

Upwelling features near Sri Lanka in the Bay of Bengal

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The Bay of Bengal is a semi-enclosed tropical ocean basin that is highly influenced by monsoons and receives large volume of freshwater from both river discharge and rainfall. Over the Bay of Bengal two distinct wind systems prevail during the year, the southwest monsoon in summer and the northeast monsoon in winter. The wind stress associated with these winds cause mass drift of oceanic waters leading to upwelling and downwelling. In this paper, we have studied the upwelling features in the Bay of Bengal with a special mention about the Sri Lanka region, where strong upwelling features observed during the summer monsoon.

Introduction

The Bay of Bengal is a region of large fresh water input, high sea-surface temperature, and variable monsoon forcing (Hacker *et al.*, 1998). The upper layer circulation of the Bay of Bengal is subject to strong seasonal variability. The oceanic region around Sri Lanka is a highly energetic physical environment during the summer monsoon. Increased Chlorophyll-a in the waters near Sri Lanka during summer monsoon is observed around Sri Lanka (Vinayachandran *et al.*, 2004). The southwest monsoon drives advection of upwelled water eastward along its path near Sri Lanka. The circulation along the coast of Sri Lanka is crucial for the interaction among the Arabian Sea and Bay of Bengal and the equatorial Indian Ocean. The monsoon current south of Sri Lanka is westward during the winter and eastward during the summer. The circulation is particularly complex during the southwest monsoon due to interaction of the eastward southwest monsoon current with a Rossby wave radiated from the eastern boundary (Schott *et al.*, 1994). The coupling of the oceanic circulation in the Bay of Bengal to the monsoon forcing is different from that in the Arabian Sea, where the development of the Somali current closely follows the cycle of the wind forcing, with a time lag of only a few weeks (Schott *et al.*, 1990).

Data and Methodology

The data used in this study is NCEP reanalysis wind climatology ($2.5^\circ \times 2.5^\circ$). Offshore upwelling is computed following the method by Mohan and Ali (1995). Mean monthly wind data is used to compute the offshore upwelling. Wind stress is computed using a bulk aerodynamic formula (Apel, 1987).

$$\vec{\tau} = \rho_a C_D |\vec{v}|^2 \vec{v}, \text{ Where, } \rho_a = 0.00129 \text{ g cm}^{-3} \text{ (density of air)}$$
$$C_D = 1.3 \times 10^{-3} \text{ (non dimensional drag coefficient)}$$

Results and discussion

Wind pattern over the Bay of Bengal is presented in Fig. 1. The north western part of the Bay of Bengal experiences a sort of anti-cyclonic gyre with weak winds and the wind speed gradually increasing southward. This anti-

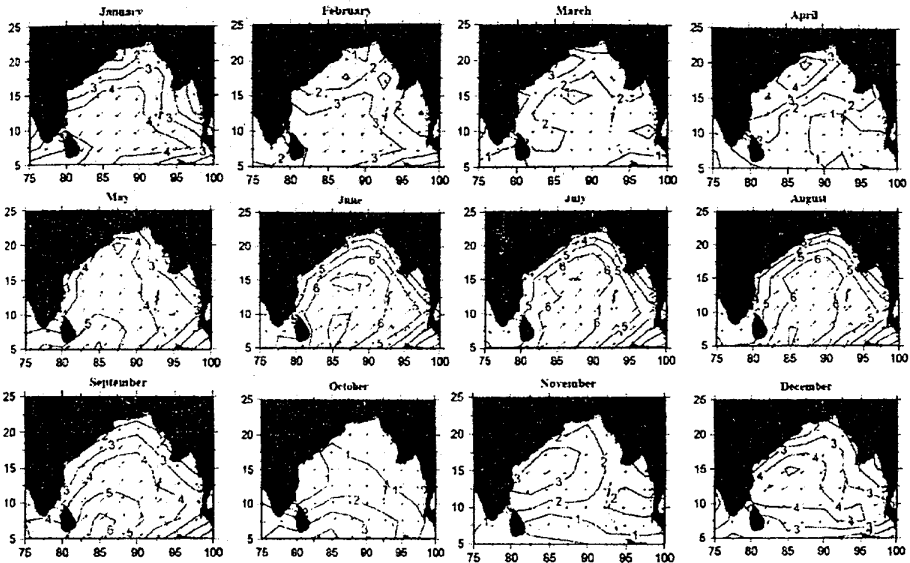


Fig. 1: Sea surface wind speed (ms^{-1}) and direction (vectors) X - Longitude, Y - Latitude

cyclonic gyre has shifted its position to the centre of the Bay by March. Direction of the wind is highly unstable during April due to the transition between northeast and southwest monsoon systems. A sudden reversal of the wind direction is observed by May. High winds are observed off Sri Lanka (about 7 m/s). By June, the onset of the southwest monsoon shows its presence over the Bay which leads to high wind speeds. A similar pattern continued till September.

