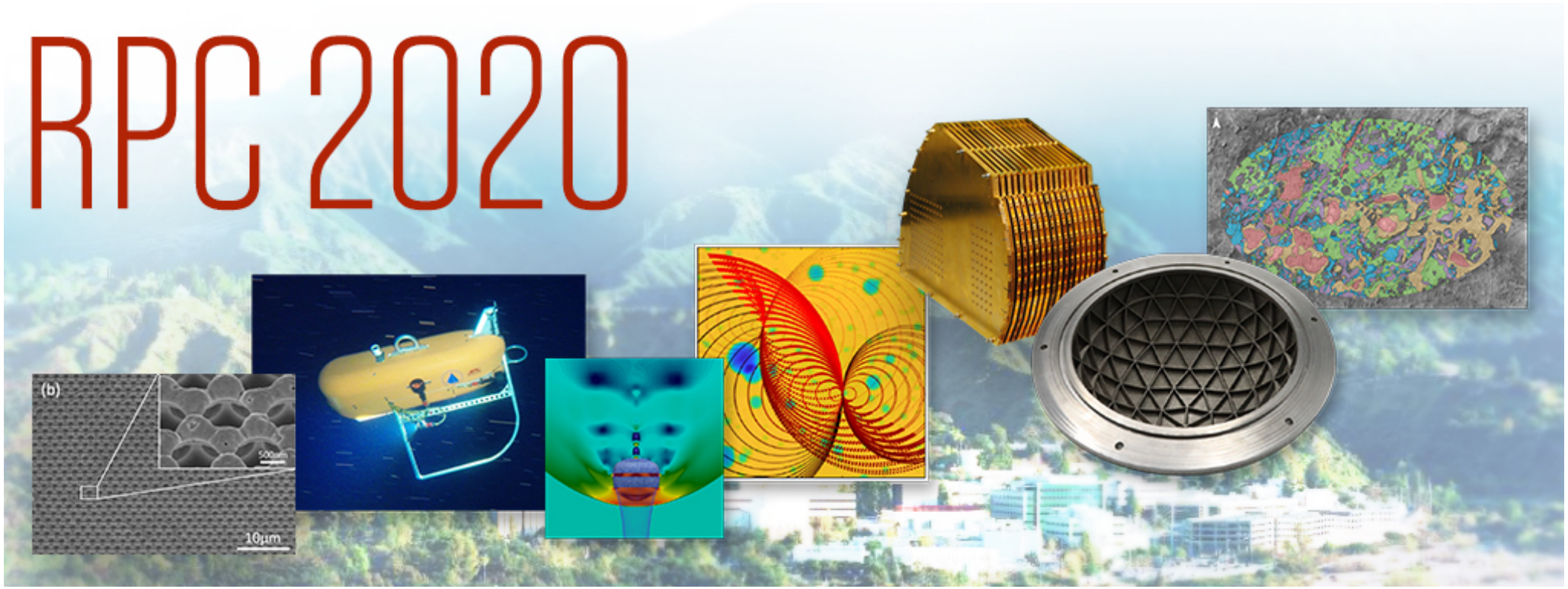

Virtual Research Presentation Conference

Interdisciplinary Data Environment for Exoplanet Research

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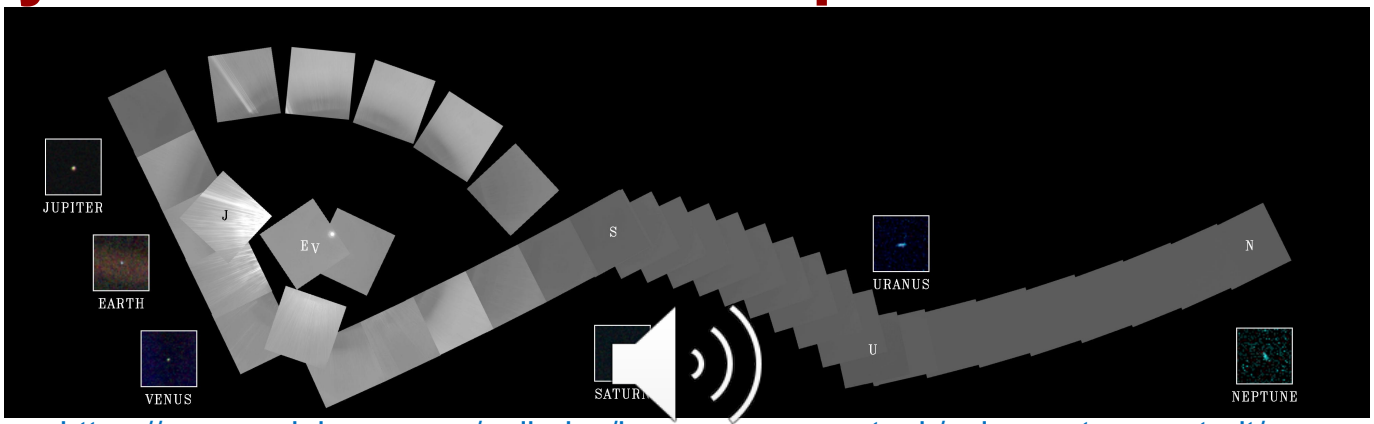
Program: Strategic Initiative

