Activity-sensitive spectral lines of M dwarfs in the CARMENES visible and near-infrared spectral range: impact on radial velocity determinations and stellar parameters determination

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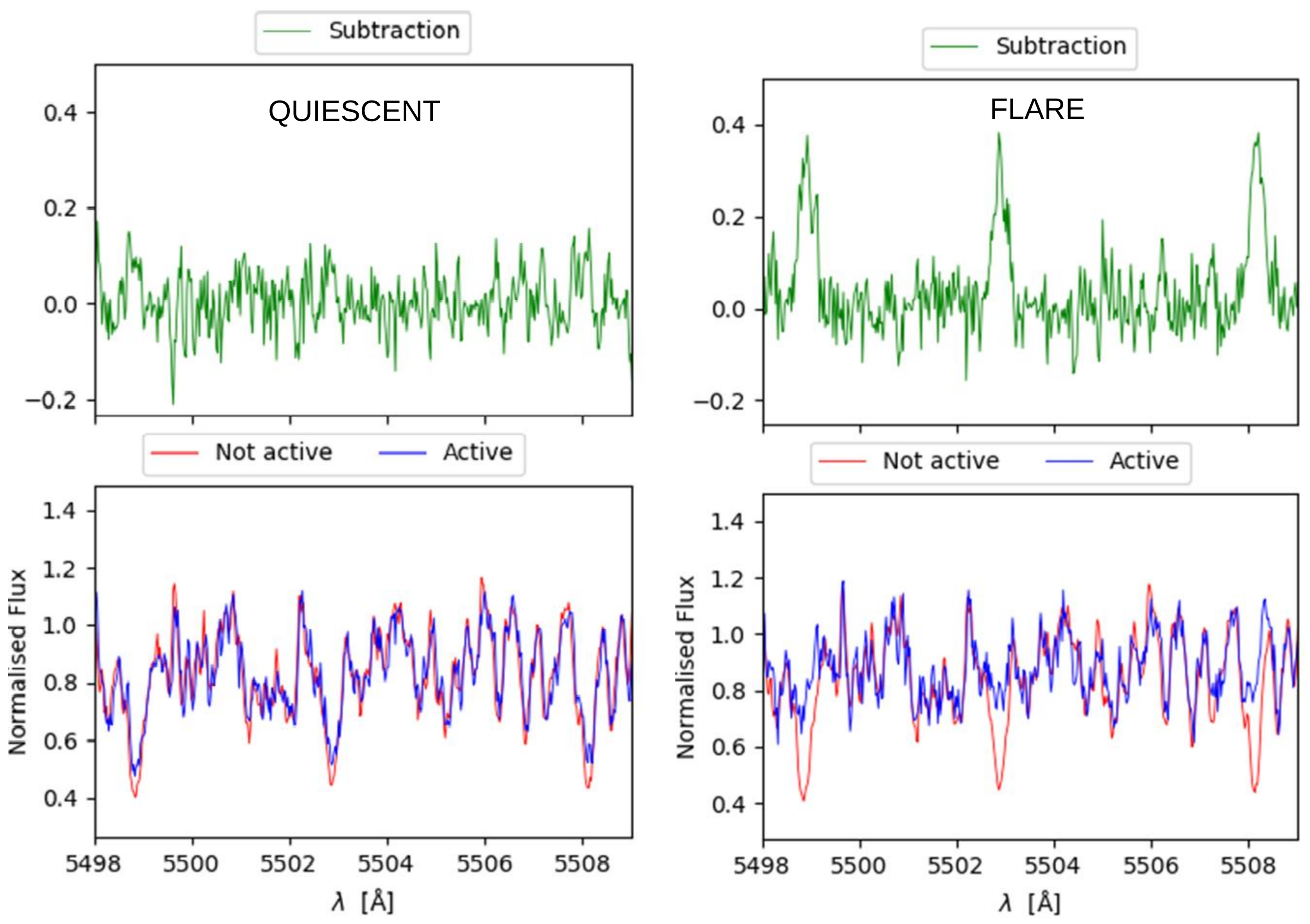
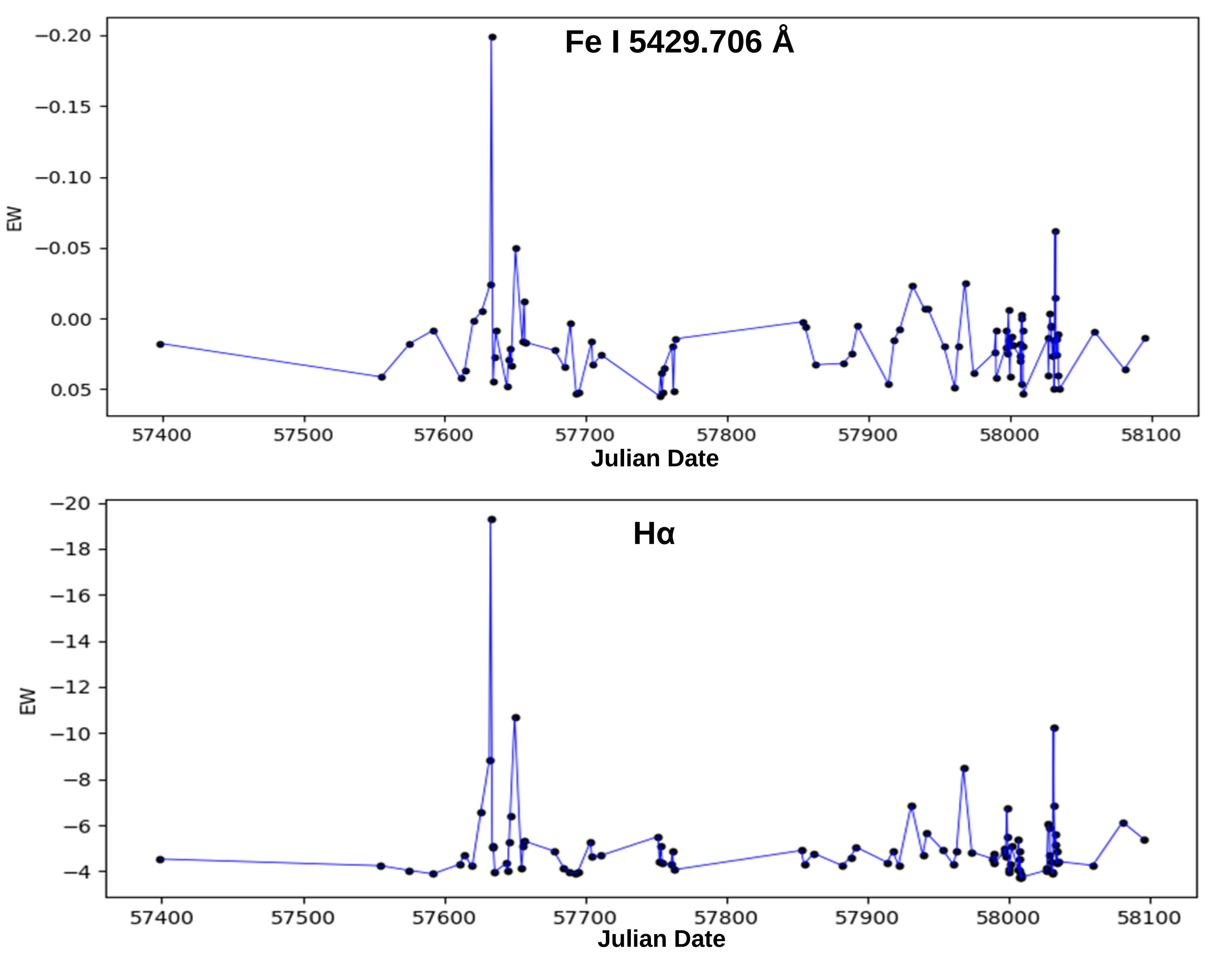
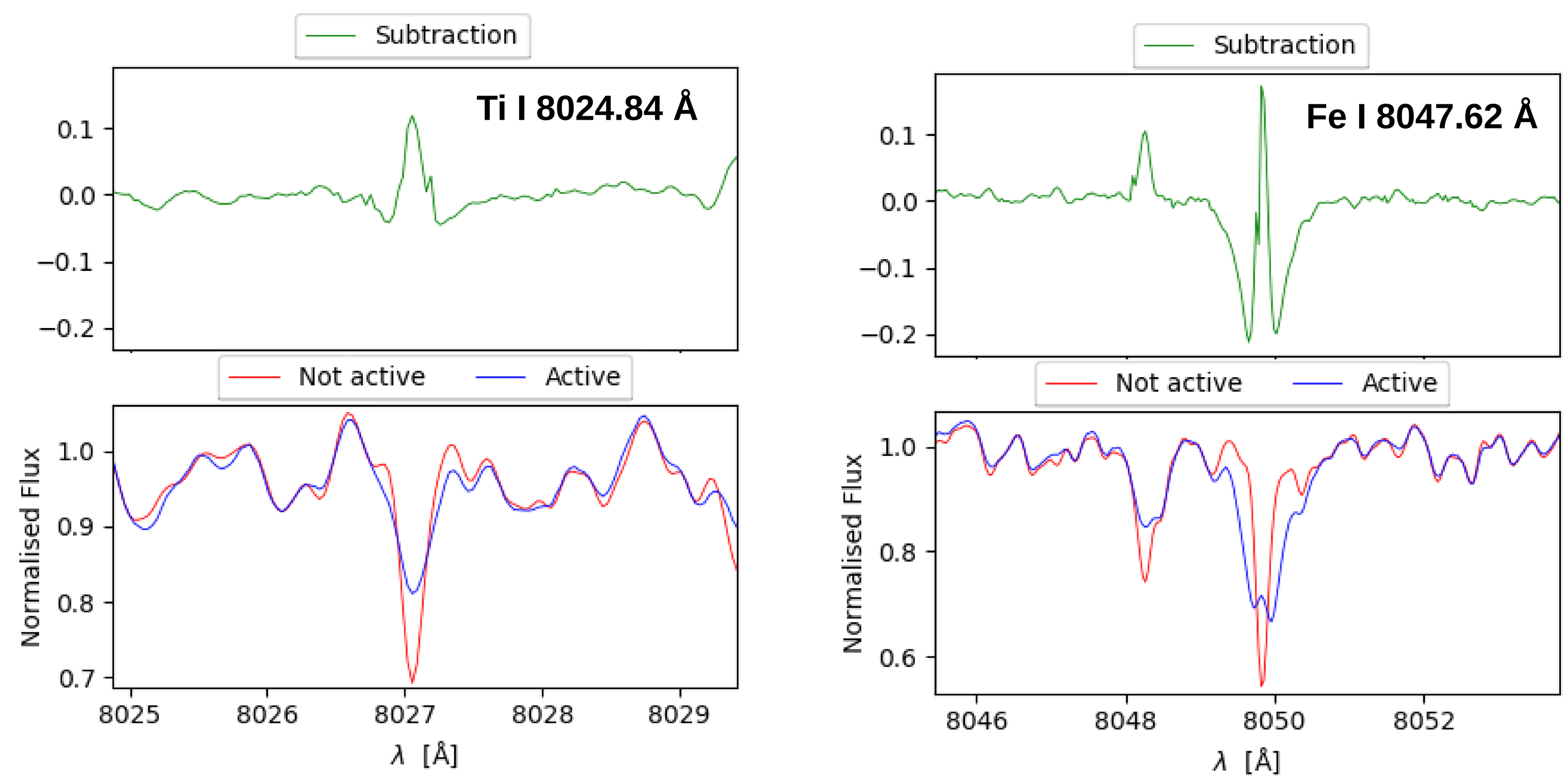
ABSTRACT. In this contribution we summarize our project devoted to **identify activity-sensitive spectral lines** in the **CARMENES visible and near-infrared** spectral range of **M dwarfs**. The aim is to contribute to solve the problem of stellar activity in RV measurements to search for exoplanets around these stars and in the determination of precise stellar parameters. To identify lines with a significant chromospheric contribution, apart from well known activity indicators (Na I D1, D2 He I D3 , Hα, and Ca II IRT lines, He I 10830 Å, Paγ and Paβ lines), we have used the spectral subtraction technique using our Python code **iSTARMOD** (Labarga & Montes 2020) choosing as reference the spectrum of the star with lower activity. We confirm the **new activity-sensitive lines** by analysing the correlation with the other well known activity indicators in the same spectra and their temporal evolution in two particular active stars **EV Lac (EV Lacertae, M3.5)** and **YZ CMi (YZ Canis Minoris, M4.5).** They are specially active stars with strong flares and strong magnetic fields. In addition, we analyse line by line the template spectrum (co-added of all the individual spectra available) of these two stars applying also the spectral subtraction using in this case as reference star an inactive M dwarf of similar spectral type to search for magnetically-sensitive lines, that is lines with detectable Zeeman broadening. After this analysis on YZ CMi and EV Lac, we have found **84 and 97 chromospheric activity-sensitive lines and 160 and 170 magnetically-sensitive** spectral lines respectively. We are now studying the impact of the elimination of the activity-sensitive spectral lines identified in this way on the RV determination using cross-correlation functions with weighted binary masks as in Lafarga et al. (2020) and on the stellar parameters determination by spectral synthesis as in Marfil et al. (2021).



