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Centro Nacional de Supercomputación



EC-Earth, a coupled Climate Model for extreme Event Prediction

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Oriol Tintó, Xavier Yepes**

Computational Earth Sciences

Tornados, Disaster

& Early Warning ISC 2018

26/06/2018

esiwace
CENTRE OF EXCELLENCE IN SIMULATION OF WEATHER
AND CLIMATE IN EUROPE



Outline

- Introduction
- Hurricanes at ISC
- EC-Earth model
- Performance analysis to increase resolution
- Using Machine Learning for hurricanes

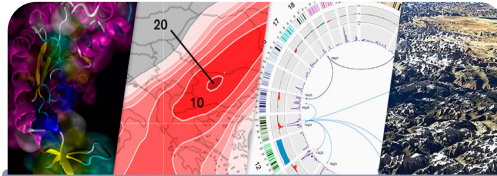
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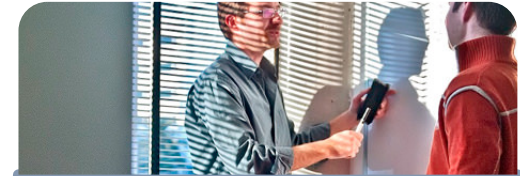
BSC-CNS objectives



Supercomputing services
to Spanish and
EU researchers



R&D in Computer,
Life, Earth and
Engineering Sciences



PhD programme,
technology transfer,
public engagement

BSC-CNS is
a consortium
that includes

Spanish Government

60%



Catalonian Government

30%



Univ. Politècnica de Catalunya (UPC)

10%

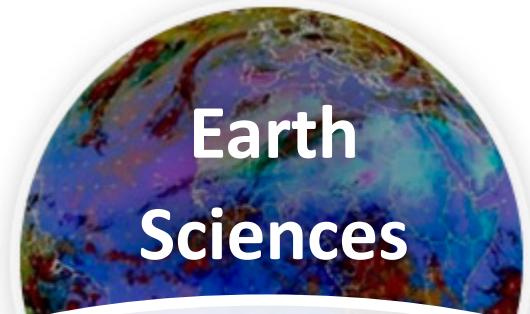


Mission of BSC Scientific Departments



Computer Sciences

To influence the way machines are built, programmed and used: programming models, performance tools, Big Data, computer architecture, energy efficiency



Earth Sciences

To develop and implement global and regional state-of-the-art models for short-term air quality forecast and long-term climate applications



Life Sciences

To understand living organisms by means of theoretical and computational methods (molecular modeling, genomics, proteomics)



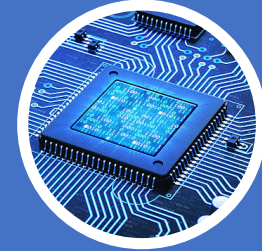
CASE

To develop scientific and engineering software to efficiently exploit super-computing capabilities (biomedical, geophysics, atmospheric, energy, social and economic simulations)

Interdisciplinary work



Weather and
Climate Science



Computer
Science



- Knowledge about the mathematical and computational side of Earth System Applications
- Knowledge about the specific needs in HPC of the Earth System Applications
- Researching about HPC methods specifically used for Earth System Applications

Why hurricanes in ISC?



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EC-Earth



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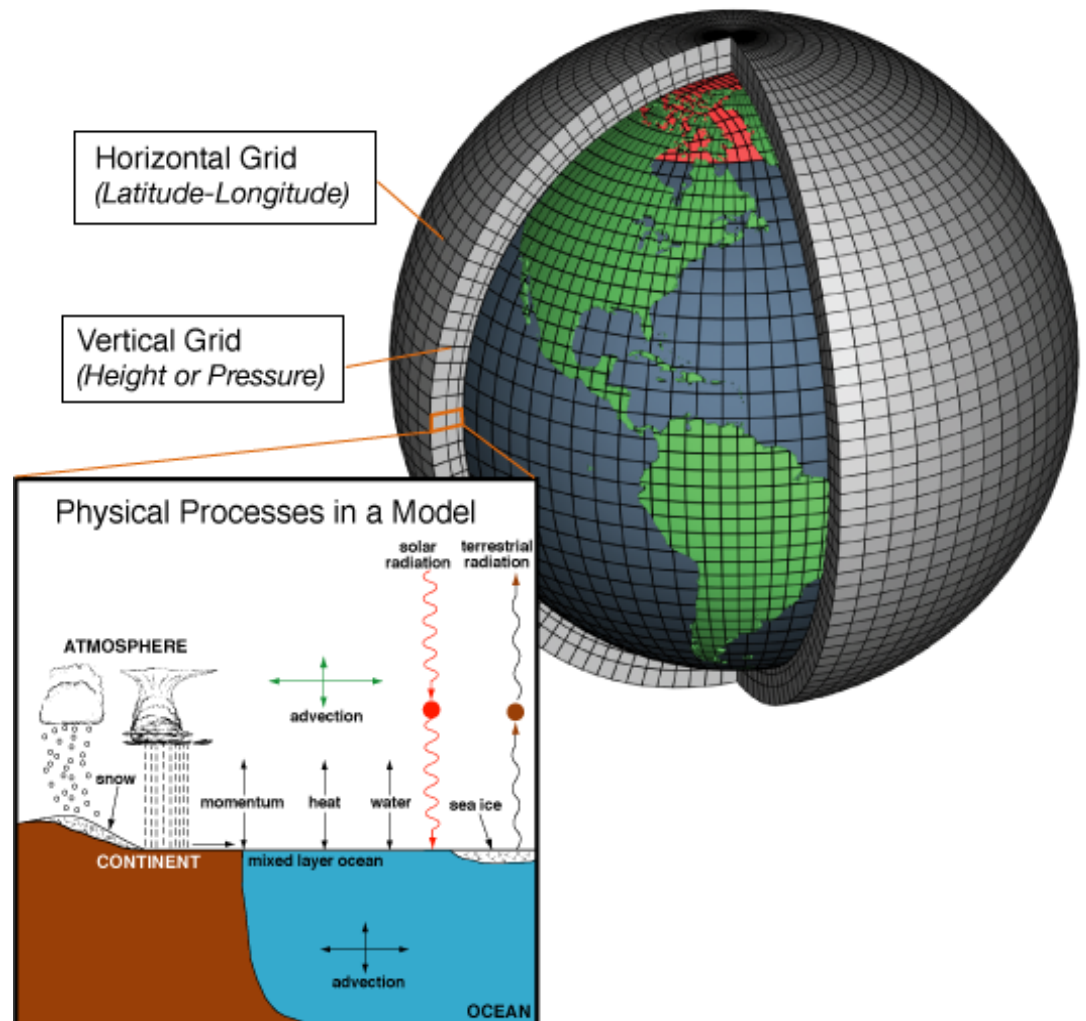
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EC-Earth Model

