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Universidad de Oviedo

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Foreword

It is with great pleasure that we present the Proceedings of the 26th Congress of Differential Equations and Applications / 16th Congress of Applied Mathematics (XXVI CEDYA / XVI CMA), the biennial congress of the Spanish Society of Applied Mathematics S$\vec{e}$MA, which is held in Gijón, Spain from June 14 to June 18, 2021.

In this volume we gather the short papers sent by some of the almost three hundred and twenty communications presented in the conference. Abstracts of all those communications can be found in the abstract book of the congress. Moreover, full papers by invited lecturers will shortly appear in a special issue of the S$\vec{e}$MA Journal.

The first CEDYA was celebrated in 1978 in Madrid, and the first joint CEDYA / CMA took place in Málaga in 1989. Our congress focuses on different fields of applied mathematics: Dynamical Systems and Ordinary Differential Equations, Partial Differential Equations, Numerical Analysis and Simulation, Numerical Linear Algebra, Optimal Control and Inverse Problems and Applications of Mathematics to Industry, Social Sciences, and Biology. Communications in other related topics such as Scientific Computation, Approximation Theory, Discrete Mathematics and Mathematical Education are also common.

For the last few editions, the congress has been structured in mini-symposia. In Gijón, we will have eighteen minis-symposia, proposed by different researchers and groups, and also five thematic sessions organized by the local organizing committee to distribute the individual contributions. We will also have a poster session and ten invited lectures. Among all the mini-symposia, we want to highlight the one dedicated to the memory of our colleague Francisco Javier "Pancho" Sayas, which gathers two plenary lectures, thirty-six talks, and more than forty invited people that have expressed their wish to pay tribute to his figure and work.

This edition has been deeply marked by the COVID-19 pandemic. First scheduled for June 2020, we had to postpone it one year, and move to a hybrid format. Roughly half of the participants attended the conference online, while the other half came to Gijón. Taking a normal conference and moving to a hybrid format in one year has meant a lot of efforts from all the parties involved. Not only did we, as organizing committee, see how much of the work already done had to be undone and redone in a different way, but also the administration staff, the scientific committee, the mini-symposia organizers, and many of the contributors had to work overtime for the change.

Just to name a few of the problems that all of us faced: some of the already accepted mini-symposia and contributed talks had to be withdrawn for different reasons (mainly because of the lack of flexibility of the funding agencies); it became quite clear since the very first moment that, no matter how well things evolved, it would be nearly impossible for most international participants to come to Gijón; reservations with the hotels and contracts with the suppliers had to be cancelled; and there was a lot of uncertainty, and even anxiety could be said, until we were able to confirm that the face-to-face part of the congress could take place as planned.

On the other hand, in the new open call for scientific proposals, we had a nice surprise: many people that would have not been able to participate in the original congress were sending new ideas for mini-symposia, individual contributions and posters. This meant that the total number of communications was about twenty percent greater than the original one, with most of the new contributions sent by students.

There were almost one hundred and twenty students registered for this CEDYA / CMA. The hybrid format allows students to participate at very low expense for their funding agencies, and this gives them the opportunity to attend different conferences and get more merits. But this, which can be seen as an advantage, makes it harder for them to obtain a full conference experience. Alfréd Rényi said: "a mathematician is a device for turning coffee into theorems". Experience has taught us that a congress is the best place for a mathematician to have a lot of coffee. And coffee cannot be served online.

In Gijón, June 4, 2021

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What is the humanitarian aid required after tsunami?

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Abstract

In this work it is illustrated how the urgent computing (UC) capabilities in the tsunami natural hazard framework are strengthening the monitoring and analysis functions of the European Emergency Response Coordination Centre (ERCC) and its Situational Awareness Sector (SAS) by helping to design the multi-hazard advice service at global level and on a 24/7 operational basis. In this context, the ARISTOTLE-eENHSP project (All Risk Integrated System TOwards Trans-boundary hoListic Early-warning - enhanced European Natural Hazards Scientific Partnership) has been designed to offer a flexible and scalable system that can provide new hazard-related services to the ERCC.

