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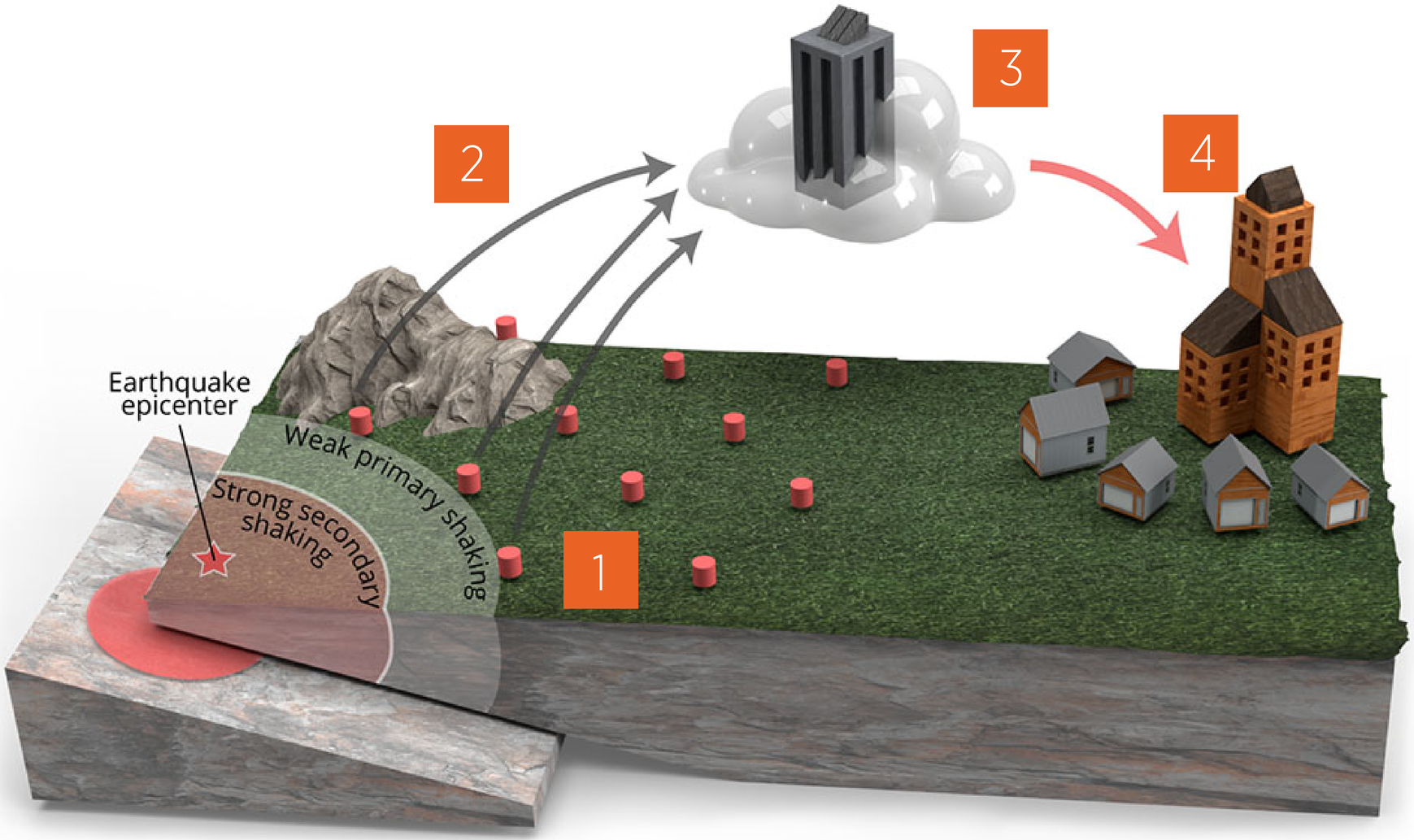
Society of Exploration Geophysicists

Development and feasibility testing of a low-cost earthquake early warning system in Nepal

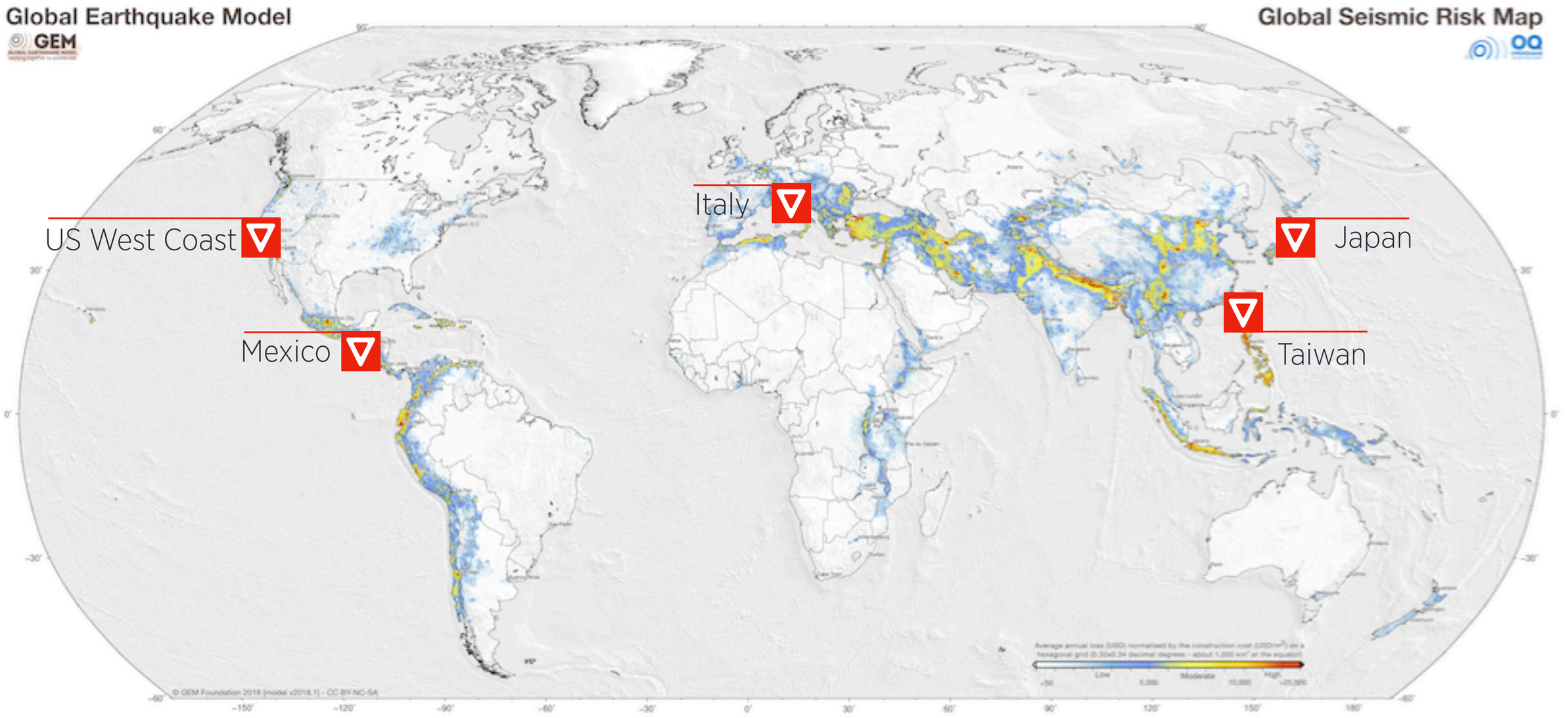
Václav Kuna

Active Plate Tectonic Processes Group, Institute of Geophysics AS CR

Earthquake early warning system



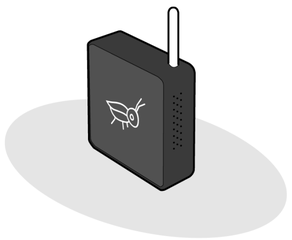
Existing EEW systems



Grillo/OpenEEW

A low-cost, open-source EEW system based on IoT infrastructure.

