Long Term Monitoring of the Mediterranean and Red Sea Levels in Israel

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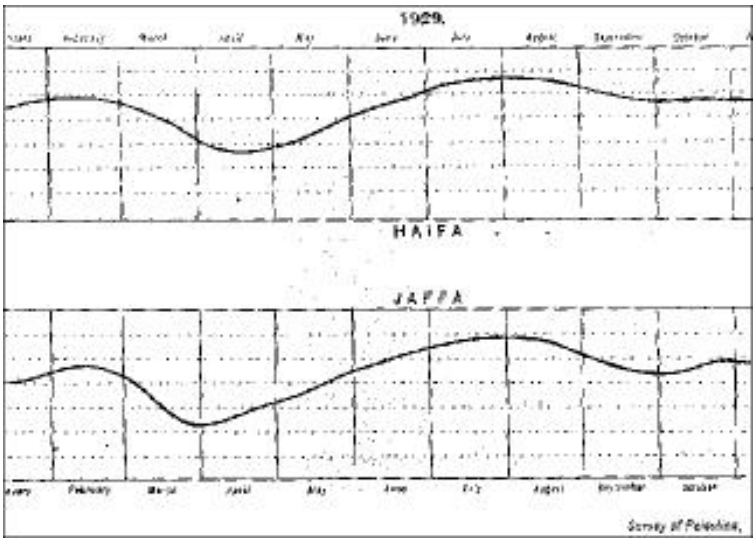
The Survey of Israel has been monitoring the sea level along the East Mediterranean Coast for decades.

The aim of this work is to follow the long term changes of sea levels and to discuss the reasons responsible for such changes

History

Sea level measurements during the British Mandate (1917-1948)

Initially, the aim of sea leveling was to define the zero level value of the geodetic vertical network



Seasonal variations of MSL in 1929

Goals of Sea Level Monitoring in SOI

To determine the long term changes and variations in sea level

To relate bathymetry to the zero level

To determine coast line in Israel according to sea upper level

To collect Data Base for interdisciplinary research

The Mediterranean Basin

and the Israeli Coast

Station Locations

SOI tide gauge array

along the Mediterranean sea

(satellite image)

Tide gauge benchmark (TGBM) and modern equipment

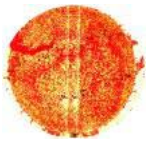
TGBM at the Akko (Acre) station It's **height is derived from a local geodetic leveling, it is connected to the national leveling network.**

Radar sensor (f=24,125 GHz, p=25mW) was installed at Haifa port in 2001 and at the Ashdod port in 2004

Float type tide gauges at the Ashqelon, Tel-Aviv and Akko stations record Sea level changes in digital form with 5-min sampling and 1 cm resolution

The Factors that Influence Sea level Changes

$$Z(t) = Zo + A(t) + M(t) + O(t)$$



The Sun

The Moon

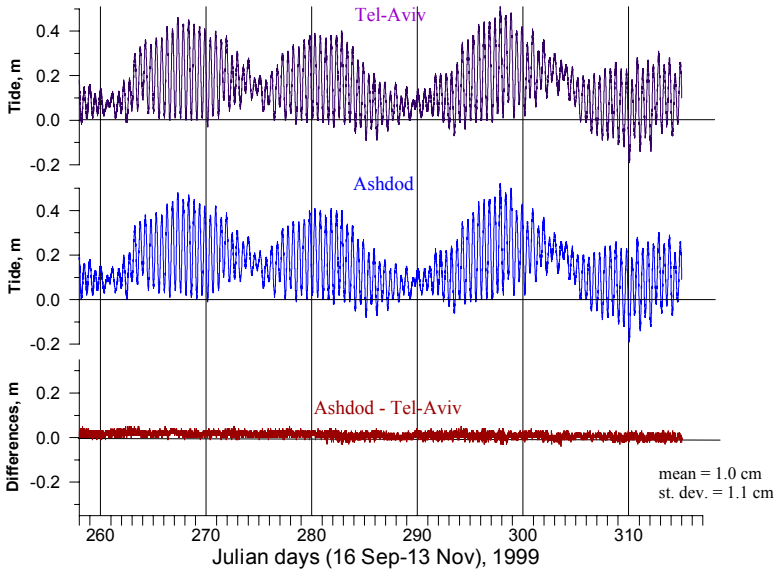
Zo – a mean Sea level (Earth's gravitation: Geoid)
It is assumed to be constant over a period of decades

