Language-agnostic UQ-model interfaces

DAFNI at Durham

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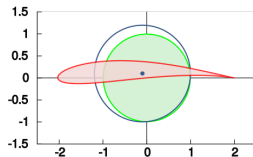
Given observations, how likely is a parameter? And what quantity of interest is therefore likely?

$$\underbrace{Q(F^{-1}(y))}_{\text{Quantity of interest}} \quad \leftarrow \quad \underbrace{F^{-1}(y)}_{\text{Inverse model}} \quad \leftarrow \quad \underbrace{y}_{\text{Observation distribution}}$$
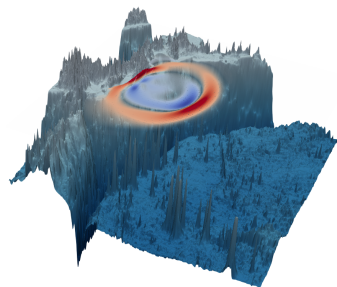
UQ and Model in Math

Model in UQ: (Often) Just a function
$F : \mathbb{R}^n \to \mathbb{R}^m$ with

- Model evaluation $F(\theta)$,
- Gradient evaluation
- Jacobian action $J(\theta)v$,
- Hessian action $H(\theta)v$.

$\to$ Simple, model- and language-agnostic interface!

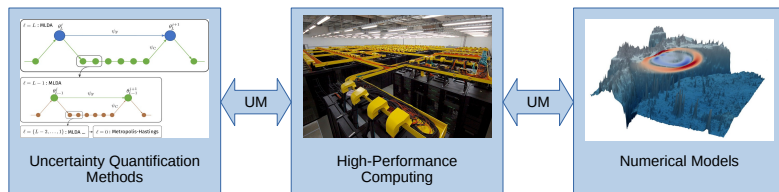Propagation of the Tohoku tsunami from
(Seelinger et al, 2021)

Model **software** and UQ **software**: Not so easy!
Conflicts in buildsystems, dependencies, languages, parallelization; need experts from both sides, ...

Uncertainty Quantification Methods

High-Performance Computing

Numerical Models

Make UQ more widely accessible and accelerate the development of UQ methods by

- establishing unified interfaces between modeling and UQ software
- providing fully portable models, e.g. system (OS) and language-independent
- enabling easy access to HPC and automatic scaling

and more comparable and reproducible by

- providing a library of ready-to-run benchmark problems based on that interface.

UM-Bridge: Model Abstraction in Software
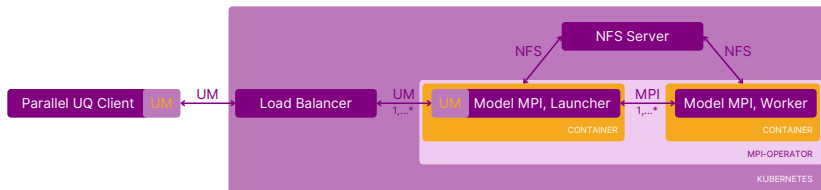
- Full **language support**: C++, python, julia, R, MATLAB
- Fully integrated **UQ software:** emcee, MUQ, QMC, PyMC, SG Matlab kit, tinyDA, TT Toolbox, UQPy
- **Modeling software:** e.g. resistance estimation of the DTMB 5415 destroyer-type vessel by potential flow (FORTRAN), propagation of the 2011 Tohoku tsunami modeled by solving the shallow water equation (C++), Microscopic transport of tritium through fusion reactor materials using the Foster-McNabb equations (C++) and transmission of disease in a heterogenous population using a stochastic agent based disease transmission model (C)...