A challenging use case for TeRABIT: urgent computing for seismic risk assessment in North-Eastern Italy

Elisa Zuccolo, Chiara Scaini

Bologna, 25 Giugno 2024

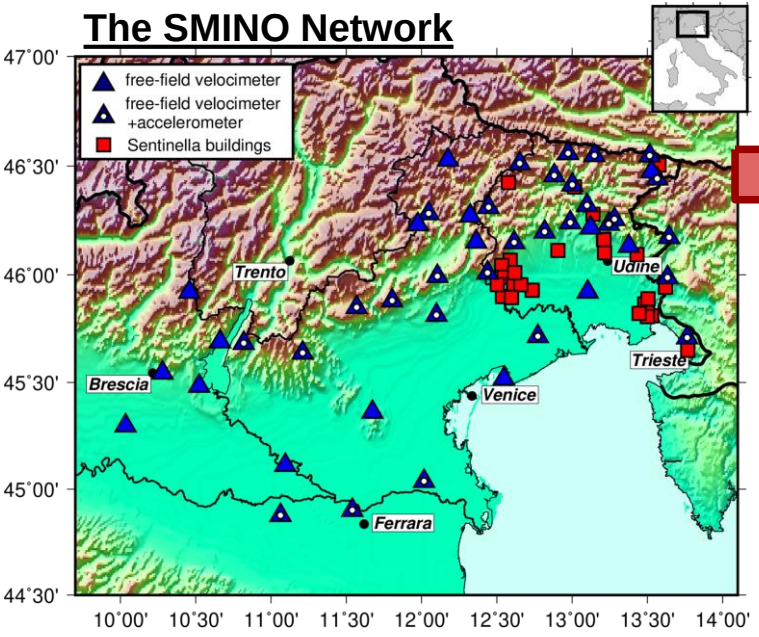
Conferenza TeRABIT

Outline

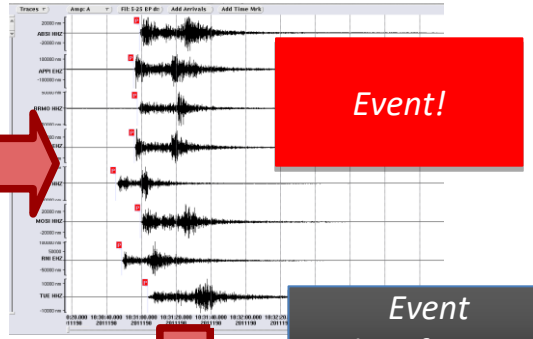
- Introduction to the use case (C. Scaini)
- Description of the use use (E. Zuccolo)

The seismological research center of OGS

Seismic monitoring and research to improve understanding of seismicity in the region
Institutional mandate to support civil protection in case of seismic events in northeastern Italy

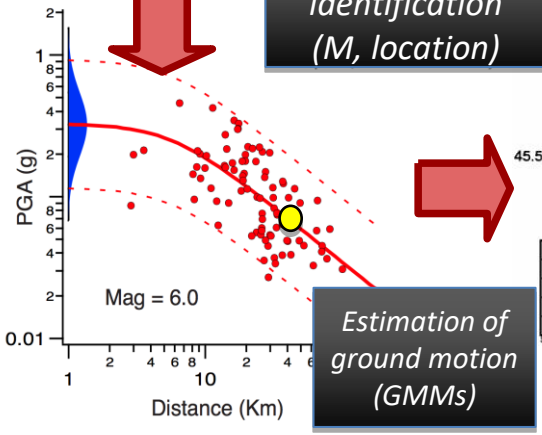


Increasing number of sensors on soils and buildings (currently 400+)



Event!

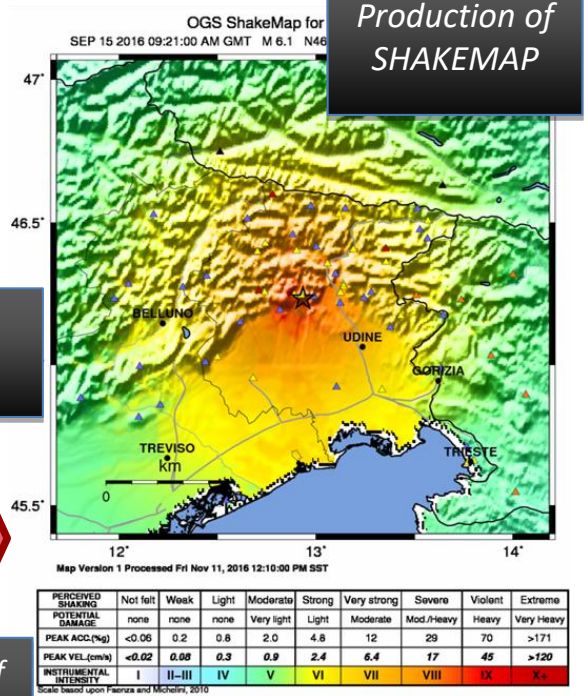
Event identification (M, location)



Estimation of ground motion (GMMs)

time: < 5 min

Production of SHAKEMAP



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.06	0.2	0.8	2.0	4.8	12	29	70	>171
PEAK VEL.(cm/s)	<0.02	0.08	0.3	0.9	2.4	6.4	17	45	>120
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Faenza and Michelini, 2010

(Bragato et al., 2021)

Near real-time impact assessment

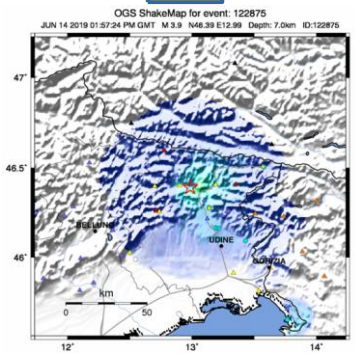
Scenario Hazard (ground motion model)

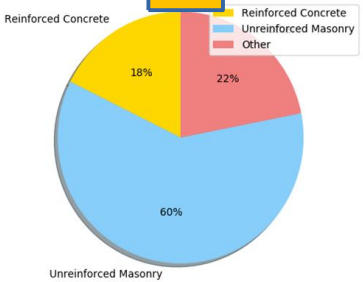
Exposure (building type and distribution)

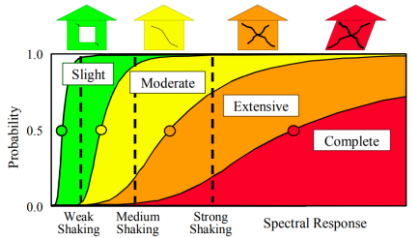
Fragility (dynamic behavior of structures)