Mean monthly distribution of open ocean upwelling is shown in Fig.2. During January and February, upwelling is observed in the southern parts of Bay of Bengal. March and April months observe transition period and during this period weak signatures of upwelling are found in the southern part of the Bay of Bengal. Upwelling spreads to the western part of Sri Lanka by April. By June, the southwest monsoon establishes completely over the north Indian Ocean and as a consequence, upwelling intensifies near Sri Lanka. An upwelling front is observed in the Bay of Bengal along 85°E longitude and intensity is increasing towards west in May. During this month, the southern part of the east coast of India experiences upwelling. Vinayachandran et al. (1998) have shown the thermal structure along 85°E , which shows a well developed dome located east of Sri Lanka during July. They have also shown that their model has captured the dome. By June, the upwelling front spread further east and extended northward. This feature continued till August. A close look into the figures gives an idea that a strong signal in the upwelling found in Sri Lanka is diminishing eastward. This strong signal is driven by the equatorial currents that are present during the monsoon months. With lower values, the feature continued in September too, but disappeared by October.

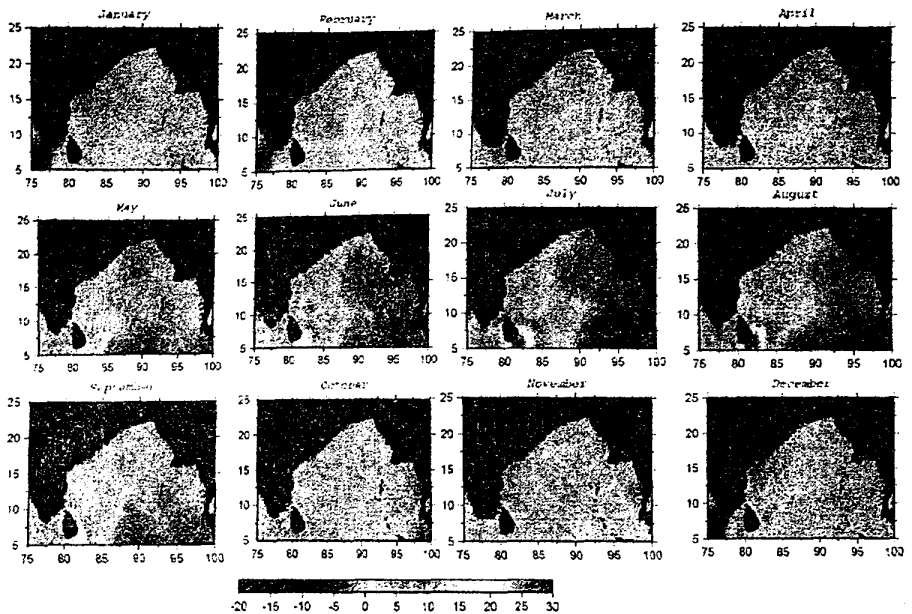


Fig.2: Offshore upwelling (cm/day) in the Bay of Bengal

The coastal winds do not favor upwelling along the western and eastern coasts of Sri Lanka (Vinayachandran *et al.*, 2004). The manifestation of upwelling intruding from Bay of Bengal to Arabian Sea through south of Sri Lanka is remotely forced by westward propagating Rossby waves and also by the coastally trapped low frequency waves. Eigenheer and Quadfasel (2000) argue that the long midlatitude Rossby waves forced by the wind stress curl in the interior of the oceans carry potential vorticity to the western boundary. Rossby wave associated with reflection of the spring Wyrтки jet is present south and east of Sri Lanka during the summer monsoon (Vinayachandran *et al.*, 1999).

Conclusions

The east and western regions of Sri Lanka experiences strong upwelling during the summer monsoon period, though the winds are not favorable. The role of remote forcing from the equatorial Wyrтки jet and the westward propagating Rossby waves is to be investigated in view of the strong upwelling near Sri Lanka region.

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