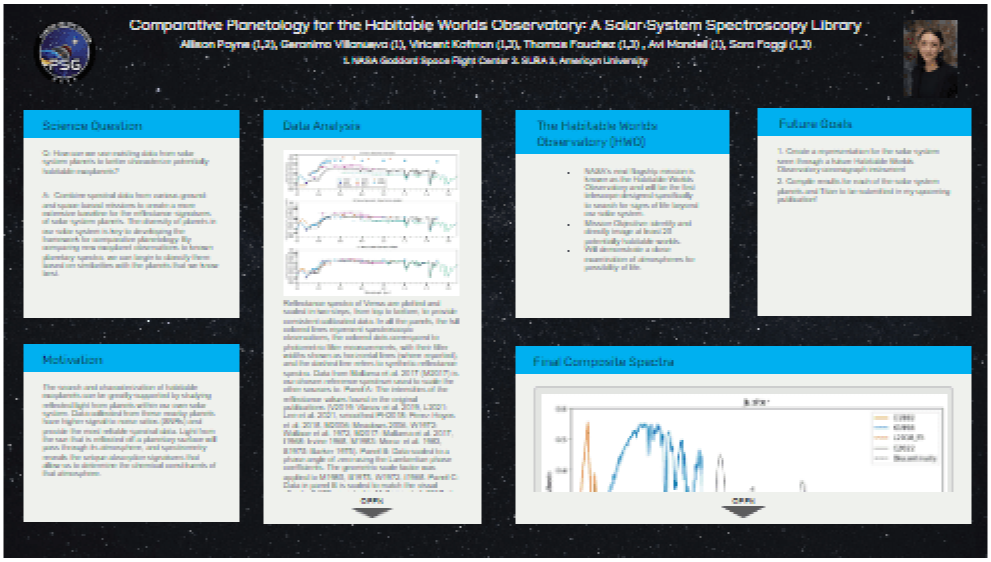
Comparative Planetology for the Habitable Worlds Observatory: A Solar System Spectroscopy Library



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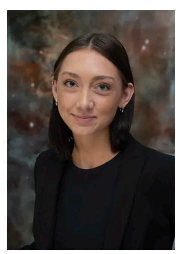


PRESENTED AT:

AAS 245 iPoster Sessions Sponsored by AAS PUBLISHING

SCIENCE QUESTION

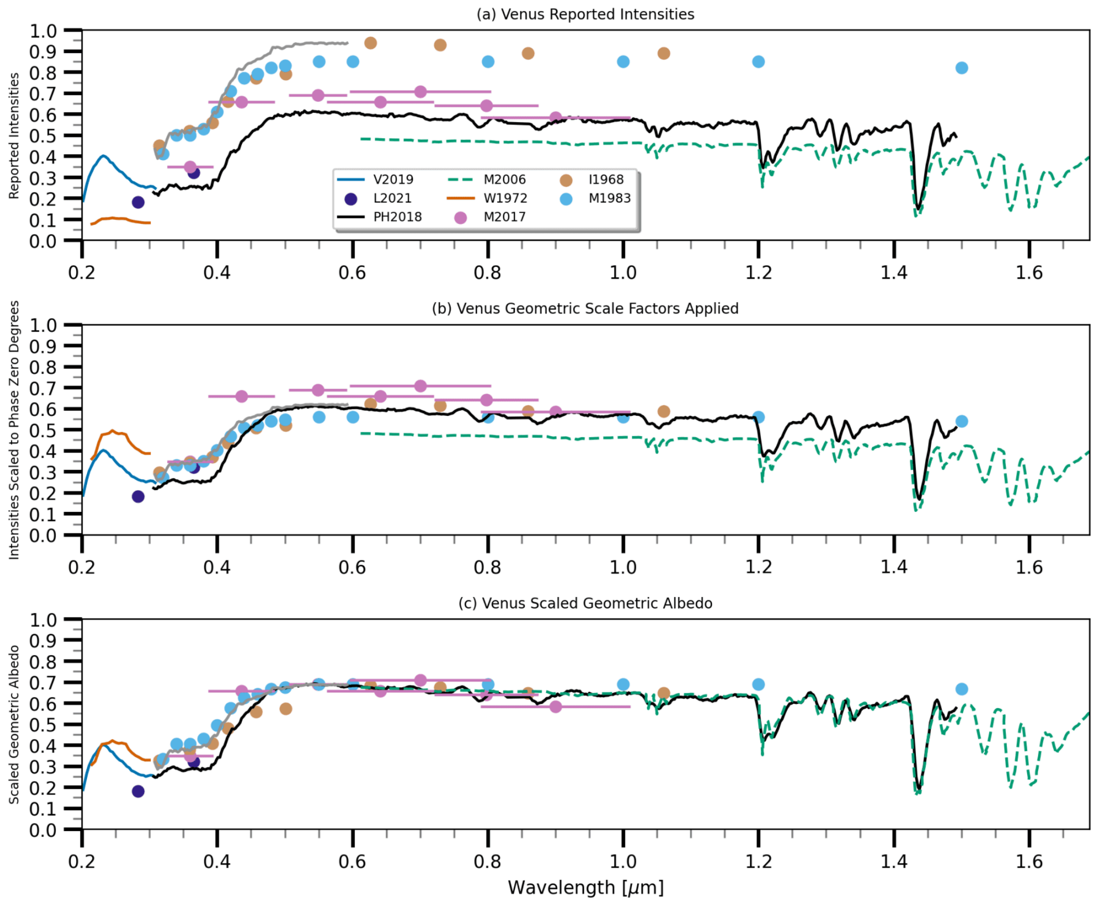
Q: How can we use existing data from solar system planets to better characterize potentially habitable exoplanets?

