

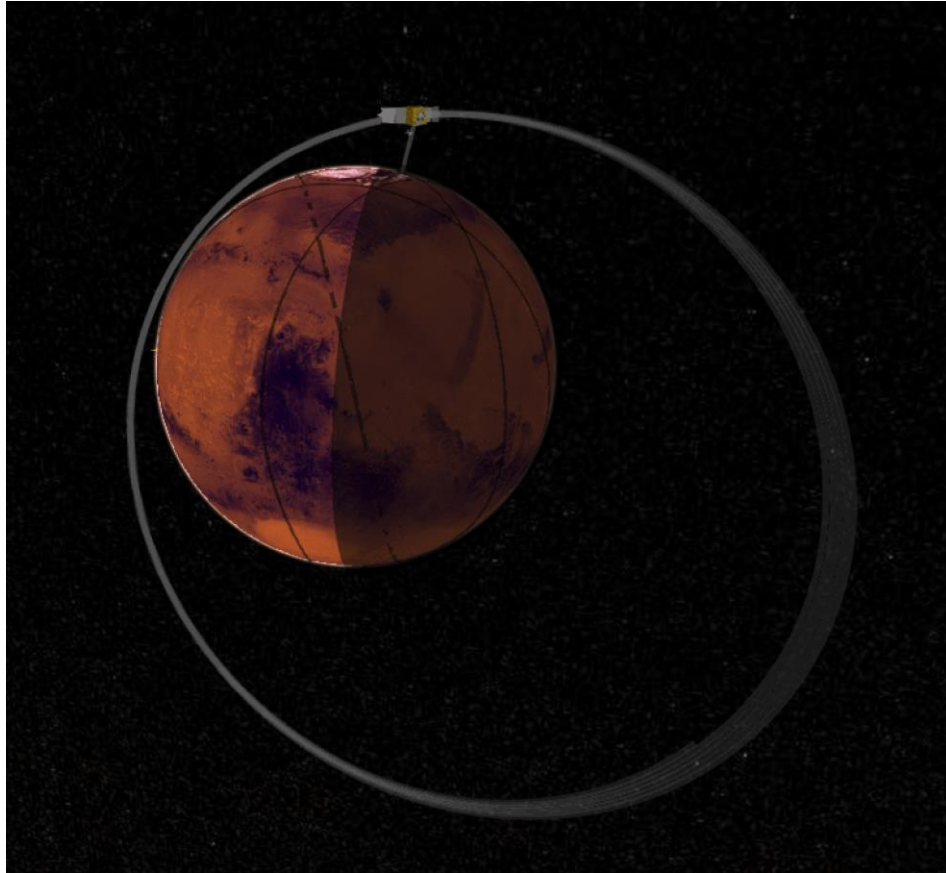
3D Visualization for Planetary Missions

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Laboratory for Atmospheric & Space Physics

