Planetary Data Services

Astrogeology: what are working on

Outline

- Quick intro: Astrogeology
- Web Map Services (WMS)
- Tiled WMS (or TMS) services
- STAC/COG
- QGIS

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Feb. 2022

USGS Astrogeology Science Center

Interdisciplinary science, research and production group

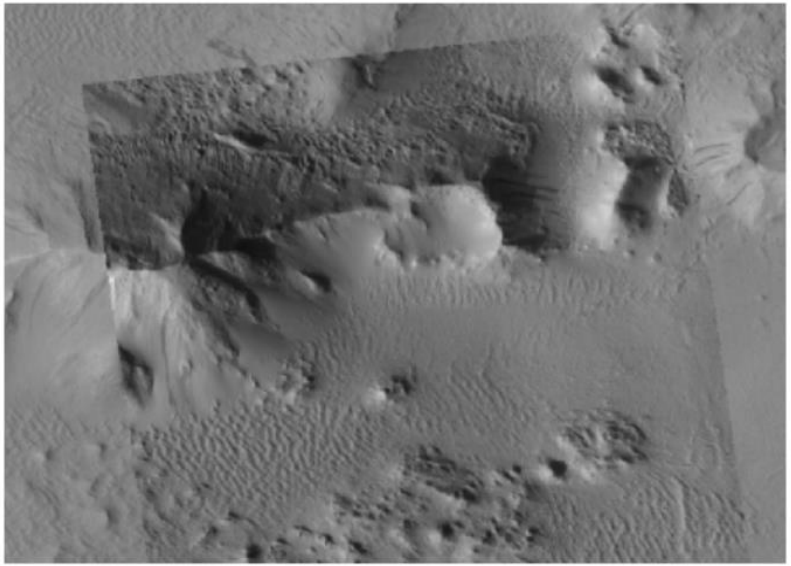
- Partnered with NASA, universities, international space agencies, and primary research institutions since the Apollo era
- Focus on **foundational** data products (geodetic control networks, topography, and orthoimagery) and **framework** data products (compositional maps, nomenclature, and geologic maps)
- Development of planetary imagery processing software (ISIS3), and home to several facilities that represent the broader planetary science community

Lobby of the Astrogeology Science Center in Flagstaff, AZ

slide credit: Marc Hunter

MRCTR GIS Lab

Mapping, Remote-Sensing, Cartography, Technology, and Research



HiRISE image web service overlying CTX blended mosaic web service

GIS Tools

- Python Toolboxes and Esri Add-Ins
- Contracted tools
- Python scripts

Tutorials

- Videos published to YouTube
- Workflows and self-paced exercises

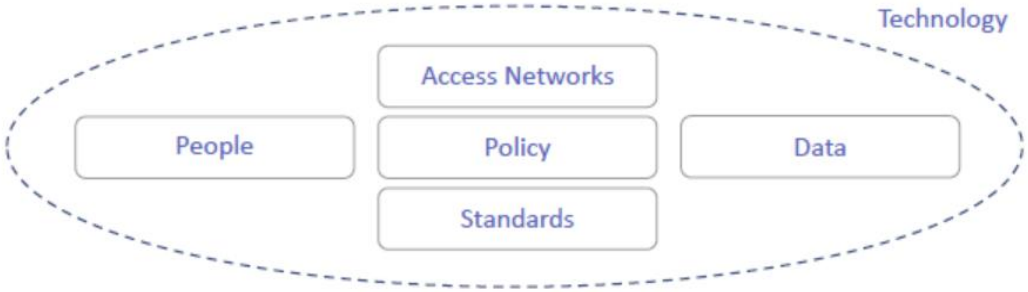
Technology Tests & Standards

- Tiled imagery web services for global mosaics via MRF with LERC compression
  - Special thanks to Esri's Lucian Plesea
- Representation at OGC and USGS standards WGs

slide credit: Marc Hunter

Our Goals

Develop within a Planetary Spatial Data Infrastructure framework



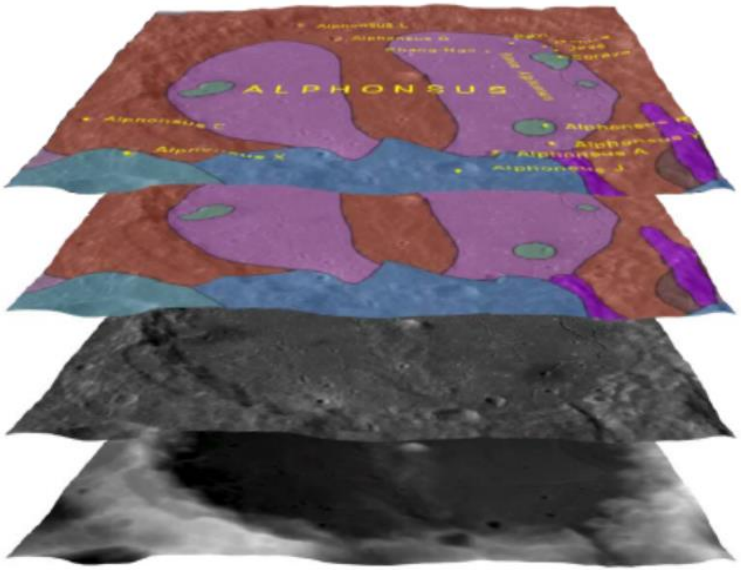
Product-base view of PSDI. Laura, et al. (2017).

Promote discoverability, accessibility and interoperability of spatial data (Naß et al., 2017)

Leverage best practices in terrestrial geoscience mapping (Hare et al., 2018)

slide credit: Marc Hunter

Life-Cycle Approach to Geospatial Data



Well-controlled foundational data products served in GIS-ready formats

Tools that help to avoid common pitfalls of planetary GIS

Leverage current publication and visualization technologies

Long-term archive and open web services

Community-driven standards to enhance discovery and coordinate advancement

slide credit: Marc Hunter

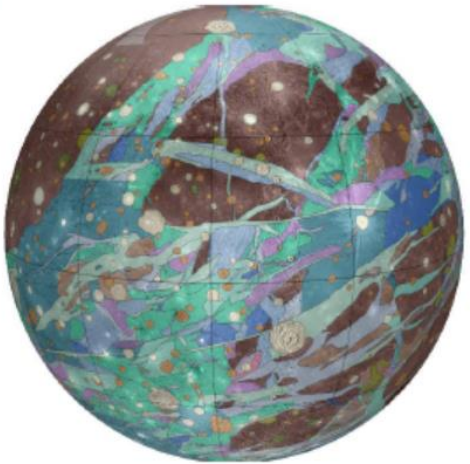
Aim to meet user expectations that spatial data should 'just work'

- Develop policies, standards and access needed to connect people and data
- Create tools and training that help geologists think geographically
- Support appropriate use of data mapped at different scales

Build on existing spatial data standards

- Extend relevant data models for use in planetary domain
- Plug into modern visualization and analysis applications

Continued advocacy for support of planetary coordinate reference systems in web protocols and visualization tools



Global geologic map of Ganymede

slide credit: Marc Hunter

Groups to help or join

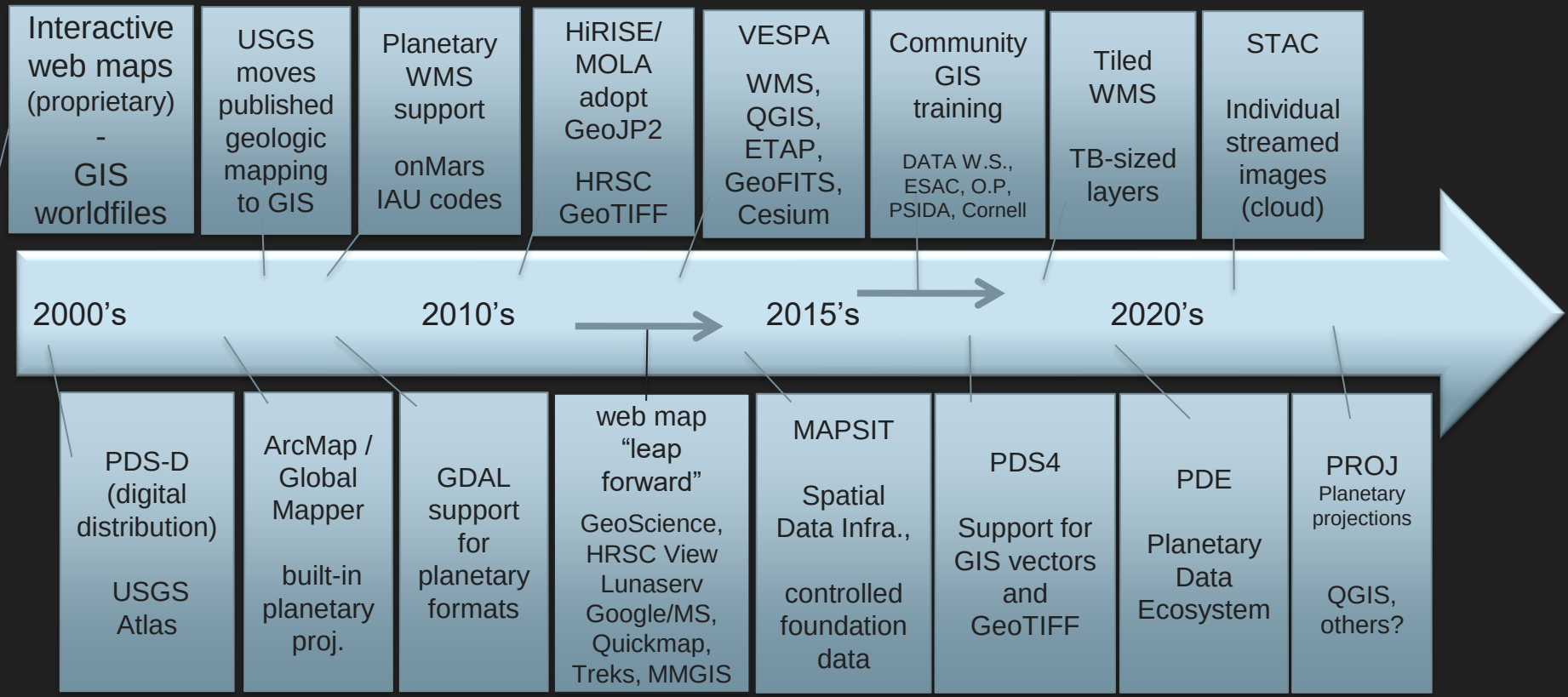
International Cartography Association
- Members working towards in situ (rover) symbologies

