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CENTRE OF EXCELLENCE IN SIMULATION OF WEATHER AND CLIMATE IN EUROPE

Joachim Biercamp
Deutsches Klimarechenzentrum (DKRZ)

With input from Peter Bauer, Reinhard Budich, Sylvie Joussaume, Bryan Lawrence ….

The ESiWACE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 675191

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The project ESiWACE has received funding (ca 5 Mio €) from the European Union's Horizon 2020 research and innovation programme grant agreement *No 675191*.

Horizon2020 Work Programme 2014-2015, European research infrastructures

Call: e-Infrastructures
Topic: Centres of excellence for computing applications
Type of action: Research and Innovation Action

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From the Call

- Establishing a limited number of Centres of Excellence (CoE) is necessary to **ensure EU competitiveness in the application of HPC** for addressing scientific, industrial or societal challenges.

- CoEs will be **user-focused**, develop a culture of excellence, both scientific and industrial, placing computational science and the harnessing of 'big data' at the centre of scientific discovery and industrial competitiveness.

- CoEs may be 'thematic', addressing specific application domains ….. or '**challenge-driven**', addressing societal or industrial challenges (e.g. ageing, **climate change**, clean transport etc.) …

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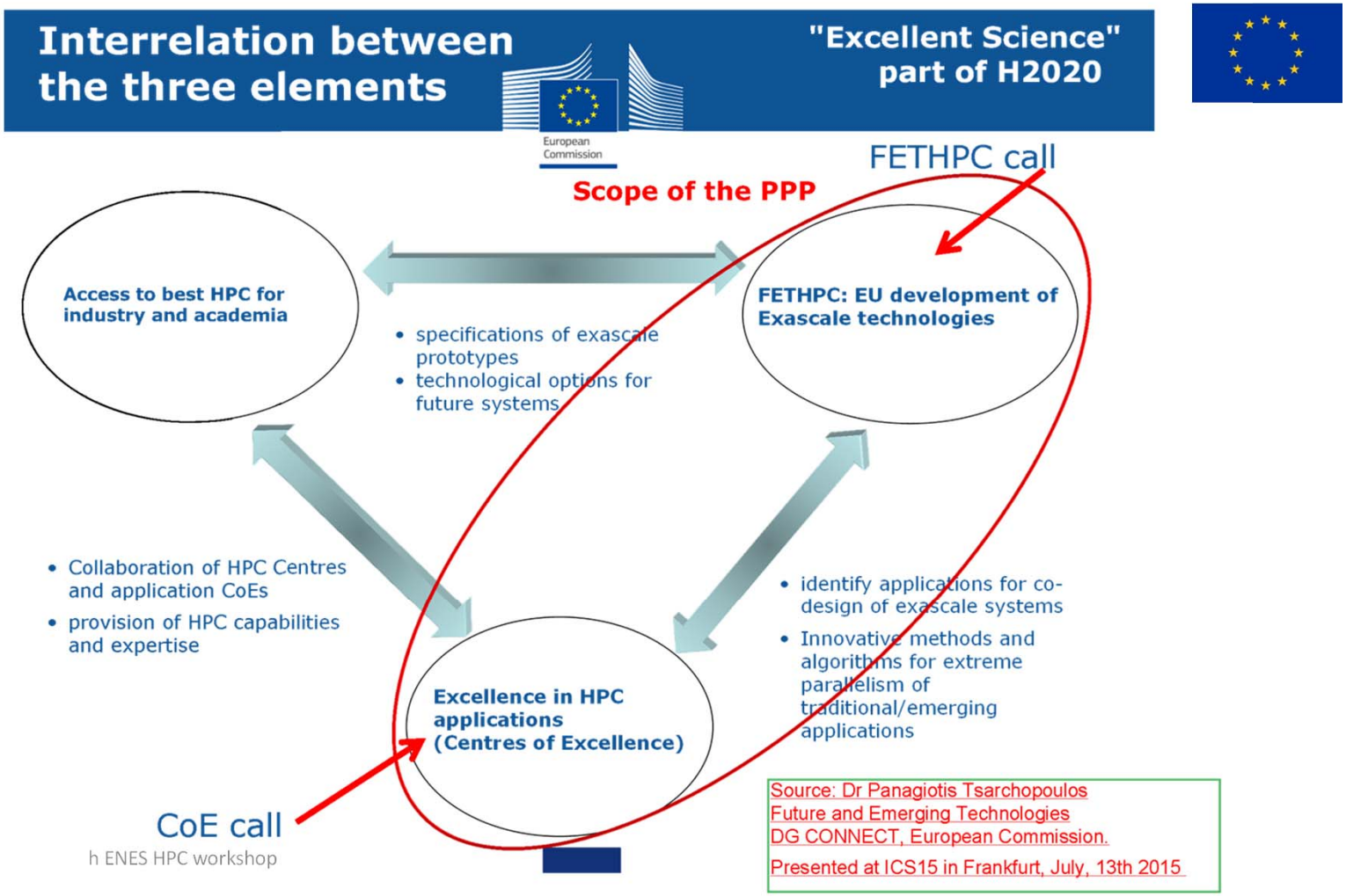
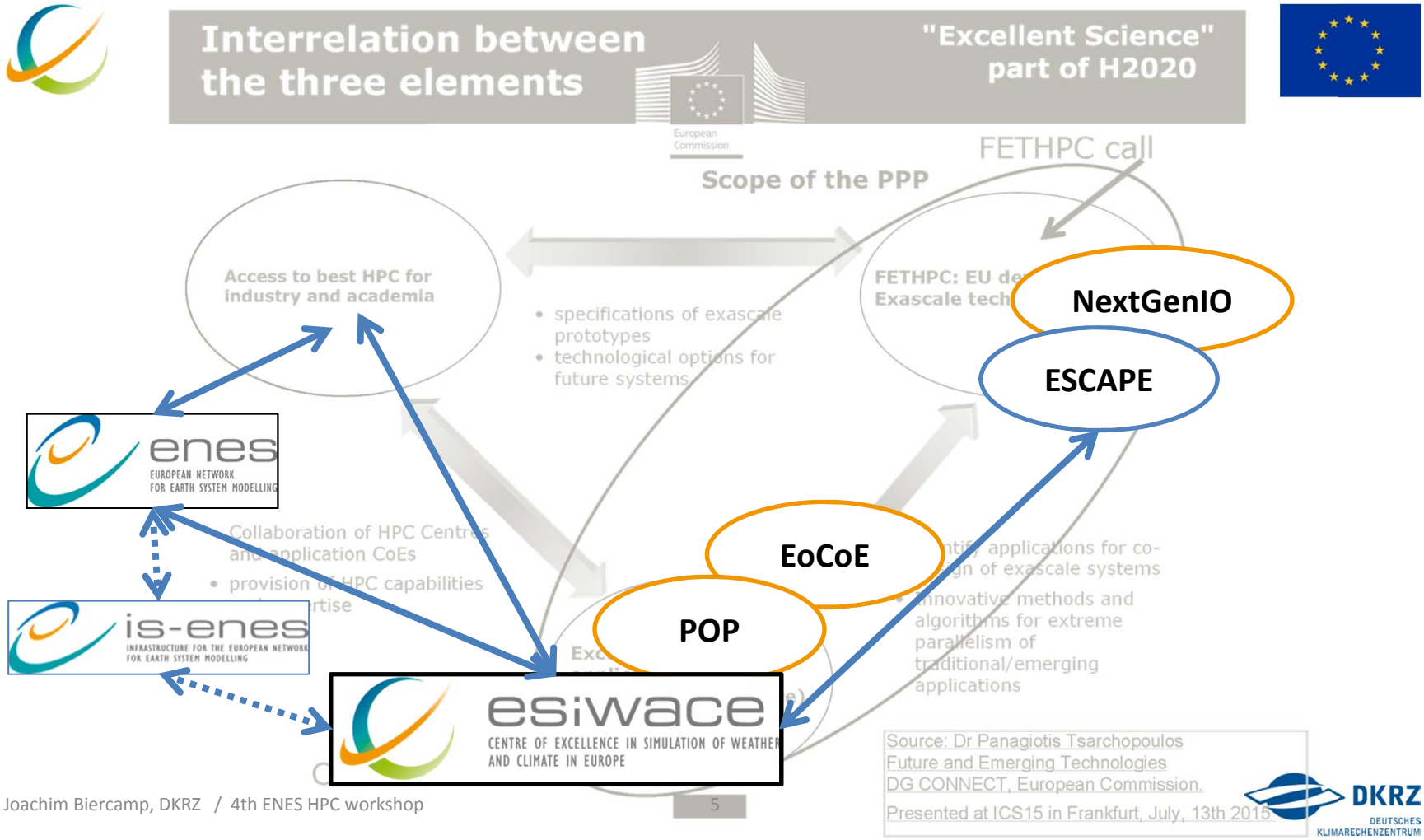

