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Systematic method for identification of L-type variable brown dwarfs

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Most brown dwarfs show some level of photometric or spectral variability. However, obtaining light curves for brown dwarfs is a resource-intensive task, since in general at least a few hours of telescope monitoring are required per object to be able to obtain a useful light curve. Thus, selecting the most likely variable brown dwarfs is key to optimally employing resources. A few years ago, the design of spectral indices to find the most probable L and T dwarfs using a single epoch spectrum in the near-infrared presented by Ashraf et al. 2022 and Oliveros-Gomez et al. 2022 gave us an important tool to observe more probable objects to measure their variability.

In this work, we designed and tested near-infrared spectral indices to pre-select the most likely variable L4-L8 dwarfs to broaden the spectral types of brown dwarfs to which this spectral index method can be applied. We used time-resolved near-infrared *Hubble Space Telescope Wide Field Camera 3* spectra of an L6.0 dwarf, LP 261–75b, to design our novel spectral indices (six in total) analyzing in detail the regions in the spectrum and their variation in time. We improve the method, using machine learning to classify the variable and non-variable spectra and obtain an index-index plot more accurately (shown in Figure 1). We did a histogram showing how many variable or non-variable areas typically each of the variable or non-variable are found. Using the histogram, we defined the variability threshold in 9/15 index-index plots. The spectra/objects found in more than 9 out of 15 variable areas are classified as *variable candidates*.

We tested these spectral indices on 75 L4.0-L8.0 near-infrared SpeX/IRTF spectra, providing 27 new variable candidates for brown dwarfs. Using the reports about variability of some objects of our initial sample we obtain a recovery rate of our indices method of ~92%, and a false negative rate of ~25%. Also, all the known non-variable brown dwarfs were found to be non-variable by our indices.

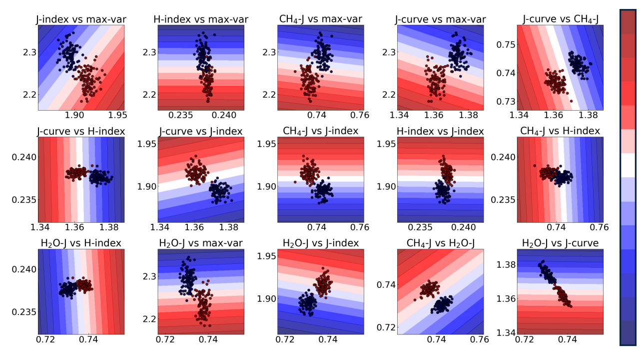

Figure 1. Index-index plot, using the synthetic spectra generated with the Monte Carlo method from the HST/WFC3 spectra of LP 261-75b. The flux maximum spectra are shown as red dots, and the flux minimum spectra are shown as blue dots. We show the areas of variability computed using *machine learning* (`scikit-learn`) with their respective reliability regions.

We estimated the variability fraction of our sample to be 51^{+4}_{-38}%, which agrees with the variability fractions provided by Buenzli et al. 2014, Radigan et al. 2014 and Metchev et al. 2015 for this spectral range of L4–L8 dwarfs. These spectral indices may support in the future the selection of the most likely variable directly-imaged exoplanets for studies with the *James Webb Space Telescope* and as well as the 30-m telescopes.

The Python code to find variable candidates using the spectral indices presented in this work is publically available in Github: https://github.com/ntlucia/BrownDwarf-SpectralIndices.

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