



NRC Staff Review of Environmental Models

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Presentation Outline

- Assess Materials Decommissioning Sites, Uranium Recovery Facilities and High-Level Radioactive Waste Tank Farm Closures
- Input to Probabilistic Consequence Analysis using MACCS
- Assess Hydrologic Hazards such as Floods at Nuclear Power Plant Sites
- Identify Opportunities to Share Models and Databases

Interagency Steering Committee on Multimedia Environmental Models (ISCMEM)

December 14, 2016

Environmental Modeling

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NRC/NMSS Examples of Environmental Model Reviews

Materials Decommissioning Sites

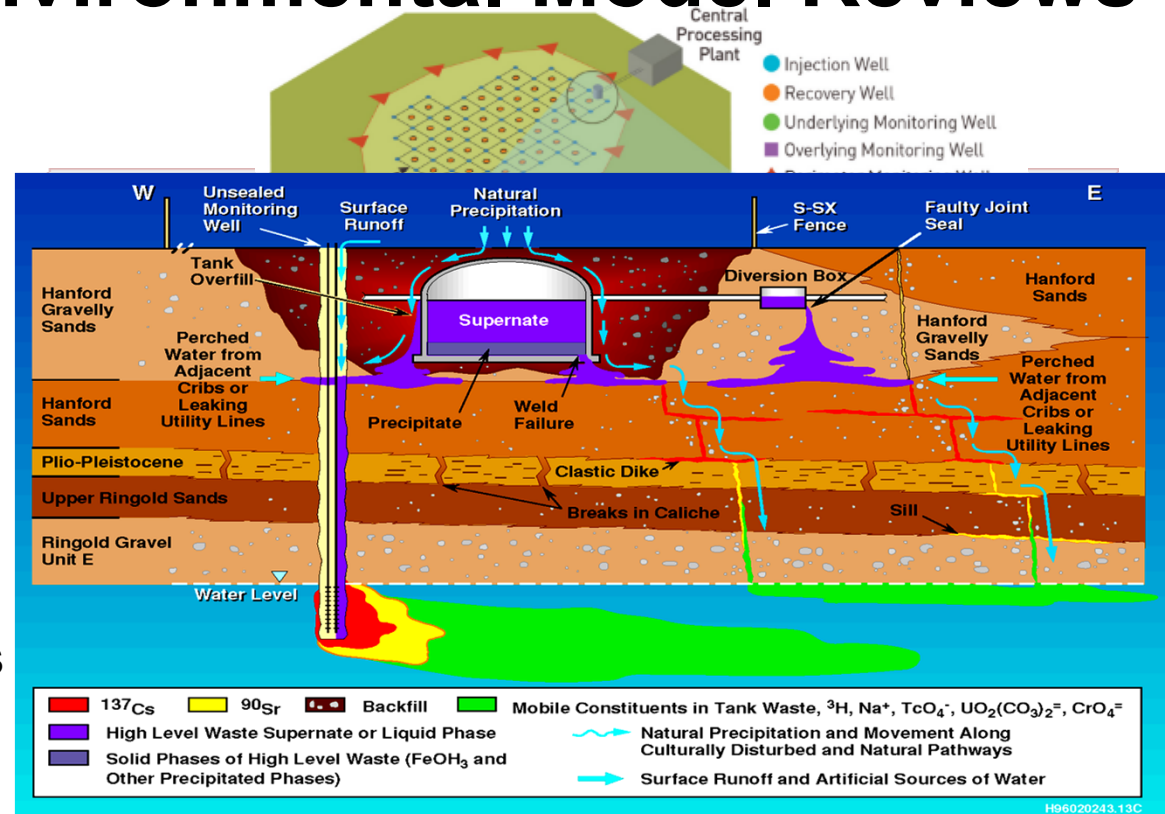
- Sampling plans
- Dose modeling

Uranium Recovery

- Geochemical modeling
- Flow and transport

DOE Tank Farm Closure Activities

- Infiltration and erosion control
- Geochemical modeling
- Flow and transport
- Probabilistic simulations



HLW Tank Farm Conceptual Model

(Caggiano JA. 1996. Assessment Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area S-SX. WHC-SD-EN-AP-191, Westinghouse Hanford Company, Richland, Washington.)