Low-cost sensor

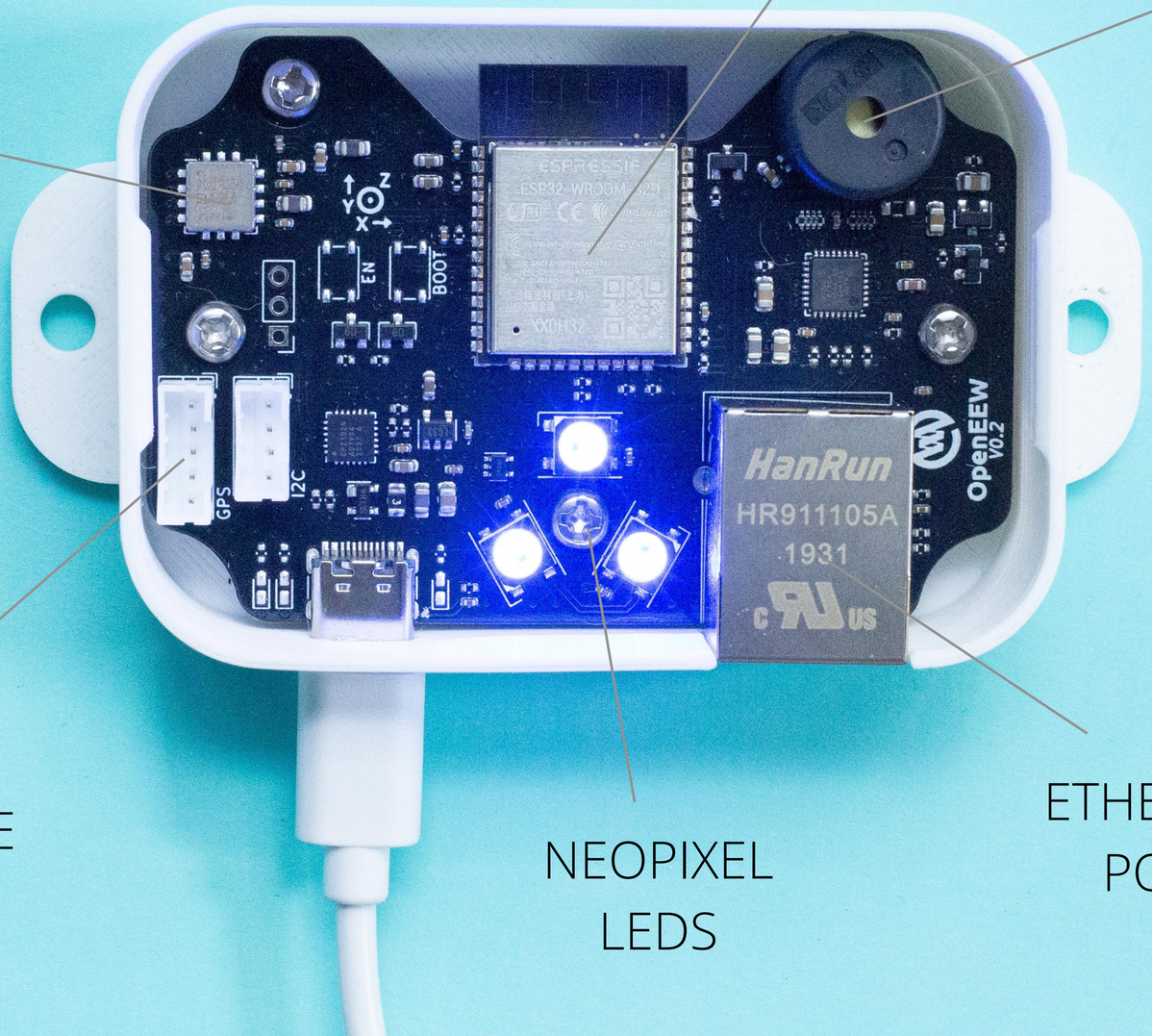


Cloud-based platform

Smart alert

Grillo/OpenEEW Support:

