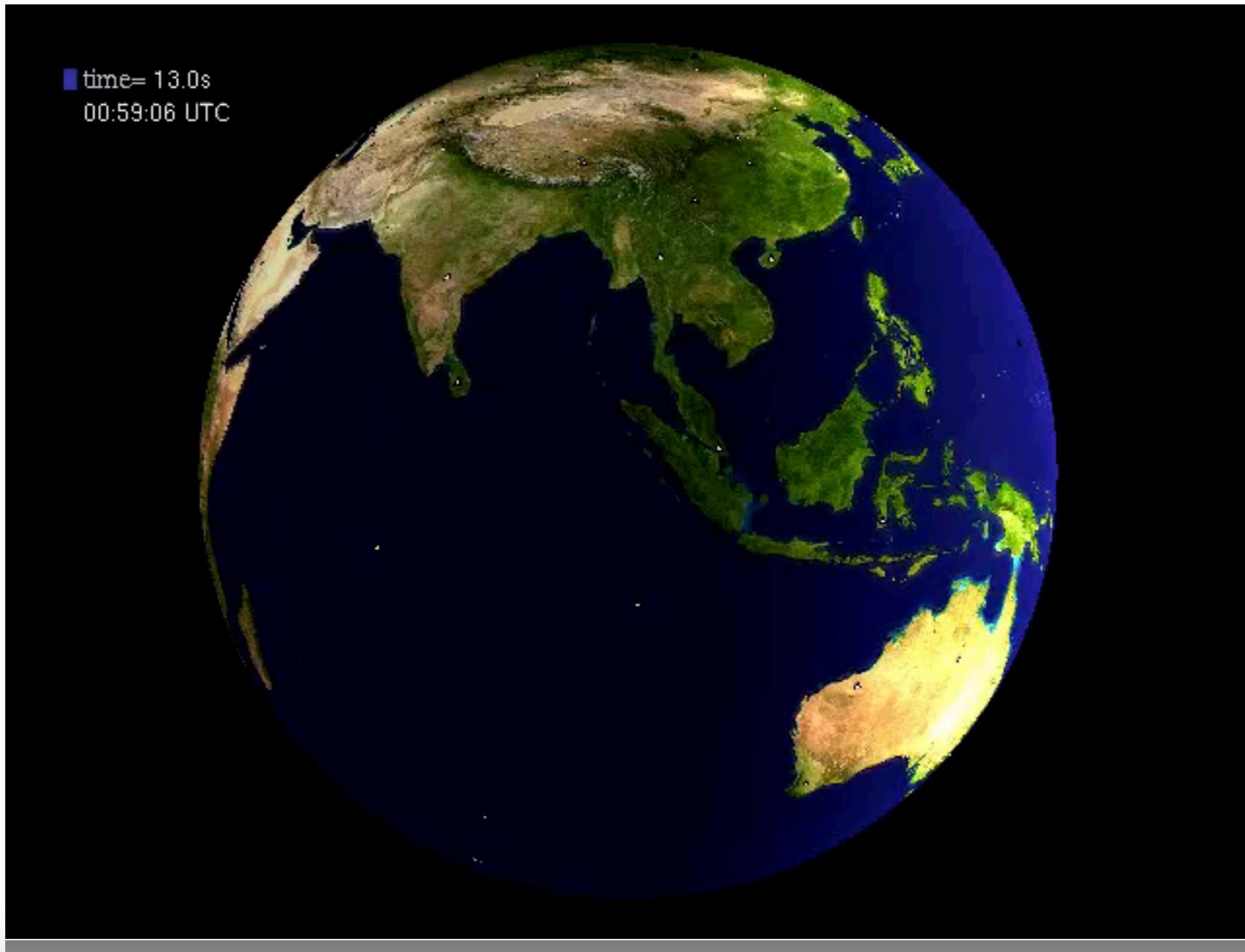
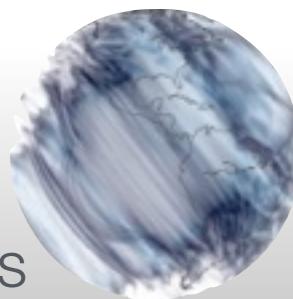


Computational Geophysics

ErSE 326



Computational Geophysics



Introduction:

- computational trends

Geophysics:

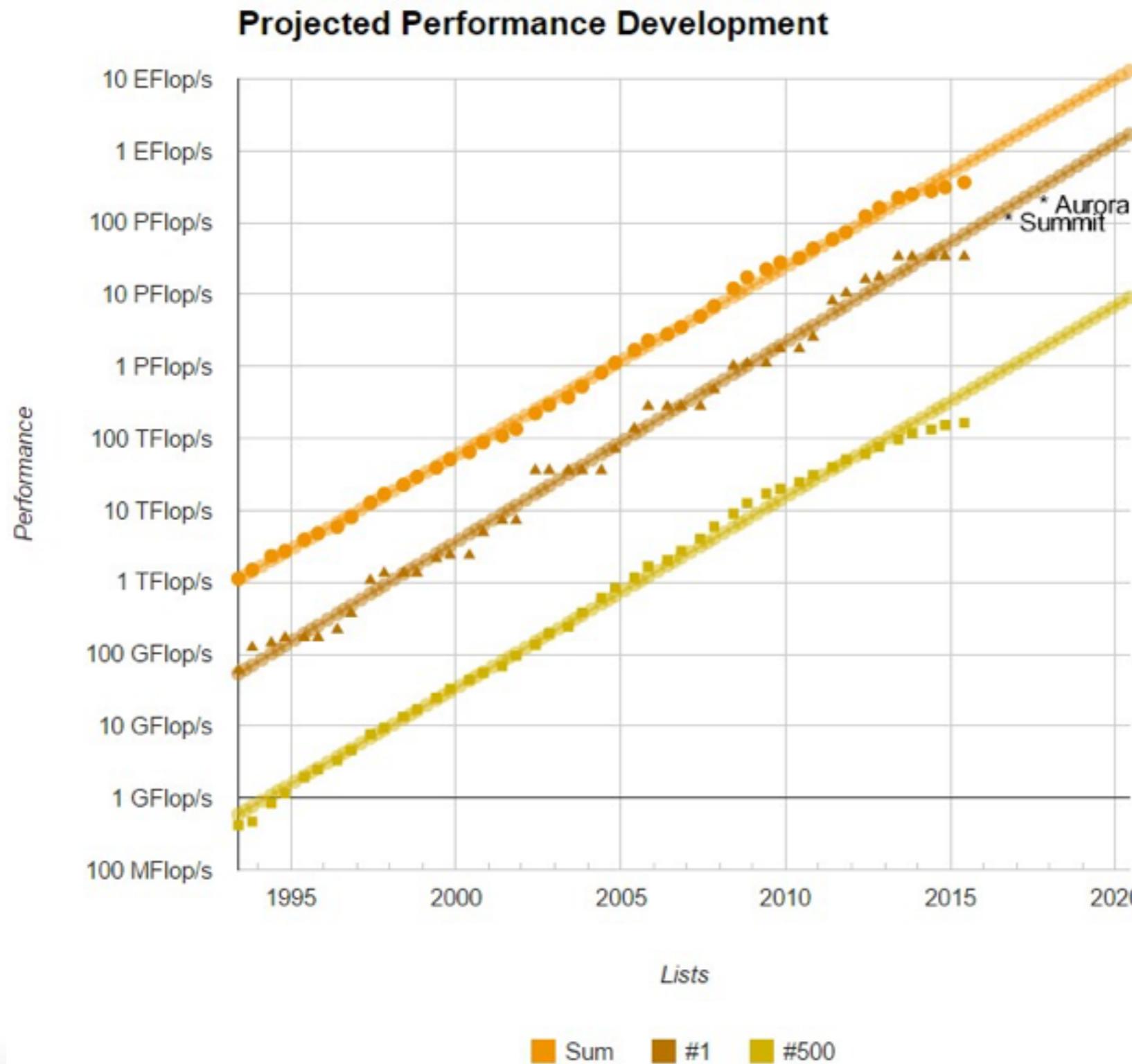
- Heat Flow
- Wave propagation

Numerical methods:

- finite-differences (FD)
- pseudo-spectral (PS)
- finite-element method (FEM)
- spectral-element method (SEM)



