

Environmental (Friendly) Supercomputing on SuperMUC

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of the Bavarian Academy of Sciences and Humanities



http://www.drihm.eu/images/video/DRIHM_final.mp4

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN **Flash Floods** lrz

- Form swiftly due to (extremely) high rainfall rates
- Little or no prior warning
- Devastating consequences (casualties, economic losses, ...)

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LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN **UNISDR – The United Nations Office for Disaster Risk Reduction** lrz

UNISDR The United Nations Office for Disaster Risk Reduction Search GO *Connect and convince to reduce disaster impacts*

WHO WE ARE ▾ WHAT WE DO ▾ WHERE WE WORK ▾ WHO WE WORK WITH ▾

HOME WHAT WE DO WE INFORM GLOBAL ASSESSMENT REPORT

Global Assessment Report

Source: United Nations

MAKING DEVELOPMENT SUSTAINABLE: THE FUTURE OF DISASTER RISK MANAGEMENT
The GAR is a comprehensive review and analysis of disaster risk and risk management. It is published every two years.
 GAR15 was launched in March 2015, it looks at how to make development sustainable.

[Visit the GAR15 website →](#)

The Third World Conference on Disaster Risk Reduction took place in 2015.

"World threatened by dangerous and unacceptable levels of risk from disasters."
 – Ban Ki-moon, United Nations Secretary-General, 2015

The Global Assessment Report on Disaster Risk Reduction (GAR) is a biennial global assessment of disaster risk reduction and comprehensive review and analysis of the natural hazards that are affecting humanity. The GAR contributes to achieving the Hyogo Framework of Action (HFA) through monitoring risk patterns and trends and progress in disaster risk reduction while providing strategic policy

we Campaign
<https://www.unisdr.org/>

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GAR – Global Assessment Report on Disaster Risk Reduction 2015 lrz

GAR Global Assessment Report on Disaster Risk Reduction 2015
Making development sustainable: The future of disaster risk management

Home Pocket GAR **GAR 2015 Main Report** Documents Data Download Press

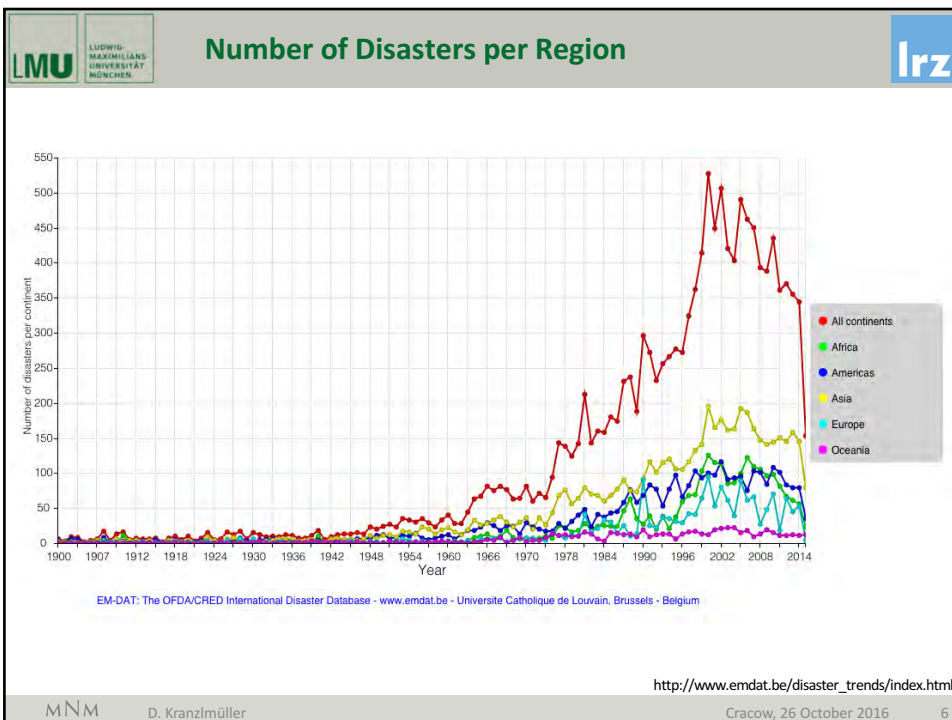
Foreword At a glance Preface Introduction Part I Part II Part III Backmatter

Most disasters that could happen have not happened yet.

