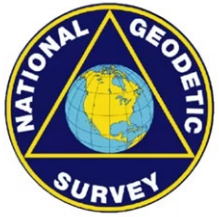

SURVEYING AND GEOMATICS CONFERENCE
Corvallis, Oregon | June 2-4

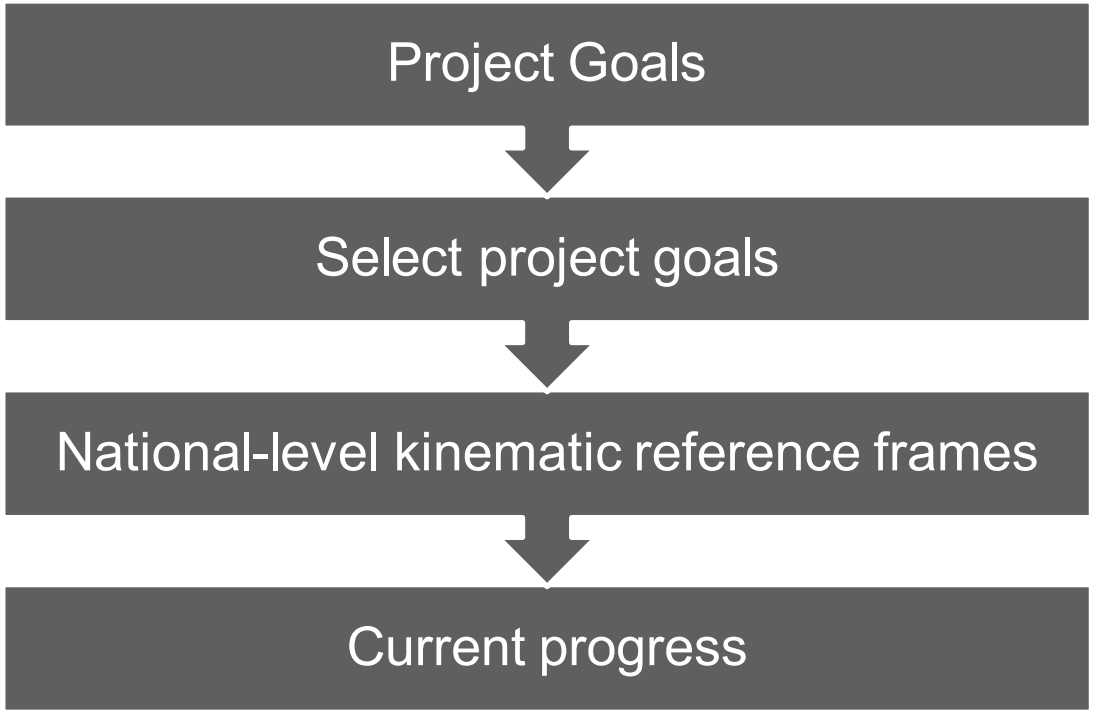




THE OHIO STATE UNIVERSITY

# Developing a Fully Kinematic, Backwards-Compatible Reference Frame for the Continental United States of America and Canada

Mara A. Figueroa, Demián D. Gómez, Michael G. Bevis, and Joachim Moortgat

# Presentation Outline



# Project goals

- **Develop a workflow** involving data curation, processing, and analysis to create an operational (*sandbox*) kinematic reference frame.
- We call this workflow the ***Geometric Geodesy Processing Line* (GGPL)**
- Features of the GGPL include:
  - A **relational database** (PostgreSQL) to store **all** the data and products, including the frame itself
  - **Integration** between **GNSS solutions**, station **trajectory models**, and other observations such as **InSAR**
  - **Artificial intelligence** techniques to **improve** trajectory models and model deformation constraints using InSAR observations
  - A software package that **streamlines creation of models and frame access**

# Select project goals

- Development of the **operational (sandbox) kinematic reference frame (KRF)**.

  Will require automation processes to detect and model deformation from, for example, earthquakes, GIA, and other crustal motions

- **Parallelization wrapper for M-PAGES** (adapted from our existing Parallel.GAMIT)

  Process **all** existing data in the US and Canada

- **Intraframe deformation** (i.e. trajectory prediction models) using GNSS and InSAR aided by AI to access the conventional epoch of the frame.

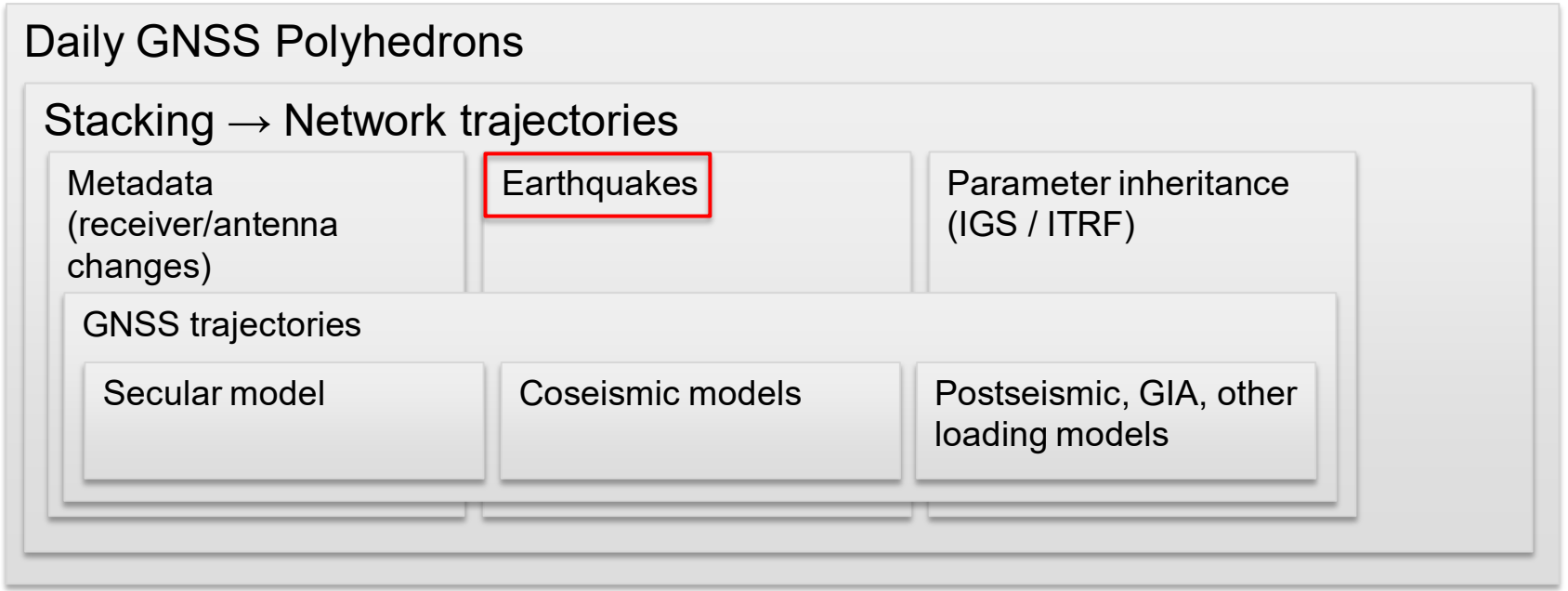
  Include as many observations as possible and also provide the users with a maps of "stable areas" to facilitate access to the frame using differential processing

# National-level kinematic reference frames (KFR)

- Definition: the coordinates and model parameters defining the reference frame are time-dependent
- **Single or multiple conventional epochs**, accessible to all users anytime and anywhere to guarantee topologic homogeneity.
- **Models to access the conventional epoch are mandatory, even after an earthquake**
- Kinematic implies constant update of the reference frame parameters to "honor" the frame's internal geometry.

