6.10 OCEAN HEAT CONTENT AS A LOWER BOUNDARY CONDITION FOR NUMERICAL WEATHER PREDICTION MODELS

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1. INTRODUCTION

Numerical weather prediction models often use fixed sea surface temperatures (SSTs) as a lower boundary condition, as they are readily available and easy to implement. Nevertheless, it is likely that a measure of the heat content of the upper layers of the ocean is a more physically relevant variable for atmospheric systems, particularly tropical cyclones, which rely on the ocean as a source of heat and moisture. For tropical cyclones, ocean heat content may be termed the hurricane heat potential (Leipper and Volgenau 1972). The general topic of air-sea interaction in tropical cyclones was recently reviewed by Walsh (2002).

Hurricane heat potential has been defined as the integrated temperature in excess of 26ºC in the region of the upper ocean warmer than 26ºC. The value of 26ºC is chosen because many studies have shown than in the current climate tropical cyclones do not form at SSTs less than this value (Palmén 1948). Shay et al. (2000) demonstrated that Hurricane Opal (1995) intensified strongly when passing over a region of high ocean heat content. This region took the form of a warm eddy in the Gulf of Mexico. In passing over this feature, Hurricane Opal deepened from 965 hPa to 916 hPa in fourteen hours. Thus very large impacts on tropical cyclone intensity can be caused by anomalies in ocean heat content.

This paper outlines a project to be undertaken to assess the impact of inclusion of ocean heat content as a lower boundary condition for a tropical cyclone prediction model. There is some confidence that this will improve the simulated prediction of intensity changes, as Mainelli et al. (2002) showed that substitution of ocean heat content for SST improved the performance of the statistically-based SHIPS tropical cyclone intensity forecast model of DeMaria and Kaplan (1999).

2. METHODS

The Australian Bureau of Meteorology currently employs a dynamical tropical cyclone prediction system known as TC-LAPS (Davidson and Weber 2000). This system is based upon the LAPS limited area model of Puri et al. (1998) and is a nested modelling system with an outer domain of horizontal resolution 0.75º x 0.75º and an inner domain of 0.15º x 0.15º (approximately 15 km), with 19 levels in the vertical. A sophisticated suite of physical parameterizations is incorporated in the model.

The TC-LAPS system includes data assimilation. Tropical cyclones are initialized in the model by the specification of an artificial cyclone vortex whose characteristics are derived from satellite observations of observed cyclone structure (known as “bogussing”). The bogussing method to be used here is that of Davidson and Weber (2000); this scheme is able to account for the asymmetrical structure in the initial vortex. The current performance of the system is very competitive for track predictions, although somewhat inconsistent for predictions of intensity changes (N. Davidson, 2002, personal communication).

Ocean heat content values will be estimated using the method of Goni et al. (1996), as implemented by Shay et al. (2000). Experimental hurricane heat potential maps are now available for many of the tropical cyclone formation basins (see, for example, http://www7320.nrlssc.navy.mil/hhc/). Subject to availability, these data will be interpolated to the resolution of TC-LAPS and a number of historical tropical cyclone cases in the Australian region will be selected for testing. Results of preliminary tests will be presented at the conference.

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