Visualizing Planetary Missions in 3D with CesiumJS

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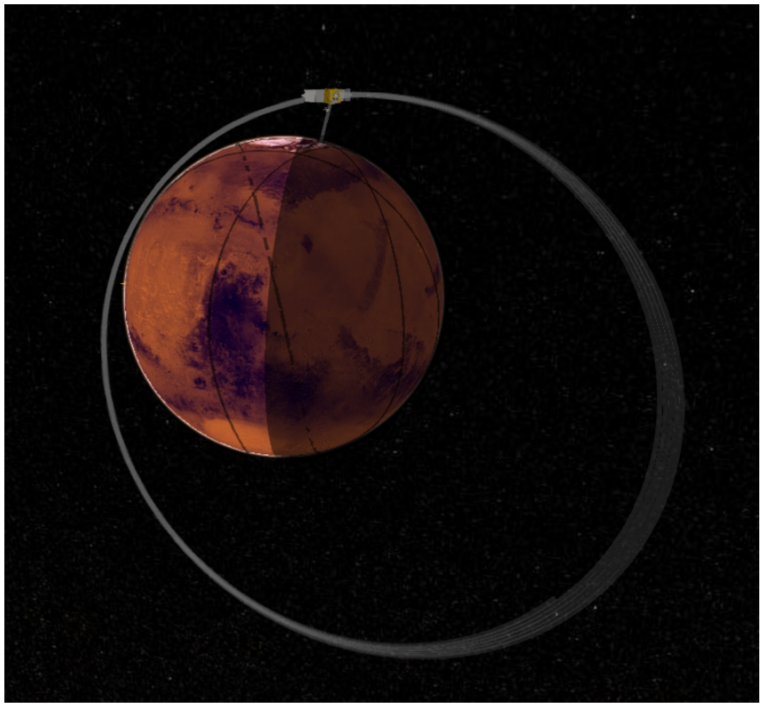
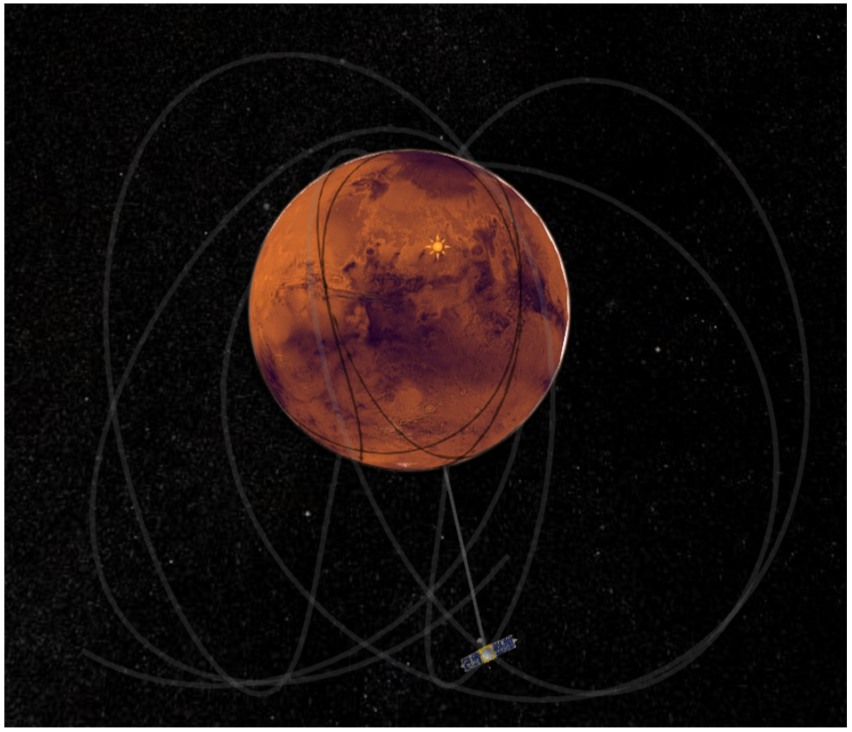
MAVEN



