TECHNICAL PROPOSAL

87-GLOBAL-CMEMS-NEMO Lot 5: HPC ORCA36

87-GLOBAL-CMEMS-NEMO: EVOLUTION AND OPTIMISATION OF THE NEMO CODE USED FOR THE MFC-GLO IN CMEMS

ISSUED BY:
Barcelona Supercomputing Center-Centro Nacional de Supercomputación (BSC-CNS)
Earth Science Department

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Version: Final

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1 Executive Summary

The goal of this project is to assess the suitability of the NEMO code to run simulations on extremely high resolution global grids and provide information on the major bottlenecks constraining its scalability, in order to address the ever-increasing demands of oceanic forecasting and facilitate the deployment of these configurations in the next years.

Special focus will be put into 1/36º resolution, one of the target configurations in the NEMO Development Strategy, whose performance will be assessed and compared with other resolutions.

The experts that will develop this project belong to the Performance Team of the Earth Sciences Department at the Barcelona Supercomputing Center (BSC). This is an experienced team specialised in parallel model's performance, with proven expertise in analysing parallel programming model codes using cutting-edge performance tools.

2 Track Record

The members of the Computational Earth Sciences group in general, and the Performance Team in particular, have been involved in a range of projects related to the improvement and optimization of Earth Sciences models in HPC. As an example, they contributed to the IS-ENES2 (GA 312979) FP7 project on fostering the integration of the European climate modelling community and the development of Earth System Models (ESM) for advancing the understanding and predictions of climate variability and change, by providing scalability and performance analysis using cutting-edge performance tools; nowadays they are contributing to the ESiWACE (GA 675191) H2020 project, whose aim is to improve efficiency and productivity of numerical weather and climate simulation on high-performance computing platforms by supporting the end-to-end workflow of global Earth system modelling in HPC environment, by constructing an Extreme-scale climate demonstrator, based on EC-Earth model, featuring the NEMO ORCA12 configuration. Also, they will participate in the recently approved ESCAPE2 (GA 800897) H2020 project, which aims to develop world-class, extreme-scale computing capabilities for European operational numerical weather and climate prediction, and provide the key components for weather and climate domain benchmarks to be deployed on extreme-scale demonstrators and beyond. They contribution to this project will be, among other activities, to define and analyze benchmarks and assess their performance.

The Barcelona Supercomputing Center was established in 2005 and is a key element of and coordinates the Spanish Supercomputing Network, which is the main framework for granting competitive HPC time to Spanish research institutions. Furthermore, BSC-CNS is one of six hosting nodes in France, Germany, Italy and Spain that form the core of the Partnership for Advanced Computing in Europe (PRACE) network. PRACE provides competitive computing time on world-class supercomputers to researchers in the 25 European member countries.

The Center houses Mare Nostrum, one of the most powerful supercomputers in Europe with 165,888 cores and 11.15 Pflops capacity. The mission of BSC is to research, develop and manage information technologies in order to facilitate scientific progress. BSC combines HPC service provision, and R&D into both computer and computational science (life, earth and engineering sciences) under one roof and currently has over 480 staff from 44 countries. BSC has collaborated with industry since its creation, and participates in various bilateral joint research centers with companies such as IBM, Microsoft, Intel, NVIDIA and Spanish oil company Repsol. The Center has been extremely active in the EC Framework Programs and has participated in over 100 projects funded by it. BSC is a founding member of HiPEAC, the ETP4HPC and other international fora.

The ES-BSC activities with the focus on global climate modelling and prediction are based on research, development and predictions with the EC-Earth climate forecast system. EC-Earth is the

state-of-the art coupled climate model that is being developed and used for climate predictions and projections by the European consortium of more than 20 research and operational institutions from European Centre for Mid-range weather Forecasts (ECMWF is provider of the atmospheric and land components) to ES-BSC. Beside contributing to the 5th phase of the Coupled Model Intercomparison Project (CIMP5) critical for the UN IPCC Fifth Assessment Report (AR5), global climate research activities at ES-BSC enable provision of various historical reconstructions and initial conditions to the EC-Earth community for analysis of climate dynamics and for seasonal to decadal climate predictions. The ES-BSC is already active in the planning and design of the future Coupled Climate Model Intercomparison project, CIMP6, and is preparing to make key contributions including the ground-breaking high-resolution climate simulations with EC-Earth.

BSC-CNS hosts a range of high-performance computing (HPC) systems of which the most relevant is Mare Nostrum IV, deployed in 2017, and 12.4 times more powerful than the previous Mare Nostrum 3, with an overall performance capacity of 13.7 Petaflop/s. The general-purpose element, counts with 48 racks and more than 3,400 nodes of next generation Intel Xeon processors and a central memory of 390 Terabytes. The second element of Mare Nostrum 4 is formed by clusters of three different technologies that are being added and updated as they become available. These are technologies currently being developed in the US and Japan to accelerate the arrival of the new generation of pre-exascale supercomputers.