1. Introduction

"When a disaster strikes, every minute counts. An immediate, coordinated and pre-planned response saves lives". The Emergency Response Coordination Centre (ERCC) has been established exactly for this reason: to enable the EU and its Member States to respond to overwhelming natural and man-made disasters in a timely and efficient manner. This is one of the key messages presented by the ERCC in the European Civil Protection and Humanitarian Aid Operations (ECHO) factsheet and it is on the basis goal of the ARISTOTLE-eENHSP project (see http://aristotle.ingv.it).

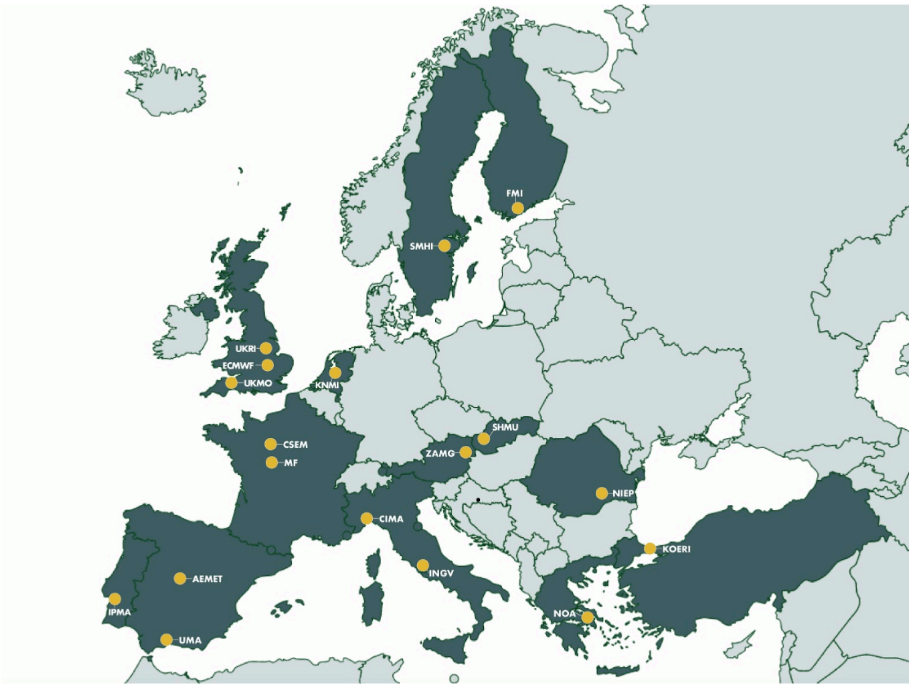

Fig. 1 Geographical distribution of the ARISTOTLE-eENHSP Consortium.

ARISTOTLE-eENHSP has been designed to offer a flexible and scalable system that can provide new hazard-related services to the ERCC. The ARISTOTLE consortium includes 18 partner institutions operating in the Meteorological and Geophysical domains (see Fig. 1). It builds on a consolidated and multi-disciplinary partnership consisting of world-leading scientific centres in the areas of Earth and Climate sciences (see Fig. 2), providing operational and monitoring services, early warning and information systems as well as contributing to innovation and research actions. The ARISTOTLE-eENHSP Consortium is currently providing advice in a multi-hazard fashion for the following inter-related hazards:

- Earthquakes,
- Tsunamis,
- Volcanic eruptions,
- Severe Weather events,
- Flooding events and
- Wildfires/Forest fires.

The operational capacity of the ARISTOTLE-eENHSP service relies on a blueprint in which experts from each of the different hazard groups provide the collective expertise into a multi-hazard virtual 24/7 operational centre, named "Multi-Hazard Board" (MHB). The MHB, composed of a representative of each hazard group, brings together the best information from the multi-hazard perspective in a single and unified multi-hazard scientific assessment of the ongoing and future events provided to the ERCC and SAS in two different modes, the *Emergency* and the *Routine* modes. Both modes facilitate the accommodation to the different temporal scales of both, the hazards considered, as well as the relative preparatory actions or feedback required for effective emergency response.