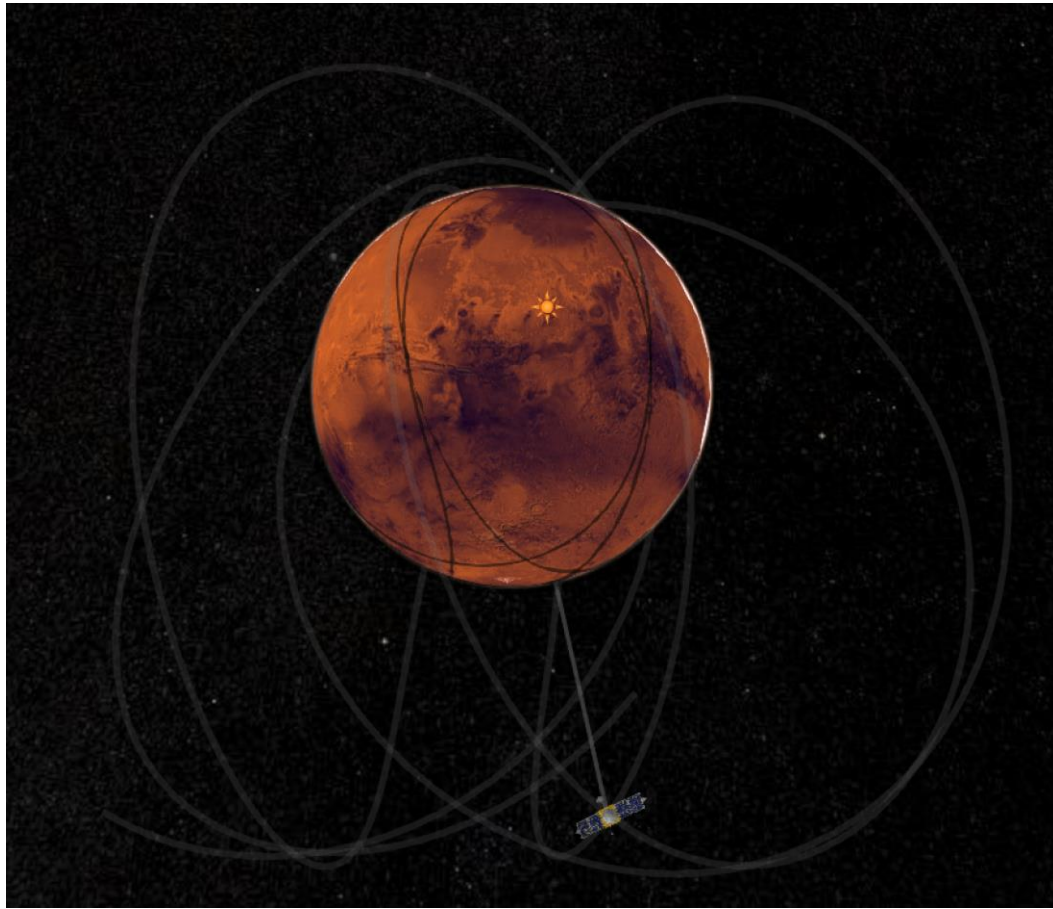
University of Colorado, Boulder

MAVEN



- Mars orbiter mission
- Launched in 2013
- Highly elliptical 4.5-hour orbit
- Studying evolution of the Martian atmosphere

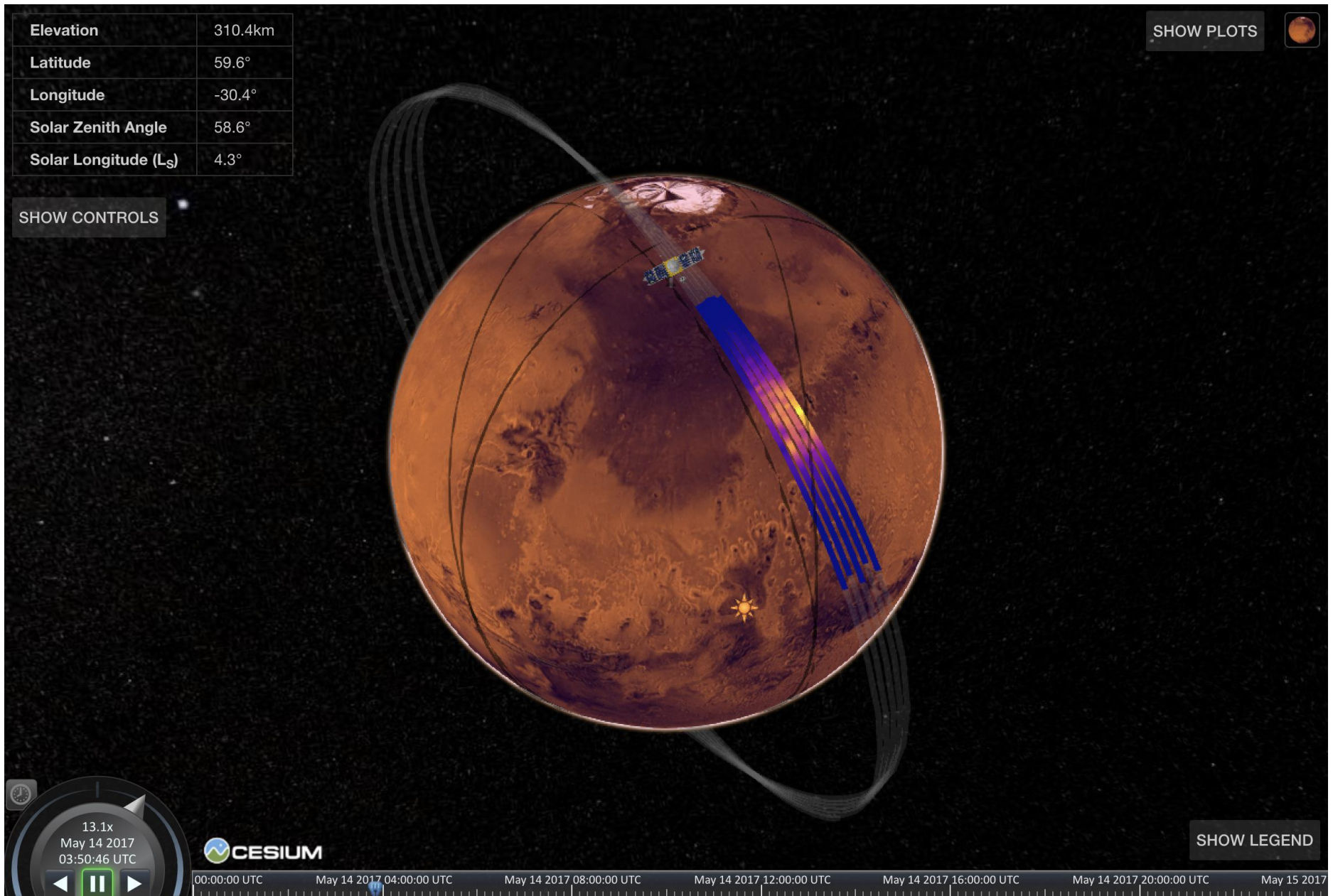
Visualizing spacecraft orbits



- Useful to know where/when your data was taken.
- Also helpful to visualize orientation: where spacecraft was pointed at any given part of the orbit.
- And of course it's nice to know where the sun was during the observation.
- And so on...

