Opportunities for observations in the Solar System with the James Webb Space Telescope

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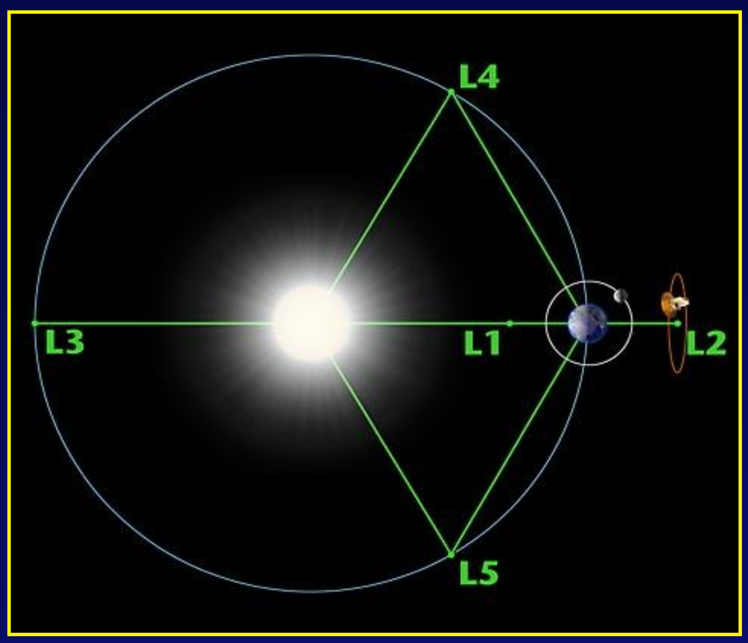
Abstract

The James Webb Space Telescope (JWST) is optimized for observations in the near and mid infrared and will provide essential observations for targets that cannot be conducted from the ground or other missions. The state-of-the-art science instruments, along with the telescope's moving target capabilities, will enable the infrared study, with unprecedented detail, for nearly every object (Mars and beyond) in the solar system. This presentation features highlights for planetary science applications, extracted from the recent articles submitted to PASP as a special edition. The goals of this special issue are to stimulate discussion and encourage participation in JWST planning among members of the planetary science community. Key science goals for various targets, observing strategies for JWST, and highlights for the complementary nature with other missions/observatories will be presented.

PASP Special Issue:

- **11 articles on Solar System Observations with JWST.**
- **Accepted 10/2015**
- **Flyers and Papers produced by planetary science community.**



SOLAR SYSTEM OBSERVATIONS

- Mission requirements for moving target capability
  - Capability to observe moving targets with apparent rates **up to 0.030 arcsec/second**
  - Recent pointing stability simulations: <0.010 arcsec (1σ) for all rates
- **Non-linear ephemeris** uplinked,
  - Ephemeris defined by 5th order Chebychev polynomial derived from JPL HORIZONS
  - Supports time-critical observations, **Targets of Opportunity** (48 hrs from approval to execution)
  - JWST will reside at the L2 halo orbit and employ solar array power.
  - Field of Regard: Solar elongation angles 85 – 135 degrees
  - Planets observed near quadrature.

COMETS

– Imaging will provide information on nuclear composition, diameter, albedo and thermo-physical properties

– Compositional studies of cometary nuclei, gas and dust with unprecedented sensitivity throughout the 1-28.5 μm range

– JWST Cometary Frontiers:
- CO_2, H_2O and CO sensitive measurements in dozens of comets.
- Sampling of numerous organic species.
- Characterization of faint and distant comets (before the activation of water).