Assigned Presentation # RPC-121

Jet Propulsion Laboratory
California Institute of Technology

Solar System Planets as “Exoplanets”



https://voyager.jpl.nasa.gov/galleries/images-voyager-took/solar-system-portrait/

Abstract Voyager 1’s Solar System portrait illustrates what we can learn from studying planets as exoplanet analogs. Previous missions have resolved Solar System objects at high spatial and spectral resolution, enabling detailed physical models of their interior structure and atmospheres. These measurements, stored in the Planetary Data System (PDS), can be used as “ground-truth” for the analysis of exoplanets, allowing us to quantify predicted signal-to-noise of exoplanet observables through detailed simulation of solar system planets as exoplanets. To realize this potential, there is a need to develop technologies for exoplanet science motivated search of the PDS. Our “Interdisciplinary Data Environment for Exoplanet Science” project was a task funded under the Strategic Initiative “Bringing the Outer Solar System Closer”, with the dual focus of developing communication technologies for future Outer Solar System missions, and exploring novel applications of PDS data for synergistic exoplanet studies. To advance communication technologies for future Outer Solar System missions, we also explored the application advanced data compression algorithms for future outer solar system missions. We evaluated compression algorithms on data sets in the PDS from Cassini as a case study, and found substantial compression of the data could be achieved without harmful impact to science results.

Problem Description

Enabling Exoplanet Science with PDS data:

- There is a need to develop technologies that enable the vast amount of observations of the outer solar system in the Planetary Data System to be extracted, pre-processed, and calibrated for use with exoplanet pipelines providing “ground-truth”.
- Examples include the validation of exoplanet phase curve analysis with the modeling of Jupiter’s atmosphere from phase curve data in the PDS.
- With HST, and future JWST, transit spectroscopy observations on the way, it is timely to develop the advanced tools enabling data discovery and access within and between the PDS and astrophysics archives.

Data Compression for Future Outer Solar System missions:

- Every bit of data returned represents an engineering triumph over severe constraints on mass (limiting antenna size) and power (limiting signal strength).
- Instrument technology development has resulted in data volumes straining communication download limits, motivating the development of complementary compression algorithms tailored to the science goals of any specific instrument.

