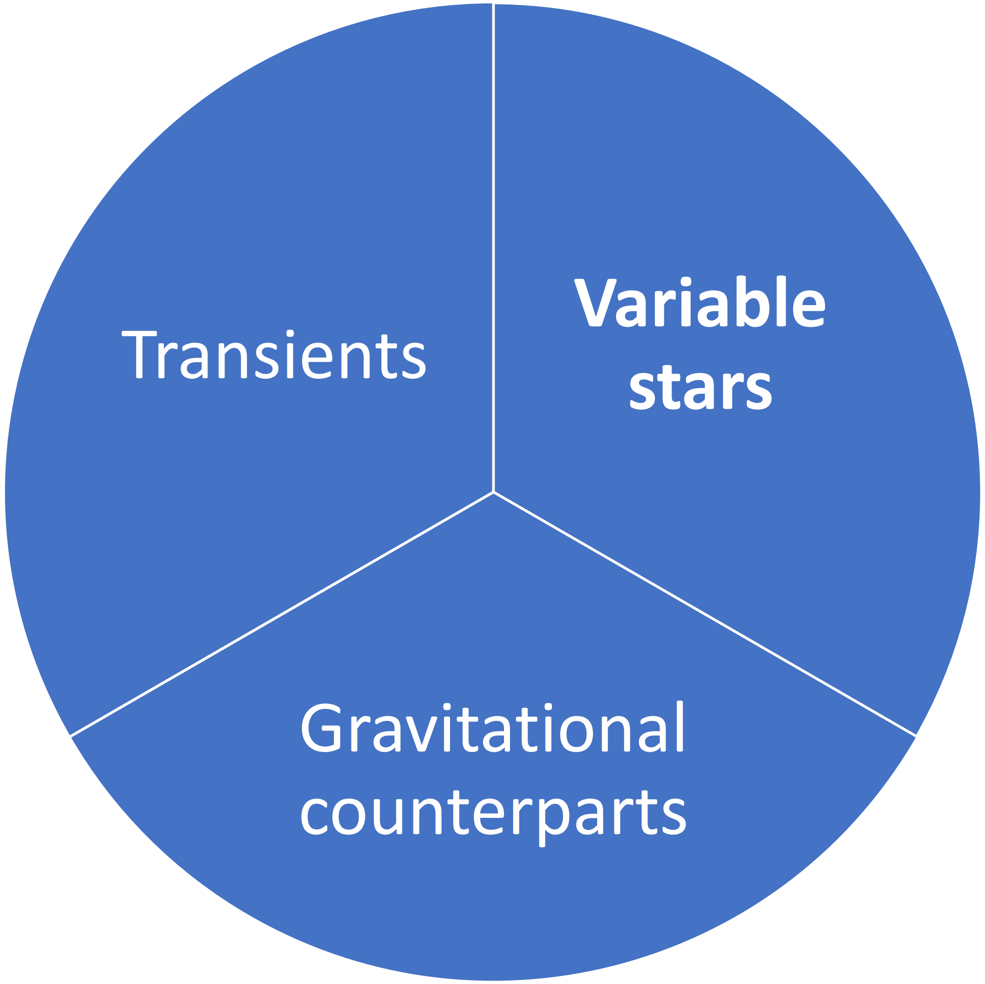
MeerLICHT

- Southern all-sky survey
- **fully robotic telescope**
- pixel scale: 0.56 arcsec/pixel.

BlackGEM

MeerLICHT and BlackGEM

Scientific goals



Filter	Wavelength range (nm)
u	350 – 410
g	410 – 550
q	440 – 720
r	563 – 690
i	690 – 840
z	840 – 990

Classification of variable stars

Motivation

- Multiband lightcurves → Better characterisation
- Characterise fainter object: ~23 mag
- 60s integration

+ 10s readout time

Classification of variable stars

Motivation

- Multiband lightcurves
- Observe fainter object: ~23 mag → More sources
- 60s integration

+ 10s readout time

Classification of variable stars

Motivation

- Multiband lightcurves
- Observe fainter object: ~23 mag
- 60s integration

+ 10s readout time

→ Detect high-frequency variables

Problems we want to solve

Automatically …	Given …
1) Characterise lightcurves	a) Unevenly sampled multi-band lightcurves
2) Classify variables	b) Few labelled (in our) dataset
3) Detect new class of variables	c) Imbalanced class dataset

Related work

ASAS-SN catalog of variable stars (Jayasinghe et al. 2018, 2019b, 2021)

Labelled data from Variable Star Index (VSX),

General Catalog of Variable Stars (GCVS),

Upsilon (Kim & Bailer-Jones 2015)

+ Manual selection

+ Random Forest

Supernova photometric classification (Ashley Villar et al., 2020)

