



Treatment of Model Uncertainty

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Outline

- **Definitions**
 - **Models, model uncertainty**
- **Approach for evaluating model uncertainty**
- **Conclusions**



Hierarchy of Models

- **Conceptual** – set of assumptions used to describe a system
- **Mathematical** – set of equations designed to represent the conceptual model
- **Computational** – code or other tools to evaluate mathematical model



Other Uncertainties

- **Model Uncertainty distinguished from**
- **Parameter Uncertainty**
 - Uncertainties associated with the values of the parameters that are used in the implemented models
- **Scenario Uncertainty**
 - Uncertainties associated with significant changes or events that may occur over time
- **Yucca Mountain Example**
 - Occurrence of an igneous event – scenario uncertainty
 - Effect of magma on engineered barriers – model uncertainty
 - Solubility of uranium in waters percolating through cooled magma – parameter uncertainty

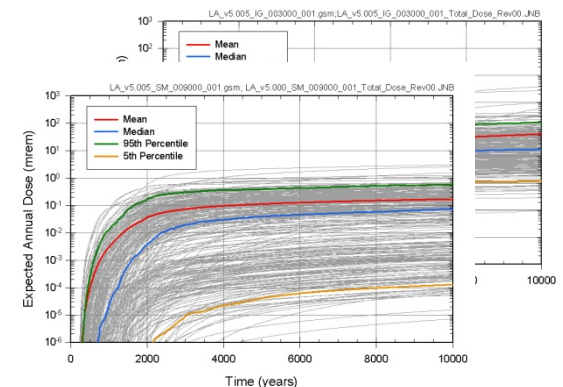
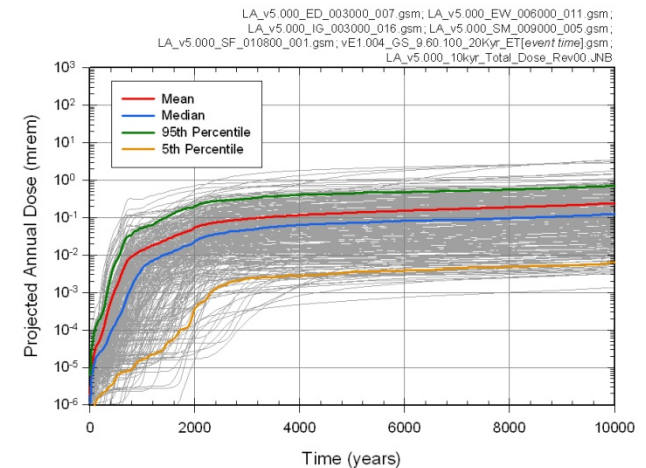


Definition – Model Uncertainty

- **Model Uncertainty arises from:**
 - an incomplete knowledge of the behaviour of engineered systems, physical processes, or site characteristics,
 - representation of features, events and processes using simplified models and computer codes.
- **Embodied by assumptions associated with:**
 - the formulation of process models,
 - the reduction of complex “process” models to simplified or stylised conceptual models for PA purposes,
 - the representation of conceptual models in mathematical form,
 - the inexact implementation of mathematical models in numerical form and in computer codes.
- **Includes conservatisms**

Constraints on Evaluation of Model Uncertainty

- Parameter uncertainty can be propagated numerically
- Scenario uncertainty managed by various techniques
- Evaluation of model uncertainty presents a significant challenge
 - Quantitative evaluation entails developing and calculating alternate models
 - Limited by practical considerations





Proposed Approach

- **Screening approach to reduce scope**
- **Identify and characterize model uncertainty in the safety case**
 - **Catalog sources of model uncertainty**
 - **Identify reasonable alternative assumptions**
 - **Identify key model uncertainties**
 - **During development of the performance assessment**
- **Evaluate key model uncertainties**
 - **Part of analysis of the performance assessment**



Catalog sources of model uncertainty

- **Assumptions inherent in**
 - **Conceptual models**
 - E.g. flow is steady-state through a porous media
 - **Mathematical models**
 - E.g. Darcy's law
 - **Computational models**
 - E.g. implement Darcy's law on a 1D grid
- **Assumptions inherent in linkages between models**
 - Independent vs. coupled processes
- **Assumptions made by the use of conservatism**



Identify reasonable alternative assumptions

- **A reasonable alternative assumption is one that has a technical basis at least as sound as the baseline assumption**
 - Consistent with available data and observations
- **Techniques to identify reasonable alternative assumptions**
 - Model comparison studies
 - Peer or regulator review
- **Model uncertainty is present only when reasonable alternative assumptions are identified**



Identify key model uncertainties

- A model uncertainty is key when use of reasonable alternative assumptions has the potential to have a significant effect
- Effects are judged in the context of the model's use
 - Estimating performance measures
 - key if contributes to magnitude or uncertainty
 - Judgments about safety
 - key if significant to the decision being considered
 - Particularly important for conservatism



Identify and Evaluate key model uncertainties

- **Some type of analysis is needed to:**
 - Identify key model uncertainties
 - Evaluate the effects of key model uncertainties
- **Quantitative methods**
 - Develop and compare alternate models
 - Represent alternate models with uncertain parameter(s), then apply parameter sensitivity methods
 - “Level-of-detail” and convergence studies
 - Various schemes for combining results across alternate models
- **Qualitative methods**
 - Influence diagrams, reasoned arguments
 - Informed by sensitivity analyses of PA results



Conservatisms

- **Conservatisms are assumptions made to simplify PA models in such a way that system performance is not over-estimated (i.e. risk is not under-estimated)**
- **Judicious use of conservatisms enhances confidence in the safety case, but**
- **May also obscure understanding of the physical processes that contribute to system performance**
- **Conservatisms should be acknowledged and, where reasonable to do so, their effects evaluated**



Conclusion

- **Screening approach to reduce scope**
- **Identify and characterize model uncertainty in the safety case**
 - **During development of the performance assessment**
- **Evaluate key model uncertainties**
 - **Part of analysis of the performance assessment**
- **Address conservatisms**
- **Unproven process**