Seismic sensor



MICROCONTROLLER
ESP32

BUZZER

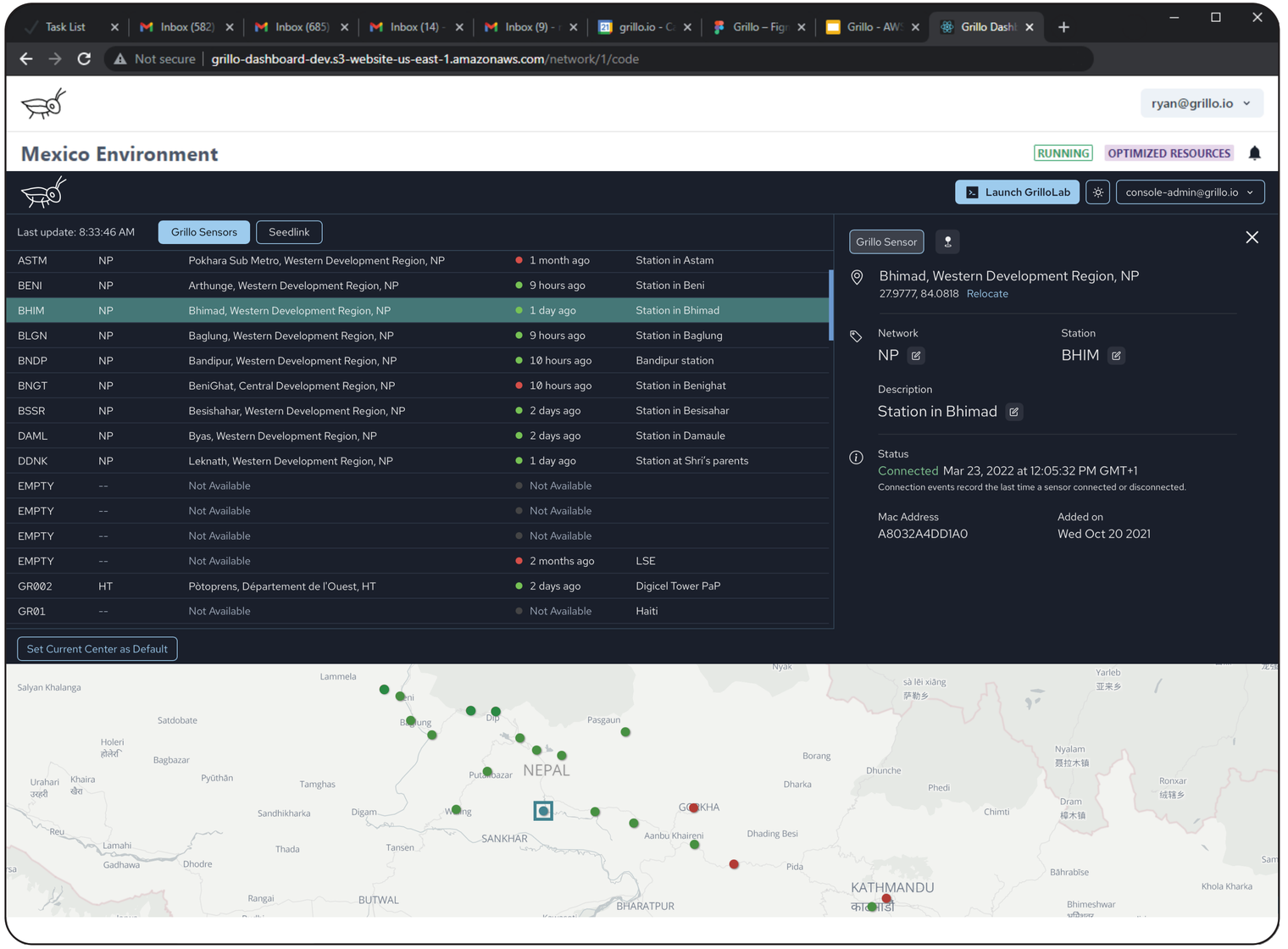
ACCELEROMETER
ADXL355

UART
INTERFACE

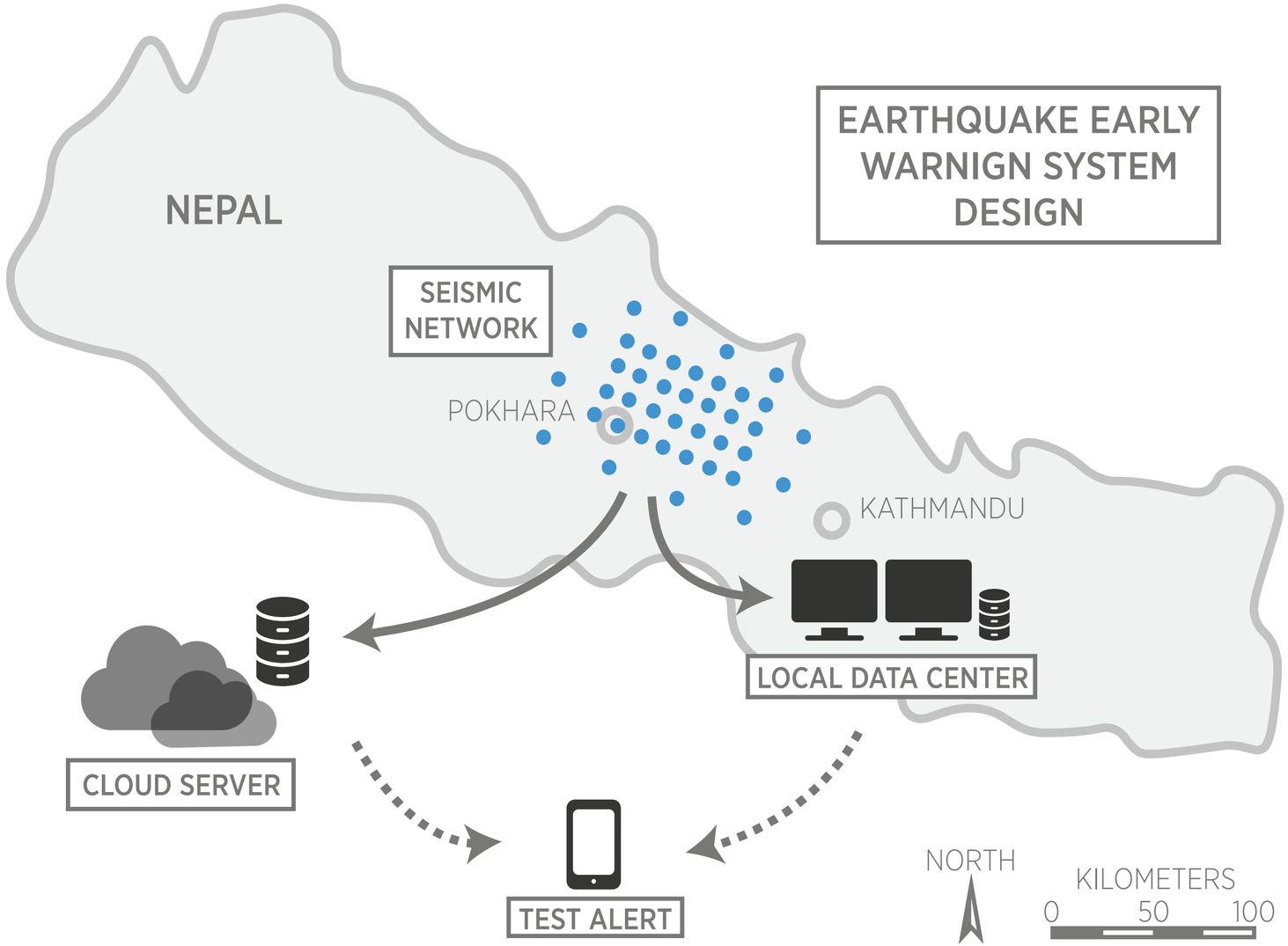
NEOPIXEL
LEDS

ETHERNET
PORT

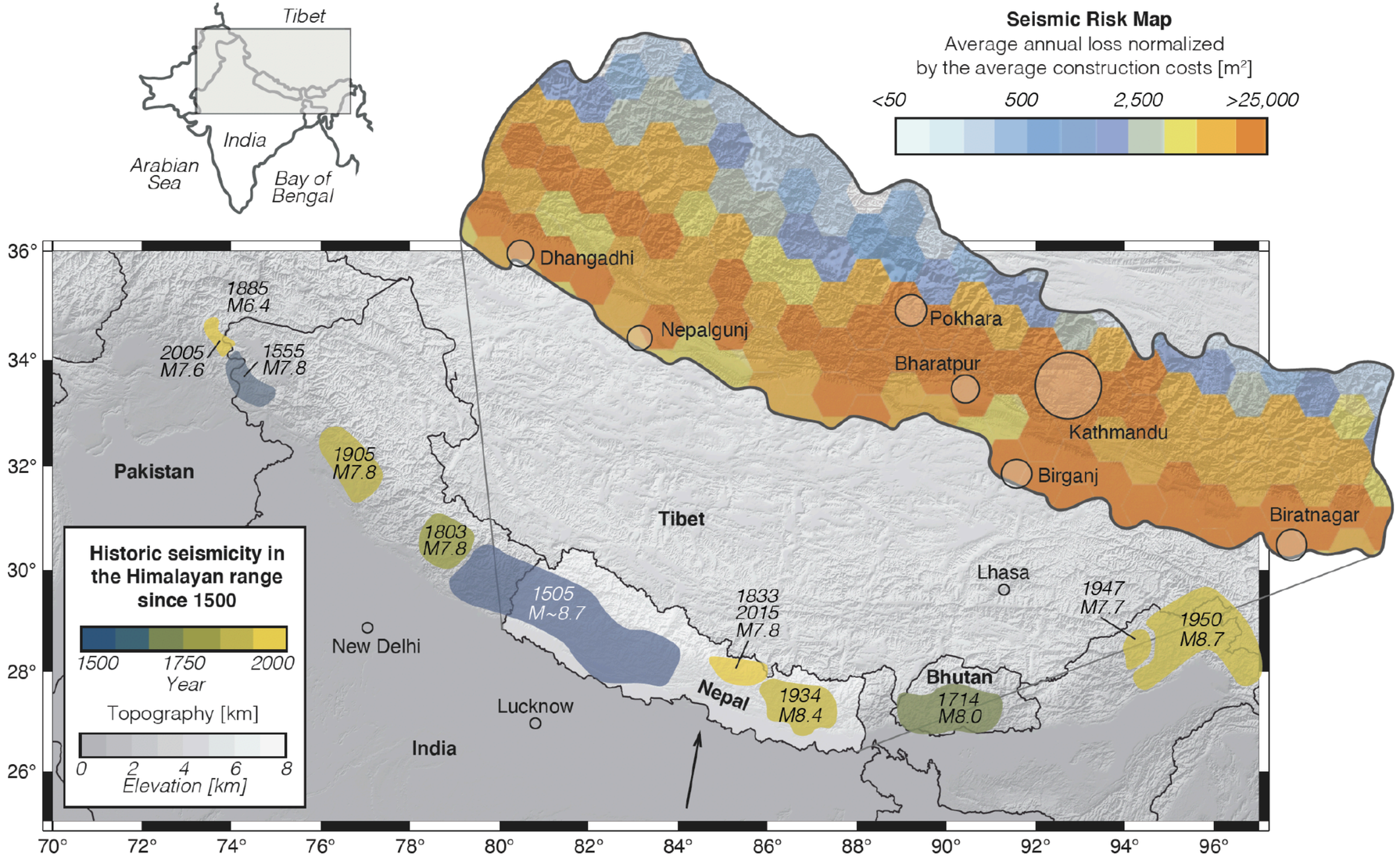