The EDANYA Group of the University of Málaga participates in this consortium since 2018 providing services of Faster than Real Time (FTRT) tsunami computations with the numerical model Tsunami-HySEA.

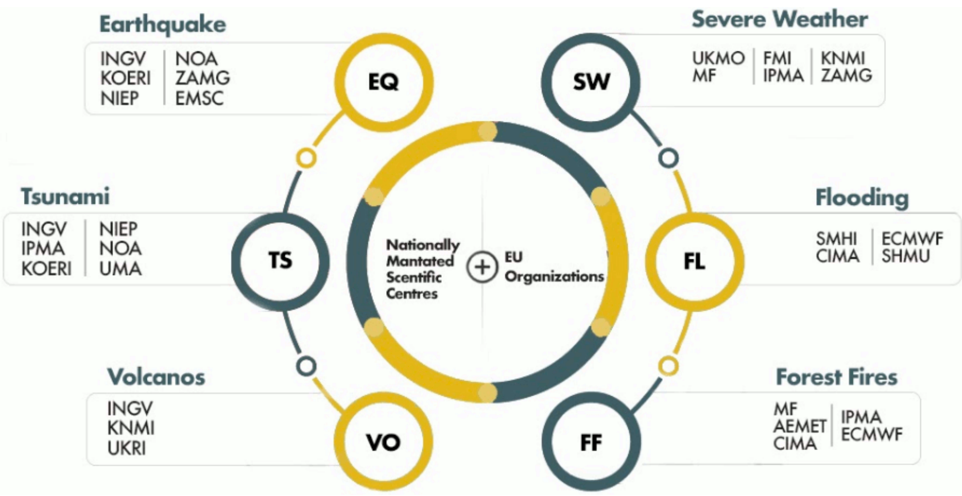

Fig. 2 The experienced multi-hazard scientific ARISTOTLE-eENHSP Partnership and related hazards.

2. The tsunami service

Tsunami-HySEA (see [1, 2]) is a finite-volume numerical model that solves the 2D non-linear shallow water equations in spherical coordinates. It has been developed by the EDANYA group of the University of Málaga specifically for simulations of seismically induced tsunamis. Implemented for graphic processing unit (GPU) architecture, Tsunami-HySEA is a robust, reliable and accurate model capable of simulating the generation, propagation and inundation of a tsunami in a region covered by a grid with several million cells in only a few minutes. This model has been extensively validated under the standard benchmarks proposed by the National Tsunami Hazards Mitigation Program (NTHMP) of the U.S.A. (see [3,4]) and has been extensively tested in several scenarios and compared with other well-established tsunami models (see [5,6]).

Tsunami-HySEA has been implemented using CUDA and MPI in order to take advantage of the massive parallel architecture of multi-GPU clusters, so that the computing time required could be dramatically reduced with respect to the use of a single CPU core or even a multi-core processor and, at the same time, numerical resolution could be increased still computing extremely fast. Many features are included in Tsunami-HySEA, such as the possibility of using nested meshes, direct output of time series, the computation of the initial seafloor deformation using the Okada (1992) model, support for rectangular or triangular faults, etc. By means of a very efficient implementation, the model is able to simulate 8 hours of real time tsunami in the Mediterranean Sea (in a mesh with 10 million volumes and a resolution of 30 arc-sec) in 257 seconds using two NVidia Tesla P100, or even in 284 seconds with one NVidia Tesla V100.

