

Saving the World with Computing

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Computing Sciences at Berkeley

Lab

Computing
Sciences

Computational
Research

ESnet Facility

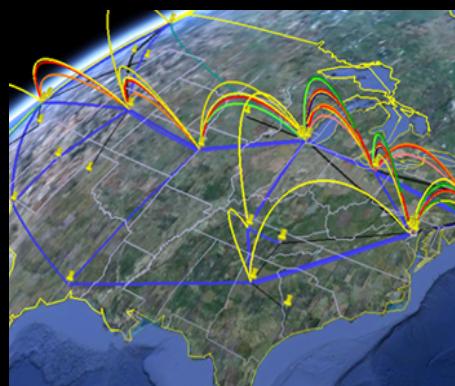
NERSC
Facility

Applied Math

Computer
Science

Data Science

Science
Partnerships

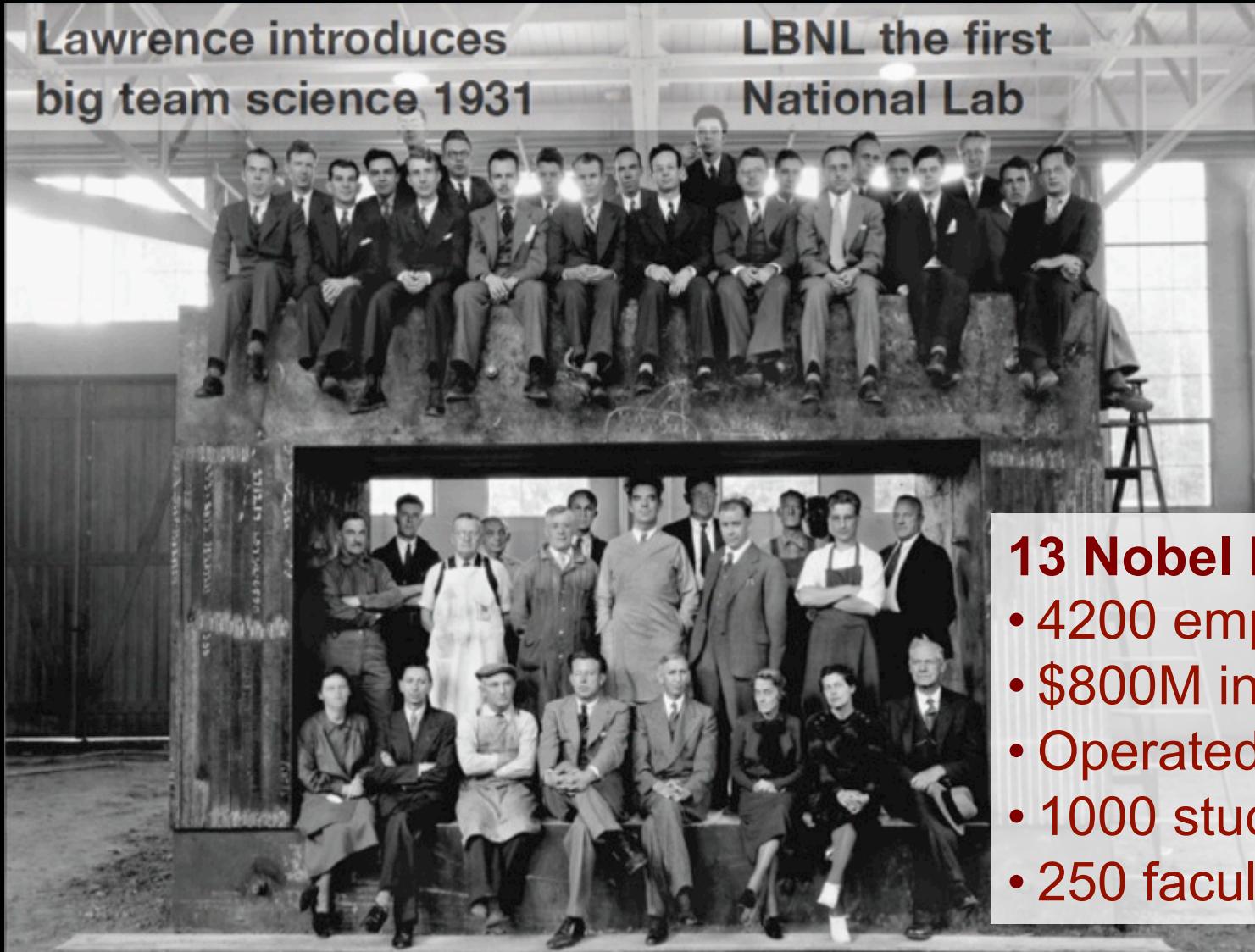


My research group

Berkeley Lab Changes Science

Lawrence introduces
big team science 1931

LBNL the first
National Lab



- 13 Nobel Prizes**
- 4200 employees
 - \$800M in funding
 - Operated by UC
 - 1000 student
 - 250 faculty

Why are you Interested in Computer Science?

I want to:

- A. Build computer hardware
- B. Build computer software
- C. Create new companies and industries
- D. Use computers to solve important problems
- E. All of the above

Computing in Science and Engineering

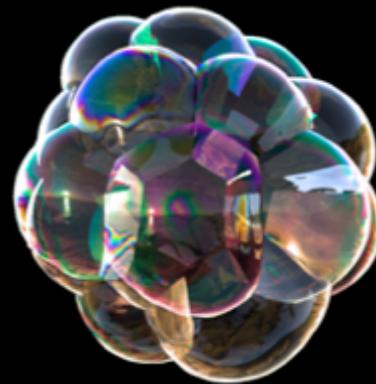
Computers are used to understand things that are:

