SAND2013-1515C

Possible Sandia Applications of Uninvented Probabilistic and/or Massively-Interconnected Computers

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Distinguished Member of Technical Staff
Organization 5563, Next Generation Monitoring Systems
February 26, 2013

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Third time

North Korea carried out its third, most powerful nuclear test despite UN warnings.

Previous tests

- **Oct. 2006** Detonates nuclear device for first time; yield is 0.5 to 1 kiloton
- **May 2009** Second detonation is partial success; larger yield of 2 to 6 kilotons
- **Feb. 2013** Early estimates put yield at 6 to 10 kilotons

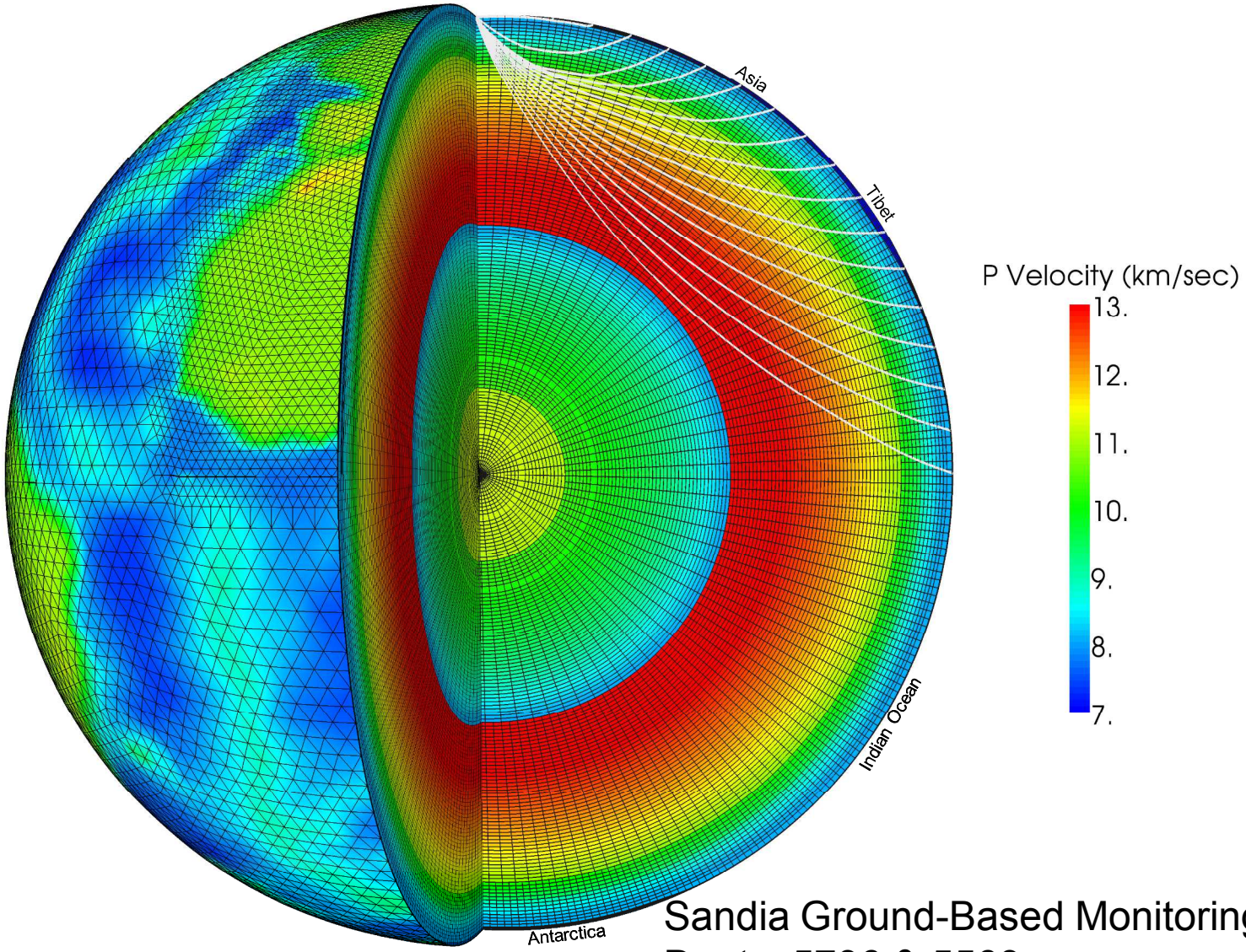
NOTE: Experts consider 10 kilotons a successful blast

Source: ESRI, AP

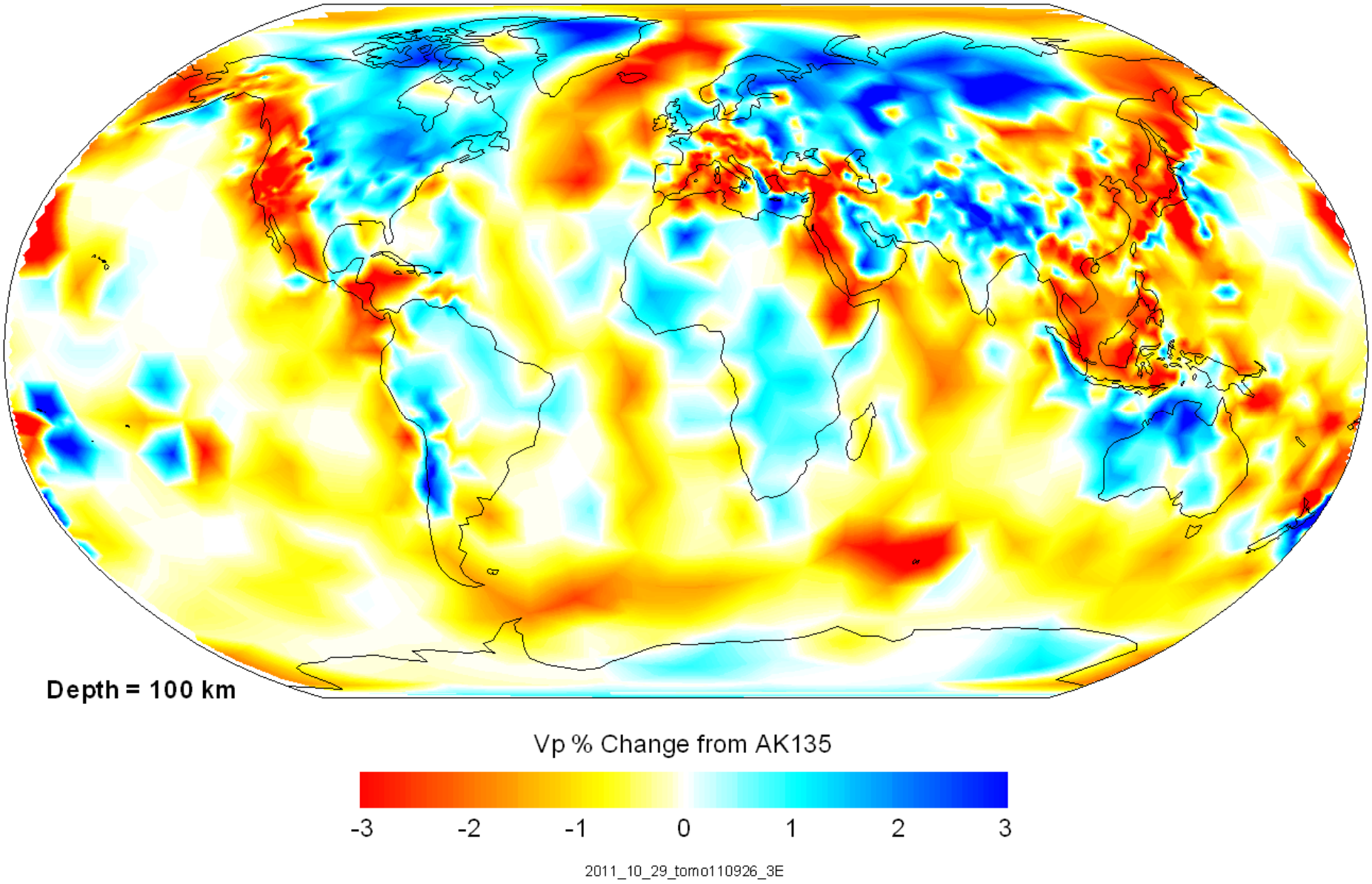
N. Korea says it tested miniaturized, more powerful nuclear bomb, Stars & Stripes, Friday Feb. 15, 2013

On the CTBTO's Detection in North Korea, CTBTO Preparatory Commission, Feb 12, 2013

SALSA3D - A GLOBAL 3D P-VELOCITY MODEL OF THE EARTH'S CRUST AND MANTLE FOR IMPROVED SEISMIC EVENT LOCATION IN NUCLEAR EXPLOSION MONITORING



