



Project ESIWACE: Towards Global Kilometre-Scale Weather and Climate Predictions

Philipp Neumann
Deutsches Klimarechenzentrum (DKRZ)

...and the members of ESIWACE and DYAMOND

Outline

1. Motivation: Towards Global Kilometre-Scale Models (KSMs)
2. The ESiWACE Projects
 1. Overview & Infrastructure
 2. The Demonstrator Concept
3. DYAMOND: The Science Case
4. Scalability and Performance of the ESiWACE Demonstrators
5. Summary and Further Reading

Deficiencies of Climate Models and the Hi-Res Case

- 1.25km resolution,
335 544 320 horiz. cells,
45 vert. levels
- 1408 nodes,
2MPI x 18 OpenMP
- Throughput: 1.8 SDPD,
no IO
- **Actual target: 1km ensembles,
1SYPD=365 SDPD throughput**
- Benchmark (160km-5km)
available at:

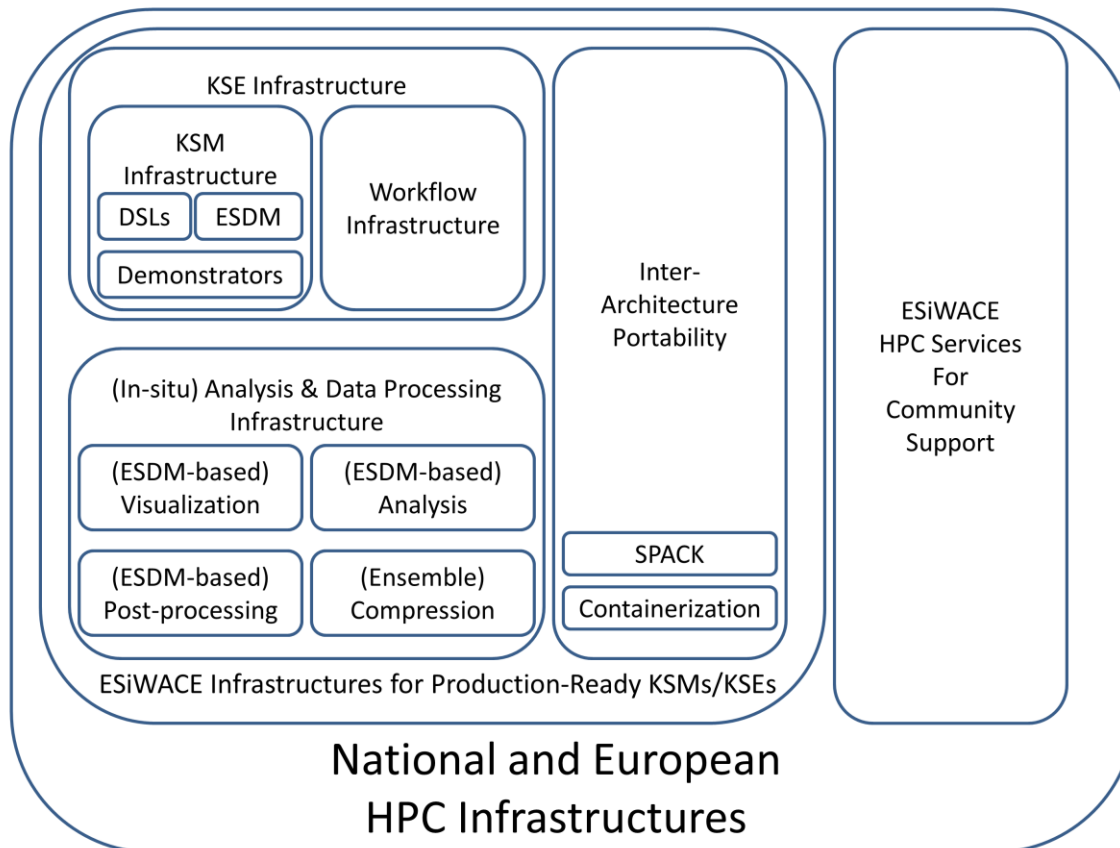
<https://redmine.dkrz.de/projects/icon-benchmark/wiki/>

[Instructions on download execution and analysis ICON Benchmark v160](#)

ESiWACE: Centre of Excellence in Simulation of Weather and Climate in Europe

- European e-infrastructure projects
- Goals
 - Substantially improve efficiency and productivity of weather & climate models
 - Prepare models for exascale systems → performance analysis, tuning, ...
- ESiWACE: 09/2015 – 09/2019, 5M €, 16 partners/7 countries
Kilometre-scale demonstrators (prototypical)
→ ICON, IFS, NEMO, EC-Earth
- ESiWACE2: 01/2019 – 12/2022, 8M €, 20 partners/9 countries
Towards production-ready models and ensemble simulation at pre-exascale
- Read more: Website: www.esiwace.eu
ESiWACE newsletters: www.esiwace.eu/newsletter

