A Regulator's Perspective on Interpretation of Performance and Risk Assessment Results

David Esh, George Alexander, Christopher Grossman, Christepher McKenney

Division of Decommissioning, Uranium Recovery, and Waste Programs

Office of Nuclear Material, Safety and Safeguards

Performance and Risk Assessment Community of Practice

Richland WA, December 15, 2015

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Overview

1. Performance Assessment and Components
2. Compliance Metric and Examples
3. Uncertainty and Scenarios
4. Conservatism
5. Model Support

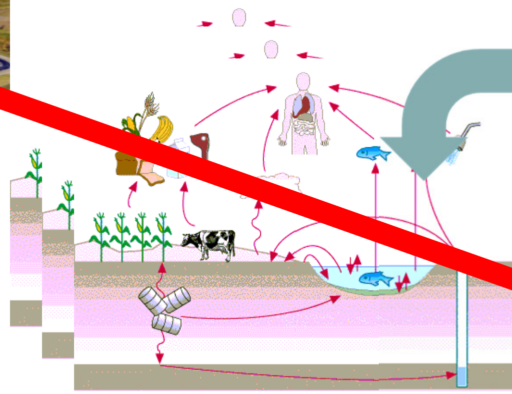
Performance Assessment

Performance assessment is an analysis that:

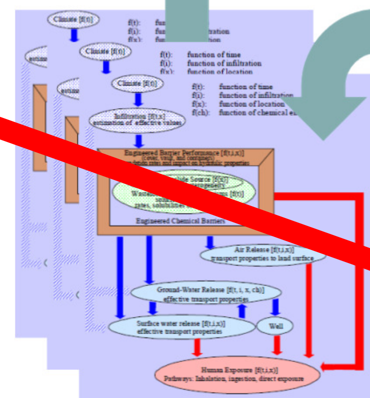
(1) Identifies the features, events, and processes that might affect the disposal system;
(2) Examines the effects of these features, events, and processes on the performance of the disposal system; and
(3) Estimates the annual dose to any member of the public caused by all significant features, events, and processes.

Performance Assessment

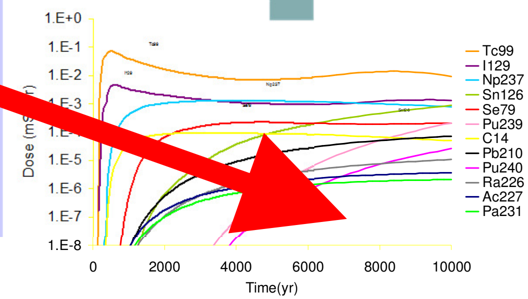
1 Real system



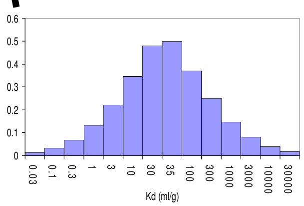
2 Conceptual model

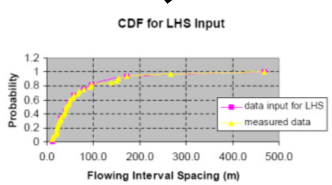


3 Numerical model



4 Estimated performance





5 Model support

Performance Assessment

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

	1	Real system
Contractor/licensee	2	Conceptual model
Regulator →	3	Numerical model
Public stakeholder	4	Estimated performance
	5	Model support

How would different groups rank the importance of each component?

