

UCIS4EQ applied to Mediterranean earthquakes

M. MONTERRUBIO-VELASCO (1), M. PIENKOWSKA (2), J.E. RODRIGUEZ (1), L. MINGARI (1), J. DE LA PUENTE (1)

- 1. Barcelona Supercomputing Center, Spain
- 2. ETH Zurich, Switzerland

Motivation

URGENT COMPUTING



UC for Natural Hazards links:

Paper Nr 964

• HPC

- Optimized State-of-art physics-based simulation codes
- Readily available highresolution data
- HPDA

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

Background











Poznan Supercomputing and Networking Center





Pillar III: UC workflows for Earthquakes and Tsunamis

The development and improvement of UC workflows for earthquakes and tsunamis involves the deployments of advanced tools and developments of complex tasks to ultimately bring them to an operational level.





1. Urgent Computing for Seismic simulations

2. Challenges

- 3. UCIS4EQ
- 5. Front-end
- 5. M7.0 Samos-Izmir 2020
- 6. M6.6 Kos-Bodrum 2017

1. Urgent Computing for Seismic simulations

Paper Nr 964

Resilience Workflow



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





- Obtaining **high-resolution Earth models** (velocity models that define the properties of the subsurface).
- Rapidly constraining source parameters 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 Integrated Services for Earthquakes

4. Front-end

				UCIS4EQ Portal Monitor dashboard provides real-time information about urgent computing EQ simulations													
		Alert	s	User Event	Sys	stem Monitor	Results										
	÷ Origin	Source	Magnitude	≎ Latitude	Longitude	Depth (m)	<pre>time (UTC)</pre>	Elapsed Time	(hours)								
ChEESE	Northern Peru [Land: Peru]	INGV	7.6	-4.43672	-76.7883	108594	28/11/2021, 10:52:13	1105.93									
Center of Excellence for Execute in Solid Earth	NORTHERN PERU	IRIS	7.5	-4.4528	-76.8109	126000	28/11/2021, 10:52:14	1105.93									
	Northeast Deep	SCEDC	7.5	-4.4898	-76.8461	112480	28/11/2021, 10:52:13	1105.93									
	Indepenia (Sea)	TNCV	7.42	-4.420	-70.750	9766	20/11/2021, 10:52:15	729.46									
2FIOWS4HPC inabling dynamics and intelligent workflows	Thomesta (Sea)	1107		-7.02333		5700	14/11/1011, 03:10:11	« < 1 /	4 > >>								
									Alerts	N	UCIS4 Monitor dashboard about urgent User Event	EQ F	Porta I-time informati 2 simulations System Monito	n r	Results		
		1					¢ Status	¢ Origin	¢ Site	Latitude	e 🗘 Longitude	• Min. Mw	≑ Max. Mw ≎	Min. Depth	Max. Depth	¢ # Alerts	e Run
				ChEE	SE		 REJECTED 	East Nusa Tenggara		-7.63	122.23	7.1	7.3	7.1	7.3	4	61e539ec739c12a603c903a7
		and the second second		Carter of Excellence for Encore	volatio Solid Earth		 REJECTED 	Lauten		-7.58	127.57	7.27	7.3	7.27	7.3	4	61e539ec739c12a603c903a8
	and the second s						O REJECTED	Loreto	Datem Del Maranon	-4.45	-76.8	7.42	7.6	7.42	7.6	4	61e539ec739c12a603c903a9
		_	_				EAUNCHED	North Aegean	Nomos Samou	37.92	26.79	7	7	7	7	1	61e53a97739c12a603c903ae
			E In	EFlows4 nabling dynamic and Intel hthe future EuroHPC ecco	IHPC ligent workflows system				43 %						38*457N	(ma	A Contraction of the contraction

Service	🗢 Status 🗘	InitTime	EndTime	
EventDomains	SUCCESS	2022-01-17 09:44:55	2022-01-17 09	44:55
CMTInputs	SUCCESS	2022-01-17 09:44:55	2022-01-17 09	44:55
ComputeResources	SUCCESS	2022-01-17 09:44:55	2022-01-17 09	44:55
CMTCalculation	SUCCESS	2022-01-17 09:44:55	2022-01-17 09	45:06
SourceType	SUCCESS	2022-01-17 09:45:06	2022-01-17 09	45:06
SlipGenGP	SUCCESS	2022-01-17 09:45:06	2022-01-17 09	46:44
InputParametersBuilder	SUCCESS	2022-01-17 09:46:44	2022-01-17 09	46:44
SalvusPrepare	SUCCESS	2022-01-17 09:46:44	2022-01-17 09	49:02
SalvusRun	RUNNING	2022-01-17 09:49:02		



8

Paper Nr 9 964

Mw 6.9 Samos-Izmir 2020

- Off-shore the North coast of Samos Island in the eastern Aegean Sea
- 2020-10-30 11:51:27 (UTC)
- 118 fatalities, \sim 100 injuries, collapse of structures
- Local high-intensity effects, Tsunami run-up



Source: https://earthquake.usgs.gov/earthquakes/eventpage/us7000c7y0/shakemap/pga

5. Mediterranean Earthquakes: Samos-Izmir

- 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 ensemble

Paper Nr

964

10

 90 GPUs (Piz Daint) per simulation



5. Mediterranean Earthquakes: Samos-Izmir





11

6. Mediterranean Earthquakes: Kos-Bodrum

 M6.6 Off-shore between the Bodrum Peninsula (Turkey) and the Greek Island of Kos, in the eastern Aegean Sea

12

- 2017-07-20 22:31:11 (UTC)
- 2 fatalities, hundreds injuries, significant structural damage
- Tsunami with wave heights reaching 1.4 m



6. Mediterranean Earthquakes: Kos-Bodrum

- 2,432,623 number of mesh elements
- Domain: 120km in longitude, 100km in latitude, 20km in depth

- 24 simulations
- 57m wall clock per ensemble
- 54 GPUs (Piz Daint) per simulation

Paper Nr

....

13

• Up to 5 Hz





- The first end-to-end executions of the UCIS4EQ workflow take as use-case two Mediterranean earthquakes, Mw 6.9 Samos-Izmir, 2020, and Mw 6.6 Kos-Bodrum, 2017.
- The results are encouraging, with synthetics reproducing the right orders of magnitude 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 of the Earth, including testing their effects on results.
- Machine learning capabilities for fast simulation-based predictions at lower frequencies.



Thank you!

Marisol Monterrubio-Velasco marisol.monterrubio@bsc.es





This project has received funding from the European High-Performance Computing Joint Undertaking (JU) under grant agreement No 955558. The JU receives support from the European Union's Horizon 2020 research and innovation programme and Spain, Germany, France, Italy, Poland, Switzerland, Norway.

🖄 Springer | Publishing Partner