Previous 3D vis attempts

- IDL visualization tools
 - Proprietary, expensive for users
 - Learning curve for users
 - Hard to get interactive 3D that's usable
- Google Mars
 - Difficulty getting our own data to display the way we wanted it
 - More surface-oriented, less about orbit data
- D3.js
 - Steep learning curve, lots of custom development needed




<https://lasp.colorado.edu/maven/sdc/public/pages/maven3d/>

Controls ✕

Date Range ^

Available Dates: 2014-09-21 – 2017-08-31

Date (UTC)

 2017-08-31

RELOAD

Maven In-Situ Data ^

Reference frame

Inertial ▼

Orbit Path Color (1D Parameters)

None ▼


Orbit Path 'Whiskers' (3D Parameters)

None ▼

Note: Not every parameter will have data available for a given time range. This could mean that data was

Elevation	1702.9km
Latitude	-27.8°
Longitude	67.4°
Solar Zenith Angle	82.1°
Solar Longitude (L_S)	54.5°


HIDE CONTROLS



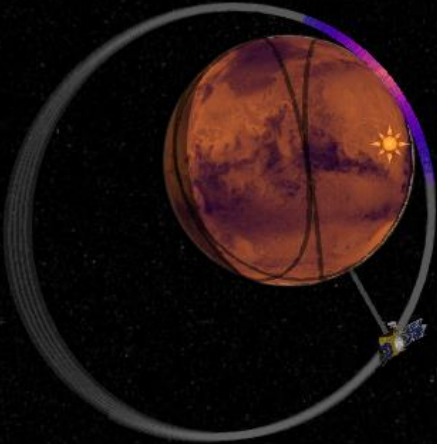
- Controls
 - Date selection
 - Datasets
 - Orbital reference frame

Secure | <https://lasp.colorado.edu/maven/sdc/public/pages/maven3d/>

Elevation	2295.6km
Latitude	-60.3°
Longitude	84.3°
Solar Zenith Angle	71.8°
Solar Longitude (L_s)	4.2°

HIDE PLOTS 

SHOW CONTROLS



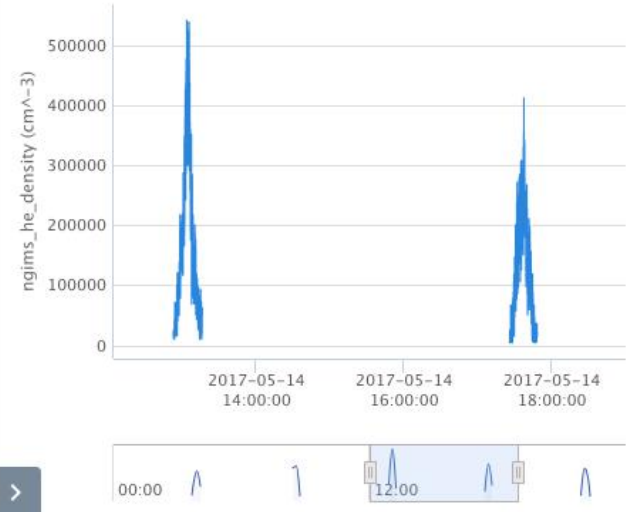
SHOW LEGEND

1000x
May 14 2017
00:00:00 UTC

00:00:00 UTC May 14 2017 12:00:00 UTC May 15 2017

ngims_he_density

ngims_he_density (cm⁻³): 49700.0



00:00 12:00

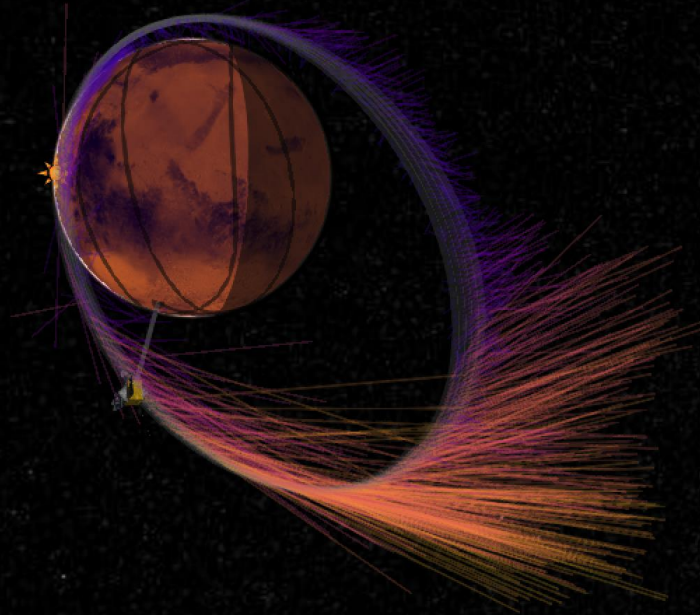
- Added 2D plots with Highcharts.
- Time slider, zoom