Economic losses from disasters such as earthquakes, tsunamis, cyclones and flooding are now reaching an average of **US\$250 billion to US\$300 billion** each year. **Future losses** (expected annual losses) are now estimated at US\$314 billion in the built environment alone. **This is the amount that countries should set aside each year to cover future disaster losses.** (→ Chapter 3)

http://www.preventionweb.net/english/hyogo/gar/2015/en/home/GAR_2015/GAR_2015_6.html

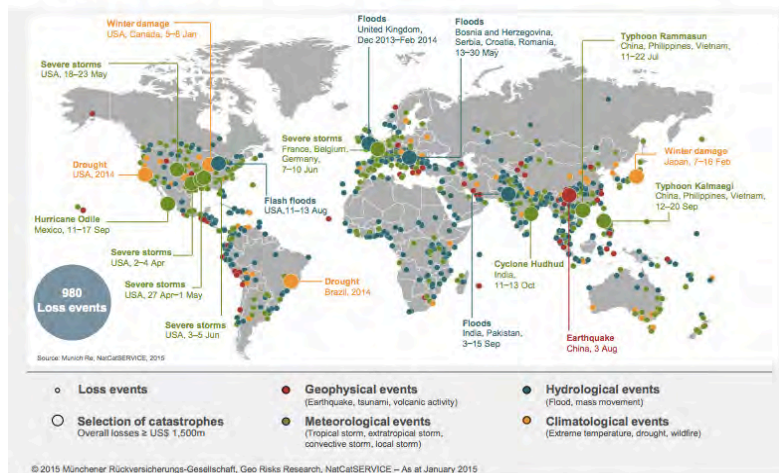
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NatCatSERVICE

Loss events worldwide 2014
Geographical overview

Munich RE



- Form swiftly due to (extremely) high rainfall rates
- Little or no prior warning
- Devastating consequences (casualties, economic losses, ...)
- Monitoring and forecasting of floods:
 - European Flood Awareness System (EFAS)
 - Global Flood Detection System (GFDS)
 - Global Flood Awareness System (GloFAS)
- Problem: spatial resolution 50-100 km
 - ➔ Flash floods remain undetected

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The EU Project Series DRIHM*

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DRIHM

Home About DRIHM Dissemination User Forum Support Centre Get involved

DRIHM
DISTRIBUTED RESEARCH INFRASTRUCTURE
FOR HYDRO-METEOROLOGY
Creating smart environments

DRIHM ICT-Video

DRIHM presents an interesting video explaining the objectives and best practices of the project

Login Form

Home

The DRIHM project is a European running from 1st September 2011 February 2015 aiming at providing fully integrated workflow platform predicting, managing and mitigating related to extreme weather phenomena

Predicting weather and climate and its impact on the environment, including hazards such as landslides, is still one of the main challenges of the 21st century with significant societal and economic implications. At the heart of this challenge, as also success

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Possible Solution – Environmental Computing

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- Combine meteorology, hydrology, hydraulics through computer science
- Increase spatial and temporal resolution (data quality)
 - Regional Climate Models (RCM)
- Compute ensembles of forecasts to cover all potential outcomes
- Start and finish computation in time to provide lead time for evacuation measures

→ Simulate ensembles of forecasts
with high-resolution on
high-performance computing (HPC) infrastructures
~~on demand when triggered by increased rainfall rates~~

Not in this talk

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Leibniz Supercomputing Centre
of the Bavarian Academy of Sciences and Humanities

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With approx. 230 employees for more than 100.000 students and for more than 30.000 employees including 8.500 scientists



- European Supercomputing Centre
- National Supercomputing Centre
- Regional Computer Centre for all Bavarian Universities
 - Computer Centre for all Munich Universities

Photo: Ernst Graf

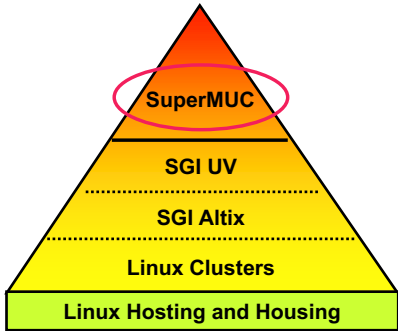
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- European Supercomputing Centre
- National Supercomputing Centre
- Regional Computer Centre for all Bavarian Universities
- Computer Centre for all Munich Universities





