CINECA

Supporting **Research** and
the Italian **Academic System**
Since 1969

Leonardo: A simulator4Earth

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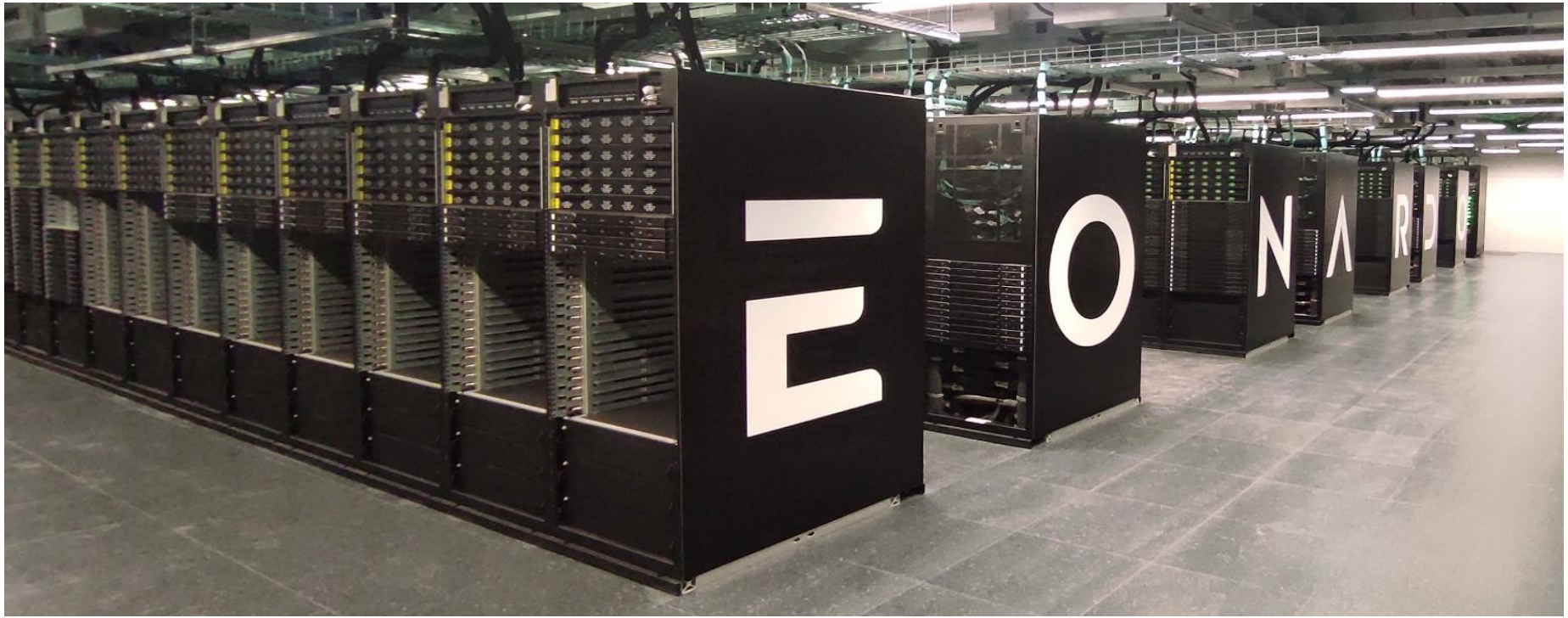
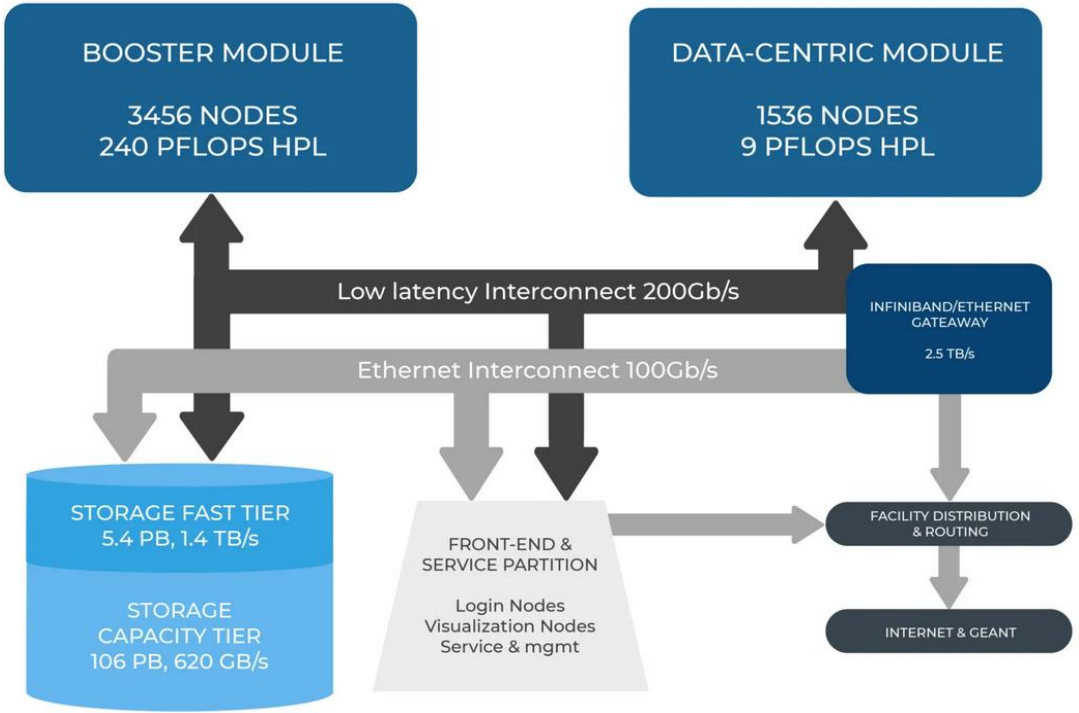
Leonardo



