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

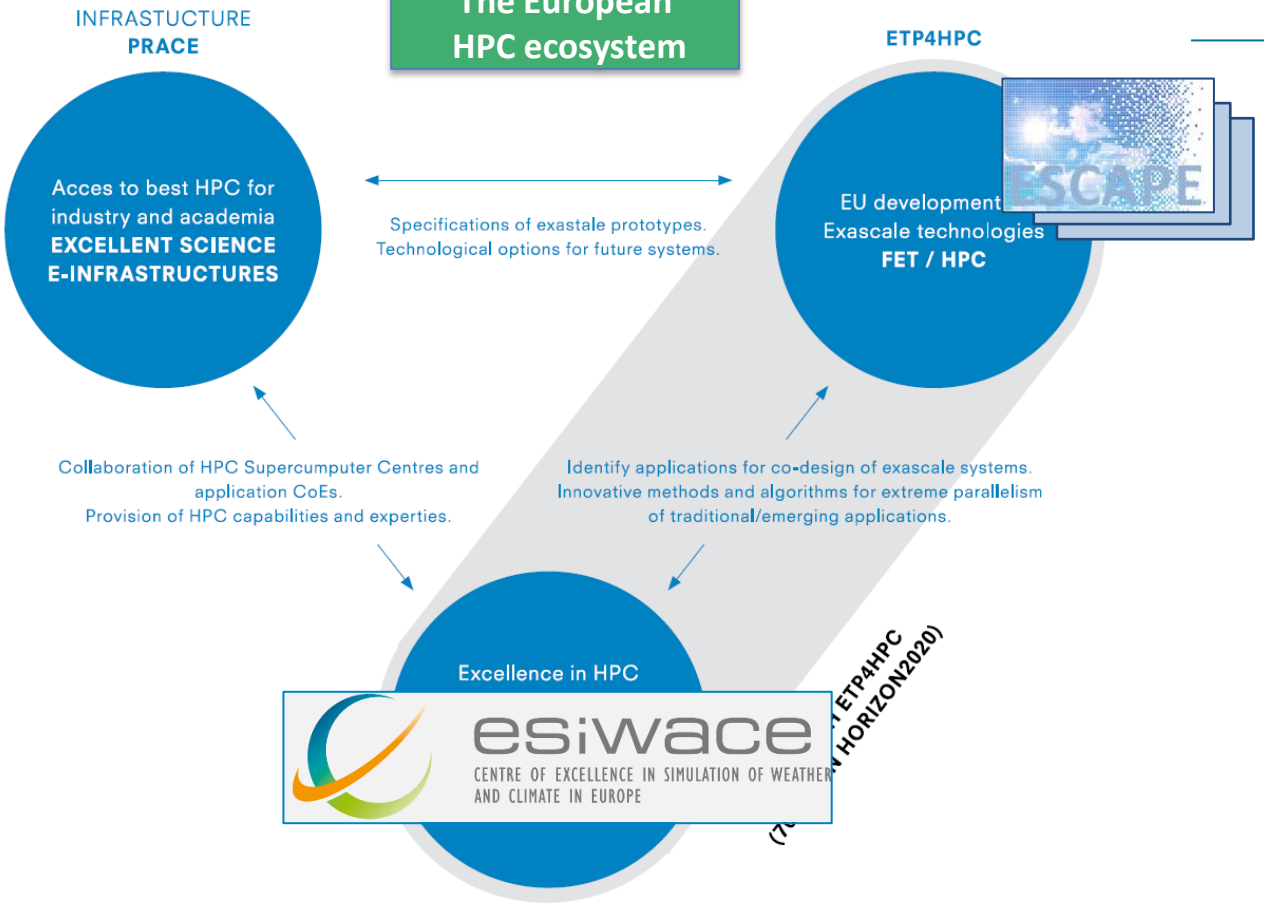
Joachim Biercamp (DKRZ)

IS-ENES3 Kick-off, Paris

The ESiWACE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 675191
The ESiWACE2 project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 823988

