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GENII Uncertainty Modeling

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Uncertainty Analyses

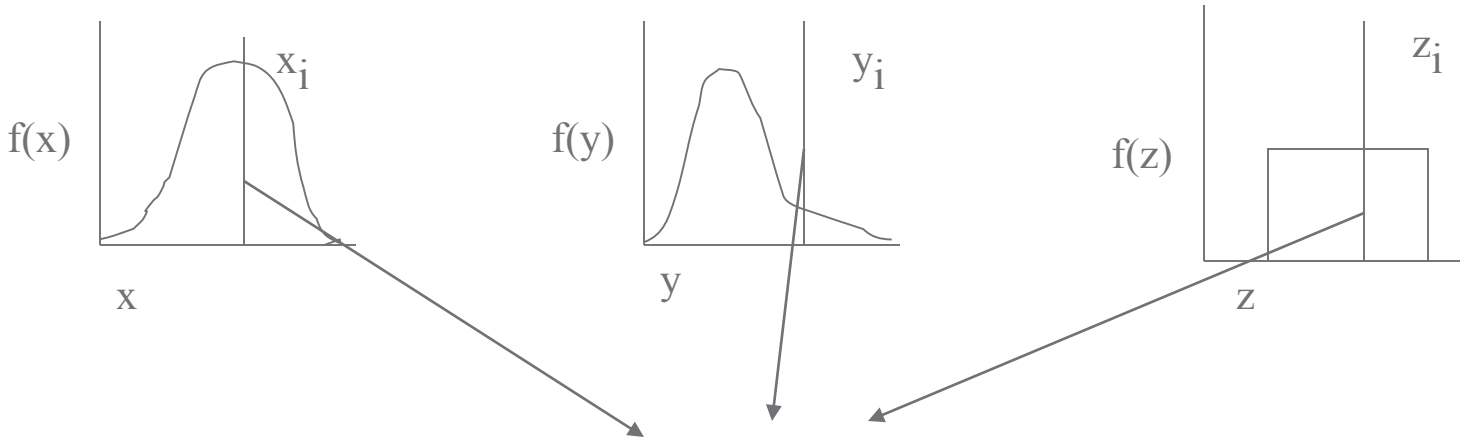
- Benefits
- Specifying the problem
- Conceptual/computational models
- Parameter uncertainty analysis
- Sensitivity analysis

What is Uncertainty Analysis?

- An assessment of the probability of obtaining a specific output from a mathematical model, e.g.:
  - Will the result exceed a specified limit?
  - How much variation is there in the results of this model?

Deterministic Models

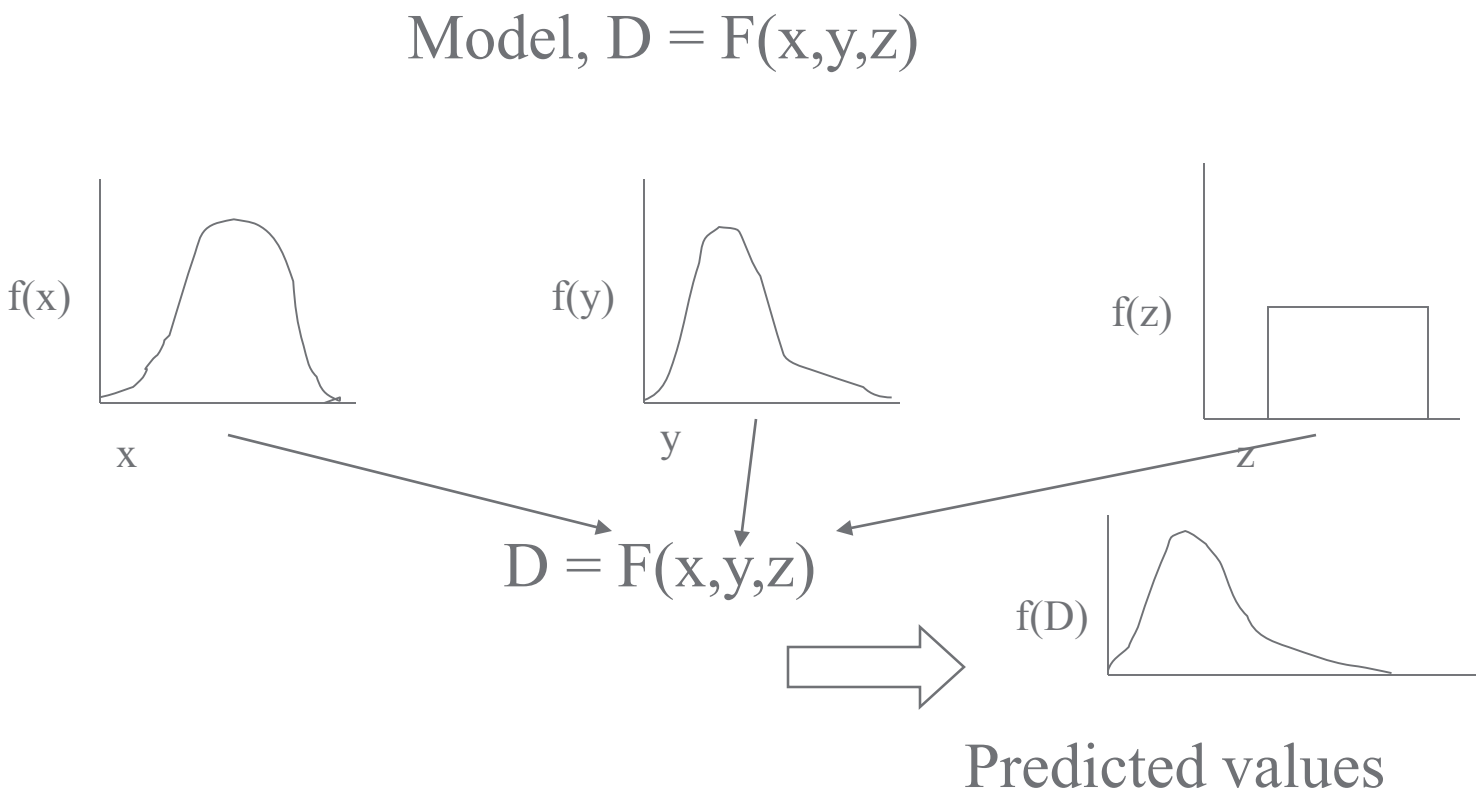
Model, D = F(x,y,z)



