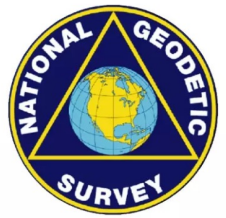
Jet Propulsion Laboratory
California Institute of Technology



THE OHIO STATE UNIVERSITY

GeoDE: the Geodetic Database Engine for GNSS Data Processing, Management, and Trajectory Analysis

Mara A. Figueroa and Demián D. Gómez

Motivation

- Currently, there is no single software available on the market (whether commercial or open access) that provides an **integrated processing workflow** for GNSS geodesy.
- GNSS data, which are essential for generating high-precision reference frames, are generally stored using ***ad-hoc* formats** that are difficult to manage.
- Moreover, GNSS metadata are stored in text formats with poor quality controls that do not always ensure the **consistency of the information.**
- Data management through a geographic interface is often limited to **static GIS systems** that do not display the complete or most updated status of the information.
- To make matters worse, there are more than **20,000 permanent GNSS stations** worldwide, which makes data management extremely challenging.

Software description

GeoDE
Geodetic Database Engine

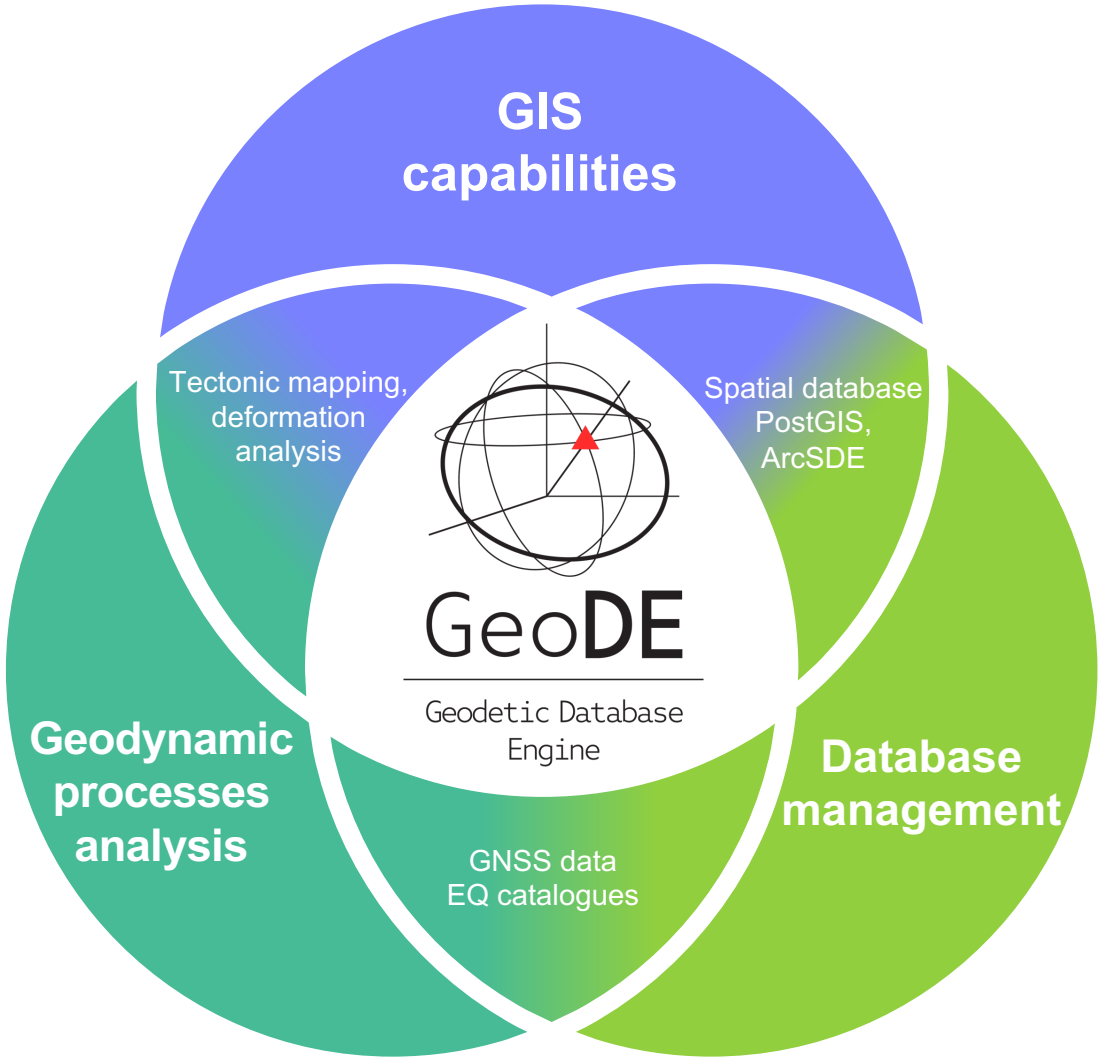
In response to these needs, we created **GeoDE**, a comprehensive solution for managing GNSS geodetic information, and expandable to other techniques, such as gravity.

