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COUPLED ATMOSPHERE-OCEAN OBSERVATIONS AND MODELLING FOR LUNENBURG BAY, NOVA SCOTIA

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1. INTRODUCTION

*This presentation contains some early results for the physical conditions simulated by the coupled atmosphere-ocean modelling system that is being developed for Lunenburg Bay (LB) on the south coast of Nova Scotia, Canada. The Meteorological Service of Canada is providing the atmospheric modelling, eventually consisting of an operational regional model configuration and an embedded hi-resolution research model, as well as the coupler through which the various component models will interact. The LB ocean model is a high-resolution eddy resolving coastal model using the free-surface version of CANDIE (Sheng et al., 2001), with lateral boundary conditions provided by a larger scale Scotian shelf model. The modelling system performance is being evaluated by comparing with measured atmospheric, ocean surface elevation, and ocean current observations from the LB observing system for several periods.

Section 2 gives background information on the interdisciplinary project under which this study is being conducted. Section 3 presents the experimental configuration, using the ocean circulation model described in section 4, and producing some early modelling results summarized in section 5.

2. THE LUNENBURG BAY PROJECT

In a major project entitled "Inter-disciplinary Marine Environmental Prediction in the Atlantic Coastal Region", a team of collaborators is developing a real-time prediction capability for the coastal regions of Atlantic Canada. This research and development is making heavy use of the newly established atmosphere-ocean observing system in LB. The observations will be used to guide and test the marine coastal prediction system in an examination of many marine environmental phenomena such as waves, surface winds, sea breezes, fog, coastal upwelling, and currents in coastal embayments, that are important on daily to weekly time scales. The outcomes will be particularly relevant for the problem of coastal pollution, and the resulting technology will be transferable to other similar coastal areas. This project will lead to significantly improved knowledge and understanding of: (i) how the coupled ocean / atmosphere system works in the Atlantic sector; (ii) how ecological processes can be incorporated into realistic physical models; (iii) the predictive skill of interdisciplinary coupled atmosphere / shelf / bay models on time scales of days to weeks; and (iv) the consequences of episodic phenomena including extreme weather events. It will result in coupled atmosphere / ocean / wave models and techniques that will be suitable for adaptation by government agencies and it will produce improved numerical models for describing and forecasting coastal ocean physical and biological conditions.

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3. EXPERIMENTAL CONFIGURATION

LB is a shallow coastal embayment situated on the south shore of Nova Scotia. It is about 8 km long, 5 km wide and at most 25 m deep. LB is connected to Upper South Cove (USC) and Lower South Cove (LSC) via a narrow channel known as Corkum's channel. Circulation in LB and the two coves is dominated by the semi-diurnal tide (Thompson et al., 1998), with spring and neap tidal ranges of about 2 m and 1 m, respectively. Due to the hydraulic control of the narrow mouth between the two coves, the tidal circulation in USC differs significantly from that in LB and LSC.

Here we use a high-resolution coastal circulation model to study the three-dimensional barotropic circulation in LB, USC and LSC. The model is driven by tidal forcing and shelf waves specified at the model open boundaries and wind stress applied at the sea surface. The tidal forcing at the model open boundaries is inferred from the tidal sea level prediction at Lunenburg Harbour produced by the Canadian Hydrographic Service using pre-calculated tidal harmonic constants. The local wind forcing is provided by the Meteorological Service of Canada. The remotely generated sub-inertial shelf waves that propagate into the model domain through the model open boundaries are calculated by a coarse-resolution storm surge model for the eastern Canadian seaboard (Bobanovic and Thompson, 2001).

4. OCEAN CIRCULATION MODEL

The ocean circulation model used in this study is the three-dimensional primitive equation z-level ocean circulation model known as CANDIE (see Sheng et al., 2001). This model has been successfully applied to various modelling problems. In this study we use a recently developed nonlinear free-surface version of CANDIE) which includes the nonlinear terms in the continuity equation and in the kinematic boundary condition at the sea surface. We run the ocean circulation model in barotropic mode, with the model temperature and salinity (and therefore the model density) set to be invariant in time and space. The model horizontal resolution is 60 m and the vertical resolution is 2 m, except 3 m at the top z-level. At the model lateral closed boundaries a no-slip condition is applied to the horizontal currents, and a radiation condition is applied along the model open boundaries.

5. SUMMARY OF RESULTS

Previous studies in the region demonstrate that the semi-diurnal tide is the principal tidal constituent in LB, accounting for about 80% of the total observed variance of the bottom pressure and 60% of the total observed variance of the currents on the region (Thompson et al., 1998; Sheng and Wang, 2003). The high-resolution coastal circulation model has been used to investigate the nonlinear tidal dynamics in the study region. The model results demonstrate that tidal circulation in LB and the two coves is highly nonlinear with strong tidal asymmetry between flooding and ebbing, with an intense narrow jet flowing outward from USC to LB during the ebb. The coastal circulation model has also been used to simulate the barotropic circulation in LB during the passage of the remnants of Hurricane Gustav in the second week of September, 2002. The model results demonstrate strong interactions between the local wind stress, tidal forcing, and remotely generated shelf waves during this period. More detail and latest results will be presented at the conference.

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