NRC/NMSS Independent Environmental Modeling

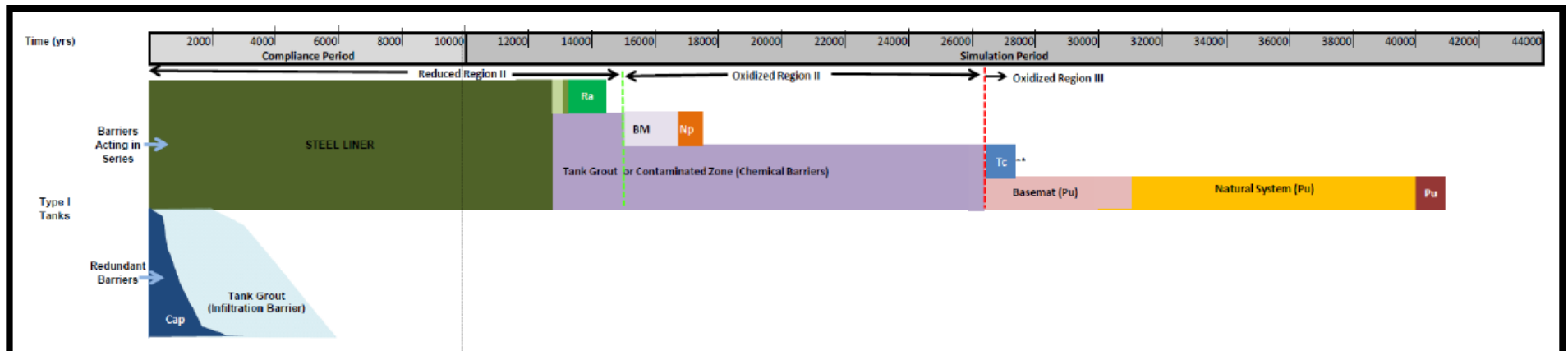
Improve understanding through additional analyses