Recent Incidents

Beatty

WIPP

NRC Metric

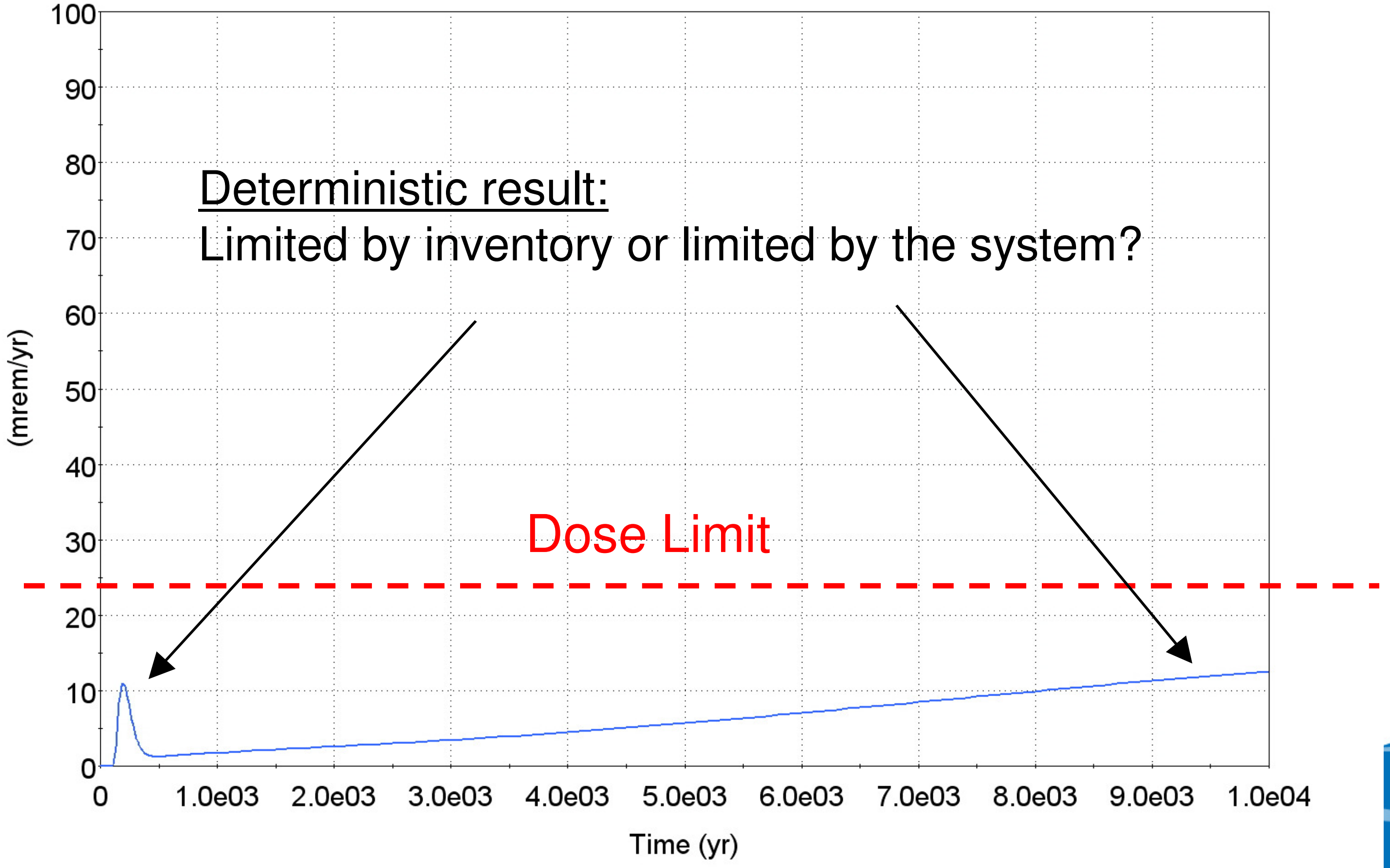
- Demonstration of compliance with the performance objectives is based on a standard of reasonable assurance.
- Compliance review would consider quality of information, model support, and independent technical review.