# Assembling the KRF puzzle

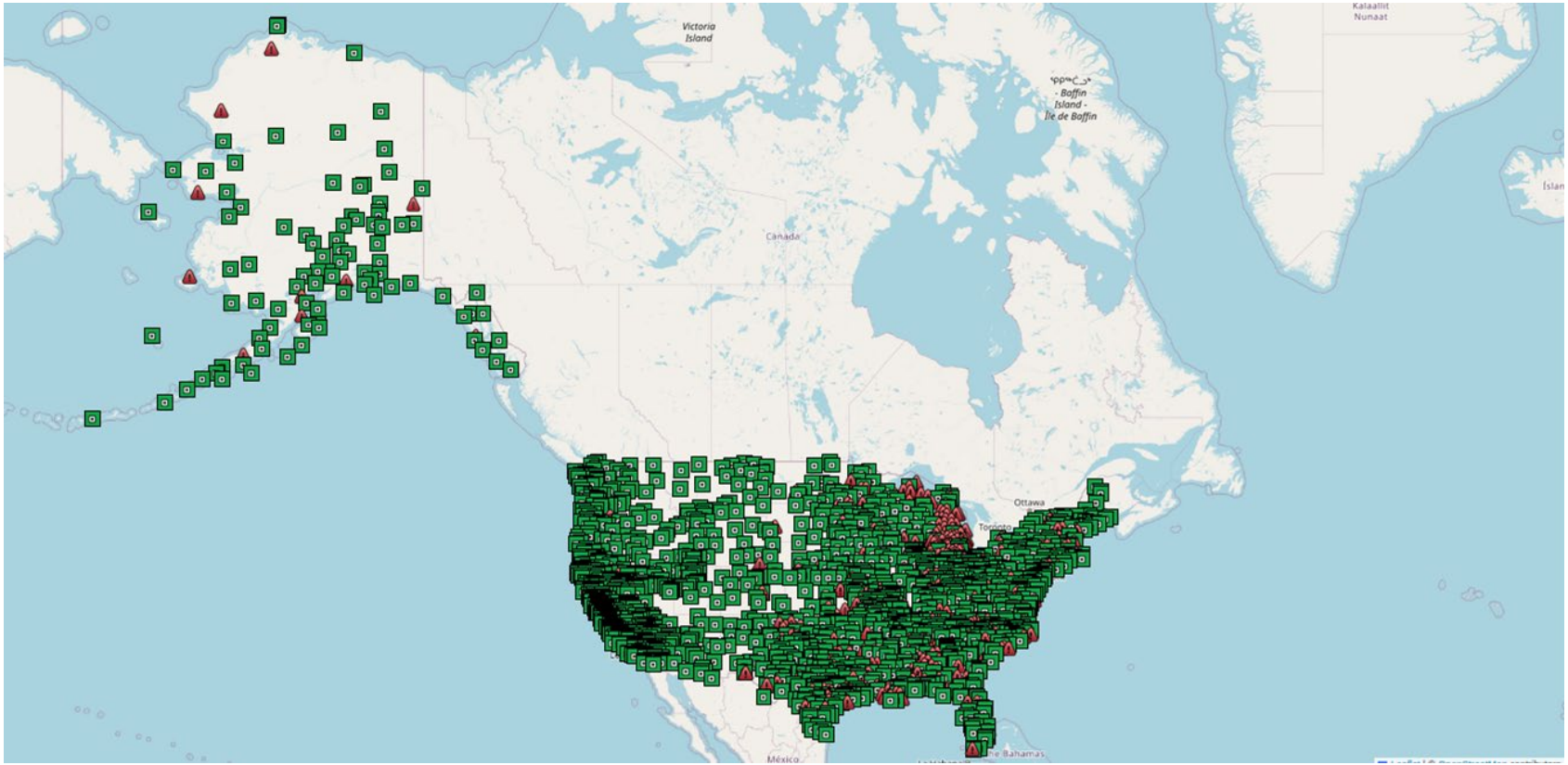
## Steps for the realization of a kinematic RF




