Overview of the Heterogeneous Computing Project in the Weather & Climate Center of Excellence

ECMWF - 19th Workshop on high performance computing in meteorology

Erwan Raffin, Philippe Couvee – Atos
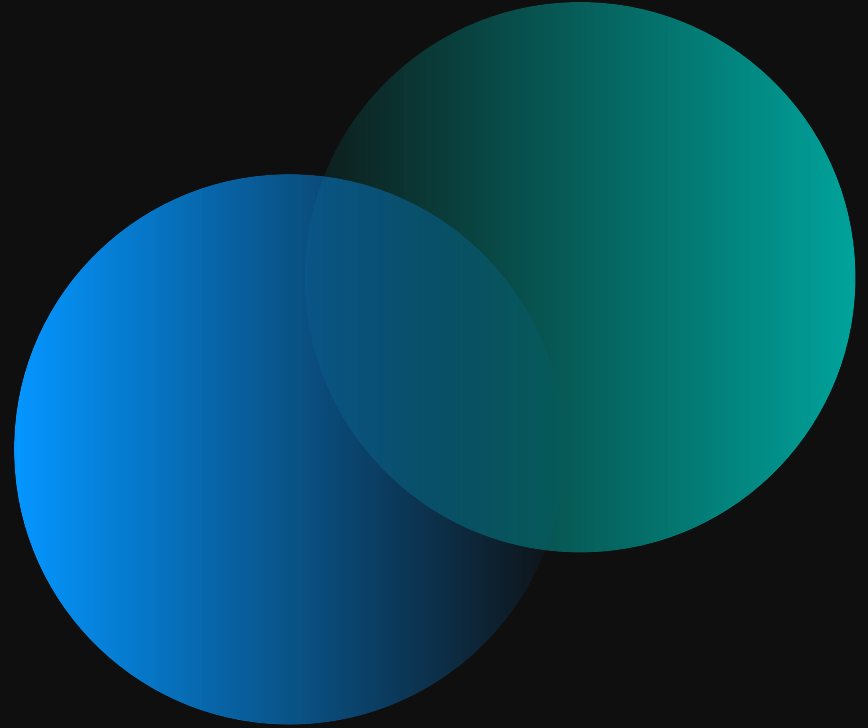Nils Wedi, Tiago Quintino, Michael Lange, Olivier Marsden – ECMWF
24/09/2021

AtoS

Content overview

AtoS

CoE overview

Atos

Center of Excellence in Weather & Climate Modelling
## Long lasting collaboration already in place

- ECMWF and Atos already collaborate in EU collaborative projects
- The CoE strengthens this collaboration focusing on ECMWF roadmap

1 Oct. 2015 – 30 Sept. 2018

1 Oct. 2018 – 30 Sept. 2021

Phase 1: 1 Sep 2015 – 31 Aug 2019
Phase 2: 1 Jan 2019 – 31 Dec 2022

1 Jan 2019 – 31 Dec 2021

1 Apr 2019 – 31 Mar 2024

Center of Excellence in Weather & Climate Modelling
A long-term collaborative effort