Leonardo: main figures

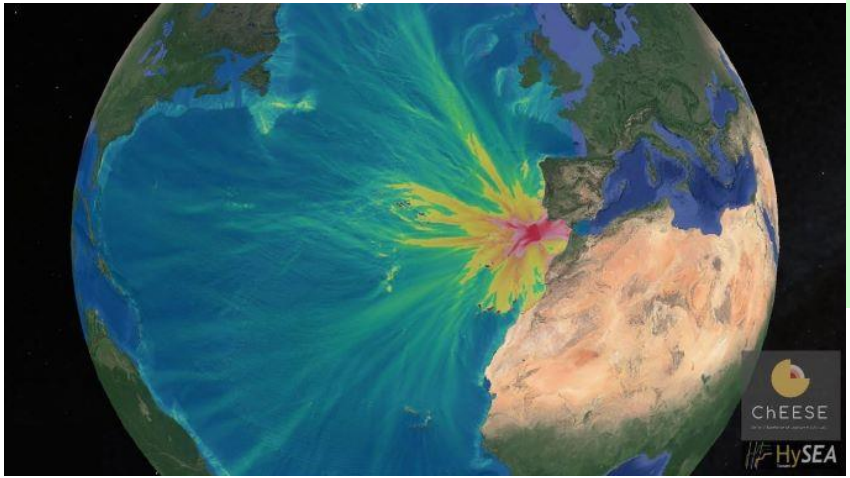
- 1.536 CPU-based nodes
  - 172.032 cores
- 3.456 GPU-based nodes
  - 13.824 GPU
  - 110.592 cores
- 155 Racks
  - 16 CPU racks
  - 116 GPU racks
  - 12 I/O racks
  - 1 System racks
  - About 300.000 Kg!
- Power Requirements
  - HPL: ~ 8.0 MW
  - Operational: ~ 6.0 MW



