

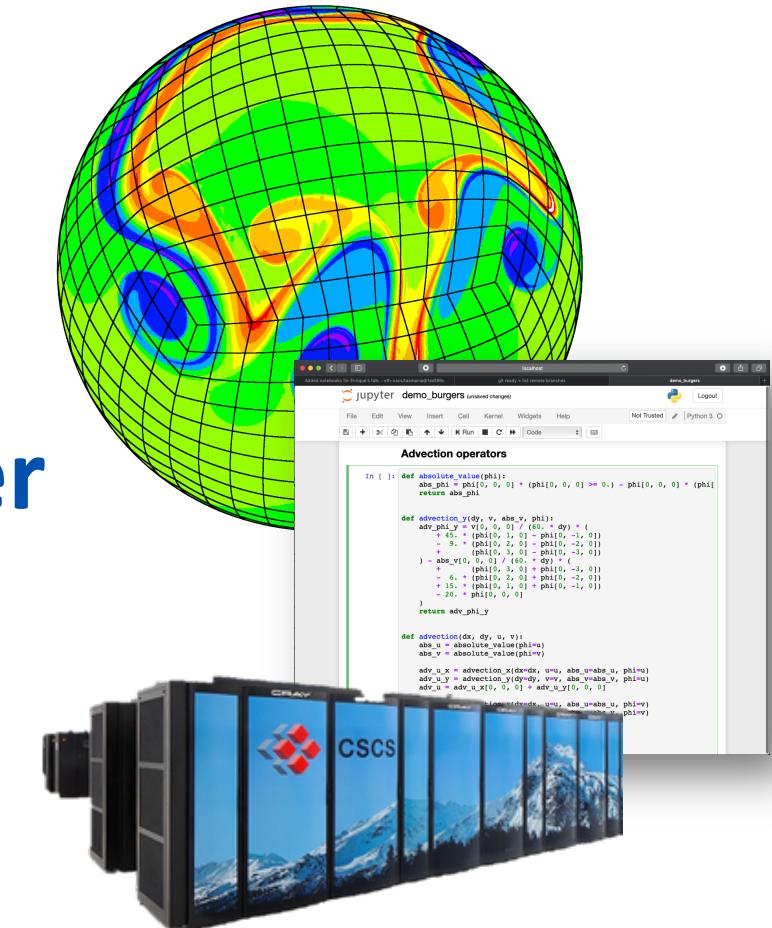
High Performance Computing for Weather and Climate (HPC4WC)

