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CENTRE OF EXCELLENCE IN SIMULATION OF WEATHER AND CLIMATE IN EUROPE

# Implementation of EC-Earth 10km global coupled demonstrator and performance analysis

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Barcelona Supercomputing Center
Centro Nacional de Supercomputación

- **EC-Earth - A European community Earth-System Model**
  - **IFS** (atmosphere)
    - T1279L91: ~16km grid point distance, **2.1M** grid points
  - **NEMO-LIM** (ocean – sea-ice)
    - ORCA12L75: ~9km grid point distance, **13.2M** grid points
  - Total 3D space: 1,024kM vertices

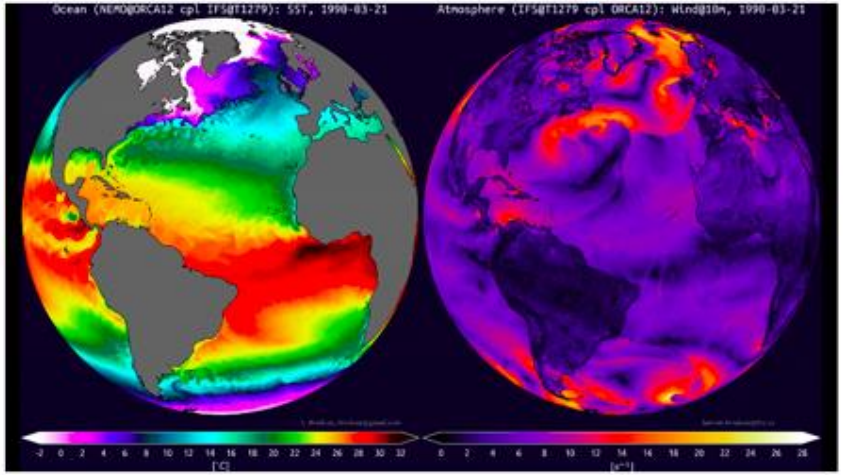
# Development of T1279-ORCA12

- Develop **initial data**
  - Including OASIS **interpolation weight** files
- Create **namelists** for IFS, NEMO-LIM (XIOS) and OASIS
- Adapt **source code** and existing **runscripts**
- Introduce required changes in the experiment **workflow**
- **Scalability** tests / load **balance** studies / **profiling**

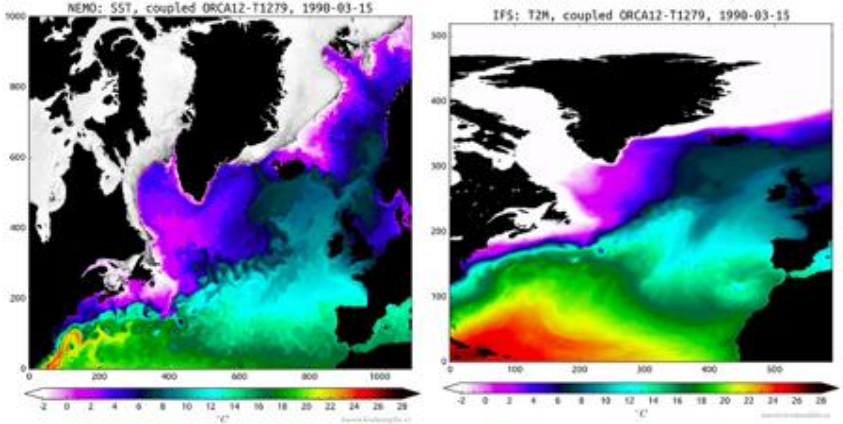
- **First global, coupled ~10km simulations (T1279 – ORCA12):**
  - **EC-Earth 3.2** (IFS36r4 + NEMO 3.6 + OASIS3-MCT)
  - 2,035 MPI tasks - 60 SDPD
    - 1,170 NEMO
    - 848 IFS
    - 16 XIOS
    - 1 runoff mapper
  - **MareNostrum3** @ BSC

# First simulations from the EC-Earth coupled 10km demonstrator

- **First global, coupled ~16km simulations (T1279 – ORCA12):**




Left, Global Sea Surface Temperature of the ocean component NEMO. Right, Global Speed Wind at 10m of atmosphere component IFS.