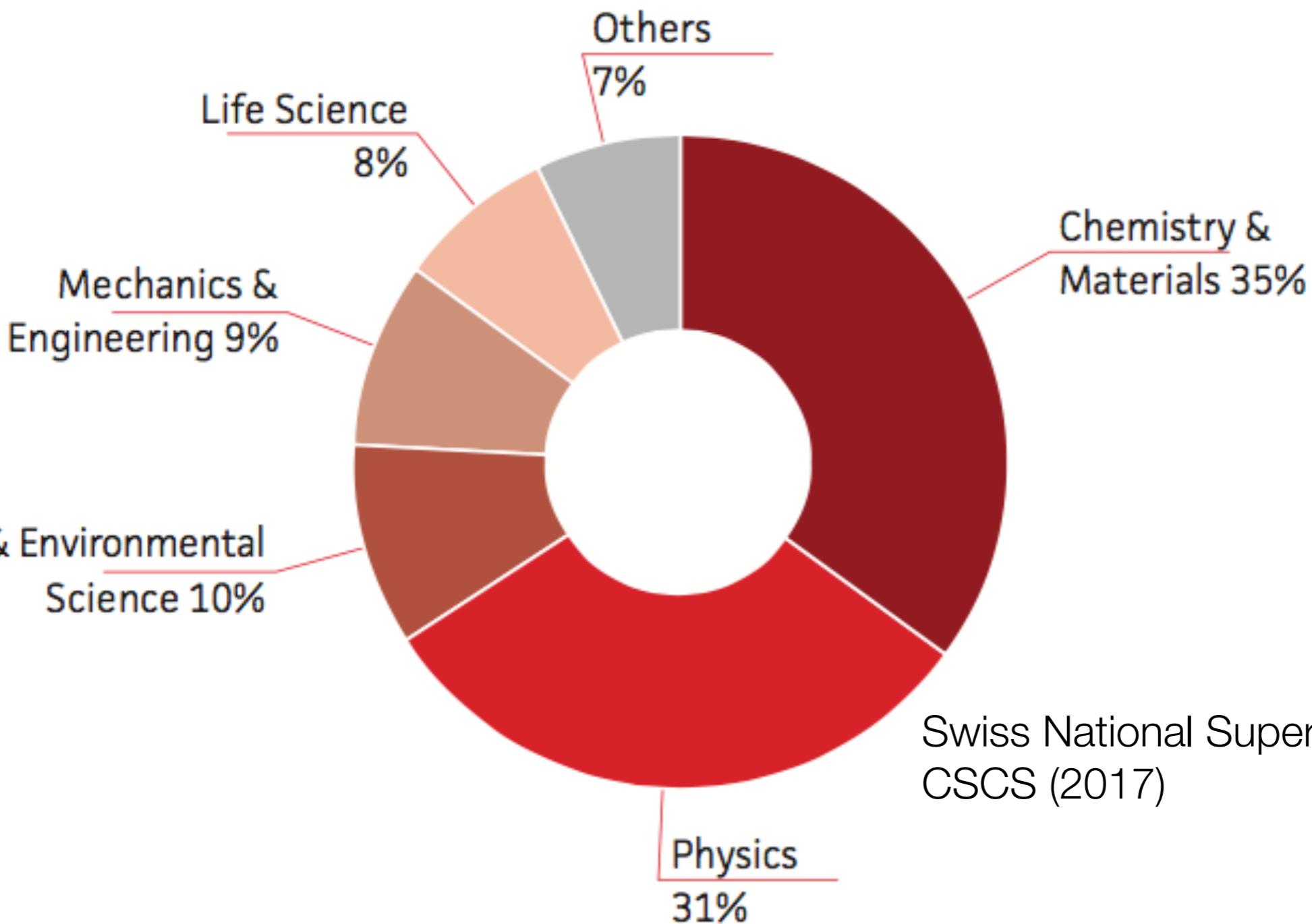
Trends - fastest supercomputers



exa-scale system
year ~2020

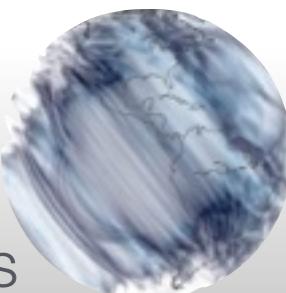


Trends - Usage by Research Field

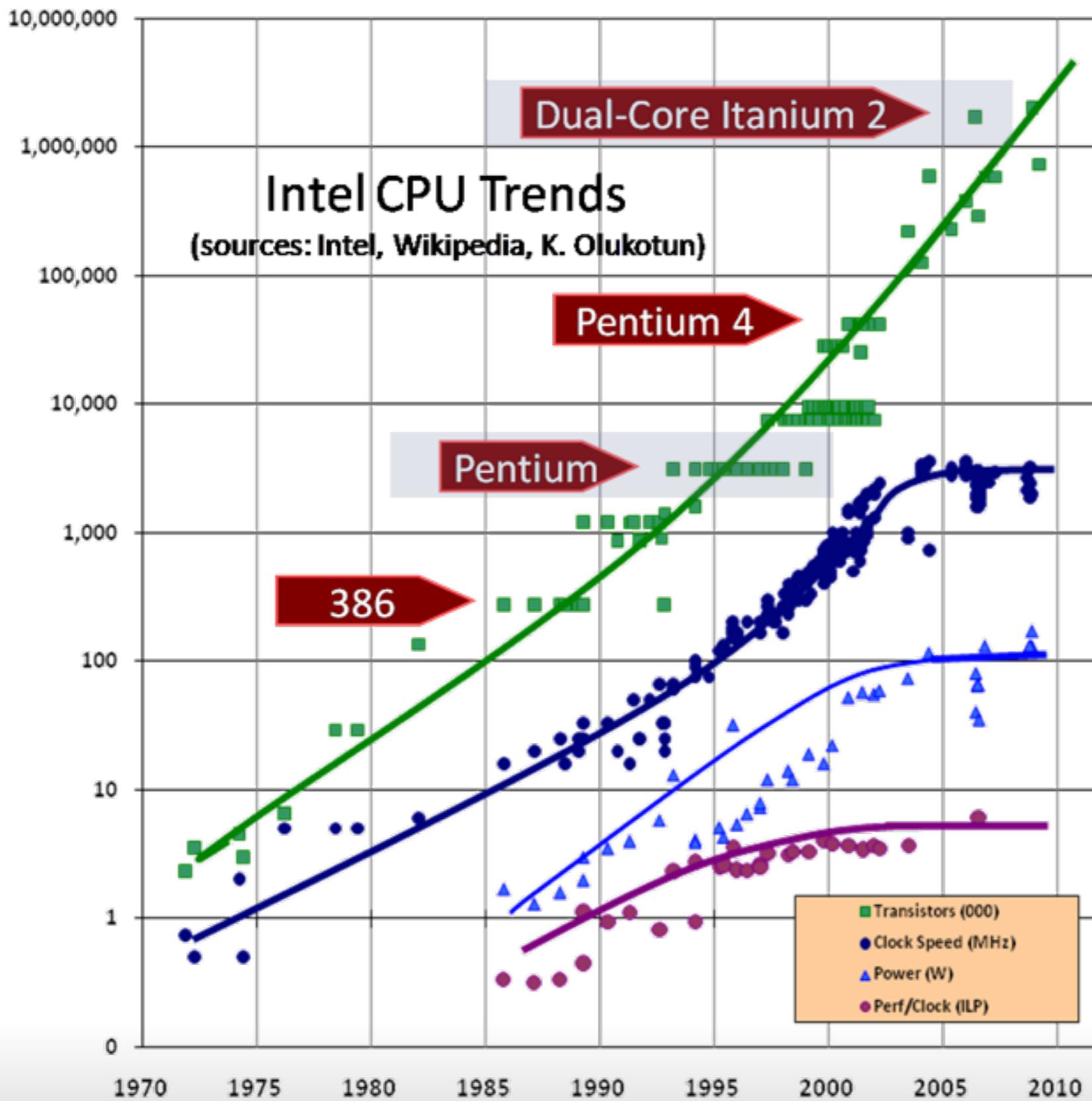


Swiss National Supercomputing Center
CSCS (2017)