MAPSIT
- Spatial Data Infrastructure and Planetary Data Ecosystem

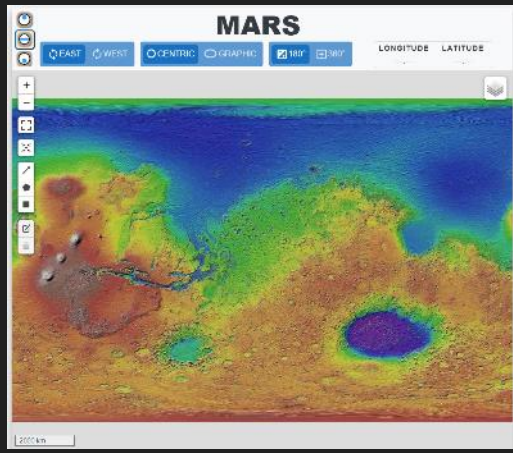
IAU
- Nomenclature
- Coordinate Systems

Open Geospatial Consortium
- Planetary Domain Working Group

Evolution of planetary GIS services (my viewpoint)



What is WMS



Web Map Service Interface Standard (WMS) provides a simple https interface for requesting geo-registered map images. Available since late 90s. Requires map server.

OGC WMTS (Web Map Tile Service, aka TMS): For heavy use and high scalability the OGC has developed the WMTS service standard. It is an area-wide collection of consistently addressable seamless map image tiles organized in a pyramid with fixed scales. Clients request as many tiles as needed to cover the requested area. Available since mid-2000s. Required pre-processing tiles and simple https address (map server optional).

More: http://planetarygis.blogspot.com/2014/09/tips-to-interact-with-astros-wms-maps.html

WMS

Some Staying Power

- Simple API, thus it can still be useful
- Interfaces can “deal” with earth-centric issues (e.g. web map libraries, QGIS, ArcMap, …)
- Strive to implement IAU 2015 codes across standard (is it too late?)
- Tiled WMS can support TB-sized mosaics

Challenges remain

- Based on Earth-centric Open Geospatial Consortium (OGC) standard
- IAU 2000 codes only implemented in retired USGS WMS server, ASU’s Lunaserv and Mapserver branch (by Jean-Christophe M.)
- Technology dated (large move toward tiles and streaming formats like COG)

Astrogeology WMS Layers (in degrees or polar stereographic)

http://planetarygis.blogspot.com/2014/09/tips-to-interact-with-astros-wms-maps.html

Planetary GIS

Discussion and tips for the planetary researcher using GIS.

Thursday, January 6, 2022

Tips to interact with Astro's WMS maps

update from the original 2014 post:

For years we have supported our live mapping services (called Web Mapping Services, WMS) for use within our own web mapping tools but also for the community to use. For example, these layers are viewable from our Planetary Nomenclature, PILOT, Geologic Mapping sites, etc (example Aram Chaos on Mars). Thus they are ideal for use in web mapping apps like OpenLayers and Leaflet and also GISs like QGIS, ArcMap, or ENVI. And you can

Tiled WMS Layers (in degrees or polar stereogrphic)

https://bit.ly/HiRISE_mosaic

Uncontrolled Global HiRISE Mosaic

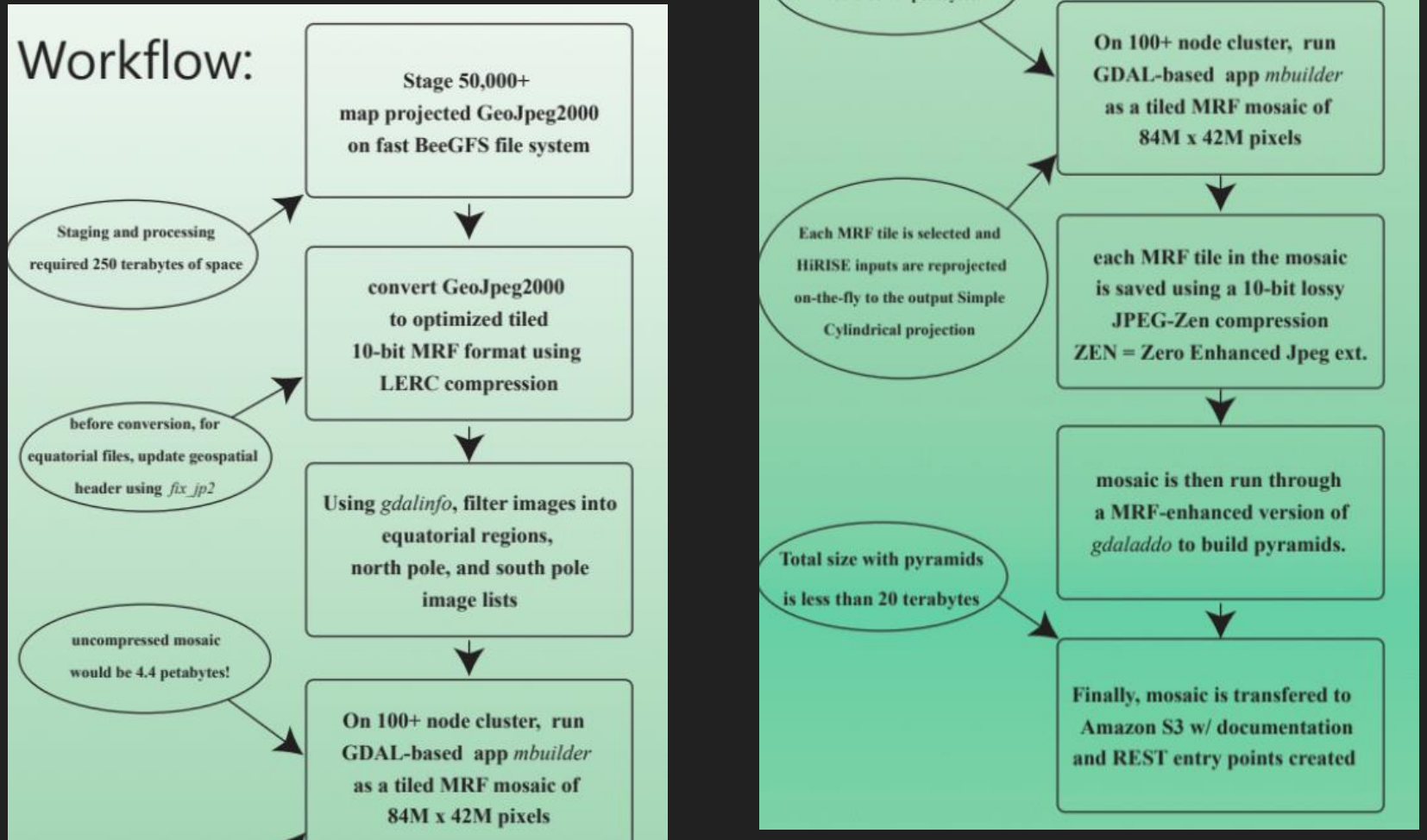
Mars High-Resolution Tiled Web Services

linked from: http://bit.ly/HiRISE_mosaic

An Esri introduction and Story Map for these layers: https://www.esri.com/arcgis-blog/products/arcgis-online/imagery/observing-the-red-planet/

