Life Cycle of a Planetary Body Definition for Scientific Analysis

Planetary Science Informatics & Data Analytics (PSIDA)

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Agenda

- Quick introduction to planetary body definition lifecycle
- IAU Planetary Codes for OGC web services
  - code by Jean-Christophe (on GitHub)
- OGC Planetary CRS Registry API
  - implemented by Jean-Christophe
- Codes in PROJ
  - implemented by Even Rouault (available from GitHub, OSGeo)
  - binaries released with PROJ (GDAL, QGIS, Mapserver, …), Lunaserv

Body Definition - typical lifecycle

The definition of body's size typically follows this lifecycle

- Earth-based observations
- Refined using acquired data from planetary mission
  - Published in the peer-reviewed literature
  - Adopted by standards setting working groups (e.g., IAU)
  - Definitions added to coordinate reference definitions (e.g., SPICE, OGC)
  - Integrated into various libraries and applications (e.g., PROJ, ArcGIS)
  - Used in the creation of derived cartographic data products.
- New mission, better data, repeat

Enceladus as an example

- moon of Saturn (tidally locked)
- orbits at a distance of 238,000 km, orbital resonance with Dione
- radius ~206 km

- -200 Celsius, active hydrothermal vents

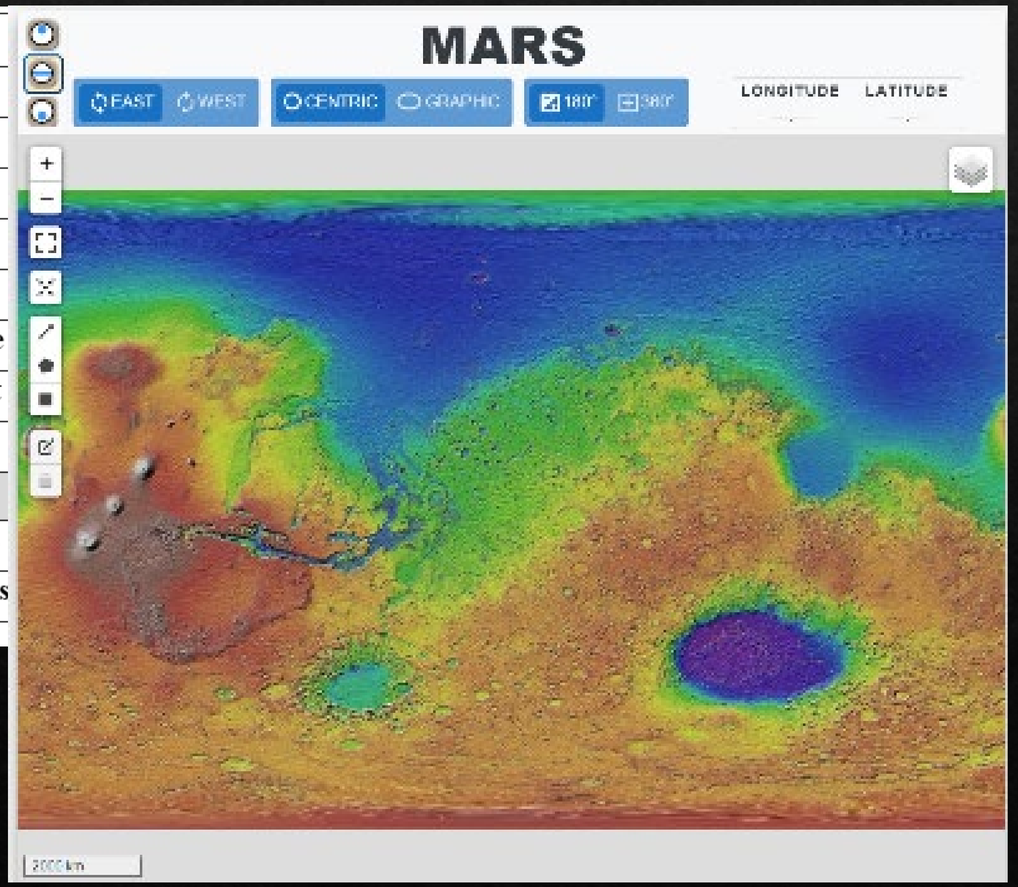
Enceladus as an example

- Enceladus was discovered by William Herschel in 1789.
- In 1980/81 NASA Voyager 1/2 missions imaged Enceladus as they flew by Saturn.
  - Photogrammetric control methods for Enceladus were first employed by Davies and Katayama [1] in 1983.
