ChEESE

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Center of Excellence for Exascale in Solid Earth

e-infrastructures and natural hazards. The Center of Excellence for Exascale in Solid Earth (ChEESE)

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Centers of Excellence (CoE)

Centers of Excellence have been funded under H2020 in order to:

- Promote research in HPC **applications** towards highly scalable, optimised codes and the path to Exascale performance
- Provision of **services** supporting different usage models for the community needs addressing the full scientific/industrial workflow
- Commitment to the **co-design** approach, including the identification of suitable applications relevant to the development of HPC technologies towards Exascale
- Provide specialised **training** and capacity building for increased adoption of advanced HPC in industry and academia
- Widening the **access to codes** and fostering transfer of know-how to user communities

ChEESE General Objectives

1. Preparation of **10 flagship codes** in the area of Solid Earth
2. To develop **12 Pilot Demonstrators** (PDs) and related **workflows** to enable services oriented to society on hazard assessment, urgent computing, and early warning forecast
3. Engage with the European Plate Observing System (EPOS) to facilitate **access to HPC applications**, infrastructures and large volumes of data across the SE Community.
4. In collaboration with the Consortium stakeholders (IUB), test the services in an **operational environment** and perform a market analysis for exploitation of services.
5. Provide specialized **training**, including on services and capacity building measures.

Consortium of 13 partners from 7 countries

	BSC	Barcelona Supercomputing Center
	INGV	Istituto Nazionale di Geofisica e Vulcanologia
	IMO	Icelandic Met Office
	ETH	Swiss Federal Institute of Technology
	HLRS	High Performance Computing Center Stuttgart
	CINECA	CINECA
	TUM	Technical University of Munich
	LMU	Ludwig Maximillians Universität
	UMA	Universidad de Malaga
	NGI	Norges Geotekniske Institutt
	IPGP	Institut de Physique du Globe de Paris
	CNRS	Centre National de la Recherche Scientifique
	BA	Bull SAS

10 flagship (open source) codes

No	Area	Code name
1	Computational Seismology	ExaHyPE
2		Salvus
3		SeisSol
4		SPECFEM3D
5	Magnetohydrodynamics	PARODY_PDAF
6		XSHELLS
7	Physical Volcanology	ASHEE
8		FALL3D
9	Tsunamis	T-HySEA
10		L-HySEA

- Intra-node optimization
- Thread parallelism
- Memory optimization
- Porting to accelerators
- Heterogeneous computing
- Load balance
- Fault tolerance
- Parallel asynchronous I/O
- Workflow manager
- Schedulers
- Pre-process utilities
- Visualization and post-process

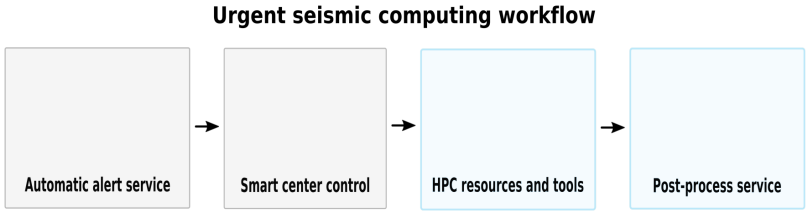
12 Pilot Demonstrators and related services