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SHOW PLOTS



SHOW CONTROLS



- Vectors: “whiskers” coming off the orbit track

13.1x
May 14 2017
00:00:00 UTC

CESIUM

SHOW LEGEND

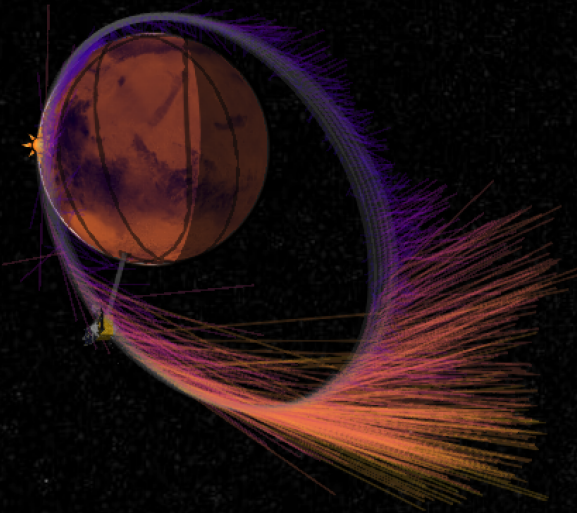
00:00:00 UTC May 14 2017 04:00:00 UTC May 14 2017 08:00:00 UTC May 14 2017 12:00:00 UTC May 14 2017 16:00:00 UTC May 14 2017 20:00:00 UTC May 15 2017

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HIDE PLOTS



SHOW CONTROLS

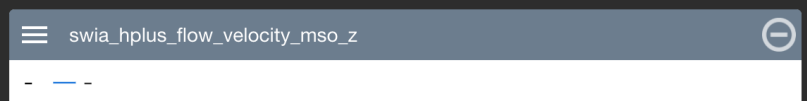
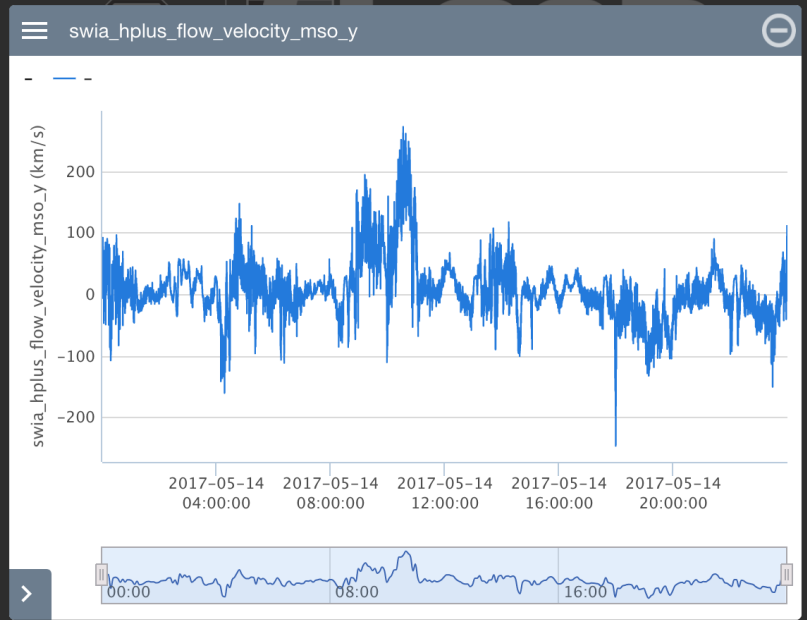
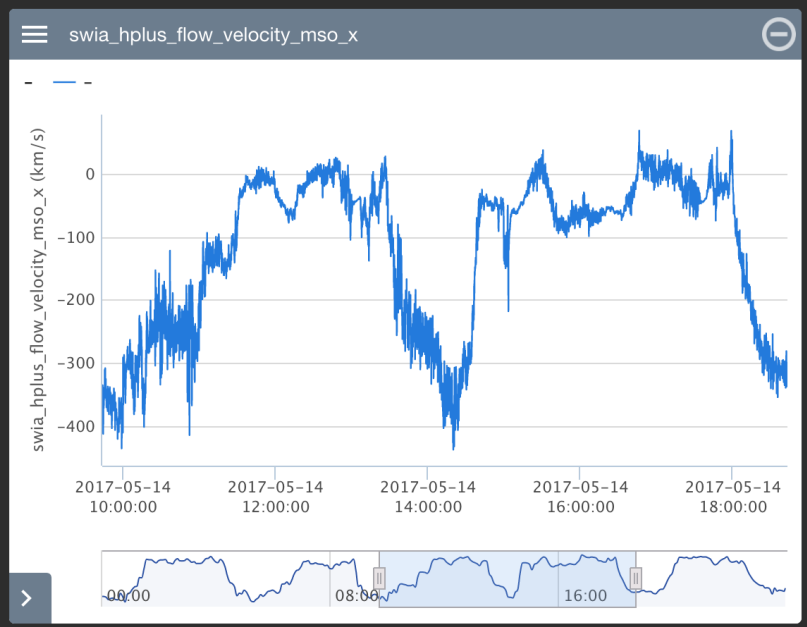