DKRZ DEUTSCHES KLIMARECHENZENTRUM

The European HPC ecosystem



The new kid in town: EuroHPC JU

- The EuroHPC joint undertaking
  - https://eurohpc-ju.europa.eu/index.html
  - factsheet
- New or continued CoEs
  - One of nine: ESiWACE2
  - explicitly required to support EuroHPC
  - List: https://exdci.eu/collaboration/coe

The Joint Undertaking will pool EU and national resources in High-Performance Computing with the aim of:

- **acquiring and providing a world-class petascale and pre-exascale supercomputing and data infrastructure** for Europe's scientific, industrial and public users, matching their demanding application requirements by 2020. This would be widely available to users from the public and private sector, to be used primarily for research purposes;
- supporting an ambitious research and innovation agenda to develop and **maintain in the EU a world-class High-Performance Computing ecosystem**, exascale and beyond, covering all scientific and industrial value chain segments, including low-power processor and middleware technologies, **algorithms and code design, applications** and systems, services and engineering, interconnections, know-how and skills for the next generation supercomputing era.

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esiwace

CENTRE OF EXCELLENCE IN SIMULATION OF WEATHER AND CLIMATE IN EUROPE

Funded from European Union; Horizon 2020;
Research agreement No 675191
Duration Oct. 2016 – Sept. 2019
Funding: ca 5Mio €

DKRZ DEUTSCHES KLIMARECHENZENTRUM · ECMWF · Institut Pierre Simon Laplace · Max-Planck-Institut für Meteorologie · BSC · SMHI · Met Office · ICHEC · Bull atos technologies · cmcc · SEAGATE · National Centre for Atmospheric Science NATURAL ENVIRONMENT RESEARCH COUNCIL · Science & Technology Facilities Council · CERFACS

esiwace2

CENTRE OF EXCELLENCE IN SIMULATION OF WEATHER AND CLIMATE IN EUROPE

Funded from European Union; Horizon 2020;
Research agreement No 823988
Duration Jan. 2019 – Dec. 2022
Funding: ca 8 Mio €

New Partners: eScience center · MeteoSwiss · CSCS · University of Reading · DDN STORAGE · MERCATOR OCEAN INTERNATIONAL

ESIWACE2 objectives

1. Enable leading European weather and climate models to leverage the available performance of pre-exascale systems with regard to both compute and data capacity in 2021.

2. Prepare the weather and climate community to be able to make use of exascale systems when they become available.

Path to Exascale (Core Codes)

Codes: Leading European Weather & Climate Models
(coupled models of atmosphere and ocean)

