MSEE SHORT COURSE:

Uncertainty Quantification in physics-based modeling using Python

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EGLIN AFB, FLORIDA

INSTRUCTORS:
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ABOUT THE COURSE:

This **in-person, two-day short course** will introduce participants to uncertainty quantification (UQ) in computational modeling using the Python programming language. Participants will be introduced to a variety of UQ methods, including forward propagation of uncertainty, surrogate modelling and Bayesian inference using the UQpy toolbox. By the end of the course, the goal for attendees is to have the foundations to begin applying UQ to computational models of their fields of study. The course will be divided into a morning and an afternoon session. During the morning session, instructors will guide the participants step-by-step through introductory activities of the day. In the afternoon session, participants will work independently on UQ activities, with the instructors available to assist.

Methods covered in the course will include: Monte Carlo methods for uncertainty propagation, surrogate model construction using Gaussian processes and polynomial chaos expansions, global sensitivity analysis, and Bayesian inference methods for parameter estimation, model calibration, and model selection.

Prerequisites and Pre-Workshop Activities:

- Participants will be provided with links to video lectures on UQ topics, which they should watch prior to attending the workshop.
- Participants are expected to be proficient in the Python programming language with knowledge that includes Python syntax, data types and structures (e.g. lists and dictionaries), importing and using widely available libraries (e.g. numpy and scipy), and object-oriented programming in Python.
- Participants must bring their own laptop computer with all necessary software installed, including Python 3. Although we will review installation of UQpy and setting the user environment, we will not review Python installation.

HOW CAN YOU USE UQ?

Uncertainty quantification (UQ) is the science of characterizing and estimating the uncertainties in both computational applications and real-world phenomena. These uncertainties may stem from various sources, such as inadequacies of computational models to capture real-phenomena, uncertainties in model parameters or initial conditions, and errors in experimental measurements. UQ can be highly valuable for a wide-range of defense applications, including:

- Understanding the influence of uncertainty on complex systems modeled using physics-based solvers, e.g. high-speed fluid flow, structures and materials under extreme conditions, and multi-scale and multi-physics applications.
- Estimating the sensitivity of physics-based models to various uncertain inputs.
- Assessing safety and reliability of structures and materials in extreme and uncertain environments.
- Model calibration from limited and noisy data, e.g. calibrating of material models and/or equation of state models for modeling materials in extreme conditions.
- Uncertainty-informed experimental design

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