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Ocean data assimilation with a reduced rank smoother

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The Kalman filter is a widely used data assimilation method in oceanography. It runs sequentially: the numerical model propagates the ocean state through time, and an analysis is performed on a regular basis, using the available observation data. A specificity of the Kalman Filter lies in that each analysis product contains the information of past, present, but not subsequent observations. The methods extending the Kalman filter to introduce subsequent observations in the estimation process are the optimal smoothers. Smoothers appear particularly attractive for the applications of data assimilation other than numerical forecast, when "future" observations are available: reanalyses for example.

We present here a smoother extension (Cosme et al, 2010) of the Singular, Evolutive, Extended Kalman (SEEK, Pham et al, 1998) filter, a reduced rank filter specifically developed and used for oceanographic problems. The smoother is based on an algorithm that explicitly propagates the error statistics according to the model dynamics. It is shown that observations can be used to retrospectively correct the previous filter analysis states, at a limited numerical cost.
The SEEK smoother was first implemented with an ocean circulation model in a double-gyre, 1/4° configuration, able to represent mid-latitude mesoscale dynamics. It results in a significant reduction of the global error.
The implementation of the SEEK smoother with a high resolution model configuration of the Tropical Atlantic ocean, currently under development, is presented. This region is of specific interest due to the presence of Tropical Instability Waves (TIWs): fast oscillations travelling from East to West, and difficult to track with a "forward-only" data assimilation method feeded with uncomplete observations such as along-track altimetric measurements. Another specific region is the North-Brazil rings area where instabilities may quickly develop if the initial state of the model is not well defined. The smoother exhibits interesting skill to prevent these kind of instabilities. Consequently, it is shown to be a usefull tool to create initial states for the forecasting problems and we will present these aspects here.

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