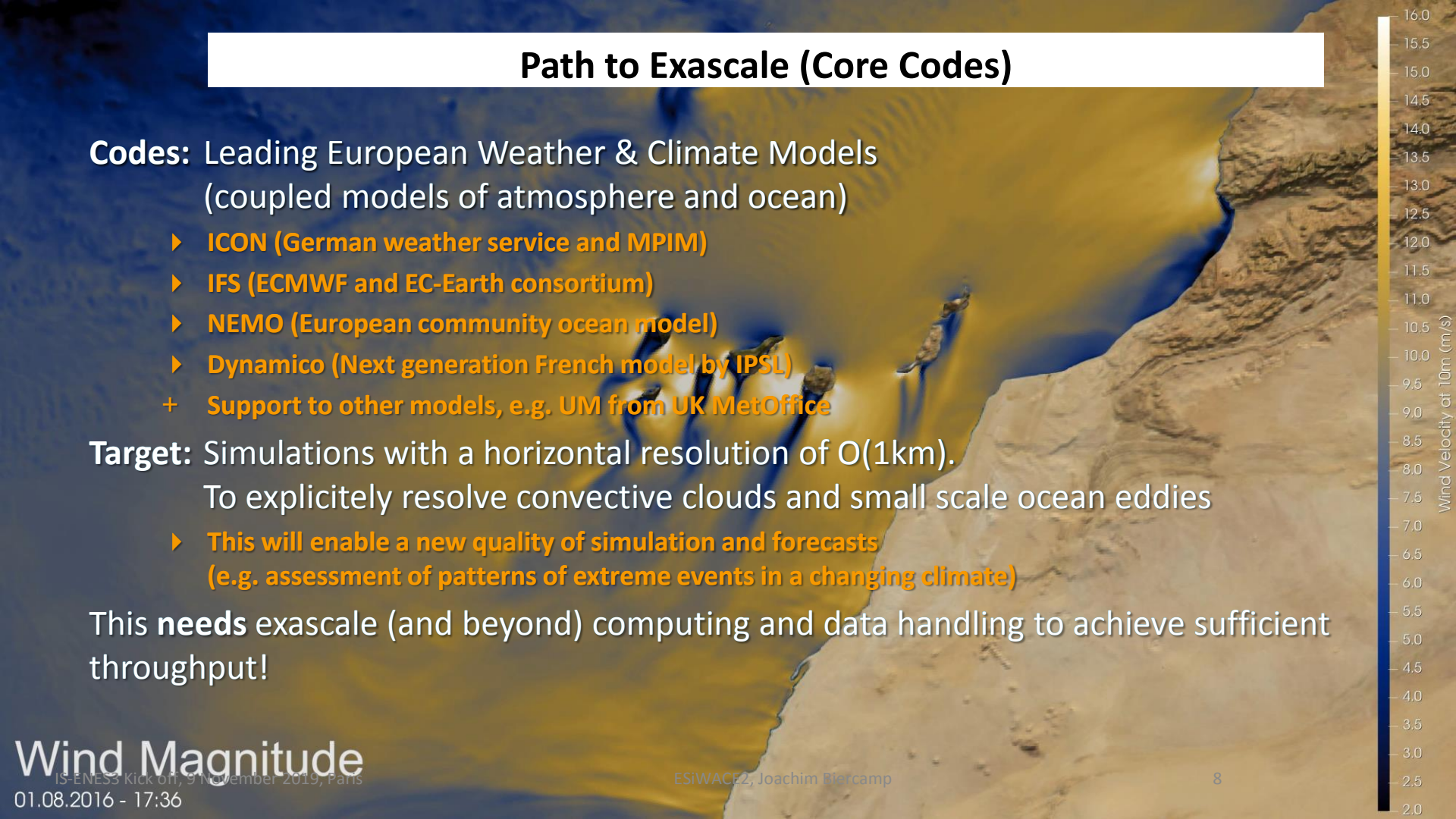
- **ICON (German weather service and MPIM)**
- **IFS (ECMWF and EC-Earth consortium)**
- **NEMO (European community ocean model)**
- **Dynamico (Next generation French model by IPSL)**

\+ **Support to other models, e.g. UM from UK MetOffice**

Target: Simulations with a horizontal resolution of O(1km).
To explicitely resolve convective clouds and small scale ocean eddies

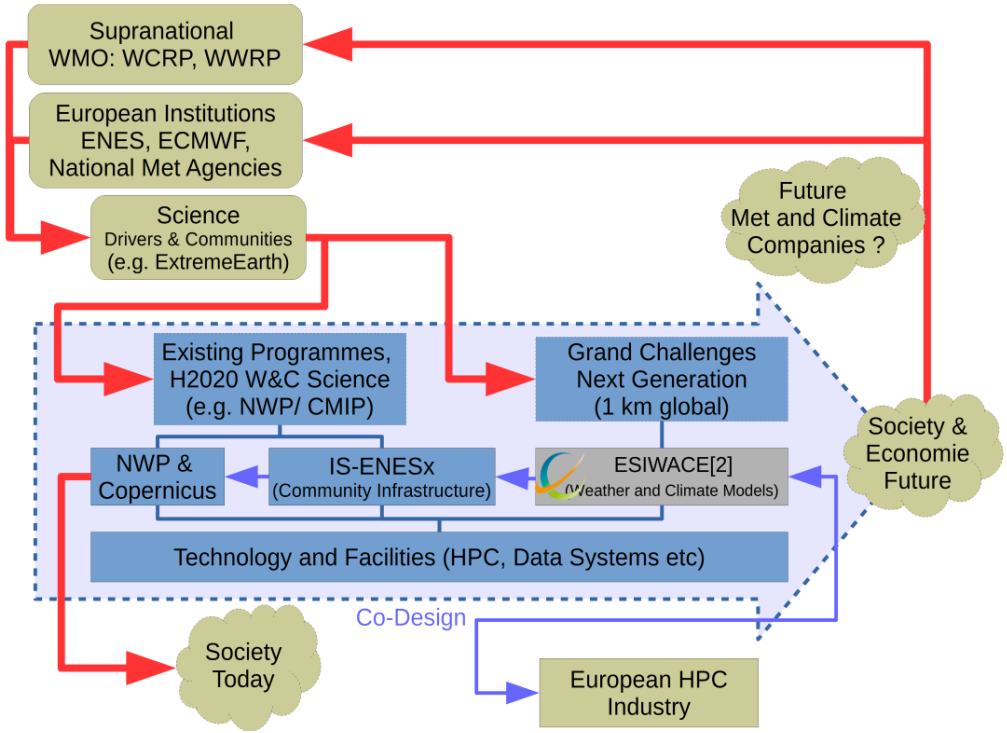
- **This will enable a new quality of simulation and forecasts (e.g. assessment of patterns of extreme events in a changing climate)**