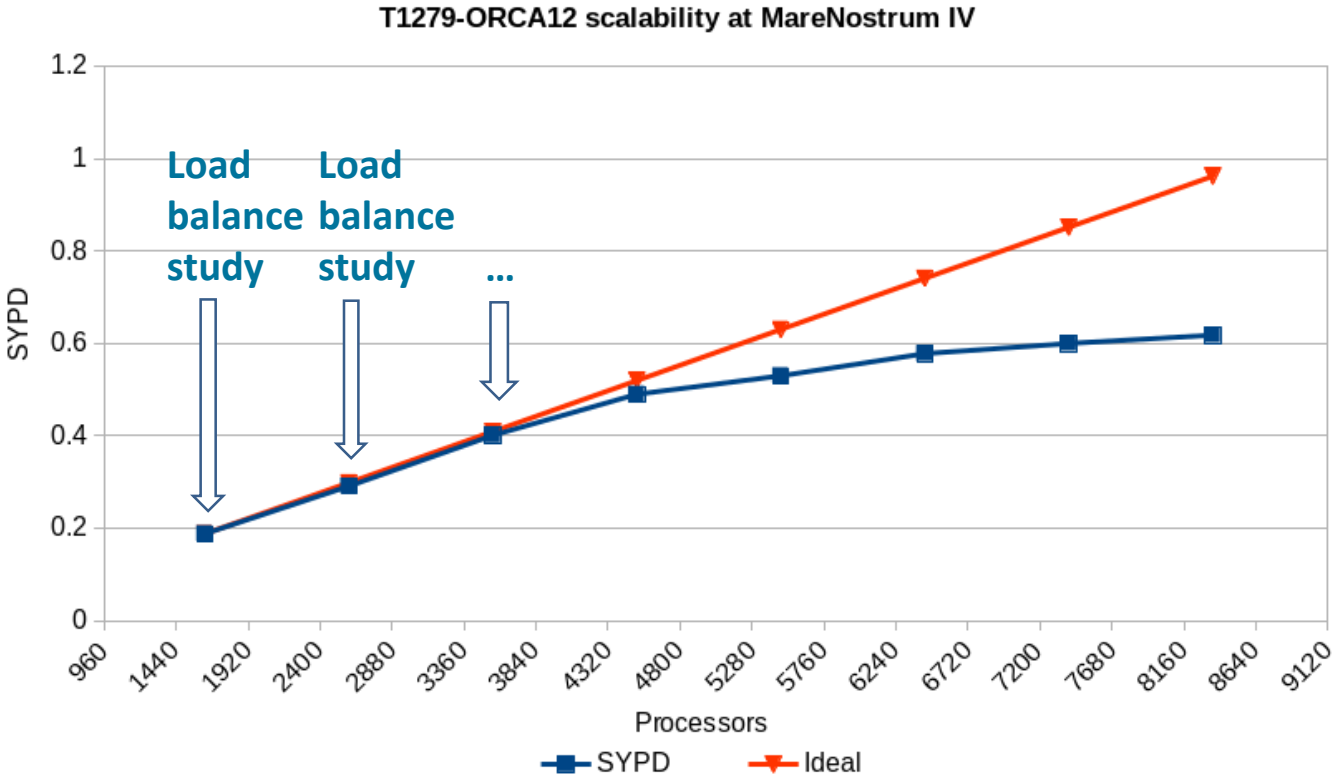

Left, regional crop Sea Surface Temperature of the ocean component NEMO. Right, regional crop Temperature at 2m of the atmosphere component IFS.

[Surface current speed in ORCA12 coupled to IFS (EC-Earth 3.2)]
[Wind speed at 10m in IFS T1279 coupled to ORCA12 (EC-Earth 3.2)]

# Deployment for production in MareNostrum4: Tackled issues

- **I/O management**
  - Use of MareNostrum4 **data-transfer nodes**
- Optimal libraries and **dependencies**
- Come up with a **stable environment**
  - OmniPath: numerous **tests** and **collaboration** with operations to find a good **configuration** (tmi, PSM2)
  - XIOS update: decrease number of **communications**
  - Controlling process pinning: better **memory management**

