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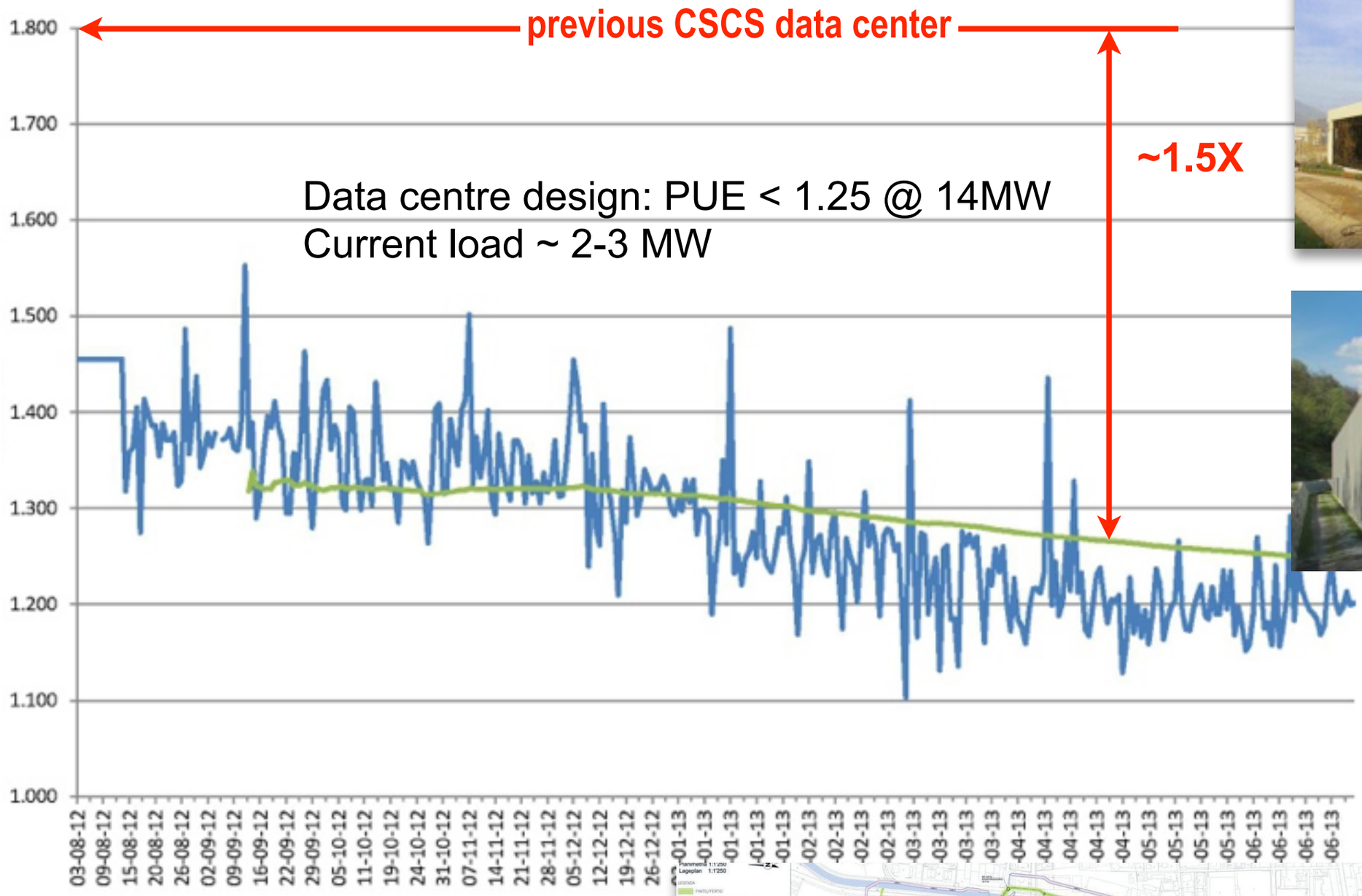
Energy efficiency or performance?

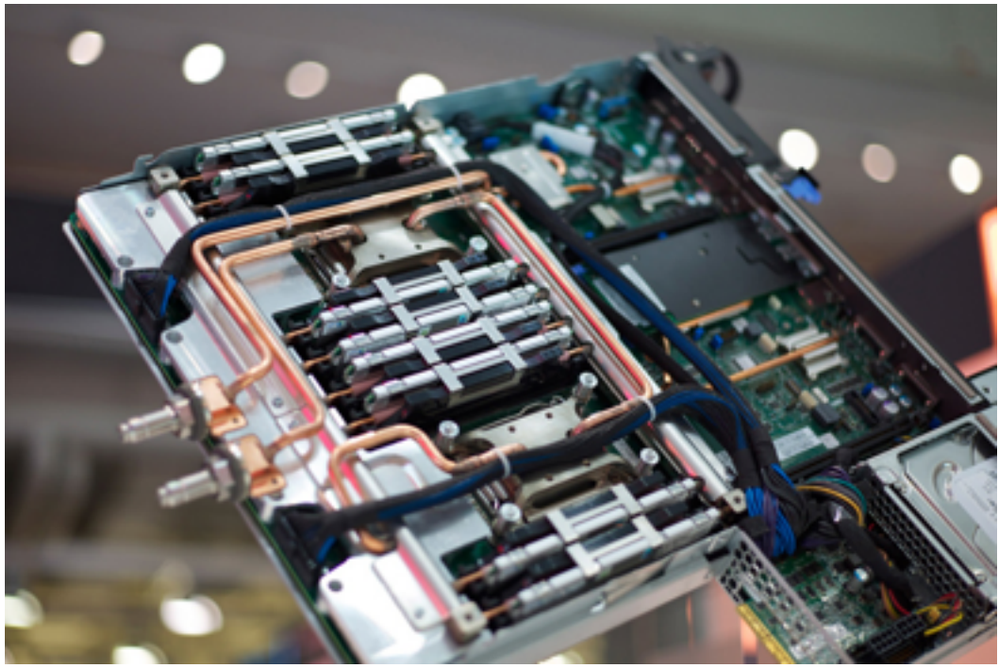
Thomas C. Schulthess

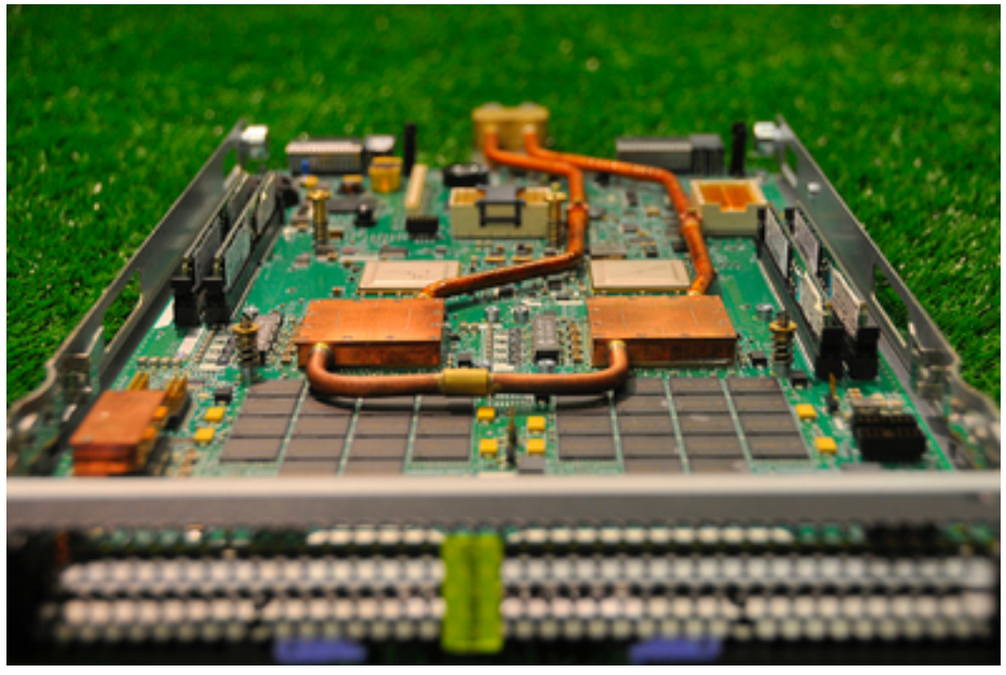
Focus on energy efficiency: PUE



Focus on energy efficiency: reuse

SuperMUC @ LRZ, 2012



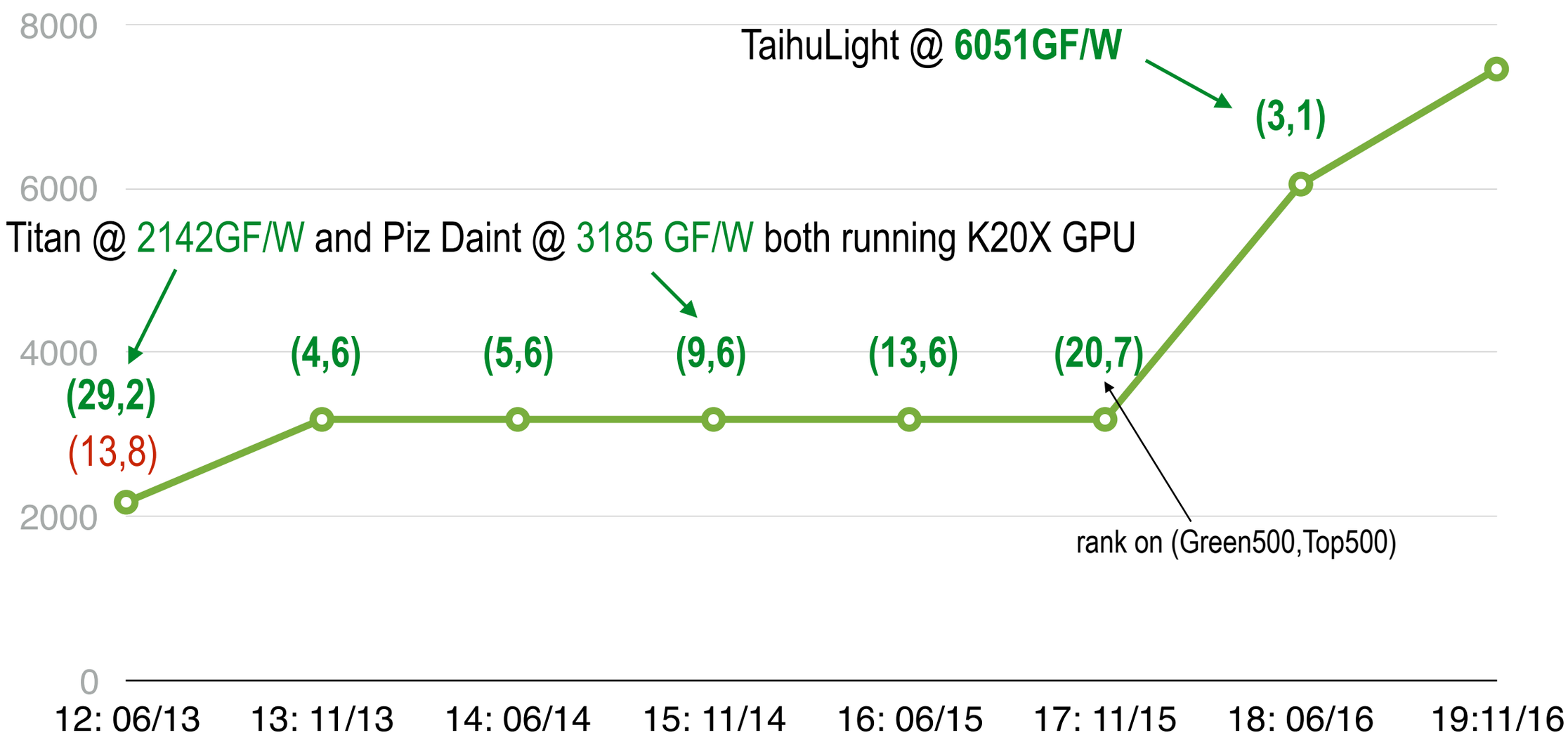


Hot water cooling of any commodity processor
> run data centre on tap water
> improve potential for energy reuse

Aquasar project @ IBM ZRL & ETH Zurich, 2010

Focus on energy efficiency: compute system

June 2012: Sequoia (#1 on Top500) reports **2069 GF/W** while SuperMUC has **846 GF/W**



Since energy cost amounts to only about 10% of TCO (4y), why is energy efficiency so important?