- Mare Nostrum 4: Intel Xeon Platinum 8160 CPU with 24 cores each, 2.10 GHz, for a total of 48 cores per node, 100 Gbit/s Intel Omni-Path.
- Future Emerging Technologies clusters (part of Mare Nostrum 4). Available during 2018-2019:
    - cluster IBM POWER9 processors and NVIDIA Tesla GPUs
    - cluster Intel Knights Hill processors.
    - cluster formed of 64 bit ARMv8 processors (technologies from the Japanese Post-K supercomputer)

3 Quality of Resources to be Deployed

3.1 Description of Resources

The BSC-ES is a collaborator of the NEMO development team, and member of the NEMO HPC working group, providing the consortium with performance reports and code optimisations. As a result of this collaboration two optimisation branches were created in the NEMO code repository, being both merged into the NEMO 3.6 stable version and trunk. These developments are taken as a basis for further improvements in the communications within the model. Following the success of this cooperation, a similar collaboration has been established with the OpenIFS and IFS developers at ECMWF. Besides, led by the BSC-ES, ECMWF and the EC-Earth community are integrating an IO server for OpenIFS, which will increase the computational performance of the atmospheric model considerably. In parallel, the BSC-ES is also member of the EC-Earth Technical Working Group, where several profiling analysis have been done to increase the performance of the coupled version of the model.

Title	Broad description of work in relation to Service	List of personnel who fit the profile and whose CVs are submitted with tender	Qualifications	Effort / engagement in months
M.Eng.	Setting up of the configuration, performance analysis, application of optimizations, execution of the ultra-	Miguel Castrillo	7	4.5

	high resolution, writing of reports.			
PhD	Setting up of the configuration, performance suggestions, writing of reports.	Mario Acosta	8	2.5

3.2 CV's of Key Personnel

The CVs of the key personnel involved in this contract are attached to the Technical Report (Annex I).

4 Technical Solution Proposed

In Ocean applications such as the NEMO model, the progress is intricately linked to the computing power and energy efficiency available due to the need for increasingly higher model resolutions, many more simulations, and greater complexity in ocean models. Operational oceanography is a new and rapidly growing sector, providing key assessments for coastal water quality, fisheries and marine ecosystems, offshore, military, transport, etc. However, the subsurface and deep ocean remains drastically under sampled. We must therefore assimilate available data into models and make sure that those models account for the key ocean physical and biogeochemical processes to be able to predict the evolution of ocean characteristics and of marine ecosystems at all relevant scales. A key concern in the ocean, such as in the atmosphere, is the correct simulation of eddies. This key concern can be addressed only by building upon recent advances in ocean modelling to construct more accurate, high resolution models.

High Resolution (O (10 km) grid) experiments have now begun to capture eddy processes in the subtropics and mid latitudes (with strong effects, for example, on the Gulf Stream), but much higher resolution is needed to achieve comparable progress in the subpolar and polar oceans. Nevertheless, it remains a challenge to run realistic global ocean/sea ice models such as NEMO at resolutions high enough to ensure dynamical consistency over a wide range of resolved scales.

The increase of the resolution and in general the capability of ocean models is strongly linked to the amount of computing power and data storage capacity available. Therefore there is a vital need for high performance computing in order to predict the future evolution of climate and answer key societal questions as the impact of global warming on human activities. Actually, sustained computing power of the order of at least 1 Pflop/s is already required today in Europe to maintain its scientific importance in climate prediction research worldwide.

However, more computing power means more resources of a supercomputer used in parallel. But, the more resources in parallel are used, the more overhead is introduced to achieve the parallelization. This means that it is mandatory that the models used scale. Models such as NEMO scale with difficulty on supercomputers fundamentally because the problems they represent are connected, physically and algorithmically. This requires significant communication results in an increasing overhead with increasing domain decomposition.