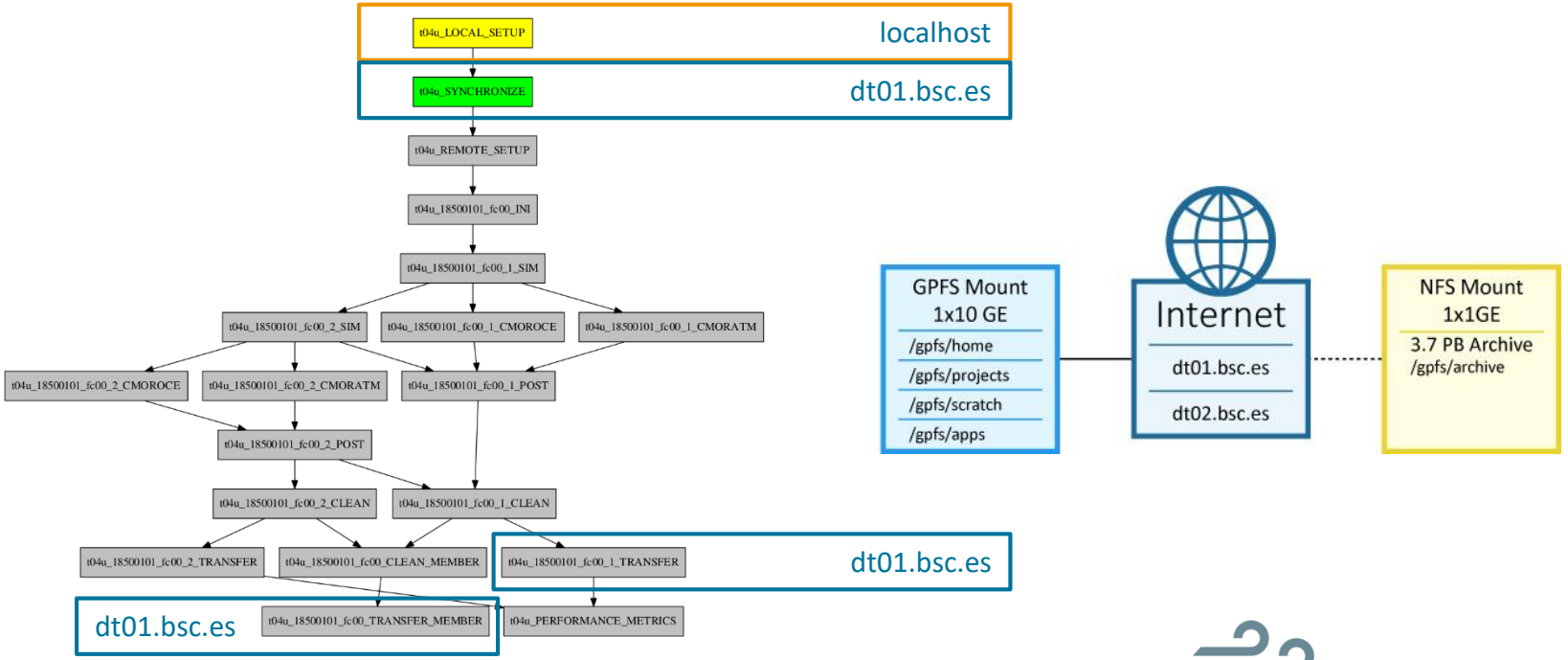
# The EC-Earth coupled 10km demonstrator in MareNostrum4



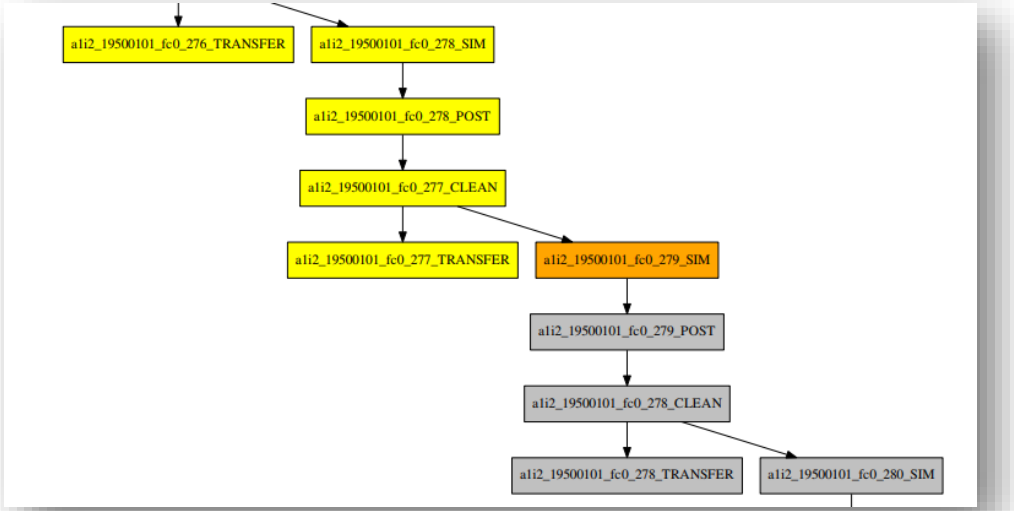
- **Operational global, coupled ~10 km simulations (T1279 – ORCA12):**
  - **EC-Earth 3.2** (IFS36r4 + NEMO 3.6 + OASIS3-MCT)
  - **5,040 MPI tasks** - 0.44 SYPD, 160 SDPD
    - 3,209 NEMO
    - 1,584 IFS
    - 69 XIOS
    - 1 runoff mapper
  - **MareNostrum4** @ BSC

