Grid Search Based SVM Approach for Sea Level Rise

S.K.Pramada, O Archana Sajith, S Sithara and Santosh G Thampi

1 Assistant Professor, Department of Civil Engineering, NIT Calicut, Kerala, India
2 Former M.Tech Student, Department of Civil Engineering, NIT Calicut, Kerala, India E-mail: pramada@nitc.ac.in
3 Research Scholar, Department of Civil Engineering, NIT Calicut, Kerala, India Email: pramada@nitc.ac.in

Abstract. Sea level rise is one of the most damaging impacts of climate change. Rising sea levels leads to loss of coastal wetlands, coastal flooding, degradation of coastal ecosystem, sinking of islands and general loss of quality of life. Countries which are located in low-lying areas as well as small islands are concerned that their land areas would be decreased due to inundation and coastal erosion. In this paper, a hybrid wavelet and grid search based support vector machine was used for statistical downscaling of sea level using climatic variables. The results of the hybrid model were compared with the observed sea level data and the results indicate that the hybrid wavelet and grid search based support vector machine can be used for future sea level projection. Thus the effect of sea level rise on low lying island can be studied with the model.

1. Introduction

In the present scenario drastic changes are occurring to Earth surfaces, processes and Earth's environmental status. Sea-level rise (SLR) due to climate change is a serious global threat. Human activities such as burning coal and oil and cutting down tropical forests increase atmospheric concentrations of heat-trapping gases. The result is that the planet has already warmed by 1.4°F since 1880 [1]. Global warming is the main contributor to the rise in global sea level since the Industrial revolution. Between 1901 and 2010 the global mean sea level rise was 1.7 mm/year and Between 1993 and 2010, the rate was very likely higher at 3.2 mm/year [2]. Unfortunately, many large cities are located on coastlines that are particularly vulnerable to sea level rises. The main reason accounted for the sinking of many islands include sea level rise. The islands that sunk includes Solomon islands which is composed of 33 reef islands in the Pacific ocean, Maldives surrounded by the Indian ocean, Micronesia which is a Pacific island, Kiribati which is a Pacific atoll, Palau which is an island country located in the western Pacific Ocean. Island Mauji in Assam, Andaman Nicobar islands, Lohachara island located near the Indian state of West Bengal. The main reason for sinking mentioned in literatures was the sea level rise in the low lying areas. A few studies have conducted on the effect of sea level rise in low lying islands [3-4]. Around the globe, the sea level changes is not uniform. Some areas experience greater rise than others because of localized effects such as local terrain factors, local hydrological factors, and oceanic currents etc A few studies have already been done on sea level changes locally and globally [5-7]. Improvements in modelling have made it possible for the expected sea level rises in specific locations to be mapped. The main objectives of this study is to model sea level rise using grid search based support vector machine (SVM) to understand the effect of sea level rise on an island.
2. Study area and data collection

The study area selected is Munroe Island. Munroe island lies between North latitudes 8°58’ & 9°00’. East longitudes 76°35’ & 76°37’ and is present at the confluence of Ashtamudi lake and Kallada river. The island is named after one of the most popular administrators of Travancore state, Colonel John Munroe. The island spreads over an area of 13.4 Km² and has around 10380 people residing on it [8]. The island village is a tourism destination. However, now the island is at a different spectacle. Low-lying areas of the Island are now under a threat of Submerging in high tides. The study is shown in Fig.1.

![Study area map](image)

**Figure 1.** Study area.

In order to model sea level changes and study the effect of sea level rise on the island the data regarding sea surface temperature, sea surface pressure, precipitation, salinity, downwards solar radiation at surface, downward UV radiation at the surface and evaporation are retrieved from ECMWF (European Centre for Medium-Range Weather Forecasts). Also, data regarding sea level rise and sea surface salinity was obtained from Copernicus Marine Environment Monitoring services (CMEMS). The data were downloaded for the period of 1-1-1993 to 31-12-2015 in the form of NetCDF format.
3. Methodology
The first phase is the data collection. As the data is obtained in the NetCDF format, it needs to be extracted using ArcGIS. Then correlation analysis of the data is performed and most correlated variables is identified. Monthly data from 1-1-1993 to 31-12-2015 was used for performing correlation analysis. Then Wavelet based denoising technique is performed for the data. The past data is trained and tested using support vector machine in R. Optimization of the parameters is done using grid search method.

3.1. Wavelet analysis
Wavelet analysis (also called wavelet theory or just wavelets) has attracted much attention recently in signal processing. It has been successfully applied in many applications such as transient signal analysis, time series signal analysis, communication systems and other signal processing systems [9]. Wavelet analysis is carried out with the help of wavelets which are generated in the form of translations and dilations of a fixed function called mother wavelet. The wavelets obtained in this way have special scaling properties. Wavelets transform are effectively used in data compression and de-noising such as in signal and image compression and de-noising. One of the advantages of wavelets method is that there exist fast algorithm in order to use wavelet for various applications.