CINECA Marconi100 and Leonardo-Booster

	Marconi100	Leonardo-Booster
CPU	2 POWER9	1 Ice Lake
Cores	32 (16 x 2 POWER9)	32 (32 x 1 Ice Lake)
Memory	256 GB	512 GB
CPUs : Accelerators	2:4	1:4
Accelerators	4 Volta V100	4 Ampere based GPU
GPU-GPU bandwidth	150 GB/s	400 GB/s
Accelerator DP FLOPS (peak)	7,8 TFLOPS FP64	22,4 TFLOPS FP64 (TC)
Accelerator Memory	64 GB HBM2 (4 x 16 GB)	256 GB HBM2e (4 x 64 GB)
Accelerator Memory Bandwidth	3,6 TB/s (900 GB/s x 4 GPUs)	6,5 TB/s (1.6 TB/s x 4 GPUs)

Enabling Earth Science at Exascale: key aspects



Access to (pre)exascale hardware able to efficiently solve complex scientific challenging problems in Earth Science

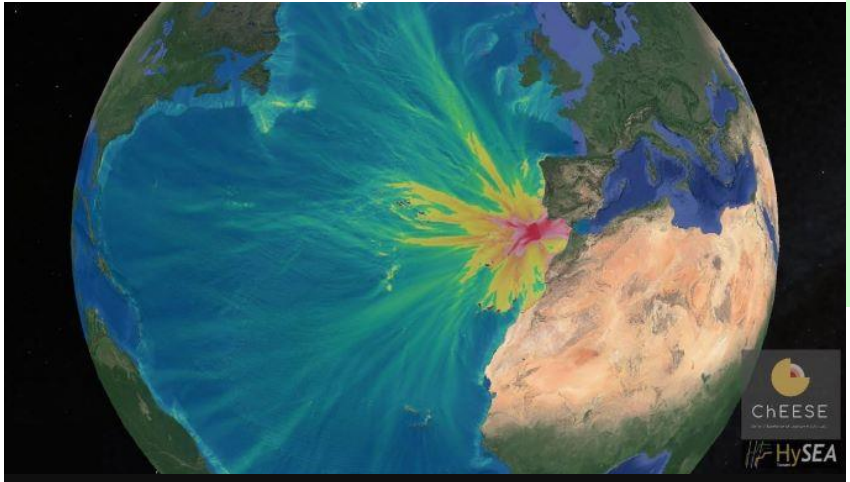
Enabling of available software to GPU architectures (porting issue)

Urgent computing

Use of highly optimized and tuned GPU enabled software able to efficiently run on current (pre)exascale available systems

Enabling of available software to different GPU architectures (performance portability issue)

Enabling Earth Science at Exascale: key aspects



Access to (pre)exascale hardware able to efficiently solve complex scientific challenging problems in Earth Science

Institutional level:
Agreements (DT-GEO, Geo-INQUIRE,DestinE,...)

National level:
ISCRA (B,C)

European level:
EuroHPC calls

Italian SuperComputing Resource Allocation - ISCRA

- Open to all scientific researchers affiliated to an Italian research organization needing large allocations of computer time, supporting resources and data storage to pursue transformational advances in science.
- Projects' Principal Investigators are expected to be affiliated to an Italian institution, while no restriction is applied for the Co-PI and collaborators.
- Further information and for applying

[ISCRA | SCAI (cineca.it)]

- **ISCRA C:**
  - **Small Projects for research, test and developments**
  - **up to 10.000 GPU hours on Leonardo**
  - **Duration: maximum 9 months**
  - **Easy to submit (few data needed)**
  - **Only technical evaluation**
  - **Continuous submission, 1 cut-off per month**
- **ISCRA B:**
  - **Mid-size projects**
  - **up to 250.000 GPU hours on Leonardo**
  - **Duration: maximum 1 year**
  - **More detailed proposal (some pages, scalability plot, detailed budget estimation, technical and scientific details needed)**
  - **Technical and Scientific evaluation**
  - **2 calls per year**

EuroHPC – Benchmark and Development Access Calls

- Open to researchers from academia, research institutes, public authorities and industry established or located in a Member State or in a country associated to Horizon 2020, are eligible to apply.
- Further informations and for applying:

[EuroHPC JU Call for Proposals for Benchmark & Development Access (europa.eu)]

EuroHPC Joint Undertaking

- **Benchmark call:**
  - Small Project for benchmarking (scalability tests…)
  - allocation on Leonardo: Tbd (similar to ISCRA C)
  - Duration: maximum 3 months
  - Administrative check
  - Technical evaluation
  - Continuous submission, 1 cut-off per month
- **Development call:**
  - Small, mid-size project for development, optimisation, porting…
  - allocation on Leonardo: Tbd (similar to ISCRA C)
  - Duration: maximum 1 year
  - Administrative check
  - Technical evaluation
  - Continuous submission, 1 cut-off per month

EuroHPC – Regular Access Mode Calls

- Open to researchers from academia, research institutes, public authorities and industry established or located in a Member State or in a country associated to Horizon 2020, are eligible to apply.
- Further informations and for applying:

[EuroHPC JU Call for Proposals for Regular Access Mode (europa.eu)]

EuroHPC Joint Undertaking

- Three distinctive calls:
  - Scientific access track to enable progress of science in the domain sectors
  - Industry access track for proposals with a PI from industry
  - Public administration access track for proposals with a PI from public sector
- allocation on Leonardo:
  - Total resources: ~ 300.000 node-hours
  - Minimum amount per project: 20.000 node-hours
- Duration: maximum 12 months
- Administrative check
- Scientific and Technical evaluation (excellence)
- Continuous submission, next cut-off in July

EuroHPC – Extreme Scale Access Mode Calls

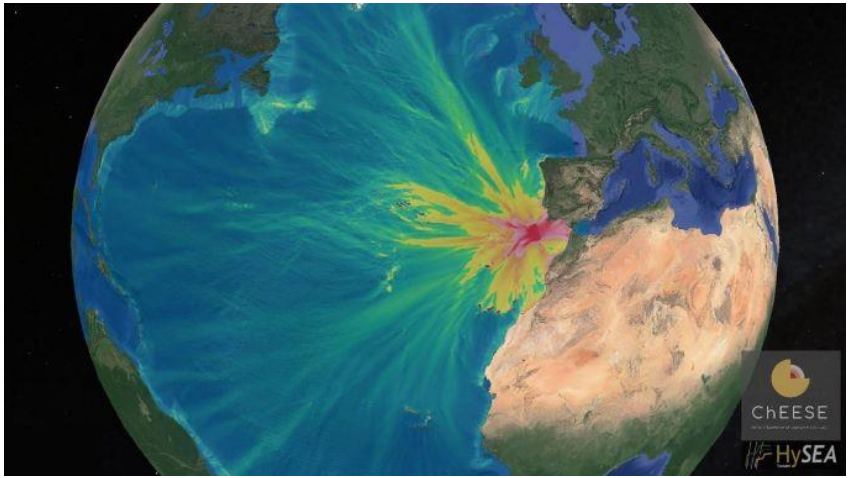
- Open to researchers from academia, research institutes, public authorities and industry established or located in a Member State or in a country associated to Horizon 2020, are eligible to apply.
- Further informations and for applying:

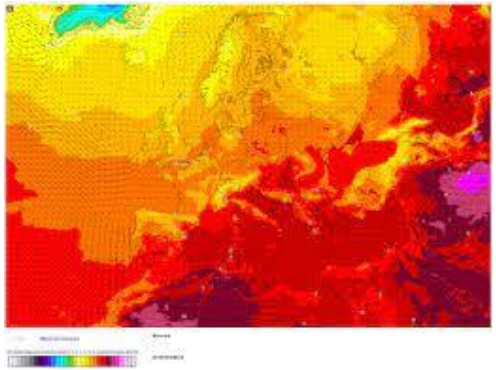
[EuroHPC JU Call for Proposals for Extreme Scale Access Mode (europa.eu)]

