Visualizing and Analyzing Martian Atmospheric Data in JMARS

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Introduction:

JMARS (Java Mission-planning and Analysis for Remote Sensing) is a free GIS (Geospatial Information System) tool (Christensen et al. 2009) that has been used to visualize and analyze Mars remote sensing data for over 20 years. In addition to allowing users to easily access visible, thermal, RADAR, and spectral datasets that have been collected over the years, JMARS also offers a number of tools and layers for working with modeled and measured Martian atmospheric datasets. The JMARS application as well as numerous tutorials, videos, and helpful links can be found at http://jmars.asu.edu.

This abstract will highlight some of the more recent JMARS layers that support Mars atmospheric visualization and analysis. Other datasets included in JMARS but not highlighted here include the TES (Christensen et al. 2001) spectral layer as well as both a queryable wind vector layer and global wind speed maps (Adler et al. 2016) based on the NASA Ames GCM (Haberle et al. 2019).

MCD Map Slider:

Built from a set of pre-generated maps based on an MCD 5.3 model (Forget et al. 1999; Millour et al. 2018) run, the JMARS MCD Map Slider layer offers the user a choice of many different parameters that can then be viewed in sequence as part of a playlist.

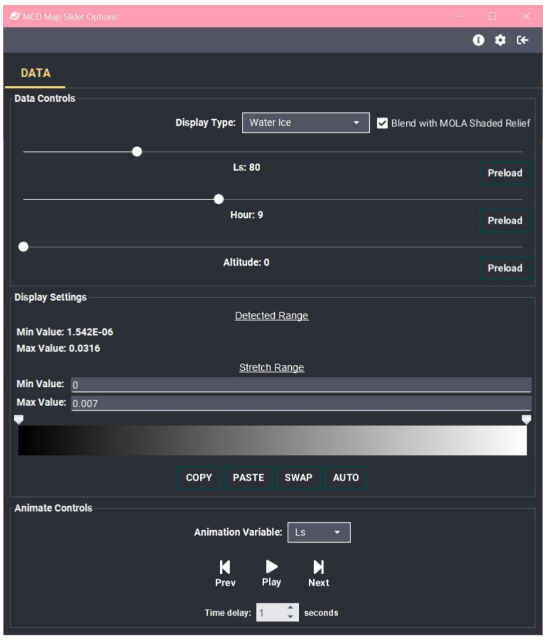

Figure 1. JMARS Map Slider Layer showing initial input values.

First, the user can pick from a variety of display types:

Temperature
Atmospheric Pressure
Zonal Wind
Atmospheric Density (Rho)
Water Vapor
Water Ice
Dust Column
Dust Deposition
Radius of Dust Particle
Solar Flux Reflected to Space
Solar Flux to Surface
Thermal Flux from Surface to Space
Thermal Flux from Space to Surface
Meridional Wind

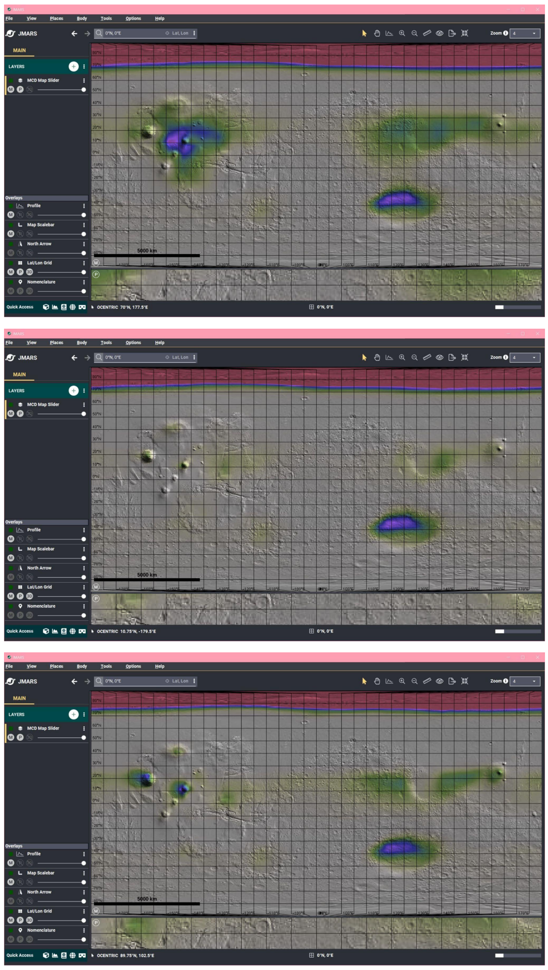

Figure 2. JMARS Map Slider Layer showing three corresponding Water Ice maps for 9 a.m., noon, and 5 p.m (top to bottom)

By default, data will be displayed in grayscale space stretched uniformly between the detected minimum and maximum values contained in each map, but the user can override the min and max values for a custom stretch if desired. A standard JMARS color palette can be optionally applied to turn the grayscale image into a colorized map. The resulting map can also be blended on the fly with the MOLA Shaded Relief to provide additional surface context.

Then the user can then further refine the data by adjusting three input sliders:

Ls values from 0-350 in 10 degree increments.

Hour values from 0-23 in 1 hour increments.

Altitude values of 0, 1, 10, 100, 1k, 5k, 10k, 20k, 40k, 60k, 80k, or 100k meters.