Taking into account the computational challenges of increasing the efficiency of NEMO using more computing power with massive parallel platforms, it is clear that the parallel overhead should be reduced. To achieve this, the project focuses in the next goals:

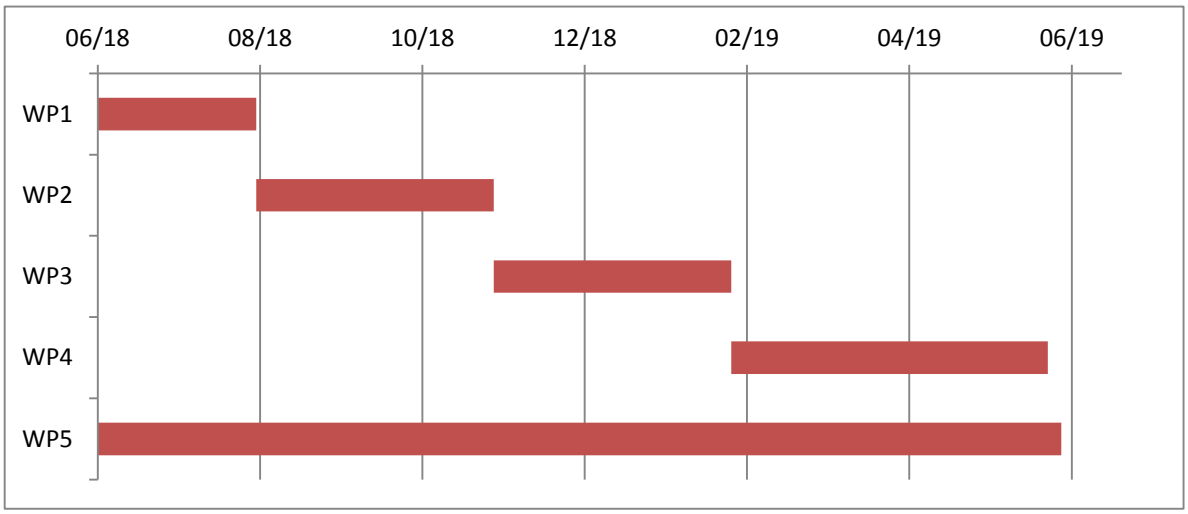
(1) Analysing the main bottlenecks of NEMO when it runs in parallel with high resolution configurations.

(2) Trying to exploit high-end architectures efficiently, reducing the energy consumption of these models through optimizations.

(3) Evaluating the results with and without optimizations, including different tests to check the new implementations and the hardware used.

5 Management and implementation plan

5.1 Gantt chart



5.2 Work package description

The work plan has been designed with the aim of tailoring the objectives. The project is divided in four work packages (WP): one for research (WP1), three for research and development (WPs 2, 3 & 4) and one for management (WP5).

Work package #	**WP1**	**Start/End date**	M1-M2
Work package title	Preparation of the new ultra-high resolution configuration		
Participants (person months)	BSC (1.3)		
Other main direct cost elements	N/A		

Main objectives
The goal of this WP is to create all the files and input data needed to run the new resolution. It comprises task 1.1 and its output will be used by the rest of the WPs. It will be monitored by the CMS-GLO-NEMO-QR (Q3 2018) milestone.

Description of activities
Task 1.1 Creation of the new ultra-high configuration This task includes the creation of all the input files needed for the ultra-high resolution configuration of NEMO. This includes the creation of a repository where the inputs will be available for future simulations. This means that the new configuration will be available in an automatic way for all the community. Preliminary tests for the new configuration will be done in this task too.

Work package #	**WP2**	**Start/End date**	M2-M5

Work package title	Apply a profiling analysis to highlight computational problems of NEMO in parallel platforms.
Participants (person months)	BSC (1.5)
Other main direct cost elements	N/A

Main objectives

The goal of this WP is to do a profiling analysis of NEMO specially tailored for this kind of ocean models. The study will be used to facilitate the task of improving the energy efficiency of the model, using a methodology oriented to optimize these kind of models in large clusters. It comprises task 2.1 and its outcome will be used in WP3. It will be monitored by the CMS-GLO-NEMO-QR (Q3 2018) and the CMS-GLO-NEMO-QR (Q4 2018) milestones.

Description of activities

Task 2.1. NEMO specific profiling study

In the ocean models case, an in-depth performance analysis can lead to feasible and productive solutions that do not require a full rewriting of the code while effectively improving the performance of the model. Preliminary studies proved that an exhaustive profiling analysis of NEMO will be useful to improve its performance (Tintó Prims et al, 2015). Having a deep understanding of the computational behaviour of applications, running in HPC systems, is not straightforward, so this task will develop an analysis lead by experts on the matter.

The main outcome of this task will be to highlight problems not previously identified, explaining the reasons for their occurrence and proposing optimizations to substantially improve the computational performance of the model using the new ultra-high resolution configuration. Cutting-edge profiling tools will be used to highlight the main bottlenecks of the model in parallel executions using a moderate number of resources and state-of-the-art high resolution grids, pointing out which parts of the code should be optimized before running experiments with ultra-high resolution grids.

