Machine learning in APOGEE: Unsupervised spectral classification with K-means

Rafael A. Garcia-Dias

Instituto de Astrofísica de Canarias - IAC

Supervisors:

Carlos Allende Prieto

Jorge Sánchez Almeida

May 23th, 2017

Machine learning vs. AI

Machine learning

"such algorithms overcome following strictly static program instructions by making data-driven predictions or decisions."

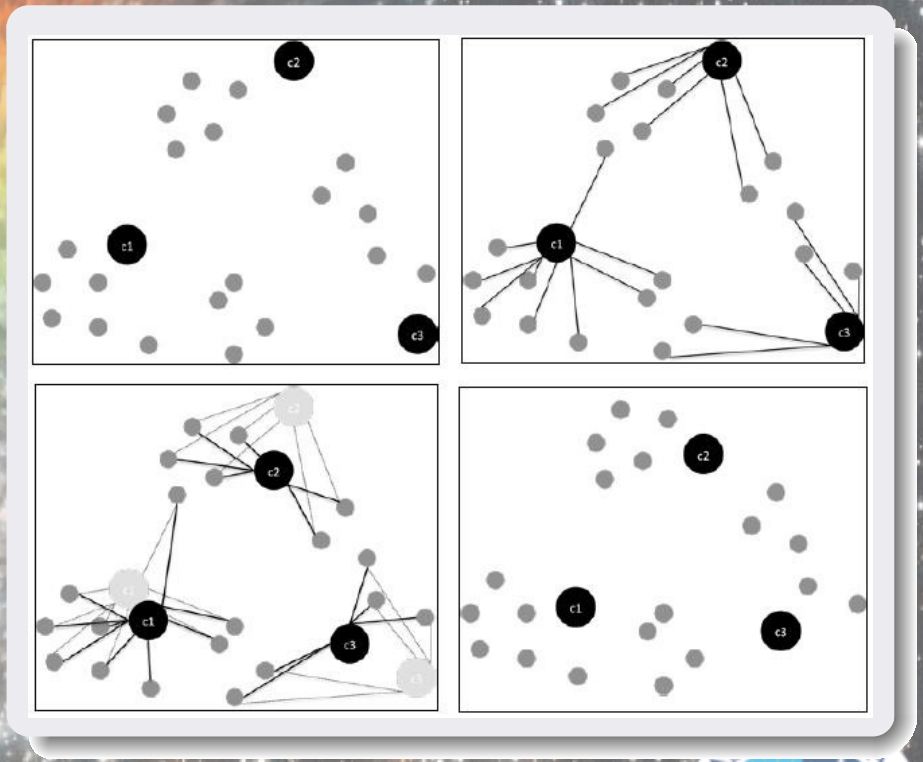
Artificial Intelligence

"the term *artificial intelligence* is applied when a machine mimics *cognitive* functions that humans associate with other human minds."

