

Earth System Sciences and Brilliant HPC

Russian Supercomputing Days, Moscow, Russia

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Abstract

HPC is now used for most of the natural sciences and numerical simulation is a major method to gain new insights. Climate and weather were one of the first sciences to use computers and today they use huge installations and produce enormous amounts of data. The increase is exponential and the complexity of the scientific workflow is steadily growing. The talk will highlight current and future aspects of HPC for climate science. It will also show the effect on society by these ever more powerful IT concepts.

28 Years of German Climate Computing Centre (1987-2016)

First computer in 1987

- Control Data Cyber-205
 - 1 processor, 200 MFLOPS
32 MB main memory
 - 2.5 GB hard drive
100 GB tape library



“Mistral” system 2015-2020

- Atos/Bull
 - 6.000 processors, 3.6 PFLOPS
240 TB main memory
 - 54 PB hard drives
up to 390 PB tape library



factor 15,000,000 in processing (20,000,000 for disk)

Mistral

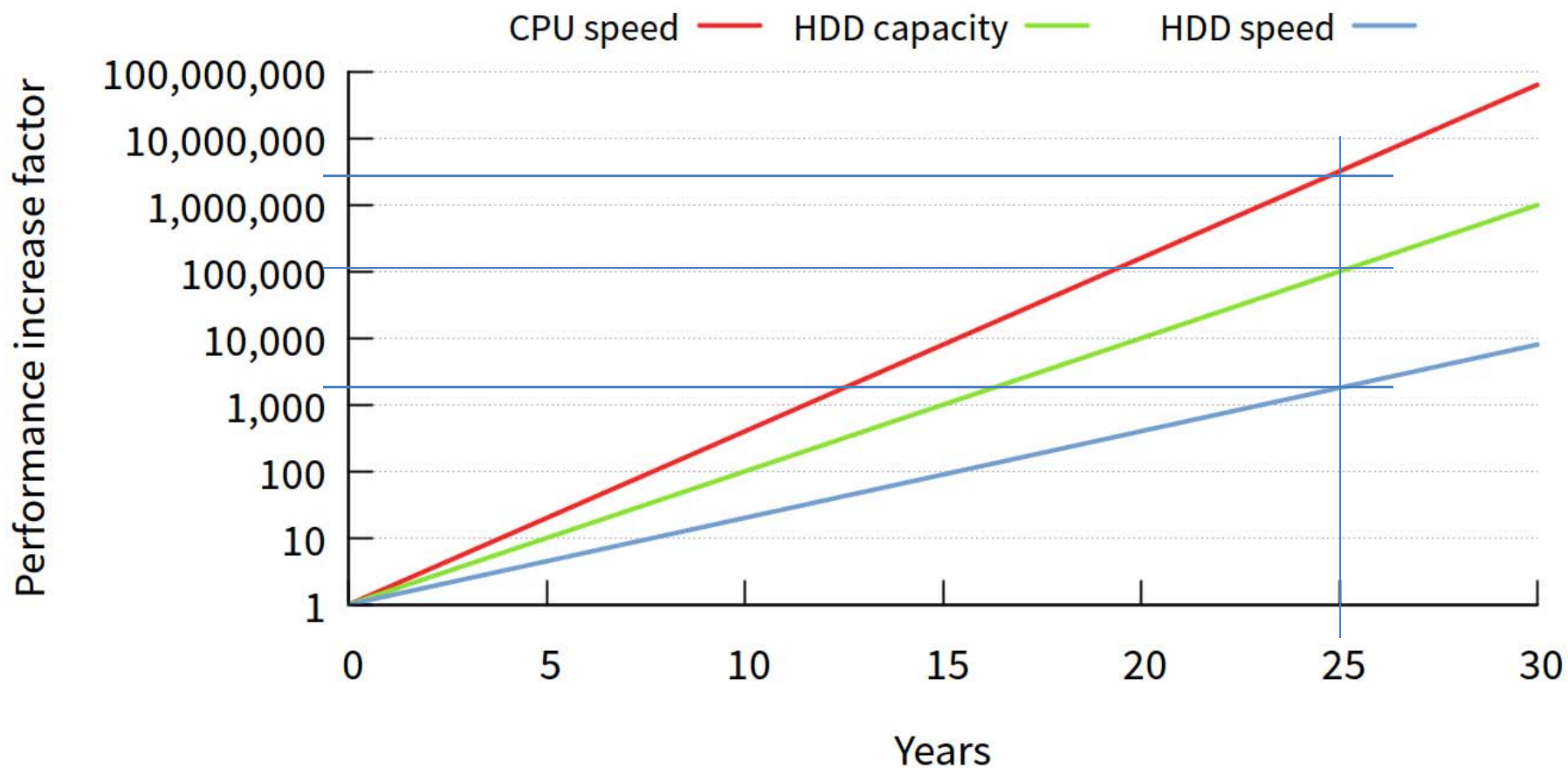


hot liquid cooled – guarantees high efficiency

From “Blizzard” to “Mistral”