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SuperMUC @ LRZ






Video: SuperMUC rendered on SuperMUC by LRZ
<http://youtu.be/OIAS6iiqWrQ>




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Top 500 Supercomputer List (June 2012)



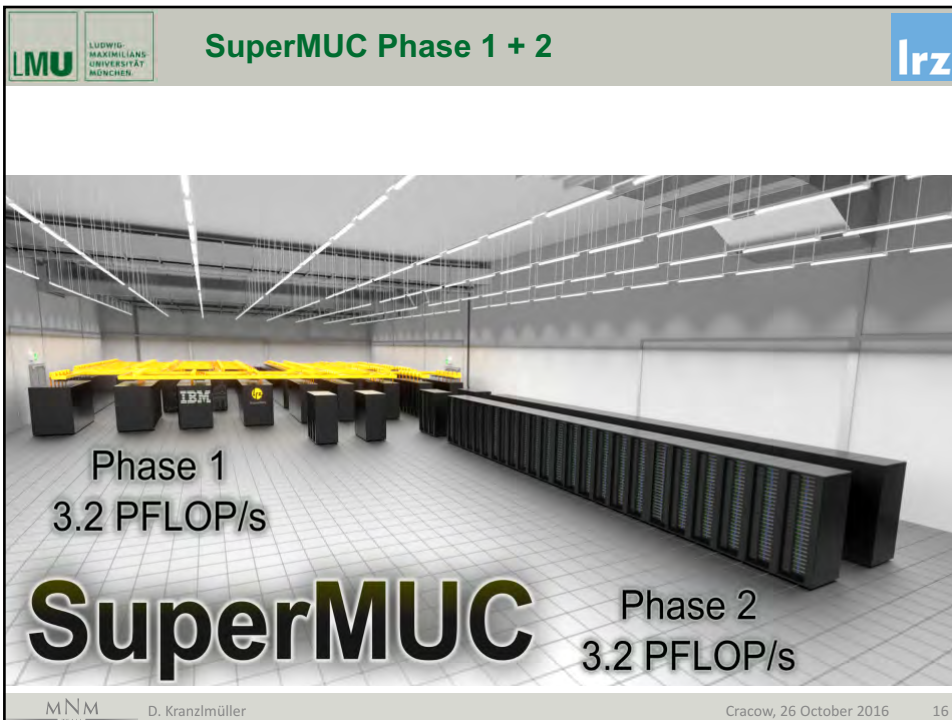
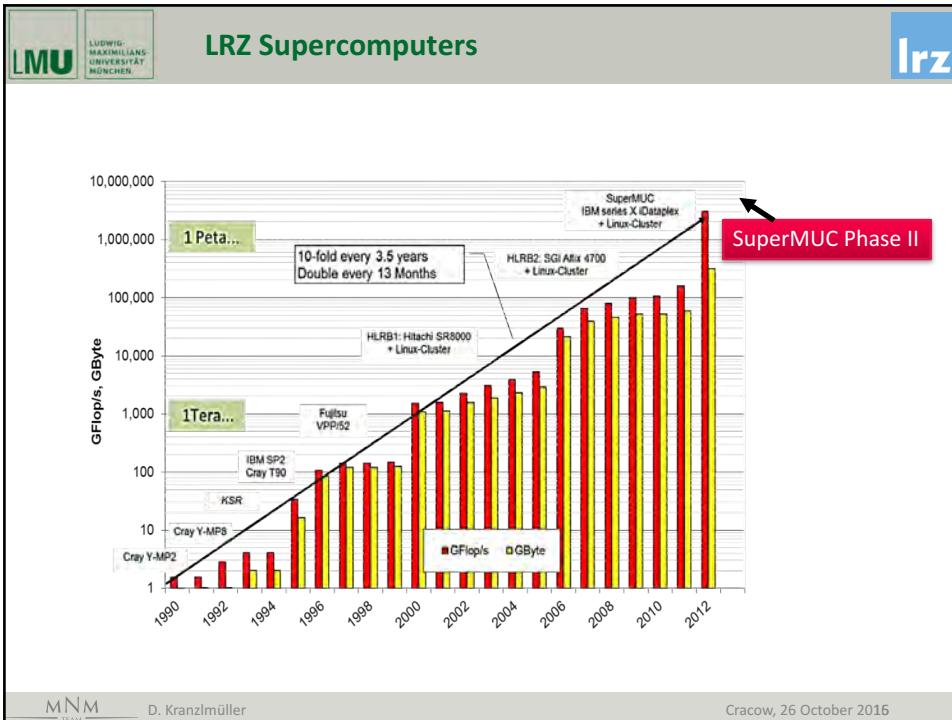
Rank	Site	Computer/Year Vendor	Cores	R _{max}	R _{peak}	Power
1	DOE/NNSA/LLNL United States	Sequoia - BlueGene/Q, Power BQC 16C 1.60 GHz, Custom / 2011 IBM	1572864	16324.75	20132.66	7890.0
2	RIKEN Advanced Institute for Computational Science (AICS) Japan	K computer, SPARC64 VIII/fx 2.0GHz, Tofu interconnect / 2011 Fujitsu	705024	10510.00	11280.38	12659.9
3	DOE/SC/Argonne National Laboratory United States	Mira - BlueGene/Q, Power BQC 16C 1.60GHz, Custom / 2012 IBM	786432	8162.38	10066.33	3945.0
4	Leibniz Rechenzentrum Germany	SuperMUC - iDataFlex DX360M4, Xeon E5-2680 8C 2.70GHz, Infiniband FDR / 2012 IBM	147456	2897.00	3185.05	3422.7