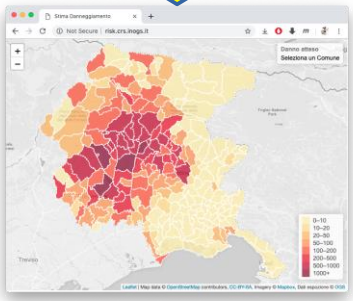
Expected damage

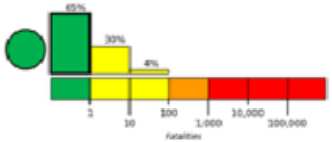
Losses (human, material)







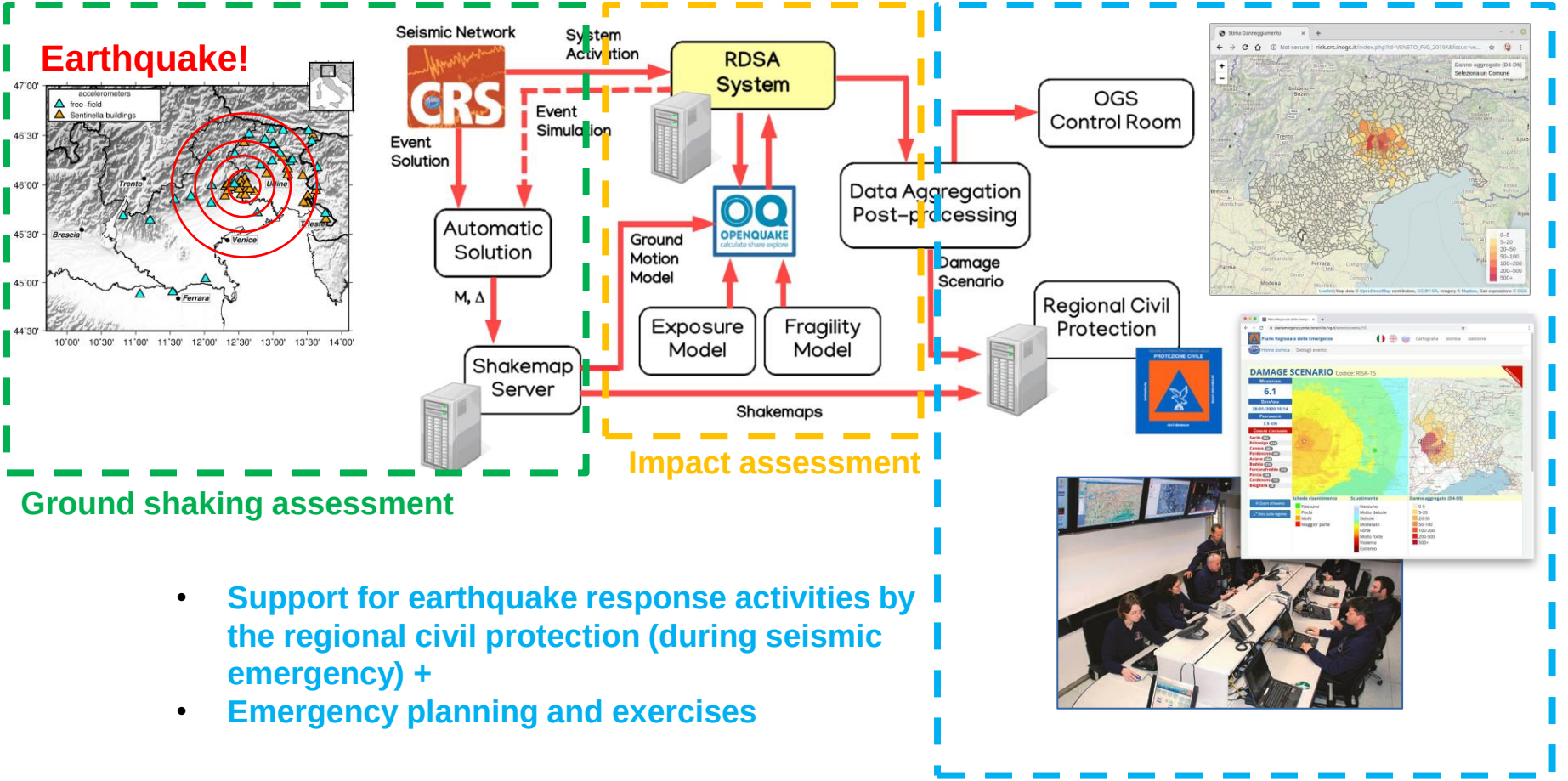




Why assessing damages in near real-time? To support rapid response

(Poggi et al., 2020)

OGS operational infrastructure



- **Support for earthquake response activities by the regional civil protection (during seismic emergency) +**
- **Emergency planning and exercises**

The TeRABIT contribution

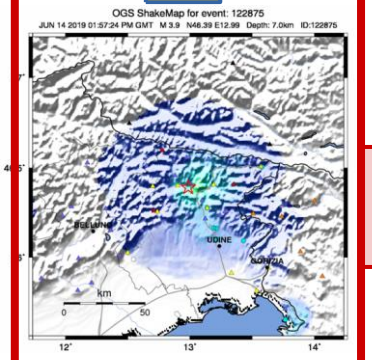
Scenario Hazard (ground motion model)

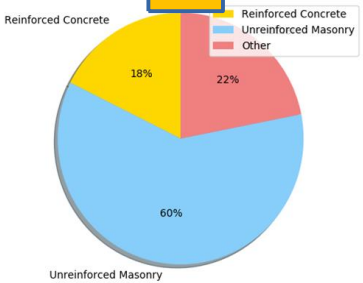
Exposure (building type and distribution)

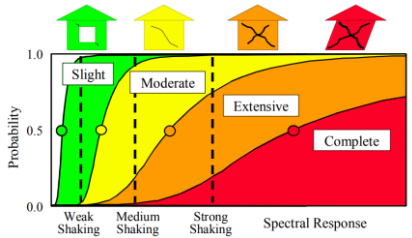
Fragility (dynamic behavior of structures)

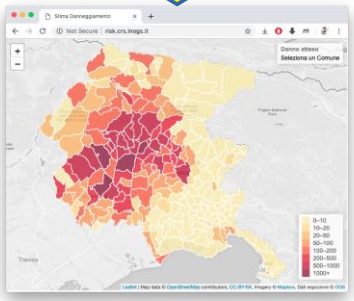
Expected damage

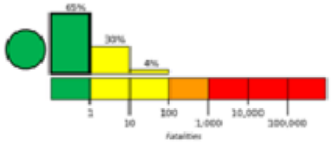
Losses (human, material)











Improve the ground motion estimation to get more reliable damage estimates!