These new Mars service hosted by Esri highlights controlled "foundational" mosaics including Viking MDIM v2.1 [231 m/p], MOLA/HRSC Blended Hillshade [200 m/p], and the USGS-created THEMIS Daytime and Nighttime mosaics [100 m/p]. We have also included the preliminary uncontrolled but high-resolution mosaics created by the Caltech Murray Lab for CTX [5 m/p] and USGS-generated HiRISE PSP/ESP mosaic [0.25 m/p]. Note on disk the

Tiled WMS Layers (in degrees or polar stereographic)

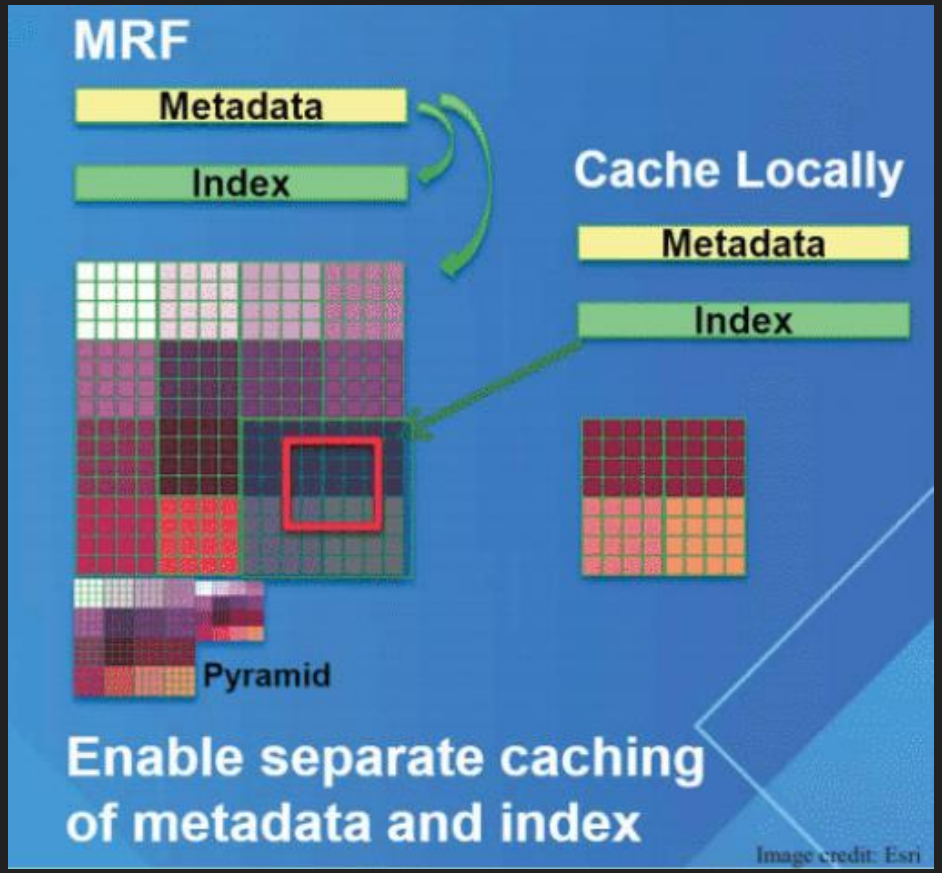


Tiled WMS Layers (in degrees or polar stereographic)

https://github.com/nasa-gibs/mrf

HiRISE helper:

https://github.com/lucianpls/mbuilder



Spatial Temporal Asset Catalog (STAC)

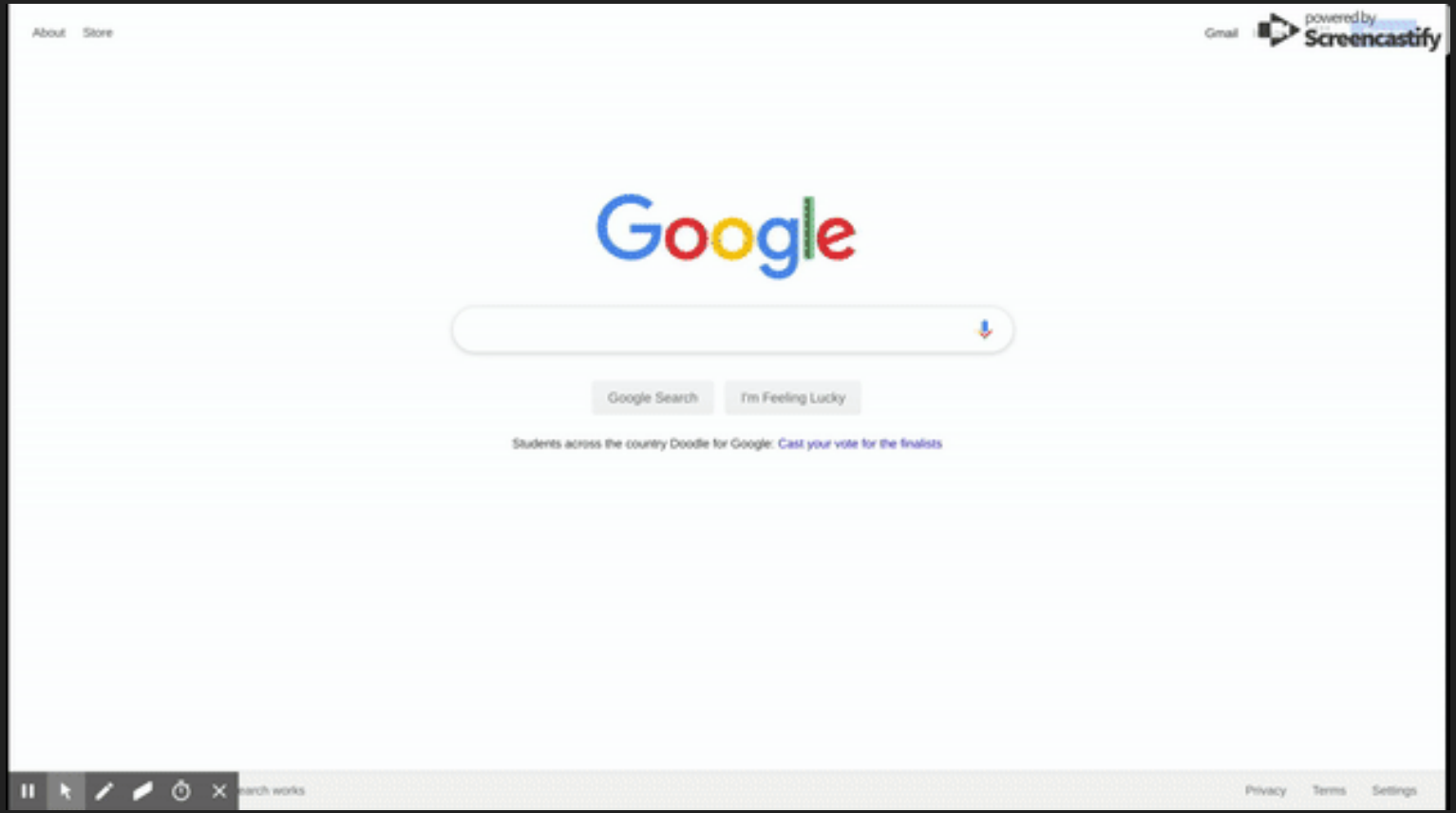
The STAC specification provides a common language to describe a range of geospatial information, so it can more easily be indexed and discovered. A 'spatiotemporal asset' is any file that represents information about the earth captured in a certain space and time.

