LA-UR-16-25089
Approved for public release; distribution is unlimited.

Title: Quantifying uncertainty and sensitivity in sea ice models

Author(s): Urrego Blanco, Jorge Rolando
Hunke, Elizabeth Clare
Urban, Nathan Mark

Intended for: LANL institutional computing annual report

Issued: 2016-07-15

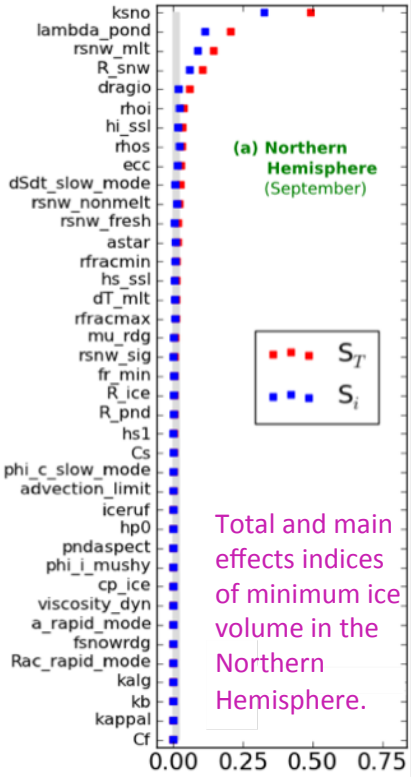
Quantifying uncertainty and sensitivity in sea ice models

Objective

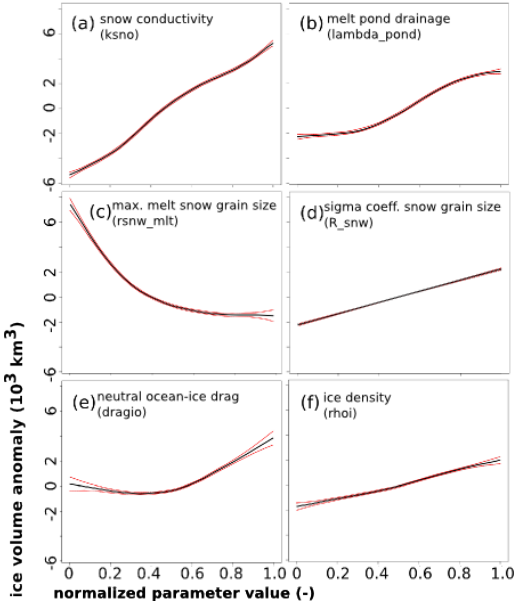
The Los Alamos Sea Ice model has a number of input parameters for which accurate values are not always well established. We conduct a variance-based sensitivity analysis of hemispheric sea ice properties to 39 input parameters. The method accounts for non-linear and non-additive effects in the model.

Approach

- Sample entire high dimensional parametric space using Sobol' sequences and fitting a fast statistical emulator for sea ice volume, area, and extent.
- Determine sensitivity indices (main and total effects) from variance decomposition and apportion output uncertainty to input parameters.
- Determine main effects and second order interactions using generalized additive models.



Total and main effects indices of minimum ice volume in the Northern Hemisphere.



Main effects indicating first order functional relationships between parameters and September sea ice volume.

Impact

We identified the most important parameters driving uncertainty in CICE (standalone mode), and determined non-linear and non-additive functional relationships with hemispheric sea ice quantities. The results are useful to guide research and calibration activities.

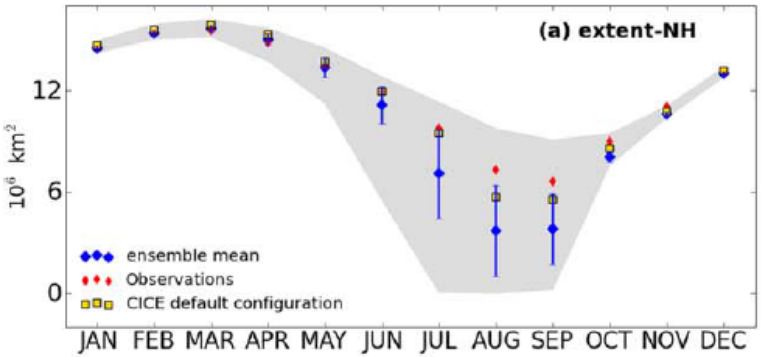
Urrego-Blanco, J. R., N. M. Urban, E. C. Hunke, A. K. Turner, and N. Jeffery (2016), Uncertainty quantification and global sensitivity analysis of the Los Alamos sea ice model, J. Geophys. Res. Oceans, 121, 2709–2732, doi:10.1002/2015JC011558.

