Los Alamos National Laboratory
Modeling & Simulation

Lawrence J. Cox, Ph.D.
Deputy Division Leader
Computer, Computational and Statistical Sciences

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Modeling and Simulation is Core to LANL's Missions

- **Simulation is actively/successfully used in all LANL missions, and has been since the days of the Manhattan Project**
  - ***National Security*** **from all aspects**
    - Stockpile Stewardship, Nuclear Non-proliferation, Global Threat Reduction, Energy Security
  - **Fundamental and Applied** ***Science & Technology*** **of every type**
    - Chemistry, Physics, Biology, Materials, Astrophysics
    - Infrastructure, Manufacturing, Informatics

- **1.64 pFLOP/s of computing resources in active use**
  - *Roadrunner* – 1.1 pFLOP/s hybrid system; currently #1 on Top500 list

LANL has been a Pioneer of Cutting Edge Computing for 65 Years

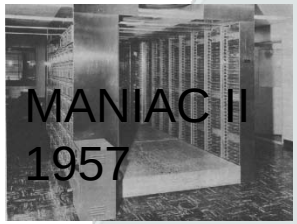
[Small/large core memory]

Cray 1 1976
[Vector machine]

Cray X-MP
1983

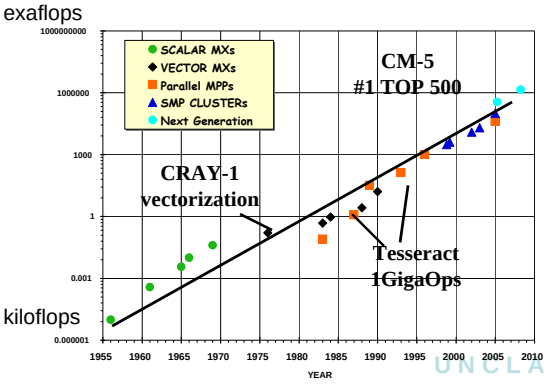
TMC CM-5
1992 [hypercube]

Blue Mountain 1998
[Massively parallel]



- Core NW mission needs have been major industry driver, but that has changed.
- Significant changes in architecture have accompanied the increasing power
- Resulted in rich capability of coupling scientific algorithms to varied architectures (i.e. scaling, messaging, and vectorization)

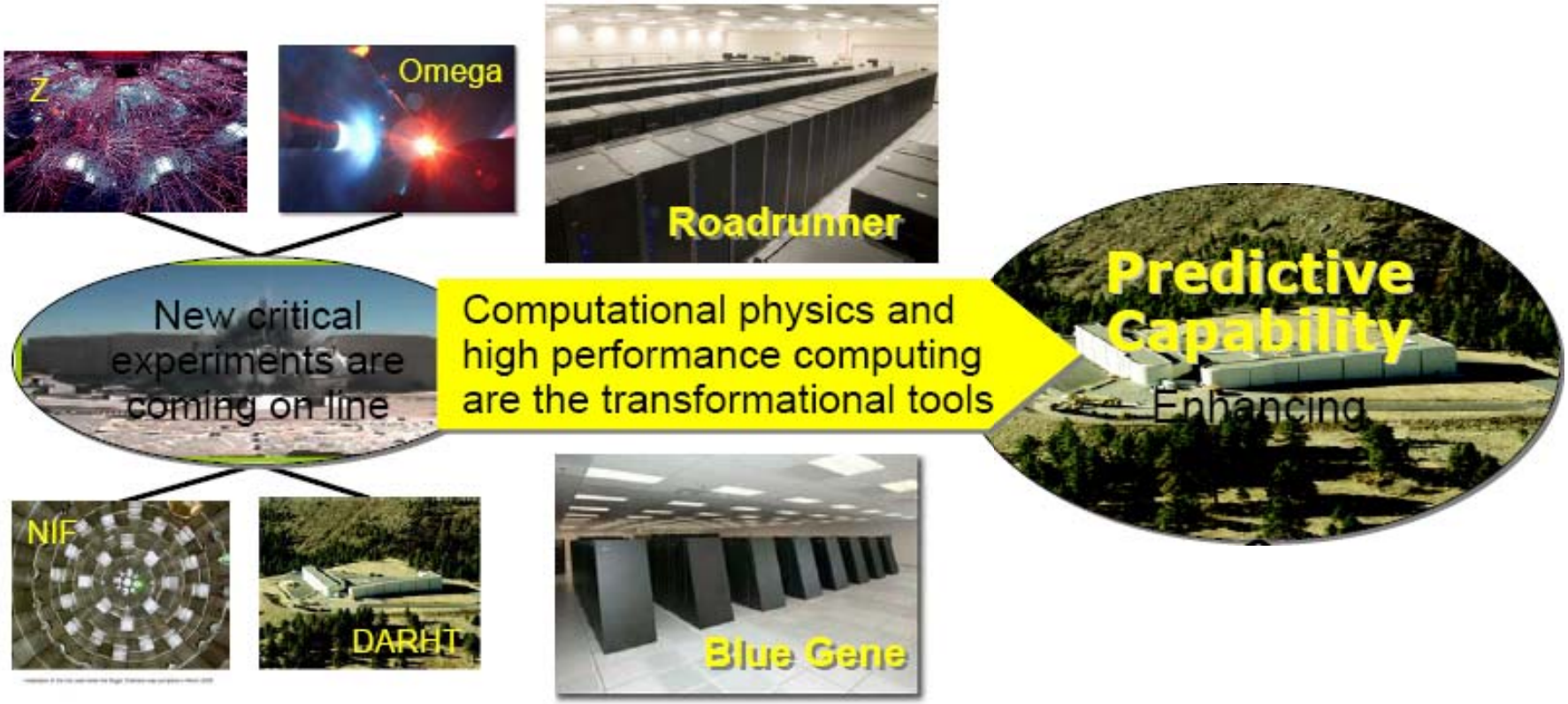
Lightning (LNXI) 2004
[commodity computing]



