

## The Coastal Current of the Andaman Sea Revealed by Reprocessed Observations

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**Abstract: Problem statement:** The surface currents in the Andaman Sea are observed and quantified by many studies in opposite of the local coastal current that is unclear. Knowing the contributor to this local current improves the simulation work in the most accurate way. This study reviews reprocessed observations from satellites and creates an oceanic model by taking data of 1995 to generally explain the character of local coastal currents. **Approach:** The reprocessed data from satellite altimeter and Acoustic Doppler Currents Profilers (ADCP) ship are reviewed. The oceanic models based on the data of calm weather in 1995 are created to explain the character of coastal currents and associated intra-seasonal cycles in the no storm condition of other years. **Results:** Reprocessed satellite data and ADCP after comparing with models reveal the effects of the local wind along the coast and Rossby waves (triggered by Elman pumping or radiated by Equatorial Kelvin waves). That causes the intra-seasonal coastal current instead of regional monsoonal winds. **Conclusion/Recommendations:** The effects of regional monsoon winds are less than local winds and meso-scale eddies in the coastal current in the Andaman Sea. The simulation based on regional winds can not explain the coastal current in the no storm condition. Local winds and meso-scale eddies need to take into account in the model in order to capture these coastal currents.

**Key words:** Andaman sea, bay of Bengal, coastal current, satellite data analysis, reprocessed observations, oceanic model

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### INTRODUCTION

The Andaman Sea is a famous tourist attraction for the last 20 years that currents during high monsoons are the prohibition of access for sometime during a year. Well understanding these currents allows us to forecast the open windows and consequently ease the tourism. Even the Andaman Sea has long been studied and known that heavily seasonal forcing in agreement with the reversing monsoon winds but it has the unique circulation (Hacker *et al.*, 1998). Recent observational data from satellites give the images of these intra-seasonal cycles.

### MATERIALS AND METHODS

**Past observations:** In the early day, scientists observed the currents in the Andaman Sea by hydrographic ships.

The satellite-tracked drifter buoys reveal dramatically reversal winds and currents by main seasonal monsoons which are North-East wind in the winter (November-February) and the South-West wind in the raining season (July-October). The transition is between these two windows and vary geographically from year to year. Approaching the North-East monsoon end, the surface water of Andaman Sea seems to be warmer, more saline and reaches the peak in May, in contrast, the end of South-West monsoon is the time highly stratified and mix layers and cool and warm surface and perturbation are observed. The river run-off gives the greatest drop of salinity in November and December and flows toward to the Bay of Bengal (Potemra *et al.*, 1991).

**Reprocessed observations:** ADCP ships, hydrographic observations and the satellite altimeter are reprocessed

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and carefully reviewed in the domain. The currents of the Bay of Bengal are influenced by Regional winds and meso-scale eddies. Reprocessing the altimeter data gives higher resolution along shore and the understanding in coastal currents (Durand *et al.*, 2009).

As a result, local along shore winds and Ekman pumping are as important as seasonal winds dominating to coastal currents (Shenoi, 2010). The coastal current could also flow in opposite the direction of offshore currents (Durand *et al.*, 2009).

**Simulation:** The ocean model with the domain of the Bay of Bengal (78°E-102°E, 0°-26°N) (Fig. 1) has been created from; the 1 Arc-minute terrain data, ETOPO1 (Amante and Eakins, 2009), World Ocean Atlas 2005, WOA05 temperature/salinity (Levitus *et al.*, 1994), ECMWF wind (Viterbo and Betts, 1999). The dimension of this sigma-coordinate, free surface, primitive equation model is 96×104 grid points on horizon and 16 layers in the vertical direction. It is

bounded by 3 enclosures on the east, west and north and open on the south assuming as close boundary. The 3-D sector (Fig. 2) Has been created to spot an error and level age before defining the temperature and salinity for individual grid point at each layer (Wannawong *et al.*, 2010). The temperature, salinity and wind data of 1995 are selected because they represent the calm weather. Lastly the surface wind of January, May and October 1995 are inputted to drive the surface current. In May (Fig. 3), it is a transition period when South-West monsoons coming to replace the North-East monsoon. The winds do not laminar flow and there are many turbulents scattering within the domain. This cause a weak surface current during this transition period. In October (Fig. 4), the South-West wind is strongest during a year. This drive Northward flows in the domain whereas January (Fig. 5 and 6) has a laminar North-East wind throughout the domain driving the water southeastward.

