Toward the Development of a Coupled COAMPS-ROMS Ensemble Kalman Filter and Adjoint with a focus on the Indian Ocean and the Intraseasonal Oscillation

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LONG-TERM GOALS

The long-term goals of this research project are to:

1. Develop a regional coupled ocean-atmosphere model comprising the Navy's Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) and the Regional Ocean Modeling System (ROMS).
2. Explore data assimilation strategies in regional coupled ocean-atmosphere models with a specific focus on air-sea interaction in the tropical Indian Ocean.

OBJECTIVES

The project has the following objectives:

(1) Interface ROMS and COAMPS with the Data Assimilation Research Testbed (DART) system at NCAR.

(2) Compare the performance of the Ensemble Kalman Filter (EnKF) using the Data Assimilation Research Testbed (DART) and 4-dimensional variational (4D-Var) approaches to data assimilation in ocean only and atmosphere only experiments.

(3) Develop a coupled model capability based on the pre-existing COAMPS and ROMS systems using the Earth System Modeling Framework (ESMF).

(4) Investigate the merits of the EnKF approach for assimilating data into a coupled model, particularly in the highly dynamic tropical Indian Ocean where air-sea interactions play a fundamental role shaping the monsoon circulation.

APPROACH

As part of this project, eight major research tasks are envisaged:

Task 1: Development of a coupled COAMPS-ROMS code using the ESMF.
Task 2: Configuration of ROMS for the Indian Ocean.
Task 3: Configuration of COAMPS for the Indian Ocean.
Task 4: Interfacing ROMS with DART.
Task 5: Interfacing COAMPS with DART.
Task 6: Testing of the coupled model via a series of idealized problems.
Task 7: Configuration of the coupled COAMPS-ROMS system with DART.
Task 8: Preparation of observations from the Indian Ocean for data assimilation.

WORK COMPLETED

This project is still in its very early stages so we will report here on our plans for the next year.

Discussions between the PI and Co-PIs at Rutgers and NRL have identified the following strategy for moving forward during the next 12-18 months of the project:

(1) ROMS has been configured for the Indian Ocean with a resolution that telescopes from 26 km at the northern and southern boundaries to 7 km the equator. The model domain is illustrated in Figure 1.
(2) The ROMS code will be updated to be fully compliant with the NUOPC version of ESMF.
(3) Project personnel will spend time at NCAR working on the interface of ROMS with DART. The initial plan is to use a low resolution version of ROMS configured for the California Current system for which we have considerable data assimilation experience.
(4) COAMPS will be configured for the Indian Ocean on the same grid as ROMS (Figure 1). This grid is quite a bit smaller than the original COAMPS Indian Ocean grid which also included the Indonesian Archipelago and part of the South China Sea. However, including both of these regions in ROMS would present a significant challenge at the resolutions proposed here, so the smaller domain of Figure 1 was chosen as a compromise.
(5) Development of the coupling interface between COAMPS and ROMS will proceed for the atmosphere and ocean only (no wave model, sea-ice model, etc), and two test cases have been identified: (i) a simple periodic channel; (ii) a low resolution California Current configuration.
(6) We are proceeding with the necessary legal agreements with NRL so that Rutgers University and UC Santa Cruz can access the latest COAMPS code. This is critical so that all parties can run test cases.

RESULTS

The Indian Ocean ROMS was spun-up for 5 yrs using the surface flux climatology from the Southampton Ocean Centre and constrained at the open boundaries by SODA. Following the spin-up, the forcing was switched to NOGAPS. Figure 1 shows the model configuration along with the sea surface height and ocean currents at the depth of the main thermocline (~120 m) in March 2012, corresponding to the end of the DYNAMO field campaign in the Indian Ocean. The equatorial undercurrent is clearly visible. Figure 2 shows the horizontal temperature structure and circulation at a depth of 50 m within the surface mixed layer at the same time. Both figures show a number of interesting features, including the development of instabilities in the equatorial currents.

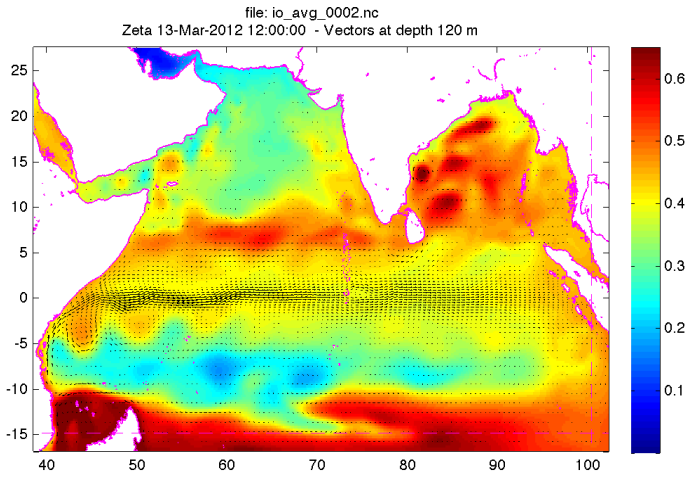

Figure 1: Sea surface height and the ocean currents in the thermocline from the ROMS Indian Ocean simulation.

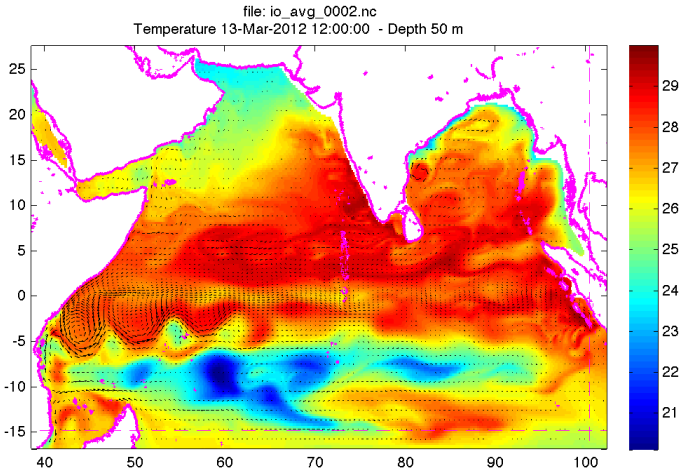

Figure 2: Temperature and ocean currents within the surface mixed layer (~50 m) in the ROMS Indian Ocean model.

IMPACT/APPLICATIONS

This project will contribute significantly to the functionality and utility of COAMPS and ROMS, both widely used and important community models and resources.

TRANSITIONS

The new ROMS utilities developed as part of this project will be freely available from the ROMS web site http://myroms.org and will be actively used and further developed by other research groups in the U.S. and elsewhere as user competence increases. Improvements to the COAMPS systems will be transitioned through the Navy's 6.4 Small-Scale Modeling program.

RELATED PROJECTS

COAMPS and COAMPS-TC will be used in related 6.1 projects within PE 0601153N that include studies of tropical cyclone dynamics, air-ocean coupling, and boundary layer studies, and in related 6.2 projects within PE 0602435N that focus on the development of the atmospheric components (QC, analysis, initialization, and forecast model) of COAMPS and COAMPS-TC.

None.

REFERENCES

None.