- Backed by a powerful database engine (Postgres) and tested with more than **20 million RINEX files and 10,000 GNSS stations (continuous+campaign)**.
- Allows for the management of both the **scientific processing**, and the **metadata**.
- Includes the management of data sources (e.g., FTP servers) for automatic acquisition of RINEX and RAW files.
- Offers tools for **time series** analysis, geodynamic events, and **field visits**.
- Manages **contact information** associated with each GNSS station.
- The system features a user-friendly interface and a powerful command-line management engine for fast in-bulk execution of tasks.
- The software is **open access**.

OSU geodesy

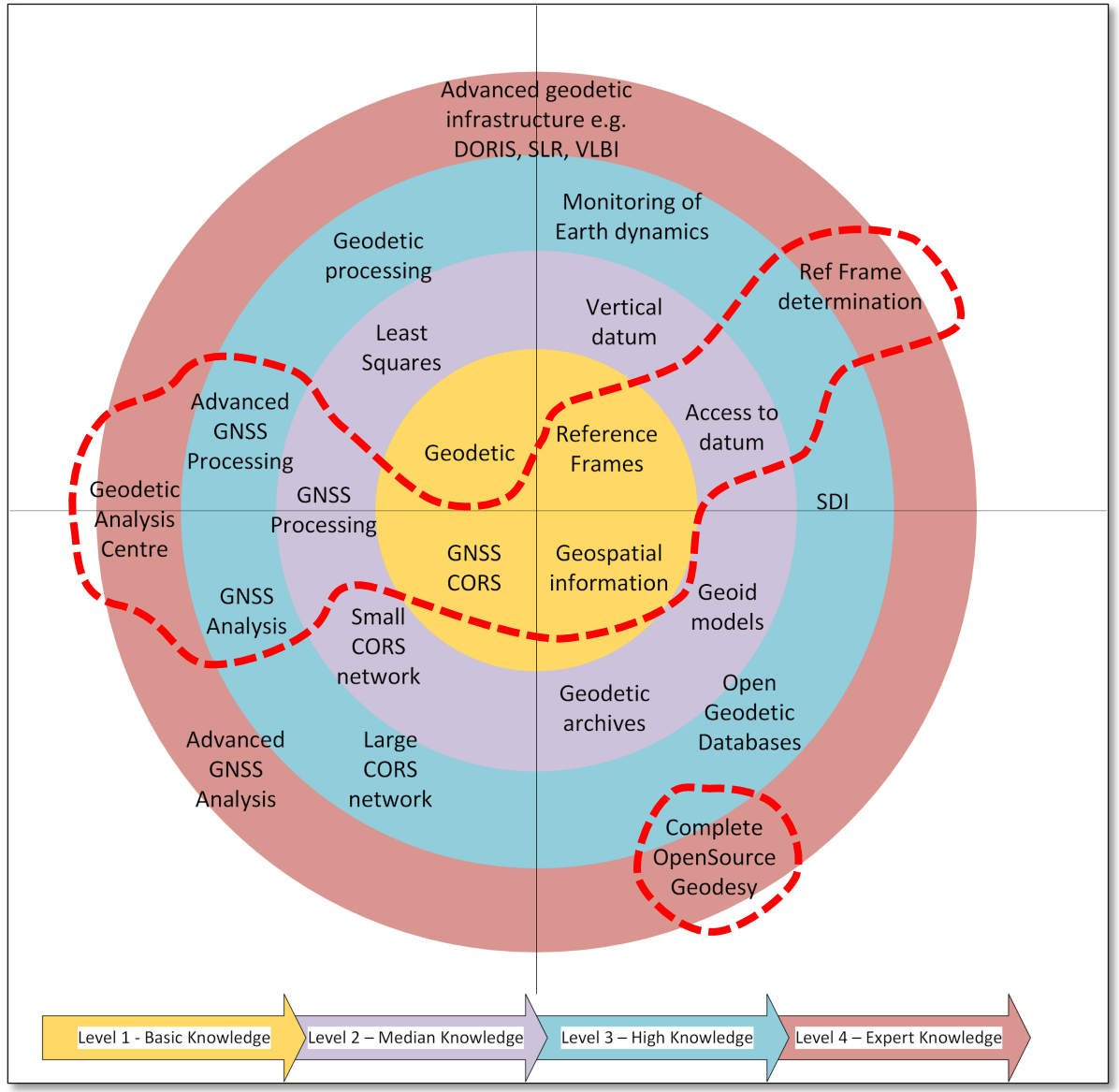
Key features

GeoDE integrates...



