Numerical Simulation-Based Decision Support System for Water Infrastructural SEcurity (DSS-WISE) (63891)

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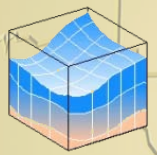


National Center for Computational Hydroscience and Engineering
The University of Mississippi

SERRI Southeast Region Research Initiative

Regional & National Problem Solved

One of the principal missions of the

Department of Homeland Security

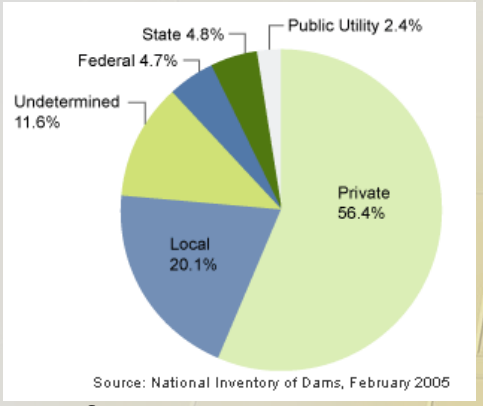
To put forward a “National Infrastructure Protection Plan” that provides a unifying structure for the integration of a wide range of efforts for the enhanced protection and resiliency of the nation's critical infrastructure and key resources (CIKR) into a single national program.

This can be achieved by employing a **risk assessment framework** that takes into account **uncertainties**.

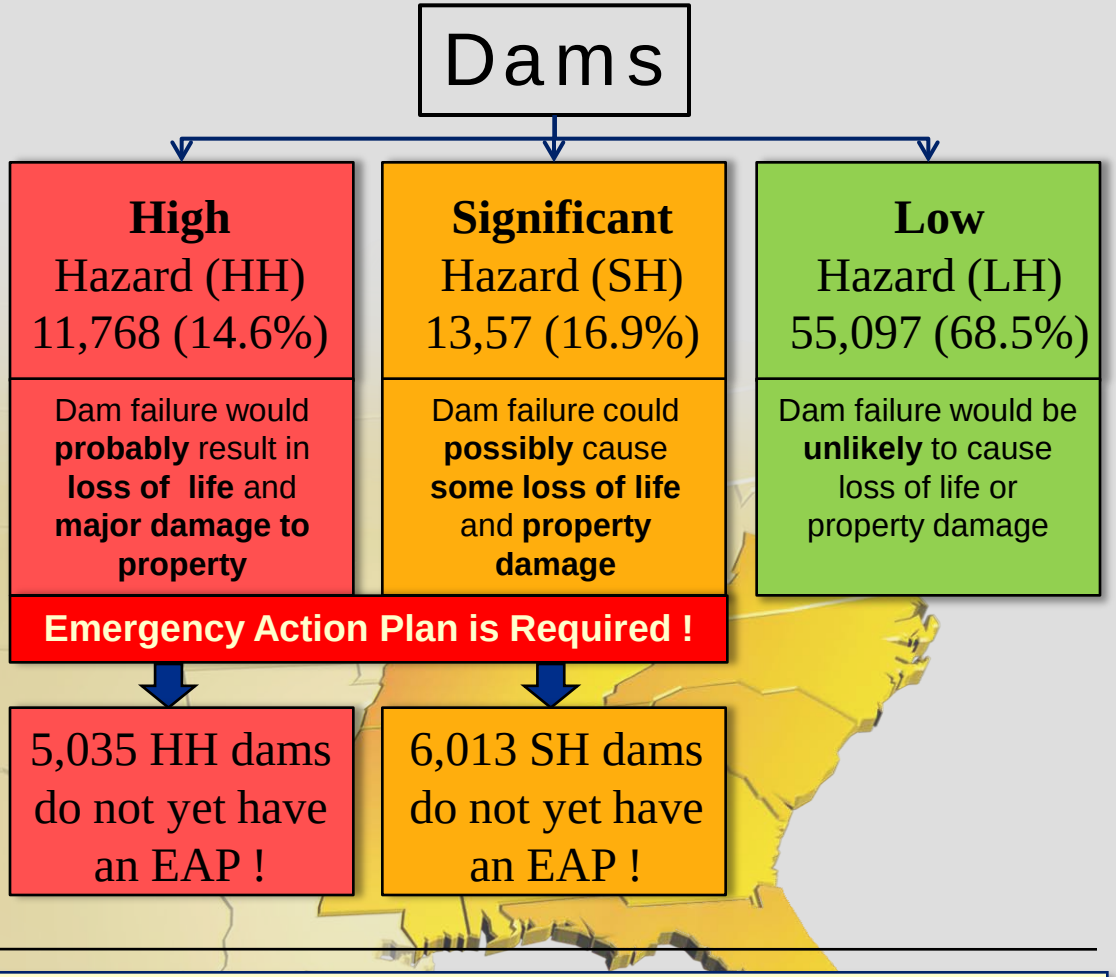
DSS-WISE Project focuses on security of water storage and control infrastructures, such as **dams and levees**, whose failure may lead to catastrophic floods, which could lead to potential loss of life, urban and agricultural property damage, and environmental degradation.

Dams

Currently, **80,443 dams** are registered in the National Inventory of Dams.



