# Overview of NCSA
## Defining the Future of Computing

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# Outline of Presentation

- **NCSA Strategic Directions**
- **Blue Waters Project**
  - NSF HPC Strategy
  - Blue Waters Petascale Computing System
  - Accelerators for Blue Waters
- **Advanced Information Systems**
  - Cyberenvironments
    - MAEViz cyberenvironment
    - Cyberenvironments for environmental observatories
    - LSST Cyberenvironment
- **Advanced Visualization**
  - Birth of a Tornado

# NCSA Strategic Directions

- **Cyber-resources**
  *... enabling discovery at the leading edge*
  - Provide leading edge computing and data storage resources and network connectivity as well as user services
  - Assess innovative computing technologies that promise to decrease the cost or extend the range of computational science and engineering
  - Develop and deploy a *sustained* petaflops system: *Blue Waters*
- **Cyberenvironments**
  *... harnessing the power of the national cyberinfrastructure*
  - Develop integrated, end-to-end software environments to coordinate, automate, and apply high-end resources and capabilities
  - Develop cyberservices and cybertechnologies needed to build cyberenvironments

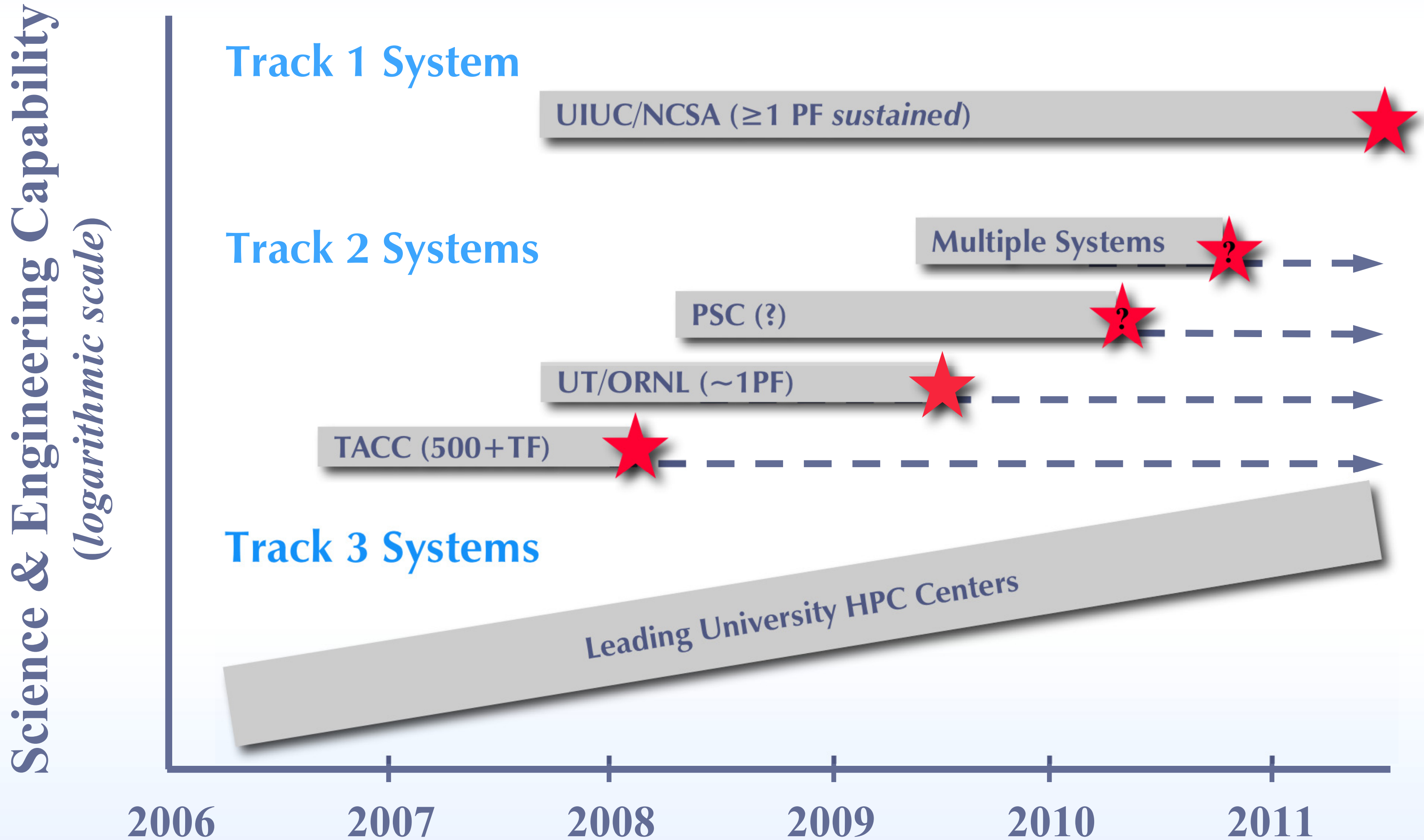
# NCSA Strategic Directions *(cont'd)*

- **Advanced Visualization**
  *... providing critical insights, educating the public*
  - Develop scientific visualization for scientists and engineers
  - Create popular visualizations for the public
- **Data-intensive Computing**
  *... processing massive data sets, extracting knowledge from data*
  - Manage, process and analyze large data sets and data streams
  - Develop and apply automated analysis and learning techniques
- **Cybereducation**
  *... bringing cyber-enabled science into the classroom*
  - Scientific literacy *through* computational science and technology
  - *Virtual School of Computational Science and Engineering*