Sandia Ground-Based Monitoring R&E,
Depts. 5736 & 5563



Sandia Ground-Based Monitoring R&E,
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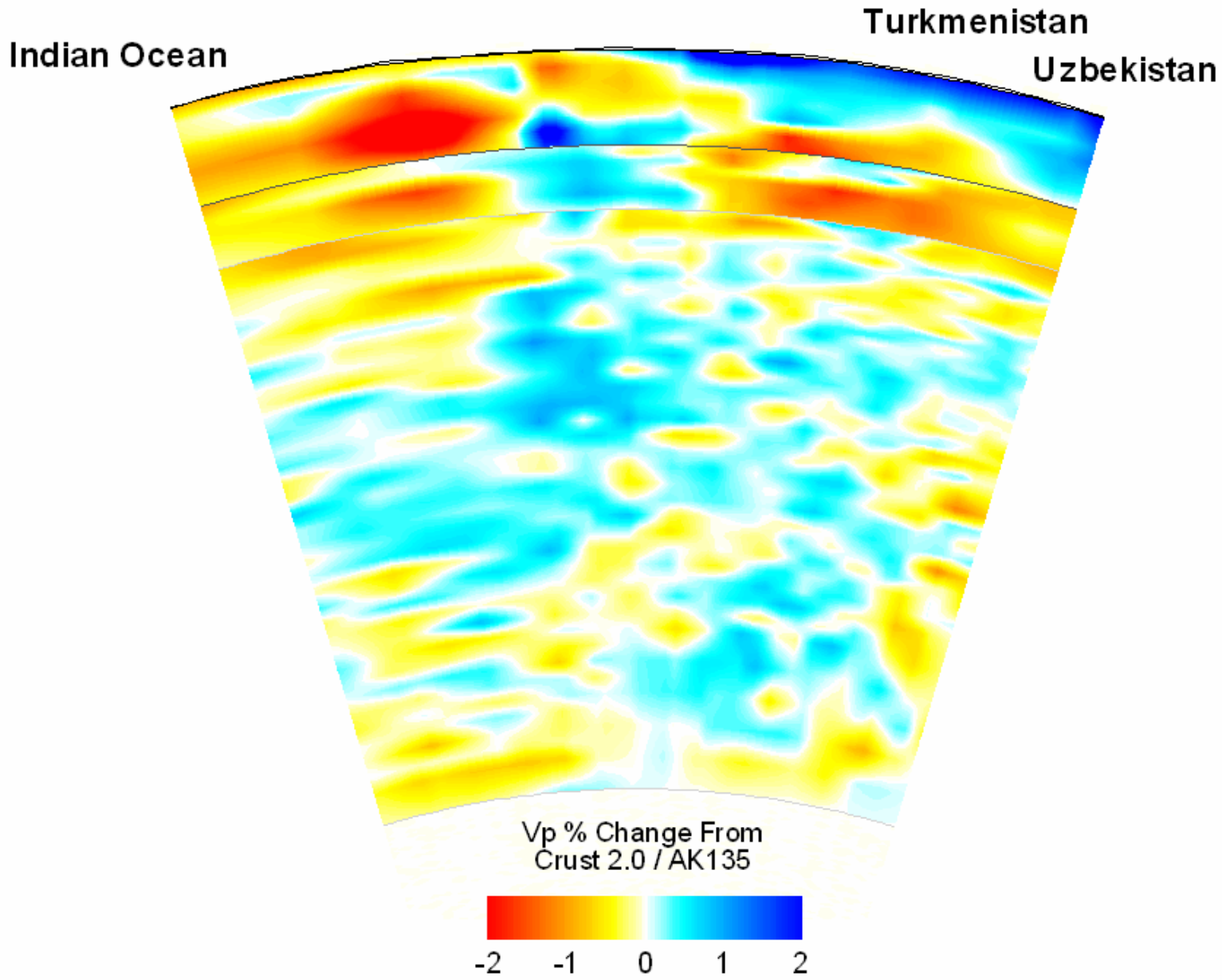

Sandia Ground-Based Monitoring R&E,
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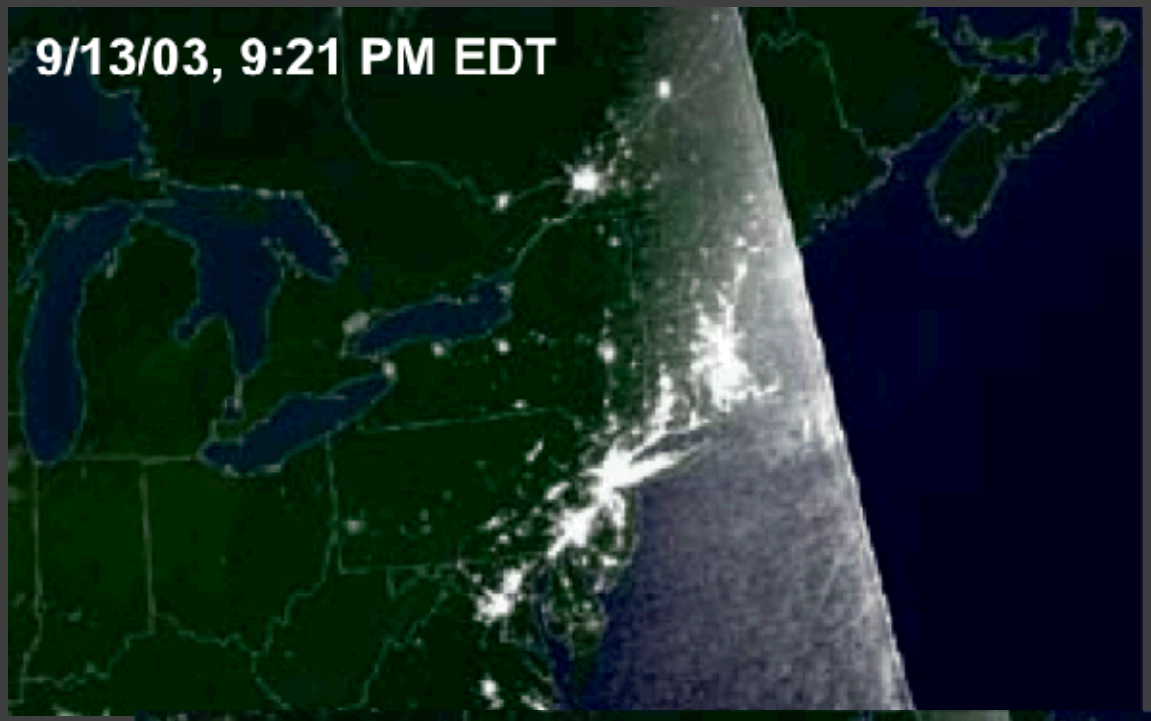
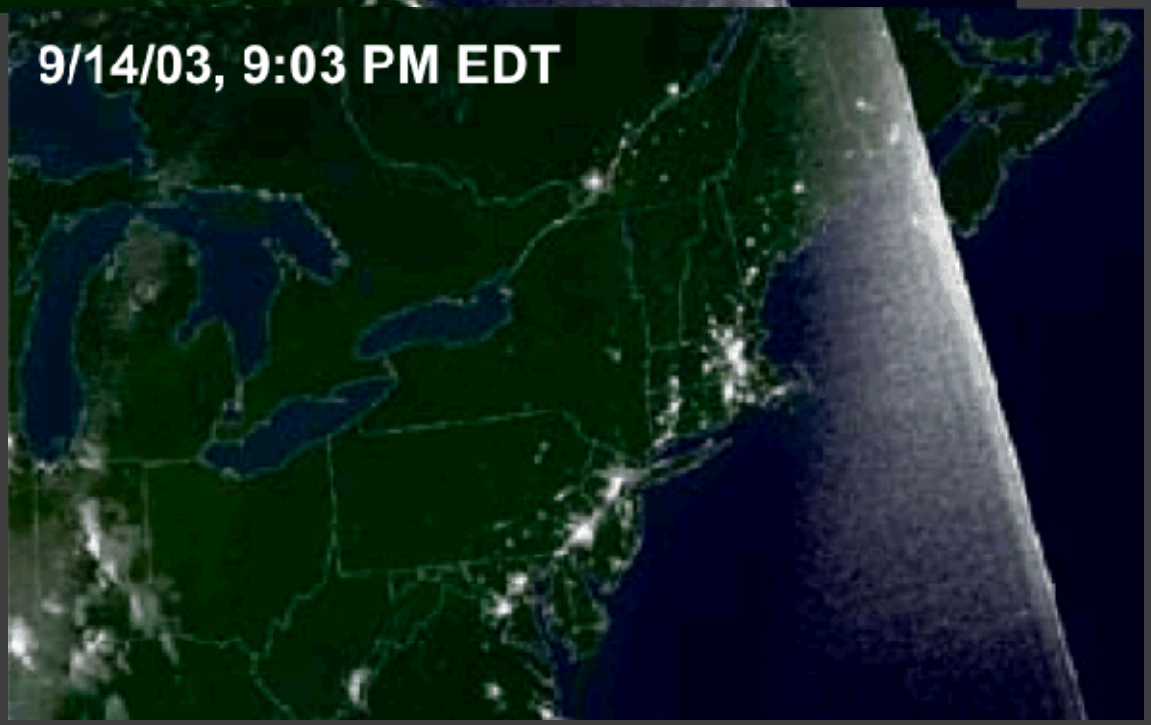
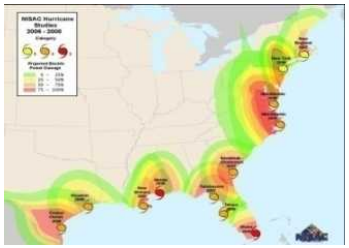