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

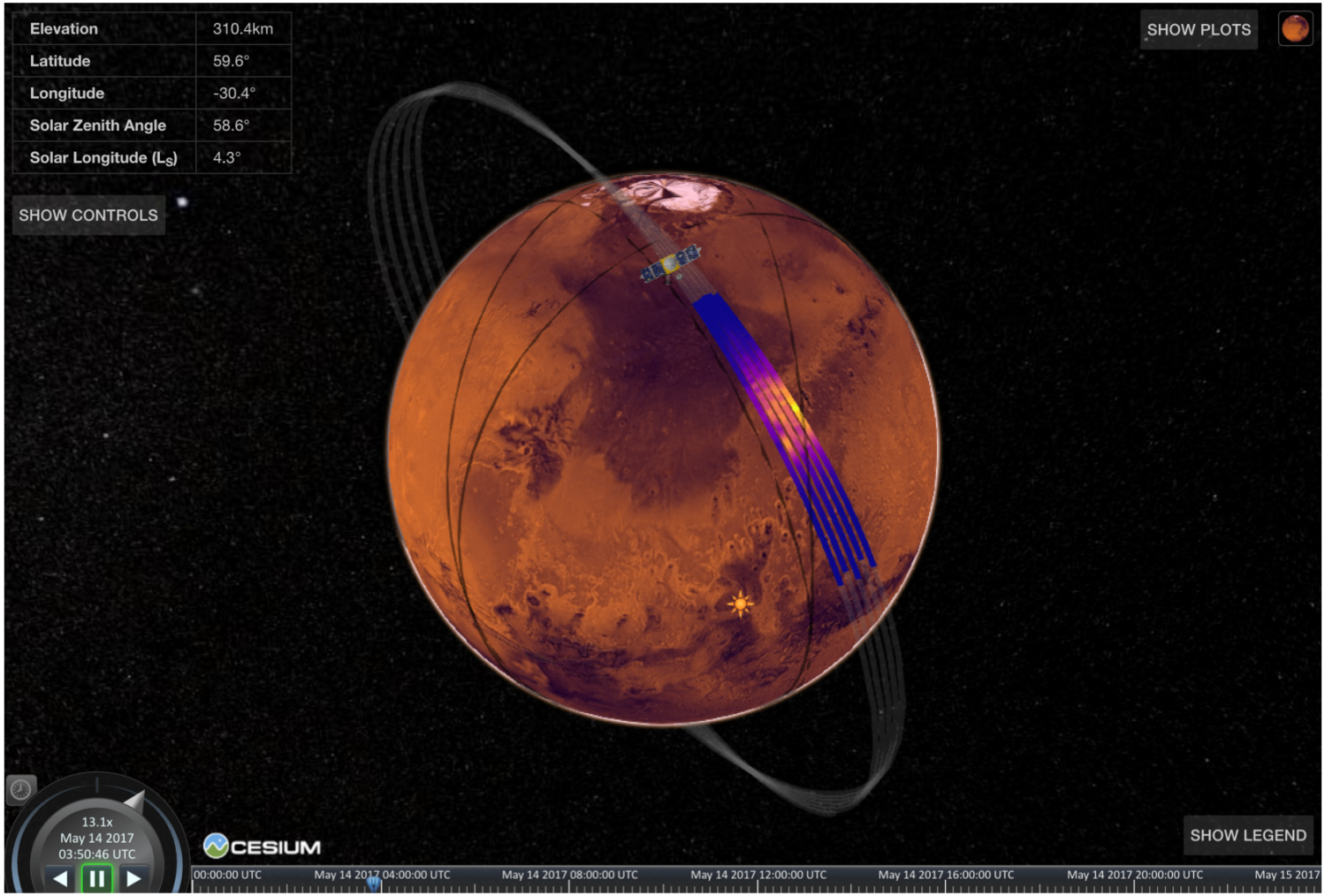
Visualizing spacecraft orbits



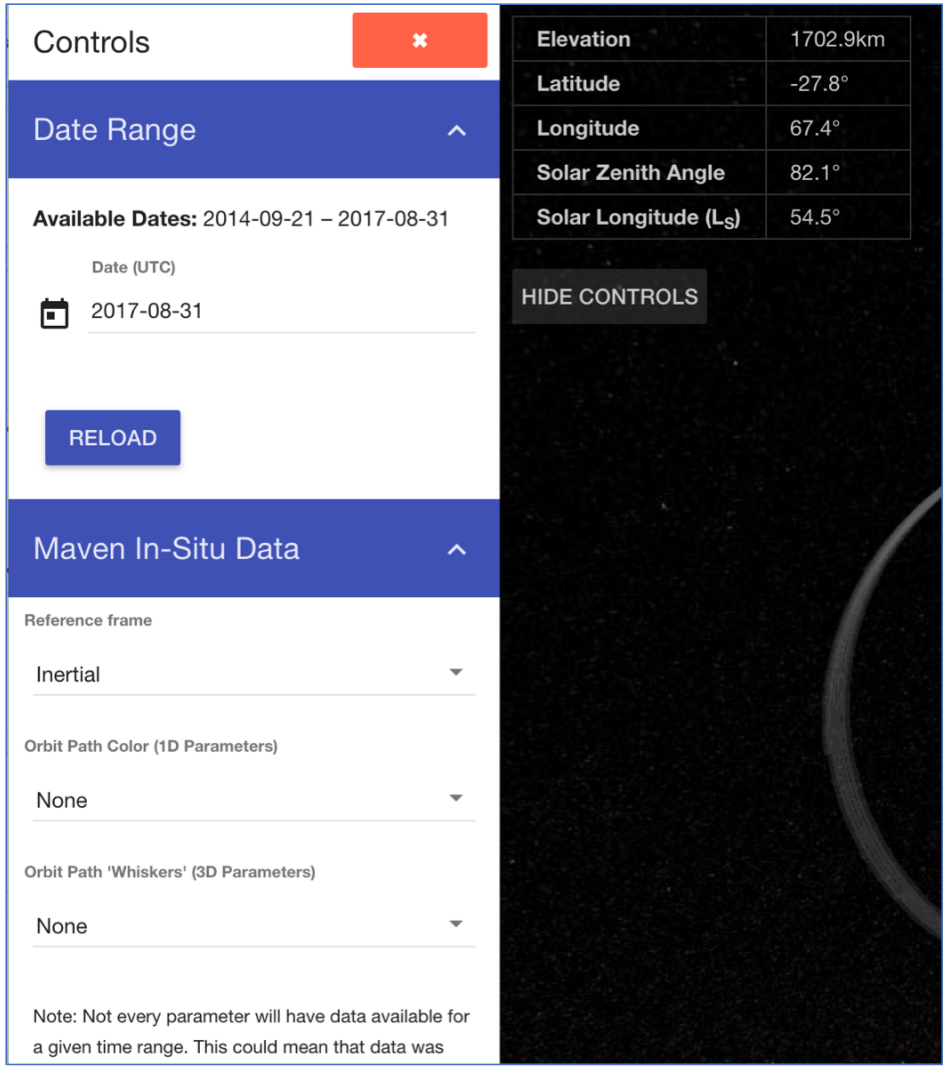
- Useful to know where/when your data was taken.
- Also helpful to visualize orientation: where spacecraft was pointed at any given part of the orbit.
- And of course it's nice to know where the sun was during the observation.
- And so on…