- GIS-like environment to manage GNSS stations
- Spatial database with embedded PostGIS capabilities
- Metadata analysis tools (including AI integrations) for solving complex issues
- GNSS data and earthquake catalogs for generating automatic and reliable time series
- Tools for geodynamic analysis and visualization
- Full realization of GNSS-based reference frames and associated deformation models
- Management of cluster runs for GAMIT and GPSPACE PPP

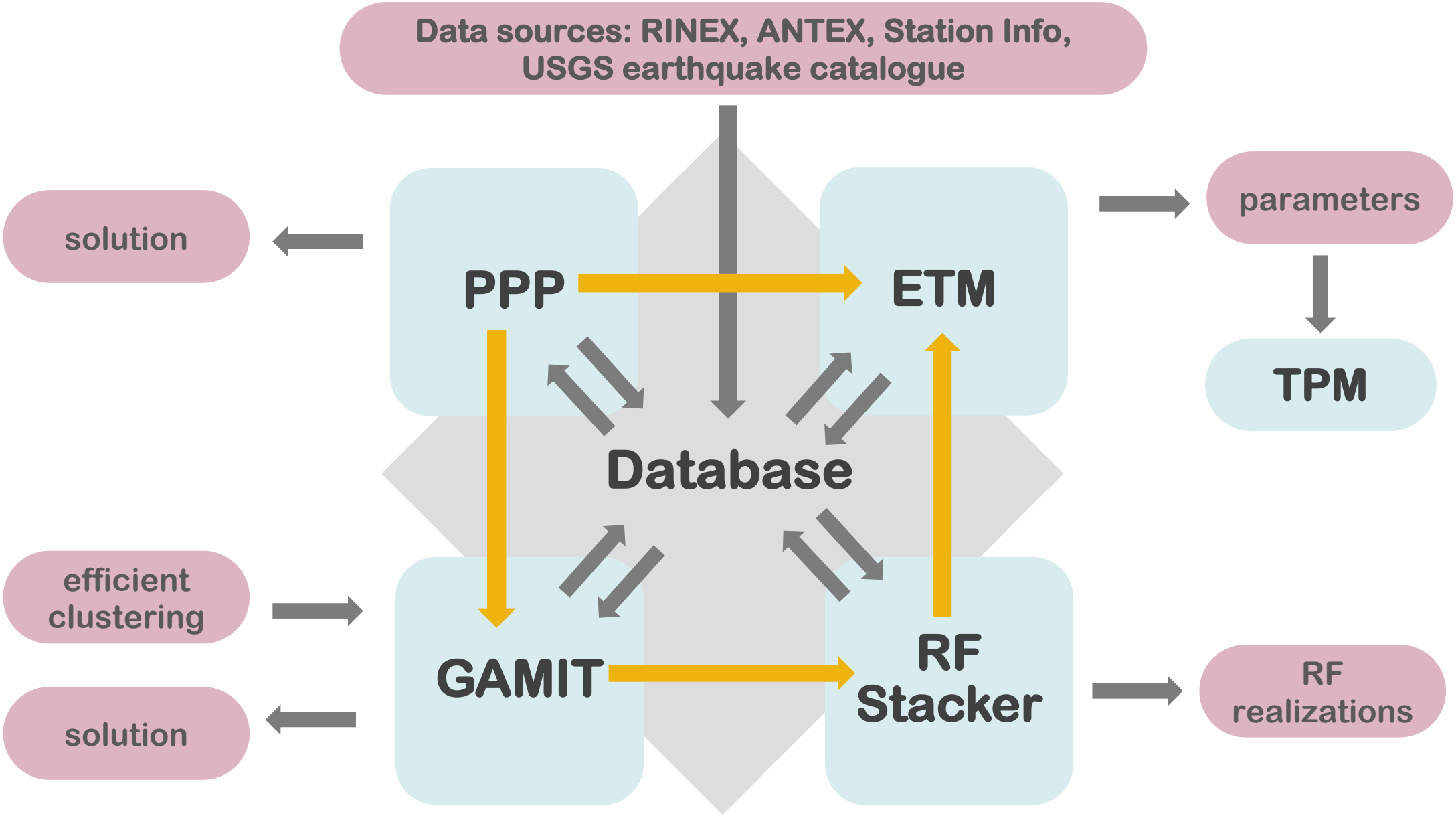
A comprehensive solution



- Based on the capacity framework developed by the UN-GGIM Subcommittee on Geodesy, GeoDE spans multiple categories across the four capacity levels.
- From managing a network of permanent stations and fitting time series, to reference frame realization.
- This solution can rapidly strengthen the capacity status of a mapping agency by providing a ready-to-use tool.

