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CENTRE OF EXCELLENCE IN SIMULATION OF WEATHER AND CLIMATE IN EUROPE

ESiWACE3 - Excellence in Simulation of Weather and Climate in Europe, Phase 3

Services and Benchmark Suite for Weather and Climate

Readiness of HPC Extreme-scale Applications - ISC HPC 2025 Workshop

Erwan Raffin (Eviden)

EuroHPC Joint Undertaking

Funded by the European Union. This work has received funding from the European High Performance Computing Joint Undertaking (JU) under grant agreement No 101093054.

Co-funded by the European Union

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Fraternité

anr agence nationale de la recherche
AU SERVICE DE LA SCIENCE

ESiWACE3 - Centre of Excellence in Simulation of Weather and Climate in Europe

ESiWACE3 focuses on **supporting the weather and climate modelling community** in achieving **the excellence in exascale supercomputing**

Coordinated Barcelona Supercomputing Center – Centro Nacional de Supercomputación

Consortium of 12 partners from 8 different countries

Start: 1 January 2023
End: 31 December 2026

ESiWACE3 partners

DKRZ DEUTSCHES KLIMARECHENZENTRUM
SMHI
MAX-PLANCK-INSTITUT FÜR METEOROLOGIE
HELSINGIN YLIOPISTO
cmcc Centro Euro-Mediterraneo sui Cambiamenti Climatici
ECMWF

Weather forecast
Climate research

BSC
CSC
JÜLICH Forschungszentrum

High-performance computing

EVIDEN
netherlands eScience center
BSC

Software engineering

SMHI
HELSINGIN YLIOPISTO

Training and teaching

LT

Communicating academic research


Technical developments and research activities
Services, training, and networking activities to support the community
WP1: Support to effective applications
WP2: Develop community tools
WP3: Tackle the data challenge
WP4: Community services to enhance HPC applications
WP5: Training and capacity building
WP6: Community engagement, dissemination and exploitation
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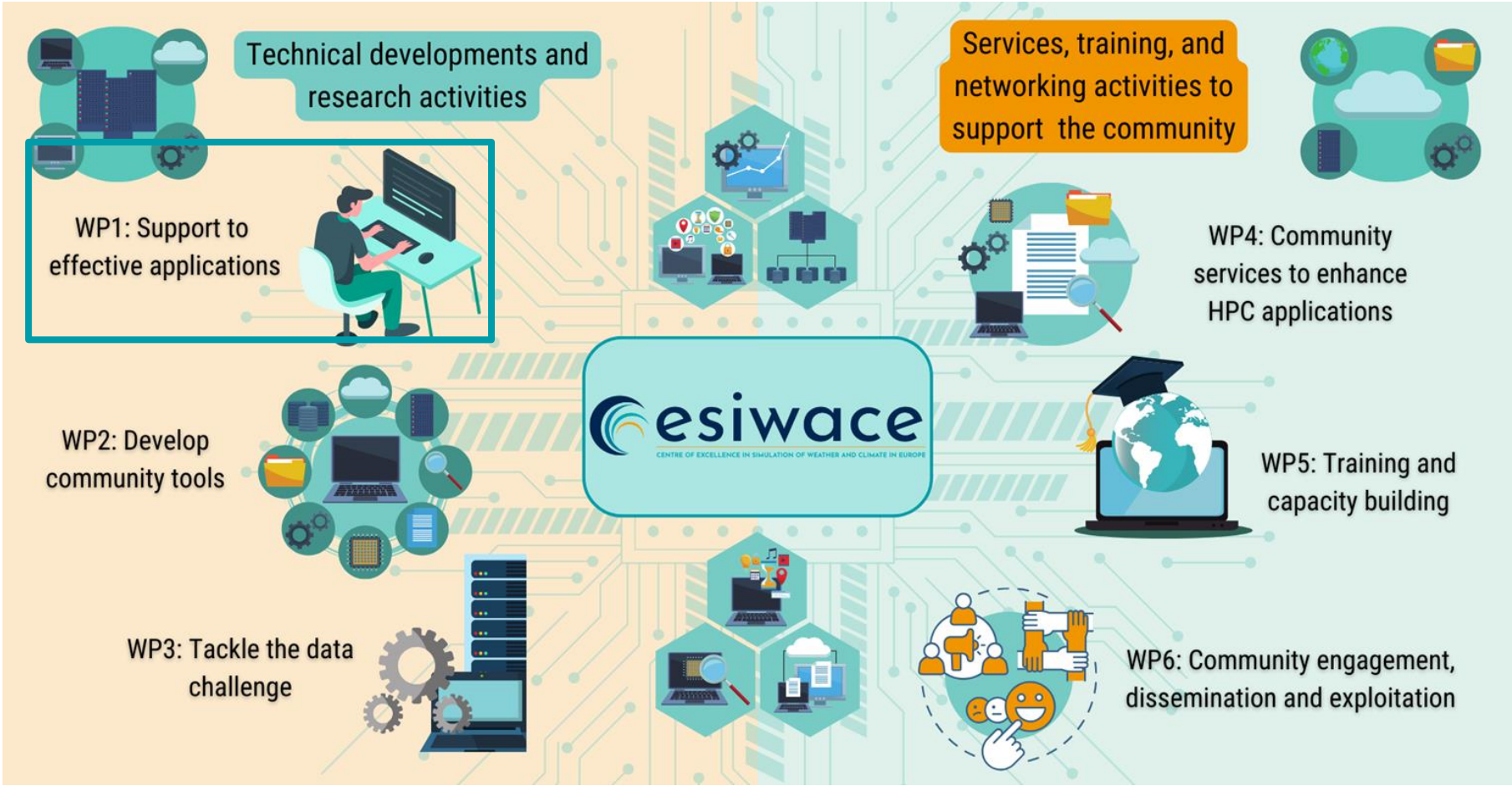
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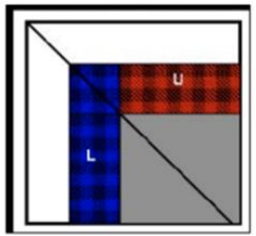
From synthetic to Domain Specific Benchmark

