Long-term Cycles of Variability of Jupiter's Atmosphere from Ground-based Infrared Observations

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Jupiter's atmosphere displays some of the most dramatic weather of any planet in our Solar System, with cycles of activity changing the upper tropospheric and stratospheric temperatures, aerosols, and cloud structures through physical processes that are not yet well understood. In the troposphere, Jupiter's banded structure undergoes dramatic planetary-scale disturbances that can evolve over short timescales changing its appearance completely at a range of altitudes, from the cloud tops (~500 mbar) to the deeper levels (1-4 bar). Some of these tropospheric variations seem to occur randomly, like the impressive fading and revival of the South Equatorial Belt at 7°-17° S (planetocentric latitude), while others follow a periodic pattern, like the North Equatorial Belt expansions at 7°-17° N (with a ~4.5-year periodicity), the Equatorial Zone disturbances (~7-year period) within ±7° of the equator (Antuñano et al. 2018 doi: https://doi.org/10.1029/2018GL080382) and the convective outbreaks at 21° N in the North Temperate Belt (~5-year period) (Antuñano et al., 2019 doi: https://doi.org/10.3847/1538-3881/ab2cd6). In the stratosphere, Jupiter's equatorial and off-equatorial temperature and winds at 10-20 mbar exhibit a remarkable 4-5-year periodic oscillation with height forced by waves produced from tropospheric meteorological activity at the equatorial latitudes.

Here we use almost 40 years (more than 3 jovian years) of ground-based infrared observations captured at NASA's Infrared Telescope Facility (IRTF), the Very Large Telescope (VLT) and Subaru between 1980 and 2019 in a number of filters spanning from 7.9 to 24.5 µm. These filters sample upper tropospheric and stratospheric temperatures and aerosols via collision-induced hydrogen and helium absorption, and emission from stratospheric hydrocarbons. This long-term time series is used to (i) understand the impact of the previously mentioned tropospheric activity on the periodicity of the stratospheric temperature oscillations, (ii) characterize the long-term variability of Jupiter's atmosphere at different altitudes in the upper troposphere and stratosphere, and (iii) investigate the long-term thermal, chemical and aerosol changes in Jupiter's troposphere. In particular, we generate Lomb-Scargle periodograms and apply a Wavelet Transform analysis to our dataset to look for potential periodicities on the brightness temperature variability in different filters and compare them to previously reported cyclic activity at visible wavelengths (sensing the ammonia cloud top at ~500 mbar) and 5 µm (sensing the 1-4 bar pressure level). Finally, a Principal Component Analyses (PCA) is also performed to analyse the correlation of the brightness temperature variations at different belts and zones.