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SEA LEVEL VARIATIONS OF BOTH THE SOUTH CHINA SEA AND THE MALACCA STRAITS DUE TO THE NORTHEAST AND THE SOUTHWEST MONSOON WINDS

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ABSTRACT

Monthly sea level variations in Peninsular Malaysia and Sabah are studied. Previous results are confirmed. However, due to the fact that this is the first study involving such a large number of stations, a clearer understanding of the dynamics of mean sea level variations at selected port of Peninsular Malaysia and Sabah is attained. It is shown that Johor Bahru may be identified as having an east coast pattern.

RESUMEN

El promedio mensual del nivel del mar en la peninsula malaya y Sabah es motivo de estudio. Una mejor interpretacion de la dinamica de la variacion del nivel medio del mar se obtiene al estudiarse records (prolongados) de analisis de mareas de varias estaciones portuarias. Lo novedoso de nuestro trabajo es que se demuestra que Johor Bahru responde al regimen de la costa este.

1. INTRODUCTION

The current pattern of the South China Sea (SCS) is influenced, primarily, by the wind system. Therefore, the mean sea level is principally affected by the monsoon wind system. Other factors, such as atmospheric pressure variations, sea surface temperature variations may also contribute to the sea level rise. Because of the fact that these other factors play a secondary role in the sea level rise, they will not be considered in the present study.

The North-east (NE) monsoon wind affect the SCS from November to February, whereas the South-west (SW) monsoon affect the SCS from May to September (Nasir and Camerlengo, 1996). During the transitional periods between both monsoon seasons, the wind system is light and variable (Nasir and Marghany, 1996).

Yanagi *et al.* (1996) has studied the variation of the mean sea level in Peninsular Malaysia due to both the effects of the NE and the SW monsoon winds at Kuantan, Johor Bahru and Port Klang. Their study represents the first attempt to comprehend seasonal and interannual variations of the throughflow (from the Pacific Ocean to the Indian Ocean) in the Malacca Straits.

Our aim is to better understand sea level variations all along Peninsular Malaysia and Sabah. No similar undertaking, other than Yanagi *et al.* (1996), has been done before. Because of the fact that a larger number of stations are analyzed in our study, in comparison to Yanagi *et al.* (1996), a clearer understanding of the dynamics involved in the sea level variation (in response to both the NE and the SW monsoon winds) emerges. For this purpose, monthly mean tidal records of 12 selected ports in Peninsular Malaysia and Sabah are analyzed.

2. DATA

Monthly (mean) sea level of Langkawi, Lumut, Port Klang, Tanjung Keling, Kukup, Johor Bahru, Tanjung Sedili, Kuantan, Chendering, Geting, Kota Kinabalu and Tawau are analyzed. The location of the stations as well as the years of monthly records are given in Figure 1. This data has been obtained from the "Tidal Observation Record", published by the Department of Survey and Mapping, Malaysia.

