An all-sky stellar variability machine learning classification framework for TESS and PLATO

ESA/ESO SciOps 2022: Artificial Intelligence for Science and Operations in Astronomy
May 16 - 20, 2022

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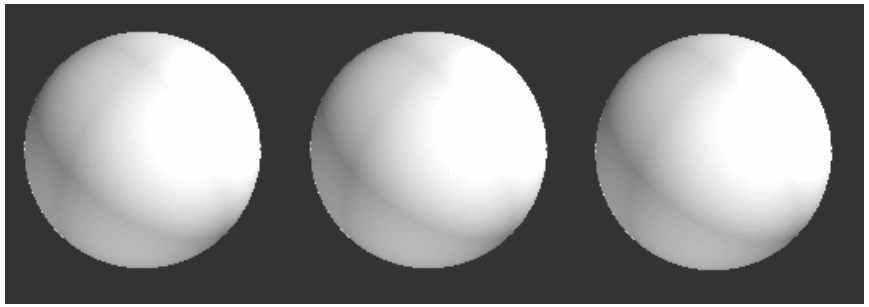
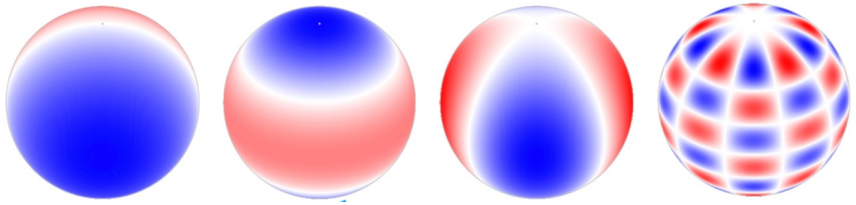
Stellar variability

Credit: Joey Mombarg





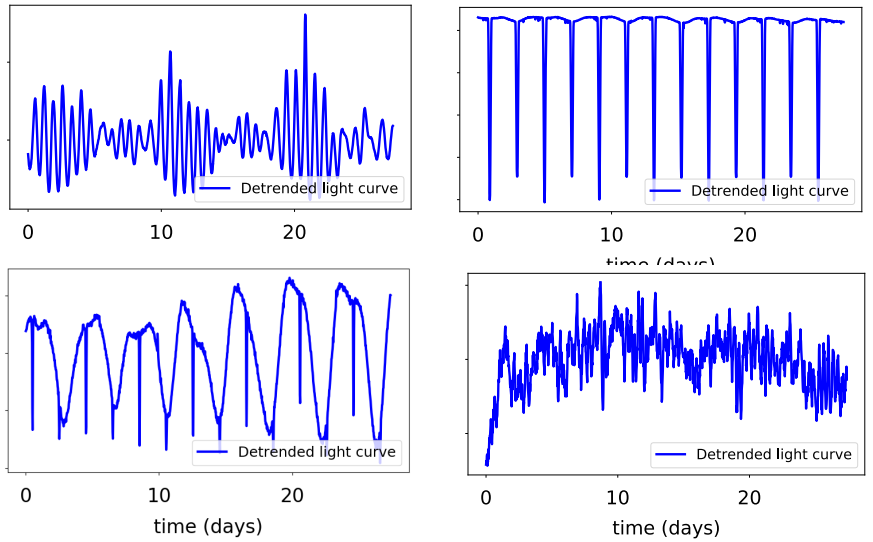
Credit: Aerts et al. (2010)

Surface of a **pulsating** star:
red and blue are hotter and cooler regions
alternating during the pulsation cycle