# Cyber-resources
## Blue Waters Project

*Blue Waters Project*

# NSF's Strategy for High-end Computing



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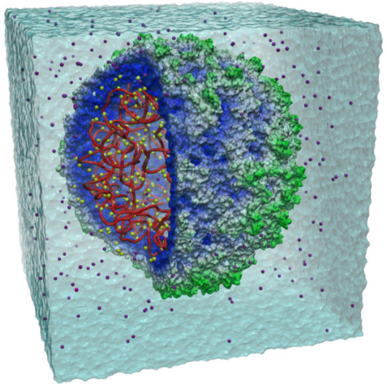
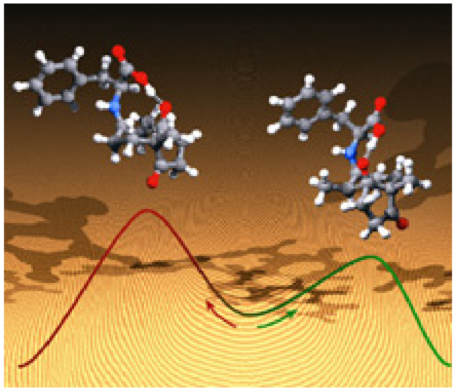
# Science @ Petascale

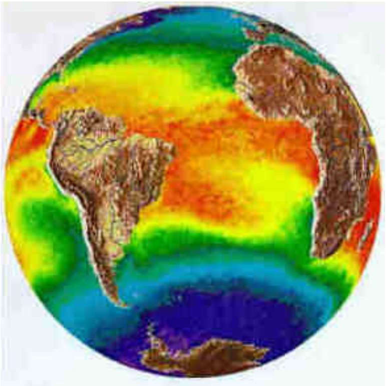
*Petascale computing will enable advances in a broad range of science and engineering disciplines:*

**Molecular Science**

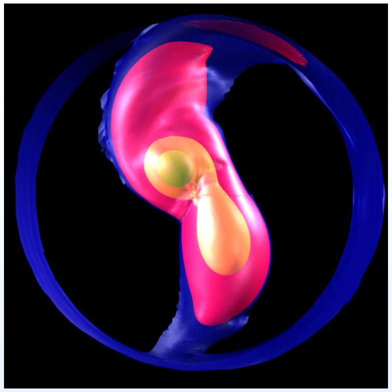




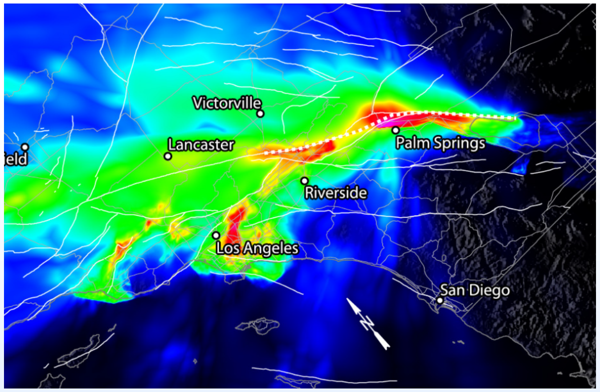
**Weather & Climate Forecasting**



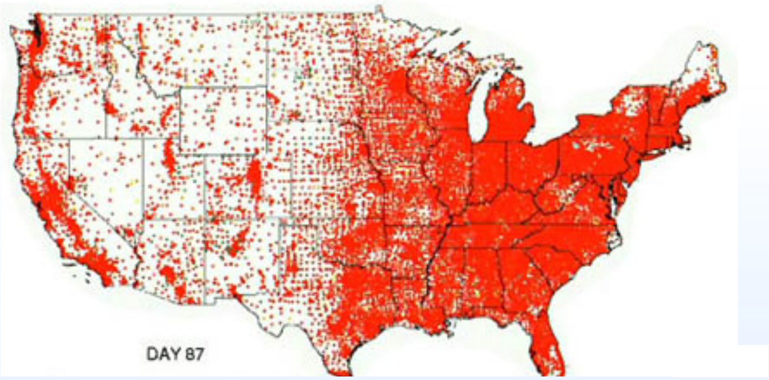
**Astronomy**



**Earth Science**




**Health**



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# Selection Criteria for Petascale Computer

- **Maximize Core Performance**

  …to minimize number of cores needed for a given level of performance as well as lessen the impact of sections of code with limited scalability

- **Incorporate Large, High-bandwidth Memory Subsystem**

  …to enable the solution of memory-intensive problems

- **Maximize Interconnect Performance**

  …to facilitate scaling to the large numbers of processors required for sustained petascale performance

- **Integrate High-performance I/O Subsystem**

  …to enable solution of data-intensive problems

- **Maximize System Integration, Leverage Mainframe Reliability, Availability, Serviceability (RAS) Technologies**