Why? To support rapid response

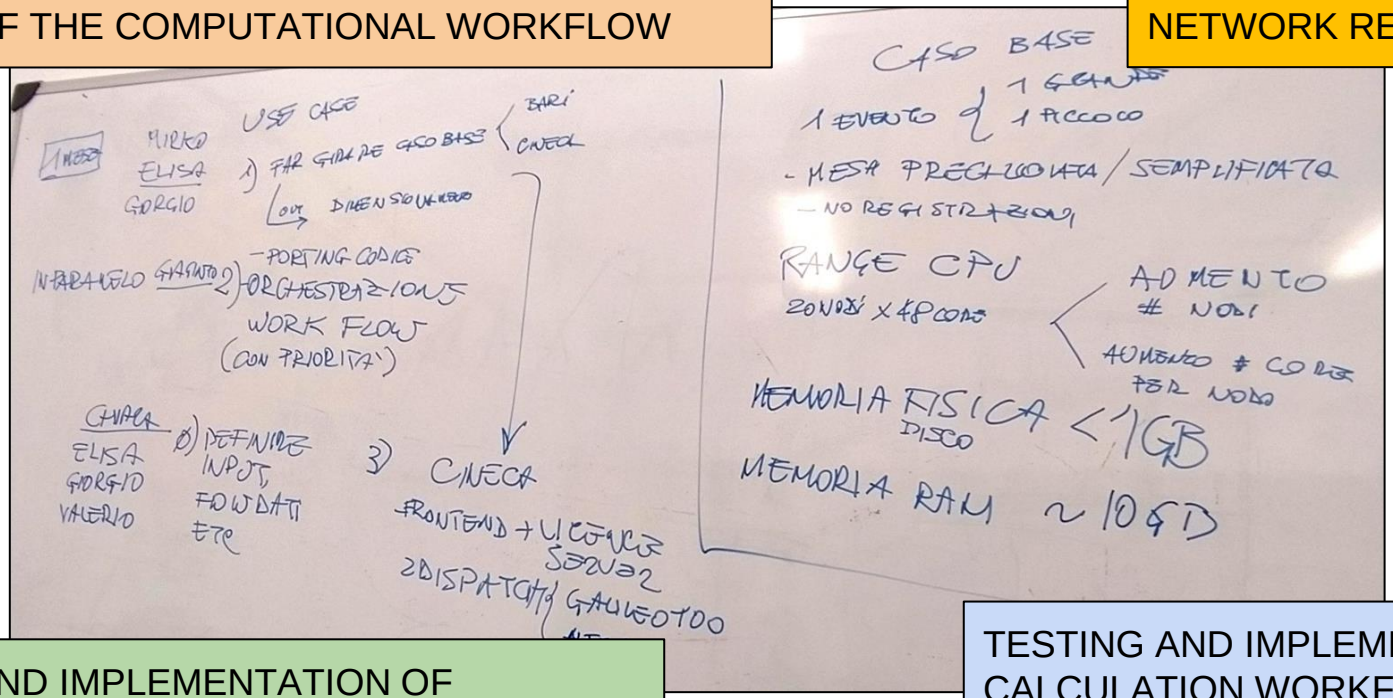
TeRABIT Team working

terabit

Feasibility analysis and definition of pilot case-study together with the team
Knowledge sharing and identification of main steps and potential bottlenecks
Assessment of memory (physical, RAM) and calculation requirements

DESIGN OF THE COMPUTATIONAL WORKFLOW

NETWORK REQUIREMENTS



Consortium GARR

INFN
Istituto Nazionale di Fisica Nucleare

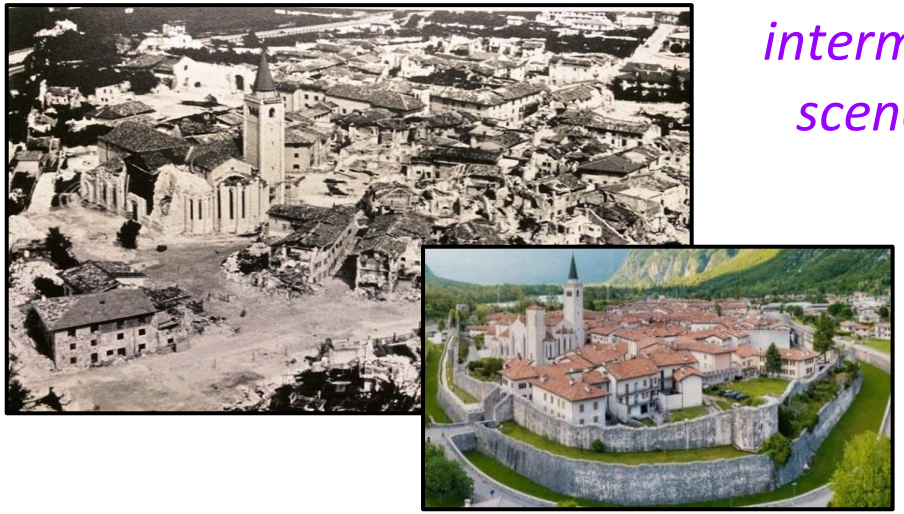
CINECA

TESTING AND IMPLEMENTATION OF CALCULATION WORKFLOW ON HPC-BUBBLES

TESTING AND IMPLEMENTATION OF CALCULATION WORKFLOW ON G100 AND LEONARDO

Realistic scenarios for infrastructure test

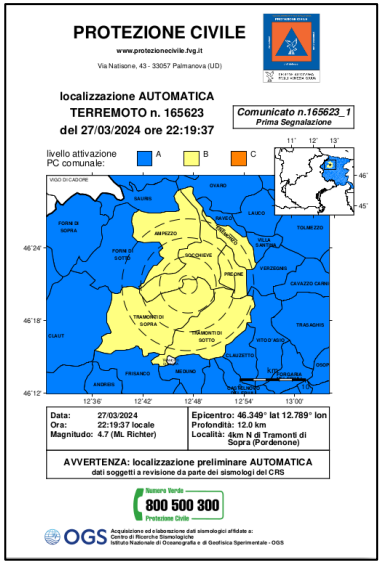
Friuli Earthquake
6th May 1976, Mw 6.4

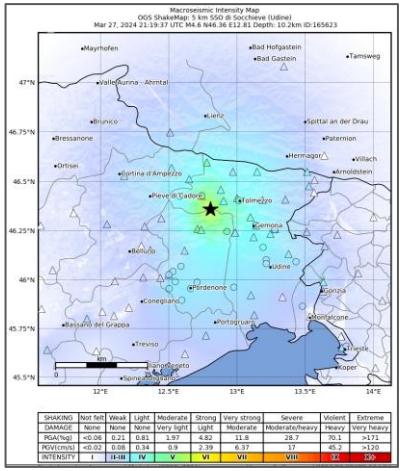


- Documented damages
- Very few recordings
- Past seismological studies (location, intensities, effects)