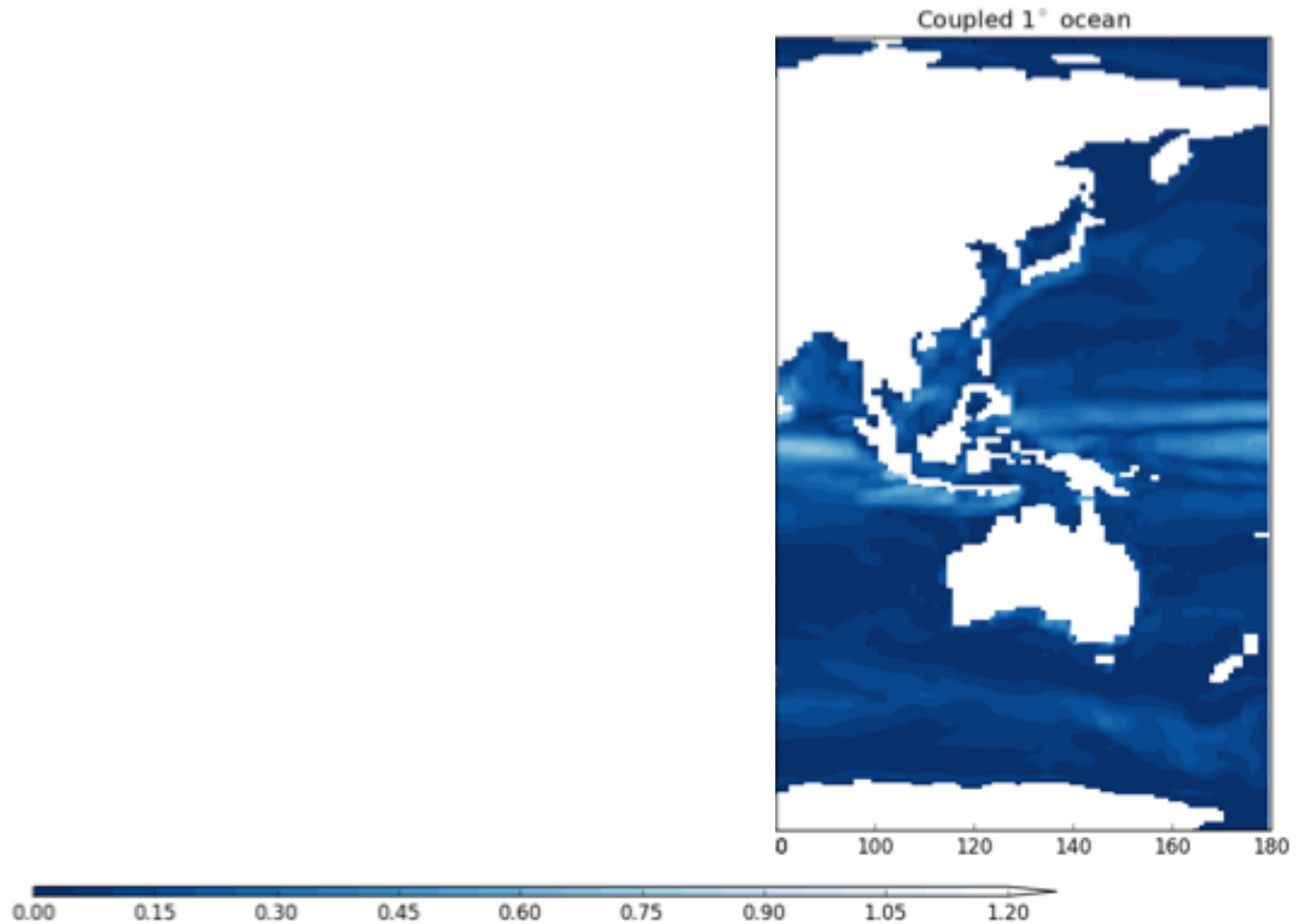


- The Integrated Forecasting System (**IFS**) as atmosphere model
- The Nucleus for European Modelling of the Ocean (**NEMO**) as ocean model
- The **OASIS3-MCT** coupler
- The Louvain-la-Neuve sea-Ice Model 3 (**LIM3**) as sea ice model