Previous 3D vis attempts

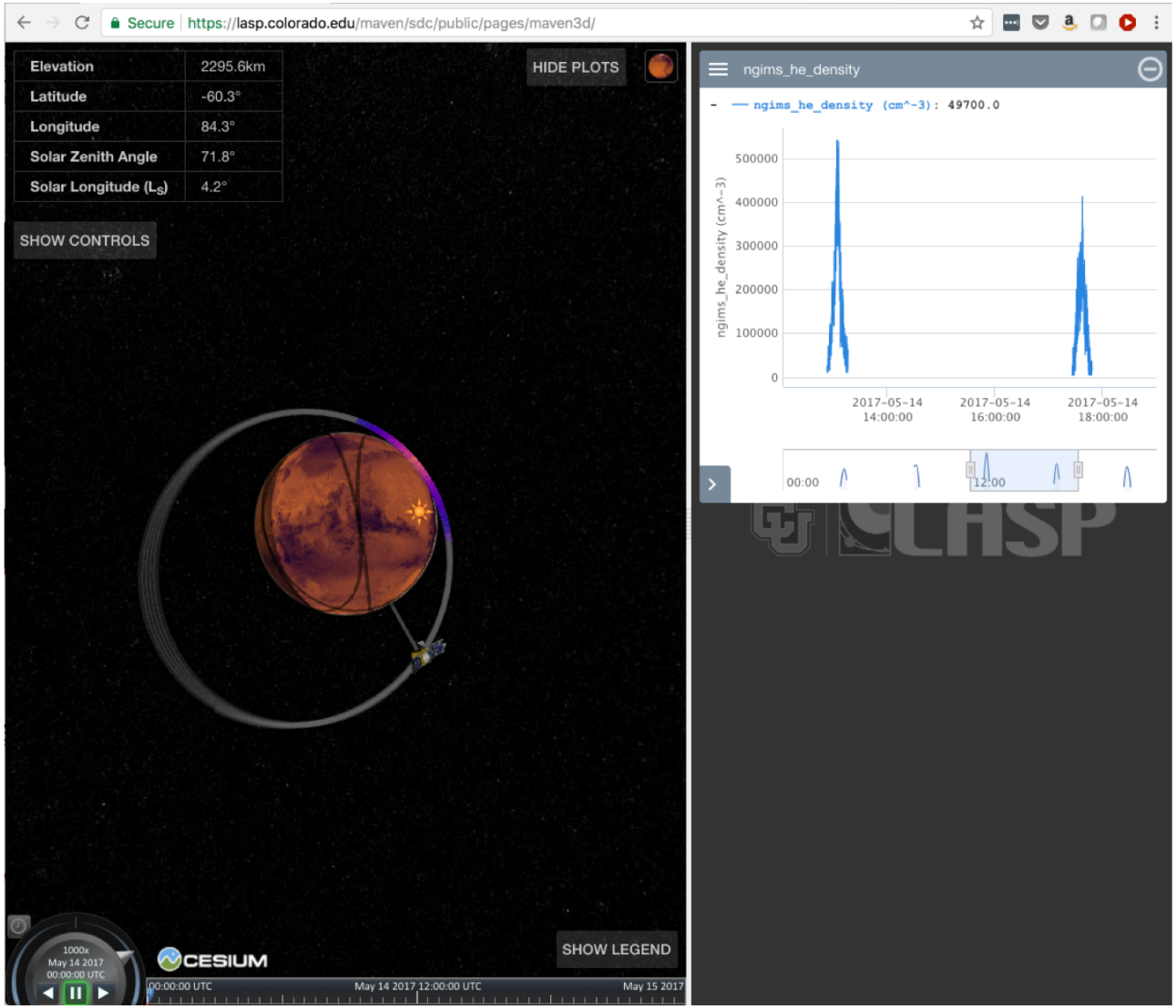
- IDL visualization tools
  - Proprietary, expensive for users
  - Learning curve for users
  - Hard to get interactive 3D that's usable
- Google Mars
  - Difficulty getting our own data to display the way we wanted it
  - More surface-oriented, less about orbit data
- D3.js
  - Steep learning curve,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