(Other intermediate scenarios)

Socchieve Earthquake
27th March 2024, Mw 4.2



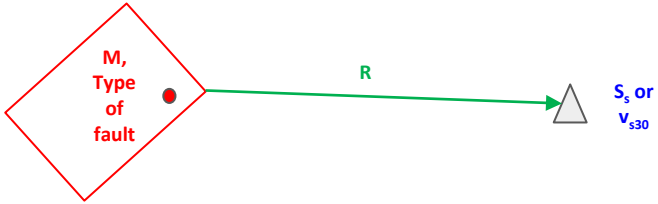


Intensity V “Felt by nearly everyone; many awakened: Some dishes and windows are broken. Unstable objects are overturned. Pendulum clocks may stop”

- No damage evidence but perceived by many residents in the area
- Recordings from the OGS network

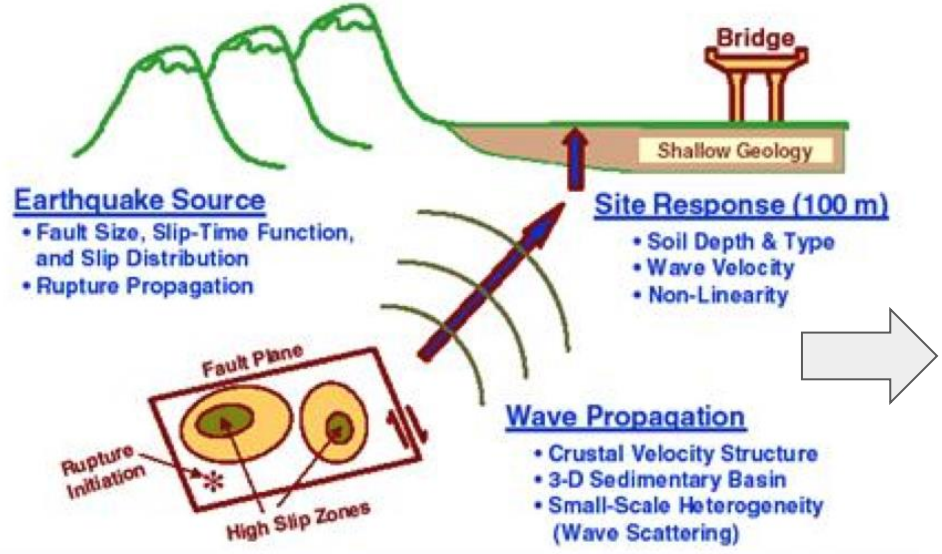
Ground shaking assessment

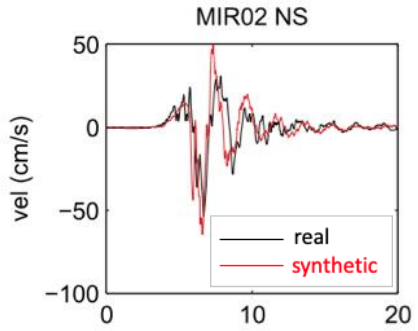
GMMs *IM = f(seismic source, source-site distance, site effects)*