Common Points of Difference

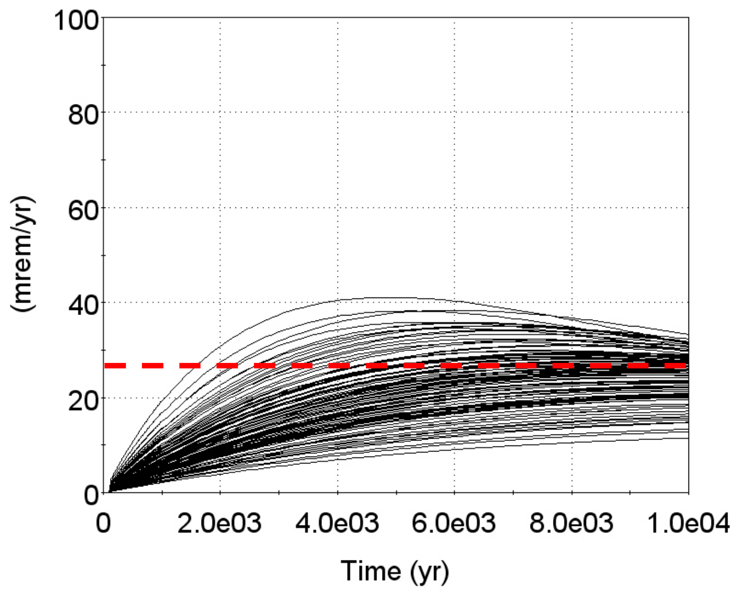
- What is ‘reasonable assurance’?
- What is adequate justification or model support?
- How do alternate scenarios relate to what one party considers the “likely” scenario? Is there a “likely” scenario?

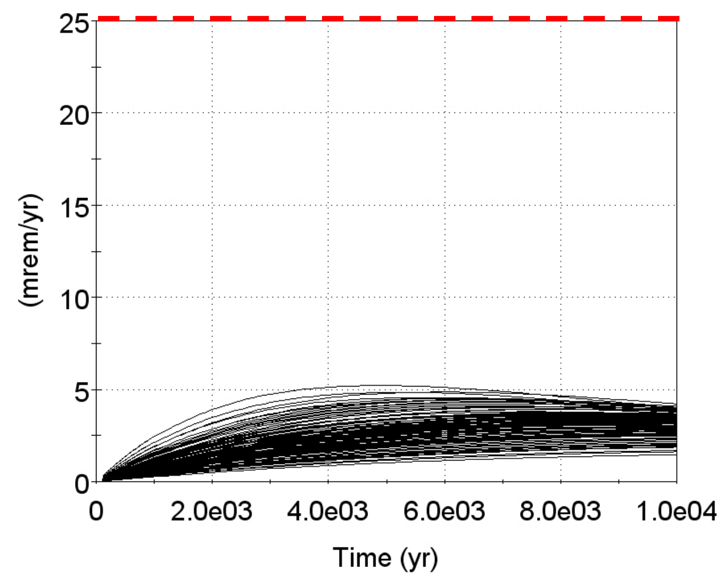
Each party is going to have a different viewpoint on these questions.