The user can adjust the values for any of these parameters as desired, and the displayed map will be updated appropriately. If desired, a user can choose to preload an entire range of maps, for example, all of the available Ls values, which will cause JMARS to request and cache each map in turn. This then allows for quick cycling between maps, either manually or by using the layer's Animation controls to iterate through each available option (10 degrees of Ls in this example) every 1-5 seconds.

MCD Point Layer:

The JMARS MCD Point Layer allows a user to input a few parameters for a single point and then dynamically generate modeled climate data at that location. Multiple points can be created and compared against one another.

In addition to the point (which defines the latitude and longitude), the user can also input:

Local Time
Ls
Height above surface
Scenario (1-8)
Elevations

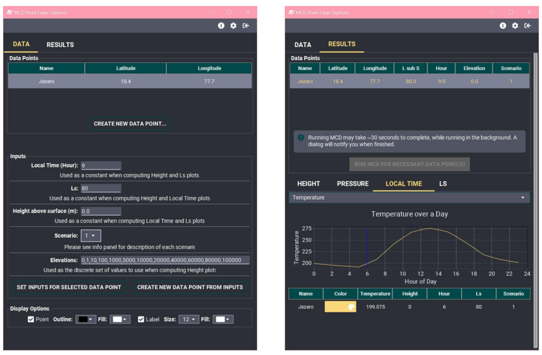

Figure 3. JMARS MCD Point Layer showing initial input values (left), and a corresponding diurnal temperature curve (right).

With the points and their parameters now defined, the user can press a button to calculate MCD data for them. The user interface then provides options to view plots of the generated data based on Height, Pressure, Local Time, or Ls against 78 different calculated parameters, including Temperature, Pressure, Altitude, Water Vapor, Water Ice, and many different volume mixing ratios.

KRC Point Layer:

The JMARS KRC Point Layer allows a user to specify a number of parameters for a location and then use krc (Keiffer 2013) to calculate the remaining parameter.

In addition to the point (which defines the latitude and longitude), the user can also input:

Ls
Local Time
Elevation
Albedo
Slope
Opacity
Azimuth
and either Thermal Inertia
or Temperature

Defaults for all of these inputs will be provided by JMARS based on global maps or common input values. The user can accept the defaults or override with a different value. Multiple points can be defined and compared against one another.

Once krc has been run on the input parameters, the user will be provided with diurnal and annual temperature curves.

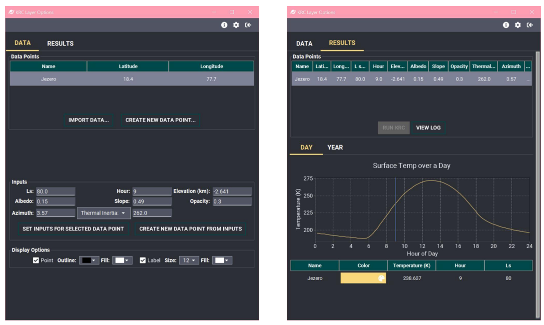

Figure 4. JMARS KRC Point Layer showing initial input values (left), and the resulting diurnal temperature plot (right).

EMIRS Spots Layer:

The EMIRS Spots layer in JMARS allows a user to query spectral data collected by the EMIRS instrument (Edwards 2021) on the Emirates Mars Mission (EMM) to study Mars atmosphere (Almatroushi et al. 2021; Amiri et al. 2022). Metadata for each spot can be viewed in a standard table, while observational footprints can be viewed in the spatial context of any other dataset available in JMARS. In addition, each of the footprint spots can be colorized based on metadata values or custom on the fly expressions to produce dynamic data maps.

In addition to retrieving EMIRS spots that fall within a specified spatial extent, the user can query on many of the most popular metadata fields, including:

Incidence Angle
Emission Angle
Phase Angle
Solar Longitude
Local Time
Spacecraft Clock
Year-DOY
UTC
Orbit Number
Max Brightness Temperature

Users can also view spectral data for each collected spot, such as Brightness Temperature, Emissivity, and Calibrated Radiance. Such spectra data can be added, subtracted, divided, and averaged against other spectra to do quick comparisons and analysis within the JMARS tool. All retrieved data can also be easily exported into CSV formatted files for advanced analysis in other tools.

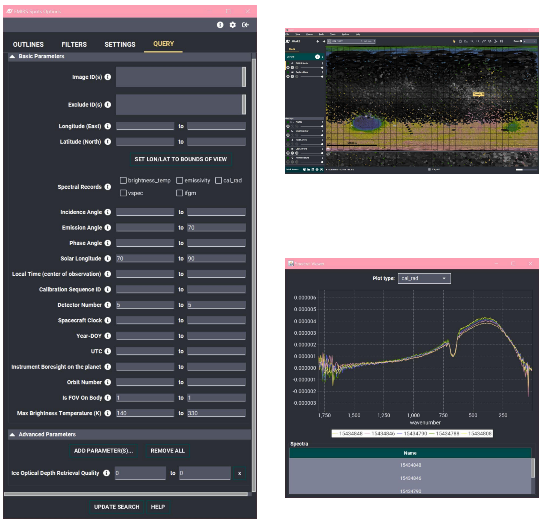

Figure 5. JMARS EMIRS Spots Layer showing initial input values (left), and the resulting observation spots colorized by the infrared opacity of ice aerosols (tauice) (top right). A spectral plot of the calibrated radiance for five selected EMIRS observations (bottom right).

Future work:

The JMARS team will continue to add and update datasets to support visualization of acquired and modeled atmospheric data. Current plans include providing access to EXI level 2b data collected by the EMM mission, as well as a series of gridded map projects that will be produced by the EMIRS instrument team.

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