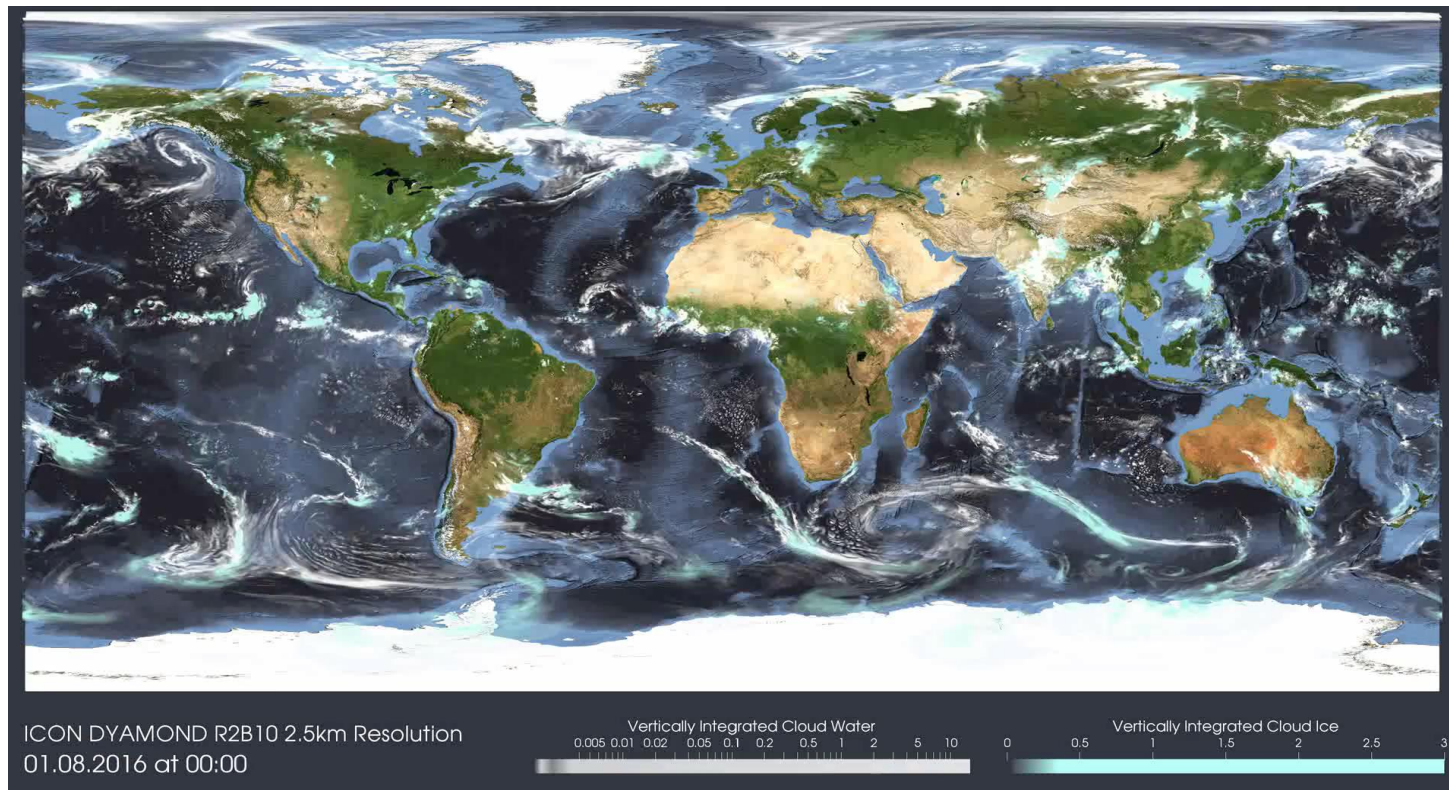
ESiWACE: Infrastructure Overview



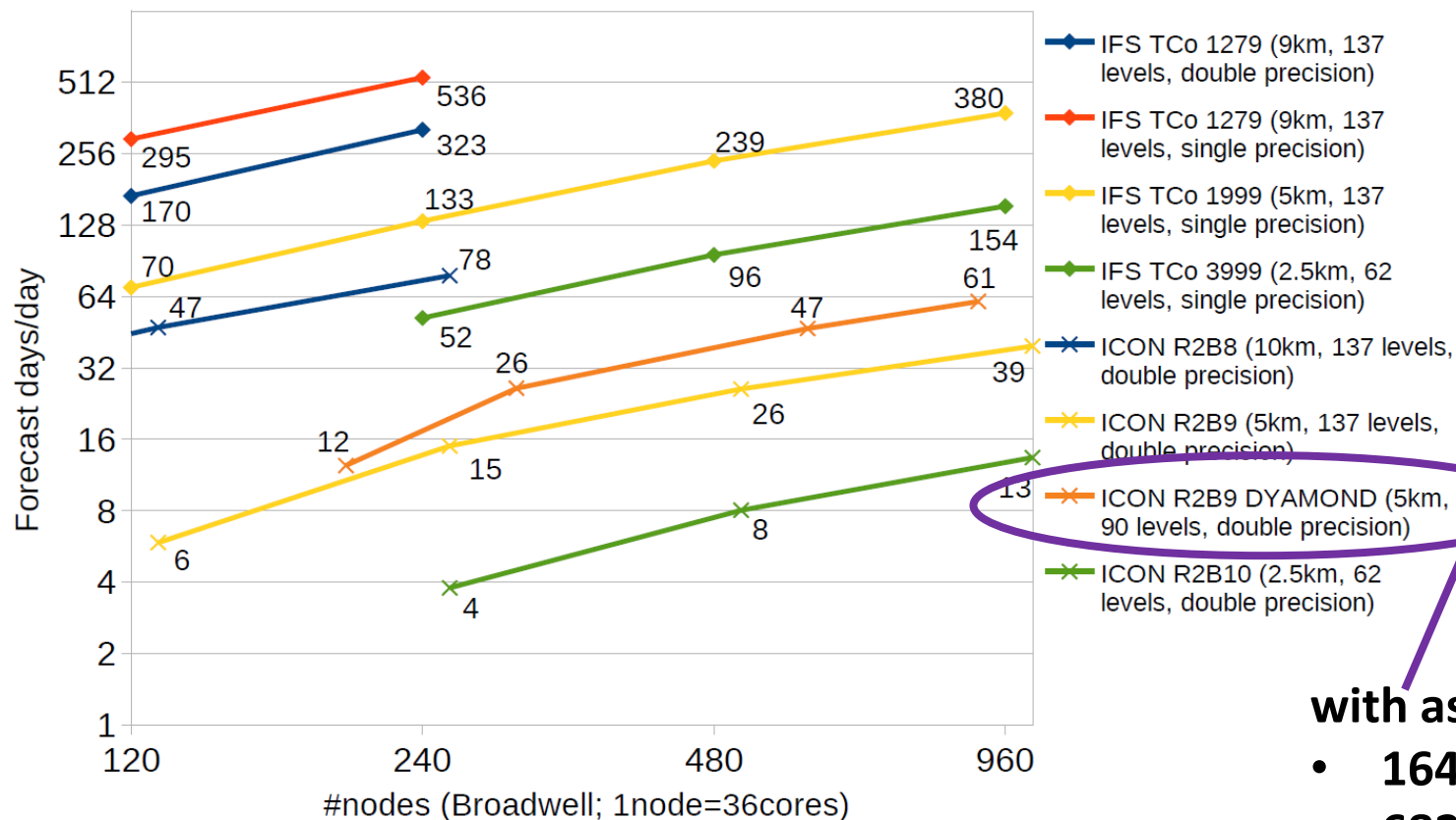
DYAMOND: Dynamics of the Atmospheric General Circulation Modeled on Non-hydrostatic Domains

- Intercomparison of O(3km) atmospheric global models
→ ICON, NICAM, MPAS, GEOS, FV3, SAM, UM, ARPEGE-NH, IFS-H
 - ICON 2.5km throughput: ca. 6 SDPD (540 nodes/19 440 cores)
 - Scientific use case of ESiWACE demonstrators
- Read more: www.esiwace.eu/services/dyamond

Towards Global Kilometre-Scale Models (KSMs)