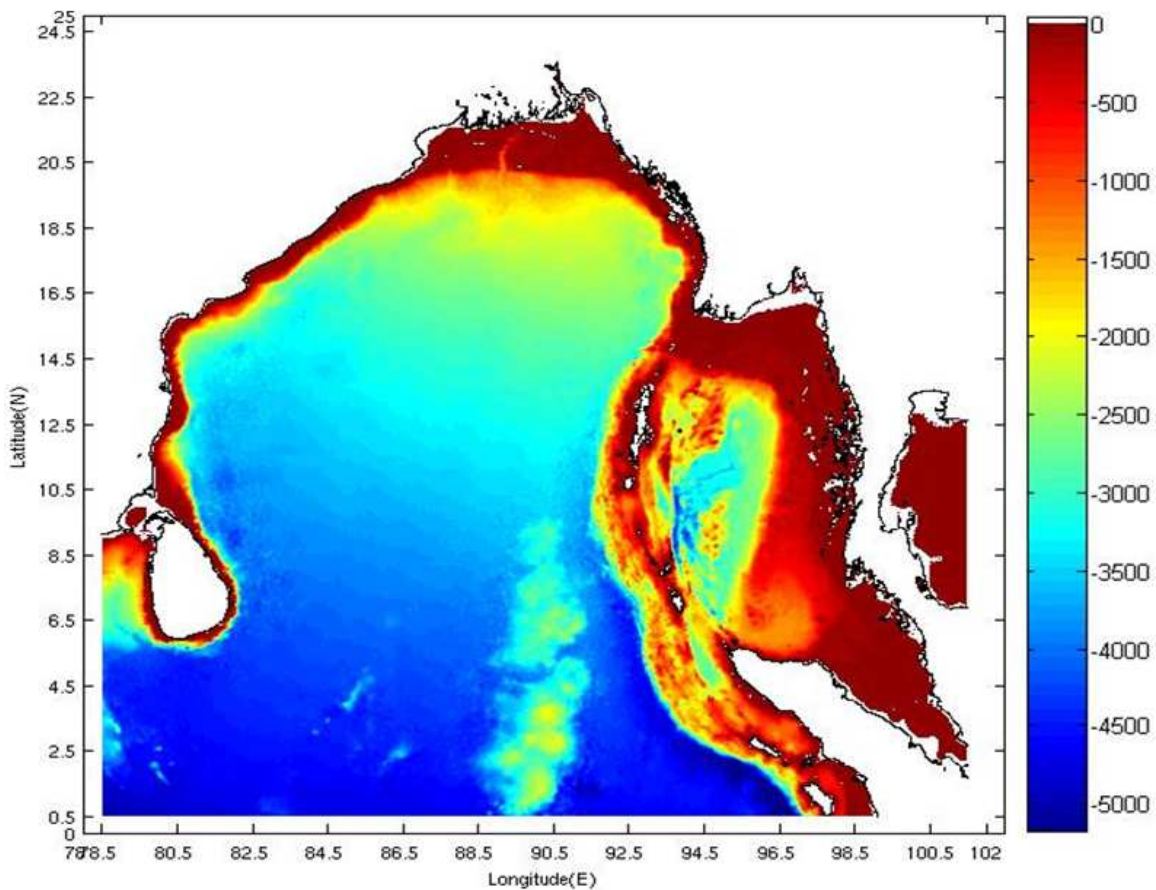


Fig. 1: The map of the the study area covers the Bay of Bengal

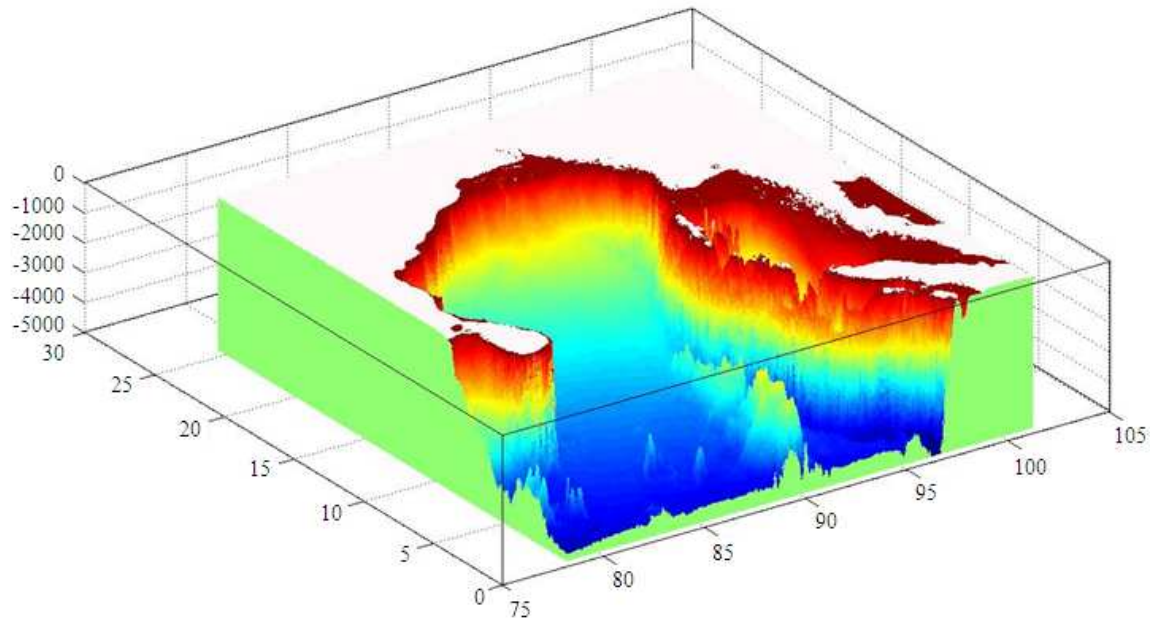