Cloud platform



System tesing in Nepal

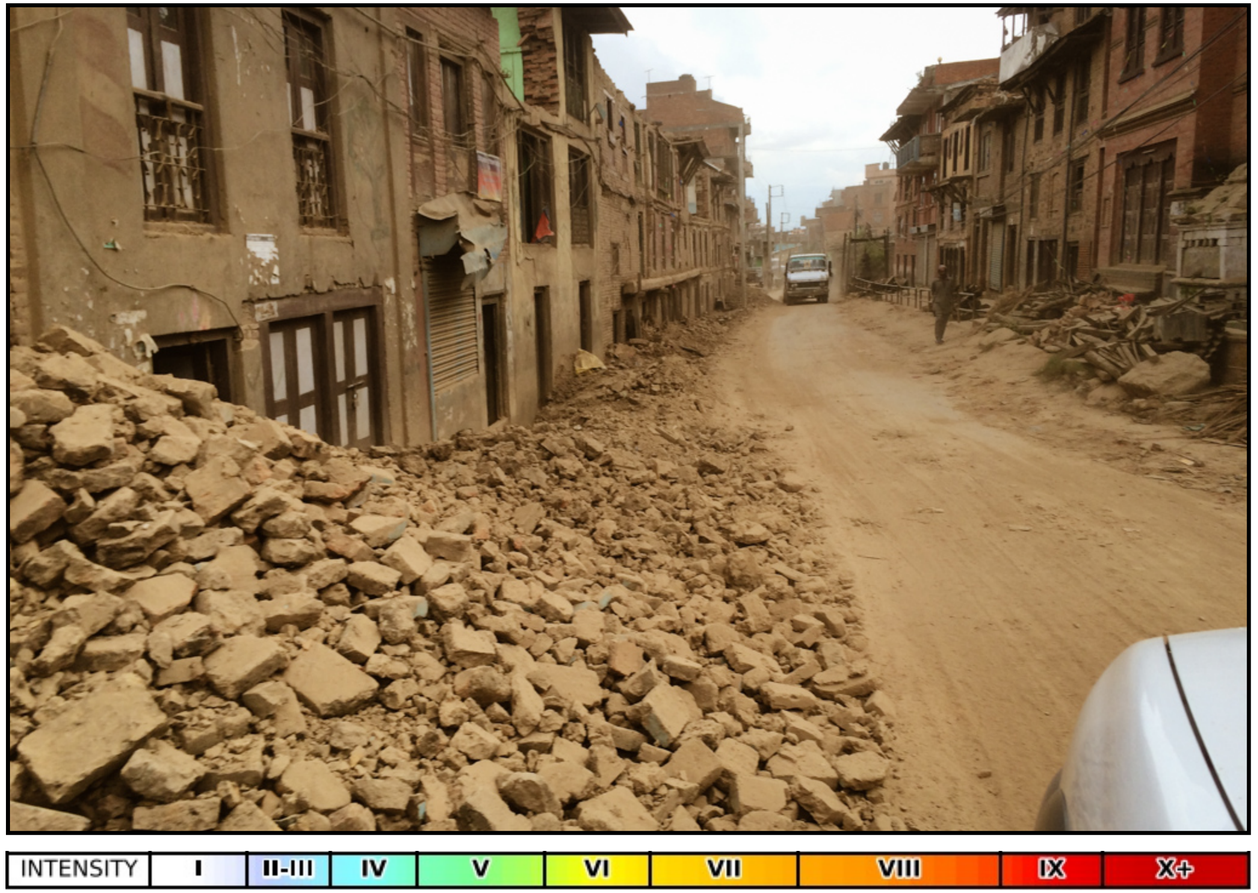


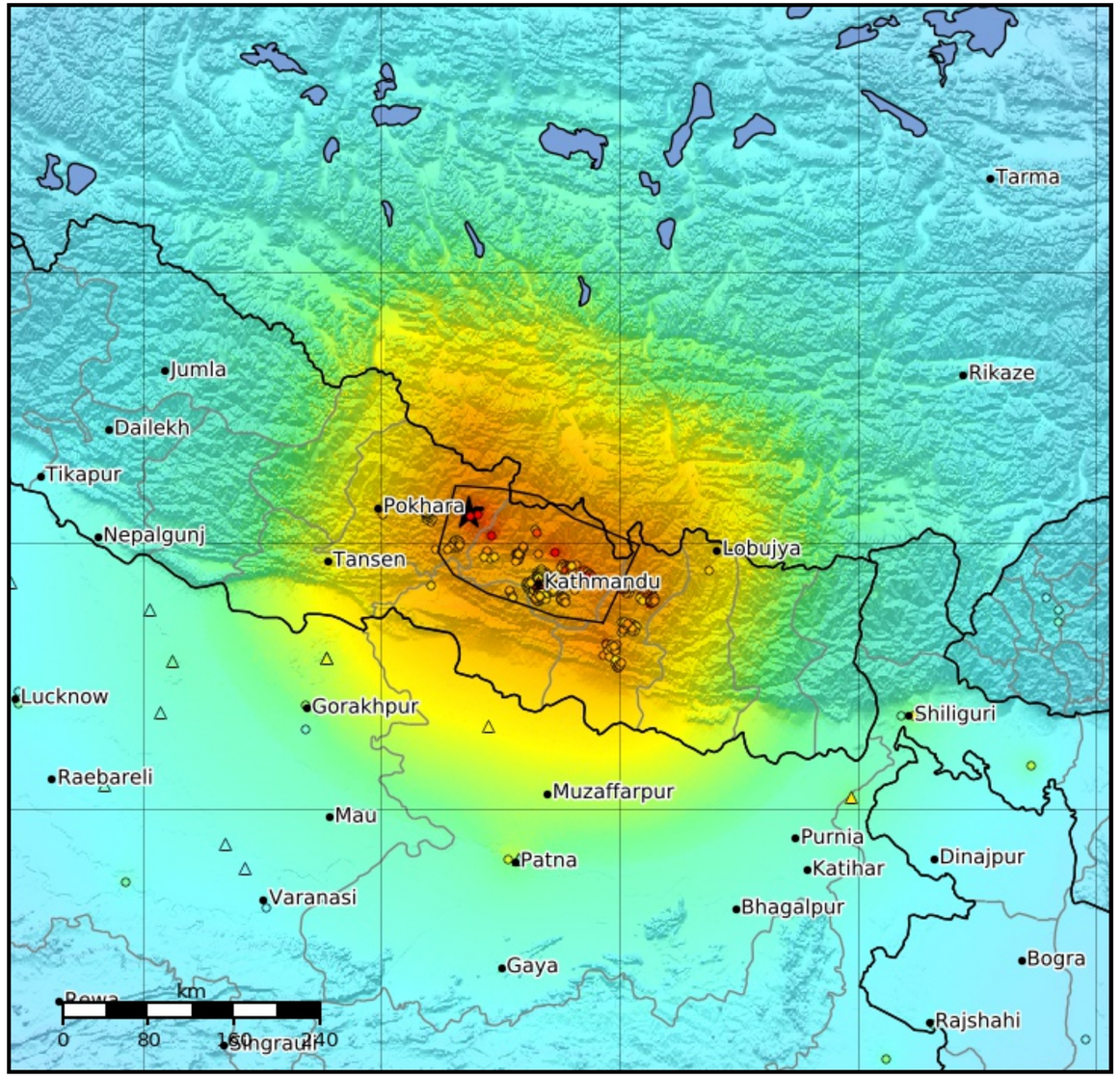
Seismic hazard and risk in Nepal



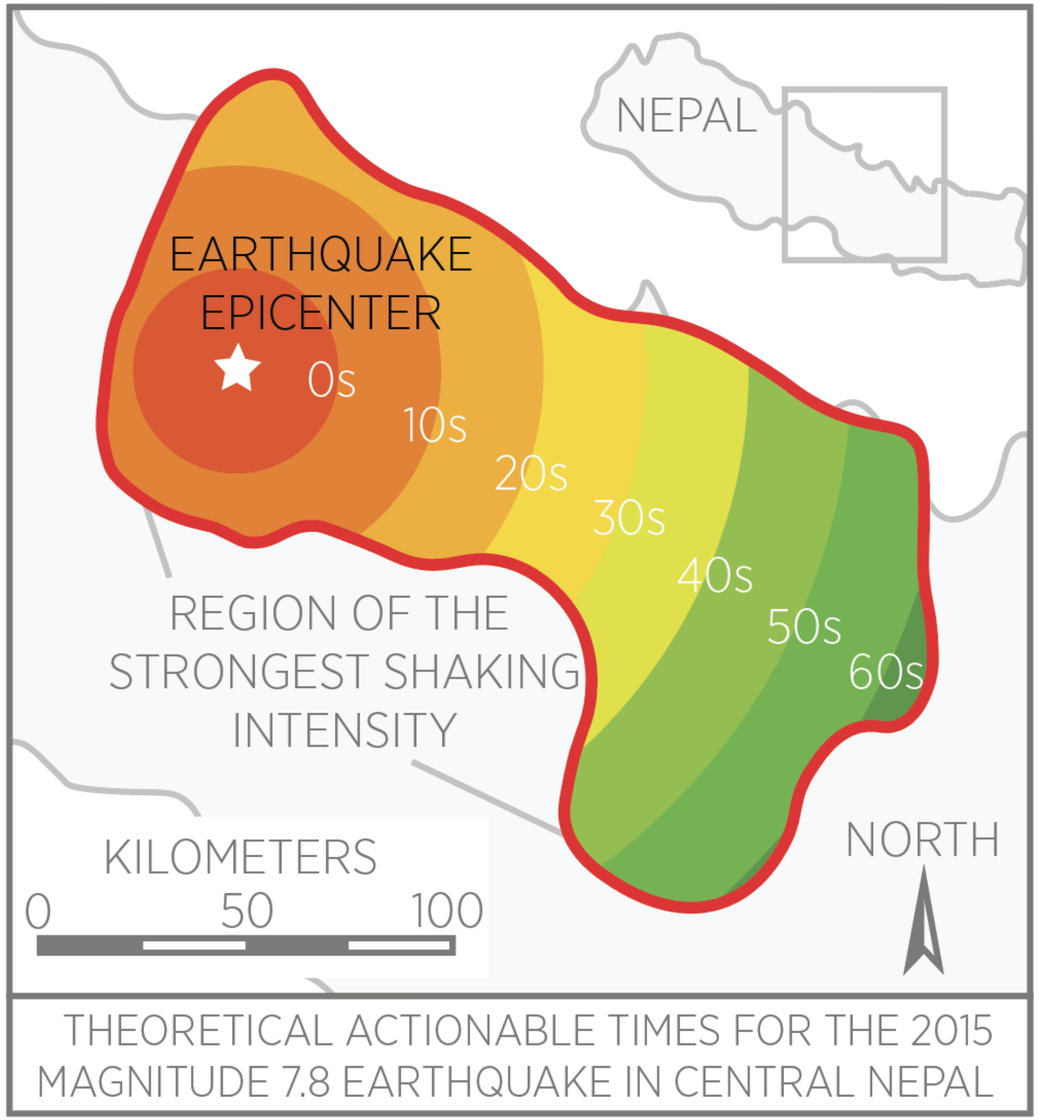
Gorkha earthquake - April 25, 2015, M 7.8