EuroHPC Joint Undertaking

- Three distinctive calls:
  - Scientific access track to enable progress of science in the domain sectors
  - Industry access track for proposals with a PI from industry
  - Public administration access track for proposals with a PI from public sector
- allocation on Leonardo:
  - Total resources: ~ 4.000.000 node-hours
  - Minimum amount per project: 420.000 node-hours
- Duration: one-year access or two years (multi-year access)
- Administrative check
- Scientific and Technical evaluation (excellence)
- Continuous submission, next cut-off in September

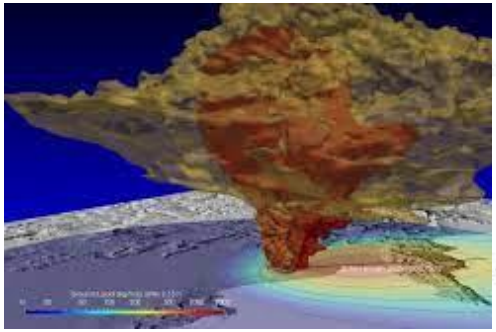
Enabling Earth Science at Exascale: key aspects

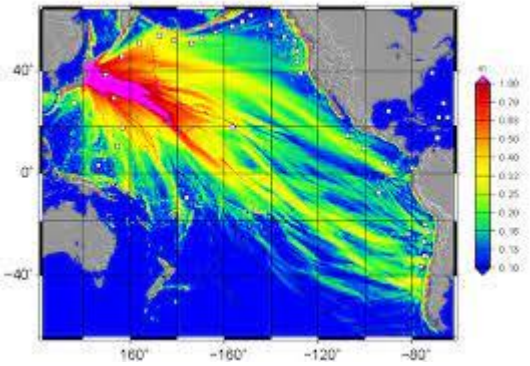




Case studies in different sectors (seismology, volcanology, tsunamis...)

Use of highly optimized and tuned GPU enabled software able to efficiently run on current (pre)exascale available systems





Case study: SPECFEM3D modelisation at exascale

ChEESE

Sismo-acoustic modelization : fluid (acoustic) / solid (viscoelastic)

Test case : Coastal zone of the Râde d'Hyère (Southern France)

Sedimentary basin ➡ very low shear wave velocity ➡ small size elements

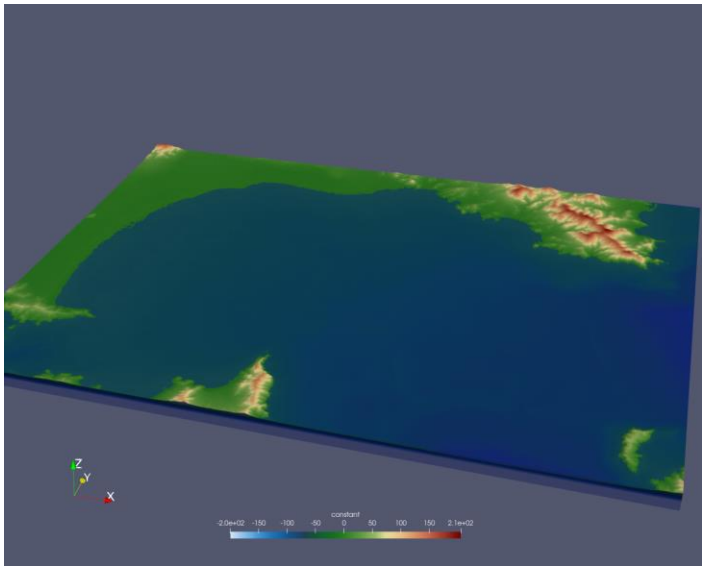
Computation at 30 Hz.