Interrelation between the three elements
European Commission
"Excellent Science" part of H2020
FETHPC call
Scope of the PPP
Access to best HPC for industry and academia
FETHPC: EU development of Exascale technologies
• specifications of exascale prototypes
• technological options for future systems
• Collaboration of HPC Centres and application CoEs
• provision of HPC capabilities and expertise
• identify applications for co-design of exascale systems
• Innovative methods and algorithms for extreme parallelism of traditional/emerging applications
Excellence in HPC applications (Centres of Excellence)
CoE call
Source: Dr Panagiotis Tsarchopoulos
Future and Emerging Technologies
DG CONNECT, European Commission.
Presented at ICS15 in Frankfurt, July, 13th 2015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NextGenIO
ESCAPE
enes
EUROPEAN NETWORK FOR EARTH SYSTEM MODELLING
Collaboration of HPC Centres and application CoEs
• provision of HPC capabilities
EoCoE
POP
is-enes
INFRASTRUCTURE FOR THE EUROPEAN NETWORK FOR EARTH SYSTEM MODELLING
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• innovative methods and algorithms for extreme parallelism of traditional/emerging applications
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ENES

European Network for Earth System modelling

Since 2001, European groups from academia, public and industrial world with interest in climate/Earth system modelling (ca 50)

Main objective:

Strategy to accelerate progress in Earth system modelling and understanding

Infrastructure

Models & their environment / Data / HPC ecosystem

Users :

