7. Error estimation for reduced models (CSU, FSU)

Research thrusts: *Fast and reliable solution of multiphysics, multiscale problems; Validation, adaptation, and management of models*
Research sub-thrusts: *Error estimation, Goal-driven adaptive model reduction*

Exploration of the behavior of multiscale, multiphysics models over a wide range of model parameters is the focus of much of DOE computational science. A significant challenge for such studies is the sheer computational cost of model evaluation, which has led to a significant investment in reduced order modeling (ROM) methods by the DOE. However, ROM itself faces significant challenges, including lack of computable estimates of ROM accuracy and the requirement of homogeneous behavior to obtain optimal accuracy and efficiency. In a collaboration between PI Estep (CSU), PI Gunzburger (FSU), and postdoc J. Chaudhry (now assistant professor at University of New Mexico), we tackled the problems of deriving computable accurate a posteriori error estimates and algorithms for the efficient computation of a ROM based on the POD methodology for the solution of parameterized stationary convection-diffusion partial differential equations. The results of this project include [25]: (1) A new approach to computation of ROM/POD solutions that leads to orders of magnitude gains in computational efficiency; (2) New a posteriori error estimates that provide quantitative information on the accuracy of ROM/POD results; (3) Use of ROM/POD methods to significantly reduce the cost of computing a posterior error estimates involving the solution of adjoint problems and computable residuals. The novel adaptive algorithm partitions the parameter space into subdomains on which a hierarchical collection of local spectral bases is constructed, yielding significant increases in efficiency in both offline and online stages. The new approach achieves better accuracy at a greatly reduced computational cost. We also use the POD approach to compute accurate error estimates for the full-order model at a tremendously reduced cost.

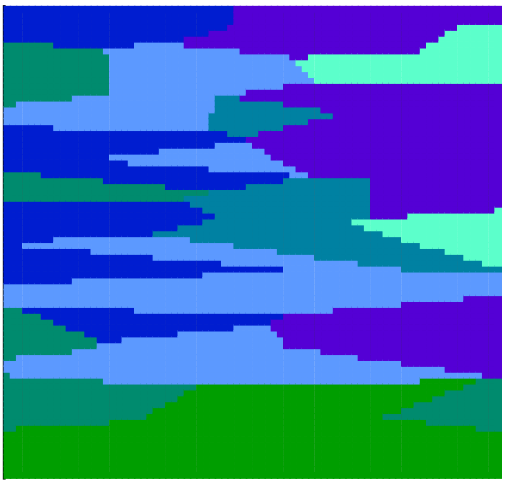

Figure 11: Typical collection of subdivisions of a parameter domain. Regions of the same color form subdomains, which do not have to be connected. A hierarchical localized POD basis is used to represent behavior on each subdomain.