K-means

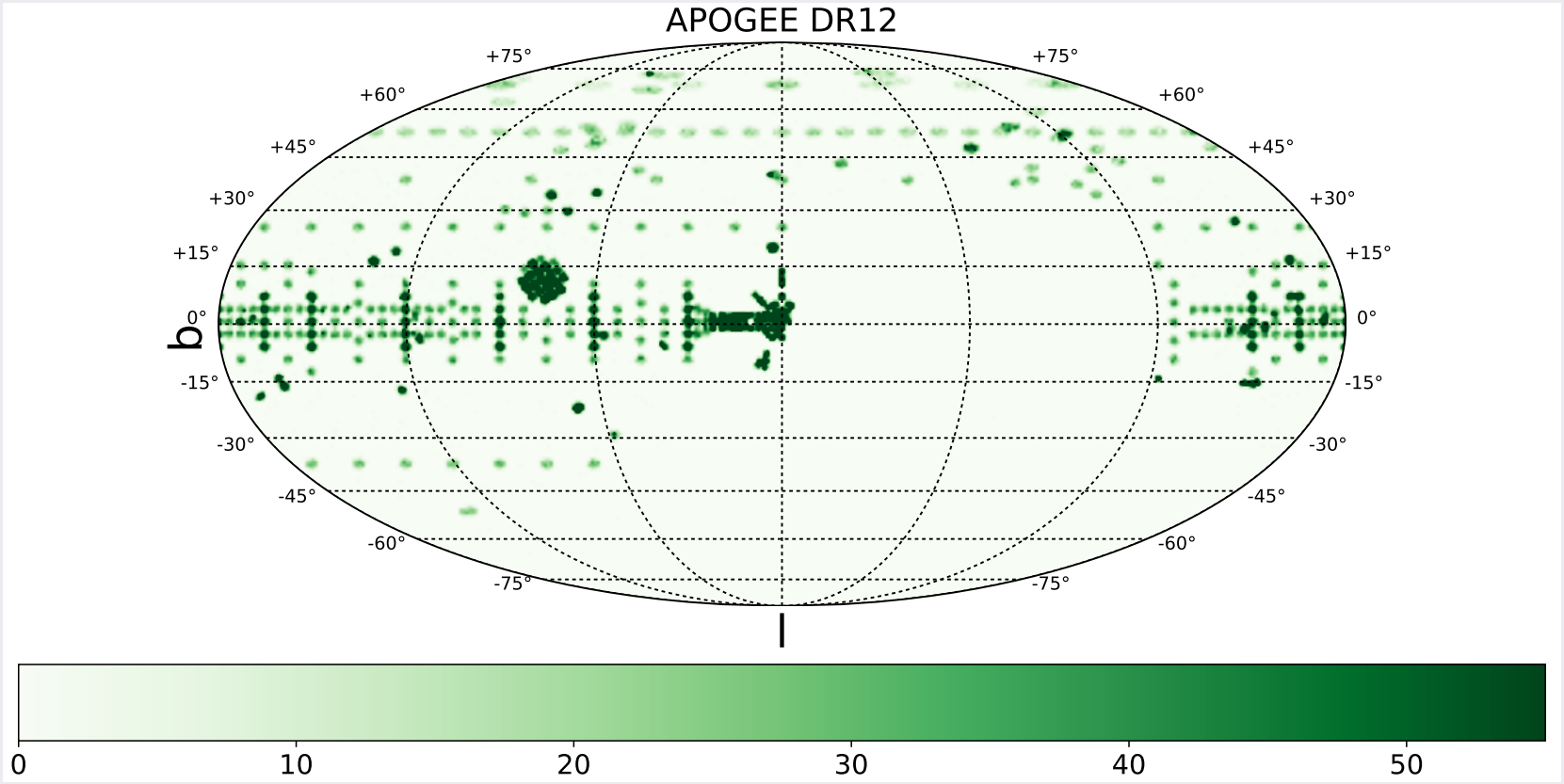
Algorithm

- Choose initial centroids;
- While != Stability condition:
  - Assign objects to the nearest centroid;
  - Recalculate centroids as the mean of the objects in each class;
- Finish.
- Repeat as many times you need to be sure the random initialization doesn't affect the results.