  - IAU Working Group on Cartographic Coordinates and Rotational Elements (WGCCRE) adopted updates in their standardized body report (released ~3 years)
- Starting in 2005, the Cassini spacecraft greatly improved our knowledge based on Enceladus fly-bys.
  - WGCCRE updates definition for 2006 report, SPICE libraries updated
    - SPICE, body602_radii = (256.6, 251.4, 248.3)
    - No changes in the next WGCCRE reports, adopted by PROJ (IAU 2015 report)
- Latest solution provided in 2018 by Bland et al. (publication and data products).
  - WGCCRE Will update definition for forthcoming publication
    - SPICE, OGC registry, PROJ

IAU Coded Planetary Definitions

- Why do we need these codes … interoperability of web services

IAU:version	IAU Codes	GEOIDS
IAU:2015	49900	Mars 2015, sphere, aerocentric latitudes, positive east longitudes
IAU:2015	49901	Mars 2015, ellipse, aerographic latitudes, positive west longitudes
IAU:2015	49902	Mars 2015, ellipse, aerocentric latitudes, positive east longitudes
IAU:2015	49903	Mars 2015, triaxial, aerographic latitudes, positive east longitudes
IAU:2015	49904	Mars 2015, triaxial, aerocentric latitudes, positive east longitudes
IAU:2015	49905*	Mars 2015, Mars truncated sphere (3396000), aerocentric latitudes, positive
IAU:2015	49906*	Mars 2015, Mars polar radius (3376200), aerocentric latitudes, positive east
IAU:2015	49907 – 49909*	*Reserved for special cases
		Non-triaxial map projections
IAU:2015	49910	Equirectangular (Simple Cyl.), clon=0º, sphere, areocentric, east longitudes
IAU:2015	49911	Equirectangular (Simple Cyl.), clon=0º, ellipse, aerographic, west longitudes
IAU:2015	49912	Equirectangular (Simple Cyl.), clon=0º, ellipse, areocentric, east longitudes



