SATREPS PROJECT 2021 -2026

Development of an Integrated Expert System for Estimation and Observation of Damage Level of Infrastructure in Lima Metropolitan Area

PERU – JAPAN JCC

August 8-10 2022

Activity of G1A group:

Improve Earthquake Analysis and Seismic Hazard Assessment System

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APCI
Agencia Peruana de Cooperación Internacional

JICA

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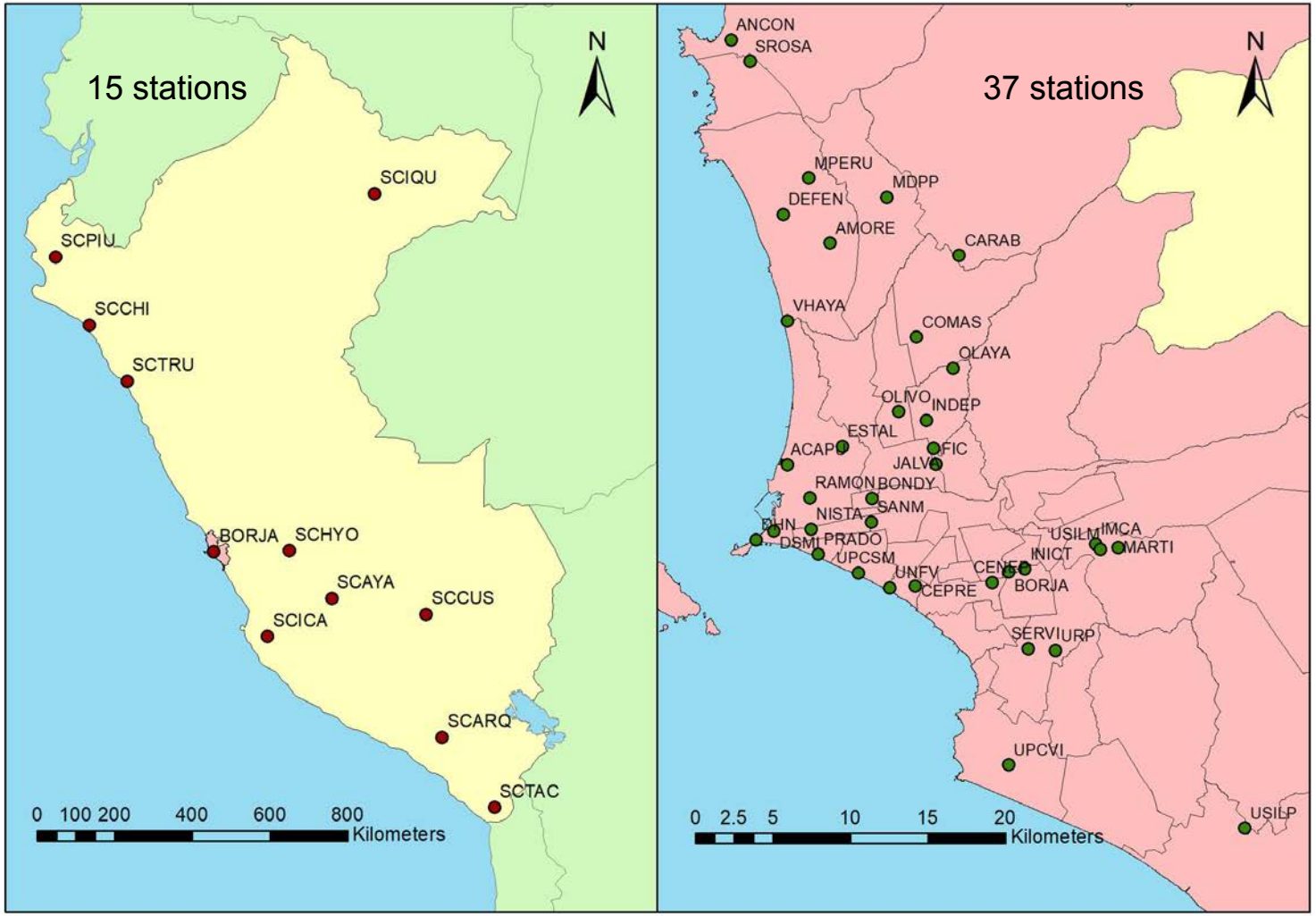
JST

CISMID´s Seismic Network

Kinemetrics Basalt (5)

Kinemetrics Obsidian (6)

Gaiacode Sigma-TS4G-ACC (4)



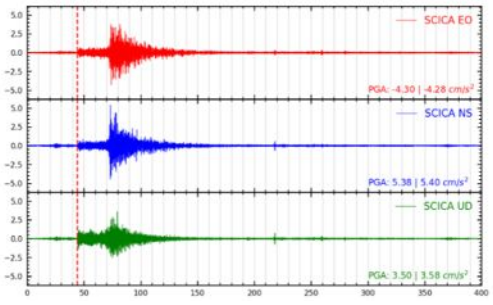
REF TEK 130 SMA

CISMID´s Seismic Network

CM
CISMID Network - REDACIS
37

PG
CITDI/Graduate School Network
38

SC
SENCICO Network
15



CISMID Firewall

Virtual Machines

2543

RTPD

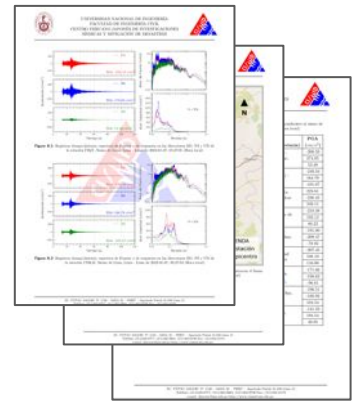
REFTEK
arc_pas

SEISCOMP4
archive

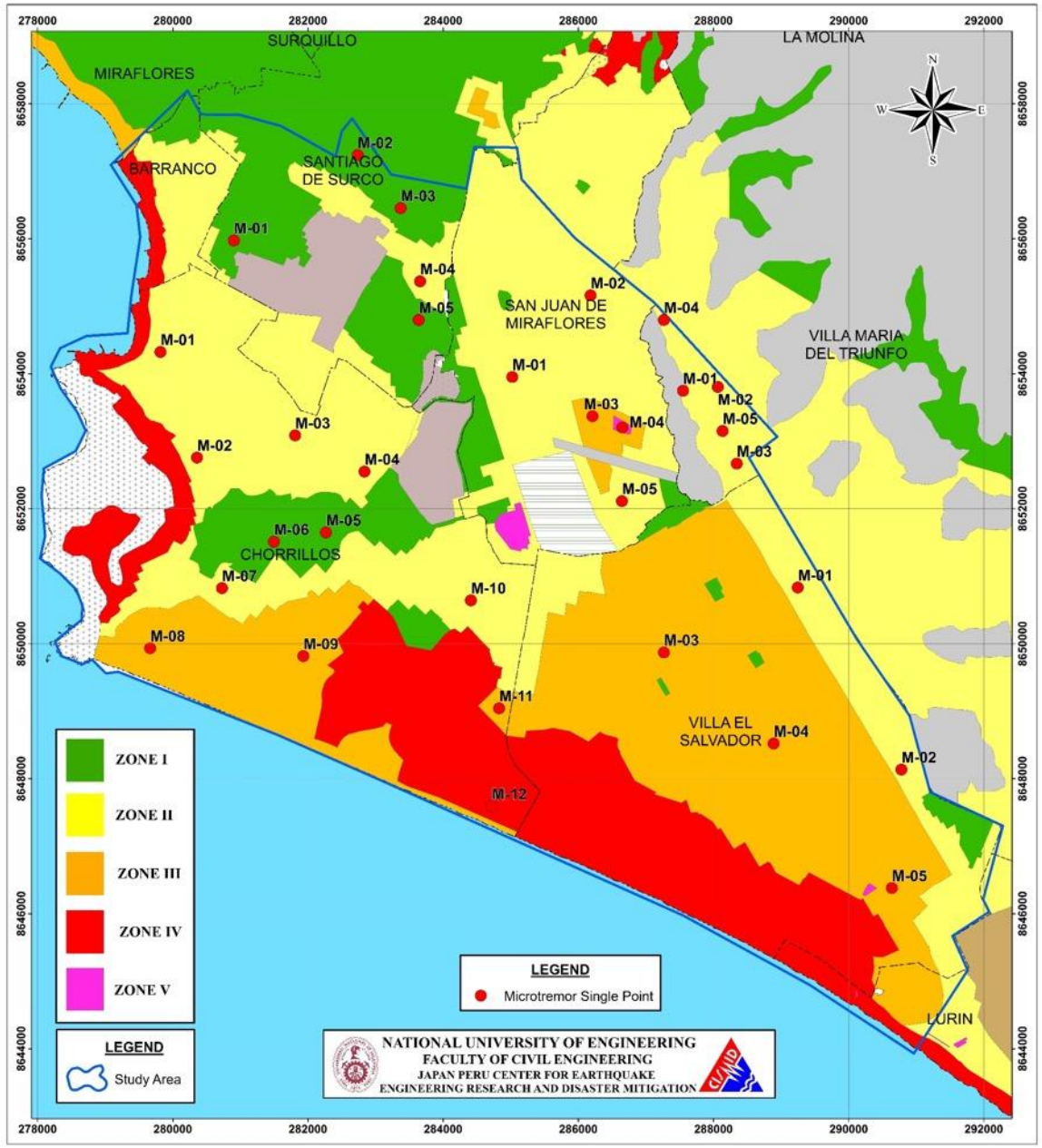
Uploading seismic records and report

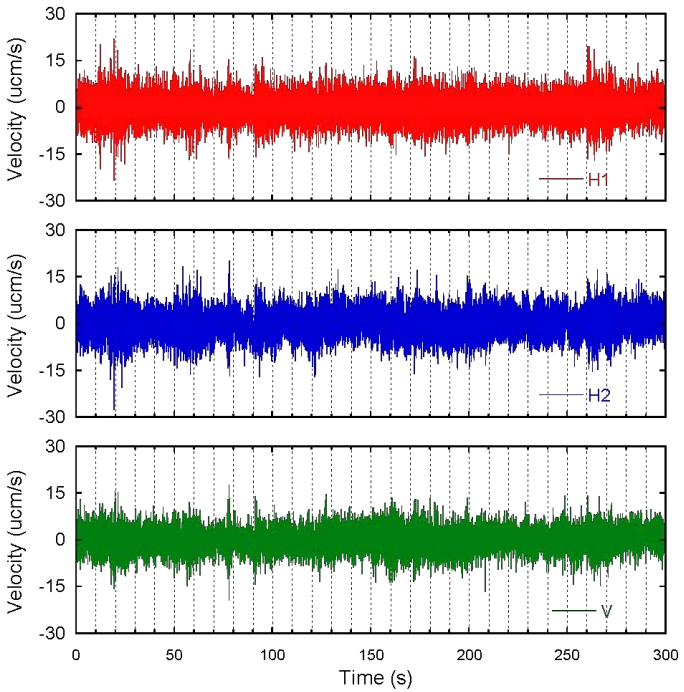
Seedlink protocol

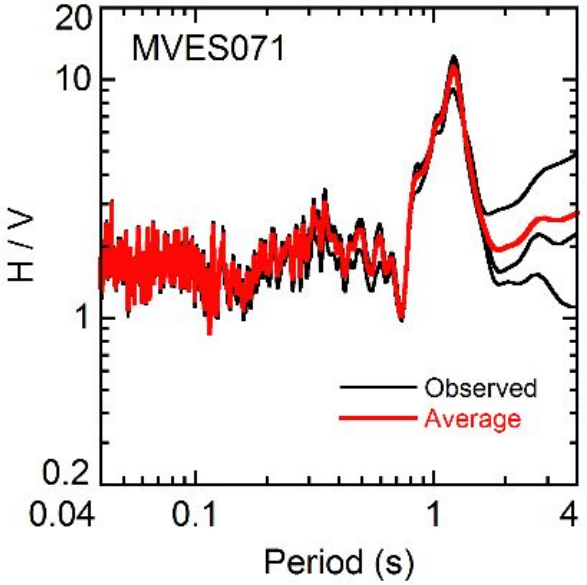
The integration of the new JEP-6A3 sensors will be conducted via Seedlink