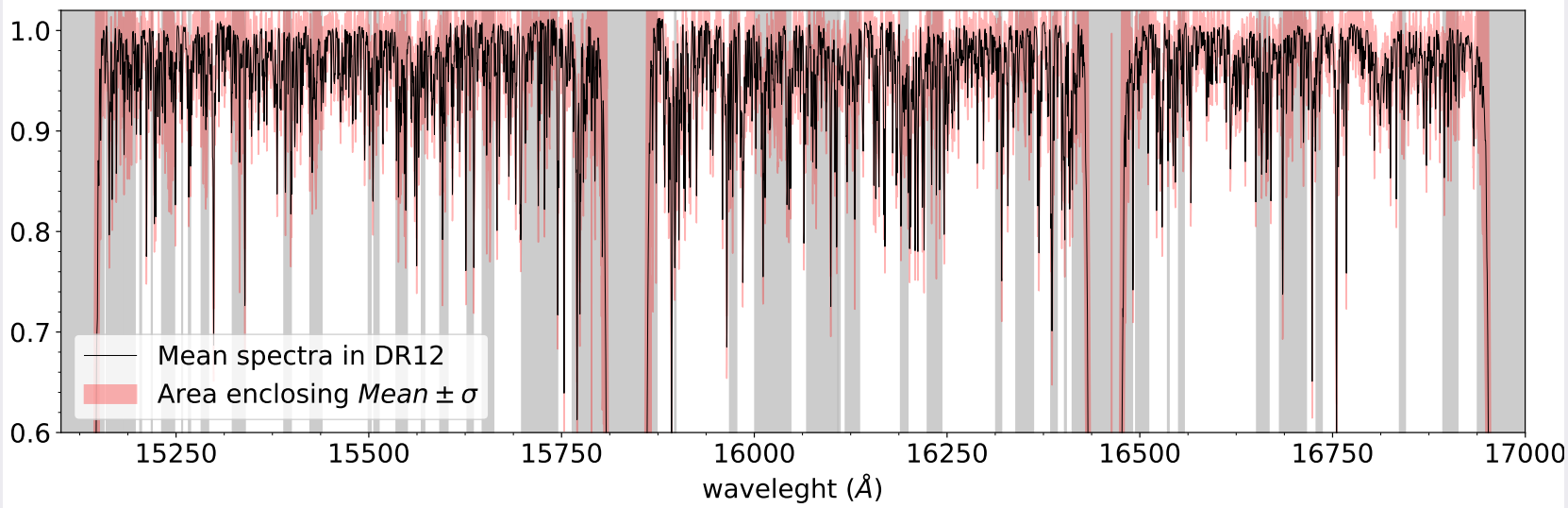


Data

153,847 stars



Data

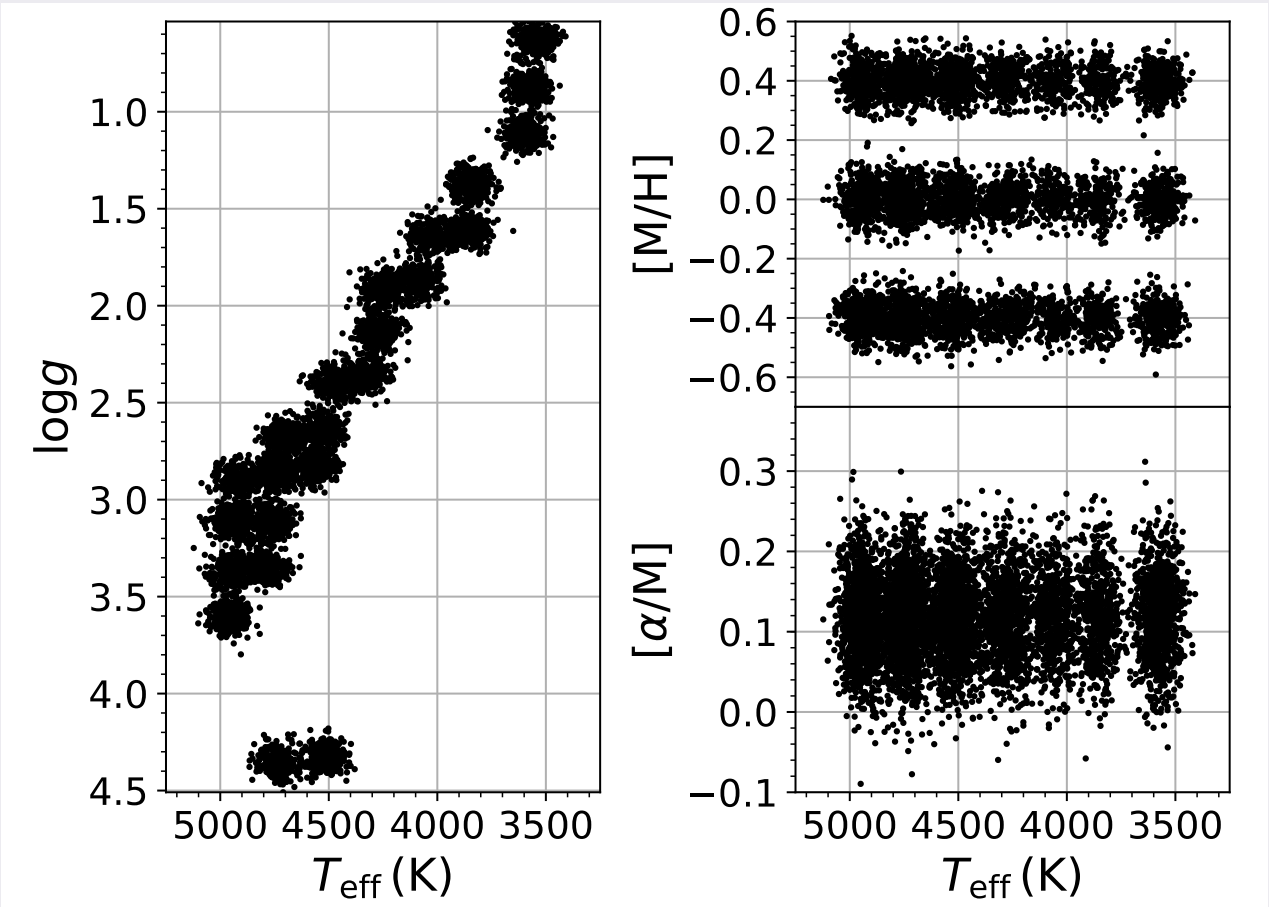


Mask

- Mask were based in telluric absorption and sky emittions.
- We use 4838 pixels from the 8575 pixels in APOGEE.