5	National Supercomputing Center in Tianjin China	Tianhe-1A - NUDT YH MPP, Xeon X5670 6C 2.93 GHz, NVIDIA 2050 / 2010 NUDT	186368	2566.00	4701.00	4040.0
6	DOE/SC/Oak Ridge National Laboratory United States	Jaguar - Cray XK6, Opleton 6274 16C 2.200GHz, Cray Gemini interconnect, NVIDIA 2080 / 2009 Cray Inc.	298592	1941.00	2627.61	5142.0
7	CINECA Italy	Fermi - BlueGene/Q, Power BQC 16C 1.50GHz, Custom / 2012 IBM	163840	1725.49	2097.15	821.9
8	Forschungszentrum Juelich (FZJ) Germany	JuQUEEN - BlueGene/D, Power BQC 16C 1.60GHz, Custom / 2012 IBM	131072	1380.39	1677.72	657.5
9	CEA/GCC-GENCI France	Curie thin nodes - Bullx B510, Xeon E5- 2680 8C 2.700GHz, Infiniband QDR / 2012 Bull	77184	1358.00	1667.17	2251.0
10	National Supercomputing Centre in Shenzhen (NSCS) China	Nebulae - Dawning TC3600 Blade System, Xeon X5850 6C 2.66GHz, Infiniband QDR, NVIDIA 2050 / 2010 Dawning	120640	1271.00	2984.30	2580.0

