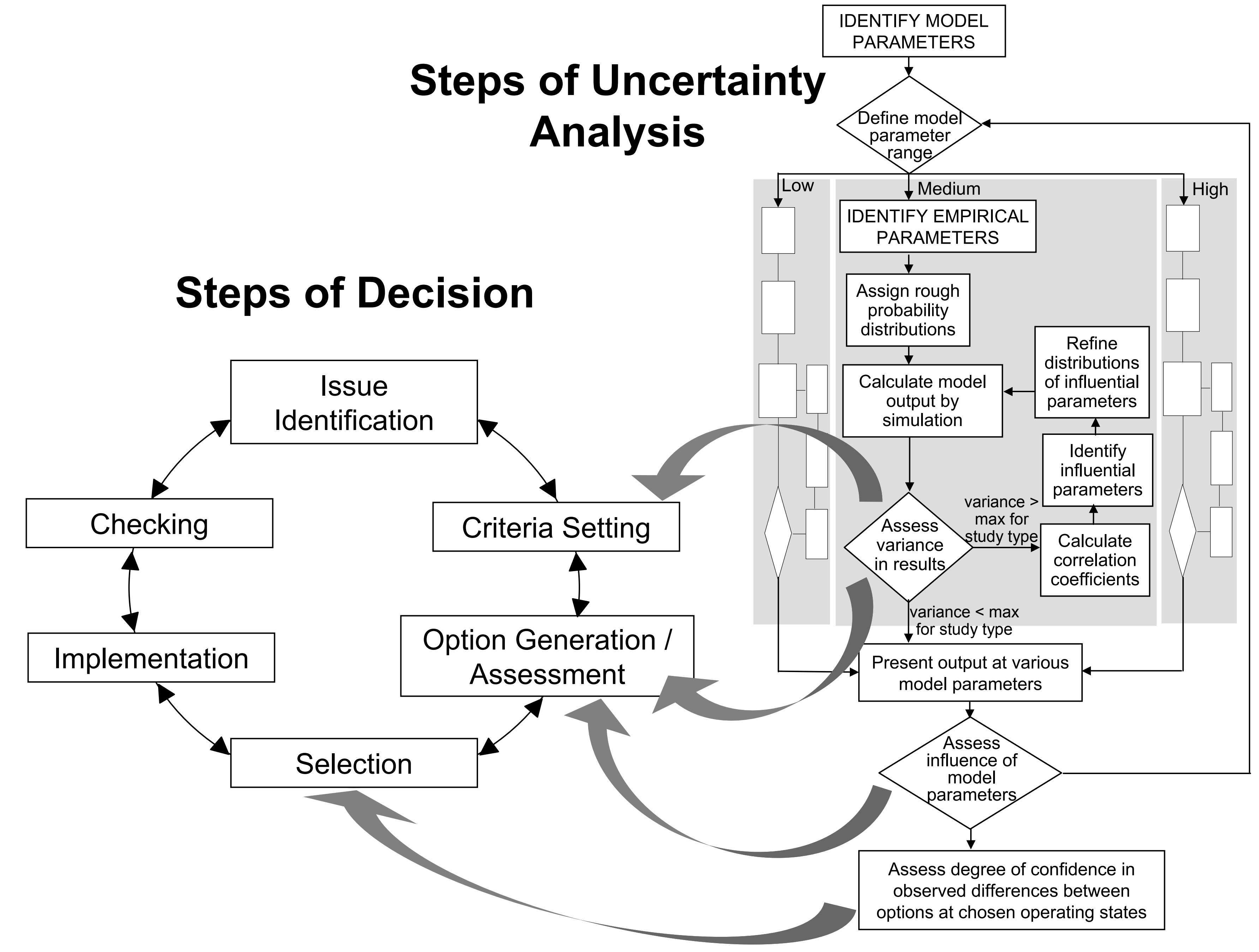
AN INTEGRATED APPROACH TO UNCERTAINTY ASSESSMENT IN LCA

Pippa Notten[1] and Jim Petrie[2]

[1]Department of Chemical Engineering, University of Cape Town, South Africa
[2]Department of Chemical Engineering, University of Sydney, Australia