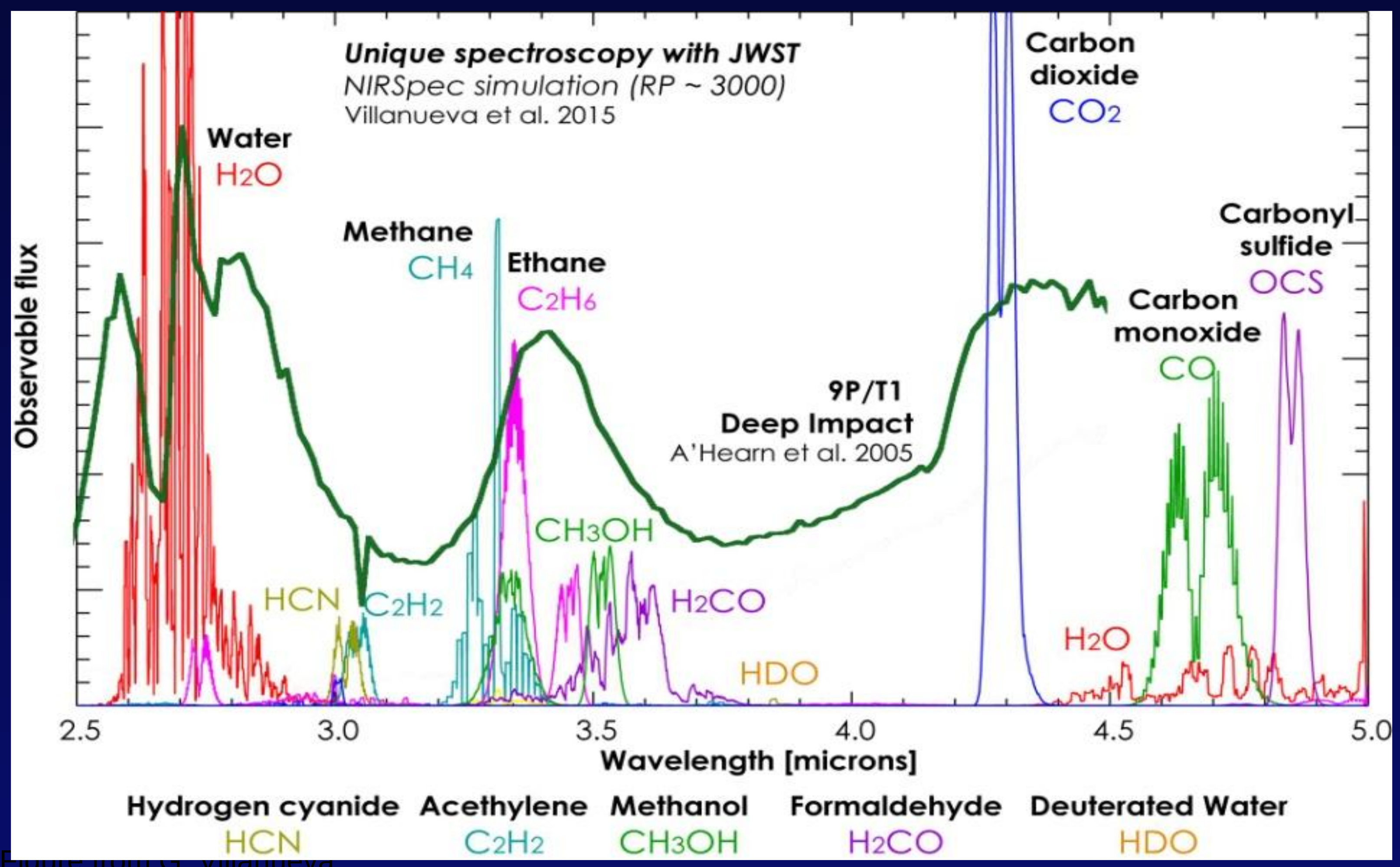
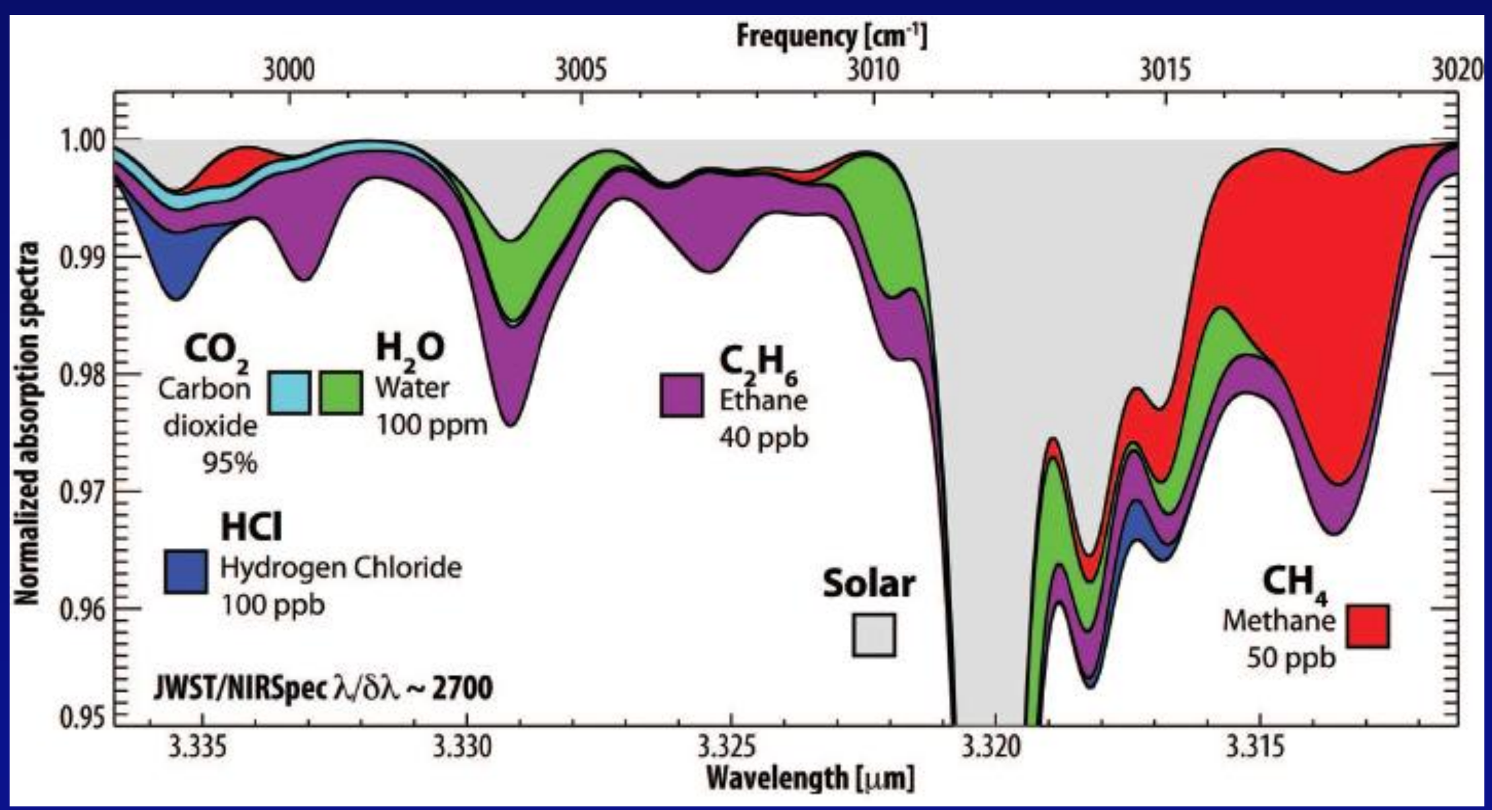