- too big
- too small
- too fast
- too slow
- too expensive or
- too dangerous

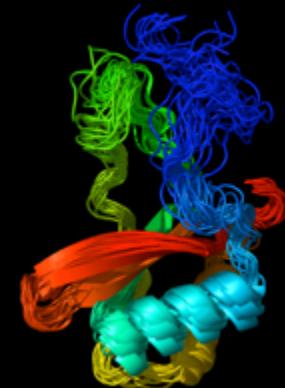
for experiments



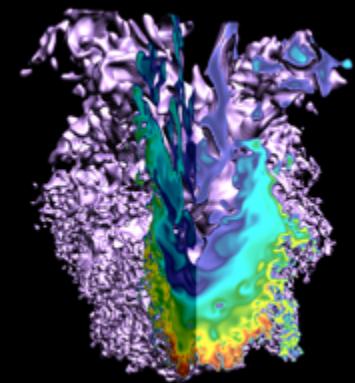
Understanding the universe



Industrial products and processes

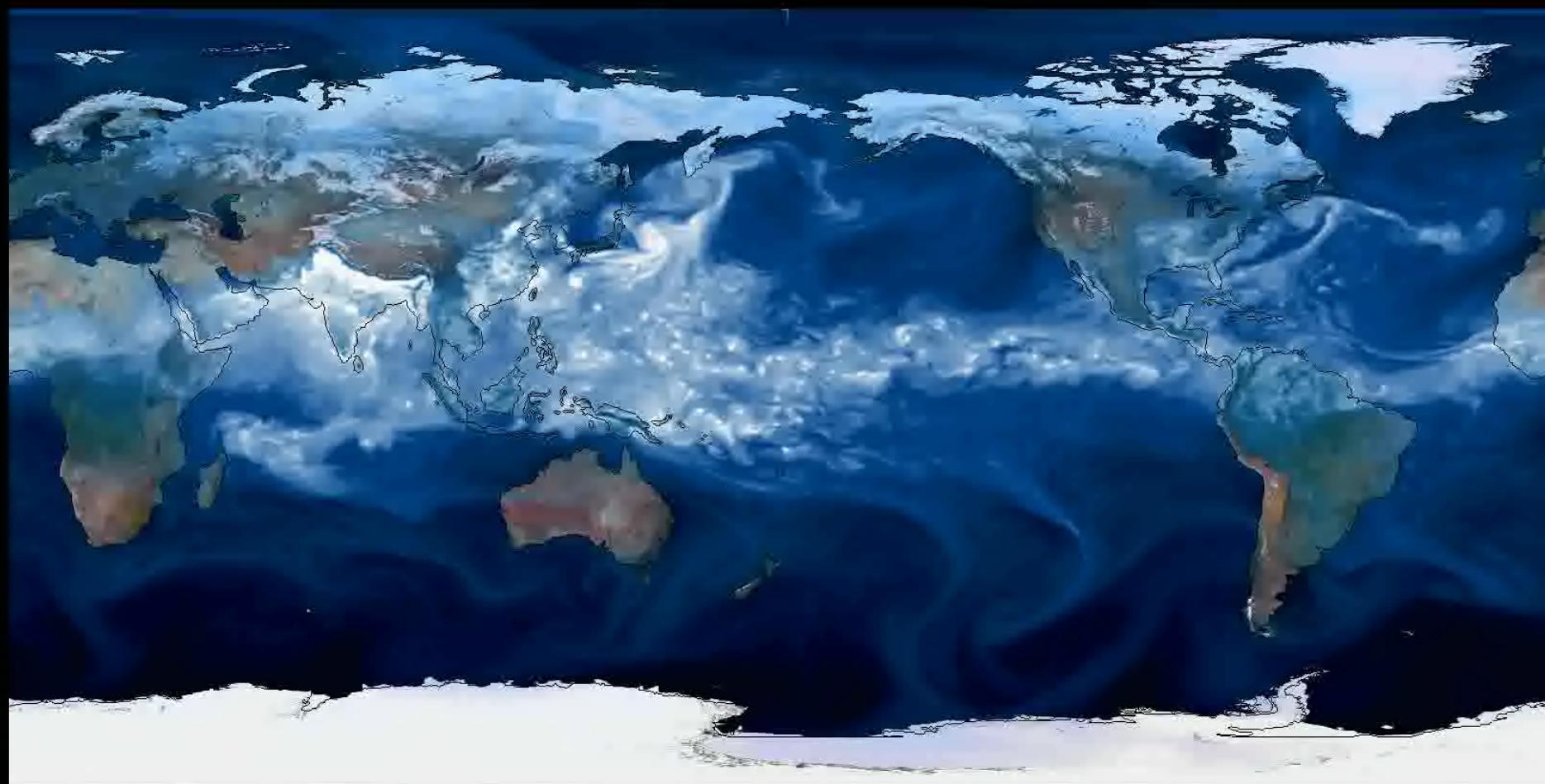


Proteins and diseases like Alzheimer's



Energy-efficient combustion engines

Simulations Show the Effects of Climate Change on Hurricanes