Work package #	**WP3**	**Start/End date**	M5-M8
Work package title	Improving the energy efficiency of the NEMO ocean model, to take advantage of parallel computers in an efficient way. Preparing ultra-high resolution experiments for massive parallelization.		
Participants (person months)	BSC (2)		
Other main direct cost elements	N/A		

Main objectives

The goal of this WP is to improve the energy efficiency of the NEMO ocean model in order to enable the realization of tests in ultra-high resolution. Preliminary work, in collaboration with the NEMO consortium, proved that optimizations for NEMO can increase the computational performance (Tinto et al. 2018). It comprises task 3.1 and its results will be to produce the HPC-COD-01 deliverable and will be used by WP4. It will be monitored by the CMS-GLO-NEMO-QR (Q4 2018) and the CMS-GLO-NEMO-QR (Q1 2019) milestones.

Description of activities

Task 3.1. Energy efficiency optimization of NEMO

The profiling study developed by WP2 will reveal the main bottlenecks of the code. Preliminary works proved that this methodology is useful to increase the NEMO model performance. Some of the strategies that could be developed and tested for NEMO are:

- Reduction of the accuracy of the variables from double to single precision. This task will determine which computational phases of NEMO can use single precision to improve the model throughput without impacting on the results, this is a novel technique which is currently being developed at the BSC and is part of the NEMO 2018 Working Plan.
- Optimizing the distributed memory paradigm (MPI), improving the algorithms used for the MPI communications.
- Optimizing the domain decomposition of the model to reduce the load unbalance in the parallel execution and avoid the waste of resources.

Work package #	**WP4**	**Start/End date**	M8-M12
Work package title	Running the ultra-high resolution experiments and assessing their performance on state-of-the-art architectures.		
Participants (person months)	BSC (2)		
Other main direct cost elements	N/A		

Main objectives

The goal of this WP is to assess the performance of NEMO using an ultra-high configuration in large state-of-the-art clusters, gathering information of its main bottlenecks to provide knowledge and inspire future developments. It comprises task 4.1 and its conclusions will allow the finalization of the deliverable HPC-REP-02. It will be monitored by the CMS-GLO-NEMO-QR (Q1 2019) milestone.

Description of activities

Task 4.1. Execution of NEMO on ultra-high resolution configurations and evaluation of its performance

The task will develop the final outcome of this project, which is a deep performance evaluation of NEMO running on the developed ultra-high resolution configuration after the application of the optimizations developed in WP3:

- A strong scaling exercise will be performed to show the maximum throughput that can be obtained while keeping the parallel efficiency at a reasonable level.
- A weak scaling study will put in contrast the performance of the ultra-high configuration with respect to other high resolution ORCA grids.
- A profiling analysis will disclose which regions of the NEMO model need a deeper redesign to enable the setting up of the new configurations at the operational level.

Work package #	**WP5**	**Start/End date**	M1-M12
Work package title	Management and communication		
Participants (person months)	BSC (0.2)		
Other main direct cost elements	Travel (EUR 2,000); Contract translation cost (EUR 500)		

Main objectives

This work-package will ensure the appropriate management of the project and broadly disseminate the outputs throughout its duration. It will be feasible thanks to the Project Management Department at the host institution (BSC) and the strong group of "Earth System Services" established at the department level (BSC-ES). WP5 will monitor the progress of the project, ensure timely preparation of scientific reports (milestones and deliverables) and outreach activities, facilitate communication among and organize the project meetings. Under WP5, the project will also undertake a final report that, in addition to the

summary of the scientific achievements, will identify priority research lines to enhance the energy efficiency of NEMO in the path to take advantage of the new ultra-high resolution platform.

Description of activities

Task 5.1 Contract management

The contract will require a solid management to ensure that the adequate level of reporting reaches Mercator Ocean. The contractor will ensure that the human resources are in place at the right time and that new hiring is communicated to Mercator Ocean (if necessary).

Task 5.2 Project meetings

The researchers involved in this contract will participate in two Annual Meetings to allow for the interaction between other lots and to keep Mercator Ocean informed about the updates and outcomes of the contract.

Task 5.3 Reporting

A series of reports will be provided to Mercator Ocean:

- Quarterly activity reports: after each quarter, the contractor will submit an activity report.
- The final scientific report: will be delivered 60 days after the end of the contract.