  …to assure reliable operation for long-running, large-scale simulations

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# Blue Waters Computing System

| System Attribute | Abe | Blue Waters |
|---|---|---|
| Vendor | Dell | IBM |
| Processor | Intel Xeon 5300 | IBM Power7 |
| Peak Performance (PF) | 0.090 | |
| Sustained Performance (PF) | 0.005 | ≥1 |
| Number of Cores/Chip | 4 | |
| Number of Processor Cores | 9,600 | >200,000 |
| Amount of Memory (TB) | 14.4 | >800 |
| Amount of Disk Storage (TB) | 100 | >10,000 |
| Amount of Archival Storage (PB) | 5 | >500 |
| External Bandwidth (Gbps) | 40 | 100-400 |

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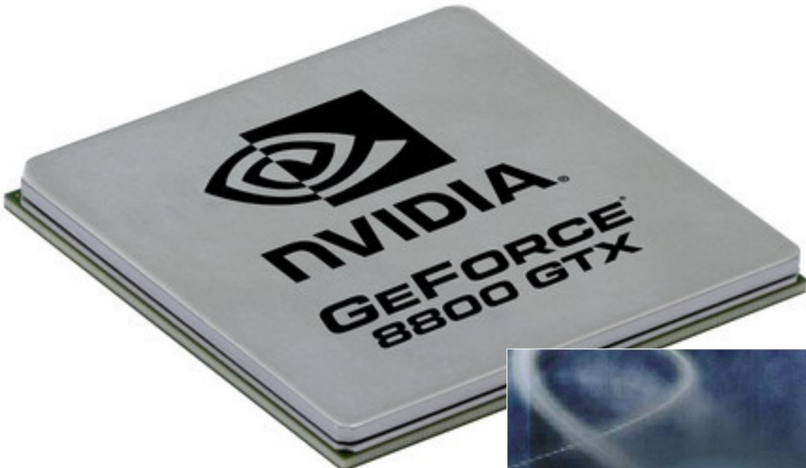
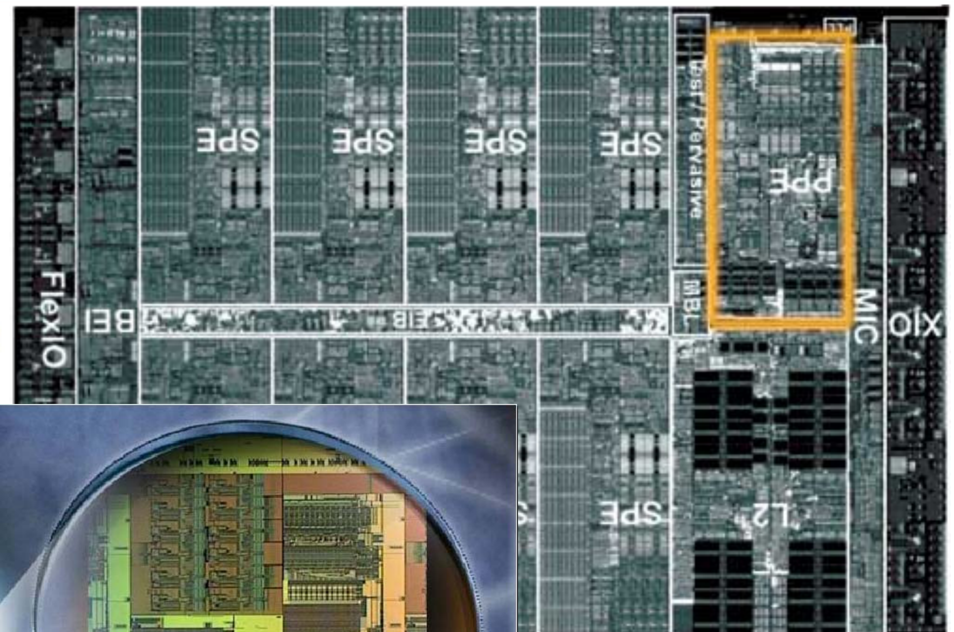
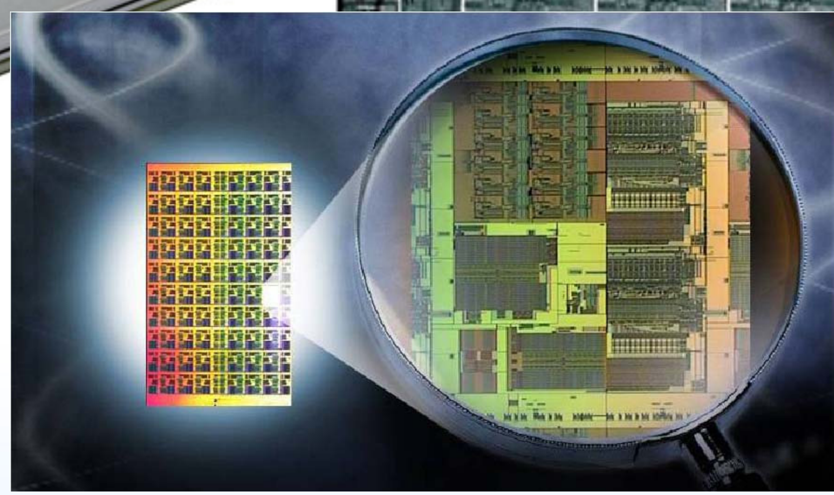
# Accelerators for Blue Waters