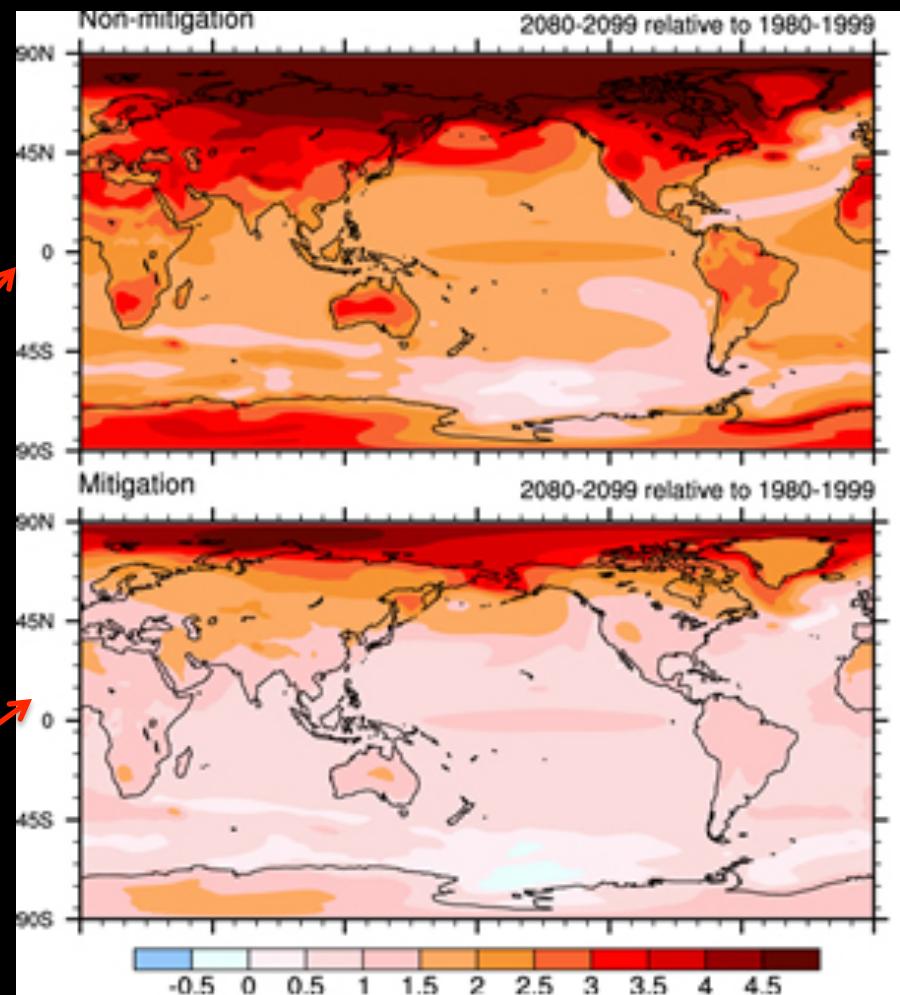
Michael Wehner and Prabhat, Berkeley

Mitigating Global Climate Change

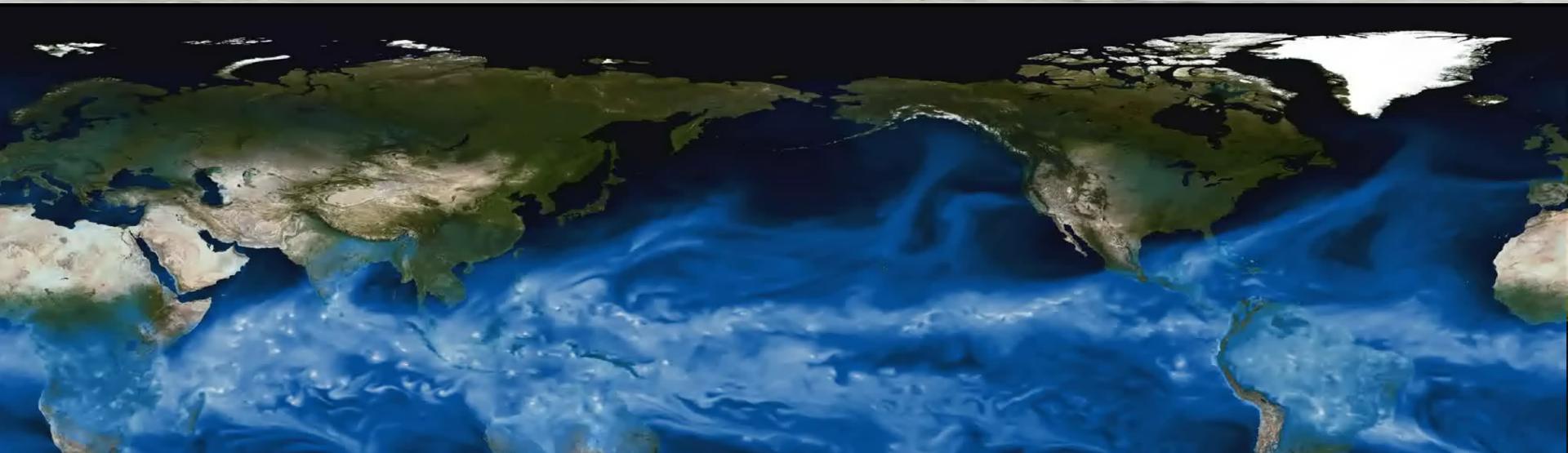
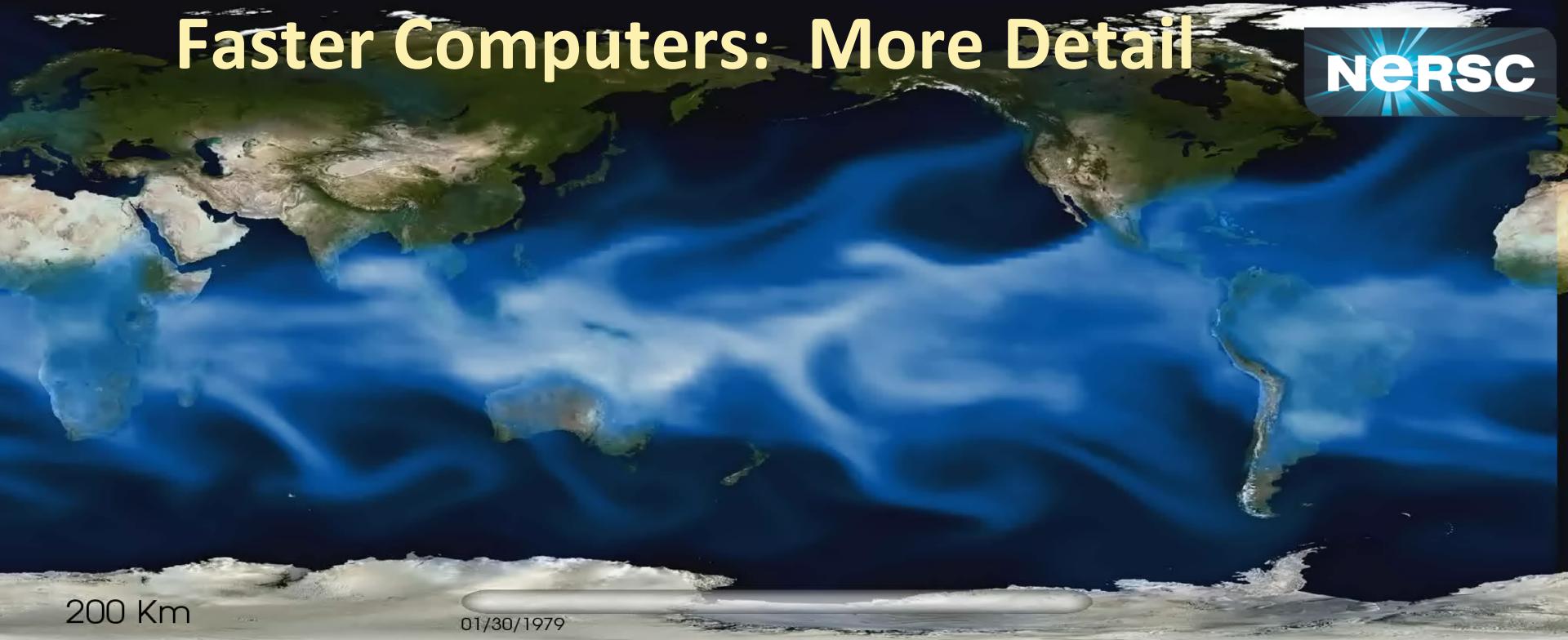
Can global warming impacts be diminished if greenhouse gases are cut?

No New Policy: Average surface air temperatures rise by >3°C if emissions increase at current rate

Reduce Carbon: Temperatures rise by <2°C across nearly all populated areas if emissions are cut by 70%

