



ChEESE

Work Package 5: Farming Pilot Demonstrators

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WP5: Objectives

1

Implement novel features and coupling mechanisms in flagship codes for new PD workflows.

2

Develop the **new workflows** of the PD farm.



Flagship codes

No	Code	Area	Level	Lead
1	SeisSol	CS, T	1	LMU
2	SPECFEM3D	CS	1	CNRS
3	ExaHyPE	CS, T	2	TUM
4	Tandem	CS	2	LMU
5	xSHEELS	MHD	1	CNRS
6	HySEA	T	2	UMA
7	FALL3D	V	2	CSIC
8	OpenPDAC	V	2	INGV
9	LaMEM	GD	1	UM
10	pTatin3D	GD	1	SU
11	Elmer/Ice	GL	2	CSC

CS : computational seismology, T: Tsunami, MHD: Magnetohydrodynamics
V : Volcanology, GD : Geodynamics, GL Glacier hazards.



Task 5.1 : Novel features (physics) in flagship codes

Multiphysics

- coupling of codes
- new physical models

Multisource

- new sources for accurate representation
- forcing term

Multiscale

- capture physical effects from local to global scales

Timeline : Month 1 - Month 24

Deliverable D5.1 (TUM) : New version release of flagship codes

- Code version releases with the new functionalities available in the ChEESE-2P Zenodo repository



WP5: Task 5.2 Developments in Pilot Demonstrators

Pilot Demonstrator (PD): Workflow based on flagship codes

- Capacity/capability simulation on (pre-)exascale computer
- Farm 9 PDs (2 in CS, 2 in tsunamis, 2 in physical volcanology, 1 in MHD, 1 in geodynamics, and 1 in glacier hazards)
- Basic research, subsurface imaging, hazard assessment, urgent computing early warning system.
- Increase the Technology Readiness Level (TRL) of each PD by at least 2 points

Timeline : 7-42

Deliverables : D5.(2-10) (1 per PD)

TRL	1	2	3	4	5	6	7	8	9
	basic principles observed	technology concept formulated	experimental proof of concept	technology validated in lab	tech valid in relevant environment	demonstration in relevant environment	demonstration in operational environment	system complete and qualified	system proven in operational environment



WP5: Task 5.2 Developments in Pilot Demonstrators

No	PD name	Aera	Realted flagship codes	Initial TRL	Target TRL	Underpinning concept	ECC
1	Extreme-scale modeling of seismic hazards	CS	All CS codes	5	7	multiphysics multiscale	ECC1 ECC3
2	High-resolution seismic inversion and tomography	CS	SPECFEM3D	4	6	multisource	ECC1
3	Global tsunami hazard and uncertainty quantification	T	HySEA	6	8-9	multiscale	ECC6
4	Complex multi-source tsunami modeling	T	HySEA, ExaHype, SeiSol	3	5	multisource multiphysics	ECC4 ECC5
5	Ensemble-based volcanic dispersal at multiple scales	V	FALL3D	5	7-8	multiscale	ECC7 ECC9
6	Multiphase 3D volcanic explosion modeling	V	OpenPDAC	4	7	multiphysics multiscale	ECC8
7	The Earth's dynamo model	MHD	xSHELLS	3	5	multiscale	ECC10
8	Geodynamics to geohazards	GD	LaMEM, pTatin3D	3	5	multiscale	ECC11 ECC12
9	Glacial outburst floods	GL	Elmer/Ice	2	4	multiphysics	none



PD1 : Extreme-scale modeling of seismic hazards

LMU, TMU, CNRS, INGV

Problem description :

- Earthquake and seismic wave simulations

Objective :

- Improve the scalability and time-to-solution
- New features in model physics (visco-elasticity)
- IO capabilities for multiphysics coupling
- Mesh generation

Flagship codes : SeisSol, ExaHyPE, SPECfem3D, Tandem

Tasks : T5.1.1, T5.1.2, T5.1.3, T5.1.4

Deliverable : D5.1 (month 30)

TRL : 5 → 7



PD2 : High-resolution seismic inversion and tomography

CNRS, INGV

Problem description :

- High-resolution subsurface imaging
- Local scale (few km) → resolution of a few tens of meters

Objective :

- Computation of the initial guess model using travel time tomography
- Joint inversion with seismic and gravimetric data
- 2nd-order optimization method (Hessian)

Flagship code : SPECFEM3D

Task : T5.1.2

Deliverable : D5.7 (month 36)

TRL : 4→ 6



PD3 : Global probabilistic tsunami hazard and uncertainty quantification

INGV, NGI, TMU, LMU

Problem description :

- PTHA analysis : high resolution, any location worldwide
- new user-defined source treatment

Objective :

- Exploit tier-0 and tier-1 machines
- Provide enhanced capacity of carrying out multiscale (from global to local) PTHA at any location worldwide
- Interoperable with seismic hazard tools, Global Earthquake Models OpenQuake engine

Flagship code : HySEA

Task : 5.1.16

Deliverable : D5.8 (month 36)