**Automation required to include all possible geophysical effects**

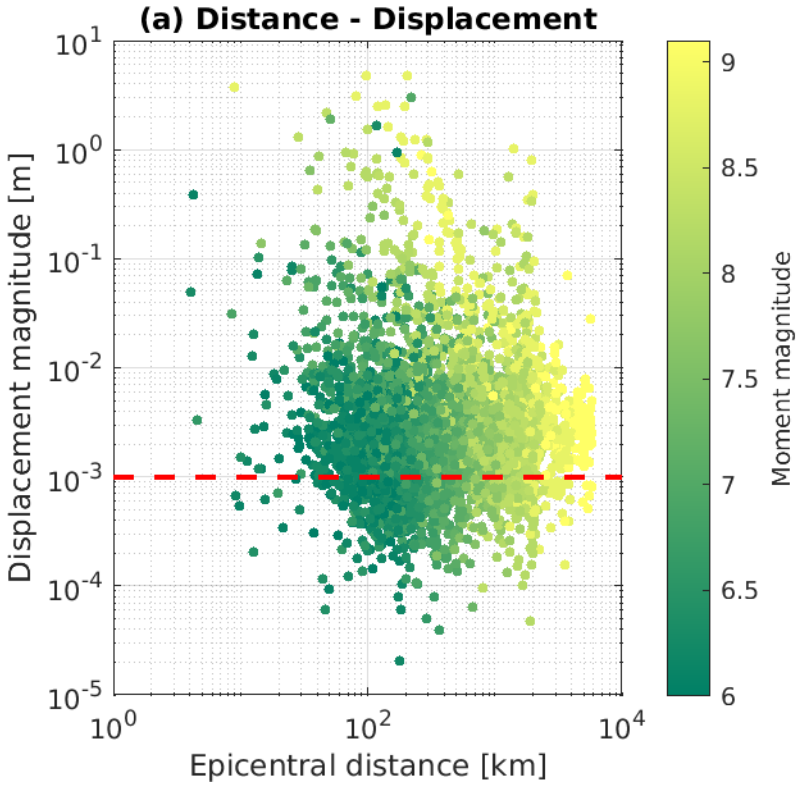
# U.S. CORS Network

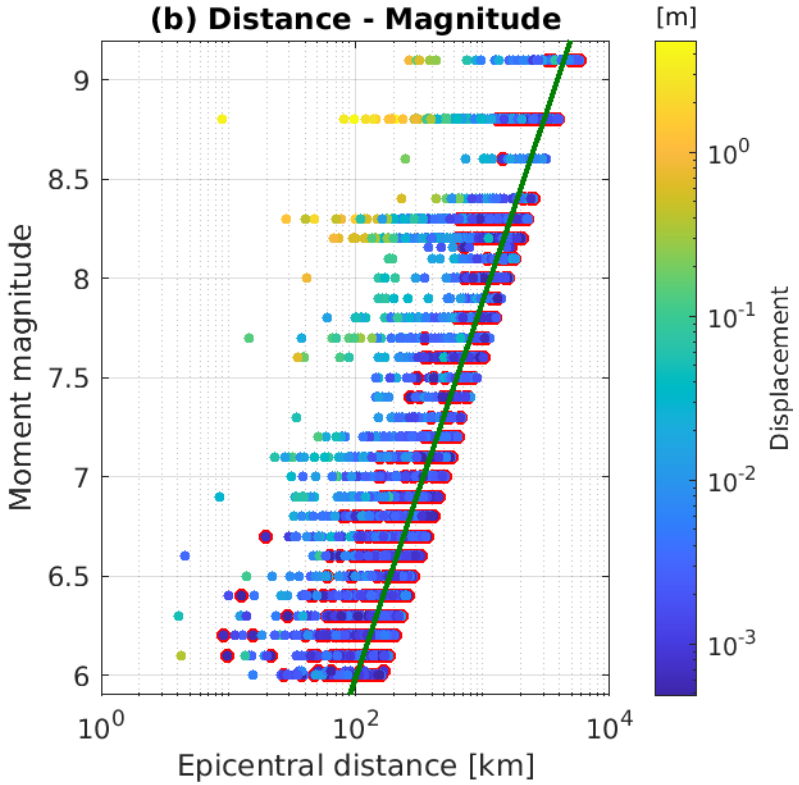
Processing GNSS observations (underway)



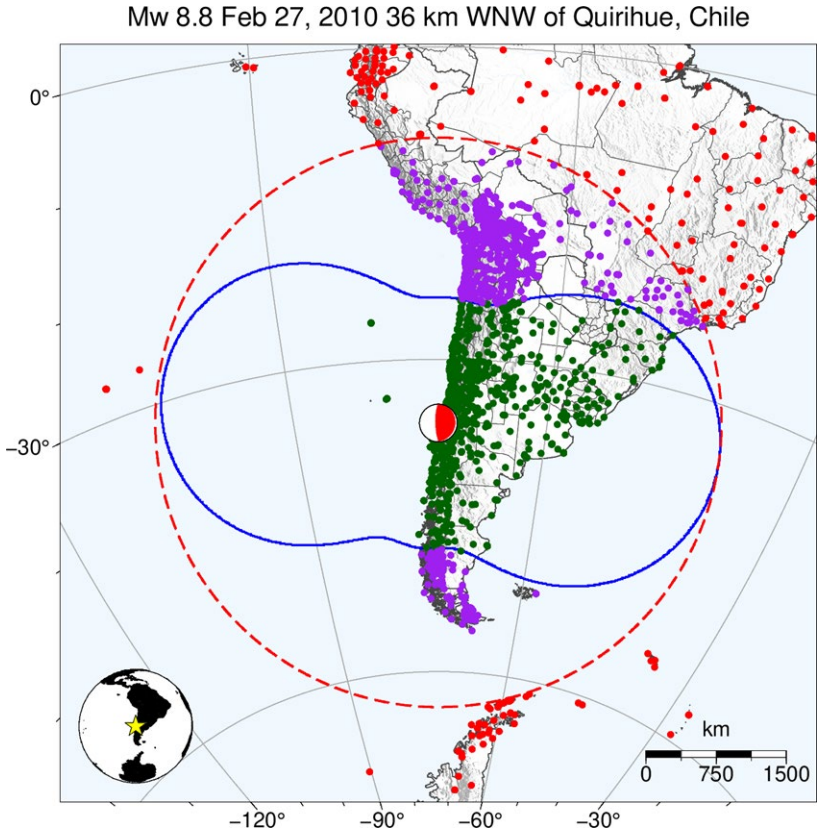
# Automation within the GGPL

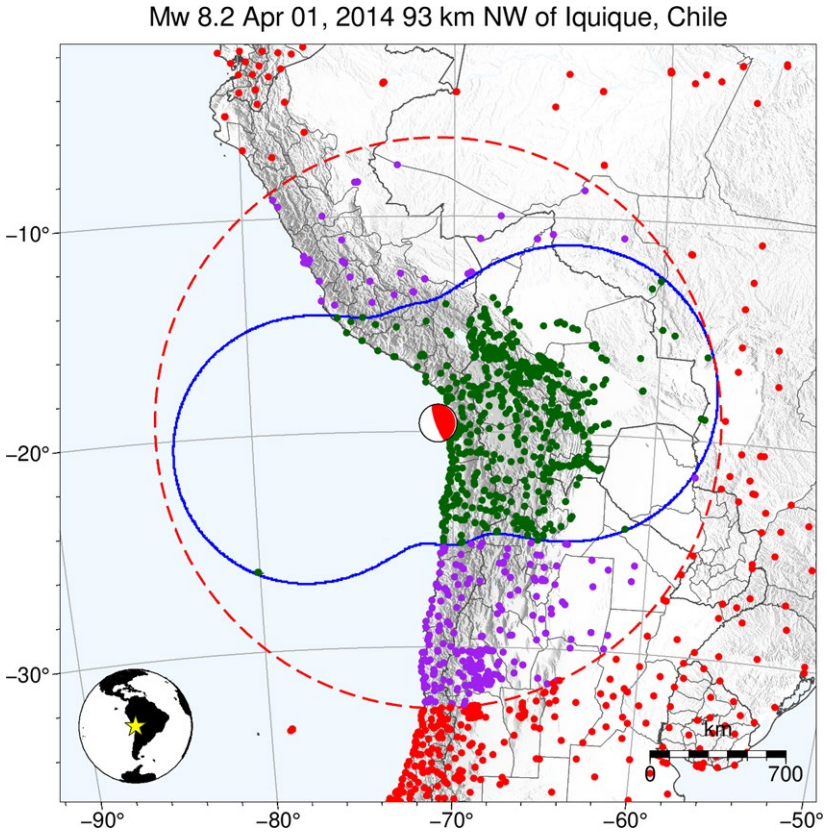
**Earthquake detection → significant improvement over current methods → better time series**