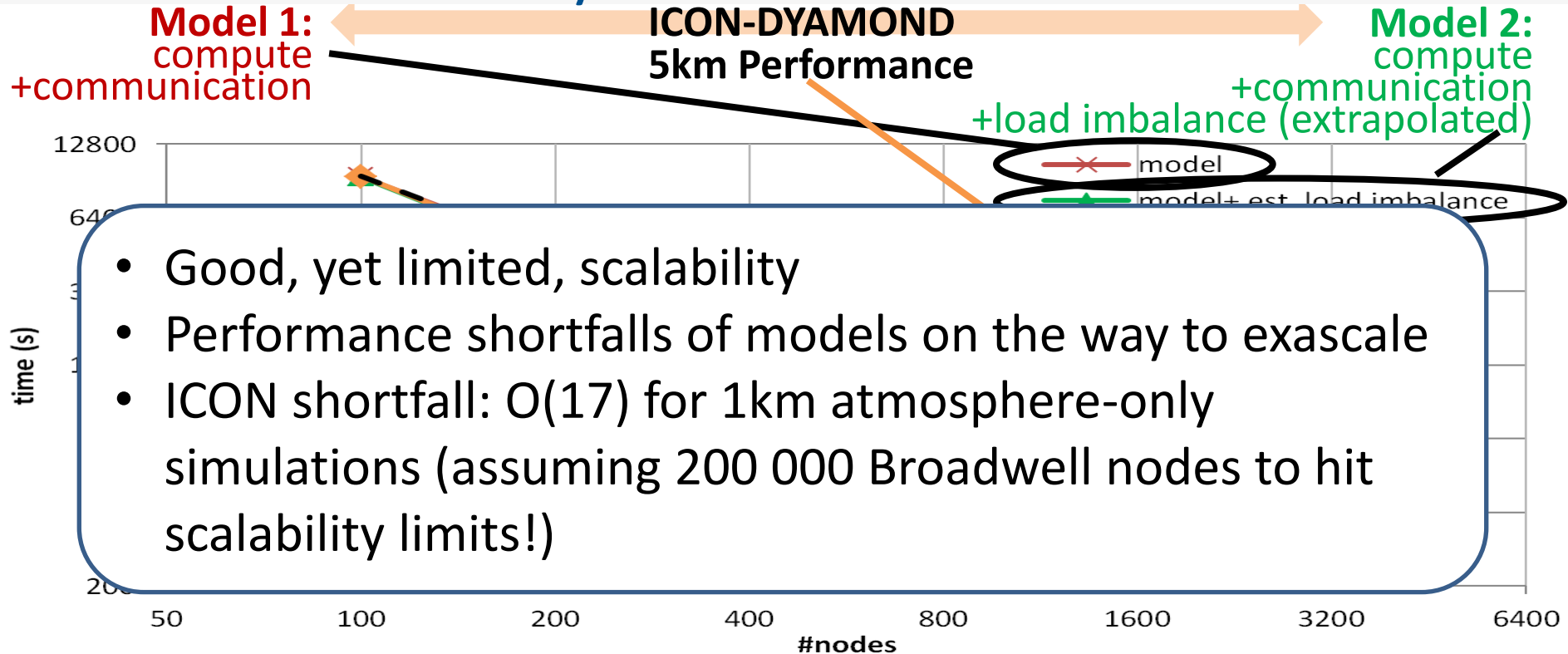


Atmosphere-Only Demonstrators: Scalability



- with async. IO:**
- **164GB per sim. day**
 - **682GB checkpoint**

Atmosphere-Only ICON Demonstrator: Performance Models for Scalability Prediction at Exascale



ICON Coupled Demonstrator: DYAMOND++

Prerequisite: DYAMOND++ Setup (MPI-M)

- 5km ocean / 5km atm (matching grids)
- 128 ocean levels, 70 atm levels
- ECHAM physics
- Parametrisations for: radiation, cloud cover, microphysics, vertical diffusion, land surface
- No parametrisations for: convection, gravity waves