A(t) –astronomical tide (attraction by the Moon & Sun)

M(t) – meteorological factors (air pressure & wind)

O(t) – oceanographic factors (temperature & water salinity, ocean topography)

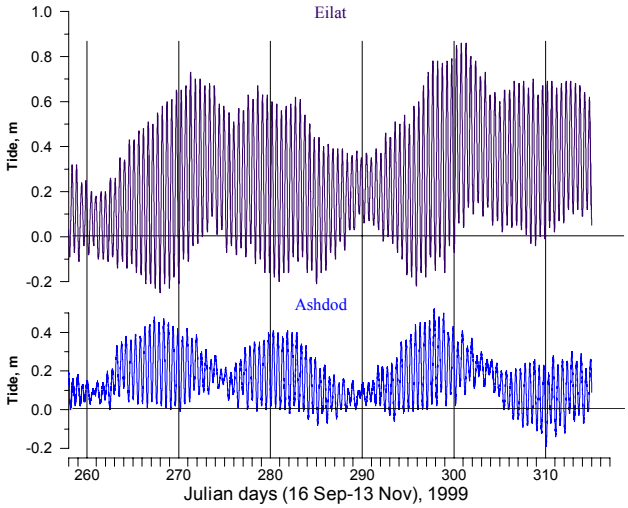
Astronomical tide



The astronomical tidal cycle, (called semidiurnal) takes an average of 12 hours 25 minutes. The semidiurnal tide changes cyclically in amplitude over a 14-day period and its maximum and minimum depends on moon phases.

The astronomical tide waves appear at the same phase and almost the same amplitude at these stations

Comparison between Eilat and Ashdod station tides

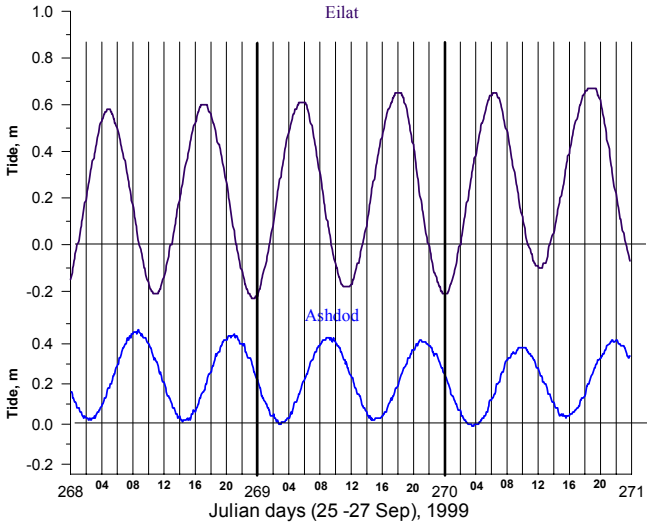


The shape and range of tides at any station depends on geographical and hydrological factors

The Mediterranean and Red Sea stations are related to different basins: North Atlantic or Indian oceans

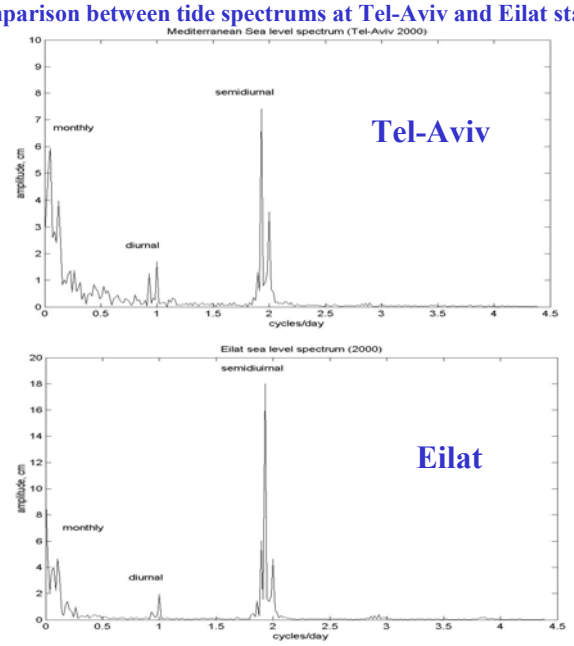
Comparison between Eilat and Ashdod station tides:

zoom in (semidiurnal cycle)