The ARISTOTLE tsunami service (TS) is integrated in the SPADA (Scientific Products Archiving and Document Assembly) IT platform that gathers the scientific, exposure and preliminary impact informations which are used by the multi-hazard operational board to assembly the reports. This platform relies on existing and newly developed web services. The TS workflow (see Fig. 3) consists on four steps: the system is triggered by an end-user who is on duty in the service. Using the earthquake parameters that can be provided by different seismic monitoring sources, the scenario parameterization is defined and it is sent to the supercomputation resources (in this case located at INGV and the University of Málaga). In this step a message passing system (RabbitMQ) is used between the SPADA system and the supercomputing services. Depending on the earthquake epicenter location the system is able to automatically select an optimal computational grid size and refinement level depending on the seismological parameters. For example, as it will be presented in the next section, if the epicenter is located in the Mediterranean Sea, the system automatically performs 8 hours of wallclock simulation in a 2 arc-min resolution grid, then detects the limits where the tsunami waves has arrived and later performs a second simulation in a new domain with more resolution (30 arc-sec). Depending on the event magnitude, the computation time can last from a few seconds to the order of minutes. The current outputs of the tsunami service system are: maximum wave height in the considered domain, wave arrival time and maximum wave height along coast locations.

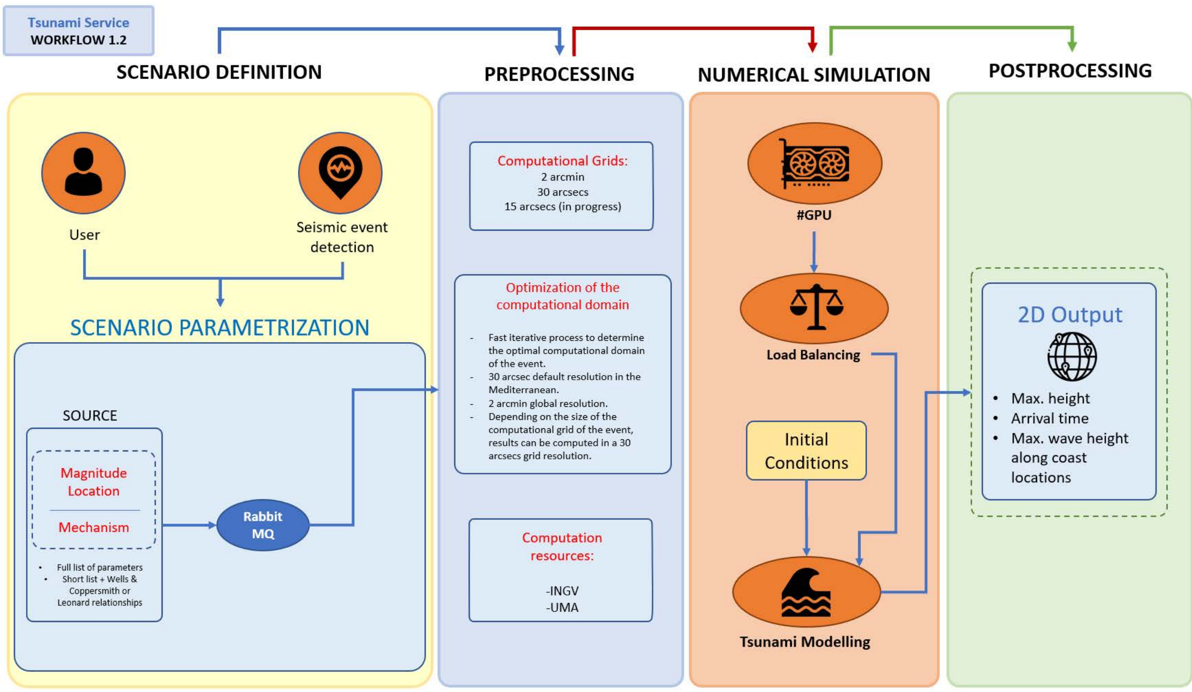

Fig. 3 Scheme of the tsunami service workflow implementation in the ARISTOTLE.

This workflow is scalable depending on different aspects, like the computation resources or the Digital Terrain Models (DTM) available. As consequence, the numerical computation output could be improved in different ways: for instance by improving the grid resolution (even using nested meshes in specific areas of interest), or even providing not only one scenario output but considering an ensemble of cases that could deliver even a Probabilistic Tsunami Forecast (PTF). We are studying these possibilities in H2020 European projects like ChEESE (Center of Excellence (CoE) in Solid Earth) (UE-H2020. Grant agreement: N^o 823844), or more recently, eFlows4HPC (Enabling dynamic and Intelligent workflows in the future EuroHPC ecosystem) (UE -H2020-JTI-EuroHPC-2019-1. Reference: 955558).