- Following the contract between ECMWF and Atos to provide a new supercomputer
- Creation of the CoE to support researchers with HPC, AI and Quantum capabilities
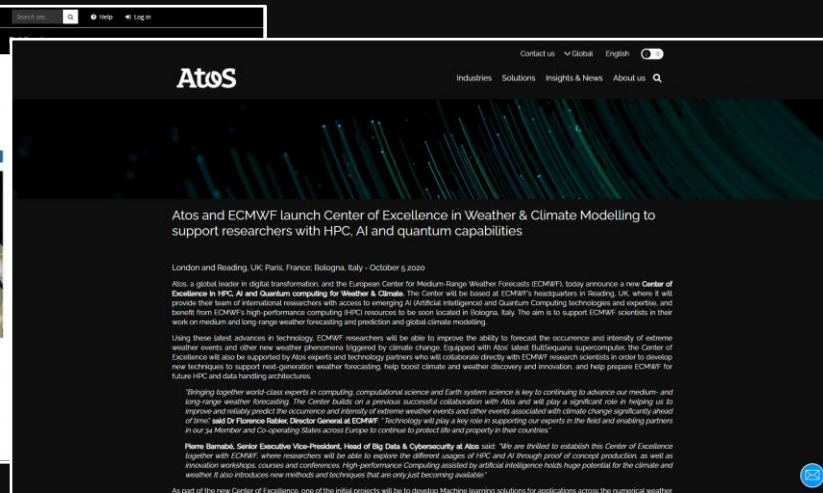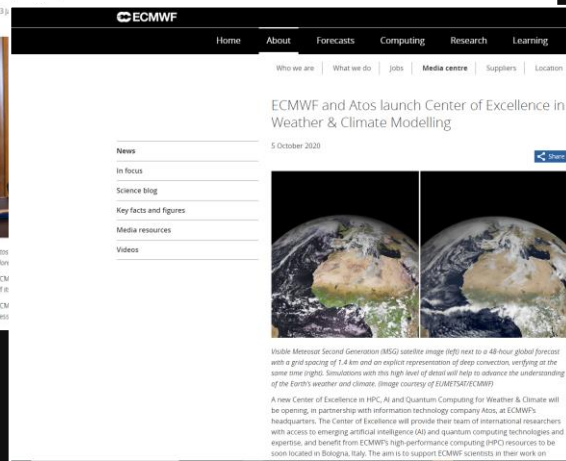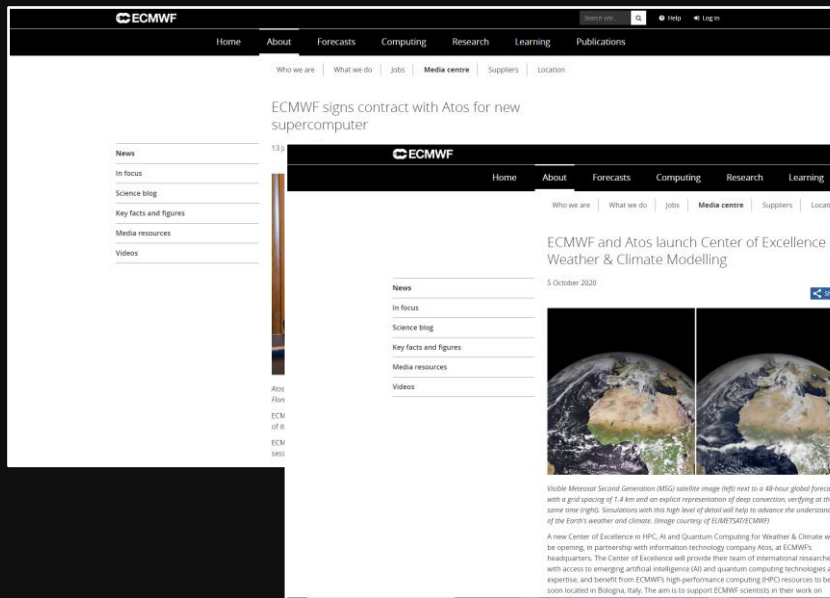
Center of Excellence in Weather & Climate Modelling
Partnership in AI, Quantum and HPC

Center of Excellence in Weather & Climate Modelling
Objectives… in brief

- Full support of the ECMWF roadmap

- Artificial Intelligence and Machine Learning: how they could be used to enhance weather and climate applications?
  - Machine learning solutions will be developed for applications across the numerical weather prediction workflow that are customized towards the needs of Earth system modelling

- Heterogenous Computing: develop a CPU-GPU-based version of ECMWF's Integrated Forecasting System (IFS) and the wave model WAM, and to prepare the ECMWF product-generation pipeline and data-centric workflows for new technologies
  - The team will develop the processes and test them on emerging hardware to explore impacts on performance
    ➔ The ultimate goal is to prepare the ECMWF model code for extreme-scale and energy-efficient computing on heterogeneous architecture
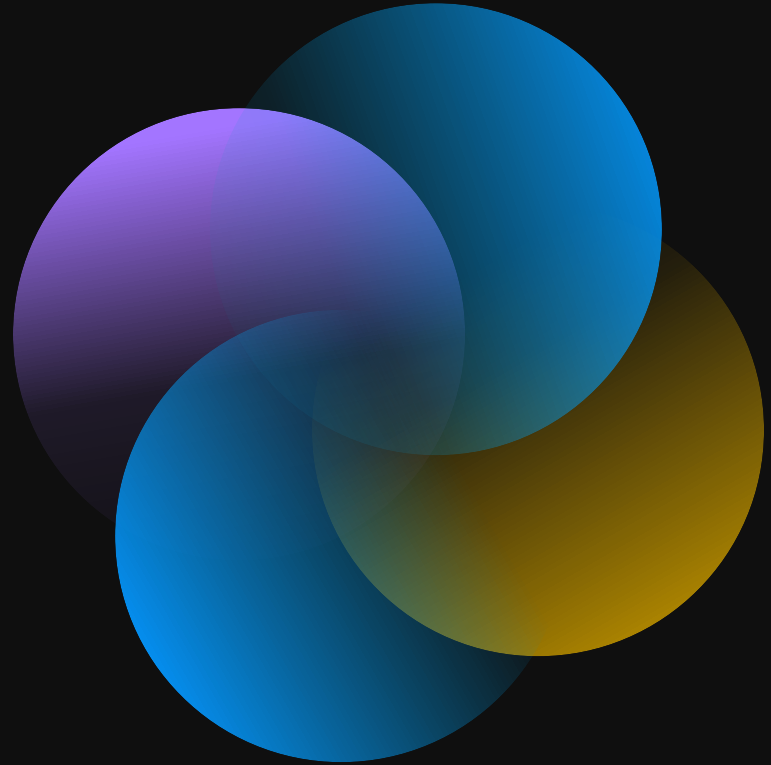
- Users experience enhancement
  - The team will develop tools that build on the user experience of operational HPC systems