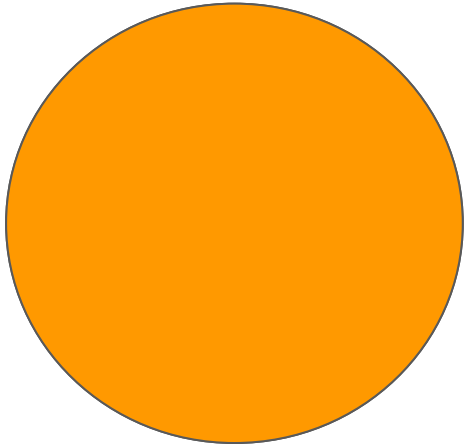


computational time

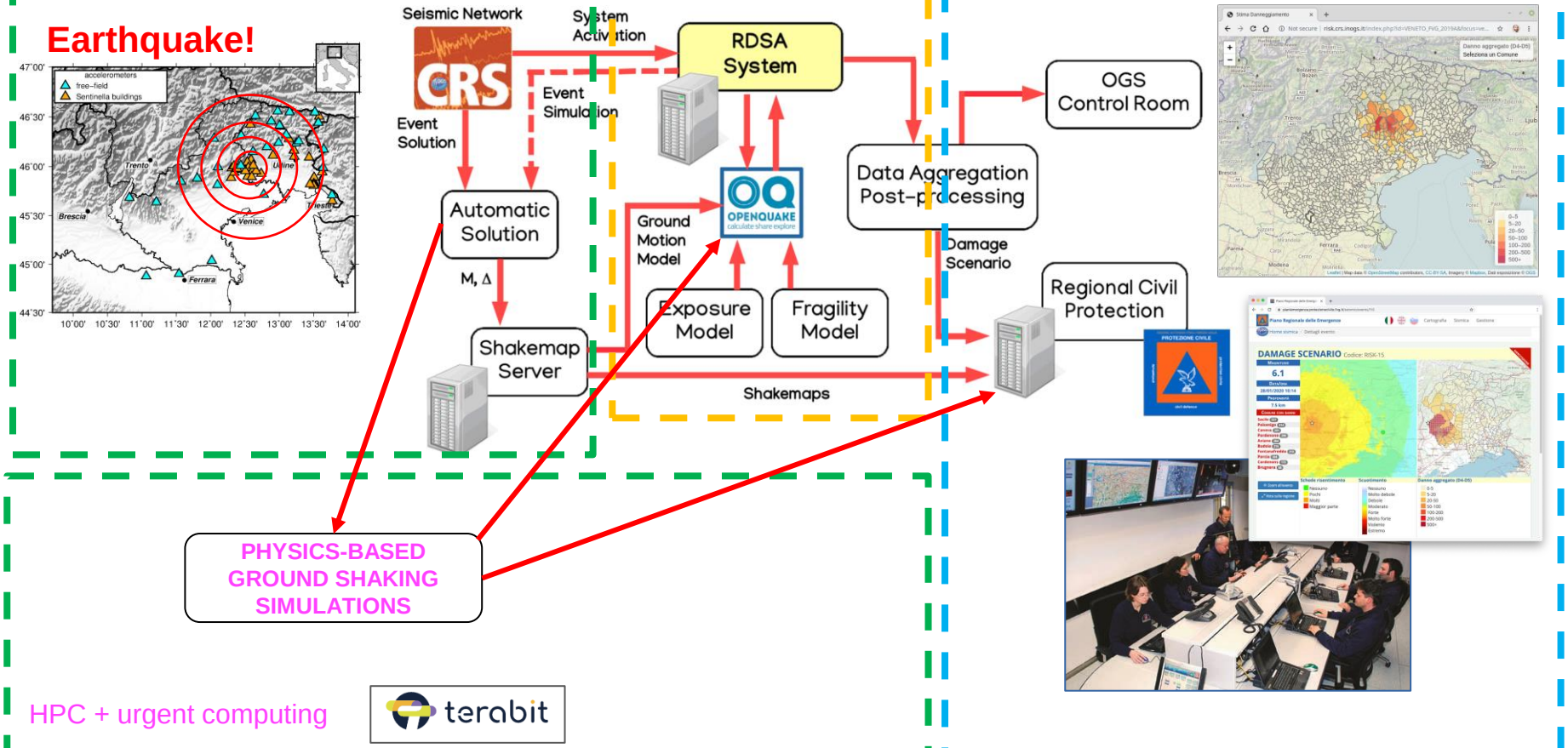
PHYSICS-BASED GROUND MOTION SIMULATIONS







OGS operational infrastructure: PBS module

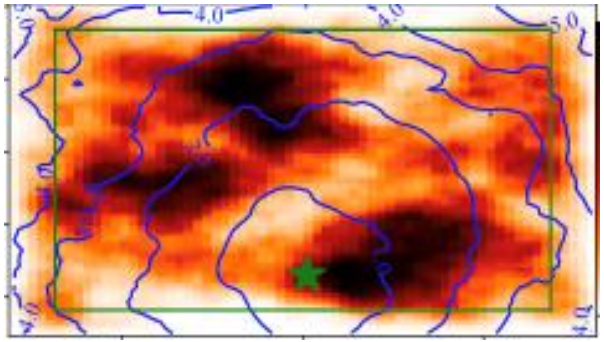


Physics-based ground shaking simulations

Different approaches offer varying precision based on parameter availability and applications

EARTHQUAKE SOURCE

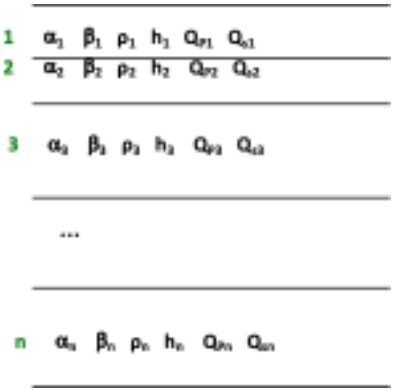
Point / Extended

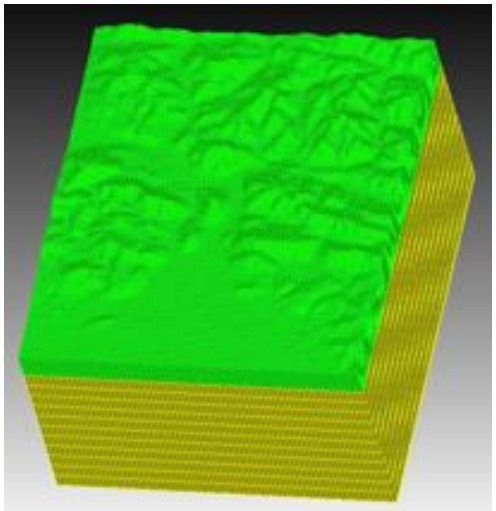


L, W, location nucl., fault coordinates, fc, rise time distribution, rupture velocity distribution, slip distribution

CRUSTAL MODEL

1D / 3D





Towards near-real time

Development of **RAPIDS** (***RA**pid input for **P**hys**I**cs-base**D** ground motion **S**imulations*), a Python tool to fasten earthquake modelling and post-processing by **automating the generation of all the inputs and outputs.**

EARTHQUAKE SOURCE

Point / Extended

UCSB rupture generator *(Crempien and Archuleta, 2015)*

SYNTHETIC SEISMOGRAM COMPUTATION

1D / 3D

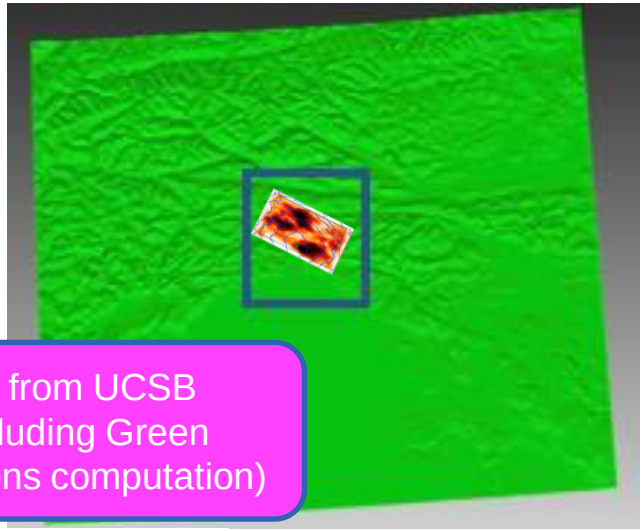
UCSB code (*Crempien and Archuleta, 2015* with Green Functions by *Zhu and Rivera, 2001*)

commercial software CUBIT for mesh generation +

spectral element code SPEED (*Mazzieri et al., 2013*)

Towards near-real time

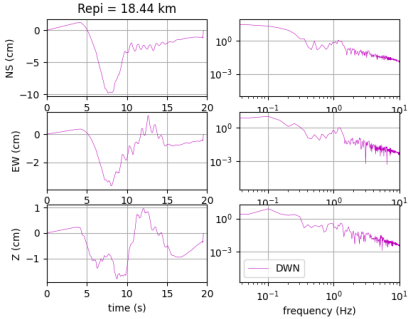
Definition of area of interest (i.e. target sites) as a function of location and M and fault geometry



Rupture source generation (UCSB)

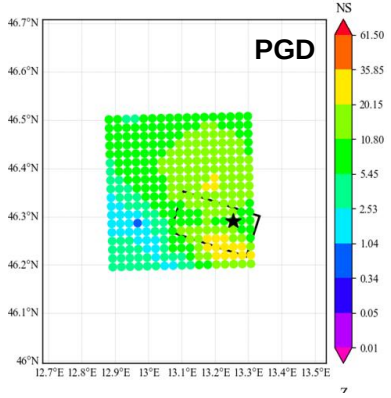
LF from SPEED (including mesh generation in CUBIT)