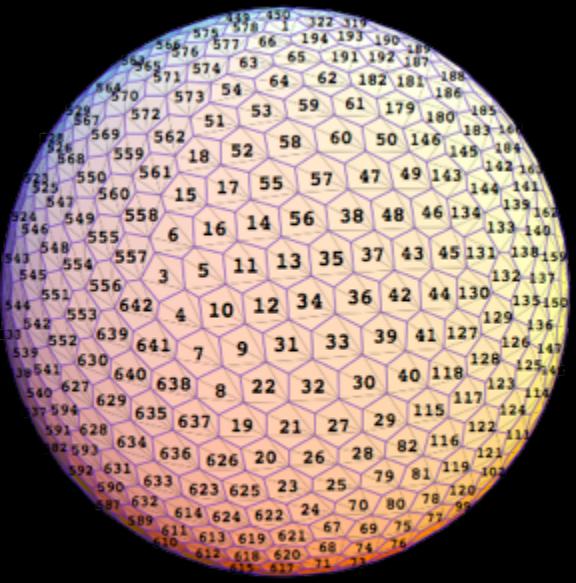
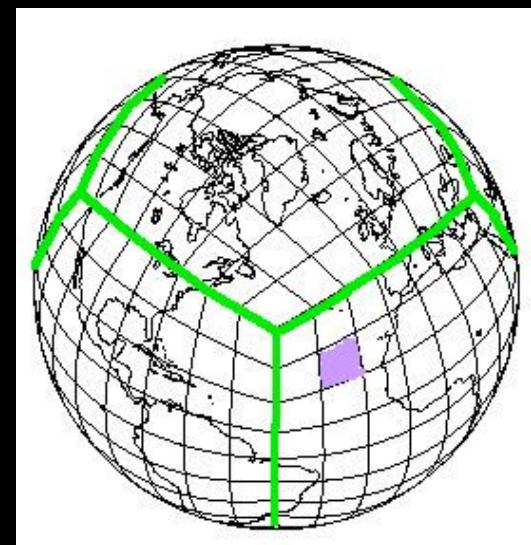
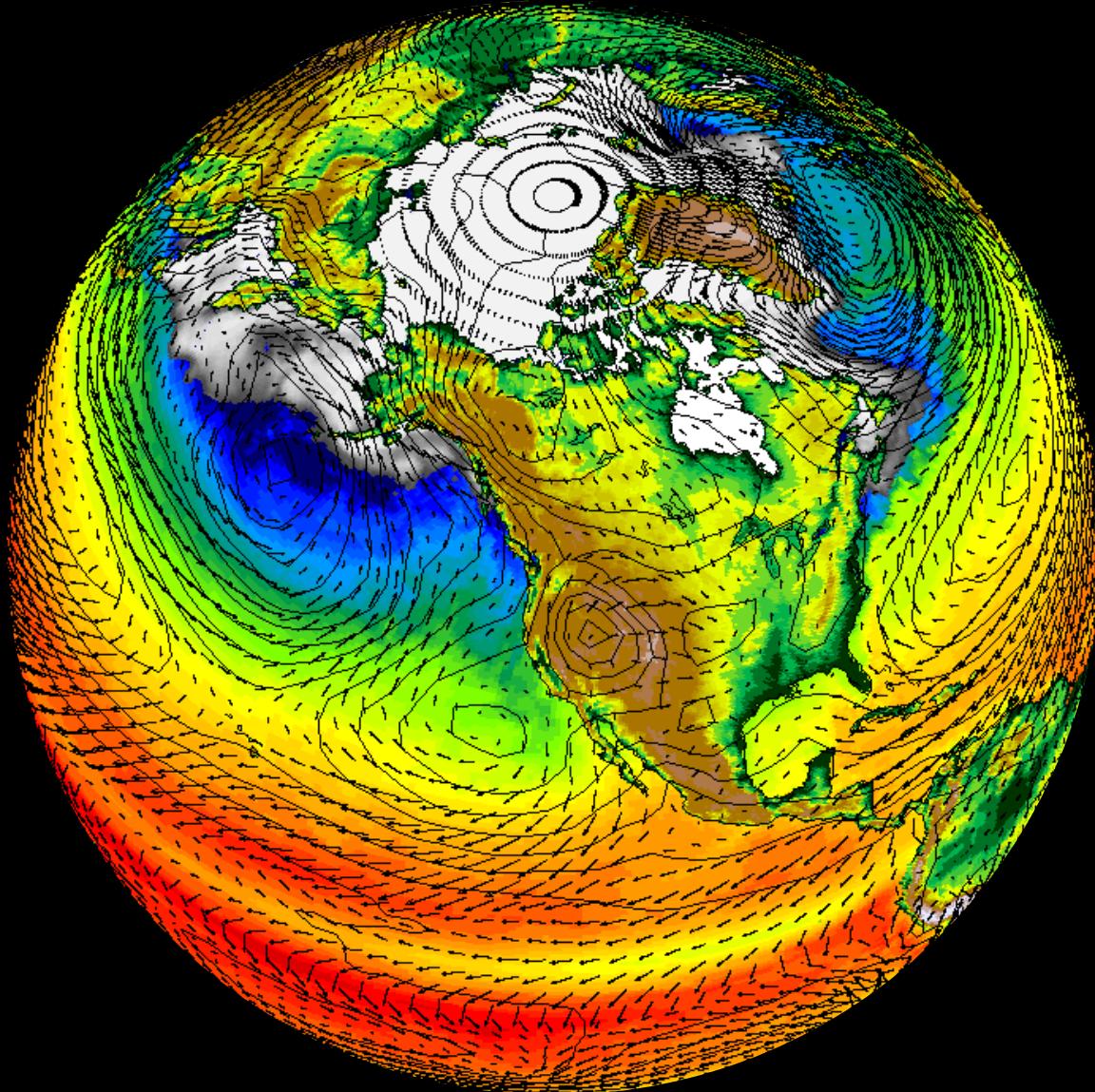


Faster Computers: More Detail

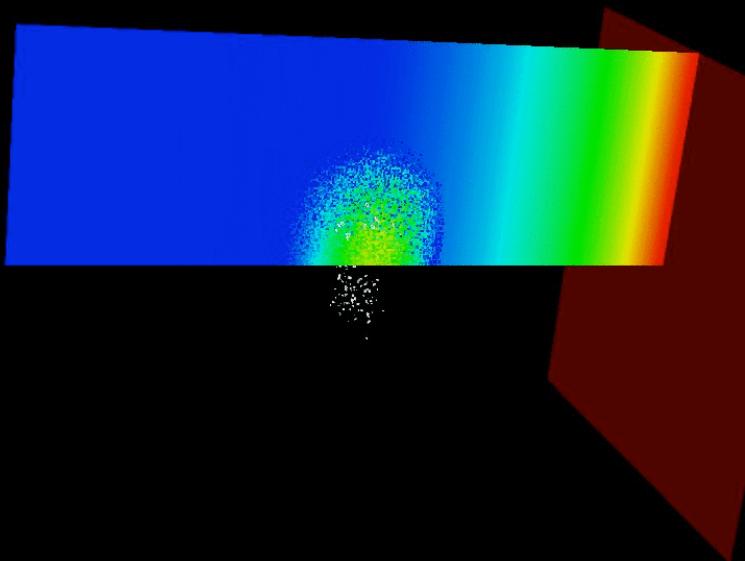


Michael Wehner, Prabhat, Chris Algieri, Fuyu Li, Bill Collins, Lawrence Berkeley National Laboratory; Kevin Reed, University of Michigan; Andrew Gettelman, Julio Bacmeister, Richard Neale, National Center for Atmospheric Research

