Sea Level variations along the Egyptian Mediterranean Coast

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Introduction

- The observed sea level variation off the Egyptian Mediterranean coast results mainly from the combination of two elevations: astronomical tides and surges. Tides, as in the whole Mediterranean basin, are mainly semidiurnal, with a general tidal range in the order of a few centimetres. Surges, on the other hand, have more impact on the Egyptian Mediterranean coast. They may reach 1.0 m elevation under the effect of the meteorological factors. The combined impact of astronomical tides, storm surges and sea level rise (SLR) can severely affect lives and coastal properties.
- Sea level data from six tide gauges were used to study four aspects of coastal sea level:

(1) Tidal characteristics,

(2) Spatial variations of the MSL,

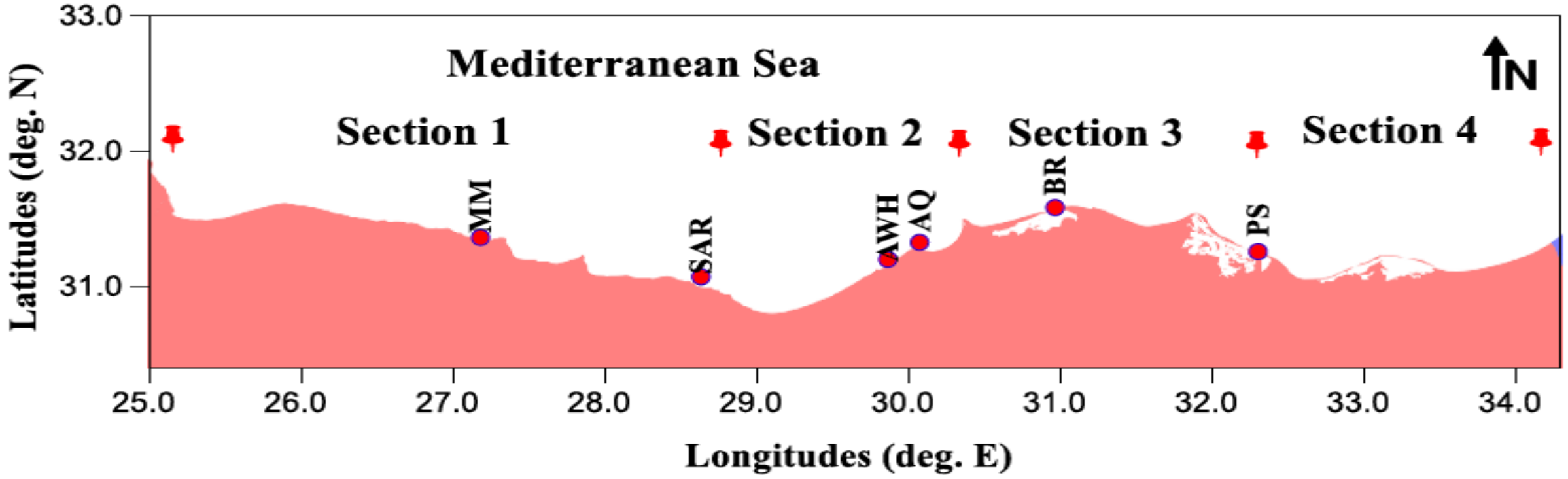
(3) Annual rates of variations in the MSL

(4) Seasonal variations of sea level, along the Egyptian Mediterranean coast. The study analysed more extensive data than previous studies along this coast.

Data and Methods of Analysis

- The present work is based on six data sets of hourly sea level records from six tide gauges distributed over the Egyptian Mediterranean coast (Fig. 1). These gauges were deployed at Port Said (PS), Burullus new harbour (BR), Abu-Qir Bay (AQ), Alexandria Western Harbour (AWH), Sidi Abdel-Rahman (SAR) and Mersa Matrouh (MM), from east to west, respectively.

Figure 1. *The Egyptian Mediterranean Coast with its Four Geographical Sections and Locations of the Six Tide Gauges Used in the Present Work*



Location names, tide gauge positions, periods of records of sea level data and percentage of the missed data

Table 1. *Location Names, Tide Gauge Positions and Periods of Records of Sea Level Data in the Present Study*