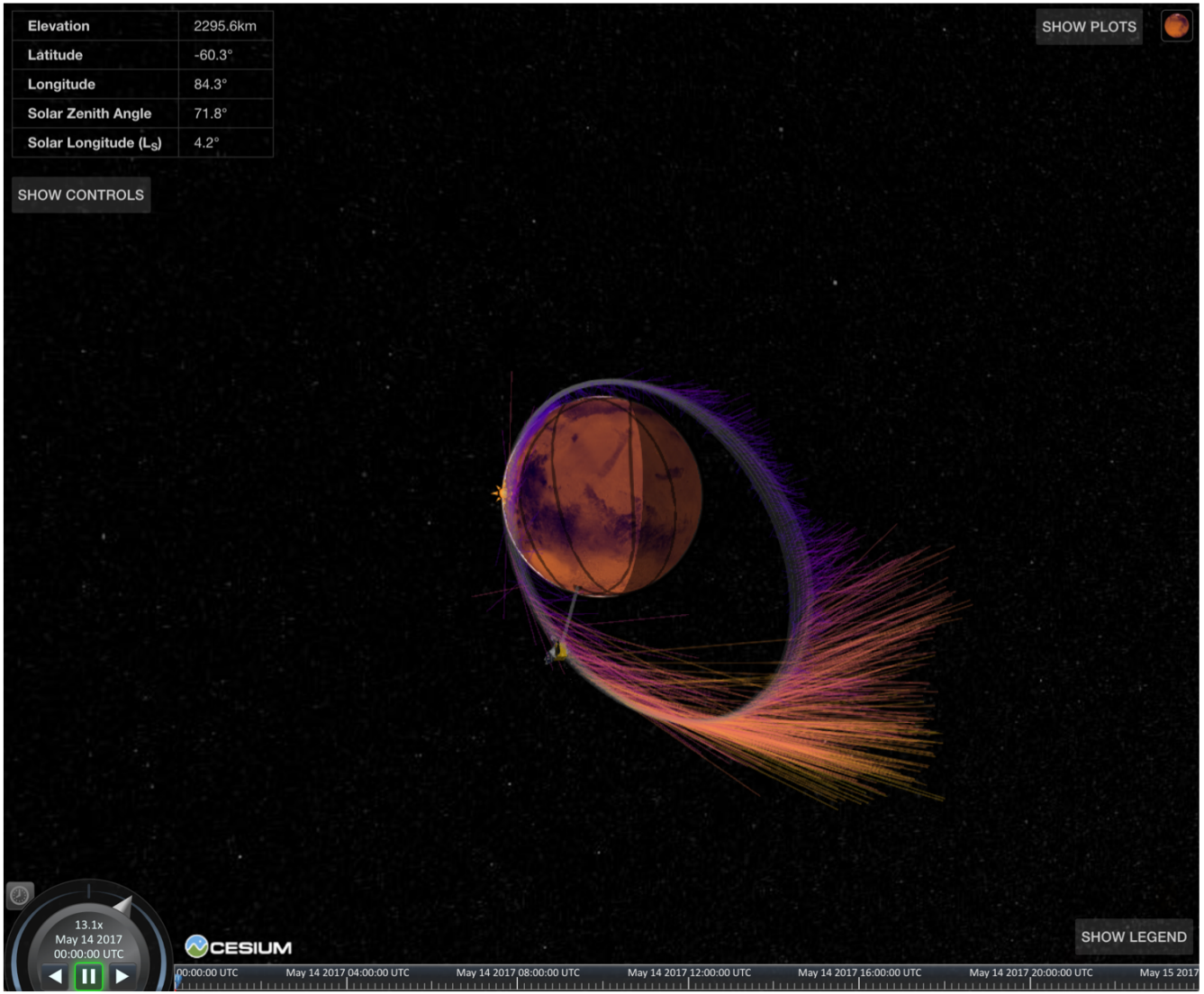
https://lasp.colorado.edu/maven/sdc/public/pages/maven3d/