Data Structures for Simulations

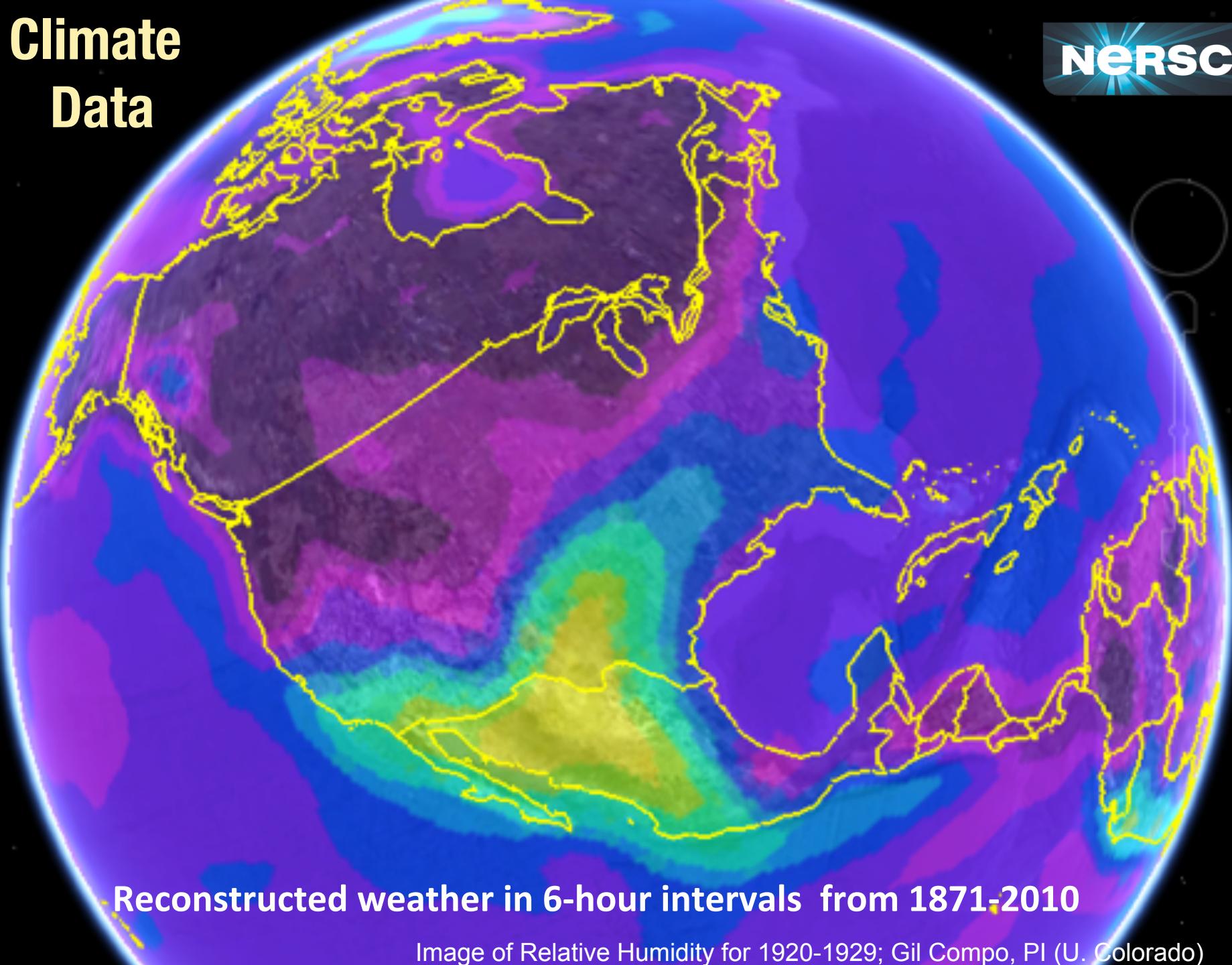


New Math Problems in Clouds



- Resolution of clouds in global models requires new math, new data structures, and faster computers

Climate Data



Reconstructed weather in 6-hour intervals from 1871-2010

Image of Relative Humidity for 1920-1929; Gil Compo, PI (U. Colorado)

Technology for Innovation

Which of the following are true?

- A. Google developed its own programming language to hide machine failures
- B. iPhones are programmed using Java
- C. Web search algorithms use only integer arithmetic, not floating point (real) numbers
- D. Scientific computing is done mostly using “Vector Supercomputers”
- E. All of the above

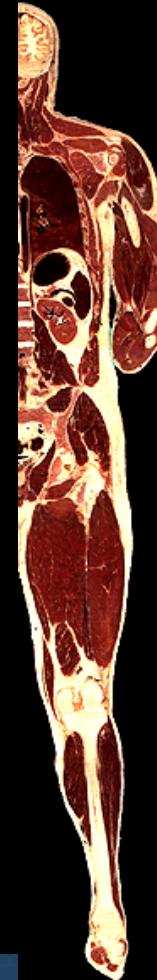
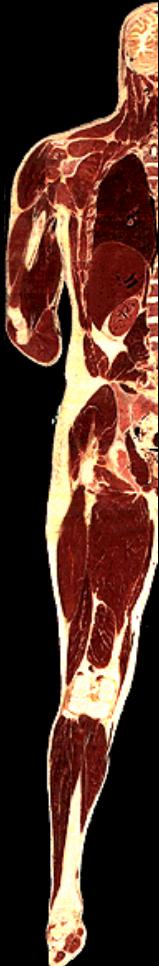
Towards a Digital Human: The 20+ Year Vision

- Digital body double
 - Diagnosis
 - Personalized medicine
 - Experimental treatments



Digital Human Today: Imaging

- The Visible Human Project
 - 18,000 digitized sections of the body
 - Male: 1mm sections, released in 1994
 - Female: .33mm sections, released in 1995
 - Goals
 - study of human anatomy
 - testing medical imaging algorithms
 - Current applications:
 - educational, diagnostic, treatment planning, virtual reality, artistic, mathematical and industrial
 - Used by > 1,400 licensees in 42 countries