**100 year** exp
**~40M ch** !!!

# Adapting workflow for production: **data transfer nodes**



# **Production** runs: **Managing the workflow**



# The EC-Earth coupled 10km demonstrator: production runs

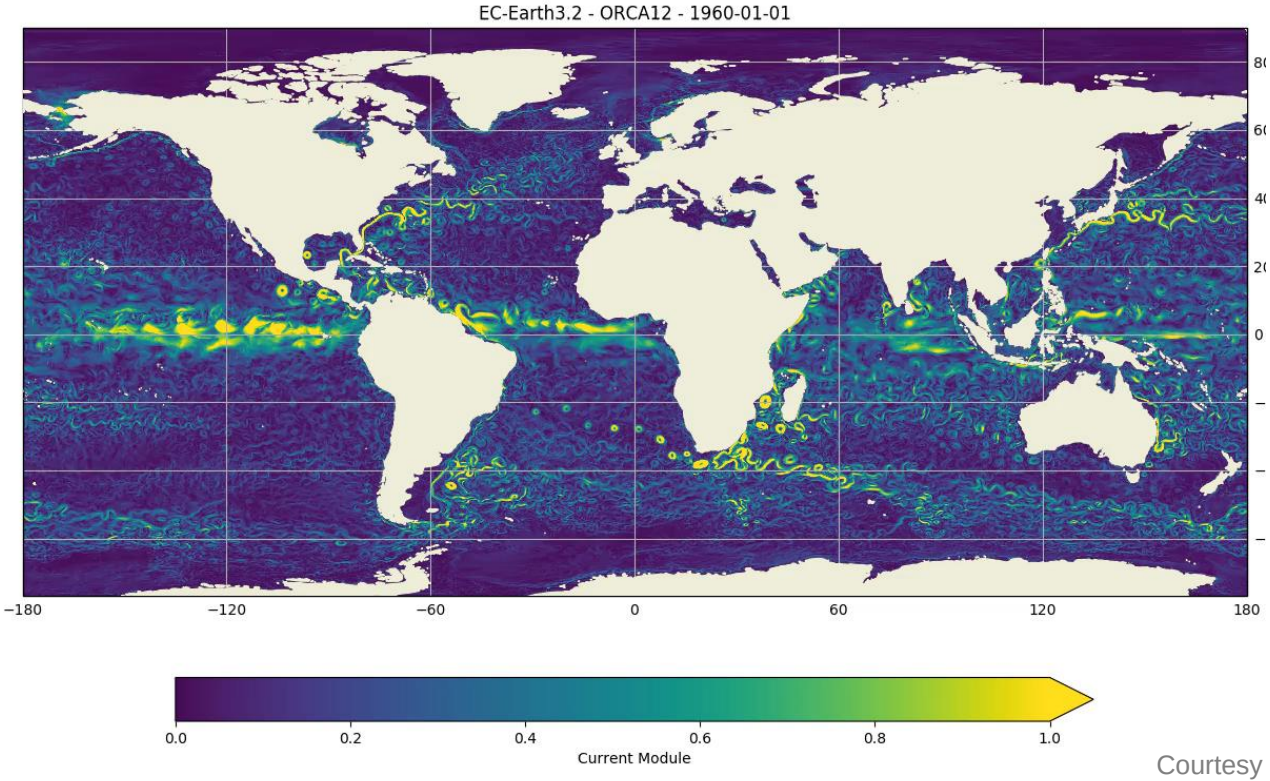
PRIMAVERA

- **PRIMAVERA** is a **Horizon 2020** project which aims to develop a **new generation of advanced and well-evaluated high-resolution global climate models**, capable of simulating and predicting regional climate with **unprecedented fidelity**, for the **benefit** of governments, business and society in general.