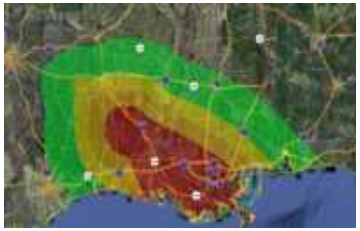


Images: NOAA

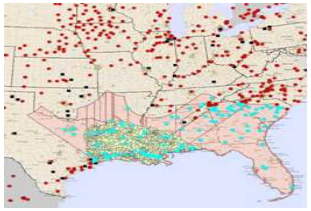
- Planning Scenarios

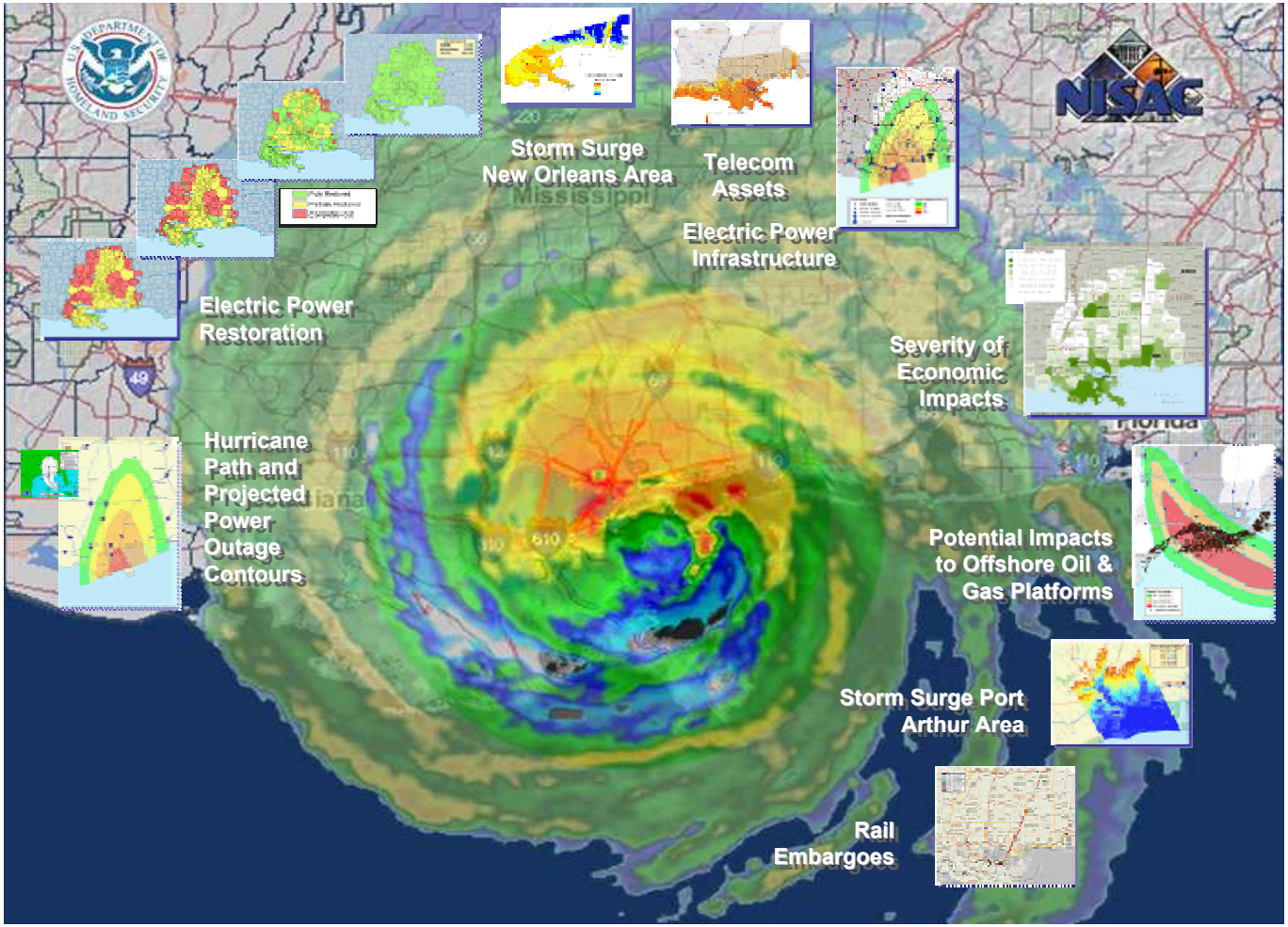


- Pre-Landfall Infrastructure & Population Impacts



- Post-Landfall Response & Recovery Issues





Dan Pless, August 2012

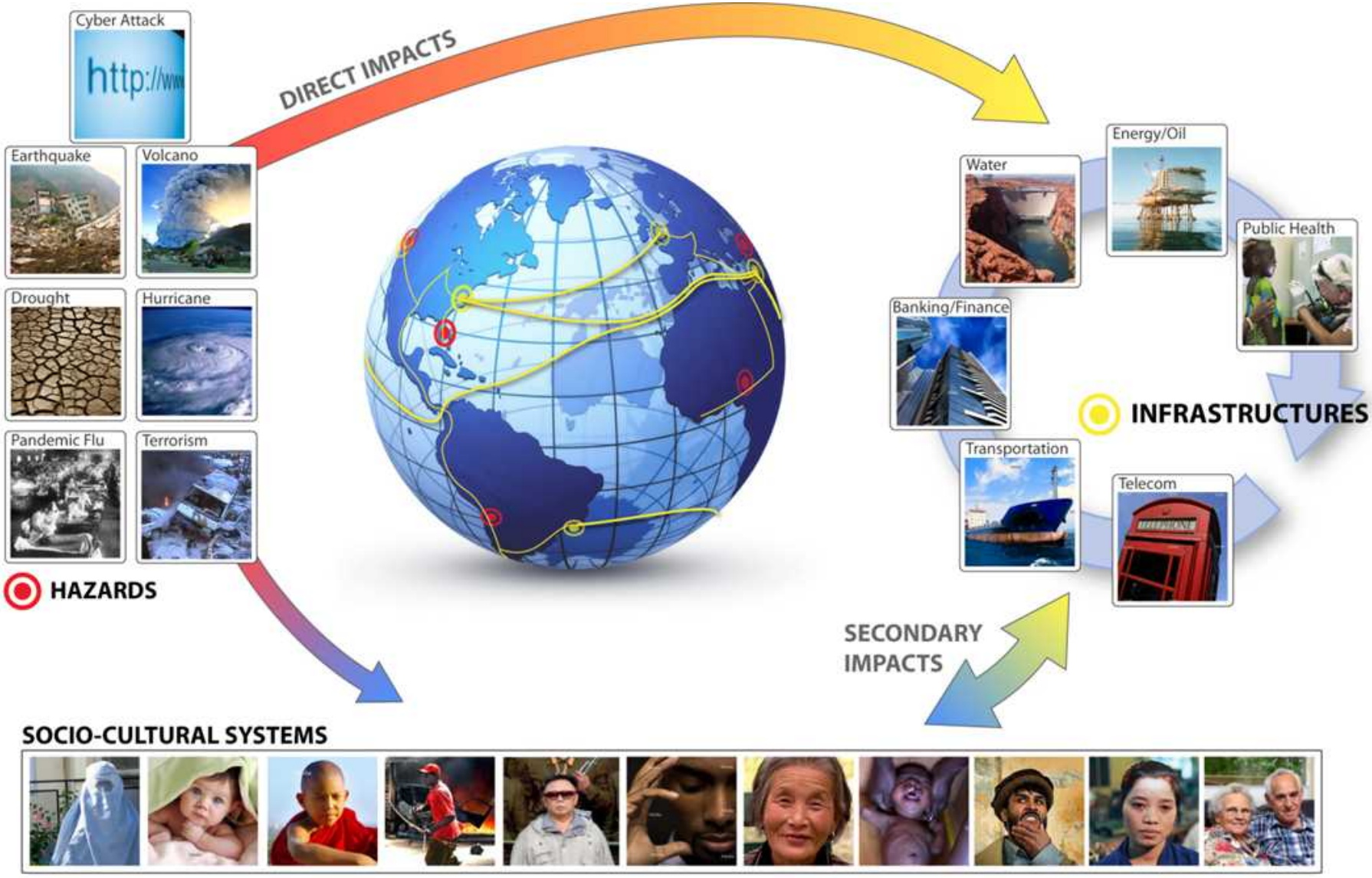
National Infrastructure Simulation and Analysis Center (NISAC)

Established by the national laboratories in 2000, NISAC was incorporated into the USA Patriot Act of 2001 and became part of DHS upon its inception in May 2003.

Congress mandated that NISAC serve as a "source of national expertise to address critical infrastructure protection" research and analysis.

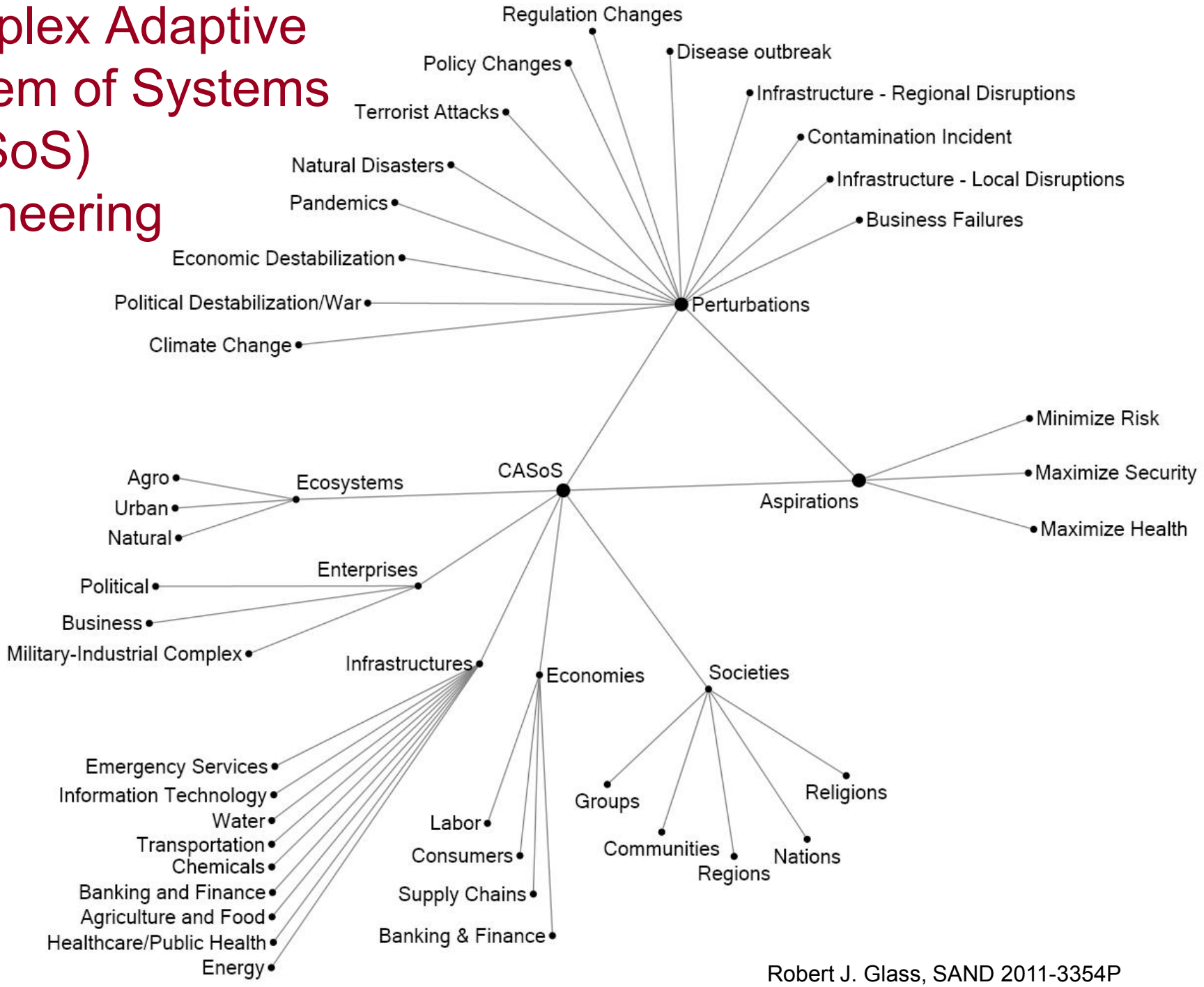
Infrastructures are the systems that provide the things we take for granted.

