

# 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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# Module Outline

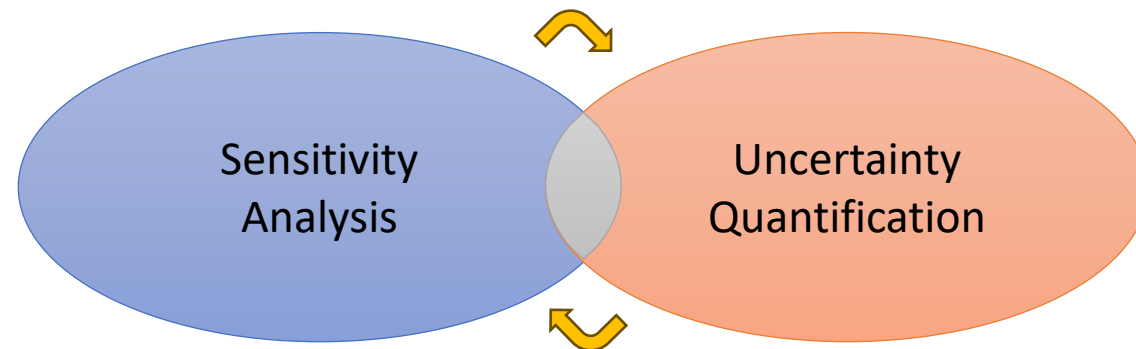
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- What is uncertainty quantification and why do we care?
- Steps of uncertainty quantification and how it is performed
  - Characterization of uncertainties
  - Propagation of uncertainties
  - Interpretation of uncertainties
- Sensitivity Analysis

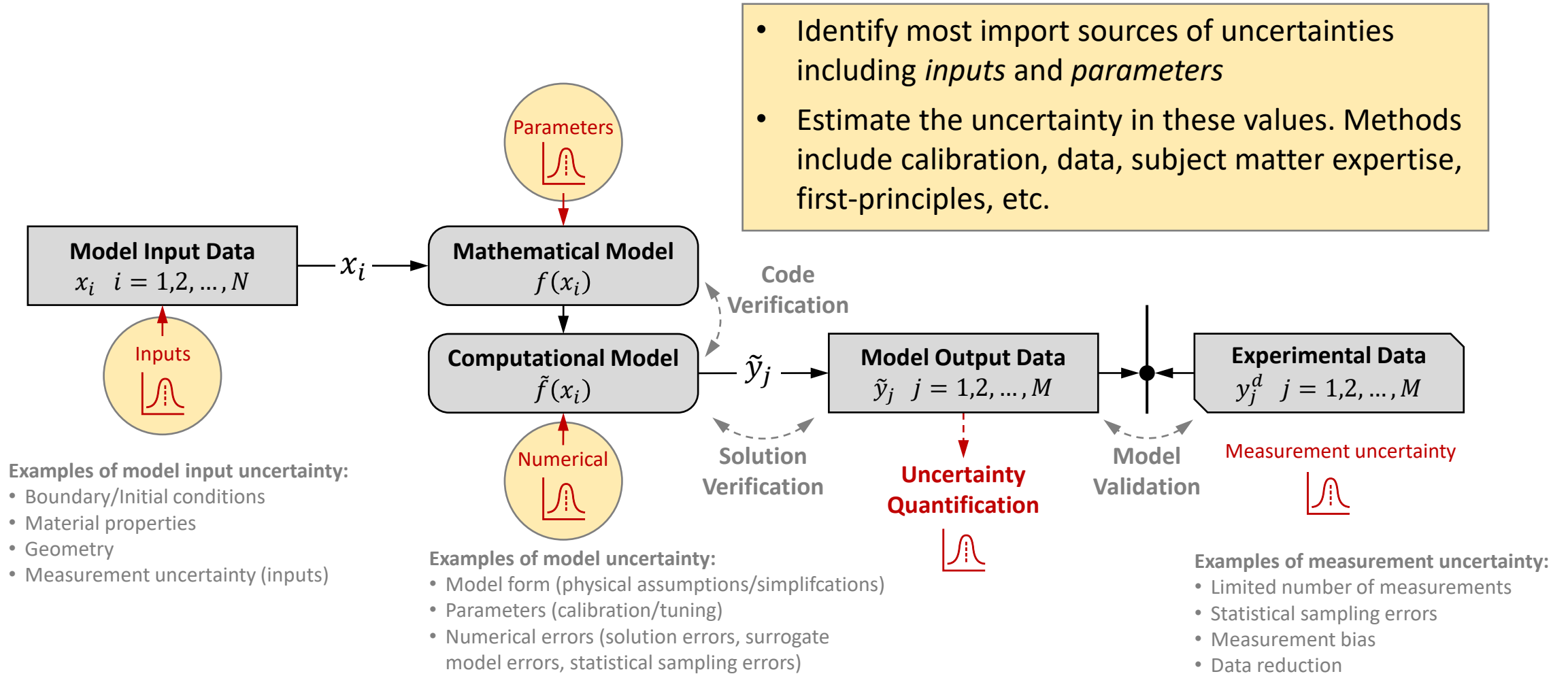
# What is uncertainty quantification and why do we care?