A: Combine spectral data from various ground- and space-based missions to create a more extensive baseline for the reflectance signatures of solar system planets. The diversity of planets in our solar system is key to developing the framework for comparative planetology. By comparing new exoplanet observations to known planetary spectra, we can begin to classify them based on similarities with the planets that we know best.

MOTIVATION

The search and characterization of habitable exoplanets can be greatly supported by studying reflected light from planets within our own solar system. Data collected from these nearby planets have higher signal-to-noise ratios (SNRs) and provide the most reliable spectral data. Light from the sun that is reflected off a planetary surface will pass through its atmosphere, and spectrometry reveals the unique absorption signatures that allow us to determine the chemical constituents of that atmosphere.

DATA ANALYSIS



Reflectance spectra of Venus are plotted and scaled in two steps, from top to bottom, to provide consistent calibrated data. In all the panels, the full colored lines represent spectroscopic observations, the colored dots correspond to photometric filter measurements, with their filter widths shown as horizontal lines (where reported), and the dashed line refers to synthetic reflectance spectra. Data from Mallama et al. 2017 (M2017) is our chosen reference spectrum used to scale the other sources to. Panel A: The intensities of the reflectance values found in the original publications (V2019: Vlasov et al. 2019, L2021: Lee et al. 2021, smoothed PH2018: Perez-Hoyos et al. 2018, M2006: Meadows 2006, W1972: Wallace et al. 1972, M2017: Mallama et al. 2017, I1968: Irvine 1968, M1983: Moroz et al. 1983, B1975: Barker 1975). Panel B: Data scaled to a phase angle of zero using the Lambertian phase coefficients. The geometric scale factor was applied to M1985, B1975, W1972, I1968. Panel C: Data in panel B is scaled to match the visual albedo, 0.689, reported in Mallama et al. 2017 at 0.549 mm.