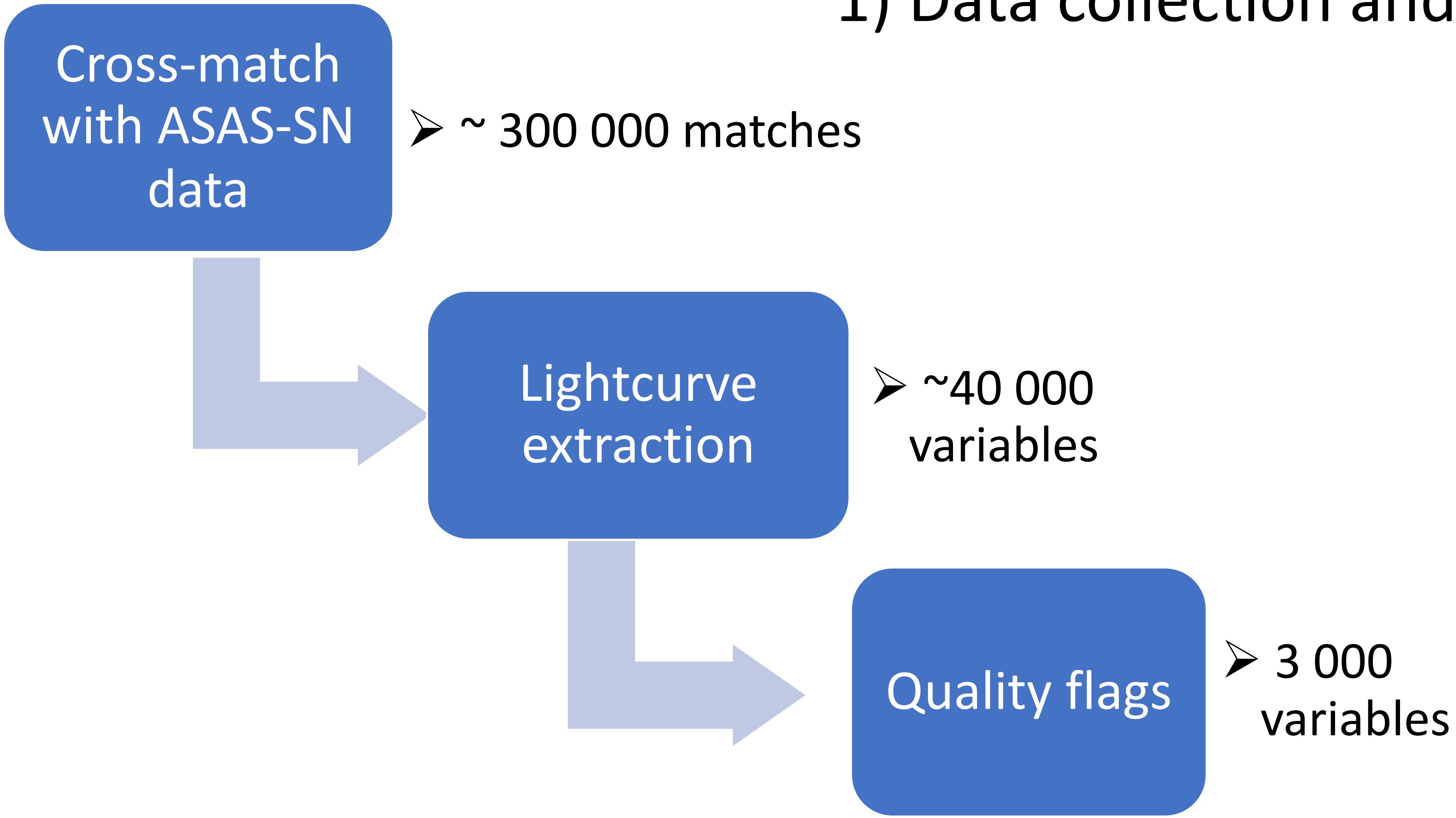
Gaussian Process

+ Neural network

+ Random Forest

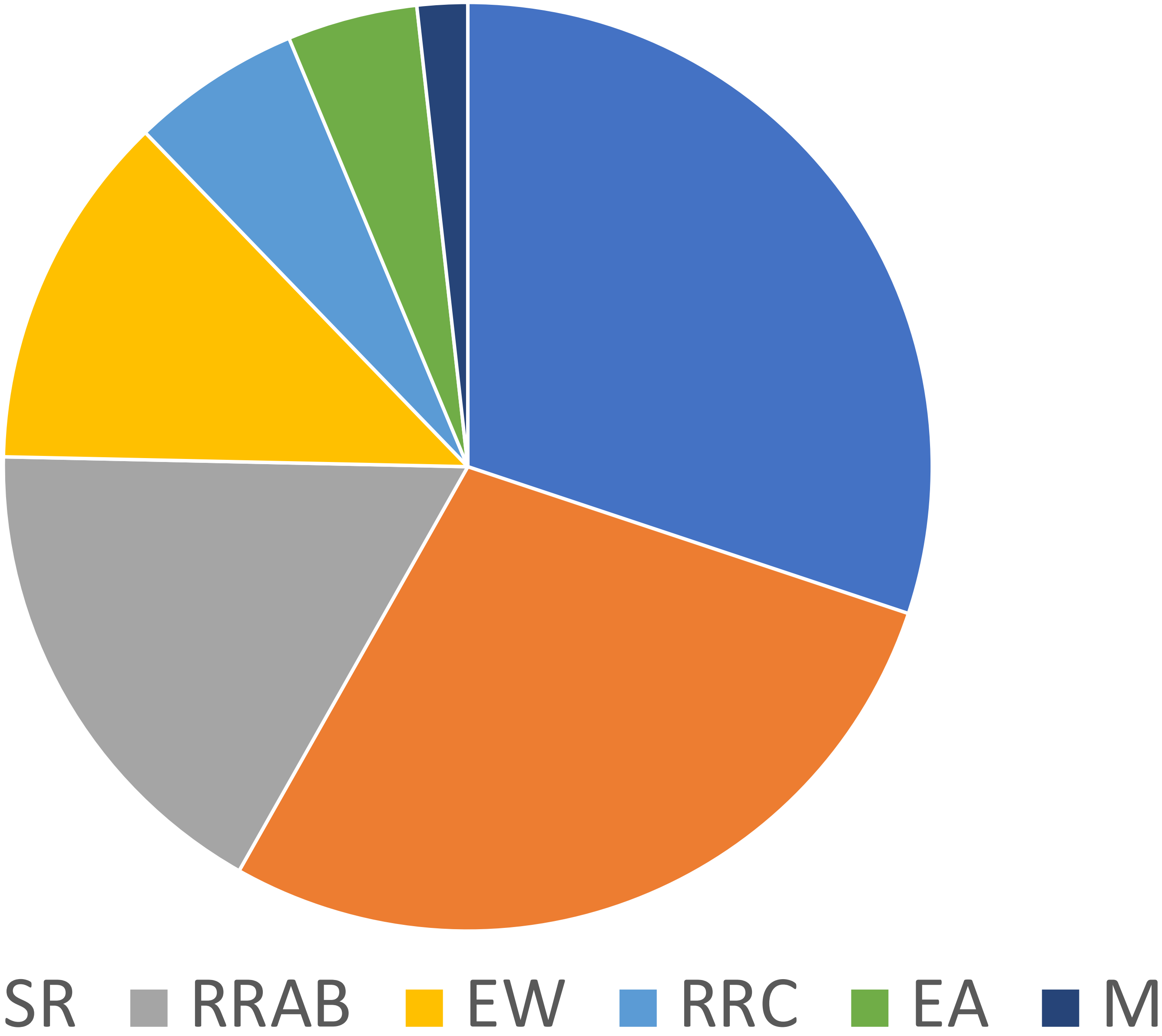
Steps towards our goals

1) Data collection and labelling



Steps towards our goals