Keenan, R., Craddock, A., Lilje, M., Sarib, R., & Blick, G. (2020). A Global Survey of Reference Frame Competency in terms of Education, Training and Capacity Building (ETCB): Results, Analysis and Update. Proceedings of the International Federation of Surveyors (FIG) 2020 Working Week

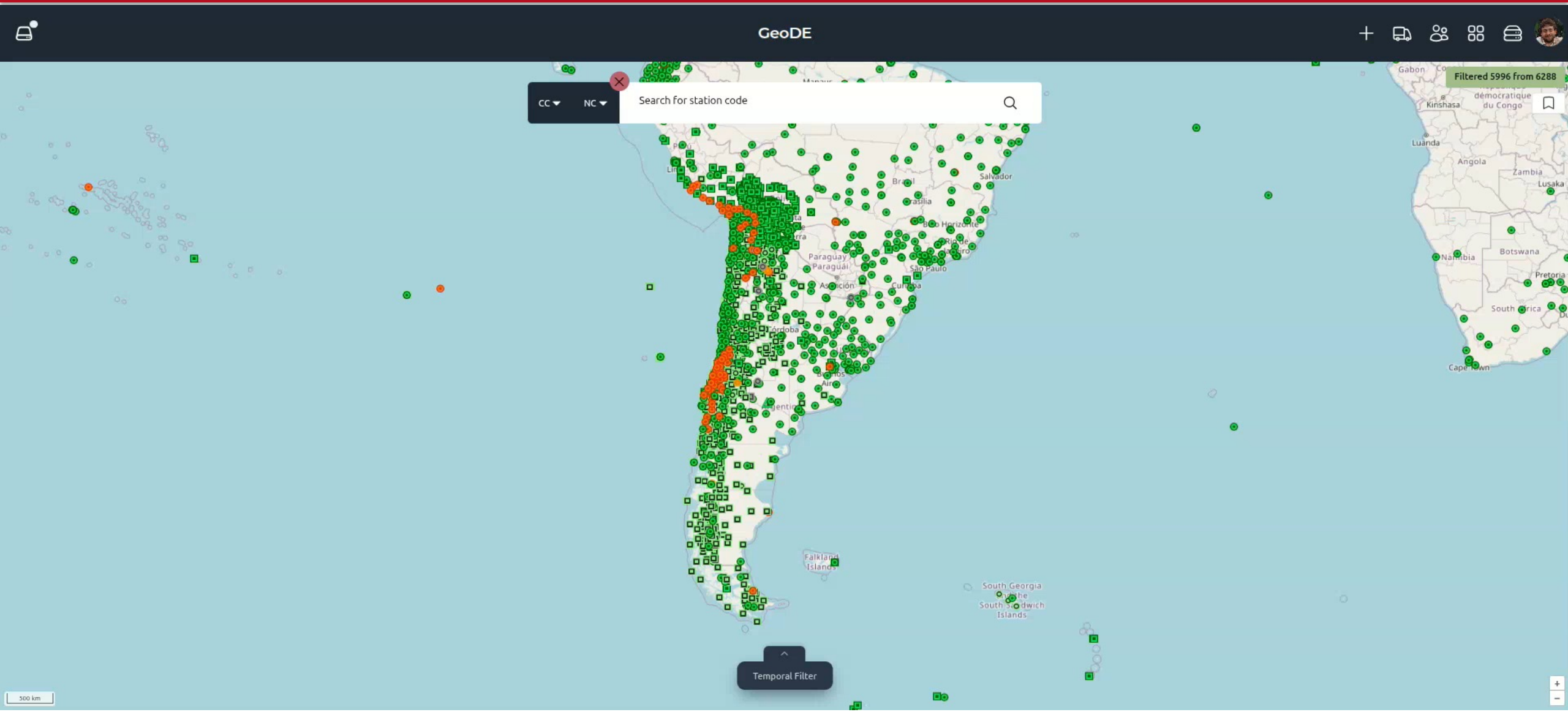
Software architecture



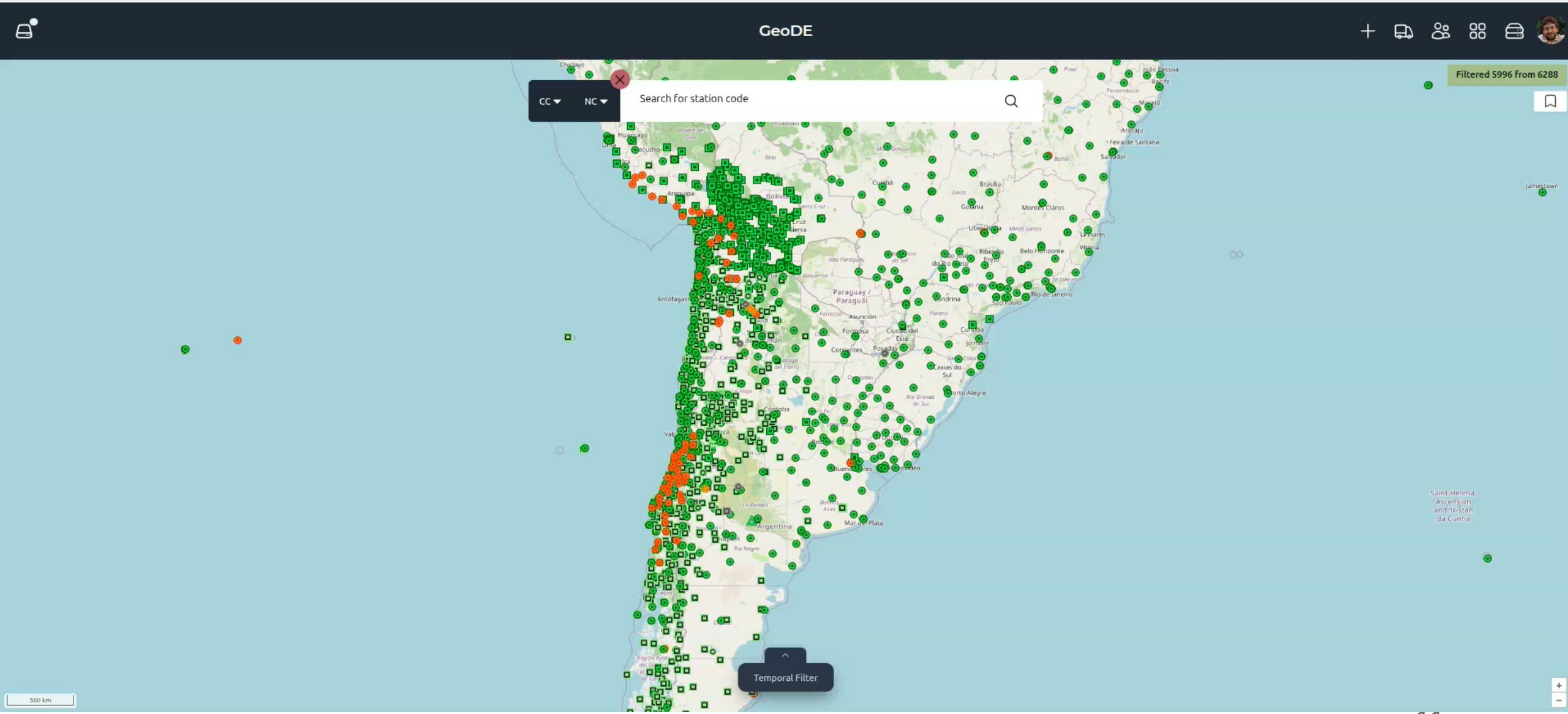
Web interface

User management with different permission levels
Fast map visualization even with thousands of stations