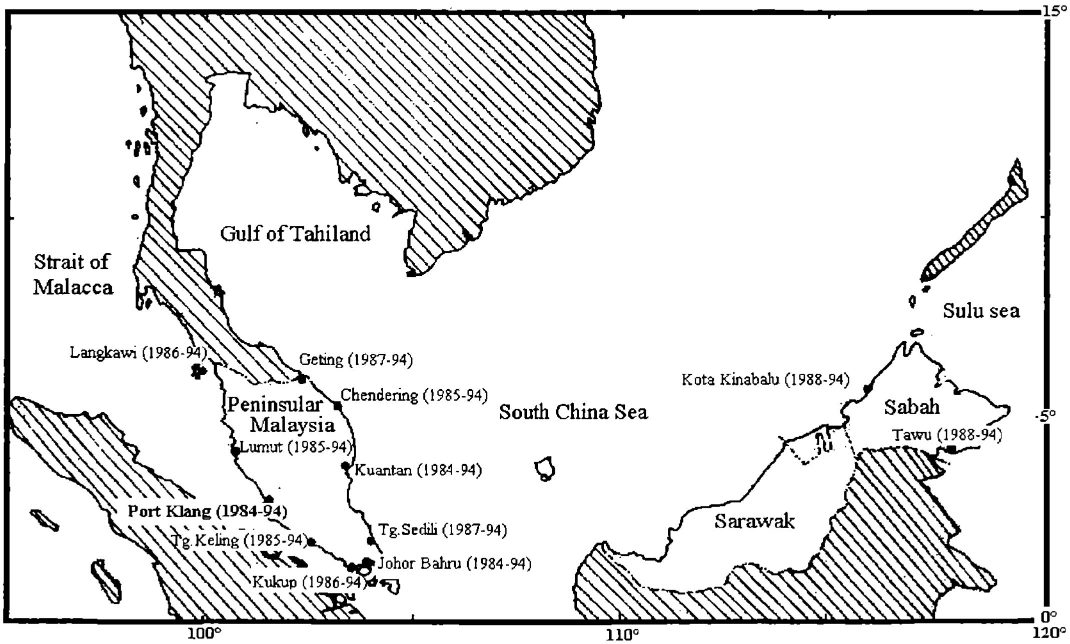

Figure 1. Location of stations being analyzed.
The years of tidal records are indicated in parenthesis.

3. RESULTS AND DISCUSSION

The average monthly mean sea level variation, for each station, is analyzed (Figs. 2, 3 and 4). The stations being analyzed as well as their respective years of records are illustrated in Figure 1. The selected ports at the west coast exhibit two maximums and a minimum (Fig. 2). The first maximum, occurring either in May or June (depending on the latitude of the particular station being considered), may be attributed to the onset of the SW monsoon. The width of the Straits of Malacca increases north of Kukup. As well as the bottom topography. Therefore, the piling up of water (POW) increases, at the west coast, in a northward direction from Kukup.

Because of the NE monsoon winds, stations at the west coast exhibit a lowering of the sea level, between January and March. Due to the fact of the disruption of the Titiwangsa mountain range, NE monsoon winds, at the west coast, are less stronger than SW monsoon winds. Therefore, the lowering of the sea level (LOSL) in winter is lesser than the POW, at the west coast, in summer. However, the magnitude of the LOSL is approximately similar all along the west coast during the winter season. The relative minimum observed in September all along the west coast may be attributed to the relaxation of the SW monsoon winds.