- Sensitivity analyses
- Uncertainty analyses
- Barrier analyses

Risk-inform the performance assessment review

Identify critical issues in complex systems

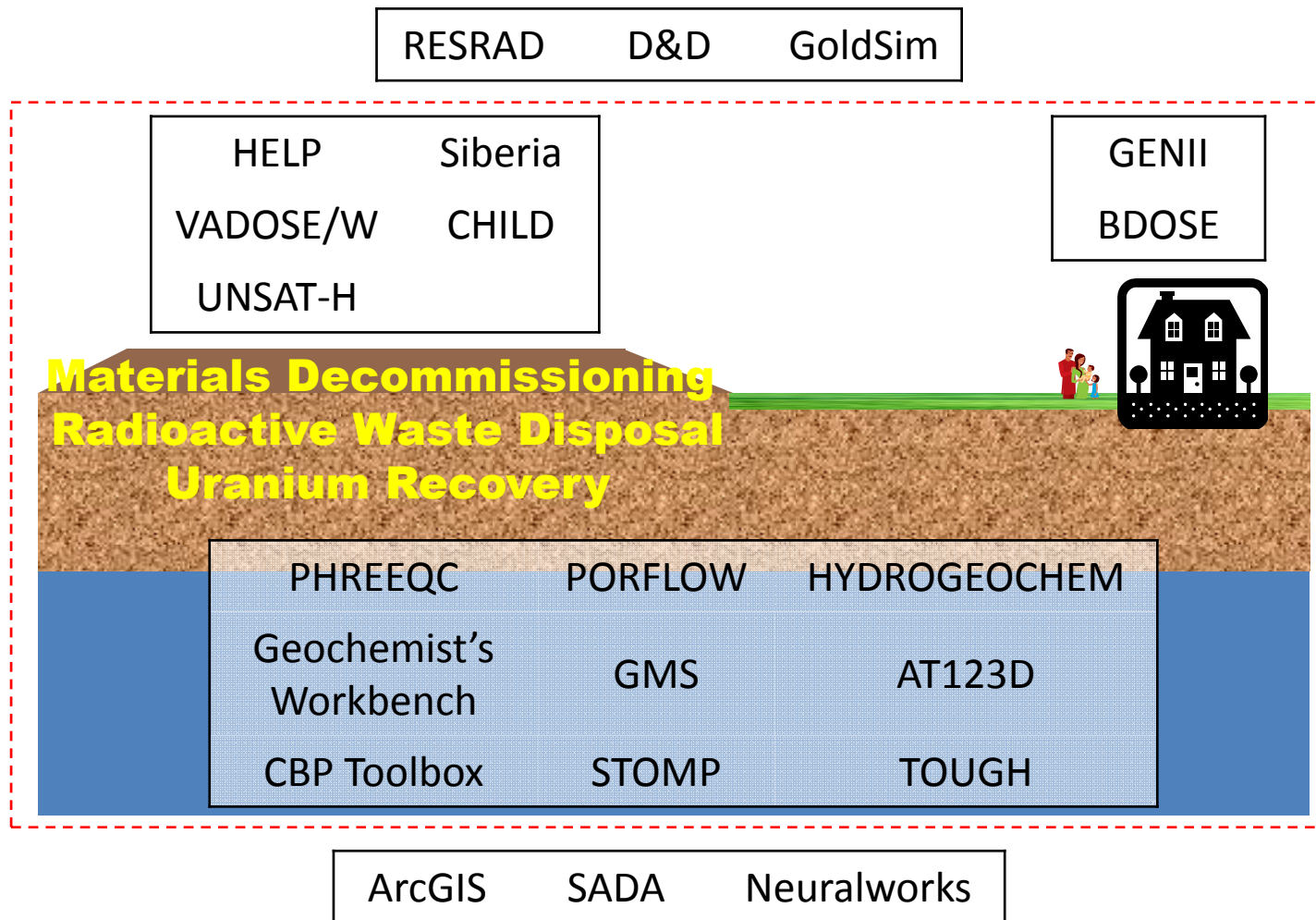
Expedite the review



Barrier Analysis - F Tank Farm DOE Savannah River Site

(Adapted from Figure 3-5 Combined F and H Tank Farm Monitoring Plan, ML15238A761)

Environmental Models and Computational Tools



Environmental Modeling Challenges and Opportunities

Challenges

- Conceptual model uncertainty
- Data versus model limitations
- Verification & “Validation”
- Model support
- Training

Opportunities

- Lessons learned
- Environmental model and data sharing
- Compendium of data
- Development of databases



Probabilistic Consequence Analysis using MACCS

Dr. Keith L. Compton

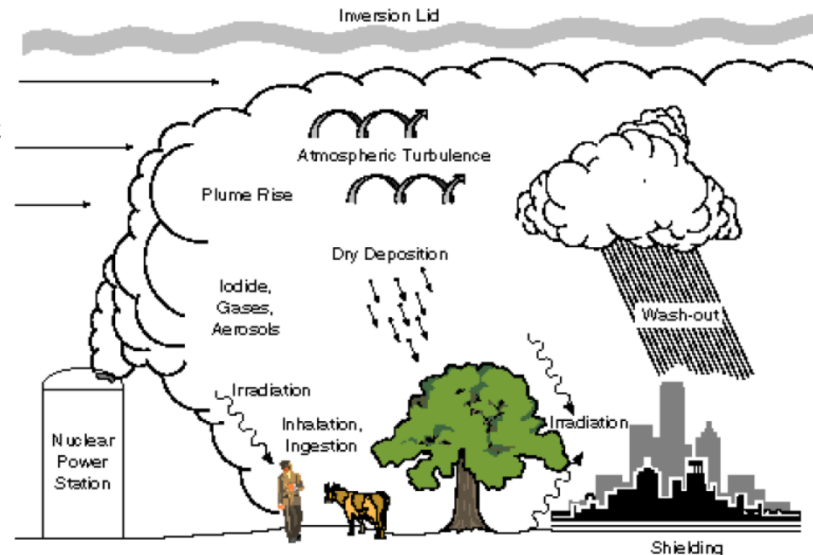
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Overview of Severe Accident Consequence Analysis

- Probabilistic consequence analysis focuses on developing realistic estimates of the consequences of a full range of potential accidents
- Prospective analysis: must consider a range of potential meteorological conditions
- Multiple types of consequences (doses, health effects, economic impacts, etc.) may be of interest
- Typically includes modeling the radioactive release to the atmosphere (e.g. plume rise, dispersion, dry and wet deposition).
- Direct releases to other media (e.g., unsaturated zone, groundwater, surface waters, etc.) have typically not been included in severe accident consequence analyses.





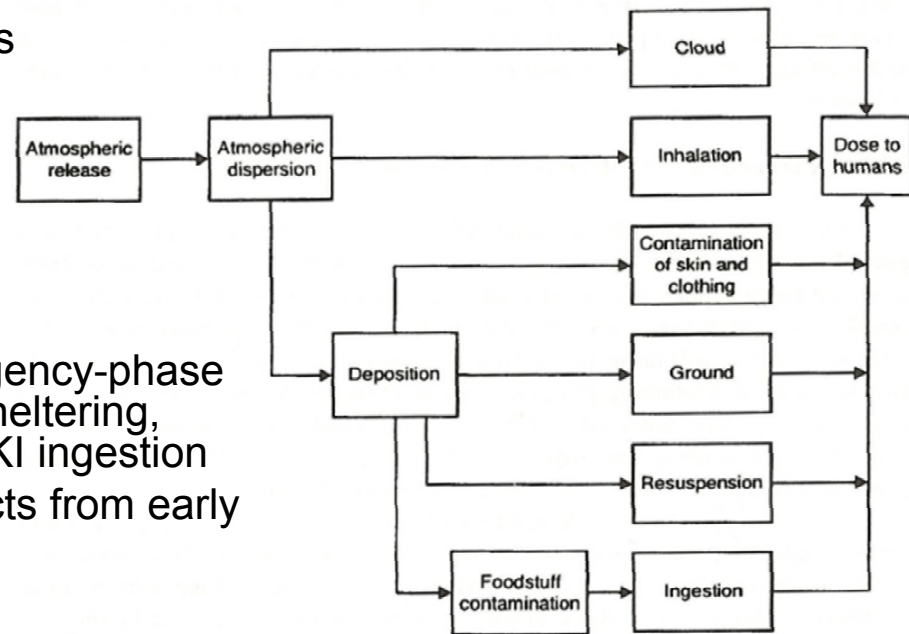
Severe Accident Consequence Analysis: MACCS Applications