- ~9,000 fatalities
- Damage: 10$ bilion



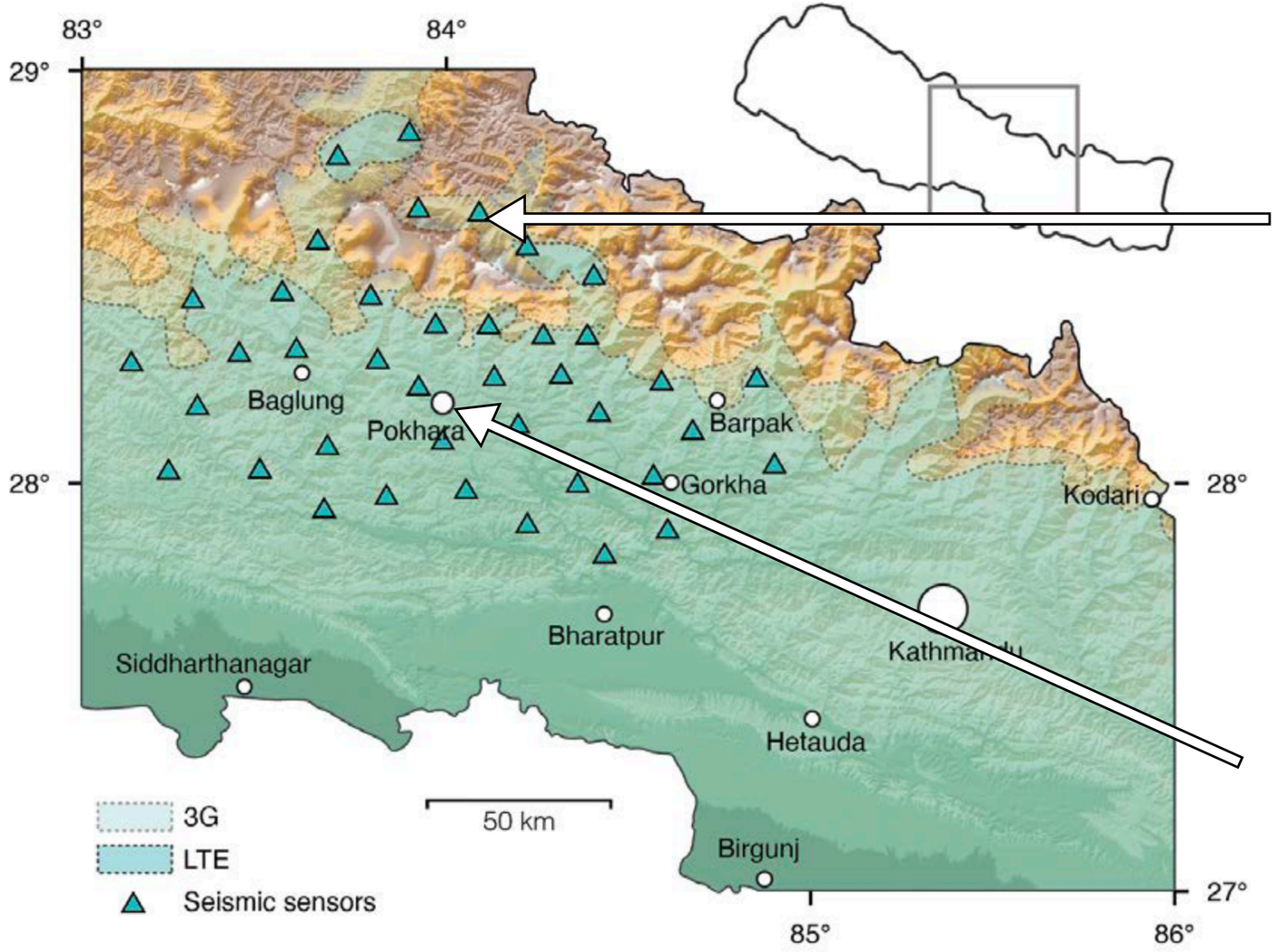


Potential actionable times provided by EEW system



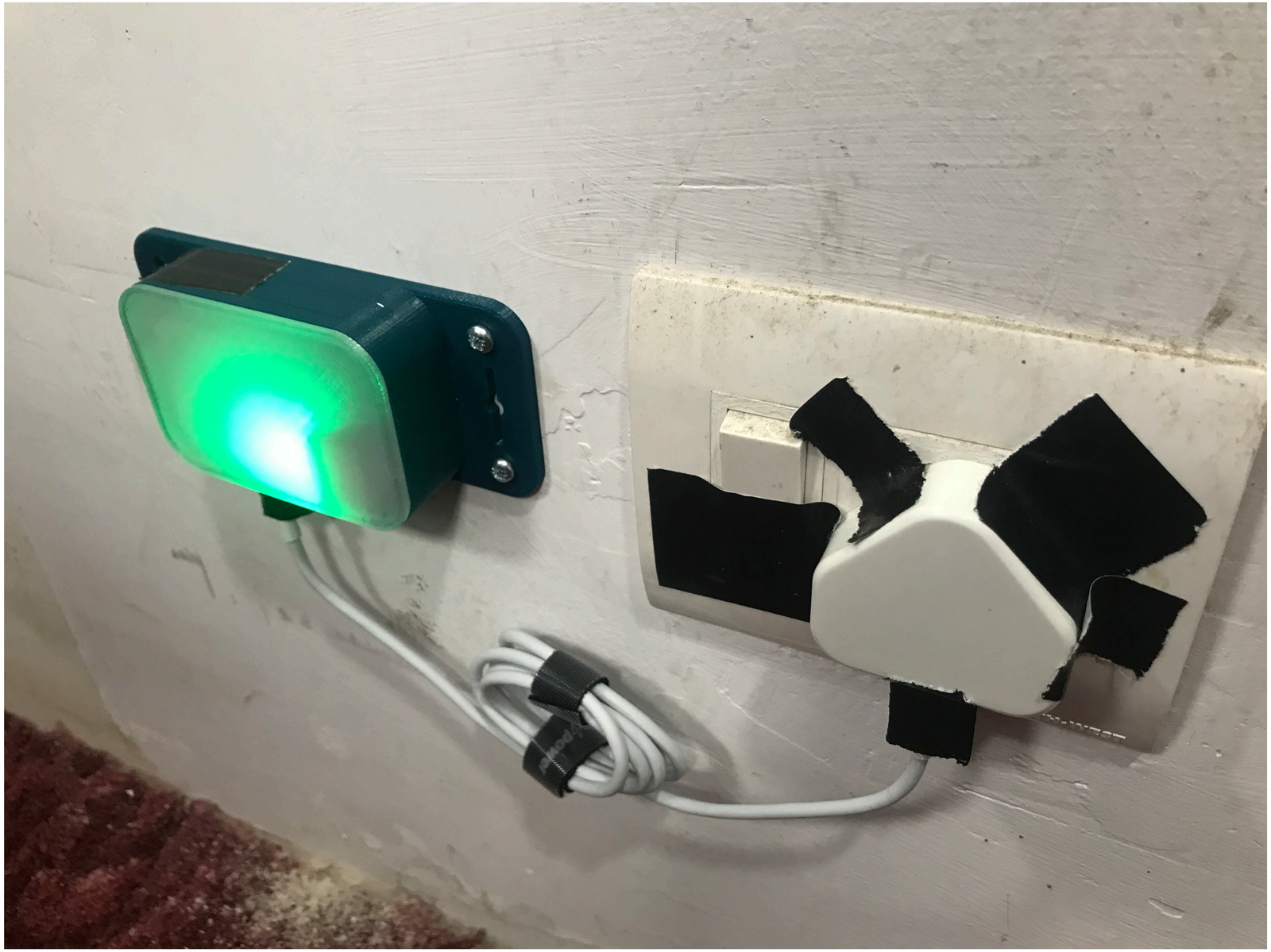
THEORETICAL ACTIONABLE TIMES FOR THE 2015 MAGNITUDE 7.8 EARTHQUAKE IN CENTRAL NEPAL