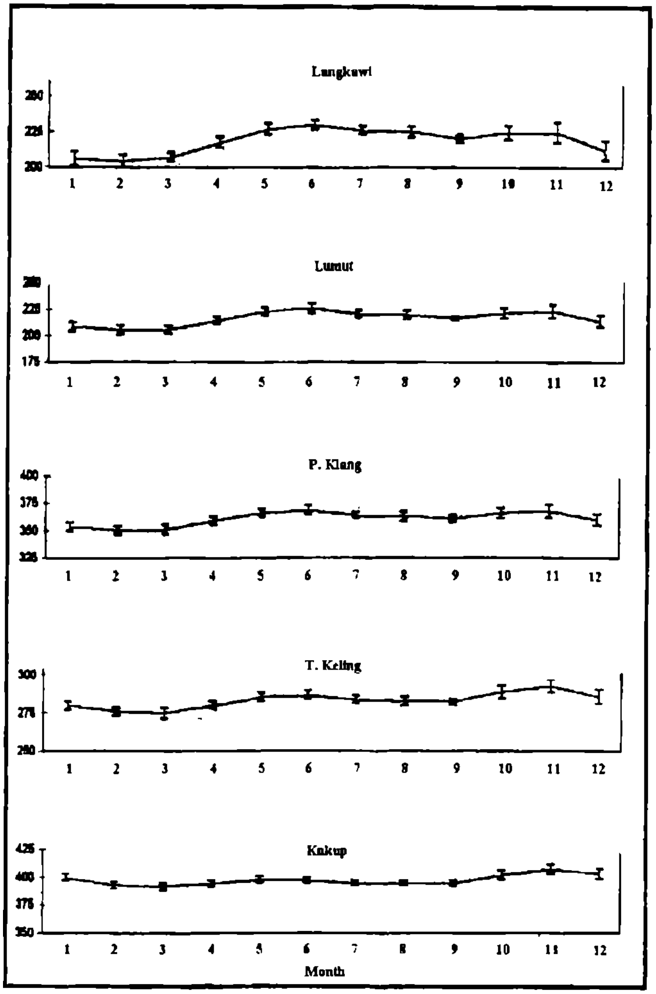

Figure 2. Monthly mean sea level variation (and its errors) at selected ports of the west coast of Peninsular Malaysia.

Stations at the east coast exhibit a minimum between June and August, and a maximum between November and December (Fig. 3). The maximum may be attributed to the POW due to the NE monsoon winds, while the minimum may be attributed to the LOSL due to the SW monsoon winds. Because of the fact that NE monsoon winds are stronger than SW monsoon winds, at the east coast, the POW in winter is greater (in magnitude) than the LOSL in summer.

A maximum occurring in October and November may be attributed to downwelling due to the SW monsoon winds. On the other hand, the minimum occurring in March may be explained by upwelling due to the NE monsoon winds (Fig. 4). On the other hand, the maximum detected in September in Tawau may be explained by the POW due to the SW monsoon winds. A decrease of the sea level occurs during the winter season. This may be attributed to the NE monsoon wind effects. Due to the fact that a larger volume of water is involved both in the downwelling and the upwelling processes in Kota Kinabalu, sea level differences are bound to be greater in Kota Kinabalu than in Tawau.

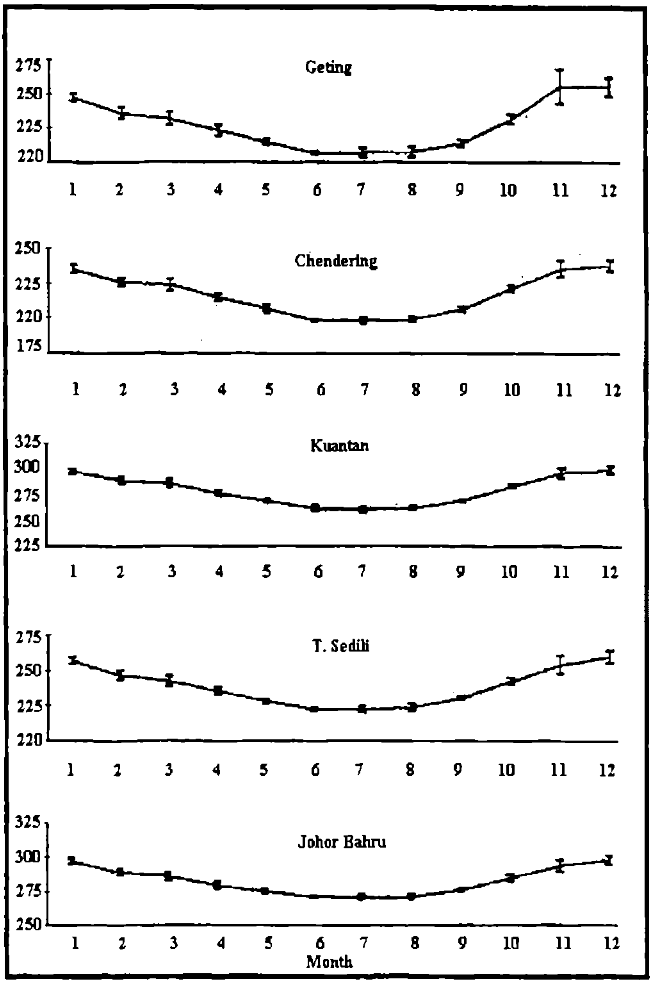

Figure 3. Monthly mean sea level variation (and its errors) at selected ports of the east coast of Peninsular Malaysia.