Deliverables

Reference	Title	Type	Due date
HPC-COD-01	Optimised version of NEMO	Code	05/2019
HPC-REP-02	Performance documentation	Document	05/2019
CMS-GLO-NEMO-FSR	Final Scientific Report	Document	07/2019

Milestones

Reference	Title	Type	Due date
CMS-GLO-NEMO-PLAN	Development Plan	Document	31/07/2018
CMS-GLO-NEMO-QR (Q3 2018)	Quarterly activity report	Document	30/09/2018
CMS-GLO-NEMO-QR (Q4 2018)	Quarterly activity report	Document	31/12/2018
CMS-GLO-NEMO-QR (Q1 2019)	Quarterly activity report	Document	31/03/2019

6 Budget

Organisation:	BSC-CNS	**LIST OF EXPENSES**
ITT Ref:	87-GLOBAL-CMEMS-NEMO Lot 5	

Contractor	**Resource Description**	**Resource Type**	**Unit of Measure**	**Euro Cost per unit**	**Margin %**	**Euro Price per unit**	**Volume**	**Total Cost**	**Total overheads**	**Euro total price**
BSC-CNS	Miguel Castrillo	Payroll	Person months	4.500,00	50,27%	6.762,15	4,50	20.250,00	10.179,68	30.429,68
BSC-CNS	Mario Acosta	Payroll	Person months	4.500,00	50,27%	6.762,15	2,50	11.250,00	5.655,38	16.905,38
BSC-CNS	Participation in the Annual Meetings	Travel	Package Price	1.000,00	0	1.000,00	2,00	2.000,00	0,00	2.000,00
BSC-CNS	Contract translation costs	Other	Package Price	500,00	0	500,00	1,00	500,00	0,00	500,00
TOTAL										**49.835,05**

7 Bibliography

Tinto, O., M. Castrillo, M.C. Acosta., A. Cortes, A. Sanchez, K. Serradell, F.J. Doblas-Reyes (2018). Finding, analyzing and optimizing MPI communication bottlenecks in Earth System models. Paper Accepted.

Tinto, O., M.C. Acosta., M. Castrillo, A. Cortes, A. Sanchez, K. Serradell, F.J. Doblas-Reyes (2017). Optimizing domain decomposition in an ocean model: the case of NEMO. Procedia of Computer Sciences.
http://www.sciencedirect.com/science/article/pii/S1877050917308888

Tintó Prims, O., M. Castrillo, K. Serradell, O. Mula-Valls and F.J. Doblas-Reyes (2015). Optimization of an ocean model using performance tools. BSC-CES Technical Memorandum 2015-002, 16 pp.

8 Annex I: CV's of Key Personnel

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PERSONAL INFORMATION

Miguel Castrillo Melguizo

C/ Mare de Deu del Remei 46, 08004 Barcelona (Spain)

(+34) 652837418

miguel.castrillo@bsc.es

WORK EXPERIENCE

11/06/2012–Present — **Research support engineer**

Barcelona Supercomputing Center, Barcelona (Spain)

Performance analysis and optimization of Earth system models
Coordination of Earth sciences software development
Deployment of climate models on different architectures
Involved in team managing and project proposal writing
Design and development of data access & visualization software for model data
Deployment and administration of scientific data servers

01/02/2008–28/05/2012 — **System Analyst**

Tecnologías viales aplicadas TEVA, S.L., Alcobendas (Spain)

Design and development of data management and visualization applications for ITS systems
Development and administration of high-capacity applications
On board recording systems design and management

01/04/2007–31/01/2008 — **Technical coordinator**

XBRL Spain Association, Madrid (Spain)

Web development and administration
Data management
XBRL taxonomies validation

27/09/2006–27/03/2007 — **Software developer**

Municípia-SA, Porto Salvo (Portugal)

GIS applications development
Research on shortest path algorithms with geo-referenced databases
ARGO Grant – Europen Internship Program Leonardo da Vinci

01/10/2005–30/06/2006 — **Computer lab sysadmin**

Universidad de León, León (Spain)

Administration of the Agricultural engineering school computer lab

01/04/2005–30/06/2005 — **Computer lab sysadmin**

Universidad de León, León (Spain)

Administration of the University of León central services computer lab

EDUCATION AND TRAINING

30/09/1999–30/06/2006	**MSc in Computer Science** Universidad de León, León (Spain)	EQF level 7
30/09/2006–30/09/2017	**BA in History** Universidad Nacional de Educación a Distancia, Madrid (Spain)	EQF level 6
24/07/2017–26/07/2017	**Fortran Modernization Workshop** NAG, Barcelona (Spain)	
13/12/2016–13/12/2016	**Introduction to OpenACC** NVIDIA	
26/06/2016–01/07/2016	**International HPC summer school** IHPCSS, Ljubljana (Slovenia)	
13/05/2016–13/05/2016	**Programming ARM based Prototypes** PATC at BSC, Barcelona (Spain)	
11/05/2016–12/05/2016	**Heterogeneous Programming on GPUs with MPI + OmpSs** PATC at BSC, Barcelona (Spain)	
13/10/2014–17/10/2014	**Parallel Programming** PATC at BSC, Barcelona (Spain)	
12/05/2014–13/05/2014	**Performance Analysis and Tools** PATC at BSC, Barcelona (Spain)	
10/02/2014–14/02/2014	**13th VI-HPS Tuning Workshop** PATC at BSC, Barcelona (Spain)	
13/12/2012–14/12/2012	**Introduction to simulation environment for Earth Sciences** PATC at BSC, Barcelona (Spain)	

