

Observed Coherency in the Seasonal Sea Level Fluctuations along the Coastline of the Indian Subcontinent

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Abstract

Seasonal sea level fluctuations result from oceanographic, meteorological and hydrological forcings. The largest seasonal signals of sea level, however, are primarily caused by hydrological forcings. The climatological seasonal cycles of pressure corrected sea level (tide gauge based) at sixteen stations along the coastline of the Indian subcontinent are examined, to assess the coherency of the seasonal sea level fluctuations. Since seasonal signals are the most prominent ones in sea level records (after excluding the semi-diurnal and diurnal tides), it is essential to understand them. The Revised Local Reference (RLR) data of PSMSL, UK, were utilised for this study. Principal Component Analysis (PCA) was used to understand the variance structure of the seasonal data on pressure corrected sea level. This analysis revealed that the first three Principal Components (PCs) are significant, with the percentage variance accounted by them being 62, 25 and 10%. Bhavnagar and Thangacchimadam showed high loadings for the first PC whereas for the second PC, Kandla and Thangacchimadam showed high loadings. The PC scores plot (PC1 versus PC2) revealed that the west coast stations (excluding Bhavnagar) and Tuticorin (east coast) were grouped together thus showing strong correlation whereas, the east coast stations were widely scattered.

Key words: Seasonal sea level; Principal Components Analysis; Indian subcontinent

1. Introduction

Several studies have been carried out in the past on sea level variability along the coastline of the Indian subcontinent in various contexts, ranging from long period waves to climate change issues (Shankar, 2000; Srinivas et al., 2005; Srinivas and Dinesh Kumar, 2006). However, an effort to understand the seasonal variability of the pressure corrected sea level (CSL) in a coherent manner using the RLR stations along the coastline of the Indian subcontinent has been lacking and hence this study.

2. Materials and methods

The sea level (Revised Local Reference - RLR) data used in this study is from the Permanent Service for Mean Sea Level (PSMSL), United Kingdom. The climatological seasonal cycles of CSL at sixteen stations along the coastline of the Indian subcontinent are examined to appreciate how coherent they are with regard to the seasonal march using the PCA technique (Emery and Thomson, 1998). Pressure correction is applied to the observed sea level to account for the "inverted barometer effect" using climatological atmospheric pressure data (India Meteorological Data, Pune, India).

3. Results and discussion

The seasonal march of CSL along the west and east coasts of the Indian subcontinent are presented in Figures 1 and 2, respectively. Bhavnagar on the west coast has the highest seasonal variation, due to the freshwater discharge of the rivers Mahi and Narmada, and also due to its unique location, inside the Gulf of Cambay. From the CSL data presented for the west coast stations, the general picture that emerges is that prolonged periods of low sea level coincide with the southwest monsoon season only. The first signals of marked low sea levels, indicating the process of upwelling are seen in the south (off Cochin) and off Karachi (Pakistan), they are seen around July. The Gulf of Cambay is very much dominated by winter cooling processes during the first quarter of the year, because of the landlocked nature / shallow depths and subsequently during July-October, the hydrological forcing dominates. The region beyond Bhavnagar also comes under the influence of winter cooling but the signal seen in the sea level is relatively weak. November-January period is dominated by conspicuously high sea levels suggesting signatures of the northward flowing West India Coastal Current, carrying low salinity waters of the Bay of Bengal.

The ranges in CSL were found to be higher along the east coast as compared to the west coast, the alongshore currents being responsible for the same. The seasonal variance of coastal alongshore currents was found to be more on the east coast than on the west coast of India (Shankar, 2000, Srinivas et al., 2005; Srinivas and Dinesh Kumar, 2006), indicating that the alongshore currents are more energetic along the east coast as compared to the west coast. The stronger coastal currents along the east coast could be the reason for higher ranges in sea level seen along the east coast, as compared to the west coast.

PCA revealed that the first three Principal Components (PC) are significant, with the percentage variance accounted by them being 62, 25 and 10%. The months February-April were grouped together suggesting strong associationship whereas June-September were also grouped, but not that closely (Figure 3). The months of October-January were widely scattered. Bhavnagar and Thangacchimadam showed high loadings for the first PC whereas for the second PC, Kandla and Thangacchimadam showed high loadings. The PC scores plot

(PC1 versus PC2) revealed that the west coast stations (excluding Bhavnagar) and Tuticorin (east coast) were grouped together whereas the east coast stations were widely scattered.