13.1x
May 14 2017
00:00:00 UTC



SHOW LEGEND

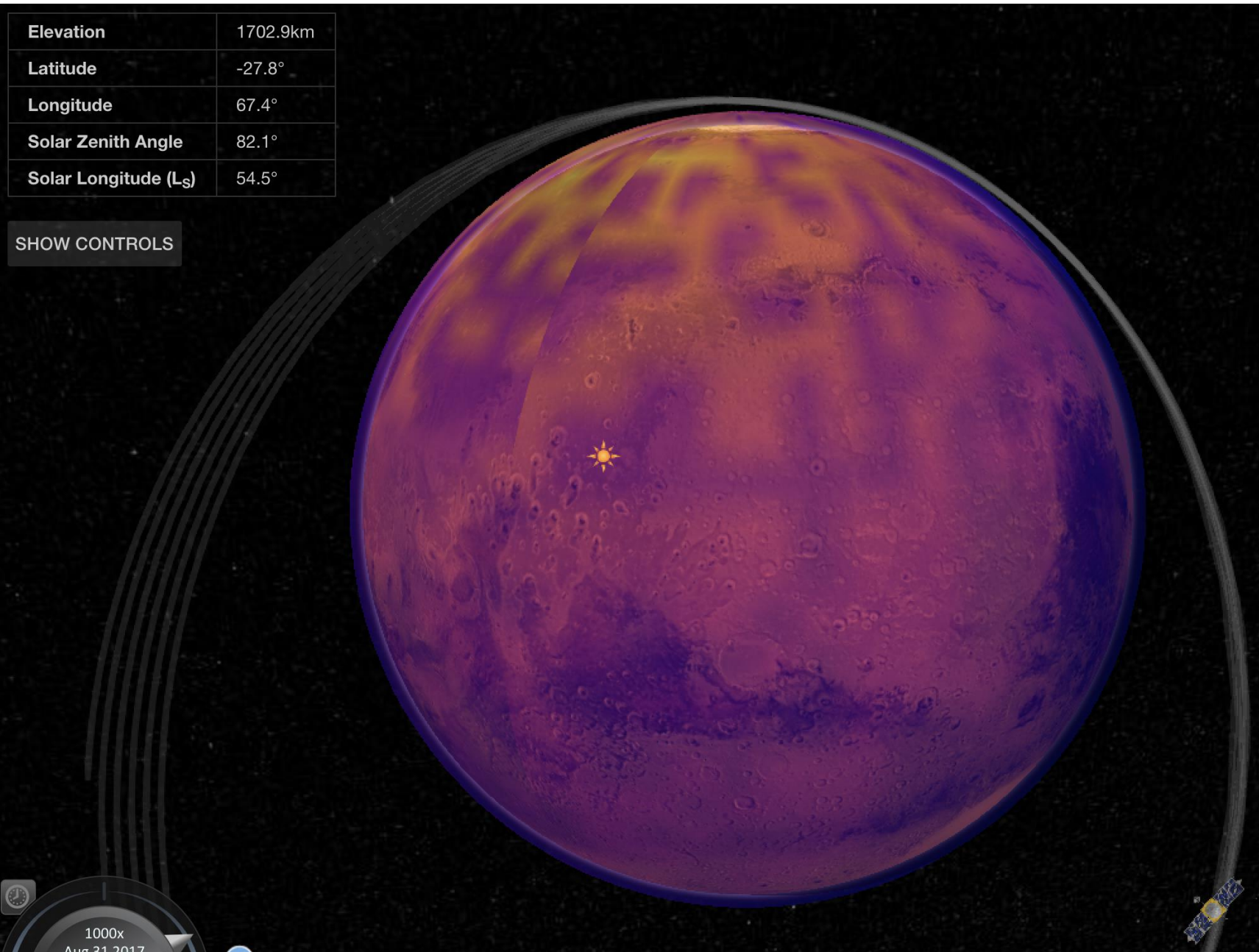
00:00:00 UTC May 14 2017 12:00:00 UTC May 15 2017