EC-EARTH coupled model



PRIMAVERA Project

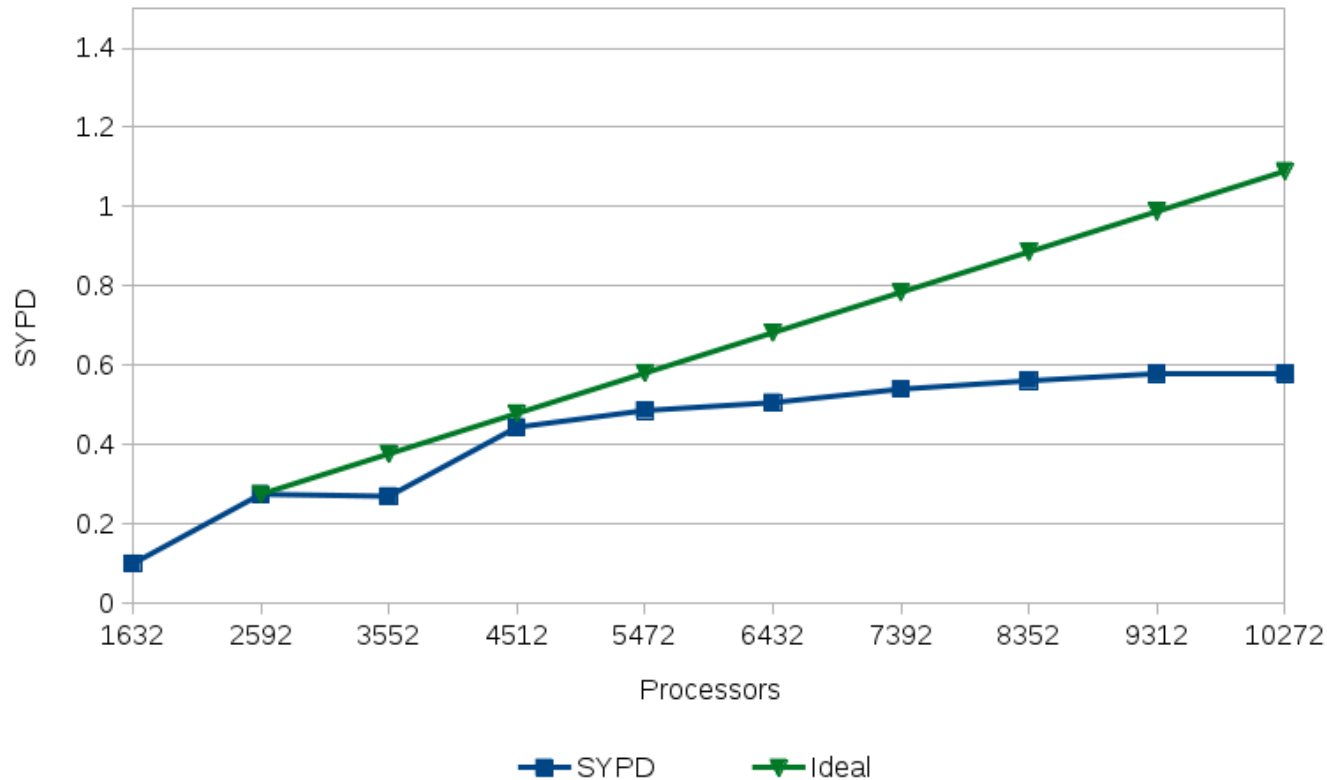


Ultra-high configuration

- In ESiWACE, BSC is developing an ultra-high configuration (T1279-ORCA12).
- Configuration T1279 - ORCA12 deployed in MareNostrum 4
- Technical issues with OPA network and large number of cores
- Run with real production output (3,5 Tb per year)

Ultra-high configuration

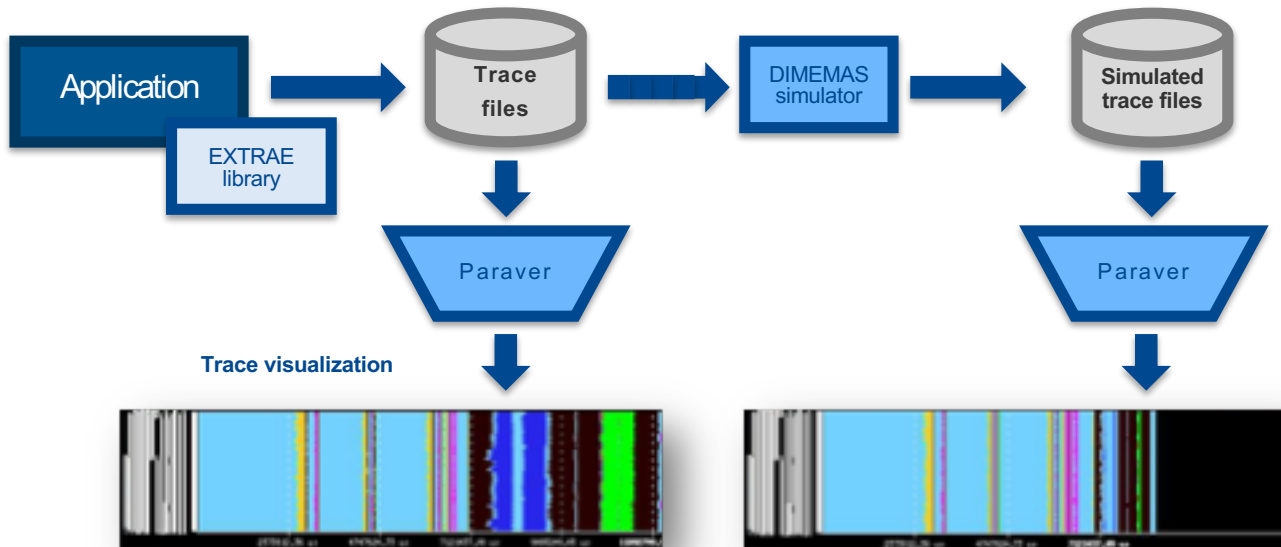
T1279-ORCA12 scalability at MareNostrum IV