Content: Graphics Processing Units

Lecturers: Oliver Fuhrer

Block course 701-1270-00L

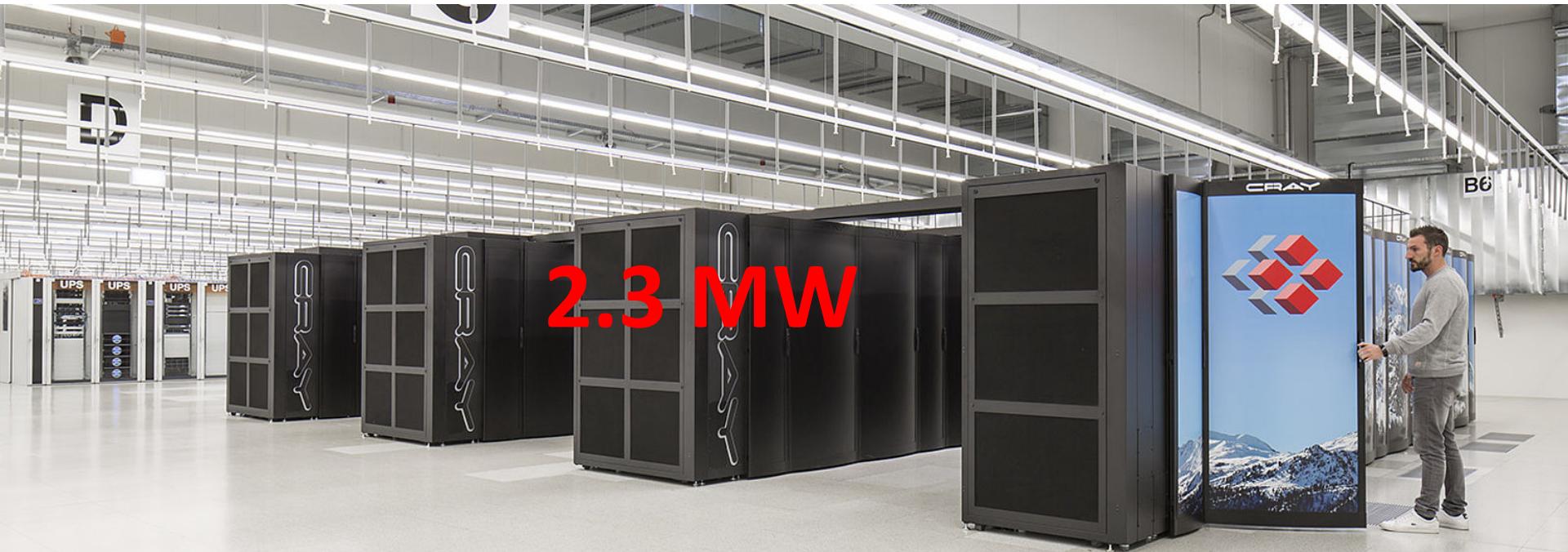
Summer 2020



Learning goals

- Understand why specialized hardware such as GPUs is become the new “normal”
- Learn how to program a GPU using a high-level programming language
- Understand potential and difficulties of GPU-computing

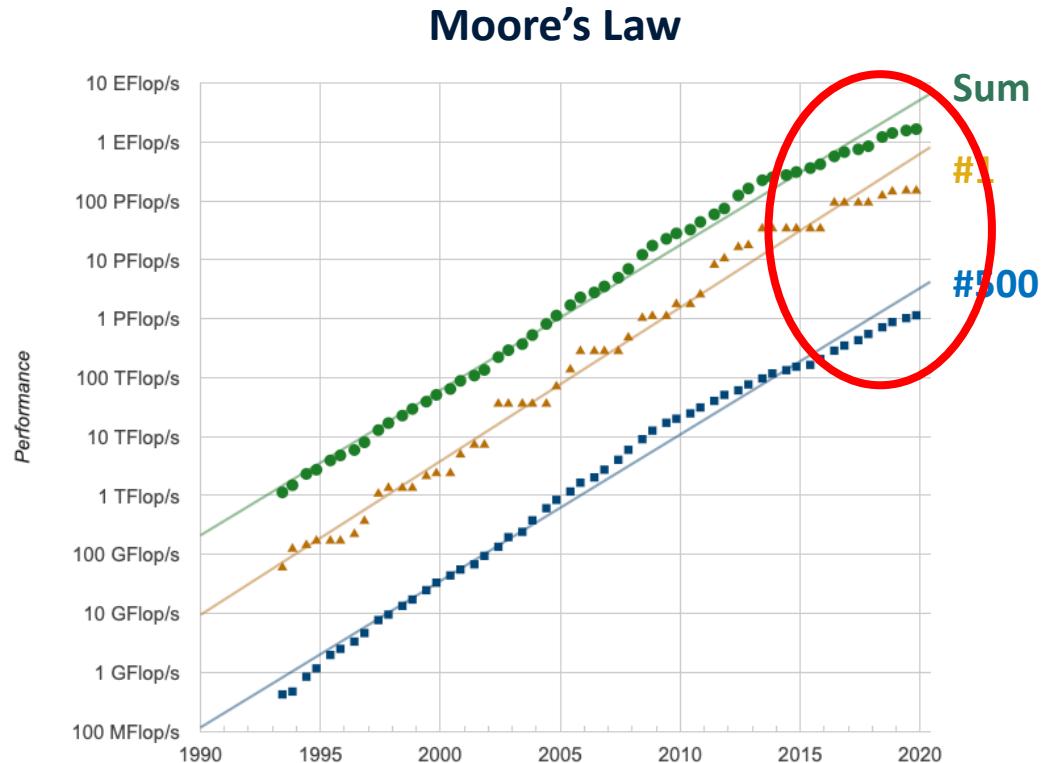
Power, power, power!