High Performance Linpack



1979

Dense linear equations
Still used for Top500 ranking (and Green500)

STREAM

STREAM
High Performance Computing

1996

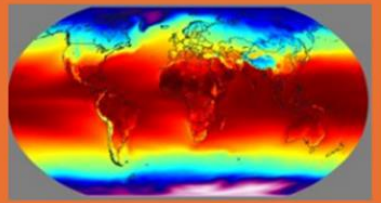
Pure memory benchmark

High Performance Conjugate Gradients

HPCG
High Performance Conjugate Gradients

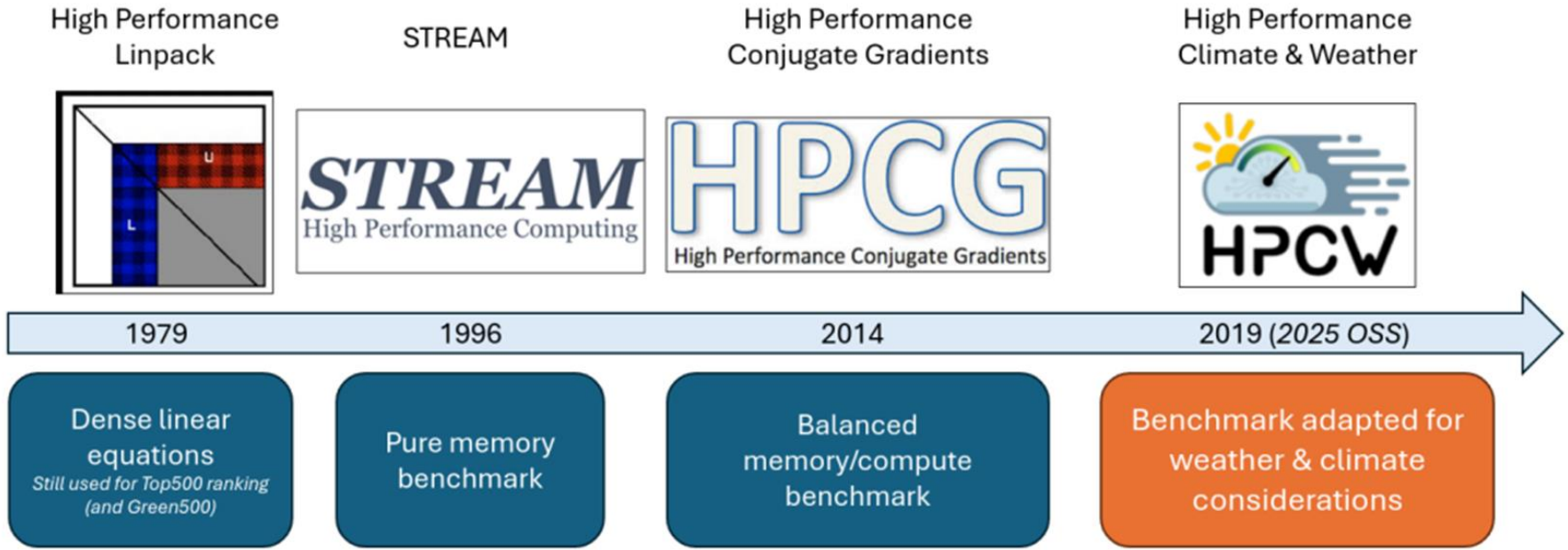
2014

Balanced memory/compute benchmark



Benchmark adapted for weather & climate considerations ?