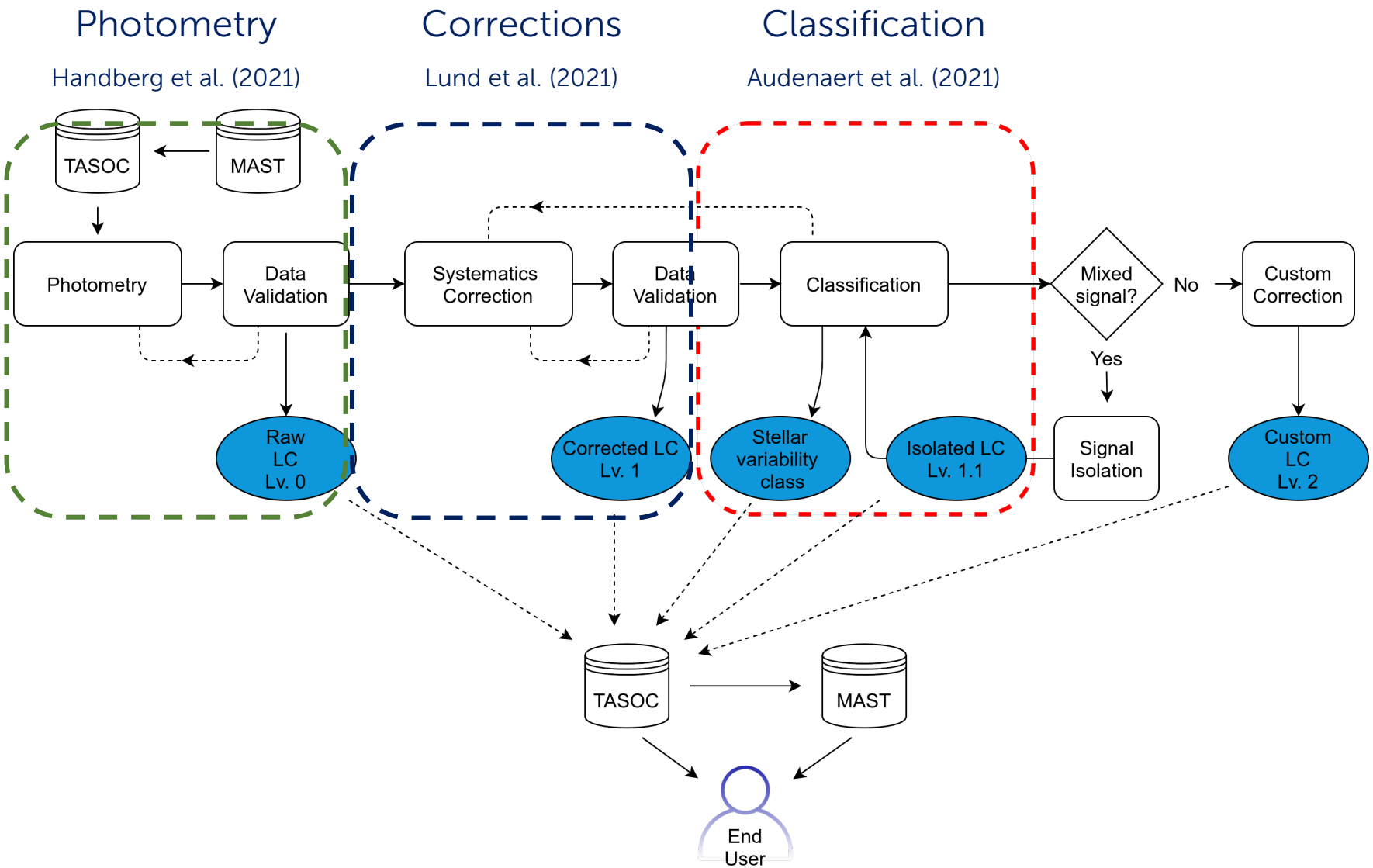
TESS

Credit: NASA Goddard Space Flight Center

Light curves



T'DA Variability Processing Pipeline



arXiv:2106.08341
arxiv:2108.11780
arXiv:2107.06301

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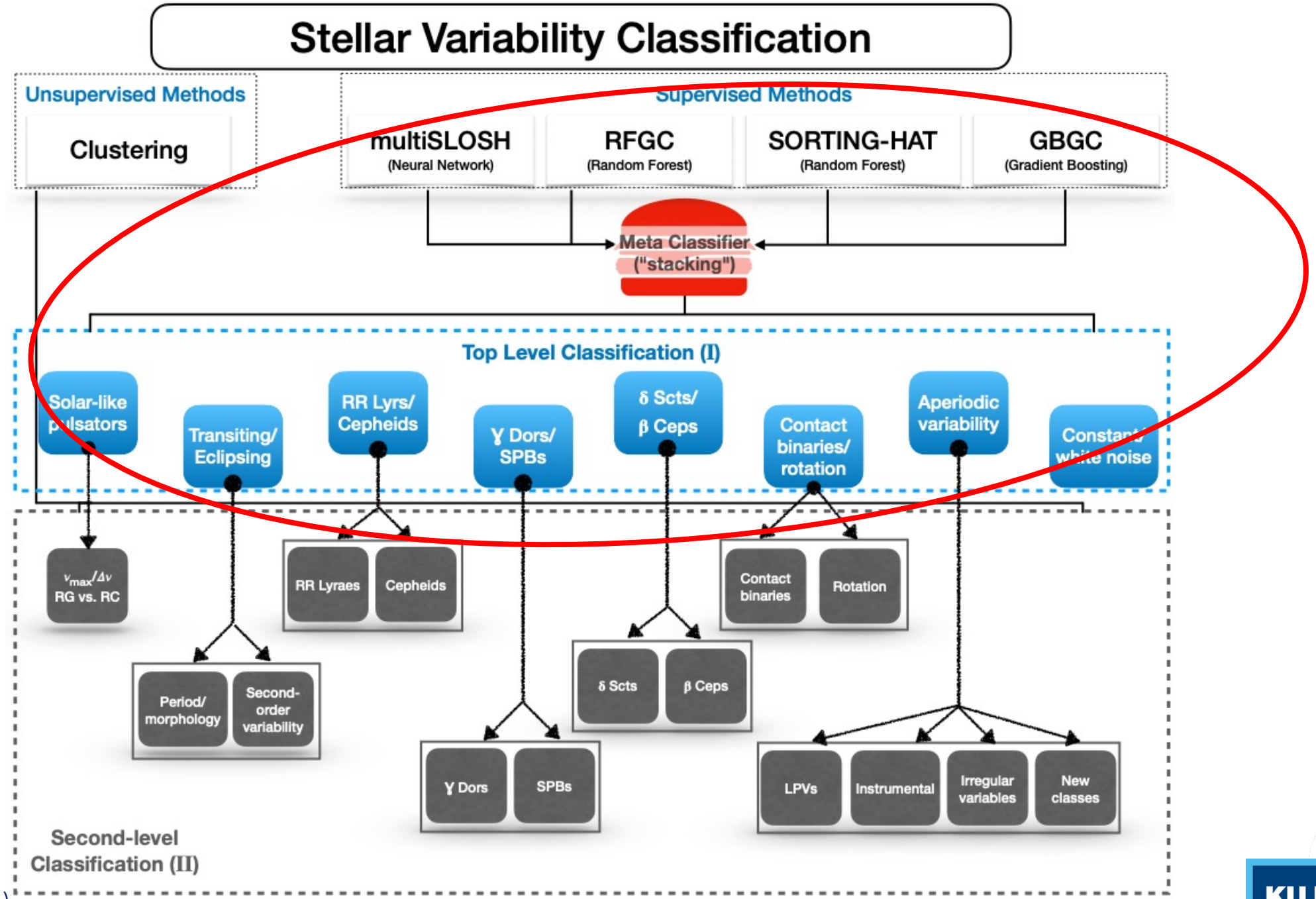
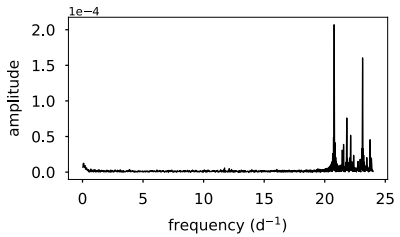