- 2D plots show vector xyz components

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SHOW CONTROLS



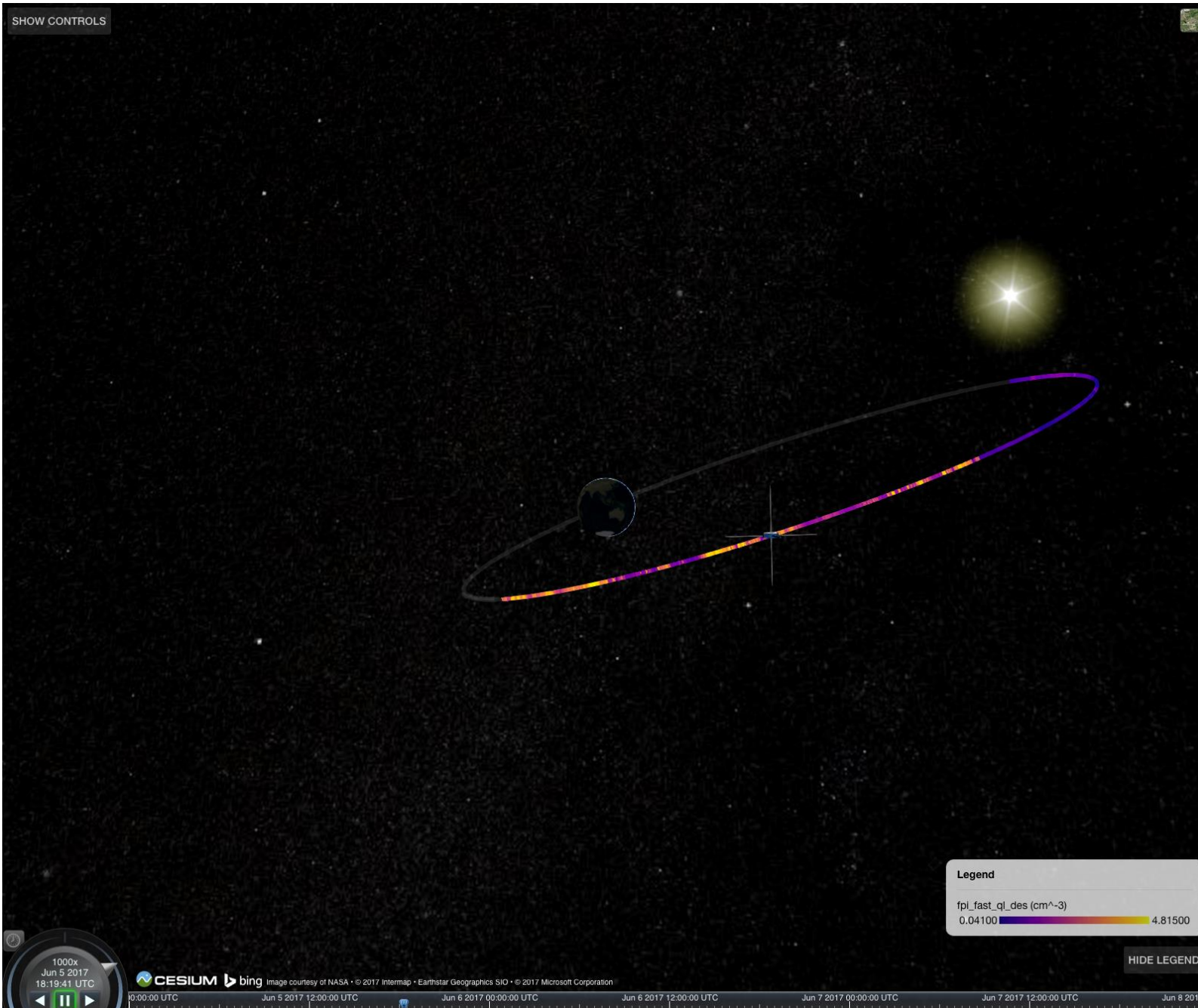
- M-GITM atmospheric model:
O+ at 106.25 km