Figure from G. Villanueva.

Mars

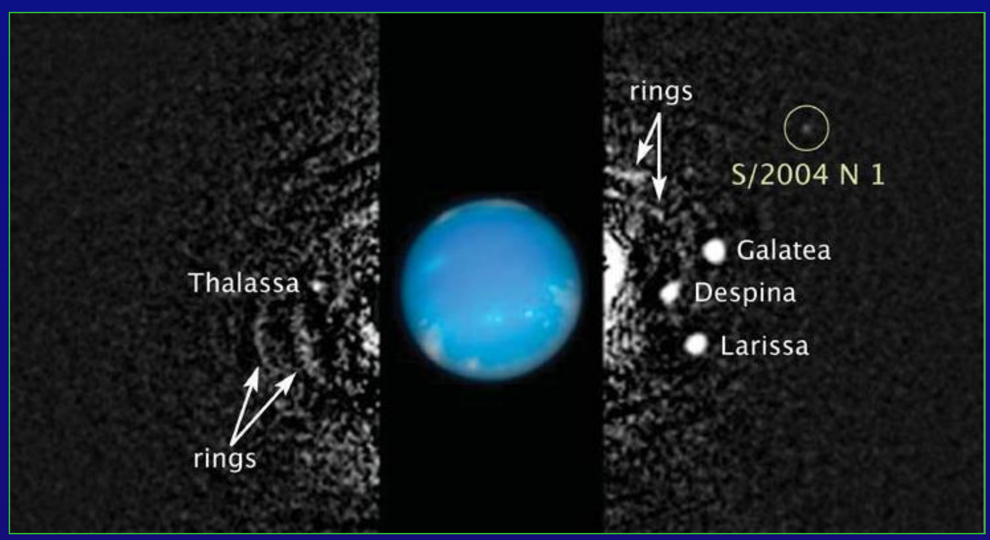
- JWST will conduct isotope studies of HDO and H_2O to help determine if the Martian atmosphere was once habitable, to search for unidentified sources of water; and to address what processes alter the atmosphere.
- Mars is observable with JWST at L2 in 2018, 2020, and 2022. Both the evening and morning terminators can be observed.
- Searches for organics at levels previously measured with rovers or orbiters can be conducted on a global level.
- The full Martian disk is available at 2 micron and the night-side hemisphere can be mapped.