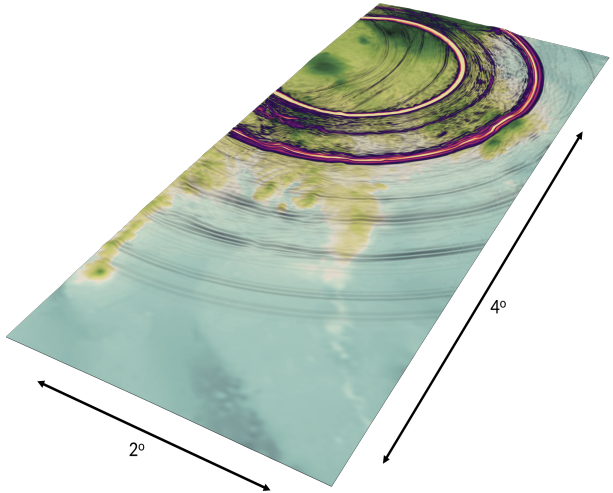
No	Pilot Demonstrator name	Area	Flagship Code	Related service
1	Urgent seismic simulations	CS	ExaHyPE, Salvus, SPECFEM3D	**Urgent computing**
2	Faster than real-time tsunami simulations	T	T-HySEA, L-HySEA	**Urgent computing**
3	High-resolution volcanic plume simulation	PV	ASHEE, FALL3D	**None**
4	Physics-based tsunami-earthquake interaction	CS	SeisSol, ExaHyPE	**None**
5	Physics-based probabilistic seismic hazard assessment (PSHA)	CS	SeisSol, ExaHyPE, AWP-ODC(*)	**Hazard assessment**
6	Probabilistic volcanic hazard assessment (PVHA)	PV	FALL3D	**Hazard assessment**
7	Probabilistic tsunami hazard assessment (PTHA)	T	T-HySEA L-HySEA	**Hazard assessment**
8	Probabilistic Tsunami Forecast (PTF) for early warning and rapid post event assessment	T	T-HySEA	**Early warning**
9	Seismic tomography	CS	SPECFEM3D, Salvus	**Other**
10	Array-based statistical source detection and restoration and Machine learning from monitoring	CS PV	BackTrackBB (**)	**None**
11	Geomagnetic forecasts	MHD	PARODY_PDAF, XSHELLS	**None**
12	High-resolution volcanic ash dispersal forecast	PV	FALL3D	**Urgent computing**

Service typologies: urgent seismic simulations

Codes	ExaHyPE, Salvus, SPECFEM3D
Lead partner(s)	ETH (L); BSC, INGV, LMU, TUM, IMO
TRL initial	3
TRL target	5-6

- Employ urgent supercomputing to obtain fast (hours) shaking maps for regions affected by recent earthquakes
- Physically-based 3D modelling of seismic waves
- Urgent seismic simulation workflow and protocol
- Test cases:
  - South Iceland Seismic zone
  - Turkey
  - Mexico

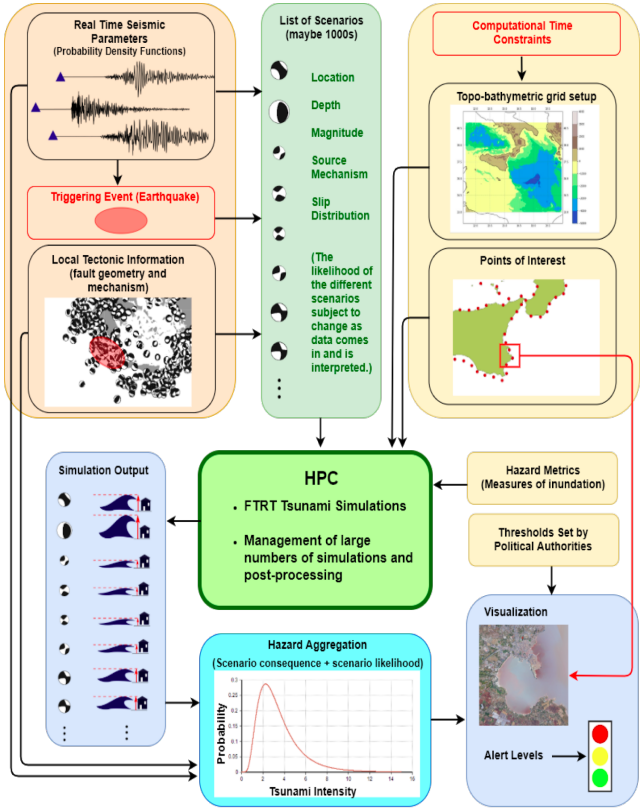




Service typologies: tsunami early warning system

Codes	Tsunami-HySEA
Lead partner(s)	INGV (L), UMA, NGI
TRL initial	3
TRL target	6-8

