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Upper ocean heat content uncertainty in the CCSM3's ocean using a large ensemble

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We examine the heat content and uptake in the ocean component (POP2) of the CCSM3.0 model using an emulator created from a large member ensemble. The uncertainty in a climate model is a combination of the uncertainty in the initial conditions, the parameter space and the model structure. "Statistical Analysis of Computer Code Output" (SACCO) methods, based on Bayesian statistics, can be used to explore uncertainties associated with such complex models. This paper discusses the results of a designed experiment to explicitly determine the formal uncertainty in the ocean and ice components of the CCSM3.0 climate model. After an initial spin-up, the ocean/ice system is forced with the NCEP reanalyses (COREv2) with the last 40 years of a 100-year simulation. A 100 member ensemble of the CCSM3.0 ocean/ice system at a 3 degree resolution was created, of which 89 are used in the final analyses. Each ensemble member uses a different set of parameter settings. The values for the parameters were determined using a Sobol sequence. Sobol sequences produce a sampling of a multiple parameter space, such that the sampling is uniform, but sparse, across input space. The parameters we varied relate to such things as ocean mixing and advection. A relatively small member ensemble (100 member, as compared to the 10000 required for determining an accurate uncertainty distribution using Monte Carlo methods) of the complex model is used to create an emulator. The emulator is then used to produce a PDF of the that is equivalent to a 10000 member ensemble based on only 100 model runs. An emulator is a tool to investigate the uncertainty characteristics of the model and its outcomes and is not a replacement for the model itself. The full PDF can then be used to determine uncertainty values associated with a metric determined by or computed from the outputs of the physical model. We compare the model output to observational data, initially, to show the realism of the model. We discuss how the model output and its emulator can be used to understand intrinsic uncertainties, related to parameter settings, in the uptake of heat in the ocean component. The analysis is shown for the global heat content, as well as for regional areas, such as the North Atlantic, the North Pacific, and the Southern Ocean.