

Use of Mayotte deformation model for coordinate transformation

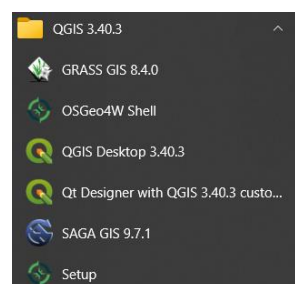
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Institutions	IGN / ENSG / IPGP
Scope	The following document explains how to perform coordinate transformation using Mayotte deformation model (Grandin et al., 2025a, 2025b). It makes use of the proj library. This documentation explains how to use it with the model in command line mode.
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Proj installation

Users should be able to use the *proj* library in command line mode. A *proj* version higher or equal to 9.5.1 is necessary¹.

The fastest way to install *proj* under *Windows* operating system is to install QGIS² (version greater than 3.40.3). 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.



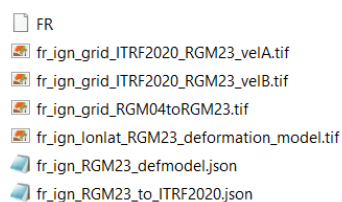
The alternative way to install *proj* is to follow the instructions provided at [Installation — PROJ documentation](#) and follow the guidelines according to your operating system.

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

7 files should be copied to your computer



Files `fr_ign_RGM23_to_ITRF2020`, `fr_ign_grid_ITRF2020_RGM23_velA.tif` and `fr_ign_grid_ITRF2020_RGM23_velB.tif` have been added in February 2025 to model the transformation from ITRF2020 to RGM23.

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 2	ITRF2020, geocentric Cartesian at epoch t	RGM23, geocentric Cartesian at epoch 2023.75	<ITRF2020toRGM23v2>	These transformations assume a different displacement of Mayotte island (1 single velocity) before and after May 2018 in addition to the deformation model
RGM23 to ITRF2020, version 2	RGM23, geocentric Cartesian at epoch 2023.75	ITRF2020, geocentric Cartesian at epoch t	<RGM23toITRF2020_at_tv2>	
RGM23 to RGM04	RGM23, geocentric Cartesian	RGM04, geocentric Cartesian	<RGM23toRGM04>	
RGM23 to	RGM23, geographic	RGM04, geographic	<RGM23geo3DtoR	

RGM04	3D (decimal degrees, meter)	3D (decimal degrees, meter)	GM04geo3D>	
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:

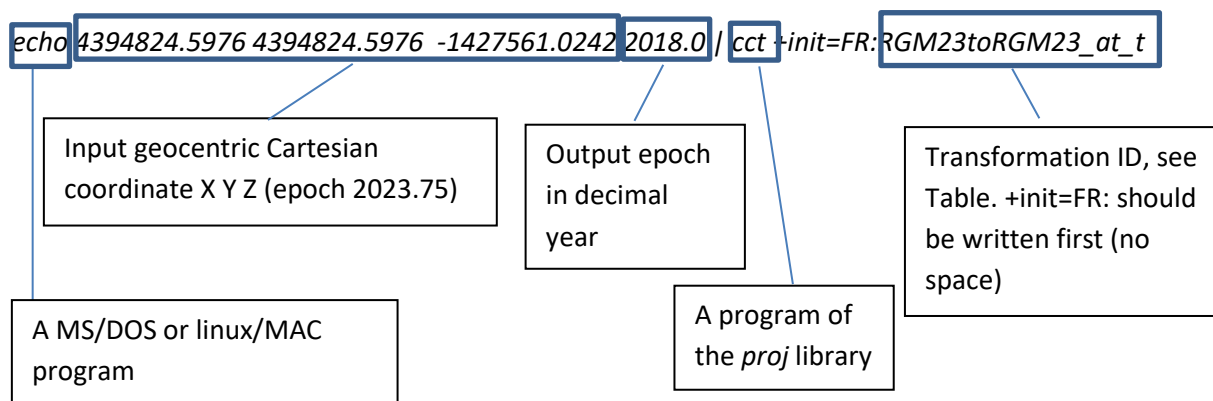
For example, you wish to transform RGM23 coordinates (the epoch is 2023.75) to RGM23 coordinates at 2018.0.

```
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:



If you wish 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 output 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:

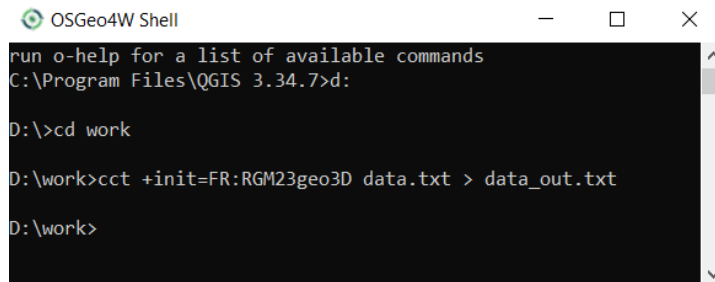
Proj command can be applied to coordinates that are stored in a text file. The number of lines is not limited.

Example: the following text file 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.



```
OSGeo4W Shell
run o-help for a list of available commands
C:\Program Files\QGIS 3.34.7>d:

D:\>cd work

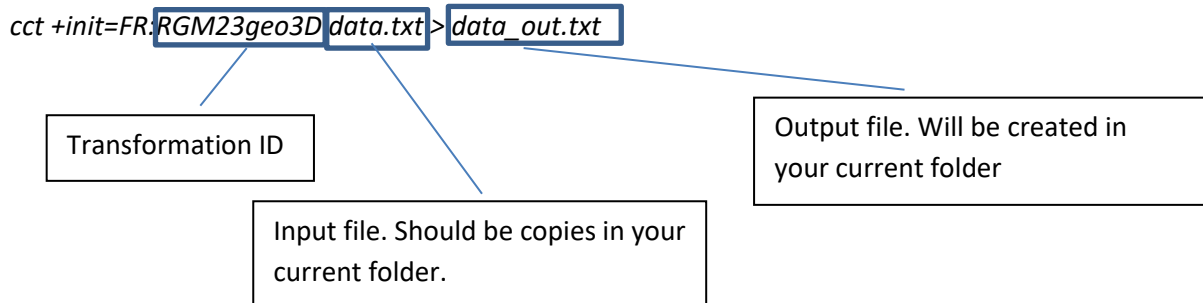
D:\work>cct +init=FR:RGM23geo3D data.txt > data_out.txt

D:\work>
```

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:



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. (2025a), Mayotte deformation model, 2018-2022 volcano-tectonic crisis [Data set], doi:10.57932/41cf41f5-5a0c-47d0-b88d-a774e06e9012
- Grandin R., Collilieux X., Pasquier I. et Jamet O. (2025b), Volcano-tectonic crisis of Mayotte (2018–2022): deformation model 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