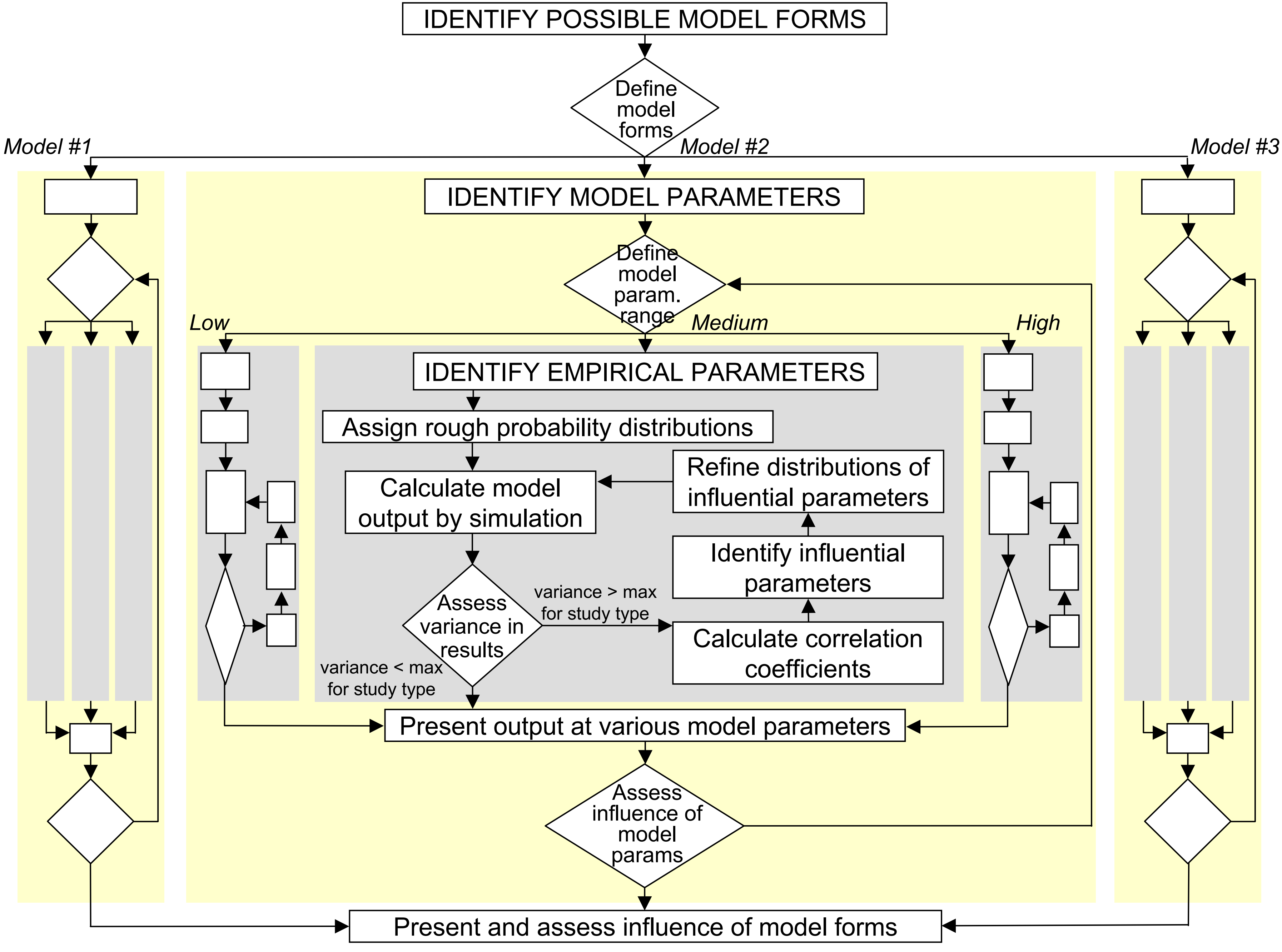
Overview

- Quantitative uncertainty analysis enhances LCA’s decision-support capabilities but:
  - Danger of over-simplifying problem
  - Creating false sense of accuracy
- Needs to be an integral part of the decision-making process
- Considerable value as a structuring / learning tool
- Should not merely quantify uncertainty but provide mechanism to manage / reduce uncertainties