Computational Geophysics



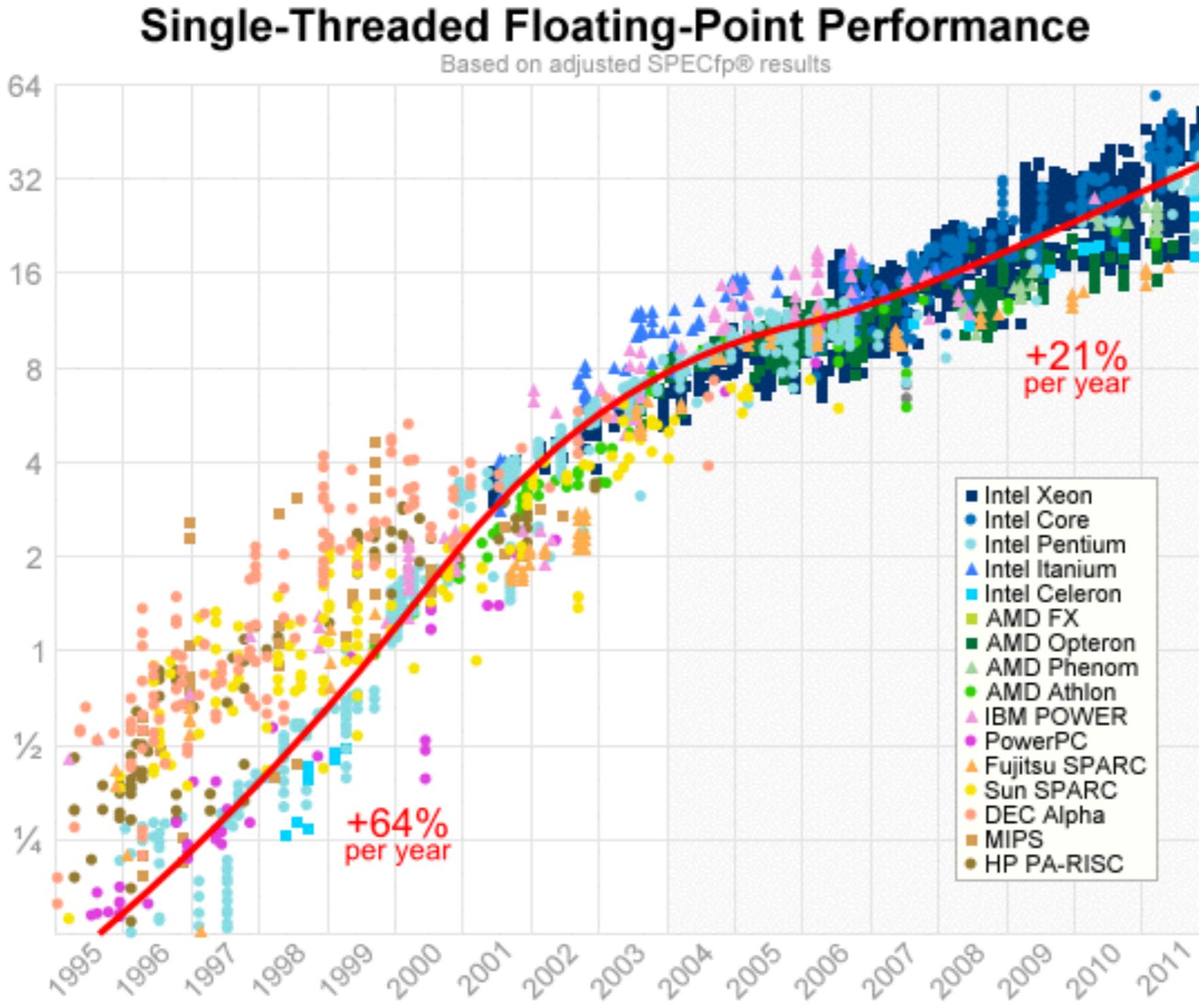
Trends - CPU



multi-core CPUs
since ~2006



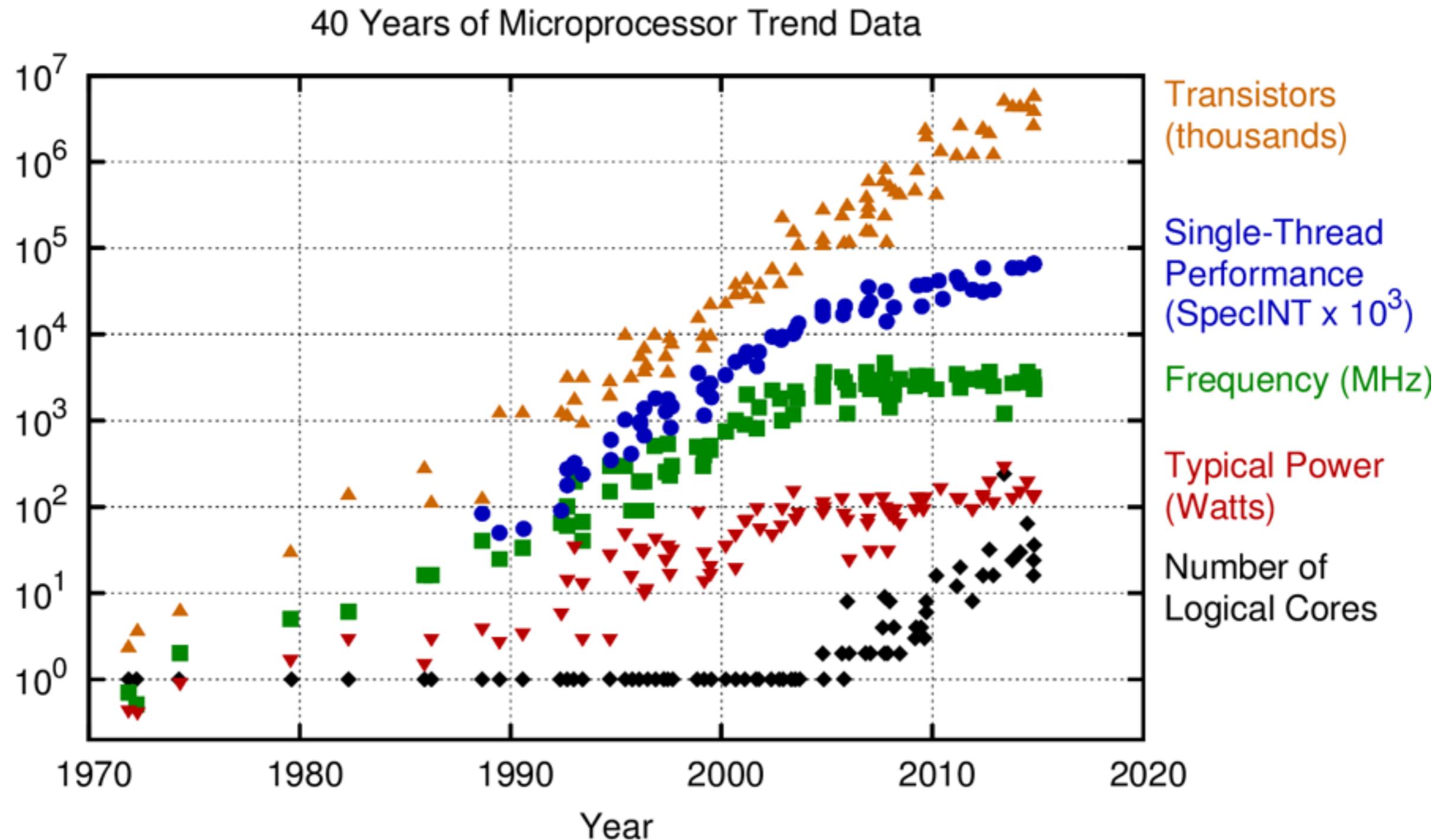
Trends - CPU



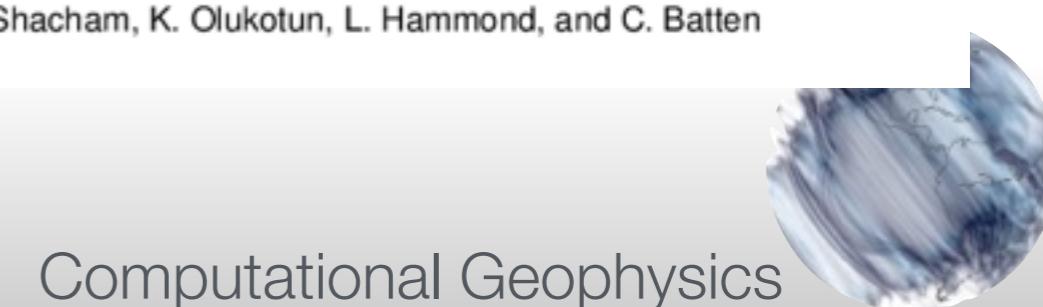
slow-down
since ~2003



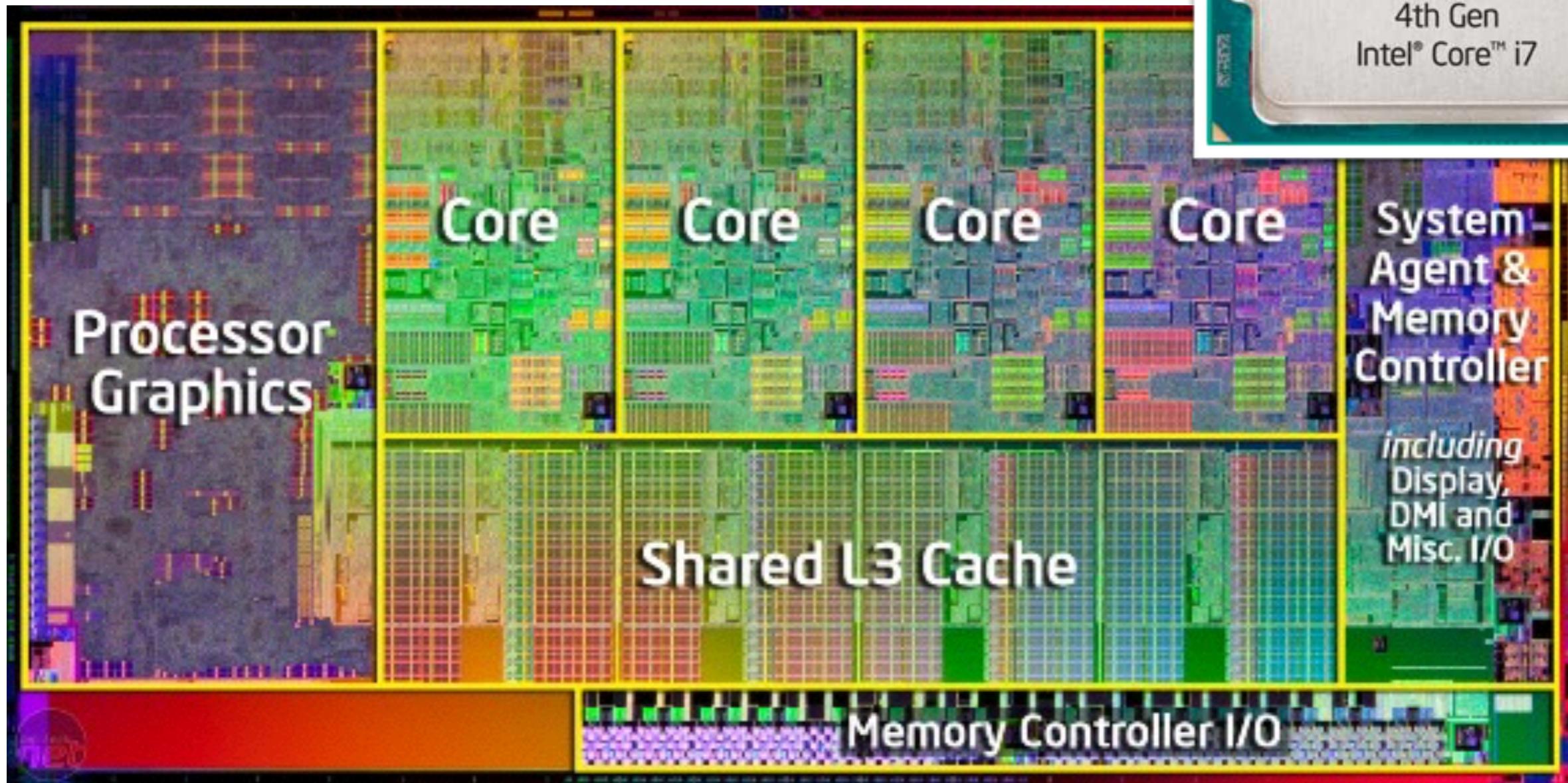
Trends - CPU



Original data up to the year 2010 collected and plotted by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond, and C. Batten
New plot and data collected for 2010-2015 by K. Rupp