Mock data

Ferre interpolated Kurucz spectral models



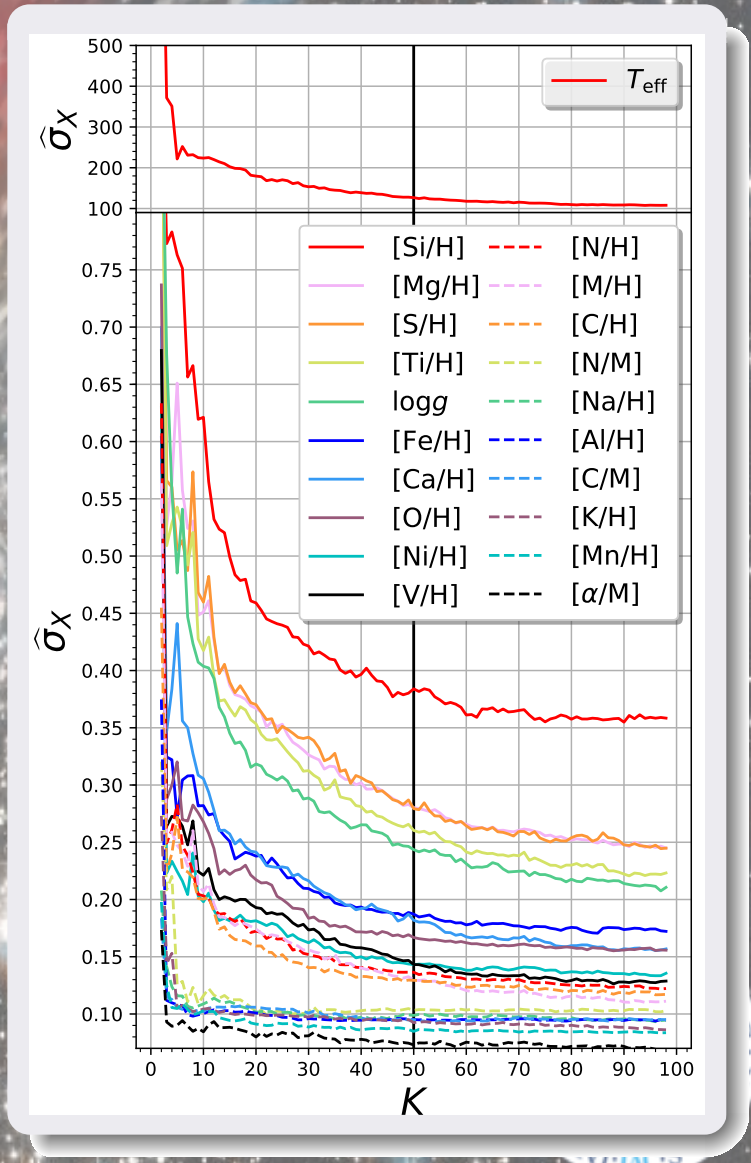
https://github.com/callendeprieto/ferre

Choosing K