Fig. 2: Perspective view (3-D) of the domain

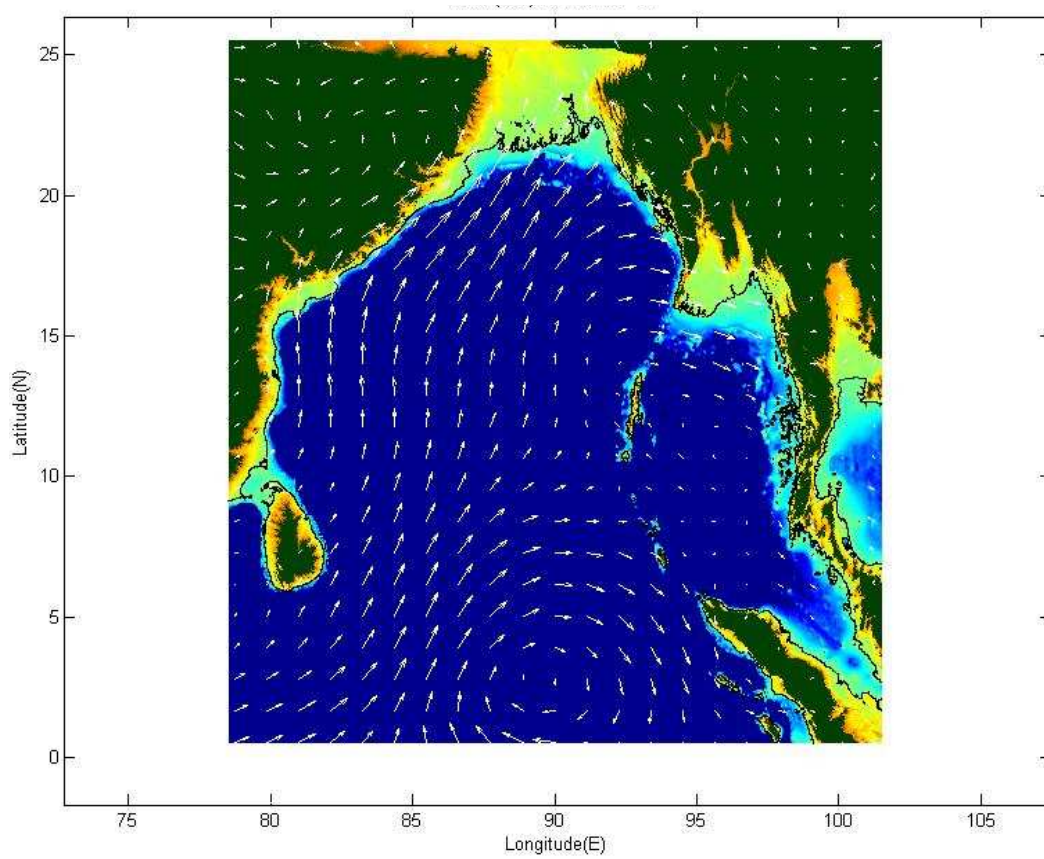


Fig. 3: Monsoon-transition regional winds in May 1995 (ECMWF)  