Climate modelling community / Impact studies / Climate services

IS-ENES & IS-ENES2

2009-2013 & 2013-2017

Integrating activities

Models/Data/Interface to HPC

Support to **WCRP** international experiments

ESiWACE

2015-2019

Centre of Excellence on High-Performance Computing

Synergies between Climate & **Weather**

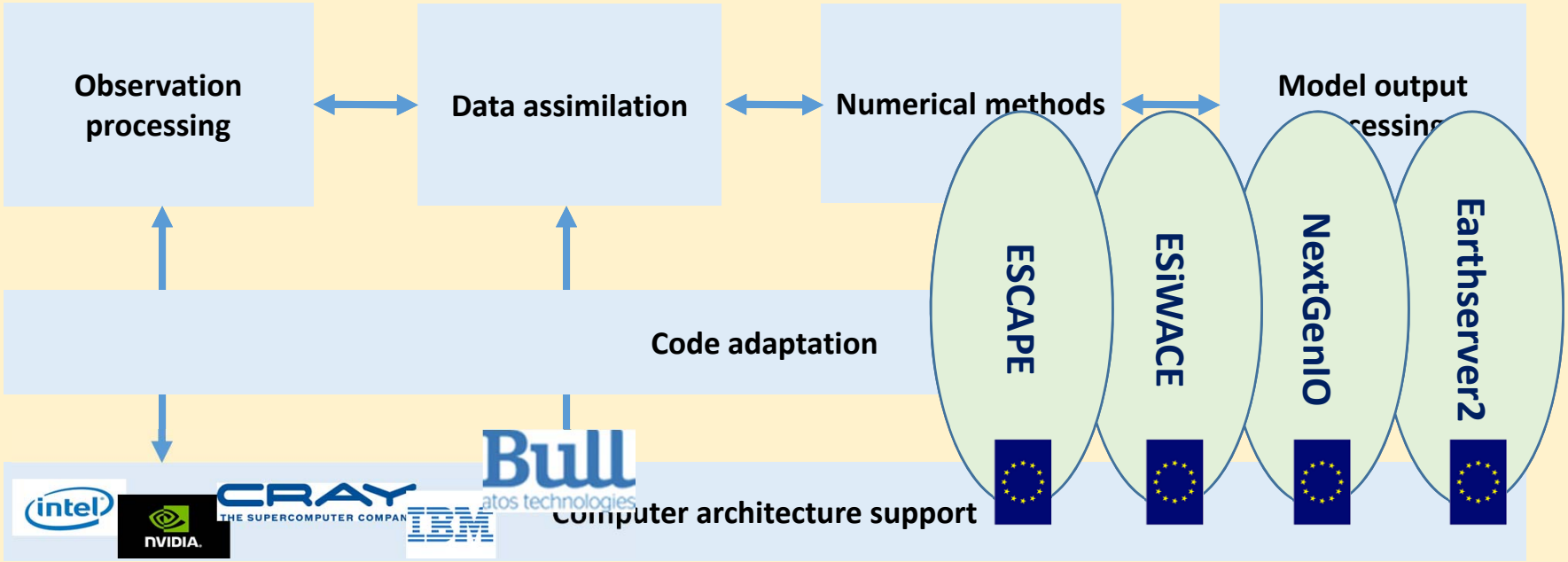
Liaising with **Industry**

ENES HPC TF

ECMWF Scalability Programme

Governance: ECMWF, Member states, Regional consortia

Projects:



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Numerical Weather Prediction and Climate Research need to invest in all areas at the same time (e.g. numerical methods, solvers, programming models, couplers, data handling, resilience*)*

(Peter Bauer, ECMWF)

… the time is right for examining the rapidly changing scientific and socio-economic drivers of weather science, and the need of new technological frameworks.

(Paolo Ruti, WMO)

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MISSION:

Join weather and climate communities

to provide support, training, services

for efficient Earth System Modelling *)

using High Performance Computing

*) We are using the term „Earth System Modelling“ (ESM) as short for „Earth System Modelling for weather and climate science”.

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ECMWF

enes
EUROPEAN NETWORK FOR EARTH SYSTEM MODELLING

to provide support,
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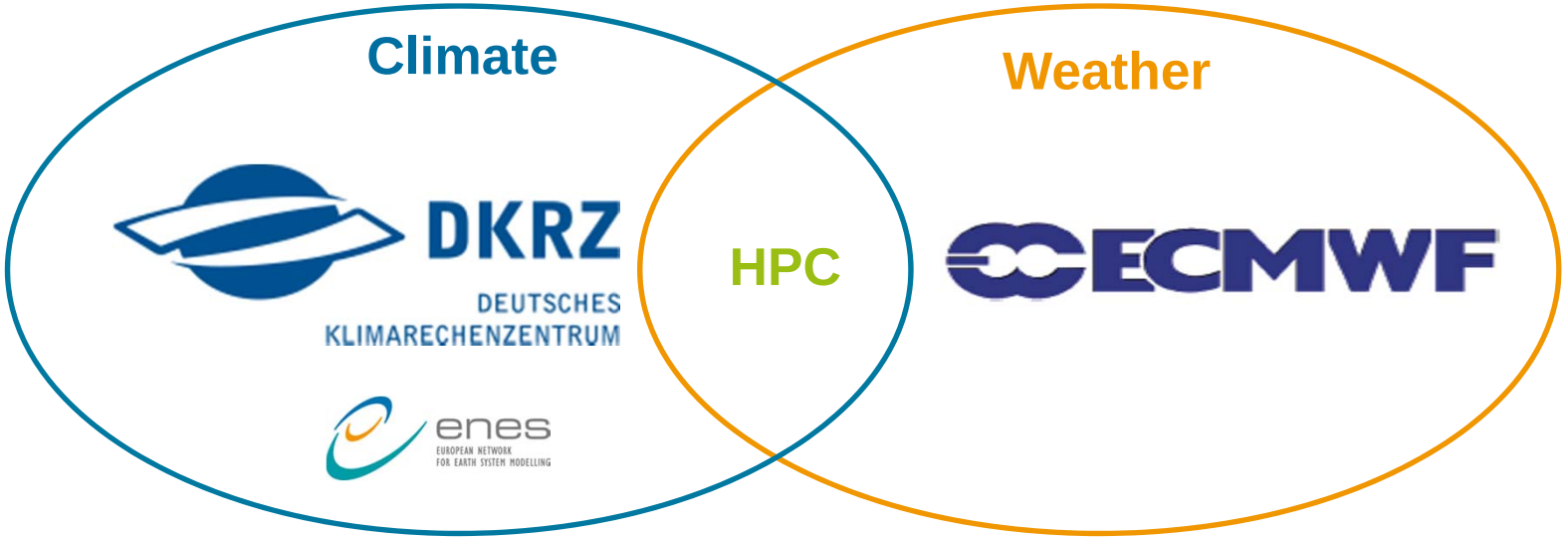
CO-ORDINATING TEAM:



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Deutsches Klimarechenzentrum GmbH COORDINATOR	DKRZ	Germany
European Centre for Medium-Range Weather Forecasts	ECMWF	United Kingdom
Centre National de la Recherche Scientifique	CNRS-IPSL	France
Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V. / Max-Planck-Institut für Meteorologie	MPG	Germany
Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique	CERFACS	France
Barcelona Supercomputing Center	BSC	Spain
Science and Technology Facilities Council	STFC	United Kingdom
Met Office	MetO	United Kingdom
The University of Reading	UREAD	United Kingdom
Sveriges meteorologiska och hydrologiska institut	SMHI	Sweden
National University of Ireland Galway (Irish Centre for High End Computing)	ICHEC	Ireland
Centro Euro-Mediterraneo sui Cambiamenti Climatici scarl	CMCC	Italy
Deutscher Wetterdienst	DWD	Germany
Seagate Systems UK Limited	SEAGATE	United Kingdom
BULL SAS	BULL	France
Allinea Software Limited	ALLINEA	United Kingdom

	UREAD	United Kingdom
	SMHI	Sweden
	ICHEC	Ireland
	CMCC	Italy
	DWD	Germany
Partner from industry:		
Storage:	SEAGATE	United Kingdom
HPC:	BULL	France
Tools:	ALLINEA	United Kingdom

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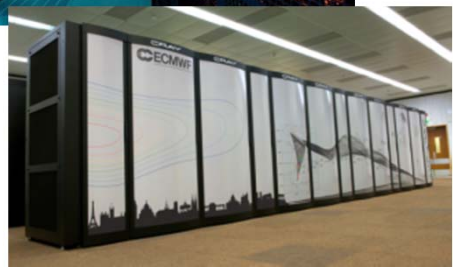
Expertise in HPC

Dedicated HPC centers



DKRZ DEUTSCHES KLIMARECHENZENTRUM — Bullx DLC, ca. 100,000 cores, 3.4 PFLOPS, 55 PBYTE disc

ECMWF — Cray XC30, ca 170,000 cores, 3.6 Pflops, 12 PBYTE
Upgrading to: 260,000 cores, 8.5 PFLOPS

Met Office — Cray XC 40, 220,000 cores ….

STFC: Jasmin 4,000 CPU, 16PB disc, 180 PB tape

DWD: Cray XC 30, 1.1 PFLOPS, 4 PBYTE

CMCC: 8,000 cores 200 TFLOPS

Science & Technology Facilities Council

DWD Deutscher Wetterdienst
Wetter und Klima aus einer Hand

cmcc Centro euro-Mediterraneo sui Cambiamenti Climatici

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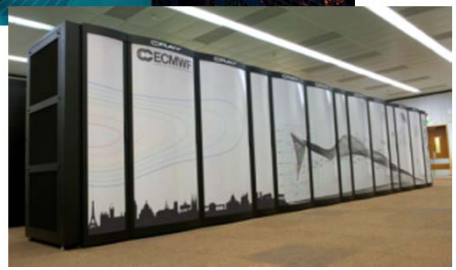

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National centers (PRACE)

BSC

ICHEC Irish Centre for High-End Computing

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Earth System Models*) in a nut shell:

- Coupled models, multi-scale, multi physics
- Models in general only weakly scalable
- Codes are memory-bound
- Models possess very high complexity and have a flat computational profile (no “Kernels”)
- Long-term integrations - requiring long year stability of HPC environment
- (multi model) ensembles - implying complex work flows
- Very high I/O and storage demands (intensive diagnostic I/O)
- We reach exabytes well before exaflops!

*) We are using the term „Earth System Modelling“ (ESM) as short for „Earth System Modelling for weather and climate science”.

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Challenges:

Scalability

of codes and also of software development

Usability

of end-to-end workflow in HPC environment

Exploitability

of huge amount of complex data

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Nr.	Work Package Title	Lead Institution short name	Co-Lead Institution, short name
WP1	Governance, Engagement & long-term sustainability	CNRS-IPSL, Sylvie Joussaume	DKRZ, Joachim Biercamp
WP2	**Scalability**	ECMWF, Peter Bauer	CERFACS, Sophie Valcke
WP3	**Usability**	MPG Reinhard Budich	BSC, Oriol Mula-Valls
WP4	**Exploitability**	STFC Bryan Lawrence	DKRZ, Thomas Ludwig
WP5	Management & Dissemination	DKRZ, Joachim Biercamp	ECMWF Peter Bauer