The goal is for all providers of spatiotemporal assets (Imagery, SAR, Point Clouds, Data Cubes, Full Motion Video, etc) to expose their data as SpatioTemporal Asset Catalogs (STAC), so that new code doesn't need to be written whenever a new data set or API is released.

from: https://stacspec.org/

The core JSON pages can be transformed into browsable, interactive HTML pages with tools like STAC Browser. When STAC is used in concert with emerging formats like Cloud Optimized GeoTIFF or TileDB arrays the result vastly lowers the barriers for anybody to find and use geospatial assets like satellite imagery:

https://stacspec.org/overview.html



Spatial Temporal Asset Catalog (STAC)

Beta docs: https://stac.astrogeology.usgs.gov/

Beta STAC browser: https://stac.astrogeology.usgs.gov/browser

STAC help for QGIS: https://stac.astrogeology.usgs.gov/docs/examples/to_qgis

What is a Cloud Optimized GeoTIFF (COG)

An imagery format for cloud-native geospatial processing

COG: https://www.cogeo.org/

Efficient Imagery Data Access

COG-aware software can stream just the portion of data that it needs, improving processing times and creating real-time workflows previously not possible

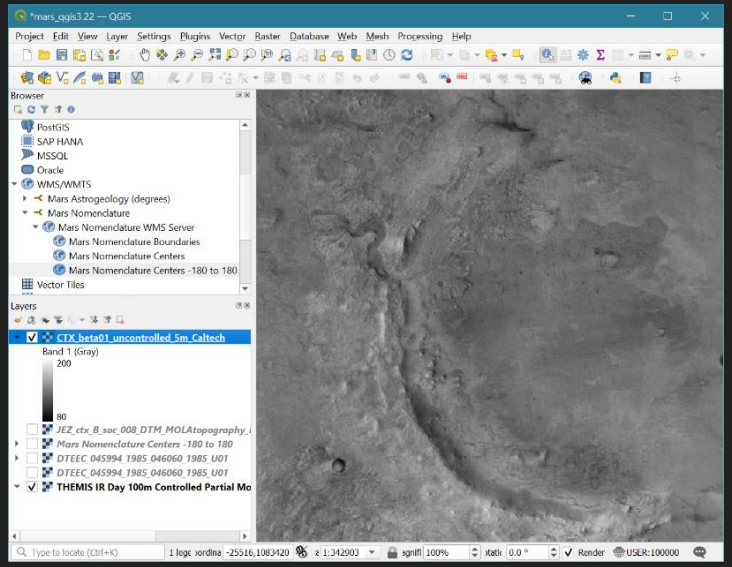
Reduced Duplication of Data

Accessing COG's with cloud workflows enables diverse software to all access a single file online instead of needing to copy and cache the data

Legacy Compatibility

Traditional GIS software is able to treat Cloud Optimized GeoTIFF's just like normal GeoTIFF's, so data providers need only produce one format

QGIS Current Version: 3.22.3 (Jan. 2022)



Qt version	5.15.2
Python version	3.9.5
GDAL/OGR version	**3.4.1**
PROJ version	**8.2.1**
EPSG Registry database	v10.041 (2021-12-03)
GEOS version	3.10.0-CAPI-1.16.0
SQLite version	**3.35.2**
PDAL version	2.3.0
PostgreSQL client version	13.0
SpatiaLite version	5.0.1