http://www.sandia.gov/nisac



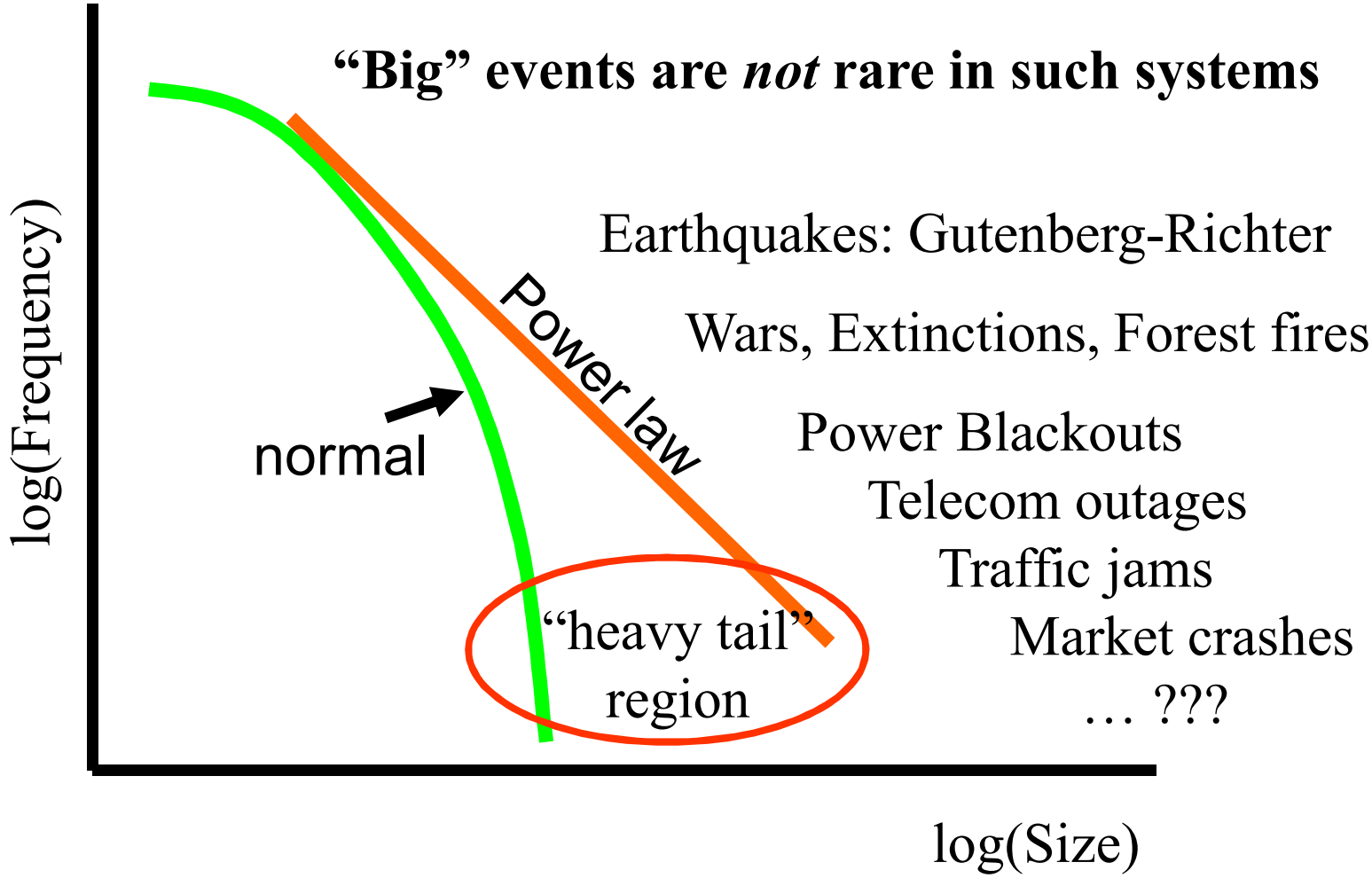
Robert J. Glass, SAND 2011-3354P

Complex Adaptive System of Systems (CASoS) Engineering



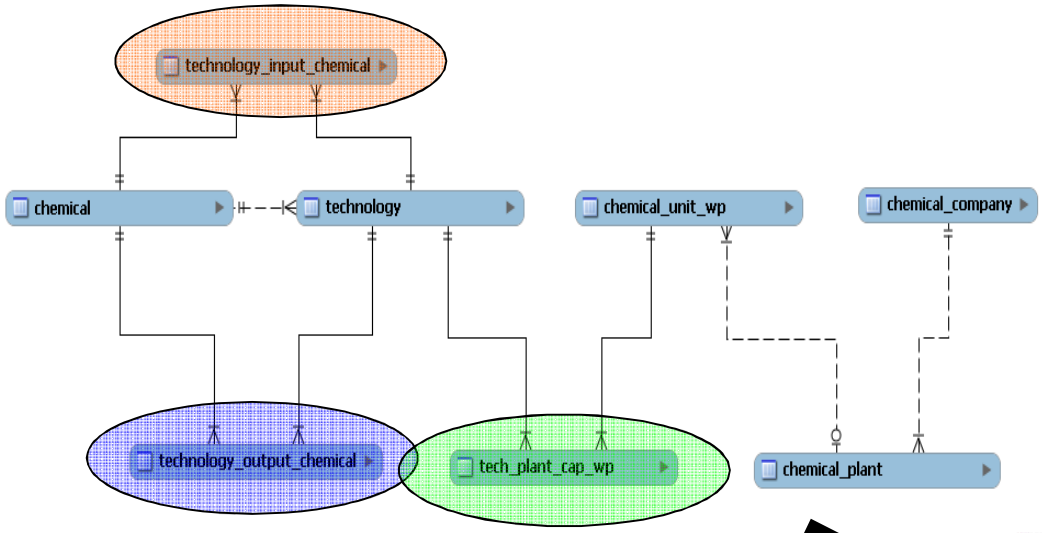
Robert J. Glass, SAND 2011-3354P

EMERGENT BEHAVIOR: Complex



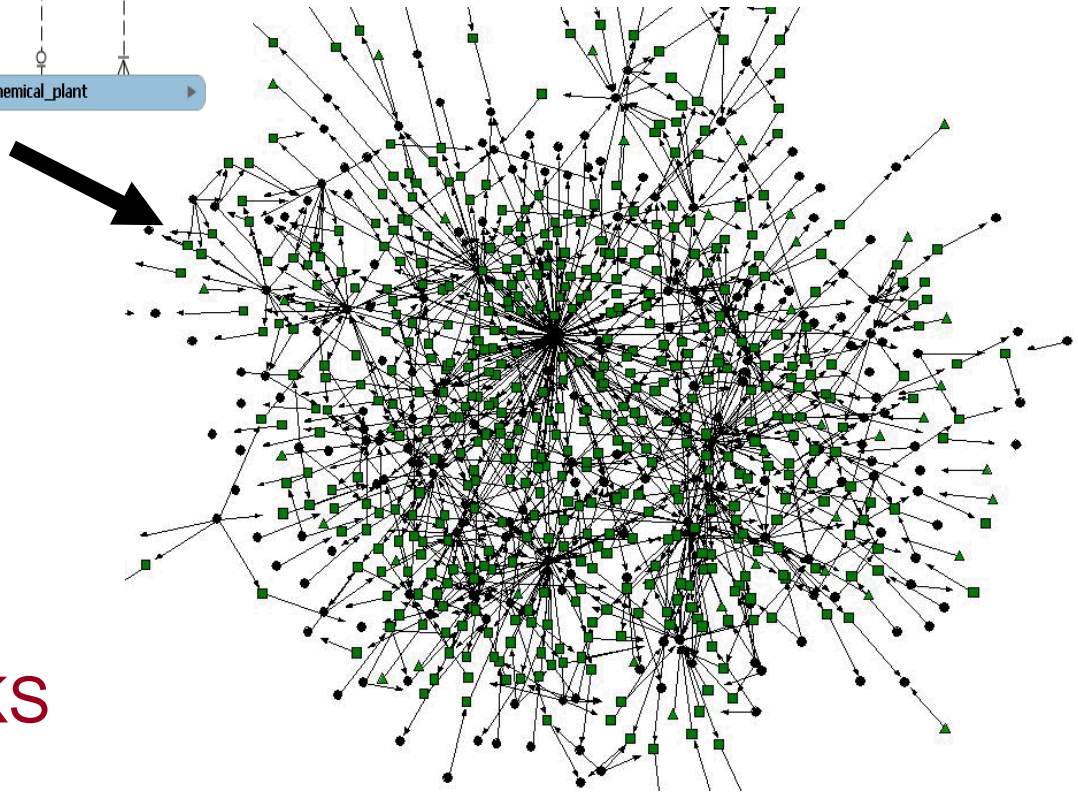
Cascades with power-laws & "heavy tails"