**NVIDIA GeForce 8800 GTX (128 cores)**




**IBM Cell (1+8 cores)**



**Intel Teraflops Chip (80 cores)**

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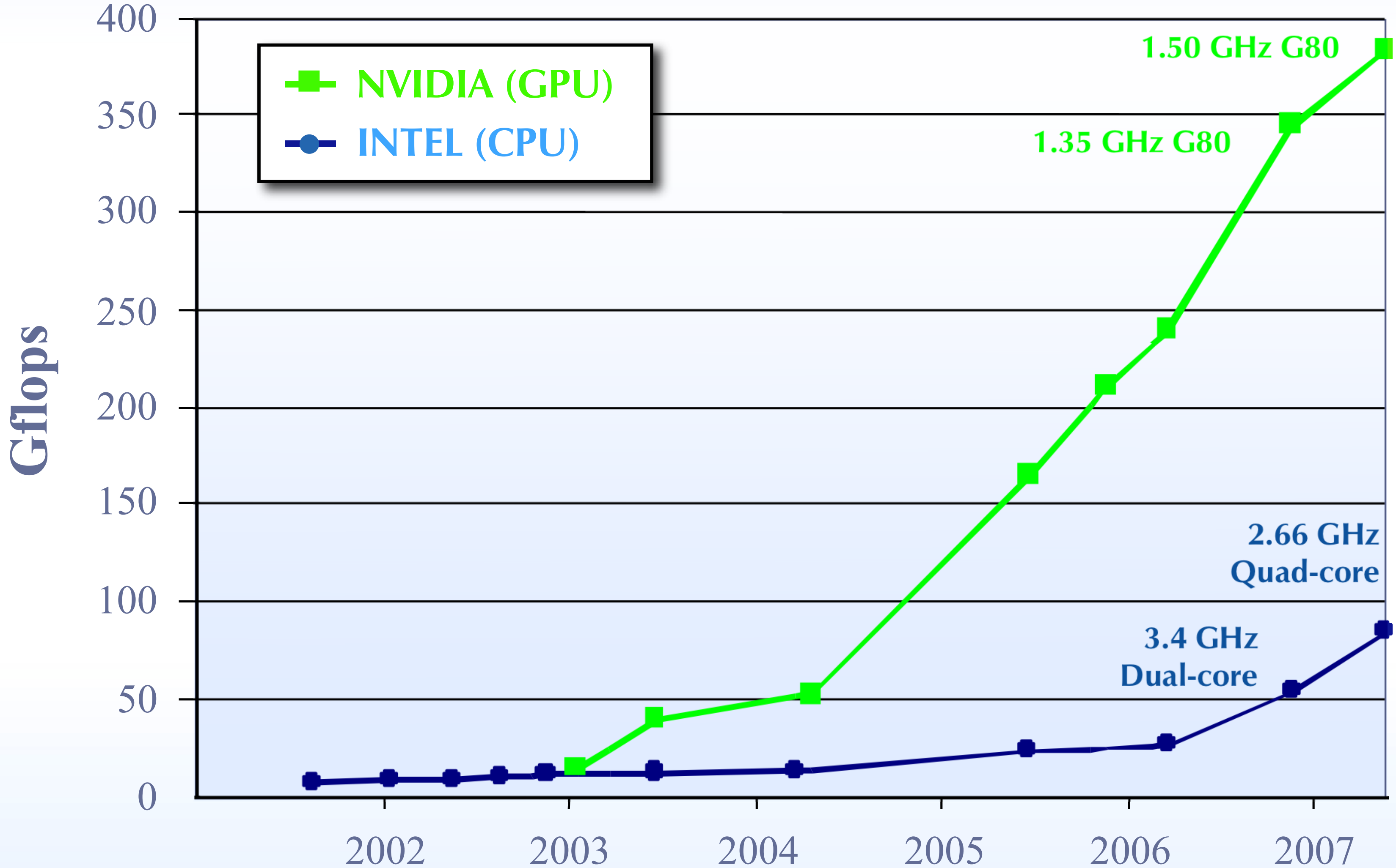
# Compaison of GPU vs. CPU Performance




*Courtesy of John Owens (UCSD) & Ian Buck (NVIDIA)*

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# NVIDIA: Selected Benchmarks

| Application | Description | Kernel X | App X |
|---|---|---|---|
| H.264 | SPEC '06 version, change in guess vector | 20.2 | 1.5 |
| LBM | SPEC '06 version, change to single precision and print fewer reports | 12.5 | 12.3 |
| FEM | Finite element modeling, simulation of 3D graded materials | 11.0 | 10.1 |
| RPES | Rys polynomial equation solver, 2-electron repulsion integrals | 210.0 | 79.4 |
| PNS | Petri net simulation of a distributed system | 24.0 | 23.7 |
| LINPACK | Single-precision implementation of saxpy, used in Gaussian elimination routine | 19.4 | 11.8 |
| TRACF | Two Point Angular Correlation Function | 60.2 | 21.6 |
| FDTD | Finite-difference time domain analysis of 2D electromagnetic wave propagation | 10.5 | 1.2 |
| MRI-Q | Computing a matrix Q, a scanner's configuration in MRI reconstruction | 457.0 | 431.0 |

* W-m. Hwu et al., 2007

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# Petascale Computing Facility


## Partners

EYP MCF/
Gensler
IBM
Yahoo!