This **needs** exascale (and beyond) computing and data handling to achieve sufficient throughput!



Engagement with users

- **Primary direct „users“ are the model developing groups which are directly linked to the project as partners**
- **Indirect users are all scientists and weather services using high resolution models on HPC.**
- **Further downstream:**
  - **Society and Policymakers.**
  - **Potentially future (commercial) weather & climate services**
  - **HPC-Industry**



Collaboration: Weather & climate computing as driver for HPC

EU funding programms (DG-connect)

2019 | 2020 | 2021 | 2022 | 2023 | 2024

FETHPC:

1. Weather and climate benchmarks, and IO (HPCW)
2. Demonstration of novel programming models (DSL)
3. Data aware numerical methods

→ **Feasibility of new concepts, computability**

ESCAPE, ESCAPE 2, MAESTRO DATA ORCHESTRATION, nextgenio, EuroEXA, EPiGRAM-HS

EINFRA:

1. Full-sized weather and climate models for EuroHPC
2. Community testing of novel programming models (DSL)
3. Data handling workflows, data analytics research

→ **Adaptation of leading models to (pre-)exascale**
→ **Strategy for achieving full-sized requirements**

esiwace, esiwace2

Plus is-enes-3 via DG-research

FETFLAG:

1. Full-sized applications with required speed/volume and power footprint
2. Ingestion of downstream applications, all ensembles
3. Domain-specific, distributed computing capability, interactive workflows

→ **Redesign entire prediction philosophy**

ExtremeEarth

EuroHPC:

EuroHPC-1&2 pre-exascale

EuroHPC-3&4 exascale

ESiWACE2 work packages

WP1 Cutting Edge Resolution in Earth system modelling

WP2 Establish and watch new technologies for the community

WP3 HPC services to prepare the weather and climate community for the pre-exascale

WP4 Data Handling at Scale

WP5 Data post-processing, analytics and visualisation

WP6 Community engagement and Training

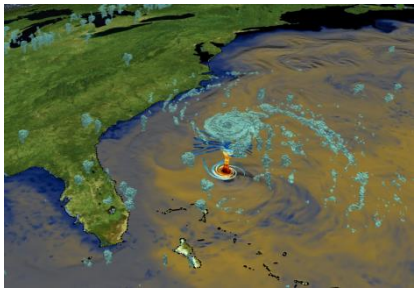
WP7 Coordination, Management and Dissemination

WP1: Cutting Edge Resolution in Earth system modelling

WP1 will develop coupled weather and climate models in unprecedented technical quality and performance as well as the organisational framework to assess their scientific performance.

