ESiWACE, High-Resolution Demonstrators and Scalability

Philipp Neumann
Deutsches Klimarechenzentrum (DKRZ)

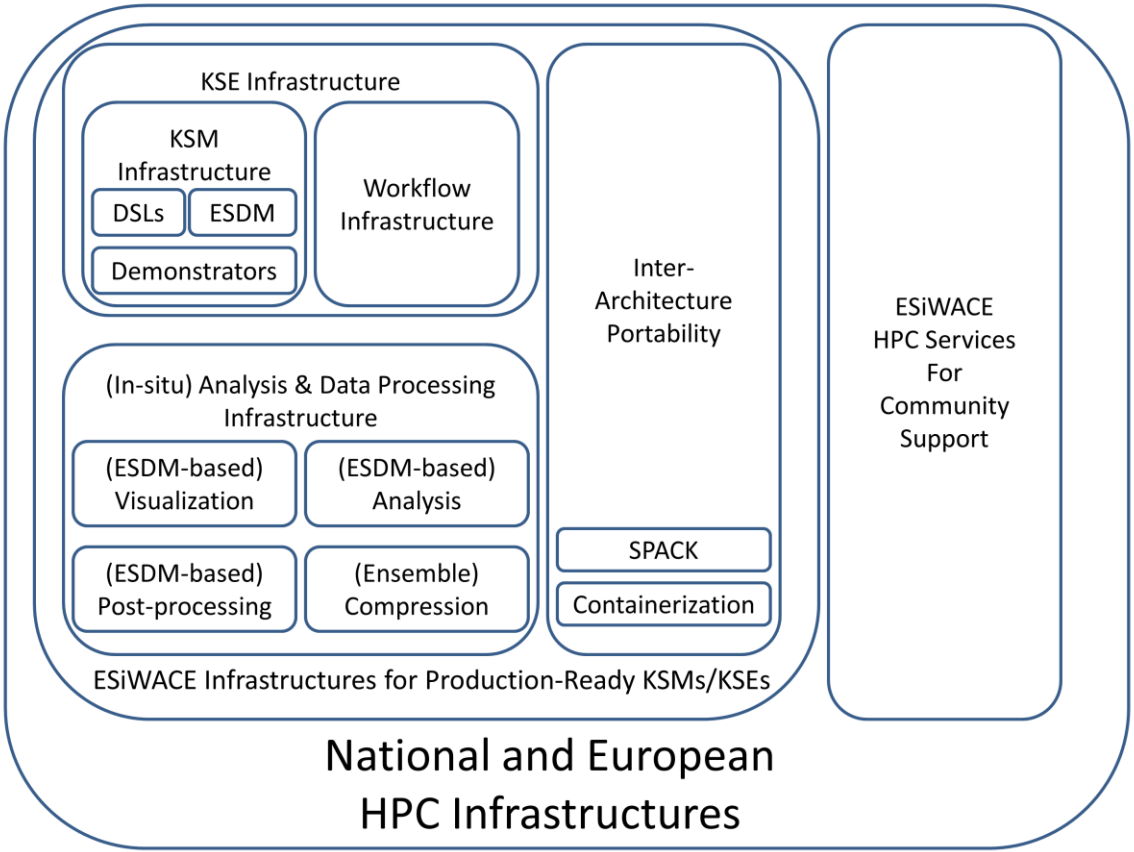
Outline

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

ESiWACE: Centre of **E**xcellence in **Si**mulation of **W**eather **a**nd **C**limate in **E**urope

- 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

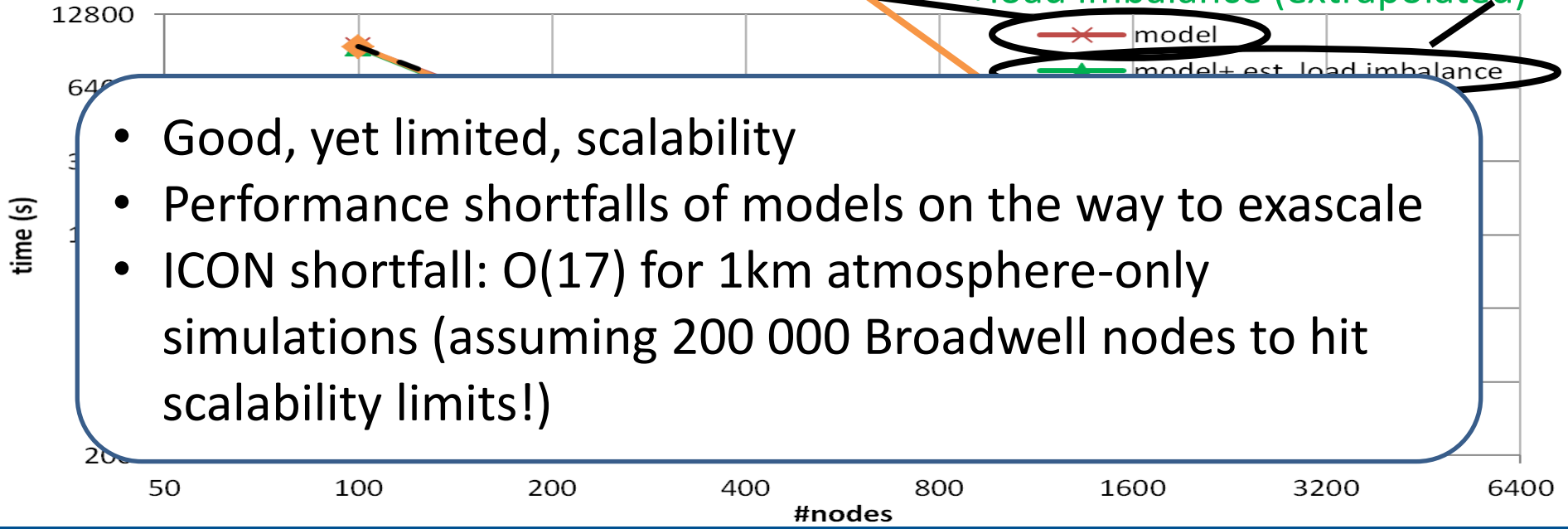


Atmosphere-Only ICON Demonstrator: Performance Models for Scalability Prediction at Exascale

Model 1: compute +communication

ICON-DYAMOND 5km Performance

Model 2: compute +communication +load imbalance (extrapolated)



- Good, yet limited, scalability
- Performance shortfalls of models on the way to exascale
- ICON shortfall: O(17) for 1km atmosphere-only simulations (assuming 200 000 Broadwell nodes to hit scalability limits!)

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

Summary

- 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

ESiWACE Infrastructure Efforts

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