- **Modern Data Center**
  - 90,000+ $ft^2$ total
  - 20,000 $ft^2$ machine room
- **Energy Efficiency**
  - LEED certified (goal: silver)
  - Efficient cooling system

www.ncsa.uiuc.edu/BlueWaters

# Great Lakes Consortium for Petascale Computation

**Goal:** Facilitate the widespread and effective use of petascale computing to address frontier research questions in science, technology and engineering at research, educational and industrial organizations across the region and nation.

## Charter Members

Argonne National Laboratory
Fermi National Accelerator Laboratory
Illinois Math and Science Academy
Illinois Wesleyan University
**Indiana University***
Iowa State University
Illinois Mathematics and Science Academy
Krell Institute, Inc.
Louisiana State University
**Michigan State University***
**Northwestern University***
Parkland Community College
**Pennsylvania State University***
**Purdue University***
**The Ohio State University***
Shiloh Community Unit School District #1
Shodor Education Foundation, Inc.
SURA – 60 plus universities
**University of Chicago***
**University of Illinois at Chicago***
**University of Illinois at Urbana-Champaign***
**University of Iowa***
**University of Michigan***
**University of Minnesota***
University of North Carolina–Chapel Hill
**University of Wisconsin–Madison***
Wayne City High School

*** CIC universities***

# Cyberenvironments

## Advanced Information Systems

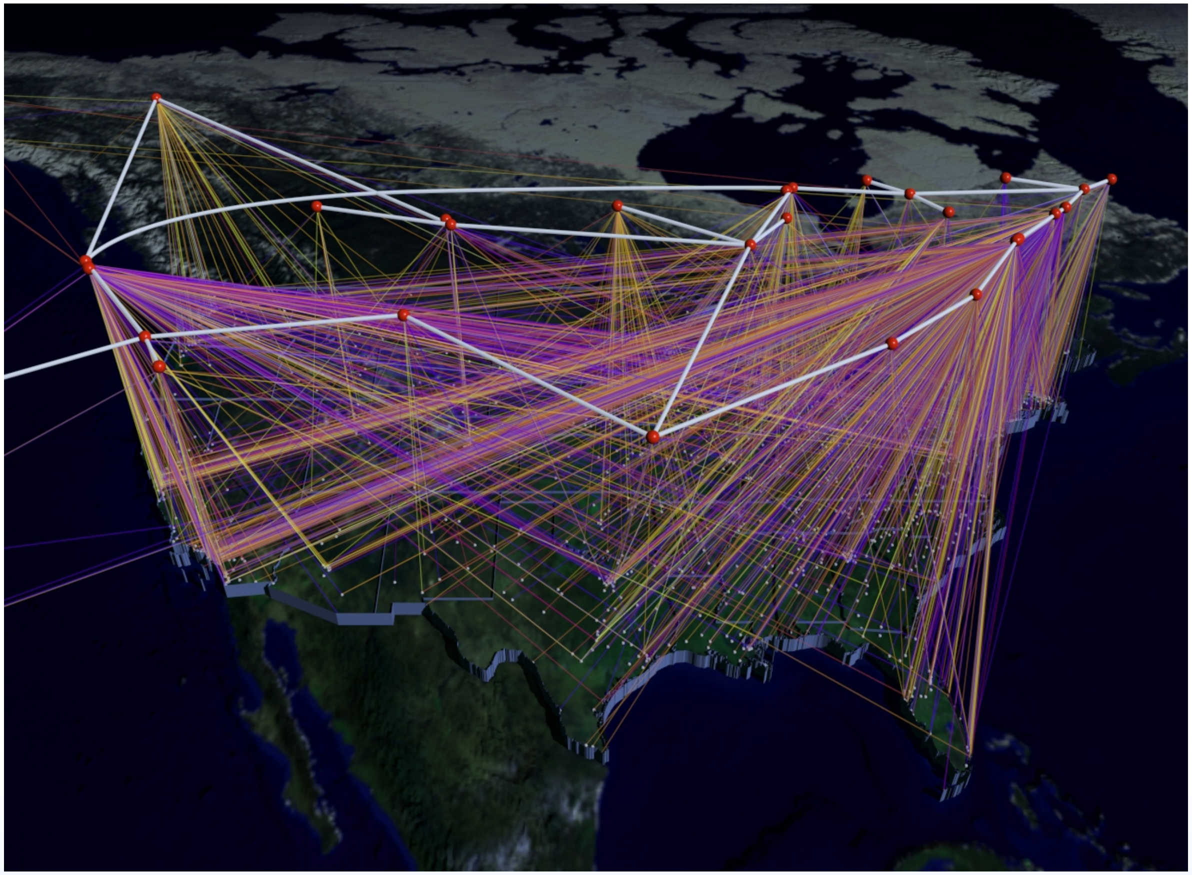
# National Cyberinfrastructure

**Hardware**

- Computers
- Data sources
- Data stores
- Networks

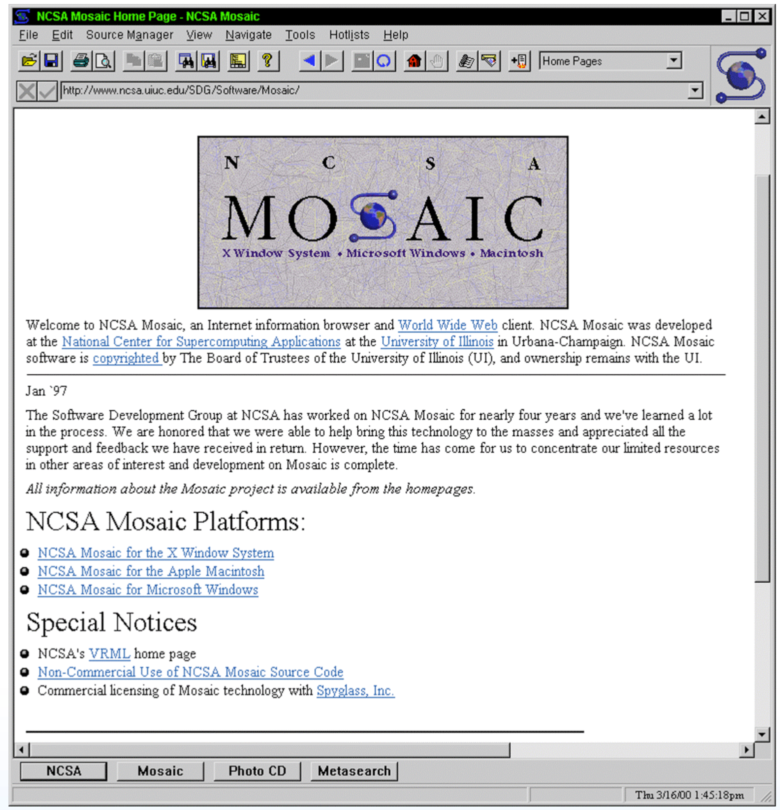
**Software**

- Middleware
- Portals
- Applications
- Visualization
- Data analysis
- …

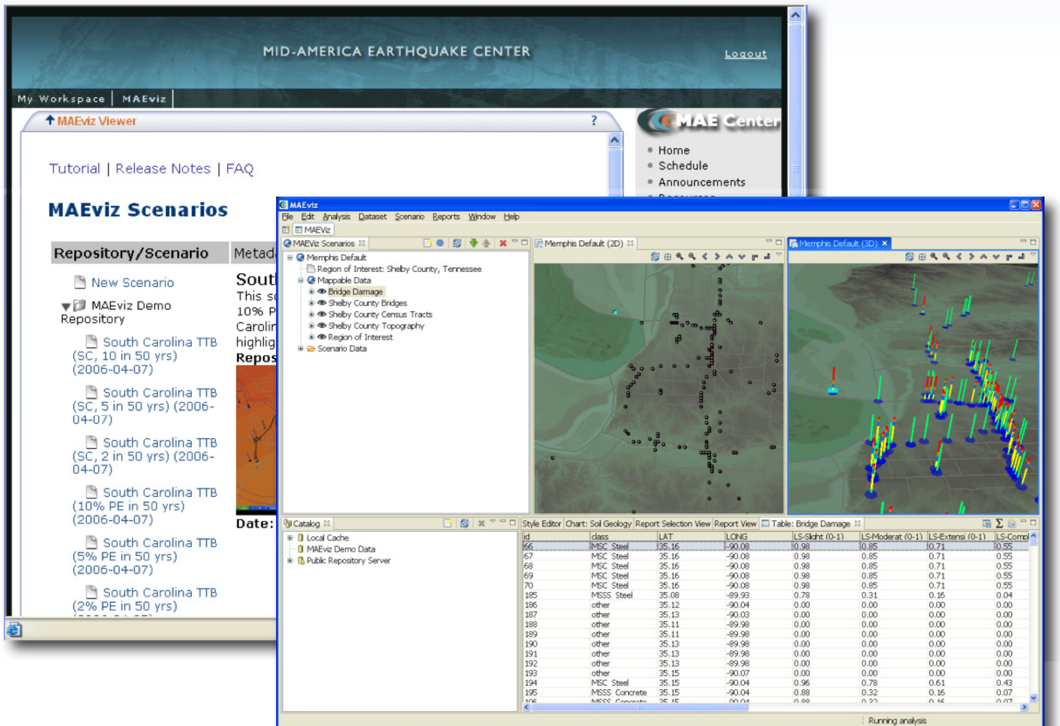


# Cyberenvironments

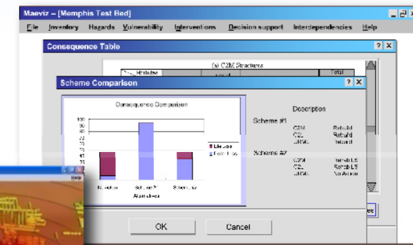
- **Mosaic**
  - By early 1990s, the internet had a wealth of resources, but they were inaccessible to most scientists
  - *Mosaic* facilitated the use of the internet by ***all*** scientists (and, eventually, by laymen!)
- **Cyberenvironments**
  - *Cyberenvironments* will facilitate the use of cyber-infrastructure by ***all*** scientists