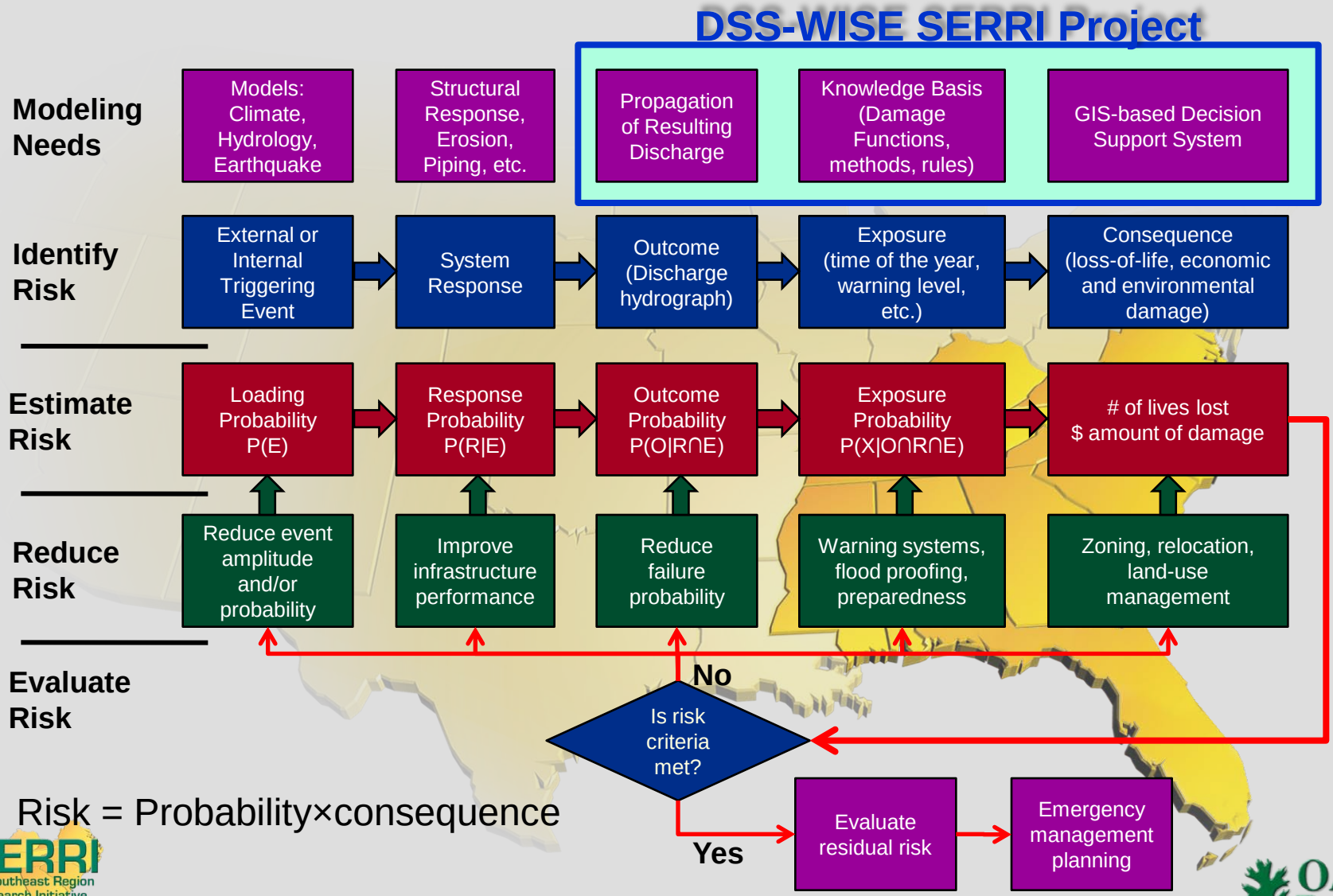
Dam safety and security is not just a federal, state, or local issue; **it requires collaboration of private dam owners.**



Levees

- It is estimated that the USA has about **100,000 miles** of levee systems.
- Some of these levee systems are protecting highly developed urban areas where vital industries and critical infrastructures are located.
- A national inventory of levees is currently under preparation.

Risk Assessment Framework

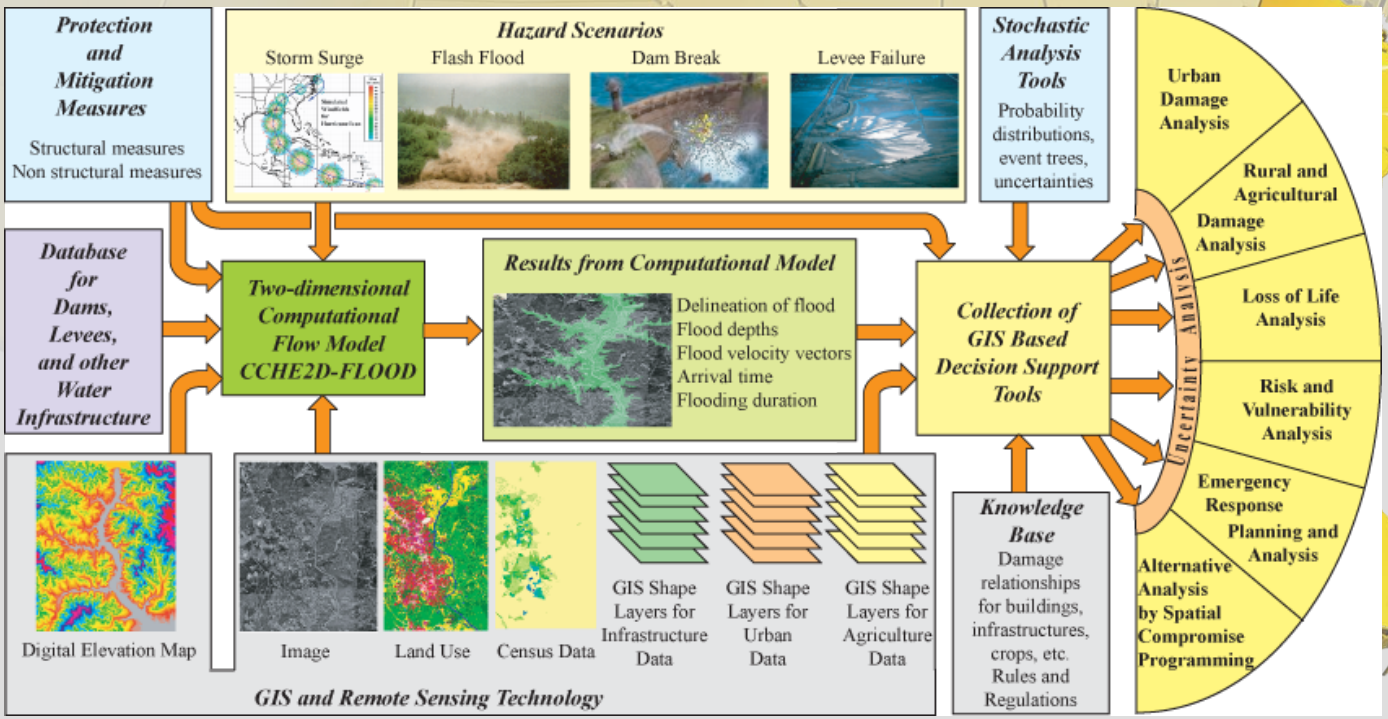


Risk = Probability×consequence

Purpose & Description of the project

The research aims to develop a set of integrated **2D computational models** and **GIS-based scenario evaluation, optimization and decision making tools** that can be used by homeland security personnel for **risk and vulnerability analyses** of critical water infrastructures (dams, levees, control structures, etc.) and emergency response planning for threats due to natural causes or terrorist attacks, by taking into account **uncertainties**,

Develop accurate, reliable, and cost- & time-effective tools to improve current practice.