ICON Coupled Demonstrator: Performance

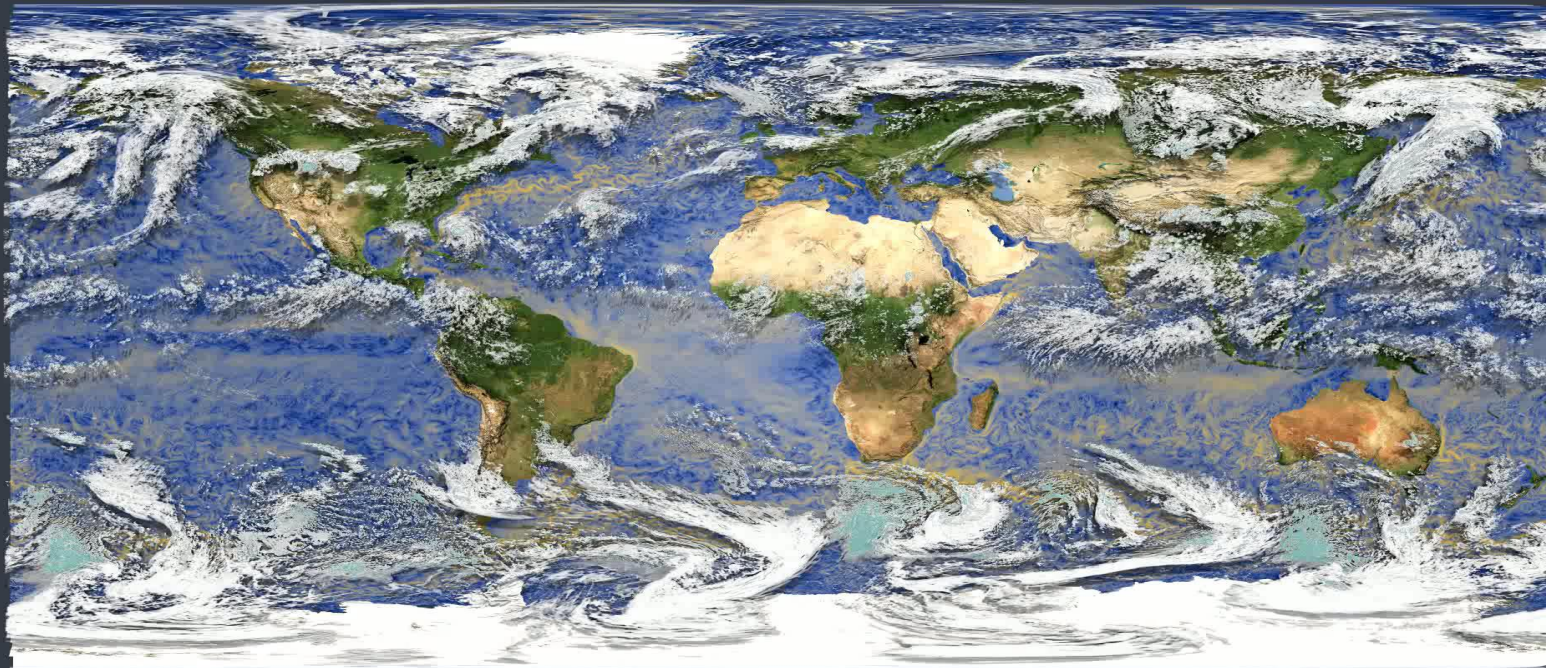
Scalability and Demonstrator Investigations

- Determine min. compute requirements
 - ca. 100 (ocean) + 150 (atm) = 250 compute nodes
 - yet: what should be a baseline for speedup calculation?
Smallest executable setup? Optimal ocean/atm splitting?
- Study to determine good column blocking for ocean/atm → nproma = 32
- Scalability study: splitting ocean<-> atm compute nodes

Nodes	Nodes (atm)	Nodes (oce)	Notes	SDPD
420	300	120	Baseline	15.6
420	300	120	nproma=32	16.4
250	150	100	Min. setup	9.8
550	450	100	Add. HCOLL opt.	15.1
420	300	120	Add. HCOLL opt.	14.5

ICON Coupled Demonstrator: The Beauty of Nature

Coupled Cloud Resolving Earth System Model - DYAMOND++
Horizontal Resolution Atmosphere & Ocean 5km, 15min Interval
September 4, 2013



Summary

- DYAMOND/ESiWACE: Towards production-ready scalable global hi-res modeling
 - scalability, performance and e-infrastructure (ESiWACE)
 - scientific insight and model intercomparison (DYAMOND)
- Performance shortfall of global high-resolution models (still) circumvents (sub)-kilometre-scale simulations
 - factor $O(17)$ for ICON, similar for other models
 - ***this factor is (quasi-)independent from the supercomputer's size!***
- Scalability investigation and prediction via performance modeling
 - ***semi-analytical model for ICON-5km describes model's scaling behaviour well***

P. Neumann acknowledges ESiWACE. ESiWACE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 675191. This material reflects only the author's view and the European Commission is not responsible for any use that may be made of the information it contains.

Further Reading

Scalability & Performance Extrapolation for KSMs

1. P. Neumann et al.
Phil. Trans. R. Soc. A. 377:20180148, 2019
2. T. Schulthess et al.
IEEE Computing in Science & Engineering 21(1):30-41, 2018

The Science Case DYAMOND

3. B. Stevens et al. DYAMOND (Submitted)

ESiWACE Infrastructure Efforts

4. P. Neumann, J. Biercamp. ESiWACE: On European Infrastructure Efforts for Weather and Climate Modeling at Exascale (Submitted)