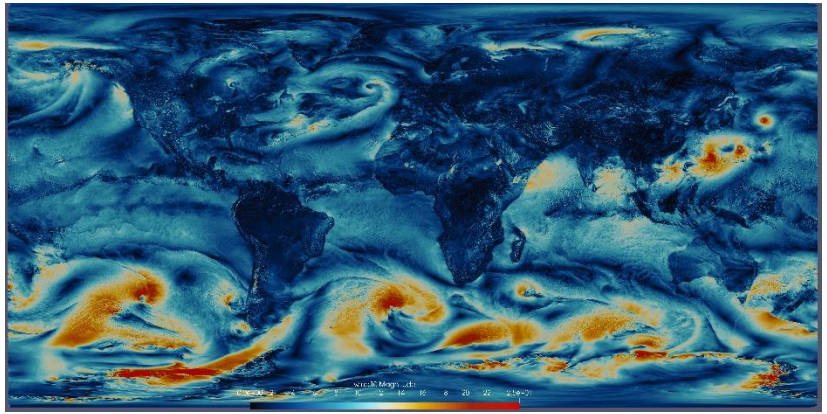
Lead: Peter Düben ECMWF; Philipp Neumann, DKRZ

- Extend the ESiWACE demonstrator approach to production type configurations: For fixed SYPD (=1) **push resolution** as high as technically feasible. Tentative goal:
  - EC-Earth: 16 km (TL1279) atmosphere coupled to a 1/12 degree (~8 km) ocean
  - ECMWF: 5 km (TCo1999) atmosphere coupled to a ¼ degree (25 km) ocean
  - ICON-ESM: 5 km atmosphere coupled to a 5 km ocean, aiming at higher resolutions for the ocean
  - The IPSL model: 10 km atmosphere coupled to a 1/12 degree (~8 km) ocean
- Extend the DYAMOND idea and provide the necessary infrastructure



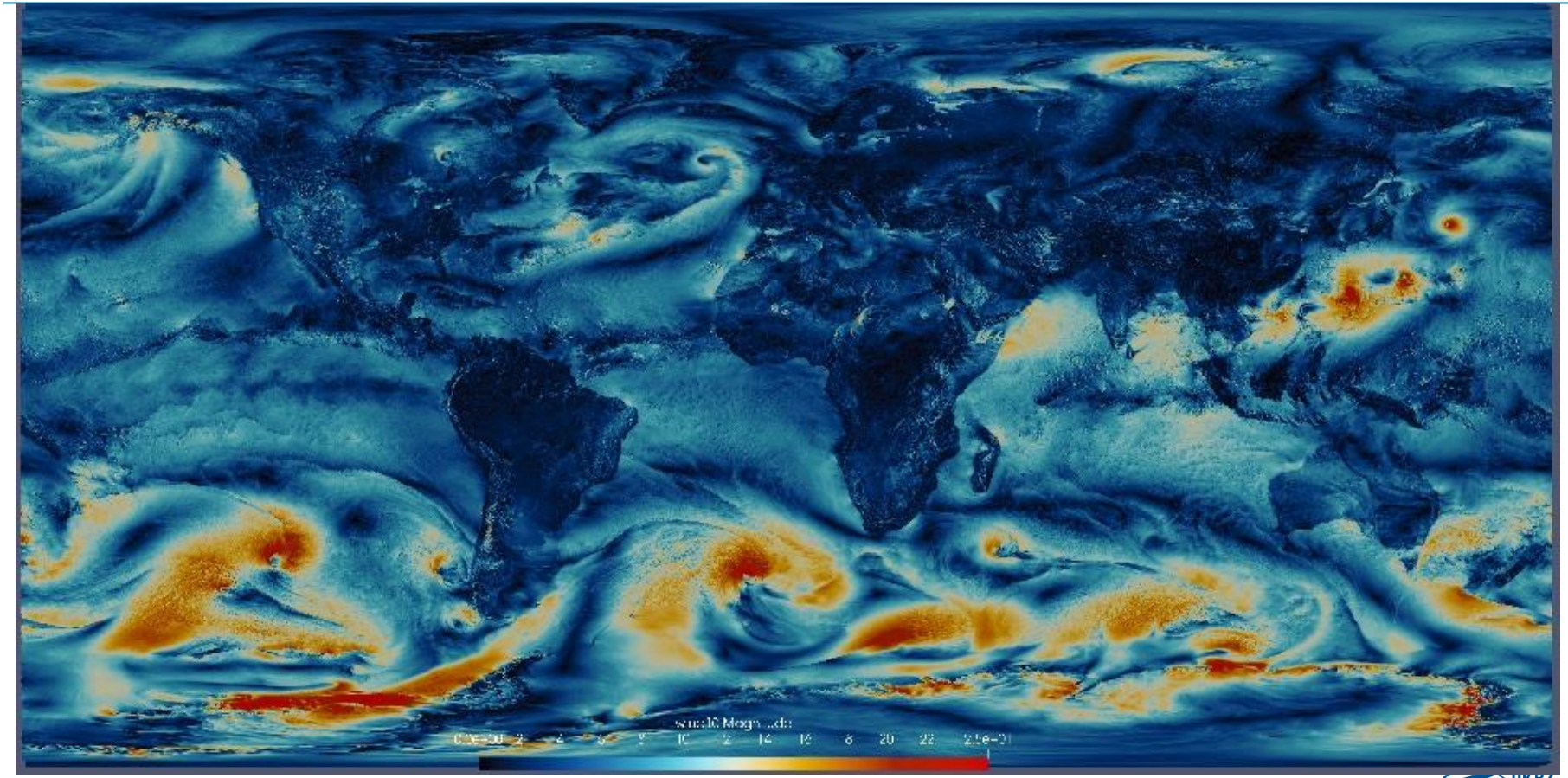
State of play: The ESiWACE demonstrators