HIGHRESMIP

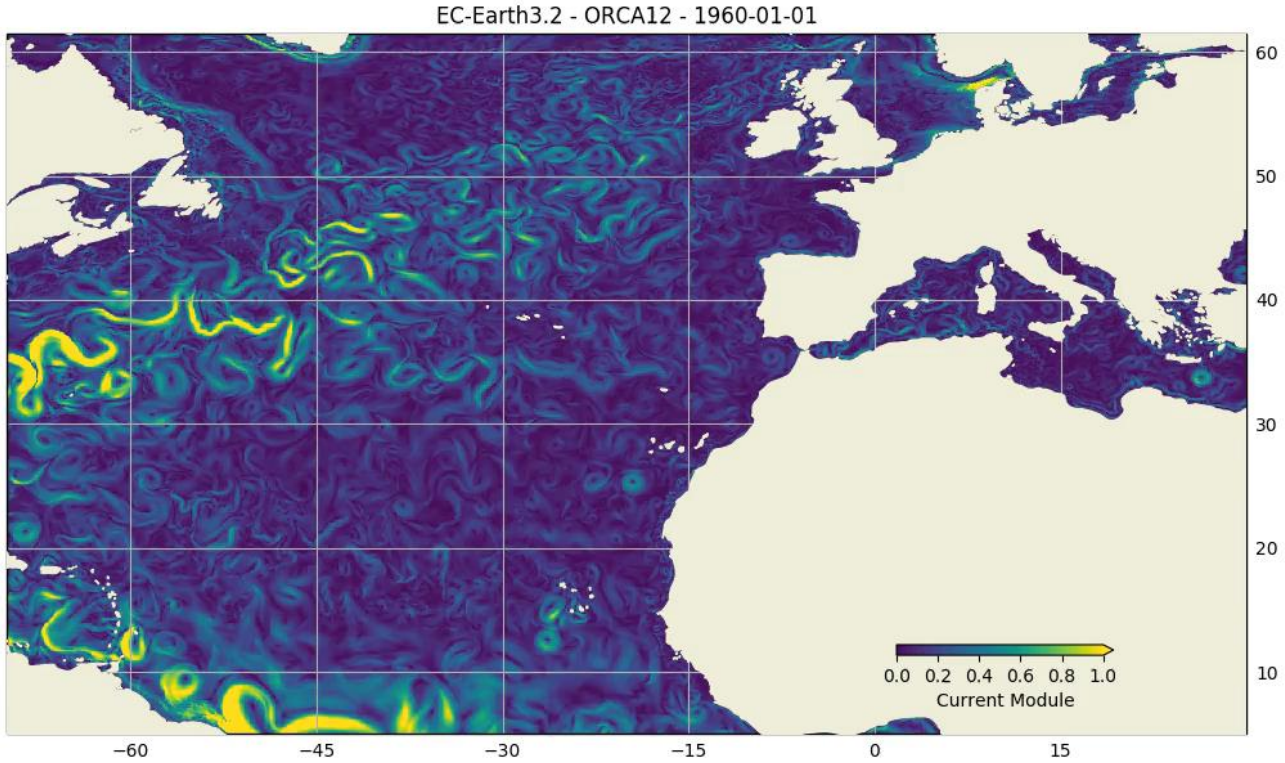
- The **High Resolution Model Intercomparison Project (HighResMIP)** is a **CMIP6** endorsed MIP that applies, for the **first time**, a **multi-model approach** to the systematic investigation of the **impact of horizontal resolution**.