What we really should care about is …

Time & Energy to solution

Optimising time and energy to solution

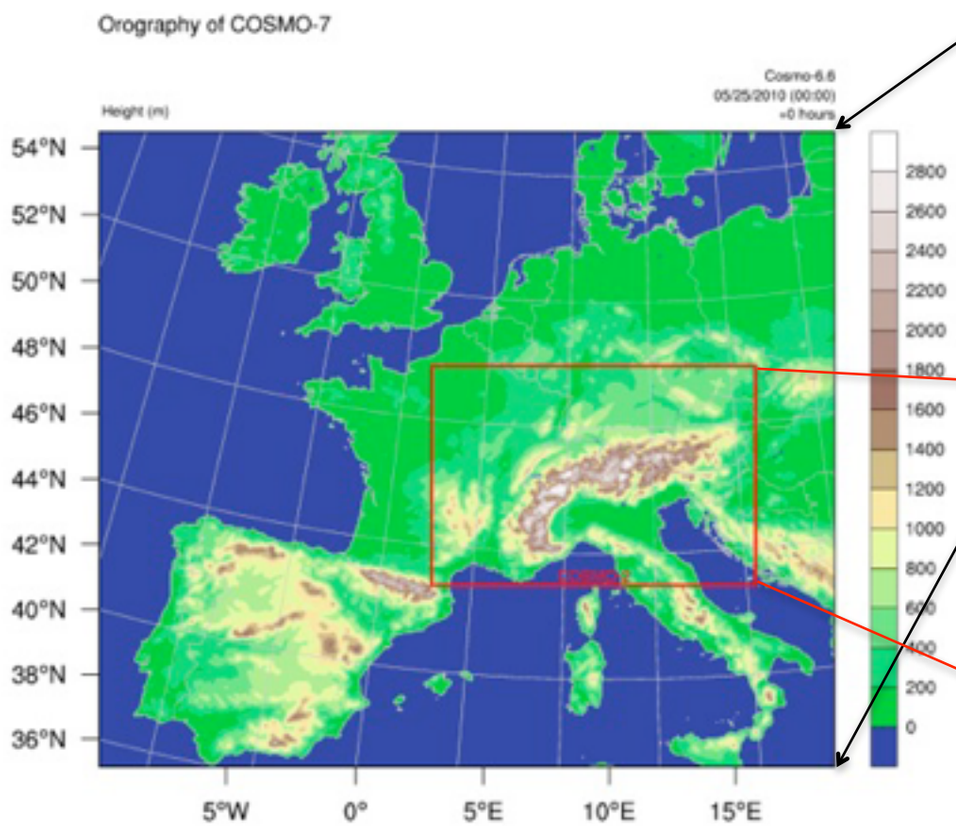
First, meet operational requirements for time to solution

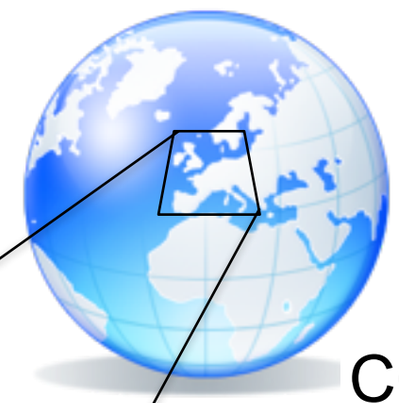
(maybe there are other constraints, such as investment budget)

Then minimise energy to solution given all operational constraints

Meteo Swiss production suite until March 30, 2016

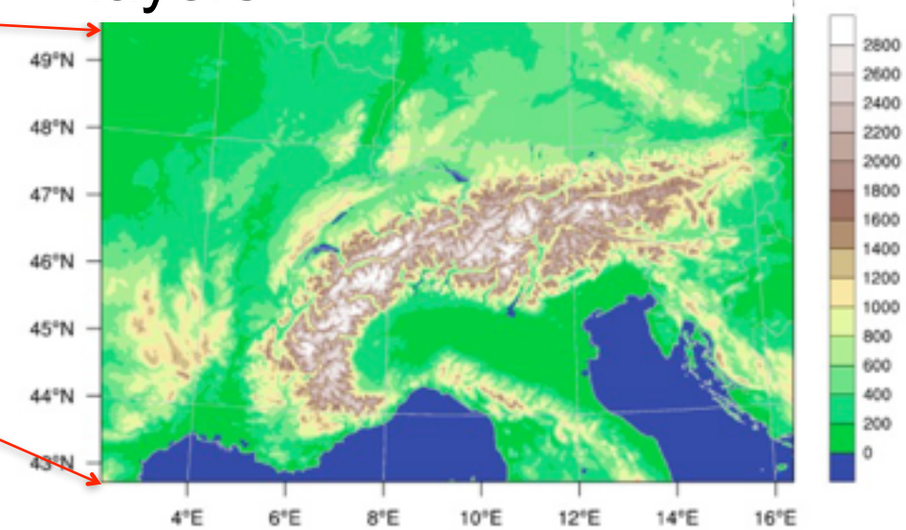
COSMO-7
3x per day 72h forecast
6.6 km lateral grid, 60 layers





ECMWF
4x per day
16 km lateral grid, 91 layers

COSMO-2
8x per day 33h forecast
2.2 km lateral grid, 60 layers



Some of the products generate from these simulations:

- Daily weather forecast on TV / radio
- Forecasting for air traffic control (Sky Guide)
- Safety management in event of nuclear incidents

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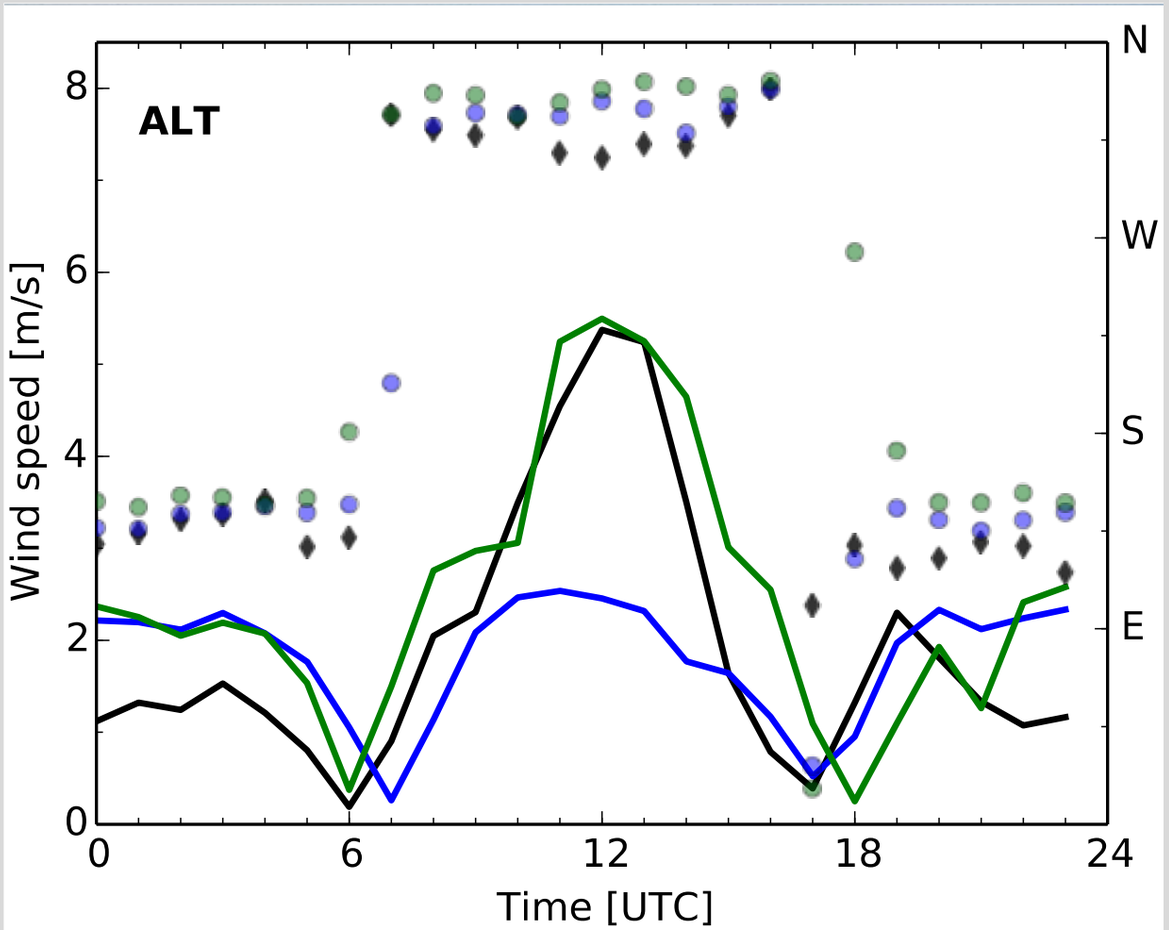
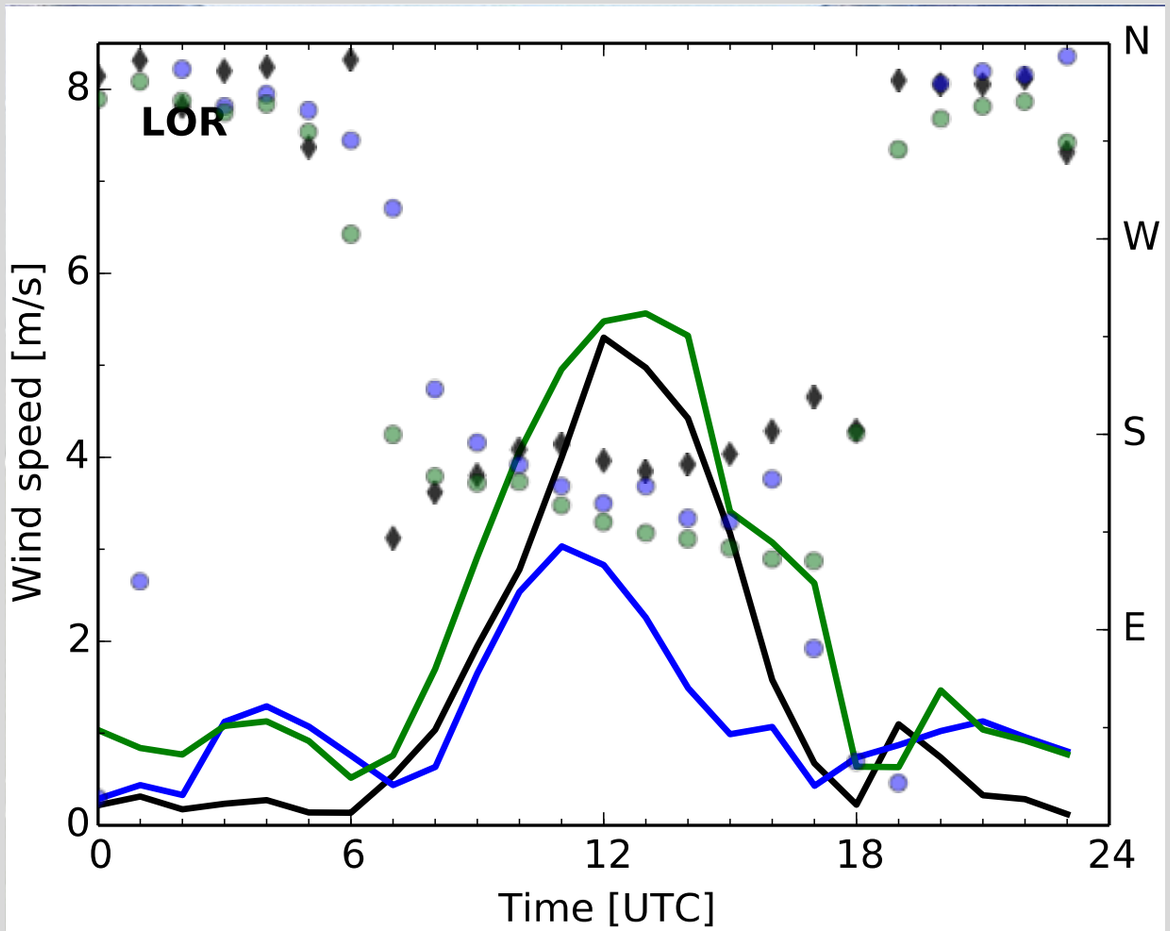
Higher resolution is necessary for quantitative agreement wth experiment