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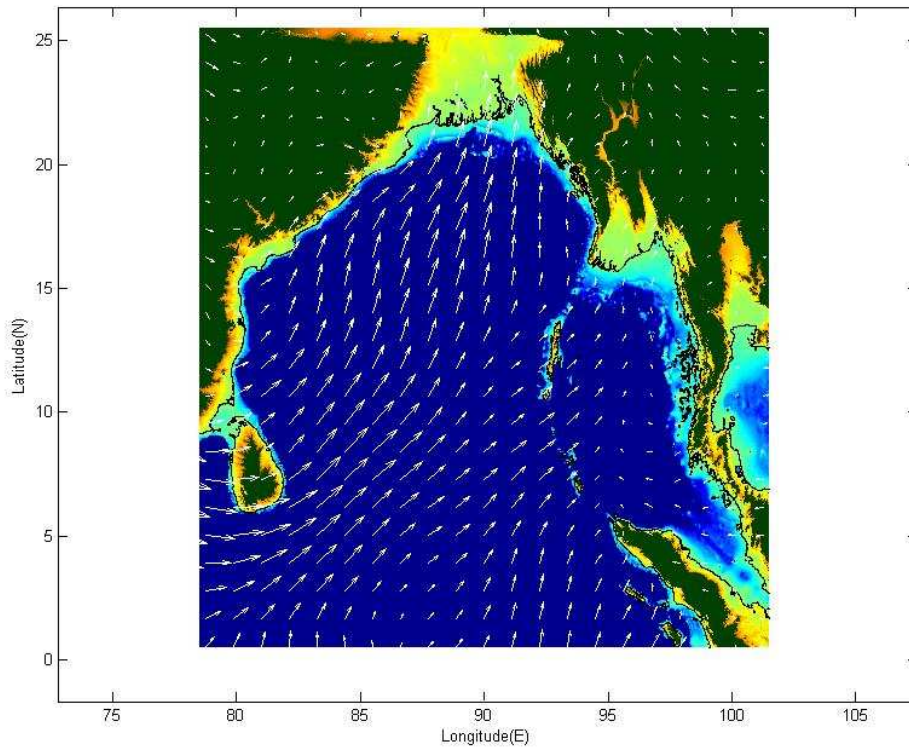


Fig. 4: South-West monsoon regional winds in October 1995 (ECMWF)