3. Outputs and computation time

The system outputs are delivered to the European Emergency Response Coordination Centre (ERCC) in a multi-hazard report providing expert analysis made by an expert panel in the different involved hazards. In our case, the tsunami service outputs are relevant in the sense that they have to be easily readable by the endusers. These aspects have been agreed with all the consortium components related with the TS. For instance, an enhanced semaphore colorbar has been designed where each semaphore color: green, yellow, orange and red has been subdivided into three subcolors. The output is clear even for endusers with a basic information (see Fig. 4. Left). The arrival times figure output has been also improved with the addition of a jet colormap that completes the information given by the isochrons.

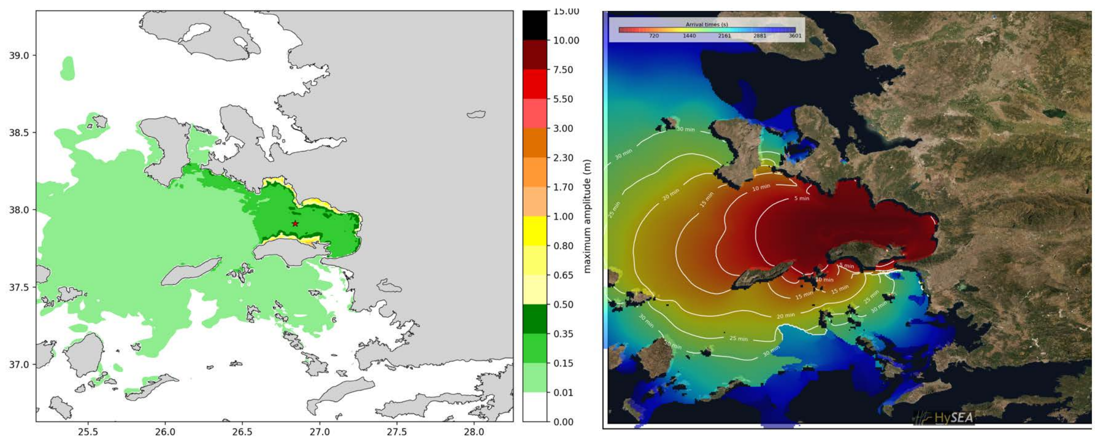

Fig. 4 Izmir (Turkey) 2020 tsunami. Left: max. wave amplitude. Right: arrival times.

To illustrate the computational efficiency of the system, in the next table are shown the computation times required to perform the process described in the previous section. In this case it is simulated one hour of wallclock propagation of the tsunami in the 2 arc-min resolution and then the same time in a 30 arc-min resolution grid adapted to the domain where the tsunami waves have arrived. The total time is 38.48 seconds in a single P100 NVidia GPU.

Scenario	Resolution	Wallclock simul. time	Nr. cells	Comp. Time	Postproc. time	Total time
Izmir	2 arc-min	60 mins (3600 secs)	1305 x 480 = 626400	1.15 secs		
Izmir	30 arc-sec	60 mins (3600 secs)	460 x 336 = 154560	2.22 secs	35.11 secs	38.48 secs

4. Conclusions

The ARISTOTLE-eENHSP project is strengthening the European response capacities to assist Member States in responding to natural disasters when national capacities are overwhelmed. ARISTOTLE has its own operational multi-hazard capacities in order to ensure that the EU can provide better crisis emergency support with maximum efficiency and minimal bureaucracy. The EDANYA group role in this project is related to the Tsunami Service with the develop and tuning of the system. In fact, the 8-9 technology readiness level (TRL) achieved with Tsunami-HySEA in this service makes it operational and at the same time scalable to incorporate the new state of the art techniques when they are available.

Acknowledgements

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