# PROJ presentation

## for

## Canada – U.S. Geospatial Software Developers Summit 2022

Even Rouault

*SPATIALYS*

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Spatialys

# PROJ in a nutshell

- C/C++ software library for coordinate transformations
- Free and open source: MIT license
- 40+ years of history, but substantial modernization in the last 5 years (PROJ >= 5).
- Capabilities
  - 100+ map projections
  - Geodetic pipelines
  - Transformations: Helmert, Molodensky, grid-based, deformation models, triangulation-based models
- Command line tools
- Multiple geodetic registries integrated: EPSG, etc.

# Database / geodetic registries

- PROJ has a dedicated SQLite3-based database of CRS and coordinate operation definitions.

- Regularly refreshed from EPSG (v10.076 at time of writing)

- Also entries from Esri, NKG (Nordic countries), IGN-France, IAU-2015

# CRS supported formats

- Legacy deprecated PROJ.4 strings (“+proj=utm +zone=11 +ellps=GRS80 +towgs84=0,0,0”)
- Well-Known Text (WKT) variants:
  - Esri WKT1
  - OGC WKT 1 (“GEOGCS”, “PROJCS”)
  - OGC WKT2:2015
  - OGC WKT2:2019 (“GEOGCRS”, “PROJCRS”)
- PROJJSON, equivalent to WKT2:2019 using a JSON encoding
- By identifier: EPSG:6340, urn:ogc:def:crs:EPSG::6340
- By name in the database: "NAD83(2011) / UTM Zone 11N"

# Grid formats

- Support for historic formats: GTX (geoids), NTv2 (.gsb, horizontal shifts)

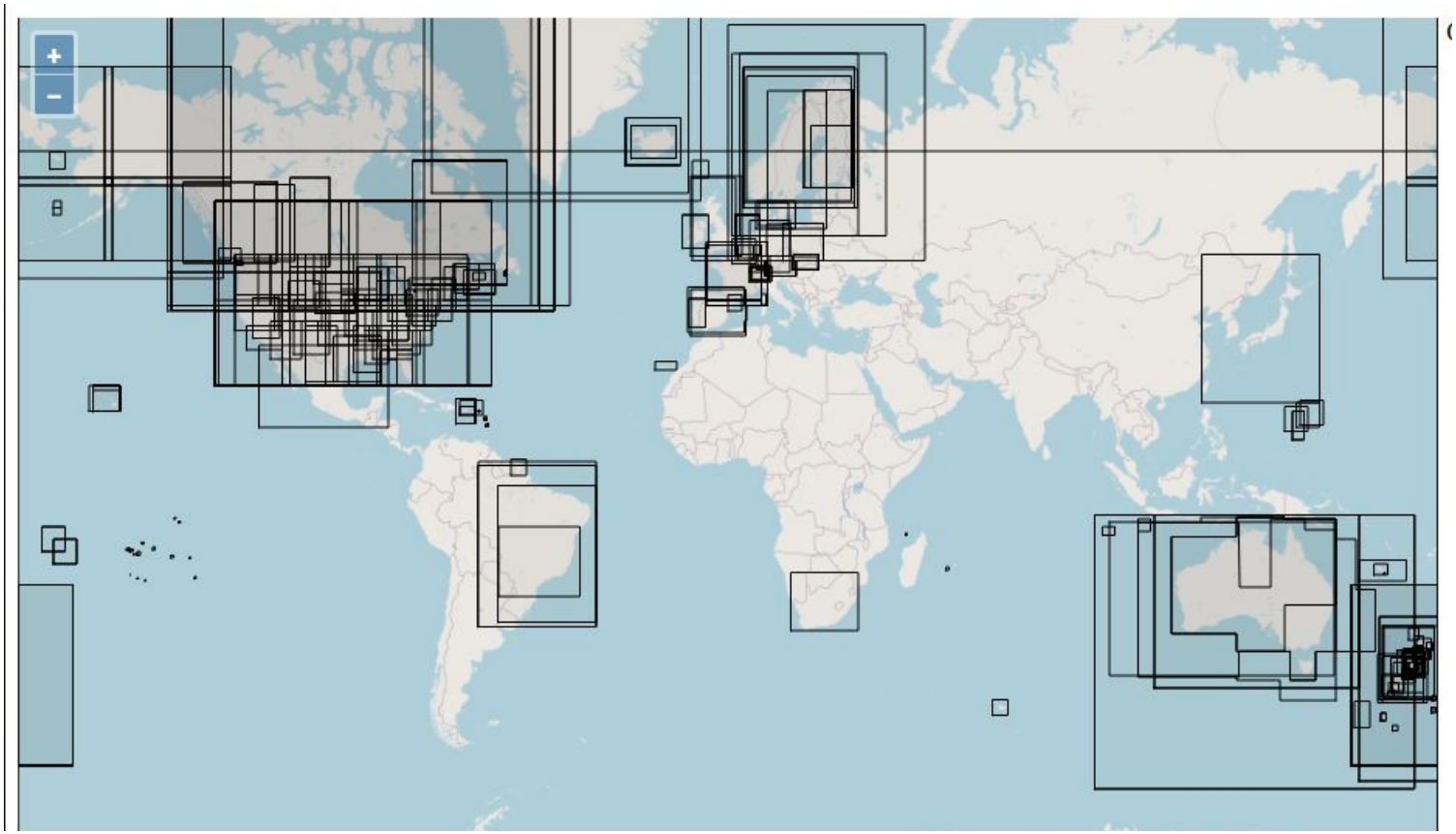
- Since PROJ 7, support for GeoTIFF-based format, GTG: Geodetic TIFF Grids: https://proj.org/specifications/geodetictiffgrids.html

