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A Survey on the Significant Wave Height of the Ocean Using Soft Computing Techniques

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Abstract: The applications of information technology as a continuous process of monitoring the various ocean parameters such as salinity, temperature, the number of waves, the movement of fish, soil and turbidity. However, there is a sporadic attempt in assessing the wave heights which is one of the important parameters to project the roughness of the sea and the smoothness of the sea bed. Once a boat man understands the expected level of wave height, he can maneuver the vessel safely particularly while crossing over the bar. In view of the deficiency in deriving the significant wave heights directly from the ocean satellites the researcher has planned to evaluate the same from the satellite imagery.

Key words: Significant wave height · Satellite imagery · Buoy datasets

INTRODUCTION

The main objective is to determine the method of significant wave height duly extracting, correlating and comparing the measurements of the other ocean parameters obtained from ocean satellite images. The various inputs extracted from the satellite imagery are compared and validated with the actual waves of data recorded from the study area and to predict the expected and anticipated potential raise in sea waves which would enable the marine community to forecast the future in sea climate changes.

Khedouri and Szczechowski (1983) had practiced purely statistical relationship between subsurface temperature files and sea temperature[1]. They had applied empirical orthogonal function analysis of ocean's subsurface, thermal and brought out relationships between dynamic height and of the first two vertical nodes. Chuetal (2000) had used this model for assessing ocean subsurface temperature profiles between sea surface temperature and subsurface thermoclime bottom depth and thermoclime temperature gradient [2]. Not limited but also used in many fields like speech recognition, sonar signal processing and in automated target recognition. (Chin *et al*, 1998) [3].

Ajith Abraham *et al*, (2001) applied satellite information through soft computing models for weather forecasting. They have taken rainfall as one of the parameters for prediction even though it is complex in view of the involvement of multi-parameters. It integrates the various parameters and calculates the required data. The other mode, it is highly time consuming and difficult. Because of that, he has gone for soft computing methods like neural networks and neural fuzzy. The soft computing technique is based on the training data and learning method of back propagation model. Thus, the accuracy of the data is left to the visual guess of the commercial shipping stage.

Wherever data of information is incomplete or missing, at that time back propagation method will help us. It assists to get the correct solution. The interpretation about the data classification, decision is carried out by the output of the back propagation method. It is also a straight forward method of reducing the errors in case of predictions.[4]

Romaine *et al*, (2007) uses Artificial Neural Network for its ability to generalize results from unseen data and well suited in modeling dynamic system for real-time base [5]. This property of Artificial Neural Network is suitable to forecast water level and missing precipitation as their physical relations are not well understood.

The multi, hyper-spectral images from satellites can be useful for various predictions like analysis of forest cover changes and even to detect forest fire. Ocean color changes can be useful in predicting the damages caused by oil spills and changes in ocean ambient. Real-time changes in any climatic conditions can be predicted automatically and reported.

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Preliminary Study: Baxevani *et al*, (2008) showed the Significant wave height (H sub(s)) was a measure of the variability of the ocean surface, from knowing the spatial and temporal characteristic operations [6]. The method was based on the Gaussian hypothesis for the logarithms and consists of estimating the mean and the covariance structure of log (H sub(s)) using the information provided by the total variation and the data used by them were those of the TOPEX-Poseidon satellite.

The well-known models which were still in use were validated by Muraleedharan *et al*, (2006) [7] (Wam, Swan and Nested-Swan models) predicted significant wave height data using the new triple collocated statistical method, suggests that the predicted values are sufficiently accurate when compared with the buoy measurements. The Wam and Nested-Swan significant wave height estimations gave significant positive correlation with deep and shallow water buoy measurements, respectively. The linear regression (LR) method was inconsistent and the new method (Functional Relationship, FR) paved way for estimating the variability of the errors in measuring and predicting the physical truth (here significant wave height). The larger the random errors, the larger were the deviations between FR and LR lines. The FR model lines aligned with the best fit-line (x=y) while comparing the model results and buoy measurements. Also the deviations of the data from the FR model lines were a minimum. FR model as compared to LR model was more realistic when the inherent error exists in both cases, measurement by instruments and model predictions.