Distribution of variables



Steps towards our goals

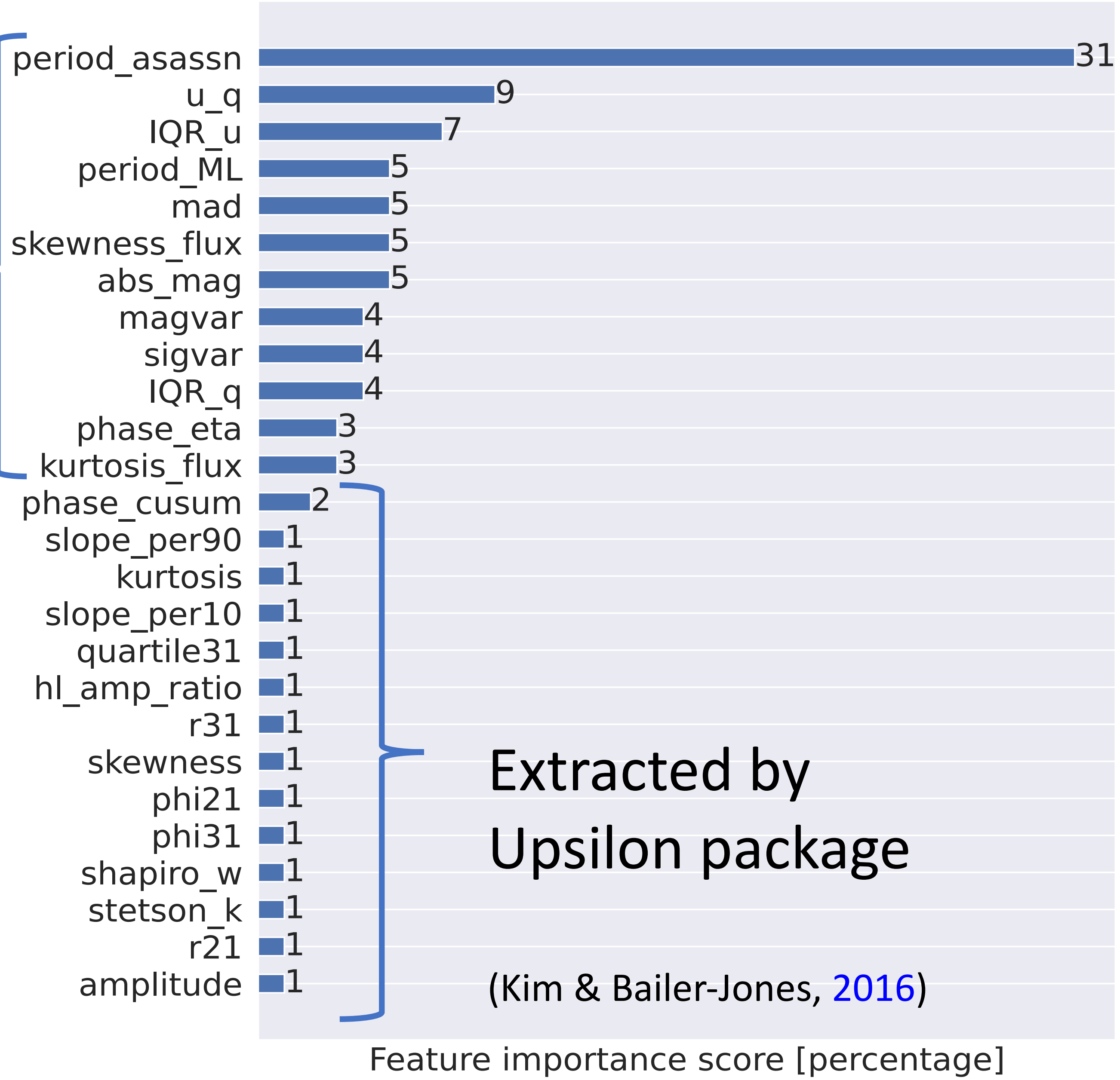
1) Data collection and labelling

2) Feature extraction/selection

3) Model selection

Random Forest (RF)