Validation metrics for the performance assessment of sea ice models

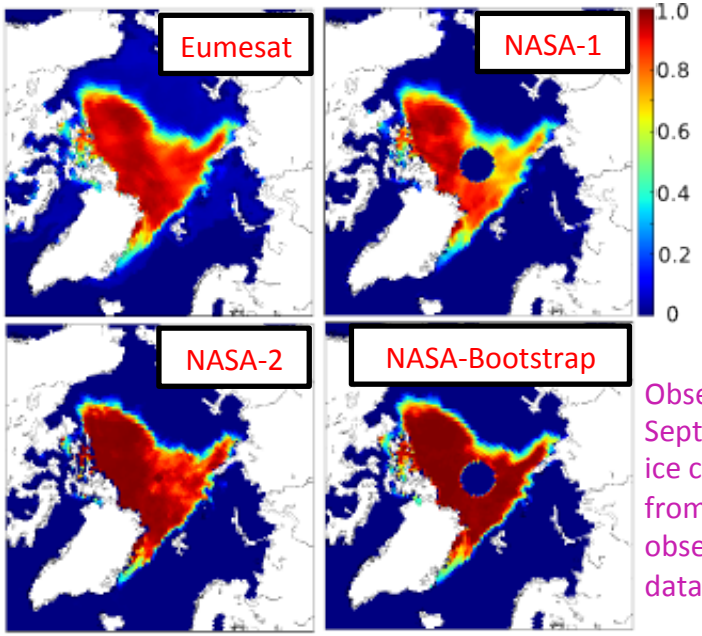
Objective and Approach

- Apply a statistically robust validation metrics for validation of sea ice models:
  - Validate multiple quantities of interest (e.g. concentration, thickness)
  - Observational uncertainties:
  - Model uncertainties:

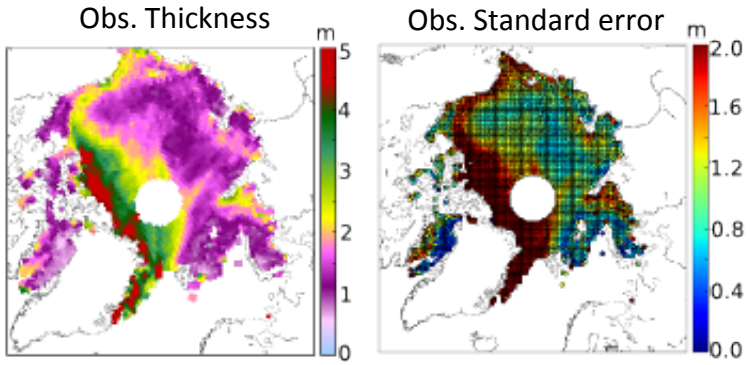
- Use the gamma distribution to assert whether or not model results and simulations match



Monthly Arctic sea ice extent from an ensemble of 400 CICE model runs. The shaded represent the range of variation of model predictions across parametric uncertainty.



Observed September-2007 sea ice concentration from four observational datasets.