Performance Assessment Results - Examples



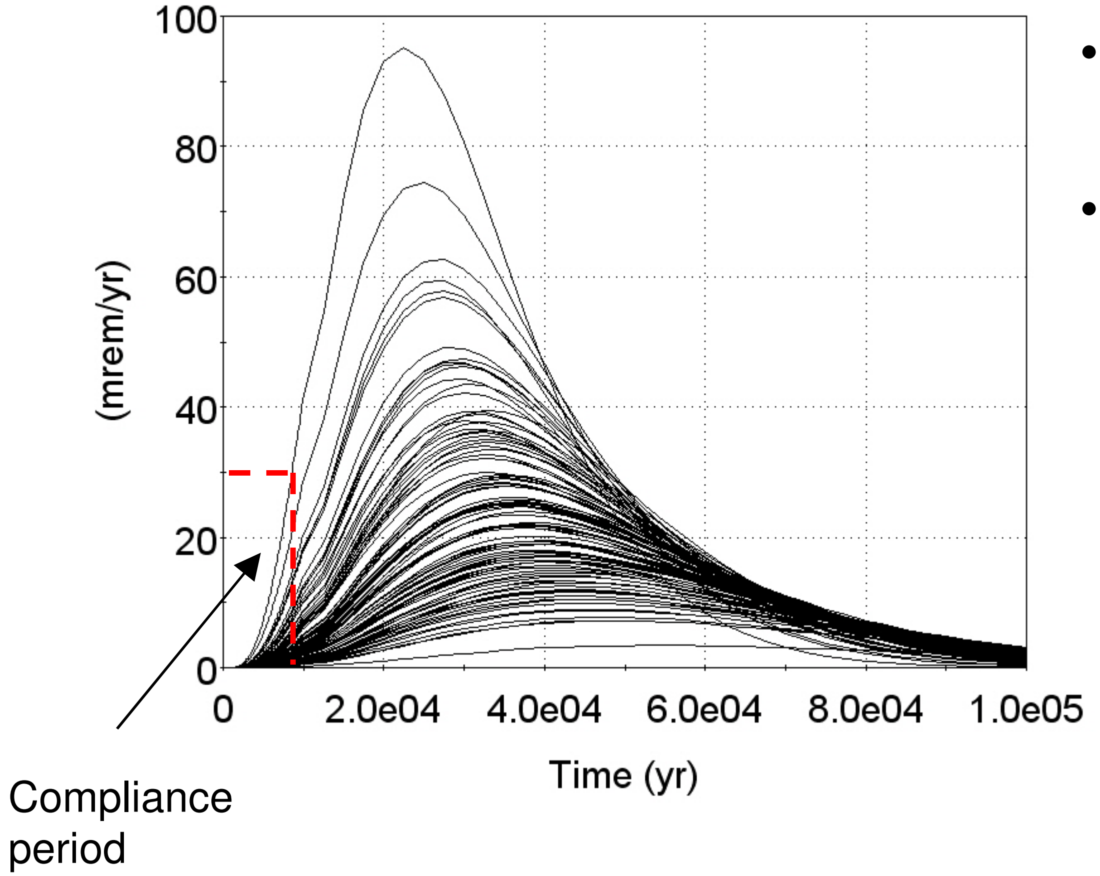
Performance Assessment Results - Examples





- Does either result demonstrate compliance with 61.41?
  - Both may or both may not

Performance Assessment Results - Examples



- Doses increasing at end of compliance period
- Consider reasons for increase:
  - Geology
  - Geochemistry
  - Materials science

Uncertainty and Alternative Cases

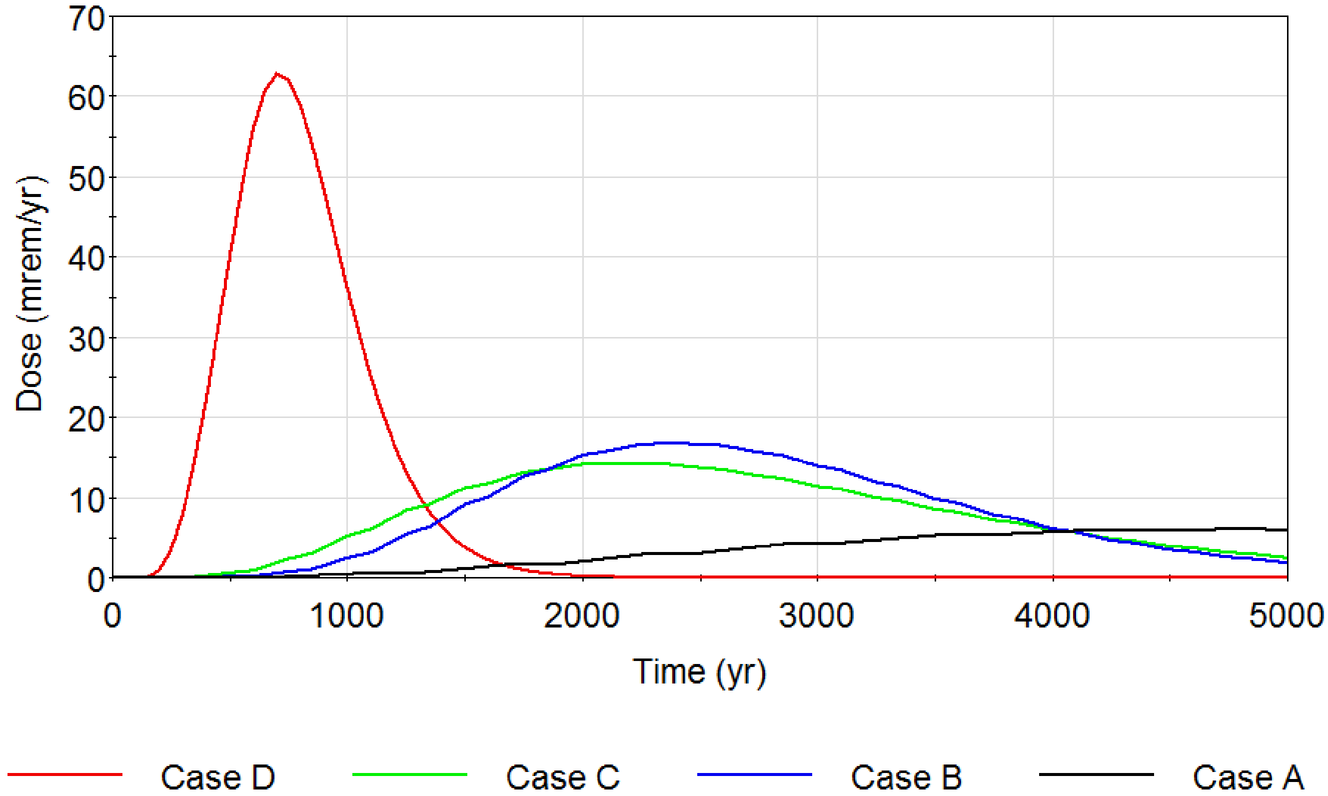
- Reviewers have numerous technical questions associated with a performance assessment.
- These questions are primarily about uncertainty in technical parameters and models used in the performance assessment.
- Uncertainties types include: data, model, scenario.
- Analysts have limited technical information to respond to the questions.
- Analysts evaluate alternative cases to show the impact of the uncertainties on the performance assessment results.