NepalEEW experiment 2021/2023

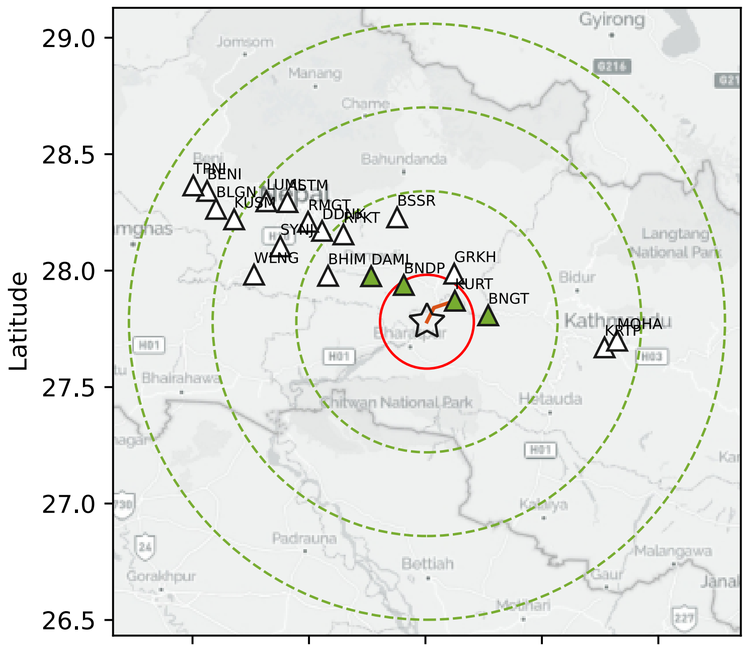


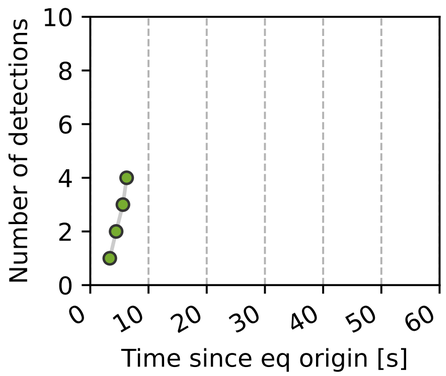
November 2021 station deployment

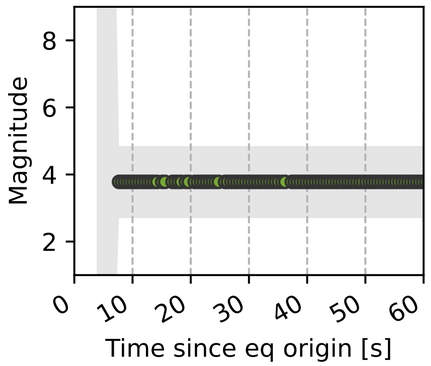
November 2021 station deployment

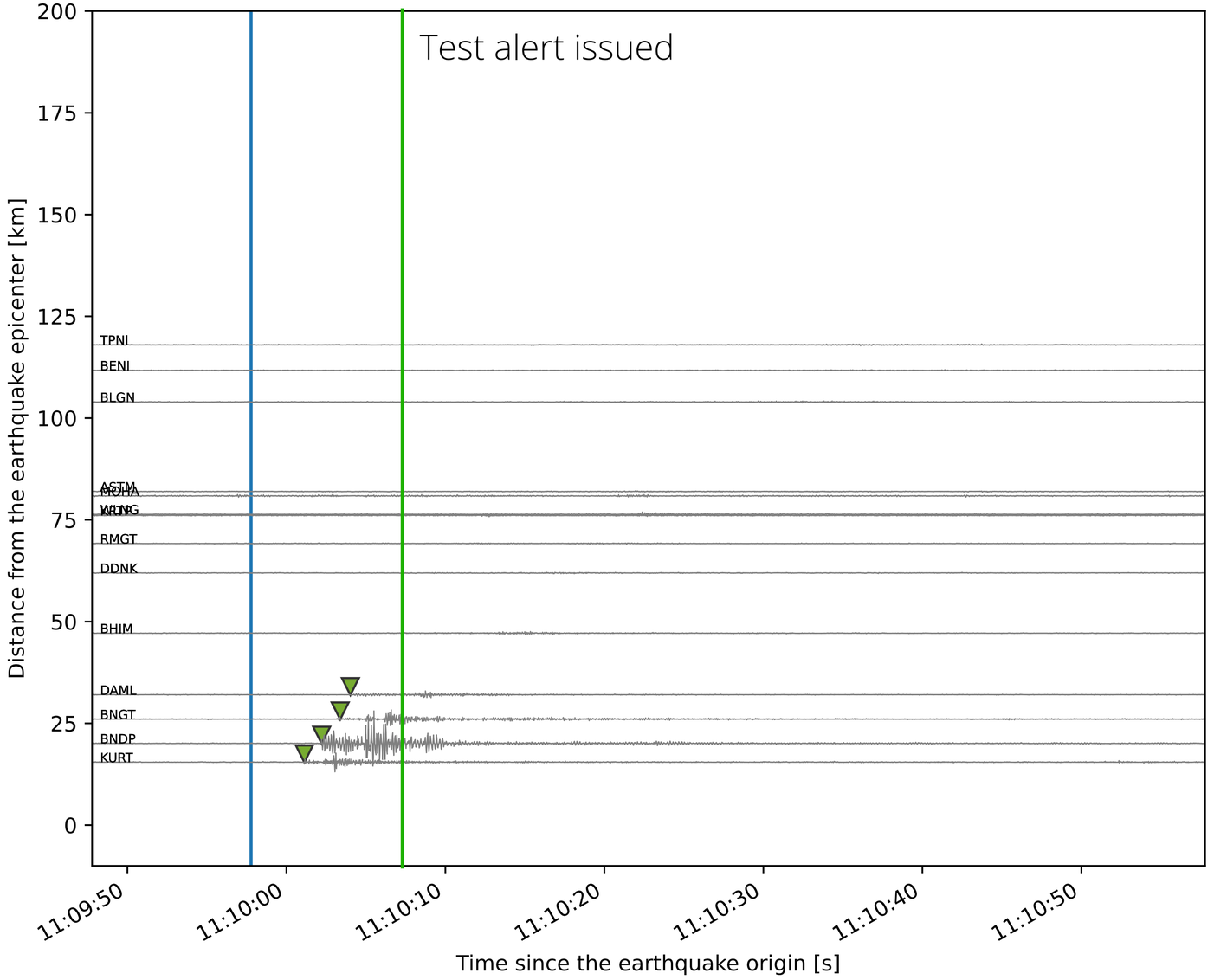


Real-time earthquake determinations

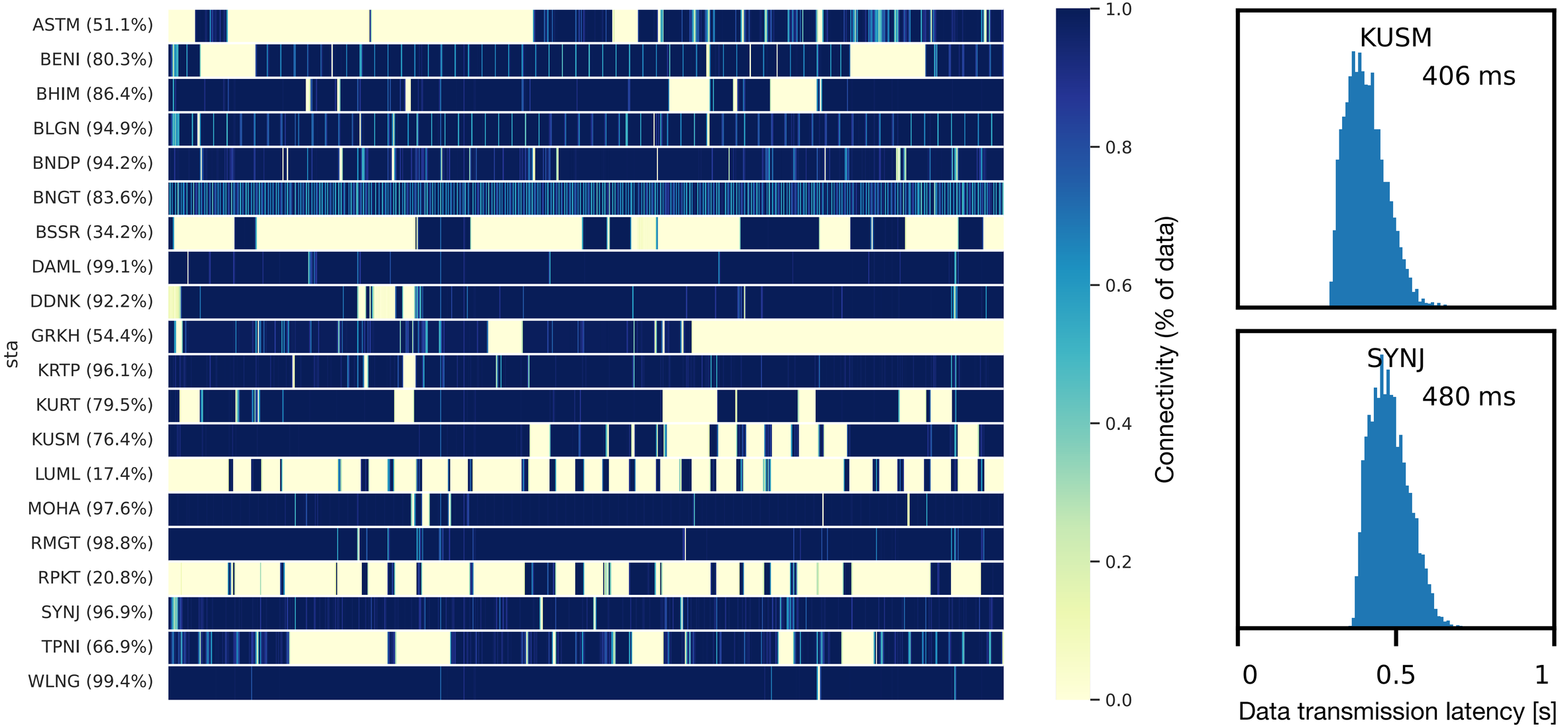








Station connectivity and data transmission latency



Thank you for your attention!

