SATURN'S EQUATORIAL JET THROUGH REANALYSIS OF NEWLY NAVIGATED VOYAGER DATA. J. Garland[1], K. M. Sayanagi[1], J. W. C. McNabb[1], and R. M. McCabe[1], [1]Hampton University, Department of Atmospheric and Planetary Sciences, 23 E. Tyler Street, Hampton, VA 23668

Introduction: We analyze images of Saturn captured by the Voyager and Cassini missions using consistent methodologies to investigate how the planet's zonal wind speeds have evolved between 1980 and the Cassini era. Zonal wind as a function of latitude during the Voyager flybys has been retrieved by previous studies; notably, Sánchez-Lavega et al. 2000's measurements using Voyager data have been treated as the standard wind profile of Saturn. Even though the Sánchez-Lavega el al. profile is treated as the standard zonal wind record, it is part of a long-standing discrepancy in the equatorial jet speed in which subsequent studies using Hubble Space Telescope[8] and Cassini[2] data have had trouble reproducing. No study has systematically analyzed the wind speeds during the Voyager flybys and the Cassini era using a consistent method. We hypothesize that the long-standing discrepancy in Saturn's equatorial wind speed is either a result of systematic selection bias introduced by manual cloud tracking methods, vertical shear, or a combination of both. We expect that analyzing the Voyager datasets with modern, automated methods will help us better constrain previously published trends in wind profiles retrieved for the planet. We also aim to produce higher-confidence Voyager wind profiles for future studies than those currently available in the literature. The focus of this presentation is our open-source image processing and navigation pipeline which has produced calibrated, re-navigated Voyager and Cassini images for use in wind measurements.

Voyager Data: Voyager 1 and 2's Imaging Science Subsystem (ISS) took images of Saturn during flybys of the planet. Images have spatial resolutions ranging from 50 km / pixel in the northern hemisphere to 150 km / pixel in the southern hemisphere due to the encounter trajectories[7]. Our work considers approximately 21,000 total images in the clear, violet, blue, orange, green, CH4-U, and CH4-JST ISS filters for wind measurements. Our image processing pipeline performs image selection in all filters based on criteria such as pixel resolution and coverage of the planet. We exclude Voyager's UV filter because the images show few trackable cloud features. All images are publicly available on the Planetary Data System (PDS).

Cassini Data: Our research group has extensive experience in analyzing Cassini ISS images to investigate the cloud dynamics on Saturn[1,10]. In this work, we focus on Cassini ISS Wide Angle Camera views in the CB2 (750 nm), MT2 (727 nm), and MT3 (889 nm) narrow-band filters as previous studies have tied the altitudes they sense in Saturn's atmosphere to those of Voyager's filters. The Voyager green filter senses approximately the same altitude as the Cassini CB2 filter[5,6,9]. Similarly, the Cassini and Voyager methane absorption filters are both sensitive at higher altitudes[5,6,9]. We use Cassini images from 2004-2017 to search for changes in the equatorial jet's speed from our measured Voyager wind speeds.

Tools: Our image processing pipeline utilizes two tools to prepare images of Saturn for cloud tracking. The Integrated Software for Imagers and Spectrometers (ISIS3)[11] is the primary software package used to process both Voyager and Cassini images. It can calibrate, map-project, and mosaic images of planetary bodies captured by various missions. A key weakness of ISIS3 for this project is the lack of options to correct image navigation beyond what was recorded in the Navigation and Ancillary Information Facility SPICE kernels. Our pipeline uses the Open-source Multi INstrument Analysis Software (OMINAS)[4], initially developed during the Cassini mission, as a secondary processing tool to rectify this issue. While its data reduction and analysis capabilities are similar to ISIS3, OMINAS includes limb, ring, and stellar navigation routines. We take advantage of these tools to update the SPICE kernels of the Voyager and Cassini datasets in order to improve the cloud tracking analysis.

Data Processing and Re-navigation: Using ISIS3, our pipeline first calibrates the raw images retrieved from the PDS and performs radiometric and photometric corrections on the data. Additionally, bilinear interpolation removes the reseau points present in Voyager images. A high pass filter improves contrast in the images. The navigation of Voyager data, particularly that taken with the narrow-angle camera, is poor due to the use of an instrument scan platform[3]. The second step of our pipeline renavigates calibrated Voyager images using OMINAS's limb-fitting, ring-fitting, and stellar navigation capabilities. Updated navigation is stored in SPICE kernels and ingested by ISIS3 in the next steps. While Cassini SPICE kernels generally provide sufficient navigation without correction, we also renavigate Cassini images in order remain consistent with the treatment of Voyager data. Third, re-navigated images are map-projected into cylindrical or polar coordinates based on their latitudinal coverage using ISIS3. These renavigated, mapped images are the final product of image processing to be used in cloud tracking.

Archival: All IDL and Python processing code used to calibrate and renavigate images is available as open-source on GitHub. This allows reproduction of all data produced in our analysis from that hosted publicly by the PDS,

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References:

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