Steps of Uncertainty Analysis
Steps of Decision
Issue Identification
Checking
Criteria Setting
Implementation
Option Generation / Assessment
Selection
IDENTIFY MODEL PARAMETERS
Define model parameter range
Low
Medium
High
IDENTIFY EMPIRICAL PARAMETERS
Assign rough probability distributions
Calculate model output by simulation
Refine distributions of influential parameters
Identify influential parameters
Assess variance in results
variance > max for study type
Calculate correlation coefficients
variance < max for study type
Present output at various model parameters
Assess influence of model parameters
Assess degree of confidence in observed differences between options at chosen operating states

Sources of Uncertainty

Empirical Parameters *(Probabilistic assessment)*	Parameter uncertainty	Measurement errors Inherent randomness Subjective judgement Approximation
	Variability	Geographic variability Temporal variability Technological variability
Model Parameters *(Parametric sensitivity analysis / multivariate analysis)*	Uncertainty arising from choice of variables to specify system	Decision variables Model domain parameters
	Disagreement	Value parameters
Model structure / form *(Sensitivity analysis)*	Limitations on form of model	Choice of LCA method
	Limitations of LCA model structure.	Spatial limitations Temporal limitations Inherent model uncertainties


IDENTIFY POSSIBLE MODEL FORMS
Define model forms
Model #1
Model #2
Model #3
IDENTIFY MODEL PARAMETERS
Define model param. range
Low
Medium
High
IDENTIFY EMPIRICAL PARAMETERS
Assign rough probability distributions
Calculate model output by simulation
Refine distributions of influential parameters
Identify influential parameters
Assess variance in results
variance > max for study type
Calculate correlation coefficients
variance < max for study type
Present output at various model parameters
Assess influence of model params
Present and assess influence of model forms

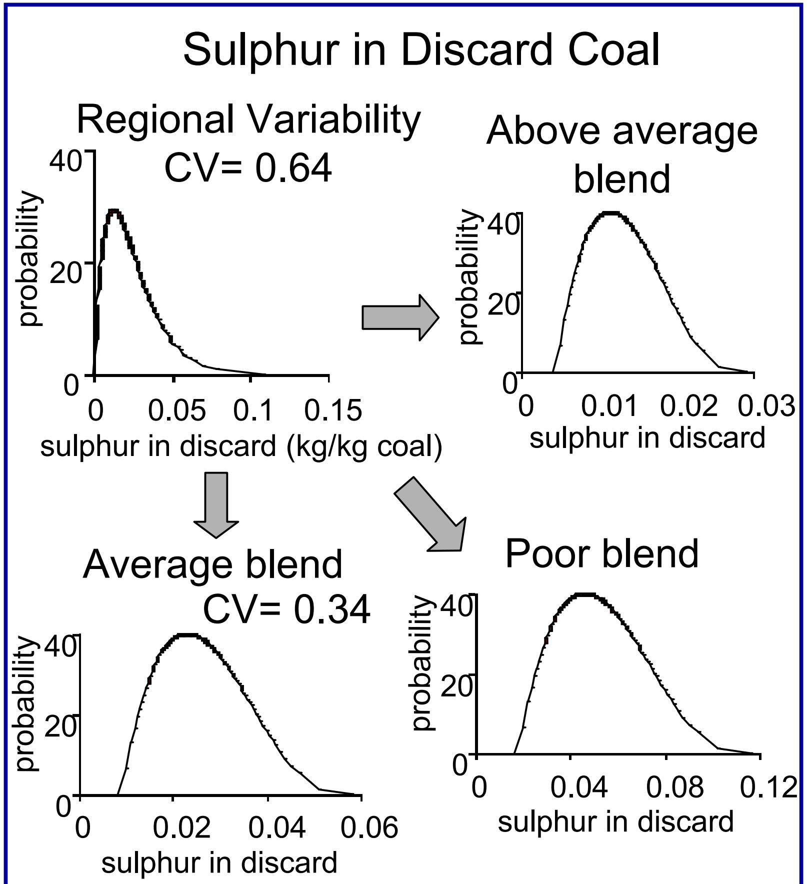
Reducing Empirical Uncertainty

Empirical Parameter Uncertainty

- Arises from short-cuts in data collection and/or model simplifications
  - Increased data collection and/or modelling effort required
  - Hence need for *uncertainty importance analysis*
  - Can't always reduce, but useful to identify limiting parameters
- Measurement errors / inherent randomness
  - Take more measurements
- Pseudo-random quantities / approximations
  - Model underlying processes
- Subjective judgement
  - Refine measurement / measure more appropriate quantity