Median within cluster σ

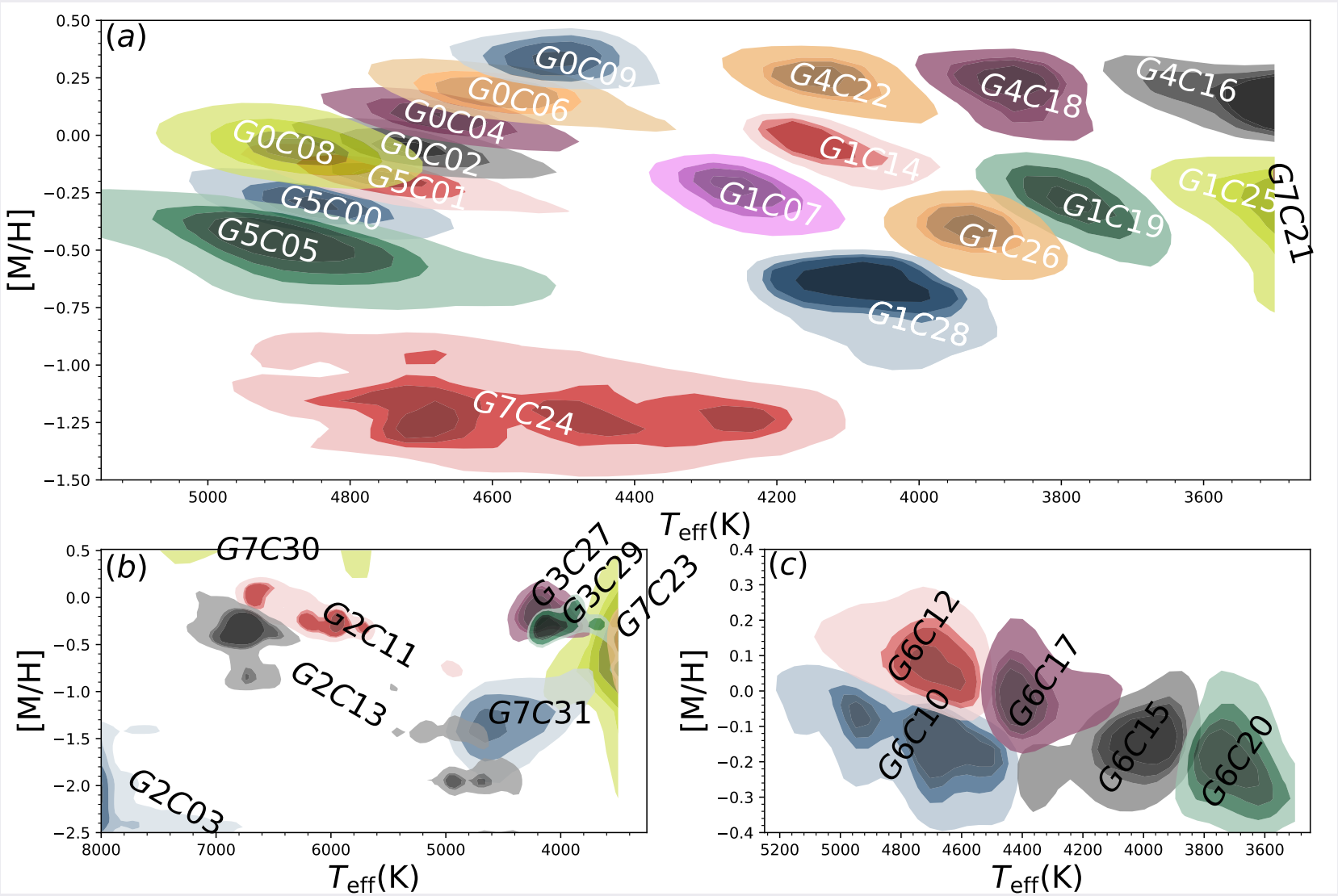
K was chosen based in the variation of the median within cluster standard deviation with K.