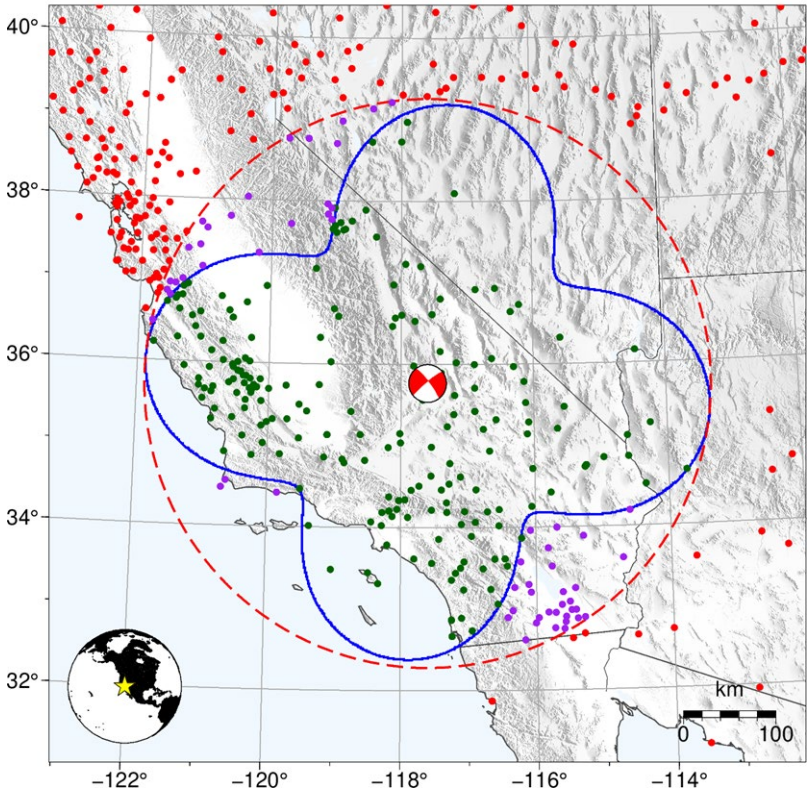
# Motivation


Mw 8.8 Feb 27, 2010 36 km WNW of Quirihue, Chile
0°
−30°
−120°
−90°
−60°
−30°
km
0
750
1500

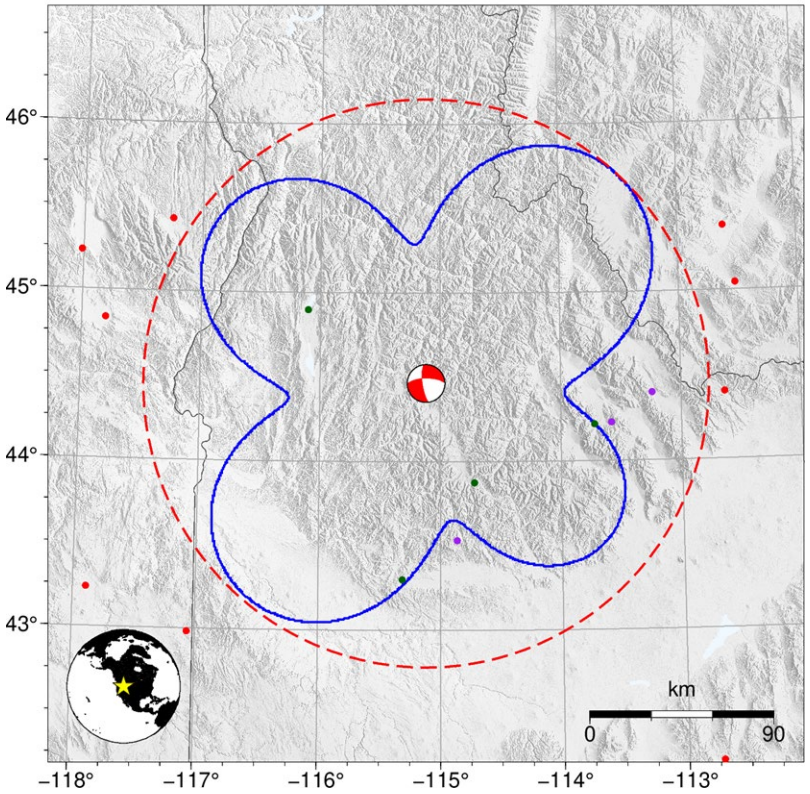

Mw 8.2 Apr 01, 2014 93 km NW of Iquique, Chile
−10°
−20°
−30°
−90°
−80°
−70°
−60°
−50°
km
0
700

# Examples within the U.S.

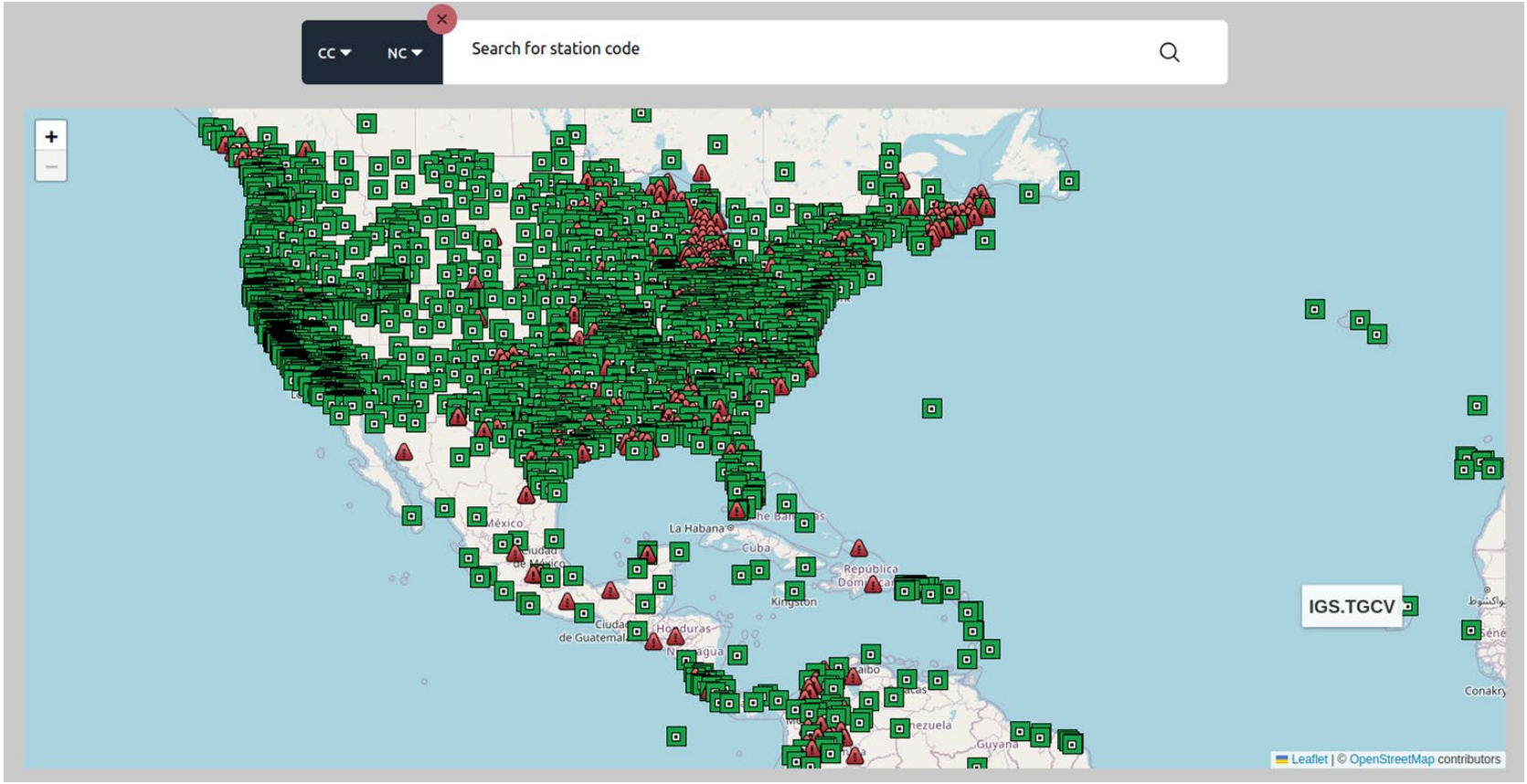
Mw 7.1 Jul 06, 2019 Ridgecrest Earthquake Sequence