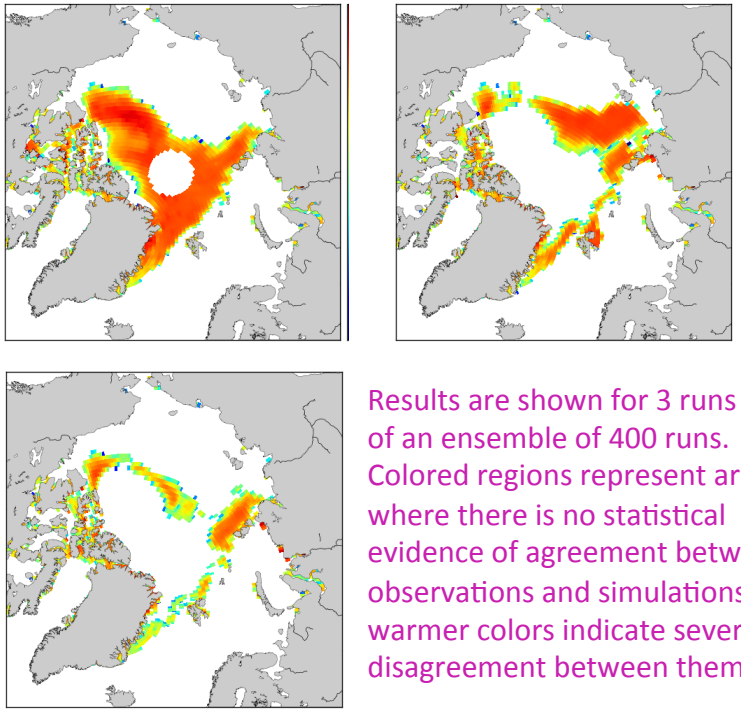


Observed March-2007 sea ice thickness and associated standard error.

Urrego-Blanco, J., Langenbrunner, J.R., Hunke, E.C., and Urban, N., Validation of Sea Ice Models Using an Uncertainty-Based Distance Metric for Multiple Quantities of Interest, in prep.

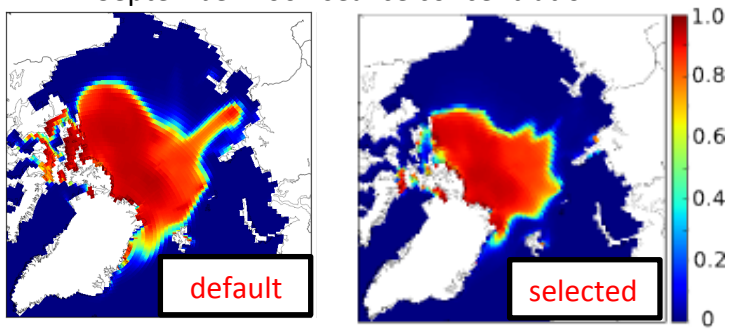
Validation metrics for the performance assessment of sea ice models

Goodness-of-fit tests between observed and simulated September sea ice concentration

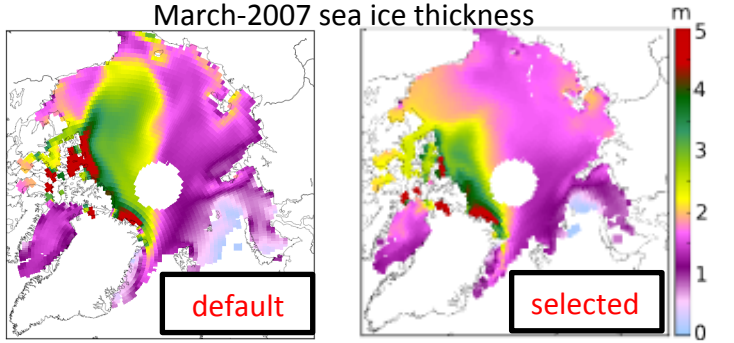


Results are shown for 3 runs out of an ensemble of 400 runs. Colored regions represent areas where there is no statistical evidence of agreement between observations and simulations, and warmer colors indicate severe disagreement between them.

September-2007 sea ice concentration



March-2007 sea ice thickness



Simulated sea ice concentration and thickness in two model runs with different parameter configurations. Based on the proposed distance metric, the selected configuration outperforms the default configuration (see figures in previous slide). According to the distance metric, the selected configuration ranks among the best in an ensemble 400 model runs. The selected configuration has been used to inform calibration of a coupled climate model.

Impact

The methodology proposed for validating sea ice models is a statistically robust framework that allows the integration of different quantities of interest, and observational and model uncertainties. It can complement the analysis of sea ice model results which can be applied during the development and refinement of new parameterizations, or for model intercomparison. The standalone model assessment results have been used to inform calibration activities of the ACME-HiLAT coupled climate model.

Urrego-Blanco, J., Langenbrunner, J.R., Hunke, E.C., and Urban, N., Validation of Sea Ice Models Using an Uncertainty-Based Distance Metric for Multiple Quantities of Interest, in prep.