# The EC-Earth coupled 10km demonstrator: production runs




Courtesy of: Thomas Arsouze

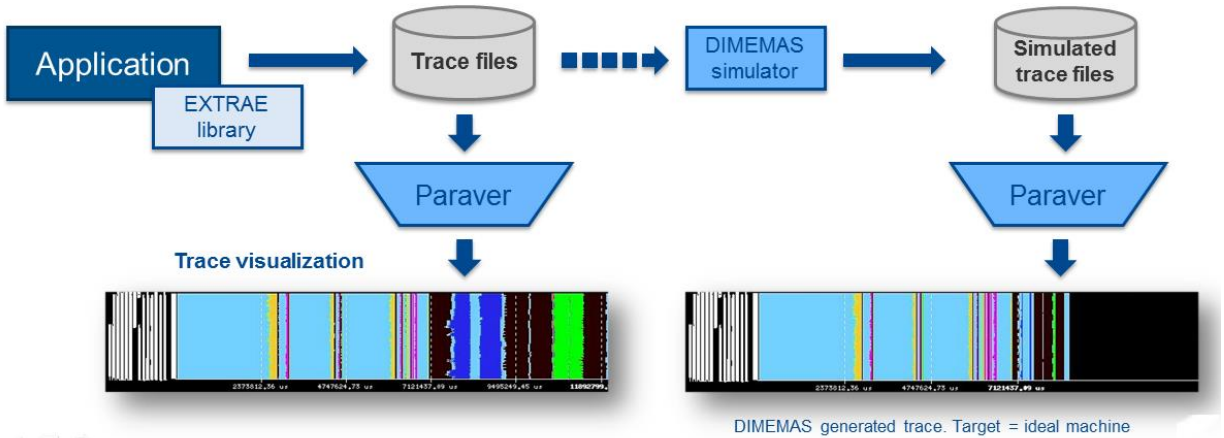
# The EC-Earth coupled 10km demonstrator: production runs