EMERGENT STRUCTURE: Complex



Petrochemical Industry Network Definition

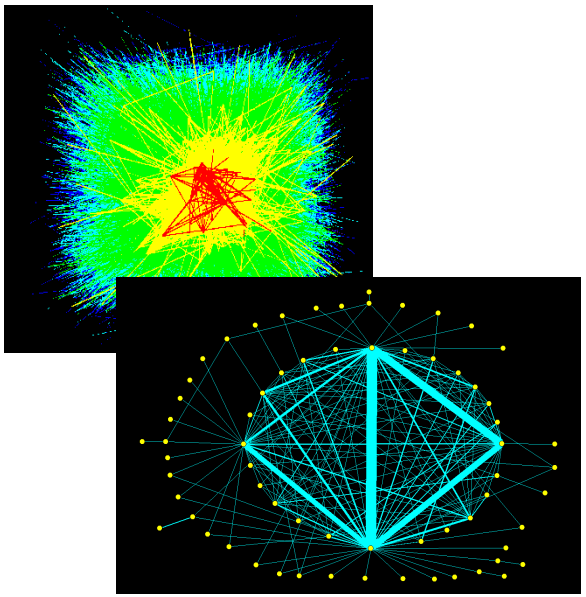
Network when populated with chemicals, technologies, plants, and supplies.

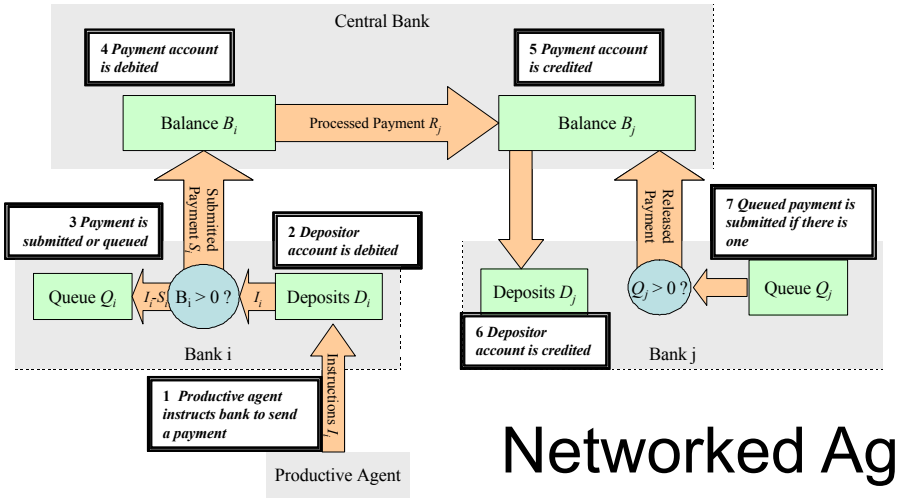


NETWORKS
within NETWORKS

W. Beyeler, 2008, and R. Glass, SAND 2011-3354P

Payment System Structure and Function





Networked Agent Based Model

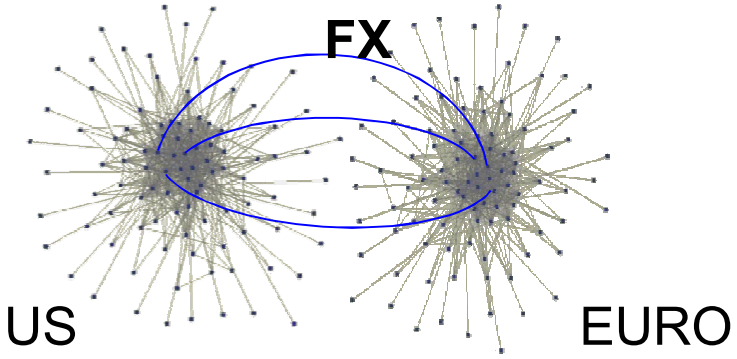
Payment system network

For Details see:

The Topology of Interbank Payment Flows, Soramäki, et al, *PhysicaA,* 1 June 2007; vol.379, no.1, p.317-33.

Congestion and Cascades in Payment Systems, Beyeler, et al, *PhysicaA,* 15 Oct. 2007; v.384, no.2, p.693-718.

Congestion and Cascades in Coupled Payment Systems, Renault, et al, Joint Bank of England/ECB Conference on Payments and monetary and financial stability, Nov, 12-13 2007.



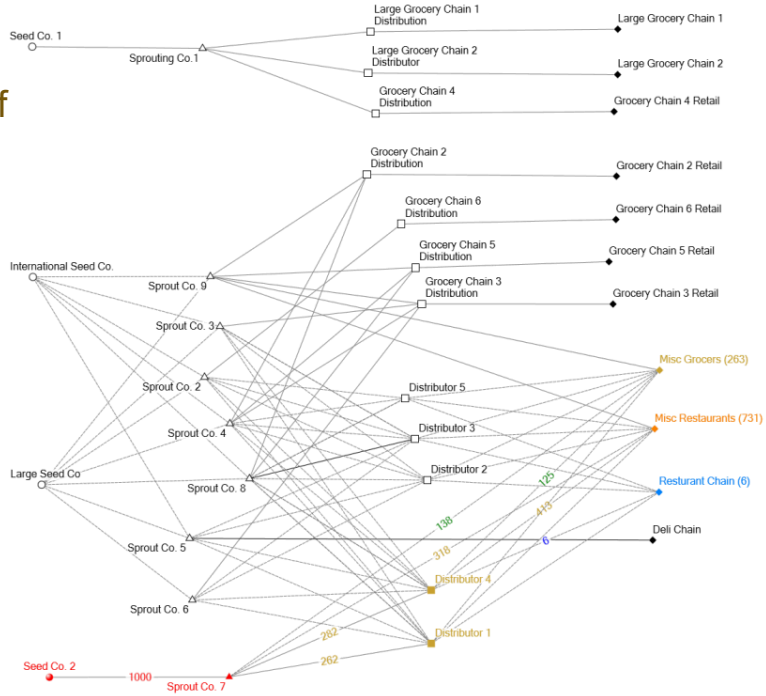
Global interdependencies

Sandia National Laboratories

Stochastic Mapping of Food Distribution Networks

- Goals:
  - Improve understanding of vulnerabilities
  - Improve contaminant tracing (forward and backward) to reduce population health risks
- Approach:
  - Risk-based analysis
  - Exchange network models to represent supply chain dynamics and interactions
  - Stochastic mapping of conditional probabilities

Forward tracing of contamination produces the conditional probability of contamination in the downstream supply chain for a specific contamination event

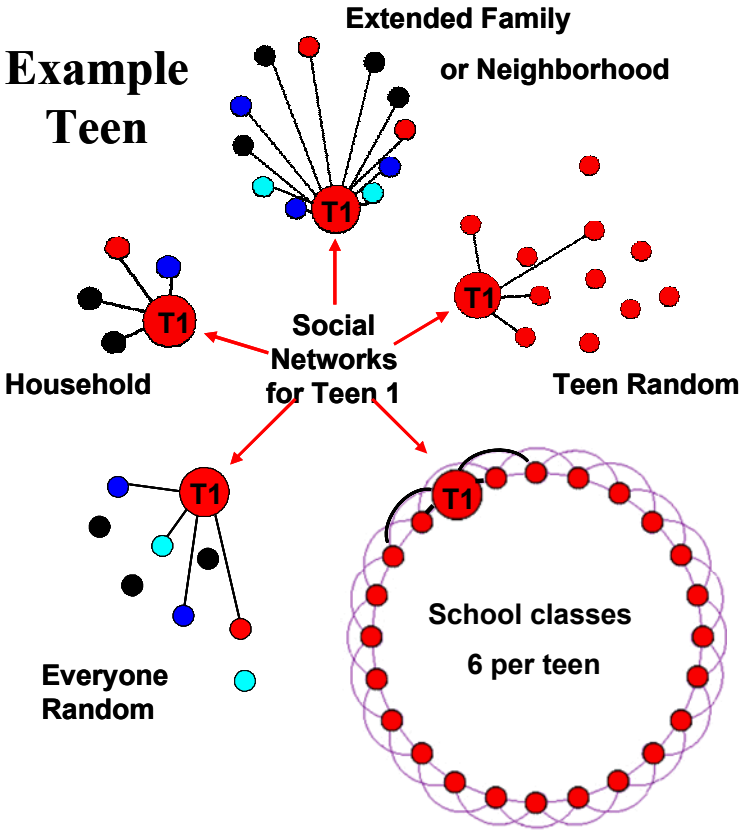


Backward tracing of contamination produces the conditional probability contamination exists at a producer if detected at a retail location

	Sprout Co 1	Sprout Co 7	Sprout Co 2	Sprout Co 4	Sprout Co 10	Sprout Co 8
Large Grocery Chain 1	1.00	0.00	0.00	0.00	0.00	0.00
Deli Chain	0.00	0.18	0.27	0.18	0.09	0.09
Sprout Co. 7 Customers	0.00	1.00	0.00	0.00	0.20	0.00
Grocery Chain 2 Retail	0.00	0.07	0.13	0.40	0.53	0.20
Misc. Grocers	0.00	0.24	0.39	0.15	0.22	0.10
Misc. Restaurants	0.00	0.24	0.38	0.14	0.24	0.10
Grocery Chain 3 Retail	0.00	0.00	0.25	0.38	0.50	0.06
Large Grocery Chain 2	1.00	0.00	0.00	0.00	0.00	0.00
Restaurant Chain	0.00	0.24	0.38	0.14	0.24	0.10
Grocery Chain 4 Retail	1.00	0.00	0.00	0.00	0.00	0.00
Distributor 5 Customers	0.00	0.11	0.11	0.11	1.00	0.00
Grocery Chain 6 Retail	0.00	0.00	1.00	0.00	0.06	0.13
Grocery Chain 5 Retail	0.00	0.00	0.13	0.40	0.53	0.20
Unconditional Probability	0.16	0.20	0.32	0.12	0.20	0.08

S.H. Conrad et al., Int. J. Critical Infrastructures, Vol. 8, Nos. 2/3, September 2012, 216-224.