	Risk-Informed Decision-making	Backfit Analysis	Reg. Analysis	SAMA/SAMDA	Envir. Assmt.	Level 3 PRA	Research Studies
	RG 1.174	NUREG-1409	NUREG/BR-0184	NUREG-1555	NUREG-1555		
Individual Early Fatality Risk	X	X	X	X	X	As specified	As specified
Individual Latent Fatality Risk	X	X	X	X	X		
Collective Dose Risk		X	X	X	X		
Offsite Property Damage Risk			X	X	X		
Total Early Fatality Risk					X		
Total Latent Fatality Risk					X		
Land Contamination Risk					X		

MACCS Modules

- **ATMOS**

- Source term definition
- Weather sampling algorithms
- Atmospheric transport, dispersion, and deposition



- **EARLY (1 day to ~1 week)**

- Includes emergency phase
- Doses as modified by emergency-phase countermeasures such as sheltering, evacuation, relocation, and KI ingestion
- Acute and latent health effects from early acute exposure

- **CHRONC (~1 week to >50 years)**

- Includes both intermediate and long term recovery phases
- Doses as modified by long-term protective actions such as decontamination, interdiction, and condemnation
- Latent health effects from chronic exposure to deposited material
- Economic impact from early and late phase protective actions



MACCS Preprocessors

- MELMACCS
 - Utility for creating a MACCS formatted source term from MELCOR
- SECPOP
 - US site specific population distribution and economic parameters based on US census and economic databases
- Dose Conversion Factor utility codes and files
 - DOSFAC2 code
 - FGRDCF code
 - ICRP-68/72 file
- COMIDA/COMIDA2 code
 - Food chain
 - Includes decay and ingrowth
 - A standard file is distributed with MACCS/WinMACCS



Freshwater Transport of Radionuclides

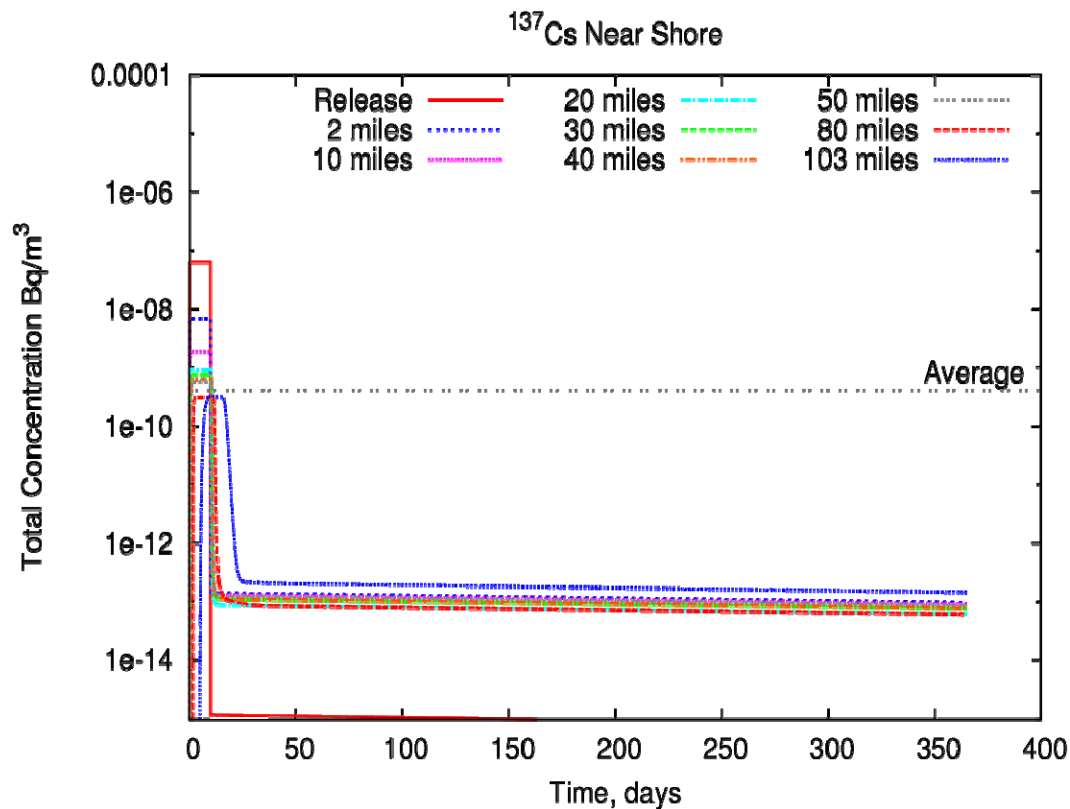
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Dr. Mark Fuhrmann

U.S. NRC Office of Nuclear Regulatory Research

NRC contracted PNNL to model contaminant flow in a Large River, a Small River and a Small Lake.
Report to be published as NUREG/CR-7231



MASS2 and TETHYS Models were used, producing very detailed results.