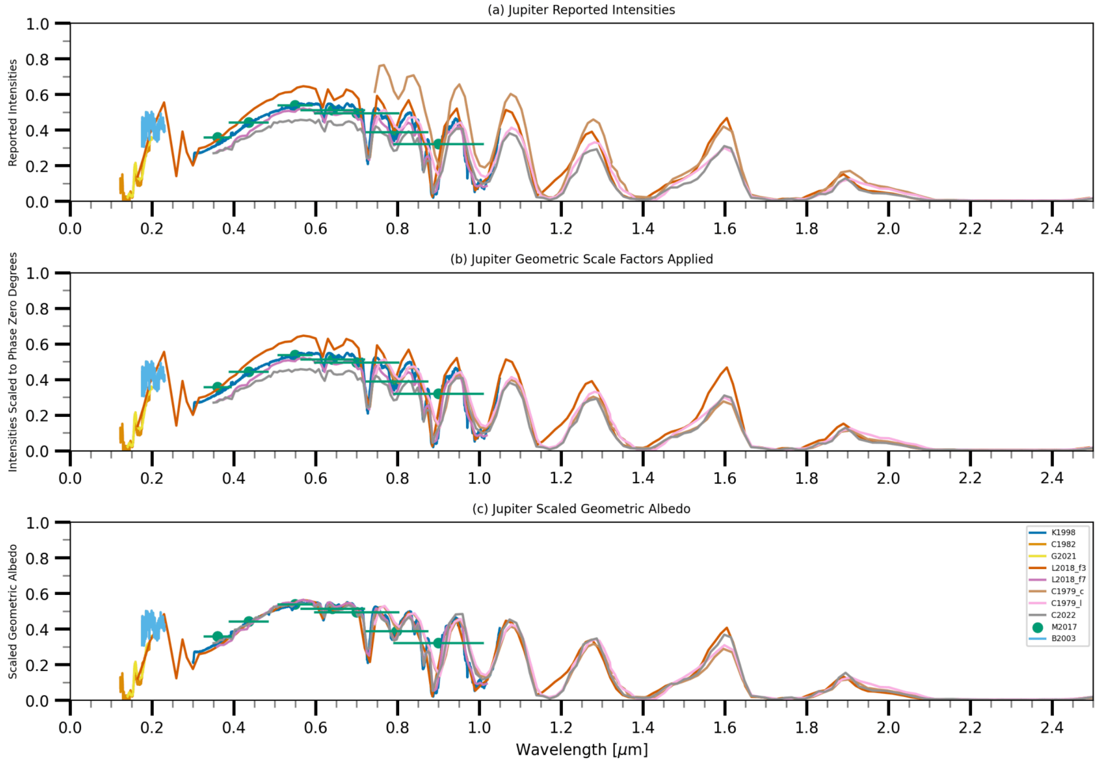


Figure 2: Reflectance spectra of Jupiter are plotted and scaled in two steps, from top to bottom, to provide consistent calibrated data. In all the panels, the full colored lines represent spectroscopic observations, the colored dots correspond to photometric filter measurements, with their filter widths shown as horizontal lines. Karkoschka 1998 provides the selected reference spectrum that is used to scale the other sources to. Panel A: The intensities of the reflectance values found in the original publications (K1998: Karkoschka 1998, H2014: Hendrix et al. 2014, G2021: Giles et al. 2021, L2018_f3: Li et al. 2018 Figure 3, L2018_f7: Li et al. 2018 Supplementary Figure 7, C1979_c: Clark and McCord 1979 Central Disk Data, C1979_l: Clark and McCord Limb Data, C2022: Coulter et al. 2022, M2017: Mallama et al. 2017, B2003: Betremieux et al. 2003). Panel B: Data is corrected to a phase angle of zero using the Lambertian phase coefficients. Geometric scale factors were applied to L2018_f7 and C1979_c. Panel C: Data in panel B is scaled to align with the intensity of the full disk albedo continuum in Karkoschka 1998. Correction factors are applied to C2022, L2018_f3, L2018_f7, C1979_c, C1979_l.

THE HABITABLE WORLDS OBSERVATORY (HWO)

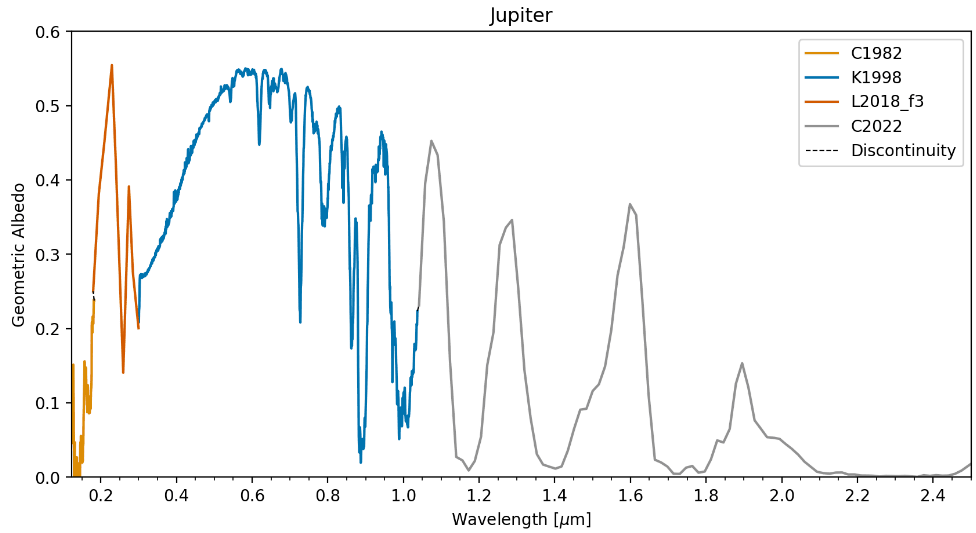
- NASA's next flagship mission is known as the Habitable Worlds Observatory and will be the first telescope designed specifically to search for signs of life beyond our solar system.
- Mission Objective: identify and directly image at least 25 potentially habitable worlds.
- Will demonstrate a close examination of atmospheres for possibility of life.