AtoS

Center of Excellence in Weather & Climate Modelling
Objectives... in brief

- Full support of the ECMWF roadmap

- Artificial Intelligence and Machine Learning: how they could be used to enhance weather and climate applications?
  - Machine learning solutions will be developed for applications across the numerical weather prediction workflow that are customized towards the needs of Earth system modelling

- Heterogeneous ~~System (IFS~~ Forecasting ~~pipeline and data-ce~~
  - The team w~~ill~~ formance
    ➔ The ultim~~ate~~ mputing on heterogene~~ous~~

- Users experience enhancement
  - The team will develop tools that build on the user experience of operational HPC systems

> Don't miss the Alexis Giorkallos' talk
> "Machine learning models to emulate gravity wave drag
> by Atos Center of Excellence"
> Today from 13:40 to 14:00 (BST)

Atos

Center of Excellence in Weather & Climate Modelling
Objectives… in brief

- Full support of the ECMWF roadmap

- Artificial Intelligence and Machine Learning: how they could be used to enhance weather and climate applications?
  - Machine learning solutions will be developed for applications across the numerical weather prediction workflow that are customized towards the needs of Earth system modelling

- Heterogenous Computing: develop a CPU-GPU-based version of ECMWF's Integrated Forecasting System (IFS) and the wave model WAM, and to prepare the ECMWF product-generation pipeline and data-centric workflows for new technologies
  - The team will develop the processes and test them on emerging hardware to explore impacts on performance
    ➔ The ultimate goal is to prepare the ECMWF model code for extreme-scale and energy-efficient computing on heterogeneous architecture

- Users experience enhancement
  - The team will develop tools that build on the user experience of operational HPC systems
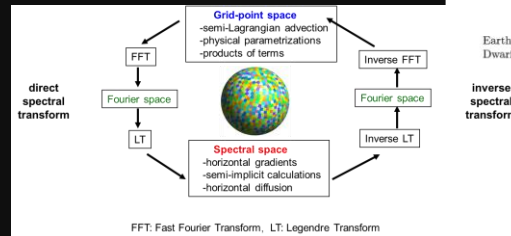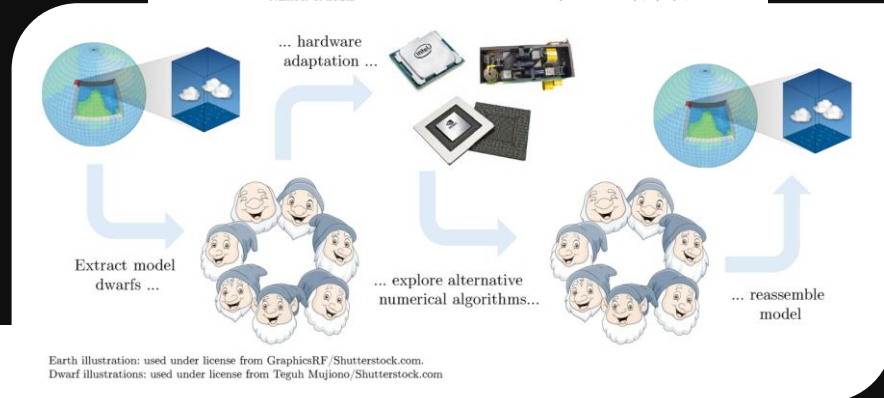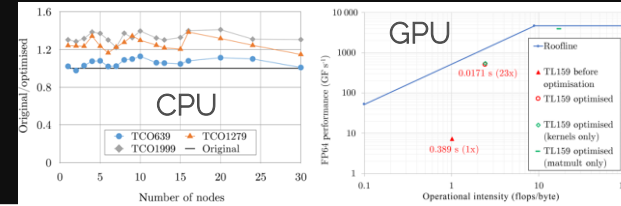
AtoS

