# Urgent computing for earthquakes.

**Marisol Monterrubio & Marta Pienkowska**

Barcelona Supercomputing Center - Spain
ETH - Zurich

DT-GEO

This project has received funding from the European Union's Horizon research and innovation programme under the grant agreement No 101058129

# Urgent Computing

- The computation operates under **strict deadline** after which the computational results may have little practical value
- The onset of events that need the computation in mostly **unpredictable**
- The computation requires **significant computational** resource usage (capacity/capability)

## Motivation:

# Urgent Computing for Natural Hazards

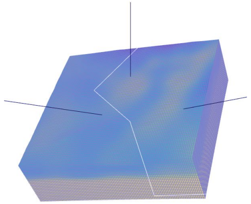
Link together

- HPC capacity/capability supercomputers
- State-of-art physics-based simulation codes
- Readily available data
- HPDA High Performance data analytics and AI tools

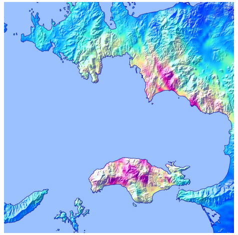
**To provide insights into the impacts and potential damages immediately after the occurrence of an extreme event**

# Urgent Computing for seismic simulations

## Resilience Workflow



SALVUS
IMAGE EVERYTHING



analysis — pre-processing — HPC simulations — post-processing

Source location
Magnitude estimation
Grid generation
Ask for resources

Launch in supercomputer
Filter data
Build maps
Uncertainty quantification
Reach conclusions

minutes / hours

**Why to use 3D-physics based seismic simulations?**

- Full time-histories
- Uniform sampling in space
- Sensitive to uncertainties in different ways than current approaches

The high resolution of this approach can complement empirical GMMs.

# Challenges

- Obtaining **high-resolution Earth models** without significant manual efforts.
- Rapidly **constraining source parameters** to reflect intra-event variability with minimal computational cost and accurately estimating the impact of parameter variations in the outcome of simulations (i.e. sensitivity to parameter uncertainties).
- Ensuring fast and reliable results with **urgent access to computational resources** and smart management of all workflow components.

# Urgent Computing Workflow for Earthquakes

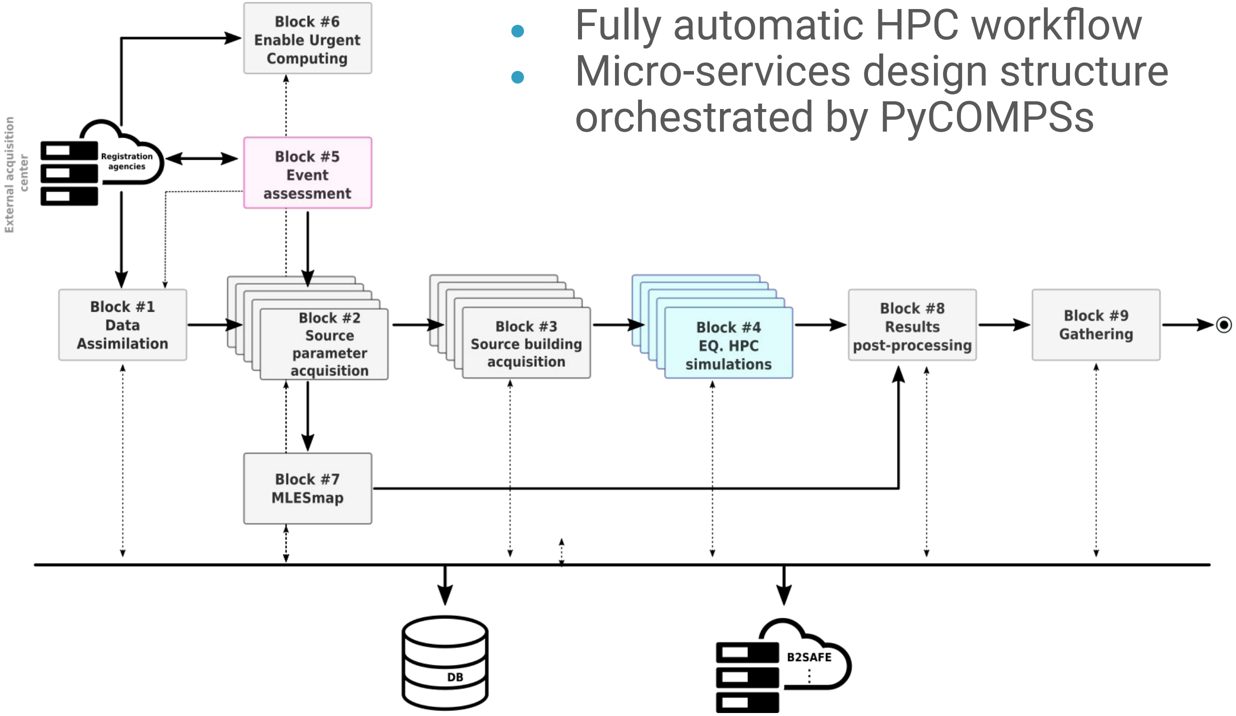
The development of an operational UC workflow for earthquakes involves the deployment of advanced tools and a complex task chain.