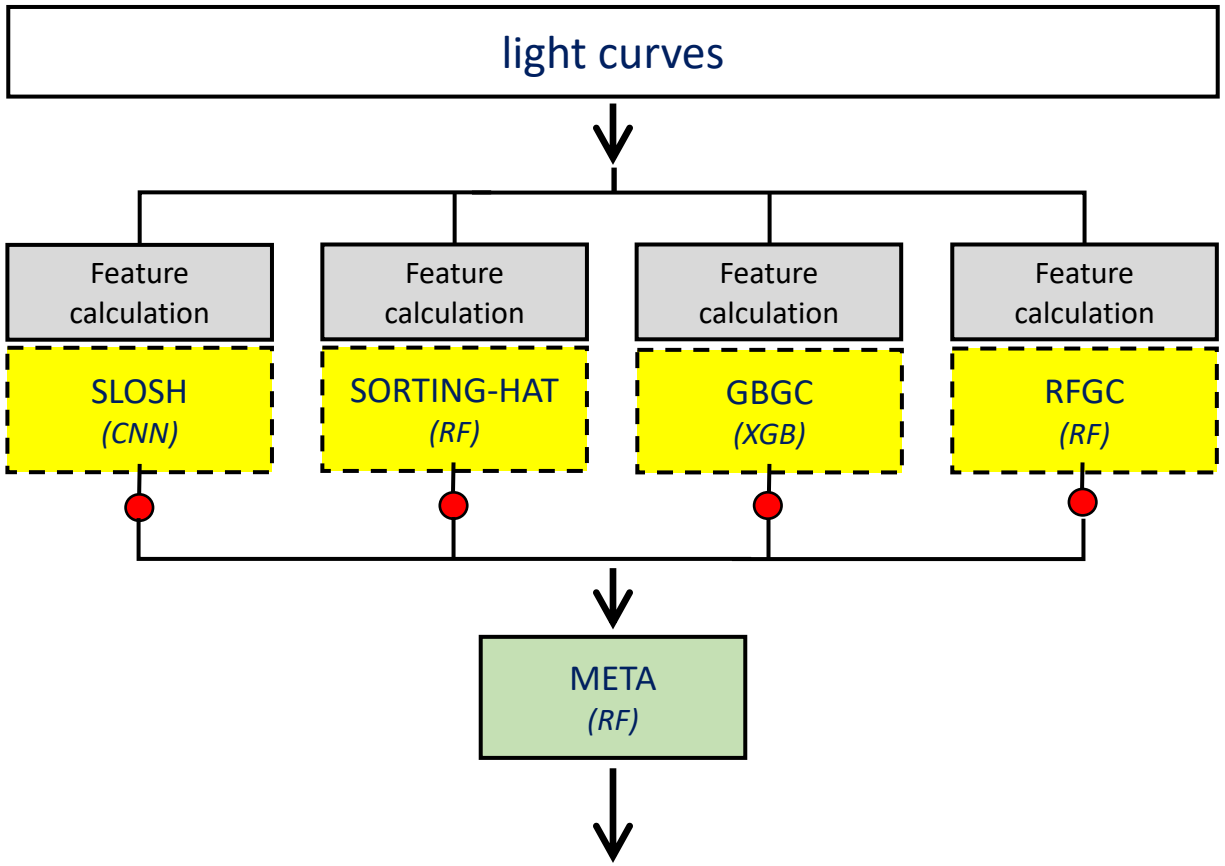
Audenaert et al. (2021)