From synthetic to Domain Specific Benchmark

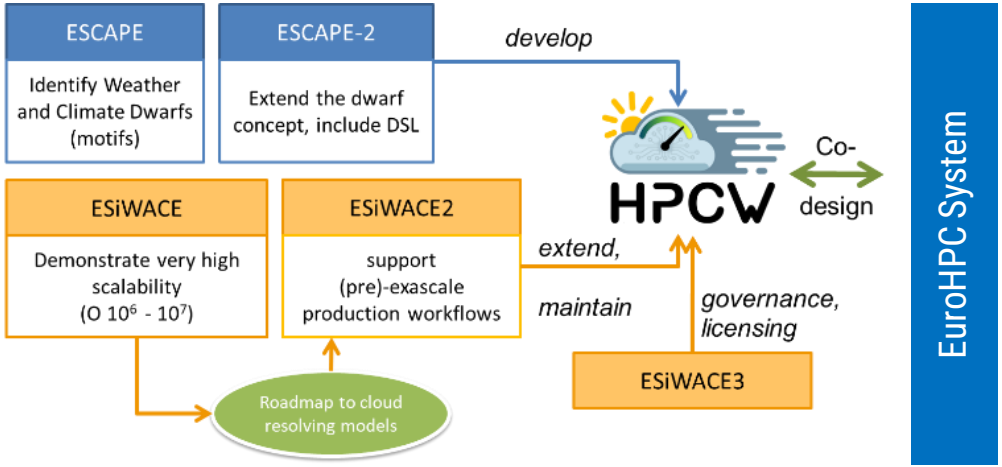


HPCW: High Performance Climate & Weather benchmark suite

Overview
- Set of relevant and realistic, near-operational weather forecast workloads
- Climate science workflows
- Same usage as HPL or HPCG including ranking

HPCW v3.0 components:
- Models: ICON, NEMO
- Dwarfs:
- IFS: ecRad, ecTrans, cloudSC (incl. GPU)
- NICAM: NICAM-DC (beta)

Benchmark framework
- Agnostic, customizable and parallel
- Multi model and multi dependencies management
- Spack recipes available



Key facts
- CI on Levante (DKRZ)
- Open source: Apache License 2.0
- Already deployed (full or partially) on different HPC systems including Levante (DKRZ), MareNostrum5 (BSC), ECMWF-ATOS, LUMI (CSC), more to come

HPCW: International collaboration

HANAMI

GANANA

EuroHPC Joint Undertaking

This project received funding from the European High Performance Computing Joint Undertaking (EuroHPC JU) under the European Union's Horizon Europe framework program for research and innovation and Grant Agreement No. 101136269.

EuroHPC Joint Undertaking

GANANA has received funding from the European High Performance Computing Joint Undertaking under grant agreement no. 101196247.

Funded by the European Union

HPCW: High Performance Climate & Weather benchmark suite

- HPCW is the Domain Specific Benchmark dedicated to the Weather and Climate community