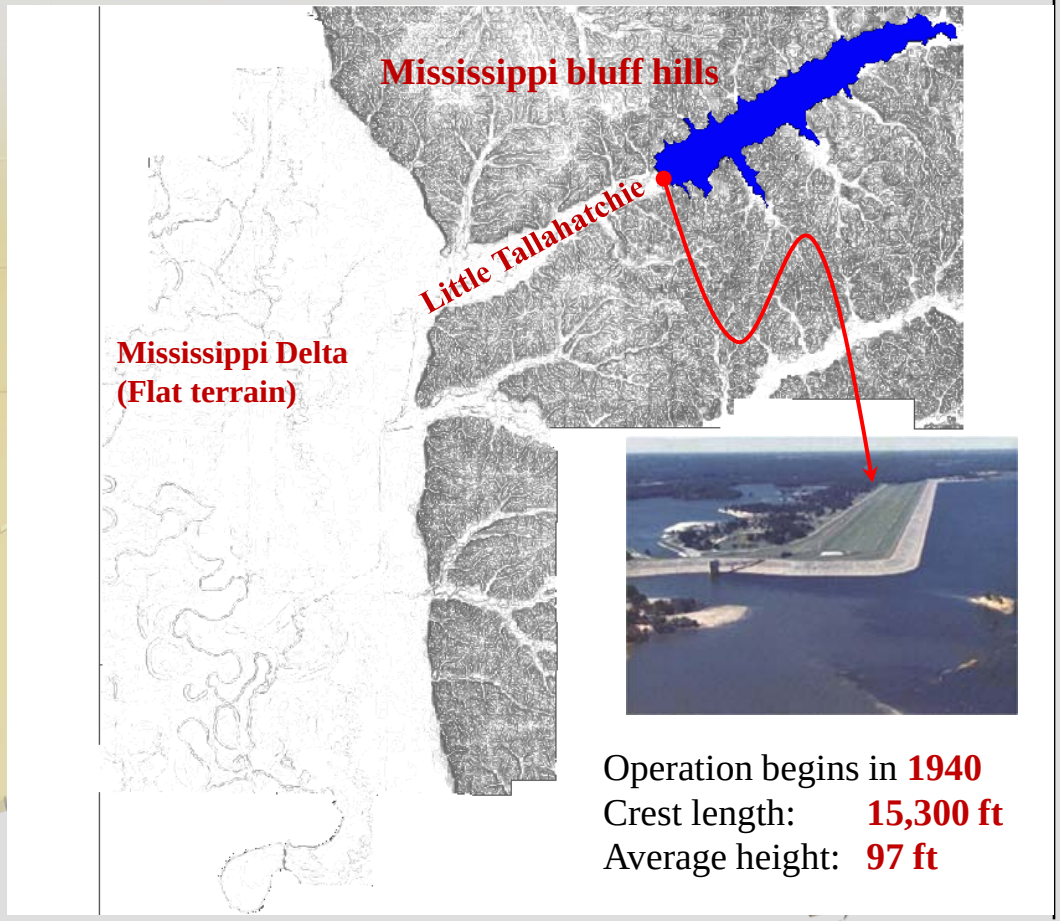


Numerical Model: CCHE2D-FLOOD

CCHE2D-FLOOD uses state-of-the-art first-order shock capturing finite volume scheme.

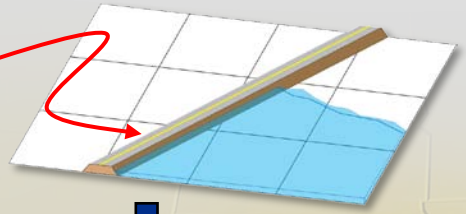
- Mixed flow regimes (sub-, trans-, and supercritical)
- Oscillation-free sharp discontinuities
- Superior source term treatment
- Rigorous mass conservation
- Disconnected flow domains are handled
- Robust algorithm even with complex topography
- Decreased computational burden
- Improved computational speed even on desktops
- Extremely easy problem set-up and running
- Fully verified and validated
- GIS platform compatible results files
- Digital Elevation Maps (DEM) can be directly used as computational mesh

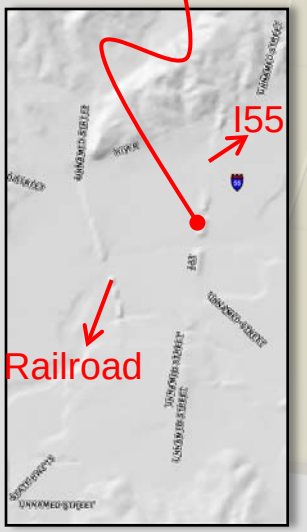
Hypothetical breaching of Sardis Dam, MS



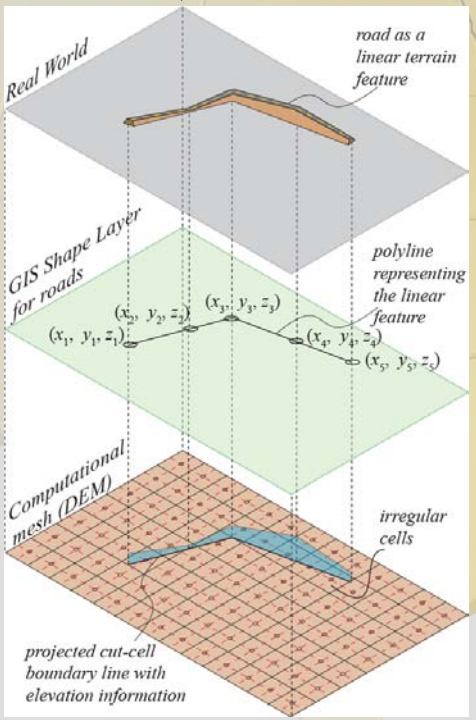
Operation begins in **1940**
Crest length: **15,300 ft**
Average height: **97 ft**