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

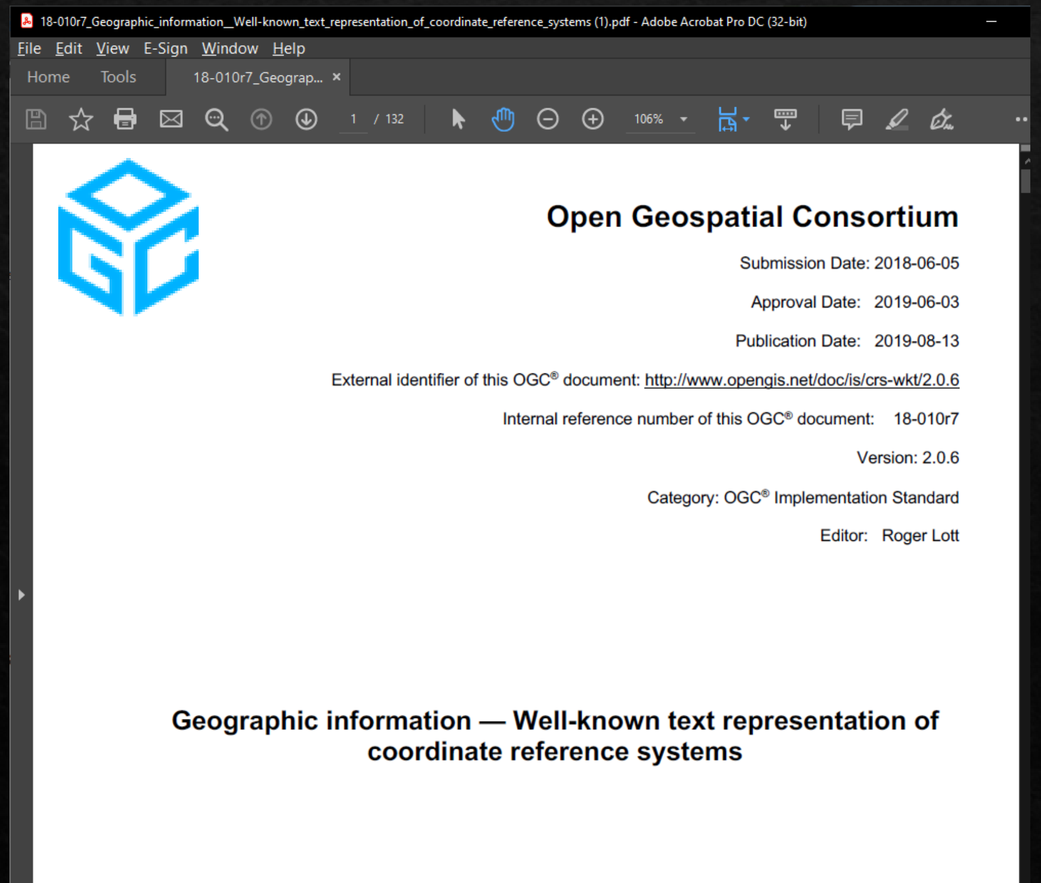
IAU Codes Planetary Definitions

- Recall, all body size definitions based on IAU WGCCRE publications (Archinal et. al., 2018*, *see poster*)
- Current codes are a joint effort between planetary community (USGS and CNES) and OGC.
  - Really nearly 20 years in the making.
    - Initial WKT1 versions incorporated in Esri's ArcView (planetary plug-in) -> AcMap and ArcGIS Pro. Showed up in various other applications (commercial and open source). Only the body size defined.
  - 2005 - 2006 initiated EPSG-like coded (WKT1) versions for OGC services. Based on a joint effort with JPL and USGS (first WMS services for Mars, called onMars). Codes implemented in a couple applications.
- Major updates needed with WKT2 standard release. Massive code refactor by Jean-Christophe. https://github.com/PlanetMap/csvForWKT

* Archinal, et al., (2018). doi: 10.1007/s10569-017-9805-5.

I digress -- what is WKT2 ?

- Geographic information — Well-known text representation of coordinate reference systems, 2019
- http://www.opengis.net/doc/is/wkt-crs/2.0.6