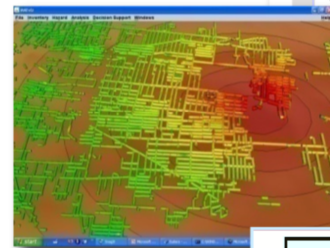
# Cyberenvironment for Earthquake Engineering



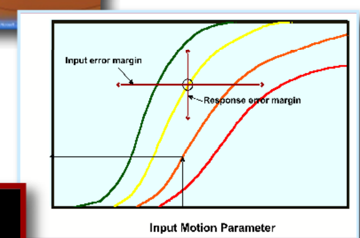

Decision Support



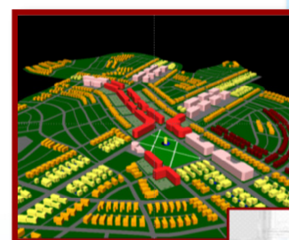
Damage Prediction



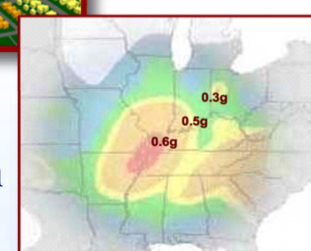
Fragility Models




Inventory Selection



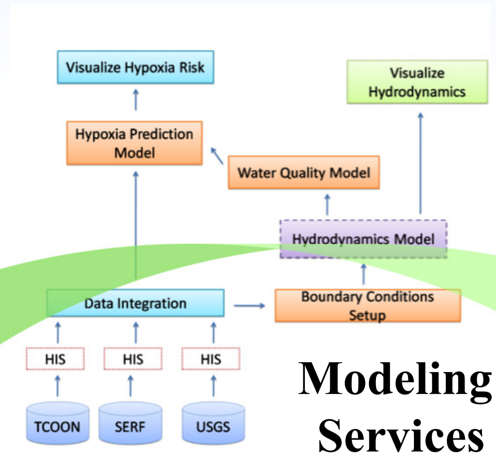
Hazard Definition



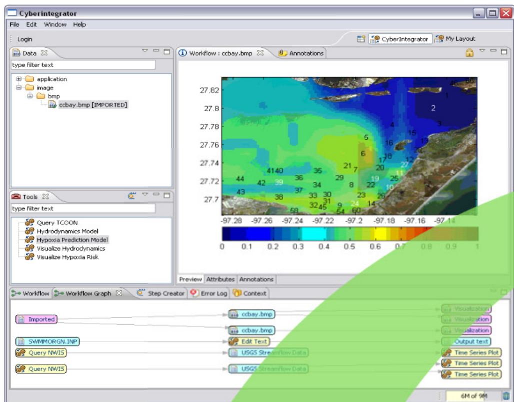

- **Mid-America Earthquake Center**

  ***Consequence-based risk management for seismic events***
  - Portal-based collaboration environment
  - Distributed data/metadata sources
  - Multi-disciplinary collaboration

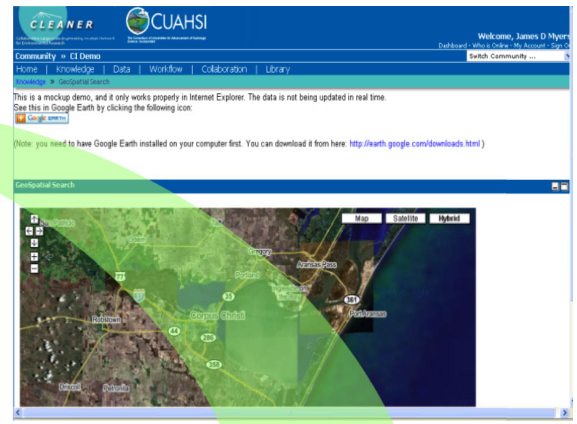
# Cyberenvironments for Environmental Observatories