(18 days for July 9-27, 2006)

Altdorf (Reuss valley)



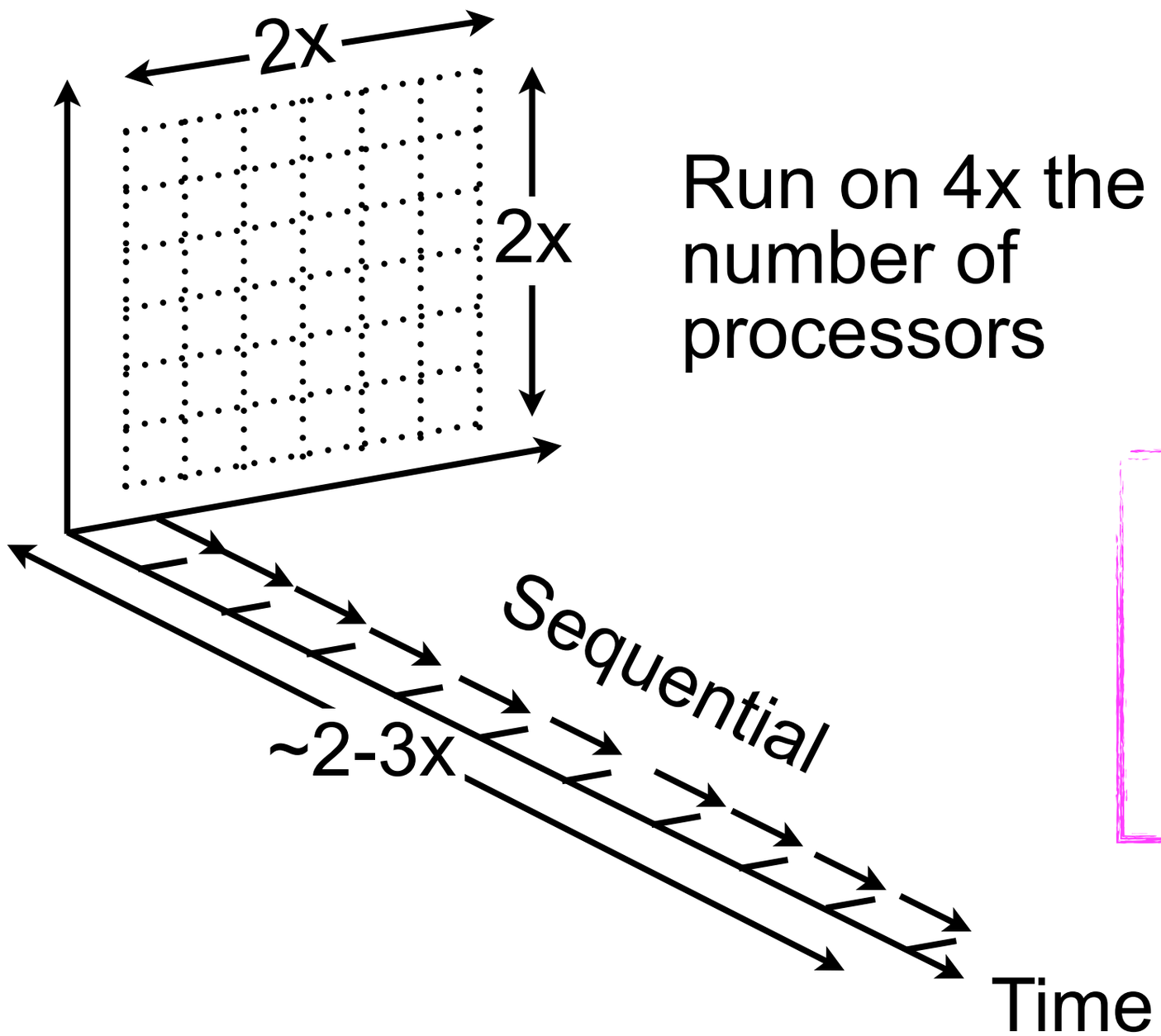
Lodrino (Leventina)



