

Observed sea-level rise in the north Indian Ocean coasts during the past century

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Introduction

Sea-level rise is one of the good indicators of global warming. Rise in sea level occurs mainly through melting of glaciers, thermal expansion due to ocean warming and some other processes of relatively smaller magnitudes. Sea level rise is a global phenomenon, since exchanges occur through different ocean basins at long time scales. However, studies on regional sea level changes are also important for impact assessment, vulnerability studies etc.

Changes in sea level occurs in different time scales, from a few hours in the case of tides, storm surges and tsunamis to decadal and longer time scales. Fortnightly changes occur due to the spring neap tidal cycle. Some oceanographic processes, such as seasonal currents driven by local winds or by remote forcing, cause changes in sea level. Besides, interannual events such as El Nino also show their signatures on sea level.

Measurement of sea level

Measurement of sea level started since 1870's by using instruments known as tide gauges. In those days, the necessity arose mainly to monitor the time of high tide and low tide and the sea level heights at the time of high tide and low tide. Normally, tide gauges are installed in the harbours. By analysing the past data, predictions of tides are done for major ports. In regions, having relatively large tidal ranges, these predictions are needed for navigational purposes. Since last three decades, past tide gauge data were used to study sea-level rise.

Data and methods

Monthly mean sea level data for all the tide gauge stations over the globe are available at the website (www.pol.ac.uk) of the Permanent Service for Mean Sea Level (PSMSL), Proudman Oceanographic Laboratory, U.K. (see Woodworth and Player, 2003) These data sets were used by many researchers (see Douglas, 2001) for the study of global and regional sea-level rise. One of the problems encountered is that measurements on vertical land movements at the locations of tide gauges are not available. These movements occur through mainly two processes, local tectonic activity and glacial isostatic adjustment (GIA). Model results can be used (Peltier, 2001, Peltier, 2004) for the latter and most of the recent studies use a GIA correction, obtained from the models. Church et al. (2001), in the Third Assessment Report of the IPCC

(Inter Governmental Panel for Climate Change), reported that the sea level rise in the past century to be between 1 and 2 mm/year. In the Fourth Assessment Report of the IPCC, Bindoff et al. (2007) reported the estimated value of global sea level rise close to 1.8 mm/year for the period 1961-2003.

Sea-level-rise trends along the Indian coasts

Earlier attempts to study the sea-level-rise along the Indian coasts were made by Emery and Aubrey (1989) and Douglas (1991) and recent work include those from Unnikrishnan et al. (2006) and Unnikrishnan and Shankar (2007). Even though studies on sea-level rise trends are a few in the north Indian Ocean, there had many studies on low-frequency variability found in the tide gauge records. (Clarke and Liu, 1994; Shankar, 1998, Shankar and Shetye, 2001 etc.)

Unnikrishnan and Shankar (2007) analysed all the records in north Indian Ocean having a duration of more than 20 years (see Fig.1 for the location of tide gauge records). They checked the inter-consistency of records and found that all the long records along the Arabian Sea coast such as Aden, Karachi are found to be consistent with that of Mumbai record. The Mumbai record, is the

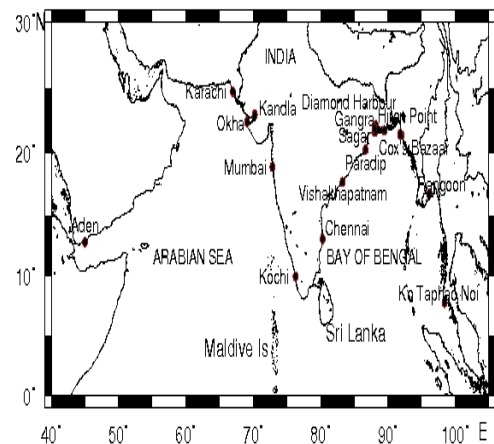


Fig. 1. Location of tide gauges. Stations having at least 20 years of data are only shown.

longest one, having a duration of more than 100 years, was taken as a reference record. In the same way, to check for inter-consistency, Vishakhapatnam record was

taken as the reference record for stations along the coast of Bay of Bengal. The records at Kochi, Chennai, Diamond Harbour (Kolkata) etc. are found to be well correlated with that of Vishakhapatnam record. The Kandla record shows a poor correlation with that of Mumbai record. One of the possible reason for this is the fact that Kandla tide gauge is located in the Kutch region, where local tectonic movements could have affected the sea level records. It is to be noted that this region suffered a massive earthquake in 2001 (Jade et al., 2003)

The estimated sea-level-rise trends for Aden, Karachi, Mumbai, Kochi, Vishakhapatnam lie in the range of 1-2 mm/year (Fig. 2), consistent with the findings of Church et al. (2001). The regional average sea-level rise trends, obtained from the estimates for the above stations, is 1.29 mm/year. The high rates of estimated sea level rise trends found at Diamond Harbour (Kolkata) cannot be explained in terms of global warming alone. This station is located in the delta of river Ganga, whose subsidence rates are known to be about 4 mm/year (Goodbred and Kuel, 2000).

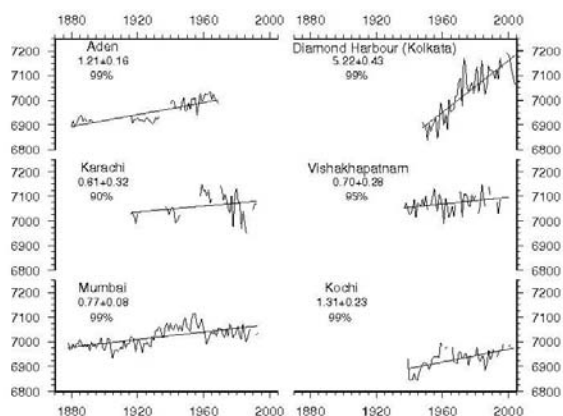


Fig. 2. Sea-level rise estimates for selected stations. Error bars and confidence limits are shown (From: Unnikrishnan and Shankar, 2007).

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