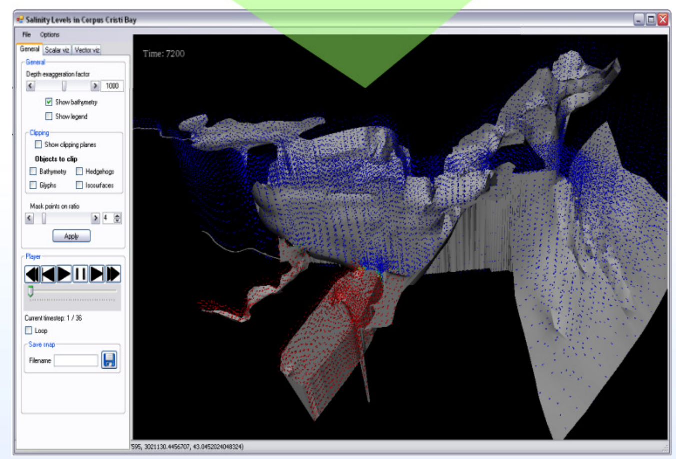

**Modeling Services**



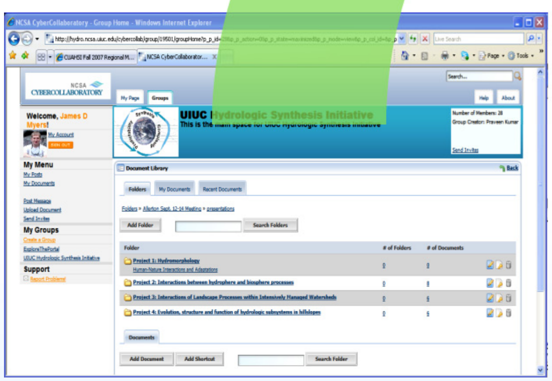
**Workflow**



**Analysis/Visualization**



## Create Experiment
## Gather Data
## Run Experiment
## Publish to the Web
## for others to explore



**Portal**

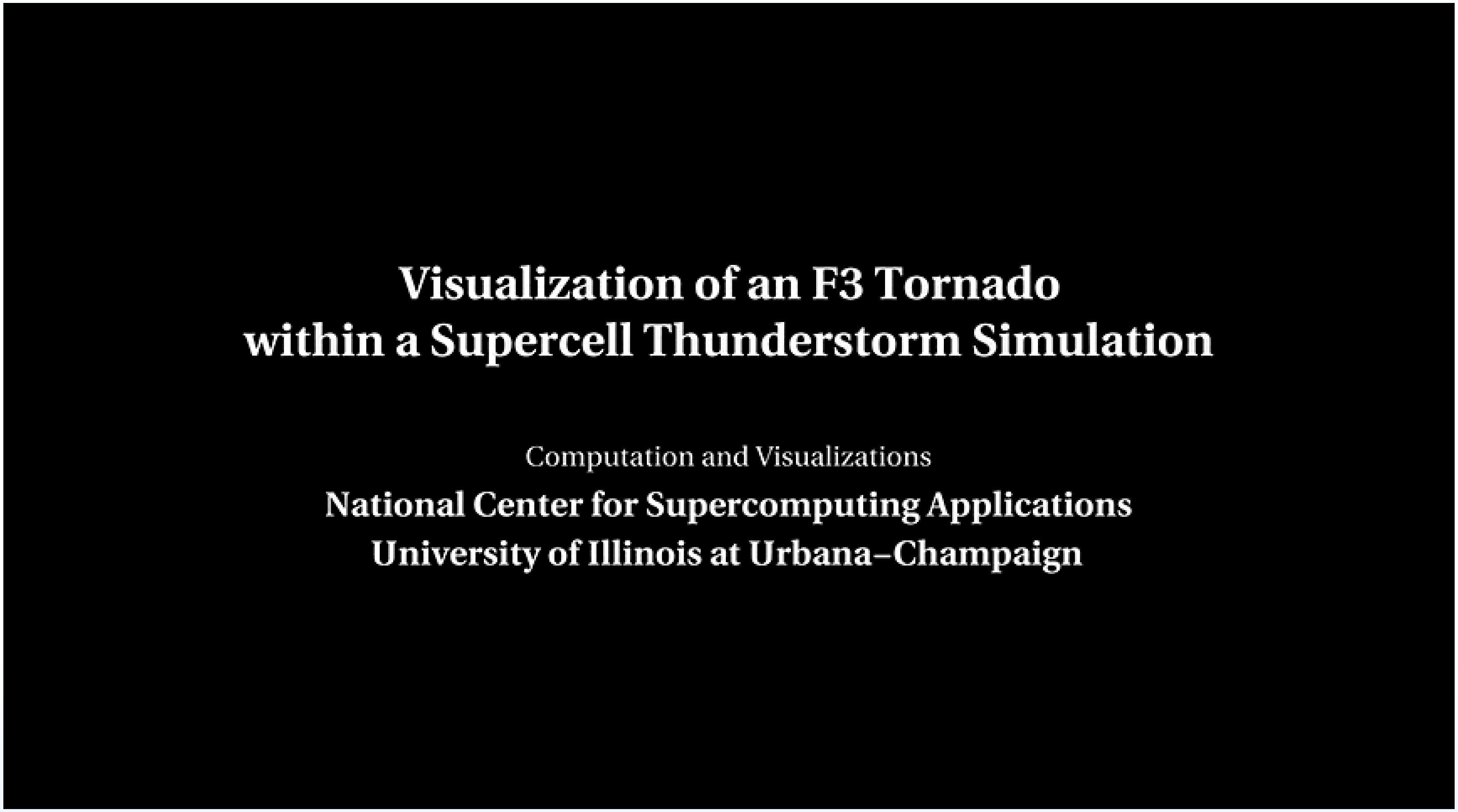
# Large Synoptic Survey Telescope (LSST)

- **New Telescope**
  - Located in Chile (El Peñon) with first light in 2013
  - 8.4-m Mirror with 3 Gigapixel camera
  - Image available sky every 3 days
- **Science Missions**
  - Nature of dark energy and accelerating universe
  - Comprehensive census of solar system objects, create galactic map
  - Explore transients and variable objects
- **Data Sets**
  - 15-20 terabytes per night
  - 50-100 petabytes in 10 years

**Data-transport, processing and analysis environment**

# Advanced Visualization

# Birth of a Tornado



# Questions?