Classification scheme

Different feature sets per classifier

e.g. Fourier domain, time domain, entropy, SOM...





general classification (Level 1)

https://github.com/tasoc/starclass

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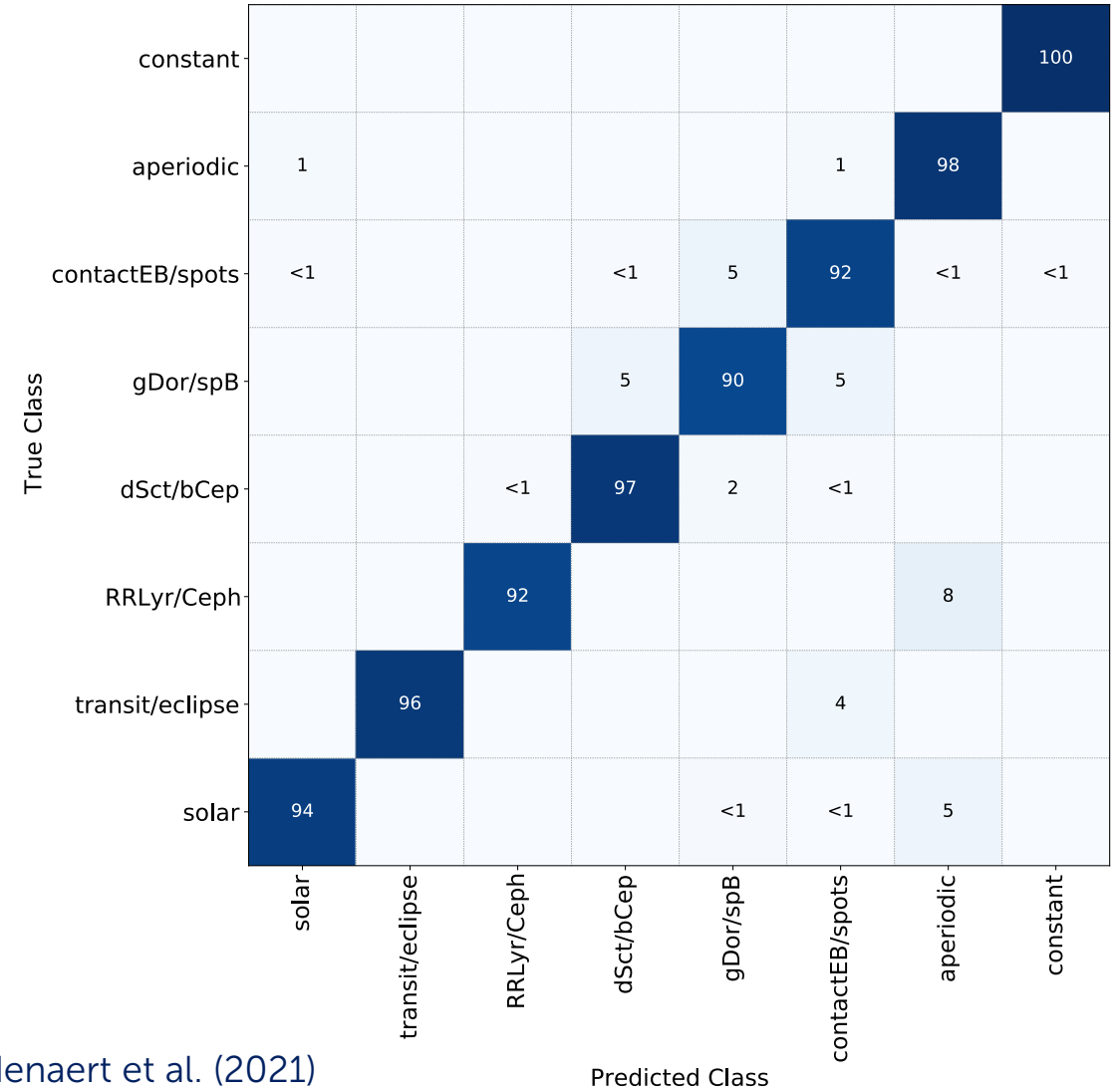
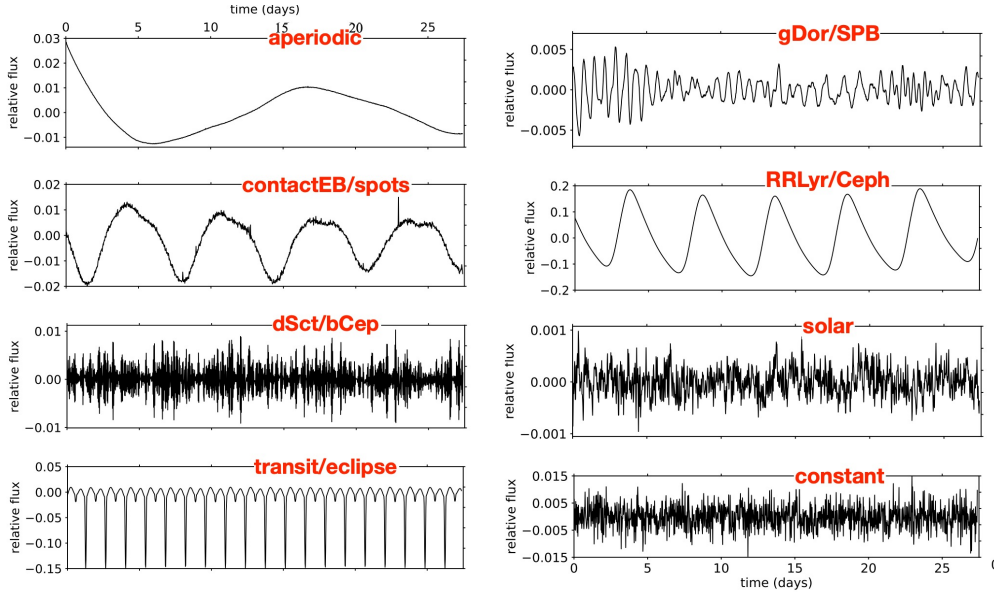
Results (metaclassifier)





