Part IV

Model validation and prediction

This section of the book presents an in-depth discussion of the topic of model validation and prediction. As discussed in Part I, this book uses the restricted meaning of model validation, i.e., assessment of model accuracy as determined by comparison of model outputs with experimental measurements. Stated differently, if you are not comparing model predictions of system response quantities (SRQs) with experimental measurements of the SRQs for the purpose of assessing the accuracy of the model, you are not conducting model validation. Prediction, as discussed in Part I, deals with the use of the model and all information that is available concerning the system of interest, as well has how well the model has performed in model validation activities, to predict the response of the system of interest for which no experimental data is presently available. That is, we use the model to foretell the response of the system of interest given our knowledge of the system, and how well the model has compared with available experimental measurements, including our estimates of all of the uncertainties involved in every element of the simulation.

Model validation can be viewed from three perspectives. First, we have the perspective of the mathematical model builder or computational analysts involved in the activity. This perspective is primarily discussed in Chapter 10, Model validation fundamentals. This perspective addresses issues such as the goals and strategy of validation and how model accuracy assessment can be conducted at different levels of physics and system complexity. Second, we have the perspective of the experimentalist involved in the activity. This perspective is discussed in Chapter 11, Design and execution of validation experiments. This perspective deals with the technical issues and practical concerns of experimentalists, such as how are validation experiments different from traditional experiments and tests of systems, what has been learned from experimentalists who have conducted high-quality validation experiments, and why validation experiments are difficult to conduct from both a technical perspective and a business perspective of experimental facility operators. Third, we have the perspective of how one quantitatively compares model and experimental results? This perspective is discussed in Chapter 12, Model accuracy assessment. The task of model accuracy assessment, which we refer to as the construction and evaluation of a validation metric, might, at first, seem fairly simple. We discuss how the task is complicated due to aleatory and epistemic uncertainty in both the model predictions and the experimental measurements. In this chapter we also discuss how model accuracy assessment differs from the common practices of model calibration and model updating. We also point out that there are widely varying perspectives on validation metrics and model calibration (updating).

Model prediction is discussed in Chapter 13, Predictive capability. This chapter will synthesize the key results of verification, validation, and uncertainty quantification from the previous chapters and incorporate them into an approach for nondeterministic predictions. This chapter, in contrast to all other chapters, does not stress the theme of assessment, but deals with the more complex issue of model extrapolation. The accuracy of the prediction is based on the fidelity of the physics, the soundness of the assumptions incorporated into the model, and the accuracy of the following at the application conditions of interest: (a) the extrapolation of the previously observed model accuracy, (b) the knowledge of all of the input data to the model, and (c) the estimation of the numerical solution error. We stress that one must be careful in the interpretation of the concept of *accuracy* in the prediction of a nondeterministic system for which one has limited knowledge. Two newly developed methods are discussed for estimating the uncertainty in model predictions. This chapter is not meant to be a comprehensive coverage of the topic of uncertainty estimation in predictions, but only give the reader an introduction to the topic and present the basic steps in nondeterministic predictions. Predictive capability is an active area of research and a number of references are given for further study.