Mw 6.5 Mar 31, 2020 Stanley, Idaho



# Visual interactive GGPL interface



# Visual interactive GGPL interface

# Visual interactive GGPL interface

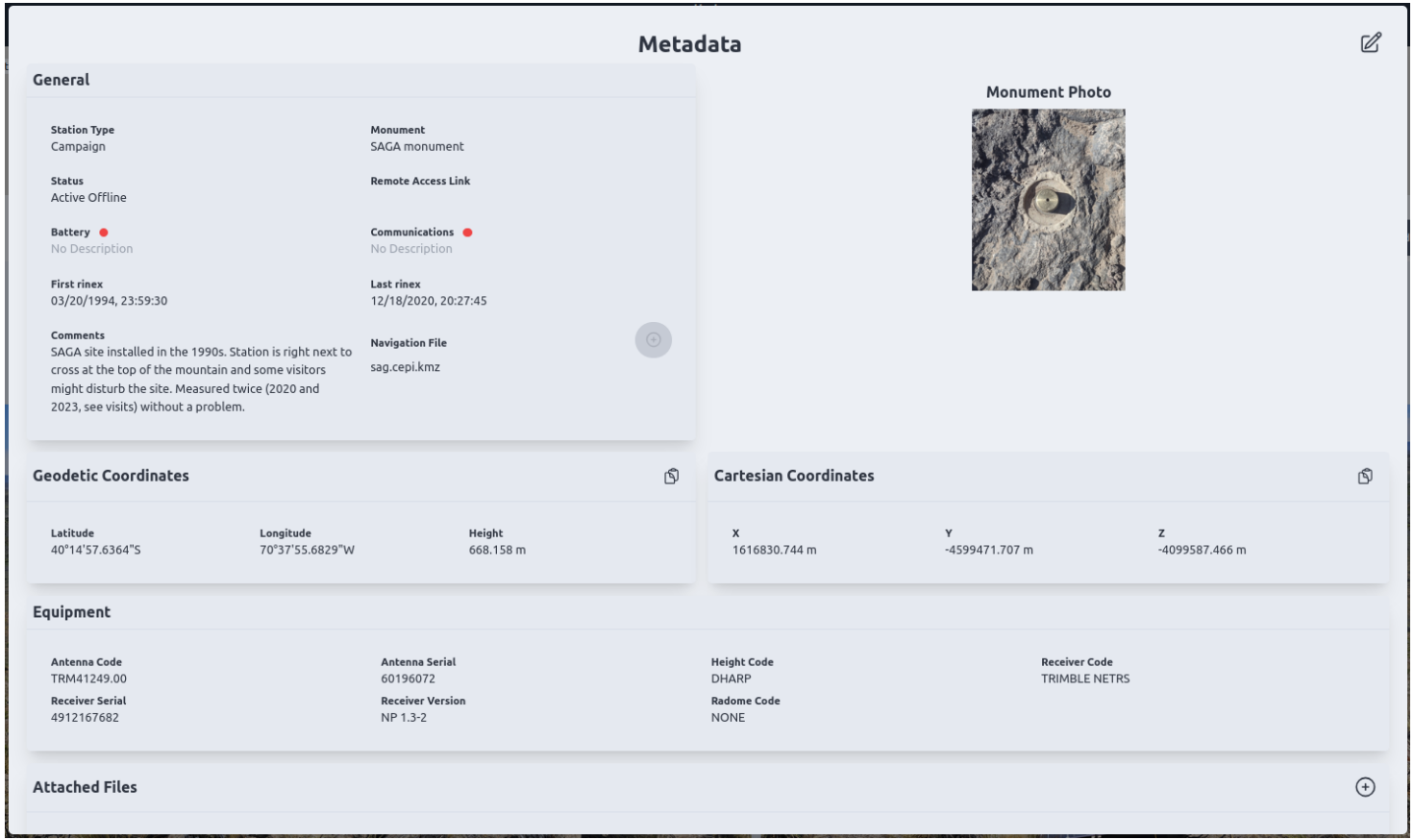
## CEPI

Add

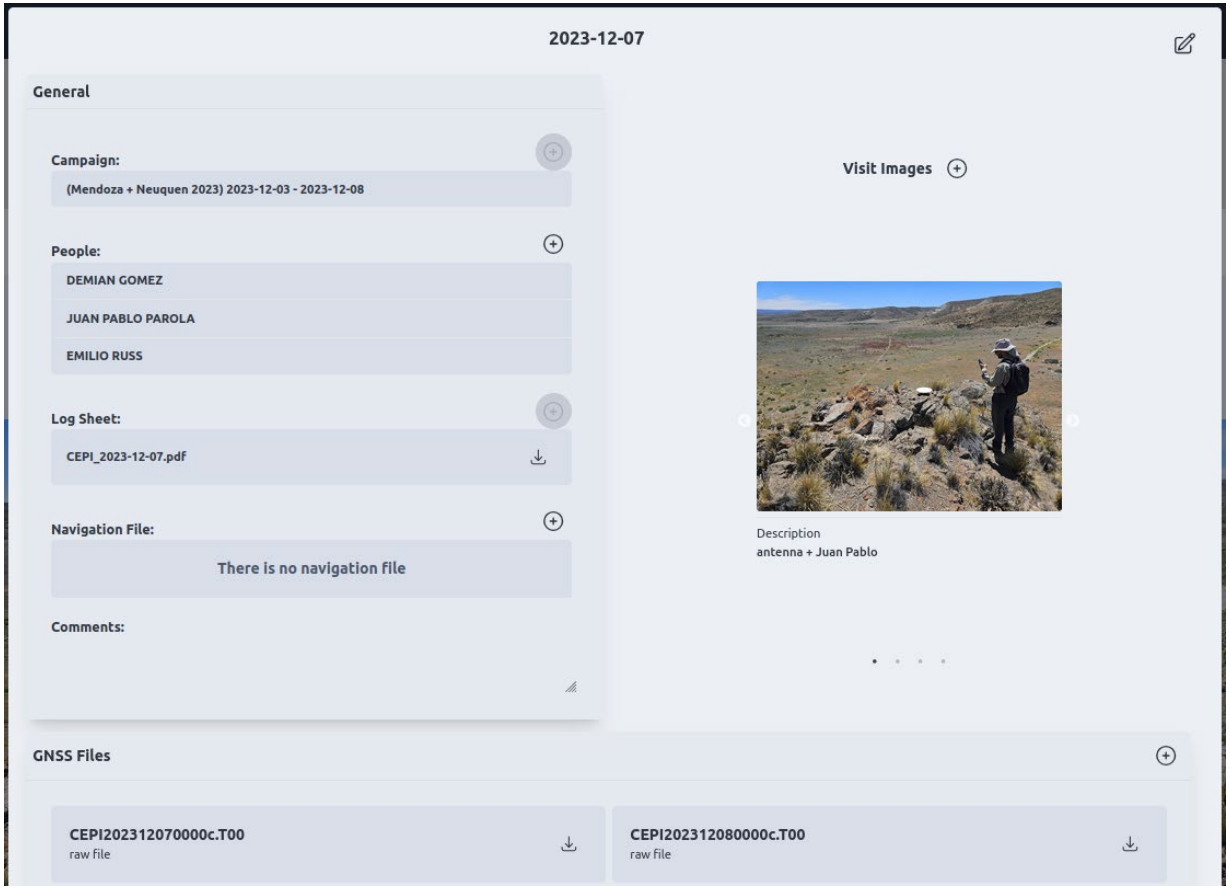
| Modify | RECEIVER CODE | RECEIVER SERIAL | RECEIVER FIRMWARE | ANTENNA CODE | ANTENNA SERIAL | ANTENNA HEIGHT | ANTENNA NORTH | ANTENNA EAST | HEIGHT CODE | RADOME CODE | D |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | TRIMBLE 4000SSE | 4036 | 5.66 | TRM22020.00+GP | 53877 | 0.046 | 0 | 0 | DHARP | NONE | 0 |
| | TRIMBLE 4000SSE | 2045 | 5.68 | TRM14532.00 | 66300 | 0.046 | 0 | 0 | DHARP | NONE | 1 |
| | TRIMBLE 4000SSE | 22015 | 1.12 | TRM33429.00+GP | 55079 | 0.046 | 0 | 0 | DHARP | NONE | 1 |
| | TRIMBLE 4000SSE | 22015 | 1.12 | TRM33429.00+GP | ----- | 0.046 | 0 | 0 | DHARP | NONE | 1 |
| | TRIMBLE 4000SSE | 22015 | 1.12 | TRM22020.00+GP | ----- | 0.046 | 0 | 0 | DHARP | NONE | 1 |
| | TRIMBLE NETRS | 4912167682 | 1.12 | TRM41249.00 | 60196072 | 0.04 | 0 | 0 | DHARP | NONE | 1 |

« ‹ 1 › »