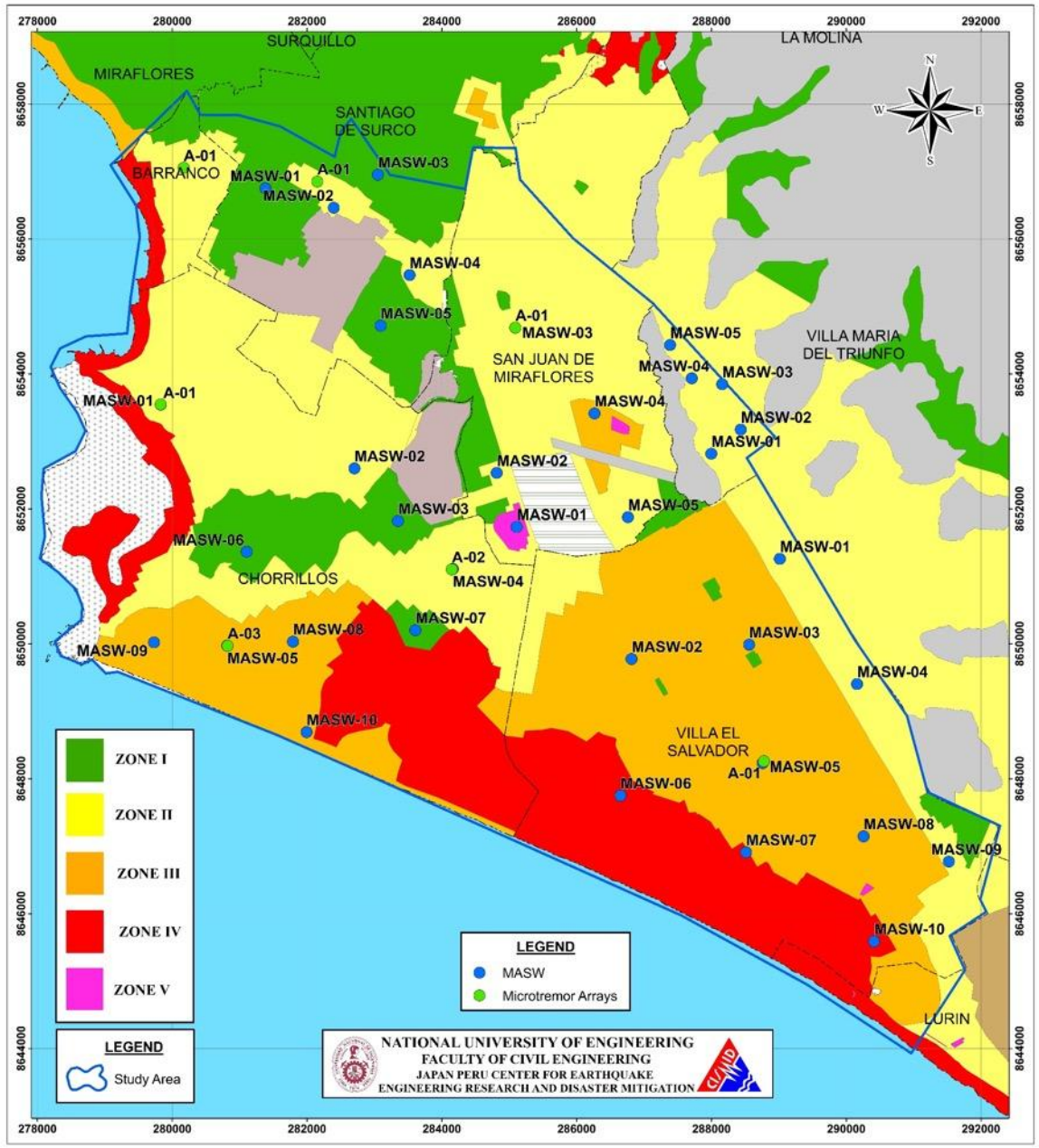
Geophysical Tests – Single Point Microtremor Measurements

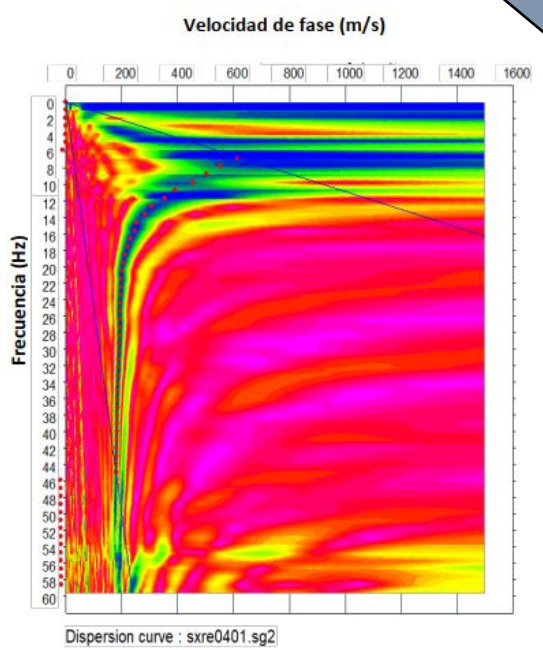


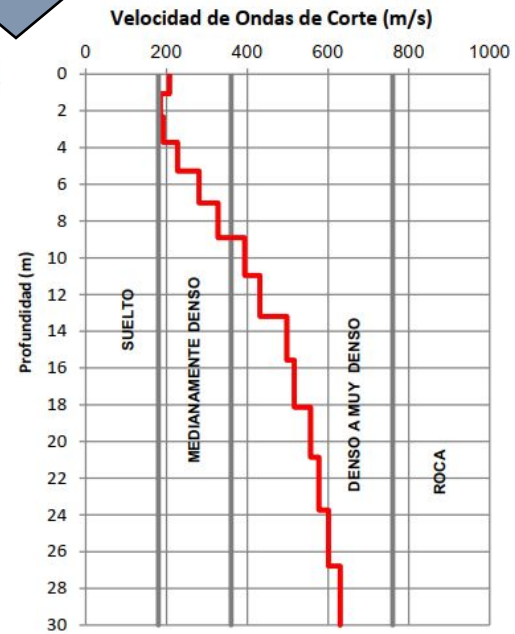




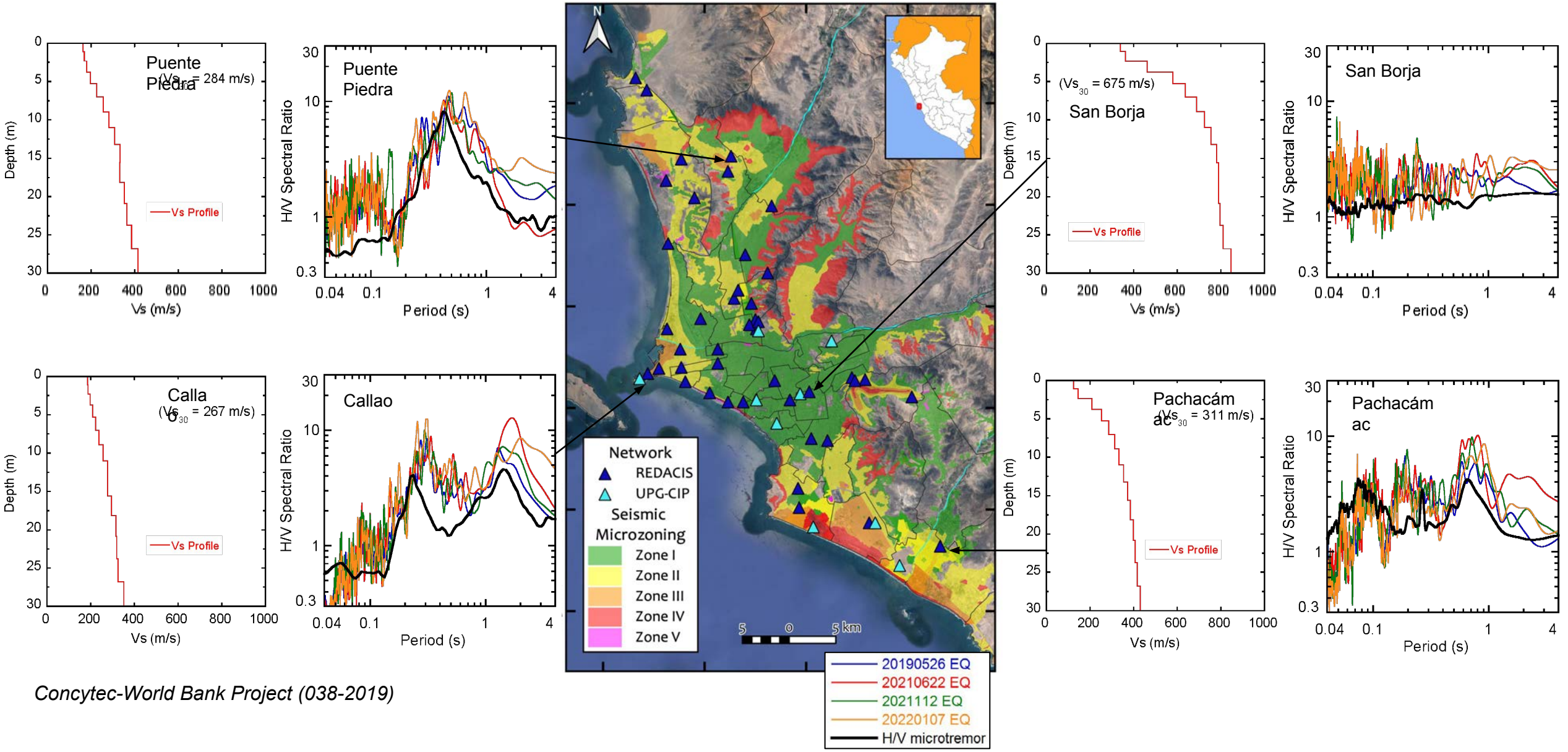
Geophysical Tests – MASW and Microtremor Arrays







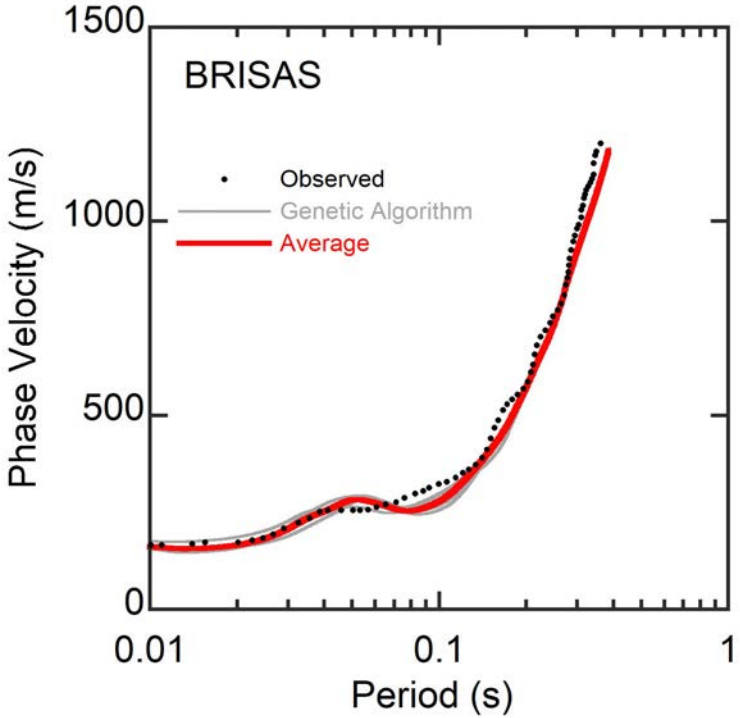
Site Characterization of Seismic Stations

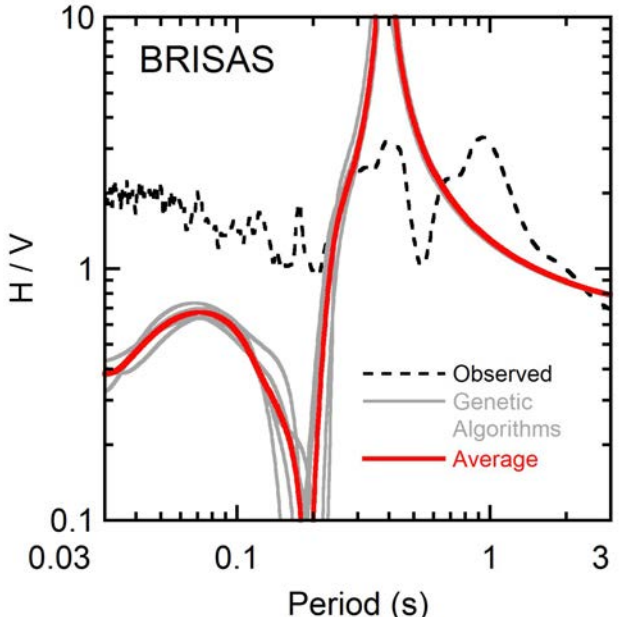


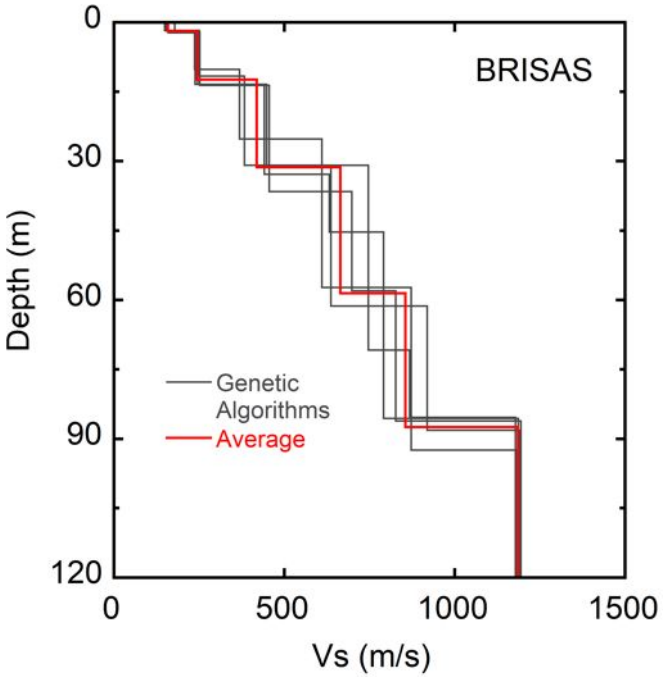
Concytec-World Bank Project (038-2019)