HF from UCSB (including Green Functions computation)



stitch of LF and HF

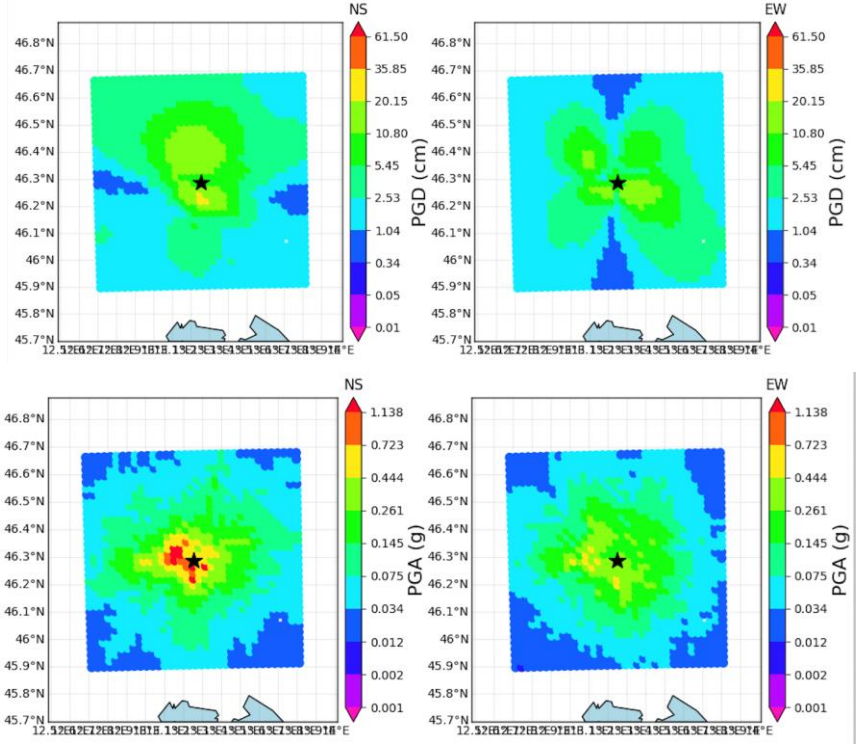
Plotting and extraction of relevant parameters and mapping