- Grids can be used locally, or remotely through a Content Delivery Network (CDN): https://cdn.proj.org . 300+ grids, ~ 600 MB of (losslessly compressed) data

# PROJ CDN (https://cdn.proj.org)

Types: ☑ Horizontal shift grids ☑ Geoid models ☑ Vertical shifts ☑ Velocity grids ☑ Deformation models ☑ Other datasets

Agencies: ☑ at_bev ☑ au_ga ☑ au_icsm ☑ be_ign ☑ br_ibge ☑ ca_nrc ☑ ca_que_mern ☑ ch_swisstopo ☑ de_adv ☑ de_geosn
☑ de_lgl_bw ☑ de_lgvl_saarland ☑ dk_sdfe ☑ es_cat_icgc ☑ es_ign ☑ eur_nkg ☑ fi_nls ☑ fr_ign ☑ is_lmi ☑ jp_gsi ☑ mx_inegi
☑ nc_dittt ☑ nl_nsgi ☑ no_kv ☑ nz_linz ☑ pl_gugik ☑ pt_dgt ☑ se_lantmateriet ☑ sk_gku ☑ uk_os ☑ us_nga ☑ us_noaa ☑ za_cdngi



# What about GGXF ?

- PROJ team not a big fan of the proposed netCDF carrier. Was discussed back in 2019 when we introduced GTG (cf https://proj.org/community/rfc/rfc-5.html).
- Issues with netCDF/HDF5:
  - C reference library libhdf5 has long-time known issues with multi-threading.
  - libnetcdf has no API to access remote files
  - No known tool to make HDF5 files “cloud-friendly”
  - Security status of those libraries is unknown. Not tested in Google’s OSSFuzz program
  - Size of those libraries is bigger than PROJ
- If grids are produced in GGTX netCDF format someday, we’ll likely have to convert them to GTG to be usable.

# Time-based transformations

- PROJ has support for them for:
  - **15-parameter Helmert transformations,**

- Currently, only between a static and a dynamic datum, for “automatic” user-friendly transformation mode.

```
echo -40 140 0 2025 | cs2cs -d 8 GDA2020 ITRF2014
-39.99999740    140.00000122 -0.00095599 2025
echo -39.99999740    140.00000122 -0.00095599 2025 |
            cs2cs -d 8 ITRF2014 GDA2020
-40.00000000    140.00000000 0.00000001 2025
```

# Time-based transformations

- PROJ has support for them for:
  - 15-parameter Helmert transformations,
  - **Velocity grids (e.g NAD83(CSRS) v6 and v7),**

- https://proj.org/operations/transformations/deformation.html

- E.g NAD83(CSRS)v7 from epoch 2020.0 to epoch 2030

```
echo -100 60 0 2030.0 | cct  +proj=pipeline \
   +step +proj=cart +ellps=GRS80 \
   +step +proj=deformation +grids=ca_nrc_NAD83v70VG.tif  +t_epoch=2020.0 \
   +step +inv +proj=cart +ellps=GRS80
-99.9999994352   59.9999998659       0.0846     2030.0000
```

# Time-based transformations

- PROJ has support for them for:
  - 15-parameter Helmert transformations,
  - Velocity grids (e.g NAD83(CSRS) v6 and v7,
  - **Multi-component time-based deformation model**
    Use of JSON master file + GeoTIFF grids.
    Served as a prototype for the Deformation Model Functional Model work
- https://proj.org/operations/transformations/defmodel.html

- E.g. New Zealand semi-dynamic NZGD2000 → ITRF96:

```
echo -44 166 0 2010.0 | cs2cs -d 8 NZGD2000 ITRF96
-43.99999587    166.00000012 0.00294622 2010.0
```

# Time-based transformations (change of epoch within dynamic CRS)

- Manual pipeline to convert from ITRF92 @1993.0 to ITRF2014 @2023.0 in the Pacific zone

```
$ echo -139.57736536   -8.95162075   2.234  1993.0 | cct -d 8 +proj=pipeline \
  +step +proj=cart +ellps=GRS80 \
  +step +proj=helmert +x=-0.0154 +y=-0.0015 +z=0.0708 +rx=0 +ry=0 +rz=-0.00026 +s=-0.00309 \
     +dx=-0.0001 +dy=0.0005 +dz=0.0033 +drx=0 +dry=0 +drz=-2e-05 +ds=-0.00012 +t_epoch=2010 +convention=position_vector \
  +step +proj=set +v_4=2023.0 \
  +step +proj=helmert +drx=-0.000409 +dry=0.001047 +drz=-0.002169 +convention=position_vector +t_epoch=1993.0 \
  +step +inv +proj=cart +ellps=GRS80
 -139.57738390         -8.95161168    2.24071029     2023.0000
```

- For “CRS A@epoch1” to “CRS A@epoch2” mode, enhancements in the internals and API would be needed to have it in user-friendly mode.

⇒  **needed** (or in-kind source code contribution)

So no schedule for now

# Support data/tools expected from NGS/CGS for CRS modernization

(Provided software developments mentioned before done):

- CRS and transformation records registered in the EPSG dataset
- Grids, ideally in GeoTIFF formats, and in a well-known established open-data license (public domain, Creative Commons CC0, etc.)
- If any new-to-EPSG transformation methods, (compact) documentation of the formulas/maths to use, ideally integrated in IOGP Guidance Note 7-2
- Online coordinate transformation tools may be used to validate PROJ output during development, but will not be used by PROJ software itself, which must be able to operate in offline mode.

# Questions?

Links:

PROJ documentation: https://proj.org/
Code repository: https://github.com/OSGeo/PROJ/
Mailing list: https://lists.osgeo.org/mailman/listinfo/proj

Contact: even.rouault@spatialys.com