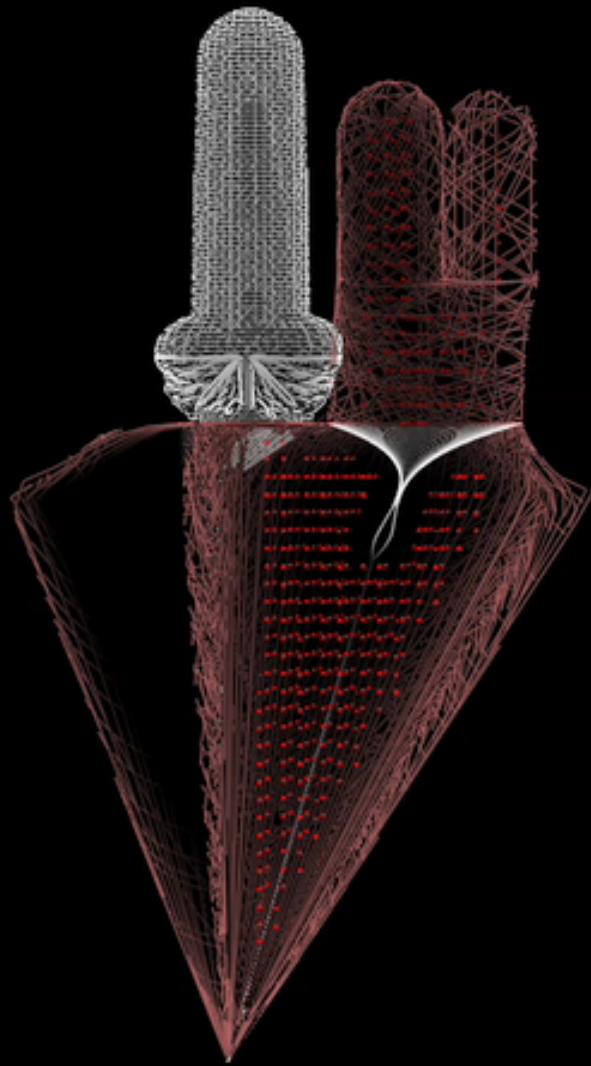
Experimental Data: Visible Human

**The National Library of Medicine's
Visible Human Project^(TM)**

**Human-Computer Interaction Lab
Univ. of Maryland at College Park**

Heart Simulation

Movie from Boyce Griffith's PhD thesis, NYU



Writing Software

Which of the following are true?

- A. Most computer software is written by brilliant hackers, working alone
- B. Parallel programming is a *solved problem*
- C. Speed of programming and speed of programs are the top goals in software
- D. Most software is rewritten from scratch every few years
- E. None of the above

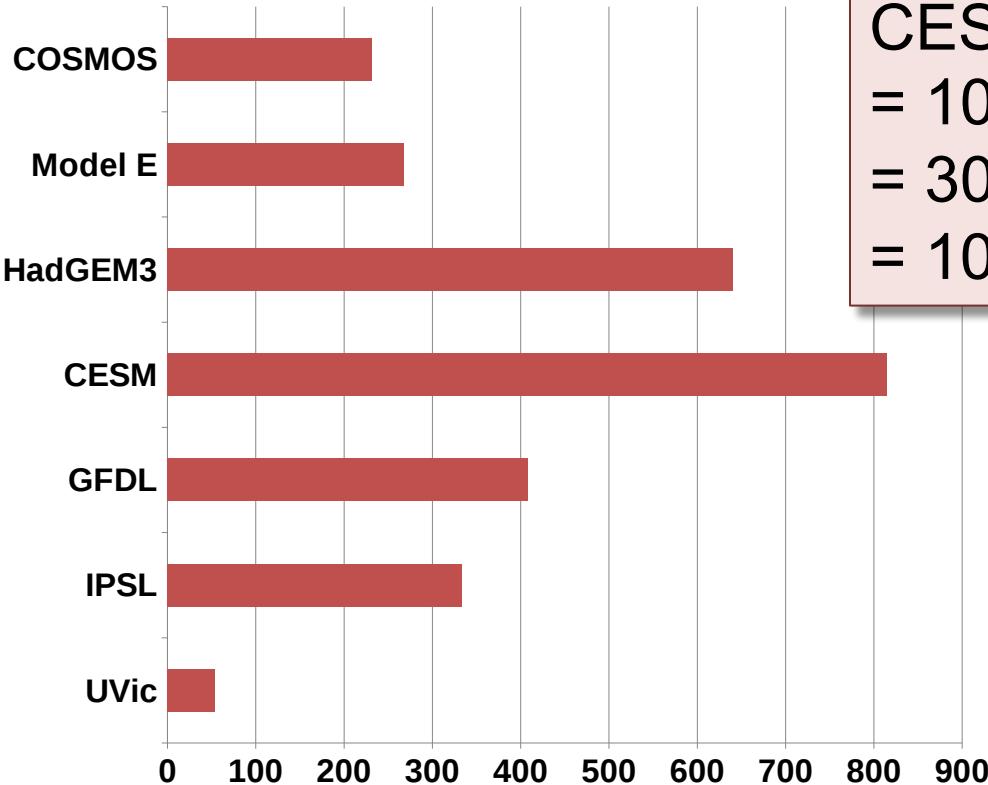
Scientific Computing is a Team Sport



IPCC Working Groups I, II and III
(Intergovernment Panel and Climate Change)

How big are these applications

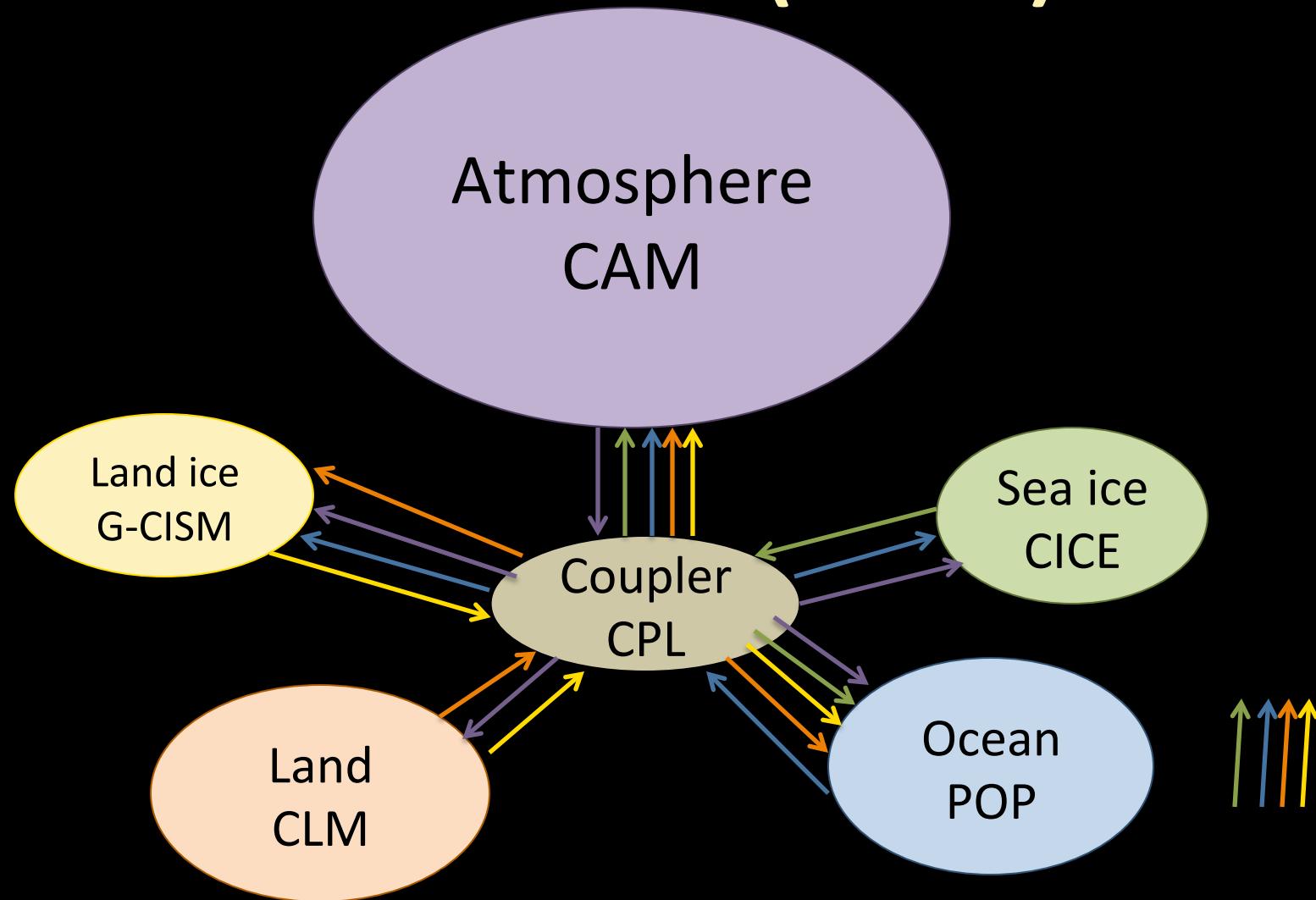
Size (thousands of lines of code)