PERSONAL SKILLS

Mother tongue(s): Spanish

Other language(s):

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	C1	C1	C1	C1	C1

	Cambridge First Certificate C1 (Universidad de León)				
Catalan/Valencian	C1	B2	B2	B2	B1
	Certificat de nivell bàsic de català				
Portuguese	B1	B2	B1	B1	A2

Levels: A1 and A2: Basic user - B1 and B2: Independent user - C1 and C2: Proficient user
Common European Framework of Reference for Languages

Communication skills

Good oral communication skills gained through my experience given speeches and presentations
Good written communication skills due to a course taken at BSC and my personal attention to details

Organisational / managerial skills

Leadership & team-leading skills (currently a lead a team of 9 people)

Job-related skills

- Both self-sufficient and collaborative
- Persistent and responsible
- Friendly and empathic
- Being a curious person, I am keen to learn about new things, specially within my fields of interest. I like problem solving and testing
- myself searching for better solutions.
- Proactive, love to take initiatives, to face new challenges and develop myself

Digital skills

SELF-ASSESSMENT				
Information processing	Communication	Content creation	Safety	Problem solving
Proficient user	Proficient user	Proficient user	Proficient user	Proficient user

Digital skills - Self-assessment grid

- Software development: C, C++, C#, Fortran, Java, Python, Bash script
- HPC performance tools: Paraver, Dimemas, Scalasca, Intel Parallel Studio XE
- Scientific data management: NCO, CDO, OPeNDAP, THREDDS, Hyrax & Dapper servers
- Parallel programming: MPI, OpenMP, OpenACC, OmpSs
- Debugging: GDB, ARM DDT, Totalview
- HPC architectures: x86-64, ARMv8, BG/Q, SPARC
- Web development: PHP, Javascript, jQuery, AngularJS, HTML5, CSS3
- Mobile App development: jQuery Mobile, Phonegap, Ionic
- Server adminstration: Linux, Windows Server, Apache, Apache Tomcat, IIS
- Database servers: MySQL, PostgreSQL, SQLServer
- IDE: Jet Brains, Netbeans, Eclipse, Xcode, Microsoft Visual Studio
- Version control: Git, SVN
- Image processing and design: GIMP, Adobe Photoshop, Adobe Illustrator, Director MX, Adobe Premiere

Driving licence B

ADDITIONAL INFORMATION

Publications:

- Finding, analyzing and optimizing MPI communication bottlenecks in Earth System models: Tinto, O., M. Castrillo, M.C. Acosta., A. Cortes, A. Sanchez, K. Serradell, F.J. Doblas-Reyes. Paper accepted, 2018.
- Using EC-Earth for climate prediction research: Francisco Doblas-Reyes, J Acosta Navarro, M Acosta, O Bellprat, R Bilbao, M Castrillo, N Fuckar, V Guemas, L Lledó, M Ménégoz, C Prodhomme, K Serradell, O Tintó, L Batté, D Volpi, A Ceglar, R Haarsma, François Massonnet. ECMWF Newsletter 154, 2018
- Optimizing domain decomposition in an ocean model: the case of NEMO, Oriol Tintó, Mario Acosta, Miguel Castrillo, Ana Cortés, Alícia Sanchez, Kim Serradell, Francisco J Doblas-Reyes. Procedia Computer Science 108, 776-785, 2017
- Optimization Of An Ocean Model Using Performance Tools: Oriol Tintó Prims, M Castrillo, K Serradell, O Mula-Valls, FJ Doblas-Reyes. Poster, SC15, 2015

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PERSONAL INFORMATION

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(+34) 660012701

macosta@bsc.es

Skype mario.acosta85

Sex Male | Date of birth 18/12/1985 | Nationality Spanish

WORK EXPERIENCE

01/12/2015–Present — Postdoc researcher

Department of Earth Sciences, Barcelona Supercomputing Centre (Barcelona, Spain)

-Research in topics related on performance analysis to identify bottlenecks and apply optimizations in ESM's and in new computational methods to apply. The topics cover both applied research on real boards and more theoretical research
-Coordination in advising PhD and Master students
-Analyse the performance of the models such as IFS and NEMO used in the Department
-Definition of the new research lines around the computational performance topic.

