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Estimating Sea Level Change at the Egyptian Coasts Using Different Data Sources

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Abstract : The sea level has been rising over the past century, and the rate increased in recent decades. In urban areas along coastlines around the world, rising seas threaten infrastructure necessary for regional industries. There are two main reasons for sea level rising; glaciers and ice sheets are melting and adding water to the ocean and the volume of the ocean is expanding as the water warms. The main objective of this research is to determine the sea level change in the Mediterranean Sea and the Red Sea by using different data sources (tide gauge, Altimetry, and GRACE satellite data) for the period 2010-2015. The results show that the estimations obtained from satellite altimetry and tide gauges measurements have a better agreement.

Keywords
Tide Gauge, Satellite Altimetry, GRACE, Vertical Land Movement, Sea Level Change

I. Introduction
The Sea Level Change (SLC) is extracted from tide gauge data that referenced to the benchmark fixed coastal land. SLC can also be determined from satellite altimetry data reference to ellipsoid with reference to the earth's mass center in terrestrial references frame (Guo, J.Y., et al., 2016). In order to know how much of the increase in sea level is due to actual mass transfer, - the water movement from land to ocean- scientists depends on a multiple of direct measurements like; melt rate and glacier elevation made during field surveys, and satellite based measurements of tiny shifts in earth's gravity field. The increase in mass increases the strength of gravity, when water shifts from land to ocean, Scientists estimate the amount of added water based on these gravity shifts, (Merrifield M.A. et al., 2014, Pelto M.S. 2015). As global temperature gets warmer warm, sea level continues to rise. How much it will rise depends mostly on the rate of future carbon dioxide emissions and future global warming. The rising speed depends mostly on the rate of glacier and ice sheet melting. Sea level alteration has a non-uniform behavior around the world, it is discovered that some regional sea level variations are larger or smaller than the average global value, this is duo to climate variability and local environments (Douglas B.C. , 2001 , Peltier W.R. , 2004, Miller L. and Douglas B.C., 2004). During the twentieth century the rate of sea level rise had an average of 1.5-2.5 mm/year (IPCC., 2013, IOC, 2006). In 2012, as a request of the US Climate Change Science Program, NOAA scientists conducted a review of the research on global sea level rise projections, and conclude that there is a very high possibility that global mean sea level will rise at least 0.2 m but no more than 2.0 m by 2100 (Climate.gov , 2009).

In Egypt (Nassar M. et al., 2003) estimated that the sea level increased by 12 cm from 1906 to 1980, which means a rate of approximately 1.5 mm per year, and (Sharaf el Din S. et al., 1989) showed that the rate of sea level rise is 1.6 mm per year at Alexandria in the period from 1958 to 1988. Other studies stated that the sea level rising rate will be higher than it is now because of the global warming that causes thermal expansion of water input from the melting of continental ice sheets and land basins.

Tide gauge and satellite missions are the main techniques used to measure sea level variations. Tide gauge has been used to monitor sea level changes with reference to the TG land for the last two centuries with low spatial and high temporal resolution (Barnett T.P., 1984). Since 1993 with the appearance of satellite altimetry, it has been commonly used to monitor the absolute sea level changes with a suitable accuracy and high spatial and temporal resolution. The tide gauge will provide the absolute coastal sea level changes when the vertical land movements are precisely observed. The absolute sea level changes contain the steric and mass components. The steric sea level variations are produced by the temperature and salinity changes, and the mass sea level variations are resulting from fresh water input and output, which could be measured by the Gravity Recovery and Climate Experiment (GRACE) mission launched in August 2002 (Tapley B.D., et al. , 2004). Many factors affect the GRACE results; the first one is GRACE instruments noise and measurements errors, the second one is the errors from the atmosphere and ocean models, the third one is noises and correlated errors in the GRACE harmonic coefficients, and the fourth one is due mainly to the low resolution and land –ocean linkage effects (Swenson S.C. and Wahr J., 2006).

The main objective of this study is to estimate the sea level change (SLC) at the Egyptian coasts using different data sources. Accordingly, two study areas were chosen, the first along the northern Egyptian Coasts (Mediterranean Sea) and the second along eastern Egyptian Coasts (Red Sea). SLC are measured and analysed from (tide gauge, satellite altimetry, and GRACE) data sources, for the period 2010-2015.

II. Data Used