SURF Interim Report 1 - Investigating the Time Dependence of Near-Infrared Zonal Waves in Jupiter's North Equatorial Belt

Joheen Chakraborty
Columbia University
jc5110@columbia.edu
Mentor: Dr. Glenn S. Orton

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1 Introduction

My project involves understanding the behavior over time of zonal upper-tropospheric near-infrared waves in Jupiter's North Equatorial Belt. In particular, I am investigating how they are related (if at all) to quasiperiodic expansions of the NEB documented over the past ∼2 decades. Previous observations have noted the presence of these waves during NEB expansions[2] without observing a strict causal relationship between the two. Establishing the relationship between the two events could suggest information about their underlying causes.

2 Completed Work

Thus far, I have completed a survey of the work completed by previous interns on the project, which involved describing the behavior and appearance of waves both manually[6] and with various analytical approaches.[3] This work suggested useful next steps might lie in stitching together multiple cylindrical map observations to improve longitudinal coverage and spectral resolution, and using analytical approaches (e.g. Fourier analysis) to characterize NEB waves. In order to make use of as much of the ∼ 1100 unique cylindrical map observations of Jupiter taken by the NASA Infrared Telescope Facility as possible, I automated a data analysis pipeline in IDL and Python which involves 1) applying angle-corrections using the Minnaert function; 2) stitching together multiple cylindrical maps from similar wavelengths and observation dates; 3) extracting the NEB region; and 4) applying both the Fast Fourier Transform[1] and Lomb-Scargle periodogram[4,5] methods to identify dominant wavenumbers and their respective wave powers. For completeness, I also used this pipeline omitting step 2, applying the analytical methods directly to single cylindrical maps, resulting in more data points each with lower coverage/resolution (I note that in this case, the Lomb-Scargle approach should be far more useful than the FFT because of the volume of missing data). Results of the batch analyses are shown in Figure 1.

Notable challenges have included implementing half of the pipeline in IDL, a language I was previously unfamiliar with; determining a method of angle corrections suitable across all cylindrical map observations; and automating the cylindrical map stitching process, which involves making delicate trade-offs between quality of maps (e.g. choosing the optimal longitudes as cutoff points) and automation volume. These tasks required patience and a steady, measured hand to tackle.

3 Plans

Figure 1 appears to contain approximate visual relationships between relative wave powers and beginnings/ends of NEB expansion events–notably, there are spikes in wave power frequently (roughly) coinciding with the beginnings/ends. My immediate next step is to statistically analyze these coincidences, with the end goal

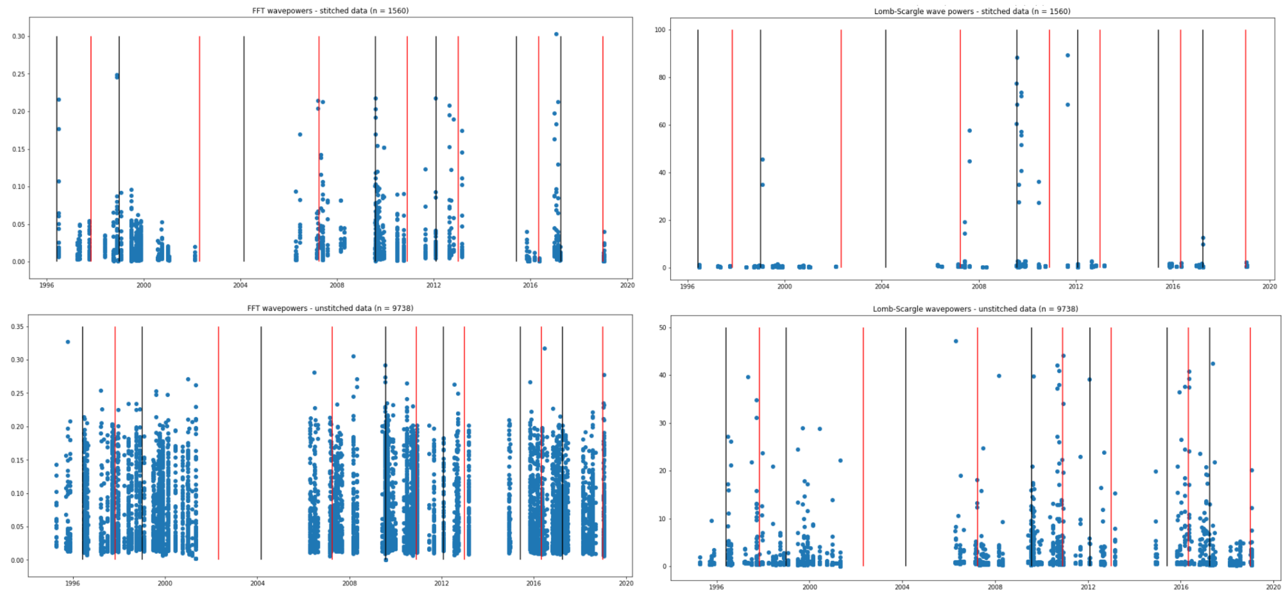

Figure 1: Top 10 wave powers (wavenumbers omitted) of both the FFT and Lomb-Scargle periodogram methods against observation date. The black vertical lines denote the beginning of an observed NEB expansion event; the red vertical lines denote their ends. Notably, there appear to be spikes in the relative wavepowers across all four graphs roughly coinciding with the solid vertical lines.

of turning this rough visual relationship into a robust scientific statement. To this end, I will look into the confidence intervals for the FFT and Lomb-Scargle wavepowers, which should provide a method of quantifying the correlation (or anticorrelation) of the zonal waves with NEB expansions.

Beyond that, other useful questions to examine could be how the wavenumbers evolve with time and the behavior of the waves across different wavelengths/altitudes.

References

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