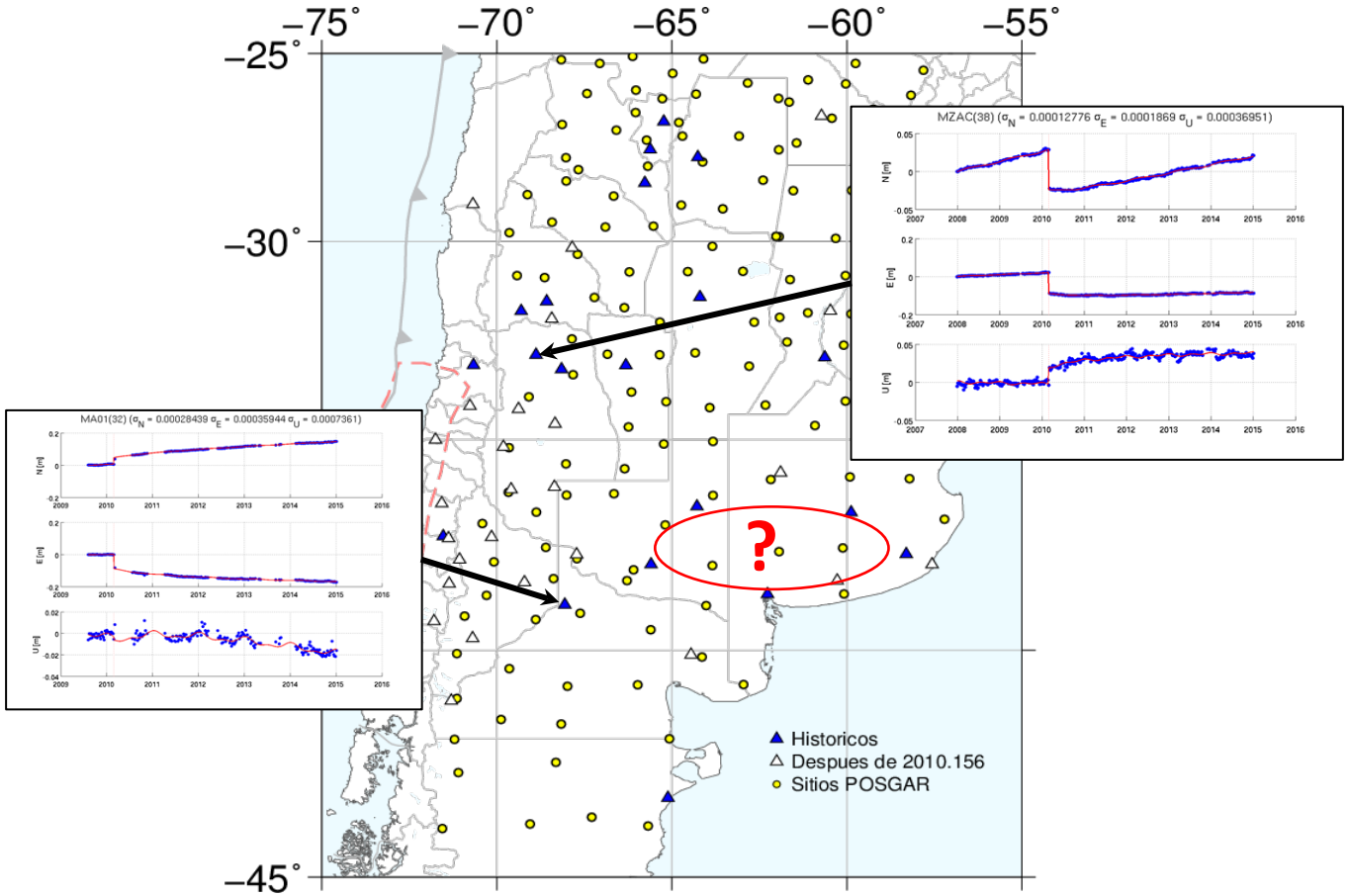
# Visual interactive GGPL interface



# Visual interactive GGPL interface

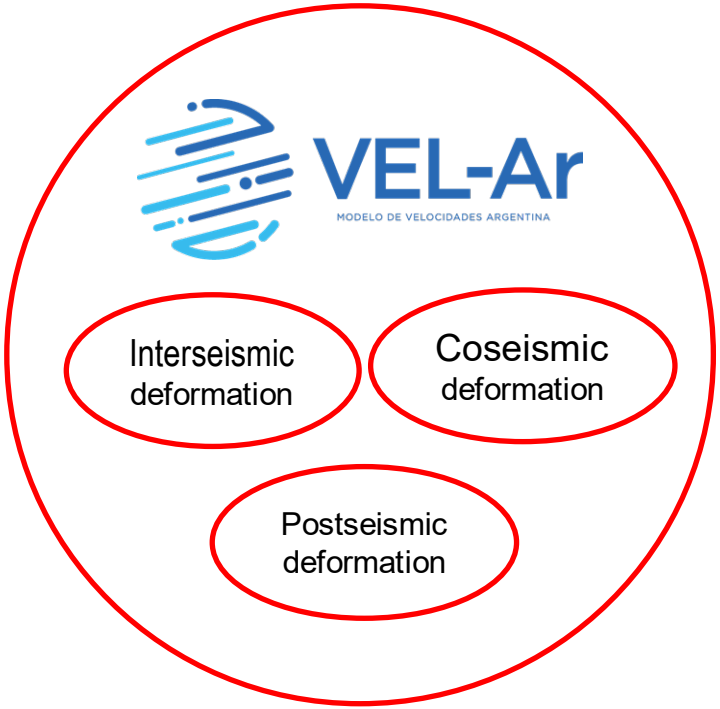


# Intraframe Deformation



# Trajectory Prediction Models

- A **TPM, continuous in space and time,** that allows us to predict the behavior of passive benchmarks.
- This model ensures the access to a geodetic reference frame after big earthquakes utilizing postseismic coordinates.



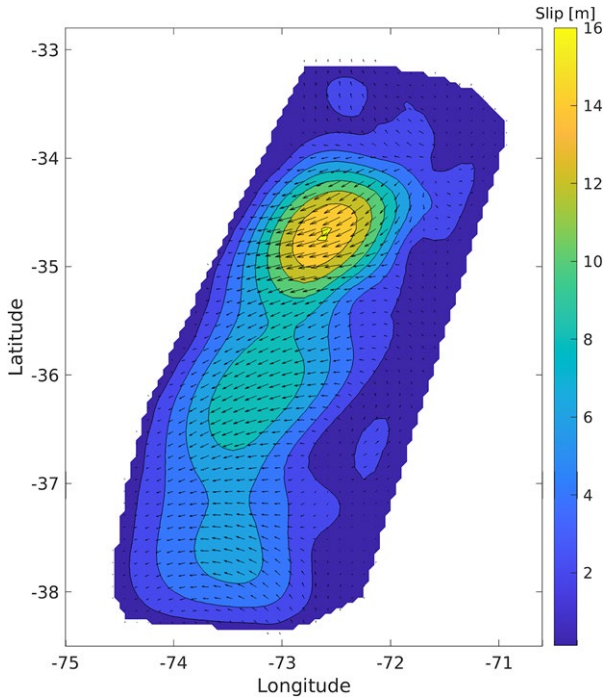
# Coseismic Component

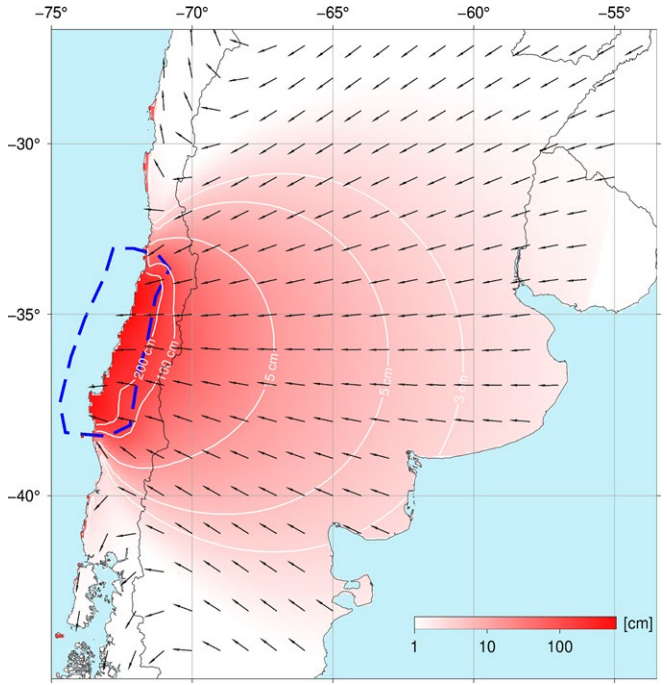
