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Strongly coupled ensemble transform Kalman filter estimation of ocean optical parameters in a coupled GCM

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Coupled general circulation models (GCM) of the atmosphere, ocean, land and sea-ice have many parameters. Some of which govern the numerics of the dynamical core, whilst others represent the influence of unresolved subgrid process based on our current fundamental physical understanding. The spatio-temporal structure of many of these parameters are known with little precision, which contributes to the inherent model biases in the underlying GCM. To address this problem we use the CSIRO Climate re-Analysis and Forecast Ensemble (CAFE) system to estimate both the climate state (atmosphere, ocean, sea-ice) and also spatio-temporally varying parameter maps of the ocean surface albedo and shortwave radiation e-folding length scale in a coupled climate GCM of CMIP resolution and complexity. The CAFE system adopts a 96 member ensemble transform Kalman filter within a strongly coupled data assimilation (DA) framework. The parameters (and states) are determined by minimising the error between short term DA cycle forecasts of the climate model and a network of real world atmospheric, oceanic, and sea-ice observations. Several DA cycle lengths are tested between 3 to 28 days. The DA system has an improved fit to observations over the period from 2010 to 2012, when estimating both of the ocean optical parameters either individually or simultaneously. However, only individually estimated maps of shortwave e-folding length scale attain systematically reduced bias in multi-year climate forecasts during the out-of-sample period from 2012 to 2020. Parameter maps determined from longer DA cycle lengths also have further reduced multi-year forecast bias. Such improved climate forecasts would potentially enable policy makers to make better informed decisions on water, energy and agricultural infrastructure and planning.