Microtremor Array in Chorrillos

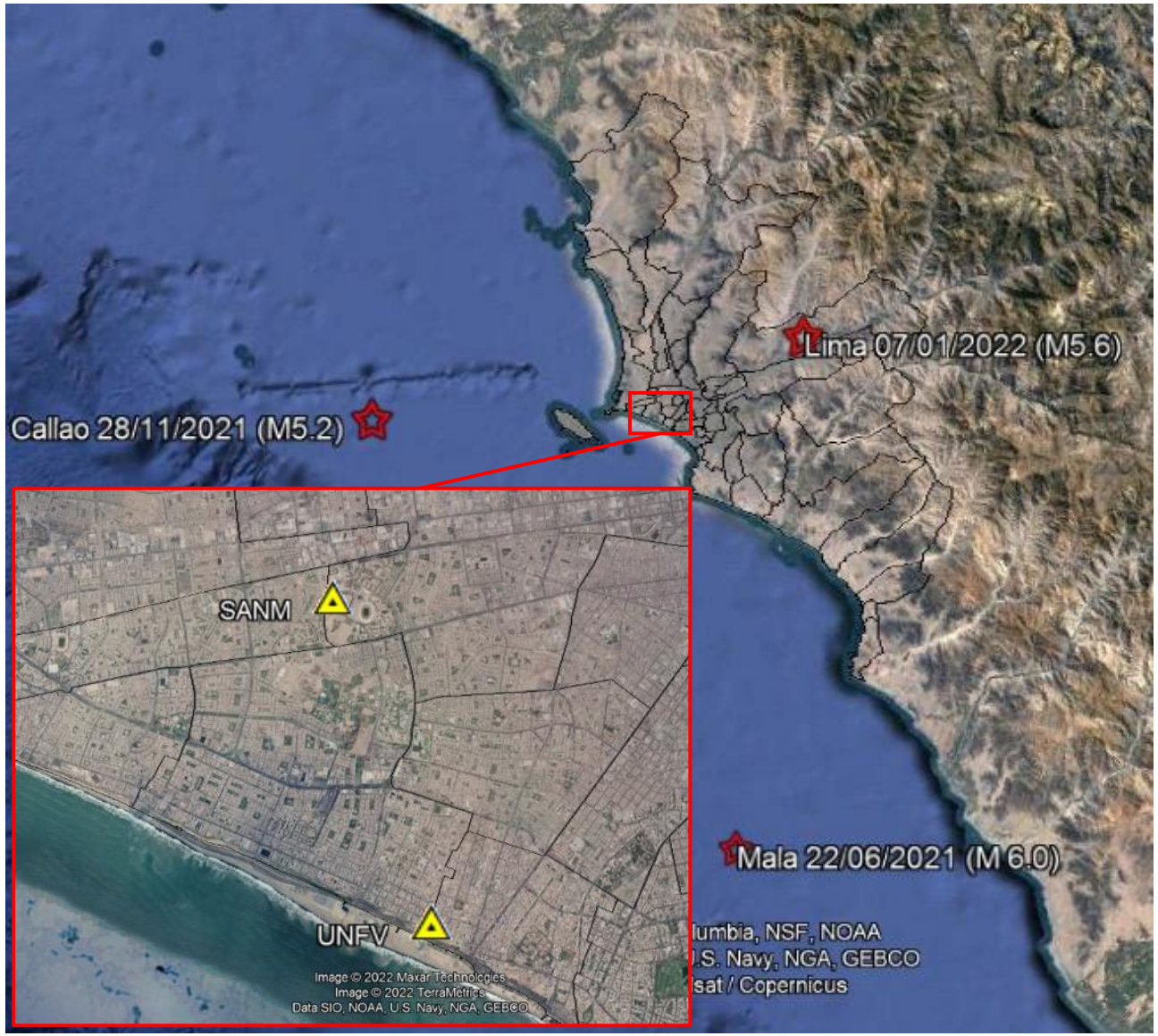
So far, linear and small-to-intermediate circular arrays were conducted close to the BRISAS station in Chorrillos. As observed, the H/V spectrum for ambient vibrations contains two peaks. The inverted Vs profile was only able to reflect the behavior for the short period range. Thus, complementary measurements for larger arrays are planned.

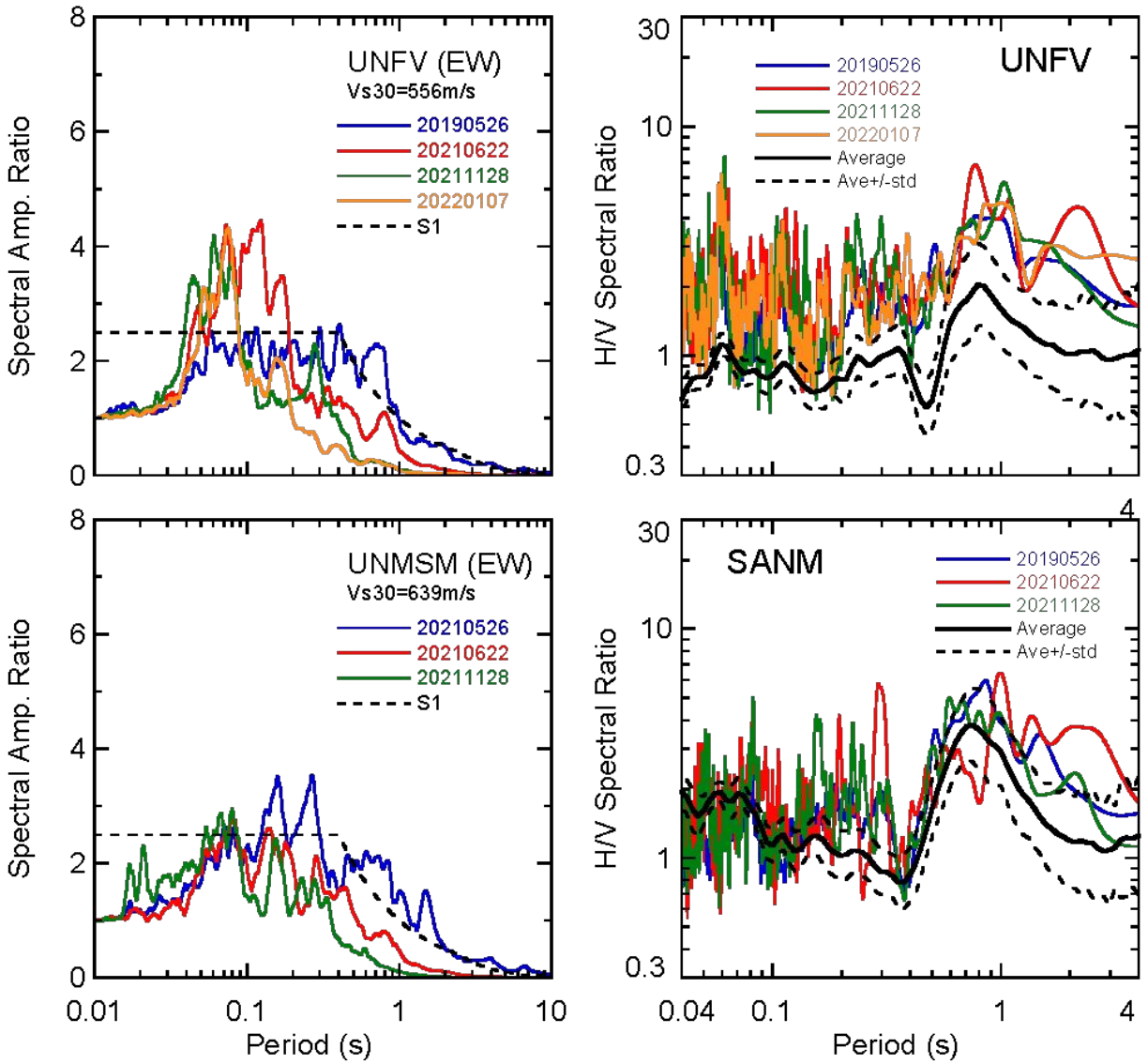




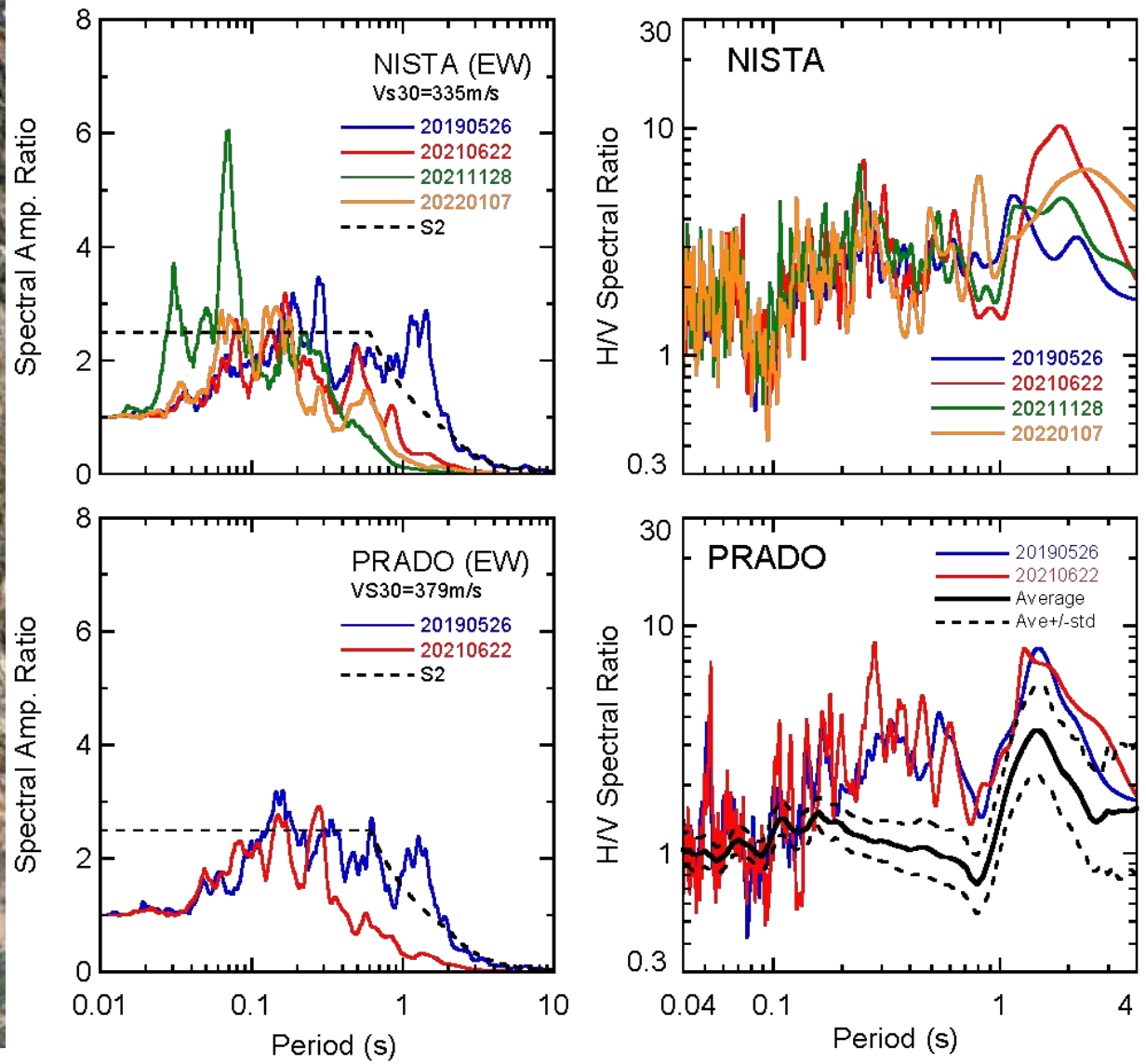


Seismic Records of Recent Earthquakes (S1 soil type)