Physics-based ground shaking scenarios

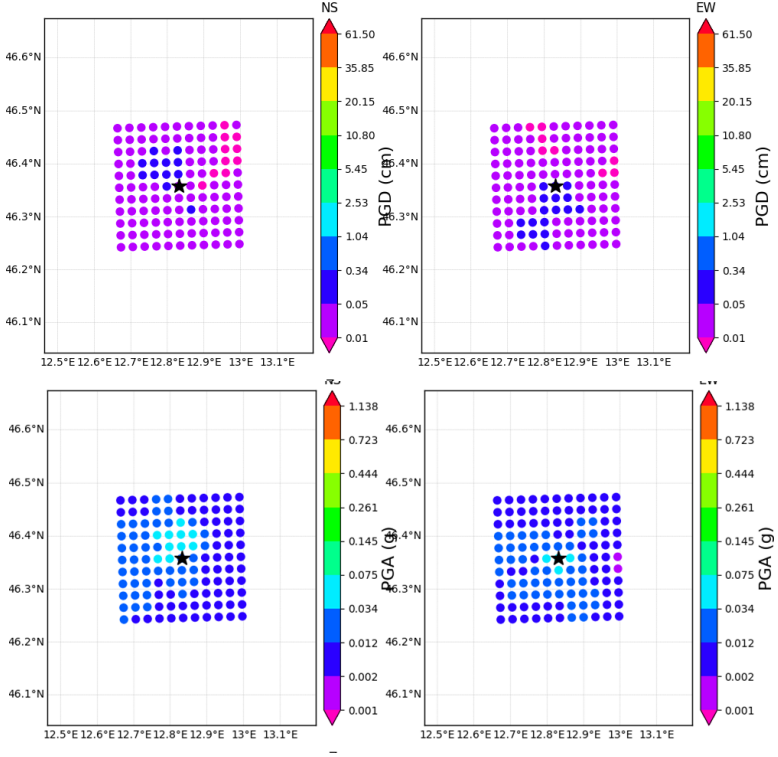
Friuli Earthquake
6th May 1976, Mw 6.4

80 x 80 km

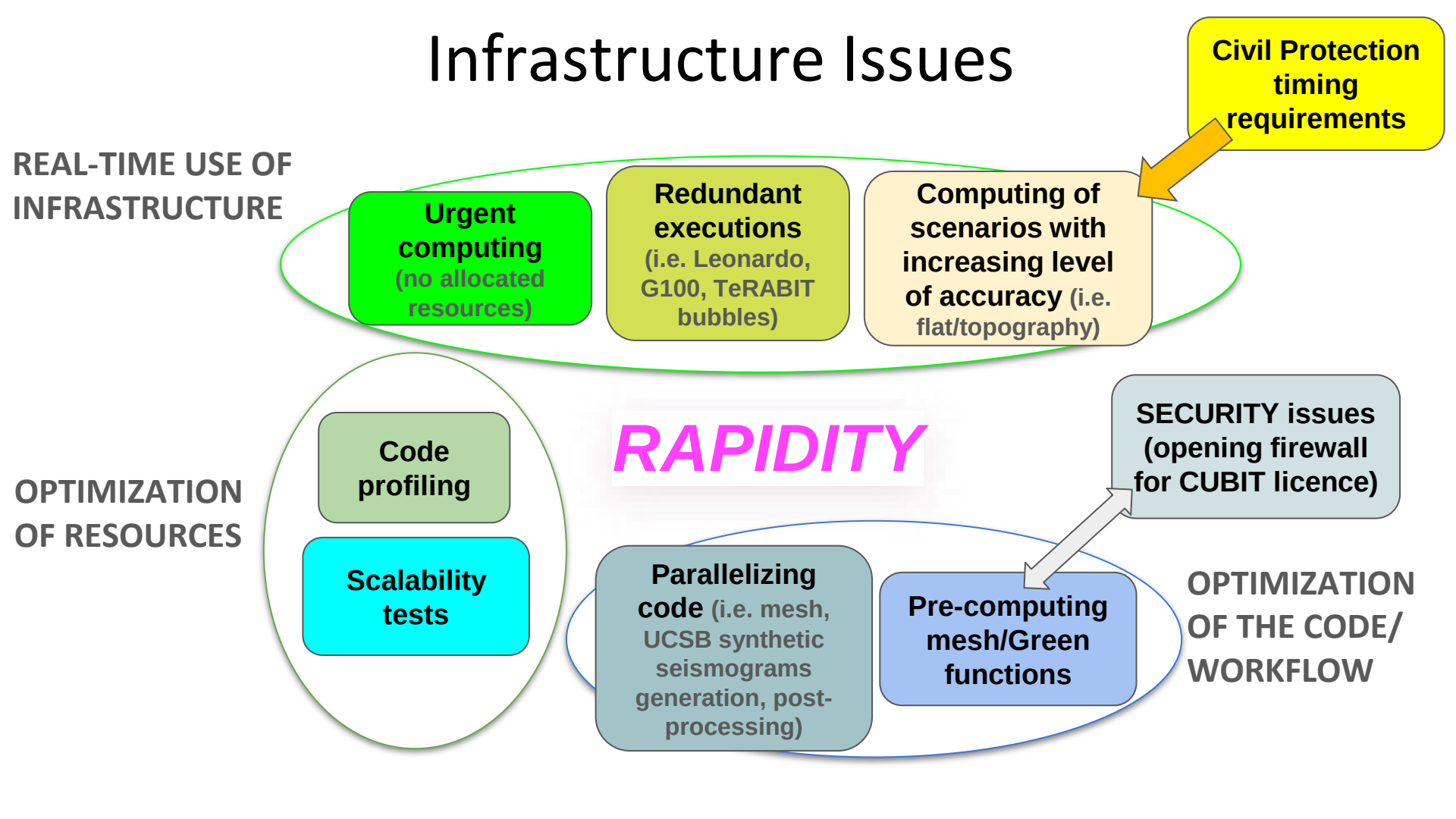


Socchieve Earthquake
27th March 2024, Mw 4.2

30 x 30 km



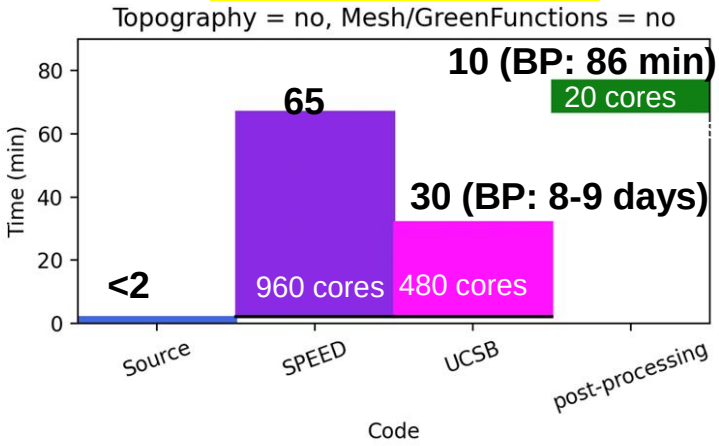
Infrastructure Issues



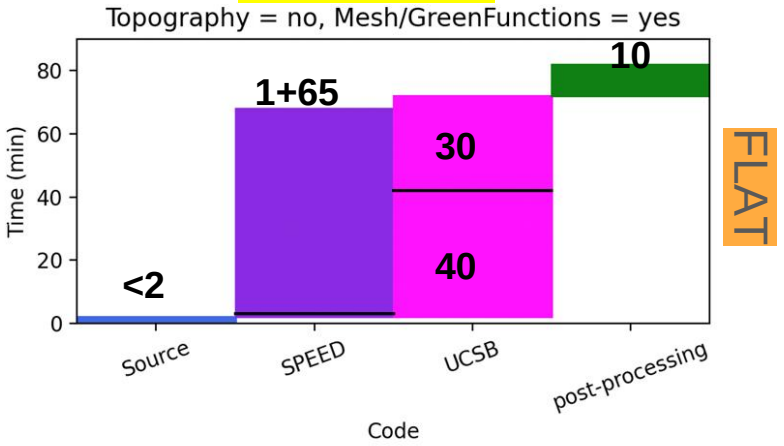
Execution times - G100

6/05/1976 Friuli earthquake, Mw 6.4

PRE-COMPUTED

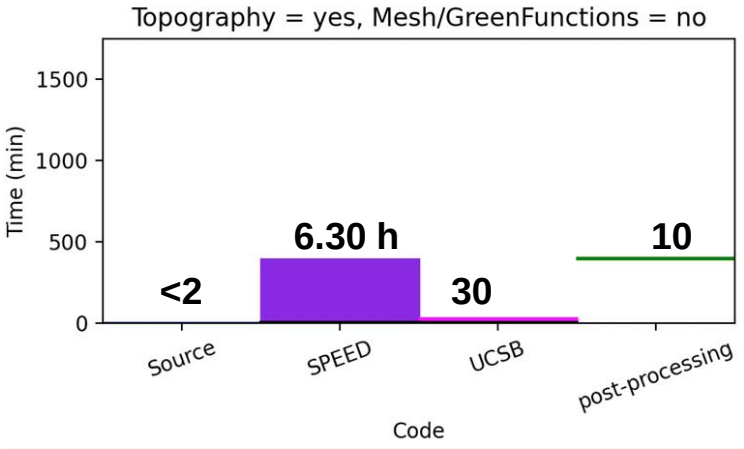


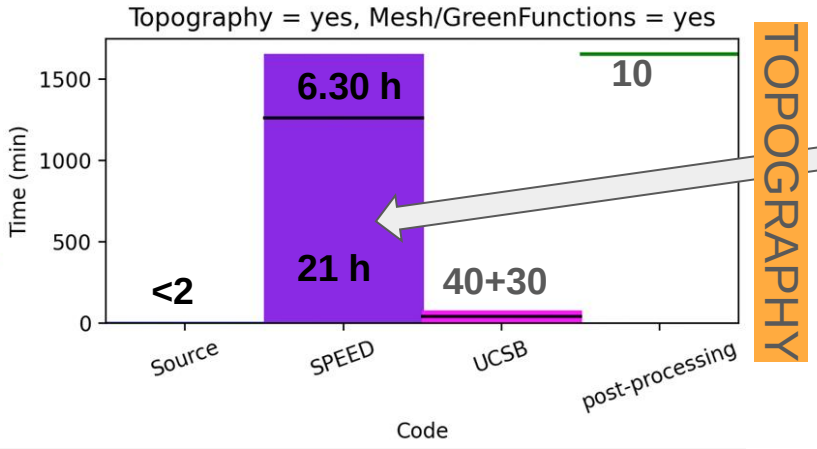
REAL-TIME



FLAT

BP = before parallelization





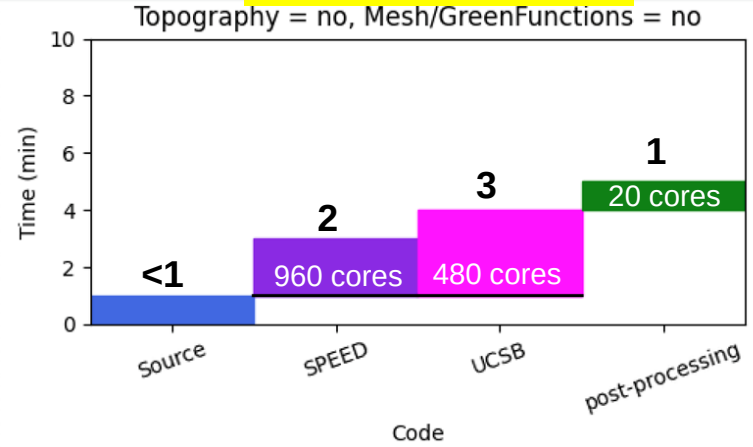
TOPOGRAPHY

need optimization and parallelization!!!

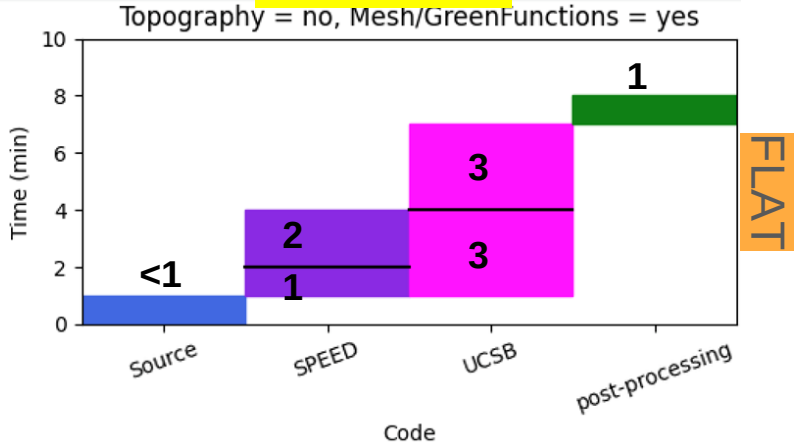
Execution times - G100

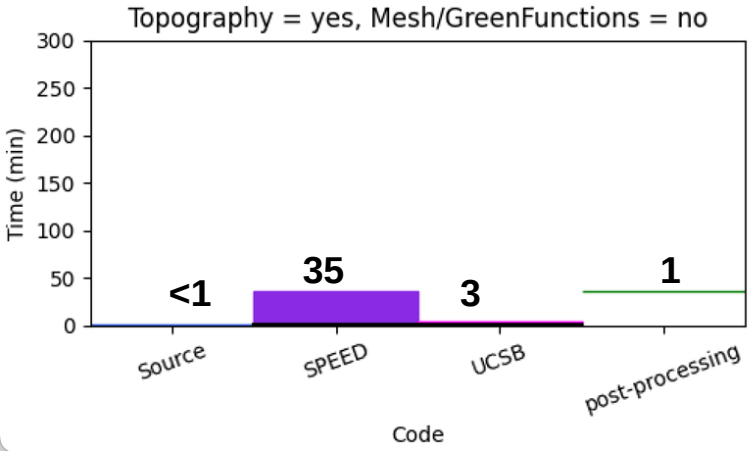
27/03/2024 Socchieve earthquake, Mw 4.2

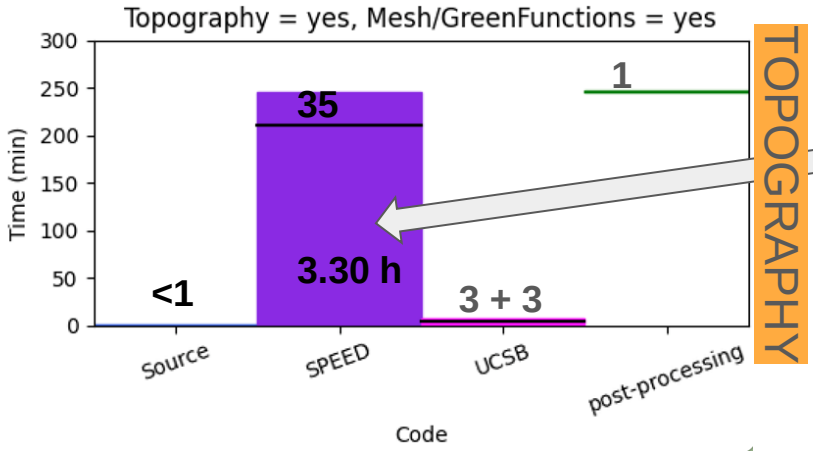
PRE-COMPUTED



REAL-TIME







need optimization and parallelization!!!

PBS module workflow