Size :

~ 27 millions of elements

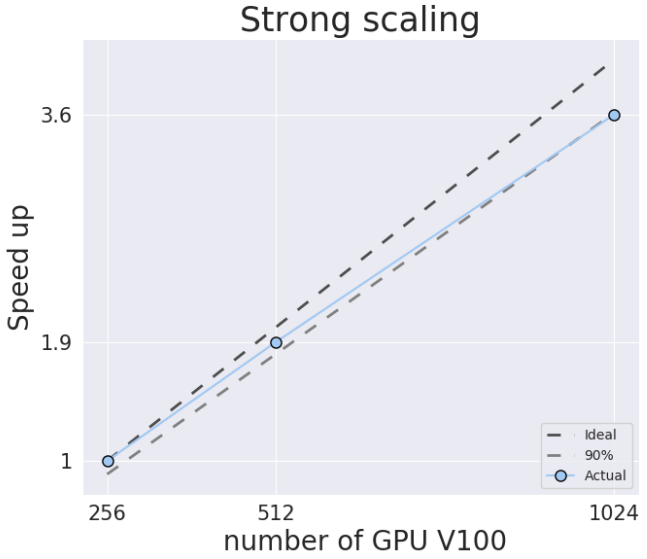
~ 9 billions of degrees of freedom

~ 2 millions of time steps



Case study: SPECFEM3D modelisation at exascale (Leonardo)

- **Scientific Challenge planned in ChEESE: increase the precision of the simulation**
  - Go from 30 Hz to 100 Hz ➡ reduce the element size by a 3.33
  - 100 Hz ➡ 1 billion elements and 4 millions time steps
- **Memory increase by a factor of 37**
- **Total computation increase by a factor of 74**
- **If the entire Leonardo system is available:**
  - Memory can be increaded by a factor of 54 compared with 1.024 V100 (Marconi 100, reference simulation)
  - The number of GPUs increased by a factor of 13,5 (compared to 1.024 V100, reference simulation)



Use of highly optimized and tuned GPU enabled software able to efficiently run on current (pre)exascale available systems

Case study: Probabilistic Tsunami Forecasting (PTF) for early warning and rapid post event assessment

Urgent computing exercise on Marconi100
On-the-fly simulations for POST-EVENT ASSESSMENT (tens of minutes) - NO Early Warning

The Samos Earthquake PTF

~38.000 scenario simulations in this exercise

~800 nodes of Marconi100 used in this exercise

~20 minutes for a complete workflow execution !!!!

Simulation ensembles to be run from scratch on large enough HPC clusters in urgent computing mode.

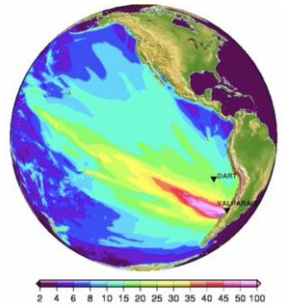
Provides exceedance probabilities for tsunami heights just off the coastline for almost equally spaced points of interest every 2 km in front of the coasts of the Mediterranean Sea (calculated along the 50 m and 10 m isobath, then extrapolated at 1 m depth).

First large scale tests allowed to identify several bottlenecks.

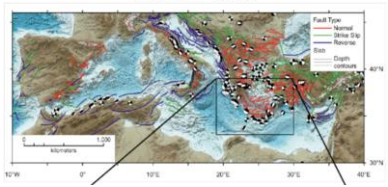
ChEESE

DT GEO

Case study: Probabilistic Tsunami Forecasting (PTF) for early warning and rapid post event assessment