Managing Empirical Uncertainty
Variable Quantities

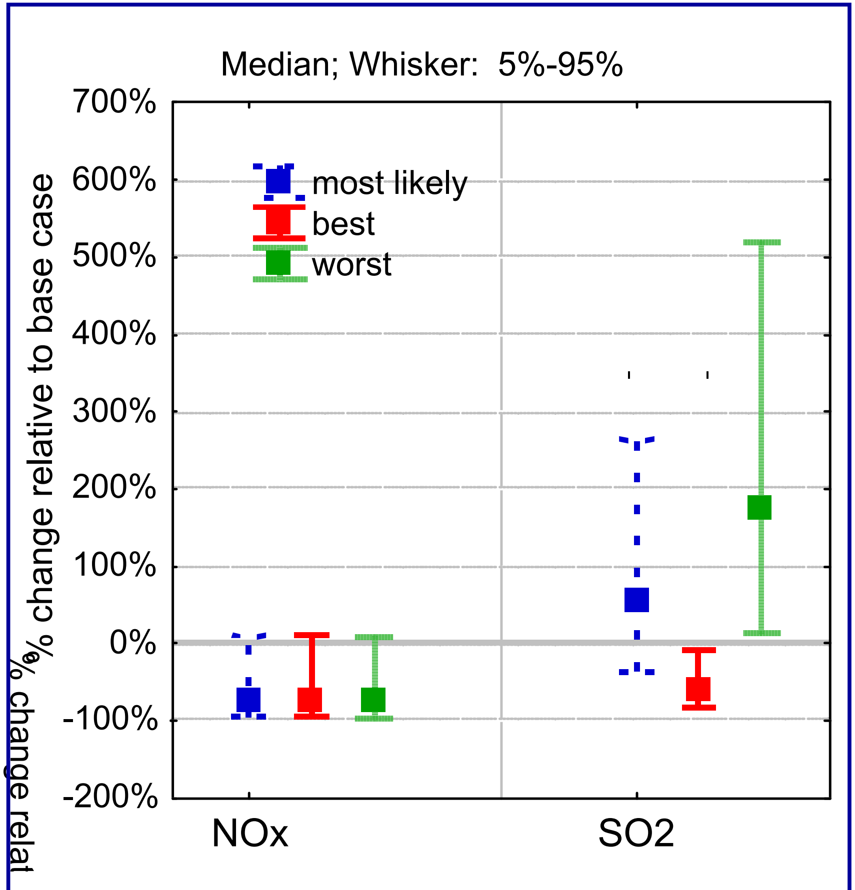
- Reduce variability by better definition of temporal, spatial, and technological placing of quantity
- Break down highly variable quantities into narrower bands of variability
  - Incorporate scenarios into model parameter uncertainty



Model Parameter Uncertainty

- Uncertainty managed rather than reduced
- Systematic parametric analysis ensures full solution space of system is explored
  - Present judicious choice of a few key scenarios covering full range of results
- Invaluable for structuring scenario generation in loosely defined problems
- Significance assessed with respect to empirical uncertainty

Model Parameter Uncertainty



- No_x emissions:
  - High degree of overlap
  - Indication model parameter uncertainty of less importance
- SO_2 emissions:
  - Widely spread scenarios
  - Effort best focussed on better definition of system than on reducing empirical uncertainty

Conclusions

- Quantitative uncertainty analysis placed in overall context of decision making process
- Shown to provide valuable assistance in:
  - Selection of meaningful criteria for comparison
  - Directing further data collection and modelling efforts
  - Generating scenarios to be taken further in analysis
- Argue for change of emphasis:
  - Unrealistic to expect objective, precise uncertainty estimates
  - Rather emphasise value in structuring and guiding the decision analysis process