Review of Models: A Regulator's Perspective

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Overview

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- Background
- Reviewing models:
  - Reviewability
  - Complexity
  - Support
- Conclusions

Performance Assessment - Example

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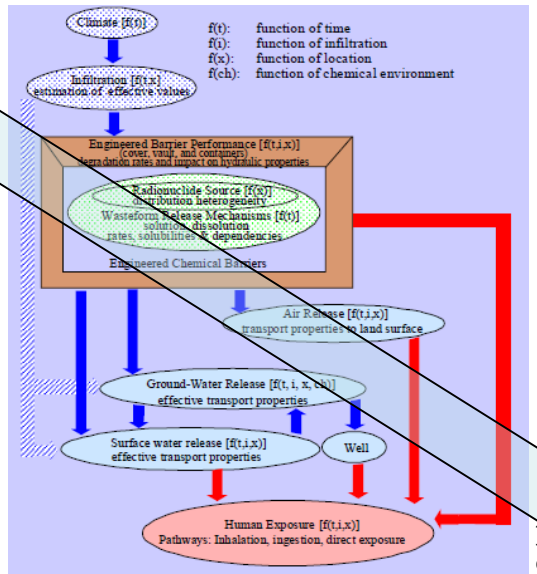
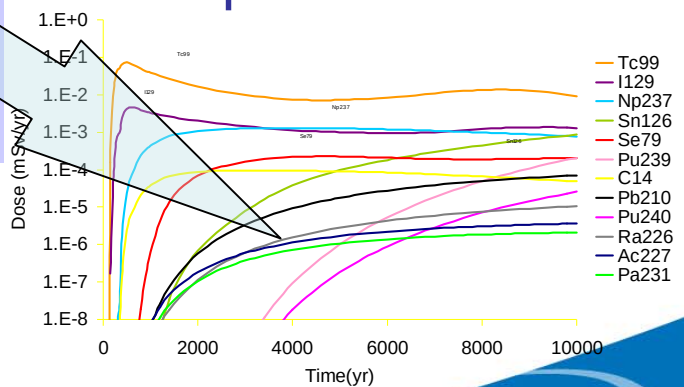
Real system



Mathematical model (abstraction)

Estimated future performance



Background

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- Models are increasingly being used in problem solving and decision making.
- Models are reviewed by the model developers, regulators, and other stakeholders.
- The objective of the review process is to develop confidence in the model results and confidence in the decisions based on those results.

Model Reviewability: Basic Guidelines

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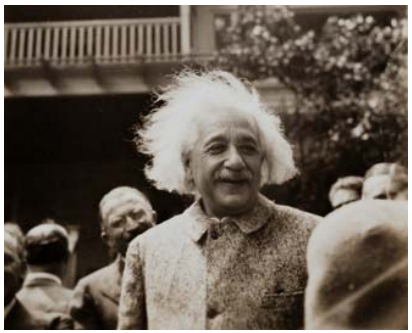
- Models must be able to be independently reviewed and understood:
  - Consider the objective of the model
  - Consider the audience
  - Models don't make decisions, humans make decisions



"Theories should be as simple as possible, but no simpler."

Model Reviewability: Basic Guidelines

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- Documentation of the modeling is as important as the modeling itself.
- The analysis and documentation must be transparent and traceable.
- Data should be traceable to the source to facilitate the review of data validity.
- Document model development decisions, especially consideration or elimination of alternate conceptual models, features, events, and processes.

Model Complexity

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- Review effort increases exponentially with increasing model complexity.
- Model complexity should be commensurate with available supporting information.
- Model building is iterative and should be risk-informed.
- If complexity is added to a model and found not to have a significant influence on the results, it should be removed.

Model Complexity – How Much?

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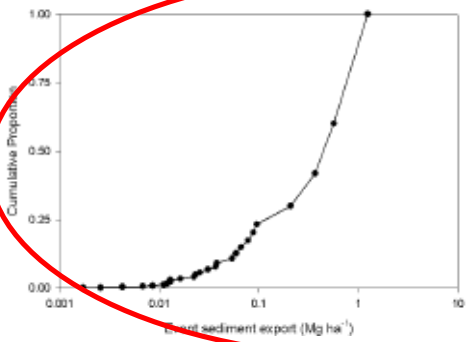
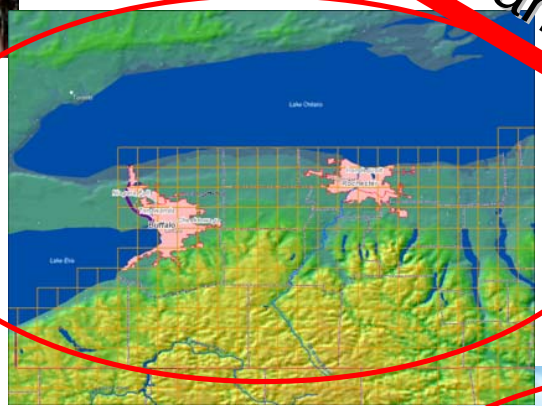
Model Complexity
>>
Model Support!



