Clemson Uncertainty Quantification (UQ) Working Group Kickoff Meeting

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About Clemson UQ Group

- Initiated by Andrew Brown a few weeks ago.
- Current group members: Qiong Zhang, Andrew Brown, Whitney Huang
- We think it is an interesting research area and we would like to invite you to join us!

What is Uncertainty Quantification (UQ)?

One definition of "Capital UQ":

> "*The synergy between Statistics, Applied Mathematics, and domain sciences required to quantify uncertainties in inputs and the quantity of interest when models are too computationally complex to permit sole reliance on sampling-based methods*" – Ralph Smith, Distinguished University Professor, NCSU Math

- A Combined Physical-Statistical Approach to model input/output relationship
- Use statistical emulators to mimic (computationally extensive) simulators and to quantify its (epistemic) uncertainty

Example: Storm Surge Modeling (video courtesy of Rick Luettich, UNC)

Click me

Model inputs: TC characteristics

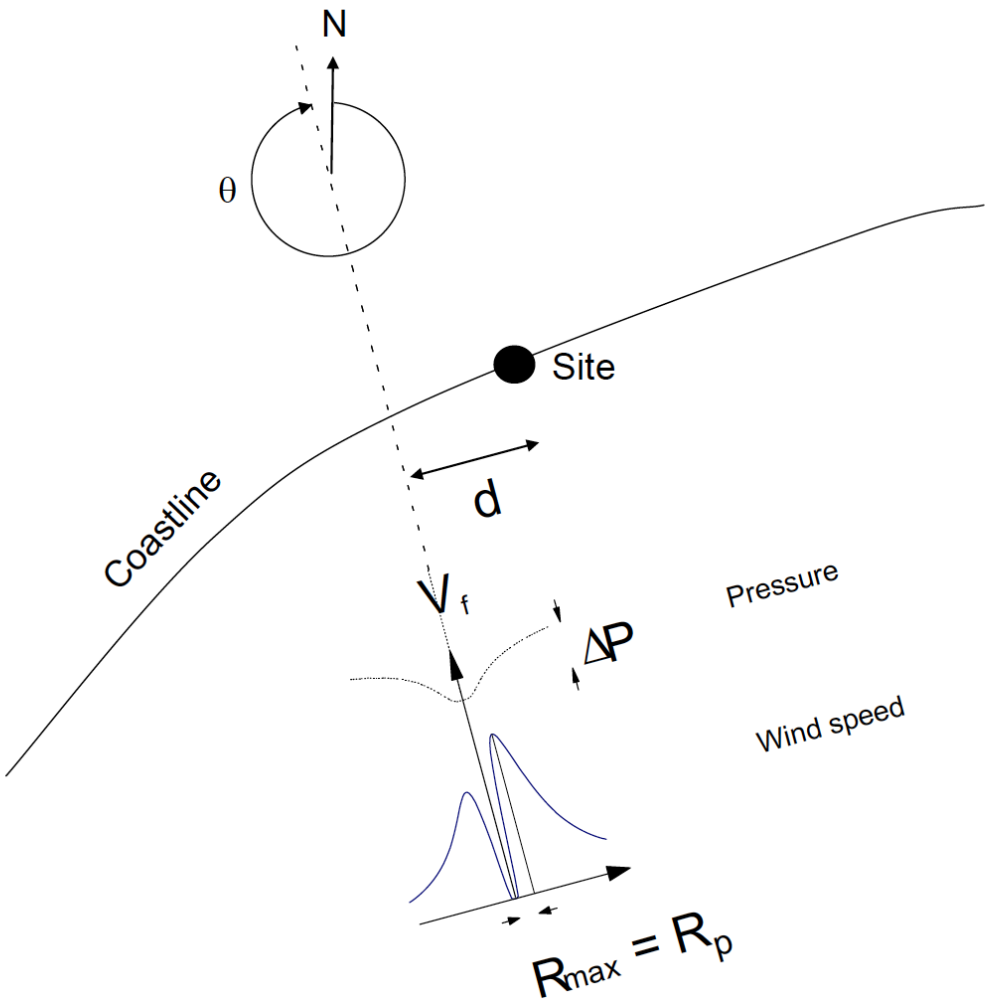

Figure courtesy of Toro, 2008

- ΔP: Pressure deficit: Far-field pressure − central pressure
- R_{max} : Radius to maximum winds
- V_f: Forward velocity
- θ: Storm heading angle
- d: Distance to the storm center

Statistical formulation

$$y_{\boldsymbol{s}} = \eta_{\boldsymbol{s}}(\boldsymbol{x}_{\boldsymbol{s}}) + \varepsilon_{\boldsymbol{s}}(\boldsymbol{x}_{\boldsymbol{s}}), \qquad \boldsymbol{s} \in \mathcal{S}$$

where

- $y_{\boldsymbol{s}} \in \mathcal{Y}_{\boldsymbol{s}} \subset \mathbb{R}_+$: peak surge level at $\boldsymbol{s}$
- $\boldsymbol{x}_{\boldsymbol{s}} \in \mathcal{X}_{\boldsymbol{s}} \subset \mathbb{R}^p$: model input ($\Delta\mathrm{P}, \mathrm{R_{max}}, \mathrm{V}_f, \theta$, d, etc)
- $\eta_{\boldsymbol{s}} : \mathcal{X}_{\boldsymbol{s}} \to \mathcal{Y}_{\boldsymbol{s}}$: surge response function at $\boldsymbol{s}$
- $\varepsilon_{\boldsymbol{s}}$: discrepancy term

Problems of interest: (1) Forecast problem (2) Flood hazard problem

1. **Input modeling**: To describe $\boldsymbol{x}_{\boldsymbol{s}}$ in a probabilistic fashion: (1) how a given storm will evolve in a few days; (2) what would be the future storms like
2. **Emulation**: a) To choose $\{\boldsymbol{x}_{\boldsymbol{s},i}\}_{i=1}^N$ to run the surge model; b) To estimate $\eta_{\boldsymbol{s}}(x), x \in \mathcal{X}$
3. **Tail estimation**: (2) To estimate the r-year return level of $\eta_{\boldsymbol{s}}(\boldsymbol{X}_{\boldsymbol{s}})$

Recent UQ activities

Passed:

- Aug. 2018-May 2019: Year-long program on Model Uncertainty: Mathematical and Statistical at Statistical and Applied Mathematical Sciences Institute (SAMSI)
- 5/16-17: workshop on Statistical Perspectives on Uncertainty Quantificati(SPUQ), Chapel Hill, NC

Upcoming:

- 11/01: Dr. Roshan Joseph, A. Russell Chandler III Professor at Georgia Tech will visit Clemson and give a statistics seminar (11:15am - 12:05pm)
- 2/17 - 2/21, 2020: Workshop on Mathematics of Reduced Order Models at The Institute for Computational and Experimental Research in Mathematics (ICERM), Providence, RI
- 3/24-3/27, 2020: SIAM Conference on Uncertainty Quantification UQ20, Munich, Germany

Further Readings


Santner, T. J., Williams, B. J., Notz, W.
The Design and Analysis of Computer Experiments.
Springer, 2003.


Smith, R. C.
Uncertainty quantification: theory, implementation, and applications.
SIAM, 2014.


Sacks, J., Welch, W. J., Mitchell, T. J., & Wynn, H. P.
Design and analysis of computer experiments
Statistical science, 409–423, 1989


Kennedy, M. C., & O'Hagan, A.
Bayesian calibration of computer models (with Discussion)
Journal of the Royal Statistical Society: Series B, 425–464, 2001