Audenaert et al. (2021)

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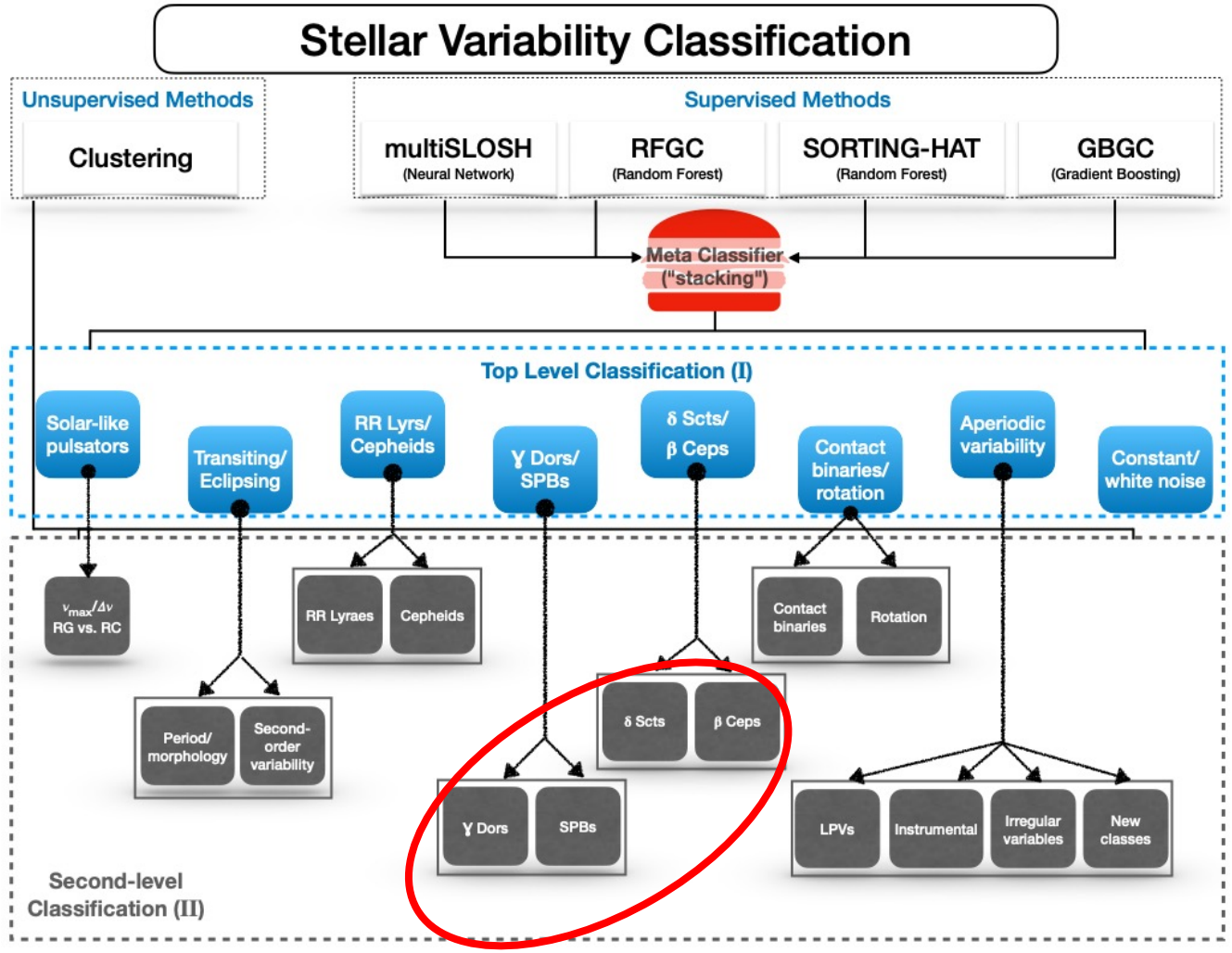
Transferring from Kepler to TESS