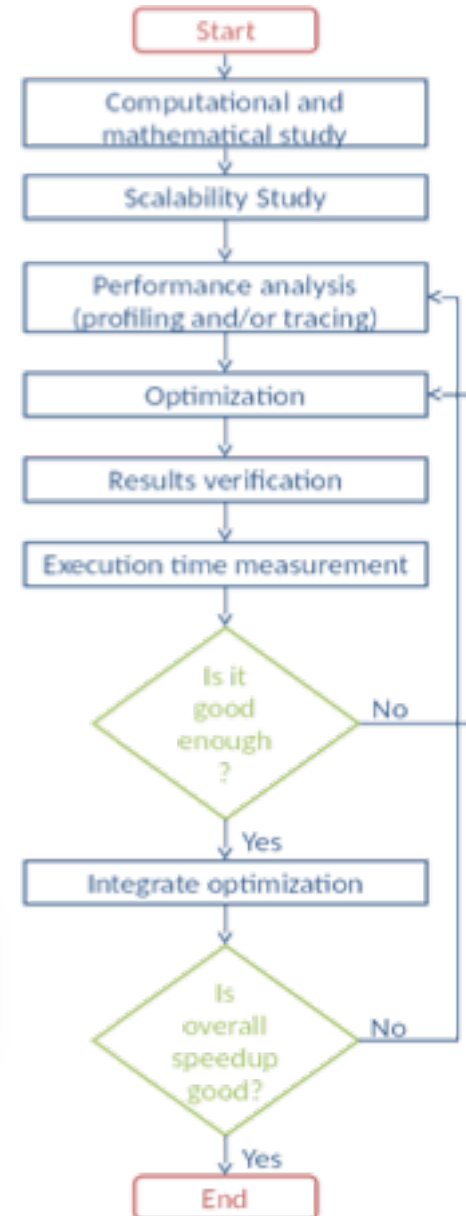
- Low amount of SYPD (360s timestep):
 - In IFS, I/O is done by a single process
 - IFS-36r4 is an old release (Nov. 2010)

Performance analysis

- We need to understand where are the bottlenecks
- Not trivial in a coupled simulation of 10.000 cores



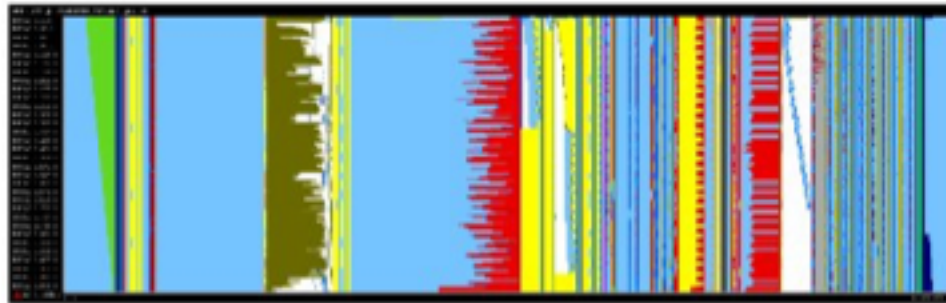
DIMEMAS generated trace. Target = ideal machine



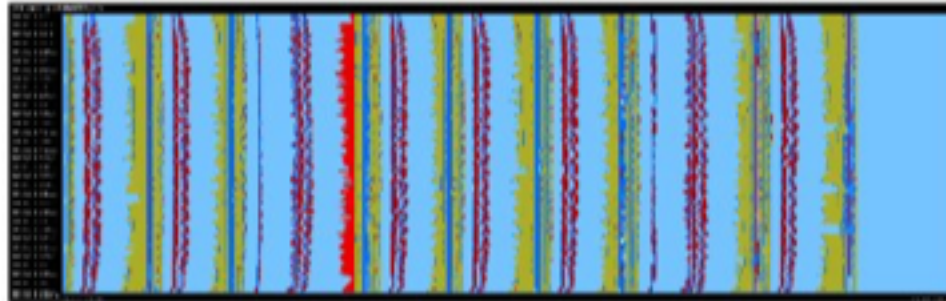
Performance analysis

- General MPI profile+Histogram → localize your study area

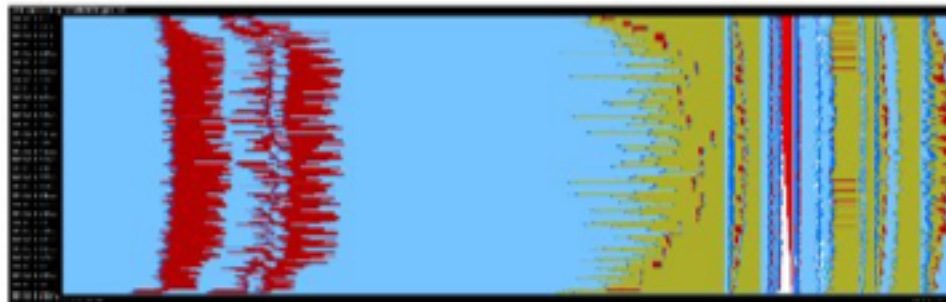
IFS CY43R1 (T511)