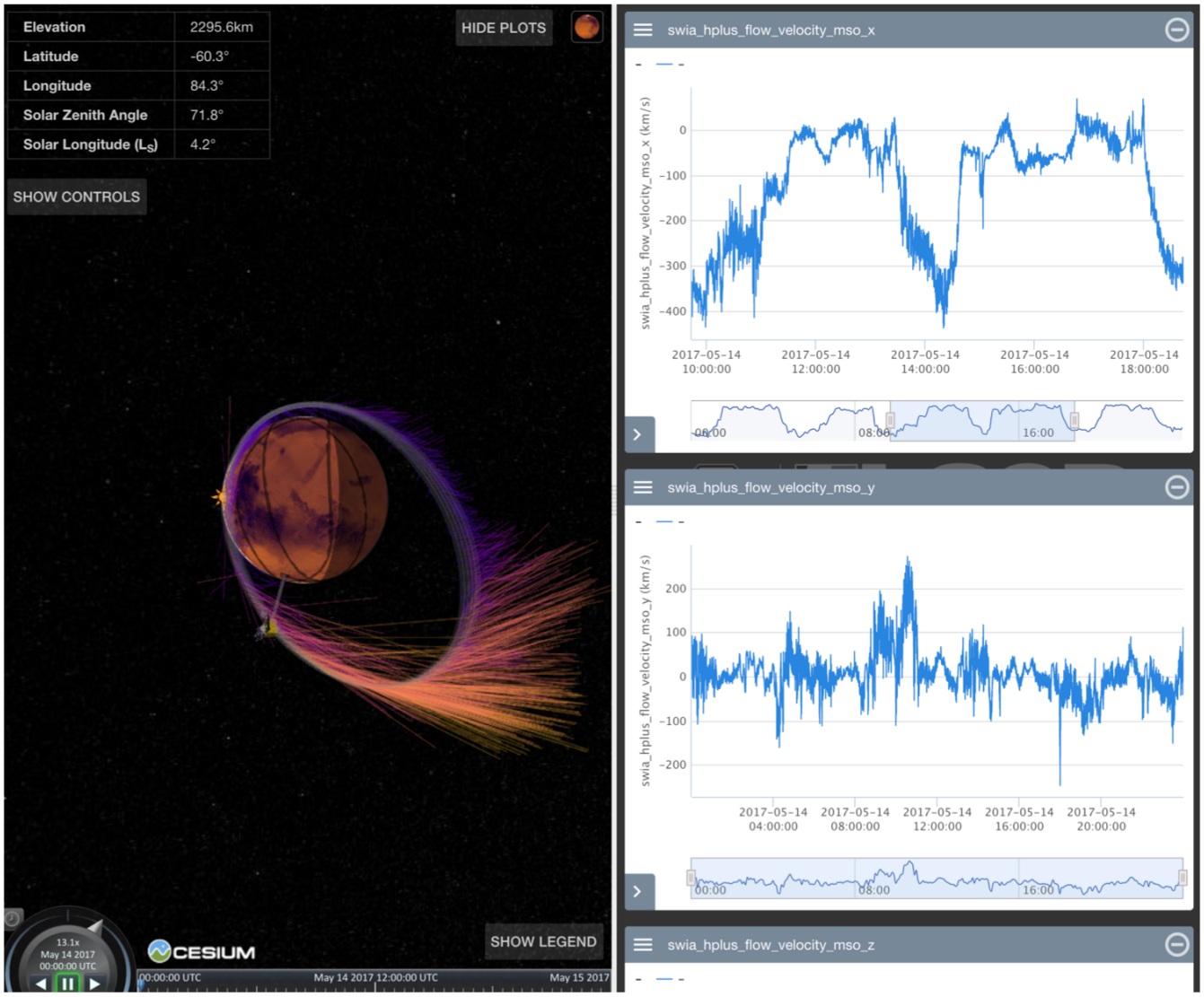
- Controls
  - Date selection
  - Datasets
  - Orbital reference frame