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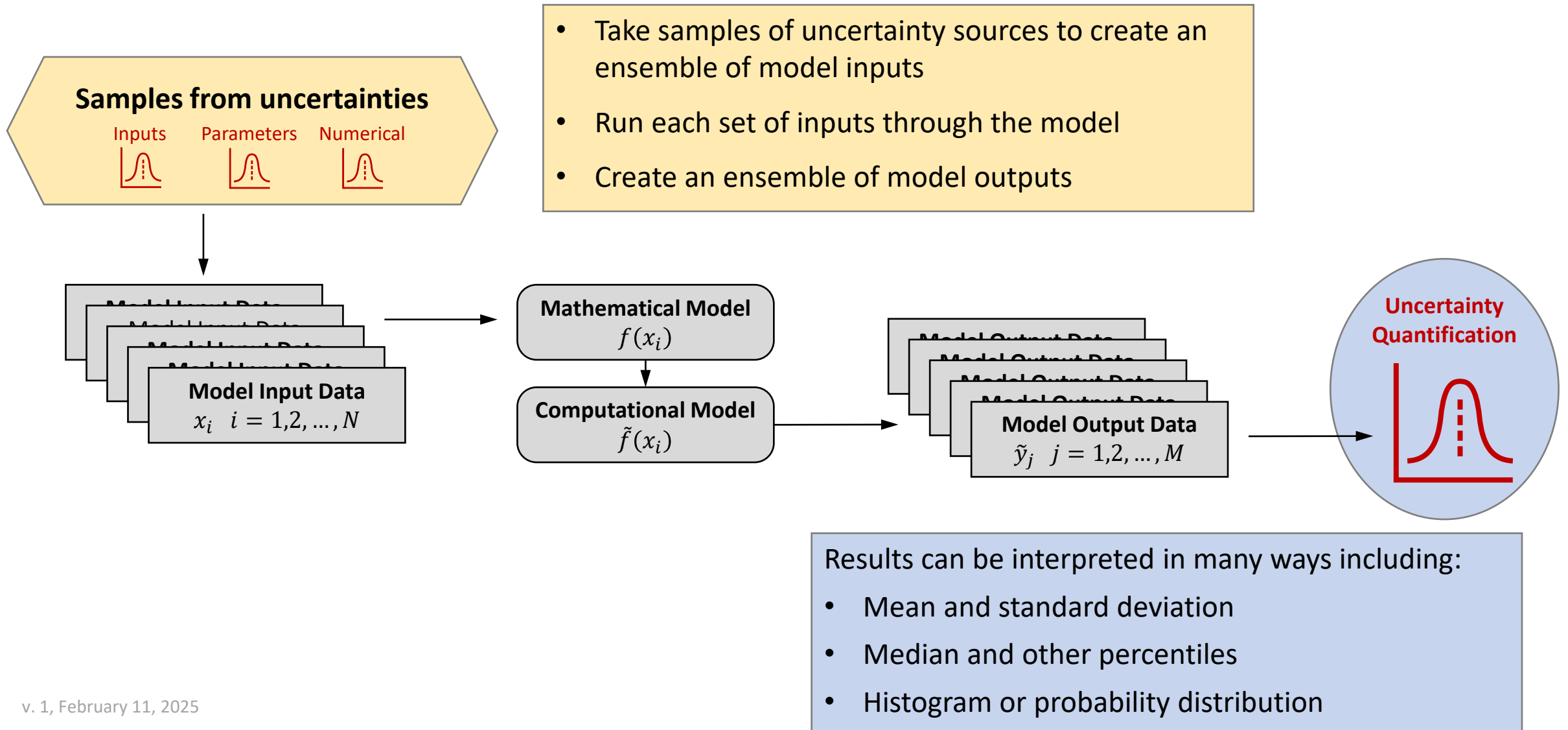
- **Uncertainty Quantification (UQ)** is the process of generating and applying mathematical models to provide a measure of uncertainty in the empirical or simulation results.
- Uncertainty Quantification has three basic steps:
  - **Characterize Uncertainties:** Identify all relevant uncertainties and characterize the uncertainties as much as is possible
  - **Propagate Uncertainties:** Perform model evaluations or modification to evaluate the input uncertainties through the model onto quantities of interest (QoIs)
  - **Interpret Results:** Compute and evaluate uncertainties
- Closely related is **Sensitivity Analysis:** The identification of which uncertainties have the largest effect on the QoIs. Sensitivity Analysis and Uncertainty Quantification are often iterated



# Characterize Uncertainties



# Propagate Uncertainties and Interpret Results



# Sensitivity Analysis

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

Various approaches:

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

Sensitivity Analysis can be used to:

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

# References

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