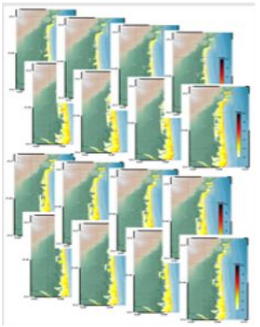
Active Faults



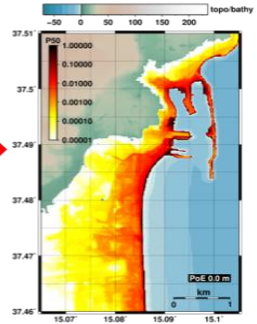
More input data

Larger Ensemble size

Inundation scenarios



Local hazard map

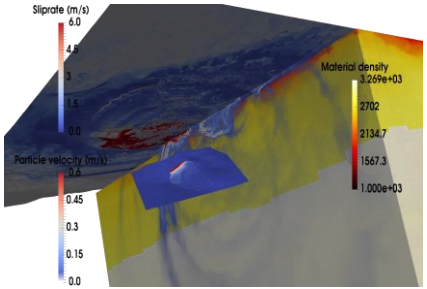


Higher resolution, larger domains

Leonardo

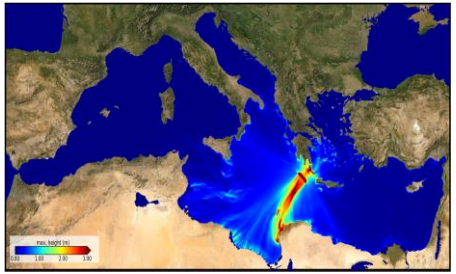
Faster and urgent simulation

Less than 5 minutes for the complete workflow execution: towards early warning



More physics

More output data

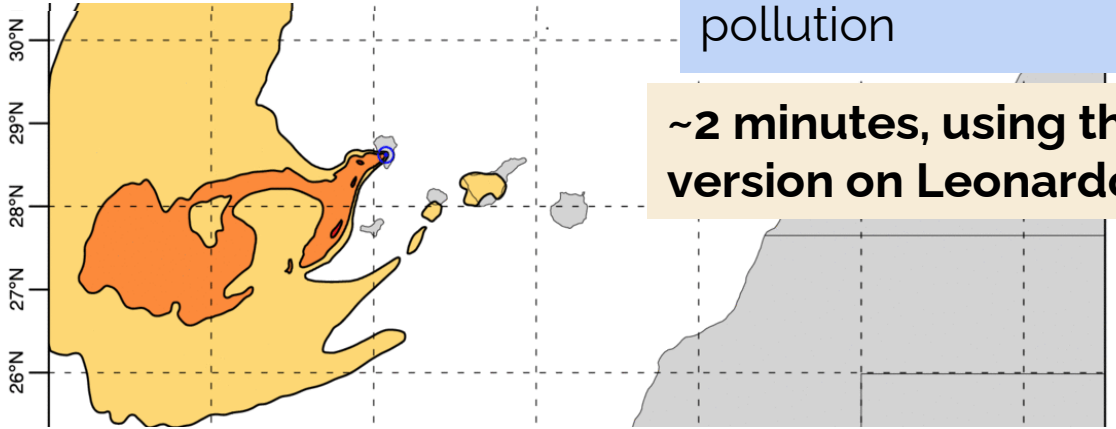


Case study: Urgent computing – Volcano simulation

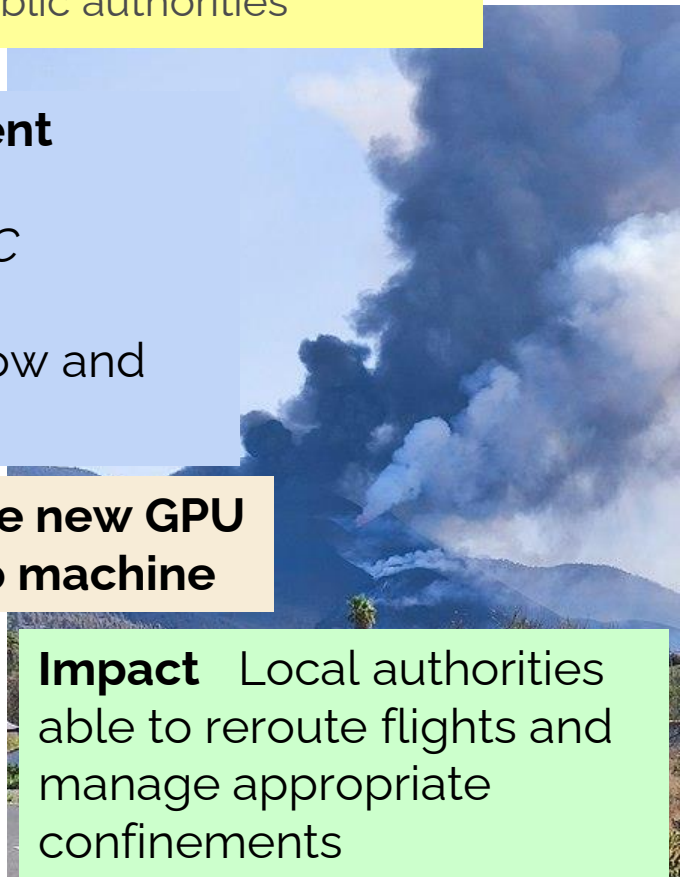
Problem Swift reaction to natural disasters by public authorities