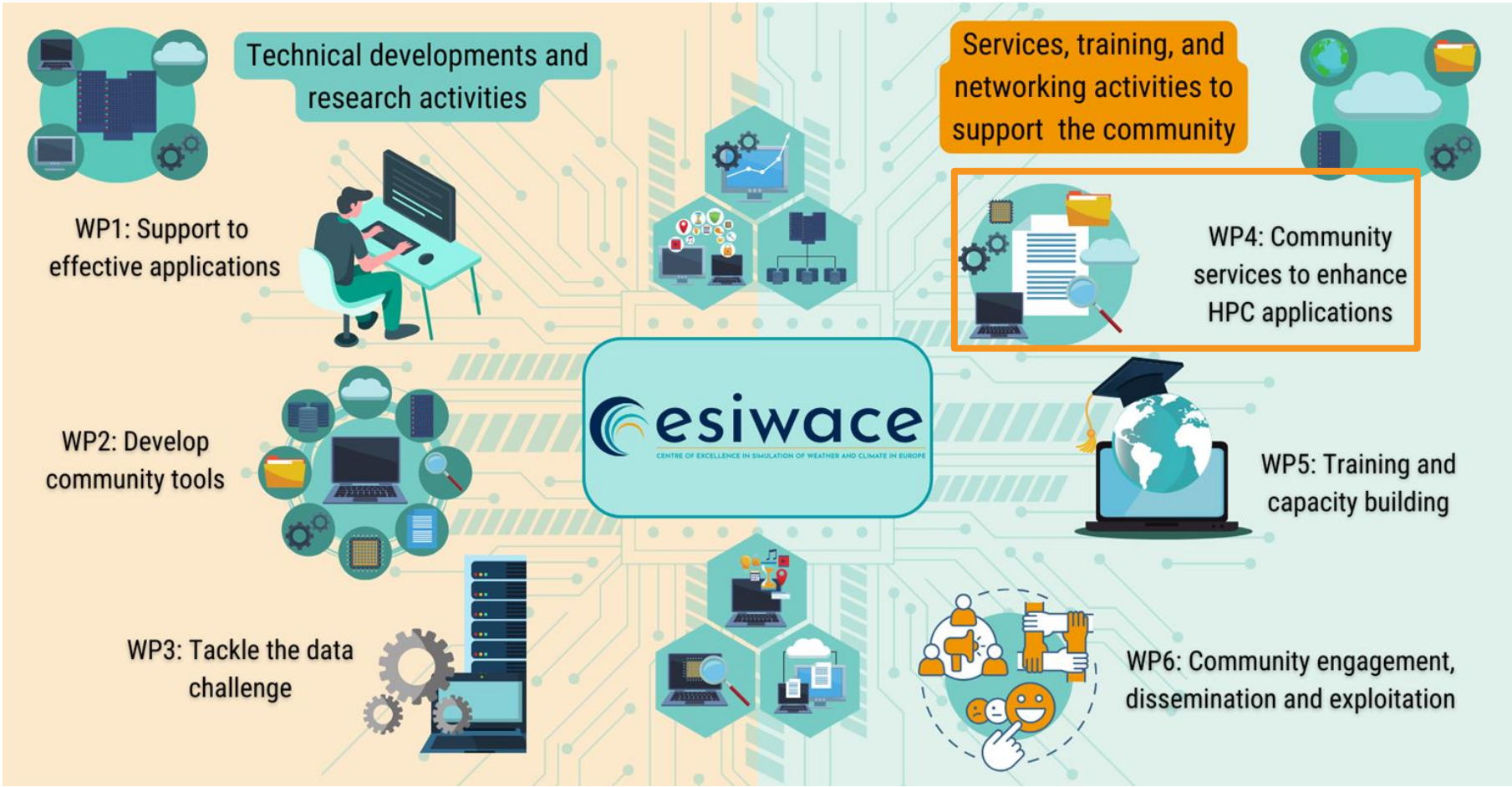
- Technology providers need trusted metrics
- Trusted metrics need reproducibility
- Reproducibility needs trusted tools

- HPCW benchmark provides:

✓ Weather and Climate models and Dwarfs from the EU, Japan and soon Indian community
✓ An easy way to deploy the software stack to build, verify and benchmark its components
✓ Table to compare trusted and reproducible metrics

- Collaborations fosters the exchange of expertise, enabling researchers and industry to be more productive and paving the way to scientific excellence

- Collaboration is key!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Services

We offer free services (help) to enhance HPC applications and improve Earth system models

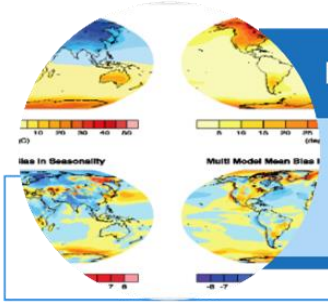
- **Model optimization and acceleration**

We offer up to 6 person months distributed over one year.
Within collaborative projects the ESiWACE experts provide **advice and engineering effort** to the applicant.

- **Support on domain specific tools and technologies**

We offer up to 2 person month distributed over half a year.
Our experts will support ESM-developers in the **adoption of tools** developed in the landscape of ESiWACE.