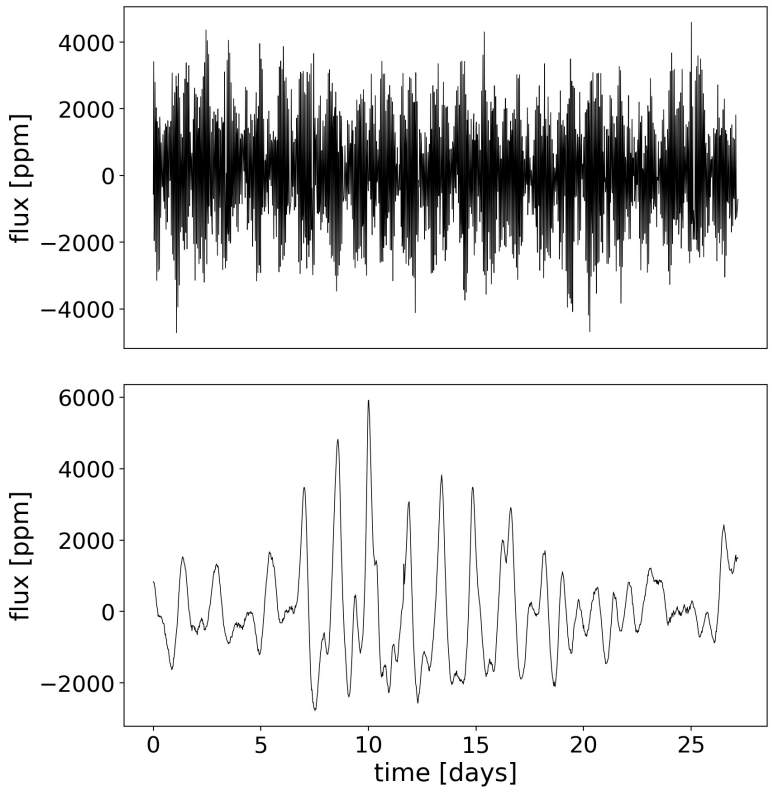
- Iterative procedure in which the training set is continuously updated
  - Kepler-trained classifier predicts on TESS
  - Good classifications are selected and added to the training set
  - Predict on TESS again with new training set
  - Repeat
- Complement this with exisiting targets from the literature

Discovering subclusters of hybrid pulsators

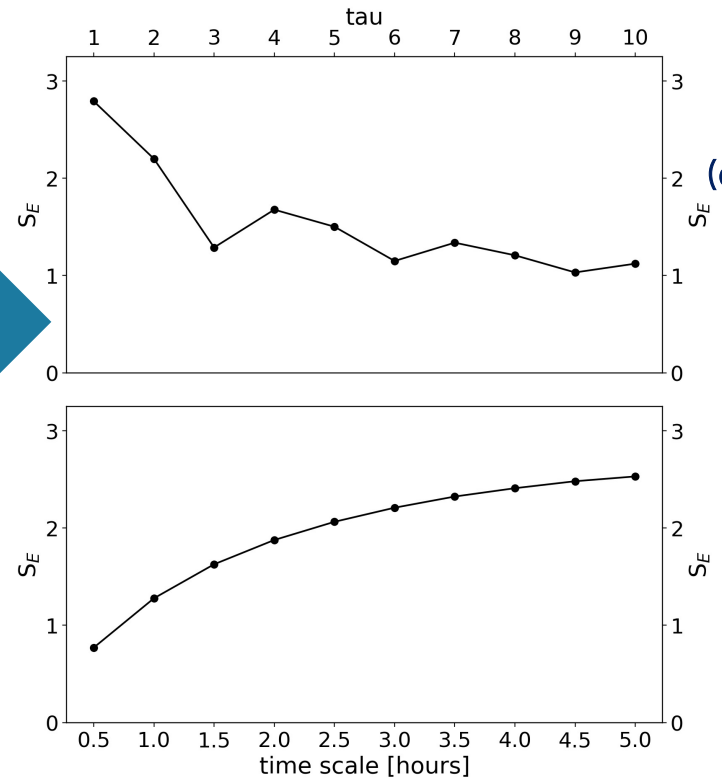


Discovering subclusters of hybrid pulsators with the multiscale entropy

Light curves



Multiscale Entropy ("complexity")

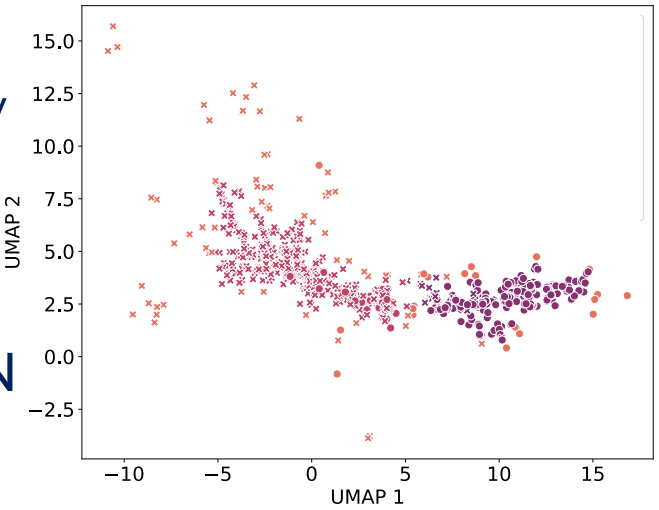


UMAP (dimensionality reduction)