$D_i = F(x_i,y_i,z_i)$

$D_i = 0.3521$ Sv/y

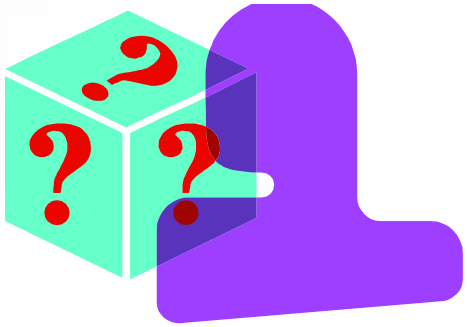
Stochastic Models



There is more than one type of uncertainty

- That caused by natural variability
  - (Type A)
  - (Aleatory)

- That caused by lack of knowledge of true values
  - (Type B)
  - (Epistemic)



Why is uncertainty analysis necessary?

- Accuracy is becoming more important as regulatory limits are lowered - "Conservative" analyses are not longer sufficient
- Site-specific data are generally limited
- Arguments on definition of parameters are avoided

Assessing Uncertainty

- Specify the problem (determine the assessment question)
- Develop the conceptual model
- Develop the computational model
- Estimate parameter values
- Calculate results

Define the Assessment Question

- Focus the uncertainty analysis on the assessment endpoint
- Results differ depending on the assessment scenario and its endpoint
- Stochastic variability may be a source of uncertainty, or it may be the assessment objective!

Parameter Uncertainty Analysis

1. List all parameters
2. Specify the maximum conceivable range
3. Specify the degree of belief that the appropriate parameter value is not larger than the values determined above
4. Select a probability distribution that best fits the degrees of belief

Parameter Uncertainty Analysis

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5. Account for dependencies
   - Introduce restrictions
   - Specify degree of association
6. Propagate parameter distributions through the computational model
7. Rank parameters with respect to their contribution to uncertainty (sensitivity)
8. Present and interpret results

Input Distributions

- In any model, an accurate representation of the output requires an accurate representation of the input. Therefore, good answers to questions concerning the output require accurate representations of the input distributions.

Obtaining Uncertainty Distributions

- Check textbook values
- Check literature
- Use experts

Risk Assessment is not Risk Management

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- **When it comes to uncertainty, honesty is more important than accuracy**

Uncertainty Methods

- Adjoint techniques
- Stochastic methods
- Perturbation theory
- Response surfaces
- Differential analysis
- **Monte Carlo Methods**

Monte Carlo

- Simple Random Sampling
- A numerical method in which multiple vectors (realizations) of input parameters are randomly selected. The resulting output vector numerically represents the distribution of the answer.