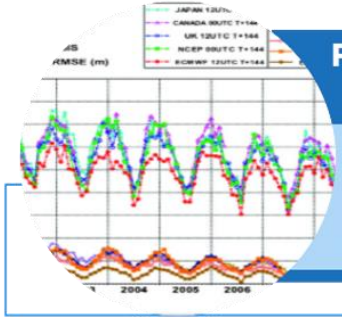
Examples of services



PERFORMANCE IMPROVEMENT

ESMValTool: Earth System Evaluation Tool

Performance improvement and parallelization using Dask



PROFILING & COMPUTATIONAL OPTIMIZATION

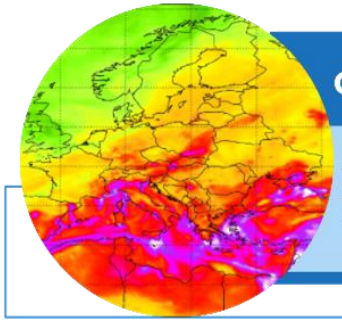
GLOBO: Atmospheric General Circulation Model

Profiling, optimizing MPI communications, Parallel I/O and Mixed/lower precision

REDUCED PRECISION FOR ESM

EC-EARTH 4: European Community Earth System Model

Porting M7 aerosols in OpenIFS 48r1 to single precision to gain performance without degrading quality



GPU PORTING & OPTIMIZATION

CAMP: Chemistry Across Multiple Phases

Revising and optimizing GPU implementation of CAMP for new HPC systems, focusing on MareNostrum5

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GLOBO

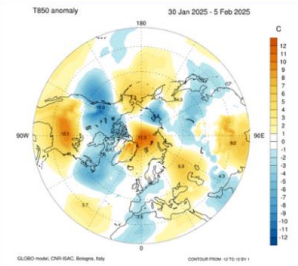
Atmospheric General Circulation Model

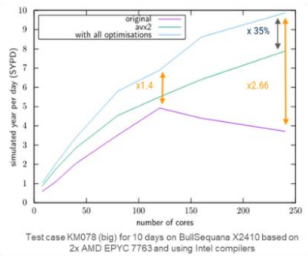
EVIDEN

CNR ISAC

Service provided

Identify bottlenecks for performance and scaling, to improve MPI communications and to implement parallel I/O or any additional aspects to optimise the code.





Benefits

2.66x

Build system improvement, loop vectorization, and communication enhancement

A speedup of up to 2.66x have been obtained on 240 CPU cores

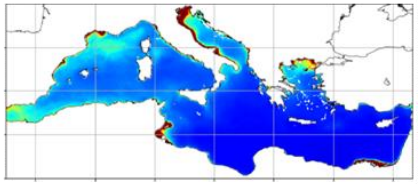
Deep code optimizations of the GLOBO atmospheric model.

Societal & economic impact

Improving the numerical performance of the model will make the whole forecasting system more efficient in delivering its products to the end users, possibly enlarging its audience.

OGSTM-BFM Service Project

OGSTM-BFM
Ocean Model with Biogeochemical Flux Model (BFM)



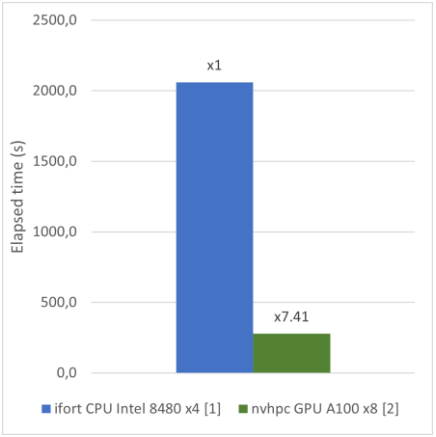
Project objectives

Porting horizontal & vertical diffusion, carbonate system solver of BFM to GPU using OpenACC

Work performed

- First project
  - Not enough work in BFM loops to keep GPU busy
  - Use of batching to increase work per GPU kernel
  - Slow down CPU version
  - Partial porting
  - Need swapping of dimensions of BFM internal arrays, this should benefit GPU execution and probably CPU as well
- Second project
  - Model developers has reversed loops indices in BFM, leading to better performance for both CPU and GPU
    → This has allowed to really exploit GPU
  - Then, the entire model has been ported on GPU
  - This represents about 300 OpenACC kernels across 60 files!
  - 7.41x speedup on GPU compared to CPU on LEONARDO

Results



Sea model 3 days simulation, without I/O dump, 2 LEONARDO nodes.

Take away message

ESiWACE contributes to the Readiness of HPC Extreme-scale Applications in Weather and Climate

- by delivering a range of services including tailored help with model performance and scaling optimization
- by developing the High Performance Climate and Weather (HPCW) benchmark suite composed of flagship models and kernels

Collaboration is key!

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Interested in getting in touch?

Website: www.esiwace.eu

YouTube: https://www.youtube.com/@esiwace880

X: https://x.com/esiwace

Bluesky: https://bsky.app/profile/esiwace-community.bsky.social

LinkedIn: https://www.linkedin.com/company/esiwace3

zenodo

ESiWACE is on Zenodo, the Open Access repository for scientific results
https://zenodo.org/communities/esiwace

OPEN ACCESS

erwan.raffin@eviden.com

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