Courtesy of: Thomas Arsouze

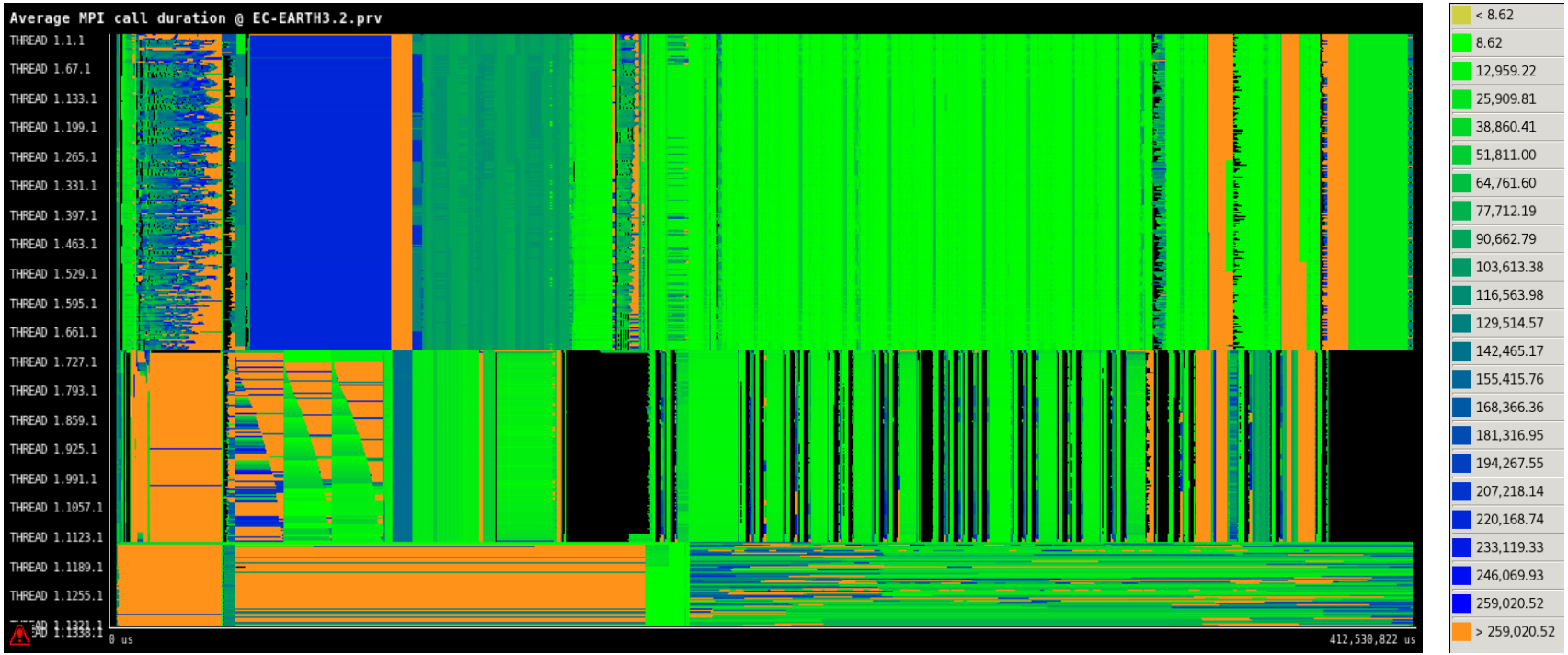
# Performance analysis

- Since 1991
- Based on traces
- Open Source: http://www.bsc.es/paraver
- **Extrae**: Package that generates Paraver trace-files for a post-mortem analysis
- **Paraver**: Trace visualization and analysis browser
  - Includes trace manipulation: Filter, cut traces
- **Dimemas**: Message passing simulator