During the NE monsoon season, due to Ekman transport, some of the water mass is deviated into the Gulf of Thailand. By continuity, and due to coastal geometry, this water mass flows in a counterclockwise rotation (Fig. 5). During the SW monsoon season, the reverse is also true (Fig. 6). The POW, during the NE monsoon season, both in Geting and in Terengganu are greater than in all other stations of the east coast. This may be attributed to the fact that both stations are nearer to the outflow of water (of the Gulf of Thailand) that moves southwards along Peninsular Malaysia's east coast.

Because of the fact that SW monsoon winds are weaker than NE monsoon winds at the east coast, sea level differences between east coast stations are almost non-

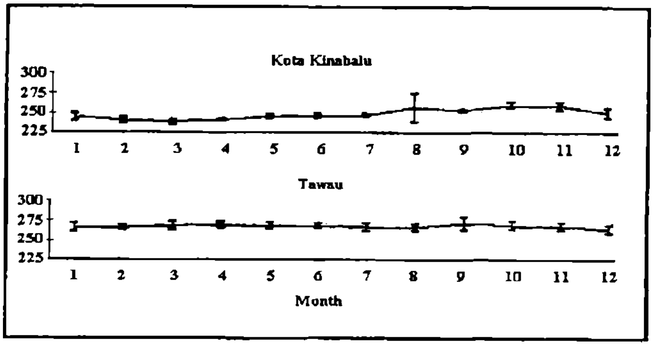

Figure 4. Monthly mean sea level variation (and its errors) at selected ports of Sabah.

existent during the summer season. However, the POW in winter is greater than the LOSL in summer. At the west coast an almost similar situation takes place. SW monsoon winds are stronger than NE monsoon winds. Thus, the POW in summer is greater than the LOSL in winter. Sea level variations in Johor Bahru exhibit an east coast pattern all year around. However, because of the fact that Johor Bahru is located in a bay, its extremes (maximum and minimum) are lesser (in magnitude) than all other east coast stations.

During the SW monsoon POW occurs in Tawau as well as in the west coast of Peninsular Malaysia. A larger volume of water is affected (by the SW monsoon winds) in the Malacca Straits (north of Kukup) as compared to Tawau. Therefore, the POW is greater for all stations of Peninsular Malaysia' s west coast (north of Kukup) than in Tawau. However, the POW in Tawau is similar to the POW in Kukup.

The magnitude of the POW at the west coast of Peninsular Malaysia, north of Kukup, from February to June, is greater than the magnitude of the downwelling in Kota Kinabalu. However, from July to October the opposite is true. Namely, downwelling in Kota Kinabalu is greater in magnitude than the POW at the west coast.

Predominance of downwelling in Kota Kinabalu, over the POW in Kukup, occurs during the whole SW monsoon season. In November, however, upwelling in Kota Kinabalu has approximately the same magnitude as the northward travelling coastal Kelvin wave in Kukup. Downwelling (upwelling) in Kota Kinabalu is much larger than the POW (LOSL) in Tawau. This may be attributed to the fact that the volume of water (being affected by the Ekman transport) in the South China Sea is far greater than the one affected by the POW in Tawau.

LOSL (POW) all along the east coast of Peninsular Malaysia is greater, in magnitude, than downwelling (upwelling) in Kota Kinabalu during the summer (winter) season.