Descriptive statistics

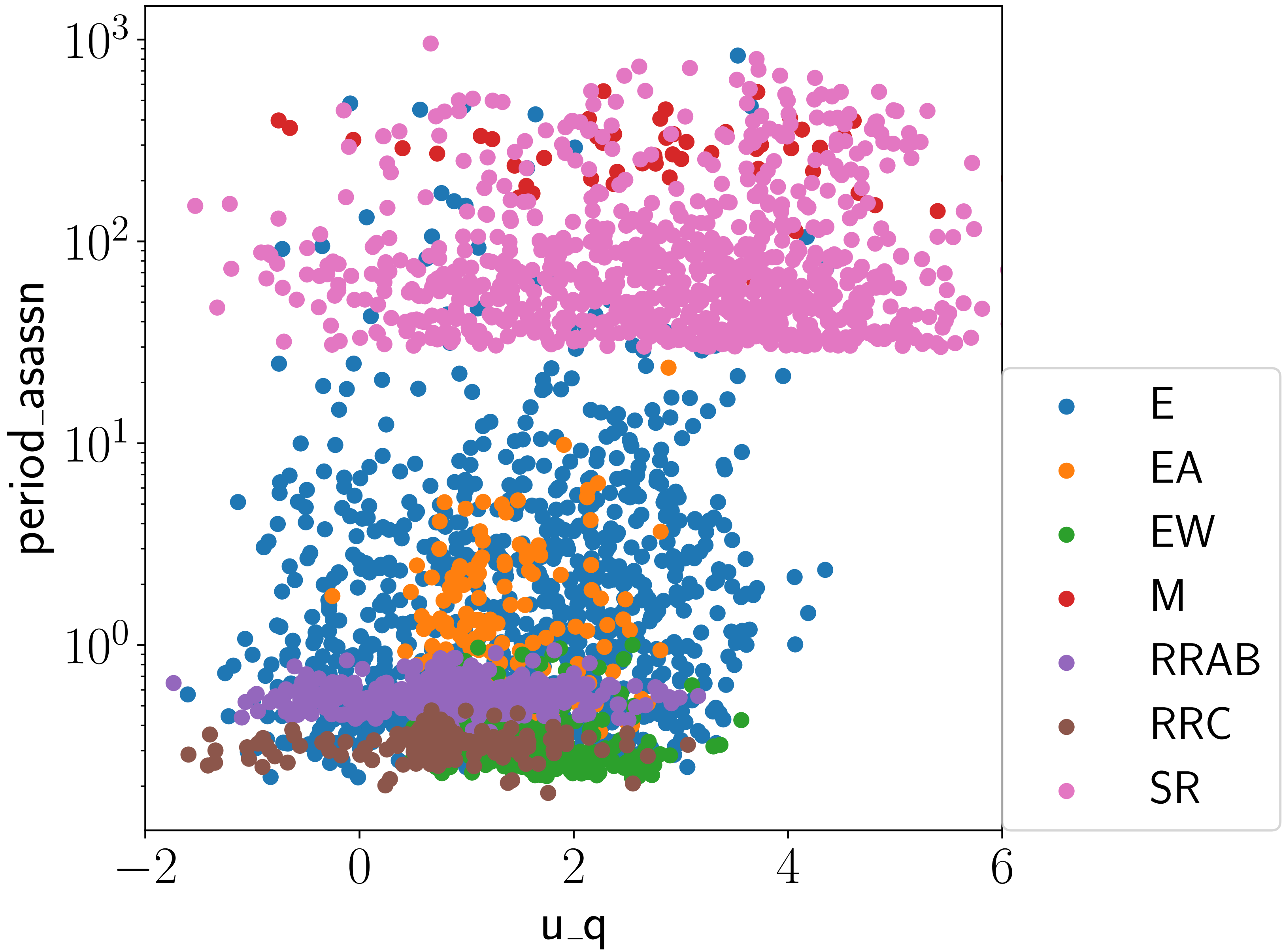


Extracted by