Complete execution



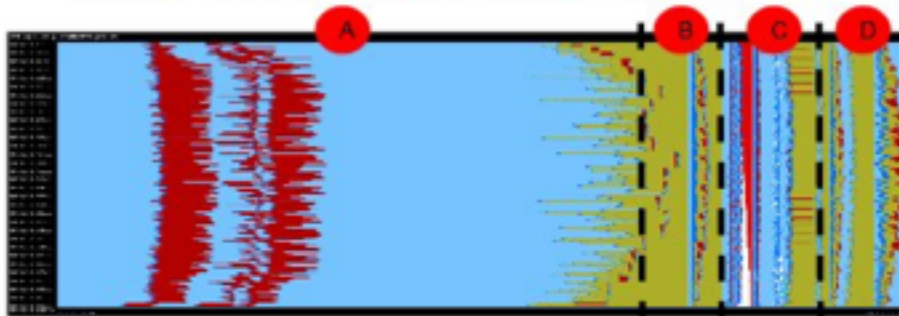
Some time steps



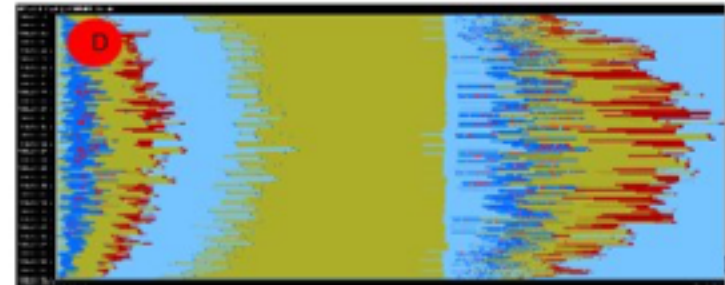
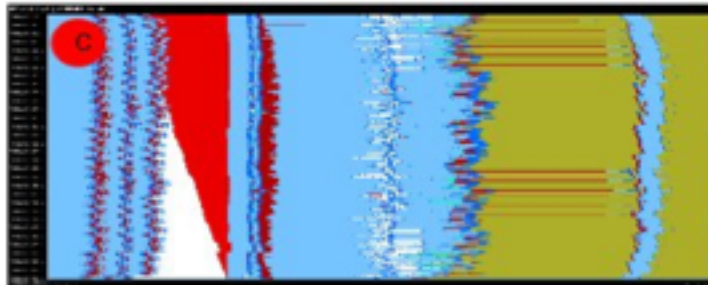
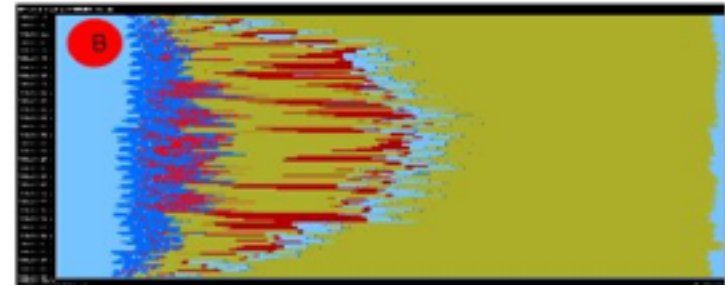
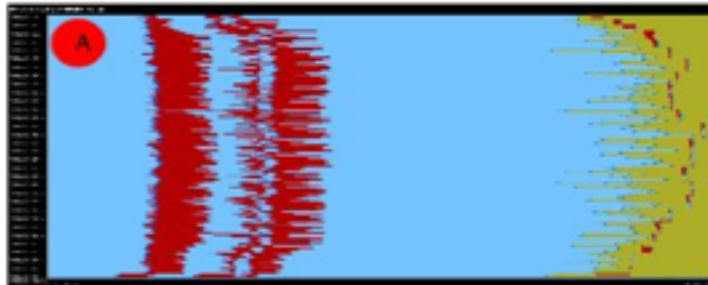
One time step