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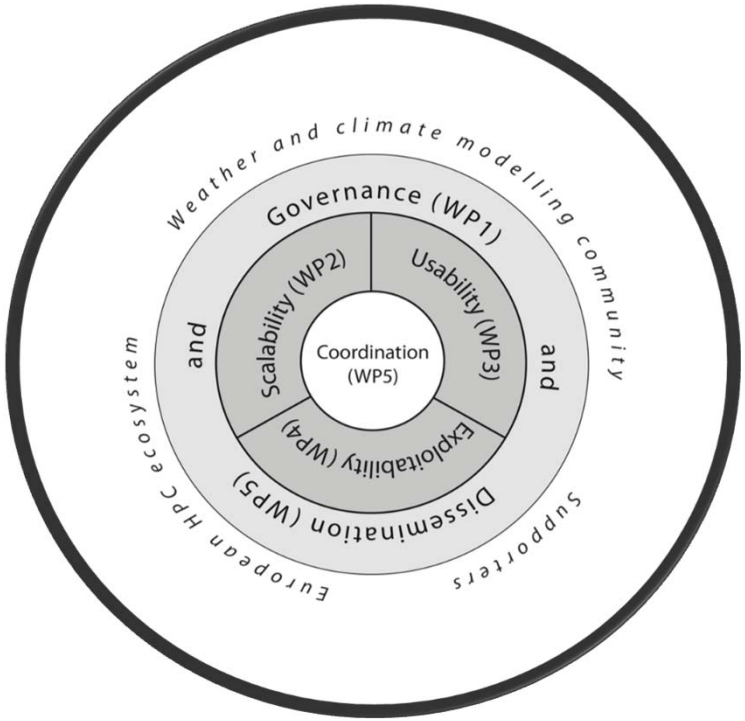

WP1 Governance and engagement

- Engagement and governance
- Enhancing community capacity in HPC
- Strategic interaction with HPC ecosystem and HPC industry
- Sustainability and business planning

WP2 Scalability

- Support, training and integration of state of-the-art community models and tools
- Performance analysis and inter-comparisons
- Efficiency enhancement of models and tools
- Preparing for exascale

WP3 Usability

- ESM end-to-end workflows recommendations
- ESM system software stack recommendations
- ESM scheduling
- Co-Design for Usability

WP4 Exploitability

- The business of storing and exploiting high volume climate data
- New storage layout for Earth system data
- New methods of exploiting tape
- Semantic mapping between netCDF and GRIB

WP5 Management and Dissemination

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D1.1 on agreed portfolio of community tools

Type of software	Project	other project	PRISM	IS-ENES phase 1	IS-ENES 2	ESiWACE
Modelling Tools	OASIS	D	D	D/S	D/S/N	D/S
	CDO	D		S	S	
	XIOS	D		D	D	D/S
	CYLC	D			N	D/S
Models	NEMO	D		D/S	S	D/S
	EC-EARTH/OPENIFS	D			S	D/S

D: development S: Support to users N: Networking

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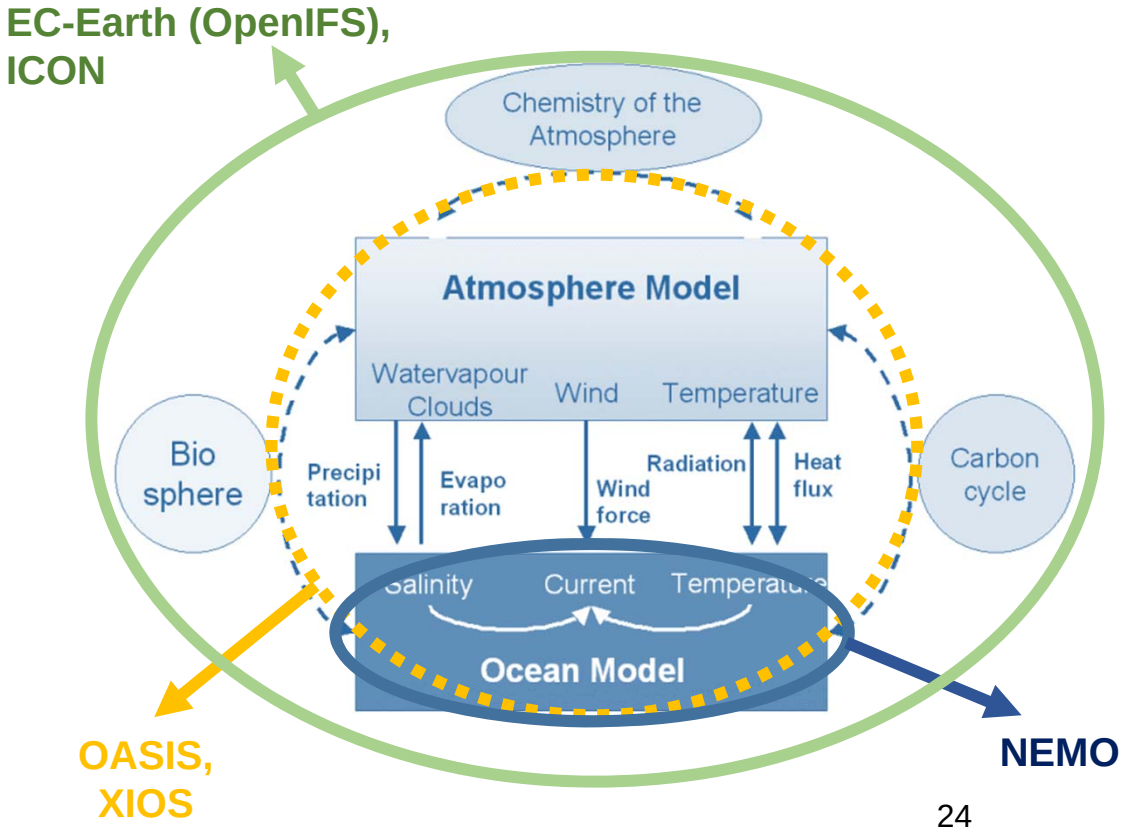
Scalability:
Community Models and Tools