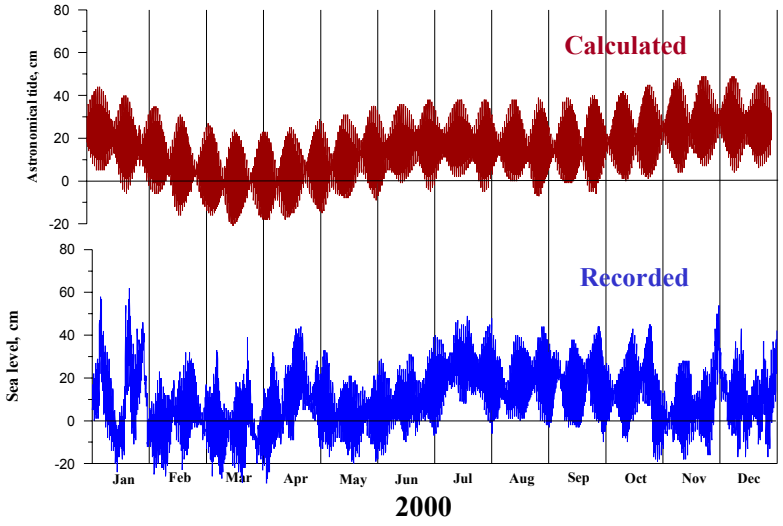
Semidiurnal tide at Eilat and Ashdod stations: they are distinguished by amplitude and phase

Comparison between tide spectrums at Tel-Aviv and Eilat stations



The ratio between semidiurnal, diurnal and monthly amplitudes of the spectrum is different

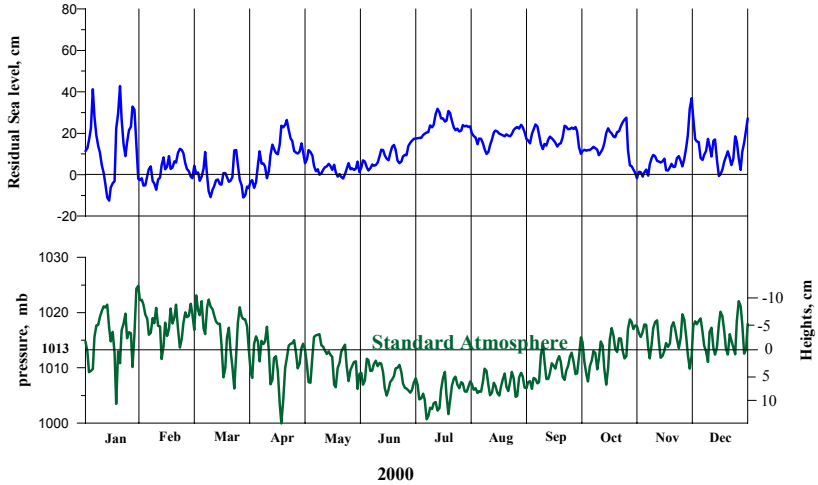
Astronomical tide and Sea level records at the Tel-Aviv tide gauge station in 2000



Astronomical and non-periodic fluctuations are superimposed: Tel-Aviv tide gauge station.

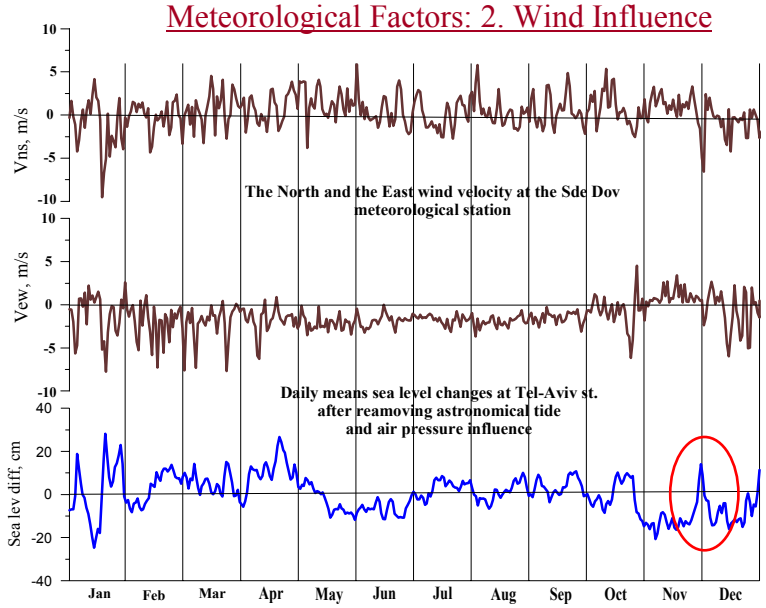
Meteorological Factors: 1.Air Pressure

Daily mean residual (records - astronomical tide) Sea level at the Tel-Aviv tide gauge station and pressure at the Sde Dov meteo station



Heightened air pressure depresses the sea level as delta(h)=-0.993*delta(Pa).