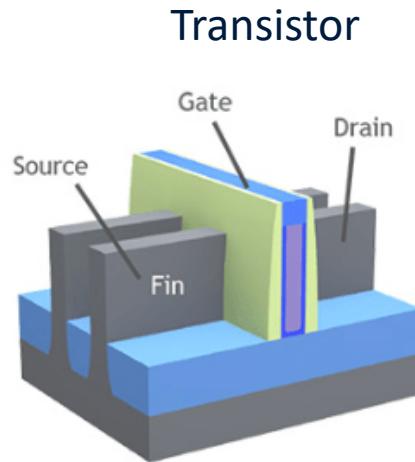
2.3 MW

Where do the Watt's go?

- CPUs are very complex and built for general purpose
- For weather and climate modeling, we often don't use all of the capabilities of a general purpose computer chips
- Historically, chips were custom-built for scientific computing
- Moore's law and the economics of developing and manufacturing chips (\$30 - \$80 M) changed that
- Era of "General Purpose Computing"

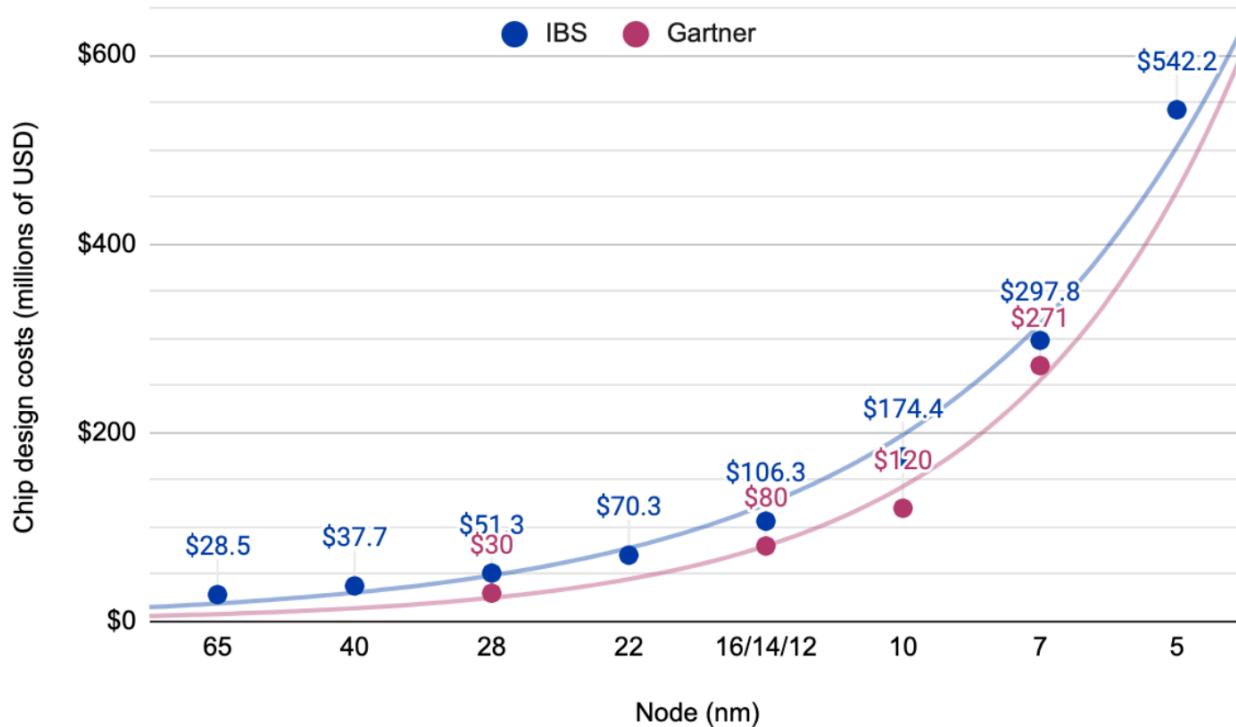


The End of General Purpose Computing

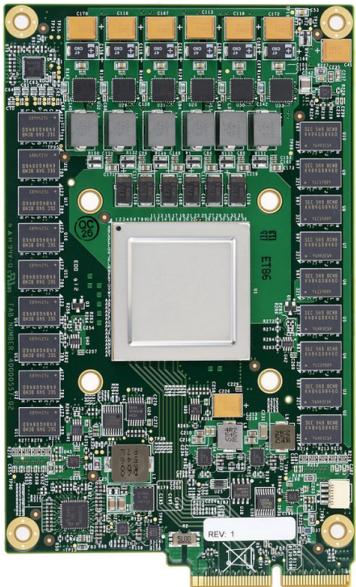


Distance between Si-atoms is 0.5 nm!