Planetary Projections now built in

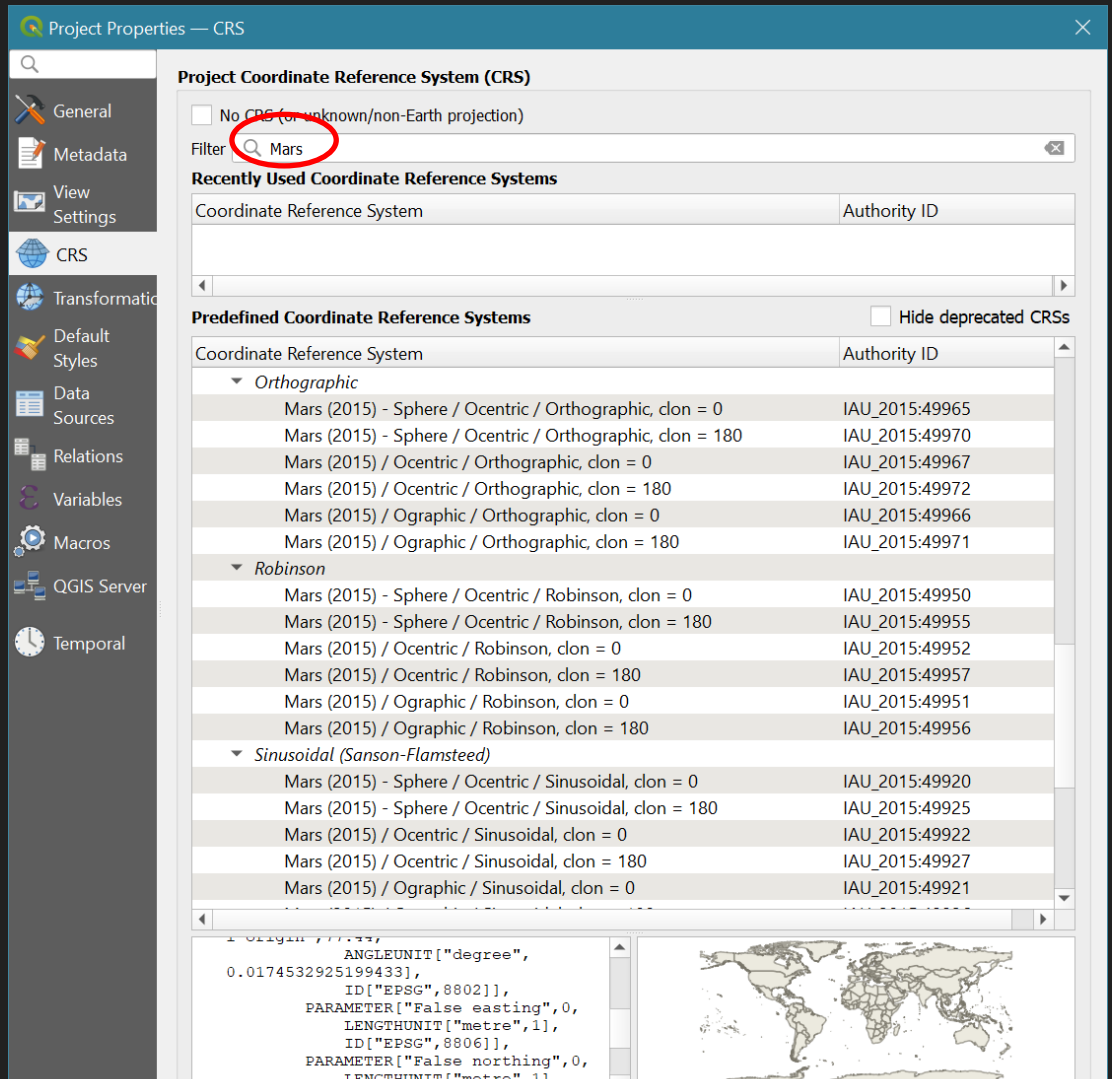
IAU_2015:aaabb

IAU_2015 report

doi.org/10.1007/s10569-017-9805-5

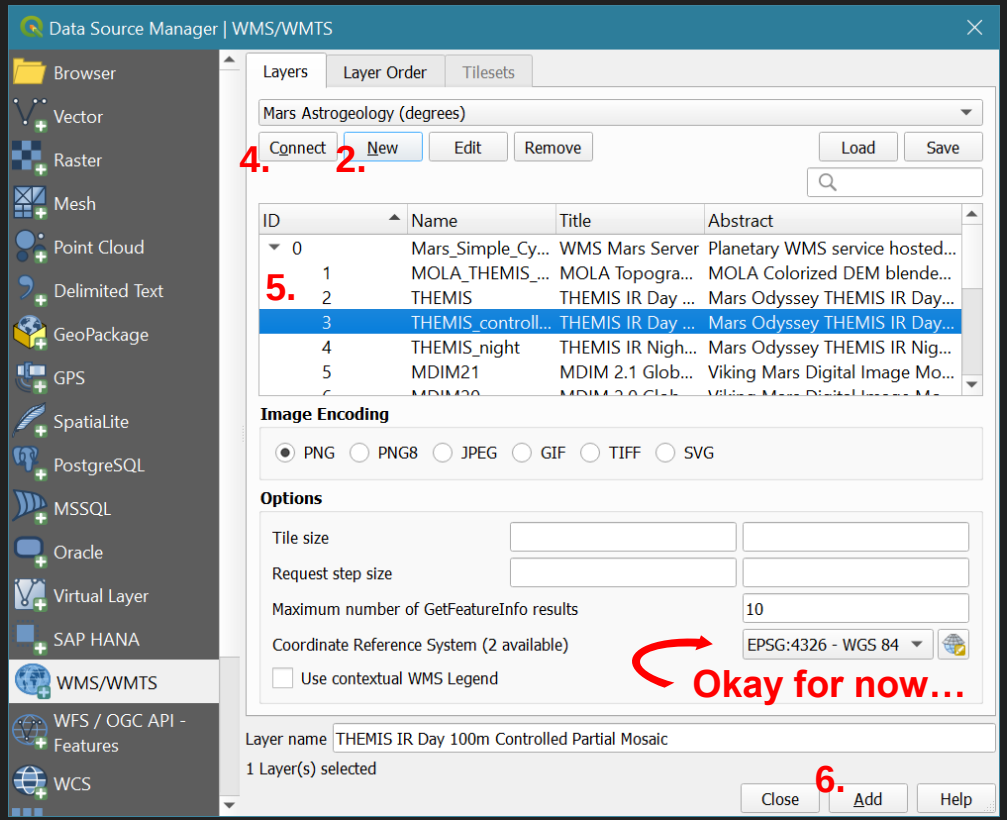
aaa = NAIF body code

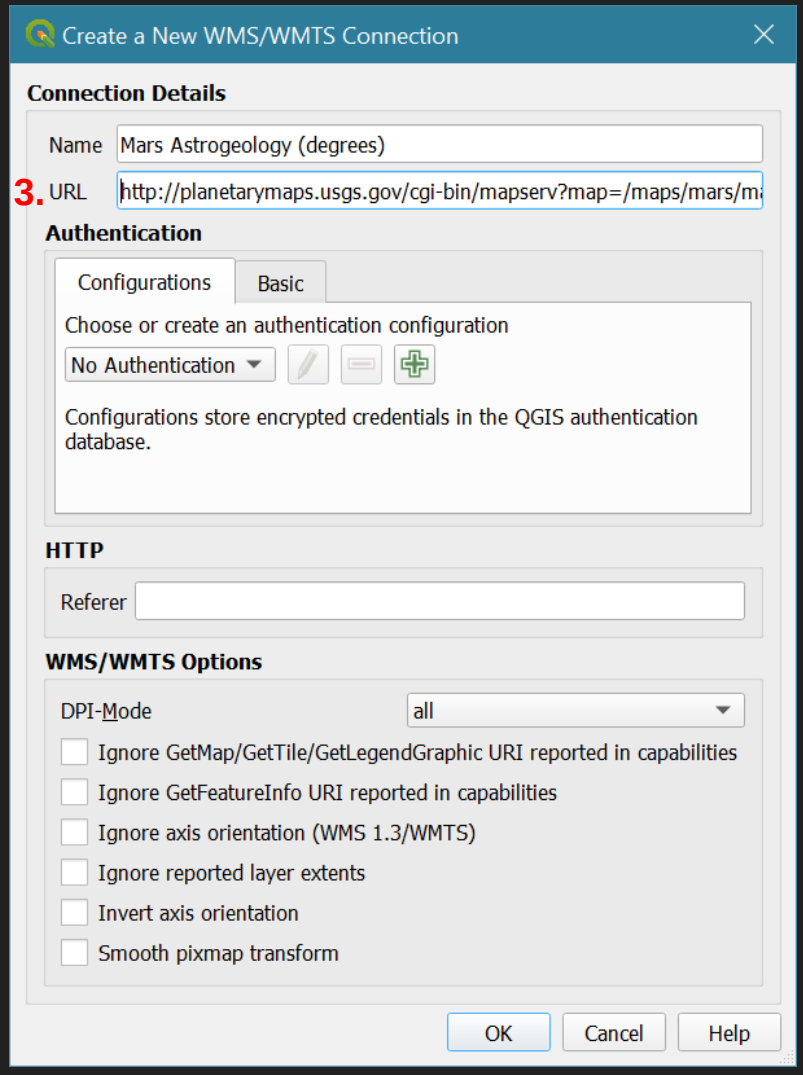
bb = projections



Adding Mars to QGIS 3.22+

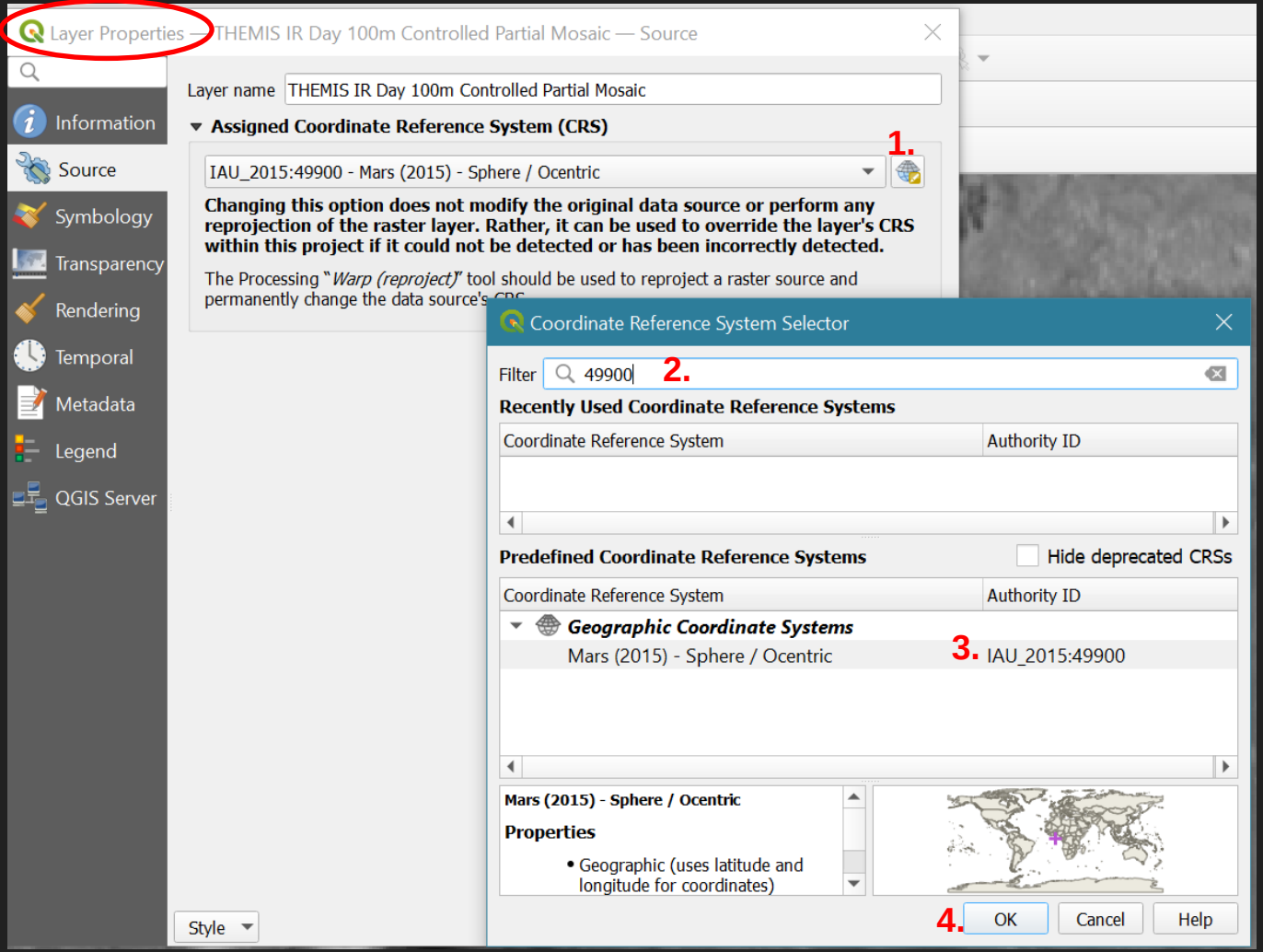
http://planetarymaps.usgs.gov/cgi-bin/mapserv?map=/maps/mars/mars_simp_cyl.map