ESiWACE objectives:

- Maintain and extend community support
- Define metrics and benchmarks for performance assessments
- Enhance level of parallelism
- Identify new approaches for:
  - programming models
  - memory management
  - output data management

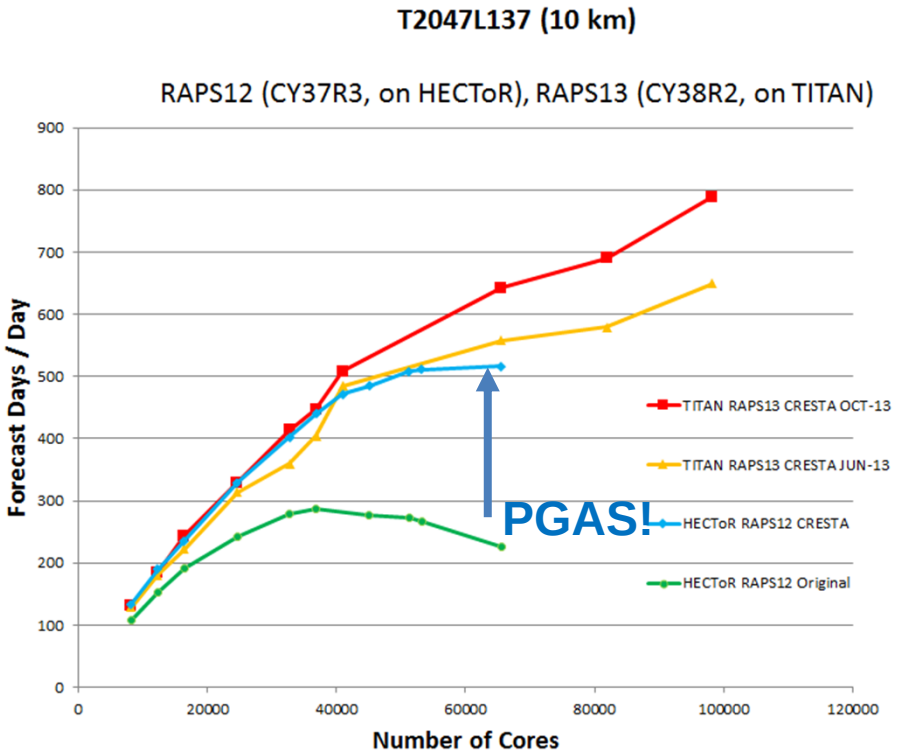
EC-Earth & OpenIFS

User services

- Code access under version control
- Bug fixes
- Diffusion of best practices
- Integration of OpenIFS in EC-Earth
- Implementation of XIOS, OASIS3-MCT, NEMO v3.6

EC-Earth optimization

- Fortran PGAS – GASPI intercomparison in OpenIFS
- BSC performance profiling and testing of OmpSs to overlap calculation & communicati



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ICON

ICON Optimizations

- Implementing YAXT in ICON
- Improve MPI communication with respect to MPI data types
- Overlap of communication and computation
- In depth profiling of ICON (link to POP)

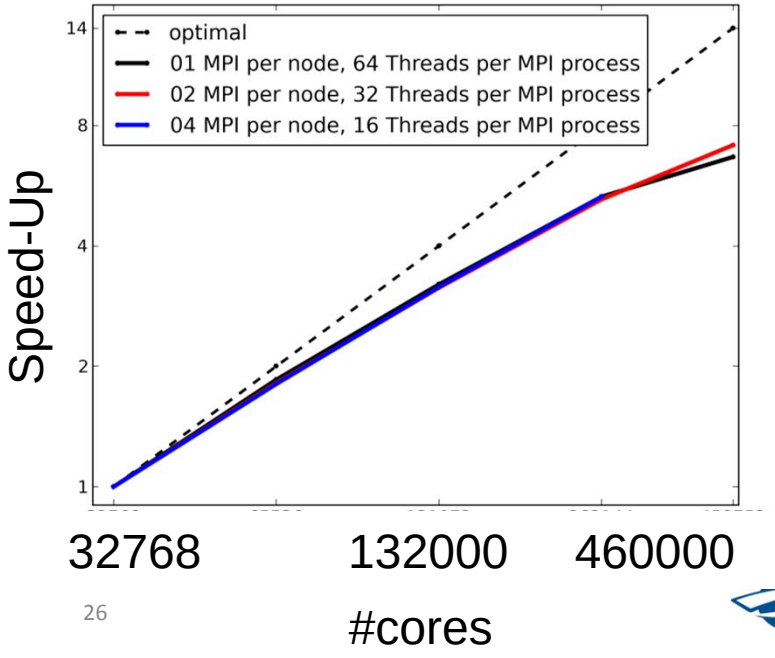
cores	resolution	wallclock for 1h sim
local area incl. I/O (bullx HSW)		
12.000	156 m	7 h

=> 3.342.345.600 cells

cores	resolution	efficiency
ICON-LES no I/O (Blue Gene/Q)		
131.072	120 m	79%
262.144	120 m	65%
458.752	120 m	51%

