Ocean mixed layer response to a Bay of Bengal cyclone : A Case Study

A.A.Deo, D.W.Ganer and P.S.Salvekar
Indian Institute of Tropical Meteorology, Pune 411 008
E-mail : aad@tropmet.ernet.in

Introduction

Tropical cyclones are one of the most dangerous natural disasters that affect many countries around globe, cause tremendous loss of lives and property and severe disruption of socio-economic development. Indian subcontinent is worst affected by tropical cyclones in virtue of it's geographical positioning in the central part of the Indian Ocean and a long coastline spanning over 7500 km. A good knowledge of the ocean response to storm forcings is one of the key factors in tropical cyclone prediction. Various observational and numerical studies have shown that tropical cyclone produces significant changes in the underlying ocean thermodynamic structures which also involves SST changes. In the earlier studies the surface circulation and mixed layer depth variation in response to moving cyclones in the Indian Ocean has been studied considering idealized vortex and tracks by using 1½ layer reduced gravity ocean model.[1,2,3,4,9] . In the present study the case of 1994 cyclone is considered.

Numerical experiments and discussion of results

Experiment 1: The 1½ layer reduced gravity ocean model[9] used for this study, gives depth averaged currents, temperature and mixed layer depth. The cyclone TC02B (26 April to 3 May) of 1994 is chosen for this case study. The idealized symmetric cyclonic vortex of radius 400 km and maximum winds 20 m/s is allowed to move along the actual path of the cyclone (the track is shown in figure). The model is integrated for 7 days from an initial state of rest. The variations in the mixed layer depth and temperature are studied.

The model temperatures show cooling (warming) in the upwelling (downwelling) region. Figure 1(***a, b***) shows temperature change of mixed layer from the initial temperature of 29°C and mixed layer depth from the initial value of 50 m. The results indicate that the maximum cooling of about 4°C occurs little right of the track for day 5, 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. The isotherms exhibit an oscillation with wavelength of ~600 km. The mixed layer depth field also has the right bias, the maximum upwelling is on the right of the storm track. The inertial wave in the wake of the cyclone has a wavelength of about 400 km. The surface circulation is also obtained which shows the divergence of the flow near the storm center. Also, the maximum magnitude of currents is located right of the storm track (figure not shown). These results are in agreement with the earlier studies. [2,5,6,7]

The model simulated temperature change is compared with the OI SST change. It is found that the model produced cooling or warming is slightly overestimated than the observed SST change (figure1 ***c,d***).

Experiment 2: In order to improve the results, another experiment is carried out. In this experiment the model response for the actual cyclonic wind data is investigated. The model is run for 10 years to reach the steady state using daily climatology of SSM/I winds obtained for the 3 years 1994 to 1996. The daily SSM/I surface winds data for the year 1994 is validated for the cyclonic vortex in the period of cyclonic storm. The cyclonic circulation is clearly visible of about 400 km radius for all the cyclone cases. The wind speed however, is less as compared to the real storms. In order to give real cyclone winds to the model as input, the idealized cyclonic vortex (bogus vortex) is superimposed on the real data[8]. The bogus cyclone winds are analytically generated by taking into account the real cyclone parameters such as size and intensity. This is considered as cyclonic wind input. The model is integrated beyond steady state using inter-annual forcing for 1994. Using the initial conditions of 25 April the model is integrated further for 7 days with superimposed cyclonic vortex.

The figure 1 ***e*** and ***f*** shows the model temperature field obtained by taking the differences of with & without cyclone case, for 5th day and for the experiment 1 discussed above. Comparing the model temperatures in both the experiments, it is seen that the magnitudes are reduced by about 1°C for the experiment 2, when compared with the experiment 1. Therefore, the model temperature change in the superimposed case is close to the observed temperature change during the passage of the cyclone. Other features such as right bias, lag between maximum cooling and storm position etc., do not change significantly.

References:

Behera S.K, Deo A.A, and Salvekar P.S., 1998: Investigation of mixed layer response to Bay of Bengal cyclone using a simple ocean model. Meteorol. Atmos. Phys.,65, 77-91.

Chang S.W. & Anthes R.A., 1978: Numerical simulation of the ocean's nonlinear baroclinic response to translating hurricanes. J. Phys. Oceano., 13, 468-480

Deo A.A, Salvekar P.S and Behera S.K,2001a: Oceanic response to cyclone moving in different directions over Indian Seas using IRG model. Mausam, 52, 163-174.

Deo A.A,Ganer, D.W.,& Salvekar P.S,2001b: Upper ocean response to a moving cyclone in south Indian Ocean. WGNE Report on Research Activities in Atmospheric and Ocean Modelling,, pp 8.3-8.4

Graetbatch R. J., 1983,:On the response of the ocean to a moving storm: The nonlinear dynamics. J. Phys.Oceano., 13, 357-367

Price J.F., 1981: Upper ocean response to a hurricane. J. Phys. Oceano., 11,153-175.