TRL : 6 → 8-9



PD4 : Complex multi-source tsunami modeling

NGI, UMA, INGV, TMU, LMU, RBI, UM

Problem description :

- Tsunami generation and propagation
 - earthquakes, landslides, volcanoes
 - acoustic pressure and atmospheric forcing

Objective :

- integrate advanced source multiphysics with tsunami propagation models
- prepare models for Urgent Computing

Flagship code : HySEA, ExaHyPE, SeisSol

Tasks : T5.1.1, T5.1.3, T5.1.6

Deliverable : D5.3 (month 30)

TRL : 3 → 5



PD5 : Ensemble-based volcanic dispersal across multiple scales

CSIC, IMO, INGV

Problem description :

- multi-scale dispersion of volcanic eruption particles
- taking into account of winds from the local to the global scale

Objective :

- wind downscaling strategy to capture local-scale effects
- model nesting strategy for telescopic PVHA

Flagship code : FALL3D

Task : T5.1.7

Deliverable : D5.9 (month 36)

TRL : 5 →7-8





PD6 : Multiphase 3D volcanic explosion modeling

INGV, CIN, CSIC

Problem description :

- High-resolution simulations of explosions associated with water flashing
- Quantification of their hazards

Objective :

- Develop a multiscale simulation capability
- Models for mechanical and thermal non-equilibrium multiphase eruptive mixtures
- Ugent Computing workflow

Flagship code : OpenPDAC

Task : T5.1.8

Deliverable : D5.4 (month 30)

TRL : 4→ 7



PD7 : The Earth's dynamo model

CNRS, IPGP

Problem description :

- Earth magnetic field :
 - turbulent flow of liquid metal
 - high degree of scale separation (multiscale)

Objective :

- Simulate the geodynamo process with an unprecedented level of realism
- Assess the impact of turbulent flow on the short and long term working of the geodynamo
- Coupling with AI for small scales.

Flagship code : xSHELLS

Task : T5.1.5

Deliverable : D5.5 (month 30)

TRL : 3 →5





PD8 : Geodynamics to geohazards

UM, SU, CSIC, LMU

Problem description :

- Slow deformation of the solid Earth on a wide range of scales
- Stress state of the lithosphere → earthquakes, magma migration

Objective :

- Simulate any part of the Earth
- Export material properties and state of stress to other codes for multiphysics modeling
- Next generation GPU

Flagship code : LaMEM, pTatin3D

Tasks : T5.1.9, T5.1.10

Deliverable : D5.6 (month 30)

TRL : 3 → 5



PD9 : Glacial outburst floods

CSC, IMO, CNRS

Problem description :

- Modeling glacier failure process triggered by water level increase, sub-glacier eruptions, earthquakes
- massive displacements of water contained in glacial reservoirs

Objective :

- Couple subglacial-hydrology and ice-deformation models (multiphysics)
- traveling pressure-wave underneath a visco-elastic plate

Flagship code : Elmer/Ice

Task : T5.1.11

Deliverable : D5.10 (month 36)

TRL : 2 →4



WP5: Tasks

Task	Task name	Start	End	Lead	Contributor
Task 5.1	Novel features (physics) in flagship codes	1	24	CNRS	
5.1.1	SeisSol	-	-		LMU, TUM
5.1.2	SPECFEM3D	-	-		CNRS, INGV
5.1.3	ExaHyPE	-	-		TUM
5.1.4	TANDEM	-	-		LMU
5.1.5	xSHELLS	-	-		CNRS, IPGP
5.1.6	HySEA	-	-		UMA, IRB
5.1.7	FALL3D	-	-		CSIC, INGV
5.1.8	OpenPDAC	-	-		INGV
5.1.9	LaMEM	-	-		UM
5.1.10	pTatin3D	-	-		SU
5.1.11	ELMER/ICE	-	-		CSC
Task 5.2	Developments in Pilot Demonstrators	7	42	CNRS	



WP5: Deliverables

D	Deliverable name	Lead	Type	Level	M	Date
5.1	New version release of flagship codes	TUM	OTHER	PU	24	Dec 2024
5.2	Demonstrator of PD1	TUM	DEM	PU	30	Jun 2025
5.3	Demonstrator of PD4	NGI	DEM	PU	30	Jun 2025
5.4	Demonstrator of PD6	INGV	DEM	PU	30	Jun 2025
5.5	Demonstrator of PD7	CNRS	DEM	PU	30	Jun 2025
5.6	Demonstrator of PD8	UM	DEM	PU	30	Jun 2025
5.7	Demonstrator of PD2	CNRS	DEM	PU	36	Dec 2025
5.8	Demonstrator of PD3	UMA	DEM	PU	36	Dec 2025
5.9	Demonstrator of PD5	IMO	DEM	PU	36	Dec 2025
5.10	Demonstrator of PD9	CSC	DEM	PU	36	Dec 2025



After development PD will be used in WP6 for Simulation Cases (SC).

PD	1	2	3	4	5	6	7	8	9
SC	1.1 1.2 1.3	2.1	3.1	4.1	5.1 5.2	6.1 6.2	7.1	8.1 8.2	9.1 9.2



Thank you!



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