Capabilities for Linear Terrain Features and Coupled 1D-2D Simulations



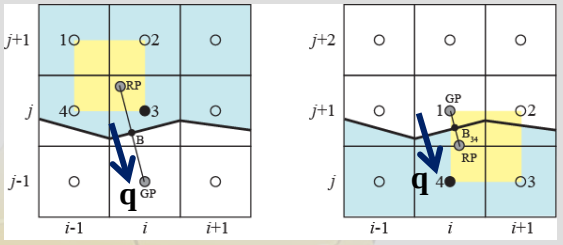


10m DEM (1/3 arc second) does not fully capture road embankments

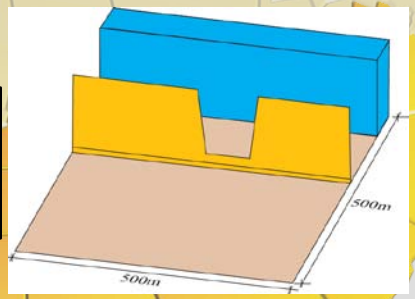


Cut-cell boundary method

Two-sided Ghost Fluid Technique

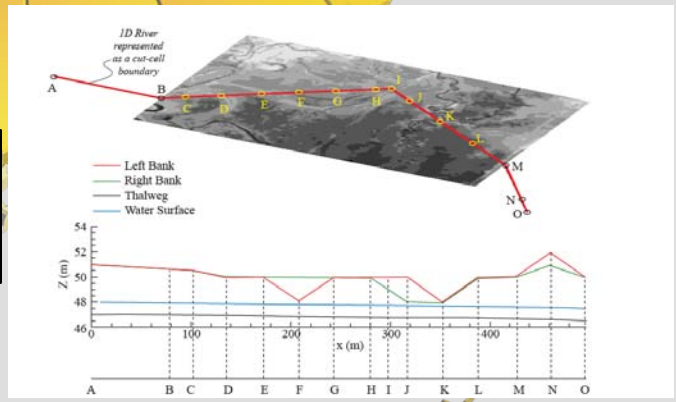


Play



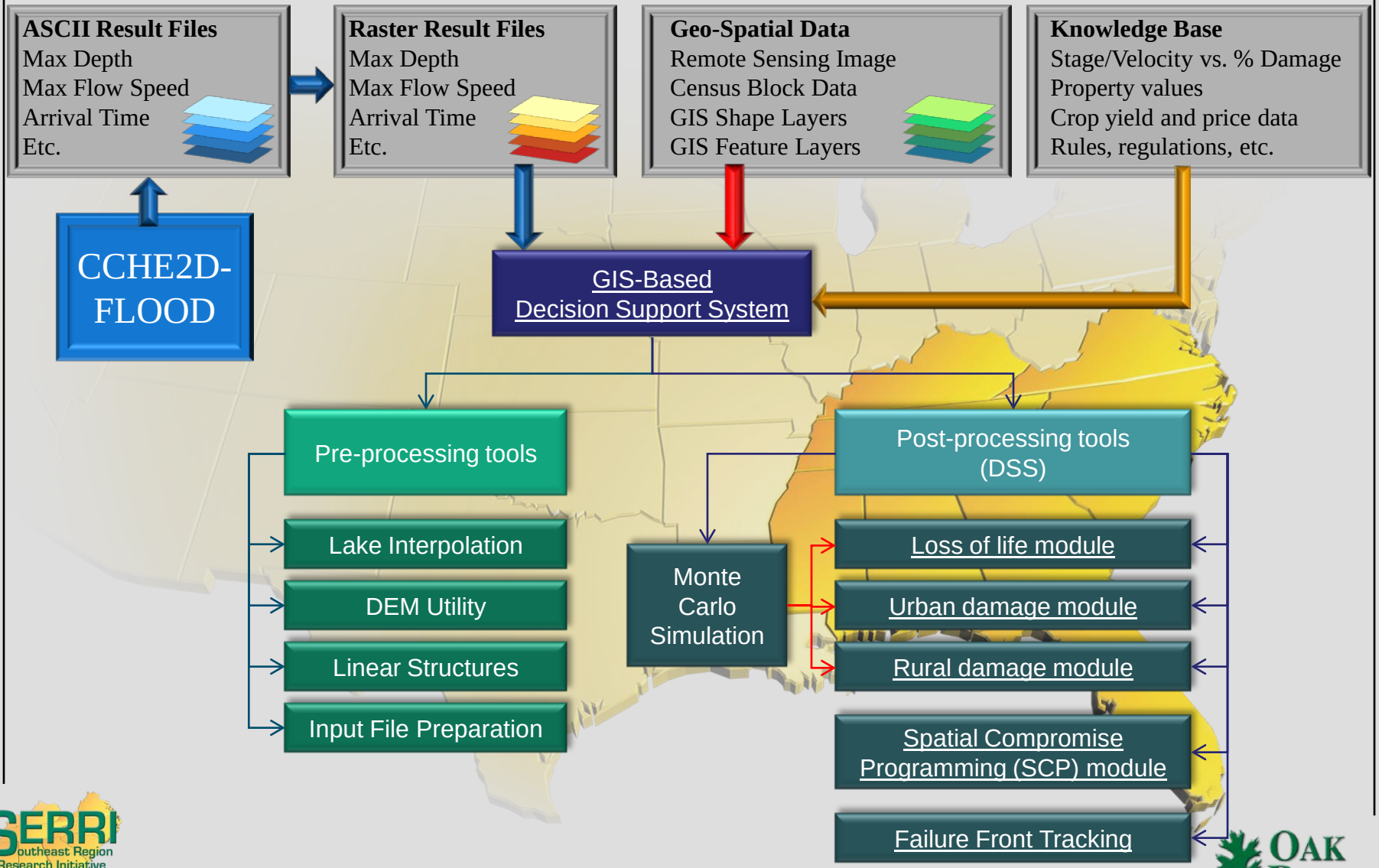
Test 1 Linear feature

Play



Test 2 Coupled 1D-2D simulation

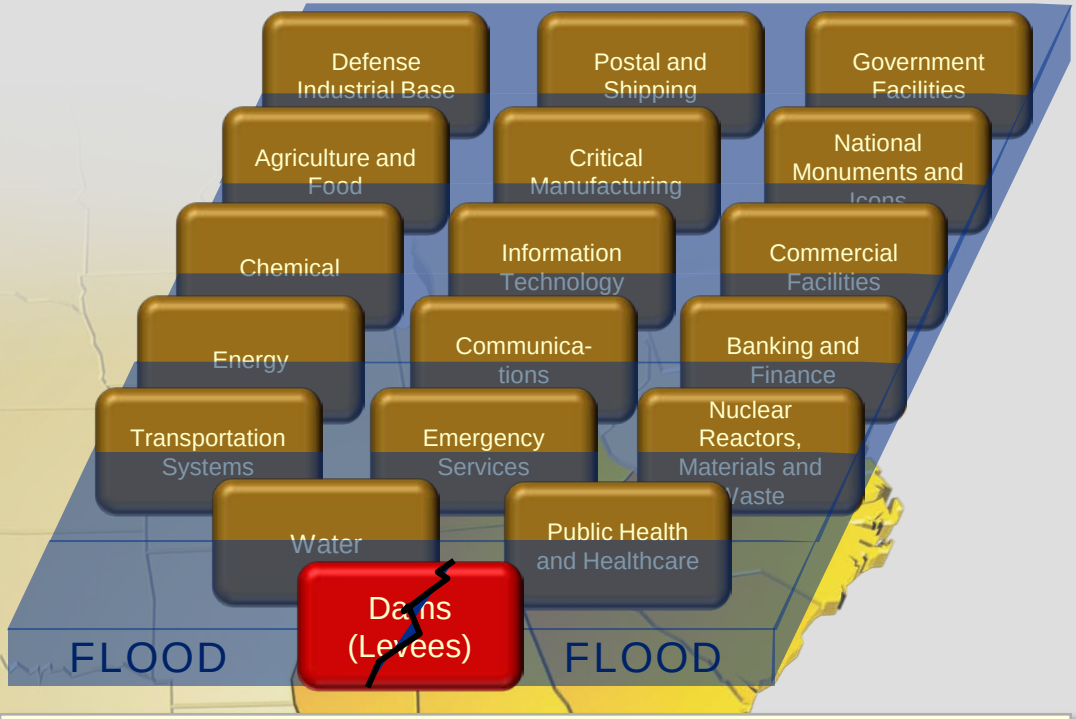
GIS-BASED Decision Support System



Expected Regional & National Impact

Vulnerabilities built by our society

1888 German map of New Orleans



Dams and levees constitute one of the 18 Sector-Specific Plans (SSPs) in support of the National Infrastructure Protection Plan (NIPP)

Failure of dams & levees could result in catastrophic floods leading to potential loss of life and property damage; but also cascading failures in other sectors.

Improving Current Practice

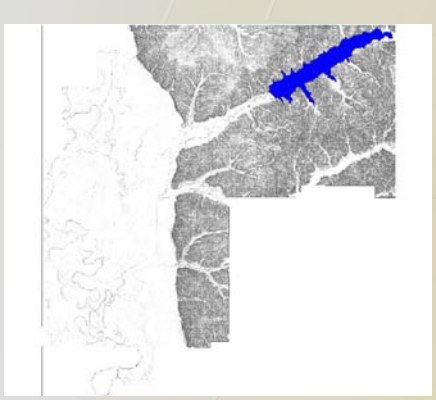