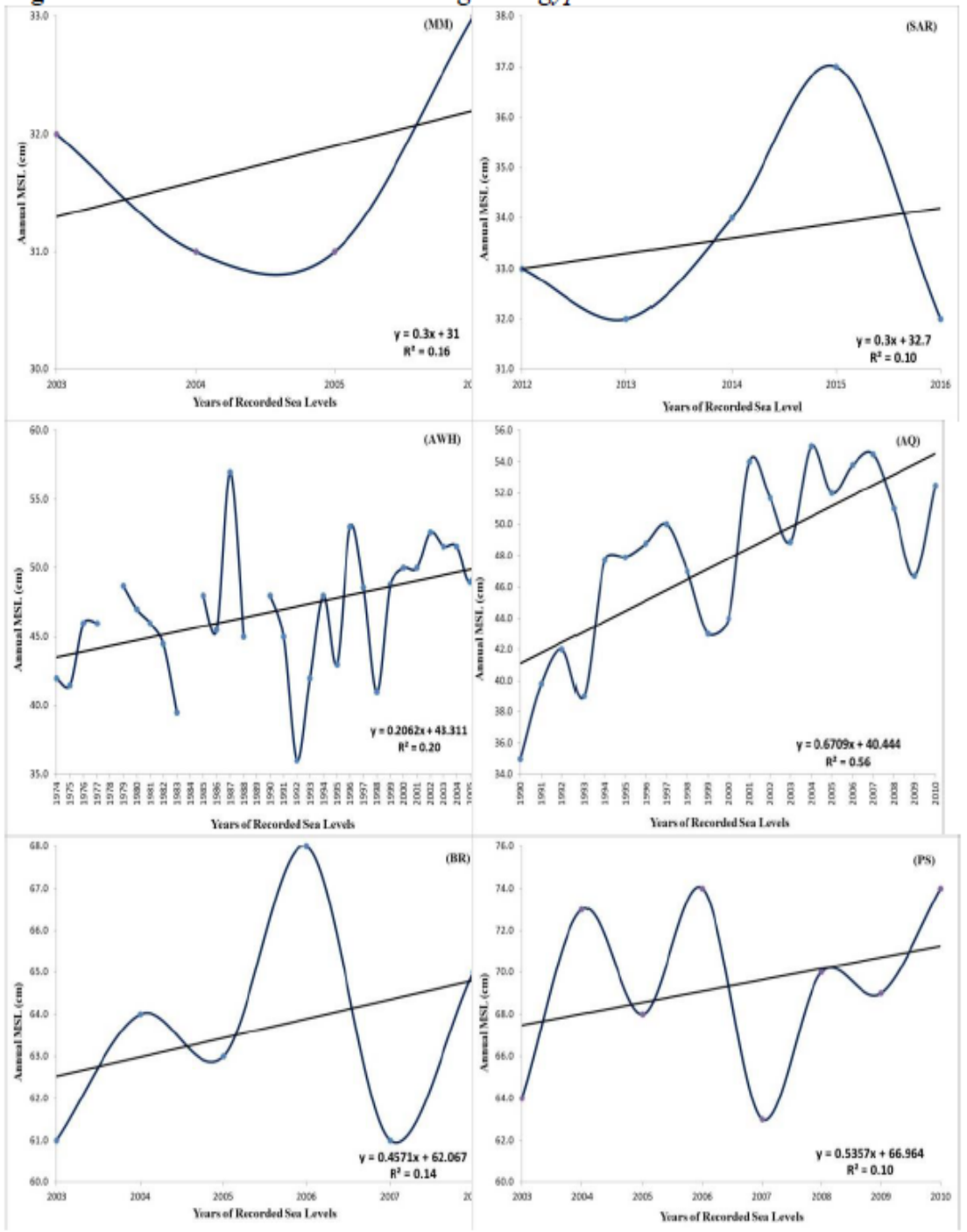
Location	Nomination	Tide Gauge Position		Period of Records	% of Missed Data
		Lat. (° N)	Long. (° E)		
Mersa Matrouh	MM	31.360	27.183	4 years (2003-2006)	0
Sidi Abdel-Rahman	SAR	31.070	28.836	5 years (2012-2016)	0
Alex. Western Harbour	AWH	31.183	29.983	33 years (1974-2006)	9.1
Abu-Qir Bay	AQ	31.325	30.075	21 years (1990-2010)	0
Burullus	BR	31.582	30.986	6 years (2003-2008)	0
Port Said	PS	31.256	32.305	8 years (2003-2010)	0

Spatial variations of the annual MSL (sea level rates)

Results revealed a general trend of increase in the annual MSL along the Egyptian Mediterranean Coast but with different rates.

The Nile Delta, examine the highest rates of increase being 4.8 mm/yr (Port Said), 3.8 mm/yr (Burullus) and 6.4 mm/yr (Abu Qir). On the other hand, the three other rates of increase are 2.2 mm/yr (Alexandria Wester Harbour), 1.0 mm/yr (Sidi Abdel Rahman) and 2.4 mm/yr (Mersa Matruh).