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      ANCHOR["Salih : 5 W"]],
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       ANGLEUNIT["degree", 0.0174532925199433, ID["EPSG", 9122]]],
   CS[ellipsoidal, 2],
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        ANGLEUNIT["degree", 0.0174532925199433]],
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        ORDER[2],
        ANGLEUNIT["degree", 0.0174532925199433]],
   ID["IAU", 60200, 2015],
   REMARK["Use mean radius as sphere for interoperability.
   Source of IAU Coordinate systems: doi://10.1007/s10569-017-9805-5"]]
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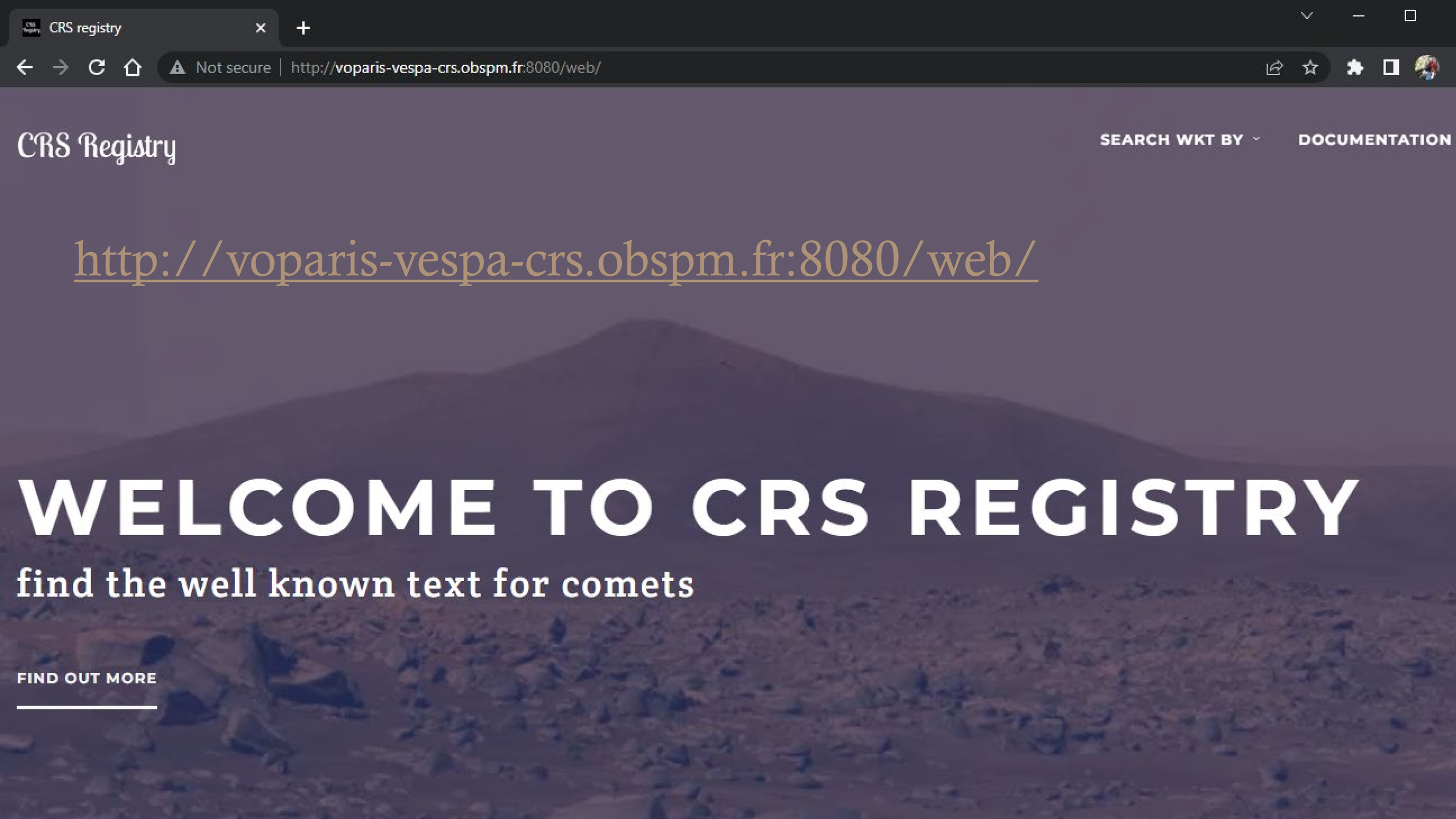
put it all together

IAU Codes + WKT2
in a searchable API


CRS registry
Not secure | http://voparis-vespa-crs.obspm.fr:8080/web/
CRS Registry
SEARCH WKT BY
DOCUMENTATION
http://voparis-vespa-crs.obspm.fr:8080/web/
WELCOME TO CRS REGISTRY
find the well known text for comets
FIND OUT MORE

CRS Registry example

Map projection for Mars “499” + "10" = Equirectangular, clon=0, clat=0, East:

- http://voparis-vespa-crs.obspm.fr:8080/ws/wkts/IAU:2015:49910

  Note versioning: IAU:2015:49910 --options IAU_2015:49910 suggestion /IAU/2015/49910


```
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```
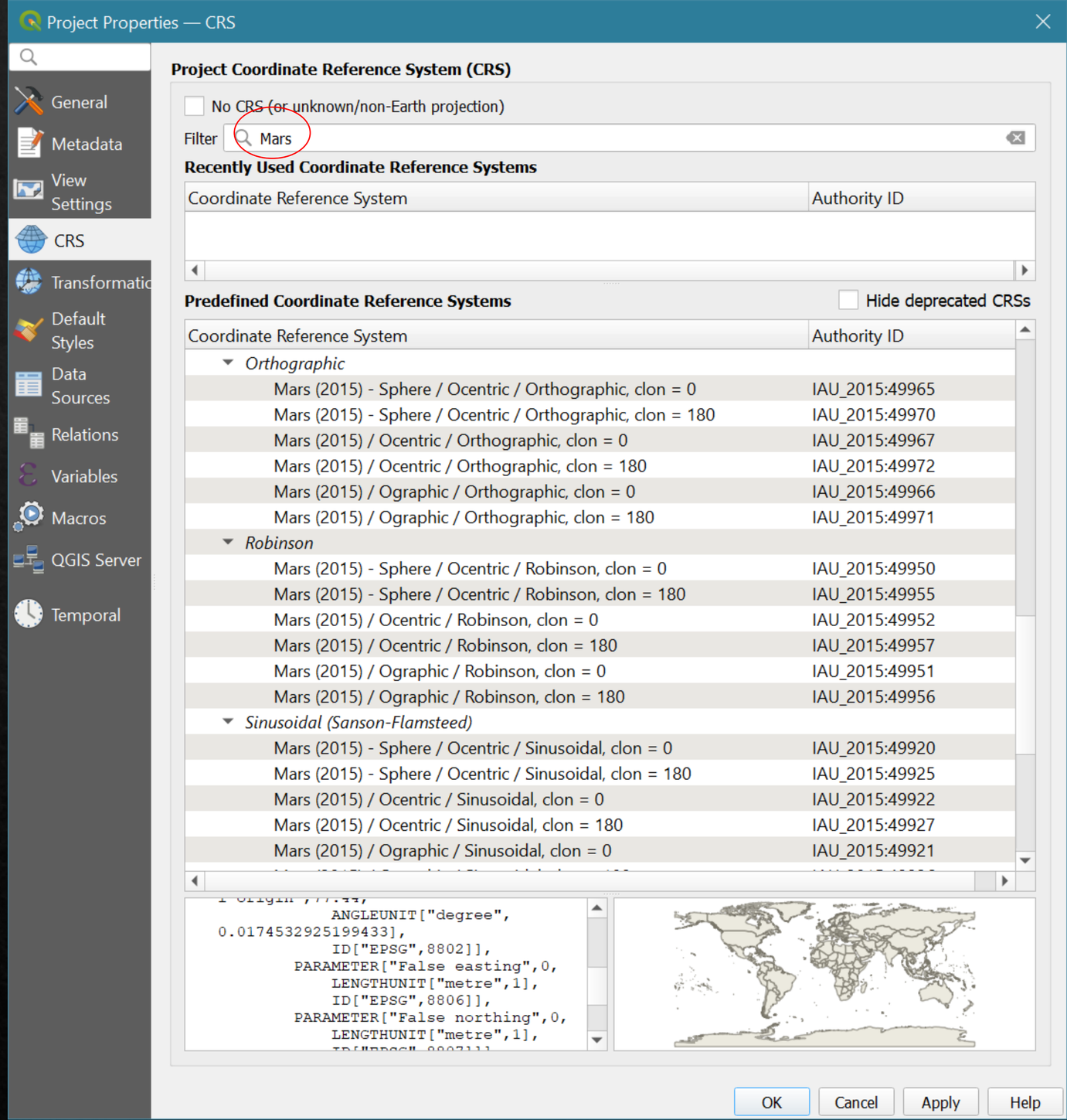

IAU Codes in PROJ

- To support broader adoption
  - Continue to work with OGC members for help.
  - Still need standard WKT2 updates (working with CRS WG, “Ocentric 2D”)
  - Even Rouault implement new implementation using same scheme (2021):
    - https://github.com/OSGeo/PROJ/blob/master/scripts/build_db_from_iau.py
  - Available in PROJ in late 2001

IAU Codes in PROJ

- makes it easier to share (GDAL, QGIS, Mapserver, …)



PROJ/GDAL example (Venus)

- gdalsrsinfo IAU_2015:29900

PROJ.4 : +proj=longlat +R=6051800 +no_defs

OGC WKT2:2018 :