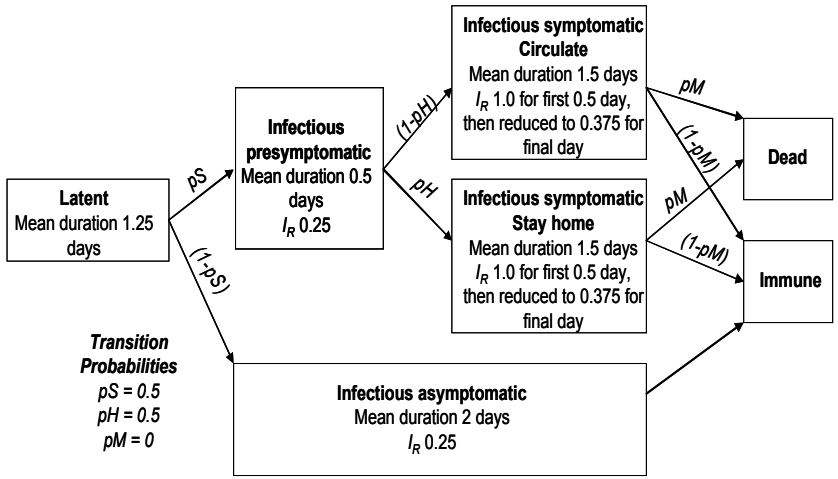
Generic Networked Agent Approach



Stylized Social Network
(nodes, links, frequency of interaction)

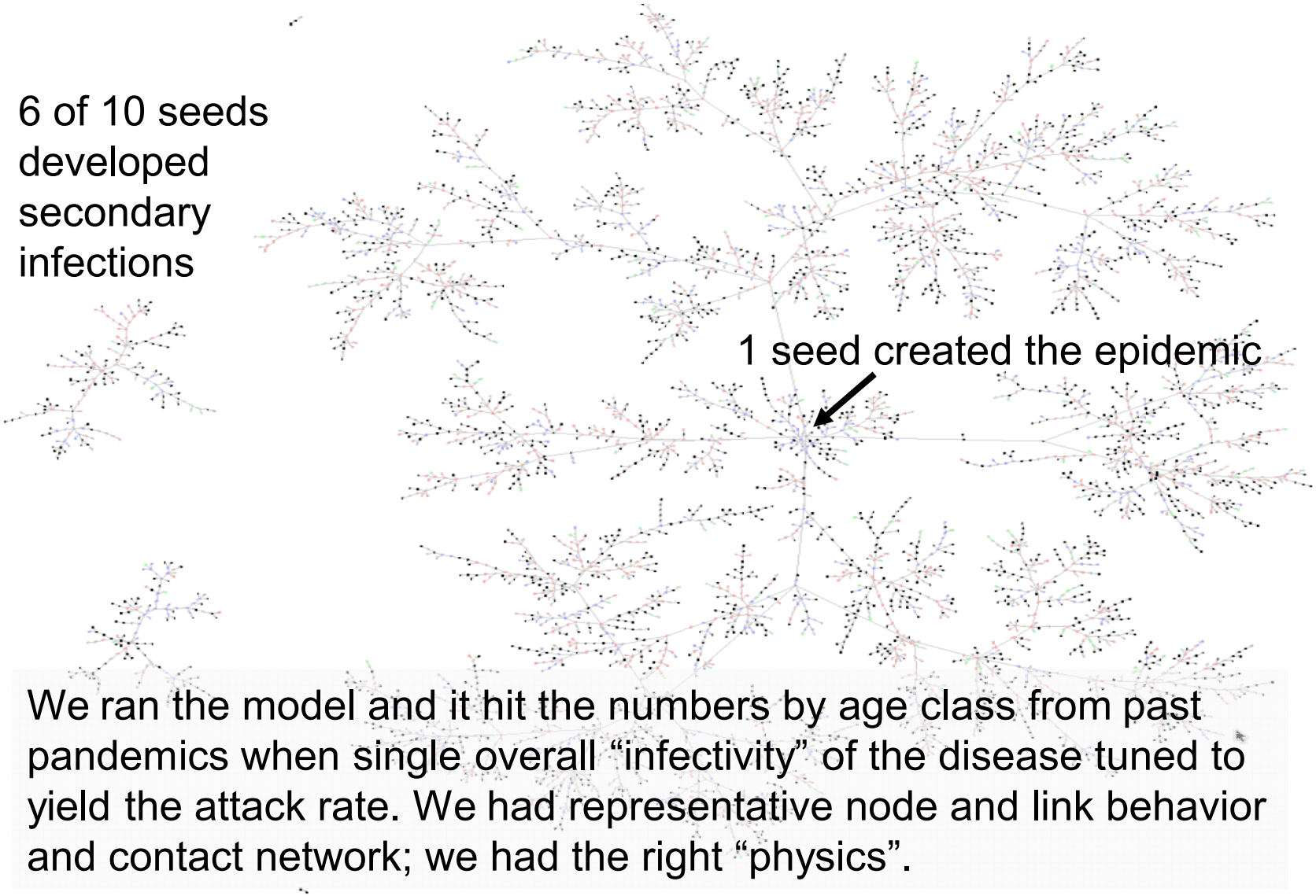
+

Disease manifestation based on data from the literature
(node and link behavior)