CESM: ~1M lines of code
= 10K programmer days?
= 300 programmer years
= 100 programmers, 3 years

Generated using David A. Wheeler's
“SLOCCount”.

Abstractions in the Community Climate Code (CESM)



Real-Time Deformation and Fracture in a Game Environment

Eric Parker
Pixelux Entertainment

James O'Brien
U.C. Berkeley

Video Edited by Sebastian Burke

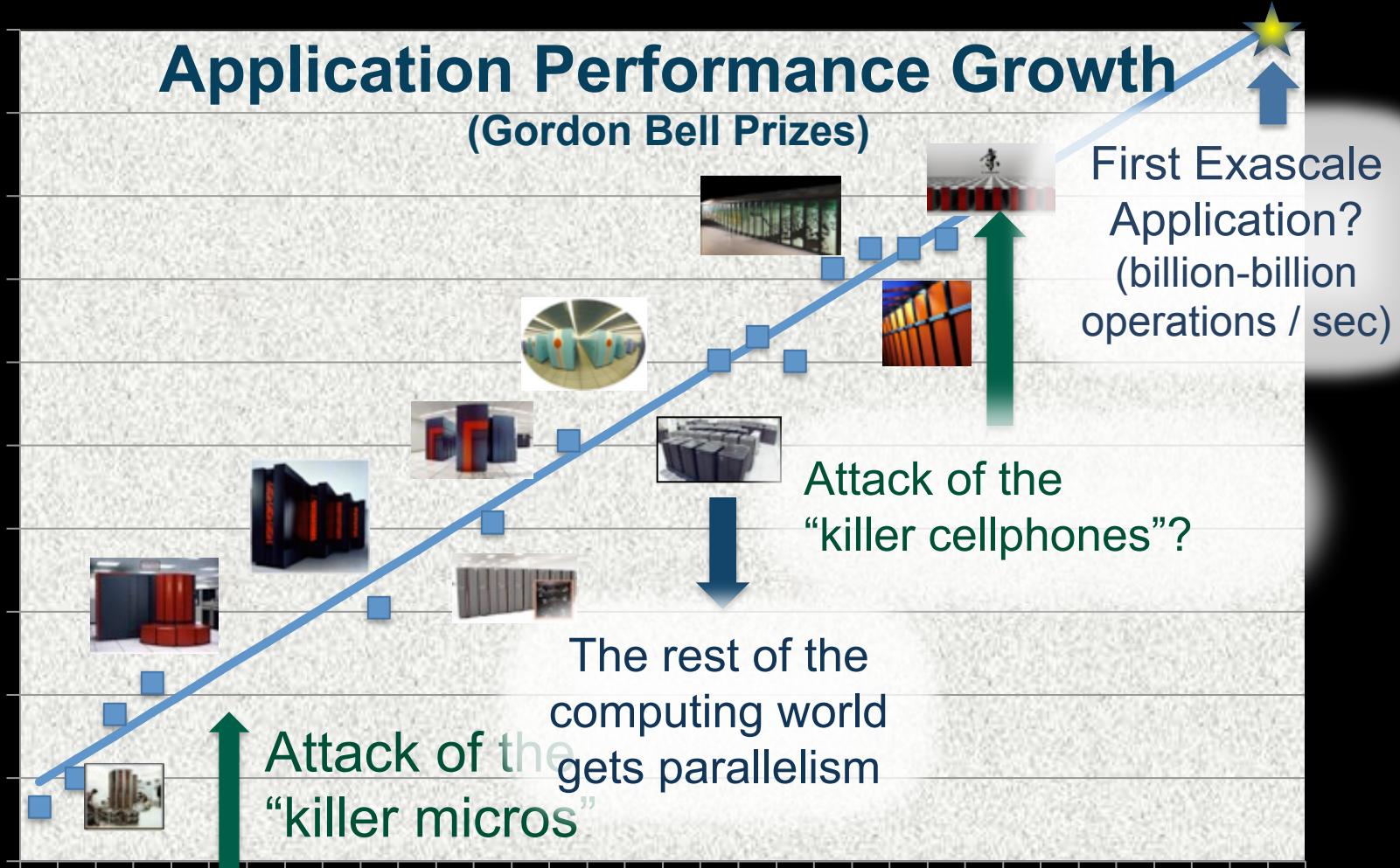
From the proceedings of SCA 2009, New Orleans

Trends in Computer Science

Which of the following are true?