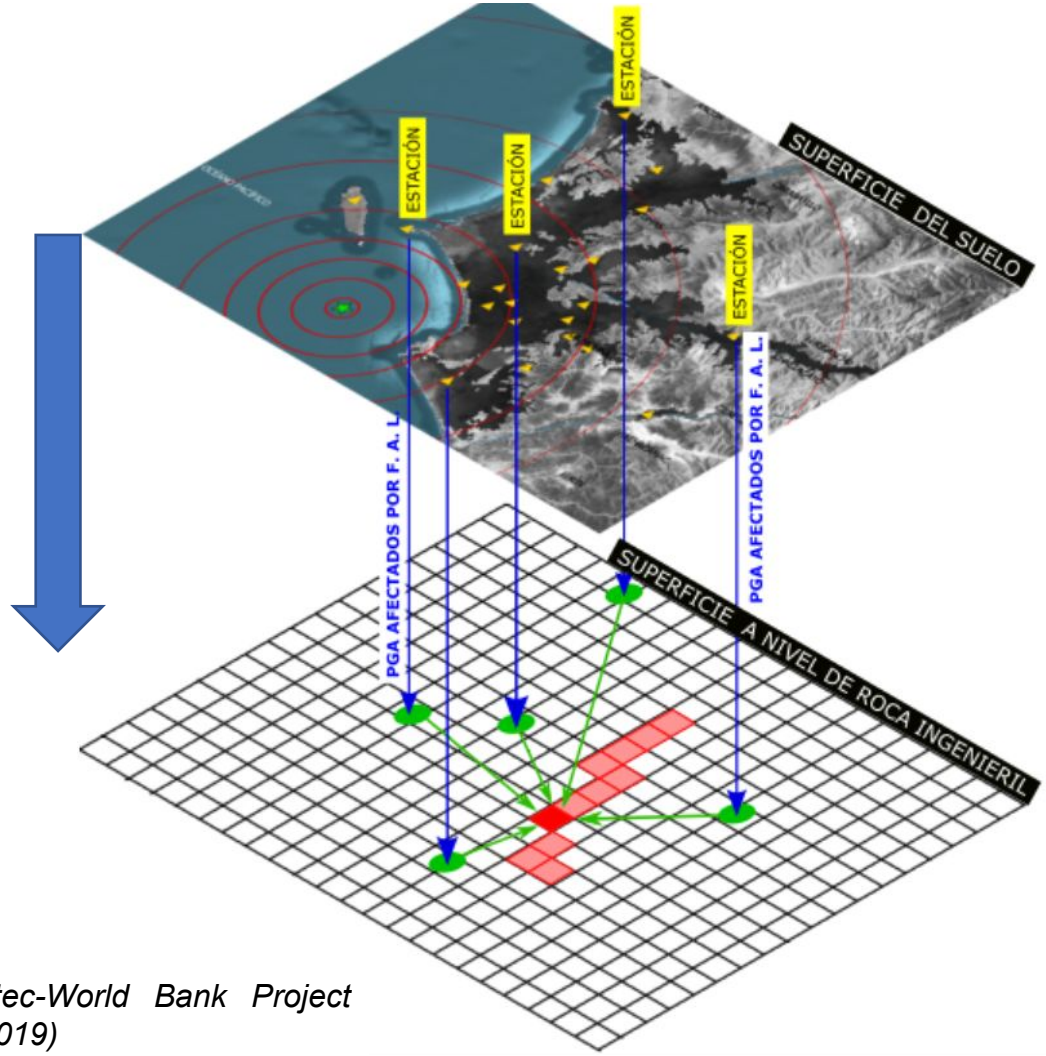


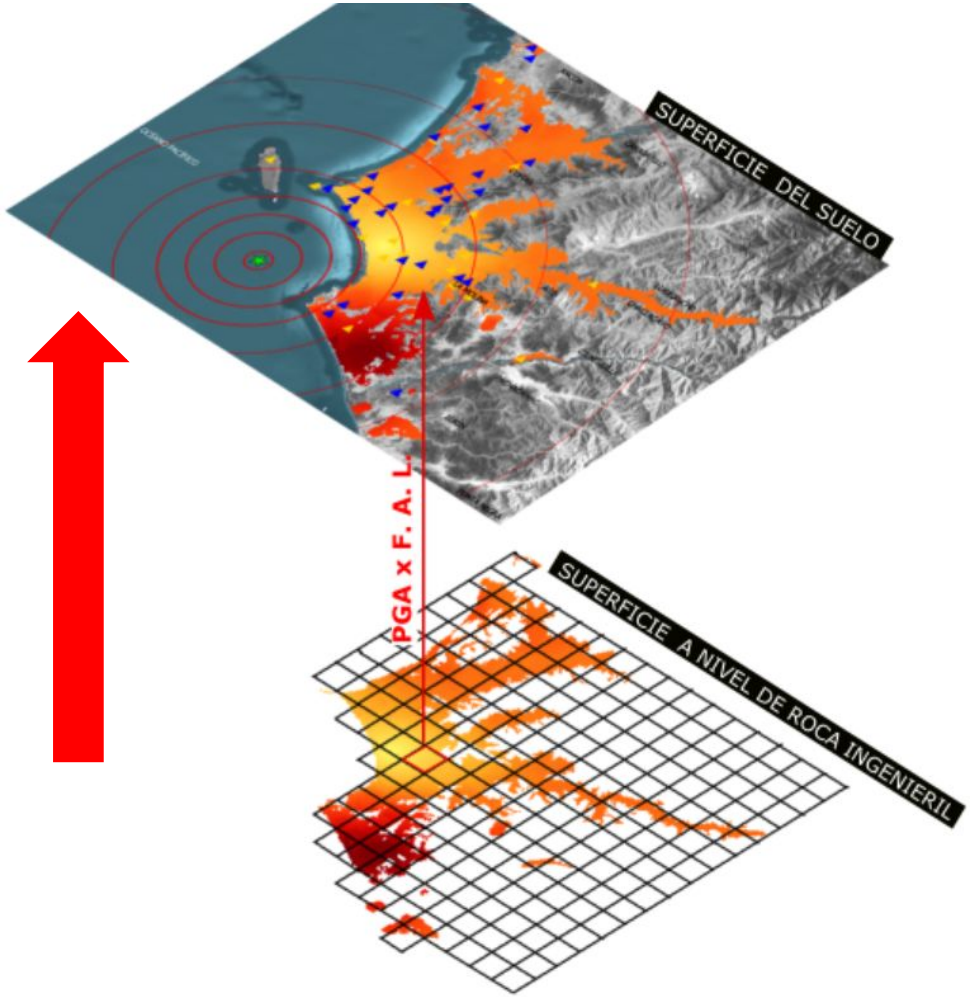
Seismic Records of Recent Earthquakes (S2 soil type)



Estimation of PGA Distribution in Metropolitan Lima

The seismic information obtained at each station is reduced down to a engineering bedrock level by means of amplification factors (Sekiguchi et al., 2013).

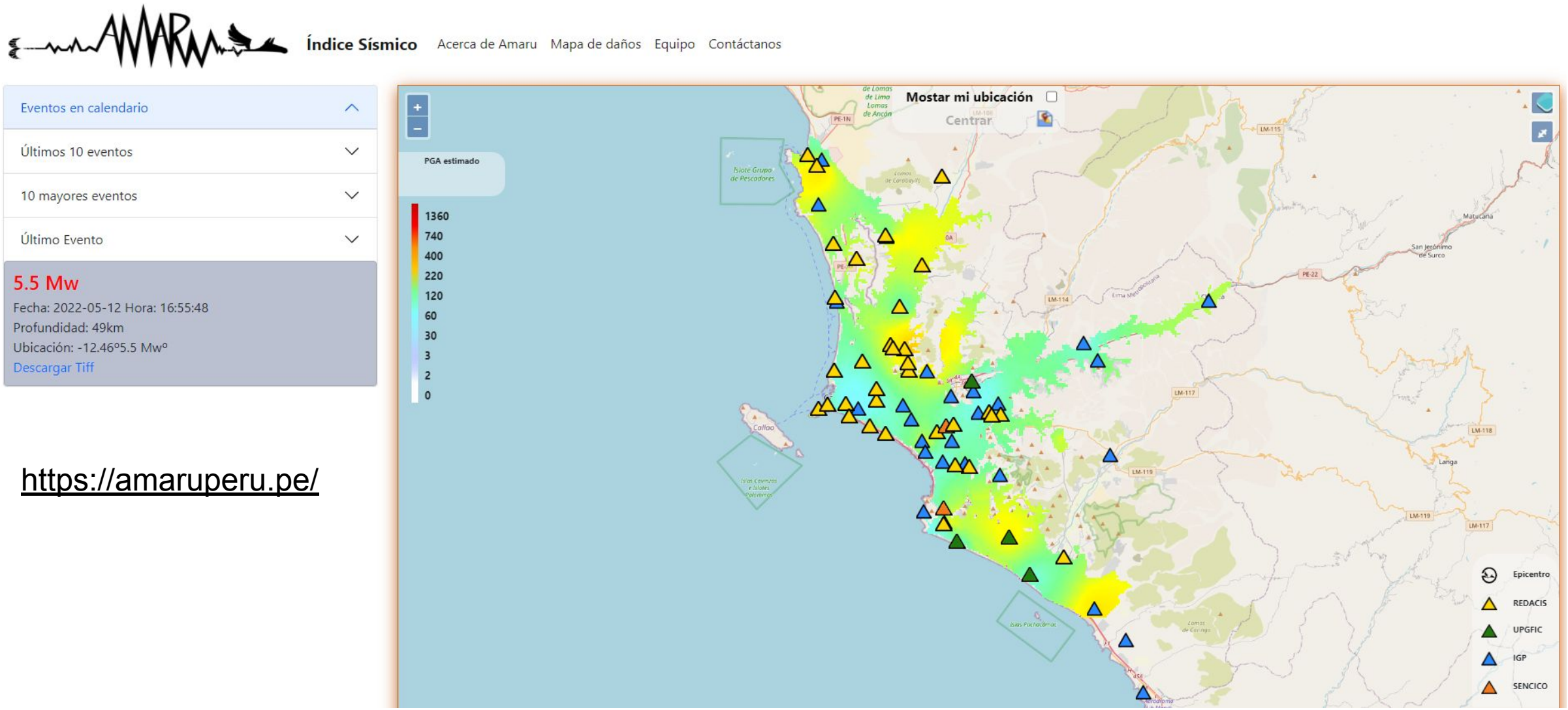




Interpolation, by means of ordinary Kriging, is conducted at this level in a grid throughout Metropolitan Lima. Finally, PGA values are amplified up to the surface.

Concytec-World Bank Project (038-2019)

Estimation of PGA Distribution in Metropolitan Lima

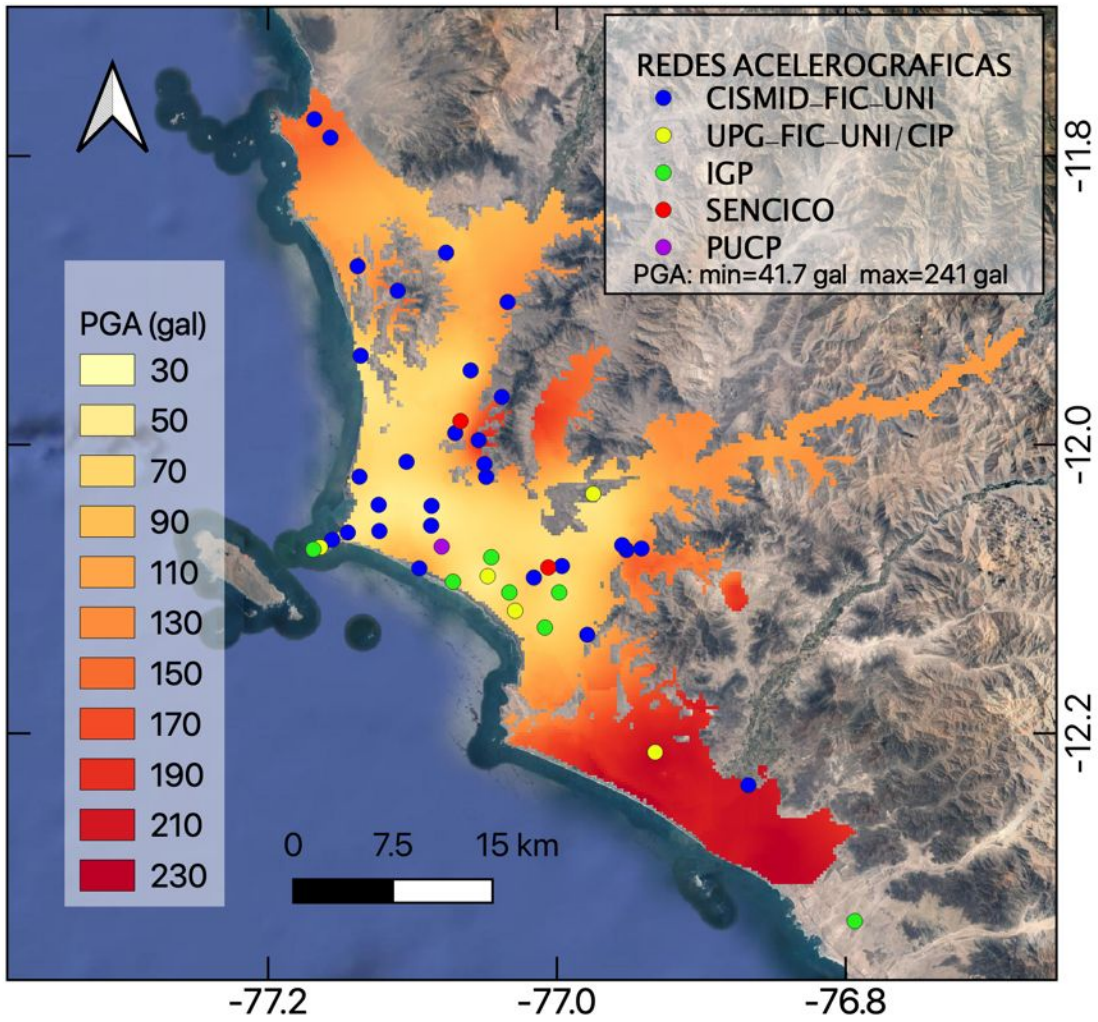


https://amaruperu.pe/

Concytec-World Bank Project (038-2019)

