Variability of the Sounding Datums Around Sri Lankan Coastline

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Key Words: Tidal Datum, Mean Sea Level, Chart Datum, Tidal Analysis

SUMMARY

Recently, there has been a growing concern on the blue economy and the necessity to manage the marine spaces in a more systematic and sustainable manner. Seamless spatial data across the land-sea boundary is essential in geo-spatial databases. The ocean depths are commonly referenced to Chart Datum (CD) which is usually a low water level such as the Lowest Astronomical Tide (LAT) while land heights are referenced to a land vertical datum like Mean Sea Level (MSL) in most of the countries. This paper discusses the variability of the tidal datum around Sri Lankan coastline using six tidal stations. Here, one year continuous tidal data were obtained for the year 2017 and analyzed using TOTIS tidal software. Computed MSL and LAT datums at each location were compared with the land survey datum. Analyzed results showed that the tide around Sri Lanka is mainly semi-diurnal to mixed semi-diurnal as the form factor varying from 0.2 to 0.5 and the tidal range around the country is varying between 0.4 to 0.6m. The largest tidal range observed at Colombo and the lowest was at Kalpitya. The difference between the land survey datum and the MSL on tide gauges were varying between 0.04m to 0.15m. The greatest variations observed at Colombo and Trincomalee, which were 0.15m and 0.14 m. The observed MSL and LAT variations were about 0.44 m at most of the stations while 0.36m and 0.34 m at Hambantota and Kalpitiya respectively. This indicates a slight variation between MSL and CD around the country. Finally, this information is very useful in generation of a separation model between land survey datum and hydrographic datum.

1. INTRODUCTION

In Geomatics profession, various vertical reference datums are used in numerous applications. Among them, Mean Sea Level (MSL) is one of the common datums usually used in land surveying. The MSL is simply defined as the geoid, the equipotential surface of the Earth's gravitational potential which coincides with the MSL. However, the geoid deviates from MSL due to the sea surface topography (SST). Therefore, this MSL surface is not a smooth surface as it fluctuates with the variation of the earth's gravitational field. This variation is significant in land surface due to the variation of topography and its density. The MSL or the zero elevation surface, when it uses as the vertical datum, is not consistent globally and that is the reason for the different vertical datum defined in place to place. This is mainly due to the nature of the tidal pattern of that area and some other oceanographic and geophysical factors.

Establishment of the MSL for Sri Lanka was done with the collaboration of the great trigonometric survey of India. The determination of Sri Lankan vertical datum as the MSL was done from the tide gauge observations established by the trigonometric survey of India during the periods of 1884 to 1889 at the Colombo, Galle and Trincomalee ports. Using these tidal observations, the levelling network was carried out fixing to zero height at Colombo by using the MSL value derived from the Colombo tide gauge observations in 1884 to 1889. Later, another set of tidal observations were made at Colombo and Trincomalee in between the period of 1923 to 1933 and MSL around Sri Lanka was verified with two stations and small variations were observed. However, the establishment of the sprit levelling network was carried out from 1926 to 1930.

Chart datum is a low water level datum in which all depths and drying height are measured in hydrographic surveying. Usually this datum levels are obtained at the tidal stations by analyzing the long-term tidal observations. In Sri Lanka, Lowest Astronomical Tide (LAT) is used as the Chart Datum (CD) in preparation of navigation chart. Mean sea level (MSL) and lowest astronomical tidal (LAT) datums are used in most of the applications and analysis in land and hydrographic purposes which can be computed from the observed tide value at each tidal station. Most countries have established tidal network along their coastline for this purpose. In the case of Sri Lanka, a proper tidal network covering the entire coastline has recently established. Therefore, the objective of this study was to evaluate the variability of the MSL and chart datum around Sri Lanka with this data.

2. METHODOLOGY.

Recently, a new tide gauge network was established by Sri Lankan Navy to re-asses the MSL of Sri Lanka (Figure 1). Kankesanthurai, Trincomalee, Oluvil, Hambantota, Galle, Colombo, Kalpitiya and Delft are the stations and continuous tidal data from each station was obtained for the year 2017 with the collaboration of Navy, National Hydrographic Office and Sri Lanka Ports Authority. However, out of the above eight tidal stations, only six stations were used in the final analysis as the data was inadequate (Oluvil and Delft stations).

Figure 1: Tidal Stations.

In the tidal analysis, first of all the date was re-formatted to be uploaded in to the analysis software TOTIS. Then, observations were filtered for outliers and harmonic analysis was carried out to determine the tidal character and the datum information of each station.

3. RESUTS

Table 1 shows the derived results from the tidal analysis. The tidal character information and the datum information are obtained for each station and compared. The ratios between the diurnal and semi diurnal components (form factor) of the stations were in the range of 0.2 to 0.5 and it indicated that the nature of the around Sri Lanka is mainly semi-diurnal. Further, the tidal range in Sri Lanka is fluctuating from 0.4 to 0.6 m. The largest tidal range observed at Colombo (0.6 m) and the lowest was at Kalpitya (0.37 m). The difference between the MSL on tide gauges and the LAT were varying between 0.34 m to 0.45 m around Sri Lanka. Kalpitiya is having the lowest value and Galle is having the largest. However, most of the other stations exhibit a uniform range about 0.4m. This indicates a slight variation East and West coast lines across the North South line of the country. The lower standard deviations (0.03 – 0.06 m) of the results reveal the accuracy of the results obtained and the performance of the software used.

Table 1. Results of the Tidal Analysis

	Colombo	Galle	Hambantota	Trincomalee	Kankesanthurai	Kalpitiya
Tidal Range	0.60	0.55	0.40	0.42	0.46	0.37
Form Factor	0.34	0.20	0.16	0.37	0.32	0.46
MSL from Zero Tide gauge	0.44	0.45	0.44	0.44	0.39	0.34
LAT	0.44	0.45	0.44	0.44	0.39	0.34
Standard Deviation	0.031	0.035	0.040	0.040	0.060	0.030

4. CONCLUSION

It is clear that the tidal environment around Sri Lanka does not exhibit a larger variation. It is more semi diurnal type and smaller in the range variation (0.4 to 0.6 m). This indicates a slight variation between of the Chart Datum around the country. The variability is slightly higher (0.44 m) in the East and West coasts, while North and South is having slightly less variations (0.35m). This might be due to the ocean circulation pattern induced by North East and South West monsoon.

Further, in recent years there has been a growing awareness of our coastal zones and the requirement to manage our marine spaces in a more structured and sustainable manner. But, the challenge is, there is an overlapping and conflicting interests covering this unique environment. The requirement is to provide seamless spatial data across the land /sea interface. A major impediment is that we do not have a consistent height datum across the land /sea interface. The ocean depths so called charted bathymetry or depths are referenced to Chart Datum which is usually the Lowest Astronomical Tide and land elevations or heights are referenced to a terrestrial vertical datum like Mean Sea Level. These different vertical datums result in inconsistent datasets and create considerable difficulties in amalgamating and analysing data from the coastal zone. The solution lies in developing a separation model which users can use to transform between different vertical datums. With that, we would be able to better manage height datum issues in the coastal zones and also in the land area.

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ACKNOWLEDGEMENT

Here, the researchers would like to express their appreciation to the National Science Foundation of Sri Lanka in funding this research. Without this financial support, this study would not be able to complete in this extent. Apart from that, our sincere gratitude to Sri Lanka Navy, National Hydrographic Office and Sri Lanka Ports Authority in providing the tidal data.

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