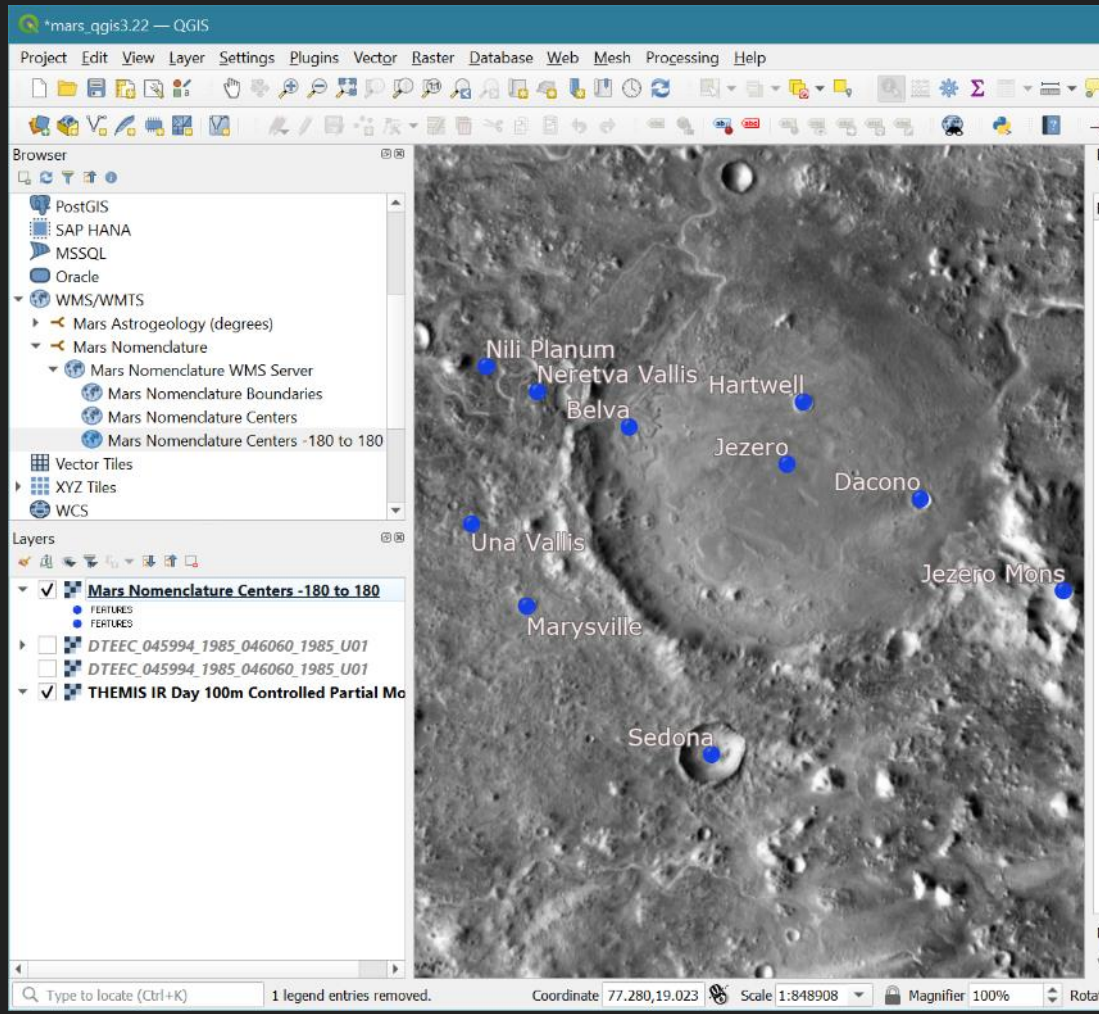
Now Override WMS layer

(if needed)



Do the same: nomenclature WMS (simple labels)

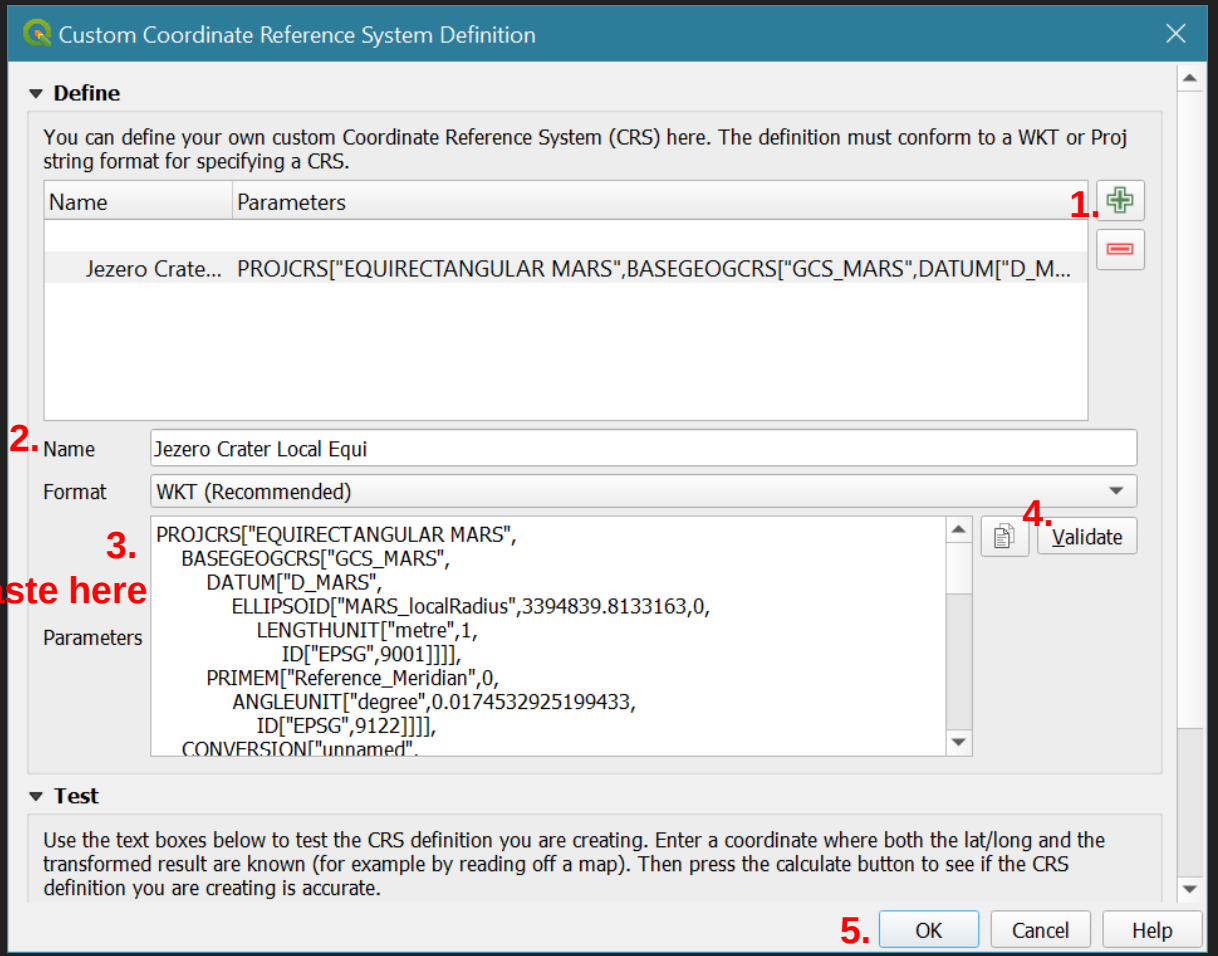
http://wms.wr.usgs.gov/cgi-bin/mapserv?map=/maps/mars/mars_nomen_wms.map



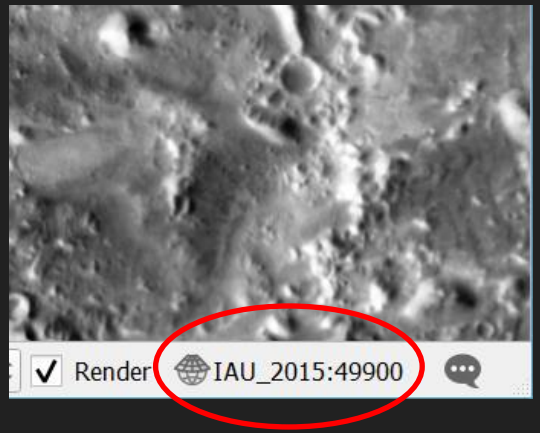
Custom or local projection

Warning: nomenclature WMS layer may not work

Copy from layer's properties and create new custom projection



Now set project's CRS to your custom projection



1. Click here

Project Properties — CRS

General
Metadata
View Settings
CRS
Transformatic
Default Styles
Data Sources
Relations
Variables
Macros
QGIS Server
Temporal

Project Coordinate Reference System (CRS)

No CRS (or unknown/non-Earth projection)

Filter: Jezero 2.

Recently Used Coordinate Reference Systems

Coordinate Reference System	Authority ID

Predefined Coordinate Reference Systems Hide deprecated CRSs

Coordinate Reference System	Authority ID
User Defined Coordinate Systems	
3. Jezero local projection	USER:100000

Jezero local projection

Properties

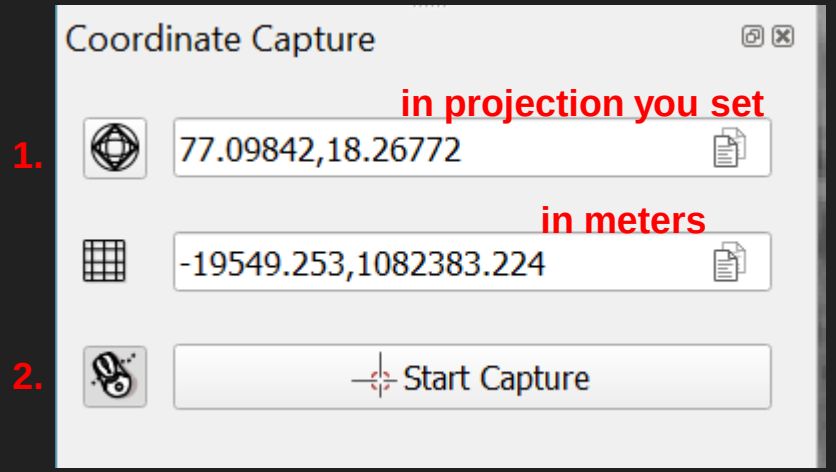
- Units: meters
- Static (relies on a datum which is plate-fixed)
- Celestial body: Mars
- Method:

WKT

```
PROJCRS["EQUIRECTANGULAR MARS",
    BASEGEOGCRS["GCS_MARS",
        DATUM["D_MARS",
            ELLIPSOID["MARS_localRadius",3394839.8133163,0,
                LENGTHUNIT["metre",1,
                    ID["EPSG",9001]]]],
        PRIMEM["Reference_Meridian",0,
            ANGLEUNIT["degree",0.0174532925199433,
```