Heterogeneous Computing

Atos

Heterogeneous Computing
Weather & Climate dwarfs

- Initiated in ESCAPE

- Profiling

- Extraction of dwarfs as Spectral Transform from IFS

- Optimization for Intel Xeon CPU and Nvidia GPU

- From proof-of-concept to re-integration into its original model

See Andreas Mueller's talk on ESCAPE-2

Atos

Heterogeneous Computing
Weather & Climate dwarfs

- Established in ESCAPE 2

- Alternative algorithms
- Reduced precision
- Adaptation to accelerators
- Profiling
- Proof-of-concept
- Verification

- Focus on: ecRad, ecWam, CloudSC

Dwarf	prototype implemented	docu-mented	based on Atlas	MPI	Open MP	Open ACC	DSL	Optalysys
D - spectral transform - SH	☑	☑	☑	☑	☑	☑		
D - spectral transform - biFFT	☑	☑		☑	☑	☑		☑
D - advection - MPDATA	☑	☑	☑	☑	☑	☑	☑	
D - advection - semi-Lagrangian	☑	☑	☑	☑	☑			
D - elliptic solver - GCR	☑	☑	☑	☑	☑		●	
P - cloud microphysics - CloudSC	☑	☑		☑	☑	☑		
P - radiation scheme - ACRANEB2	☑	🏃	🏃	☑	☑	☑		
I - LAITRI (3d interpol. algorithm)	☑	☑			☑	☑		
planned next:								
D - advection - discontinousGalerkin	●	●	●	●	●	●		
D - elliptic solver - multigridPrecon	●	●	●	●	●			

☑: first version running
🏃: in progress
●: planned
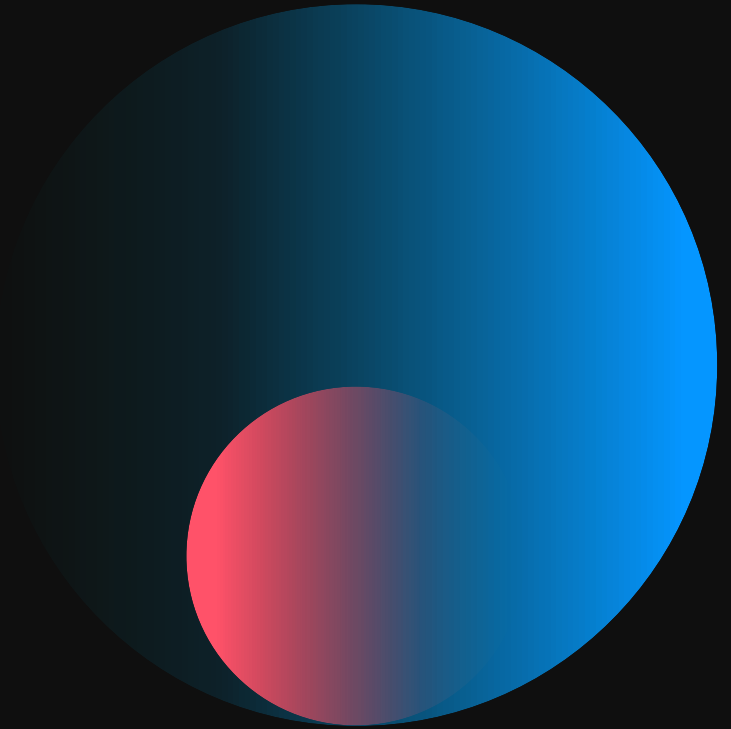empty cells: not part of ESCAPE

Comparison of software optimized for GPU and Xeon processors
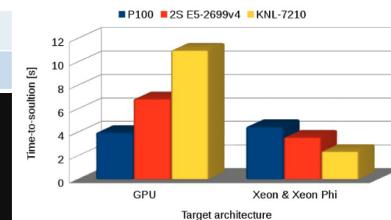
Poulsen & Berg (2017)