From OGS server

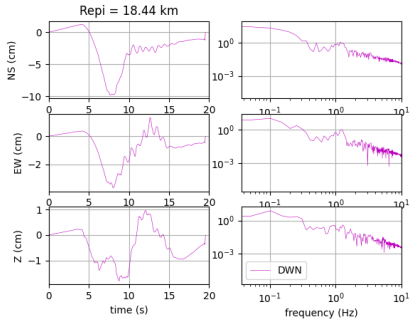
API interface (M, location, focal mechanism)

Definition of area of interest (i.e. target sites) as a function of location and M and fault geometry

Rupture source generation (UCSB)

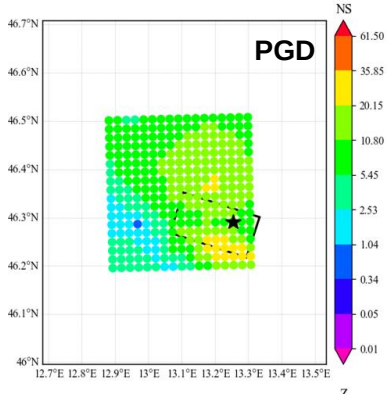
LF from SPEED (including mesh generation in CUBIT)

HF from UCSB (including Green Functions computation)



stitch of LF and HF

Plotting and extraction of relevant parameters and mapping



Webserver, email? (maps)

To OGS server

Many thanks to…

Claudia Battista, Mauro Campanella, Massimo Carboni (GARR)

Silvia Calegari, Claudio Grandi, Giacinto Donvito (INFN)

Mirko Cestari, Lucia Rodriguez Munoz, Fabio Pitari, Debora Testi (CINECA)

Giorgio Bolzon, Stefano Salon, Valerio Poggi, Tommaso Scarpa (OGS)

And everyone else involved in the project activities!

Thanks for your attention!

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