ChEESE
www.cheese-coe-eu

eFlows4HPC

DT-GEO

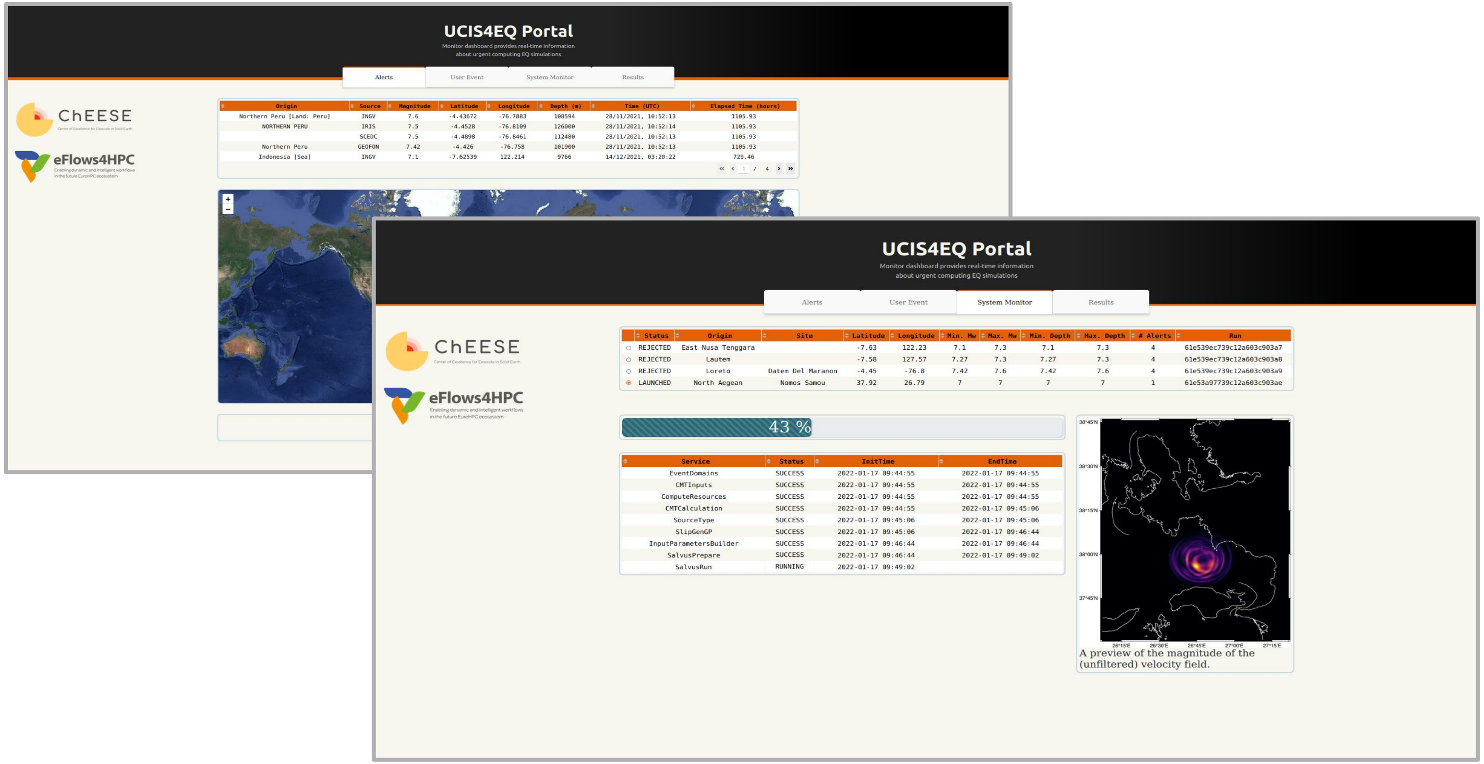
# Urgent Computing Integrated Services for Earthquakes (UCIS4EQ)