+

HDBSCAN (clustering)

Clusters



Audenaert & Tkachenko (submitted)

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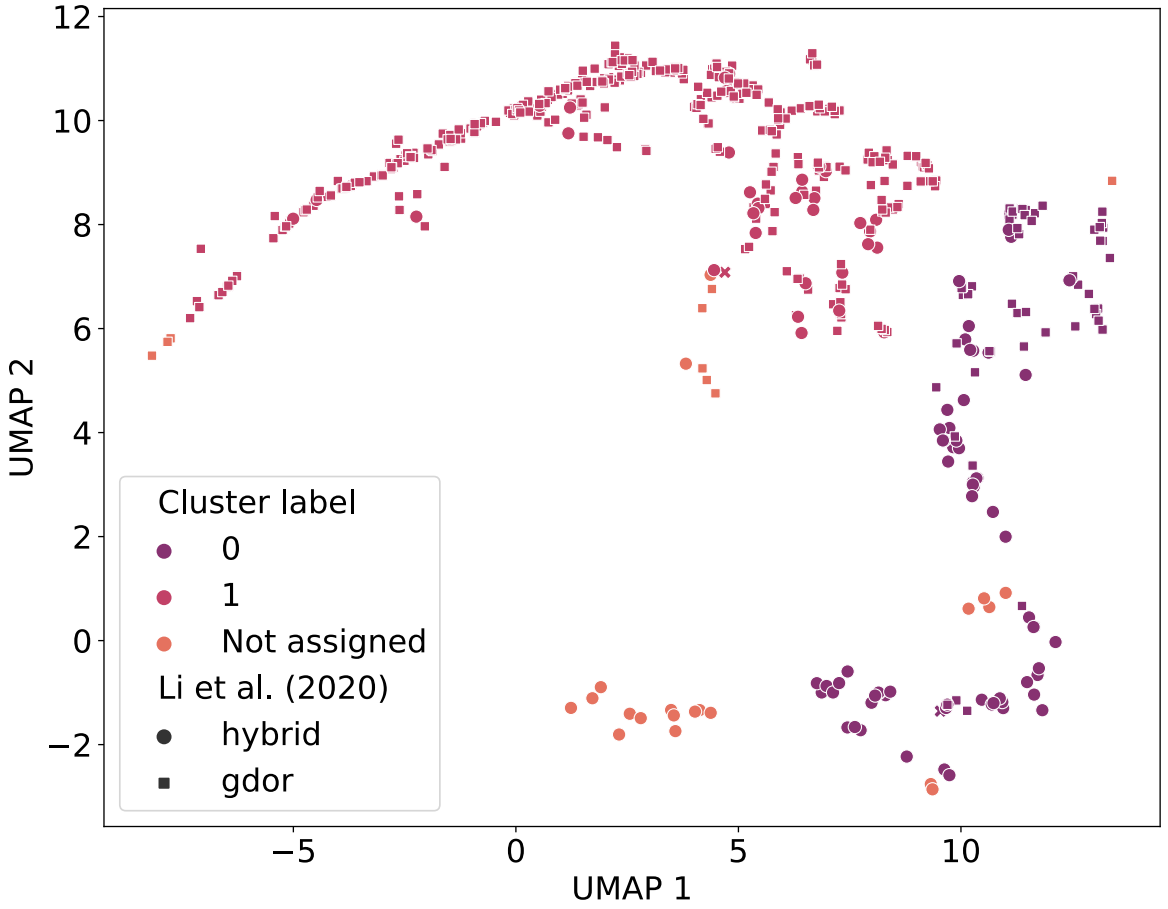
γ Dor catalog (Li et al. 2020)



Visual inspection from Li et al. (2020)

Cluster	γ Dor	hybrid	
0	59 *(12.0%)*	69 *(59.0%)*	130
1	426 *(87.2%)*	35 *(29.9%)*	462
Not assigned	3	13	16
	488	117	605

Table 2. Confusion matrix of the cluster assignments calculated with HDBSCAN and the class labels assigned by Li et al. (2020) based on visual inspection. The percentages are expressed in terms of the column total.

