National Aeronautics and Space Administration

Interdisciplinary Data Environment for Exoplanet Research

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Program: "Bringing the Outer Solar System Closer" Strategic RTD Initiative

Motivation:

Solar system planets provide an opportunity for "ground truth" testing of models and inference algorithms as applied to current and future observations of exoplanets.

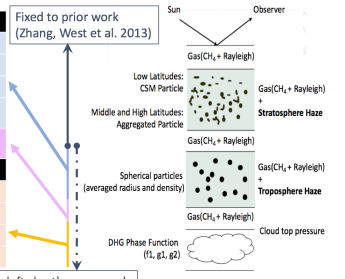
Task Goals:

- Develop new data-driven techniques for exoplanet analysis by testing with Outer Solar System objects as "exoplanet analog"
- Develop the technologies to incorporate novel exoplanet data science products into the PDS for comparative planetology

Exoplanet Phase Curve Modeling: Forward Model validation using Cassini ISS Images of Jupiter

* Latitude dependent parameters (~40 bins) → Jovian Belts / Zones

TROPOSPHERIC HAZE LAYER		
Average haze particle radius	r_{haze} *	0.1 – 1.0 um
Refractive index	n_{haze}	1.1 – 2.0
	k_{haze}	0.0001 – 1.0
Maximum haze particle number density	ρ_{haze}^{max} *	1e4 – 1e10 m^{-3}
Delta pressure between cloud-top and troposphere-base	dp	0 – 500 mbar
BOTTOM CLOUD		
Single scattering albedo	ω_{UV}, ω_{NIR} *	0.5 – 1.0
DHG phase function	f_1^{UV}, f_1^{NIR}	0 – 1
	g_1^{UV}, g_1^{NIR}	0.1 – 0.97
	g_2^{UV}, g_2^{NIR}	0.1 – 0.97



This work breaks down the lower part of the atmosphere (upper left chart) as opposed to phenomenological parametrization of the whole sub-stratospheric atmosphere

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Fig1. Parameters and Schematic atmosphere structure of our model

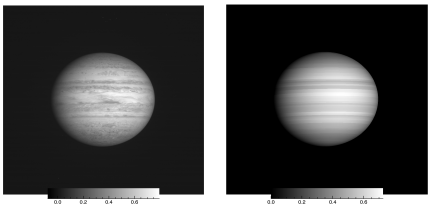


Fig2. Left: ISS CB3 Right: Image resulting from our forward model

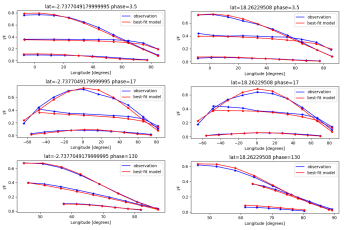


Fig3. MCMC Retrieval using combined latitudes and ISS filters

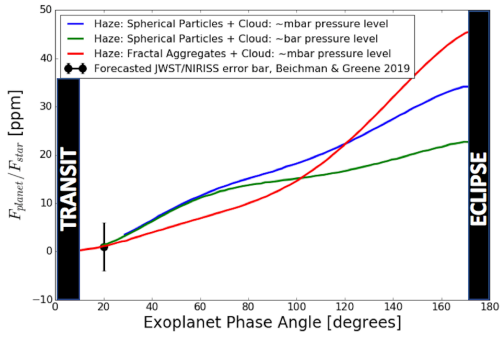
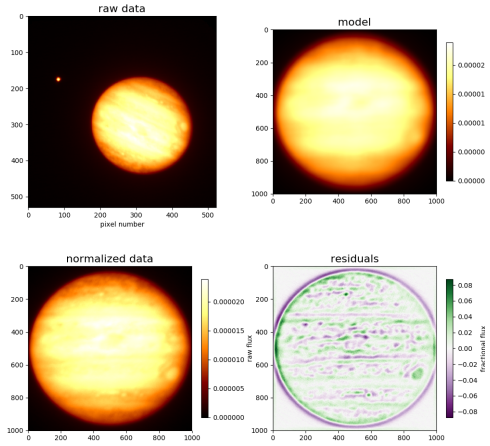


Fig4. Projection of our modeled haze particles onto an exoplanet phase curve signal

Light-Curve Rotational Modulation: Model Validation with IRTF Images of Jupiter :

- Quantify variations of Jupiter's flux as it rotates, particular at longer wavelengths (5um) where thermal emission is stronger than scattered light
- Retrieve a 2-D surface map of Jupiter as a function of wavelength
- Use the 2-D model as a template for simulated exoplanet observations, where we aim to directly image an exoplanet's rotational modulation.



Our axisymmetric model at 1.58μm (upper right) includes limb darkening and compensates for weather-related PSF variations. While the data-vs-model residuals (lower right) still exhibit some anomalous edge effects, most of the differences are due to real non-axisymmetric surface features, e.g. the Great Red (green) Spot.

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