Observation Average wind speed (—) and direction (◊) **COSMO-2** **COSMO-1**

source: Oliver Fuhrer, MeteoSwiss

Improve resolution of Meteo Swiss model from 2 to 1 km

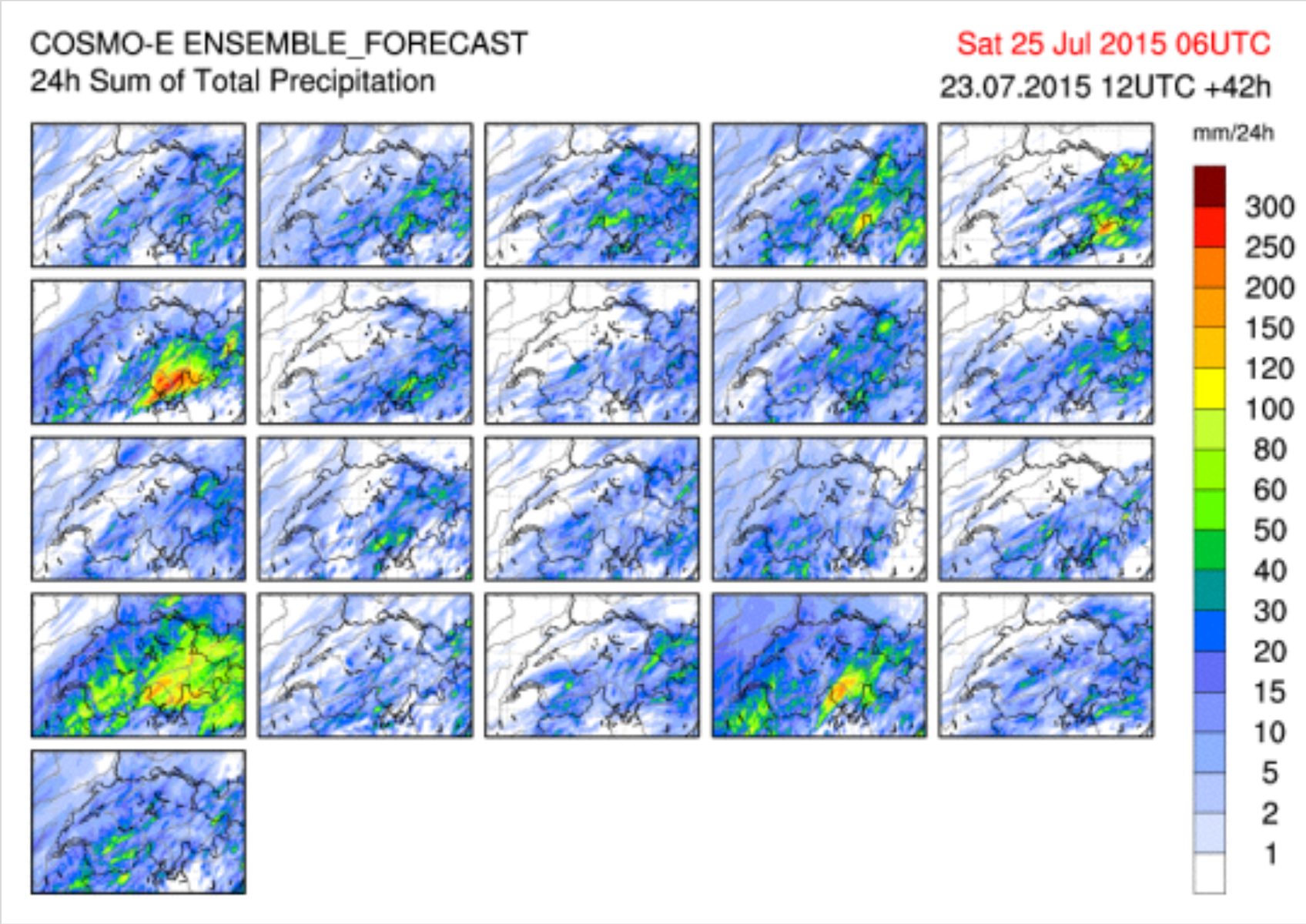


Run on 4x the number of processors

Doubling the resolution requires ~10x performance increase

Benefit of ensemble forecast

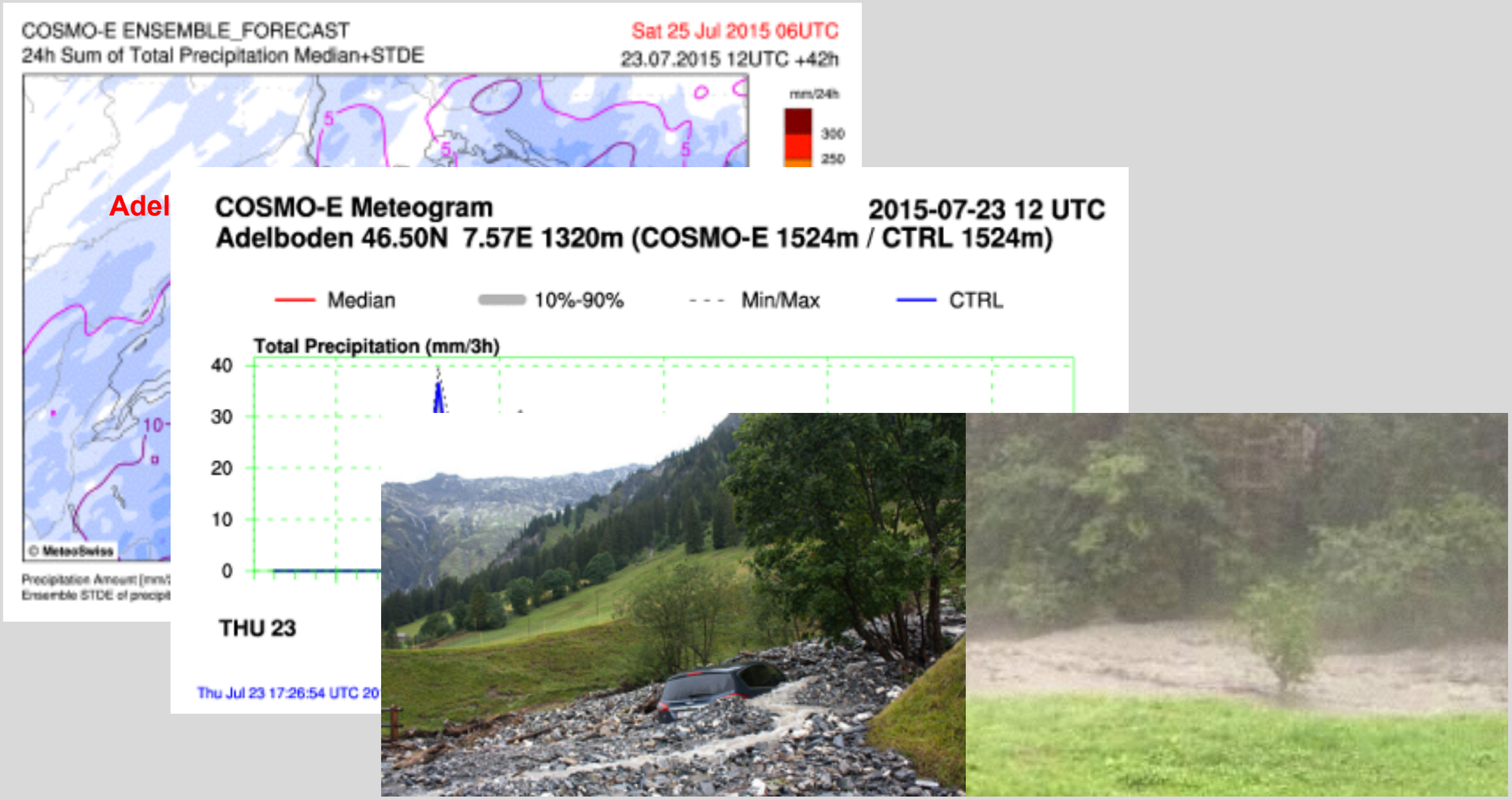
(heavy thunderstorms on July 24, 2015)



source: Oliver Fuhrer, MeteoSwiss

Benefit of ensemble forecast

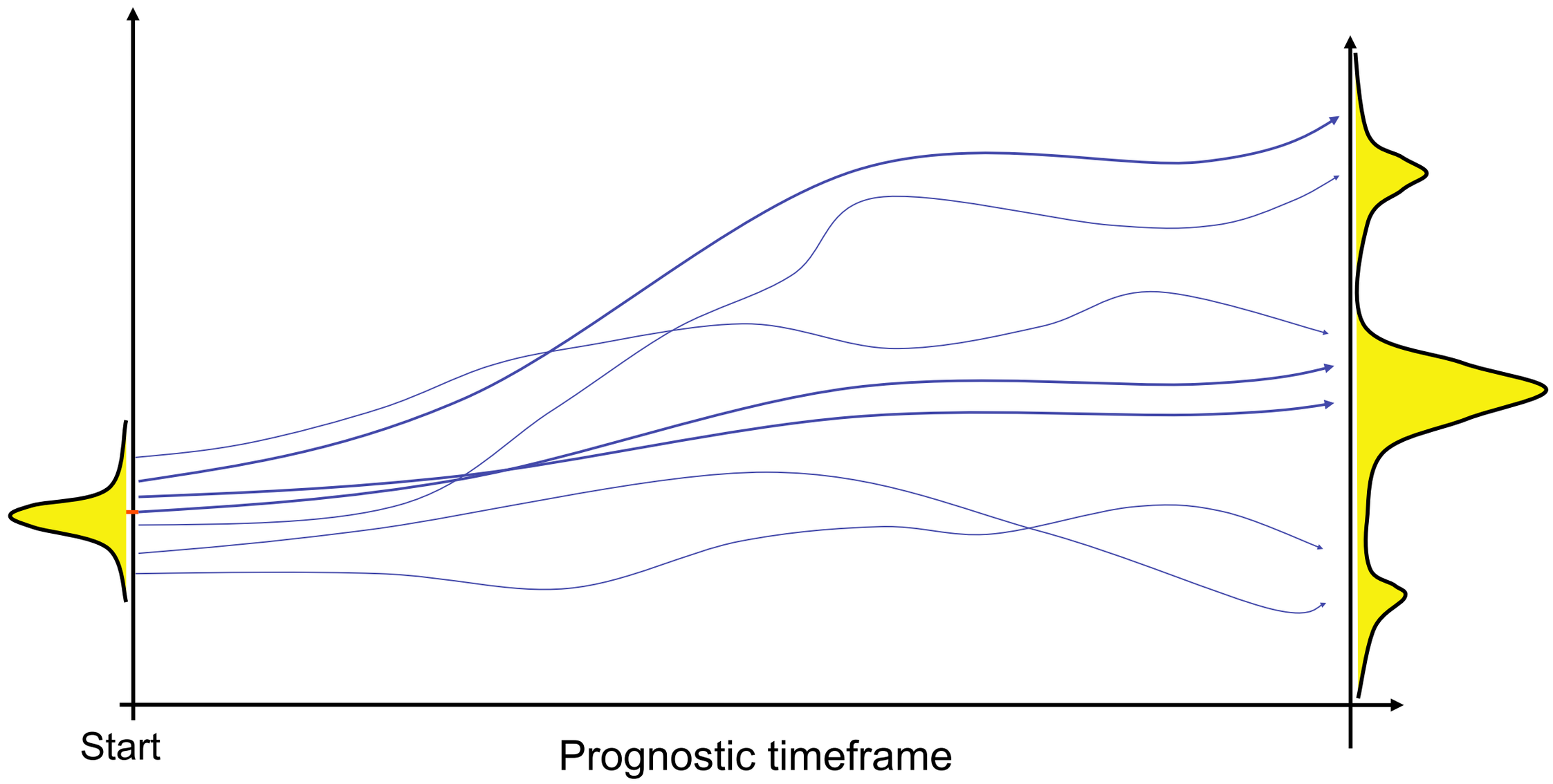
(heavy thunderstorms on July 24, 2015)



source: Oliver Fuhrer, MeteoSwiss

Prognostic uncertainty

The weather system is chaotic
→ rapid growth of small perturbations (butterfly effect)



Ensemble method: compute distribution over many simulations

COSMO-NExT

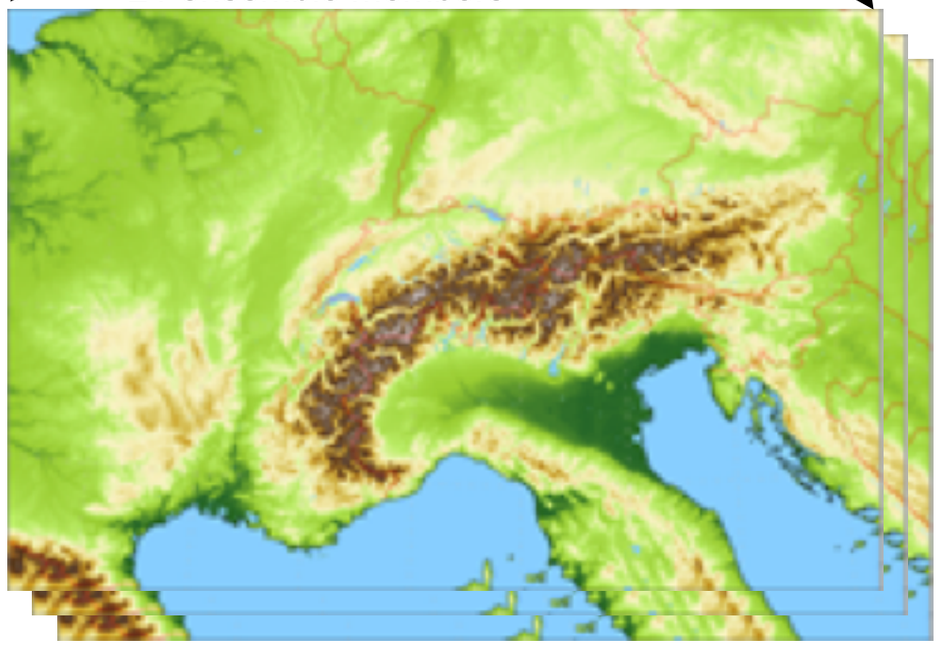
Lateral boundary conditions:
IFS-HRES
9km/0.1deg
4x per day