$$\lim_{K \to \infty} \frac{d\widehat{\sigma}}{dK} \to 0$$



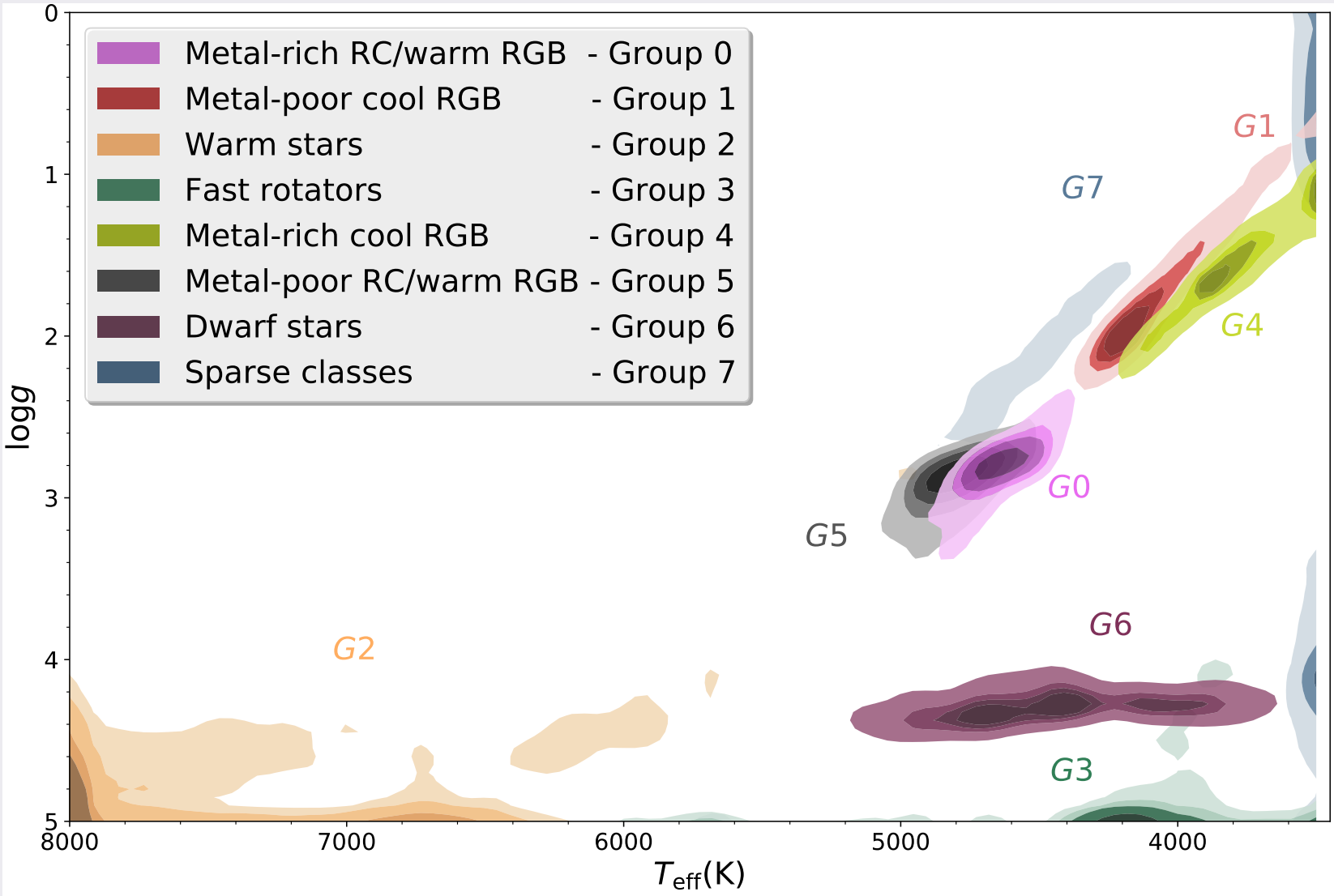
Final classification

32 classes contain 99% of the stars.