Comparison of features
Mass balance (watershed)

Complexity and Effort



GIS based analysis
Model comparisons
Analogs

Long-term field experiments
Isotopic studies

Model Complexity – Model Abstraction

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- Model abstraction can and should be used.
- A model abstraction is a simplified representation of a more complicated process.
- Reduce complexity but maintain validity.
- Show the abstraction represents the complex model.

Model Abstraction Example

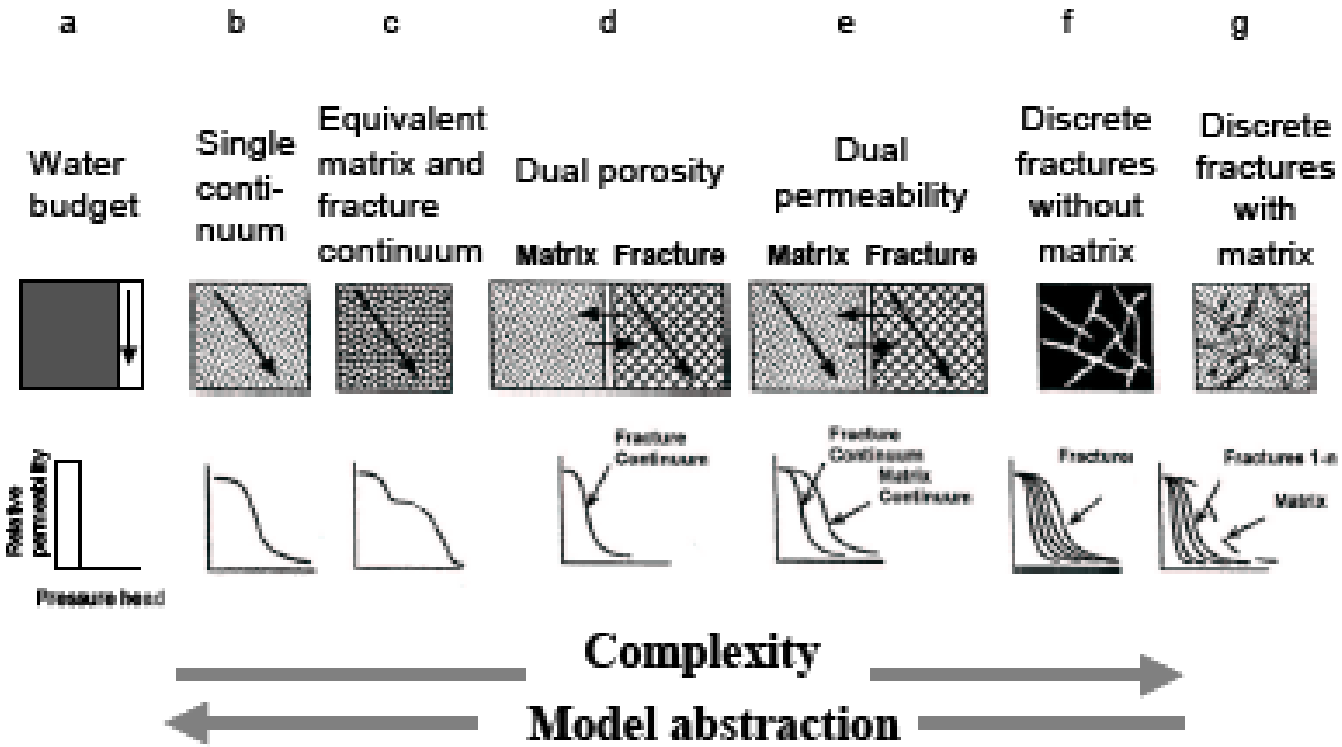

Figure 2-3. Hierarchy of models to simulate water flow and solute transport in structured soils or in unsaturated fractured rock. Modified from (Altman et al., 1996).