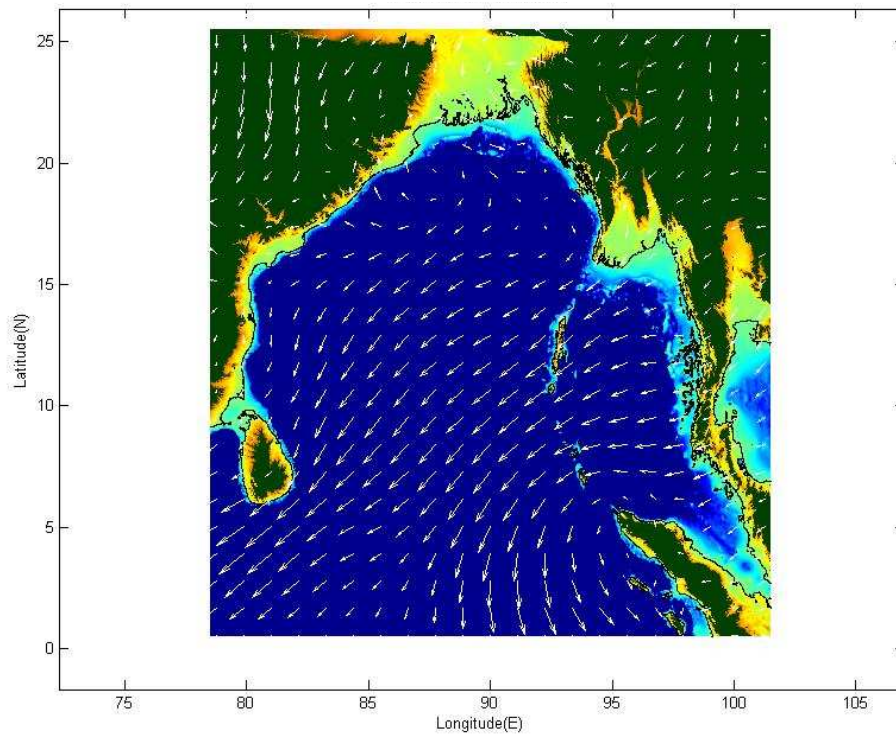


Fig. 5: North-East monsoon regional winds in January 1995 (ECMWF)