Performance analysis

- Localize each scientific phase in your model and evaluate it independently

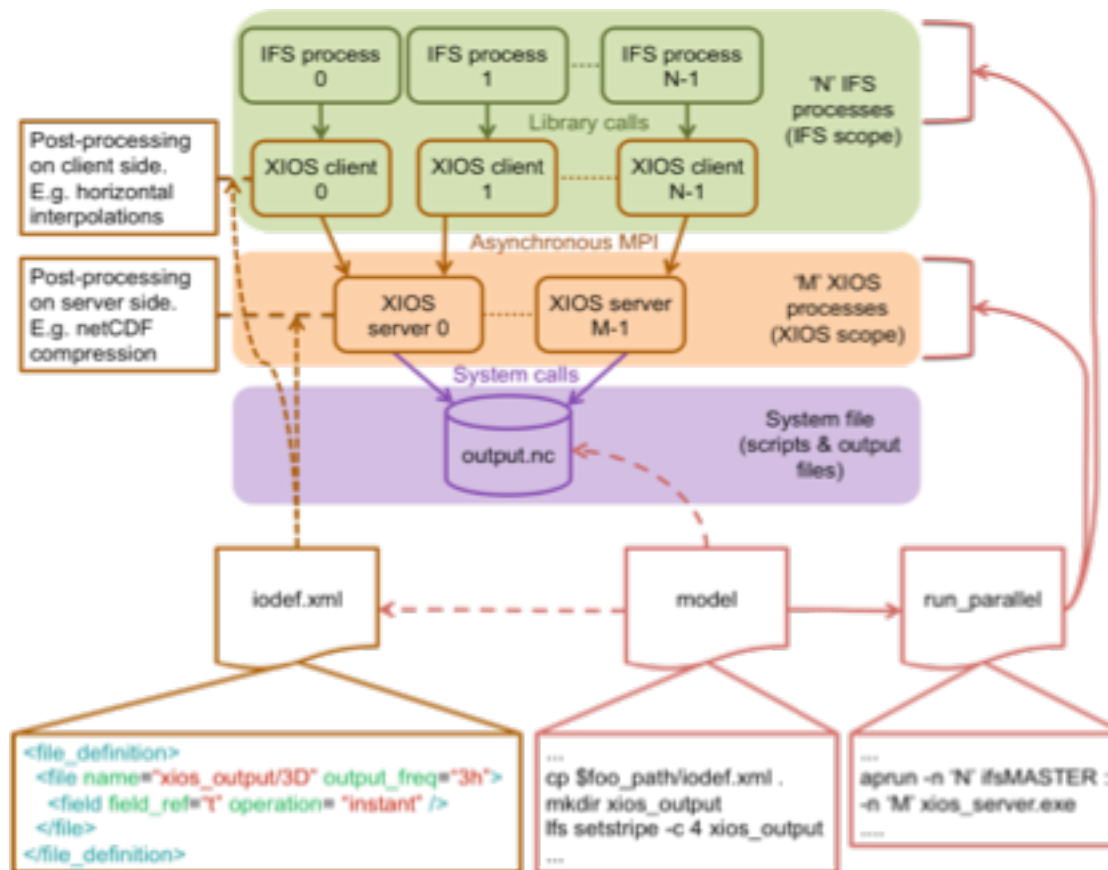


- A** Grid Point Calculations
- B** Transformations and Transpositions (Fourier + Legendre)
- C** Spectral Calculations
- D** Fourier + Legendre Inverse