Example Outbreak of *Cumbre Vieja* on La Palma (Sep-Dec 2021)

Now ChEESE **Urgent Computing** service *(~ 10 minutes on BSC MareNostrum 4)* Prediction of ash flow and pollution

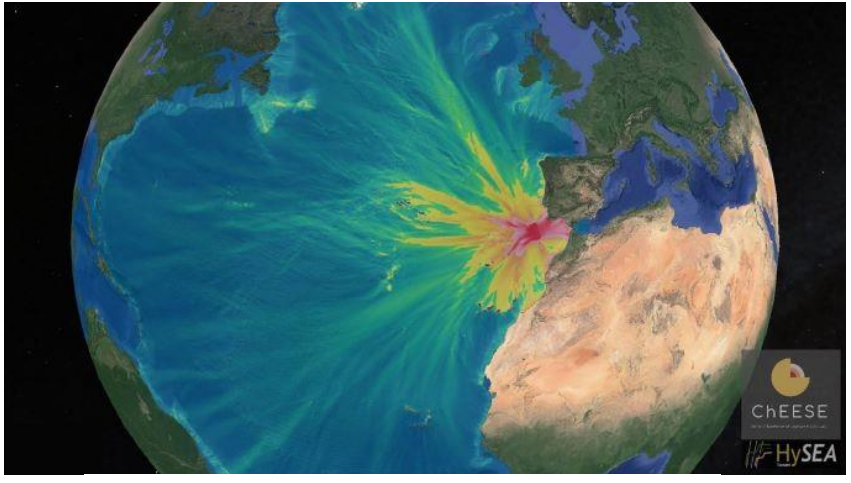


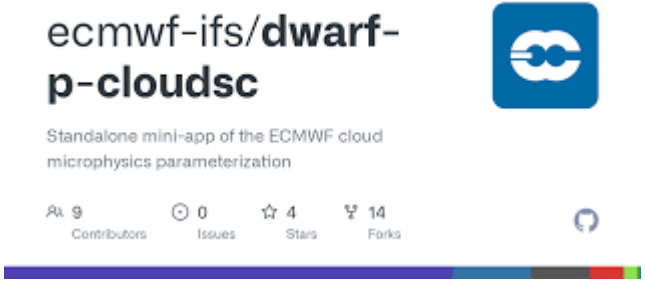
~2 minutes, using the new GPU version on Leonardo machine



Impact Local authorities able to reroute flights and manage appropriate confinements

Enabling Earth Science at Exascale: key aspects





- Projects need to focus on code development/porting to GPU

kokkos SYCL

- Use of tools for performance portability
- Dwarfs, mini-apps can be used to this purpose

Enabling of available software to GPU architectures (porting issue)

Enabling of available software to different GPU architectures (performance portability issue)

Fortran DO CONCURRENT

CINECA

Credits

…among the others….

Paola Alberigo, Giorgio Amati (co-author), Massimiliano Guarrasi CINECA

Arnau Folch, Leonardo Mingari CSIC

Stefano Lorito, Manuela Volpe INGV

Vadim Monteiller CNRS

ChEESE-2P, DE360, DT-GEO, Geo-INQUIRE projects

CINECA

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THANK YOU!