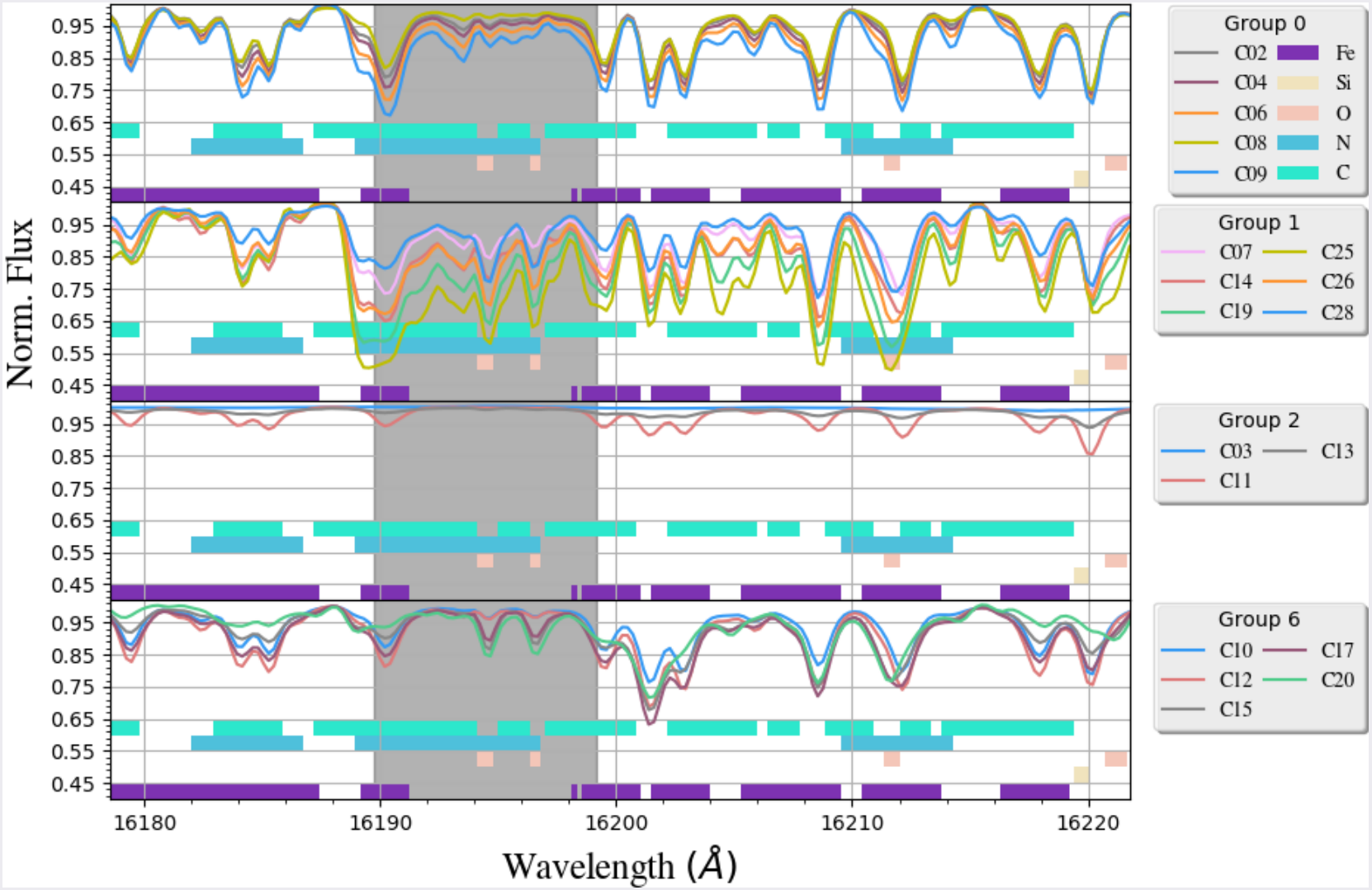
Final classification

Groups



Final classification

Mean spectra for classes



Summary

Table A1. Summary of the classes and complementary material.

Group	Class[a]	Stellar type[b]	Gal. component[c]	Comment
Metal-rich RC and RGB				
0	Class 02	K-Giants	Thin disk	Lowest [M/H] in the group, 31% RC.
0	Class 04	K-Giants	Thin disk	26% RC
0	Class 06	K-Giants	Thin disk	26% RC
0	Class 08	Sub Giants, K-Giants	Thin disk	Warmest in the group, 1% RC.
0	Class 09	K-Giants	Thin disk	[M/H] near to grid limits, 21% RC.
Metal-poor cool RGB				
1	Class 07	K-Giants	Disk	Thick disk.
1	Class 14	K-Giants	Disk	—
1	Class 19	K/M-Dwarfs	Disk	$T_{\rm eff}$ near to the grid limits.
1	Class 25	M-Giants	Disk	$T_{\rm eff}$ near to the grid limits.
1	Class 26	K-Giants	Disk	High alpha blob.
1	Class 28	K-Giants	Bulge/centre	Most metal-poor stars.
Warm stars				
2	Class 03	Blue stars	Disk	Warmest telluric standards
2	Class 11	F/G-Dwarfs	High g. latitude	Warm, telluric standards.
2	Class 13	Blue stars	—	Warm fast rotation stars. Telluric standards.
Fast rotators				
3	Class 27	K/M-Dwarfs	—	Fast rotators.
3	Class 29	M-Dwarfs	—	Fast rotators.
Metal-rich cool RGB				
4	Class 16	K/M-Giants	Disk	$T_{\rm eff}$ near to the grid limits.