Uncertainty and Alternative Cases – Example Questions

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Provide technical basis for the cement distribution coefficients (Kd's).
- Provide technical basis for the assumed failure time of the cementitious wasteform (4,000 years).

Uncertainty and Alternative Cases – Example Analyses

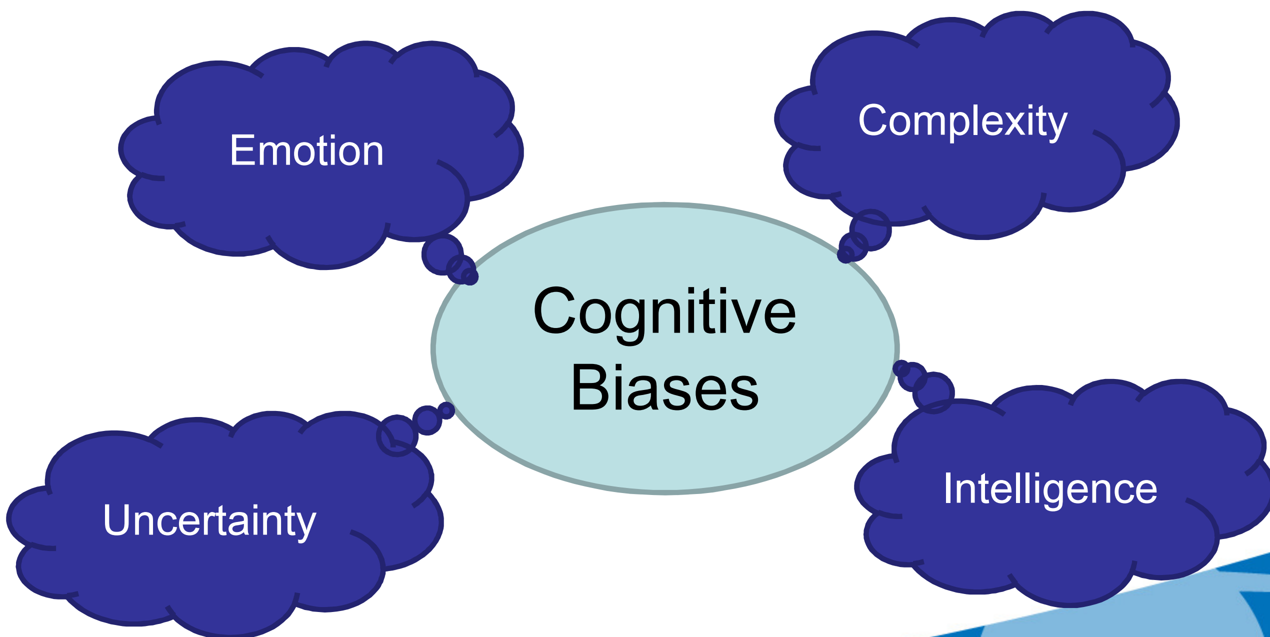


Conservatism

- It is useful to evaluate unresolved technical issues with alternative cases.
- Cases should be thought of and presented in terms of amount or degrees of support.
- Cases should not be described as "conservative" or "reasonable" unless adequate support is provided.
- Conservatism can only be defined relative to what is known. Defining conservatism relative to what is believed is unreliable.

Bias, Errors, and Pitfalls

- Modelers are not immune to the common biases, errors, and pitfalls associated with normal decision-making
- In fact modelers may be more susceptible than the average person



Bias, Errors, and Pitfalls

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- **Correlation does not imply causation** (calibration ≠ validation)
- Sunk costs (keeping model clutter/unimportant features)
- Anchoring (rely on first pieces of information too heavily)
- **Confirmation bias** (demonstrate model is great)
- **Framing** (scope of the model is narrow)
- Blind spot bias (regulators are always trying to be conservative)
- **Overconfidence** (lack of emphasis on QA, ignoring tail risk)
- Data dredging (uncovering patterns without understanding)
- Ambiguity effect (include only things that you can reliably estimate probability)
- Risk aversion (very different for different parties)
- **Kurtosis risk** (everything is not normally distributed!)
- Butterfly effect (e.g. landform evolution modeling)

Twain "It ain't what you don't know that gets you into trouble. It's what you know for sure that just ain't so."

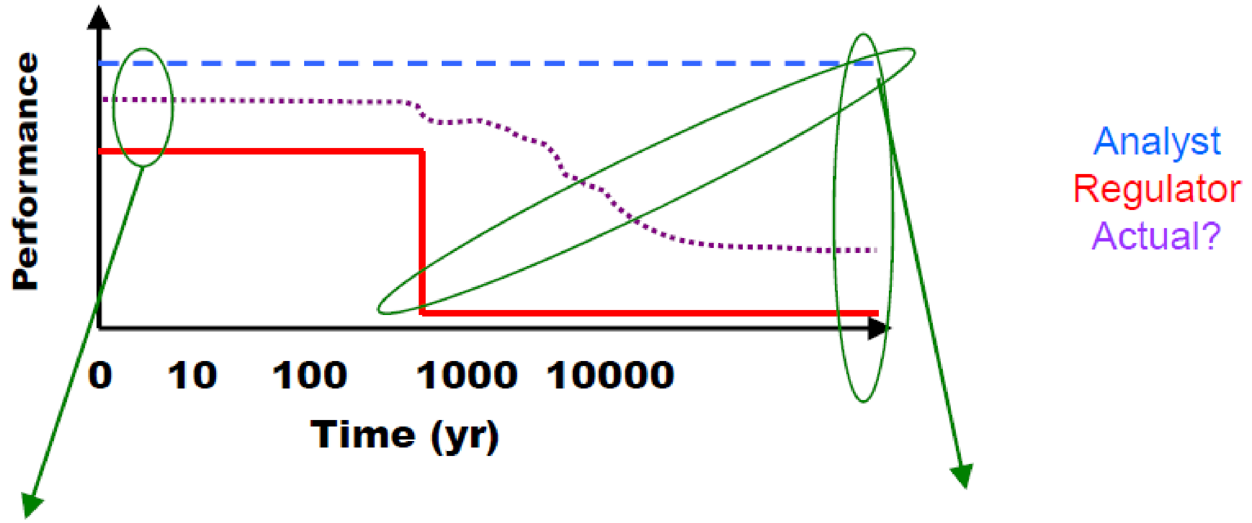
Model Support - Principles

- Multiple lines of evidence preferred.
- Direct observations preferred.
- Level of model support based on risk significance.
- Longer experience ~ less support.
- Natural analogs for very long term performance.
- Support encompasses the full range of future conditions.