- Fully automatic HPC workflow
- Micro-services design structure orchestrated by PyCOMPSs

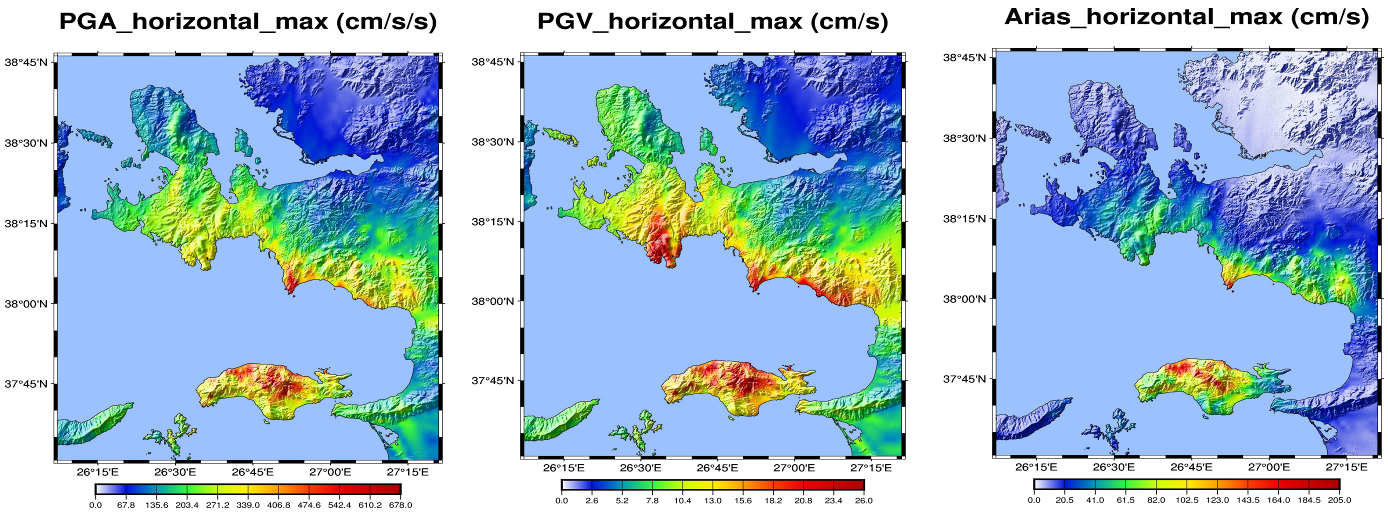
**Highlighting excellent innovations 2024**