Global high-resolution model demonstrators:



- **Demonstrate computability of:**
  - 1km global Atmosphere, IFS, 2017
  - 1km global Atmosphere, ICON, 2017
  - 1km global Ocean, NEMO, 2019
  - at least 10km global, coupled ESM, EC-EARTH, 2019
  - target 1km global, coupled ESM, ICON-ESM, 2019

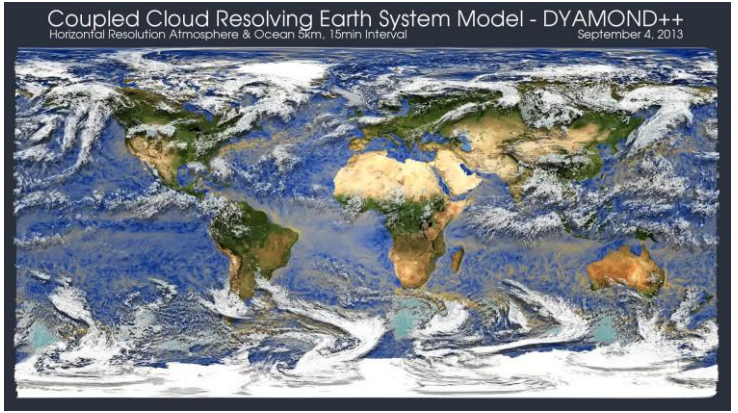
- **Demonstrate that size and communality of the problem justifies a coordinated approach and strategic investment**

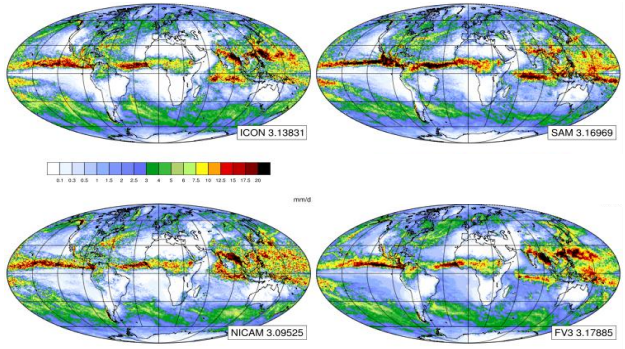


Success Story: Dyamond

Dyamond: DYnamics of the **A**tmospheric general circulation
Modeled **O**n **N**on-hydrostatic **D**omains
An intercomparison study