Chip Design Costs



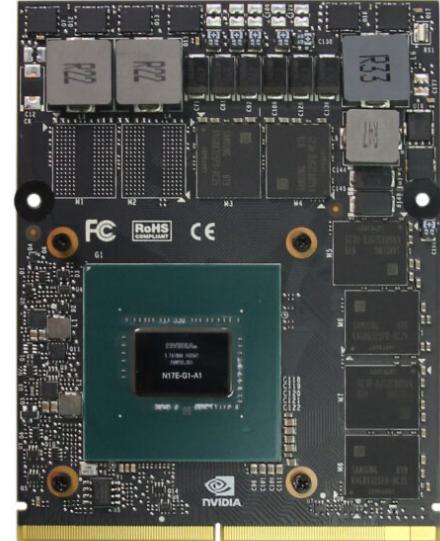
Specialized Chips are on the Rise!



Google's TPU
(e.g. machine learning)



FPGA
(e.g. bitcoin mining)



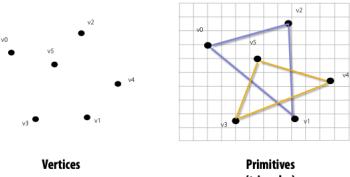
GPU
(e.g. gaming)



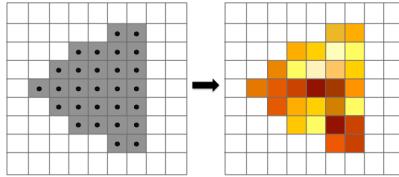
GPU's are for gaming, right?

GPU Computing

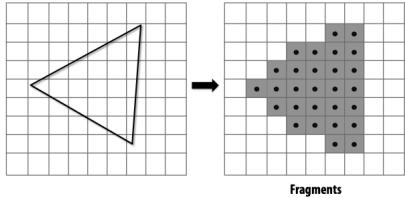
Primitive computation



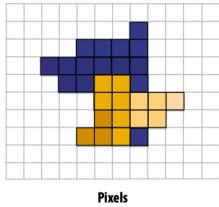
Fragment processing



Rasterization



Pixel operations



Parallel operations!

As video games became more complex, the hardware and software environment evolved to be more flexible.

With *OpenGL*, *OpenCL*, *CUDA*, ... programming languages started to appear that made general purpose computing on GPUs possible.

GPUs are great for some workloads / algorithms, but not so great for others!

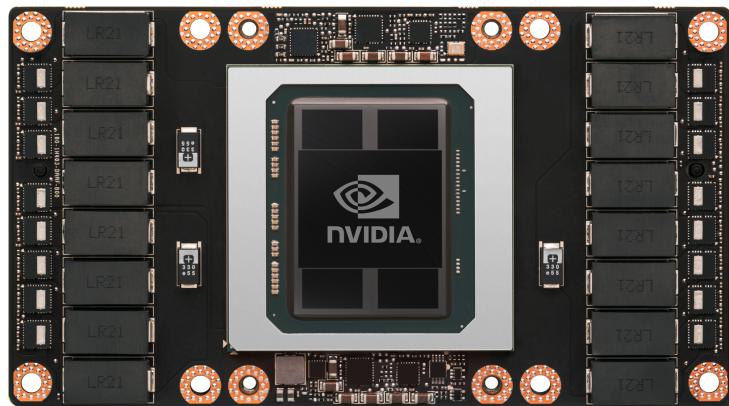
Performance / Watt

Intel Xeon E5-2690 v3 + DRAM



~ 200 W 0.5 TFLOP/s 70 GB/s

NVIDIA Tesla P100

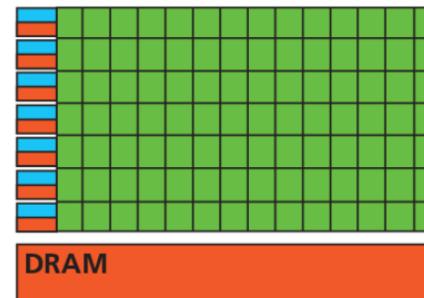
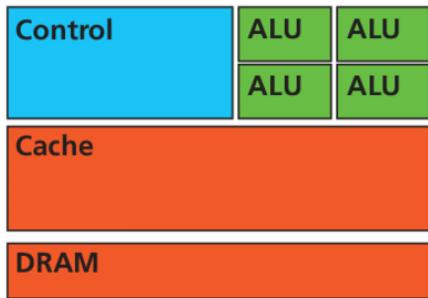