Coordinate capture plug-in (report/copy degrees)

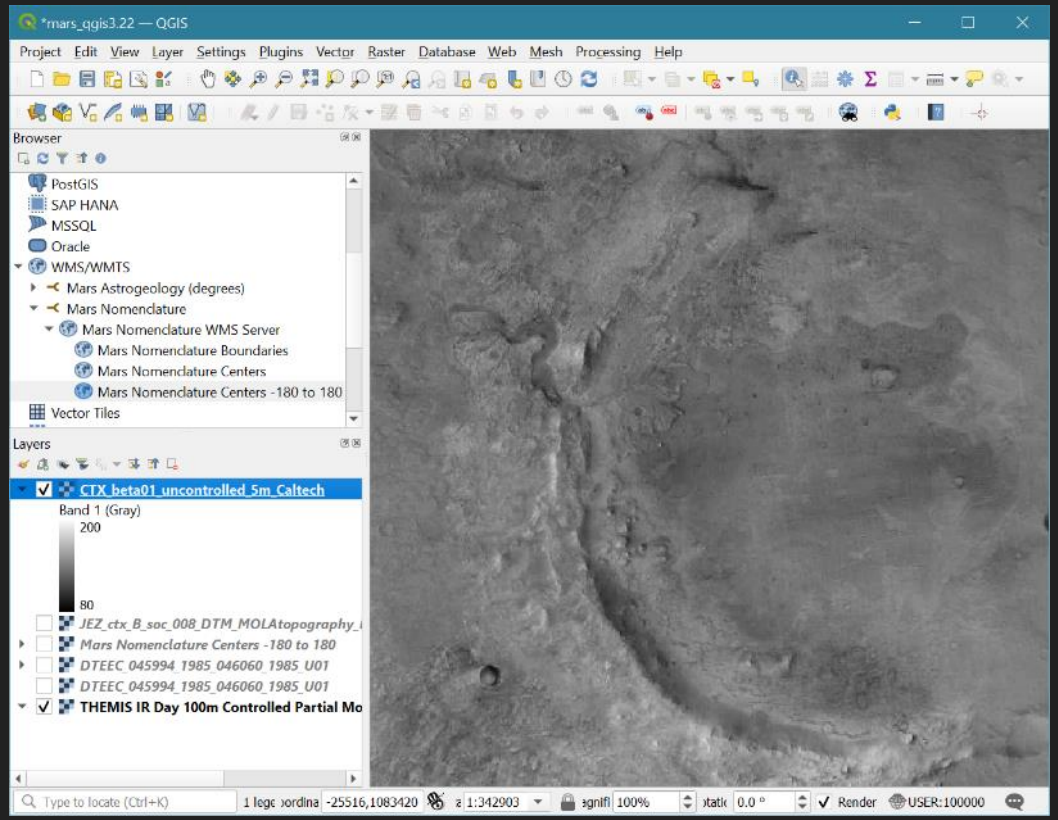
1. Set to Mars degree (49900)
2. Use stream button or single point “start capture”



TMS: download zip file (https://bit.ly/HiRISE_mosaic)

or directly:
https://www.dropbox.com/s/hhuqj7m9kc127us/OnMars_Esri_TiledWMS_layers_04282020.zip?dl=1

Simply drag *.til or *.dem into QGIS to load



What is a *.til and *.dem – a simple TMS definition

```
<?xml version="1.0"?>
<GDAL_WMS>
  <Service name="TMS">
    <ServerUrl>http://astro.arcgis.com/arcgis/rest/services/OnMars/CTX/MapServer/tile/${z}/${y}/${x}</ServerUrl>
  </Service>
  <DataWindow>
    <UpperLeftX>-180.0</UpperLeftX>
    <UpperLeftY>90.0</UpperLeftY>
    <LowerRightX>180.0</LowerRightX>
    <LowerRightY>-90.0</LowerRightY>
    <SizeX>4194304</SizeX>
    <SizeY>2097152</SizeY>
    <TileLevel>12</TileLevel>
    <YOrigin>top</YOrigin>
  </DataWindow>
  <Projection>GEOGCS["GCS_Mars_2000_Sphere",DATUM["D_Mars_2000_Sphere",SPHEROID["Mars_2000_Sphere_IAU_IAG",339619
  <BlockSizeX>512</BlockSizeX>
  <BlockSizeY>512</BlockSizeY>
  <BandsCount>1</BandsCount>
  <MaxConnections>5</MaxConnections>
  <DataValues NoData="0"/>
  <ZeroBlockHttpCodes>404,400,503</ZeroBlockHttpCodes>
</GDAL_WMS>
```

Let’s load a COG from a STAC catalog

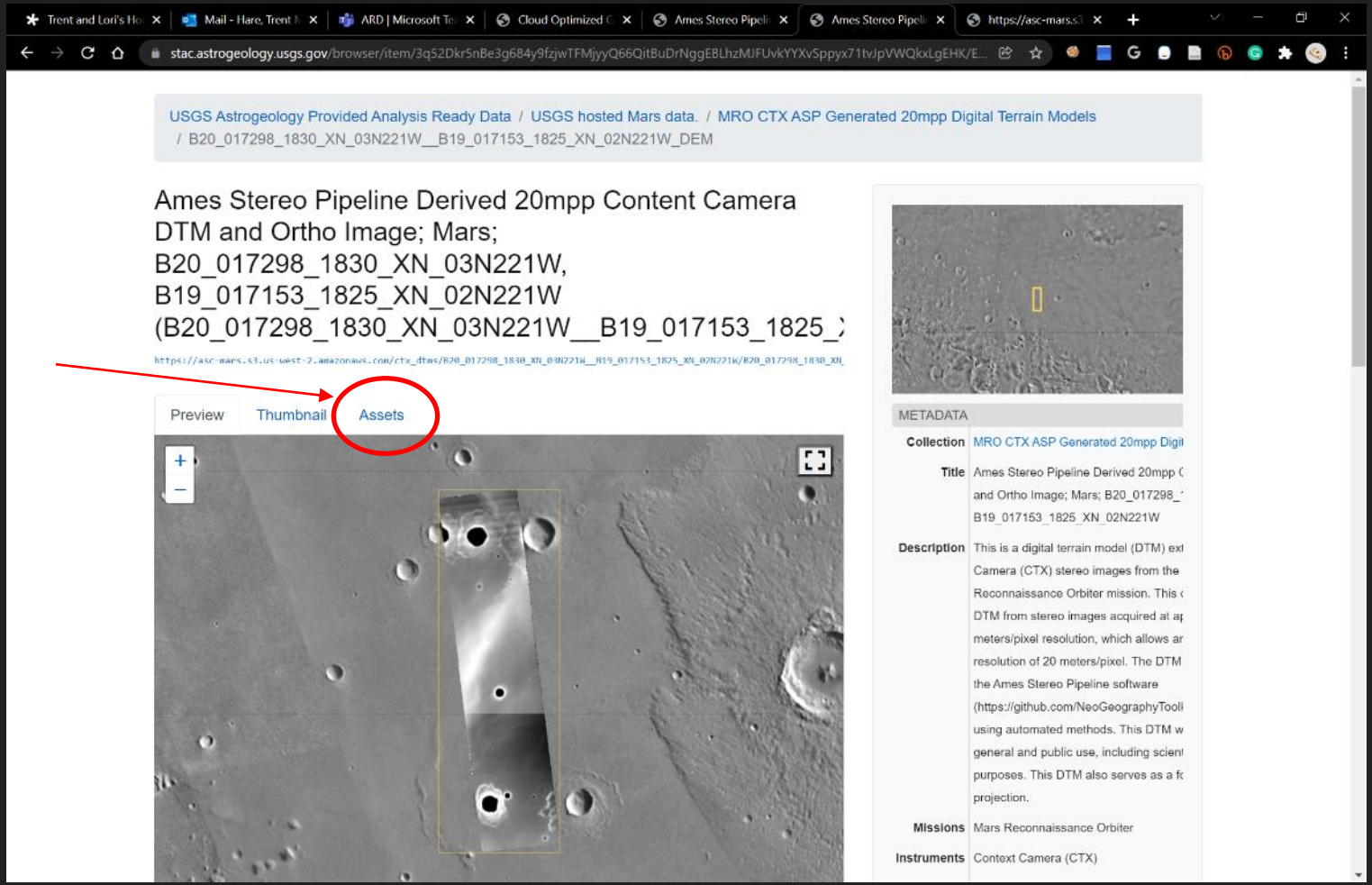
Beta STAC browser: https://stac.astrogeology.usgs.gov/browser

Find an image and copy the link (3N221W)