Price J.F., 1983: Internal wave wake of a moving storm: Part 1, Scales energy budget and observations, J. Phys.Oceano., 13(6), 949-965.

Thu T.V.& Krishnamurti, T.N., 1992: Vortex initialization for typhoon track prediction. Meteor. Atmos. Phys., 47, 117-126.

A.A.Deo, D.W.Ganer and P.S.Salvekar, 2002:Ocean mixed layer response to the tropical cyclone moving in different directions in the south Indian Ocean WGNE Report on Research Activities in Atmospheric and Ocean Modelling,, pp 8.1-8.2

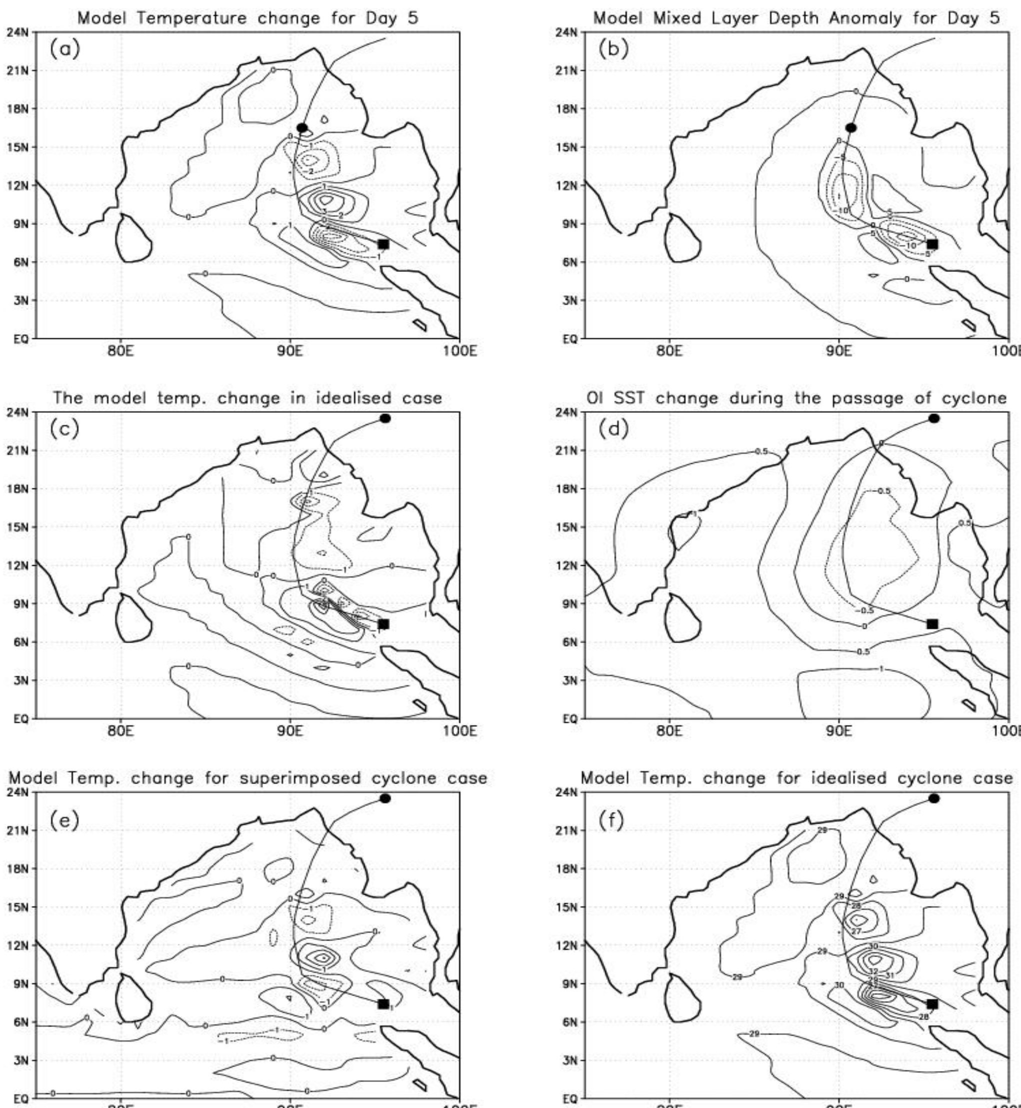

Fig1 : Model mixed layer depth anomaly and temperature change compared with observed SST change and temp. change in superimposed cyclone case. Solid line indicates the storm track.