MA 540 Uncertainty Quantification for Physical and Biological Models

Time: 11:45 - 1:00 Tuesdays and Thursdays
Place: SAS 2225
Instructor: Ralph Smith
Office: SAS 4140, Tel: 515-7552
Email: rsmith@ncsu.edu
Web: `http://www4.ncsu.edu/~rsmith/`
Prerequisites: MA 341 and basic knowledge of probability, linear algebra and scientific computation

Text: *Uncertainty Quantification: Theory, Implementation, and Applications*, Ralph Smith, SIAM, Philadelphia, PA 2014.

Computing: We will use MATLAB and provided software

Grades: The gradescale is: 90-100 A-,A; 80-89 B-,B,B+; 70-79 C-,C,C+; 60-69 D-,D,D+; below 60: F. The coursework will consist exclusively of projects.

Final Project: Due on April 26, 2018

Course Topics:

- Motivating applications and prototypical models
- Fundamentals of probability, random processes and statistics
- Representation of random inputs
- Parameter selection techniques
- Global sensitivity analysis
- Frequentist and Bayesian model calibration
- Uncertainty propagation in models
- Stochastic spectral methods and sparse grid techniques
- Surrogate models
- Prediction in the presence of model discrepancy

Learning Outcomes: By the end of the course, students will be able to:

- Determine the sources and impacts of input and response uncertainties in models arising in their discipline as well as prototypical weather, climate, hydrology, nuclear and biology models.
- Explain the basic probability, stochastic process and statistics concepts required for uncertainty quantification.
- Formulate models in a manner that isolates the influential parameters and facilitates statistical analysis. This includes the use of local and global sensitivity analysis techniques.
- Construct surrogate models for complex processes that retain the fundamental underlying behavior while providing the computational efficiency required for model calibration and uncertainty propagation.

- Compute confidence intervals using frequentist analysis and employ Markov chain Monte Carlo methods to construct posterior distributions and credible intervals for parameters. Be able to verify the accuracy of distributions constructed using Bayesian analysis.
- Compute confidence, credible and prediction intervals for model responses and quantities of interest using sampling techniques and numerical stochastic spectral methods.

Academic Integrity and Disabilities Information: This is provided at the following web sites:
`http://www.ncsu.edu/provost/academic_regulations/integrity/reg.htm`
`http://www2.ncsu.edu/ncsu/stud_affairs/counseling_center/dss/`