www.top500.org



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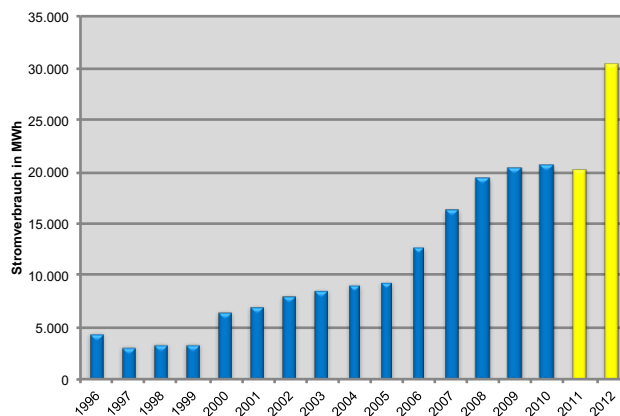
Phase 1 (IBM System x iDataPlex):

- 3.2 PFlops peak performance
- 9216 IBM iDataPlex dx360M4 nodes in 18 compute node islands
- 2 Intel Xeon E5-2680 processors and 32 GB of memory per compute node
- 147,456 compute cores
- Network Infiniband FDR10 (fat tree)

Phase 2 (Lenovo NeXtScale WCT):

- 3.6 PFlops peak performance
- 3072 Lenovo NeXtScale nx360M5 WCT nodes in 6 compute node islands
- 2 Intel Xeon E5-2697v3 processors and 64 GB of memory per compute node
- 86,016 compute cores
- Network Infiniband FDR14 (fat tree)

Common GPFS file systems with 10 PB and 5 PB usable storage size respectively
 Common programming environment
 Direct warm-water cooled system technology



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Cooling SuperMUC

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SuperMUC Phase 2 @ LRZ

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Photos: Torsten Bloth, Lenovo

High Energy Efficiency

- ✓ Usage of Intel Xeon E5 2697v3 processors
- ✓ Direct liquid cooling
 - 10% power advantage over air cooled system
 - 25% power advantage due to chiller-less cooling
- ✓ Energy-aware scheduling
 - 6% power advantage
 - ~40% power advantage
 - Total annual savings of ~2 Mio. € for SuperMUC Phase 1 and 2

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- Computational Fluid Dynamics: Optimisation of turbines and wings, noise reduction, air conditioning in trains
- Fusion: Plasma in a future fusion reactor (ITER)
- Astrophysics: Origin and evolution of stars and galaxies
- Solid State Physics: Superconductivity, surface properties
- Geophysics: Earth quake scenarios
- Material Science: Semiconductors
- Chemistry: Catalytic reactions
- Medicine and Medical Engineering: Blood flow, aneurysms, air conditioning of operating theatres
- Biophysics: Properties of viruses, genome analysis
- Climate research: Currents in oceans

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LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN **Results (Sustained TFlop/s on 128000 cores)** lrz

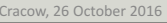

Name	MPI	# cores	Description	TFlop/s/island	TFlop/s max
Linpack	IBM	★ 128000	TOP500	161	2560
Vertex	IBM	★ 128000	Plasma Physics	15	245
GROMACS	IBM, Intel	★ 64000	Molecular Modelling	40	110
Seissol	IBM	★ 64000	Geophysics	31	95
waLBerla	IBM	★ 128000	Lattice Boltzmann	5.6	90
LAMMPS	IBM	★ 128000	Molecular Modelling	5.6	90
APES	IBM	★ 64000	CFD	6	47
BQCD	Intel	★ 128000	Quantum Physics	10	27




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**Partnership Initiative
Computational Sciences πCS**


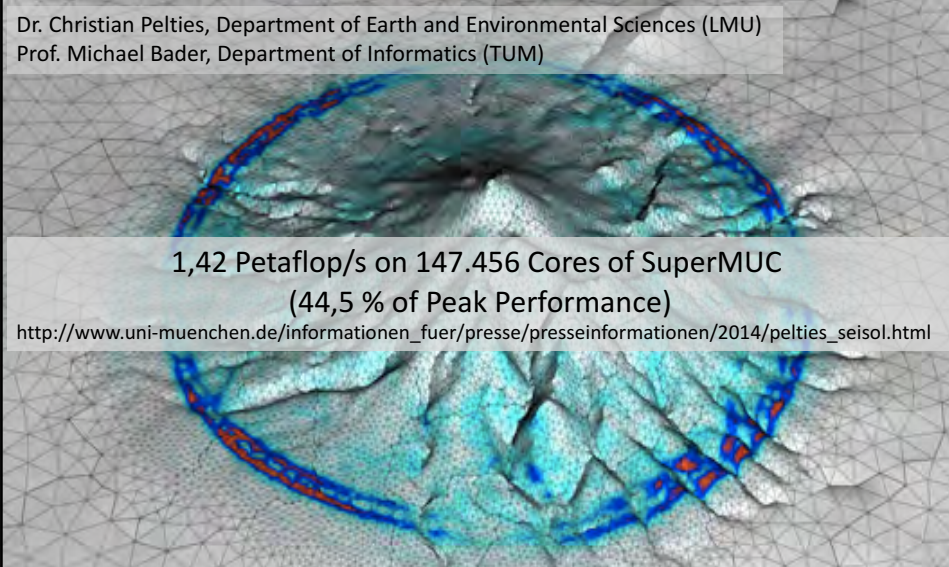
- **Individualized services** for selected scientific groups – **flagship role**
 - Dedicated point-of-contact
 - Individual support and guidance and targeted training & education
 - Planning dependability for use case specific optimized IT infrastructures
 - Early access to latest IT infrastructure (hard- and software) developments and specification of future requirements
 - Access to IT competence network and expertise at CS and Math departments
- **Partner contribution**
 - Embedding IT experts in user groups
 - Joint research projects (including funding)
 - Scientific partnership – equal footing – joint publications
- **LRZ benefits**
 - Understanding the (current and future) needs and requirements of the respective scientific domain
 - Developing future services for all user groups
 - Thematic focusing: **Environmental Computing**