Acknowledgements:

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- Dr. Soma Nath Sapkota
- Dr. Anil Pokhrel (National Disaster Risk Reduction & Management Authority)

Geoscientists without Borders,
Society of Exploration Geophysicists

Rapid earthquake characterization

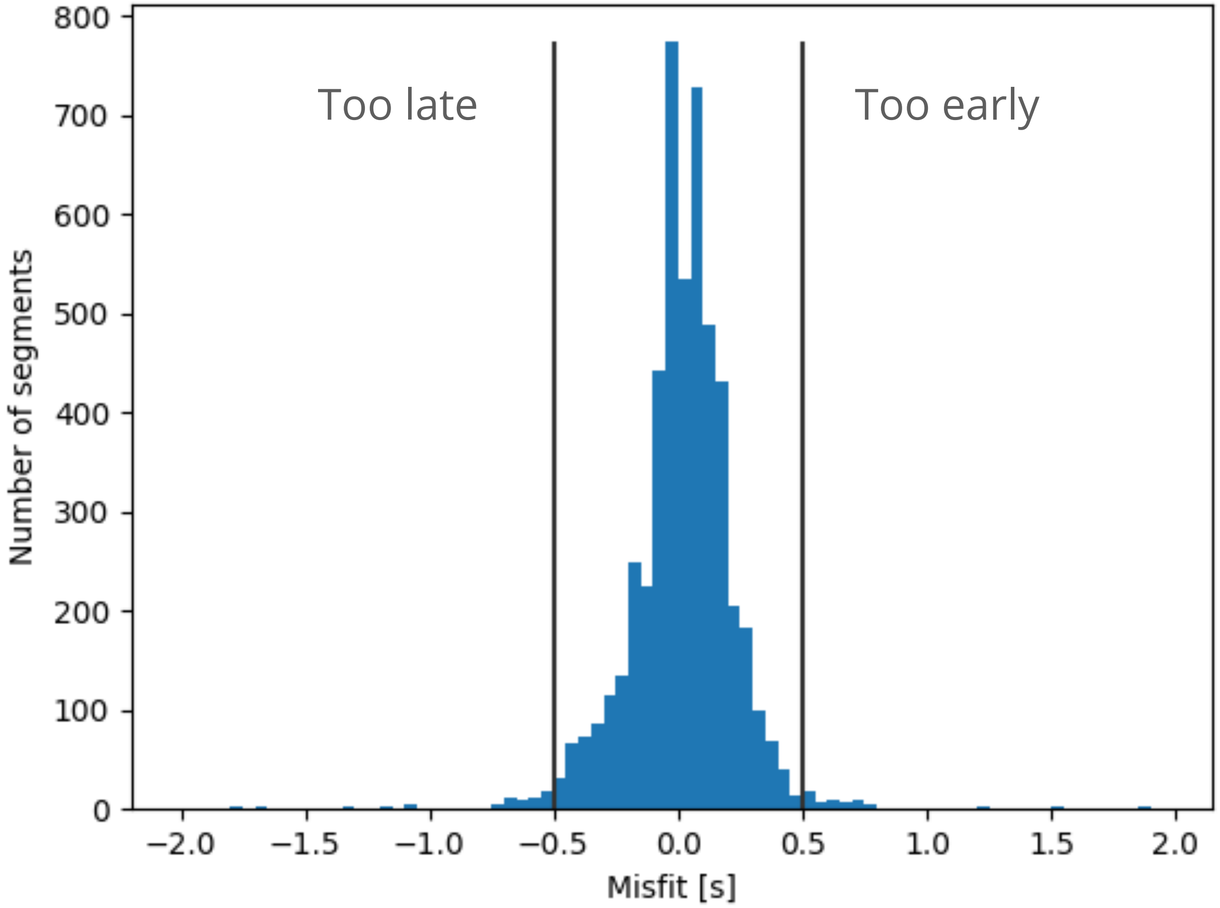
1. Detection: STA/LTA, Neural-network picking

MODEL PREDICTION EVALUATION

	P	noise
Tag	4987	185
No tag	273	84865

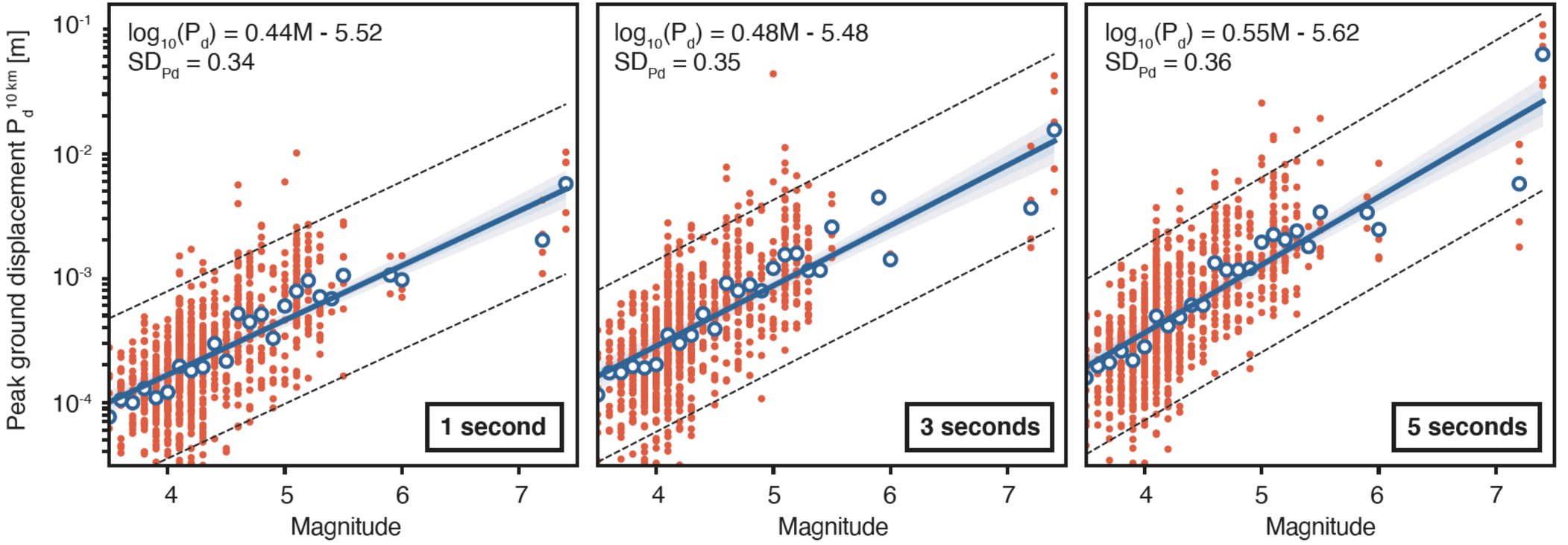
Precision: 0.96
Recall: 0.95
Hit misfit: mean 0.03, std 0.30

////////////////////
// F1 score: 0.96 //
////////////////////



Rapid earthquake characterization

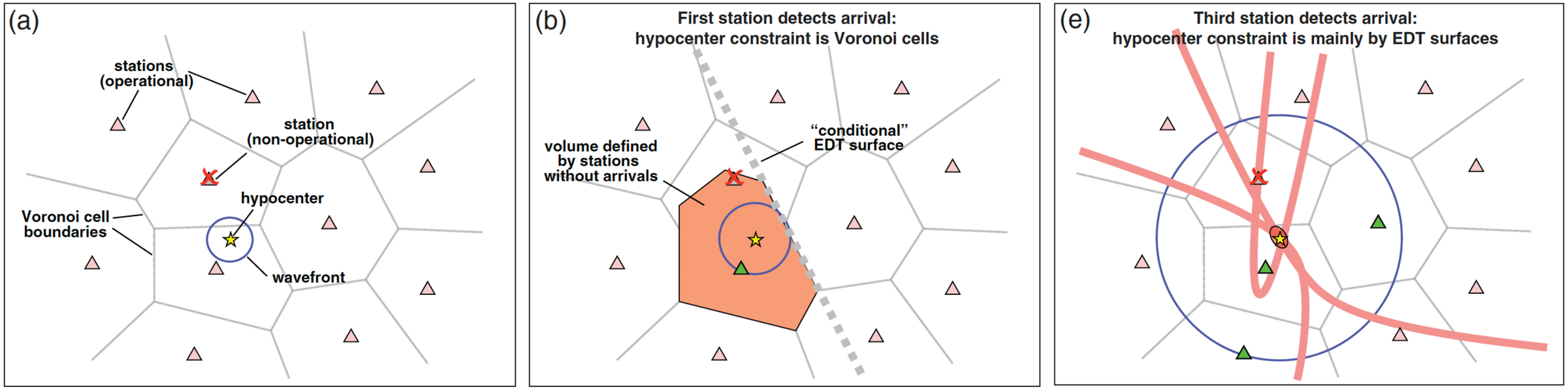
1. Detection: STA/LTA, Neural-network picking
2. Magnitude: Bayesian estimation from peak ground displacement of initial portion of P-wave



Following Lancieri, M., and A. Zollo (2008), A Bayesian approach to the real-time estimation of magnitude from the early P and S wave displacement peaks, J. Geophys. Res., 113, B12302, doi:10.1029/2007JB005386.