Upsilon package

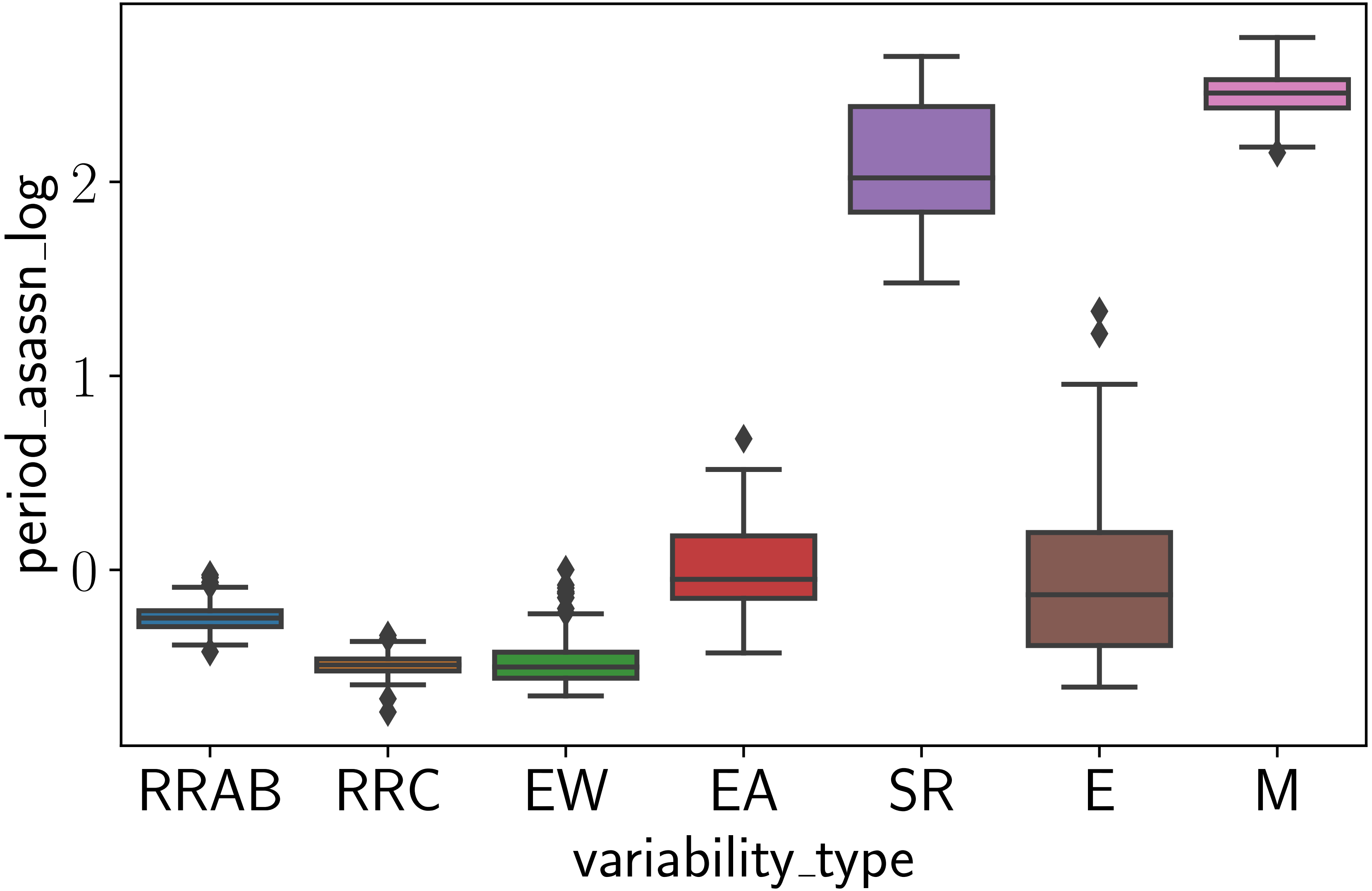
(Kim & Bailer-Jones, 2016)