NUREG/CR-6884 Model Abstraction Techniques for Soil-Water Flow and Transport

Model Abstraction Example

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Uncertainty analysis:

- Simpler model yielded stronger results (6 variables identified compared to 3)
- Allowed focused refinement of model
- Complexity can have many unintended consequences

Variable	Description	Importance Factor
Grout_deg_start	Time at which degradation of the wasteform can begin	0.98
Nm	MacMullin number. The effective diffusion coefficient is a product of Nm and the molecular diffusion coefficient.	0.93
Degraded_grout_Kh	Hydraulic conductivity for degraded region of the wasteform.	0.36
TransFactor_indoor	Factor to account for shielding of radiation when an individual is inside a residence.	0.29
Se_solubility	Solubility of Se in the pore fluid of the wasteform.	0.21
Kd_waste_Sr_ox	Distribution coefficient for Sr in the oxidized region of wasteform.	0.11
Vent_light_activity	Breathing rate for an individual during light activity.	0.11
SZ_dispersivity_factor	Used with the transport length in the saturated zone to develop the saturated zone dispersivity.	0.10
Kd_Waste_Eu	Distribution coefficient for Eu in the intact portion of the wasteform.	0.08

Model Support

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- Model support is arguably the most essential element to successful predictive decision making.
- Modeling should have support, at a minimum, with elements of verification and validation:
  - Verification – Solving the equations right
  - Validation – Solving the right 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.

Model Support

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- Modeling that allows for the independent review and understanding of intermediate outputs is strongly encouraged.
- Documentation and openness about shortcomings increases confidence.
- Modelers, by their nature, are biased to being overconfident.
- Natural and dynamic systems can be inherently difficult to predict.

Example: Model Completeness

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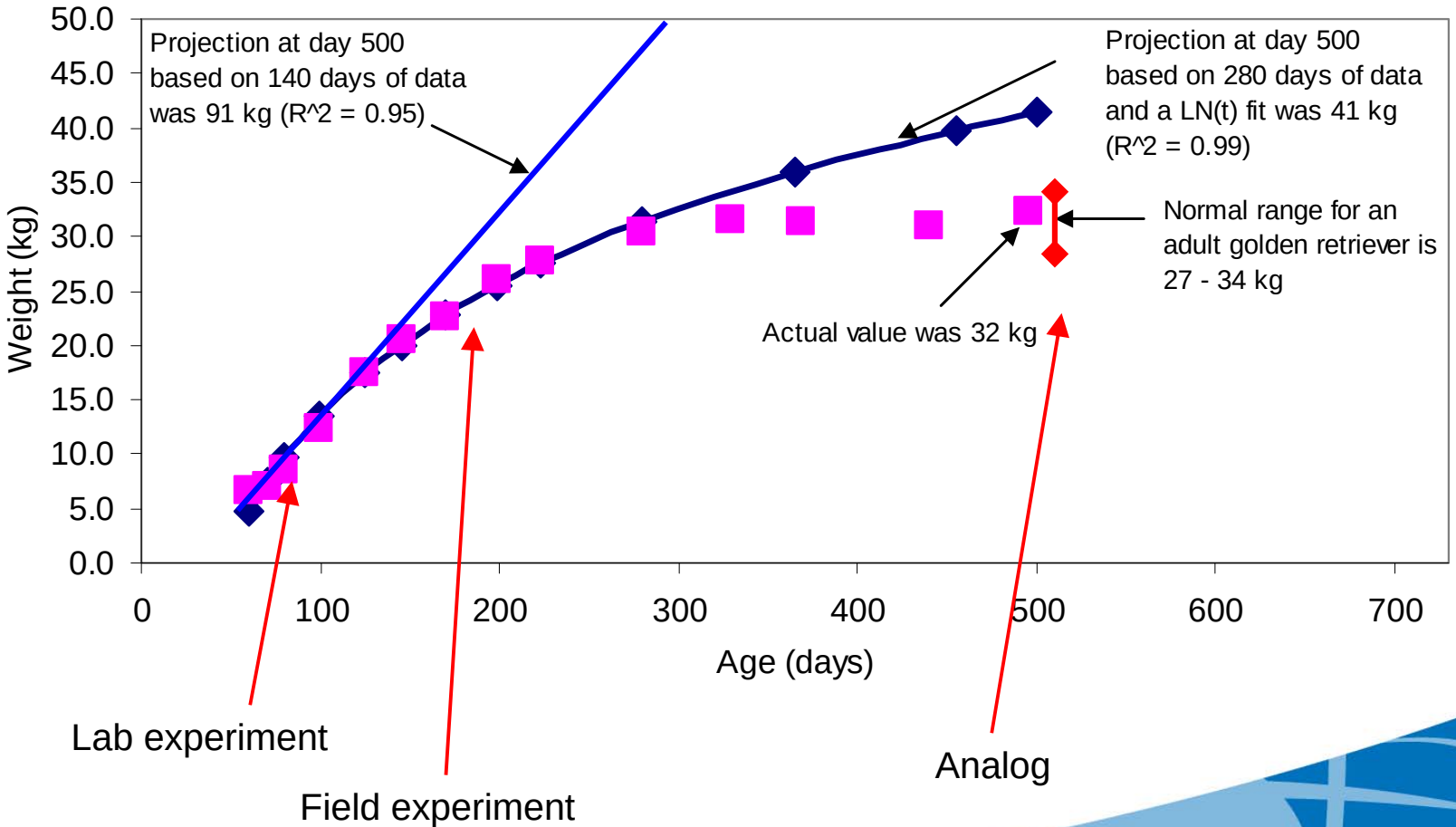