- When the **observing GNSS network is sparse**, the coseismic effect **cannot be interpolated** due to the **roughness** of the deformation field

- We use a geophysical model in a **hybrid (dynamic-kinematic) mode**: we use **elastic deformation** of a spherical earth to constrain the overall coseismic displacement field **without imposing the usual geodynamic constraints** on a fault slip distribution.

# Coseismic Component

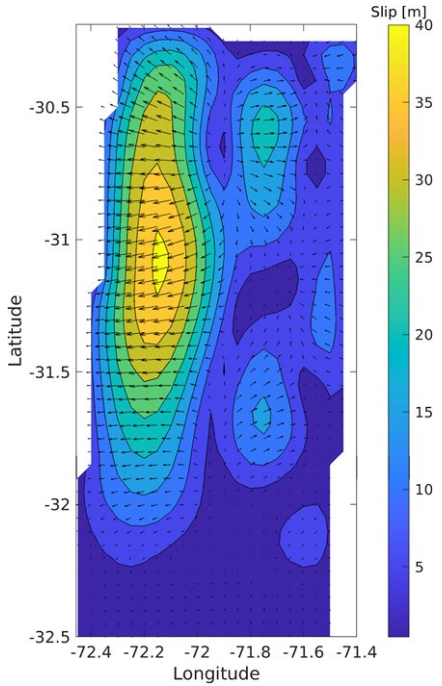
## Slip distribution and coseismic deformation grid - MAULE