Steps towards our goals

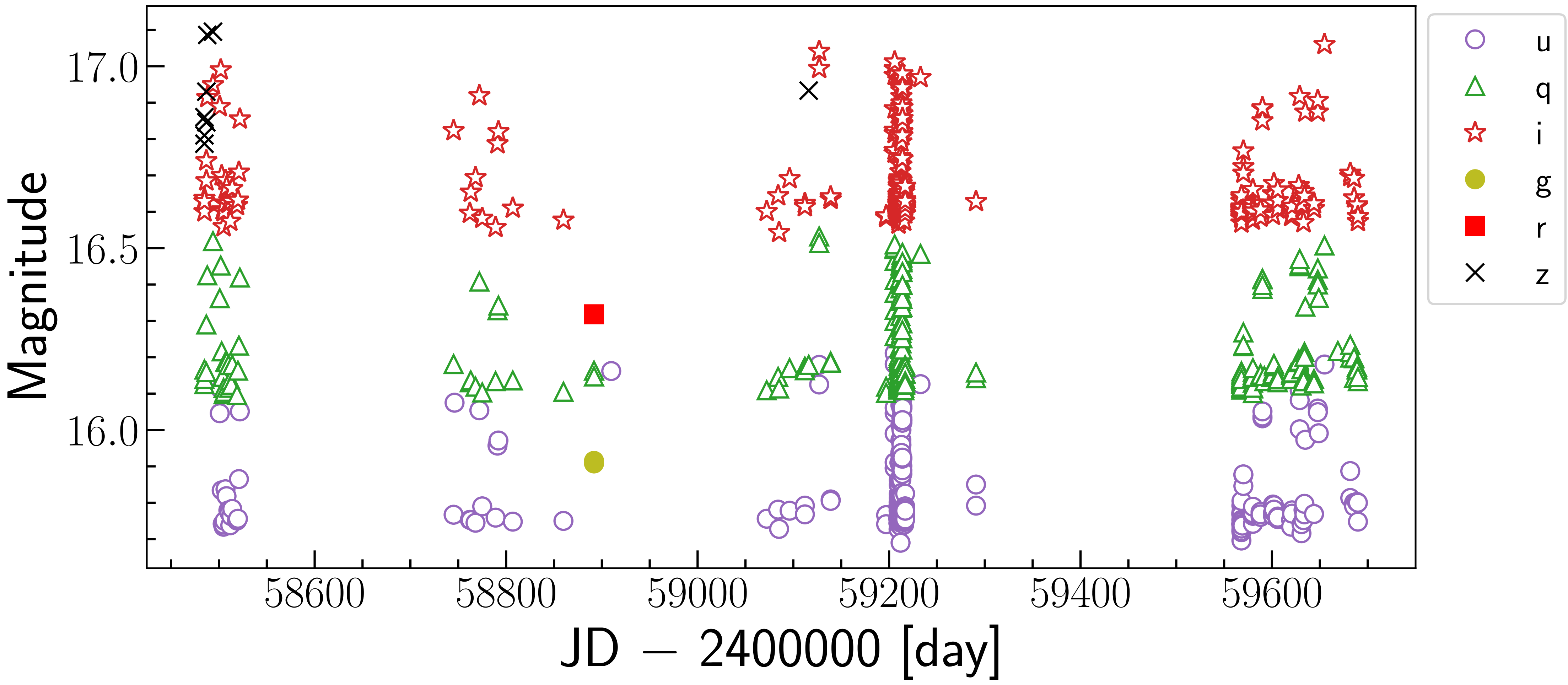
2-D feature space



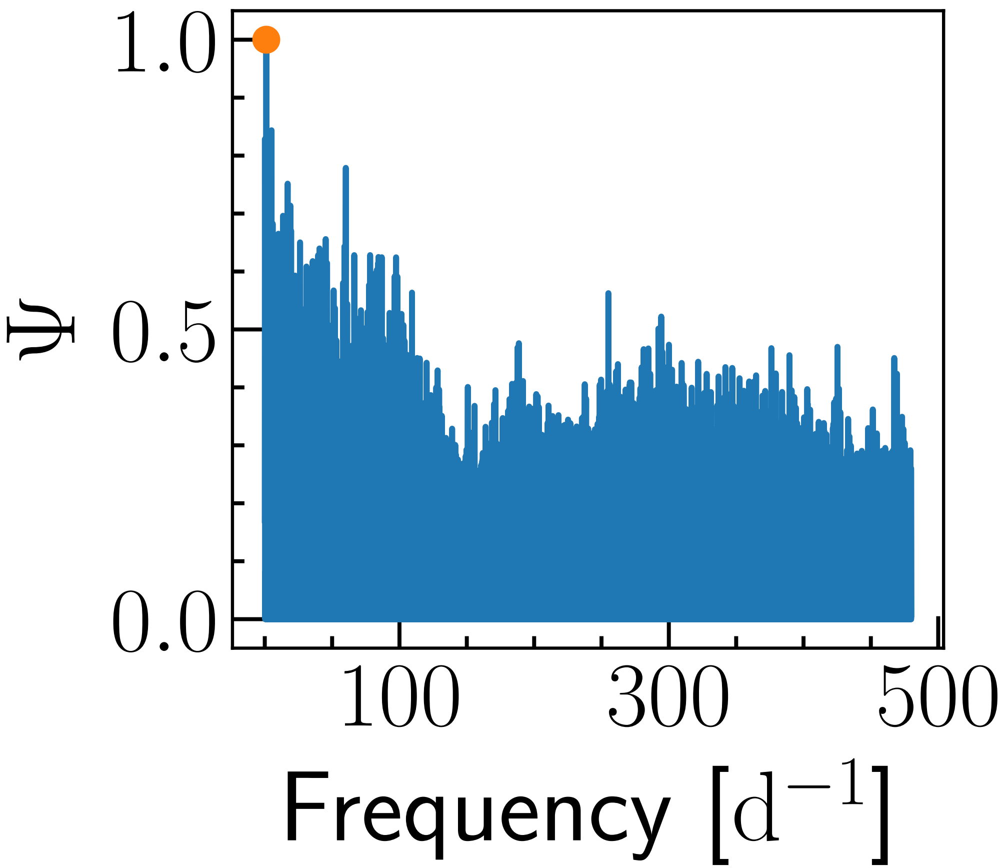
The period and variability type

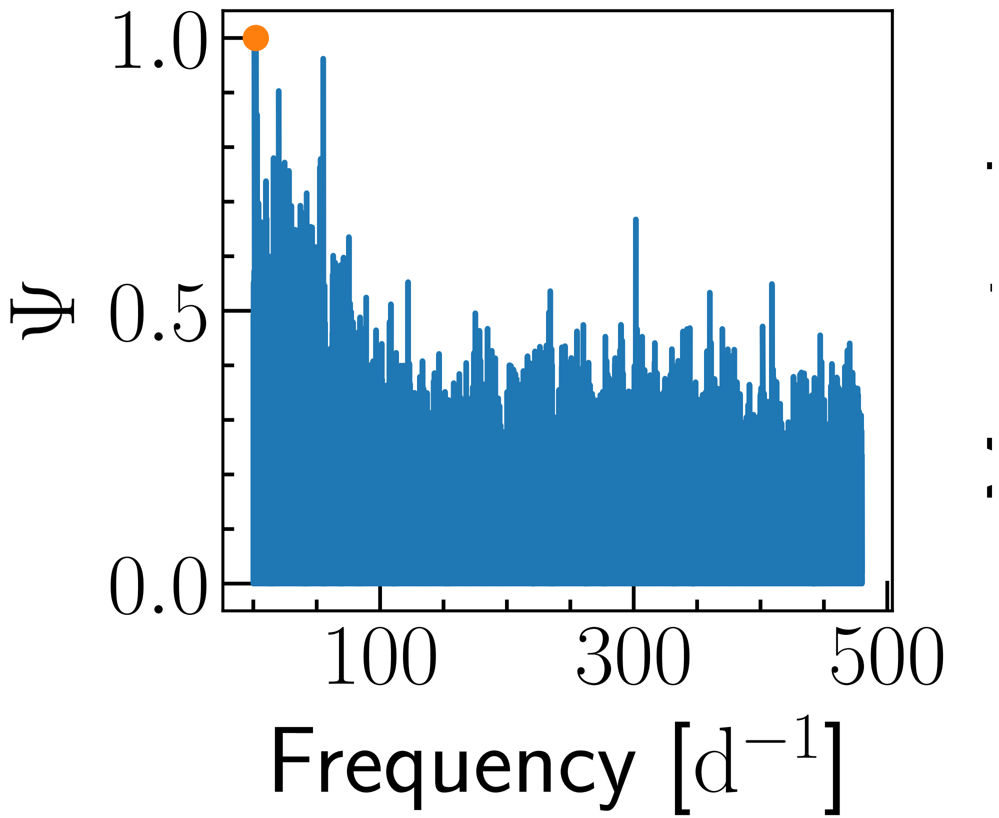


Period finding



Periodograms



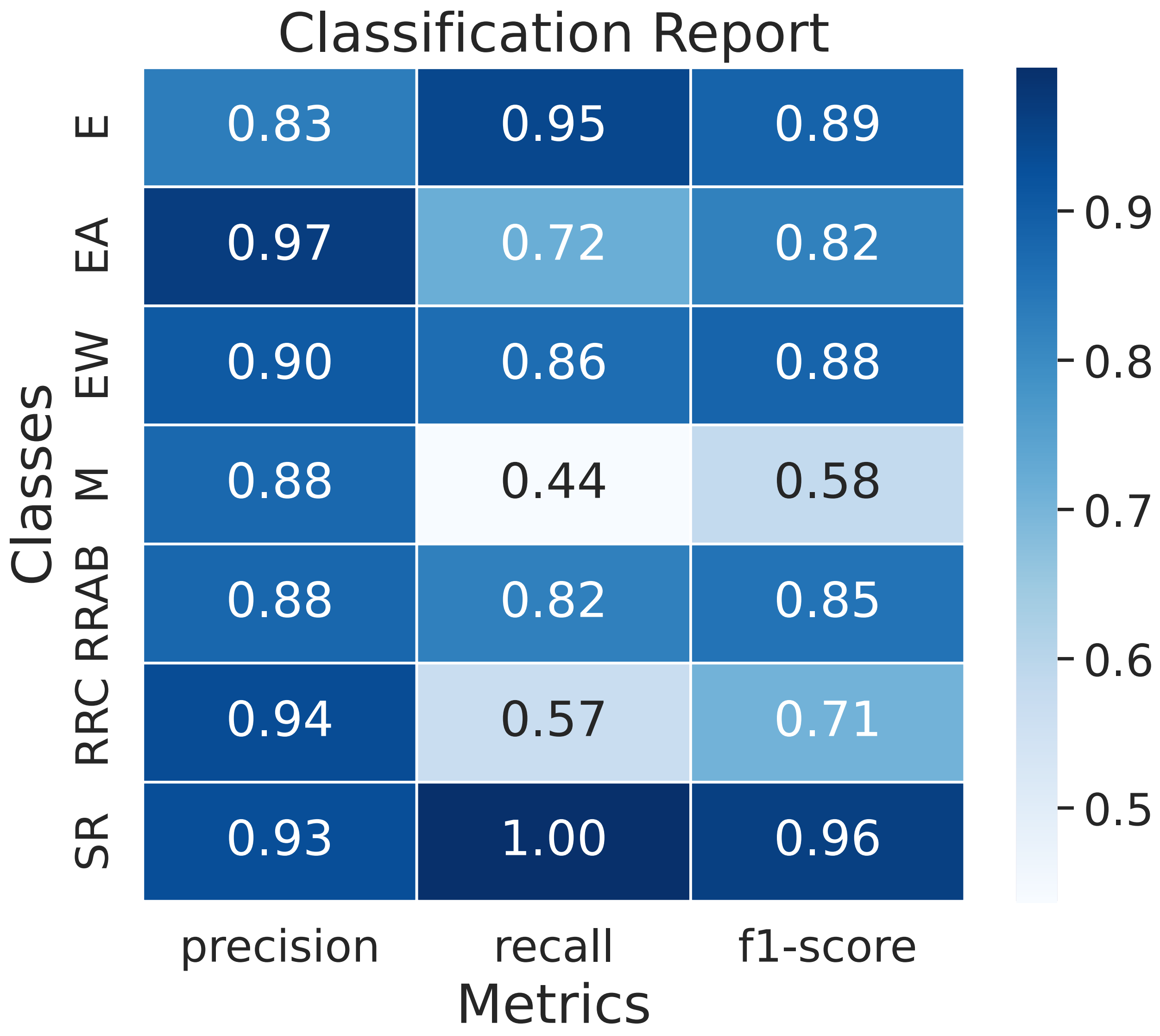


Steps towards our goals

Random Forest performance

1) Data collection and labelling
2) Feature extraction/selection
3) Model selection

4) Model evaluation



Steps towards our goals

Random Forest performance

1) Data collection and labelling
2) Feature extraction/selection
3) Model selection
4) Model evaluation

Confusion matrix

Predicted labels (columns); True labels (rows)

	E	EA	EW	M	RRAB	RRC	SR
E	235	0	1	0	3	0	9
EA	6	28	2	0	3	0	0
EW	3	1	95	0	9	2	0
M	0	0	0	7	0	0	9
RRAB	25	0	1	0	122	0	0
RRC	14	0	6	0	2	29	0
SR	0	0	0	1	0	0	245

Next steps …

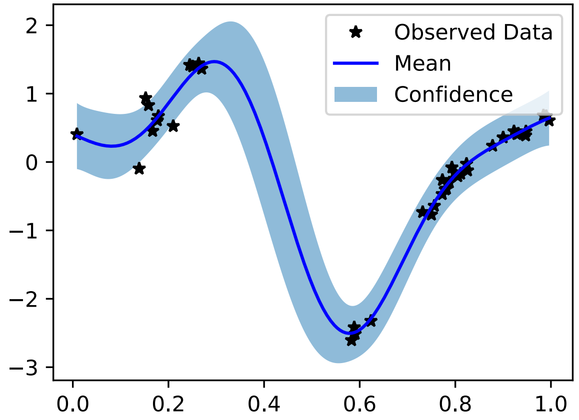
Re-evaluate class labels

	E	EA
E	235	0
EA	6	28

Data augmention

Ensemble learning

Lightcurve modelling with GP