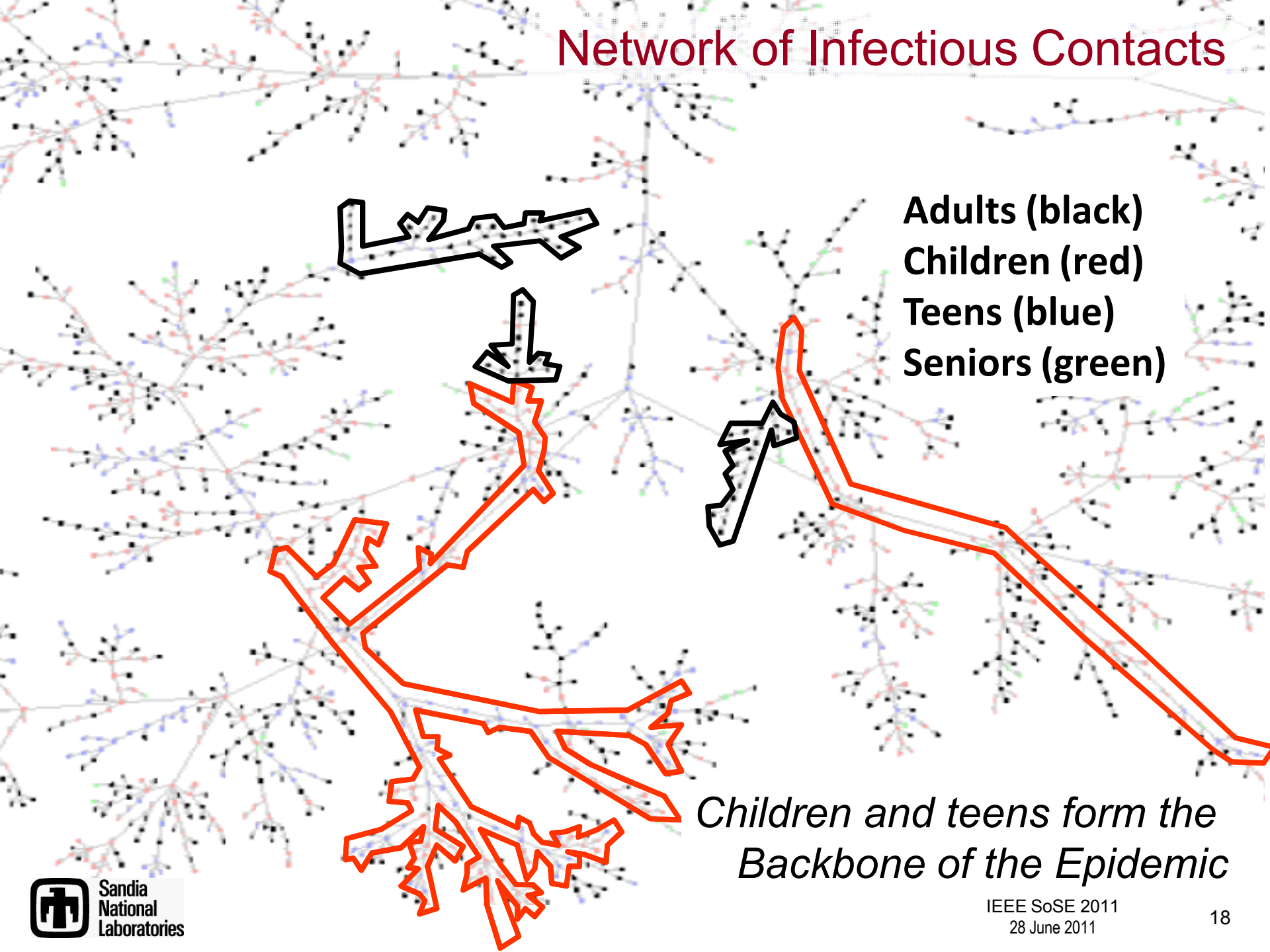
Simulation

6 of 10 seeds developed secondary infections



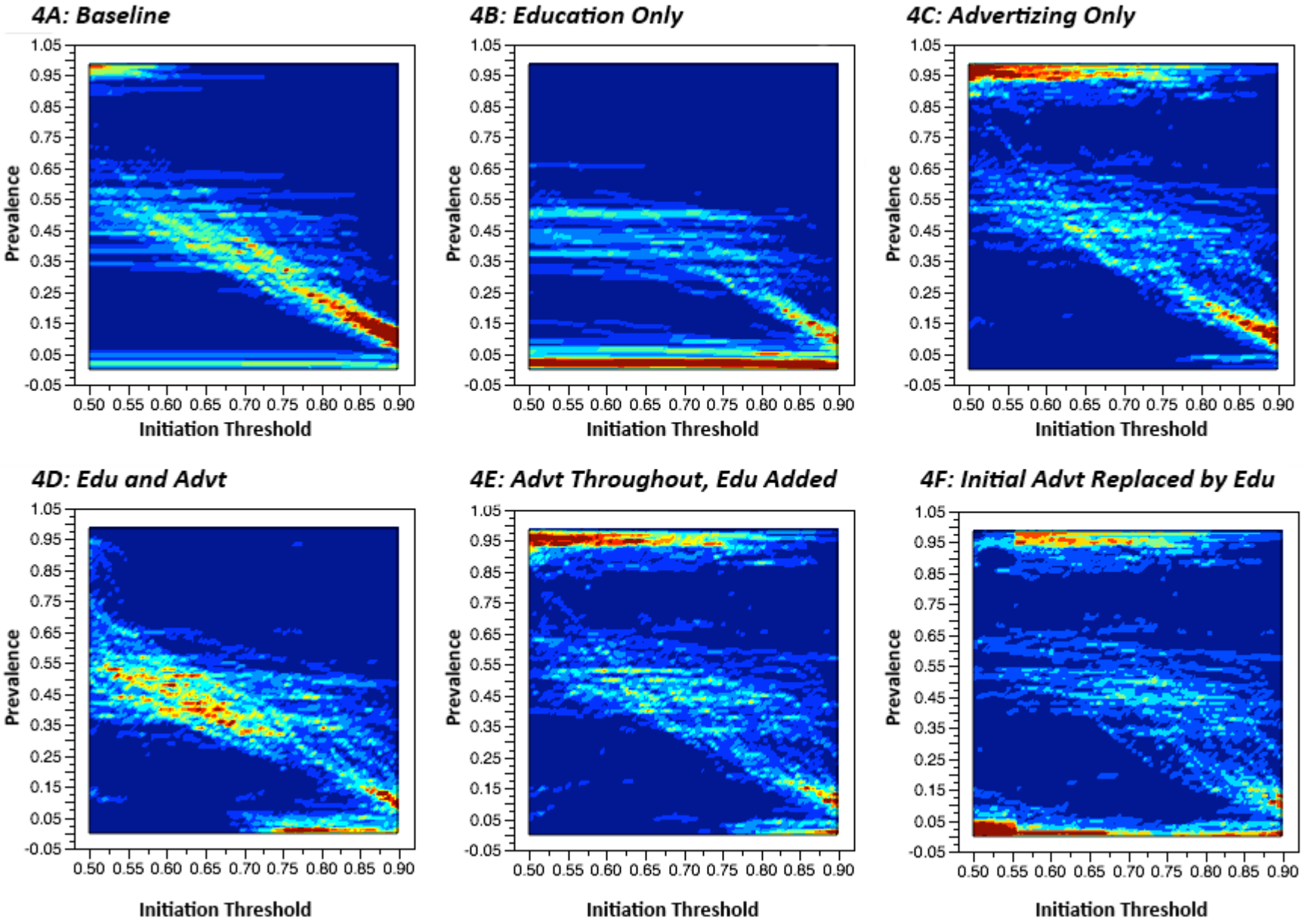
We ran the model and it hit the numbers by age class from past pandemics when single overall “infectivity” of the disease tuned to yield the attack rate. We had representative node and link behavior and contact network; we had the right “physics”.

Network of Infectious Contacts



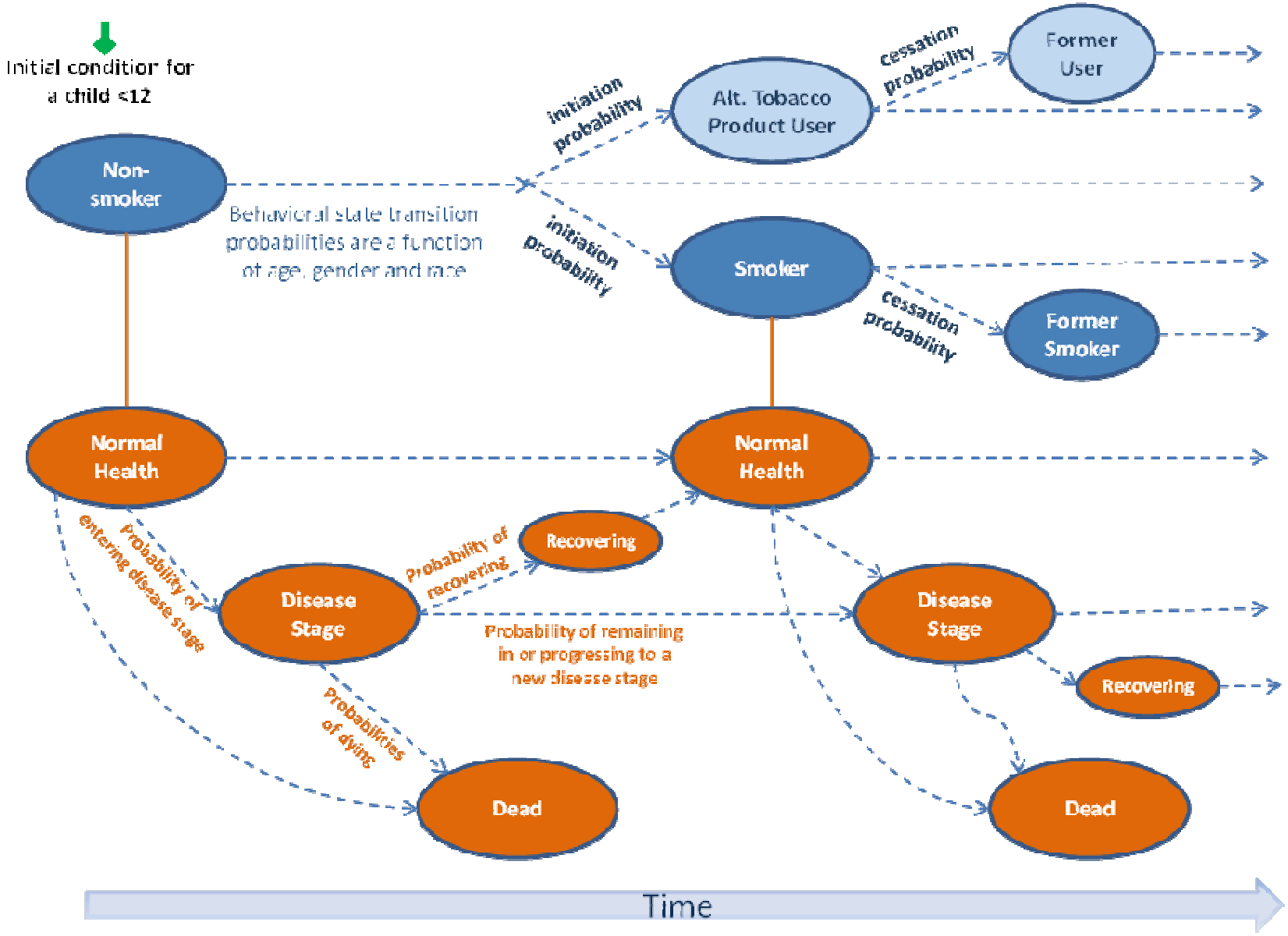
Children and teens form the Backbone of the Epidemic

FDA Tobacco Policy: Media Dynamics



Moore et al., 2013, Reviewed, in submission.

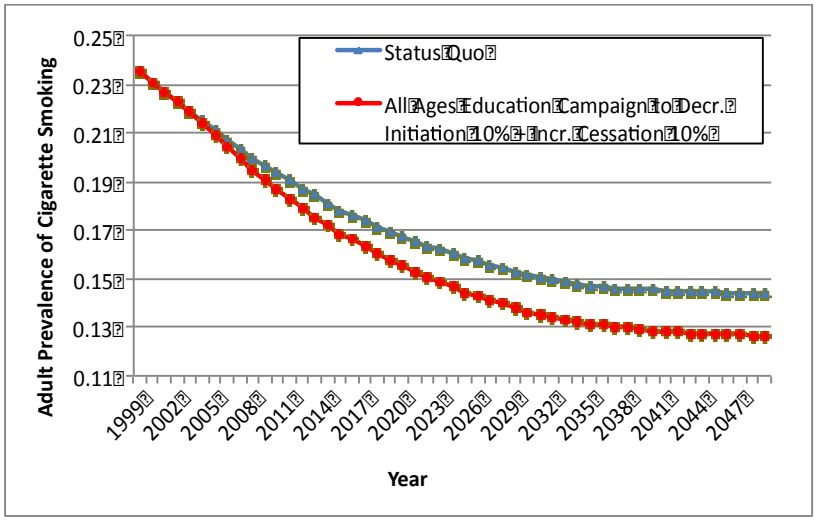
Tobacco Health Effects

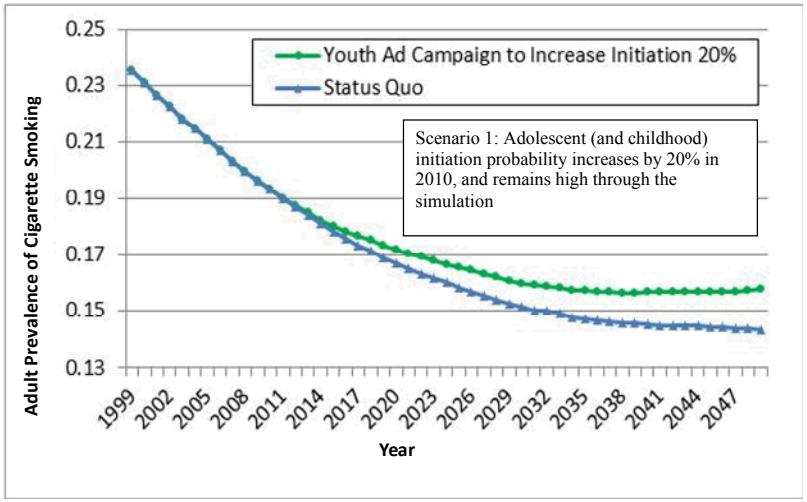


Verzi et al., Sandia National Laboratories, SAND2012-6898, 2012.