- Global climate models that explicitly resolve the major modes of atmospheric heat transport: convection-permitting resolution (1-5 km) = cutting edge science !
- Participating Models
  - **Europe:** IFS-H (4 and 9 km)
  - **Germany:** ICON (2.5 and 5 km),
  - **Japan:** NICAM (3.5 and 7 km)
  - **US:** FV3 (3.25 km), SAM (4 km), MPAS (7 .5 km)
- https://www.esiwace.eu/services/dyamond
  - This has never been done before
  - ICON is the only model with 2.5 km (= world leading).
  - 100eds of Terabyte of data.
    -> 2nd international hackathon planned for 2019





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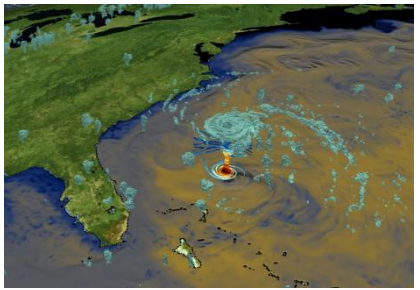


WP2: Establish and watch new technologies for the community

WP2 will establish, evaluate and watch new technologies to prepare climate and weather simulation for the exascale era.

Lead: Rupert Ford, STFC; Carlos Osuna, MeteoSwiss

- Establish DSLs in the community
- Evaluate Concurrent Components to improve performance
- Evaluate Containers to port Earth system models to new hardware
- Watch emerging technologies

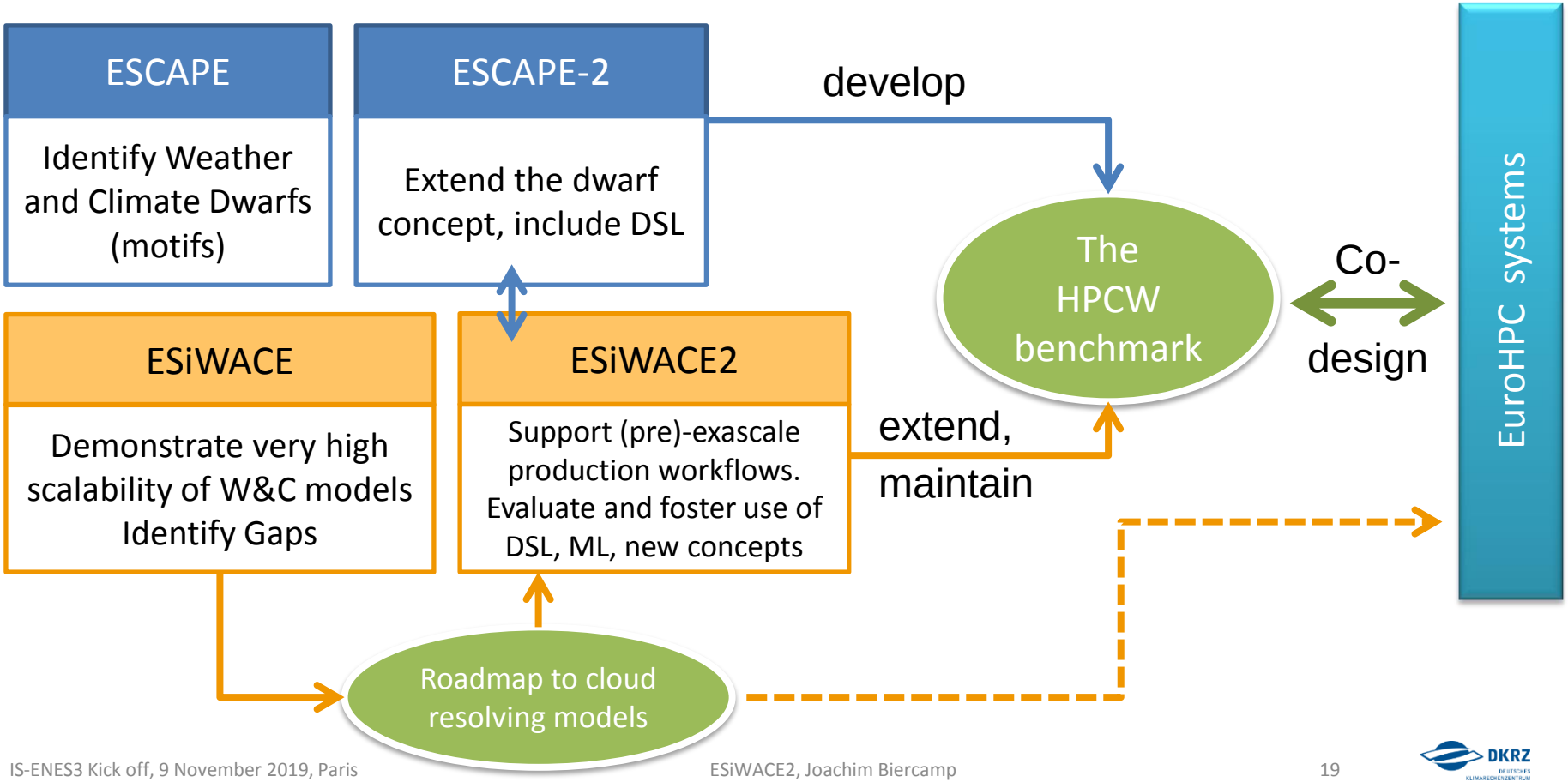
WP3: HPC services to prepare the W&C community for pre-exascale