4. Conclusions

The climatological seasonal cycles of CSL at sixteen stations along the coastline of the Indian subcontinent were examined for coherency using PSMSL data sets, using Principal Component Analysis technique. The unique nature of the sea level at Bhavnagar (west coast) and Thangacchimadam (east coast) is clearly brought out by this technique.

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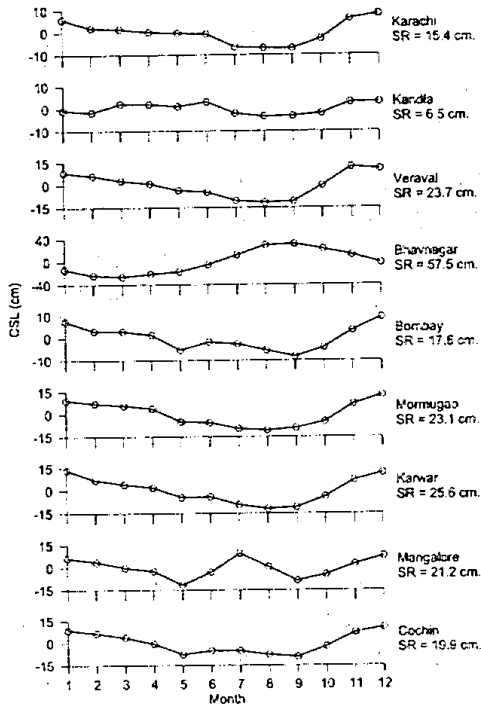


Fig 1. Seasonal cycle of the corrected sea levels for the stations along the west coast of the Indian subcontinent. Y-axis scales are different. SR = Seasonal range

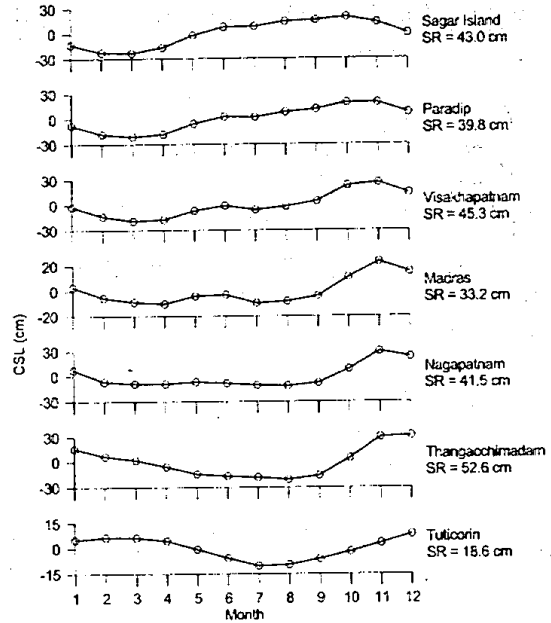


Fig 2. Seasonal cycle of the corrected sea levels for the stations along the east coast of the Indian subcontinent. Y-axis scales are different. SR = Seasonal range

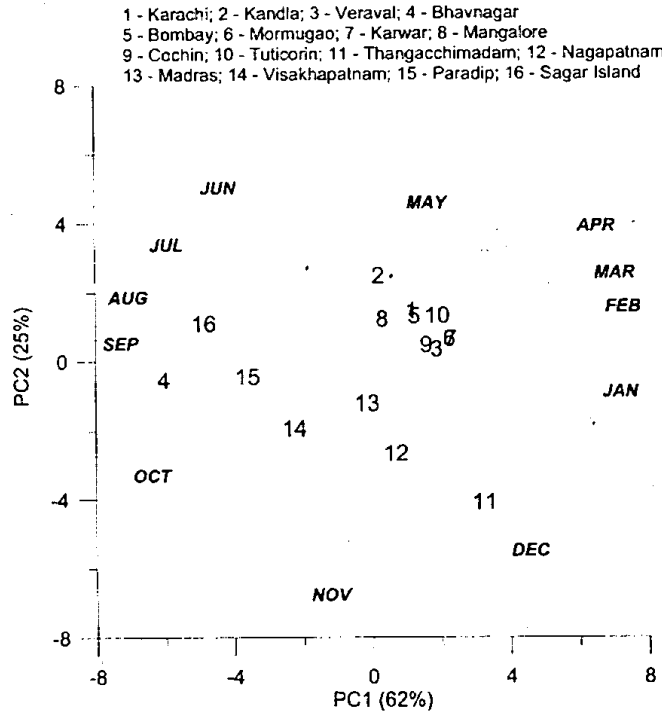


Fig. 3. Scatter plot of the PC scores for the first two PCs. The months causing the loading are also indicated. The loadings have been scaled by a factor of 7.5.