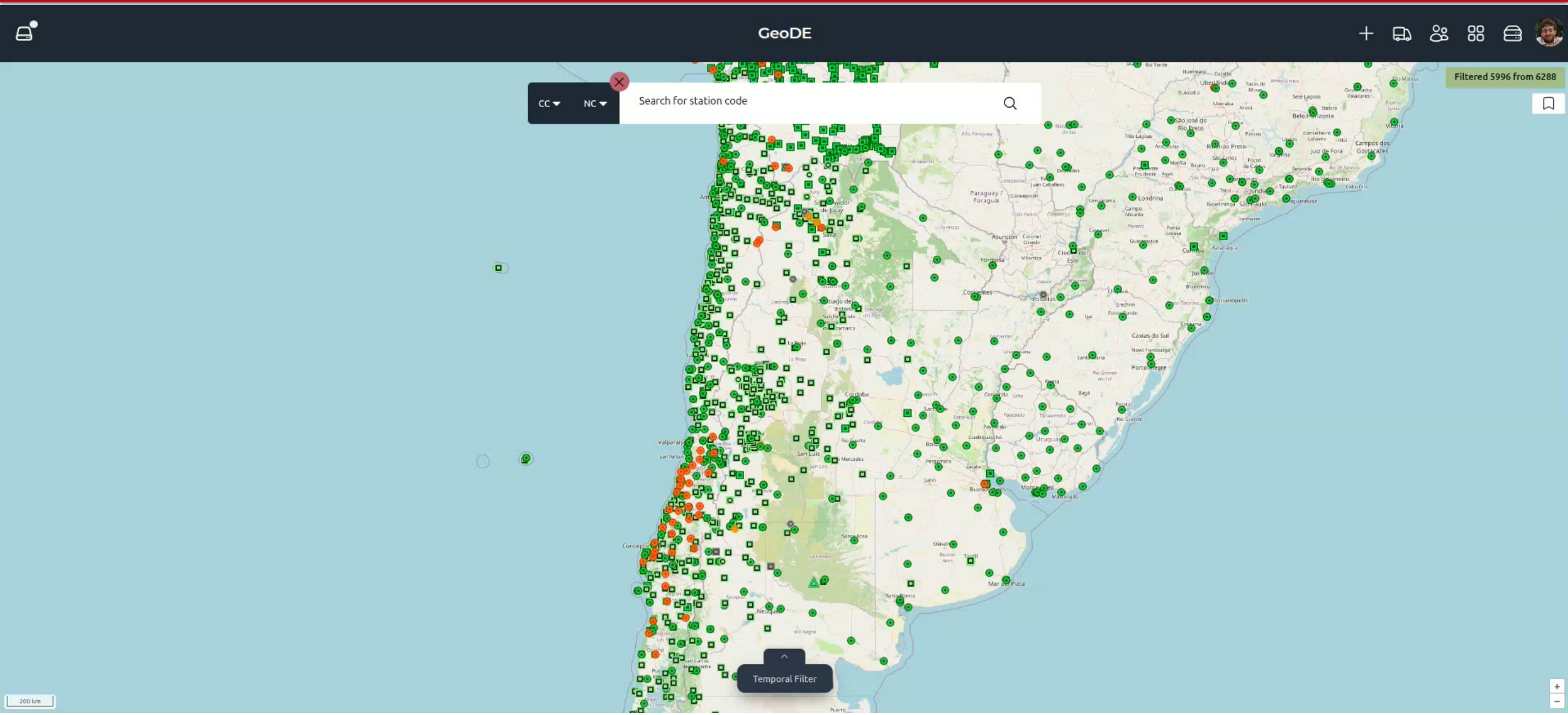
Visualization filters



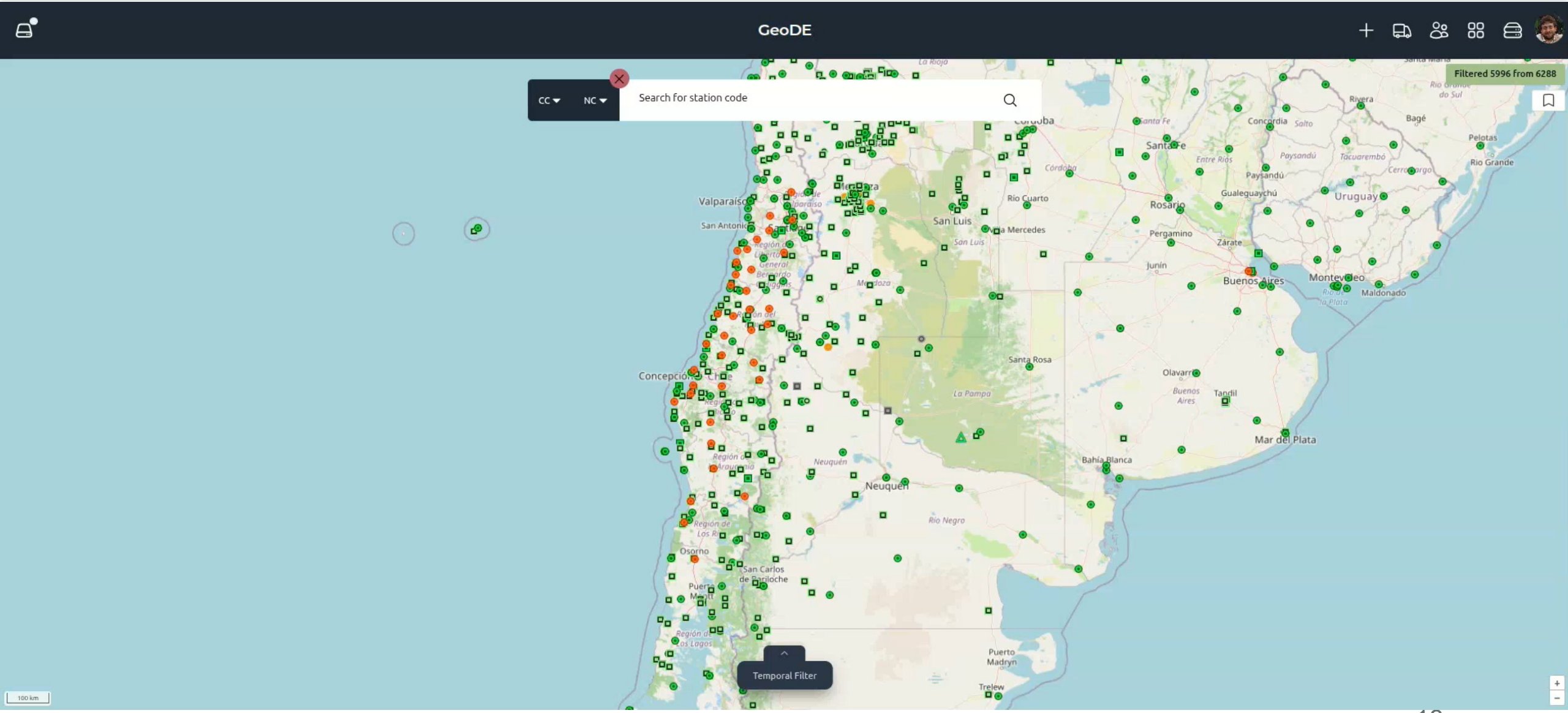
Seismic masking



Station visits (campaign sites)



Metadata and time series (continuous)