Nelson (2005) used the buoy measurements acquired in deep waters for the assessment of significant wave height retrieved using the Max Planck Institute algorithm and estimated by the WAM wave model [8]. Employed two different methods in the analysis namely investigating the cross assignment of wave systems for wave data assimilation studies for reducing the amount of interpolated data and the two dimensional directional spectra retrieved from SAR which is estimated by the WAM. In these approaches the statistics are very similar and the cross assignment is good.

Yan and Zhaohai (2005) [9] tested the SWAN model of the numeric forecast of the shallow water wave of the third generation and taken careful note of all the source functions in the Energy Balance Equation and at the same time better simulate the wave height both in near sea areas (shallow water) and complex areas were discussed in detail.

Muraleedharan *et al*, (2003) used the supremacy of Weibull distribution for ocean wave heights which were reaffirmed both logically and empirically using 10 years visually estimated wave height data. The conventional significant wave height was defined as the average of the one-third highest waves in a wave record. Kinsman (1965) pointed out that the significant wave is unreliable, as the number of waves is undefined [10]. Hence the significant wave height is redefined as the average of the highest one-third of a constant number of consecutive wave heights in a wave record. The characteristic function of the Weibull model was derived and the model was suggested for the simulation of the redefined significant wave height by the method of characteristic functions. An empirical support of 100.00% was established. Certain parameters of the redefined significant wave heights are derived such as mean maximum wave height, average of one-third highest wave height, extreme wave height and the return period of an extreme wave height and probability of realizing an extreme wave height at a time less than the designated return period. The redefined significant wave concept provided substantial advantage over the conventional concept in the modelling of wave heights and periods for climatological study.

Succession *et al*, (2003) applied linear stochastic models for the description of the evolution of the significant wave height time series [11]. Generalization of the Autoregressive Moving Average (ARMA) models as well, namely the Periodic Autoregressive Moving Average (PARMA) model was discussed. The difference between ARMA and periodically correlated (PC) models was that in the latter the model parameters varied periodically. Since the wave height time series seemed to satisfy all the prerequisites.

Dong *et al*, (2002) extended the short-term wave records, [12] by the statistical correlation model of wave heights between two close wave stations and established by using the Markov Chain theory. As a comparison result, the Markov Chain wave height correlation model had lower uncertainty results than the traditional regression model. The estimated errors were highly dependent on the wave height and wave category. For the interested high wave height, the error was less than 20%.

Mastenbroek *et al*, (1994) [13] showed the potential benefits from the assimilation of ERS-1 altimeter wave height measurements in a wave model of the North Sea. To estimate the accuracy of the satellite observations, the altimeter was validated against buoys in the North Sea.

Compared to these buoys the altimeter overestimated the height of waves lower than 2m and underestimates the height of higher waves. In the assimilation experiment, a two-step assimilation method was applied. First, the altimeter and model first-guess wave heights were combined by optimal interpolation. Then, the model was updated locally using the analyzed wave heights and the model first-guess spectrum.

Buoy observations were used to determine the quality of the analyzed wave fields. The experiment was done for a two month period in the winter 1991-92. A comparison of analyzing and observed spectra showed that, although the wave heights provided by the altimeter were more accurate than the model first-guessing, the analyzed spectra were no more real than the model first-guess spectra. In order to improve the scatter in analyzing wave fields, thereby, improving the skill of the wave forecast, the assimilation of spectral and directional information would be essential

Basu and Pandey (1991) applied Simulations of the return echo of a satellite altimeter from a rough ocean surface using an analytical formula and its sensitivity with respect to various oceanic and altimeter parameters studied [14]. Numerical experiments showed that for normally observed significant wave heights (SWH) the effect of off-nadir angle (ONA) up to 0.5 degrees on the leading edge. Also, small surface roughness skewness seemed to have little effect on the overall shape of the echo. Newton's iterative scheme was used to retrieve SWH from the mean return waveform without noise and with additive Gaussian noise typical of Seasat and Geosat altimeters. It was observed that SWH could be retrieved in the presence of noise with an accuracy of plus or minus 0.6 m for ONA less than 0.5 degrees. For higher ONA, accurate retrieval required the use of pre-computed look-up table along with the scheme.