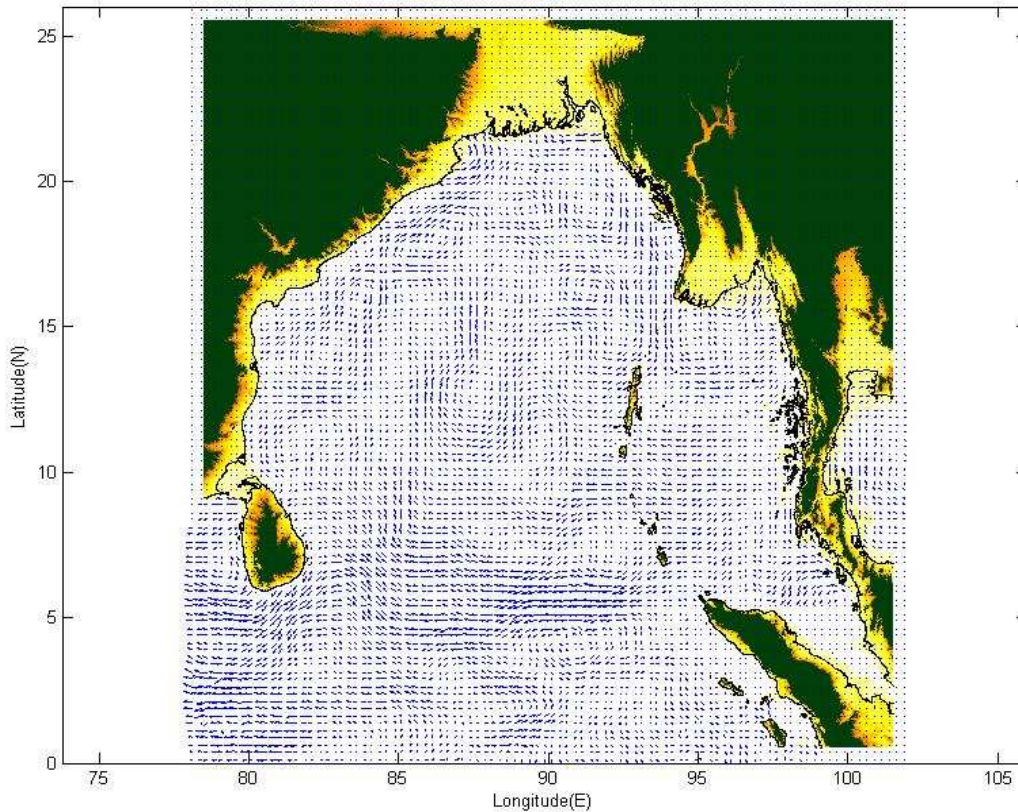


Fig. 6: The regional wind-driven currents by oceanic model in January 1995

### RESULTS

From reprocessed satellite data and ADCP, the transition period from winter to summer in March to May, Regional currents are strongest but the regional wind is weakest in the year; equatorial Kelvin waves move northward and propagate into domain at the North of Sumatra together with the divergence of Ekman transport. This cause Rossby wave contributes to the interior Bay of Bengal in driving the strong North-Eastward current of the seasonal subtropical gyre (Shenoi, 2010). This agrees with simulation results that strong North-Eastward current is observed at the North of Sumatra but going weaker approaching the coast. In the raining season (July – October), the reprocessed data and ADCP (Fig. 7) Suggest that is much weaker and turbulent, the local alongshore winds contribute many turbulent currents on the west of domain and they tend to move southward. These also draw the fresh water run-off from the river at the top of the Bay to the coast of India. The ocean model shows the same result. A few turbulents and unpattern flows occur in the Andaman Sea but very weak currents near shore are observed.

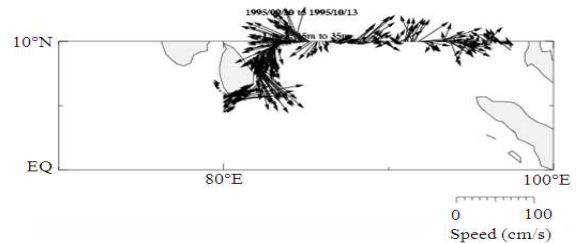


Fig. 7: ADCP ship data from R/V Knorr 30th Sep. - 13th Oct. 1995, 25-35 m. depth

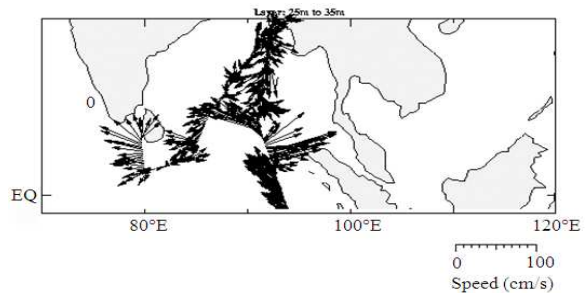


Fig. 8: ADCP ship data from R/V Knorr 24th Jan. -5th Mar. 1995, 25-35 m depth

In North-East monsoon from October to January, reprocessed data and ADCP (Fig. 8) Reveal Ekman currents and the local alongshore winds force the southward regional currents (Shenoi, 2010) while the simulation suggests the southwestward current but relatively weak.

### DISCUSSION

The review of reprocessed data and ADCP gives the agreed results with simulation at the mid Andaman sea where the water is deep. They have the same current pattern both monsoons and transition seasons. In the coastal area, currents can be seen by reprocessing data and ADCP but simulation shows a very weak currents or disappear on the coast in many months.

### CONCLUSION

The coastal currents in BOB are influenced by local coastal winds and Rossby waves triggered by Ekman currents or radiated by equatorial Kelvin waves. This is as important as seasonal winds. The shallow currents flow northeastward of equatorial Kelvin waves, Ekman pumping and Rossby waves from March to May. Local alongshore winds respond in many turbulent coastal currents with a tendency to move southward and draw in the fresh from the top of domain southward from June to September. Both Ekman current and coastal winds drive them southward in the raining season and winter. In conclusion, field measurements and local-scaled simulation that take local winds, Rossby and Kelvin waves and Ekman currents into account are the way forward in capturing these coastal currents in more detail rather than the large-scale regional wind-driven oceanic model.

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