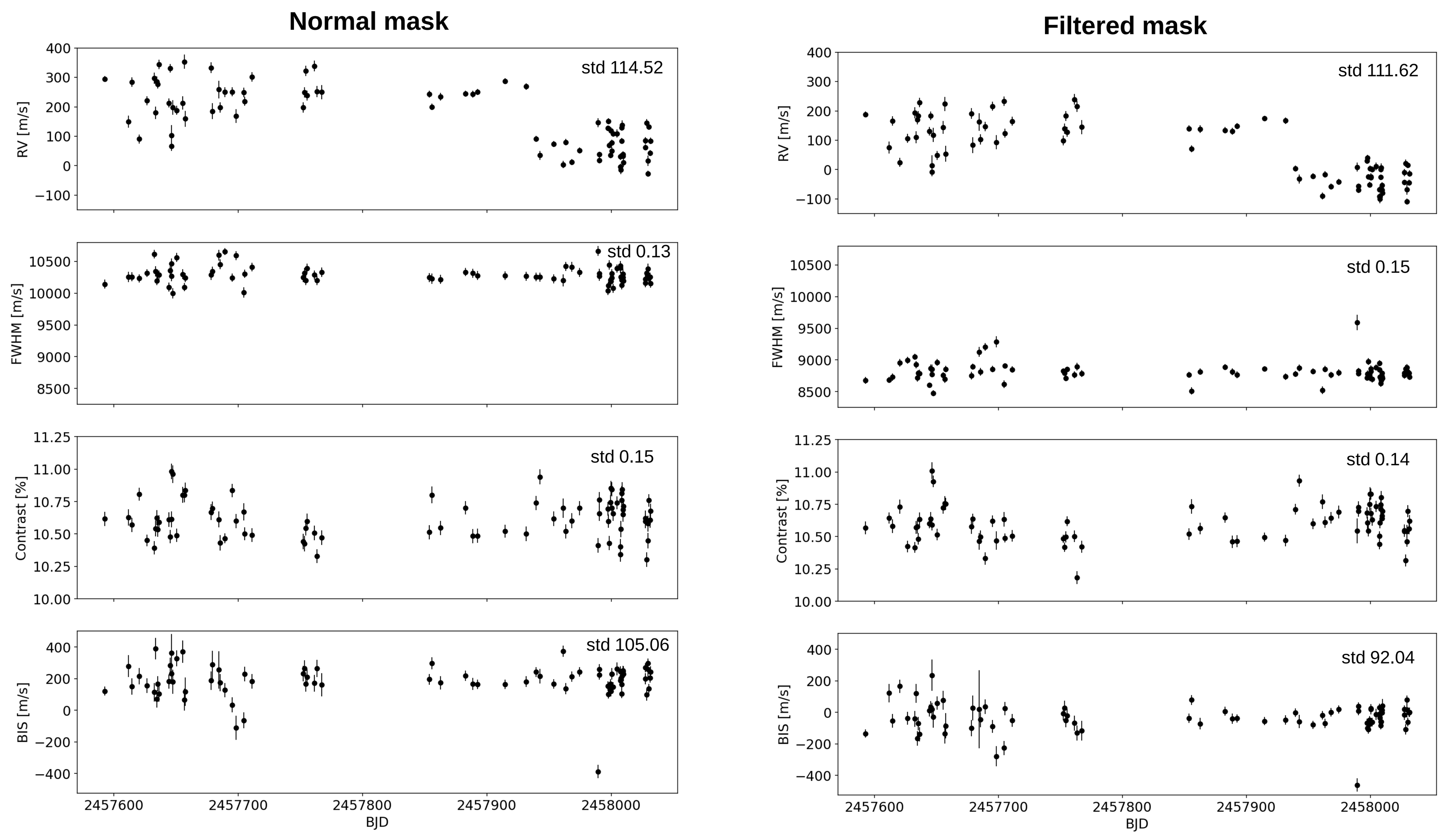
▲ **Fig. 1:** EV Lac spectrum arround 5498 – 5509 Å at quiescent (left panel) and flare state (right panel). We measure the flux change of the lines in the same range, when there is a flare and when there is not.