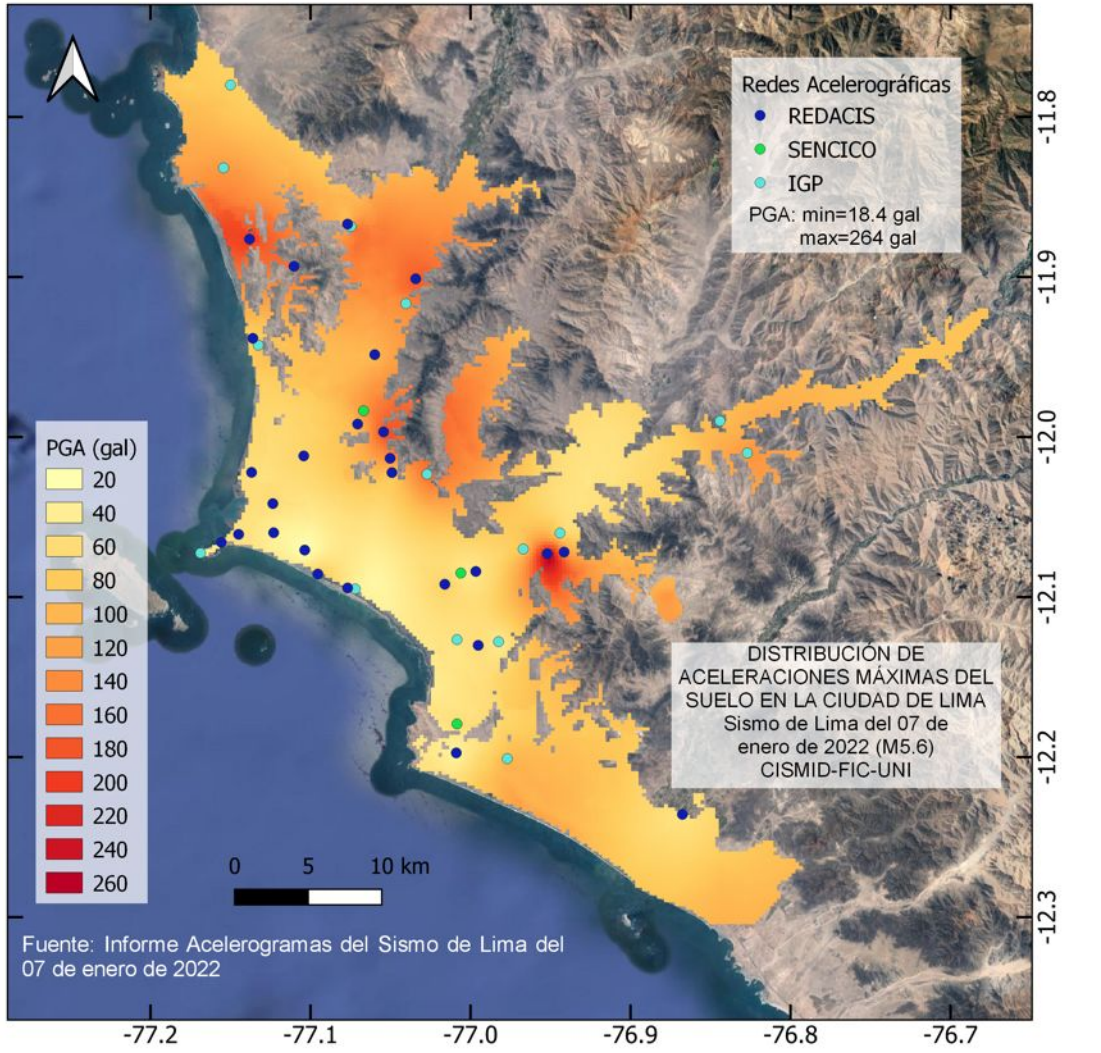
Results for PGA Distribution

Mala Earthquake (M6.0) – 22/06/2021



Concytec-World Bank Project (038-2019)

Lima Earthquake (M5.6) – 07/01/2022



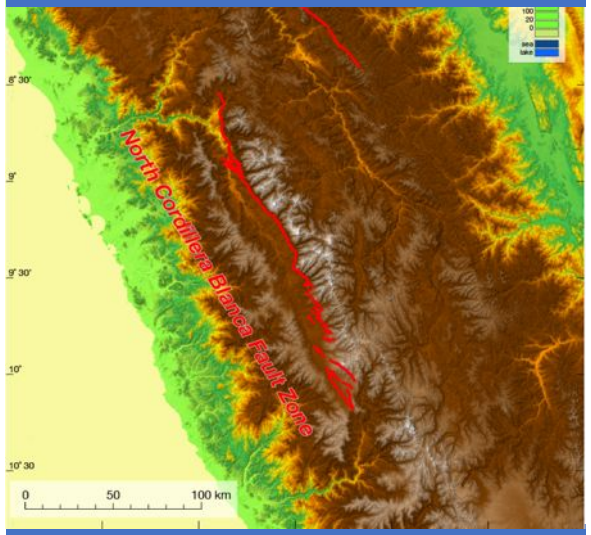
SUMMARY

- CISMID´s seismic networks comprises a variety of sensors. In order to integrate the recently purchased equipment, the Seiscomp protocol (waveforms in mseed format) is intended to be fully implemented.
- Geophysical tests, MASW and microtremor surveys, are planned to be carried out within this year in the area of study. This tests will complement those from microzonation studies.
- The analysis of seismic records for recent earthquakes suggest the existence of long period response for stiff and intermediate soil deposits.
- Distributions of PGA values for recent events were estimated taking into consideration amplification factors (AF) for the shallow soil structure and seismic records at specific points. Future plan includes additional calculations considering the results of geophysical tests at each station and the update of the AF map.