WP3 will develop and provide services to improve performance and portability of climate codes with respect to existing and upcoming tier1 and tier0 computers..

Lead: Ben van Werhoven, NLeSC; Erwan Raffin, Bull/ATOS

- Open call for service requests to organise support for existing Earth system models that target the European pre-exascale systems planned for 2021.
  - Model portability and refactoring
  - Coupling, IO and workflows
- Weather and climate benchmarking
  - "*HPCW*" (V1.0 developed by ESCAPE-2)

Example for direct cooperation with ESCAPE-2



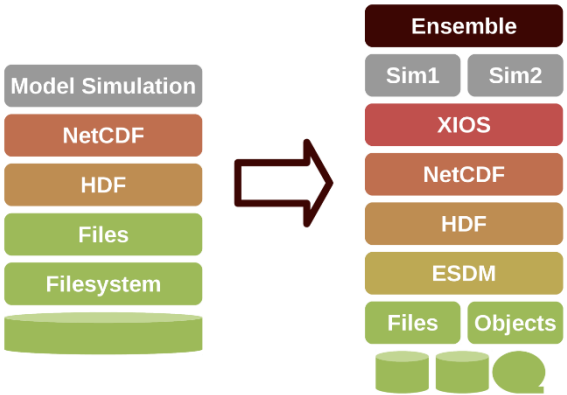
WP4 and WP5: Data Handling at Scale

WP4 will provide the necessary toolchain to handle data
at pre-exa-scale and exa-scale, for single simulations, and ensembles

Lead: Bryan Lawrence, UREAD; Julian Kunkel, UREAD

WP5 will enhance the tools to analyse and visualise these data

Sandro Fiore, CMCC; Niklas Röber, DKRZ



Control Workflow via CYLC Meta-scheduler

Handle data via Earth-System-Data Middleware (ESDM, non POSIX)

In-situ and asynchronous approaches to analytics and visualisation

WP6: Community engagement and Training

WP6 will link ESiWACE2 to the weather and climate community it serves on the one hand and to the European HPC ecosystem on the other hand

Lead: Sylvie Joussaume, CNRS-IPSL; Sophie Valcke, CERFACS

- Community engagement
  - HPC Workshops
  - HPC task force
  - Interface to PRACE

- Training and Schools
  - IO and HPC awareness
  - DSL
  - C++ for HPC
  - OASIS3-MCT
  - High performance Data Analytics
  - Docker
  - Summer school in HPC for weather and climate

Exchange and collaborate: ENES HPC workshops

The Series of ENES HPC-workshops is co-organized by ESiWACE(2) and IS-ENES with the ENES HPC task force

(Barcelona 2022)

Canary Islands

DYAMOND R2B10 - 2D Wind Visualization
(3 Minute Output - 10m Height)