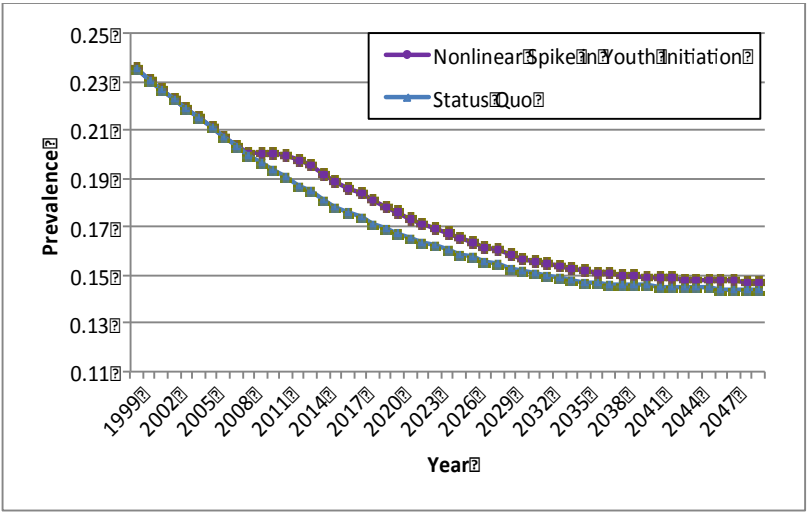
Effect of FDA vs. Producer Actions on Population Health

Education Campaign decreases initiation >
and increases cessation by 10%





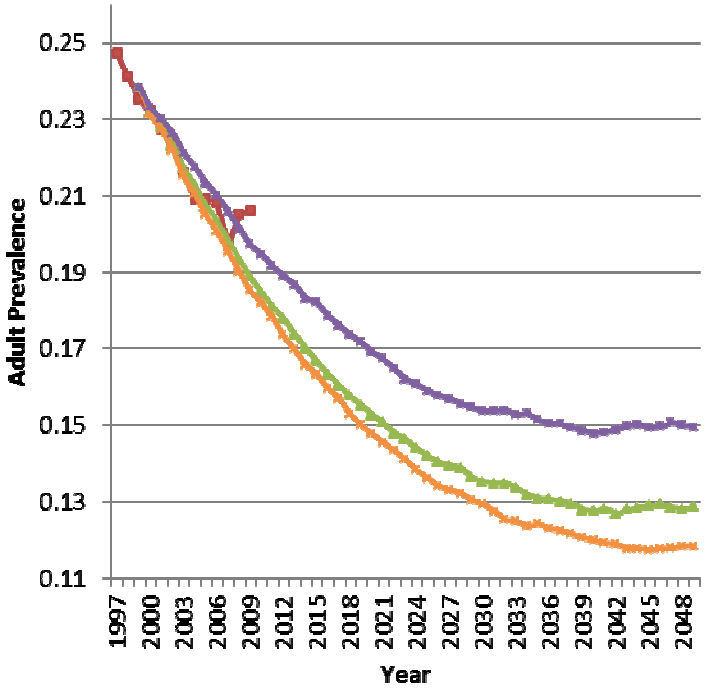
< Advertising Campaign increases youth initiation



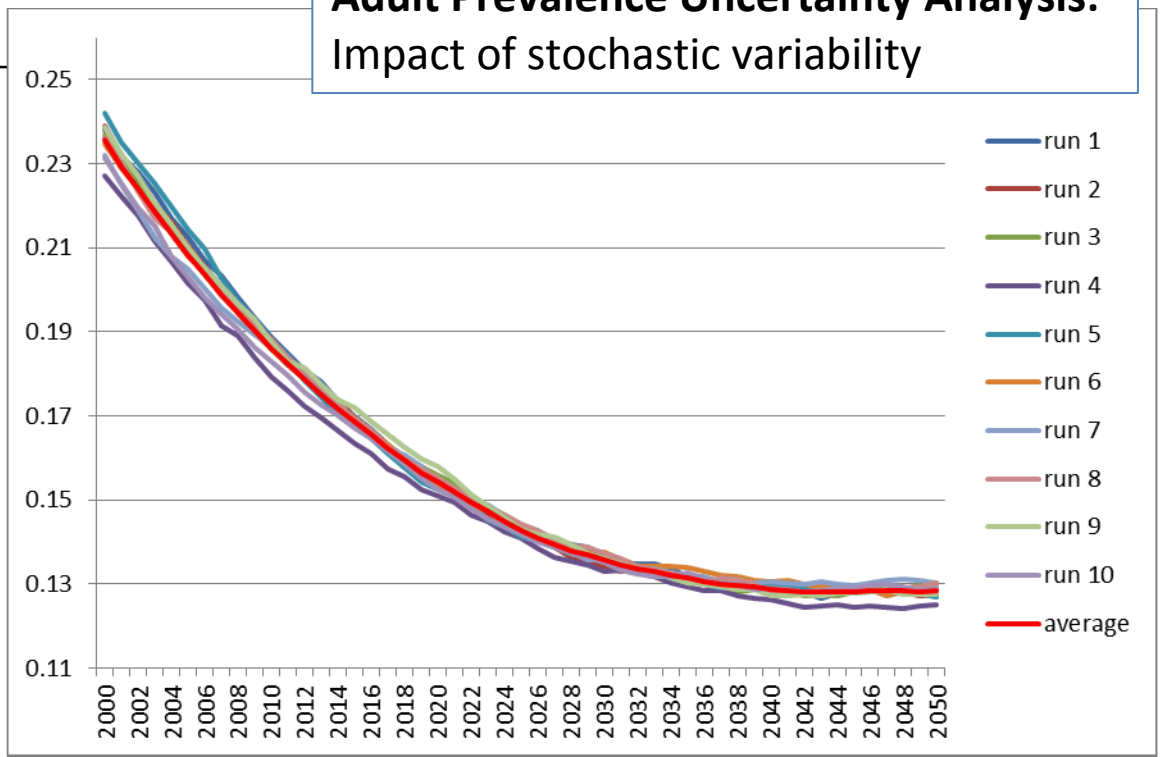
< Advertising Campaign spikes youth initiation

Verzi et al., Sandia National Laboratories, SAND2012-6898, 2012.

Adult Prevalence Sensitivity Analysis:
Impact of Immigrant Behavior

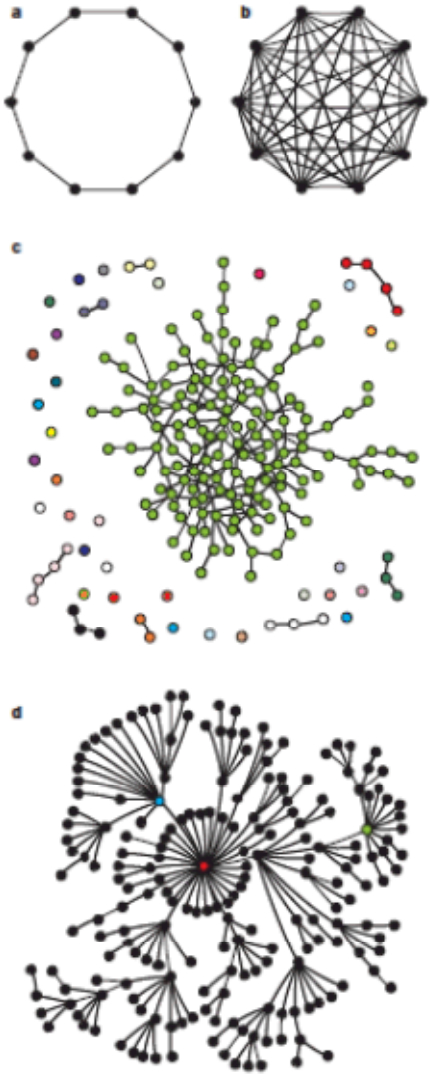


Adult Prevalence Uncertainty Analysis:
Impact of stochastic variability



Verzi et al., Sandia National Laboratories, SAND2012-6898, 2012.

Considerations: Hardware for Bayesian Inference



- Important Capabilities (?)
  - Run-time specification
  - Sparse, local, dense, random, small-world, scale-free networks
  - Auto-reconfigurable hardware
- Design Form Possibilities
  - Probabilistic Co-Processor
  - Probabilistic Processing Card
    - Analogous to GPU
  - Cluster Computing
    - +/- massively parallel interconnects
  - Probabilistic/Binary Supercomputer
    - +/- massively parallel interconnects

Figure: Strogatz, 2001, Nature