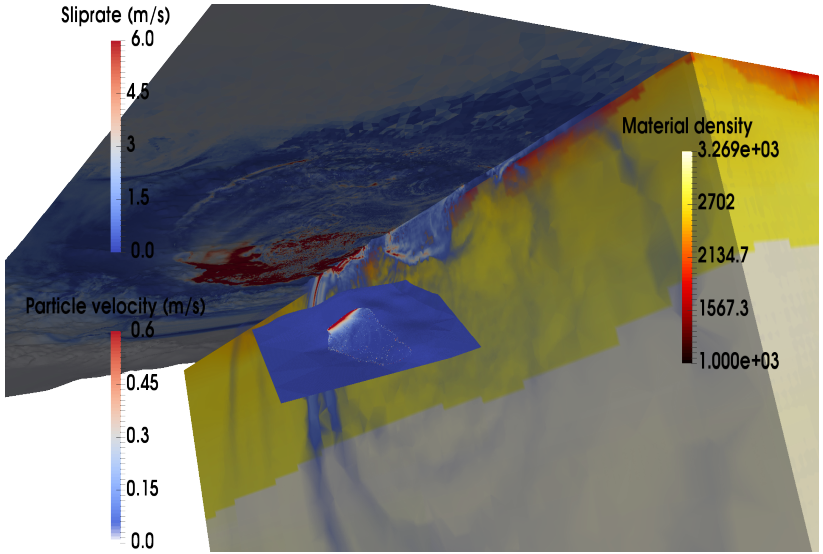
- Provide rapid tsunami impact probability distribution along the coasts
- Combines data on seismic parameters with large ensembles of FTRT tsunami simulations
- Prototype Implementation of the PTF workflow for the Mediterranean Sea, e.g. ARISTOTLE ENHSP (European Natural Hazard Scientific Partnership)



Service typologies: probabilistic hazard assessment
I. Physics-based PSHA

Codes	SeisSol, ExaHyPE, AWP-ODC(*)
Lead partner(s)	LMU, TUM, IMO, INGV, BSC
TRL initial	4
TRL target	6-7

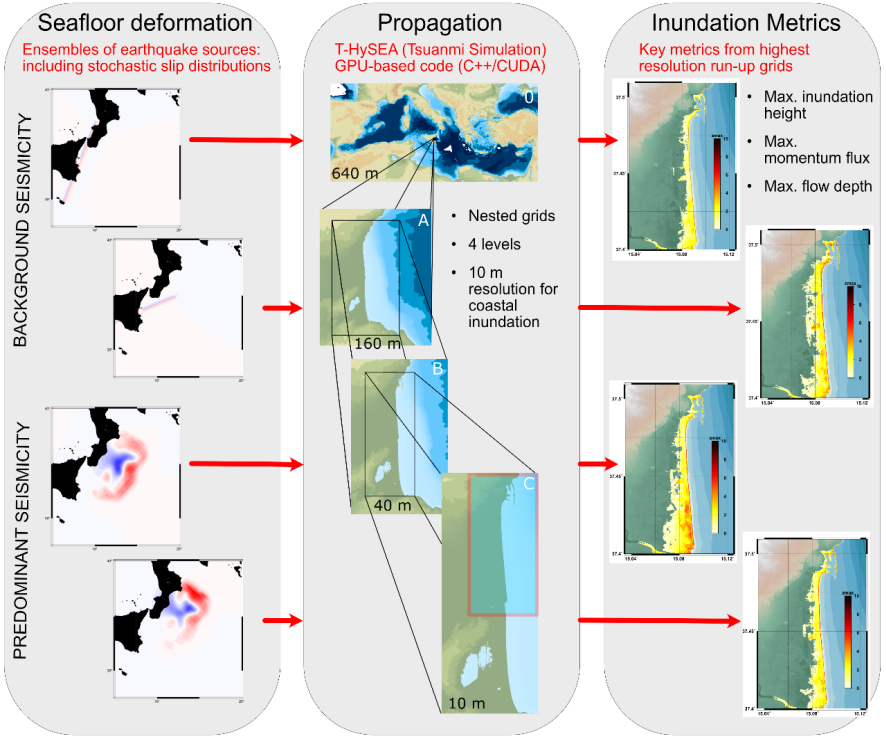
- Enable physics-based PSHA with state-of-the-art multi-physics earthquake simulation
- Target e-science environments: EPOS, USGS Science Applications for Risk Reduction (SAFRR), Nuclear Power Plants, insurance companies, etc.
- Test cases
  - Northern Iceland (Tjörnes Fracture Zone; TFZ)
  - Southern Iceland Seismic Zone



Service typologies: probabilistic hazard assessment
II. Tsunamis (PTHA)

Codes	T-HySEA and L-HySEA
Lead partner(s)	NGI (L); INGV, UMA
TRL initial	3
TRL target	5-7