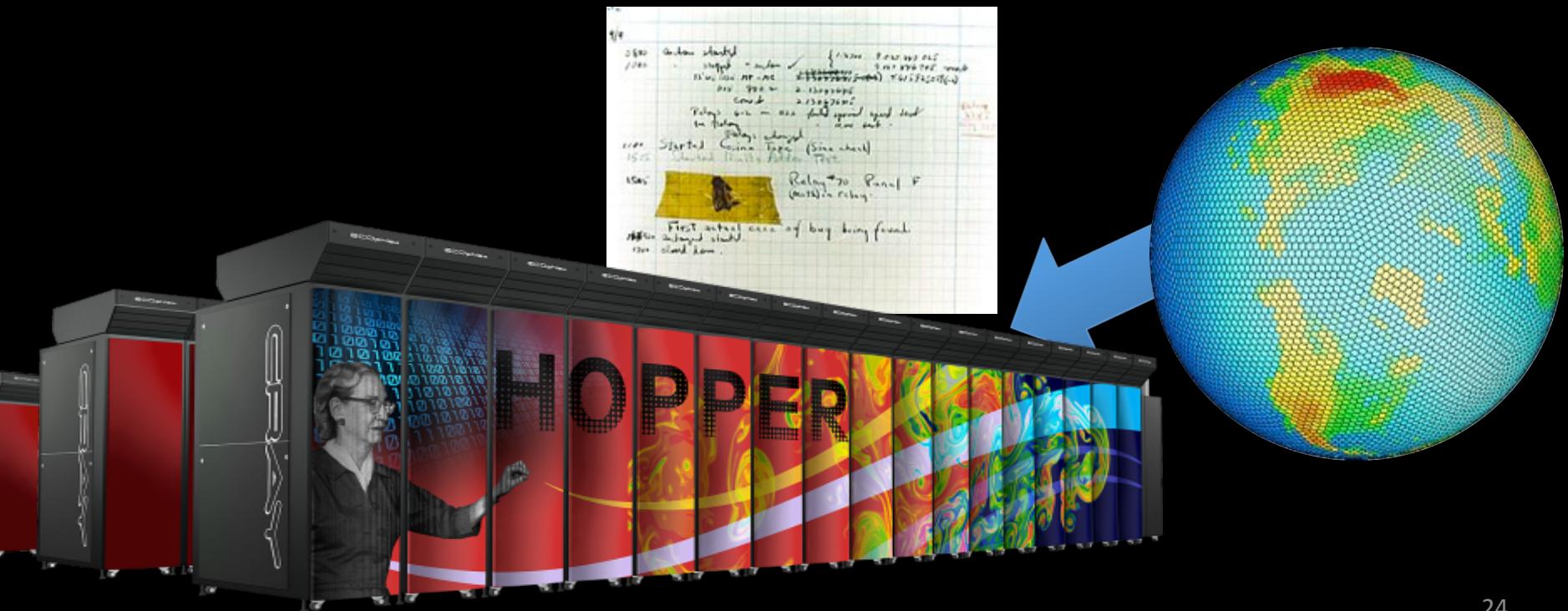
- A. Moore's Law says that processor performance doubles every 18 months
- B. Moore's Law ended in 2005
- C. Most of the time in scientific codes is spent doing arithmetic
- D. None of the above
- E. All of the above

High End Computing Revolutions

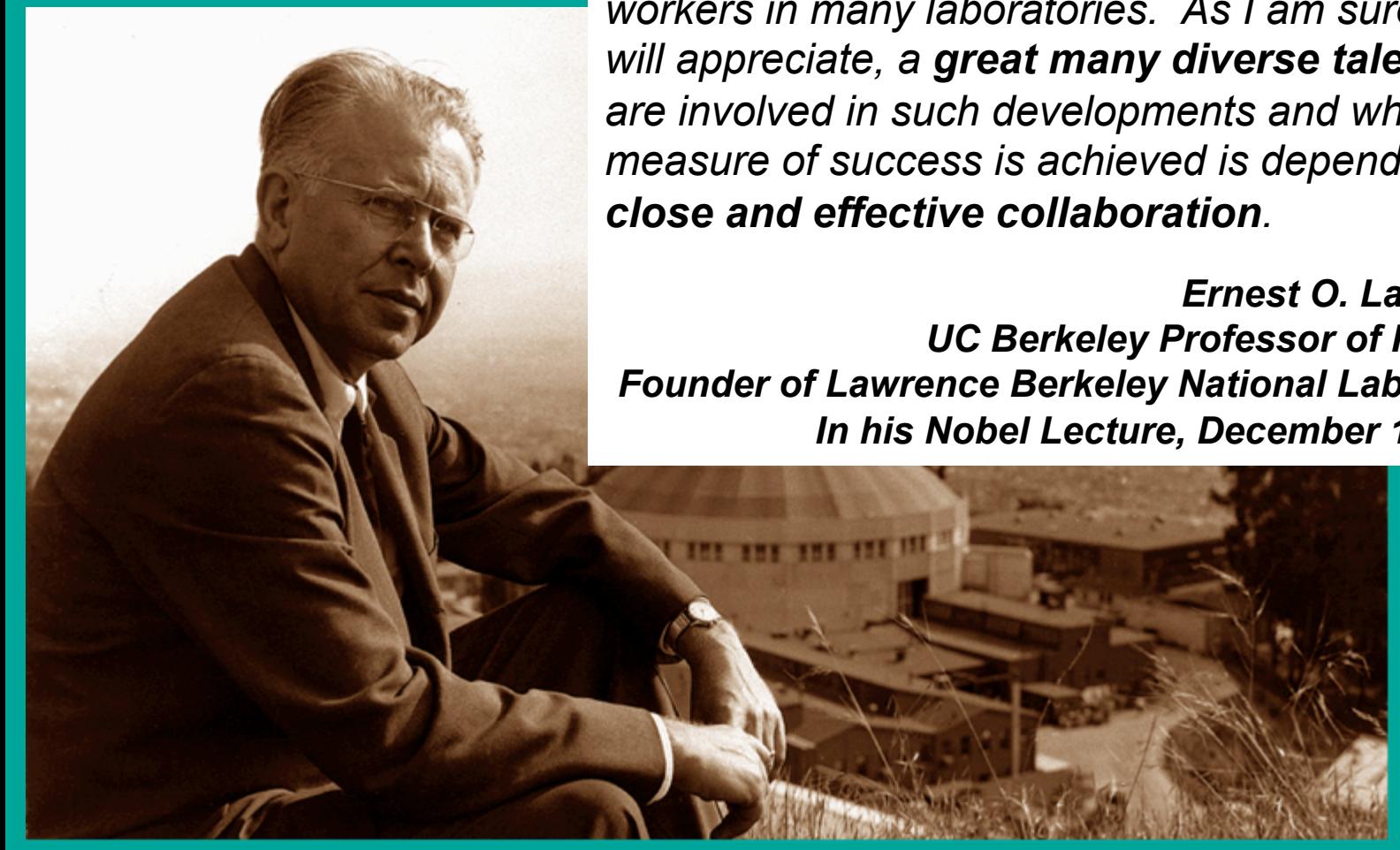


The Fastest Computers (for Science) Have Been Parallel for a Long Time

- Fastest Computers in the world: top500.org
- Our Hopper Computer has 150,000 cores and > 1 Petaflop (10^{15} math operations / second)
- Programming and “debugging” are challenging



Computational Science is Necessarily Collaborative



*... as from the beginning the work has been a team effort involving many able and devoted co-workers in many laboratories. As I am sure you will appreciate, a **great many diverse talents** are involved in such developments and whatever measure of success is achieved is dependent on **close and effective collaboration**.*

Ernest O. Lawrence
UC Berkeley Professor of Physics
Founder of Lawrence Berkeley National Laboratory
In his Nobel Lecture, December 11, 1951