Highly transient, mixed regime flows!

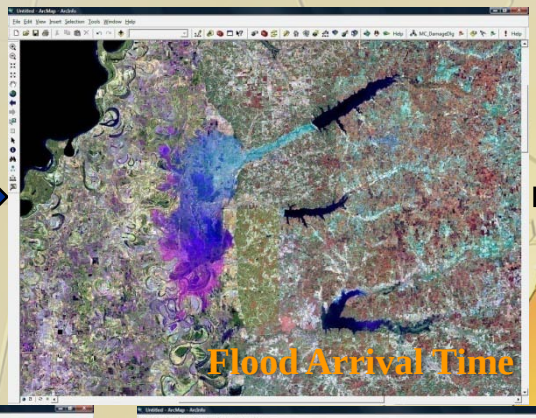
Current practice, based mostly on 1D simulations, cannot fully capture the flood dynamics and are not applicable in flat regions (non channelized flow). One dimensional model results need to be converted into two-dimensional results by interpolation.

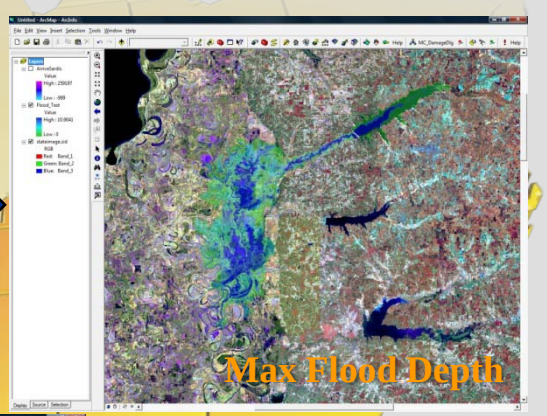
Method of dissemination of results needs to be improved.

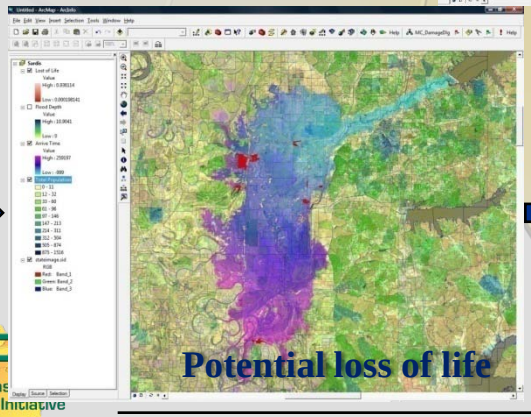
Impact of DSS-WISE Project

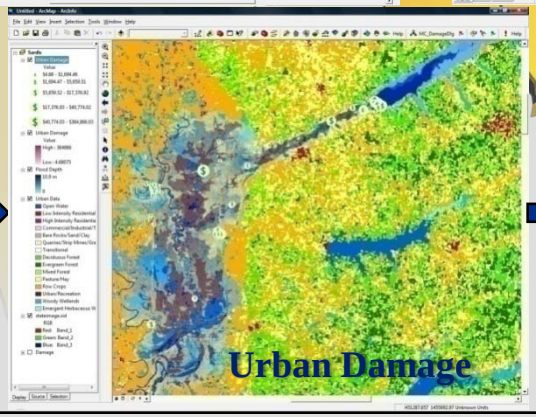
- The CCHE2D-FLOOD flood simulation model captures flow dynamics in two dimensions even on flat terrains. Discontinuous flow domains are allowed.
- GIS- and HAZUS-MH compatible results (flow depth and flow velocity distributions as a function of time, maximum flow depth and velocity distributions, flood front arrival time)
- Accompanying GIS-Based decision support system provides visualization, consequence analysis capabilities that can even be directly exploited by local authorities.

