Numerical investigation of ocean mixed layer in response to moving cyclone : Sensitivity to model resolution

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Introduction

Present work deals with the sensitivity studies of the upper mixed layer response to an idealized Indian Ocean cyclone using different horizontal resolution of the simple ocean model. In the earlier studies the surface circulation and mixed layer depth (MLD) variation in response to moving cyclones in the Indian Ocean has been studied [1,3,5]. The model used in this study is a simple 1½ layer reduced gravity ocean model over the tropical Indian Ocean (35°E-115°E, 30°S-25°N) with one active layer overlying a deep motionless inactive layer[5]. The initial thermocline is assumed to be 50 m deep and the gravity wave speed is 1m/s. The initial temperature in the mixed and bottom layer are considered as 29°C and 23°C.

Numerical experiments and discussion of results

The horizontal model resolution of the model which is used for control experiment is ½ ° x ½ °. The model cyclone assumes a symmetric rankine vortex having radius 400 km and maximum winds 20 m/s. This vortex is allowed to move along northward track in the Bay of Bengal in four days. The track is from the initial position of (90E,6N) to (90E,14N) . The sensitivity of ocean response to model resolution is examined by increasing the resolution to 1/8 ° x 1/8 ° and 1/12° x 1/12 °. The model temperature change is unrealistically high (about 10°C on 4th day) in the case of high resolution. In order to get the realistic model temperature change the temperature gradient is reduced in further sensitivity experiments. The numerical experiments performed are tabulated below.

Expt. No	Parameters changed for Sensitivity study	Horizontal Resolution	Temperature gradients along mixed layer
1	Horizontal resolution (control experiment)	½ ° x ½ °	6 °C / 50m
2	Horizontal resolution	1/8° x 1/8°	6° C / 50m
3	Horizontal resolution	1/12°x1/12°	6° C / 50m
4	Temperature gradient along mixed layer	1/12°x1/12°	5 °C / 50m
5	Temperature gradient along mixed layer	1/12°x1/12°	4 °C / 50m

Figure 1 (a – f) shows the results for the experiment no. 1 to 3 serially, with the mixed layer depth anomaly in the left panel and the temperature change in the right panel. Solid line drawn is the storm track and the dot represents the position of the storm center. It is seen that the maximum cooling of about 3°C occurs right of the track for day 3, which suggests that the mixed layer on the right of the track is cooled more than the left and there is right bias in the temperature field (Fig 1a). Similarly mixed layer depth anomaly and current field also has right bias (Fig 1b). This is in agreement with the earlier model studies[1,2,4]. The model fields became stronger as the resolution is increased (Exp. 2 & 3). The cooling is increased up to 6°C, in a small region for higher resolution (Fig. 1f). The areal extent of the affected region is reduced for the higher resolution. There is marginal difference in the model fields for the resolution of 1/8 °and 1/12 ° (Fig.1c,d,e & f).

The experiments 4 (Fig 1g &h) and 5 (Fig.1 i & j) resulted into reduction by about 2°C in the overestimated values of temperature change Therefore while using high resolution model, parameterisation

of temperature needs to be changed and initial temperature difference across mixed layer should be less, for getting realistic temperature change.

References:

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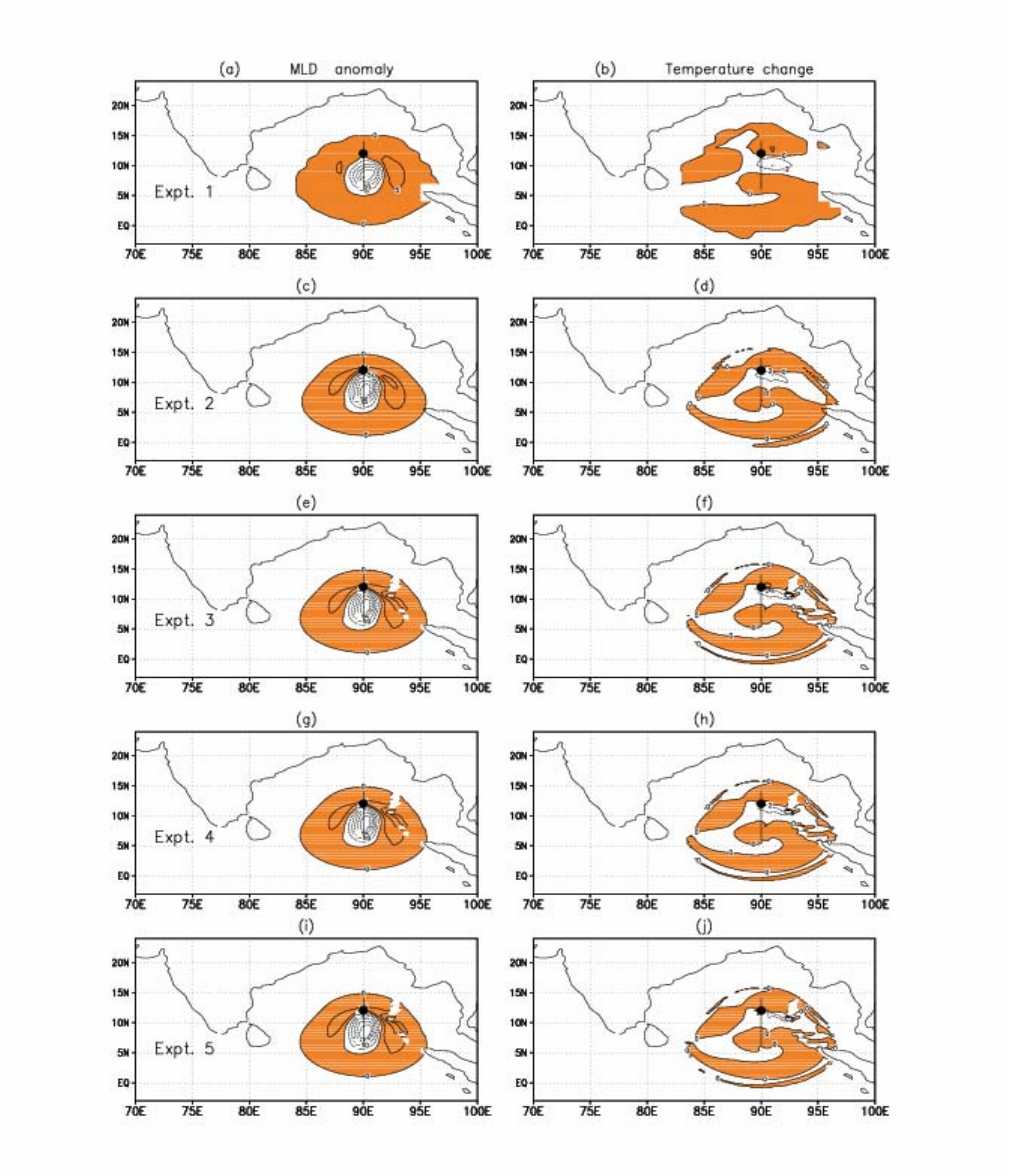

Fig. 1 Mixed layer depth anomalies and temperature change on the third day, for experiments 1-5