FUTURE GOALS

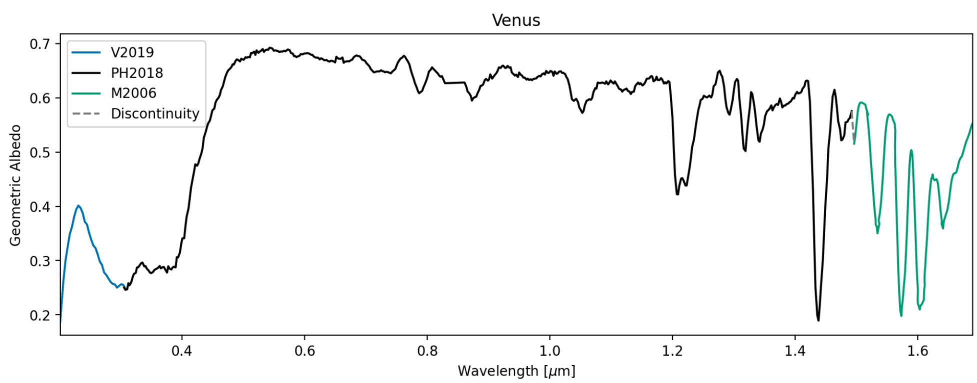
1. Create a representation for the solar system seen through a future Habitable Worlds Observatory coronagraph instrument