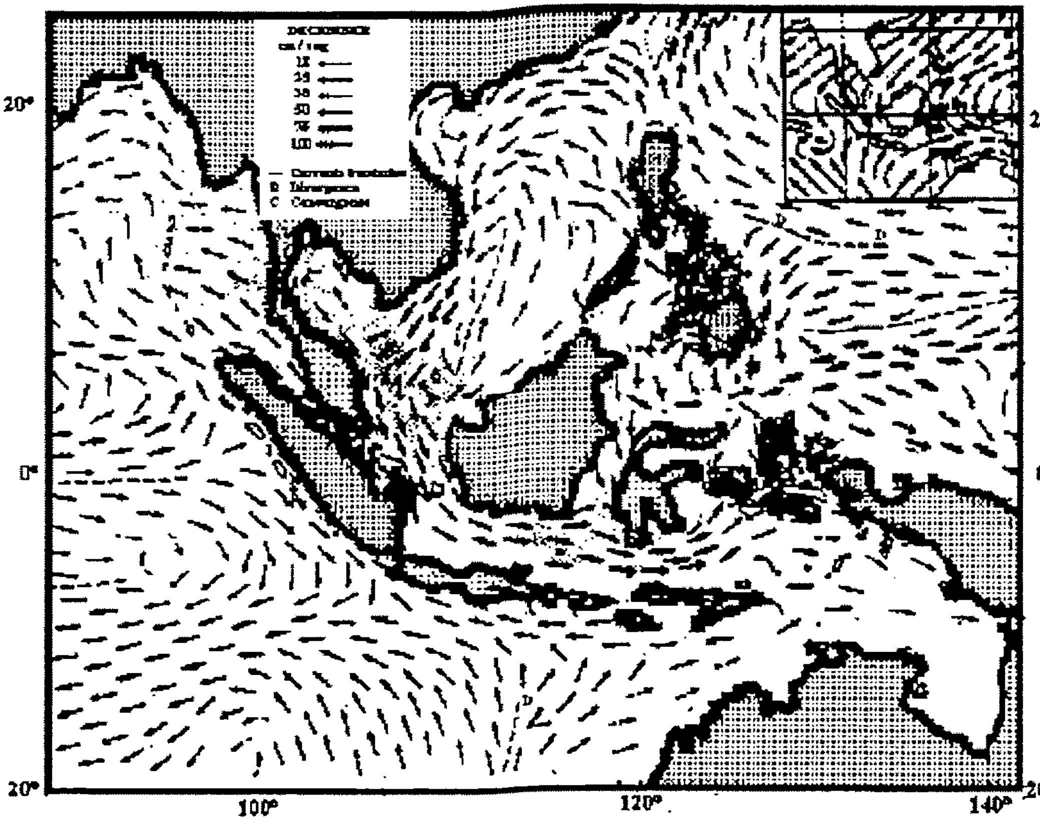

Figure 5. Wyrtki's (1961) surface currents for December.

4. CONCLUSIONS

Monthly sea level variations in Peninsular Malaysia and Sabah are studied. Our results basically confirm Yanagi *et al.* (1996) findings. However, because of the fact that a larger number of stations are analyzed, a clearer picture of the situation emerges. Namely, that Johor Bahru may be identified as having an east coast pattern.

We feel that further investigations are needed to understand the role of the double passage of the ITCZ in the dynamics of the mean sea level variations. For example, maximum rainfall occurs in the northern (southern) part of the east coast in November (December). Maximum POW occurs in Genting and Chendering in November. This same maximum occurs in Kuantan and Tanjung Sedili in December. A better understanding of the interrelation between these two phenomena (POW and the ITCZ passage) is very much needed.