Massively Parallel computing system was needed.

Large amount of bathymetry data was needed.

Modeling of Surface-Water Transport of Radionuclides

- NRC staff is interested in simple models of contaminant transport in rivers and lakes
 - Areas specific to nuclear power plants
 - May need long stretches of rivers; pulse can travel hundreds of miles with relatively little dilution
 - Need input from tributaries
 - Sediment interactions
- Suggestions?

Hydrologic Hazard Modeling

Dr. Meredith Carr

US NRC Office of Nuclear Regulatory Research

- External hazards (e.g., floods) from the environment pose a safety concern. Models and tools are used to assess and prepare for these risks
 - Review of submitted hydrologic hazard assessments (confirmatory modeling)
 - New reactor license applications
 - Operating reactor license amendment requests
 - Risk assessment of inspection findings, deficiencies, unusual events, etc.
 - Post-Fukushima flooding re-evaluations
 - Research to support regulatory guidance development

Hydrologic Hazard Modeling

- Tools
 - Used by NRC staff and contractors for hydrologic hazard modeling

Flood Frequency Analysis

Models

HEC-SSP

PeakFQ

Scientific and Statistical

Toolboxes

R (Statistical Package)

Matlab

Surface Water Models,

HEC-HMS

HEC-RAS

Flow 2D

ADCIRC

SLOSH

DELFT3D

NEUTRINO

MASS2

Numerical Weather

Models

WRF

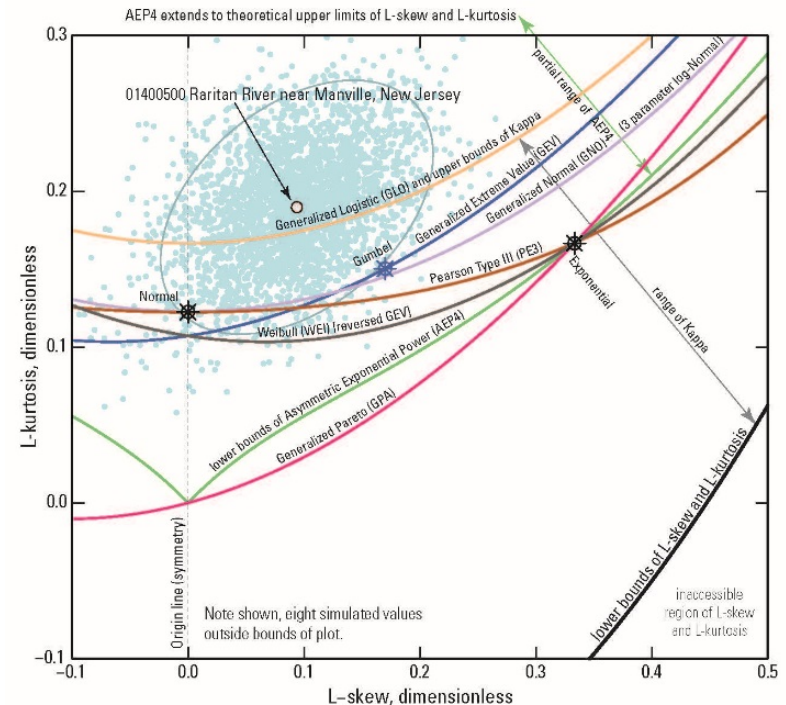
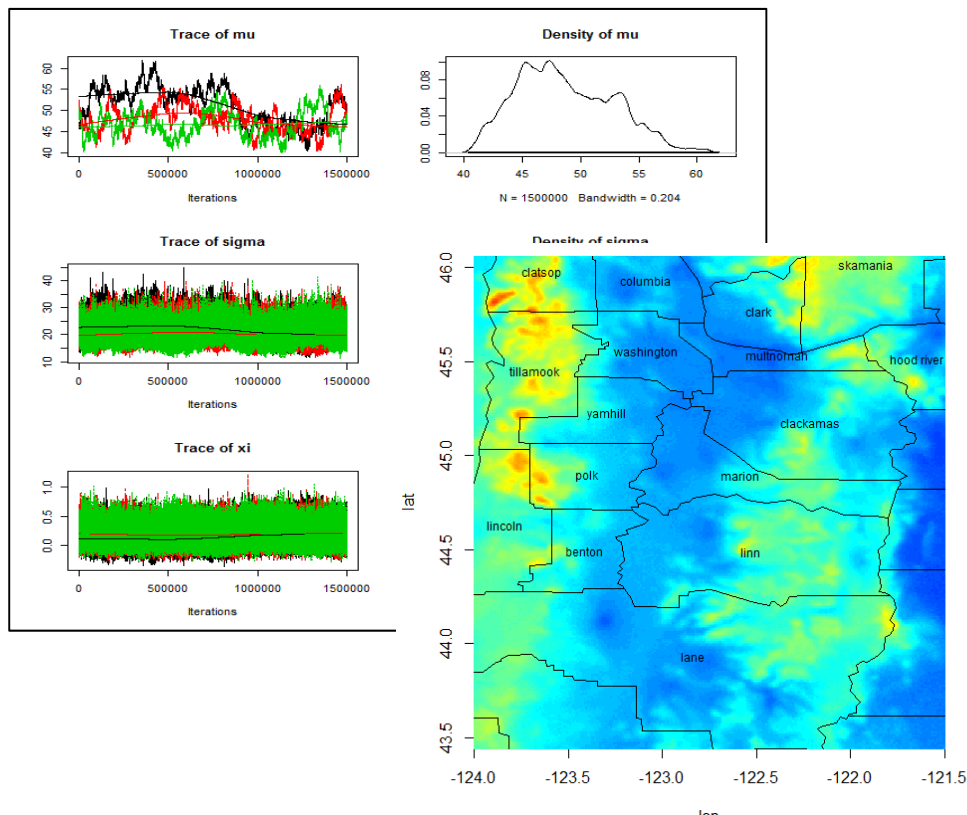
Reanalysis Models

