(1) Background and Motivation

The Initial Problem

Initial Conditions

- Initial state: inverse of covariance of errors

Log-likelihood

- 500

U, T, H

- Initial state evolution

- Triangle tiling of M

- Forward model

- Problem parameters

- Boundary conditions

- Initial state control parameters

- Solution strategies: sampling- and adjoint-based methods

- 1. Adjoints are invaluable for finding the MAP point, or optimal fit between the model and data.
- 2. Derivative-based UQ seeks to exploit sensitivity (1st-derivative, or adjoint) and geometric (2nd-derivative, curvature or Hessian) information. How best to do this is one of our research goals, and we are exploring how best to make use of DAKOTA tools.
- 3. Derivative methods are well-suited to solving time-dependent problems, and are often applied to adjoint-based methods in a context of parameter estimation. Under certain conditions, adjoint-based methods can be superior to both other derivative-based and sampling-based methods.
- 4. Including a “discrepancy term” or scaling factor in the log-likelihood to account for biases.

Solution Strategies: Sampling- and Adjoint-based methods

- 1. How to account for the lack of treatment of transients in solutions?
- 2. Data may be incompatible with model physics.
- 3. Forcing from climate model contains long-term average errors (or “biases”)
- 4. Basal traction coefficients, boundary conditions.

Figure 1.1: Schematic of observations, boundary conditions, and processes affecting ice sheet evolution.

Figure 2.3: “Dome Problem” Bayesian calibration of four parameters within an idealized distribution of basal sliding coefficients.

Figure 3.2: Objective function (log-likelihood) for a given set of control parameters.

Figure 3.3: Objective function vs. control parameter variation for different control methods

Figure 3.4: Depth-averaged ice speed for Greenland showing ice sheet/ice shelf velocity (color) and climatological ice speed (black), with the 1000 km long-ice speed (black) showing ice sheet/ice shelf velocity (color) at 100 km.

Figure 3.5: Objective function (log-likelihood) for a given set of control parameters.

(2) Sampling-Based Methods

Initial Goals

- Derived from Quasi-Newton approximations and can be applied to very large problems, such as those encountered in global climate models.

Figure 1.2: Forward modeled velocity and surface mass balance in the vicinity of the Dome A region.

Figure 2.2: Parameter estimation of uncertainty in Sea Level Rise from Next-Generation Ice Sheet Models.

Figure 3.1: Initial State Probability Distribution - Importance of Uncertainty in Sea Level Rise from Next-Generation Ice Sheet Models


References


(3) Progress Using Adjoint-Based Methods

Problem 1: Coupled Ice Sheet and Climate Model Initialization

- Objective: Derive optimal ice sheet model initial state (velocities, temperatures, and thicknesses).

Problem 2: Idealized Ice-Ocean Coupling Simulations

- Objective: Derive optimal ice sheet model initial state (velocities, temperatures, and thicknesses).

Problem 3: Quantification of Uncertainty Rise from Next-Generation Ice Sheet Models

- Objective: Derive optimal ice sheet model initial state (velocities, temperatures, and thicknesses).

Problem 4: Accounting for the lack of treatment of transients in solutions.

Problem 5: Data may be incompatible with model physics.

Problem 6: Forcing from climate model contains long-term average errors (or “biases”)

Problem 7: Basal traction coefficients, boundary conditions.

Problem 8: Includes a “discrepancy term” or scaling factor in the log-likelihood to account for biases.

Problem 9: Representing boundary condition uncertainties.

Problem 10: Sensitivity is the.

Problem 11: Counterintuitively, sensitivity is the.

Problem 12: The goal is to derive optimal ice sheet model initial state (velocities, temperatures, and thicknesses).

Problem 13: The cold function (f) is computed using the cold function (f) method. The ice sheet model is applied to a given climate model projection.

Problem 14: The ice sheet model is applied to a given climate model projection.

Problem 15: The ice sheet model is applied to a given climate model projection.

Problem 16: The ice sheet model is applied to a given climate model projection.

Problem 17: The ice sheet model is applied to a given climate model projection.

Problem 18: The ice sheet model is applied to a given climate model projection.

Problem 19: The ice sheet model is applied to a given climate model projection.

Problem 20: The ice sheet model is applied to a given climate model projection.