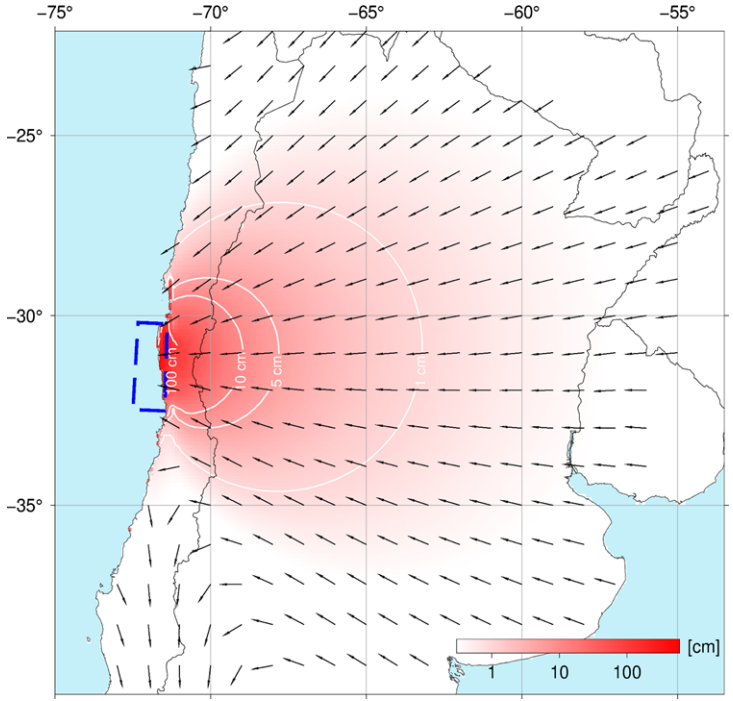


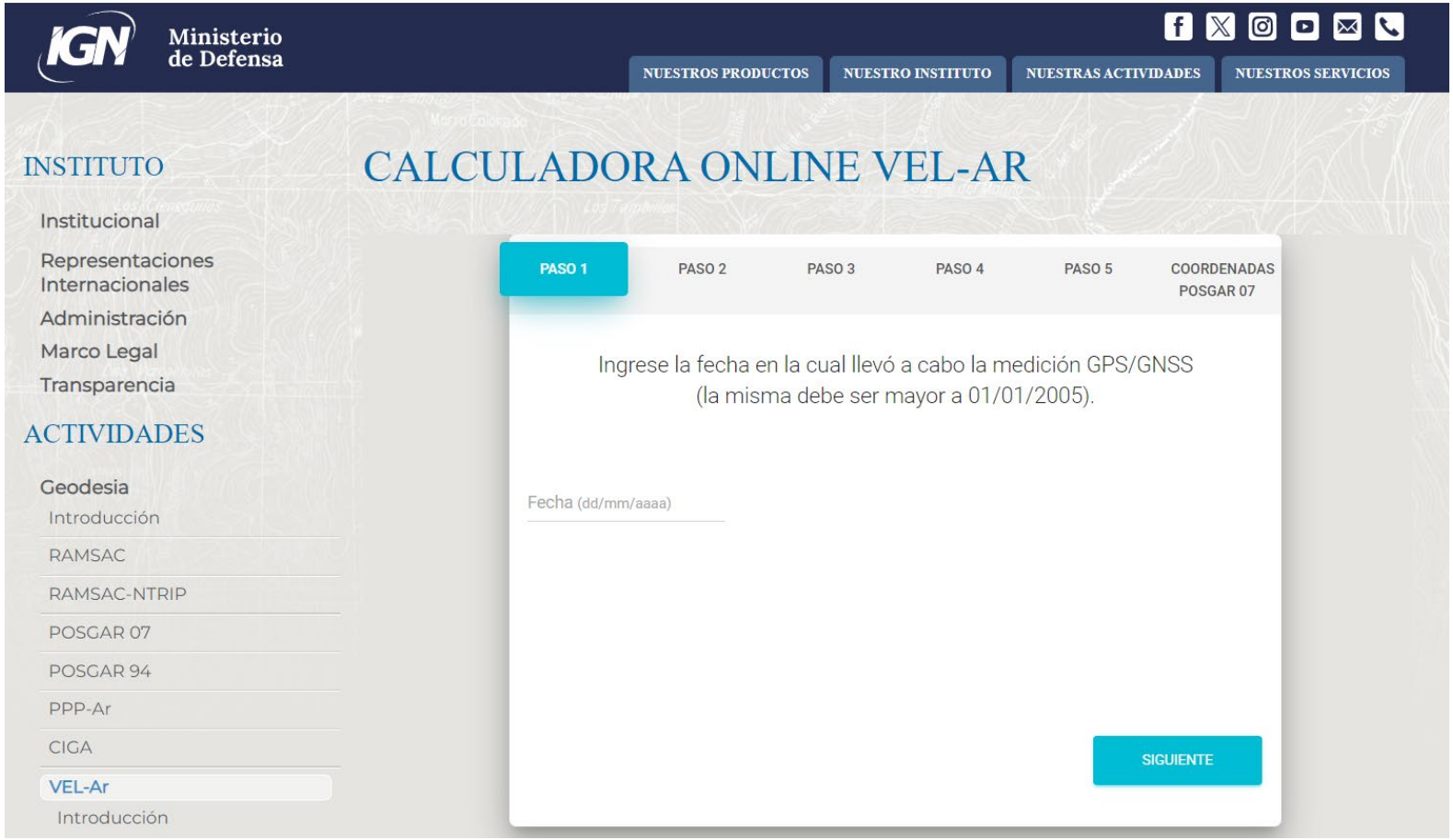
# Coseismic Component

## Slip distribution and coseismic deformation grid - ILLAPEL



# Implementation of TPMs

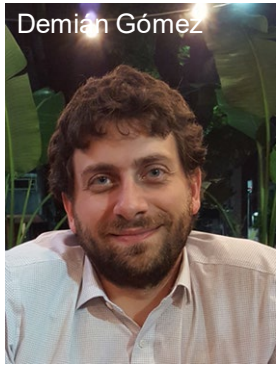


# Use of TPMs


IGN
Ministerio de Defensa
NUESTROS PRODUCTOS
NUESTRO INSTITUTO
NUESTRAS ACTIVIDADES
NUESTROS SERVICIOS
INSTITUTO
Institucional
Representaciones Internacionales
Administración
Marco Legal
Transparencia
ACTIVIDADES
Geodesia
Introducción
RAMSAC
RAMSAC-NTRIP
POSGAR 07
POSGAR 94
PPP-Ar
Introducción
Acceso al servicio
Consultas frecuentes
INTRODUCCIÓN
PPP-Ar
SERVICIO DE POSICIONAMIENTO PUNTUAL PRECISO DE LA REPÚBLICA ARGENTINA
PPP-Ar es un servicio en línea gratuito que le permite a los usuarios de la tecnología GNSS obtener coordenadas precisas vinculadas al marco de referencia geodésico POSGAR07, a partir del envío de datos en formato RINEX de receptores doble frecuencia que operan en modo estático.
El servicio PPP-Ar utiliza el programa CSRS-PPP desarrollado por la División de Geodesia del Instituto Canadiense de Recursos Naturales (NRCan) para obtener coordenadas referidas al marco de referencia geodésico de las órbitas de los satélites (actualmente IGb14) y en la época de medición. CSRS-PPP utiliza órbitas precisas de los satélites y correcciones a los relojes que genera IGS (Servicio Internacional GNSS), entre otros productos y modelos.
Luego, PPP-Ar introduce el modelo de trayectorias VEL-Ar para trasladar las coordenadas determinadas por el programa CSRS-PPP en la época de medición a la época convencional (2006.632) del marco de referencia oficial POSGAR07. Por último, se aplican parámetros de transformación para determinar las coordenadas oficiales POSGAR07 (época 2006.632).
Ante cualquier inquietud o consulta técnica envíe un correo electrónico a ppp@ign.gob.ar

# Team members

## Principal- and co-investigators






## Research Scientists


## Graduate Students

Mara Figueroa

Franco Sobrero

Kevin Wang

Bennett Kellmayer (starting in Fall 2024)

THE OHIO STATE UNIVERSITY

**gomez.124@osu.edu**

Questions?

¿Preguntas?

Thank you for your attention!

¡Muchas gracias por la atención!