Trends - CPU

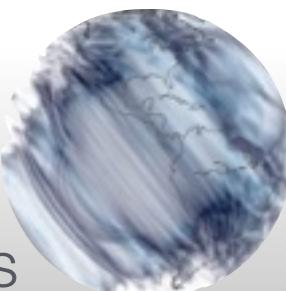


Trends - CPU



6 cores
12 threads (hyperthreading)
base frequency 2.9 GHz
lithography 14nm

(2018)



Trends - CPU



16 cores
32 threads (hyperthreading)
base frequency 2.8 GHz
lithography 14nm

(2018)



Trends - CPU



(Intel 2018)

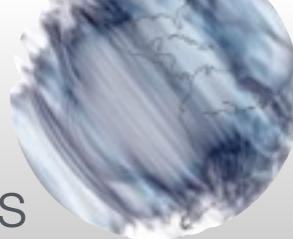
Computational Geophysics



Trends - GPU

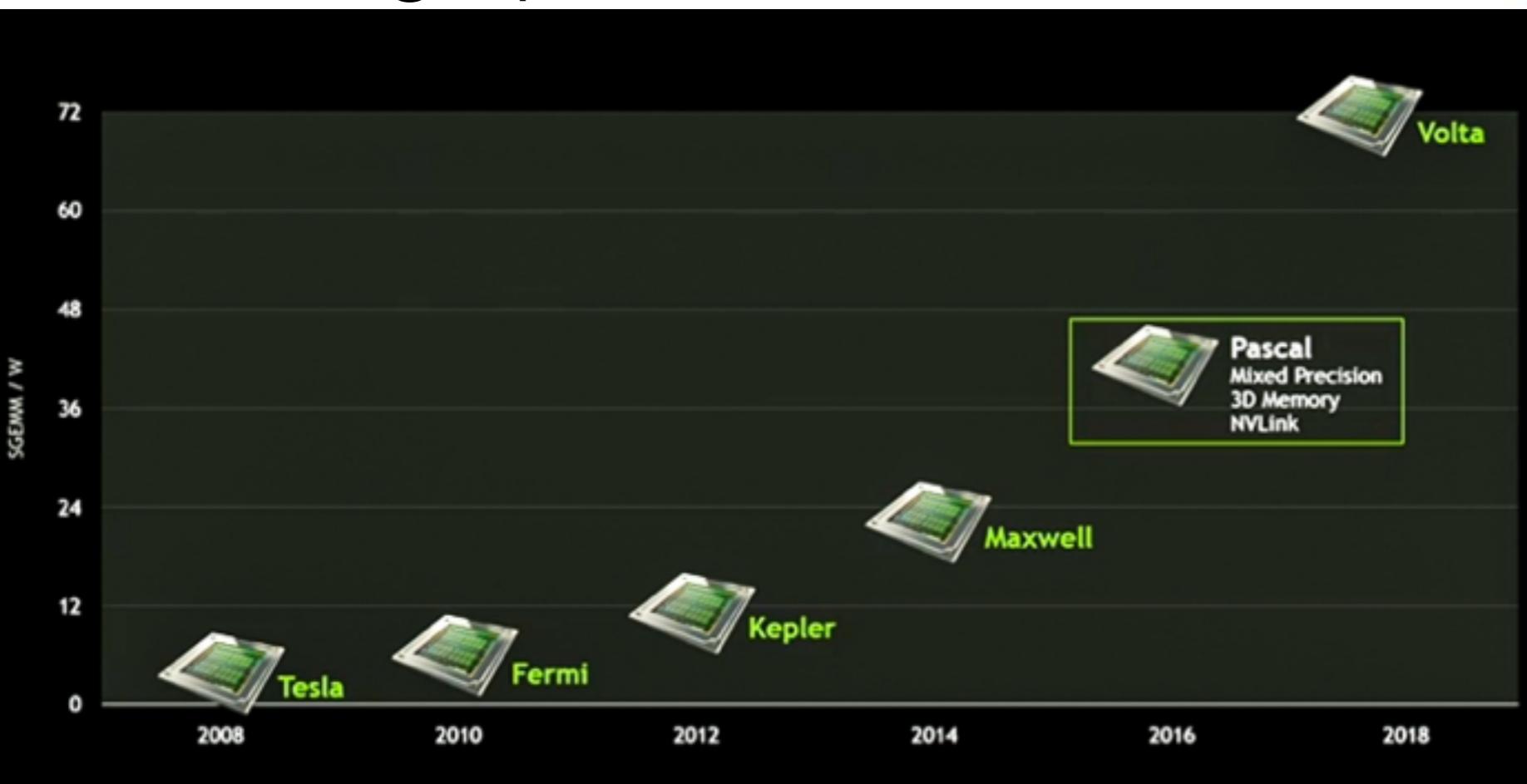


Computational Geophysics



Trends - GPU

Nvidia - graphic cards

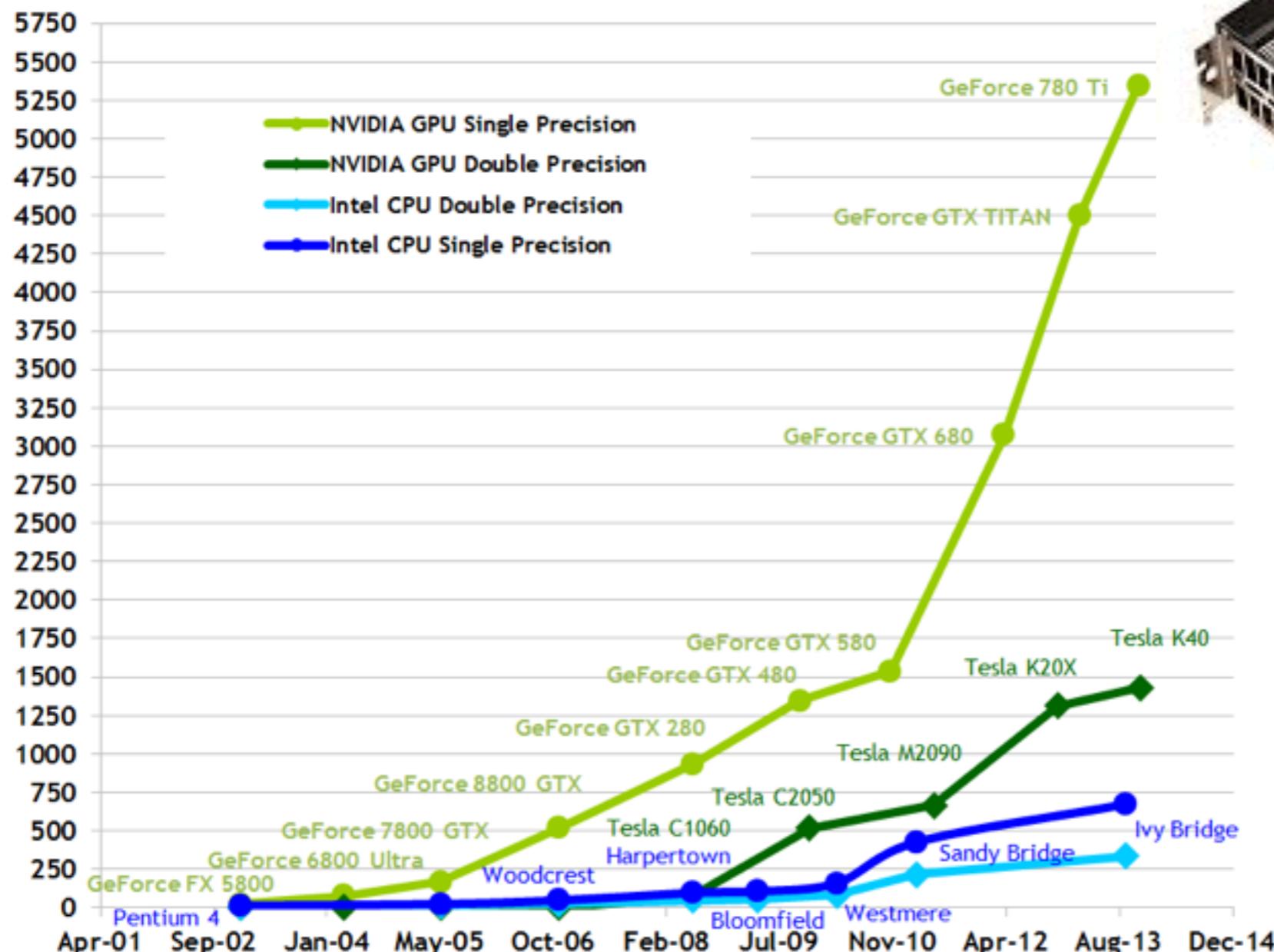


hardware
accelerators



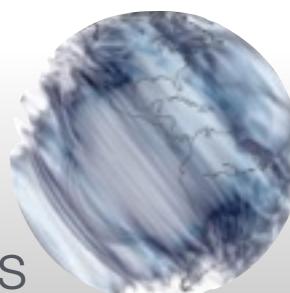