01/09/2015–30/11/2015 — Postdoc researcher

University of Granada, Granada (Spain) / Research Centre for Information and Communications Technologies of the University of Granada (CITIC-UGR)

-Optimization and Parallelization of scientific codes using C, C++ and Fortran in Linux and Windows using Eclipse as development environment.

-Parallelization and optimization of software using MPI, OpenMP and CUDA (using both threads and processes) as tools of parallel programming to take advantage of parallel and distributed computation, using both High Performance Computing (HPC) with big clusters of CPUs and GPUs and efficiently taking advantage of small architectures of multi-core processors.

-Development of software in parallel applied to computational fluid dynamics for the development and application of 3D hydrodynamic models to simulate and predict the behaviour of continental water systems such as lakes, rivers or reservoirs

-Teaching in the University of Granada.

15/04/2015–15/06/2015 — Researcher

University of Granada, Granada (Spain) / Research Centre for Information and Communications Technologies of the University of Granada (CITIC-UGR)

Research work: High Performance Computing and Computational Fluids Dynamics

01/03/2011–28/02/2015 — Researcher

University of Granada, Granada (Spain) / Research Centre for Information and Communications Technologies of the University of Granada (CITIC-UGR)

-Research and teaching grant for my PhD

01/03/2010–28/02/2011 — Researcher

University of Granada, Granada (Spain)

-Research work: High Performance Computing and Computational Fluid Dynamics.

01/09/2007–15/07/2008 — Internship

University of Cordoba, Cordoba (Spain)

-Research work: Statistical and evolutive learning to design logistic regression models based on product units.

EDUCATION AND TRAINING

01/03/2011–28/02/2018

PhD in Computer Engineering (Computer Science)

University of Granada, Granada (Spain)

-Principal subjects/occupational: Optimization and Paralellization of 3D Hydrodynamic Models Applied to the Knowledge and Prediction of Inland Waters.

-Certificate: High Performance Computing on Heterogeneous Parallel Architectures (CAPAP-H4).

-Certificate: Android, application programming.

-Certificate: Statistics for researchers.

-Certificate: GPU Parallel Programming.

-Certificate: Vaughan Classroom, English advanced course.

01/10/2008–15/09/2010

MSc in Computer and Network Engineering

University of Granada, Granada (Spain)

01/10/2003–01/10/2008

BSc in Computer Engineering (Computer Science)

University of Cordoba, Cordoba (Spain)

-Certificate: European Computer Driving License

-Certificate: Applications of Data Base

-Certificate: Design and components of computer hardware

-Certificate: Design and Animation using 3D Studio Max

-Certificate: Programming with JAVA2

PERSONAL SKILLS

Mother tongue(s): Spanish

Other language(s)

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	C1	C2	C1	C1	C1
French	A2	A2	A2	A2	A2

Levels: A1 and A2: Basic user - B1 and B2: Independent user - C1 and C2: Proficient user
Common European Framework of Reference for Languages

Job-related skills

-Experience in High performance computing.

-Experience in teamwork, including leadership roles.

-Experience in international projects.

-High capacity for learning and problem solving.

-Excellent communication, analysis and presentation skills.

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ADDITIONAL INFORMATION

Technical Skills

- *Parallel and distributed computing*: MPI, OpenMP, CUDA, OpenGL, V-Tune.
- *Mathematics and multimedia libraries:* MKL, IPP, NSPCG.
- *Embedded systems and signal processing.*
- *Distributed control systems.*
- Scientific Software: OpenFoam, Si3D, EFDC.
- *Technical and mathematical tools*: Matlab, Simulink, Octave, Mathematica.

Scientific Research Stay

Dates: 21 June - 20 September 2013 (3 months)

Principal subject/occupational: Research activities related with the parallelization and optimization of a 3D hydrodynamic model developed by the *United States Geological Survey (USGS).*

Name and type of the organisation: Department of Civil and Environmental Engineering. University of California, Davis (UCD), US

Publications

Tinto, O., M. Castrillo, M.C. Acosta., A. Cortes, A. Sanchez, K. Serradell, F.J. Doblas-Reyes (2017). Finding, analyzing and optimizing MPI communication bottlenecks in Earth System models. Paper Accepted.

Tinto, O., M.C. Acosta., M. Castrillo, A. Cortes, A. Sanchez, K. Serradell, F.J. Doblas-Reyes (2017). Optimizing domain decomposition in an ocean model: the case of NEMO. Procedia of Computer Sciences. http://www.sciencedirect.com/science/article/pii/S1877050917308888

Yepes-Arbós, X., M. C. Acosta, K. Serradell, A. Sanchez Lorente, F.J. Doblas-Reyes (2017). Simulation-based performance analysis of EC-Earth 3.2.0 using Dimemas. BSC-CES Technical Memorandum 2017-001, 30 pp.