1000x
Aug 31 2017

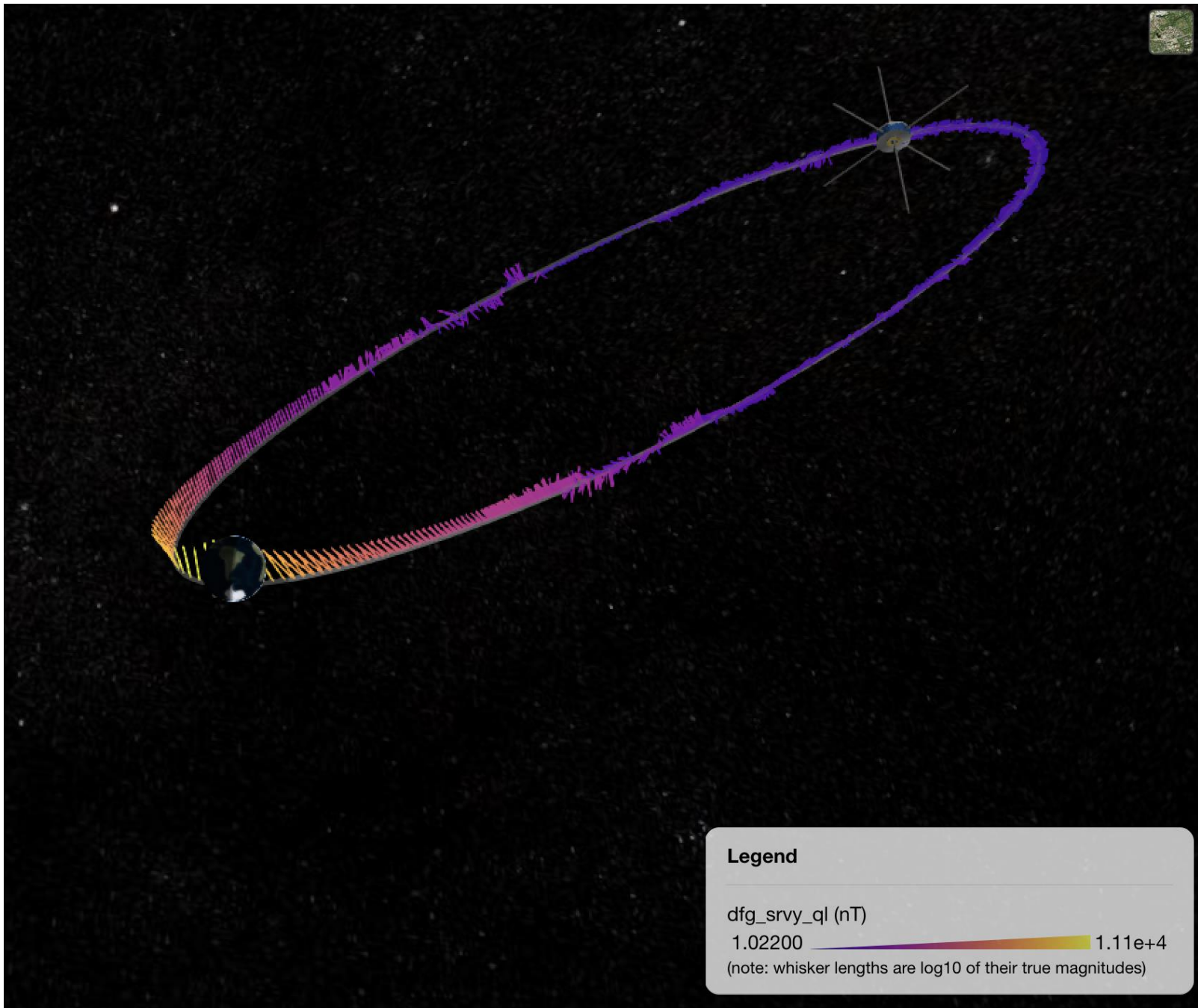
MMS



- Launched in 2015.
- Four spacecraft fly through Earth's magnetosphere in formation.
- Studying magnetic reconnection in Earth's magnetic field.



- FPI instrument observations along orbital track



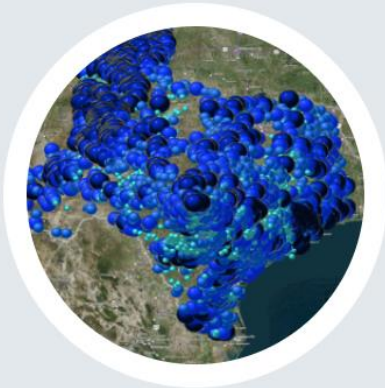
- Direction & magnitude of Earth's magnetic field

CesiumJS

“An open-source JavaScript library for world-class 3D globes and maps”

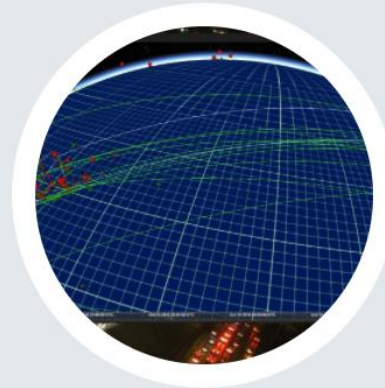
<https://cesiumjs.org/>

Examples:



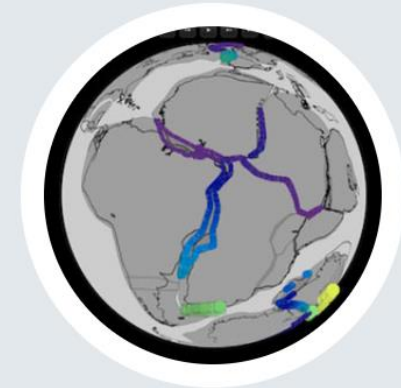
Texas Groundwater Well Levels Visualization

An interactive representation of groundwater levels over time from wells across Texas during a drought.



nextPlace Twitter Geo Stream

Uses Cesium 3D globe to visualize Twitter stream data in real time.