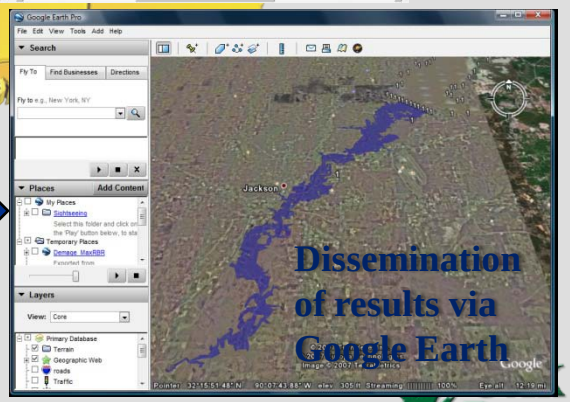












End-User Workshop and Open Forum

Federal Agencies
- Department of Homeland Security / FEMA
- US Army Corps of Engineers – ERDC
- US Army Corps of Engineers - Vicksburg District
- USDA-NRCS/National Water Management Center
- USDA-ARS National Sedimentation Laboratory (NSL)

State Agencies and Organizations
- Mississippi Emergency Management Agency (MEMA)
- Mississippi Dept of Environmental Quality (MDEQ)
- Mississippi Technology Alliance

Local Organizations
- Pearl River Valley Water Supply District (PRVWSD)
- Desoto County Emergency Services
- Community Resource Group, Inc. / RCAP

Universities
- The University of Mississippi
- Jackson State University
- Mississippi State University

Private Companies
- Waggoner Engineering, Inc.
- Radiance Technologies

Funding Agency Project Coordinator
- Oak Ridge National Laboratory

Date: June 26, 2008
Location: Mississippi e-Center, JSU
Attended by 40 Participants
Agenda included presentations of the projects, live demos and open forum for feedback.

Showcase the **research and development work**, and the **software products** developed by three SERRI Projects and request **feedback from the potential end-user community**!

Seminar Series in Disaster and Emergency Management

The University of Mississippi
School of Engineering
National Center for Computational Hydroscience and Engineering

Seminar Series in

Disaster and Emergency Management

No. 1

Date: Tuesday, March 6, 2007
Location: The University of Mississippi, Lyceum Building, Room 200

Program

9:45am–9:50am (5min)	*Welcome address of the Office of Research*	Patrick S. Brown *Assistant Vice Chancellor for Research and Sponsored Programs* *Office of Research and Sponsored Programs, The University of Mississippi*
9:50am–9:55am (5min)	*Welcome address of the School of Engineering*	Dr. Kai-Fong Lee *Dean and Professor of Engineering* *School of Engineering, The University of Mississippi*
9:55am–10:05am (10min)	*Brief Presentation of NCCHE*	Dr. Sam S. Y. Wang *F.A.P. Barnard Distinguished Professor & Director* *National Center for Computational Hydroscience and Engineering, The University of Mississippi*
10:05am–10:55am (50min)	*The Art and Science of Disaster Management*	Dr. Nezih Altay *Assistant Professor of Operations Management* *Robins School of Business, University of Richmond*
10:55am – 11:10am	Coffee Pause (15min)	
11:10am–12:00am (50min)	*Object-Oriented Decision Support and Expert System for Emergency Planning*	Dr. Haibo Wang *Assistant Professor of Decision Science* *Division of International Business and Technology Studies, Texas A&M International University*
12:00am – 1:30pm	Lunch break (1hour 30 minute) *	
1:30pm–2:20pm (50min)	*Simulation Based Decision Support System for Water Infrastructural Security (DSS-WISE)*	Dr. Mustafa S. Altinakar *Associate Director and Research Professor* *National Center for Computational Hydroscience and Engineering, The University of Mississippi*
2:20am–3:10pm 50min	*MEMA Operations with GIS Support During Catastrophic Events*	Dave Benway *Operations Officer* *Mississippi Emergency Management Agency (MEMA)*
3:20pm – 5:00pm	Closed door meeting with invited participants	

(*) Participants from outside of Oxford, MS, are kindly invited to have lunch with speakers and organizers. If you are an out-of-town participant and wish to attend the lunch, please send an email to Mustafa Altinakar (altinakar@ncche.olemiss.edu)

More information and map can be found at:

Dr. Mu

The University of Mississippi
School of Engineering
National Center for Computational Hydroscience and Engineering

Seminar Series in

Disaster and Emergency Management

No. 2

Date: Friday, April 13, 2007
Location: The University of Mississippi, Lyceum Building, Room 200

Program

9:30am – 10:00am	Morning Ice-Breaker(30 min) / Coffee and cookies will be served	
10:00am–10:35am (35min)	*An Introduction of NCCHE's Computational Modeling Capabilities in Water Infrastructure*	Sam S. Y. Wang *National Center for Computational Hydroscience and Engineering, The University of Mississippi*
10:35am–11:25am (50min)	*Contaminant Modeling Activities within ERDC/EL (part I)*	Mark S. Dortch *Recently retired from Water Quality and Contaminant Modeling Branch, Environmental Laboratory* *U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS*
11:25am – 11:35am	Pause (10min)	
11:35am–12:30pm (55min)	*Contaminant Modeling Activities within ERDC/EL (part II)*	Mark S. Dortch *Water Quality and Contaminant Modeling Branch, Environmental Laboratory* *U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS*
12:30pm – 1:30pm	Lunch break (1hour) Lunch boxes will be provided to participants	
1:30pm–2:30pm (60min)	*Warnings as Socio-Technical Systems*	Joanne M. Nigg *Disaster Research Center and* *Department of Sociology and Criminal Justice, University of Delaware, Newark, DE*
2:30pm–3:30pm (60min)	*Chemical Decontamination of Spills in Water Streams*	*Department of Chemical Engineering* *The University of Mississippi*
3:30pm – 4:00pm	Refreshment break (30min)	
4:00pm – 5:30pm (90min)	Informal discussion with Speakers and NCCHE Scientists	

More information and map can be found at:
http://www.ncche.olemiss.edu/index.php?page=ssdem

The University of Mississippi
School of Engineering
National Center for Computational Hydroscience and Engineering