Hydrologic and Hydraulic Models

- HEC-HMS, HEC-RAS, Flow 2D used in support of Flood Hazard Assessments

Flood Frequency Modeling

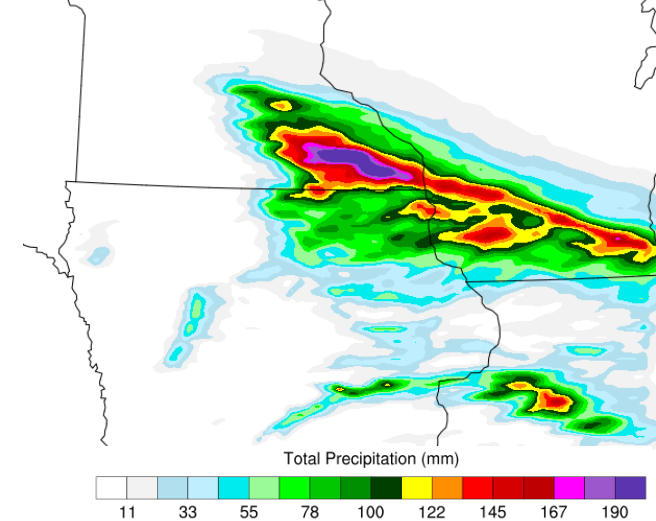
- Multiple Projects, R Programming Language and Software Environment
 - Trace and density plots of the GEV model distribution parameters resulting from three MCMC runs
 - Return Period Maps using a model dependent on 4 parameters
- L- Moment Diagram to assess fits of multiple distribution to systematic data record and simulated values based on variance-covariance



Local Intense Precipitation Processes Modeling

- USGS/UC Davis
- Assess capability of regional numerical weather simulation models (WRF) to accurately simulate extreme precipitation events
- Use models to investigate impact of climate change on extreme precipitation events
 - Benchmark simulation and validation of select intense storms
 - Simulation of selected intense storms in observational record and analysis of underlying processes responsible for intense precipitation