Example of a time series

```
ARG.IGM1 (PPP 99.71% - Robust Least Squares) lat: -34.57224 lon: -58.43932
Conventional Epoch Pos. (2006.632) X: 2751804.042 Y: -4479879.307 Z: -3598922.498 [m]
Velocity N: 11.22 ± 0.02 E: -0.74 ± 0.03 U: 1.30 ± 0.06 [mm/yr]
Seasonal Amplitude (1.0 yr 0.5 yr) N: (2.60 0.83) E: (1.14 0.41) U: (6.03 0.37) [mm]
NEU wrms [mm]: 1.96 2.91 6.54
```

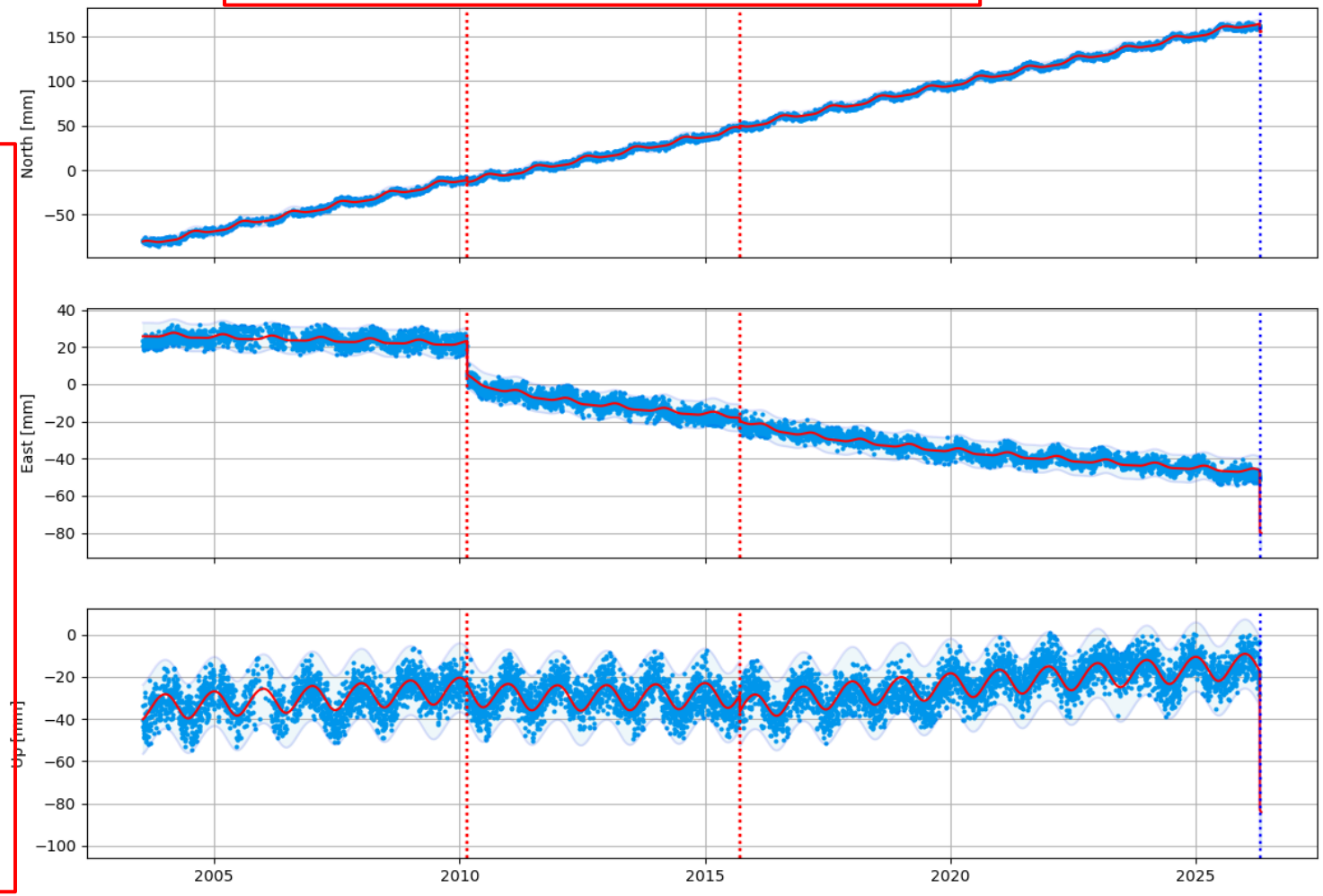
Header with station information

Jumps

```
   Year Day Relx     [mm] Mag D [km]
A 2003 200          0.0
A 2010 058         -2.1 8.8 1321.4
A 2010 058 0.50    -4.4 8.8 1321.4
A 2015 259          1.9 8.3 1276.4
A 2015 259 0.50     0.8 8.3 1276.4
A 2026 113        -10.0
```