# Urgent Computing Integrated Services for Earthquakes (UCIS4EQ)



# Urgent Computing Integrated Services for Earthquakes (UCIS4EQ)

## Mw 7.0 Samos-Izmir, 2020

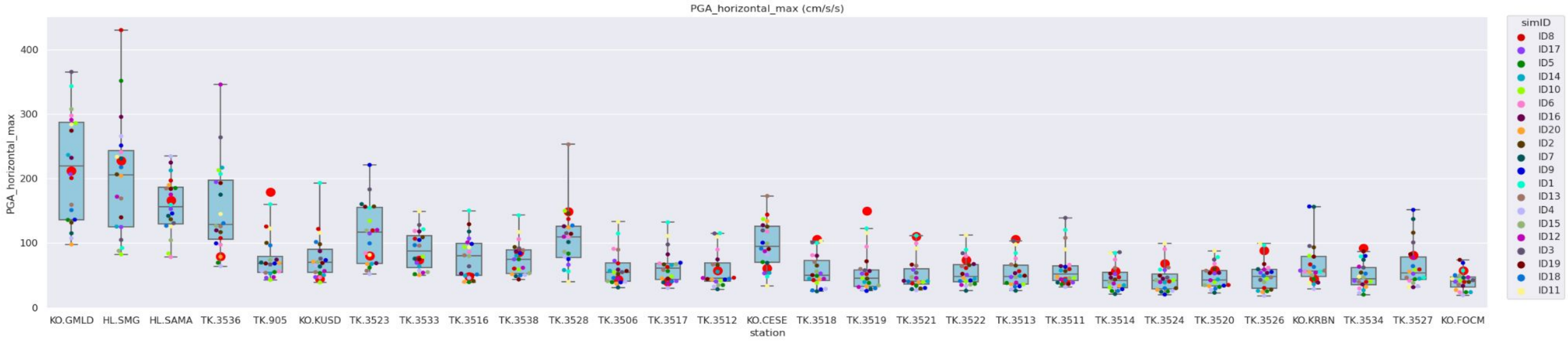


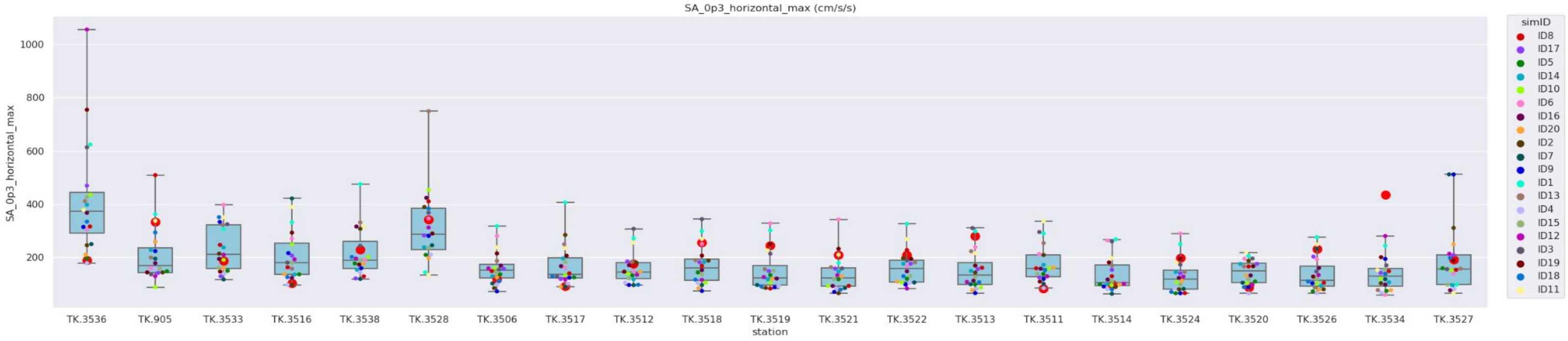

- 4,012,250 number of mesh elements
- Domain: 110km in longitude, 140km in latitude, and 35km in depth
- **Up to 5 Hz**

- 22 simulations
- **1h20m** wallclock per simulation
- 90 GPUs (Piz Daint) per simulation

# Urgent Computing Integrated Services for Earthquakes (UCIS4EQ)

## Mw 7.0 Samos-Izmir, 2020



# Conclusions

- Successful end-to-end executions of the UCIS4EQ workflow in different European earthquakes. The results are encouraging, with synthetic parameters reproducing the right orders of magnitudes observed in the recorded data.

- When well-calibrated, our results could complement GMPEs for rapid hazard assessment.

- We can boast a first working prototype, but a lot of work remains:
    - Improved rapid calibration of the source parameters, including uncertainty estimates.
    - New velocity models (and testing sensitivity of results)

- Incorporate machine learning capabilities for fast simulation-based predictions at lower frequencies.

- Towards an operational service tested in the Mexican Seismological Service

# THANK YOU

marisol.monterrubio@bsc.es
marta.pienkowska@eaps.ethz.ch

@dtgeo_eu

This project has received funding from the European Union's Horizon research and innovation programme under the grant agreement No 101058129