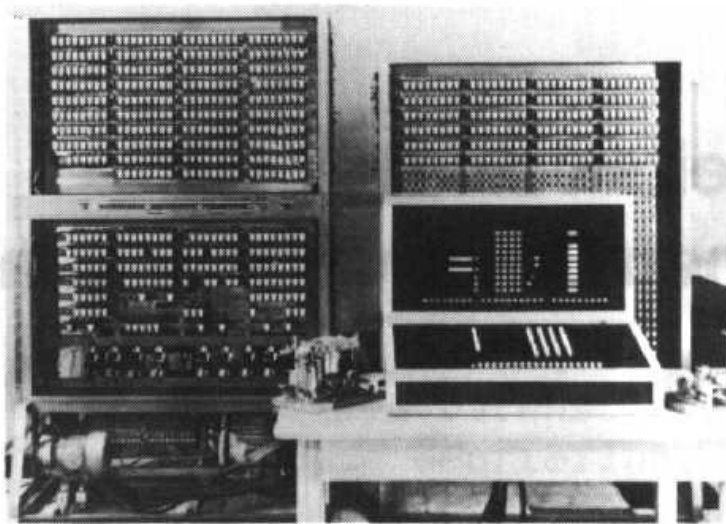
| Measure | 2009 | 2015/16 | Factor |
|------------------------------------|-------------------|-------------------|-------------|
| Performance (no accelerators) | 150 TFLOPS | 3.6 PFLOPS | 24x |
| Main memory | 20 TB | 240 TB | 12x |
| Hard disk capacity | 6 PB | 54 PB | 9x |
| Throughput memory to disk | 30 GB/s | 450 GB/s | 15x |
| Tape library capacity (2015, 2020) | 120 PB | 390 PB | 3x |
| Throughput disk to tape | 10 GB/s | 20 GB/s | 2x |
| Power consumption | 1.6 MW | 1.4 MW | 0.9x |
| Investment costs | € 30M | € 35M | 1.2x |

Technology Gap between Compute and I/O

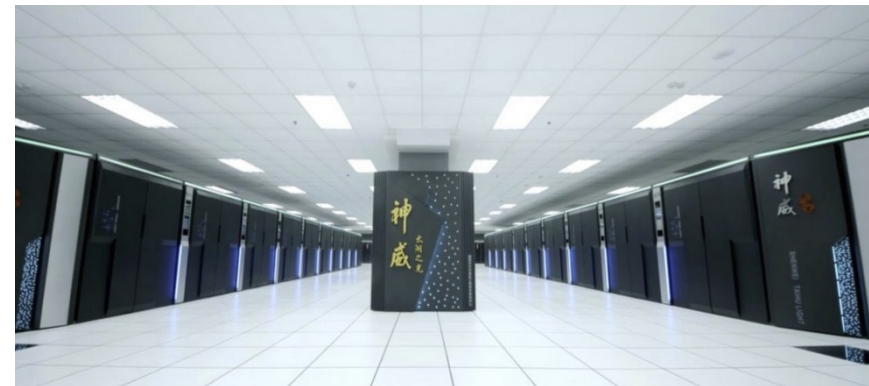


Brilliant Computer Technologies for 75 Years

#1 computer 1941: Zuses Z3
Performance 0.3 FLOPS



#1 computer June 2016:
Sunway TaihuLight
Performance $93 \cdot 10^{15}$ FLOPS



Improvement factor 300,000,000,000,000,000 in 75 years

12.5 years 12.5 years 12.5 years 12.5 years 12.5 years

Madness has a Name: Exponential Growth

Performance growth in 75 years of computers $3 \cdot 10^{17}$

We are on which square? 58

When on square 64? 2022

Increase on check board $1 \cdot 10^{19}$

Earth Sciences

We focus on computational earth sciences

- Weather
- Climate (atmosphere, ocean, biosphere, cryosphere, ...)
- Solid earth (earth quakes, tectonics, ...)
- ...