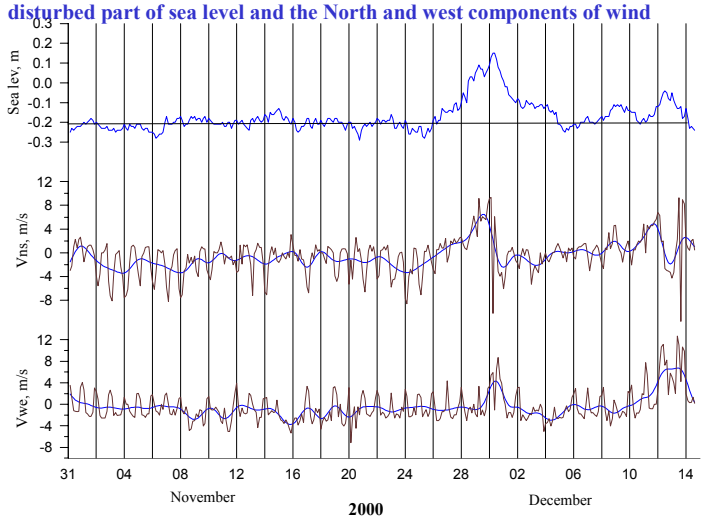
Meteorological Factors: 2. Wind Influence



Any quantitative relationship between wind and sea level is complex

Meteorological Factors: 2. Wind Influences (cont.)

A clear association between sea level and wind velocity variations. Correlation between disturbed part of sea level and the North and west components of wind



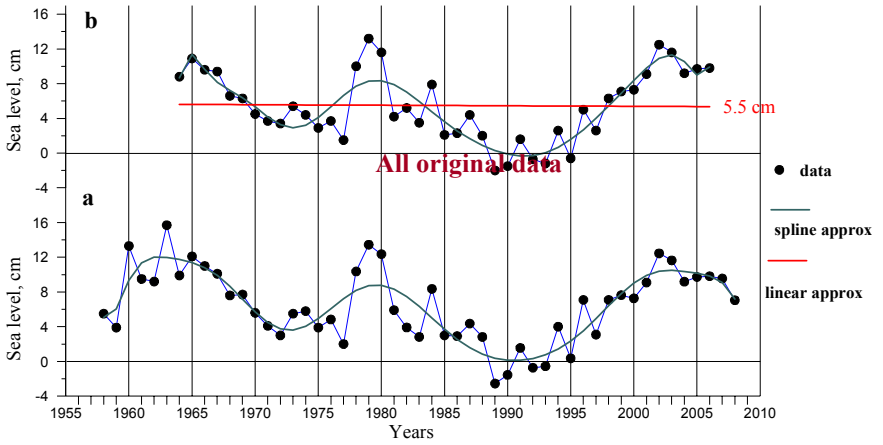
Wind increased over a long period (~5days), as a result sea level rose about 40 cm.

So, short non-periodic sea level changes may be attributed to air pressure and wind.

Long Period Mediterranean Sea Level Change

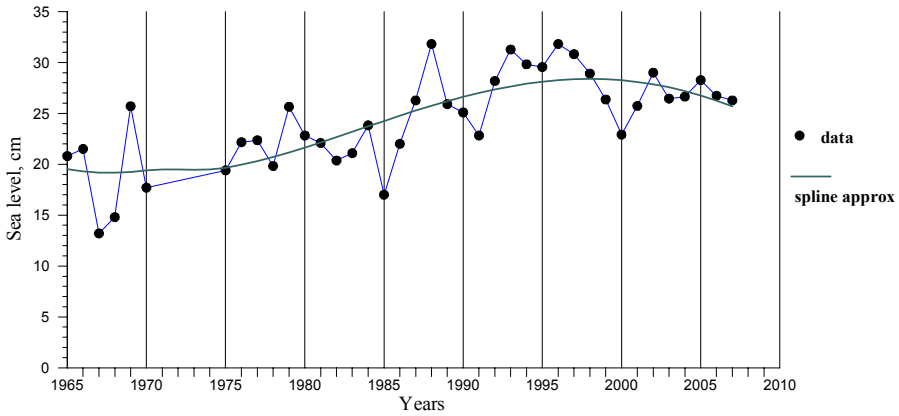
1. Yearly mean sea level change (1958-2008) and approximations