Seminar Series in

Disaster and Emergency Management

No. 3

Date: Tuesday, January 22, 2008
Location: The University of Mississippi, Lyceum Building, Room 200

Program

10:00am – 10:30am	Morning Ice-Breaker(30 min) / Coffee and cookies will be served	
10:30am–11:20am (50min)	*Dam-break flow modeling: from idealized laboratory experiments to real events*	Dr. Yves Zech *Professor, Civil and Environmental Department* *Université catholique de Louvain, Louvain-la-Neuve, Belgium*
11:30am–12:20am (50min)	*Dam-Break Analysis for Ross Barnett Dam and Reservoir*	Ralph R. Robertson, Jr., P.E. *Civil Engineer, MR&T Team,* *Watershed Division, Mississippi Valley Division, Vicksburg, Mississippi*
12:30pm – 1:30pm	Lunch break (1hour) Lunch boxes will be provided to participants	
1:30pm–2:20pm (50min)	*GIS-Based Decision Support System for Flood Simulation and Evaluation using a 2D free surface model with Ghost-Fluid Method to Represent Linear Terrain Features*	Dr. Mustafa Altinakar *Associate Director and Research Professor,* *National Center for Computational Hydroscience and Engineering, The University of Mississippi*
2:30pm–3:20pm (50min)	*Development Of An Integrated Simulation Tool For Predicting Disastrous Flooding, Water Contamination, Sediment Transport And Their Impacts On Environment*	Dr. Yafei Jia *Associate Director and Research Professor,* *National Center for Computational Hydroscience and Engineering, The University of Mississippi*
3:30pm – 3:40pm	Refreshment break (10min)	
3:40pm – 4:30pm (60min)	Informal discussion with Speakers and NCCHE Scientists	

More information and map can be found at:
http://www.ncche.olemiss.edu/index.php?page=ssdem

Contact person and organizer:
Dr. Mustafa S. Altinakar (P: 662-915-3783; F: 662-915-7796; altinakar@ncche.olemiss.edu)

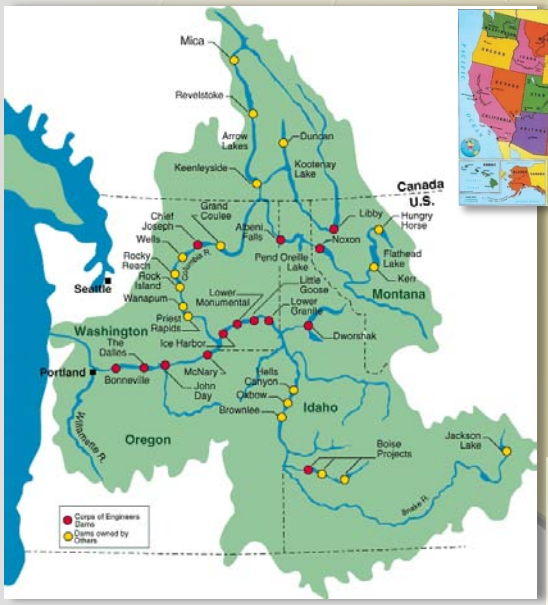
Interested persons are invited

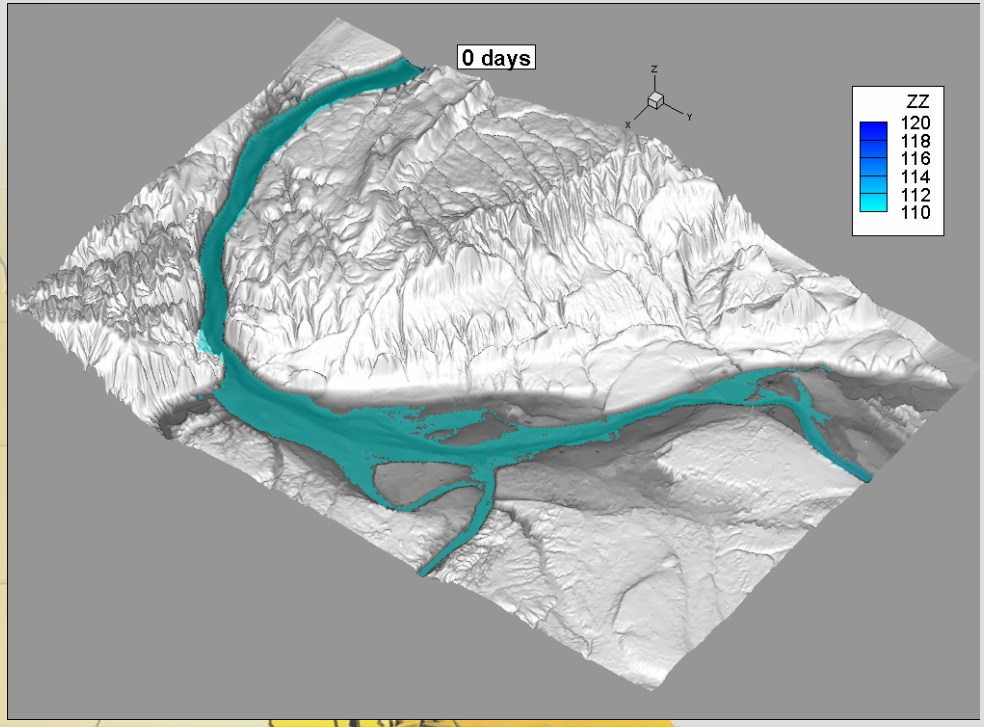
SERR Southeast Regional Research Initiative

Columbia River Basin Risk Management and Mitigation Pilot Project

2009 Dams Sector Exercise

To develop a regional disaster resilience and preparedness strategy for the Tri-Cities area that can be utilized for the broader Columbia River Basin region.





The DSS-WISE team is actively participating in the 2009 Dams Sector Exercise by carrying out unsteady, two-dimensional simulations of the selected flood scenarios for the Tri-Cities area.

Play

Contacts, Current Users & Publications

Information about the research and development work and project outcomes have been disseminated through publication of conference papers, seminars, and contacts with state and federal agencies.

The numerical model, CCHE2D-FLOOD is currently in use by:

- **US Army Corps of Engineers – ERDC (Military Hydrology)**
- **US Army Corps of Engineers - Vicksburg District**
- **National Geospatial-Intelligence Agency**

Other requests have also been received.

Currently, DSS-WISE Team is collaborating with USDA-NRCS in Arkansas to verify and validate DSS-WISE system by carrying out joint dam-break studies in view of developing a dedicated decision support system for improved agricultural damage analysis.