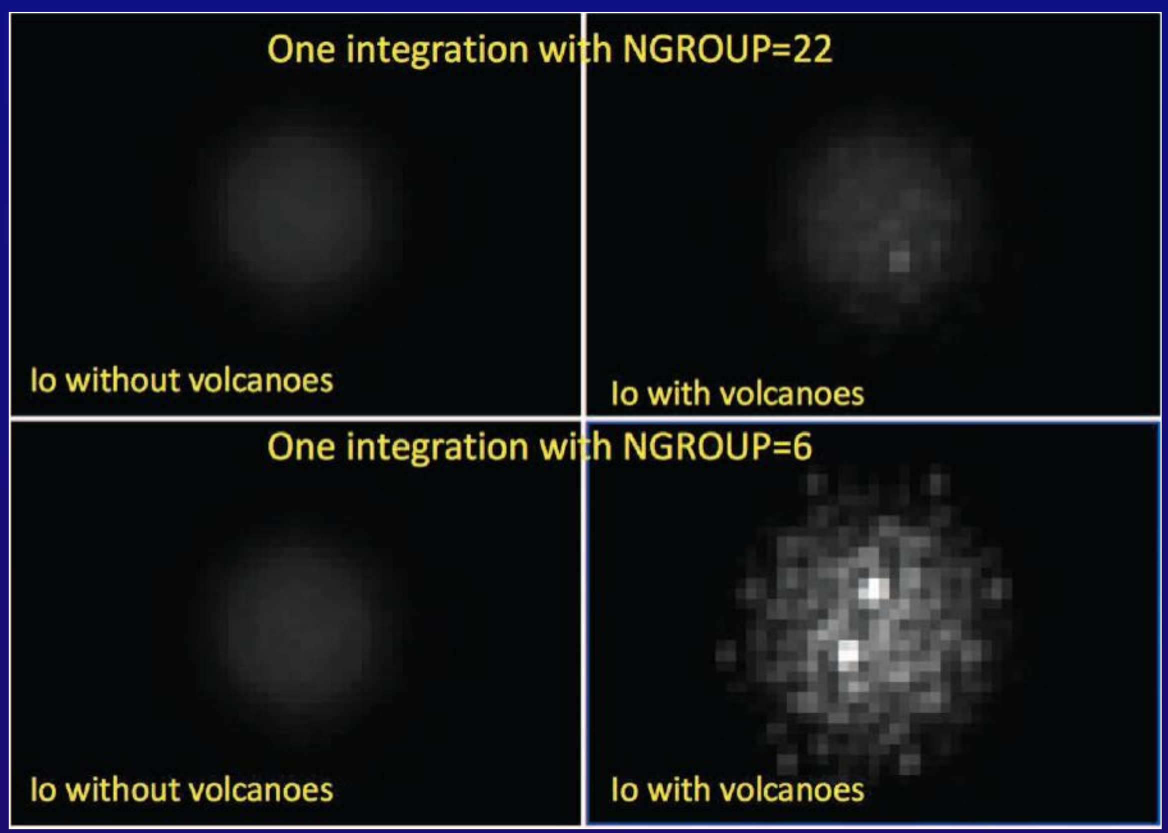
Search for organics with NIRSpec. Many trace species have strong signatures at these wavelengths (CH4, C2H6, HCl, H2O and CO2 shown), enabling sensitive searches on Mars with JWST due to the observatory superb spectrometric sensitivities and high spatial resolutions. From Villanueva et al. (2015).

