

Introduction to VVUQ | Part 4

Uncertainty Quantification

Task Group on VVUQ Concepts in Engineering Education

ASME Codes & Standards | Committee on Verification, Validation, and Uncertainty Quantification

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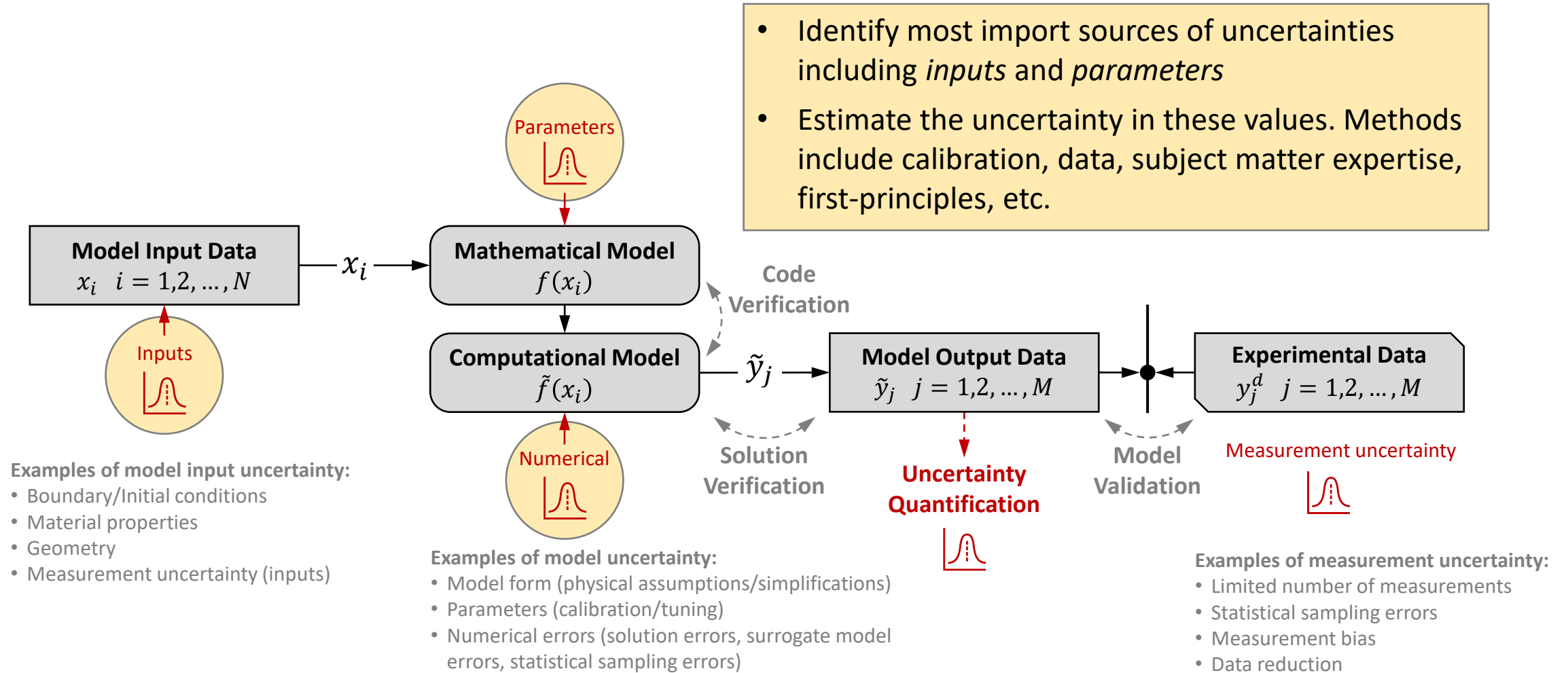
Outline

- What is uncertainty quantification and why do we care?
- Steps of uncertainty quantification and how it is performed
 - Characterization of uncertainties
 - Propagation of uncertainties
 - Interpretation of uncertainties
- Sensitivity Analysis

