

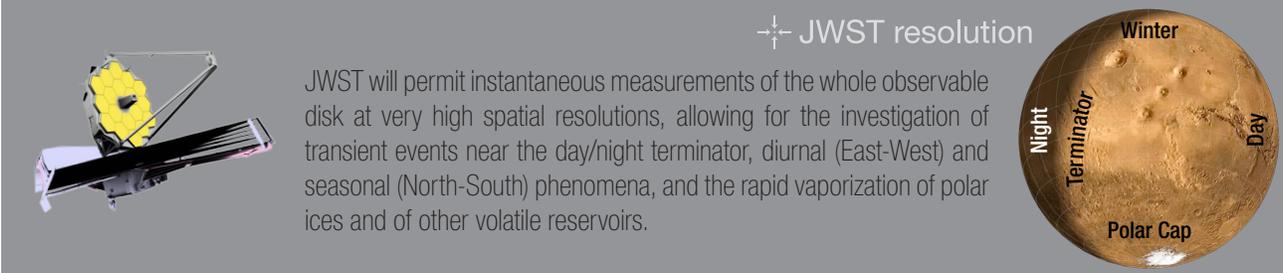
NASA's James Webb Space Telescope:

Observations of Mars

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Does the atmosphere of Mars reveal a more habitable past? Are there unidentified sources of water on Mars? What processes alter the chemical stability of its atmosphere? These are some of the questions that JWST can address by performing isotopic studies of molecular species (e.g., $\text{HDO}/\text{H}_2\text{O}$), and by investigating the role of trace species in the atmospheric photochemical cycles. The atmosphere acts as a buffer between the main reservoirs of H, C and O (e.g., regolith, polar caps, rocks) and the exosphere, consequently atmospheric isotopic/abundance ratios and their variability provide key diagnostics quantifying the exchange between these environments.

Characterization of these processes require high-spatial resolution, global coverage, superb spectroscopy and unprecedented time cadences, all qualities provided by the James Webb Space Telescope (JWST), due to its unique vantage point at the second Sun-Earth Lagrange point (L2) and its powerful suite of instruments. The broad spectral coverage provided by JWST will permit the characterization of the formation and evolution of global dust storms and cloud systems over volcanoes, while its spectral resolution allows the search for trace photochemical species and isotopic compounds.



JWST resolution

JWST will permit instantaneous measurements of the whole observable disk at very high spatial resolutions, allowing for the investigation of transient events near the day/night terminator, diurnal (East-West) and seasonal (North-South) phenomena, and the rapid vaporization of polar ices and of other volatile reservoirs.

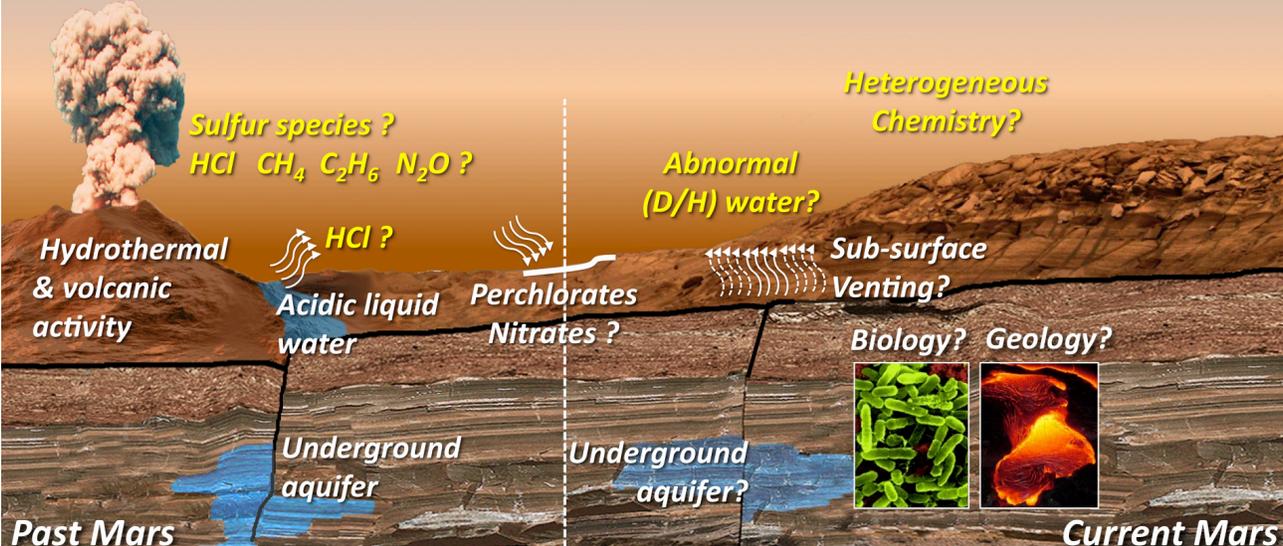
The globe shows Mars with labels: Winter, Day, Night Terminator, and Polar Cap.

Was Mars habitable? Is it now?

How wet was Mars?

How much water is currently available?