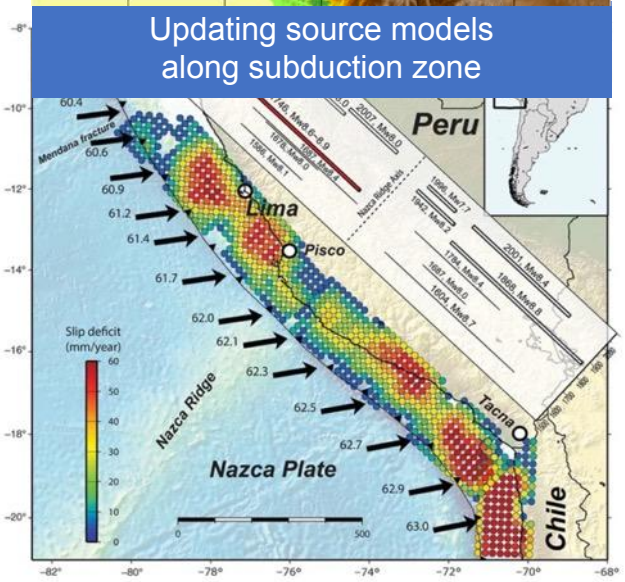
G1A Group

G1A-1: Accelerate EAS system
G1A-2: Improve seismic hazard assessment system

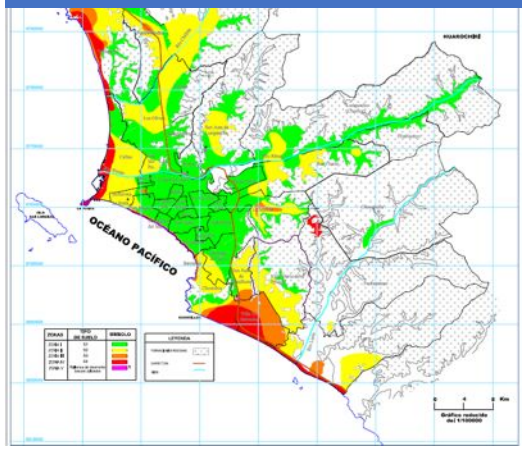
Source models along active fault zone



Updating source models along subduction zone

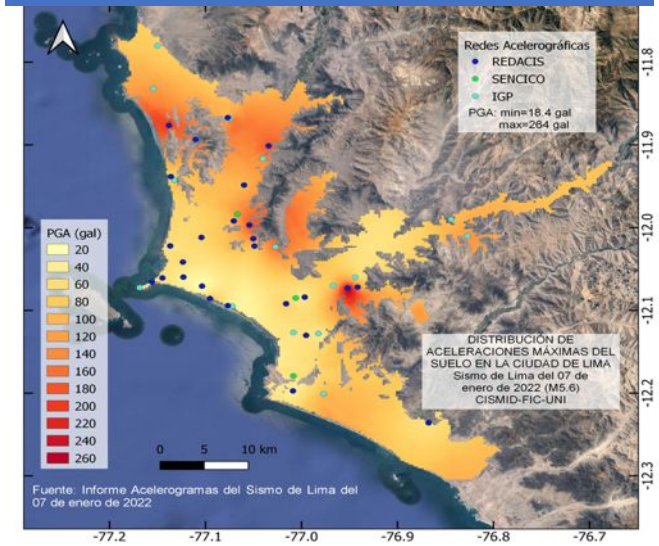


Short-period amplification map in previous SATREPS

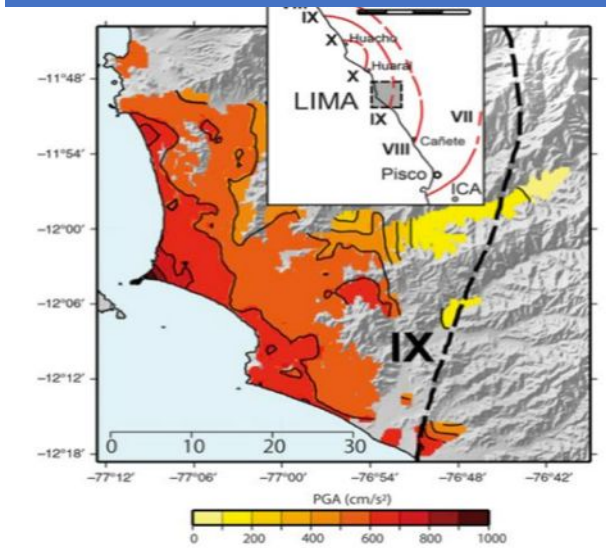


Prediction of long-period ground motion in Lima

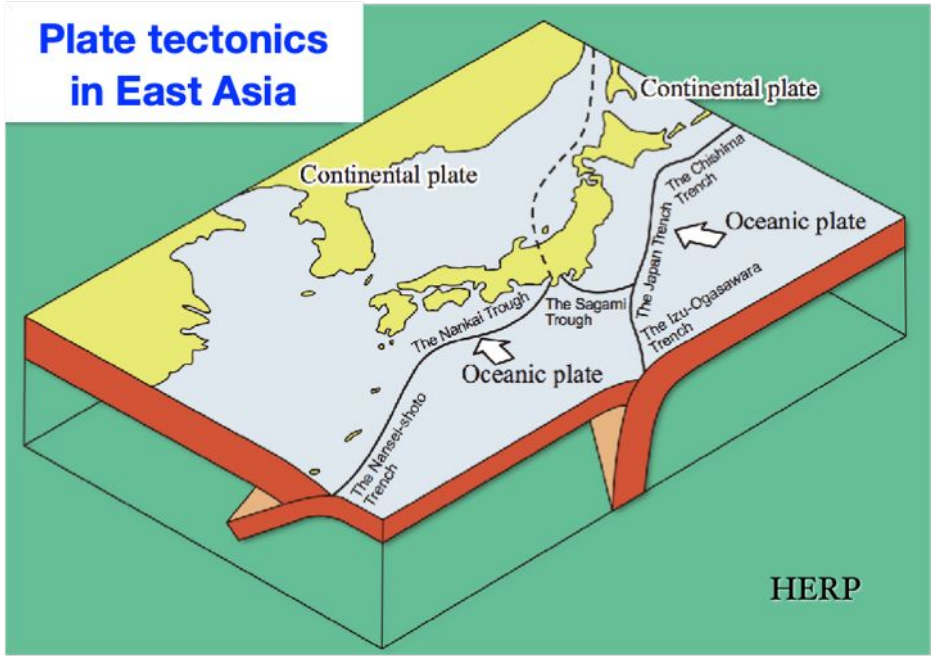
Updating Peak Ground Acceleration map



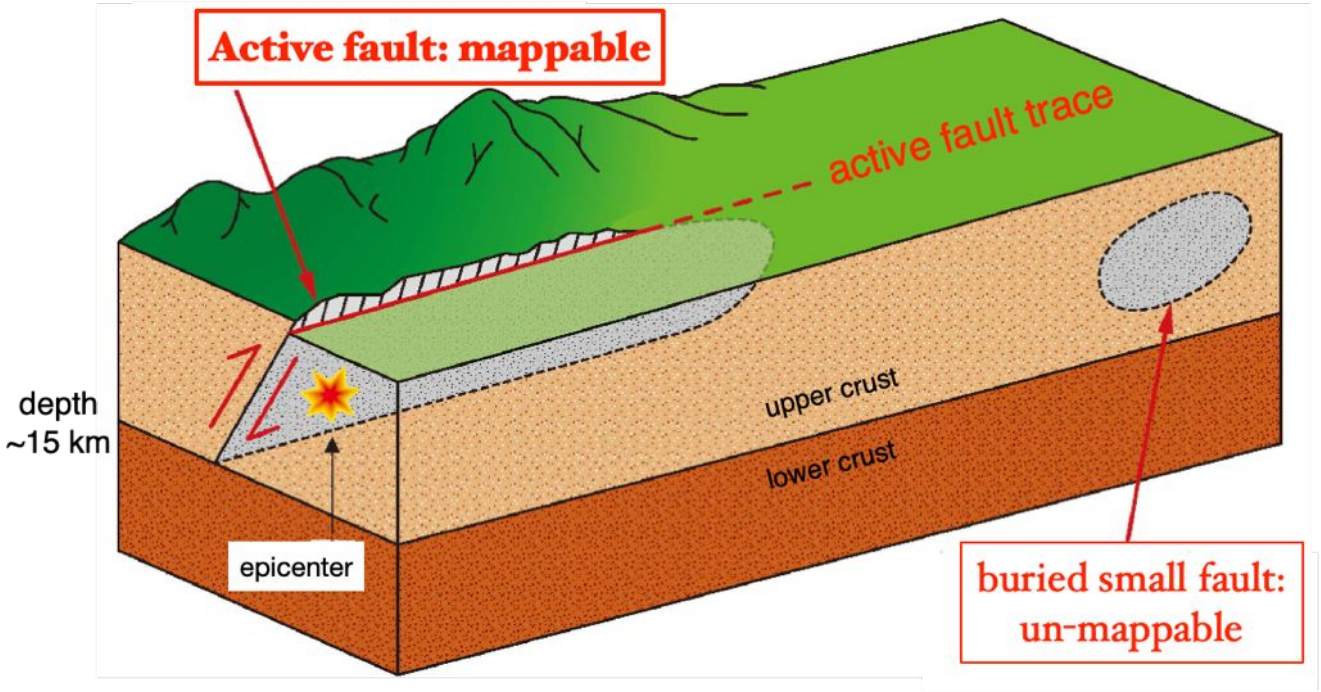
Intensity map for scenario earthquakes



Faulting causes earthquake and tsunami



Earthquakes occur underground,
but large faults reach up to ground surface



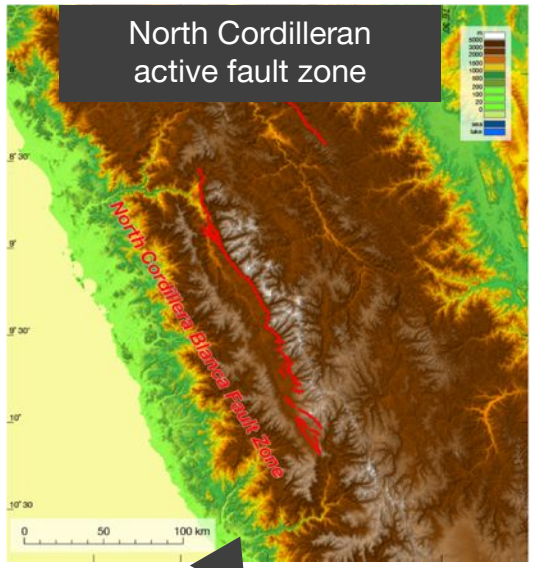
Driving force of faulting:
east-west compression
due to plate tectonics

Eurasian plate v.s. Pacific/PHS

Nazca v.s. South American plate in Peru

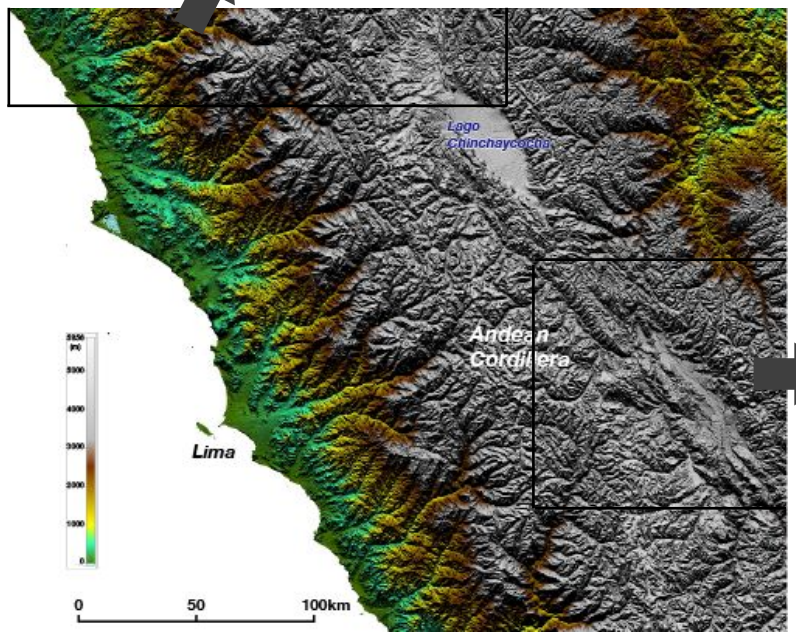
BEFORE occurrence of destructive earthquakes,
we can estimate the location, size and ground motion

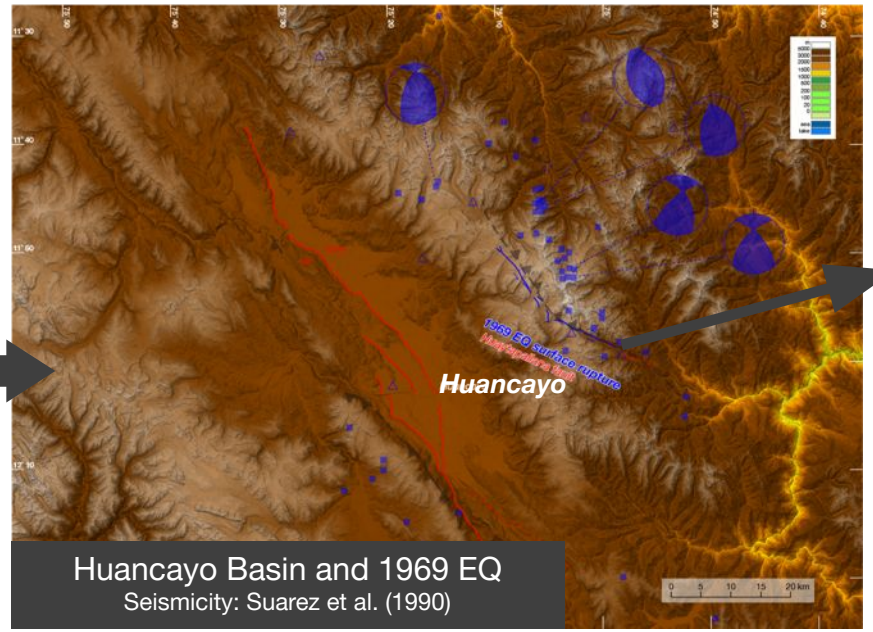
Active fault mapping to locate destructive earthquakes



Preliminary active fault map
free SRTM, ASTER DEMs, and
high-resolution satellite images

Water-supplying basin for Lima

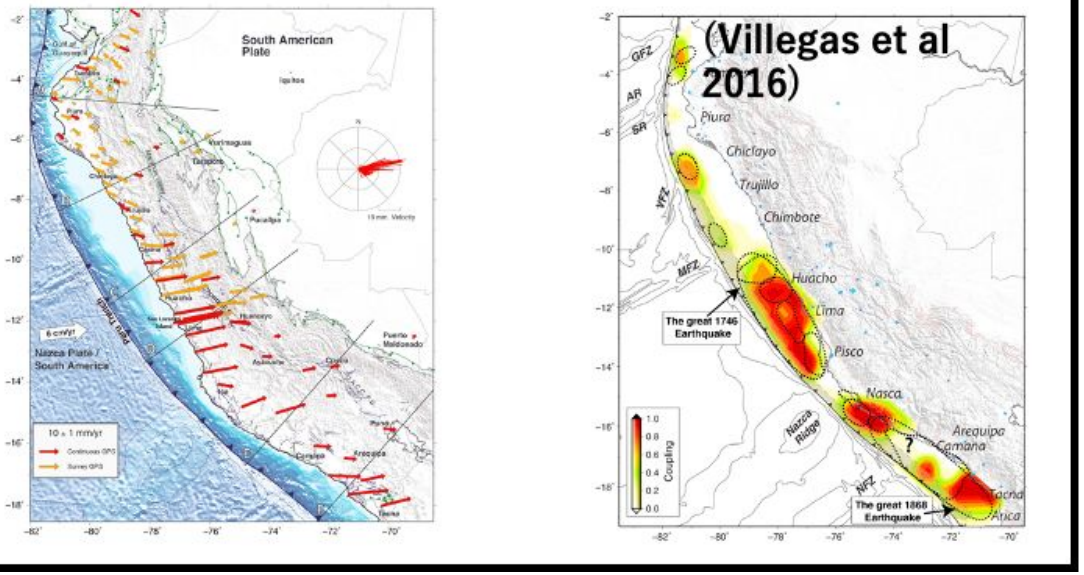




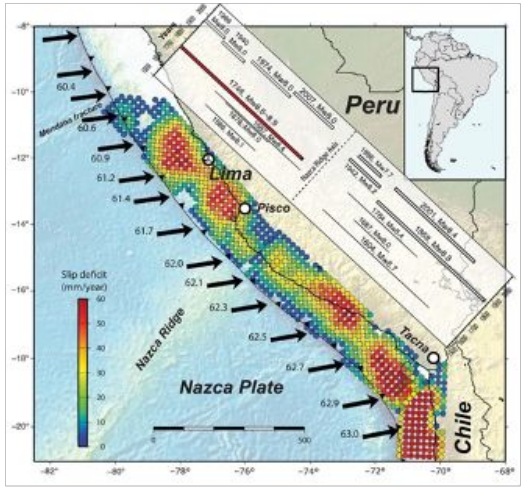
Surface rupture associated with
the 1969 earthquake, east of
Huancayo, ~130 people killed

Inter-seismic coupling and fault rupture scenarios for megathrust subduction earthquakes in Peru

Interseismic seismic coupling model and historical earthquakes of Peru



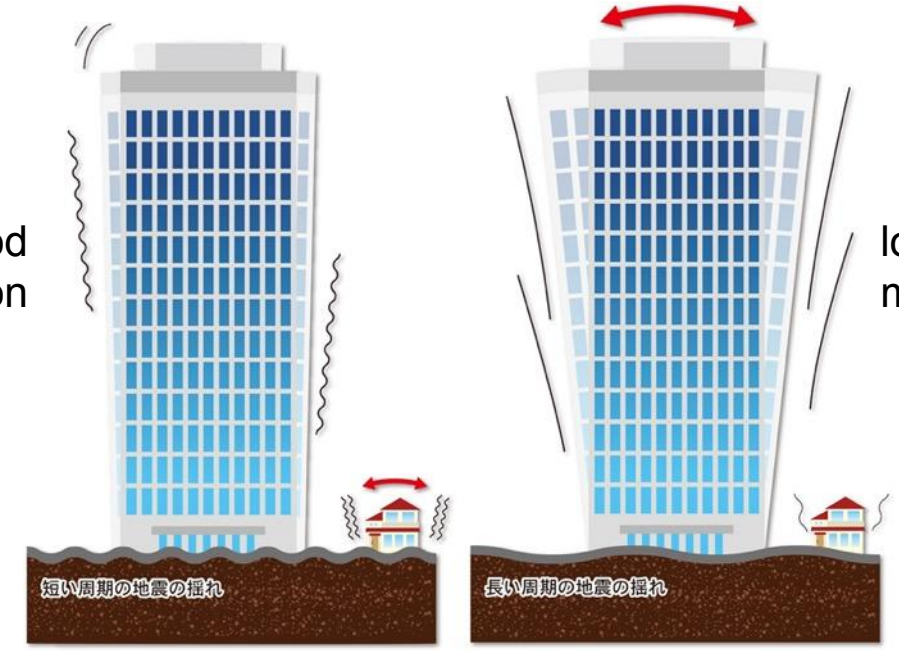
Source models for subduction zones earthquakes in Peru



- **Updated interseismic slip deficit model** at the Nazca plate subduction region in Peru **using GNSS data** of IGP.
- Obtain **physically likely fault rupture scenarios** for megathrust subduction earthquakes in Peru, based on **slip deficit model** and information of **historical megathrust earthquakes** in Peru.