2. Compile results for each of the solar system planets and Titan to be submitted in my upcoming publication!

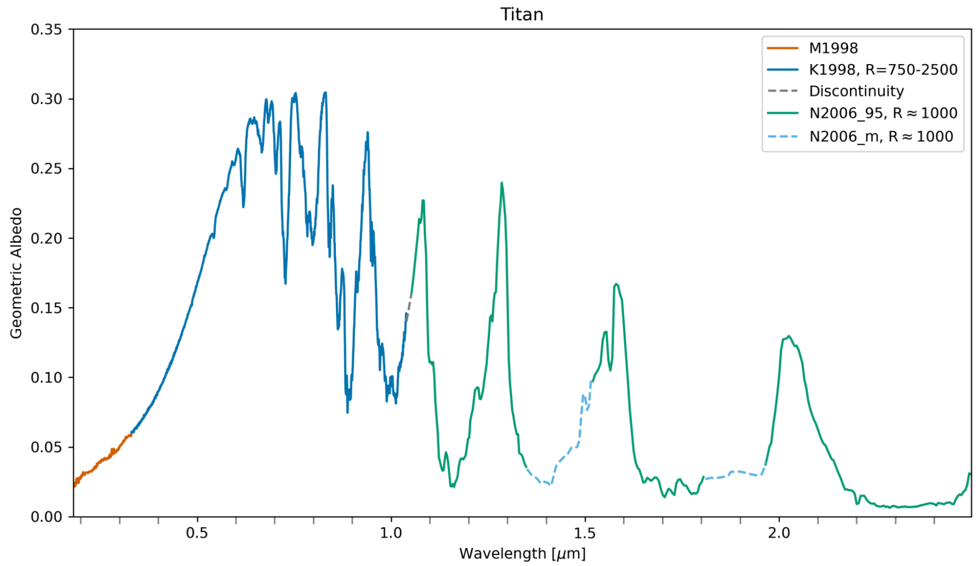
FINAL COMPOSITE SPECTRA



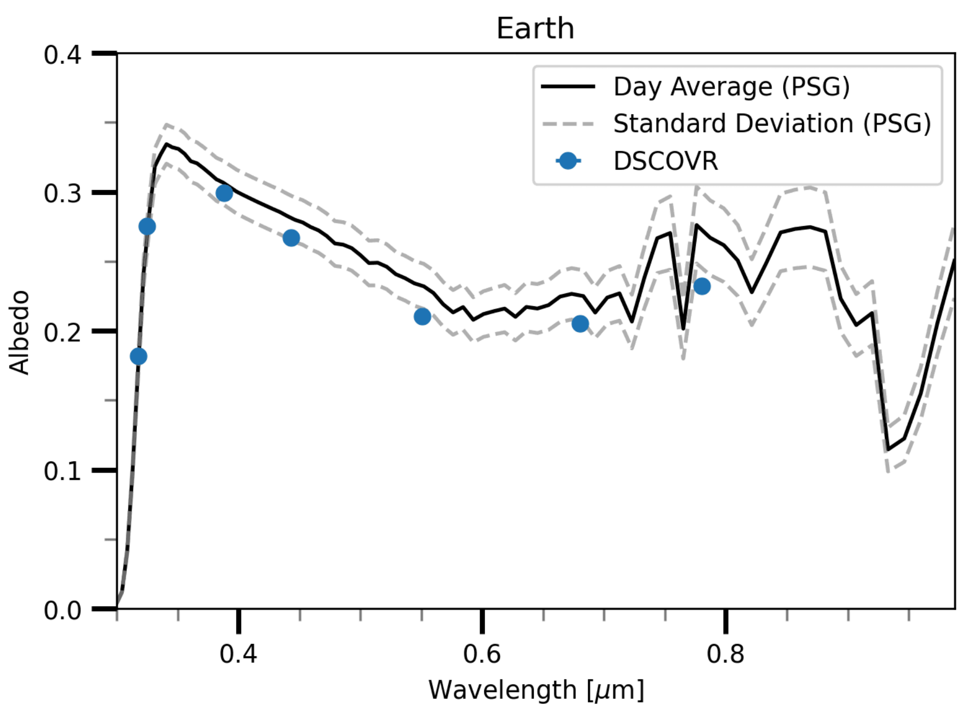
Jupiter's geometric albedo spectrum created by combining data from 4 sources. Including information from the International Ultraviolet Explorer Satellite, European Southern Observatory, and Cassini VIMS.



Venus's geometric albedo spectrum created by combining data from 3 sources. Including information from the Venus Expresss Spacecraft (SPICAV), MESSENGER spacecraft (VIRS), and synthetic spectra (Meadows 2006).



Titan's geometric albedo spectrum created by combining data from 3 sources. Including information from the Hubble Space Telescope, European Southern Observatory, the Canada France Hawaii Telescope, and synthetic spectra (Negrao et al. 2006).



Simulated Earth data created using the Planetary Spectrum Generator (PSG) validated with narrow filter measurements of Earth's refelctance spectrum from the Deep Space Climate Observatory (DSCOVR) satellite.
Vincent Kofman et al 2024 Planet. Sci. J. 5 197

TRANSCRIPT

ABSTRACT

The search and characterization of habitable exoplanets is supported by studying reflected light from planets within our own solar system. Data collected from nearby planets typically have higher signal-to-noise ratios (SNRs) and reliable spectral information can be gathered. Sunlight reflected off a planetary surface passes through the planet's atmosphere, and spectrometry reveals unique absorption signatures, allowing us to determine the atmospheric chemical constituents. Data in this survey is gathered from existing literature and spans a wide range of observational geometries, from localized to full-disk views, and includes data from both ground-based and space-based instruments. By combining these diverse datasets, we enhance our understanding of the unique reflectance signatures of each planet in the study. The diversity of planets in our solar system is crucial for developing the framework necessary for comparative planetology, and the creation of a spectral library with standardized units and planetary geometry will be essential for characterizing new exoplanet detections. Comparing future spectra to well-known solar system spectra will help us understand how these planets may be similar to or different from local celestial bodies, thus aiding the search for potentially habitable or Earth-like exoplanets. The spectral library will include data for Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Titan to be referenced by astronomers.