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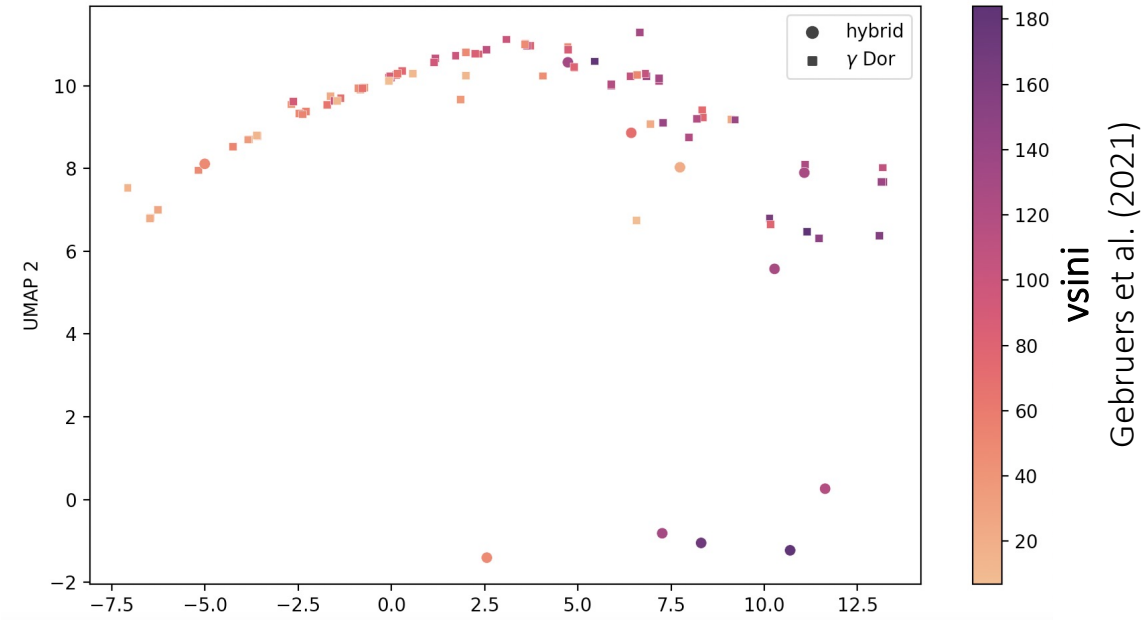
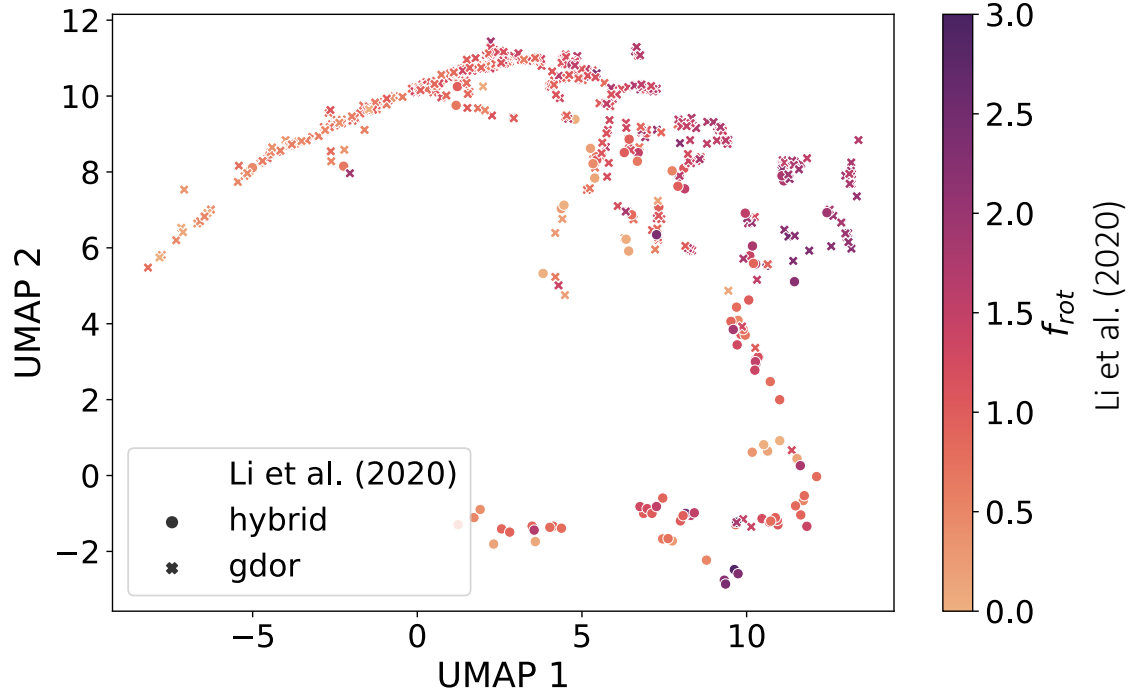
Couple with spectroscopy (FEROS/UVES) & asteroseismology





Audenaert & Tkachenko (submitted)

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Value for PLATO mission

- PLATO Input Catalog
  - PLATO Consortium can select most important stars from our detailed classifications that have to be observed
- Core science program
  - Solar-like (-type) pulsator in combination with brightness of the star (for spectroscopic follow-up).
- Complementary science program
  - γ Dor stars (specific f_{rot})
  - hybrid pulsators
  - …

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Conclusion

- Supervised classifier for high-level variability type classification
- Unsupervised classification for subclassification of pulsators
  - No transfer learning and no training set required
  - Ability to discover misclassifications and new subclasses
  - Couple with spectroscopy for physical insights
- Classifications can be used by PLATO consortium for input catalog

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