~ 300 W 5.3 TFLOP/s 720 GB/s

CPU vs. GPU

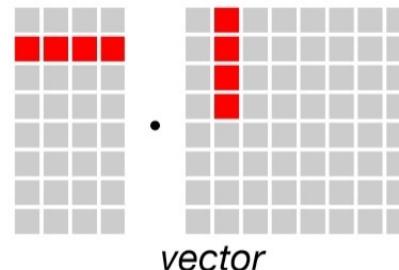
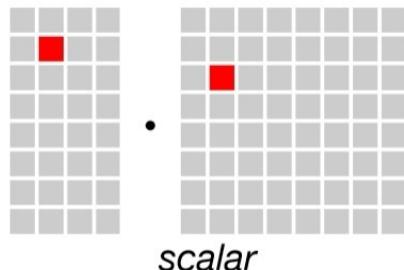
Architecture

Few complex cores
Few fast threads
Complex ILP
Little die surface for FLOPs

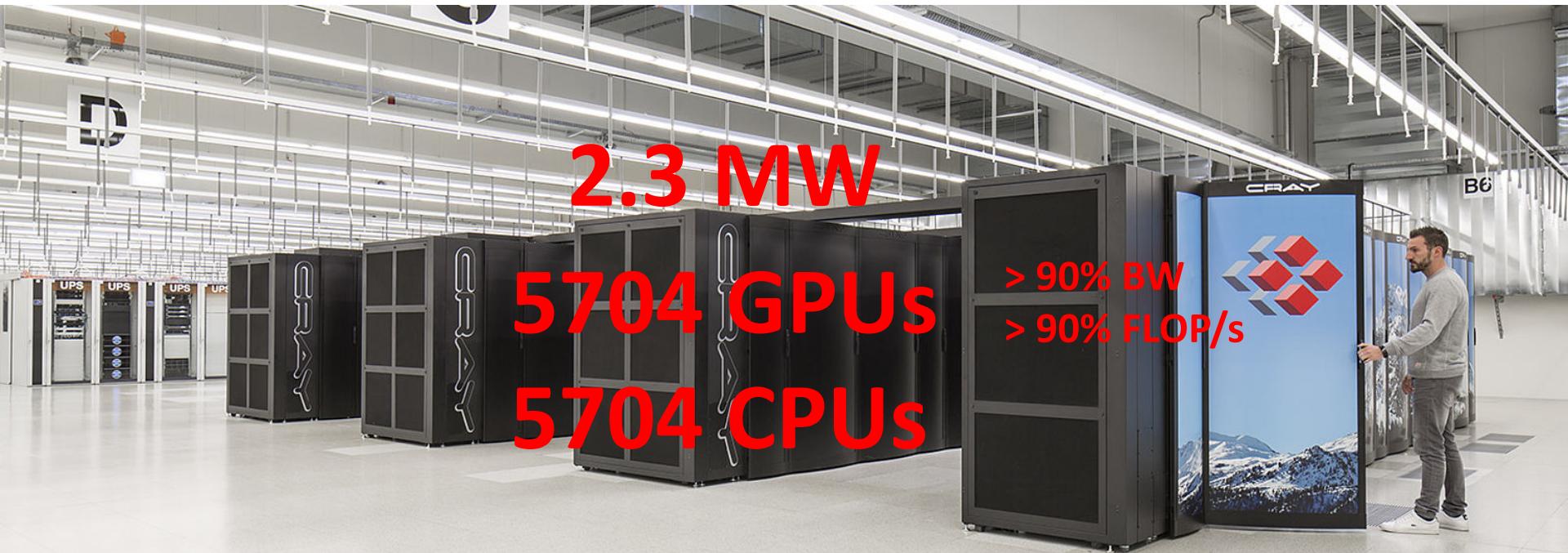


Many simple cores
Many concurrent threads
Maximize FLOP-throughput

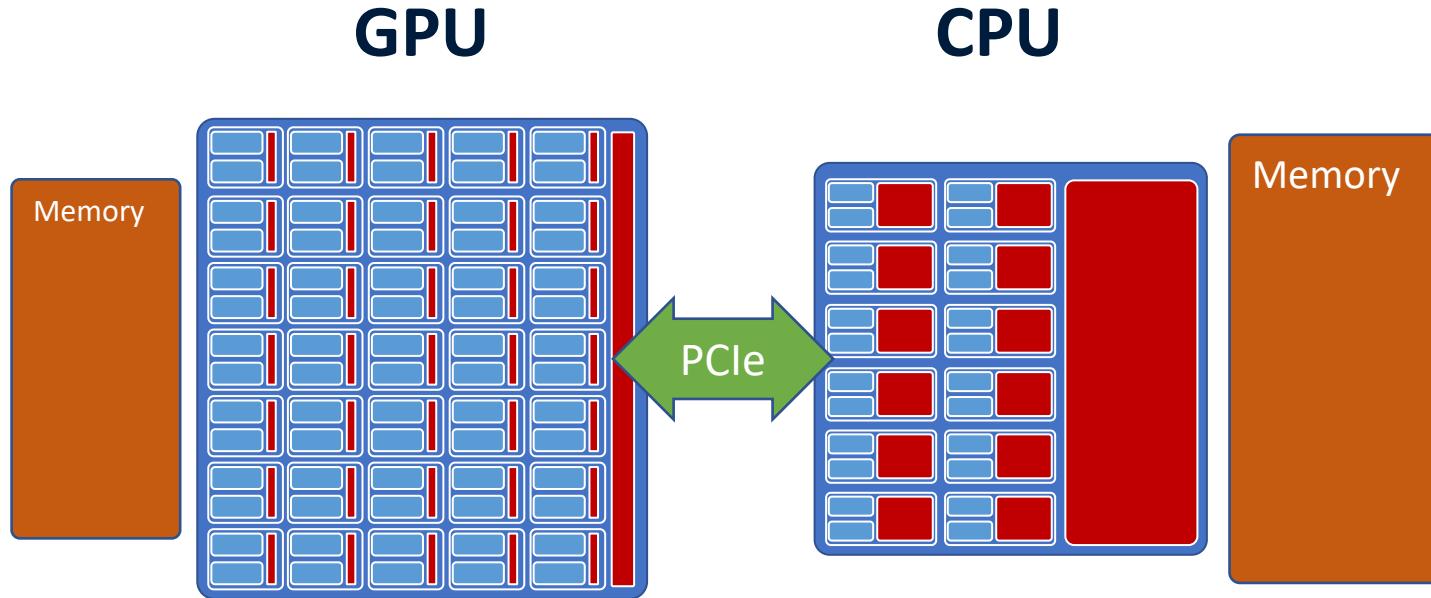
Compute primitive



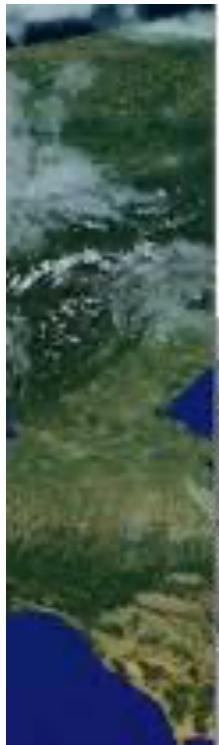
Hybrid Supercomputer



Node Architecture



Weather and Climate on GPUs



MeteoSwiss New
Weather Supercomputer
World's First GPU-Accelerated
Weather Forecasting System



2x
48
192 Tesla
> 90% of FLOPs
Operational

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HPC wire

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in the World and the People Who Run Them

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DATANAMI ENTERPRISEAI HPCWIRE JAPAN ADVANCED SCALE FORUM HPC ON WALL ST



Swiss Weather Forecasting Achieves 1.1km
Resolution on 'Piz Kesch'
By

April 1, 2016

Lab Exercises

01-GPU-programming-cupy.ipynb

- Introduction to GPU programming using a high-level programming language