▲ **Fig. 2:** A comparaison of the equivalent width (*EW*) over time of a typicall activtiy indicator (Hα) and one of our detected lines (Fe I), proving that our lines are sensitive to stellar activity. Top panel shows the temporal evolution of Fe I 5429.706 Å line. Bottom panel represents EW evolution of Hα line.



▲ **Fig. 3:** Two example of detecting lines affected by Zeeman broadening. The line is noted in our list of sensitive line to magnetic field when the Zeeman broadening can be detected in these plots.



▲ **Fig. 4:** Each of these plots are the output of RACCOON's code (Lafarga et al. 2020). The code is based on the cross-correlation functions with weighted binary masks and the output shows the radial velocity (RV), full width at half maximum (FWHM), contrast and bisector (BIS). The normal mask and the filtered one on EV Lac in the NIR. Normal mask is used in Lafarga et al. (2020) and filtered is a mask where there are only lines that are not sensitive to stellar activity. It shows how the dispersion of the RV and BIS is lower, showing that eliminating our active lines the plots have less dispersion.

References

- Labarga, F. & Montes, D. 2020, in Contributions to the XIV.0 Scientific Meeting(virtual) of the Spanish Astronomical Society, 153
- Lafarga, M. et al. 2020, A&A, 636, A36
- Marfil et al. (2021) in prep.

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