Example: Model Support/Model Complexity

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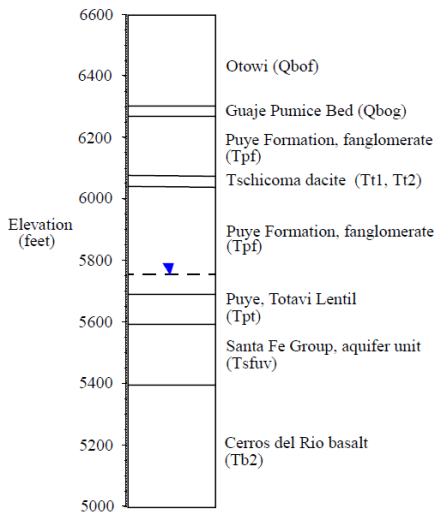
- Modeling radionuclide transport at Los Alamos following the Cerro Grande fire (Stauffer-LANL).
- Radionuclide transport times significantly altered.
- Infiltration capacity and soil structure greatly affected.
- Sediment erosion and transport impacted.



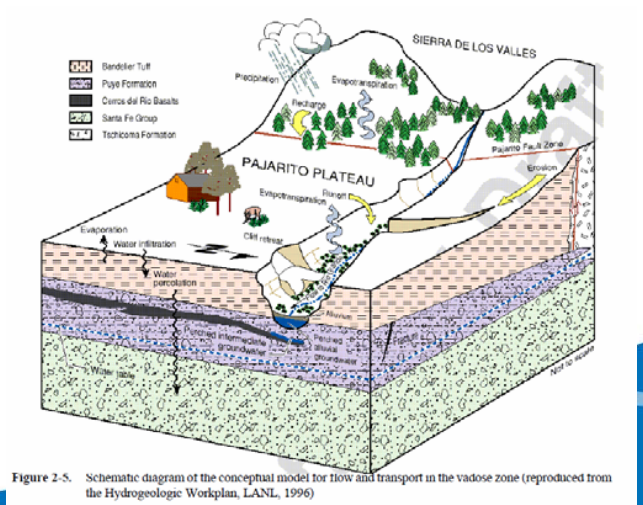
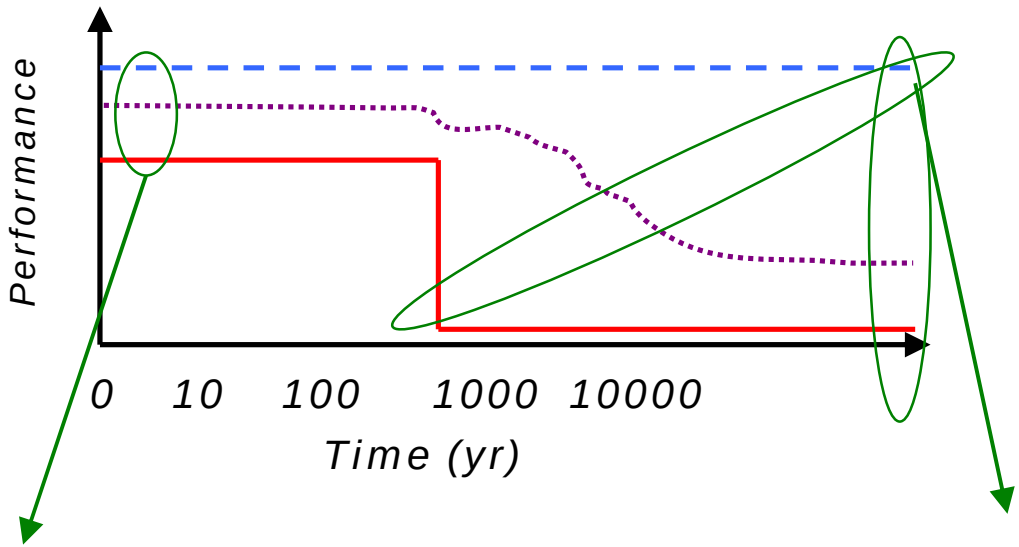


Figure 2-5. Schematic diagram of the conceptual model for flow and transport in the vadose zone (reproduced from the Hydrogeologic Workplan, LANL, 1996)

Example: Model Support/ Engineered Barriers



Analyst
Regulator
Actual?

Laboratory experiments
Field experiments
Observations – working systems
Monitoring

Analogs
Accelerated experiments
Expert elicitation
Alternative modeling

Conclusions

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- If your model is not understood, it is not sufficient.
- Keep your model as simple as possible.
- Model support is essential.