DSS-WISE Team has received a request from a private software company for incorporating CCHE2D-FLOOD in a commercial decision support system for flood emergency management.

Contacts are established with Hydrologic Engineering Center (HEC) Institute for Water Resources of the US Army Corps of Engineers for collaborative work.

Conferences and Meetings

Presentation of DSS-WISE Project to the members of Dams Sector Group (DHS, Dams Sector Branch, SSA Executive Management Office, Office of Infr. Prot.; Argonne National Laboratory Scientists and Engineers; USACE Infrastructure Division; USACE-ERDC) (3/26, 2007)

Annual Conference of the Association of State Flood Plain Managers (ASFPM), Reno-Sparks, Nevada (5/18-23, 2008)

River Flow 2008 Conference in Cesme, Izmir, Turkey (9/3-5, 2008)

International Conference in Hydroscience and Engineering (ICHE-09), Nagoya, Japan (9/10-12, 2008)

Keynote Lecture by Dr. Altinakar at the "International Symposium on Uncertainties in Hydrologic and Hydraulic Modeling" in Montreal, Canada, organized jointly by HydroQuebec and Ecole de Technologie Superieure (10/15-17, 2008).

Dams Sector Joint GCC/SCC Quarterly meeting held in Las Vegas (2/12, 2009).

Current Status of DSS-WISE Project

1st Phase of DSS-WISE Feb 2007 – Oct 2008 (19 months)	→	2nd Phase of DSS-WISE Nov 2008 – Oct 2009 (12 months)
The 2D flood simulation model, CCHE2D-FLOOD, is completed, including linear terrain feature and 1D-2D coupled simulation capabilities	→	Improve CCHE2D-FLOOD: 2nd order solver, faster computation, multi-grid techniques for better breaching simulation, multiple river definitions.
Beta testing of CCHE2D-FLOOD is now under way by third party users (USACE Vicksburg District, NGI, etc.)	→	Custom tailoring of the GIS-based GUI (Graphical User Interface) and decision support tools in collaboration with USACE and USDA-NRCS economists
An operational version of GIS-based decision support system is available. It is currently being alpha tested by NCCHE researchers.	→	Testing and demonstrating the research outcomes and capabilities of the entire software in a realistic environment close to operational conditions
Some pre-processing tools for data preparation are operational, but more development in this area is needed.	→	Collaborating with various state and federal agencies to access realistic test data and to receive feedback to improve the system.
TRL 4-5 has been achieved	→	TRL 6 will be achieved

SERRI Southeast Region Research Initiative

Future Capabilities Under Development

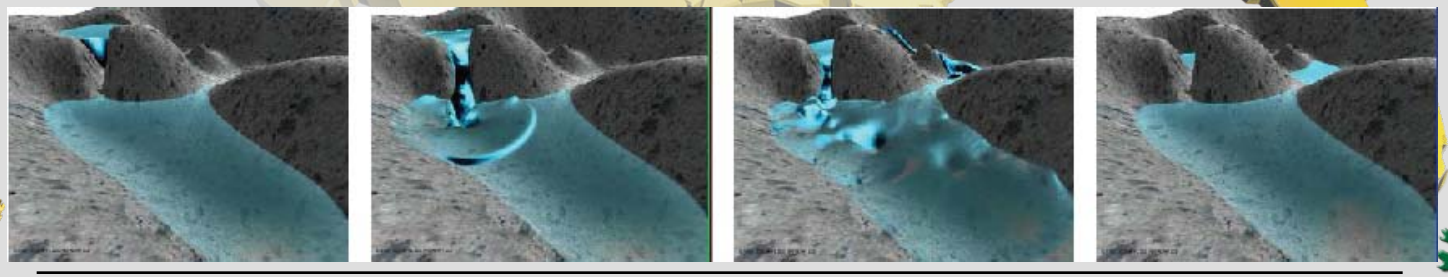
Development of a **computer-game like environment** that can simulate dam/levee break/breaching floods over complex topography at **faster than real-life frame rates and simultaneous visualization** by exploiting **parallel computing** on commodity graphics cards on **ordinary desktop computers** (GPGPU technology).

The user can:

- View the simulation in 2D or false 3D;
- Change the viewpoint, pan and zoom in and zoom out while the simulation is running;
- Stop the simulation and reel back in time;
- Make changes in the environment (modify the topography, implement flood protection works, etc.
- Restart the simulation to see the effects of the modifications.

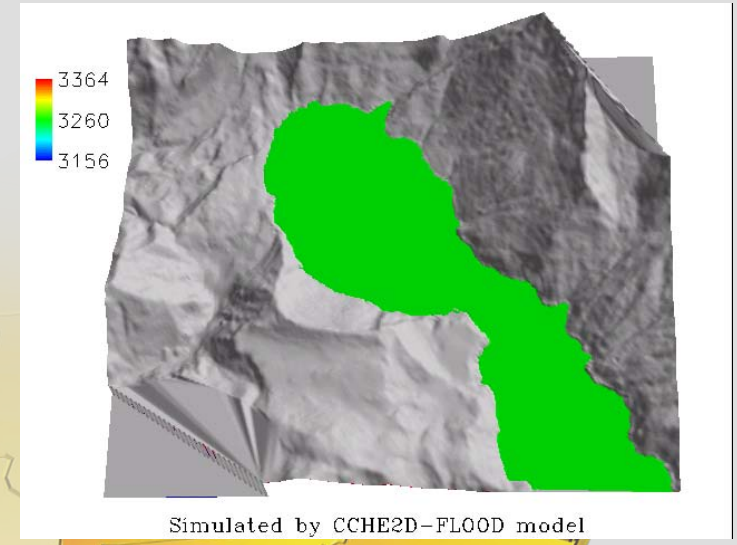
GeForce 8800 GTX by Nvidia

- Core clock speed of 575MHz
- 768MB of DDR3 RAM clocked to 900MHz with a 1,800MHz data rate.
- 128 stream processors that can process simultaneously



Final Remarks

Overtopping and Flooding due to Landslides



Acknowledgements

This project was funded through the Southeast Region Research Initiative program from the Department of Homeland Security, Science and Technology Directorate, Infrastructure and Geophysical Division.

The project team would like to express their special thanks to the project coordination team at ORNL and the members of the S&T Directorate for their continuous support and guidance, and for creating an ideal research and development environment.