Trends - GPU

Theoretical GFLOP/s

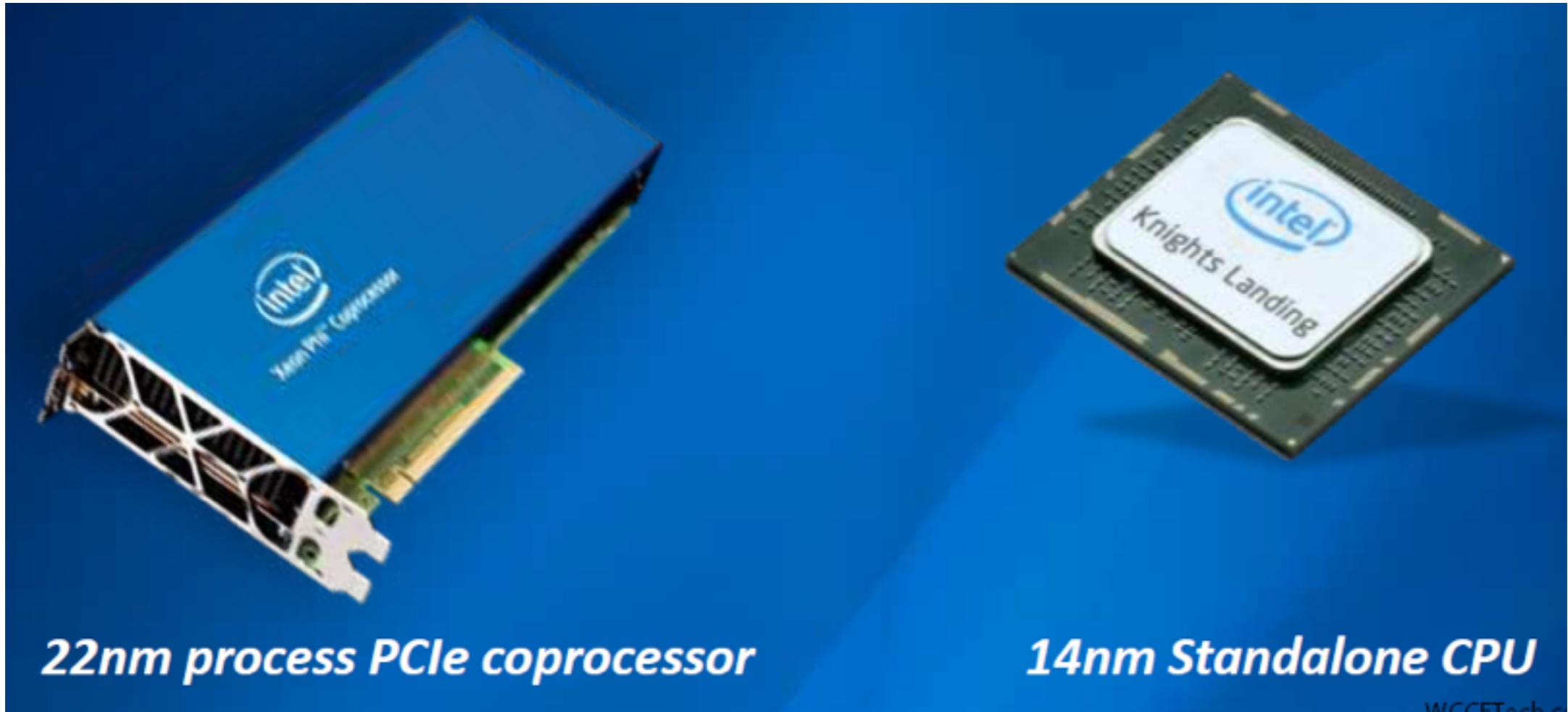


hardware
accelerators

Floating-Point Operations per Second - Nvidia CUDA C Programming Guide
Version 6.5 - 24/9/2014 - copyright Nvidia Corporation 2014



Trends - Intel Phi



22nm process PCIe coprocessor

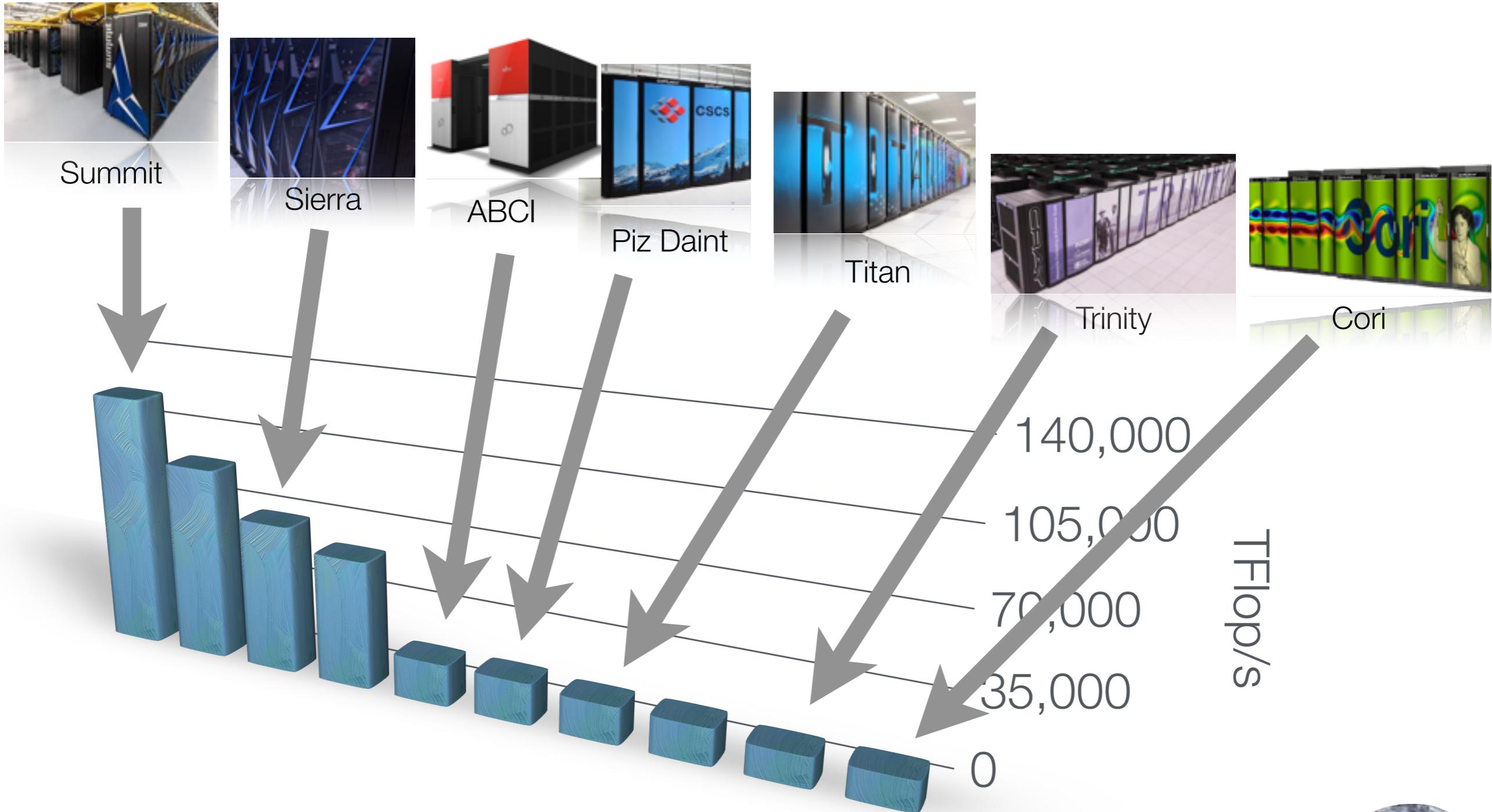
14nm Standalone CPU

WCCETech.com

hardware accelerators



Trends - Supercomputers w/ hardware accelerators



(Top500.org - June 2018)

Computational Geophysics



Introduction:

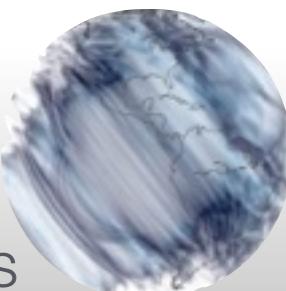
- computational trends

Geophysics:

- Heat Flow
- Wave propagation

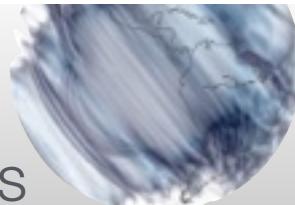
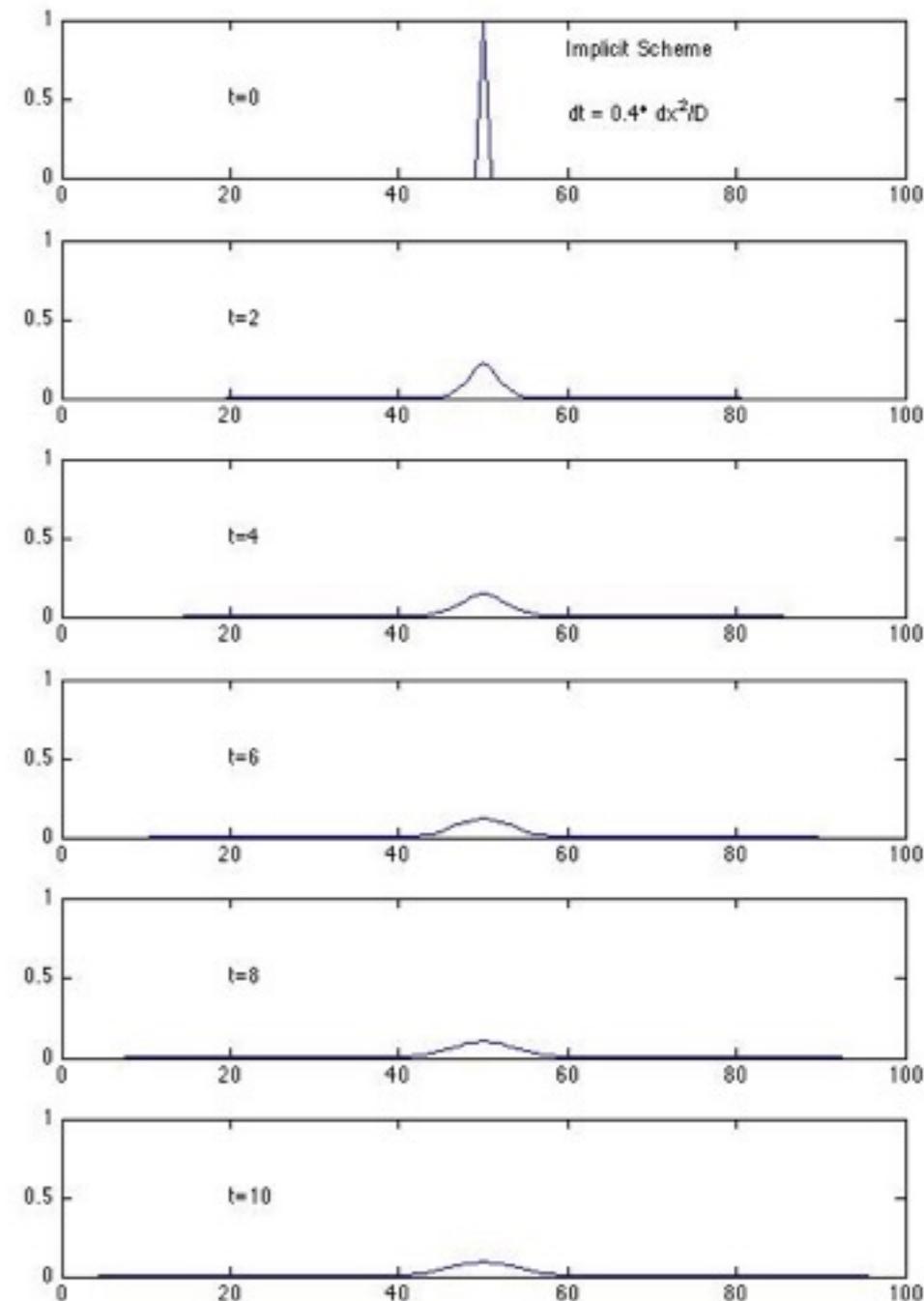
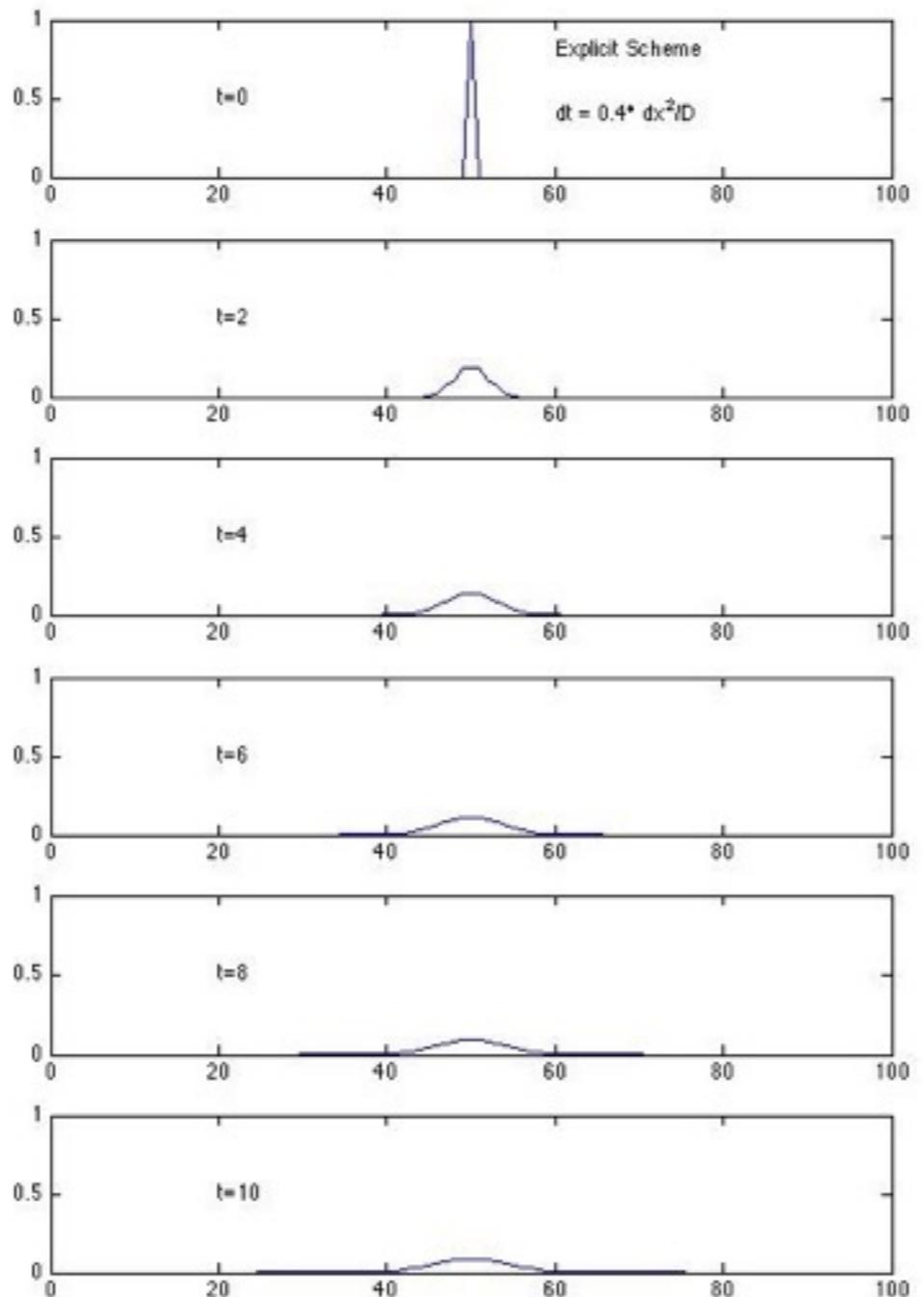
Numerical methods:

- finite-differences (FD)
- pseudo-spectral (PS)
- finite-element method (FEM)
- spectral-element method (SEM)