Lateral boundary conditions:
IFS-ENS
18km/0.2deg
4x per day

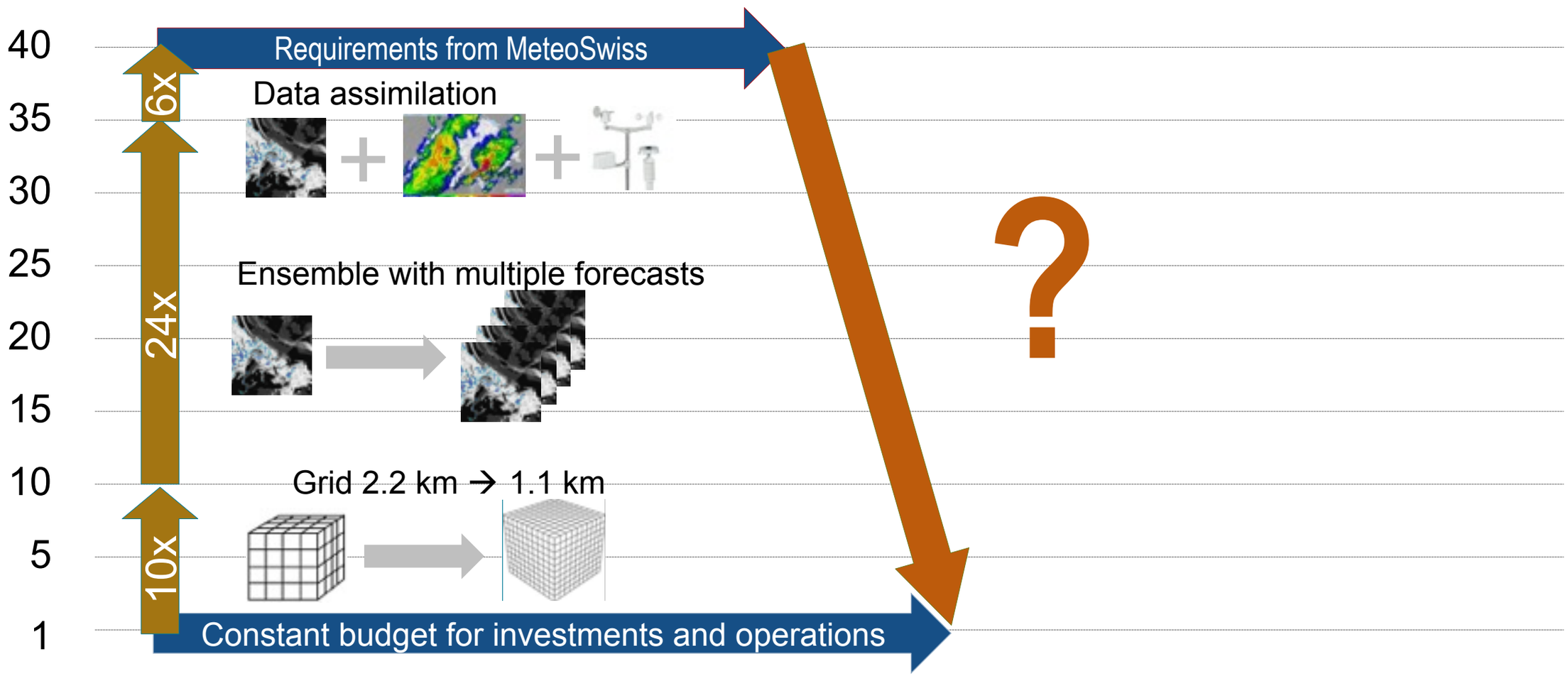
Ensemble data assimilation: LETKF

COSMO-1: 33h forecast, 8x per day
1.1km grid size (convection permitting)

COSMO-E: 5 day forecast, 2x per day
2.2km grid size (convection permitting)
21 ensemble members

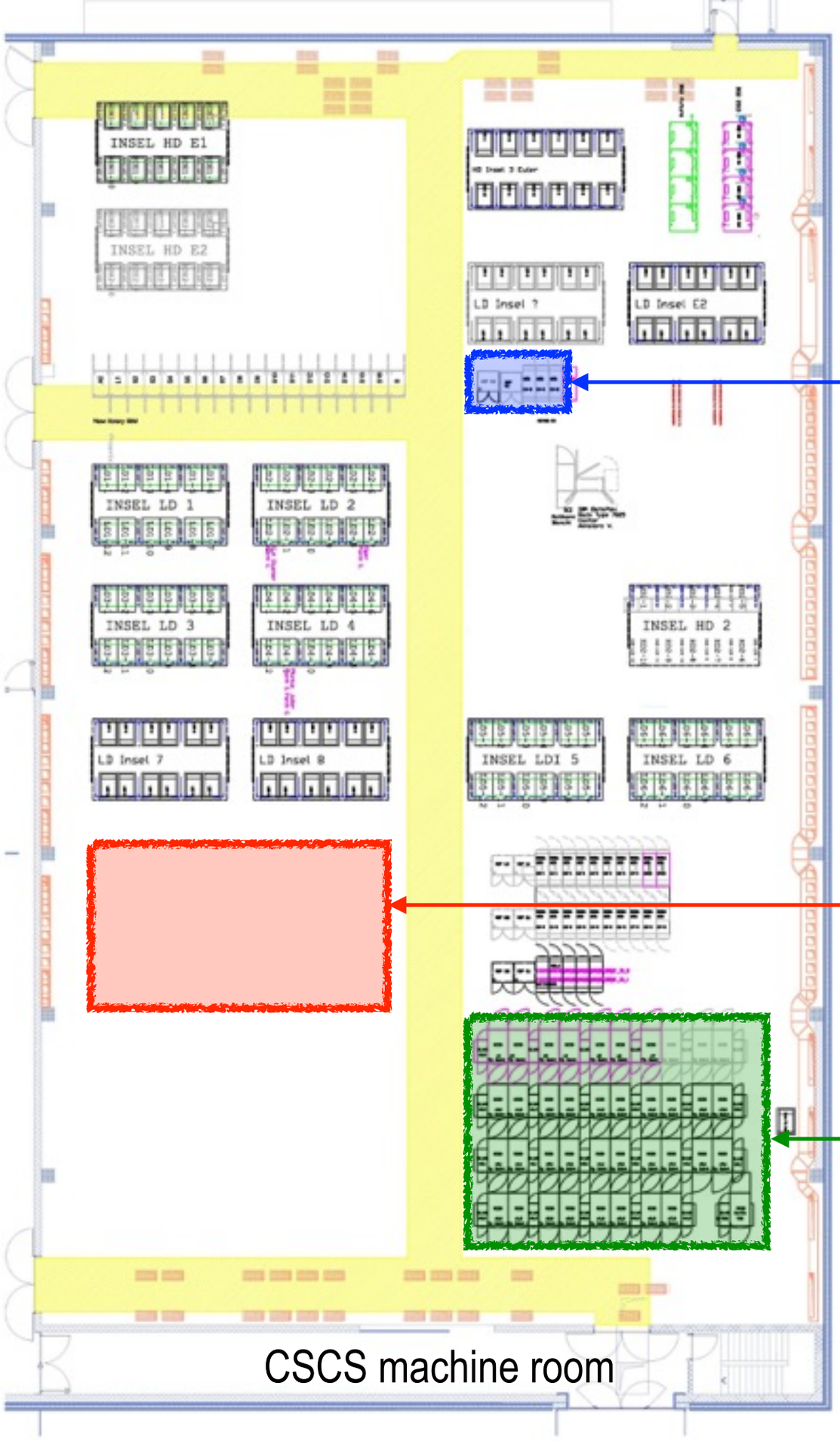


MeteoSwiss' performance ambitions



We need a 40x improvement between 2012 and 2015 at constant cost

State of the art implementation of new system for MeteoSwiss



Albis & Lema: 3 cabinets Cray XE6 installed Q2/2012

- New system needs to be installed Q3/2015
- Assuming 2x improvement in per-socket performance: ~20x more X86 sockets would require 30 Cray XC cabinets

New system for Meteo Swiss if we build it like the German Weather Service (DWD) did theirs, or UK Met Office, or ECMWF … (30 racks XC)

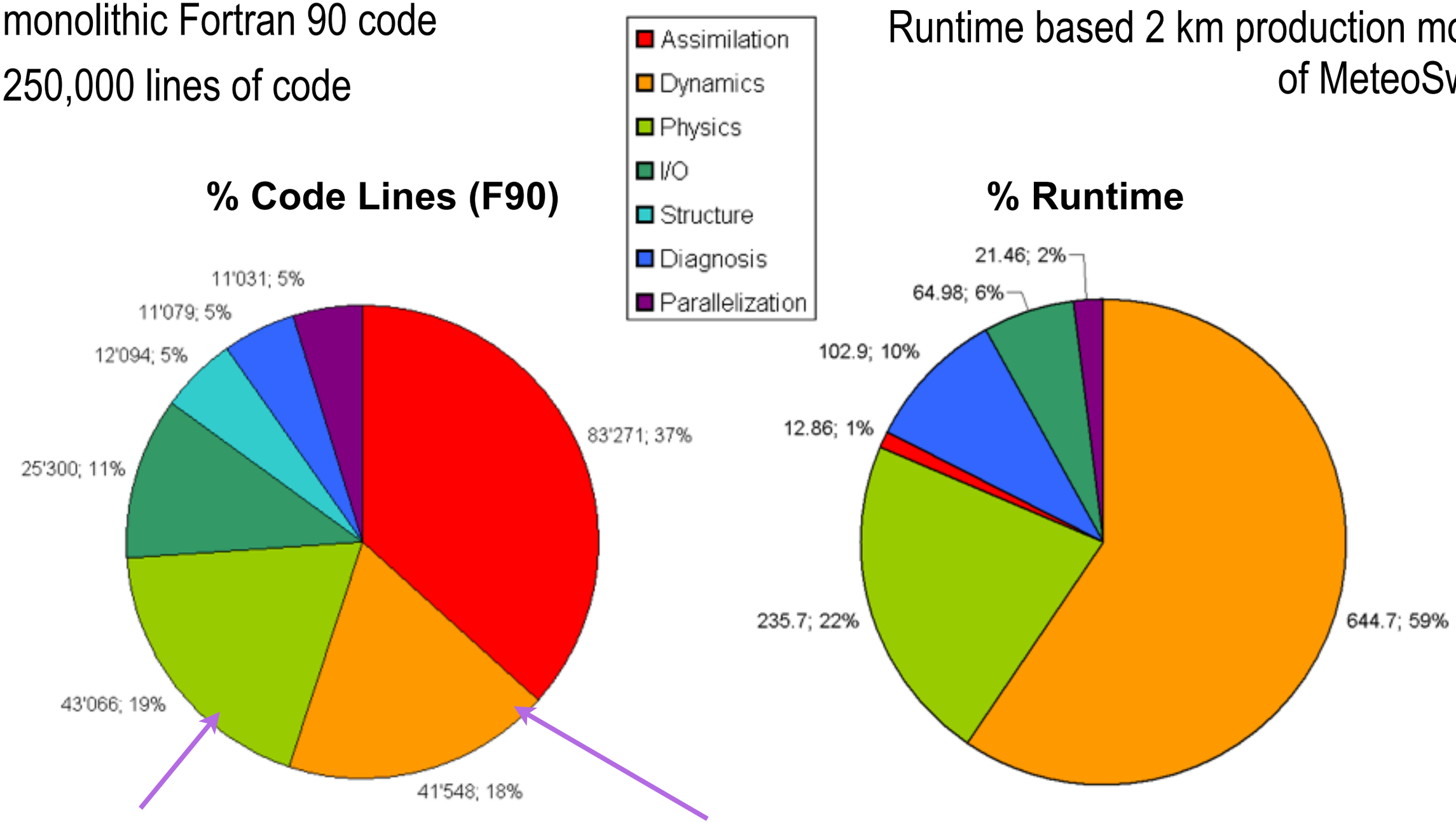
Current Cray XC30/XC40 platform (space for 40 racks XC)

Thinking inside the box was not a good option!