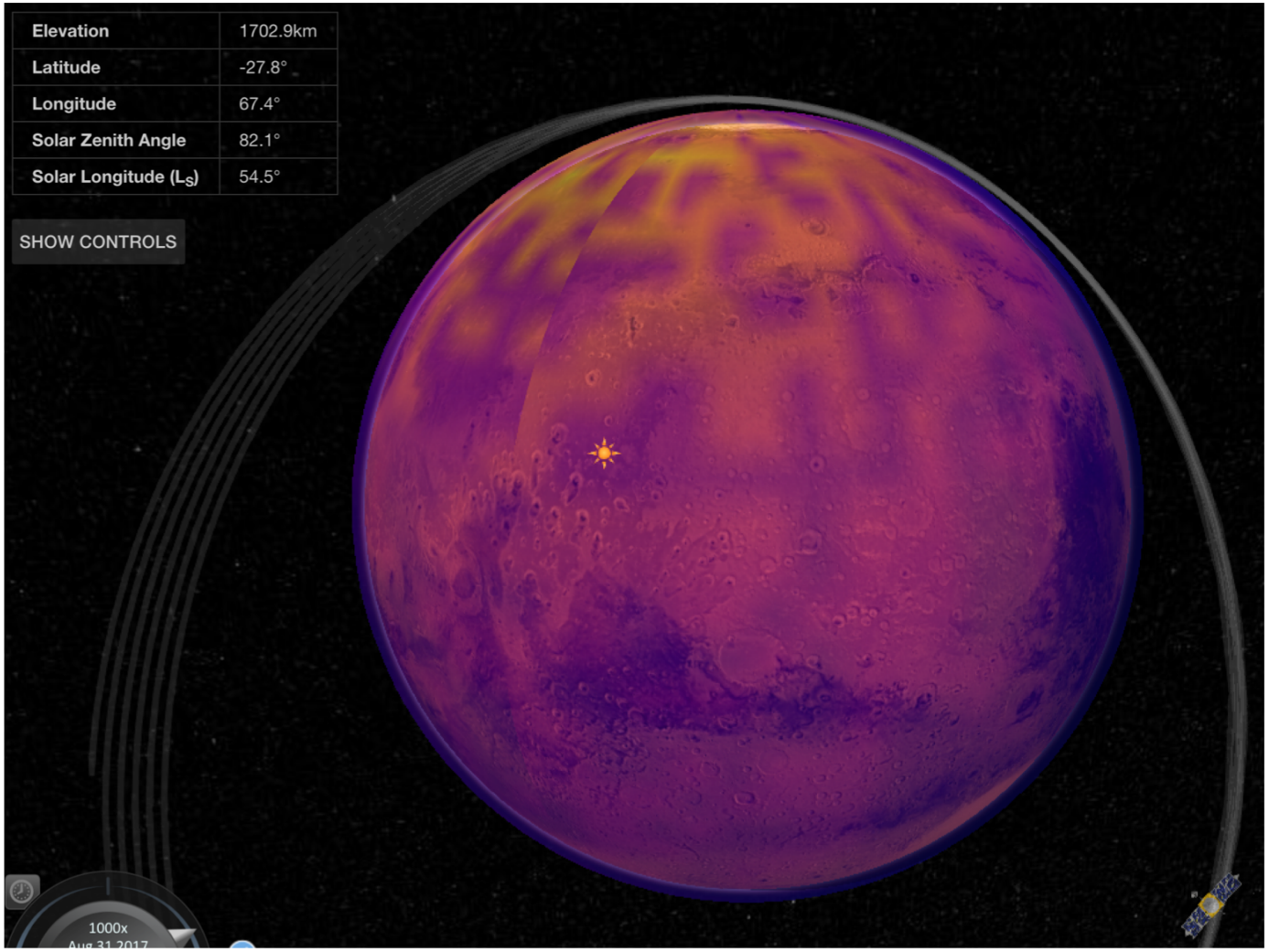
- Added 2D plots with Highcharts.
- Time slider, zoom