Earth Science Projects – Two Prominent Examples

- CMIP6 – Coupled Model Intercomparison Project
 - data intensive
- HD(CP)² – High Definition Clouds and Precipitation for Climate Prediction
 - CPU and data intensive

CMIP5 – Coupled Model Intercomparison Project

- Provides key input for the IPCC report
 - 5th AR, 2013
- ~20 modeling centers around the world
 - DKRZ being one of the biggest
- Produces 10s of PBytes of output data from ~60 experiments (“digital born data”)

Data are produced **without knowing all applications** beforehand and these data are stored and archived for **interdisciplinary utilization** by yet **unknown researchers**

CMIP5 Summary

- Status CMIP5 data archive (June 2013)
 - 1.8 PB for 59,000 data sets stored in 4.3 Mio Files in 23 ESGF data nodes
 - CMIP5 data is **about 50 times** CMIP3

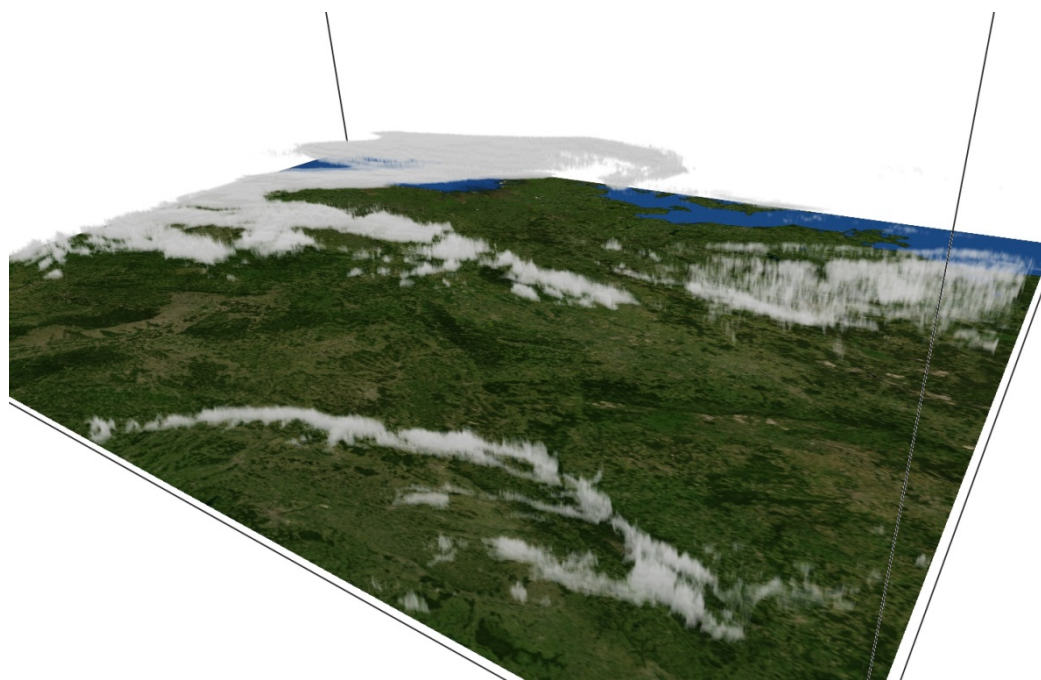
- Costs of CMIP5 at DKRZ: around € 3.3M
 - 20 M corehours in 2010/2011 = 1/3 annual capacity with IBM
 - Share of investments costs: € 1.6M
 - Share of electricity costs: € 0.6M
 - Share of tape costs: € 0.1M
 - Additional service staff: € 1.0 M

CMIP6 Data Volume Estimate

- Extrapolation to CMIP6 (2017-2019)
 - CMIP6 has a more complex experiment structure than CMIP5.
 - Expectations: more models, finer spatial resolution and larger ensembles
 - **Factor of 20:** 36 PB in 86 Mio Files
 - Potential DKRZ share: 3 PB on disk, 20 PB on tape
 - **Factor of 50:** 90 PB in 215 Mio Files

HD(CP)² – High Definition Clouds and Precipitation for Climate Prediction

- Model for Germany and Europe with 100 meter grid
- 22 million cells and 150 levels



HPC and Beyond

Internet of things

- Sensors everywhere - thanks Apple!

Internet of humans

- Citizen Science = More Science

SCIENCE

TURN YOUR UMBRELLA INTO A MOBILE WEATHER STATION

I'M PINGING IN THE RAIN, JUST PINGING IN THE RAIN...

By Douglas Main Posted May 1, 2014



The umbrella prototype *Rolf Hut / Delft University of Technology*



A sensor measures raindrops hitting the umbrella's canvas, and transmits that data to a smartphone.

Oldweather

Old Weather: Our Weather's Past, the Climate's Future

Introduction

Help scientists recover Arctic and worldwide weather observations made by United States ships since the mid-19th century by transcribing ships' logs. These transcriptions will contribute to climate model projections and will improve our knowledge of past environmental conditions. Historians will use your work to track past ship movements and tell the stories of the people on board.