Atos

Data-centric workflows and On the fly product-generation pipeline
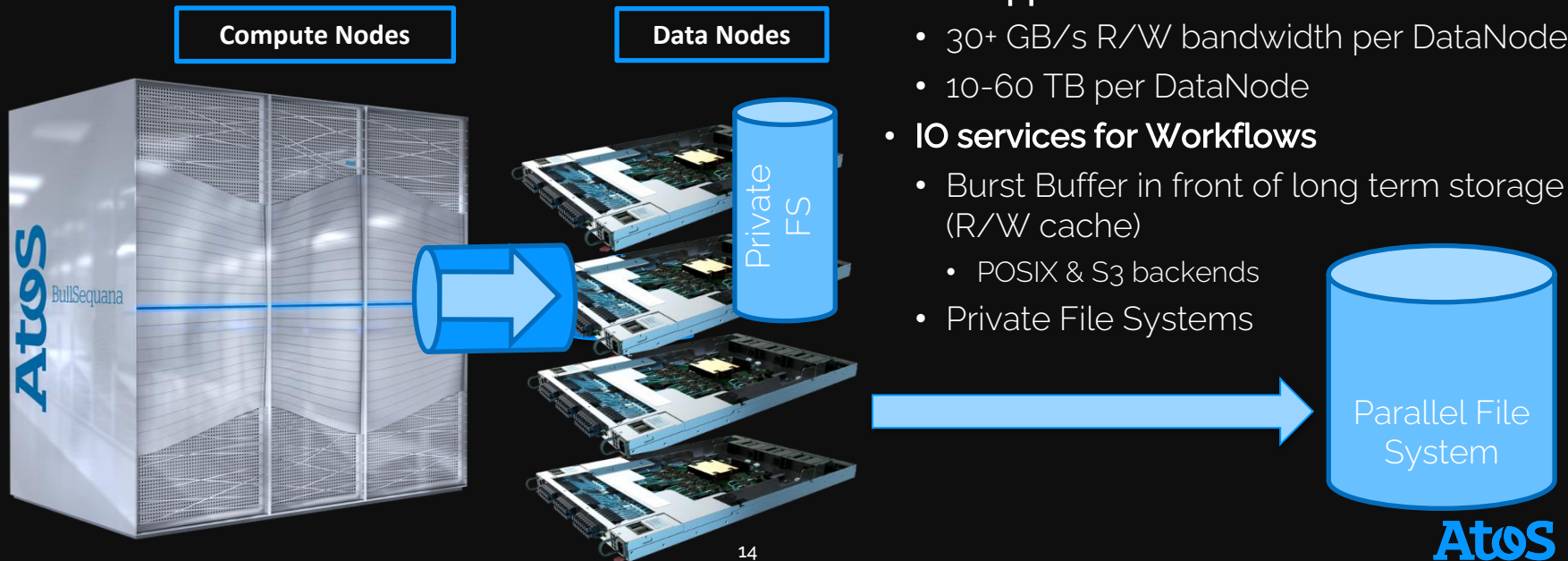
Atos

Innovative IO management from application to storage
Ephemeral IO services for Workflows

- **ATOS Flash Accelerators**
  - Dedicated IO resources and services for Workflows
  - SLURM command line options

Compute Nodes

Data Nodes

Private FS

- **HW Appliance with NVMe SDD**
  - 30+ GB/s R/W bandwidth per DataNode
 - 10-60 TB per DataNode
- **IO services for Workflows**
  - Burst Buffer in front of long term storage (R/W cache)
    - POSIX & S3 backends
  - Private File Systems