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SeisSol - Numerical Simulation of Seismic Wave Phenomena


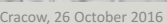

Dr. Christian Pelties, Department of Earth and Environmental Sciences (LMU)
 Prof. Michael Bader, Department of Informatics (TUM)



**1,42 Petaflop/s on 147.456 Cores of SuperMUC
(44,5 % of Peak Performance)**

http://www.uni-muenchen.de/informationen_fuer/presse/presseinformationen/2014/pelties_seisol.html


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Picture: Alex Breuer (TUM) / Christian Pelties (LMU)

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN **Conclusions** lrz

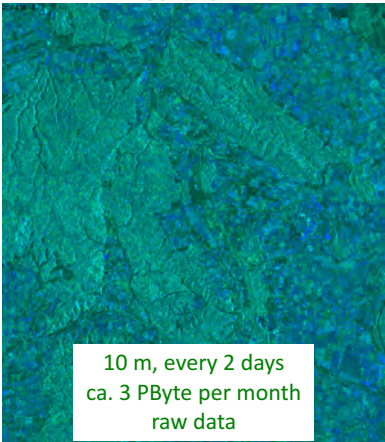
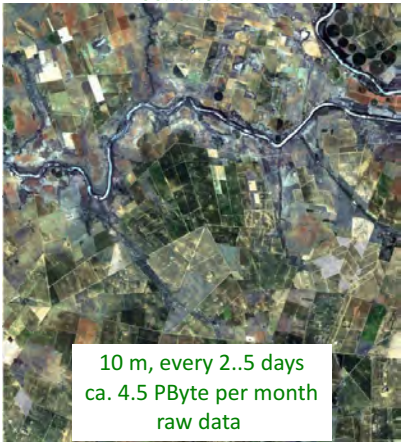
- **Environmental Computing** needs IT-Infrastructures (including HPC)
- **Energy Efficiency** is an important part to maximize scientific throughput
- Computational science needs to be an integral part of teaching domain scientists
 - Learn how to get access to HPC infrastructures
 - Learn how to program HPC infrastructures with increasing complexity, heterogeneity and scalability – efficiency, reliability, portability
- The LRZ Partnership Initiative Computational Science (piCS) tries to improve user support

<http://www.sciencedirect.com/science/article/pii/S1877050914003433>

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LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN **The EU Copernicus Earth Observation Platform** lrz

- The Copernicus Sentinel Missions are „**game changers**“ for Earth Observation: watch the heartbeat of the planet

<p>Sentinel 1</p>  <p>10 m, every 2 days ca. 3 PByte per month raw data</p>	<p>Sentinel 2</p>  <p>10 m, every 2..5 days ca. 4.5 PByte per month raw data</p>
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Slide courtesy Wolfram Mauser

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■ Example: quantitative satellite image analysis of wheat fields

Satellite image



Chlorophyll content [$\mu\text{g}/\text{m}^2$]



Parameters, e.g.: Plant species, biomass, chlorophyll, pests, phenology, ...

Slide courtesy Wolfram Mauser

- Human-Environment-Relation - Observations and Simulations for alternative Global Futures
- Massive computing resources are needed to create a **cyber-environmental system** in which the real and the virtual world can interact:
 - to turn remote sensing image data streams into meaningful environmental information for each farmer on the globe
 - to identify least invasive ways for agriculture
 - to double food production and show the global environmental benefits it has
 - to simulate and assess the total environment and the human interventions before they occur
 - to explore alternative future environments and their sustainability and quality of life



Slide courtesy Wolfram Mauser

Environmental (Friendly) Supercomputing on SuperMUC

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Photo: Karl Behler