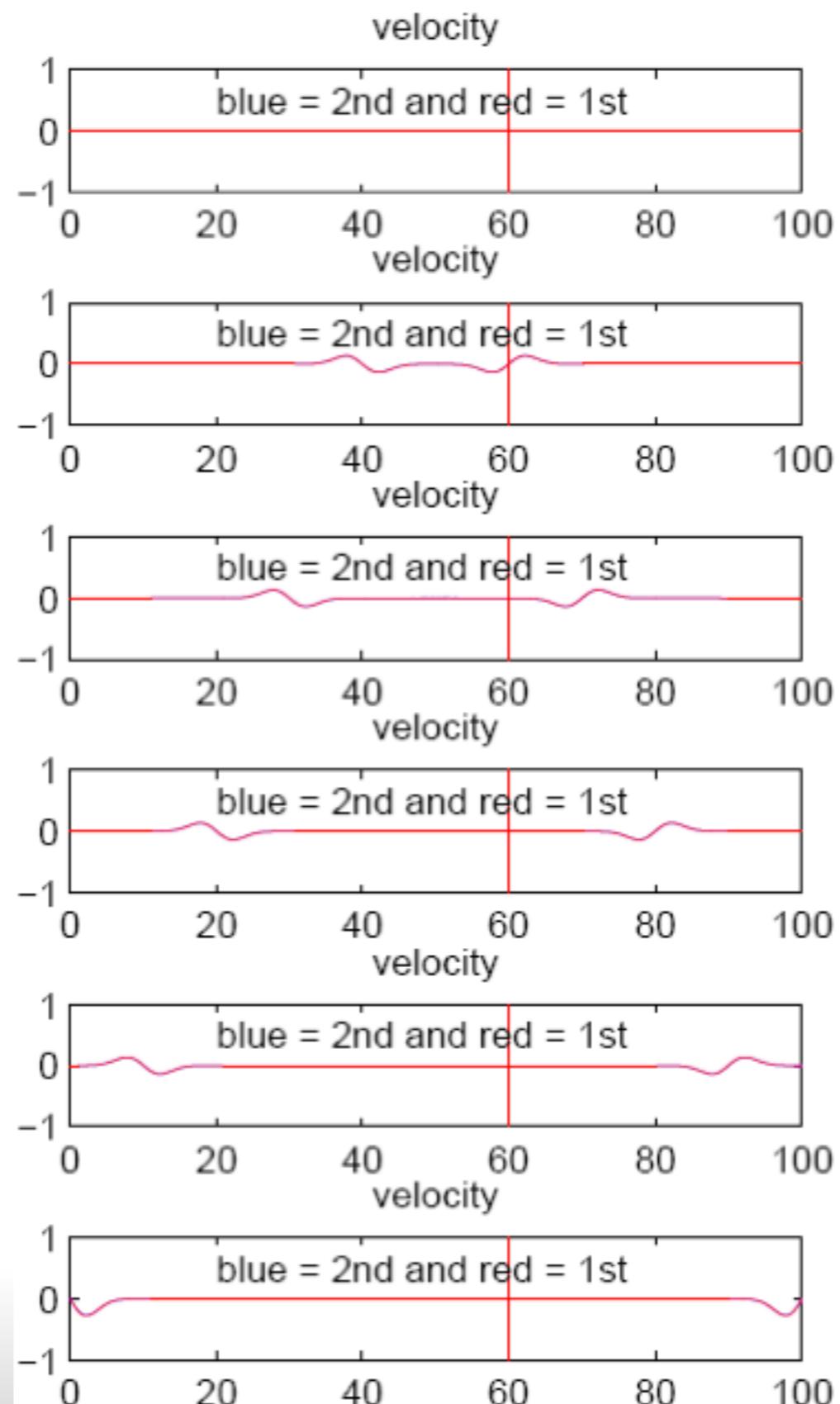
Numerical methods - Finite-Differences

heat flow



Numerical methods - Finite-Differences

wave propagation



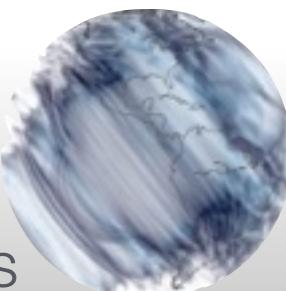
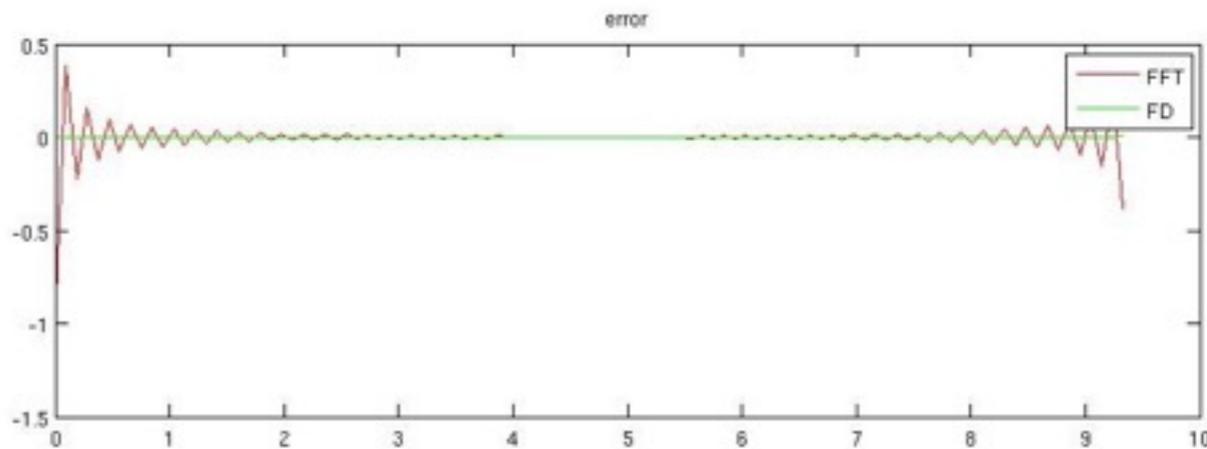
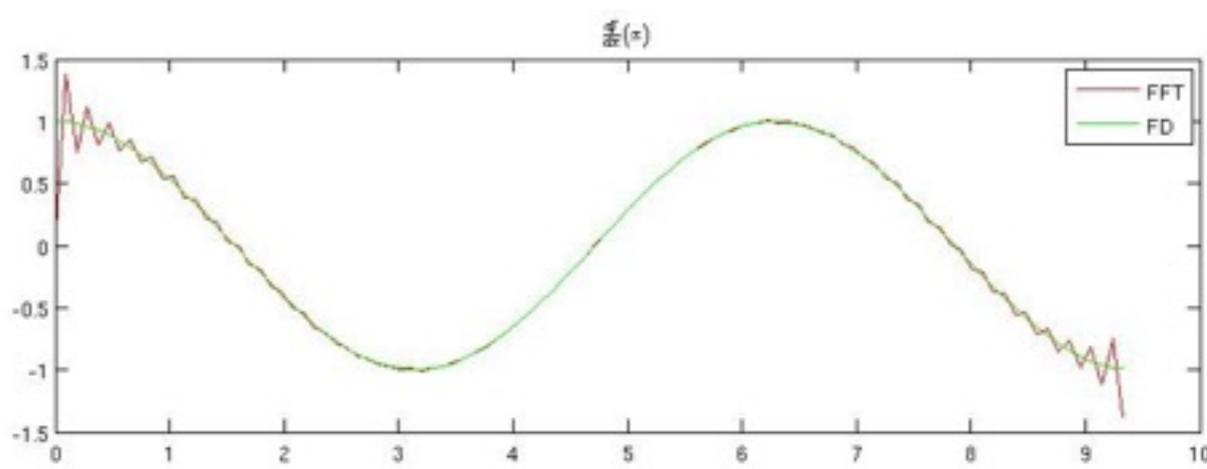
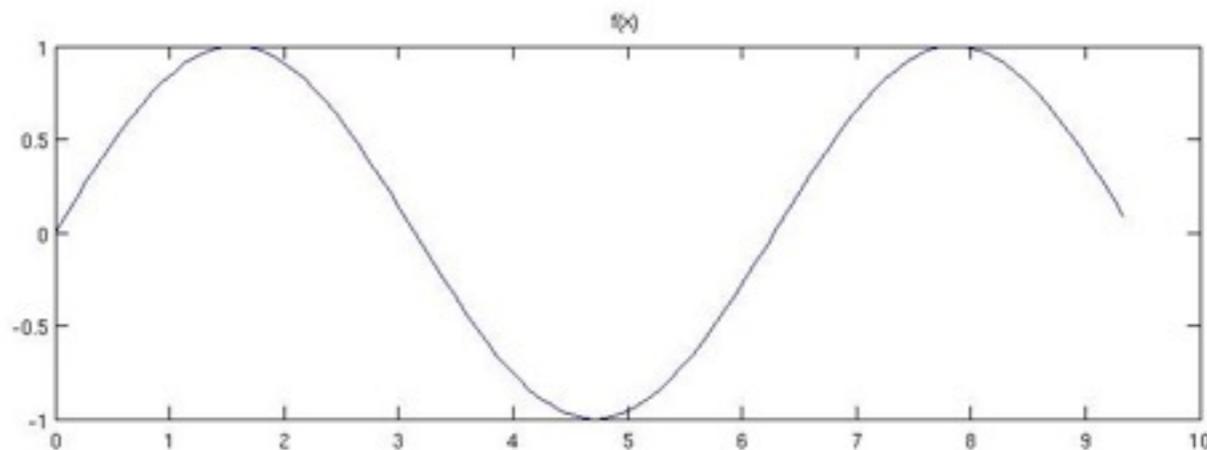
Numerical methods - Finite-Differences

