Use of Mayotte deformation model for coordinate transformation
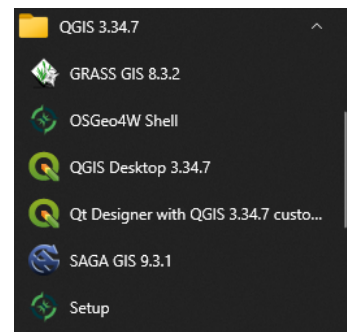
Version	1.0
Date	19/10/2024
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Institutions	IGN / ENSG / IPGP
Scope	The following document explains how to perform coordinate transformation using Mayotte deformation model (Grandin et al., 2024a, 2024b). It makes use of the proj library. This documentation explains how to use it with the model in command line mode.

Proj installation

Users should be able to use the *proj* library in command line mode. A *proj* version higher or equal to 9.2.1 is recommended[1].

The fastest way to install *proj* under *Windows* operating system is to install QGIS[2]. To install QGIS, go to https://qgis.org/download/ .

To use "proj" in command line mode with QGIS under Windows, open the "OSGeo4W Shell" terminal available from the windows start menu as shown here.
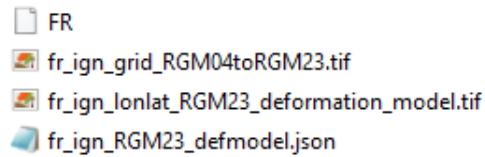

The alternative way to install *proj* is to follow the instructions provided at Installation — PROJ 9.4.1 documentation and follow the guidelines according to your operating system.

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[1] How to check your *proj* version? If proj is already installed on your computer, type "proj" in the command line terminal to display the *proj* version number.

[2] If QGIS is already installed on your computer, go to the menu "Help/About" to check the *proj* version in the displayed table.

Model installation

4 files should be copied to your computer

```
FR
fr_ign_grid_RGM04toRGM23.tif
fr_ign_lonlat_RGM23_deformation_model.tif
fr_ign_RGM23_defmodel.json
```

Unless you are a user familiar with *proj*, we recommend to copy these 4 files in the folder "share/proj/" of your *proj* install. For *Windows* users, it can be found in the following path (for version XXXX of QGIS) : *C:\Program Files\QGIS XXXX\share\proj* .

For other operating systems, please see: [Resource files — PROJ 9.4.1 documentation](#)

List of transformation

Typical coordinate transformations that make use of the Mayotte deformation model have been set up. Each of them has a specific ID (Ex: <RGM23geo3D>) that simplify their use with *proj*. The available transformations and their IDs are listed below:

Scope	Source Coordinate Reference System	Target Coordinate Reference System	ID	Comment
Application of the deformation model	RGM23, geographic 3D coordinates (decimal degrees, meter) at epoch t	RGM23, geographic 3D coordinates (decimal degrees, meter) at epoch 2023.75	<RGM23geo3D>	
Application of the deformation model	RGM23, geocentric Cartesian at epoch t	RGM23, geocentric Cartesian at epoch 2023.75	<RGM23>	
Application of the deformation model	RGM23, geographic 3D coordinates (decimal degrees, meter) at epoch 2023.75	RGM23, geographic 3D coordinates (decimal degrees, meter) at epoch t	<RGM23geo3DtoRGM23geo3D_at_t>	
Application of the deformation model	RGM23, geocentric Cartesian at epoch 2023.75	RGM23, geocentric Cartesian at epoch t	<RGM23toRGM23_at_t>	
ITRF2020 to RGM23, version 1	ITRF2020, geocentric Cartesian at epoch t	RGM23, geocentric Cartesian at epoch 2023.75	<ITRF2020toRGM23>	These transformations assume a steady displacement of Mayotte island (1 single velocity) from 2004 in addition to the deformation model
RGM23 to ITRF2020, version 1	RGM23, geocentric Cartesian at epoch 2023.75	ITRF2020, geocentric Cartesian at epoch t	<RGM23toITRF2020_at_t>	
RGM23 to RGM04	RGM23, geocentric Cartesian	RGM04, geocentric Cartesian	<RGM23toRGM04>	
RGM23 to RGM04	RGM23, geographic 3D (decimal degrees, meter)	RGM04, geographic 3D (decimal degrees, meter)	<RGM23geo3DtoRGM04geo3D>	
RGM04 to RGM23	RGM04, geocentric Cartesian	RGM23, geocentric Cartesian	<RGM04toRGM23	
RGM04 to RGM23	RGM04, geographic 3D (decimal degrees, meter)	RGM23, geographic 3D (decimal degrees, meter)	<RGM04geo3DtoRGM23geo3D>	