- Vectors: “whiskers” coming off the orbit track

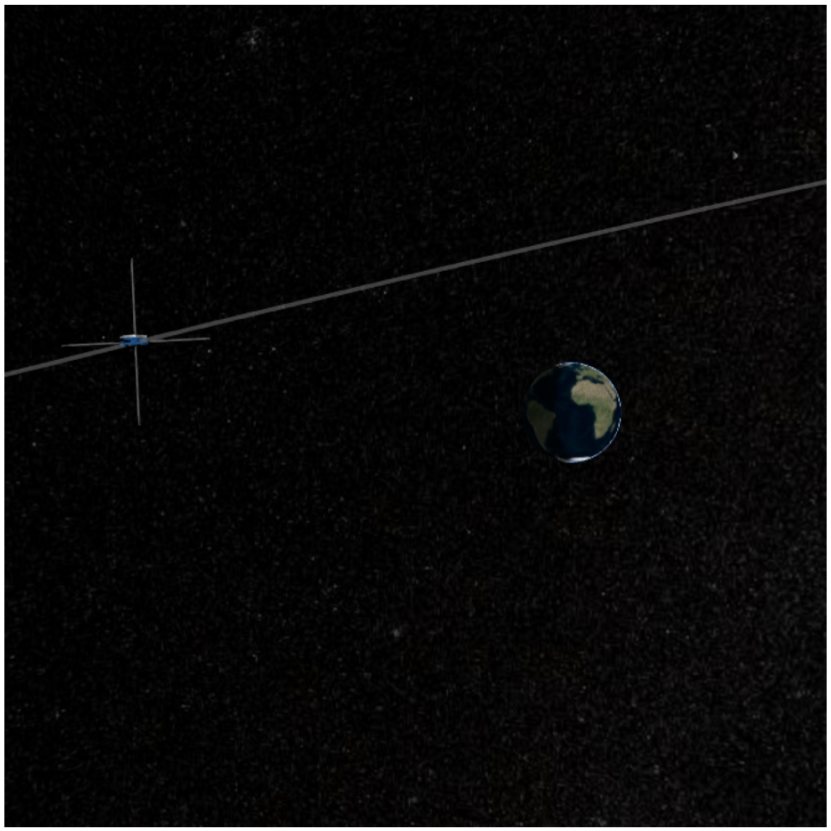


- 2D plots show vector xyz components

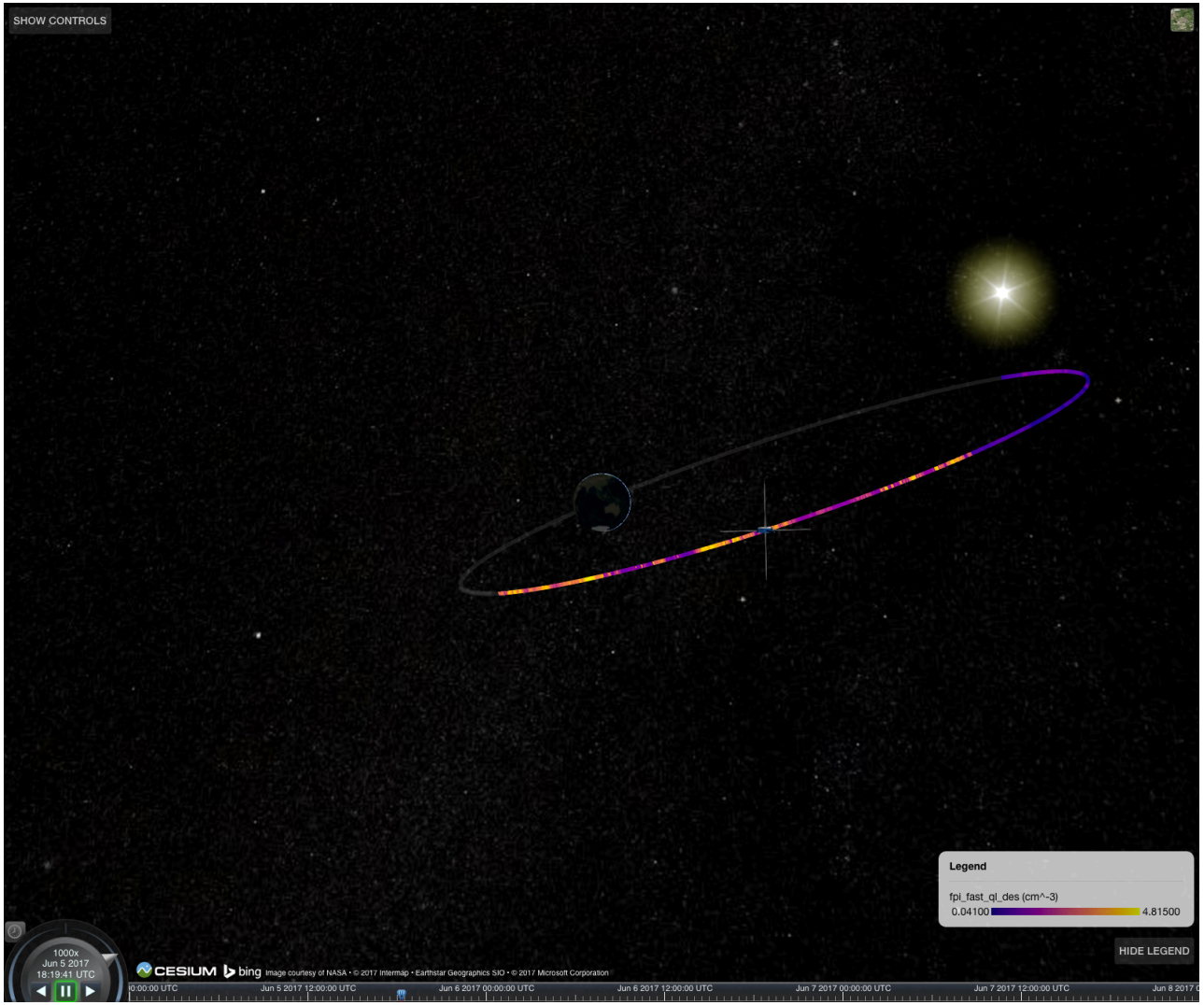


- M-GITM atmospheric model:
  O+ at 106.25 km

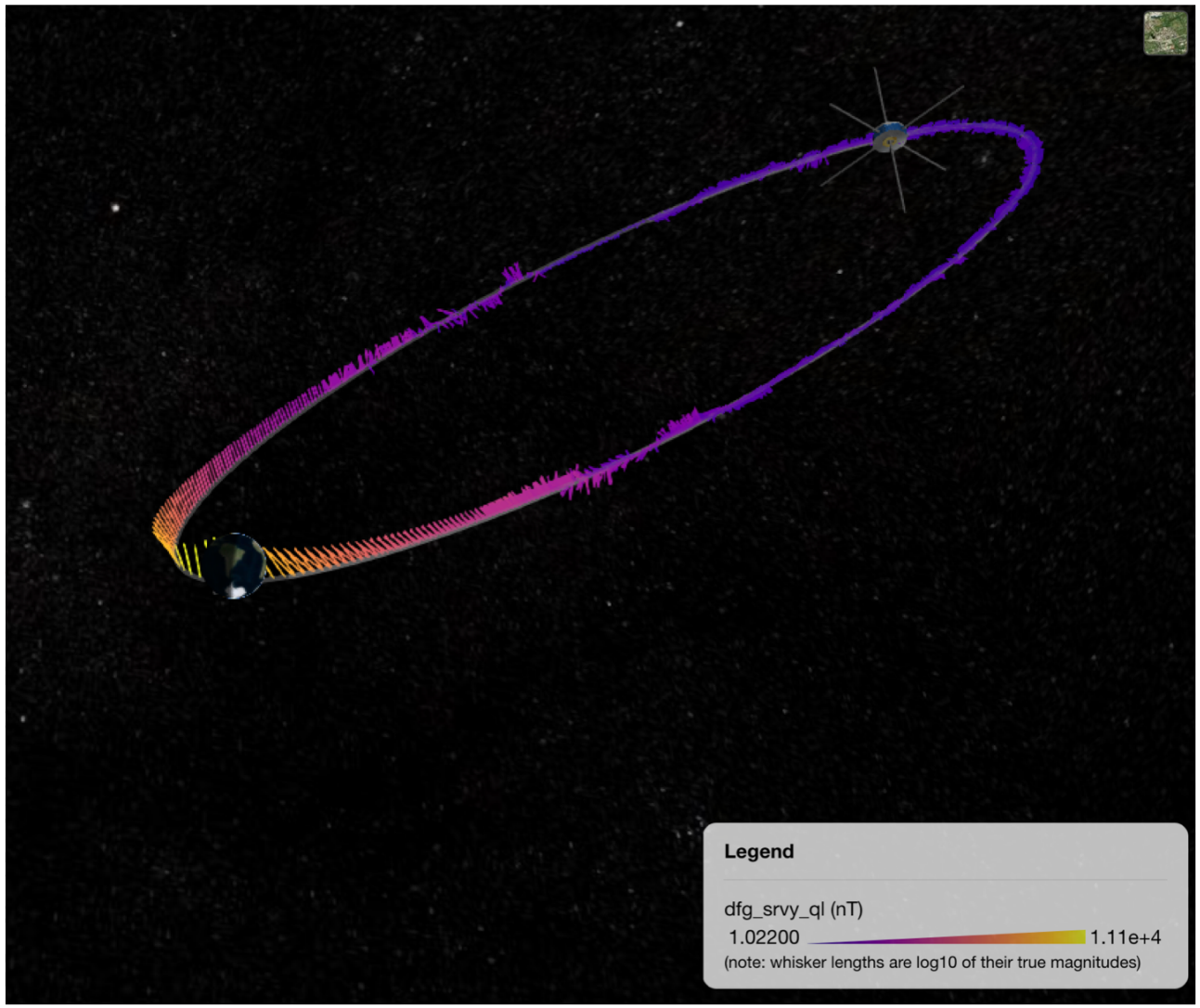
MMS



- 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

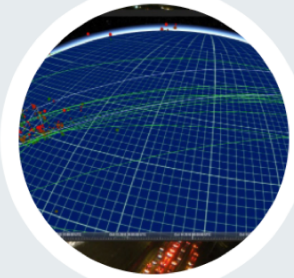