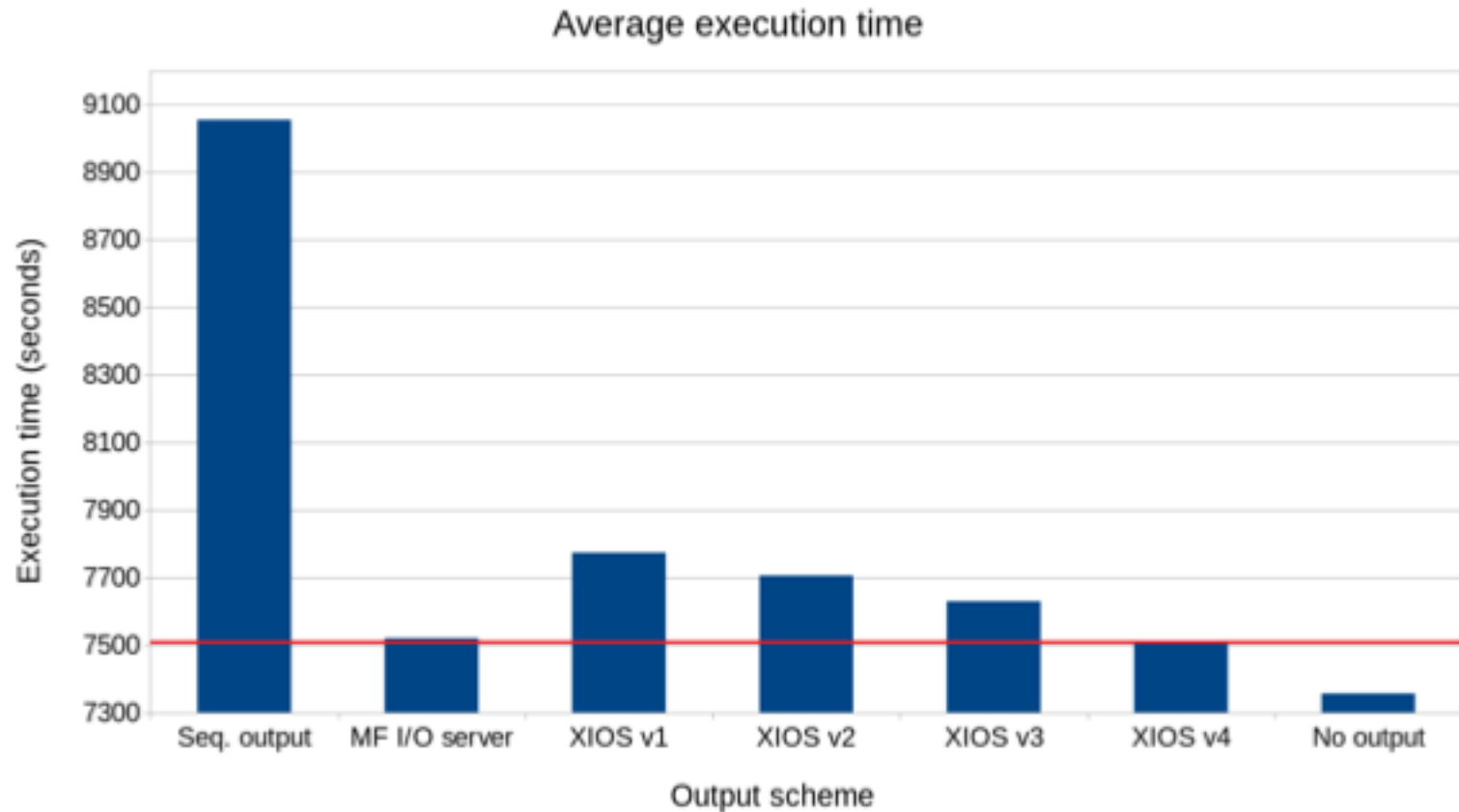


Asynchronous I/O

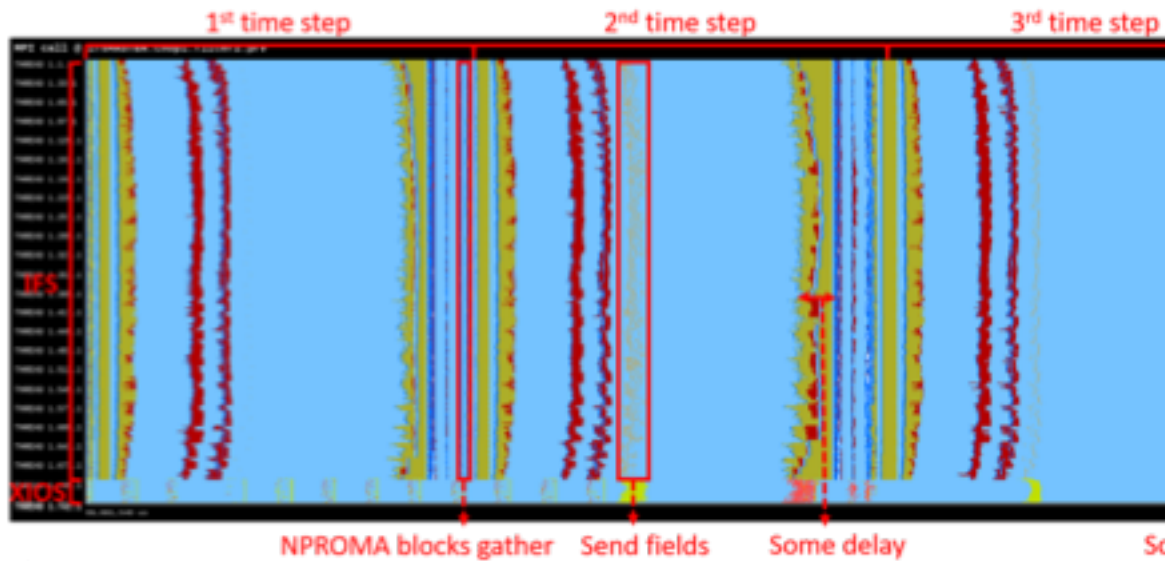
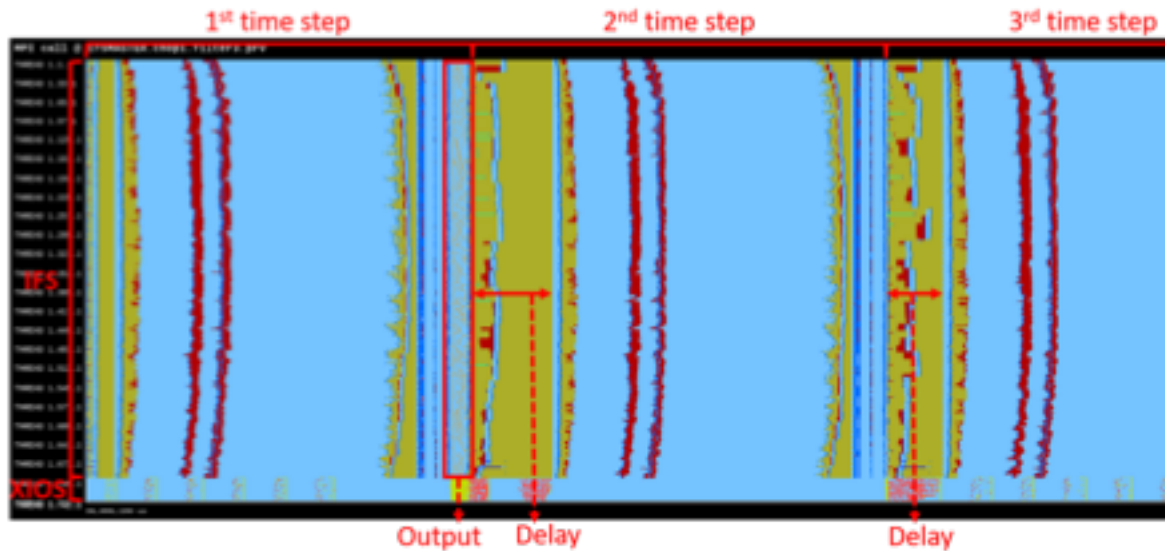
- After identifying the I/O bottleneck, we developed a solution
- Port XIOS I/O server to IFS



Asynchronous I/O



More performance analysis



Why not using ML for hurricane prediction?