Exoplanet Motivated PDS Search

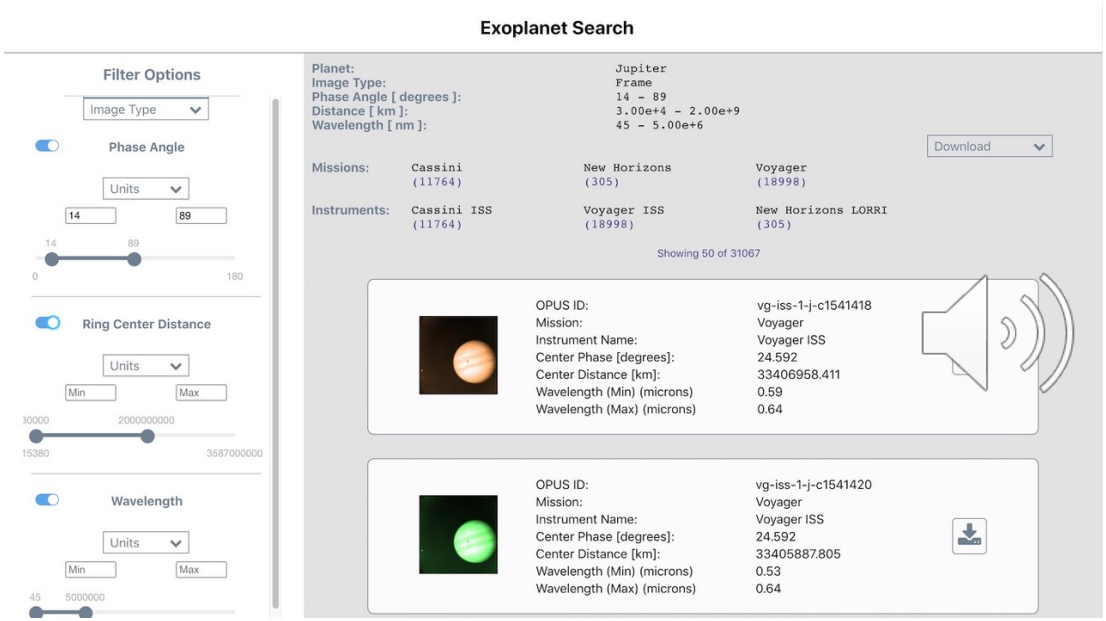


Figure: (courtesy Richard Kim and Daniel Crichton) Screen shot of the online exoplanet "phase curve" them PDS search user interface.

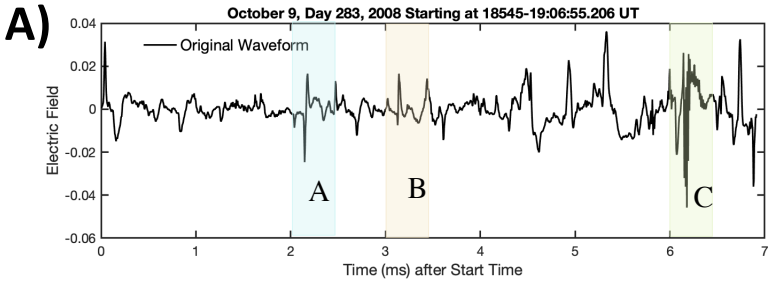
Methodology:

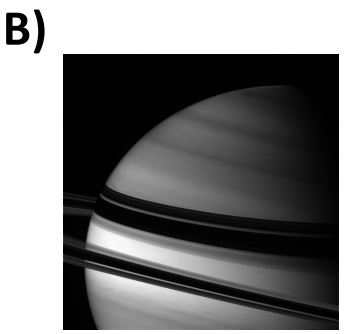
- We focused on the use case of phase curve modeling, relevant for the interpretation of exoplanet transit spectroscopy
- The PDS Rings Node provides a detailed search tool OPUS, enabling the extraction of images of Jupiter
- We isolated the metadata relevant for phase curve analysis relevant to exoplanet phase curve model validation

Results:

- A prototype online user interface developed for exoplanet scientists which simplifies data extraction from PDS (building on the OPUS search engine "under the hood")
- Potential of planetary science data for exoplanet studies: see ***D. Crichton et al, Planetary Decadal White Paper, submitted Sept. 2020***

Data Compression for Outer Solar System Missions





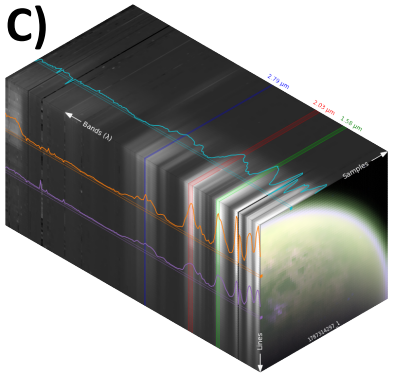


Figure: Cassini instrument data sets (stored in the PDS) used for our compression experiments included A) the Radio Plasma Wave Science (RPWS) instrument, B) the Imaging Science Subsystem (ISS), and C) spectral-image data cubes from the Visible and Infrared Mapping Spectrometer (VIMS) and Ultraviolet Imaging Spectrograph (UVIS).

Methodology:

- We investigated data compression on high data volume instruments from Cassini
- Time series (RPWS), image (ISS), and spectral-image (VIMS,UVIS) data were all compressed with relevant coding algorithms
- Impact of data compression to science return is evaluated by feedback from science team members

Results:

- Significant improvement in compression relative to what the teams had used (factor of ~5 for RPWS, ~70 for UVIS, and 2-5 for VIMS and UVIS depending on tolerance to loss)
- RPWS and UVIS science team members evaluated the compressed data, and reported the science goals were not compromised
- ***H. Xie et al, JATIS, submitted August 2020.***

Publications

Hua Xie, Robert A. West, Benoit Seignovert, Jeffrey Jewell, William Kurth, Terrance Averkamp; *"Compression Algorithms for High Data Volume Instruments on Planetary Missions: a Case Study for the Cassini Mission";* Journal of Astronomical Telescopes, Instruments, and Systems; submitted August 2020

D. Crichton, et al.; *"On the Use of Planetary Science Data for Studying Extrasolar Planets",* white paper submitted to the Planetary Science and Astrobiology Decadal Survey, September 2020.