Roadrunner 2005-2008
[Hybrid architecture]

Los Alamos NATIONAL LABORATORY EST.1943

National Security Applications of Modeling & Simulation



Regional Network Supporting STEM

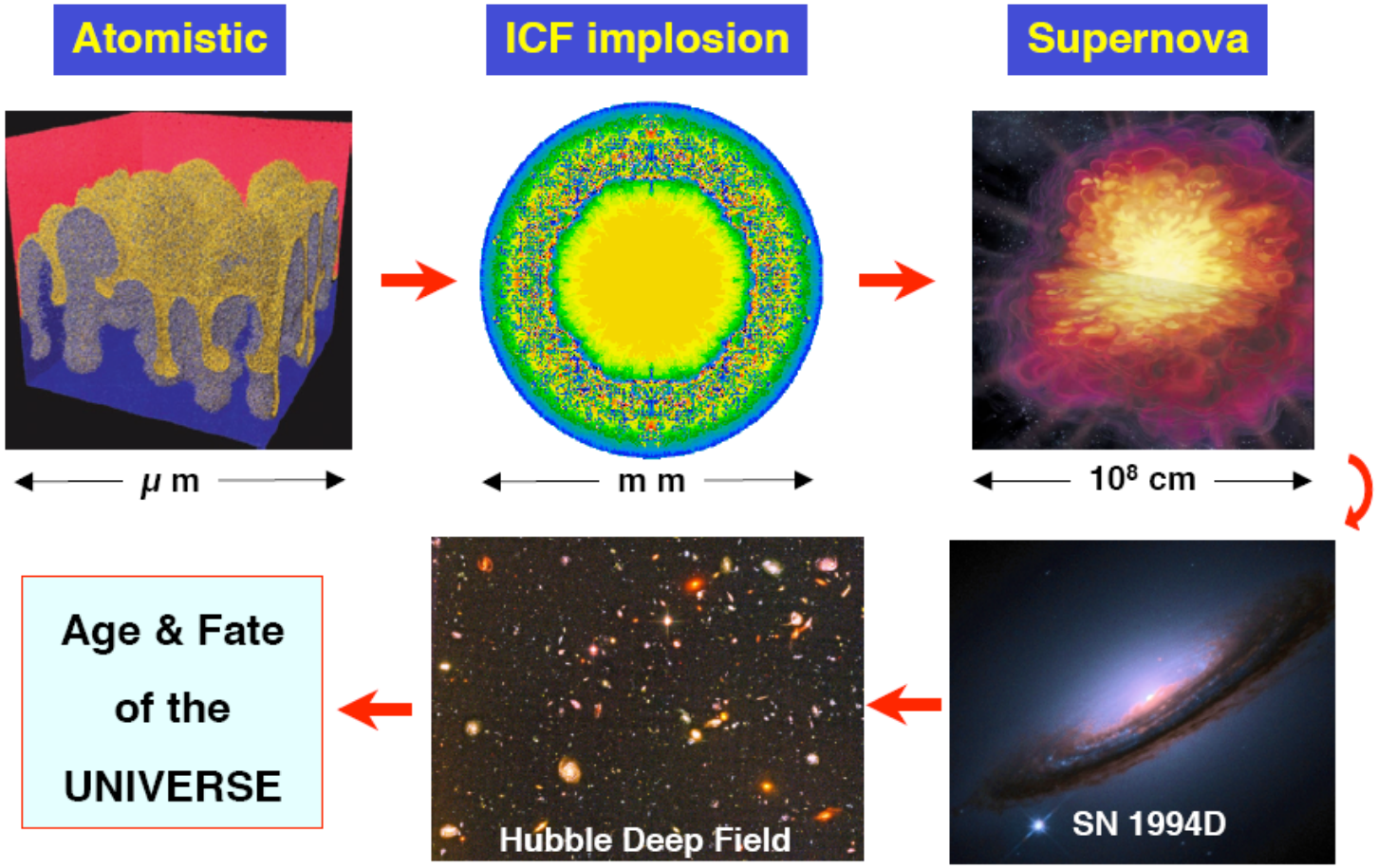
- **LANL *is* a main element of the M&S regional support for businesses in New Mexico and nationally.**
- **New Mexico Consortium** (http://newmexicoconsortium.org)
  - University of New Mexico
  - New Mexico State University
  - New Mexico Tech
  - LANL Institute for Advanced Studies (http://ias.newmexicoconsortium.org)
- **LANL Foundation** (http://lanlfoundation.org)
  - Investing in education, learning and community in the areas of *science, technology, engineering and mathematics* (STEM)
- **Los Alamos Venture Acceleration Initiative**
  - Helping spin out strategically selected LANL technologies
  - Tech Transfer: http://www.lanl.gov/orgs/tt