3.2. Grid search based support vector machine
Support Vector Machine (SVM) is one of the most eye-catching predicting methods used in latest years. A support vector machine performs classification or regression tasks by forming a hyper plane or set of hyper planes in a high or infinite dimensional space. SVM regression algorithms work like SVM classification algorithms, but are modified to be able to predict a continuous response, Instead of finding a hyper plane that separates data, SVM regression algorithms find a model that deviates from the measured data by a value not greater than a small amount. Grid-search is a way to select the best of a family of models, parametrized by a grid of parameters. Grid Search; systematically works through multiple combinations of parameter tunes, cross validate each and determine which one gives the best performance. The various parameters used for developing the model in SVM is gamma, epsilon and cost parameter.

4. Results and discussion
Analysis was done to study the past sea level changes in the study area. To study the effect of Tsunami, the past sea level data (Source: Global Ocean Physics Reanalysis (GLORYS2V4), Copernicus Marine Environment Monitoring Service) was used. Fig.2 and Fig.3 show the sea surface height plotted before December 2004 and after December 2004. From Fig.2 it is clear that there is very small change in the sealevel before Tsunami and the rise was found to be 0.16 mm/year whereas after Tsunami the rise was found to be 3.4 mm/year (Fig.3).
From the correlation analysis, most influencing variables, which influence the sea level were identified and found to be mean sea level pressure, sea surface salinity and sea surface temperature. Preparation of data for training the SVM was done using wavelet based denoising technique. The de-noising process can be described as the process to remove the noise while retaining the quality of processed signal. For this study Daubechies wavelet is used as it is the basic wavelet. The comparison of original and denoised data for the input variables namely mean sea level pressure, sea surface salinity and sea surface temperature are plotted and is shown in Fig.4 to Fig.6.
**Figure 4.** Comparison of original and de-noised Mean sea level pressure.

**Figure 5.** Comparison of original and de-noised Sea surface salinity.
The de-noised data was used for training and testing SVM. Here in this study 75% of the data is given as training data (1993-2010) and 25% of the data is given as testing data in SVM. The model parameters were optimised with Grid search method. The epsilon and cost parameters were obtained as 0.1 and 70 respectively. Fig.7 shows the actual data predicted data. The RMSE value obtained was 0.053.

**Figure 6.** Comparison of original and de-noised Sea surface temperature.

**Figure 7.** Graph showing variation of actual and predicted SSH.
5. Conclusions
The impact of sea level rise is not felt equally around the globe. Some locations experience greater rise than others because of local terrain, local hydrological factors, and oceanic currents and other regional factors. This study focuses on modeling sea level rise in an Island using grid search based support vector machine. The variables affecting the sea surface height was considered and correlation test was performed and it was found that sea surface temperature, sea surface pressure, sea surface salinity have greater influence on sea surface height. The input data was de-noised using wavelet based de-noising technique. The parameters of Support vector machine were optimised with Grid search method. Sealevel change before and after tsunami in the region was found to be 0.16 mm/year and 3.4 mm/year respectively.

6. References
[1] Hansen J, Ruedy R., Sato M. and K. Lo. 2010 Global surface temperature change. NASA Goddard Institute for Space Studies, New York
[2] IPCC, 2018 WG1AR5_Chapter13. Assessment Report of the Intergovernmental Panel on Climate Change
[3] Simon Albert, JavierXLeon, Alistair R Grinham, JohnAChurch, Badin R Gibbes and ColinDWoodroffe, 2016, Environmental research letters, Interactions between sea-level rise and wave exposure on reef island dynamics in the Solomon Islands.
[4] Stylianos M. Simaiakis, Kenneth F. Rijsdijk, Erik F.M. Koene, Sietze J. Norder, John H. Van Boxel, Paolo Stocchi, Cyril Hammoud, Konstantinos Kougiooumoutzis, Elisavet Georgopoulou, Emiel Van Loon, Kathleen M.C. Tjorve, Even Tjorve, 2017, Palaeogeography, Palaeoclimatology, Palaeoecology, Geographic changes in the Aegean Sea since the Last Glacial, 108-119.
[5] Maddah H A 2016 Modeling the relation between carbon dioxide emissions and sea level rise for the determination of future ( 2100 ) sea level. American Journal of Environmental Engineering, 6(2), 52–61
[6] Li Y , Zuo J., Lu Q, Zhang H. and Chen M. 2016 Impacts of wind forcing on sea level variations in the East China Sea: Local and remote effects. Journal of Marine Systems, 154, 172–180
[7] Nerem R. S, Beckley B D, Fasullo J T, Hamlington B D, Masters D and Mitchum G. T. 2018 Climate-change-driven accelerated sea-level rise detected in the altimeter era. Proceedings of the National Academy of Sciences.
[8] https://censusindia.gov.in/2011census/dchb/3213 PART B KOLLAM.pdf.
[9] Daniel T.L. Lee, Akio Yamamoto 1994 Wavelet Analysis: Theory and Applications. Hewlett- Packard Journal, Reading.