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Coupled atmosphere-ocean variational data assimilation in the presence of model error

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Atmosphere-only and ocean-only variational data assimilation (DA) schemes are able to use window lengths that are optimal for the error growth rate, non-linearity and observation density of the respective systems. Typical window lengths are 6-12 hours for the atmosphere and 2-10 days for the ocean. However, in the implementation of coupled DA schemes it has been necessary to match the window length of the ocean to that of the atmosphere, which may potentially sacrifice the accuracy of the ocean analysis in order to provide a more balanced coupled state. This work investigates how extending the window length in the presence of model error affects both the analysis of the coupled state and the initialized forecast when using coupled DA with differing degrees of coupling.

Results are illustrated using an idealized single column model of the coupled atmosphere-ocean system. It is found that the analysis error from an uncoupled DA scheme can be smaller than that from a coupled analysis at the initial time, due to faster error growth in the coupled system. However, this does not necessarily lead to a more accurate forecast, due to imbalances in the coupled state. Instead coupled DA is more able to change the initial state to allow for model errors and thus produce a more accurate forecast. The effect of model error is potentially most detrimental in the weakly coupled formulation due to the inconsistency between the coupled model used in the outer loop and uncoupled models used in the inner loop of the incremental scheme.