Model Support

- At a minimum, should have elements of verification and validation:
  - Verification – Solving the equations correctly.
  - Validation – Solving the correct equations
- A variety of elements can be part of the model support process:
  - Internal review (QA)
  - Independent external review
  - Documentation of verification efforts
  - Multi-faceted validation effort: comparison to lab experiments, field experiments, analogs, etc.

Example: Model Support for Engineered Barriers



Laboratory experiments

Field experiments

Observations – working systems

Monitoring

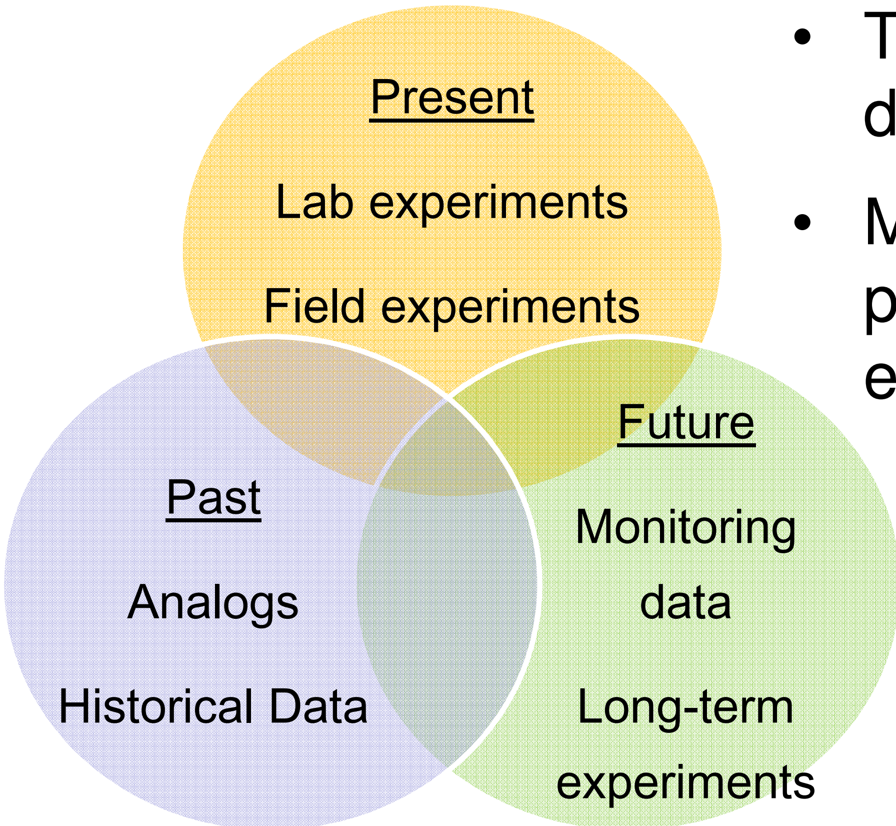
Analogs

Accelerated experiments

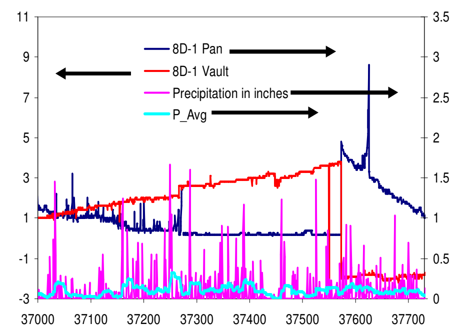
Expert elicitation

Comparison to other models

Model Support - Past, Present, and Future Conditions



- The real world can be highly dynamic.
- Model support should be provided for the full range of expected future conditions.



Conclusions

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

- Recent events should be a wake up call.
- If performance and risk assessments are considered to be robust models, they must have model support.
- Scenarios are useful, but should be used and interpreted cautiously.

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

David Esh, PhD

Senior Risk Analyst

US Nuclear Regulatory Commission

(301) 415-6705

david.esh@nrc.gov