Parallel File System

Atos

BullSequana

14

Data Nodes for « In Transit » processing
Ephemeral IO services for Workflows

- Typical use cases
  - Pre-processing : prefetching in fast storage, decompressing, formatting data…
  - Post-processing : formatting results, generating images, …
  - On the Fly processing : processing intermediate data (checkpoints,…), generating ECMWF products
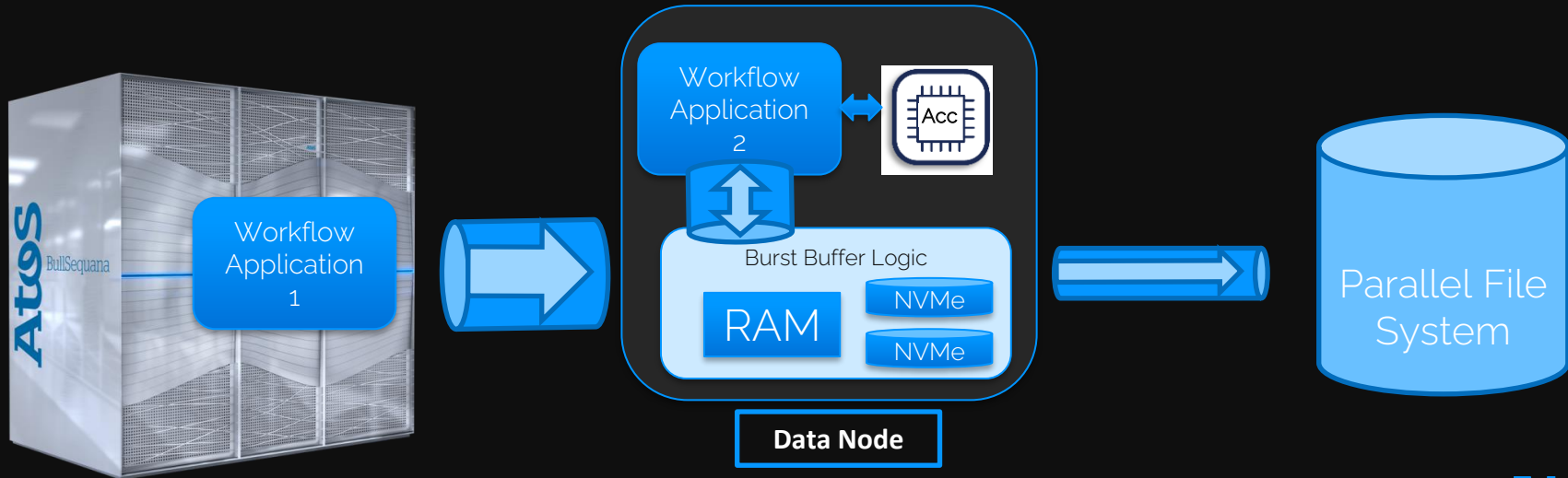
Atos Research on DataCentric Architectures
Automatic Parameter Tuning of IO Accelerators

- Automatic parameters tuning for systems, such as IO Accelerators
- https://github.com/bds-ailab/shaman
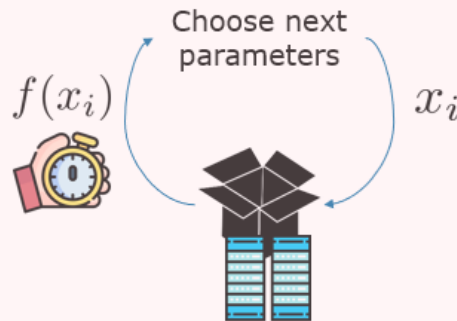
Take away message

Center of Excellence for Weather and Climate Modeling
Take away message

- CoE in W&C Modeling to investigate and develop new techniques to support next-generation weather forecasting

- Help boost climate and weather discovery and innovation

- Full support of the ECMWF roadmap

- Help prepare ECMWF for future HPC and data handling architectures

- Collaboration is key!

AtoS

Q&A
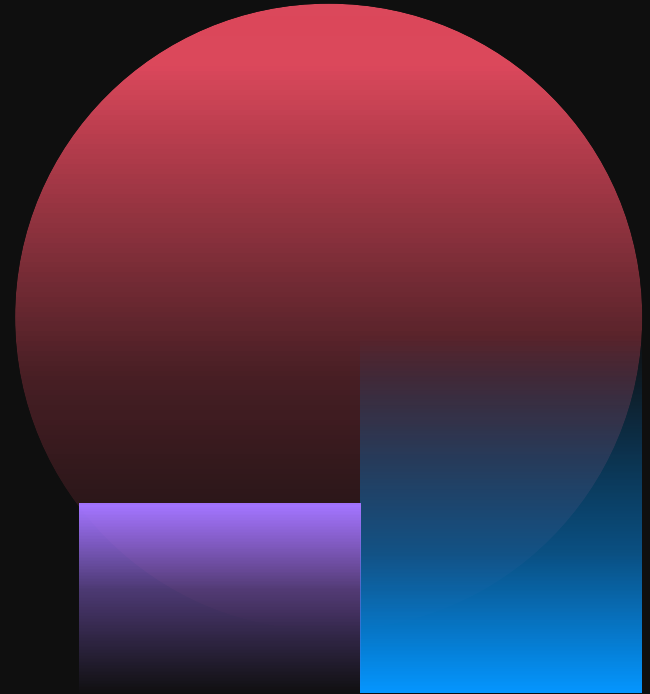
Atos

Questions?

Atos

Thank you!

For more information please contact:
erwan.raffin@atos.net

Atos

Acknoledgement
EU Funded Projects

This publications reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.