COSMO-OPCODE: a legacy code migration project

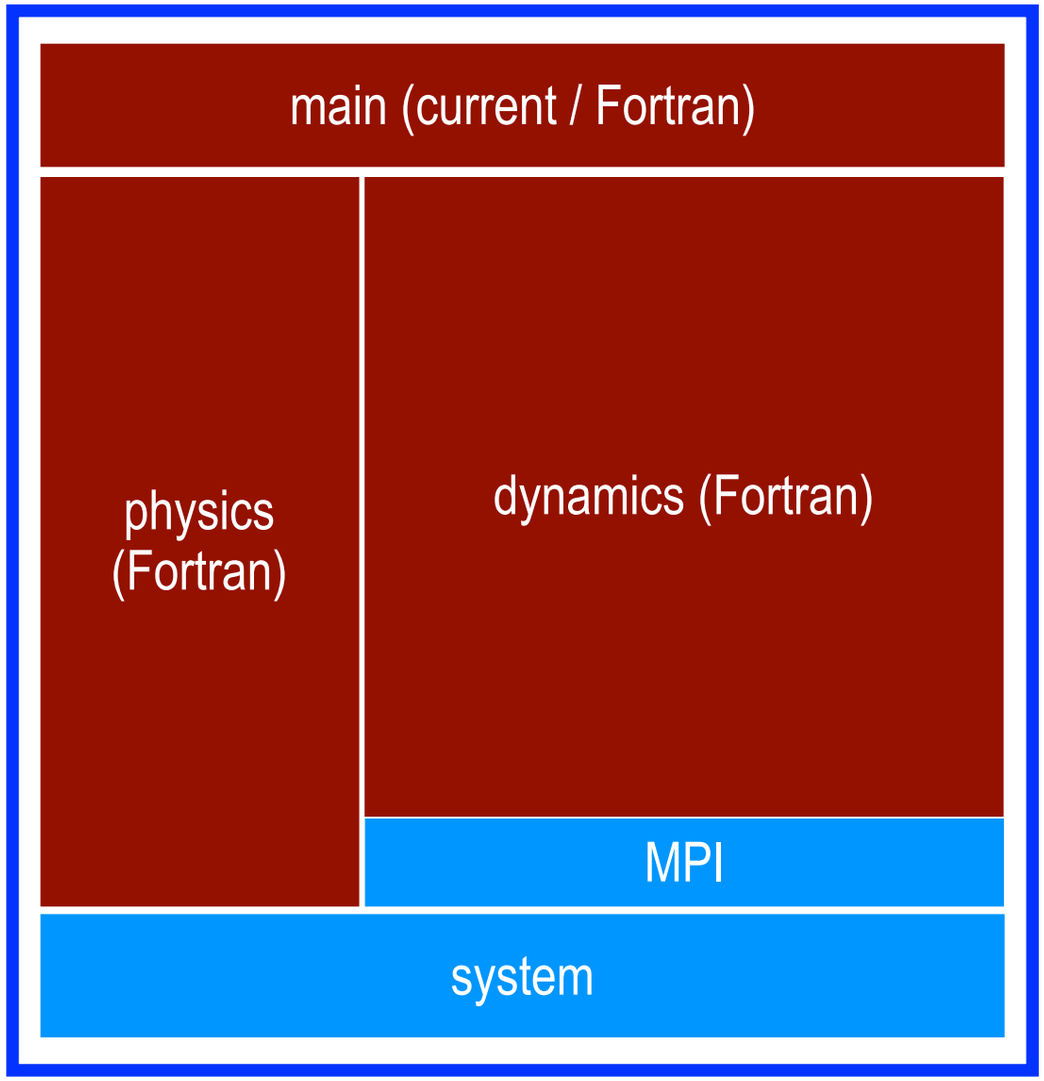
- monolithic Fortran 90 code
- 250,000 lines of code

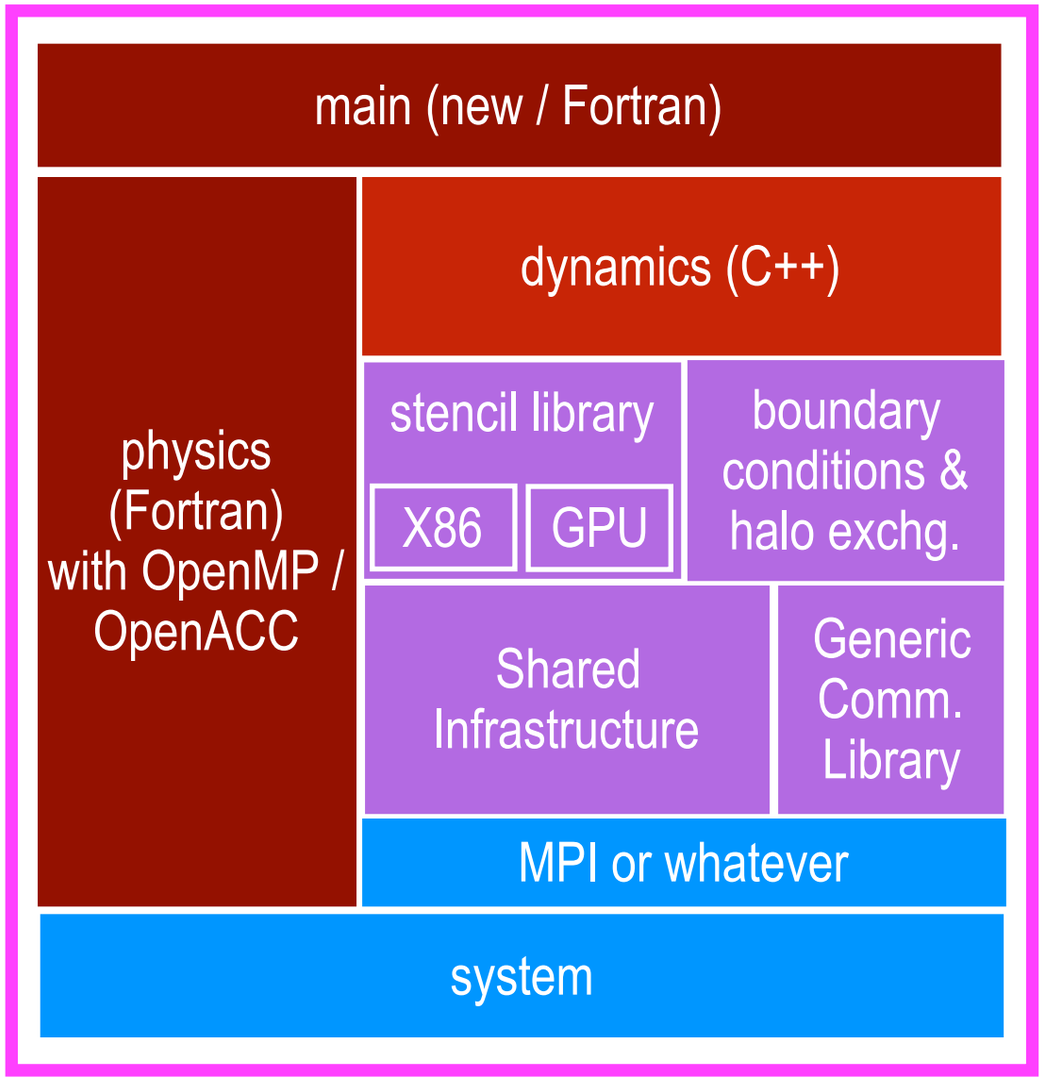
Runtime based 2 km production model of MeteoSwiss

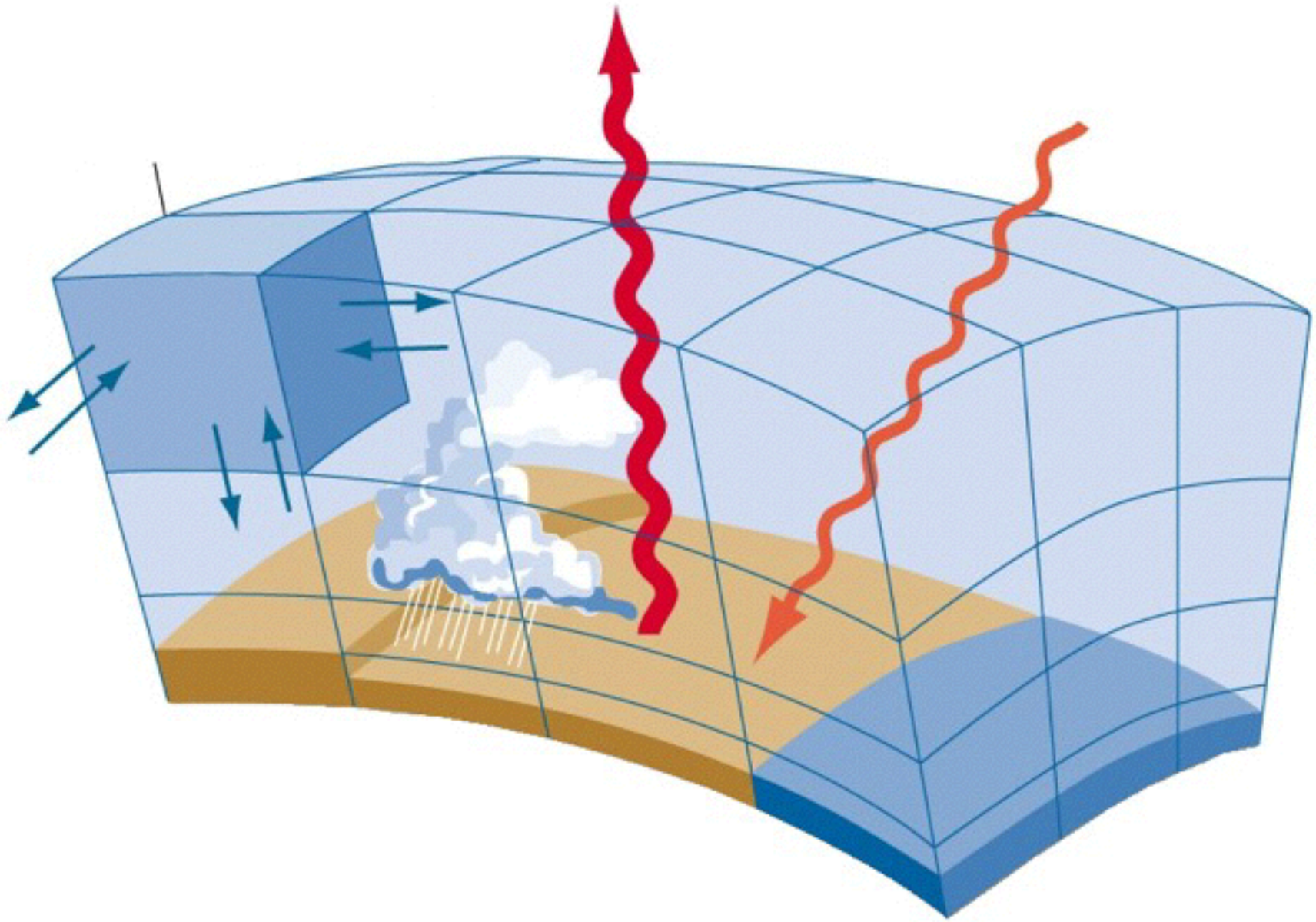


Original code (with OpenACC for GPU) Rewrite in C++ (with CUDA backend for GPU)