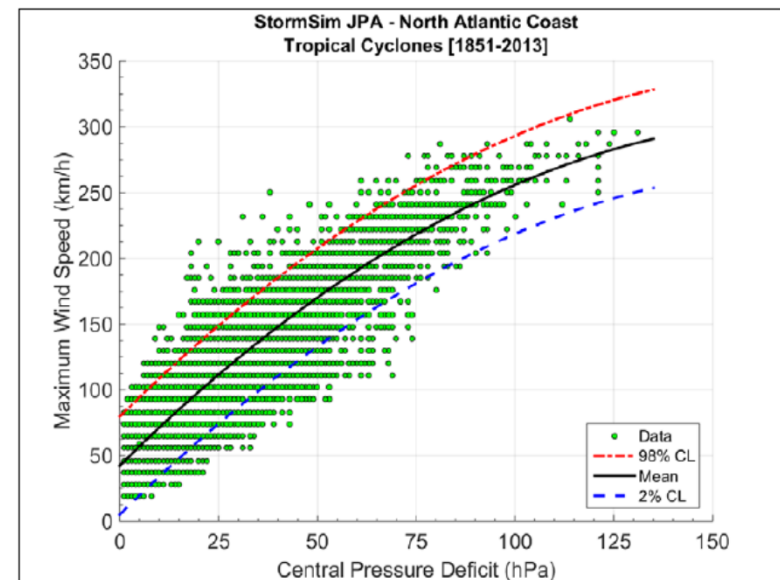
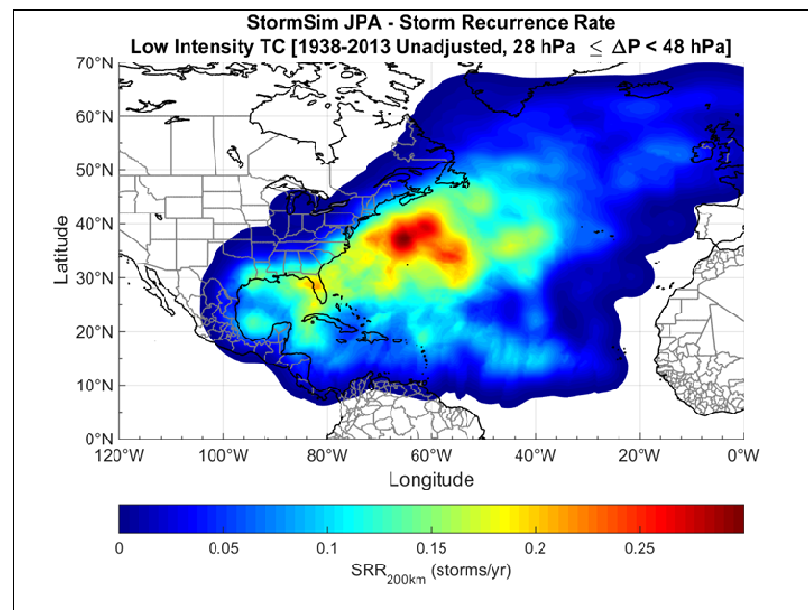
WRF Simulation – 24 hr accumulation



Mesoscale Convective System (MCS)
for August 19, 2007 event

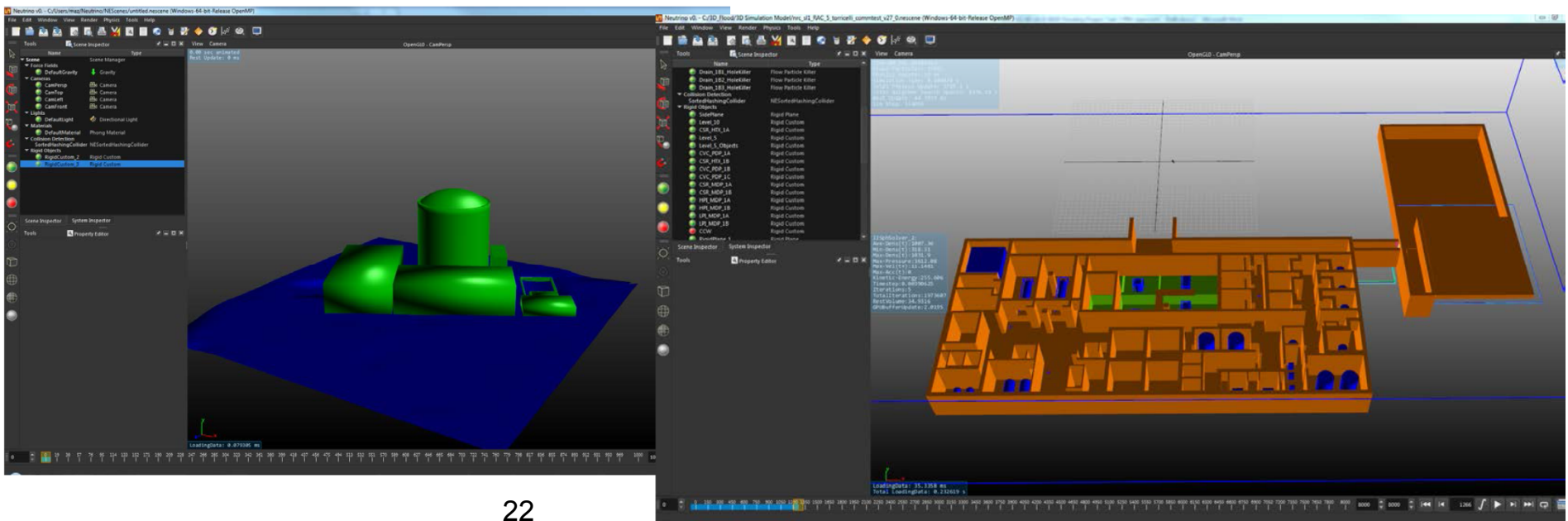
Quantifying Uncertainties in Probabilistic Storm Surge Models