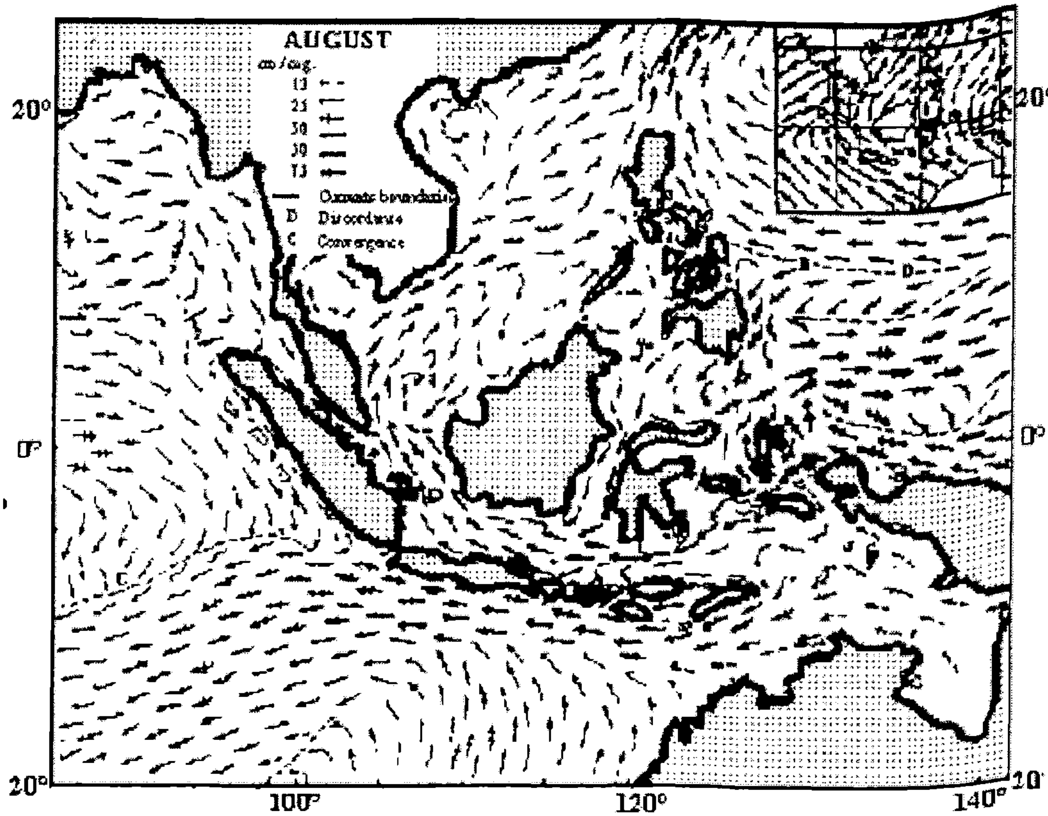

Figure 6. Wyrtki' s (1961) surface current for August.

Acknowledgments

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REFERENCES

Camerlengo, A. L., M. Rosni O., M. Nasir S, 1996a: Monthly Distribution of Precipitation in Peninsular Malaysia. Submitted for publication to the Malaysian Journal of Tropical Geography

Camerlengo, A. L., M. Nasir S and M. Hisham R., 1996b: Monthly Distribution of recipitation in Sabah and Sarawak. Submitted for publication to the Journal of Phys. Sci.

Camerlengo, A. L., M. Hisham R. and M. Nasir Saadon, 1996c: On the Passage of the Intertropical Convergence Zone in Peninsular Malaysia. Submitted for publication to the Malaysian Journal of Phys.

Department of Survey and Mapping, Malaysia (1984- 1994). Tidal Observation Records. Nasir, M. S. and A. L. Camerlengo, 1996: Response of the Ocean Mixed Layer, off the East Coast of Peninsular Malaysia, during the NE and SW monsoons. Accepted for publication in *GEOACTA*.

Nasir, M. S. and M. M. Marghany, 1996: Surface circulation off Kuala Terengganu in the Transitional Period between the NE and SW monsoons. Pertanika J. Sci and Tech., 4(1), 141-148.

Yanagi, T., N. Shiaraki, A. Rahman, A. Camerlengo and M. Nasir S., 1996. Seasonal and Year-to-Year Variations in Throughflow of Straits of Malacca. Umi to Sora (Sea and Sky), Japan. In press.

Wyrtki, K., 1961. Physical Oceanography of the Southeast Asian Waters. Report vol. 2. University of California. La Jolla, USA, 195 pp.