Concurrency and accuracy

- Evaluate coarse granular concurrency and single precision computation in ICON



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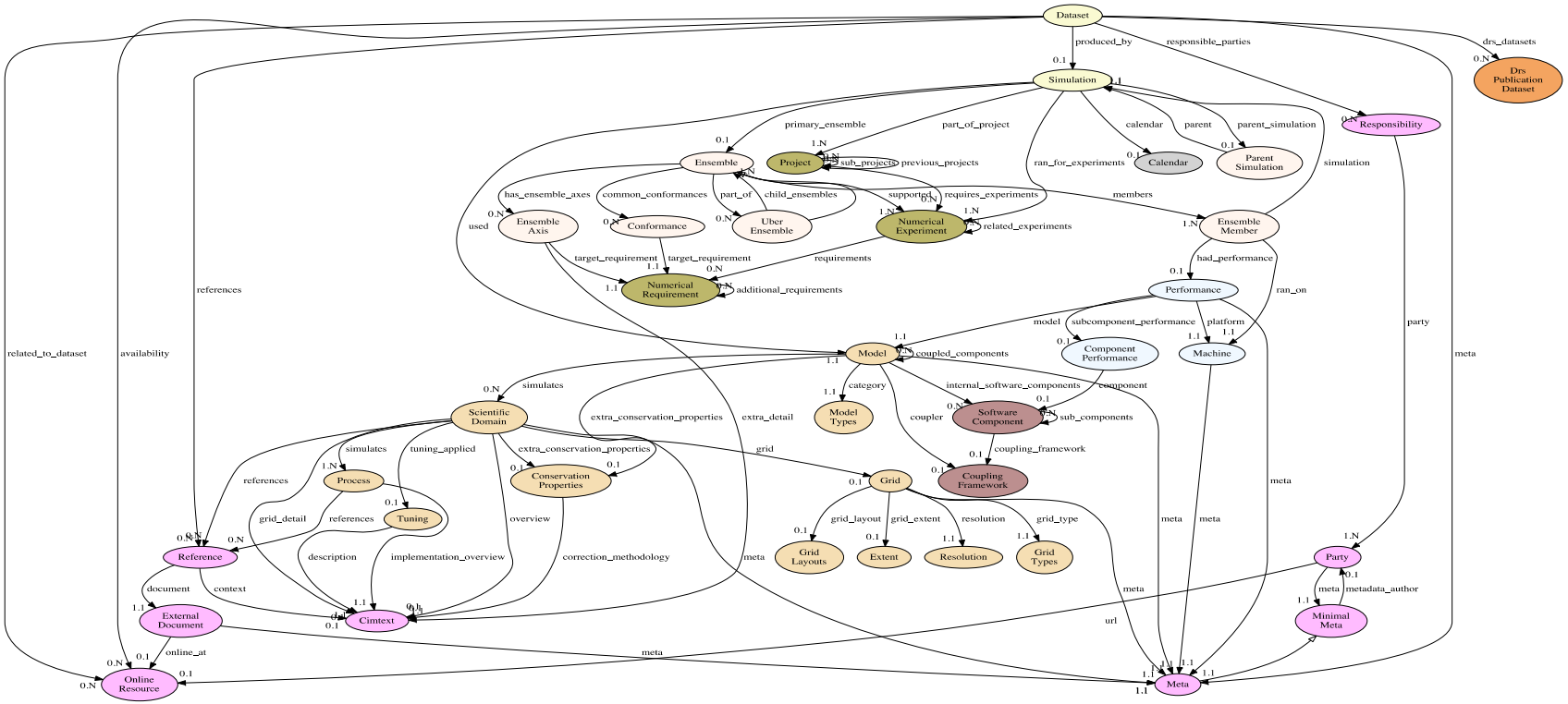
Workflows

or: Why is it hard to use climate models and there output



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Workflow (Usability)

- ESM End-to-End Workflows:
  - Application Software Environment necessary for multi-model simulations
  - prototype ESM workflow framework
- ESM System Software Stack Recommendations
  - methodology for maintaining a portable HPC system software stack
- Test bed: 3rdE2SCMS summer school in June

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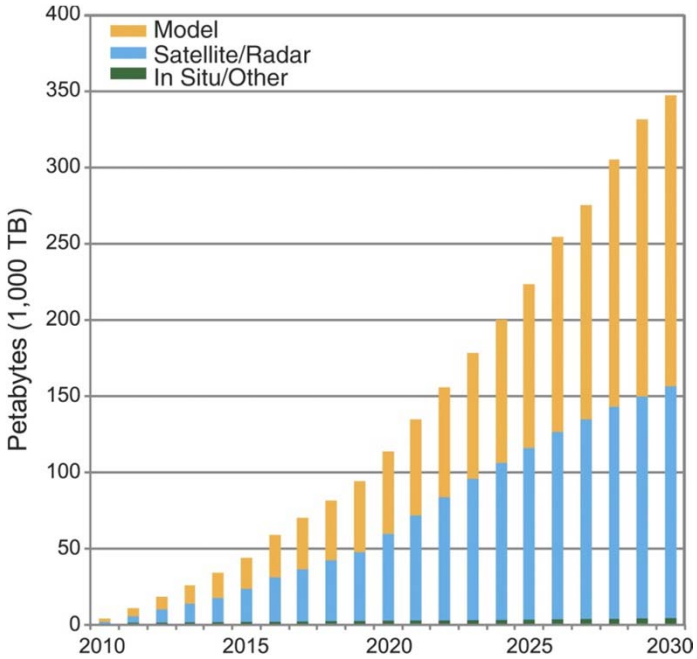
RESULTS
- Deliverables
- Milestones
- Miscellaneous
  - The Application Software Framework