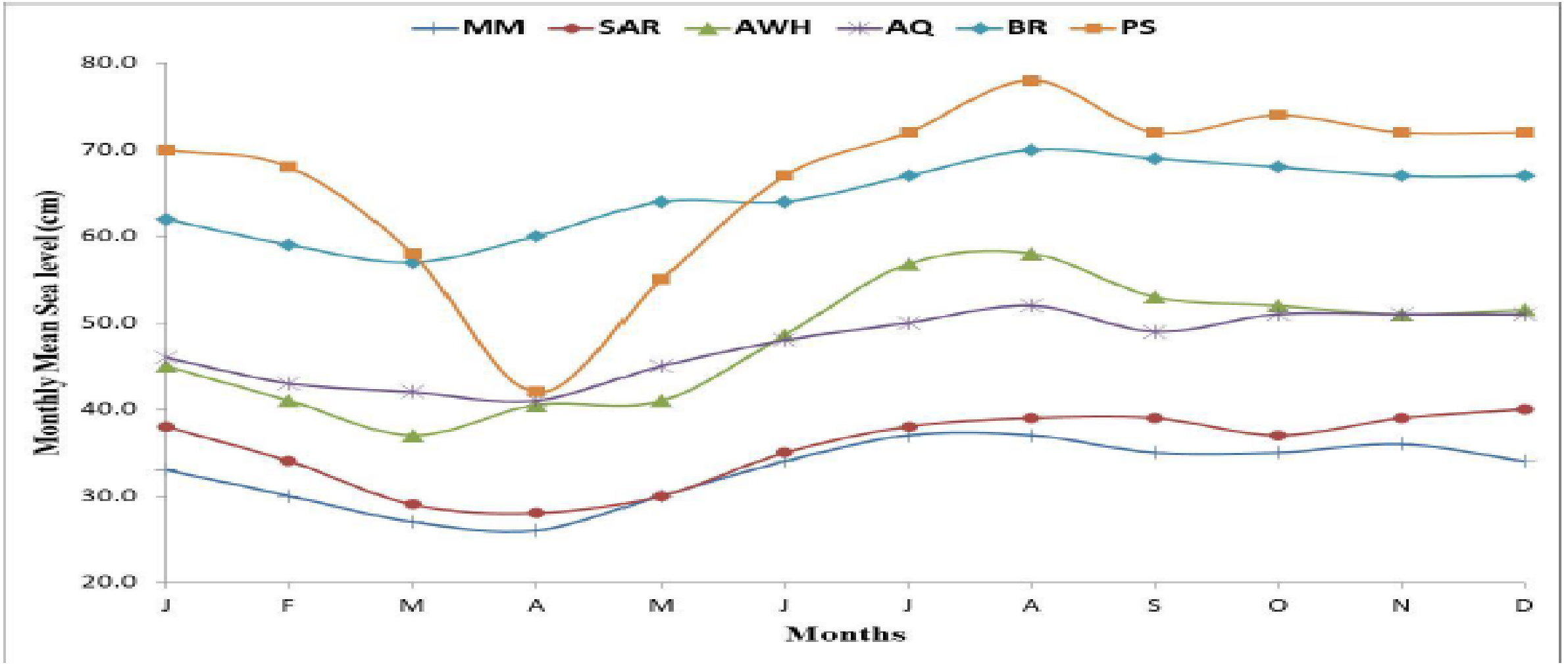
Figure 2. *Annual MSL and Trends along the Egyptian Mediterranean Coast*



Overall, the average rate of the SLR along the Egyptian Mediterranean coast is **3.4 mm/yr**. This is larger than the global Sea Level Rise rate for the 20th century of **1.8±0.5 mm/yr** (Church and White, 2006, 2011) and for the whole Mediterranean basin rates, over the same period, of **1.1-1.3 mm/yr** (Tsimplis and Baker, 2000), but meanwhile is less than the Eastern Mediterranean rates of **04-20 mm/yr** (Cazenave *et al.*, 2001; Rosen, 2002; Klein *et al.*, 2004; Tsimplis *et al.*, 2008; Vigo *et al.*, 2011; Passaro and Seitz, 2012).

Seasonal variability in the Recorded sea level along the Egyptian Mediterranean Coast

Figure 3. *Seasonal Variability in the Recorded Sea Levels along the Egyptian Mediterranean Coast*



Source: Author.

Seasonal Variability

- The sea level along the Egyptian Mediterranean coast examines a seasonal trend with usual low values in March and April (spring season) and higher ones in August (summer season), except at Sidi Abdel-Rahman, where the maximum mean monthly sea level was in December. November and December (late autumn/early winter seasons) also examines high mean monthly values. The seasonal sea level variability along the Egyptian Mediterranean coast can thus be concluded to be consistent with the atmospheric pressure scheme over the coast and the wind regime.

Conclusion

1- The Egyptian Mediterranean coast is vulnerable to the sea level rise. However, its mid-to-east part is much more vulnerable to this rise than its mid-to-west part.

2- The flooding risk assessment of this region, comprising the Nile Delta, is a must for designing plans of coastal defence and protection.

3-More research is needed on the oceanographic and meteorological forces impacting on the seasonality of variations in the sea level along the Egyptian Mediterranean coast.

4- The present study strongly recommends more investigation on the land subsidence rates along the coast in general and off the Nile Delta in particular.