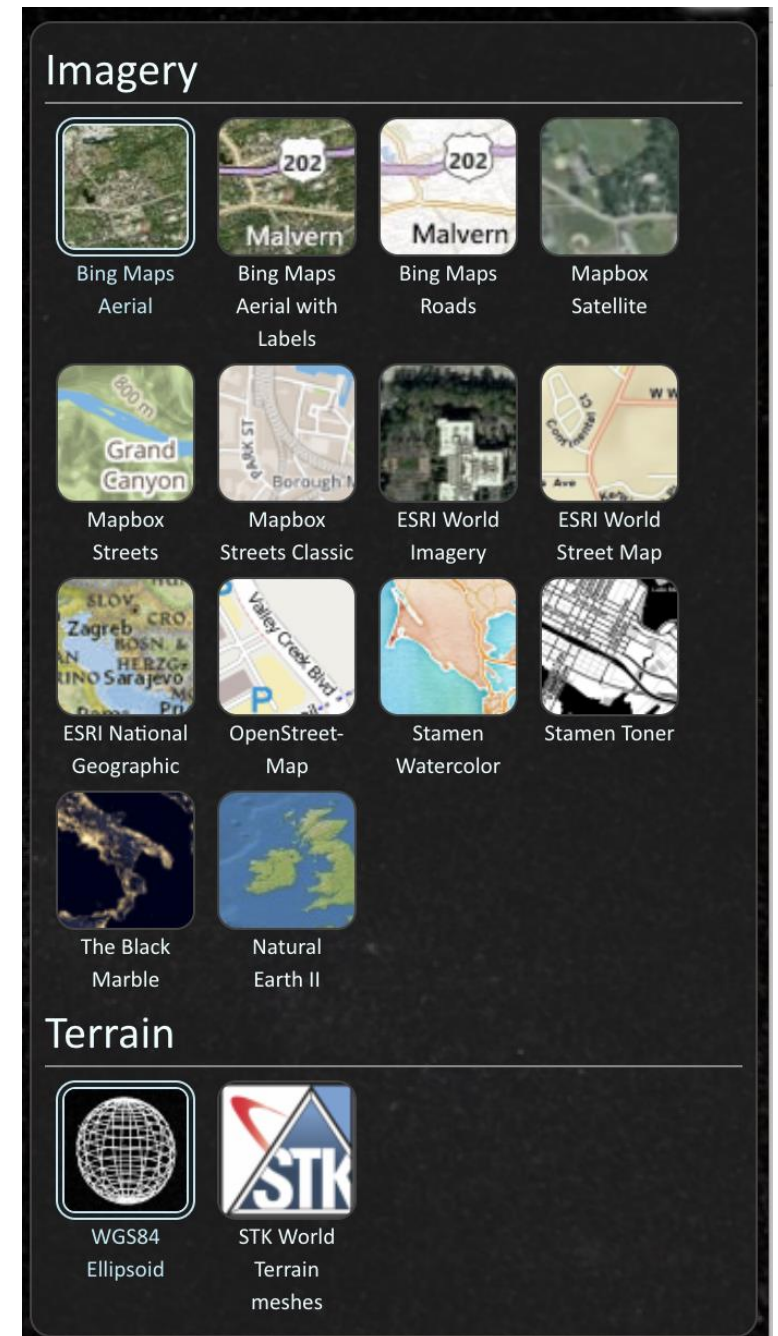


Rift Velocity Database

Visualizes the speed of continental rifting during the last 240 million years.

Advantages of Cesium

- Free and open source
- Javascript:
 - Fairly easy to work with
 - Browser-based rather than downloadable
- Offers some nice features out of the box:
 - Time controls
 - 3D & 2D map option
 - Different basemaps
- But also easy to extend and customize



Our additions & modifications

- Position and orientation:
 - MAVEN: using ASCII ephemeris & pointing data
 - MMS: using SPICE kernels
- Using LASP's LaTiS software to stream data as JSON
 - MAVEN: ASCII data files
 - MMS: CDF files
- Highstock JS library for 2D timeseries plots
- Mars is different from Earth:
 - Mars surface tiles
 - Atmosphere is a different color

Next steps

- MMS orbit formations
 - 4 spacecraft in tetrahedron sometimes, string-of-pearls sometimes
- More missions
 - Use SPICE kernels to display multiple missions simultaneously
 - Mars: MAVEN, Mars Express, EMM...
 - MMS, Van Allen Probes
- Instrument field-of-view displays

For more info

- <https://lasp.colorado.edu/maven/sdc/>
- <https://lasp.colorado.edu/mms/sdc/>
- <https://cesiumjs.org/>