Issues

- **Shortages in skilled personnel with necessary skills**
  - Computer science
  - Computational science
- **Cost of computers and operations**
  - Roadrunner system base cost $120M
  - Operations and infrastructure of similar scope
  - Power is a serious concern for peta- and exa-scale computing
- **Lack of investment in programming languages and paradigms**

- ***Bottom Line:*** **The overall cost of large scale Modeling & Simulation is approaching costs of large experimental facilities and is at risk of becoming unaffordable**

M&S can help clarify the mysteries of the Universe



As scales increase, more physics is needed ⇒ sub-grid models

Infrastructure Simulation and Analysis

National Infrastructure Simulation & Analysis Center

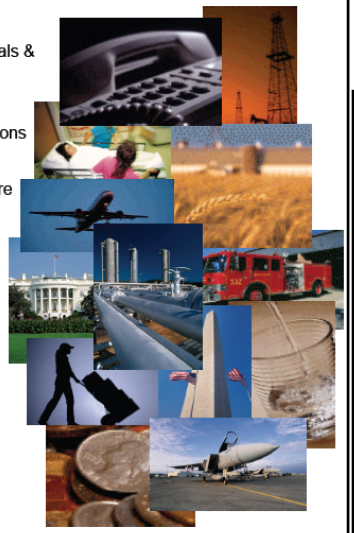
LANL (CCS and other divisions) provides analyses, models and tools to support modeling of the national and global infrastructure

- All Sectors
- All Threats
- All Scales

NISAC

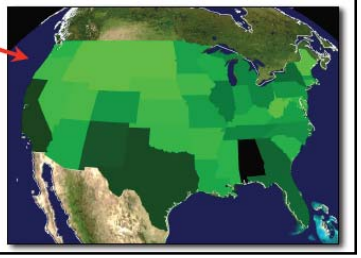
All Sectors & Interdependencies

- Agriculture & Food
  - Cheese
  - Other
- Banking & Finance
  - Banking
  - Insurance
  - Markets
- Chemical
- Commercial Facilities
- Dams
- Defense Industrial Base
- Emergency Services
  - Police
  - Fire
  - National Guard
- Energy
  - Electric Power
  - Natural Gas
  - Coal
  - Petroleum
- Government Facilities
- Nuclear Reactors, Materials & Waste
- Information Technology
- National Monuments & Icons
- Postal & Shipping
- Public Health & Healthcare
- Telecommunications
  - Wireline
  - Cellular
  - Internet
  - Broadcast
- Transportation
  - Air
  - Rail
  - Road
  - Water
- Water
  - Supply
  - Waste Treatment