Follow vessels

Choose your voyage by joining a vessel



Digitise pages

Earn points on each ship. Every page counts



Get promoted

Work your way up from Cadet to Lieutenant and even become Captain

Project Statistics

Old Weather transcriptions so far

53% OF THE LOGS COMPLETED

Arctic

📄 82,842 PAGES DONE

🚢 9 VOYAGES DONE

The Future

It´s all about algorithms...

- Machine learning
 - How to drive a car, a truck, a train...
- (Big data) data analytics
 - Numerical, visual, narrative

**HPC/Big Data and Artificial Intelligence
will merge...**

The Washington Post

The Switch

Bill Gates on dangers of artificial intelligence: 'I don't understand why some people are not concerned'

A   0

By Peter Holley January 29



Bill Gates joined Reddit for an AMA on Wednesday. (Tobias Schwarz/AFP/Getty Images)

Most Read Business

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betanews

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Apple co-founder Steve Wozniak warns of the dangers of artificial intelligence



By David Curry | Published 5 months ago

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Technology

Stephen Hawking warns artificial intelligence could end mankind

By Rory Cellan-Jones
Technology correspondent

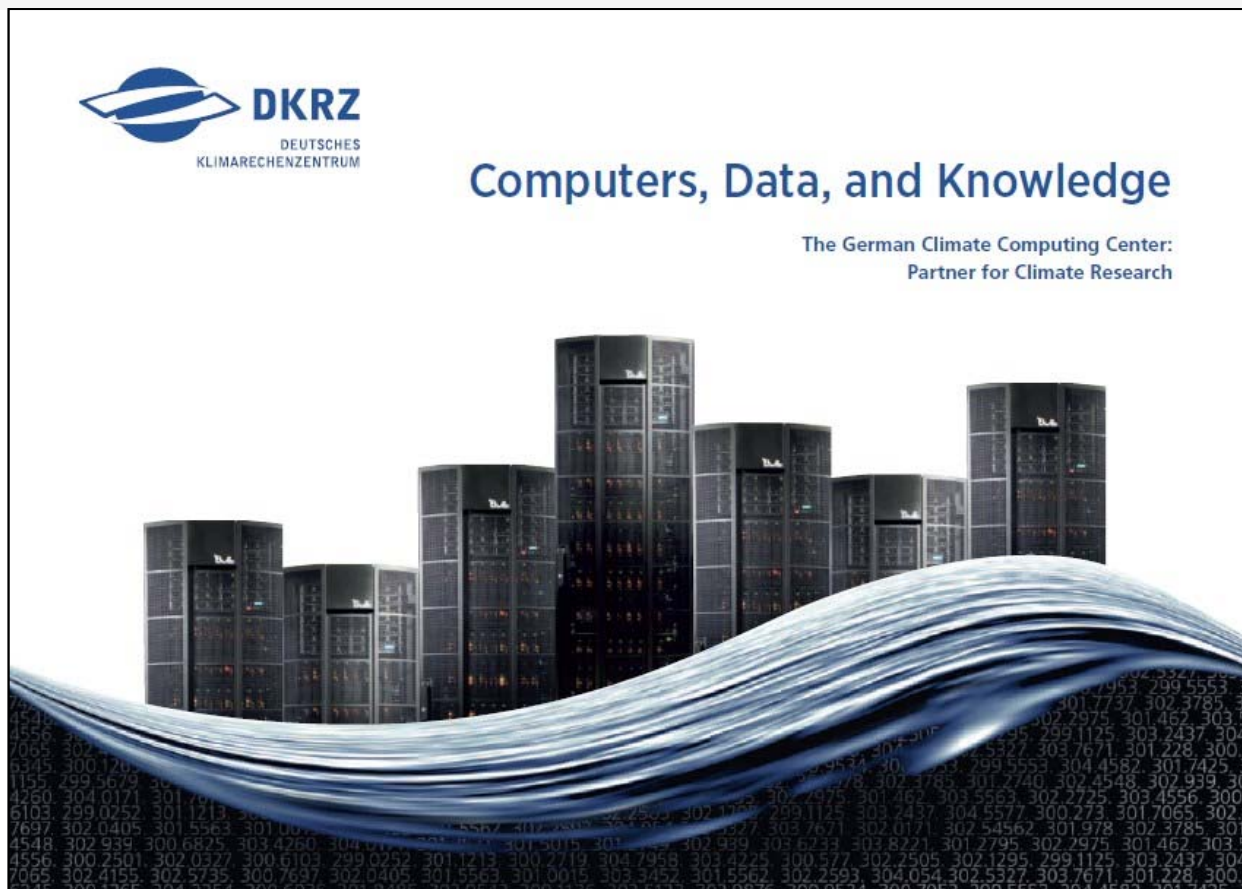
2 December 2014 | Technology | 1027



What is the bigger threat to mankind?

- Climate change?
- ✓ Progress in computer science?

October 2015



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