4	Class 22	K-Giants	Thin disk	[M/H] near to the grid limits.
Metal-poor RC and RGB				
5	Class 00	K-Giants	Disk	Broad in atmospheric parameters.
5	Class 01	K-Giants	Disk	Whole RGB
5	Class 05	Sub Giants, G/K-Giants	Disk	Broad in atmospheric parameters.
Dwarf stars				
6	Class 10	G/K-Dwarfs	Thin disk	—
6	Class 12	K-Dwarfs	Thin disk	—
6	Class 15	K-Dwarfs	High g. latitude	—
6	Class 17	K-Dwarfs	Thin disk	—
6	Class 20	M-Dwarfs	High g. latitude	Atmospheric parameter near to the grid limits.
Sparse classes				
7	Class 21	M-Giants	Bulge/Centre/Disk	Atmospheric parameter near to the grid limits.
7	Class 23	M-Dwarfs	—	Atmospheric parameter near to the grid limits.
7	Class 24	Giants	Halo	High alpha metal-poor stars.
7	Class 30	—	—	Poor fit, M31 clusters, high g. latitude.
7	Class 31	Giants	High g. latitude	metal-poor high [α/M].

Thank you

Paper

- https://garciadias.github.io/cv/k-means-apogee.pdf

Contact

- rafaelagd@gmail.com

Soon the code will be available in

- https://garciadias.github.io/StarClustering/

APOGEE links

- Link to SDSS-IV Paper 0144
- Browse coauthor requests for SDSS-IV Paper 0144
- Request coauthorship for SDSS-IV Paper 0144
- Link to SDSS-IV Project 0319: Automated algorithm for spectroscopic classification and aplications to APOGEE