How is the exchange between the polar caps with the regolith and the atmosphere?



Past Mars | **Current Mars**

Hydrothermal & volcanic activity | **Heterogeneous Chemistry?**

Sulfur species?
 HCl CH_4 C_2H_6 N_2O ?

Acidic liquid water | **Abnormal (D/H) water?**

HCl? | **Sub-surface Venting?**

Perchlorates | **Biology? Geology?**

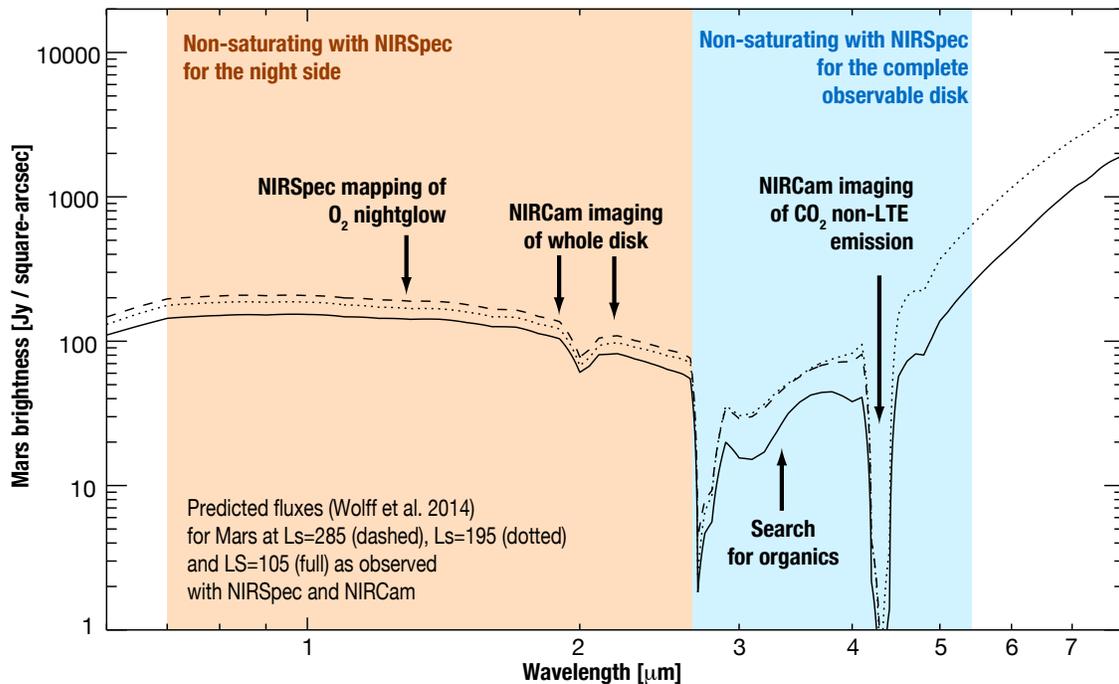
Nitrates?

Underground aquifer | **Underground aquifer?**

Polar Cap



Spectroscopy and Imaging of Mars



JWST will permit observations of Mars at infrared wavelengths with NIRSpec and NIRCams—predicted fluxes are shown for three seasons/aerocentric longitudes (Ls). Specifically, NIRSpec observations are feasible with sub-array readouts in the 2.7 to 5.2 μm spectral region for the complete observable disk, and from 0.7 to 5.2 μm in the night regions. Observations with NIRCams are accessible with two narrow filters near 2 μm for the complete disk, and with several filters from 0.5 to 2 μm across the night regions. Mapping of CO_2 non-LTE emission at 4.3 μm will be also possible with NIRCams’s filter F430M.

Near-Infrared Spectrograph (NIRSpec)

- Narrow slit spectroscopy
- ~100 km resolution at equatorial latitudes
- Moderate spectral resolution ($\lambda/\delta\lambda \sim 2700$)
- 0.7 to 5.2 μm accessible with sub-array readouts
- Measurements of D/H, O_2 nightglow, dust and clouds, CO_2 non-LTE emission and sensitive searches for trace species such as organic compounds

Near-Infrared Camera (NIRCam)

- Full disk accessible at 2 μm
- O_2 nightglow mapping at 1.3 μm
- CO_2 non-LTE mapping at 4.3 μm
- Mapping of the night-side hemisphere

Testing of MIRI performance for Mars is currently underway

Observing windows (approaching, receding)

2018 Nov/Dec to Ls:306 (14/Dec)

2020 Ls:206 (22/May) to Ls:273 (07/Sep)

2020 Ls:319 (21/Nov) to Ls:2 (10/Feb/2021)

2022 Ls:289 (16/Aug) to Ls:333 (04/Nov)

2023 Ls:9 (13/Jan) to Ls:42 (25/Mar)

Mars viewing geometry

- Most windows will sample the southern cap; polar caps only observed when illuminated
- Most of the observable disk will be in daytime (84-93%)
- When approaching, the evening terminator will be sampled, while the morning terminator will be sampled when receding

See more at www.stsci.edu/jwst and jwst.nasa.gov