- USACE
- Numerical simulations using the ADCIRC model
- Quantify epistemic and aleatory uncertainties inherent in the key steps of probabilistic storm surge modeling
 - Storm recurrence rate (SRR) models
 - Characterization of storm climatology and probability distributions of storm parameters
 - Discretization of probability distributions and generation of synthetic storms
- Investigate the propagation of uncertainties in joint probability analyses of storm surge hazard



3D Smooth Particle Hydrodynamics for Modeling Flooding in a Plant

- INL
- 3D simulation models were developed using the 3D simulation software Neutrino to simulate the flooding scenarios and communicate with the PRA model
- A 3D site terrain model was obtained for the interested plant/site with a web-based application that interacts with the Google Elevation API
- A typical 3D plant model was also developed. Flooding scenarios and pathways were identified





Radiation Protection Code Analysis and Maintenance Program (RAMP)

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RAMP

RAMP is part of the NRC's cooperative research program which supports the development and maintenance of radiation/dose assessment codes and provides in-depth services to RAMP members.

- Over 400 RAMP members including the NRC, other Federal and State Agencies, Licensees and Vendors & 10 International Agreements
- Membership is free for Federal and State Agencies
- RAMP Annual User Meetings (Domestic and International)
- More efficient use of resources (leverages group dynamics) to update dosimetry, source terms and state-of-the-art modeling in all the codes
- RAMP webpages for each code

(<https://www.usnrc-ramp.com/>)

- User Forums & Technical Support
- Technical Documentation including Benchmarking Studies
- Online Training Modules & Presentations



Dose Assessment Codes in RAMP

Environmental

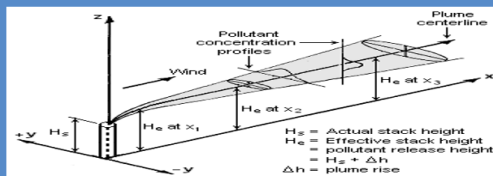


MILDOS 4

Radiological Dose from Uranium Milling



Atmospheric Codes

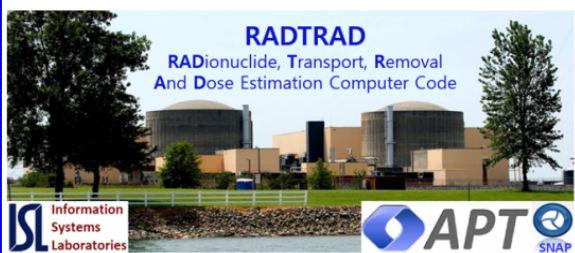


PAVAN

ARCON96

XOQ/DOQ

NPP Licensing



Gaseous And Liquid Effluent



Emergency Response Code



Other Dose Assessment Codes



VARSKIN
Computer Code for Skin
Contamination Dosimetry



Summary

- Codes used by the NRC staff provide useful tools for assessing environmental consequences involving flood risks and radionuclide releases and transport in air, soil, surface- and ground-water systems
- NRC staff is pursuing enhancement of environmental models and databases for a variety of regulatory applications, particularly for air transport modeling
- NRC staff looks forward to cooperating with other Federal Agencies, universities and users of the environmental models in the ISCMEM work groups

Information Sources

ArcGIS www.arcgis.com
AT123D <http://www.seview.com/aboutat123d.htm>
BDOSE <http://pbadupws.nrc.gov/docs/ML1107/ML110750358.pdf>
CBP Toolbox <http://cementbarriers.org/>
CHILD <https://csdms.colorado.edu/wiki/Model:CHILD>
DandD <https://www.usnrc-ramp.com/DandD>
Geochemist's Workbench <https://www.gwb.com/>
GENII <http://energy.gov/ehss/genii>
GMS <http://www.aquaveo.com/>
GoldSim <http://www.goldsim.com/Home/>
HELP <https://www3.epa.gov/>
HYDROGEOCHEM <http://www.scisoftware.com>
Neuralworks <http://www.neuralware.com/>

Information Sources (continued)

PHREEQC http://wwwbrr.cr.usgs.gov/projects/GWC_coupled/phreeqc/
PORFLOW <http://www.acricfd.com/software/porflow/>
RESRAD <http://www.evs.anl.gov/resrad/>
SADA <http://www.sadaproject.net/>
Siberia <http://www.telluricresearch.com/siberia-homepage.html>
STOMP <http://stomp.pnnl.gov/>
TOUGH <http://esd1.lbl.gov/research/projects/tough/>
UNSAT-H <http://hydrology.pnnl.gov/resources/unsath/unsath.asp>
Vadose/W <https://www.geo-slope.com/products/vadose-w>