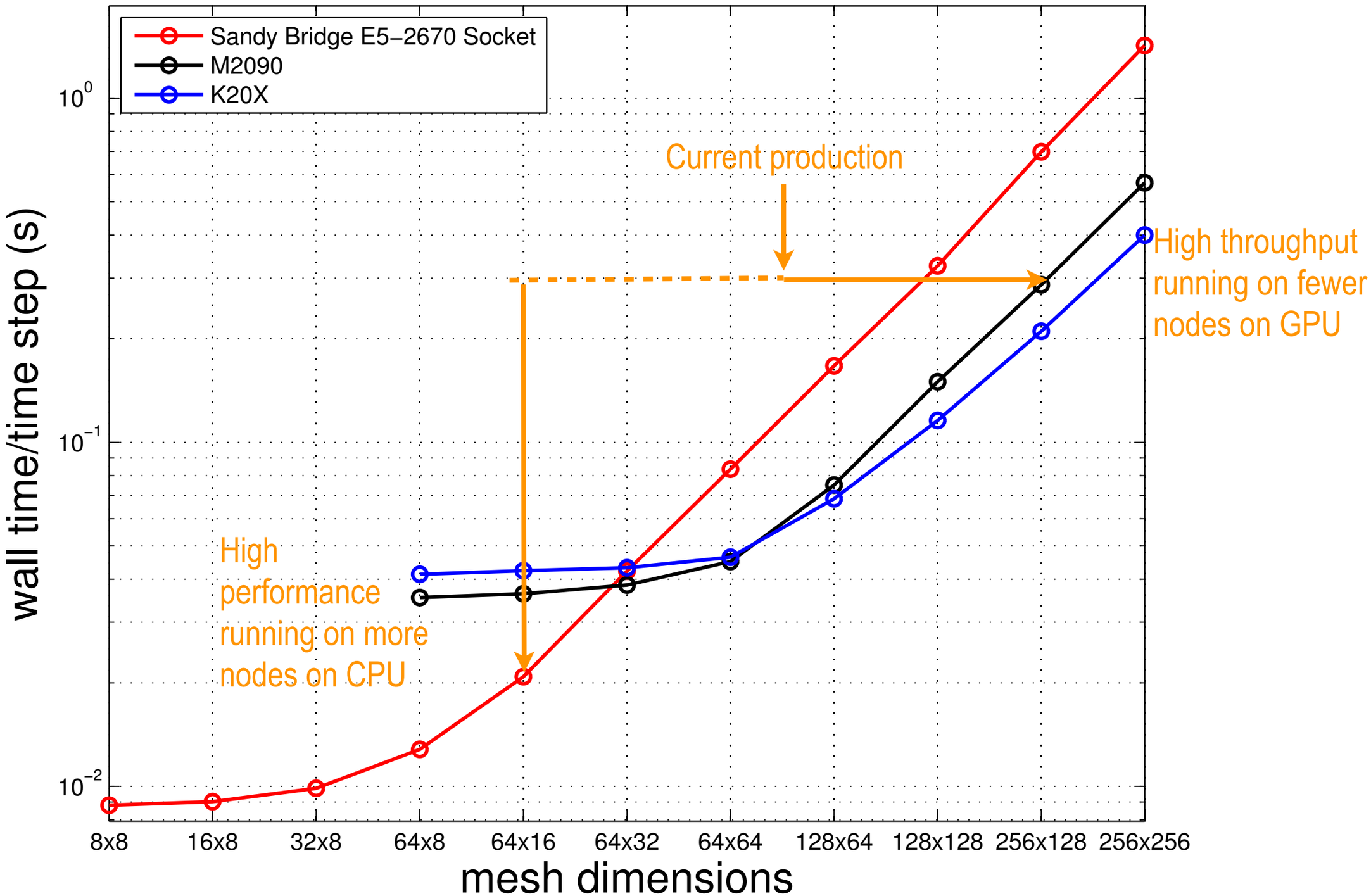
COSMO: old and new (refactored) code







Balancing time to solution with throughput



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HPC wire

September 15, 2015

Today's Outlook: GPU-accelerated Weather Forecasting

John Russell

MeteoSwiss New Weather Supercomputer

World's First GPU-Accelerated Weather Forecasting System

2x Racks

48 CPUs

192 Tesla K80 GPUs

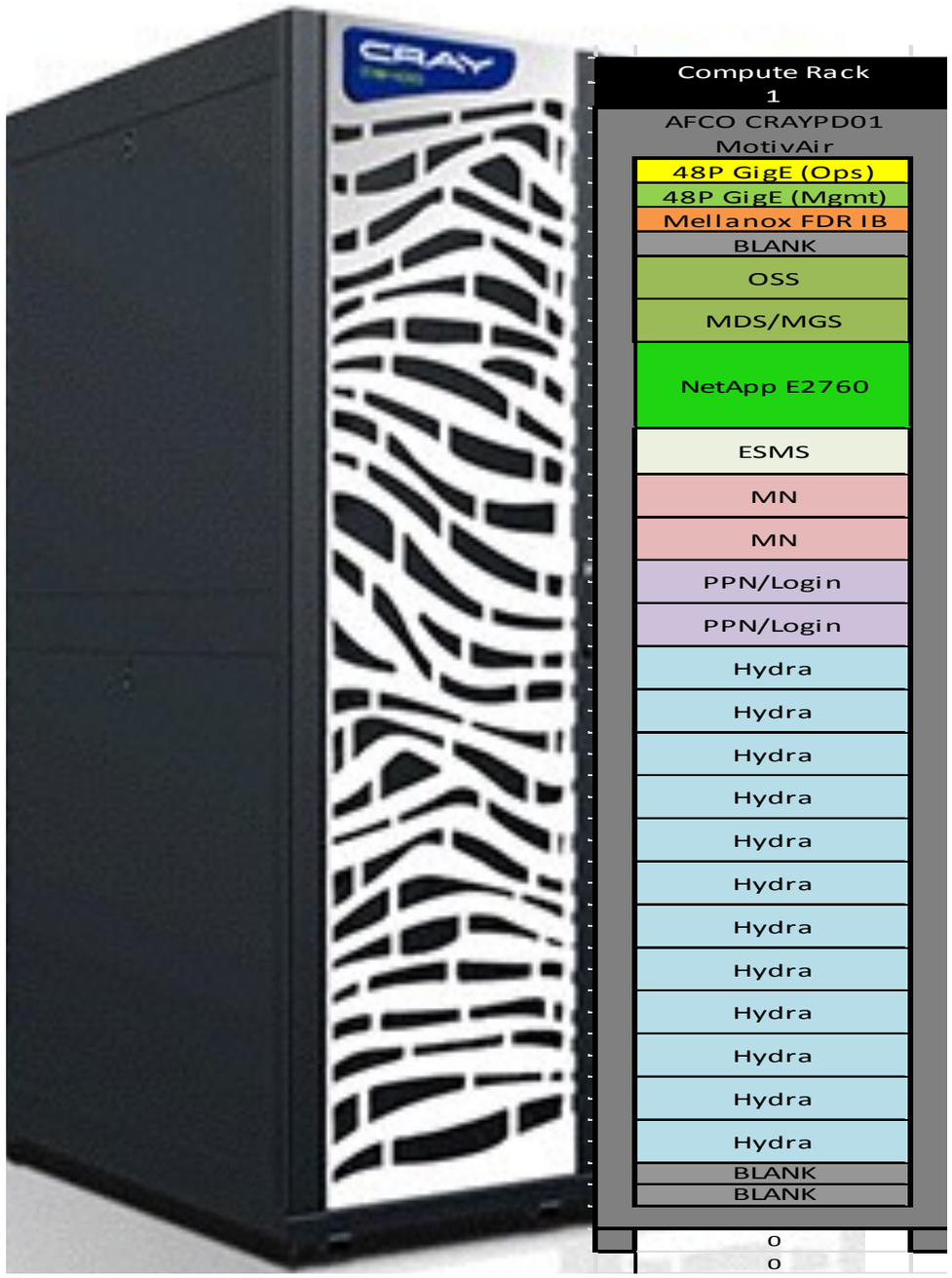
> 90% of FLOPS from GPUs

Operational in 2016

5 NVIDIA

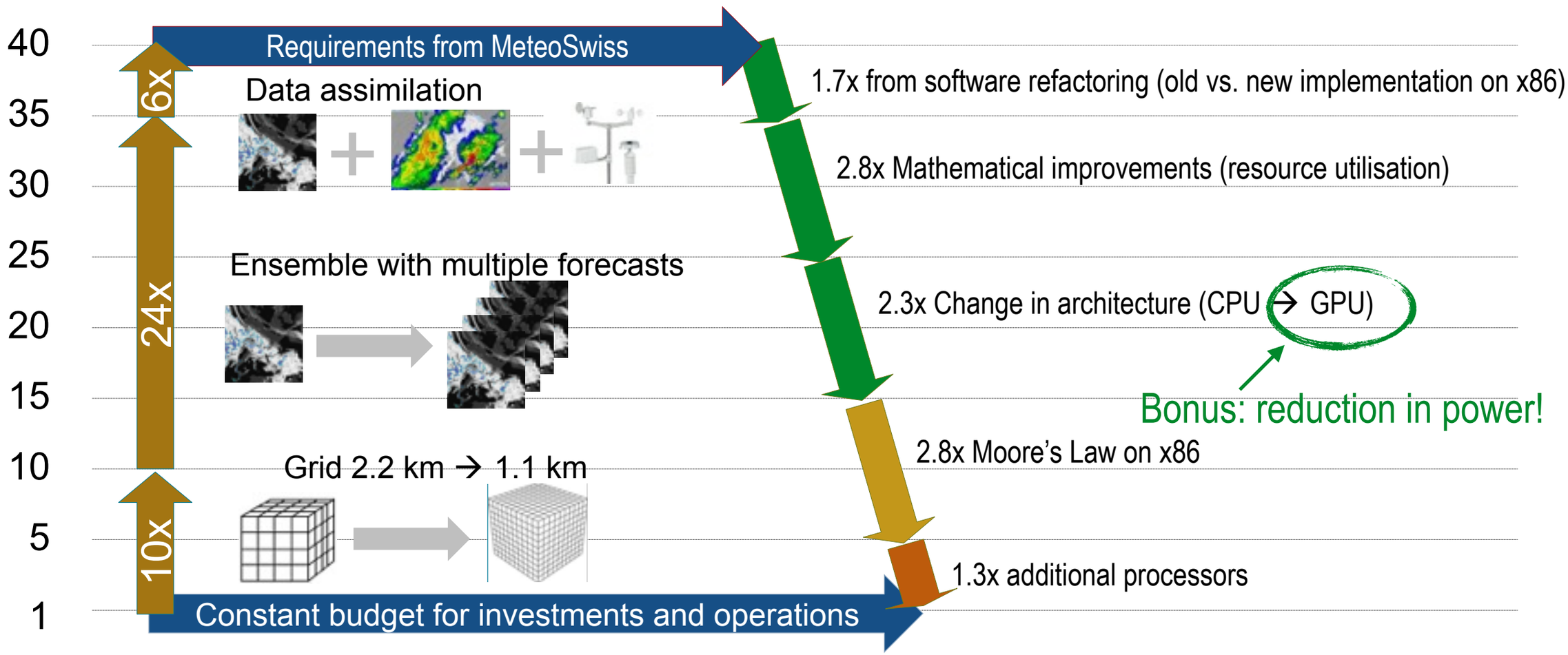
Piz Kesch / Piz Escha: appliance for meteorology