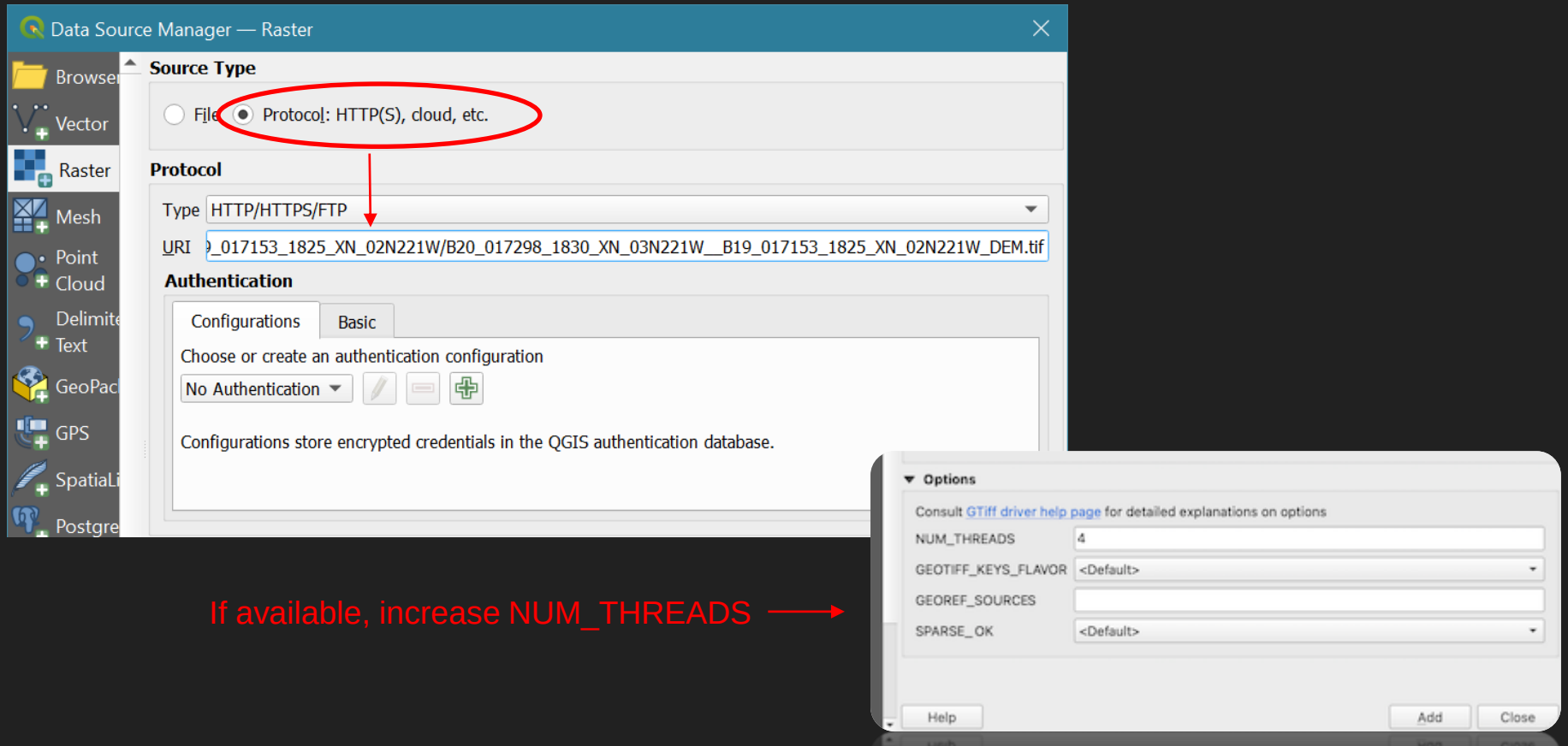
Direct COG link for DEM: https://asc-mars.s3.us-west-2.amazonaws.com/ctx_dtms/B20_017298_1830_XN_03N221W__B19_017153_1825_XN_02N221W/B20_017298_1830_XN_03N221W__B19_017153_1825_XN_02N221W_DEM.tif

Ortho: https://asc-mars.s3.us-west-2.amazonaws.com/ctx_dtms/B20_017298_1830_XN_03N221W__B19_017153_1825_XN_02N221W/B20_017298_1830_XN_03N221W__B19_017153_1825_XN_02N221W_ORTHO.tif

STAC browser

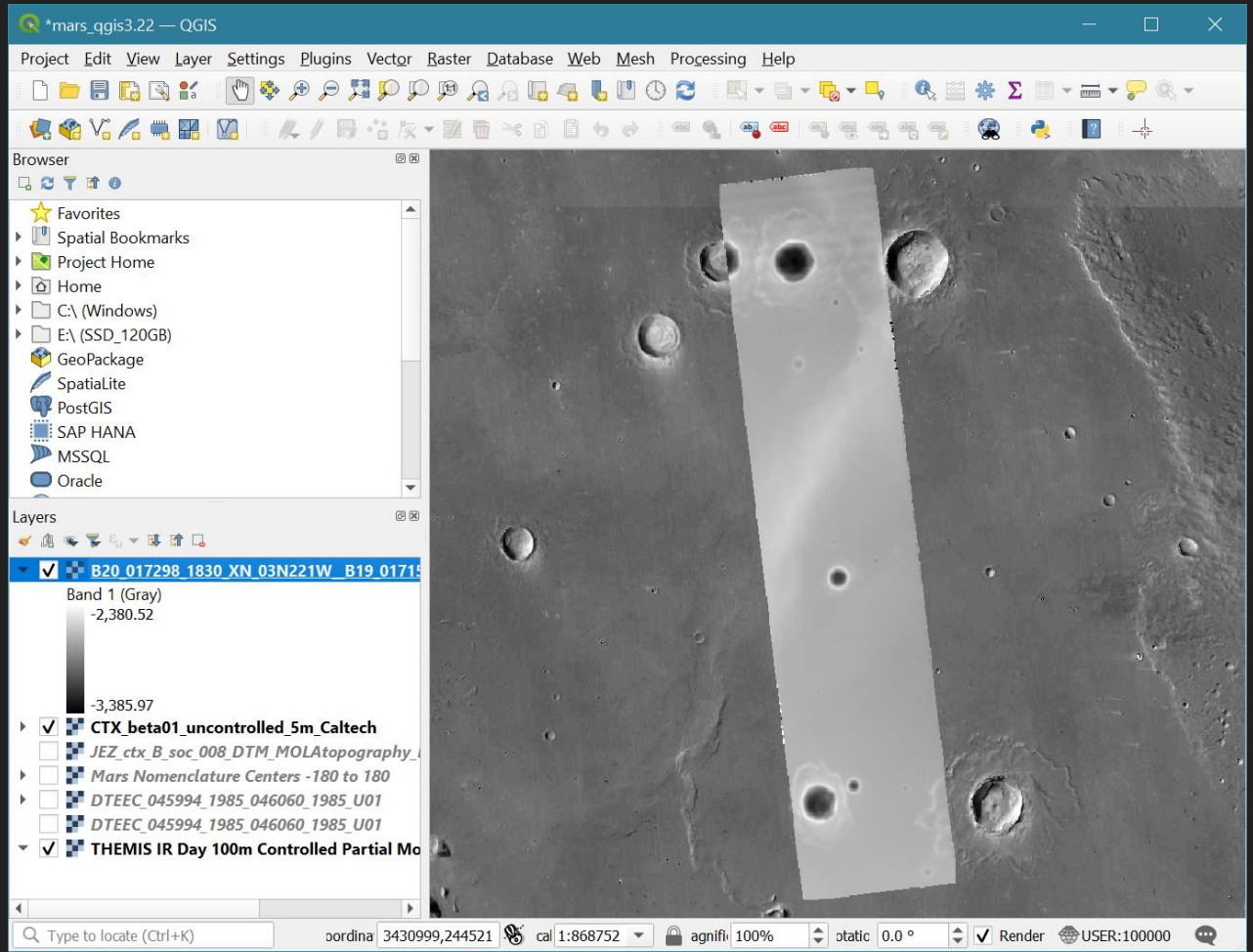


Let's load a COG from a STAC catalog



If available, increase NUM_THREADS →

Loaded COG


*mars_qgis3.22 — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Browser
Favorites
Spatial Bookmarks
Project Home
Home
C:\ (Windows)
E:\ (SSD_120GB)
GeoPackage
SpatiaLite
PostGIS
SAP HANA
MSSQL
Oracle
Layers
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Band 1 (Gray)
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-3,385.97
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JEZ_ctx_B_soc_008_DTM_MOLAtopography_
Mars Nomenclature Centers -180 to 180
DTEEC_045994_1985_046060_1985_U01
DTEEC_045994_1985_046060_1985_U01
THEMIS IR Day 100m Controlled Partial Mo
Type to locate (Ctrl+K)
3430999,244521
1:868752
100%
0.0 °
Render
USER:100000