"An open-source JavaScript library for world-class 3D globes and maps"

https://cesiumjs.org/

Examples:

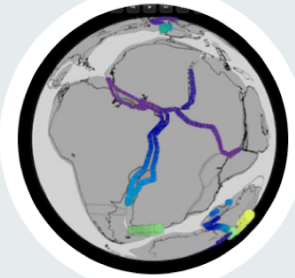
Texas Groundwater Well Levels Visualization

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.

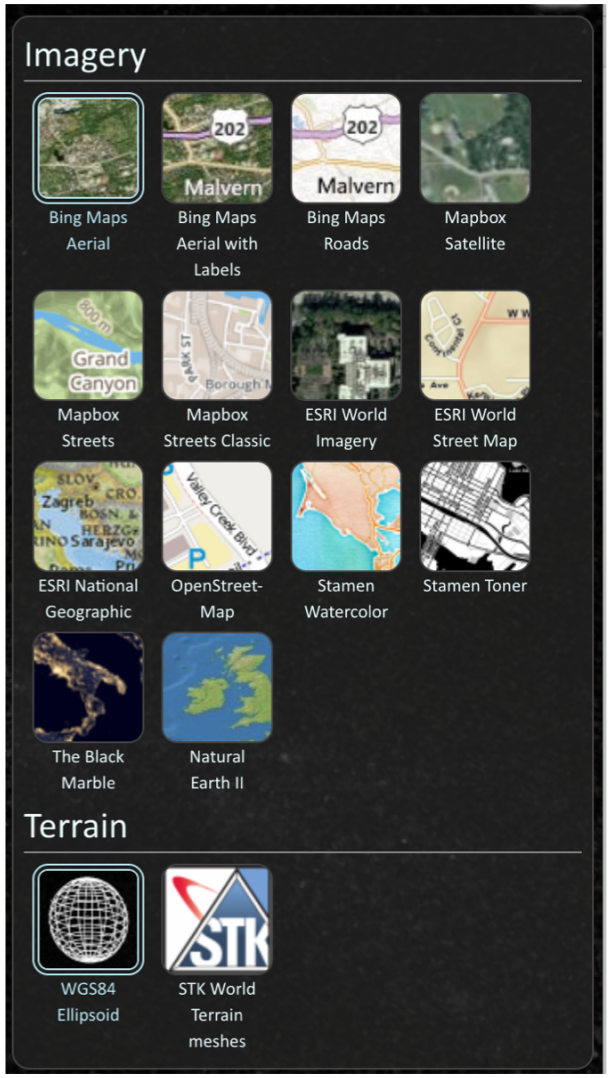


Rift Velocity Database

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/