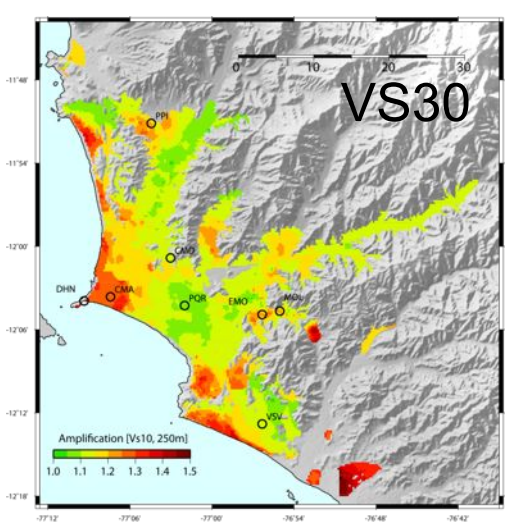
Prediction of long-period motion in Lima

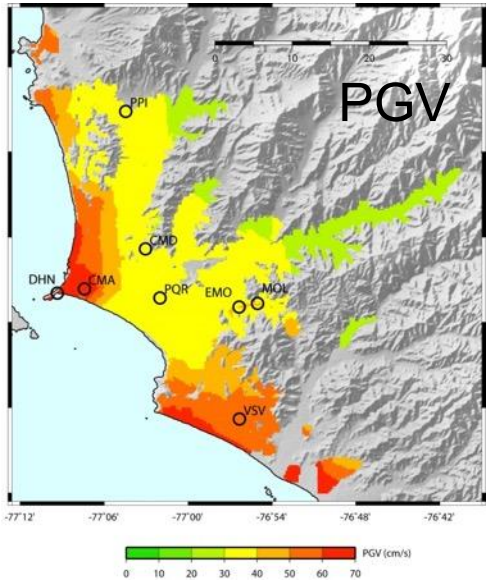
short-period motion



long-period motion

HERP



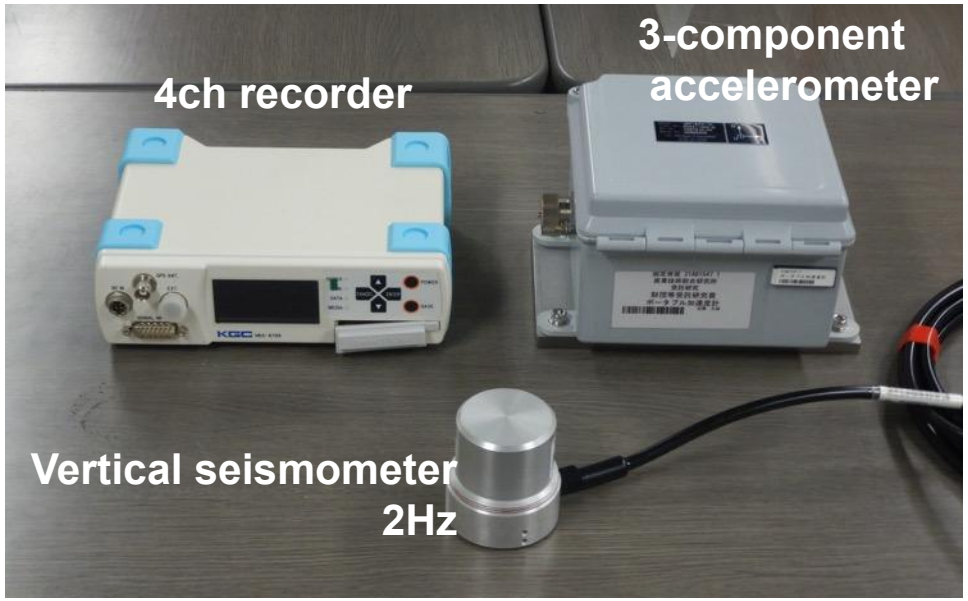


Amplification in previous SATREPS

Shallow soil amplification investigated for short-period motion in previous SATREPS

High-sensitive seismometers will be newly installed for source and deep soil layers

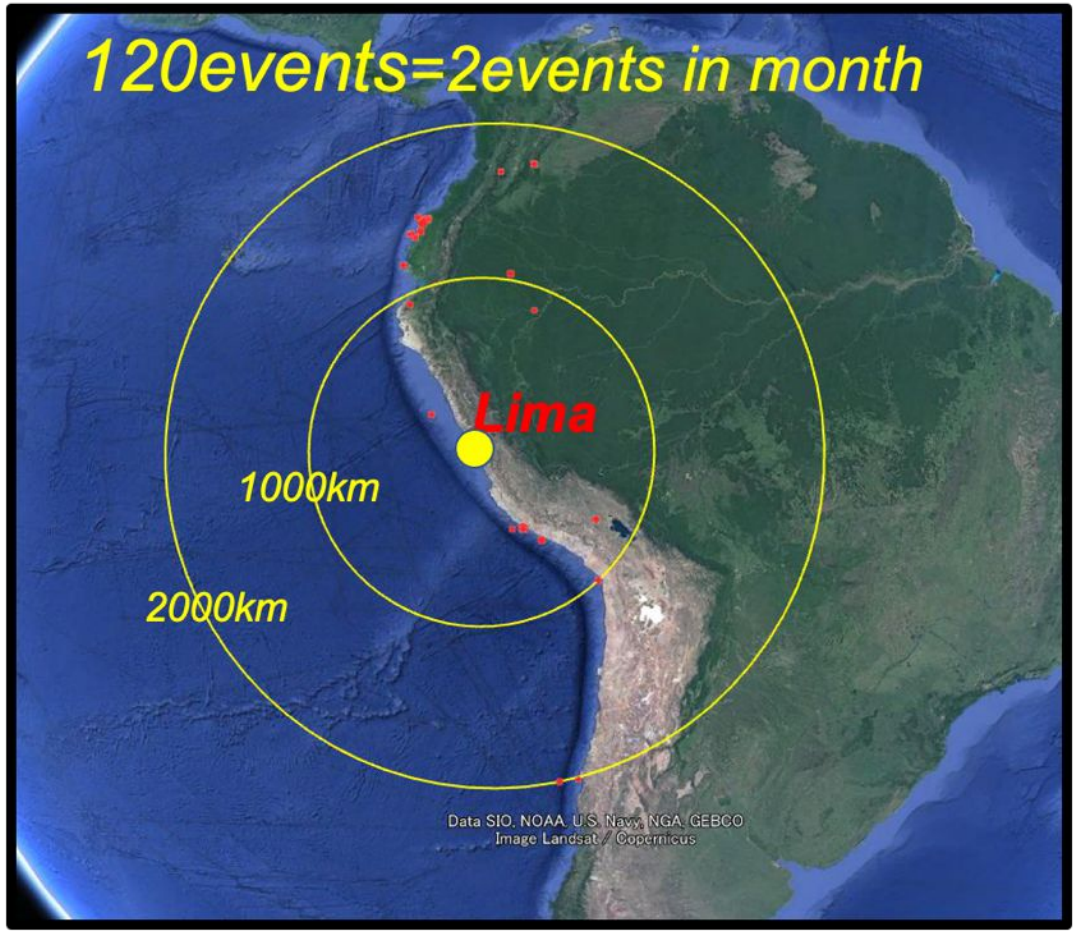
Prediction of long-period motion due to future large events for seismic safety of high-rise and base-isolated buildings in Lima

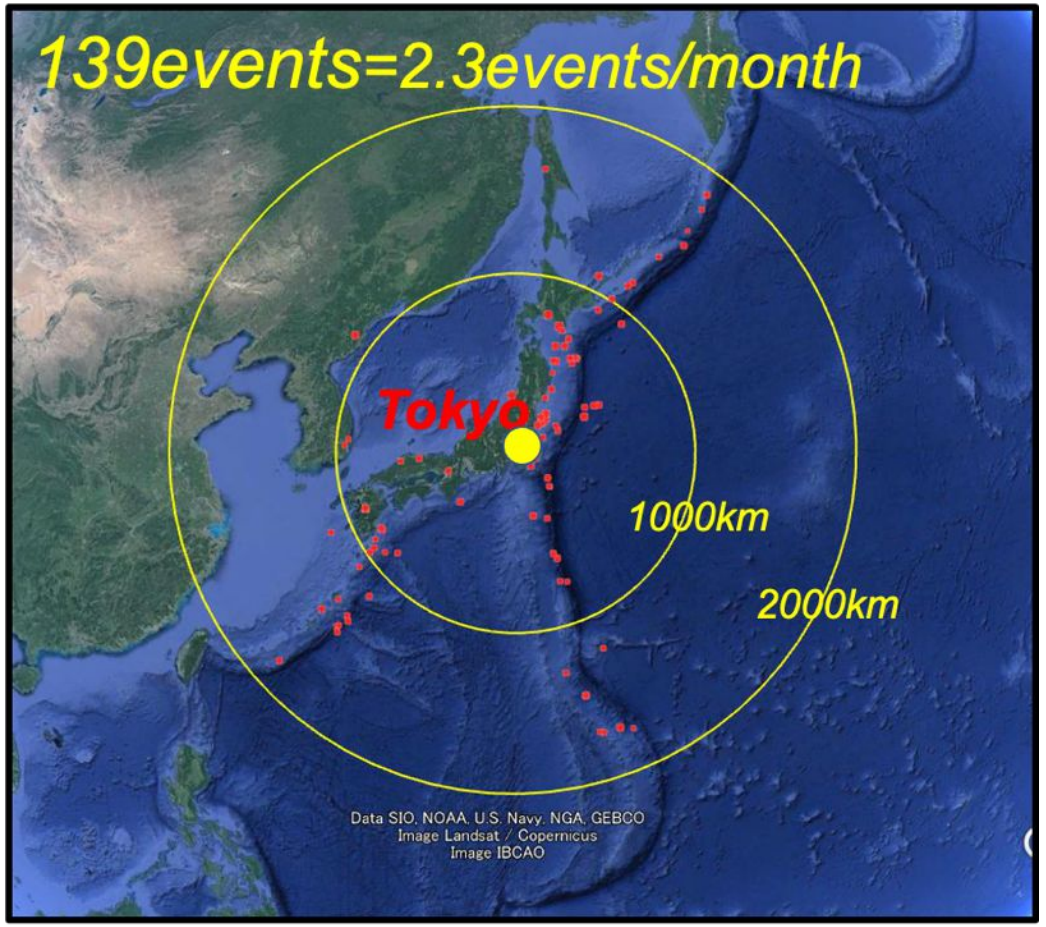


Earthquakes (M>6) around Tokyo & Lima in 2016-2020

(ISC catalogue)

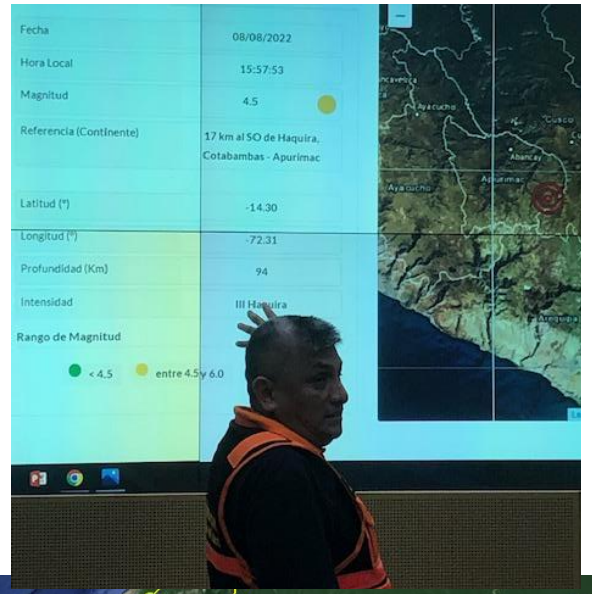
Long-period records of 4 events (M6.0-6.5) were obtained in May to June, 2022 in Tokyo.