Acosta, M.C., X. Yepes-Arbós, S. Valcke, E. Maisonnave, K. Serradell, O. Mula-Valls and F.J. Doblas-Reyes (2016). Performance analysis of EC-Earth 3.2: Coupling BSC-CES Technical Memorandum 2016-006, 38 pp.

Yepes-Arbós, X., M.C. Acosta, K. Serradell, O. Mula-Valls, F.J. Doblas-Reyes (2016). Scalability and performance analysis of EC-Earth 3.2.0 using a new metric approach (Part I) BSC-CES Technical Memorandum 2016-001, 28 pp.

Yepes-Arbós, X., M.C. Acosta, K. Serradell, O. Mula-Valls, F.J. Doblas-Reyes (2016). Scalability and performance analysis of EC-Earth 3.2.0 using a new metric approach (Part II) BSC-CES Technical Memorandum 2016-004, 56 pp..

International Conferences

-Mario Acosta; Mancia Anguita; Francisco Rueda; Javier Fernandez-Baldomero. N1Si3D: A One Way Nested-grid Procedure for a 3D Hydrodynamic Model. International Conference on Approximation Methods and Numerical Modeling in Environmental and Natural Resources. Granada (Spain). 22-25 April 2013. ISBN 978-84-3385-505-3.

-Alicia Cortes; Mario Acosta; Francisco Rueda. Mixing of Density Currents Inflowing a Mediterranean Stratified Reservoir (SPAIN). International Conference on Approximation Methods and Numerical Modeling in Environmental and Natural Resources. Granada (Spain). 22-25 April 2013. ISBN 978-84-3385-505-3

-Mario Acosta; Mancia Anguita; Francisco Rueda; Javier Fernandez-Baldomero. Heterogeneus Parallel Implementation of a Semi-Implicit 3D Hydrodynamic Model. International Conference on Computational Methods in Water Resources. Urbana&Champaign, Illinois (USA). 17-21 June 2012.

-Alicia Cortes; Mario Acosta; Francisco Rueda. Mixing of Density Currents Inflowing a Mediterranean Stratified Reservoir (SPAIN). International Conference on Great Lakes Research. Ontario (Canada). 13-17 May 2012.

-Andrea Hoyer; Mario Acosta; Mancia Anguita; Javier Fernandez-Baldomero; Geoffrey Schladow; Francisco Rueda. Spatial Expansion of an Invasive by Wind-driven Currents. 7th Symposium for European Freshwater Science (SEFS). Girona (Spain). 26-29 September 2011.

-Mario Acosta; Mancia Anguita; Francisco Rueda; Javier Fernandez-Baldomero. Evaluación de la

Paralelización de un modelo Hidrodinámico 3D. Jornadas de Paralelismo. Tenerife (Spain). 22-25 April 2011. ISBN 978-84-694-1791-1.

-Mario Acosta; Mancia Anguita; Francisco Rueda; Javier Fernandez-Baldomero. Paralelización de un Modelo Hidrodinámico 3D. Campus de verano CEI BIO-TIC Genil. Granada (Spain). 17-19 June 2011.

-Andrea Hoyer; Mario Acosta; Mancia Anguita; Javier Fernandez-Baldomero; Geoffrey Schladow; Francisco Rueda. Distribution of Invasive Species by Wind-driven Currents. Second IWA Symposium on Lake and Reservoir Managament: Sustainable Strategies to Enhance Water Quality. Granada (Spain). 15-18 March 2011.

-S. Rizkallal; Cesar Acosta; Francisco Cabrera; Mario Acosta; F. Rizkallal; Javier Bermejo. Autocontrol en la elaboración del gofio artesano. Congreso Internacional de Autocontrol y Alimentos Inocuos para Proteger la Salud (HACCP). Bilbao (Spain). 18-21 October 2010.

-M. Rizkallal; Mario Acosta. Derogado el Real Decreto 202/2000 sobre Planes de Formación ¿Es posible un estándar?. Congreso Internacional de Autocontrol y Alimentos Inocuos para Proteger la Salud (HACCP). Bilbao (Spain). 18-21 October 2010.

-Mario Acosta; Mancia Anguita; Francisco Rueda; Javier Fernandez-Baldomero. Parallel Implementation of a Semi-implicit 3D Lake Hydrodynamic Model. International Conference on Computational and Mathematical Methods in Science and Engineering. Almeria (Spain). 13-16 July 2010. ISBN 978-84-613-5510-5

Teaching

Computer Engineering. ETSIIT, University of Granada.

Computer Technology II (60 hours)

Computer Structure (40 hours)