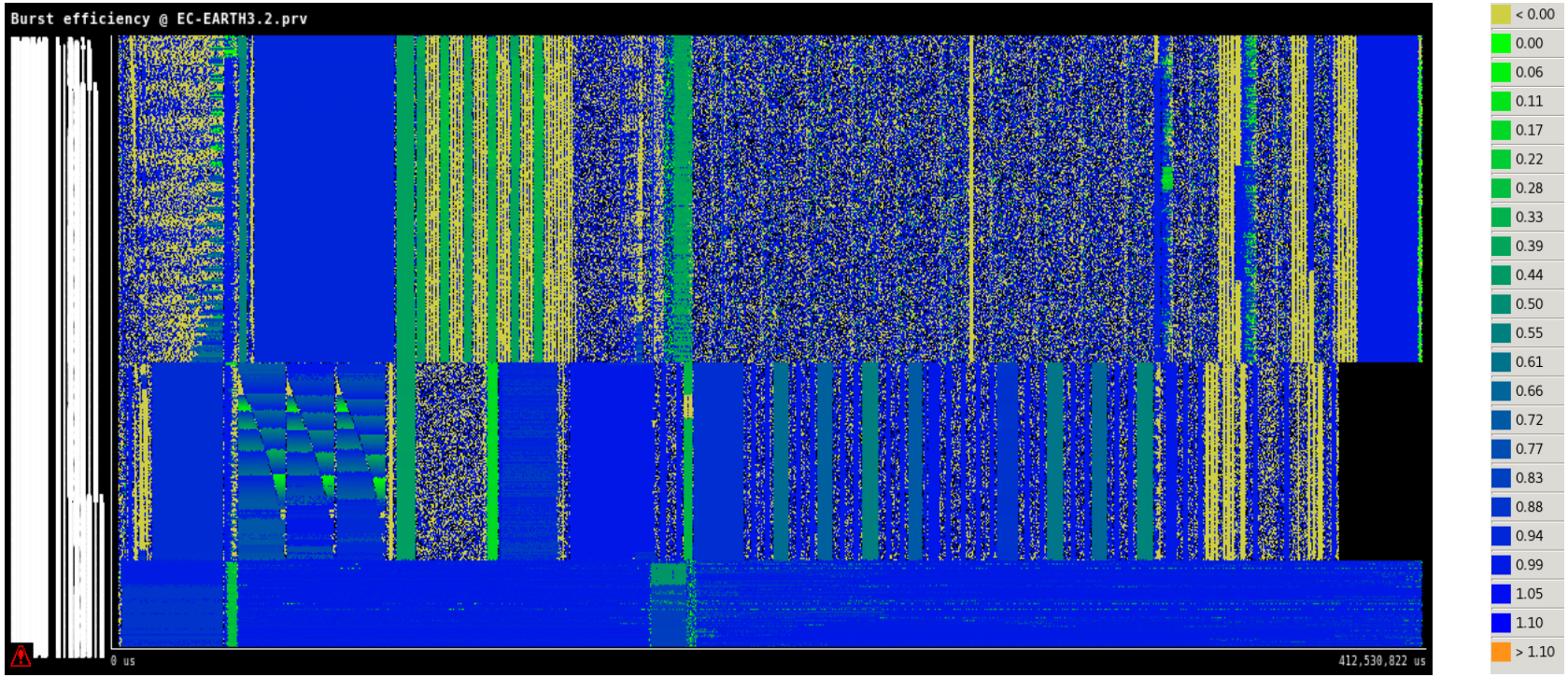



DIMEMAS generated trace. Target = ideal machine

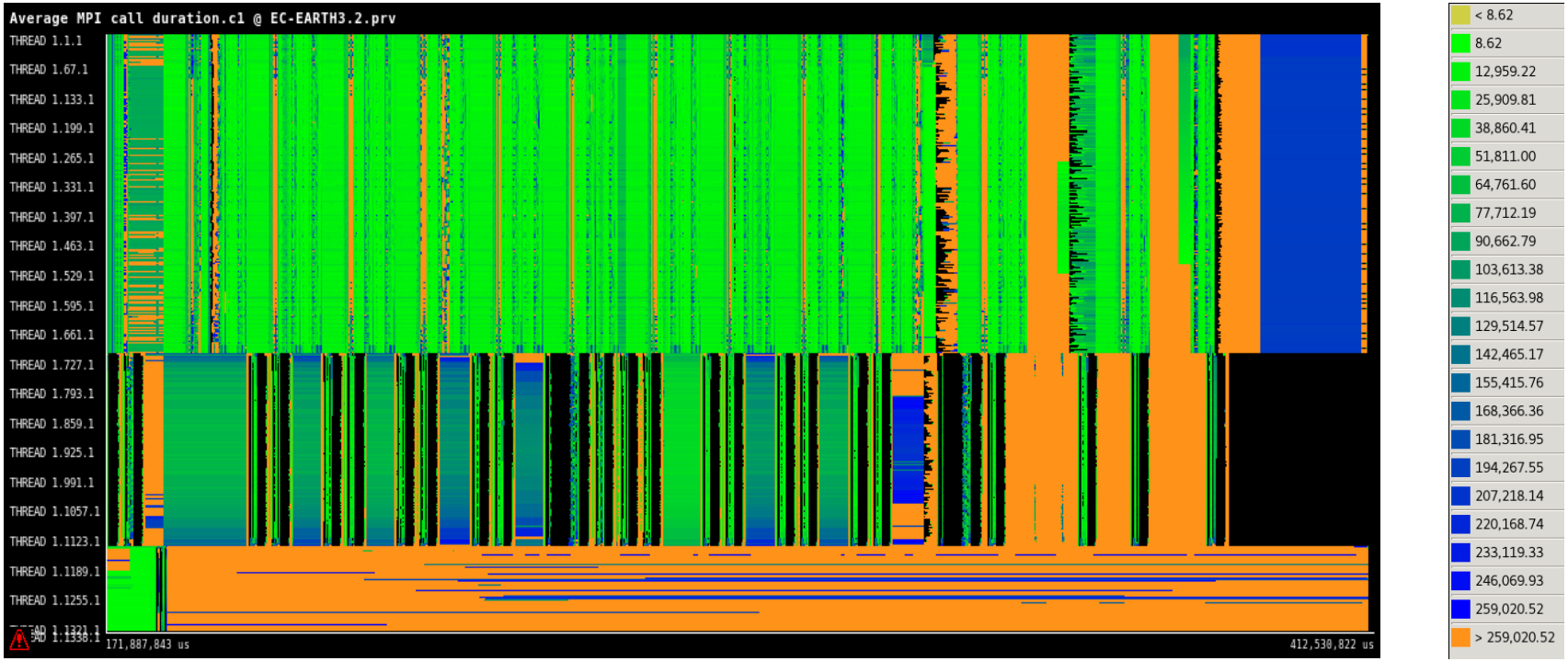
# T1279-ORCA12: Performance analysis



# T1279-ORCA12: Performance analysis



# T1279-ORCA12: Performance analysis



# Challenges (bottlenecks)

- Reduce **I/O overhead** → Interface IFS with **XIOS**
  - NEMO-LIM (ORCA12): Up to **3 SYPD** in MareNostrum4 (LIM -> 2OCE stp)
- **Detach sea-ice** from NEMO. Couple through **OASIS**.
- **Update IFS** to newest cycle, using octahedral grid
- **Update NEMO** to NEMO4 (and beyond)
- Most of these improvements can be real in **EC-Earth4**

# Results and conclusions

- At the end of this project **T1279-ORCA12** is:
  - Developed and shared among **EC-Earth consortium** partners
  - **Deployed and tested** in **MareNostrum3** and **MareNostrum4** HPC systems
  - Used in **production** for other **H2020** projects such as PRIMAVERA
  - Used to investigate the **scalability** of **ultra-high resolution** coupled models, enabling to **push computational challenges** of the current HPC generation

# THANK YOU

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