```
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    ID["IAU",29900,2015],
    REMARK["Source of IAU Coordinate systems: doi://10.1007/s10569-017-9805-5"]]
```
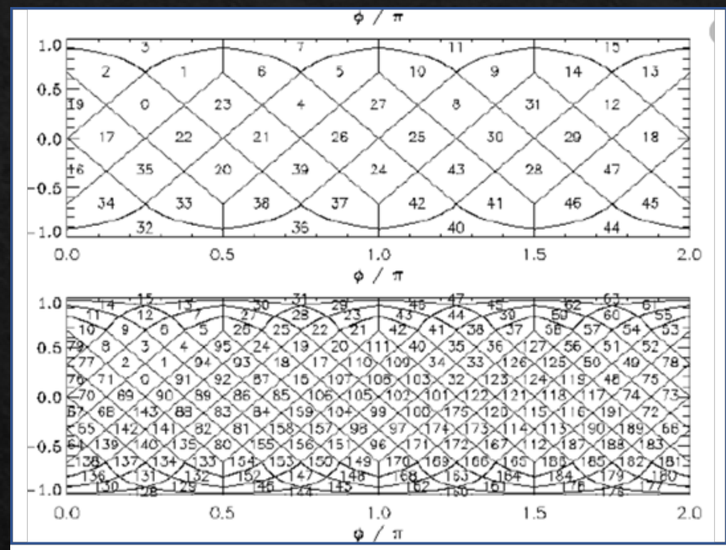
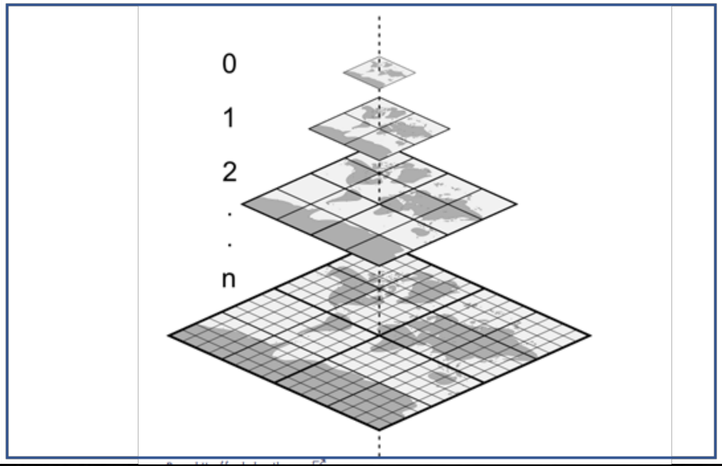

Connecting OGC and International Virtual Observatory Alliance (IVOA) web/map services

- Implementation in *MapProxy*, currently being officially accepted in codebase.
- Promote across both OGC and IVOA domains
- https://pypi.org/project/mapproxy-hips/



HIPS
Metadata



WMS/WMTS
Metadata