Rings

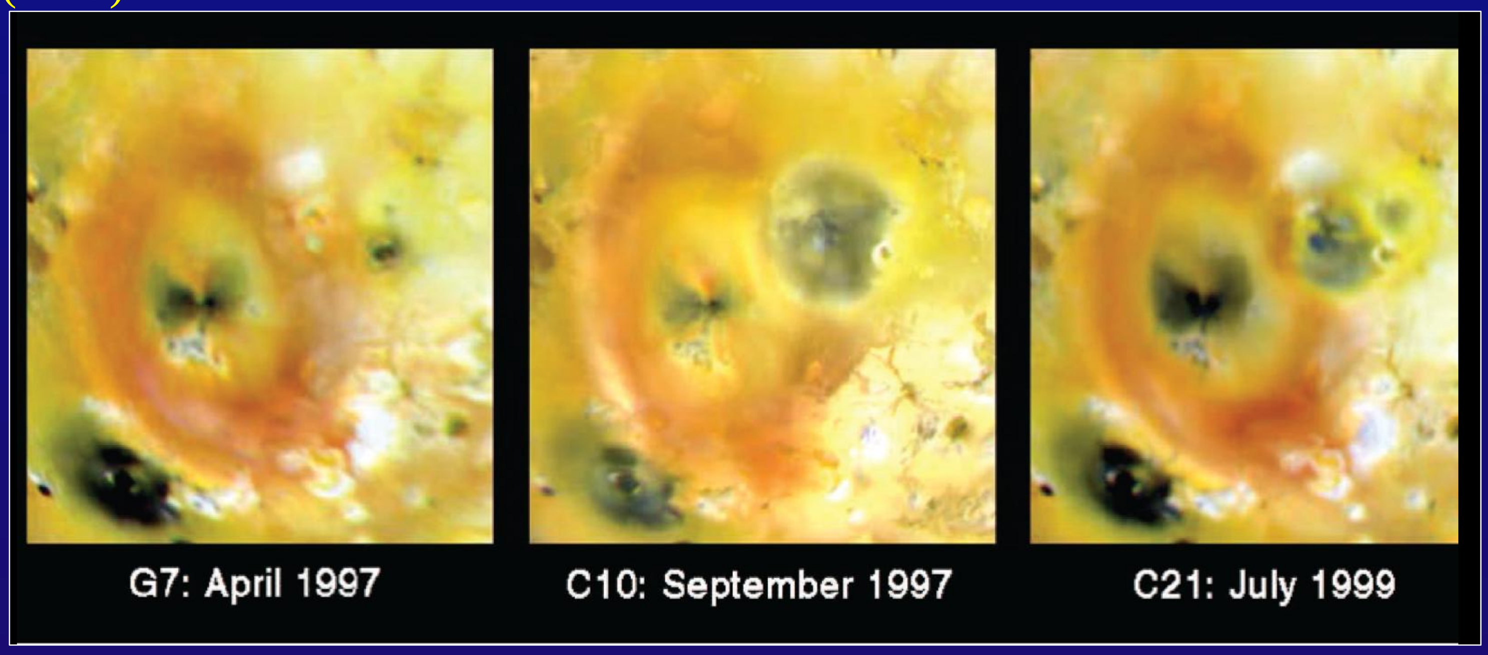
- Discovering new rings and moons by taking advantage of operating in the infrared methane bands (vastly improved signal-to-noise when suppression of glare from the planet is an important factor).
- Spectroscopy of the rings and small moons of Uranus and Neptune; these have never been the subjects of high-delity spectroscopic study.
- Spectroscopy will fill in the gap between Cassini VIMS and Cassini CIRS.
- During JWST, sun angles will decrease at Neptune and will increase at Uranus, leading to a favorable viewing for both systems. The only exact equinoxes possibly observable by JWST will be at Jupiter; these will provide optimal viewing of vertical structure in the halo/gossamer rings.



Only 18 km across, S/2004 N 1 (discovered in 2013 by Showalter et al.) is >10x fainter than any moon seen by Voyager 2. *Credit: NASA.*



Planck Function thermal emission at temperatures relevant for active silicate volcanism on Io. Note that the response in the 1-2 micron region is extremely sensitive to the highest temperature components. From Keszthelyi et al. (2015).



Galileo SSI images of the formation and fading of the Pillan plume deposit. Changes like this could be resolved, both spatially and temporally, by JWST.

Satellites

- JWST will provide a consistent set of infrared spectra for systematic or comparative studies of satellites across our Solar System. Previous orbiters or flybys provided incomplete and/or data collected under illumination conditions that are less than desirable for spectroscopy.
- Studies of smaller or captured satellites offer unique insight into their origins and further details on the formation of the Solar System.
- Geologic activity on satellites (such as plumes) can be studies by monitoring temporal or thermal variations on the surface.

Science Capability Highlights

- Important molecular (e.g. H_2O, HDO, CO, CO_2, CH_4), ice, and mineral spectral features are at wavelengths accessible with JWST but not the ground.
- Near-IR spectra or colors (composition), and mid-IR photometry (albedos, sizes), for any Kuiper belt object known today.
- Semi-annual monitoring of planetary (and satellite) weather *and seasonal changes*.
- Near-simultaneous mapping and spectroscopy of cometary gas and dust from 0.6 – *~28* μm.
- Very sensitive spectral maps at R > 2000 over a 3"x3" field and with 0.1" spatial resolution.

http://www.jwst.nasa.gov/
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