tsunami waves



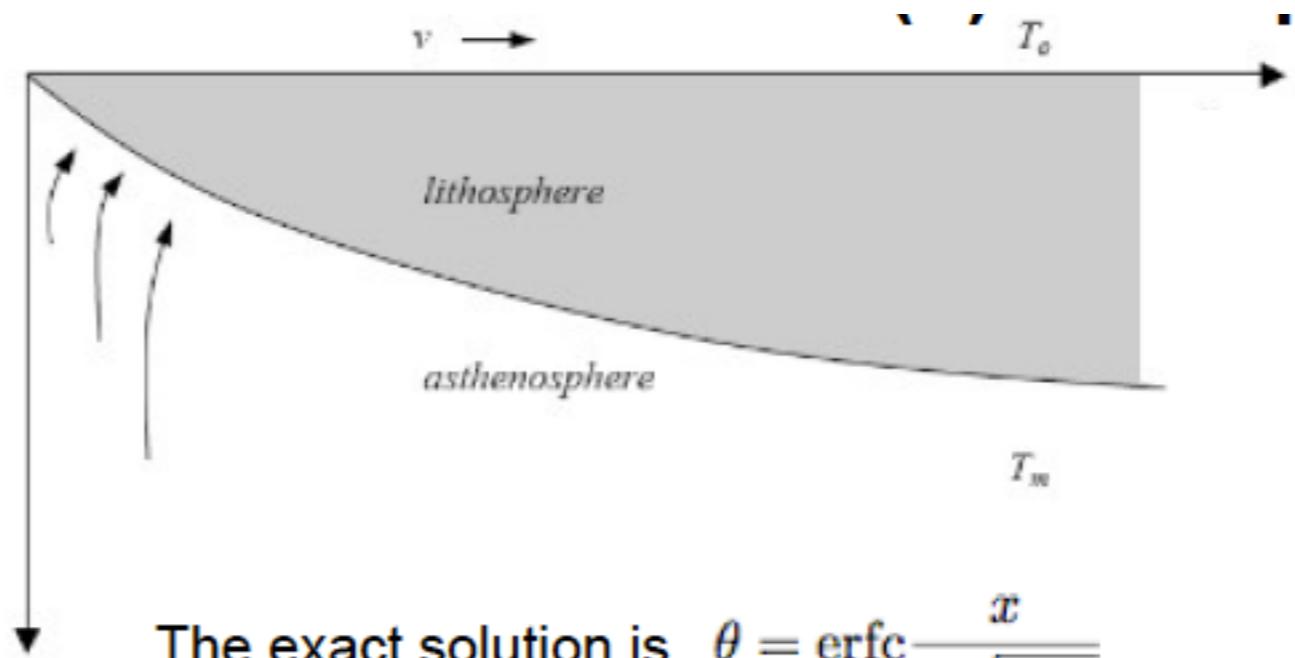
Numerical methods - Pseudo-Spectral

wave propagation

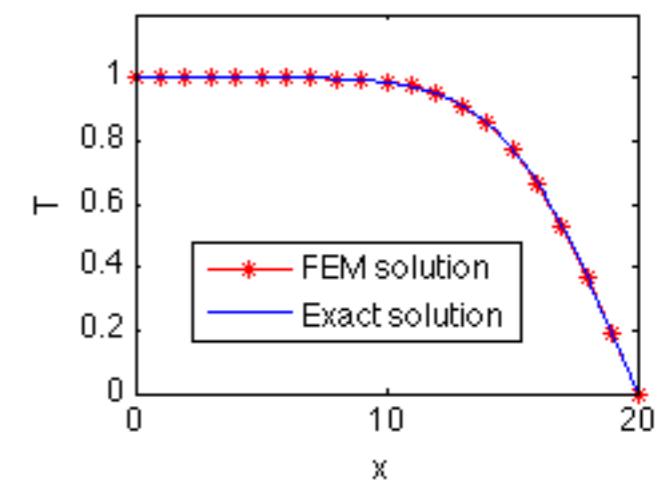
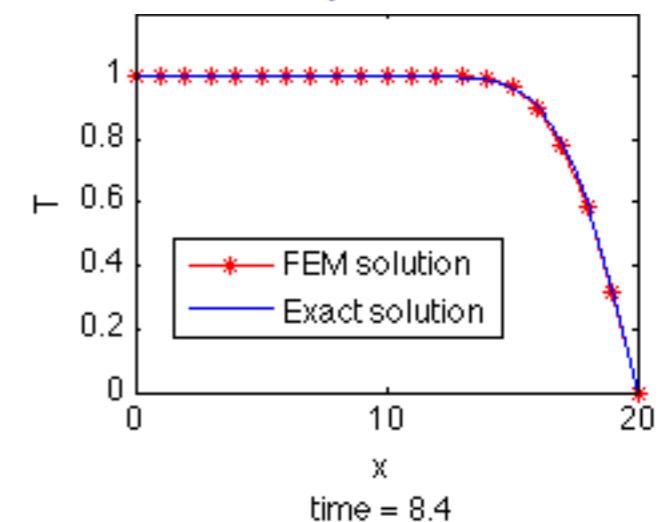
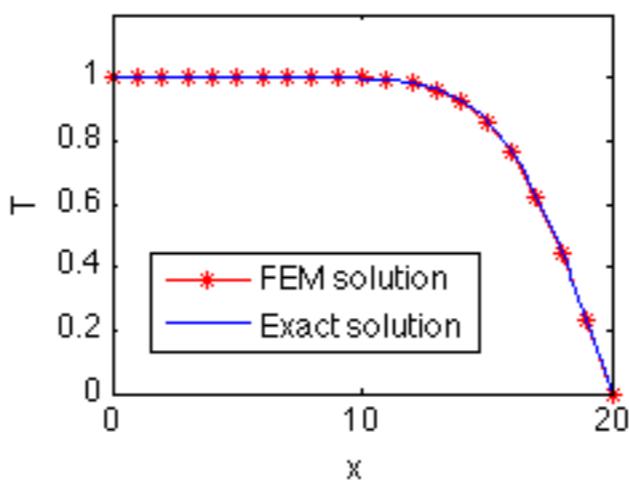
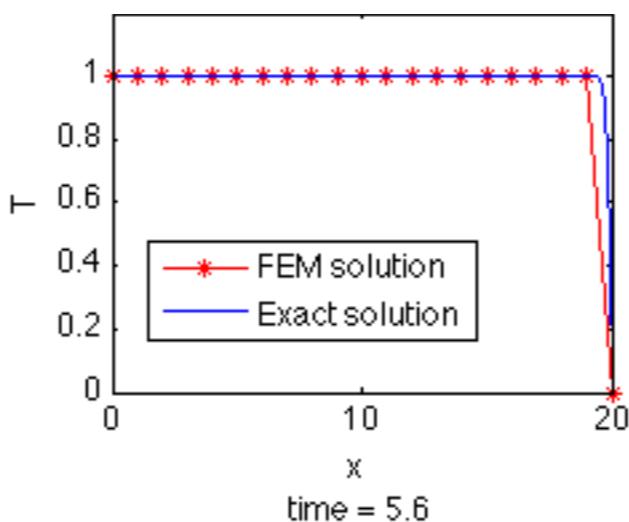


Numerical methods - Finite-element method

half-space cooling



The exact solution is $\theta = \text{erfc} \frac{x}{2\sqrt{\frac{\kappa}{\rho c_p} t}}$

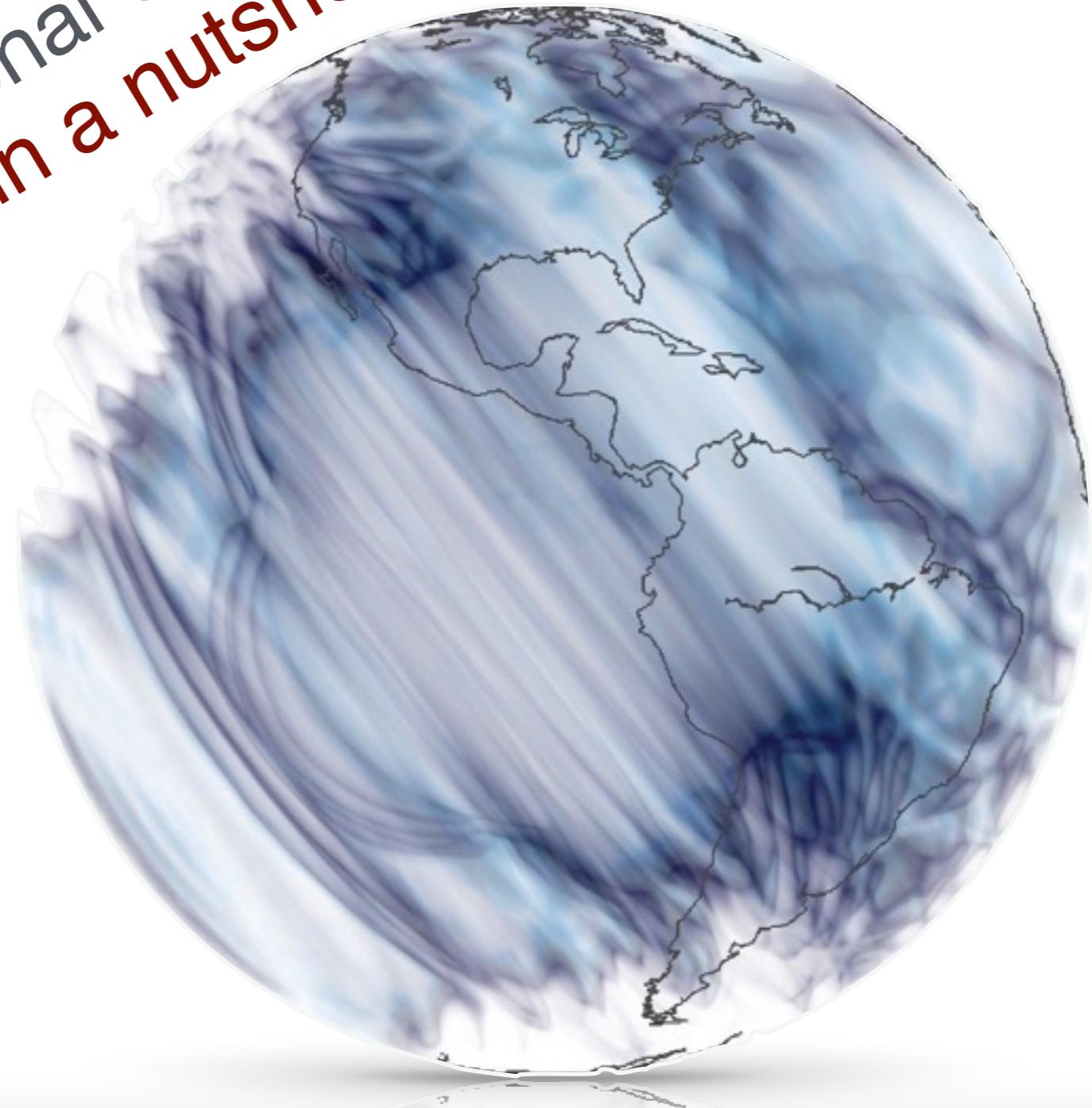


Numerical methods - **Spectral-element method**

wave propagation



Computational Geophysics → in a nutshell



Computational Geophysics