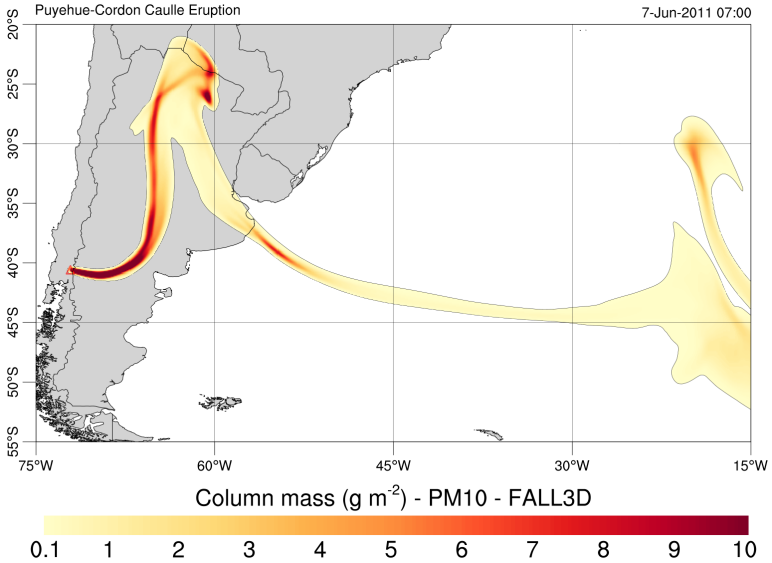
- Enable fast computation of tsunami-genesis covering uncertainty quantification
- Telescopic grids to combine regional tsunami simulations at oceanic scale with local inundation simulations
- Test case:
  - West Sicily



Service typologies: probabilistic hazard assessment
III. Volcanoes (PVHA)

Codes	FALL3D, ASHEE
Lead partner(s)	INGV (L); BSC, IMO
TRL initial	3
TRL target	6-7

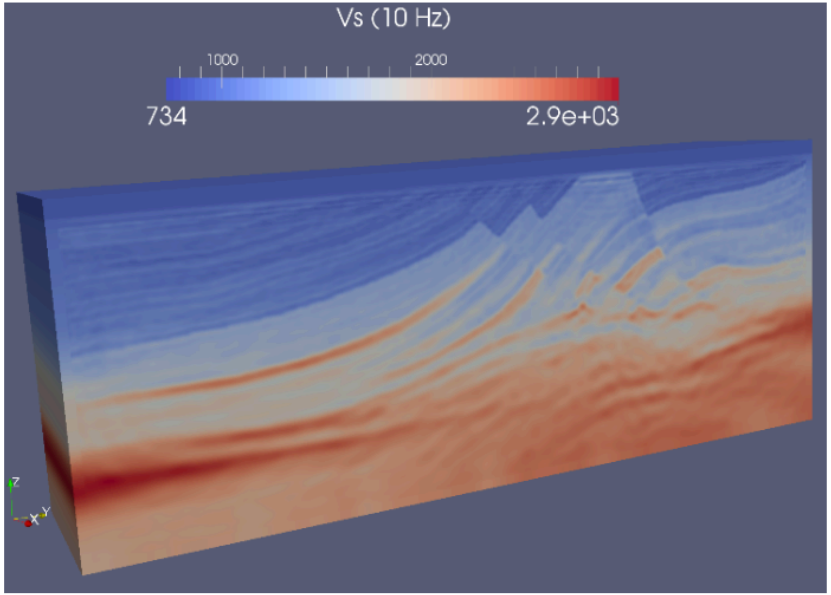
- Short-term and long-term PVHA
- Explore the natural variability associated to meteorological conditions and volcanic phenomena
- Proximal and distal tephra fallout and airborne ash concentration
- Test cases:
  - Campi Flegrei
  - Jan Mayen



Service typologies: seismic tomography

Codes	SPECFEM3D, Salvus
Lead partner(s)	INGV (L); CNRS, ETH
TRL initial	4
TRL target	6

- HPC workflow for subsurface imaging: from selection of data to visco-elastic FWI computation and post-processing of results
- Up to 15 Hz
- Test cases
  - Japan
  - Pyrenees
  - North Sea



A wide board of users and Industry

Future service integration

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