ABSTRACT

The circulation of the Bay of Bengal is studied using the GFDL ocean general circulation model (OGCM) The model, configured for the geometry of the Indian Ocean, is forced at the surface by climatological winds, temperature, and salinity The seasonal cycle of circulation is simulated, and the performance of the model is evaluated by comparing the model results with ship-drifts and hydrographic observations Further, the mechanisms forcing the seasonal cycle are investigated through several numerical experiments, and the role of ocean dynamics in the heat balance of the Bay of Bengal is examined

Prominent features of the seasonal cycle of circulation in the Bay of Bengal are the following There is a well organised anticyclonic gyre during February-May and a cyclonic gyre during October-November The annual cycle along the western boundary of the Bay has been particularly well studied recently using hydrographic observations (Shetye et al, 1991, 1993, 1995) It consists of a poleward current during February-May and an equatorward current during October-December During June-September there is a weak poleward coastal current in the south, an equatorward current in the north, and an equatorward undercurrent The model simulates all these features correctly However, unrealistically large Ekman velocities dominate the circulation in the first three model layers (i.e., from surface to 30m) during the monsoons

In order to identify the mechanisms that determine the circulation, a number of numerical experiments have been carried out by switching off the wind in selected regions and by forcing the model with idealised winds In one such experiment, spatially uniform wind stress was applied only over the Bay The coastal circulation in this case is similar to, but weaker than, that driven by climatological winds over the entire Indian Ocean and can be linked to coastal Kelvin wave pulses which originate along the eastern boundary of the Bay When the Bay is forced with observed winds, the presence of wind stress curl strengthens the poleward western boundary current during February-May and the equatorward western boundary current during October-December The principal contribution of winds in the equatorial Indian Ocean is to generate during the southwest
monsoon an equatorward current along the east coast of India. This current subducts under a shallow poleward current driven by local winds and flows as an undercurrent along the entire coast during this season. The contribution of different mechanisms to the volume transport in the coastal region has been also determined from these experiments.

Previous studies (McCreary et al., 1993, Potemra et al., 1991, Yu et al., 1991) using reduced gravity models emphasise the presence of coastal Kelvin waves propagating along the rim of the Bay and Rossby waves propagating across the Bay. The present OGCM results suggest that these waves also propagate vertically downward. Further, a picture of the three-dimensional circulation of the upper Bay has been obtained. The meridional branch of the circulation is dominated by Ekman transport into the Bay during the northeast monsoon and out of the Bay during the southwest monsoon. The return flow is shallow during most of the year, with much of it lying between 50 and 100m. The southwest monsoon meridional circulation dominates in the annual mean.

The model configuration chosen for the present study was meant to delineate the annual cycle of the upper layer circulation. Nevertheless, the results raise certain questions regarding the heat balance of the Bay that need further study. Associated with the meridional circulation mentioned above, there is a net export of heat out of the Bay during the year. Consistent with this, the net surface heat flux in the model is into the Bay. However, the surface heat flux in the model is much smaller than that suggested by climatologies. Further, a portion of the surface heat gain is not exported out of the Bay by the ocean circulation, but feeds a spurious warming of the subsurface layers. Model results suggest that the annual cycle of sea surface temperature in the Bay is controlled primarily by the surface heat flux, with advection being significant only during the summer monsoon.

A few important questions that need to be addressed in future observational and theoretical studies have emerged from this work. This study and the past work suggest that the coastal Kelvin waves and Rossby waves play an important role in the annual cycle of the circulation in the Bay of Bengal. The presence of these waves, however, has not been established by observations. Future observational studies in the Bay should attempt to resolve this and the differences between model transports and geostrophic
transports calculated from hydrographic data. Another intriguing and important question is the role of freshwater influx in the Bay of Bengal circulation. Models which can handle river discharge and freshwater flux at the surface will be necessary to address this issue. But a more immediate requirement is to modify the model to simulate the Ekman component of the flow more accurately.