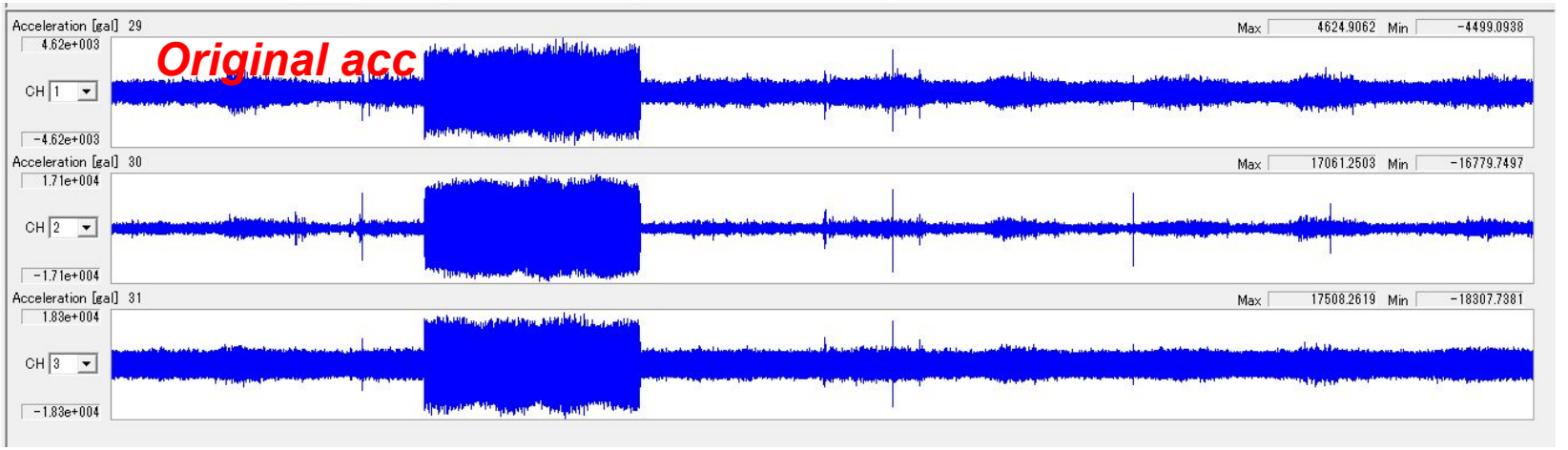


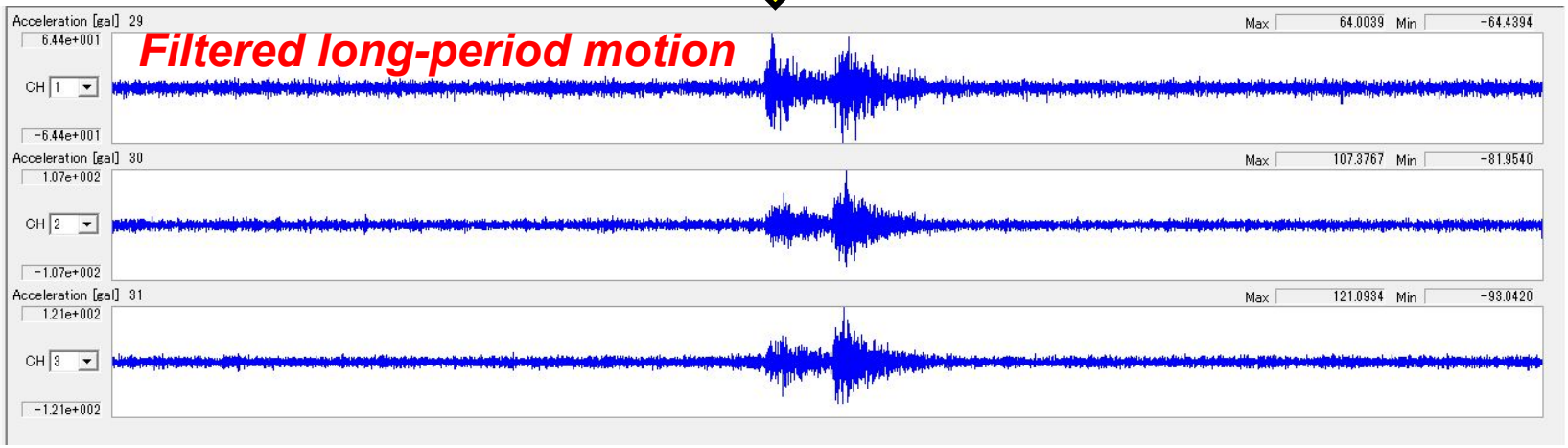
Similar environment: earthquakes, subduction zone, active faults, arc-trench system

Earthquake records during test observation at CISMID

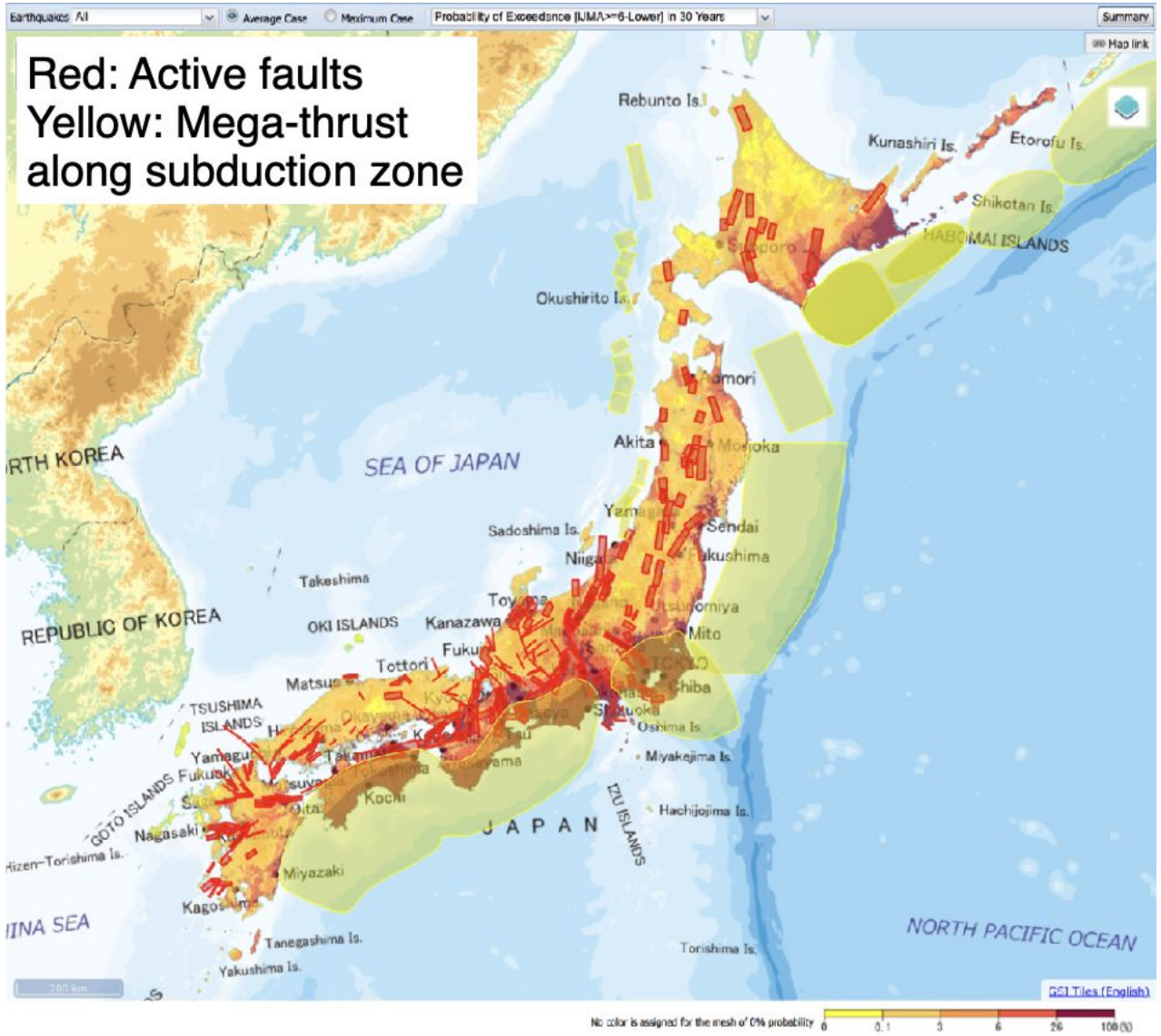


Ground motion of event (M4.5, 15:57, 08/Aug/2022) near Cusco was observed with new observation system

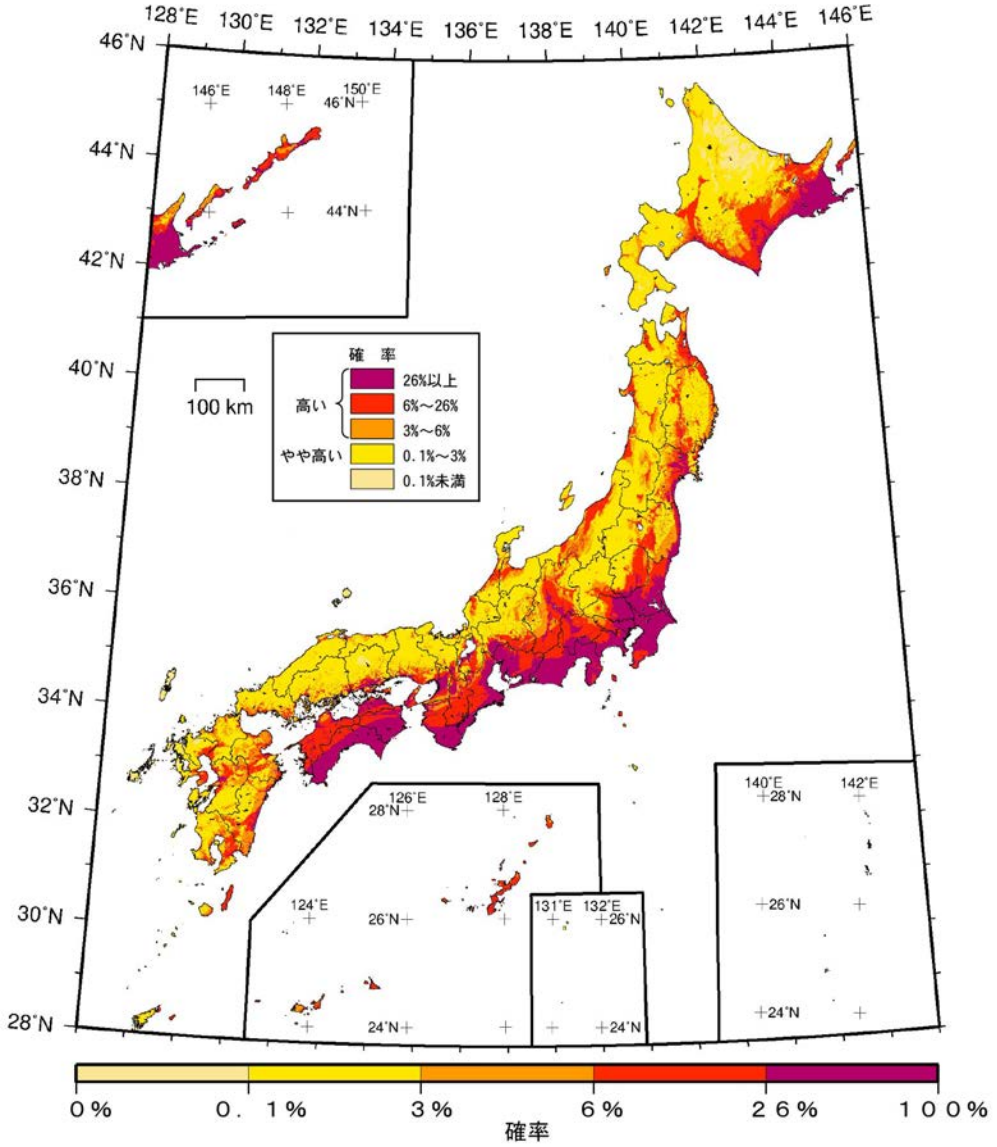




Japanese examples of seismic hazard maps



NIED: J-SHIS Japan Seismic Hazard Information



National map of probabilistic earthquake hazards by the Headquaters of Earthquake Research Promotion