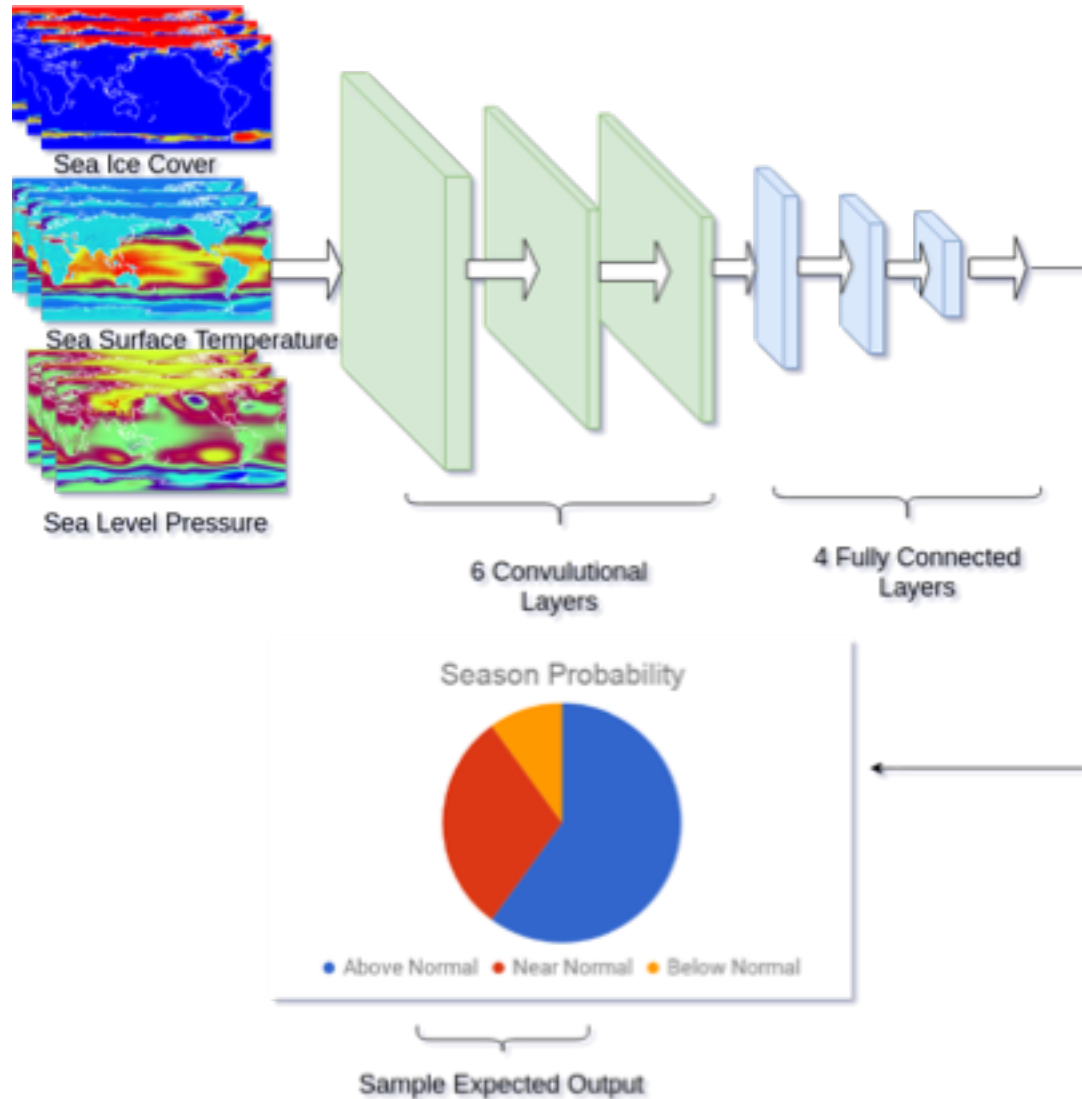


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Machine Learning

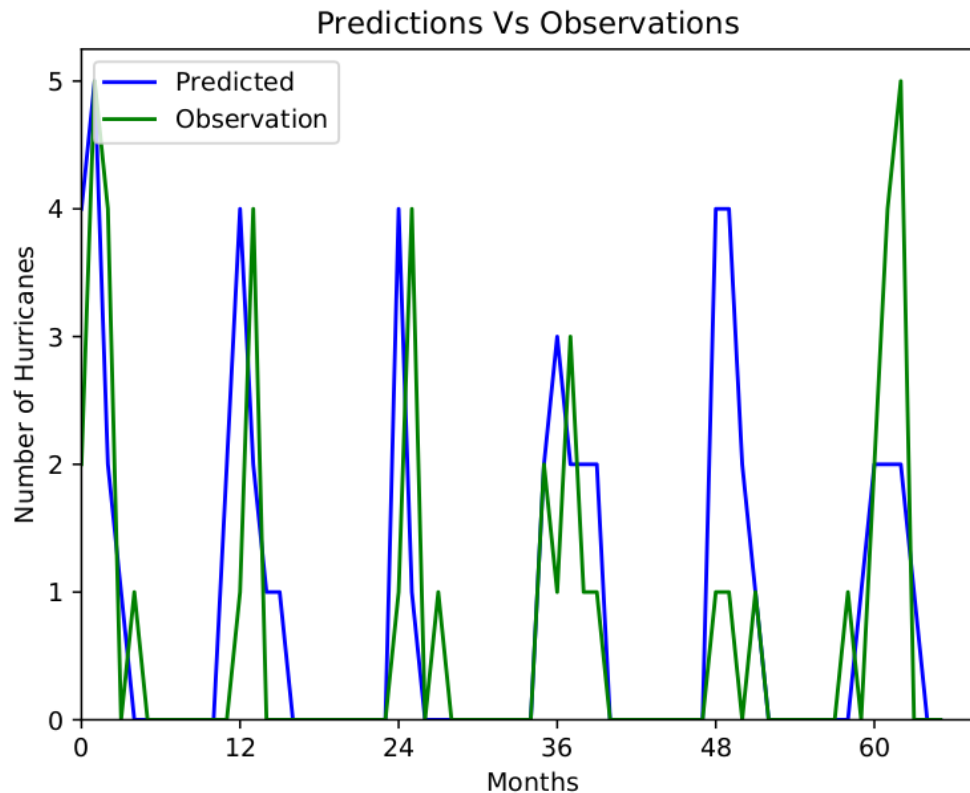
- In collaboration with Computer Sciences department at BSC to:
 - Use Machine Learning(ML) to predict the nature and number of named storms in a hurricane season
 - Build and end to end Workflow
- Using EC-Earth CMIP5 data
- Developments in Minotauro HPC – GPUs (K80) with Keras and Tensor Flow
- Thanks to Albert Kahira (in the room):
 - Poster at PhD Forum (Monday, June 25th 1pm - 3pm)
 - Workshop (Thursday, June 28th 12.00 -12.30)

Methodology



Early Results

- 72% Accuracy
- Season Pattern is clear
- Sea Surface Temperature as main determinant

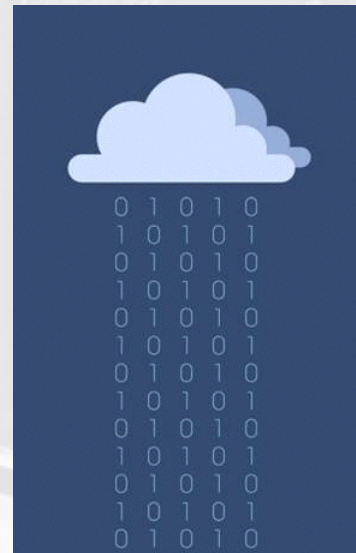




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Thank you



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