Monte Carlo

- Can directly compute confidence limits on estimates of mean, variance, fractiles, etc.
- Can easily aggregate independent samples of different size to sequentially arrive at a sufficiently large sample

Latin Hypercube

- A randomized fractional factorial sampling scheme, which places restrictions on the selection of input vectors
  - More efficient than simple random sampling
  - Less variability between sets of samples
  - Not as well developed theoretically as simple random sampling

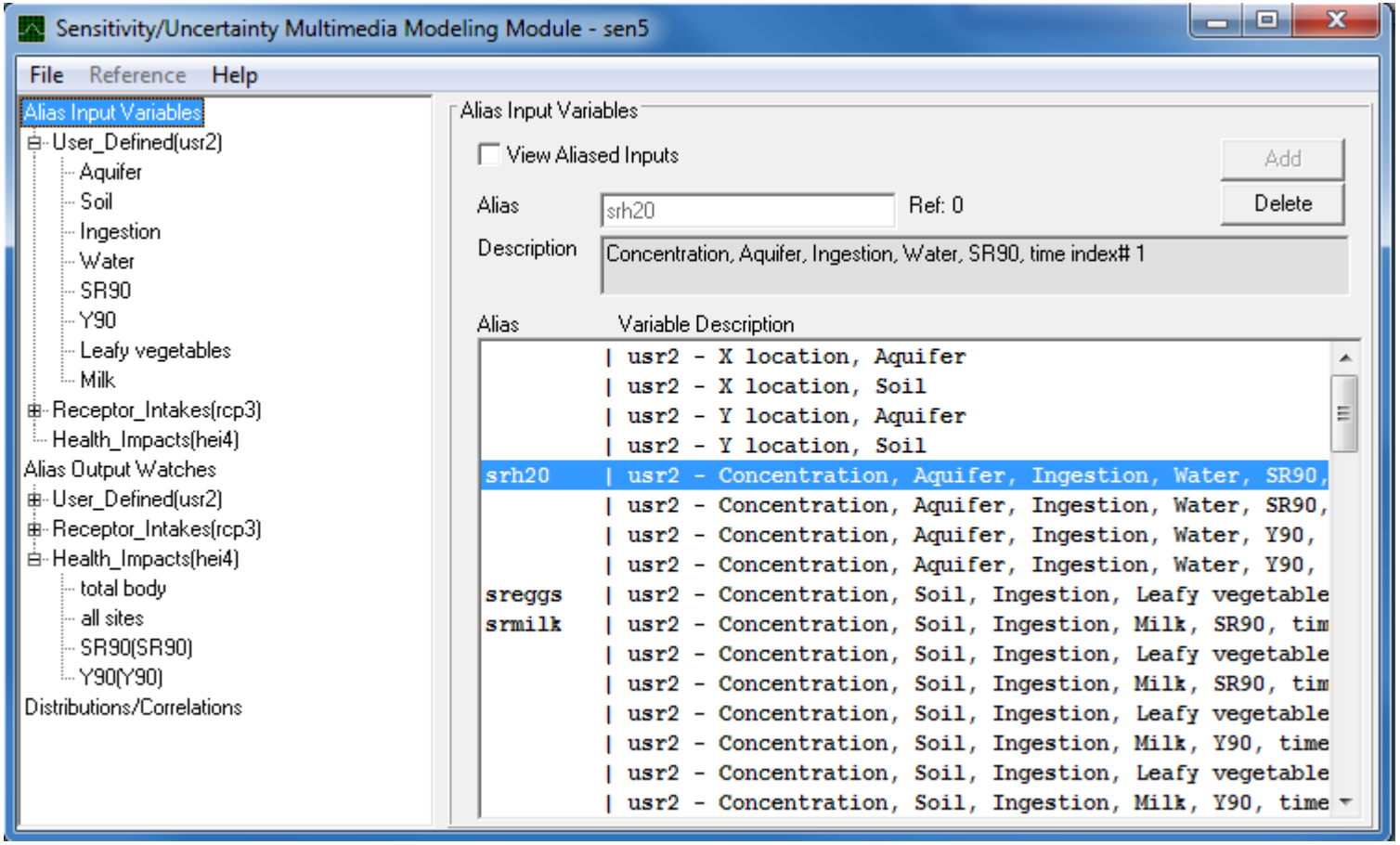
Dependence on Expert Judgement

- Expert judgement is required:
  - to formulate models
  - to define input distributions
- Therefore the answer could be somewhat different if different experts were used
- There is an evolving science of expert elicitation for this type of work

GENII: Uncertainty Analysis

- Performed using the FRAMES SUM^3 Module

Sensitivity



GENII: Evaluating Uncertain Results

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- Numerous ways to view the output; most depend upon Microsoft Excel

Chart 1

1	File:	c:\frames\examples\genii_18.suf			
2	Module:	Sensitivity			
3	Descriptic	hei4 Summed Sv peak, Age Group 1 (Sv)			
4					
5	Realizatio	Rank Orde	peak.usr2	peak.usr2	Cum. Prob.
6	8	1	0	0.00209	0.090909
7	9	2	0	0.00263	0.181818
8	7	3	1	0.00298	0.272727
9	2	4	1	0.00304	0.363636
10	4	5	0	0.00307	0.454545
11	6	6	0	0.00352	0.545455
12	3	7	0	0.00382	0.636364
13	1	8	1	0.00416	0.727273
14	10	9	1	0.00477	0.818182
15	5	10	0	0.00885	0.909091