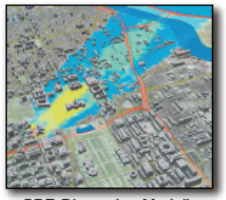


All Scales

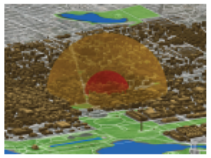
- Notional models
  - Artificial/stylized communities
  - Useful for intuition building
- Regional
  - Scaling limit of high-resolution modeling & simulation
- National
  - Calibrated to detailed models
  - Typically aggregate
- Point-model (no scale)
  - Useful for scoping studies
  - Typically very-low resolution



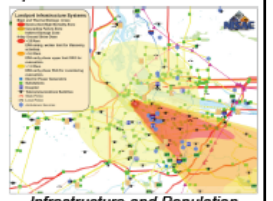
All Threats



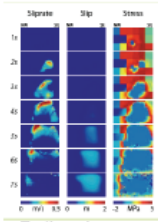
CBR Dispersion Modeling



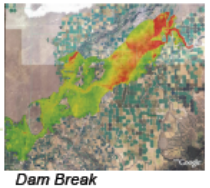
Improvised Nuclear Device



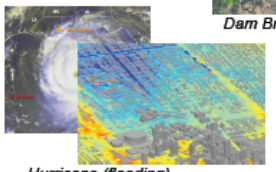
Infrastructure and Population Impacts



Earthquake



Dam Break

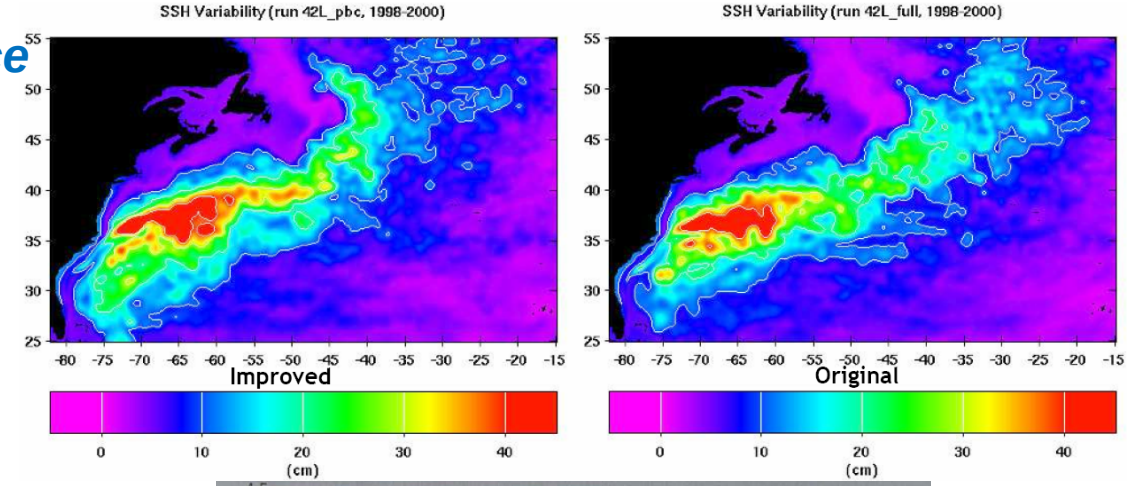


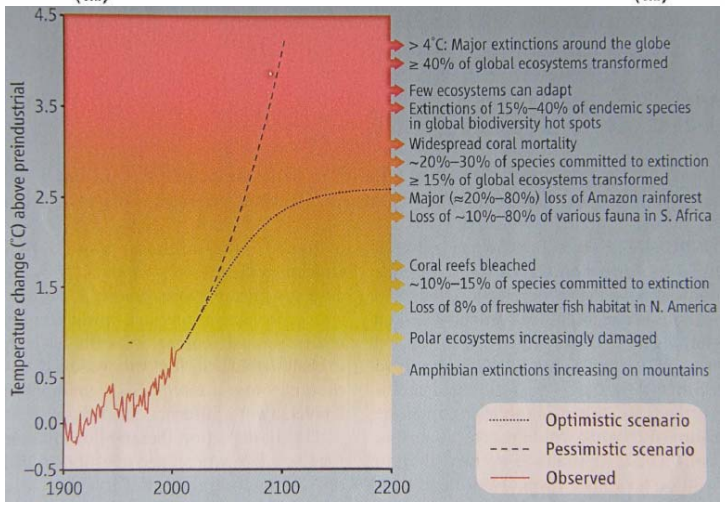
Hurricane (flooding)