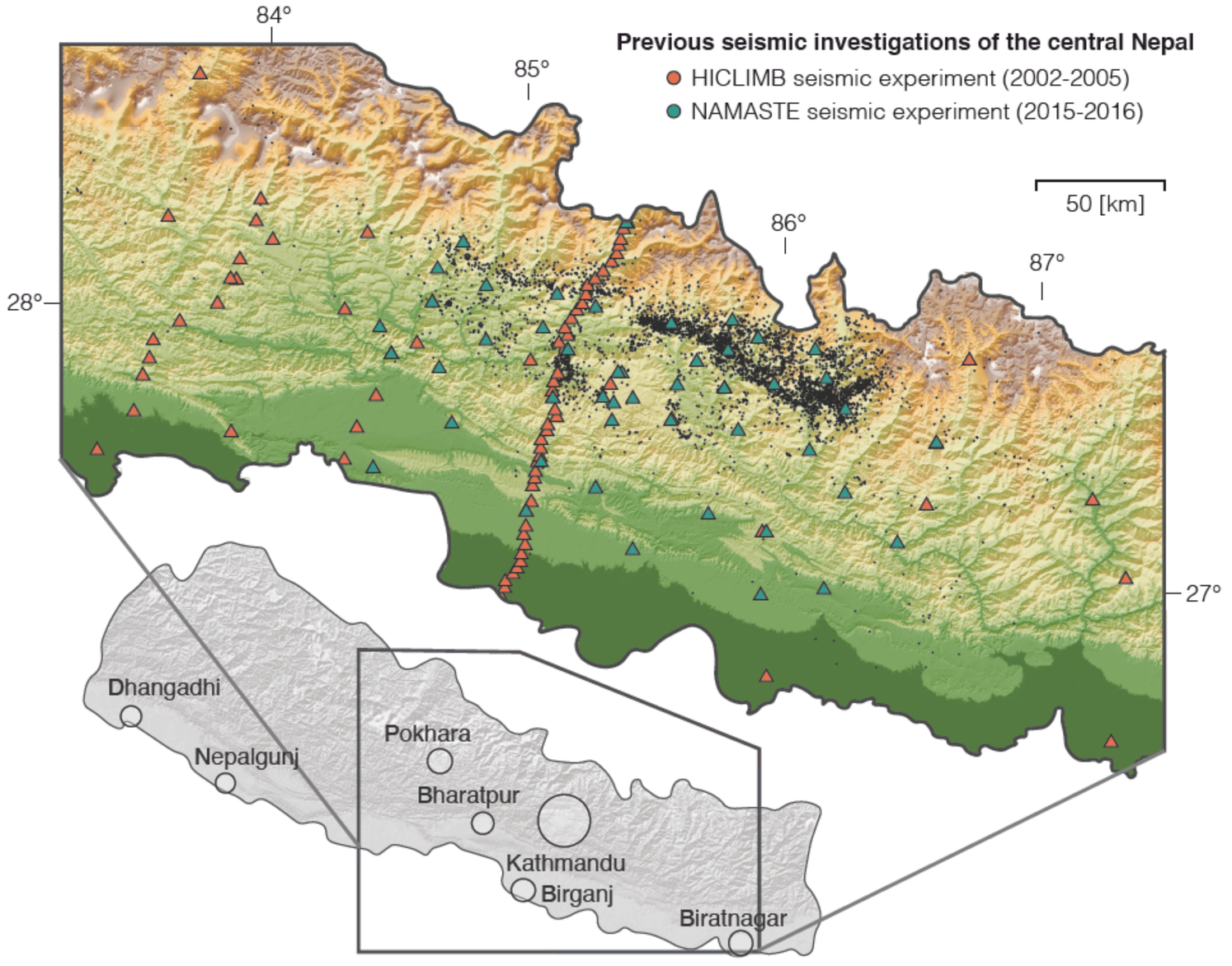
Rapid earthquake characterization

1. Detection: STA/LTA, Neural-network picking
2. Magnitude: Bayesian estimation from peak ground displacement of initial portion of P-wave
3. Location: Bayesian estimation from P-wave arrivals

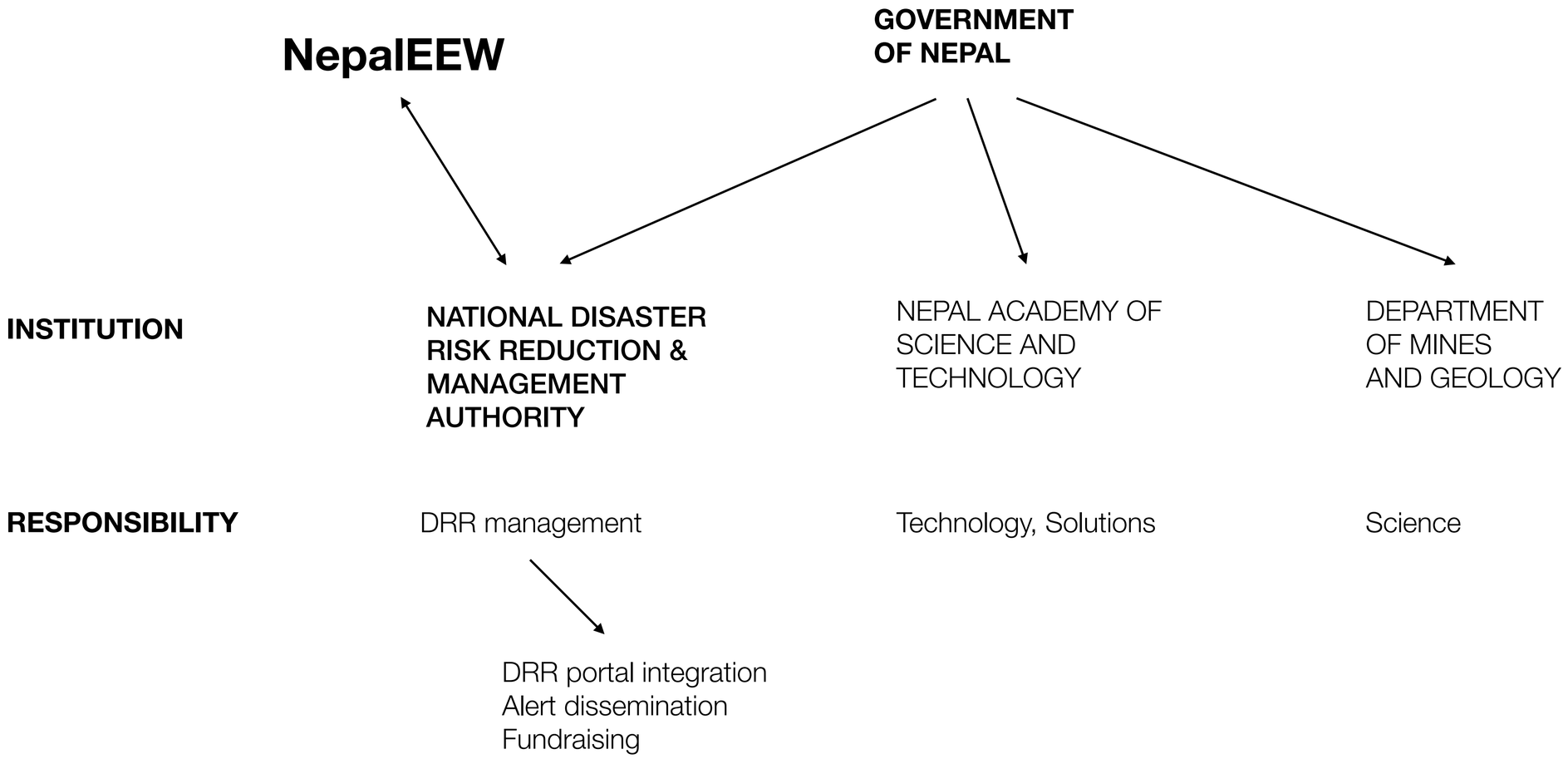


Following Satriano, C., Lomax, A. and Zollo, A., 2008. Real-time evolutionary earthquake location for seismic early warning. Bulletin of the Seismological Society of America, 98(3), pp.1482-1494.

NAMASTE experiment 2015/2016



Collaborations

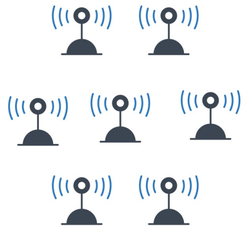


System latency

EARTHQUAKE

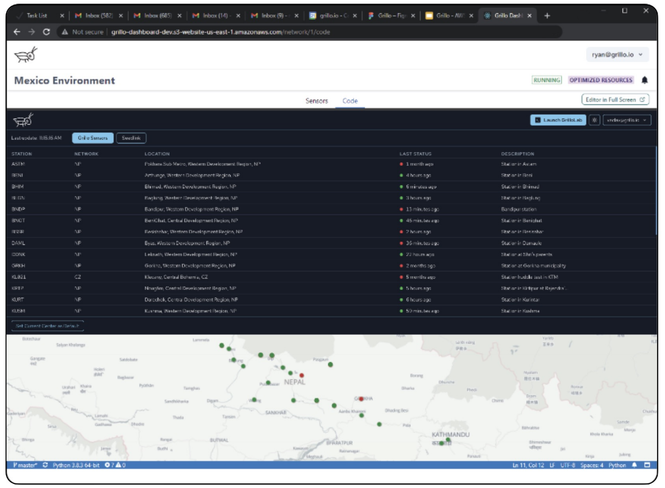
seismic waves traveling

GRILLO SENSORS



message transfer

CLOUD PLATFORM



SMS
IoT speakers
push notifications

END USERS

WAVE TRAVEL-TIME LATENCY (DEPENDS ON NETWORK DENSITY)

DATA TRANSMISSION LATENCY <0.5 s

SIGNAL PROCESSING LATENCY <2s

ALERT DELIVERY LATENCY <1s