The two full 20 year periods (air pressure effect was excluded)



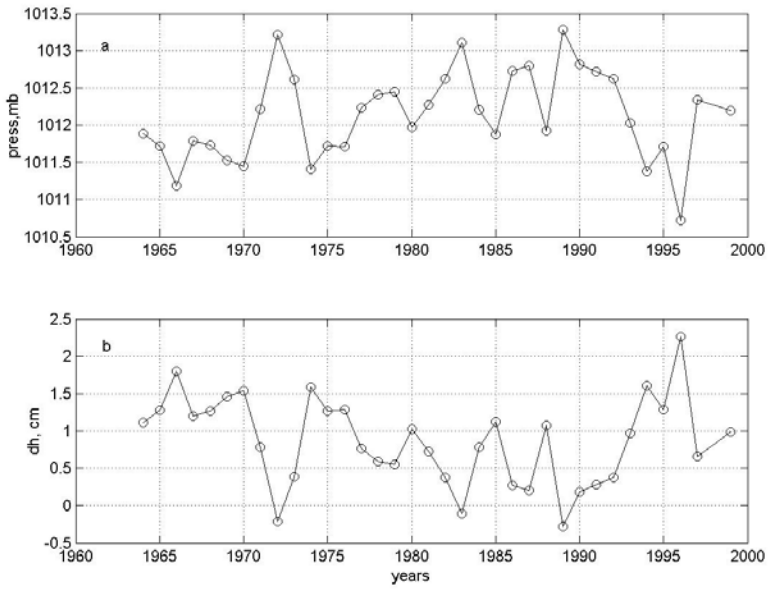
Long Period Changes

2. Yearly mean sea level changes (1965-2007) at the Eilat station and approximations



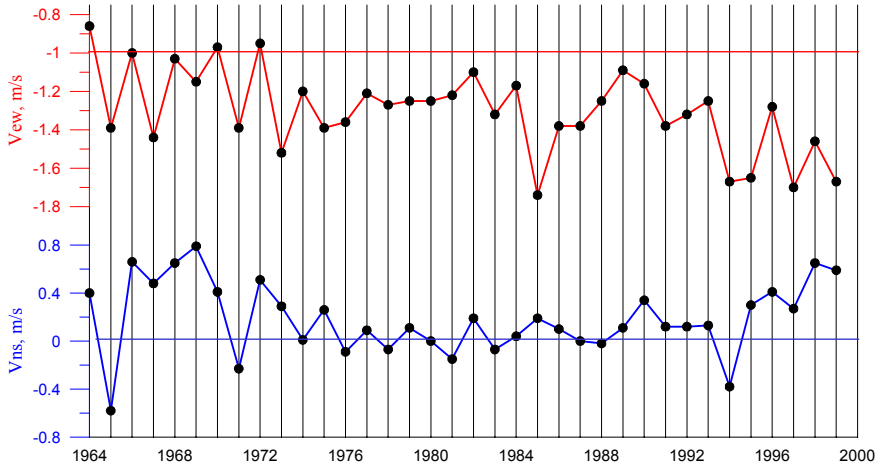
Repeat ground leveling from the Mediterranean to the Gulf of Eilat shows that the MSL of the Red Sea today is higher than the Eastern Mediterranean mean sea level by 17 cm

Yearly Air Pressure Mean



Wind yearly means

(Naharia and Sde Dov shore meteorological stations)



Results :

The time series of yearly mean values shows quasi-periodic changes of about 15-20 years with an amplitude of about 10-15 cm. The third period since 1958 indicates a gradual rise of sea level of about 10mm/year during approximately 10 years. This rise ended in 2000. In recent years we have observed stability or even a decrease in sea level.

Probably, oceanographic effects such as water density variations, permanent ocean circulations, atmospheric effects (air pressure and wind), are a principal cause for long period mean sea level changes.

Sea level changes at the Red Sea (Gulf of Eilat) differ from the Eastern Mediterranean variations. The difference is evident not only in short tide periods but also in the yearly mean changes. Tide gauge measurements since 1965 show that the sea level rose compared to the current level about 7cm.

Acknowledgments.

We thank the staff of the Research Division for the work carried out in the field

Thank you