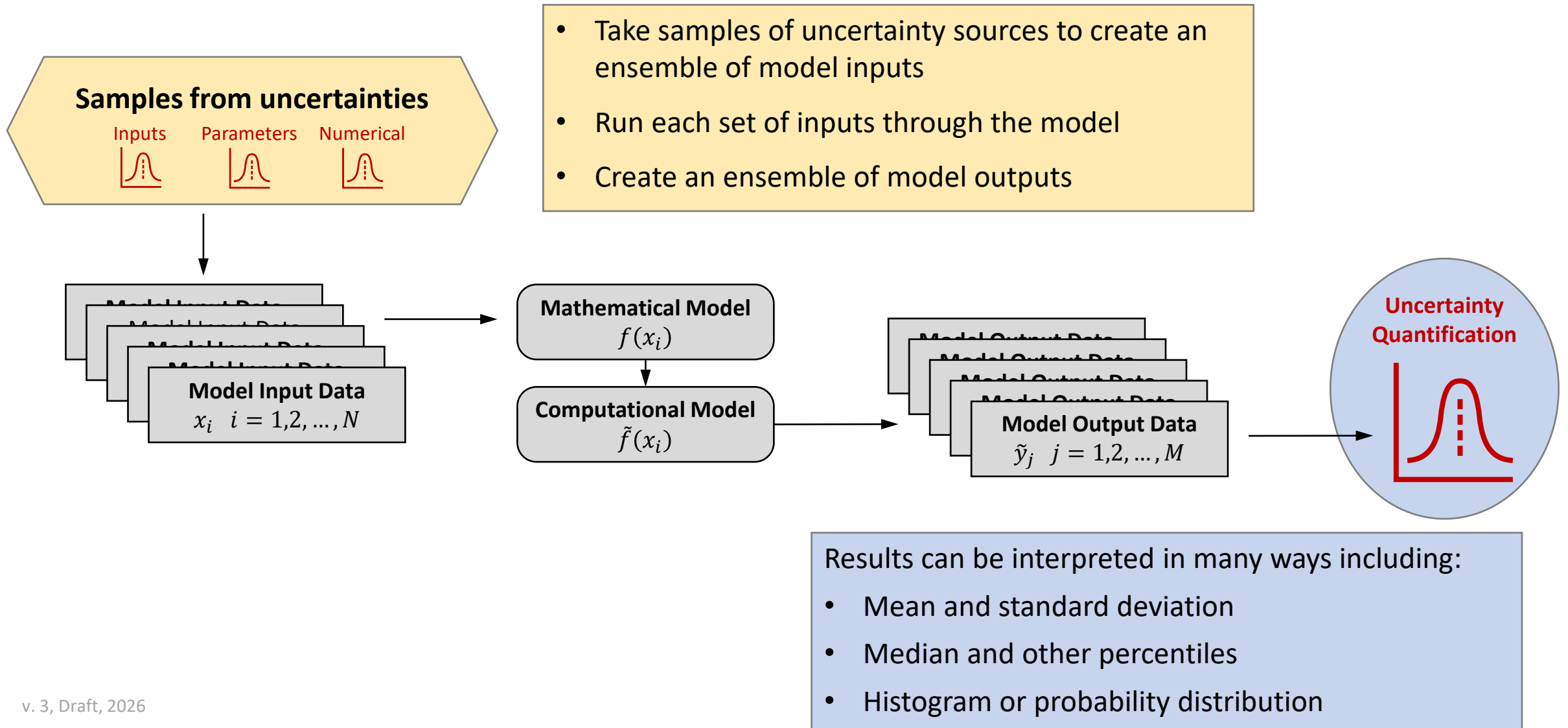
What is uncertainty quantification and why do we care?

- **Uncertainty Quantification (UQ)** is the process of using statistical models to provide an estimate of uncertainty in the experimental and simulation results.
- Uncertainty Quantification has three basic steps:
 - **Characterize Uncertainties:** Identify all relevant uncertainties and characterize the uncertainties as much as is possible
 - **Propagate Uncertainties:** Perform model evaluations to estimate the impact of model input uncertainties on the system response quantities of interest (QoIs)
 - **Interpret Results:** Compute and explain the sources and impact of the uncertainties to the simulation customer
- Uncertainty quantification is important because it informs the customer of the simulation results how the uncertainties impact the simulation results.

Characterize uncertainties



Propagate uncertainties and interpret results



Rank the impact of uncertain inputs using sensitivity analysis

Closely related to UQ is **Sensitivity Analysis** where the importance of the model parameters are identified and potentially ranked.

Various approaches:

- **Local Sensitivity Analysis:** Estimate sensitivity with small perturbations to the nominal model parameters
- **Global Sensitivity Analysis:** Evaluate the sensitivity over the full range of the parameters

Sensitivity Analysis can be used to:

- Select optimal design parameters to achieve system performance requirements
- Identify the largest contributors to uncertainty in system responses

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