Exploring Coupled 4D-Var Data Assimilation Using an Idealized Atmosphere-Ocean Model

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The successful application of data assimilation techniques to operational numerical weather prediction and ocean forecasting systems has led to an increased interest in their use for the initialization of coupled atmosphere-ocean models in seasonal to decadal timescale prediction.
Coupled data assimilation presents a significant challenge but offers a long list of potential benefits including the improved use of near-surface observations, reduction of forecast initialization shocks, and generation of a consistent system state for the initialization of coupled forecasts across all timescales.

This presentation will describe work from projects funded by the European Space Agency (ESA) and UK Natural Environment Research Council (NERC). The ESA funded component is part of the Data Assimilation Projects - Coupled Model Data Assimilation initiative whose goal is to advance data assimilation techniques in fully coupled atmosphere-ocean models (see http://www.esa-da.org/). Our research aims to investigate some of the fundamental questions in the design of coupled data assimilation systems within the context of an idealized one-dimensional system. It is being conducted in parallel to the development of the new Coupled European Centre for Medium-Range Weather Forecasts (ECMWF) Re-analysis system (CERA), a prototype weakly coupled data assimilation system.

Here, we will describe the development of our simplified single-column coupled atmosphere-ocean 4D-Var assimilation system which is based on the ECMWF Integrated Forecast System (IFS) atmosphere model and a K-Profile Parameterization (KKP) mixed layer ocean model developed by the National Centre for Atmospheric Science (NCAS) climate group at the University of Reading. The system employs a strong constraint incremental 4D-Var scheme and is designed to enable the effective exploration of various approaches to performing coupled model data assimilation whilst avoiding many of the issues associated with more complex models.

The work within this simple framework will facilitate a greater theoretical understanding of the coupled atmosphere-ocean data assimilation problem and thus help inform the design and implementation of the different coupling strategies proposed for the CERA system.

We will present preliminary results from identical twin experiments devised to investigate and compare the behavior and sensitivities of different coupled data assimilation methodologies.