List of Results

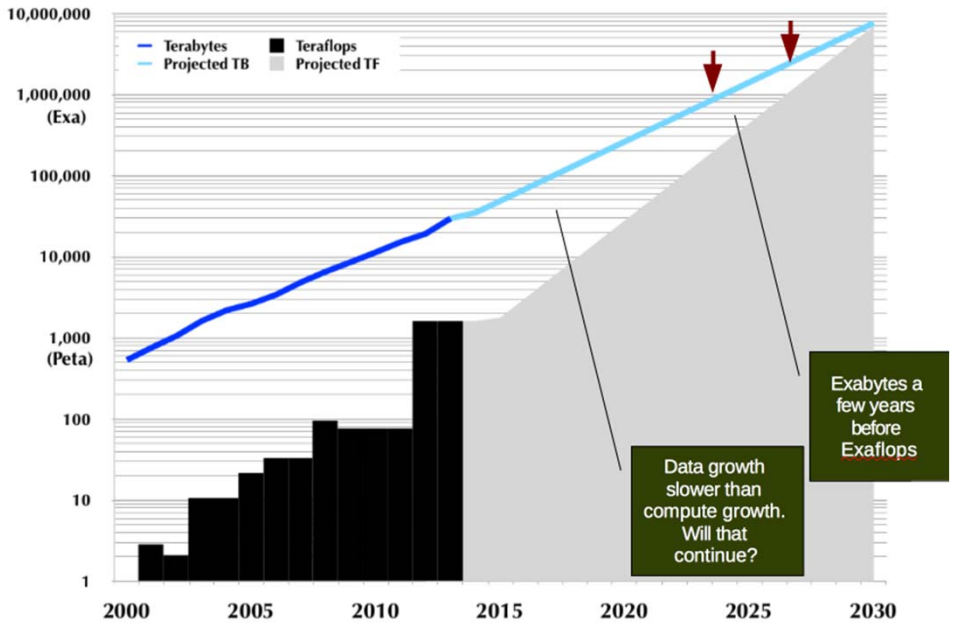
living documents, publications, etc

Title	Description	Authors	Contributors	Delivery Date	Modification Date
The Application Software Framework	This is a living document, maintained by the WP3 teams. It was originally attached to the Deliverable D3.1. Last update of this list is: 31 March 2016	Reinhard Budich	Reinhard Budich, Sergey Kosukhin, Grenville Lister, Oriol Mula-Valls, Kim Serradell		Mar 31, 2016
Application Software Specification 3rdE2SCMS	This is a living document, maintained by the WP3 teams. It was originally attached to the	Reinhard Budich	Sergey Kosukhin, Reinhard Budich, Grenville Lister,		Mar 31, 2016

Data ….



Global Shared: Overpeck et al 2011



Local (NCAR, Gary Strand, 2013ish)

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Exploitability

- **“The business of storing and exploiting high volume climate data”**
  - Build a model to understand how choices as to ensemble-size, model resolution, and run length, will impact both on compute and storage requirements
- **New storage layout for Earth System Data**
  - To address performance and physical capacity issues associated with writing, accessing, and Earth system data in the disk subsystems themselves
  - Earth System data middleware library to optimize mapping of netCDF and GRIB to storage HW environments
- ……

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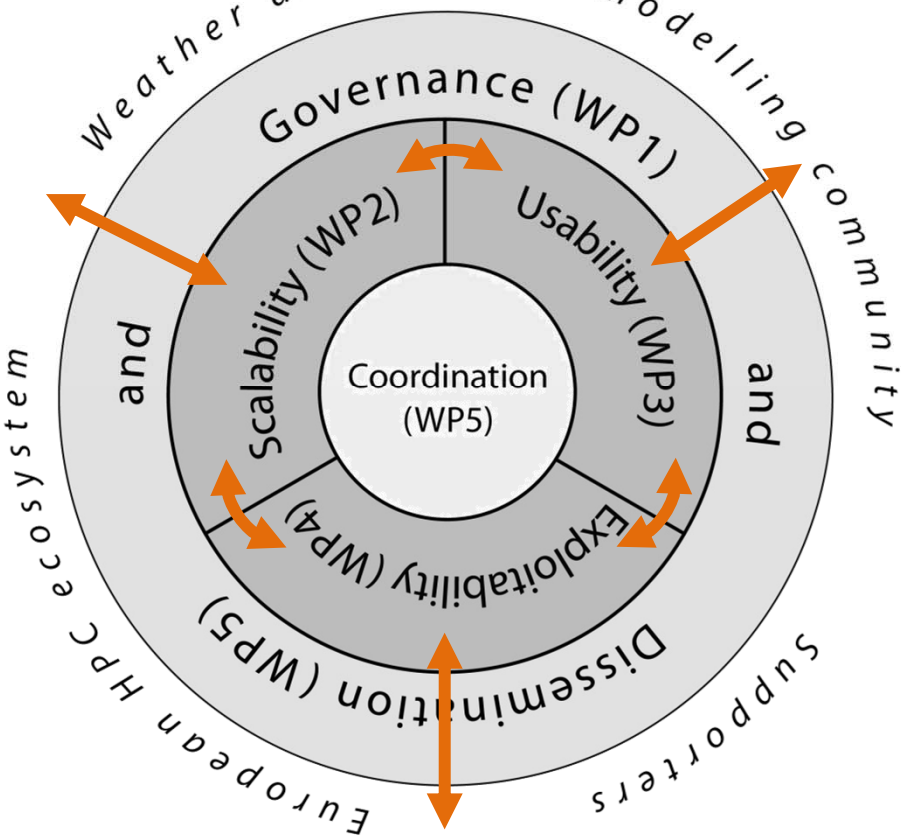
Weather and climate modelling community
and
Supporters
Dissemination (WP5)
European HPC ecosystem
and
Governance (WP1)
Scalability (WP2)
Usability (WP3)
Exploitability (WP4)
Coordination
(WP5)

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Thank you

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