Conclusion

We have seen that

- The period is the most important feature, followed by descriptive statistics.
- Period finding are extremely challenging for unevenly sampled data
- Class imbalance leads to low performance for overlapping classes
- MeerLICHT and BlackGEM have great potential in studying stellar variability

Thank you

A&A 672, A69 (2023)
https://doi.org/10.1051/0004-6361/202245560

Astronomy & Astrophysics

Identifying and characterising the population of hot sub-luminous stars with multi-colour MeerLICHT data★

P. Ranaivomanana[1,2], C. Johnston[1,2], P. J. Groot[1,3,4], C. Aerts[1,2,5,6], R. Lees[4], L. IJspeert[2], S. Bloemen[1], M. Klein-Wolt[1], P. Woudt[4], E. Körding[1], R. Le Poole[7], and D. Pieterse[1]

[1] Department of Astrophysics/IMAPP, Radboud University, PO Box 9010, 6500 GL Nijmegen, The Netherlands
e-mail: princy.ranaivomanana@ru.nl
[2] Instituut voor Sterrenkunde, KU Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium
[3] South African Astronomical Observatory, PO Box 9, Observatory 7935, Cape Town, South Africa
[4] Department of Astronomy & Inter-University Institute for Data Intensive Astronomy, University of Cape Town, Private Bag X3, 7701 Rondebosch, South Africa
[5] Max Planck Institute for Astronomy, Koenigstuhl 17, 69117 Heidelberg, Germany
[6] Guest Researcher, Center for Computational Astrophysics, Flatiron Institute, 162 Fifth Ave, New York, NY 10010, USA
[7] Leiden Observatory, Leiden University, PO Box 9513, 2300 RA Leiden, The Netherlands

Received 28 November 2022 / Accepted 5 February 2023

ABSTRACT

Context. Colour–magnitude diagrams reveal a population of blue (hot) sub-luminous objects with respect to the main sequence. These hot sub-luminous stars are the result of evolutionary processes that require stars to expel their obscuring, hydrogen-rich envelopes to reveal the hot helium core. As such, these objects offer a direct window into the hearts of stars that are otherwise inaccessible to direct observation.