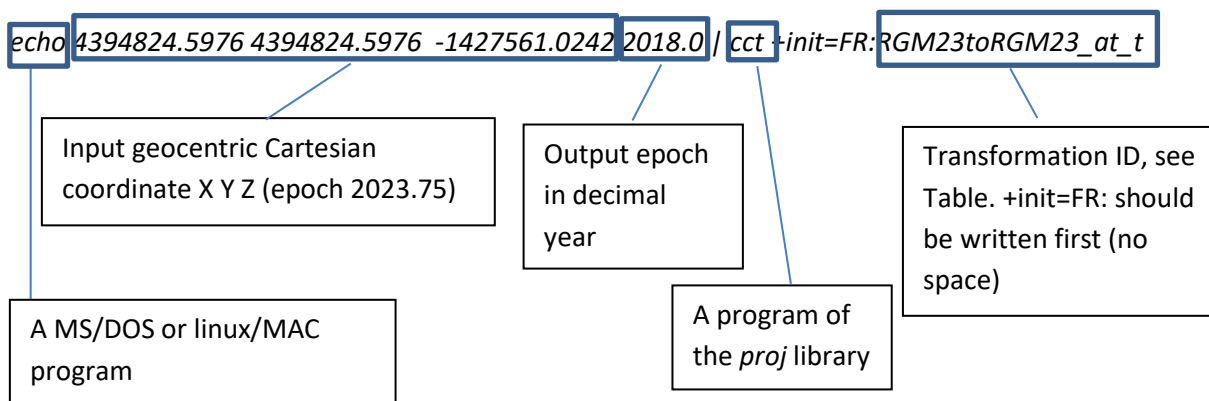## Transformation with proj

Application to single coordinates:

For example, you wish to transform RGM23 coordinates (the epoch is 2023.75) to RGM23 coordinates at 2018.0.

echo 4394824.5976 4394824.5976 -1427561.0242 2018.0 | cct +init=FR:RGM23toRGM23_at_t

The result is printed on the screen as follows:

4394824.7691   4394824.5107 -1427561.1190   2018.0000

Explanation:

echo 4394824.5976 4394824.5976 -1427561.0242 2018.0 | cct +init=FR:RGM23toRGM23_at_t

| Input geocentric Cartesian coordinate X Y Z (epoch 2023.75) | Output epoch in decimal year | Transformation ID, see Table. +init=FR: should be written first (no space) |

A MS/DOS or linux/MAC program

A program of the *proj* library

If you with to transform RGM23 coordinates at epoch 2018.0 to RGM23 coordinates (the reference epoch is 2023.75), the command is:

echo 4394824.5976   4394824.5976 -1427561.0242 2018.0 | cct +init=FR:RGM23

In this case, 2018.0 is the input epoch and not the output epoch. The ouput epoch should not be provided, it is the reference epoch of the model which is provided in the configuration file of the model. Note that the transformation ID has changed in this command line.
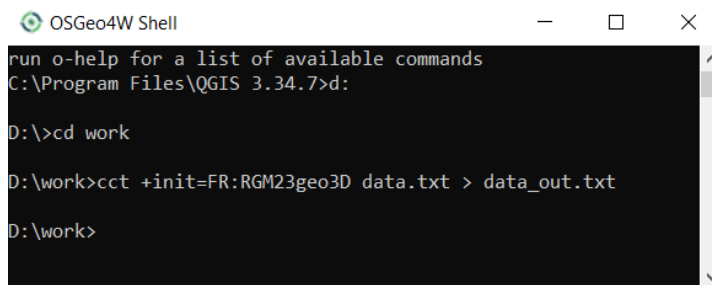
File mode:

Proj command can be applied to coordinates that are stored in a text file. The number of lines is not limited.
Example: the following text files called *data.txt* contains 3 lines that list RGM23 geographic 3D coordinates (decimal degrees and meters) at various epochs. Longitude is provided first. Note that the epoch is provided in the last column.

```
45.1927589766     -12.9108996239     -4.32896  2018.3504
45.0848691952     -12.6805872359     33.20441  2018.9418
45.1042054760     -12.9570915539      5.84821  2019.80972
```

Important: the text file should be copied in your current folder. As an example, we copied this file in the folder *D:\work*. This screenshot shows how to change the current folder and execute a *proj* command.


To convert the coordinates contained in this file to RGM23 geographic 3D coordinates (epoch 2023.75), the following command should be launched:

cct +init=FR:RGM23geo3D data.txt > data_out.txt

Explanation:

cct +init=FR:RGM23geo3D data.txt > data_out.txt

Transformation ID

Output file. Will be created in your current folder

Input file. Should be copies in your current folder.
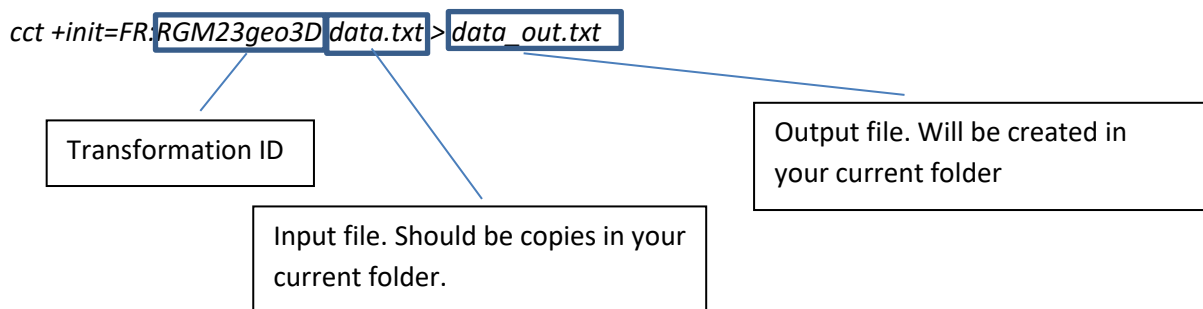
The file data_out.txt is created in your current folder (here in the example D:\work).

Here it contains:

```
45.1927613712 -12.9108988376    -4.5101   2018.3504
45.0848704051 -12.6805876046    33.1344   2018.9418
45.1042057577 -12.9570914489     5.8315   2019.8097
```

Note that the output epoch has not been changed but now, coordinates are valid at the reference epoch 2023.75.

References/citation

When using the deformation model for scientific applications, please use the two following references :

- Grandin R., Collilieux X., Pasquier I. et al. (2024a), Volcano-tectonic crisis deformation model [Data set]. https://doi.org/10.18715/IPGP.2024.XXXXXXXXX [a doi is beeing requested.]
- Grandin R., Collilieux X., Pasquier I. et al. (2024b),Volcano-tectonic crisis of Mayotte (2018– 2022): definition of a semi-kinematic reference frame for geodetic applications, in preparation

Citation for *proj*:

- PROJ contributors (2024), PROJ coordinate transformation software library. Open Source Geospatial Foundation. URL https://proj.org/ . DOI: 10.5281/zenodo.5884394