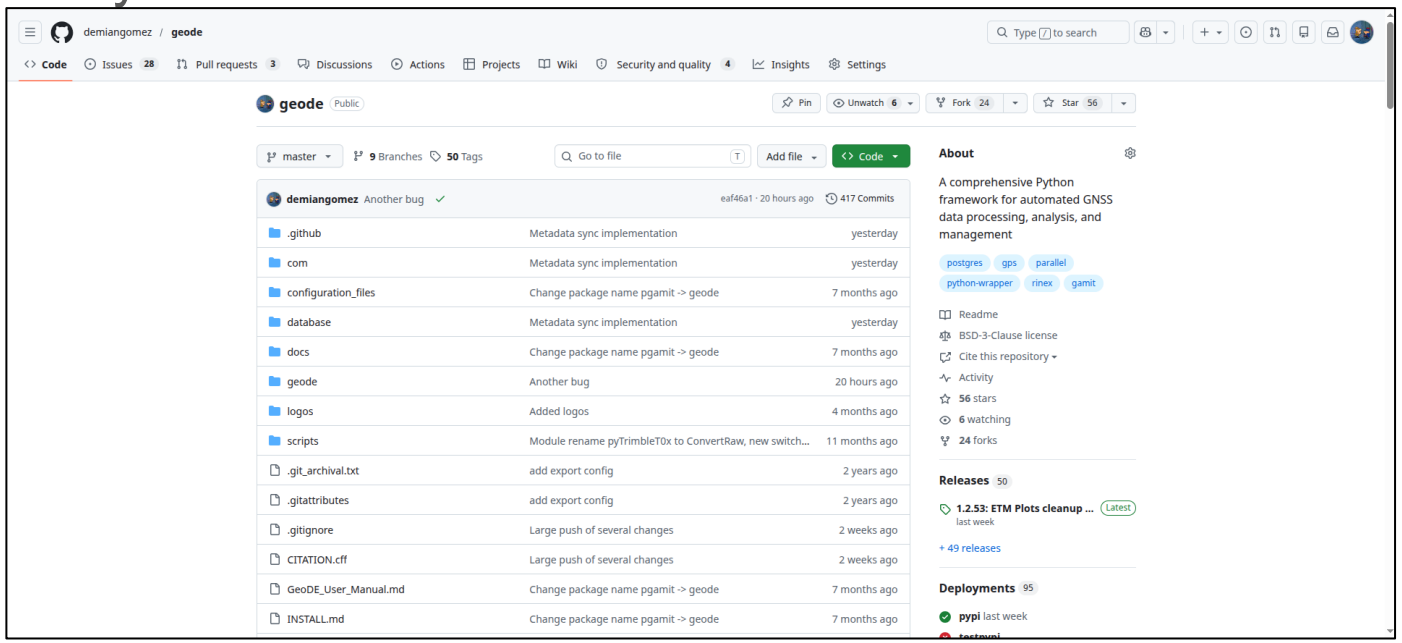
```
   Year Day Relx     [mm] Mag D [km]
A 2003 200          0.0
A 2010 058        -18.3 8.8 1321.4
A 2010 058 0.50   -15.4 8.8 1321.4
A 2015 259         -1.8 8.3 1276.4
A 2015 259 0.50    -9.9 8.3 1276.4
A 2026 113        -33.4
```

```
   Year Day Relx     [mm] Mag D [km]
A 2003 200          0.0
A 2010 058         -0.8 8.8 1321.4
A 2010 058 0.50    -8.0 8.8 1321.4
A 2015 259         -7.9 8.3 1276.4
A 2015 259 0.50     8.4 8.3 1276.4
A 2026 113        -65.9
```



Conclusions

- **GeoDE** manages the GNSS data analysis process from start to finish.
- The Python package includes command-line tools for parallel execution of **GAMIT** and **PPP.**
- The results can be viewed in the web interface by users with little or no experience in Linux.
- The software is freely available!



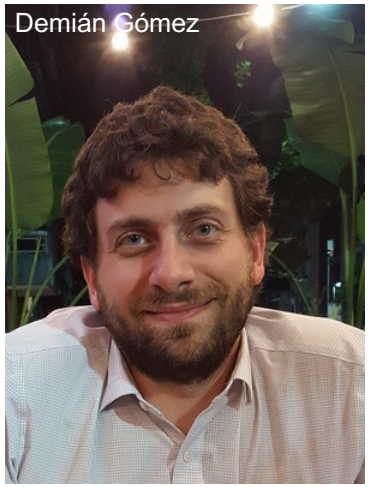
https://github.com/demiangomez/geode

Next steps for GeoDE...

- **Implementing M-PAGES** as another GNSS processing tool, along with PPP and GAMIT
- Expanding the **geophysica**l analysis tools (e.g. to visualize and extract the magnitude of coseismic jumps at specific stations)
- Adding trajectory prediction model capabilities using both GNSS and **InSAR data** through the novel CoInSAR method
- Implementation of AI integrations (metadata analysis) using Claude

OSU's team

Principal- and co-investigators



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Government of Canada
Gouvernement du Canada

THE OHIO STATE UNIVERSITY

Thank you!
Questions?