- Water cooled rack (48U)
- 12 compute nodes with
  - 2 Intel Xeon E5-2690v3 12 cores @ 2.6 GHz256 GB 2133 MHz DDR4 memory
  - 8 NVIDIA Tesla K80 GPU
- 3 login nodes
- 5 post-processing nodes
- Mellanox FDR InfiniBand
- Cray CLFS Luster Storage
- Cray Programming Environment
  - MVPICH for MPI



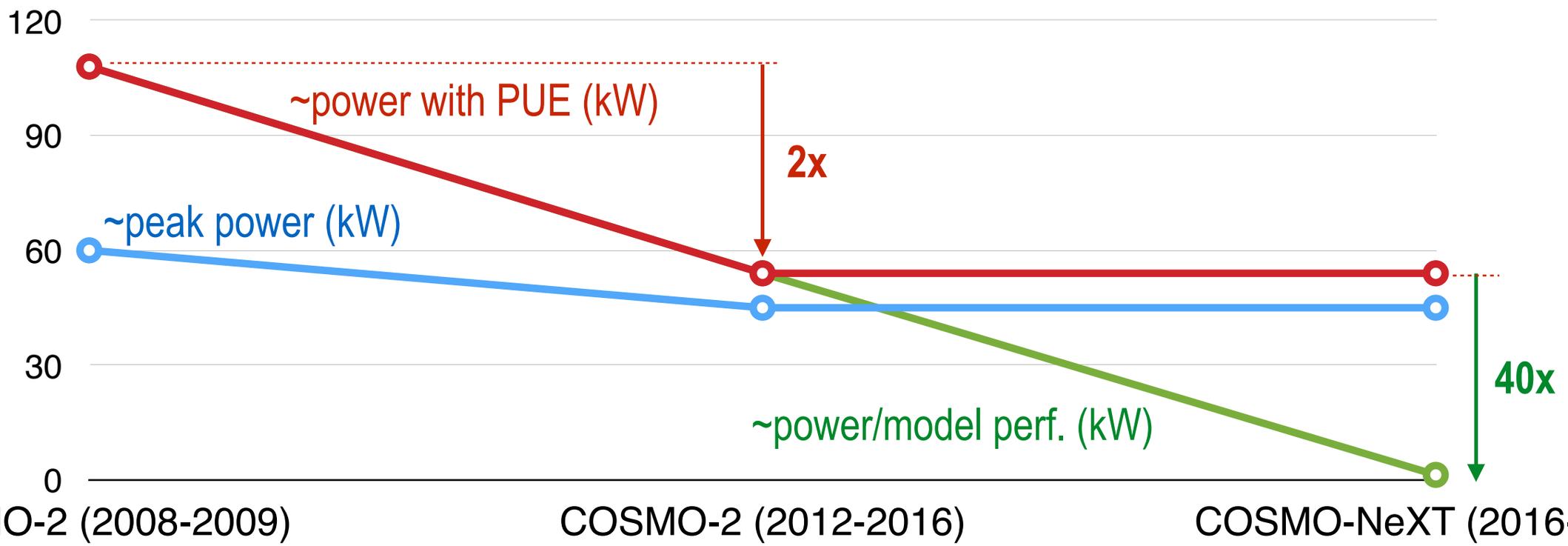
Where the factor 40 improvement if coming from

Investment in software allowed mathematical improvements and change in architecture

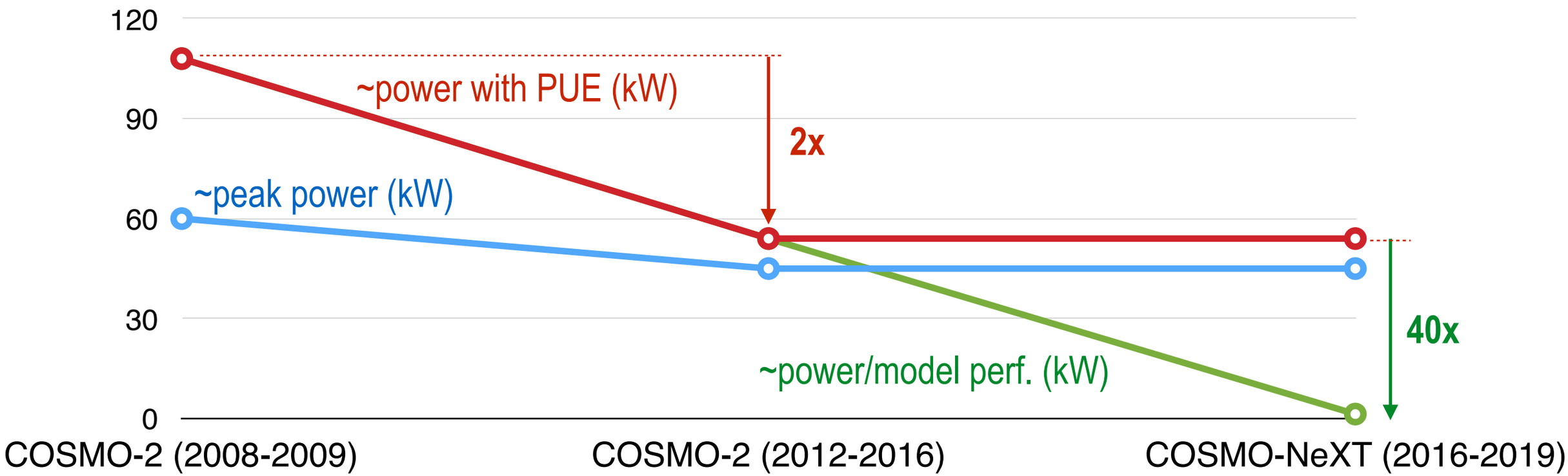


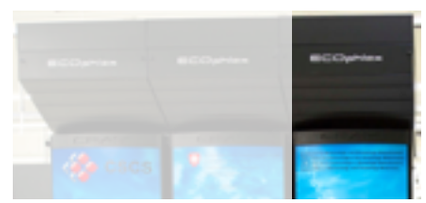
There is no silver bullet!

Combining system, PUE, and implementation



In conclusion …





Rather than focusing on energy efficiency alone, it pays off to take a wholistic co-design approach to system design.

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PASC17

Platform for Advanced Scientific Computing Conference

Lugano Switzerland

26-28 June 2017

Call for Papers

The Platform for Advanced Scientific Computing (PASC) invites submissions for the PASC17 Conference, co-sponsored by the Association for Computing Machinery (ACM) and SIGHPC, which will be held at the Palazzo dei Congressi in Lugano, Switzerland, from June 26 to 28, 2017.

PASC17

Platform for Advanced Scientific Computing Conference

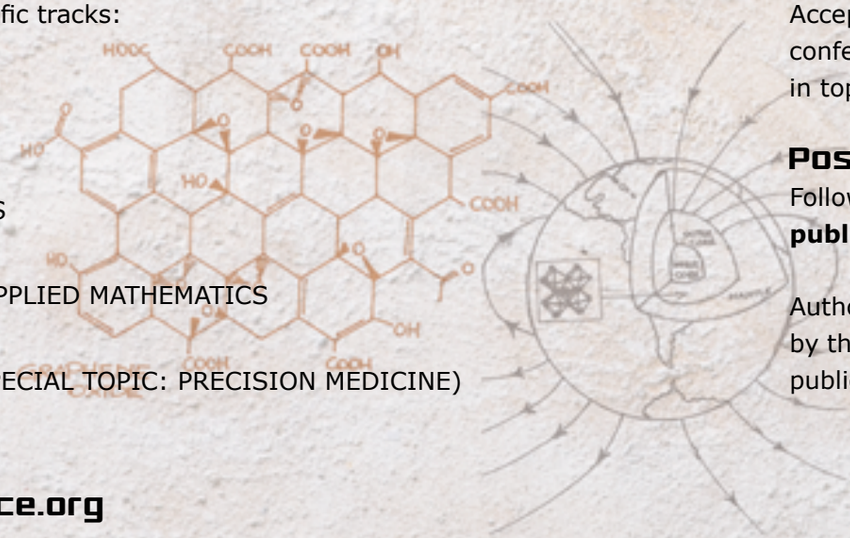
Lugano Switzerland

26-28 June 2017

PASC17 is an interdisciplinary event in high performance computing that brings together domain science, applied mathematics and computer science - where computer science is focused on enabling the realization of scientific computation.

We are soliciting high-quality contributions of original research relating to high performance computing in eight domain-specific tracks:

- CLIMATE & WEATHER
- SOLID EARTH DYNAMICS
- LIFE SCIENCES
- CHEMISTRY & MATERIALS
- PHYSICS
- COMPUTER SCIENCE & APPLIED MATHEMATICS
- ENGINEERING
- EMERGING DOMAINS (SPECIAL TOPIC: PRECISION MEDICINE)



pasc17.pasc-conference.org

Areas of interest include (but are not limited to):

- The use of advanced computing systems for large-scale scientific applications
- Implementation strategies for science applications in energy-efficient computing architectures
- Domain-specific, languages, libraries or frameworks
- The integration of large-scale experimental and observational scientific data and high-performance data analytics and computing
- Best practices for sustainable software development and scientific application development

Committee Chairs

Jack Wells (Oak Ridge National Laboratory, USA)
Torsten Hoefler (ETH Zurich, Switzerland)

Submission Guidelines

We invite papers of 5-10 pages in length, which will be reviewed double blind. Full submissions guidelines can be found at www.pasc17.org.

- Submissions close: **12 December 2016**
- First review notification: **31 January 2017**
- Revised submissions close: **1 March 2017**
- Final acceptance notification: **11 April 2017**

Conference Participation and Proceedings

Accepted manuscripts will be **published in the ACM Digital Library** on the first day of the conference. Authors will be given 30-minute presentation slots at the conference, grouped in topically focused, parallel sessions.

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Following the conference, authors will have the **opportunity to develop their papers for publication in a relevant, computationally focused, domain-specific journal.**

Authors thus stand to benefit from the rapid and broad dissemination of results afforded by the conference venue and associated proceedings, and, from the impact associated with publication in a high-quality scientific journal.

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