Congressional Modeling & Simulation Caucus

Climate modeling – *predicting change and its impact*

- ***Climate, Ocean and Sea Ice Modeling*** **(COSIM)**
  - T and CCS Divisions
  - http://climate.lanl.gov
- **State-of-the-art Ocean (POP) and Sea Ice (CICE) models contribute to:**
  - The *Earth System Grid* - http://www.earthsystemgrid.org
  - The *Community Climate System Model (CSSM)* - http://www.cgd.ucar.edu/csm/

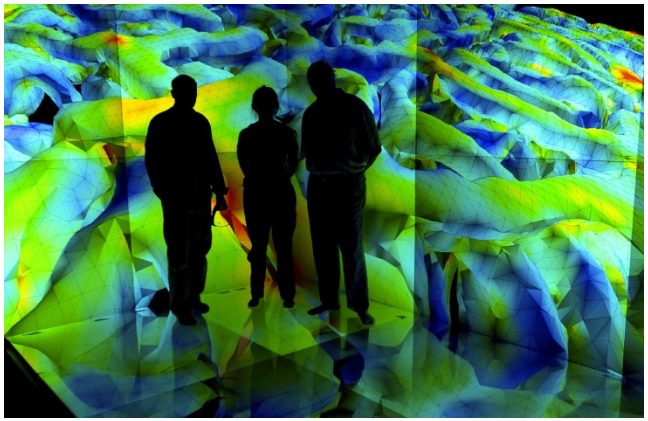




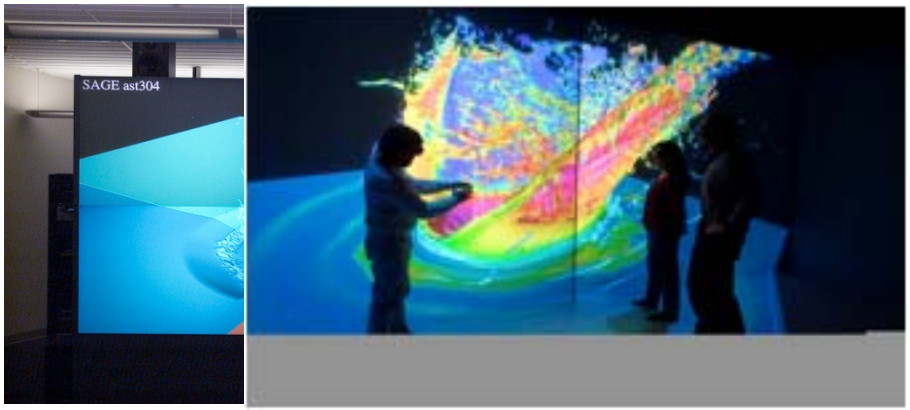
International Panel on Climate Change
http://www.ipcc.ch

World-class Visualization R&D and Facilities

PowerWall Theatre—31 Million pixels, 85 seats



CAVE



The RAVE is a unique immersive visualization facility for unclassified science

Cutting edge VIZ infrastructure
Broad ‘data pipes’ to VIZ LABS, collaboratories and desktops

Unique 3-D and interactive VIZ capabilities

Center for Advanced Architectures & Useable Supercomputing

- **Testbed for System Development and Testing**
  - Provides ability to design, build and test scalable platforms
  - Multiple (40+) heterogeneous nodes
  - Each node has mix of accelerators
    - GPU/GPU, GPU/Cell, Cell/Cell, FPGA/GPU
  - All nodes interconnected with high speed interconnect (Infiniband)
  - New additions for increased storage and high-performance local file systems

- **Performance modeling**
  - The Performance and Architecture Lab (PAL) developed a unique capability for performance analysis - highly accurate and predictive
  - Modeling is actively utilized for system design and optimization, application design, performance prediction of full applications, what-if scenarios, procurements of supercomputers, etc
  - Capability has been employed for most of the Top-5 systems deployed in the last decade