Queffeulou (1983) using the SEASAT altimeter derived wave height ('on-board' estimate) had been successfully compared with ship reports over the North Atlantic Ocean, [15] for 163 passes of SEASAT, from September 15 to October 9, 1978. Satellite wave height measurements revealed features of great interest: first, SEASAT data were used to evaluate the spectral wave forecasting model, of the French Meteorological Office. Then, the analysis of 26 SEASAT passed through low-pressure areas showed the geographic distribution of strong sea states in storms and the large variation of wave height over short distances, an important observation for wave modelling and ship routing.

Thompson (1981) proposed a model based on a three-parameter Weibull distribution function was given for the long-term distribution of significant wave height. [16] The model, formulated in dimension-less terms, was believed to provide a more general representation than the corresponding models given in the Shore Protection Model (SPM). A procedure for using available data from a site to estimate model parameters is described. The procedure extends the use of available data and leads to a model which more closely follows the data than the procedures in the SQM. The procedure is applied to shallow-water gage data from Nags Head, North Carolina.

Pierson and Salfi (1979) showed a brief summary of some of the verification results for the spectral ocean wave model (SOWM) using Geos3 wave height measurements is given. A NASA contractor's report by Pierson and Salfi (1978) [17] carried the analyses of 44 Geos3 orbit segments for 1975 and 1976, from which significant wave heights were obtained as overlapping 20-s averages every 2 or 3 s from the altimeter data. The SOWM was the presently operational wave forecasting model of the Fleet Numerical Weather Central (FNWC).

The verifications were carried out for the specification (or hindcast) model that was, past meteorological data and wind fields derived there from were used to calculate the waves as opposed to forecasts of the wind fields. The major results were that the SOWM specifications were biased too low and that the large differences between what was measured by Goes3 and what the model gave could be attributed to poor specifications of the winds over the northern hemisphere oceans. These particular features of the SOWM had been recognized at FNWC by means of verifications by other means and the bias has been removed, although there are still problems connected with the lack of adequate wind data over the oceans.

Significant wave heights estimated from the shape of the return pulse waveform of the altimeter on GEOS-3 for 44 orbit segments obtained during 1975 and 1976 were compared with the significant wave heights specified by the spectral ocean wave model (SOWM), which is the presently operational numerical wave forecasting model of the Fleet Numerical Weather Central. Except for a number of orbit segments with poor agreement and larger errors, the SOWM specifications tended to be biased from 0.5 to l. 0 m too low and to have RMS errors of 1.0 to 1.4m. The much fewer larger errors could be attributed to poor wind data for some parts of the Northern Hemisphere oceans. The bias could be attributed to the somewhat too light winds used to generate the waves in the model. Other sources of error are identified in the equatorial and trade wind areas.

Jacob and Nielsen (2006) showed the significant wave height (SWH) observations from the Jason-1 satellite were compared against buoy observations and a spectral wave model for the North Sea/Baltic Sea [18] region. The comparisons were from the year 2005 and demonstrated that the satellite SWH observations were very consistent, with a mean bias of 0.07 m and a standard deviation of 0.36m when compared with boys. The error statistics had been derived for the individual buoys and a detailed validation of the wave model was carried out using the satellite observations. It was shown that the 20 Hz standard deviation of SWH could be used as an indicator of the quality of the observations and that a significant amount of near coastal observations could be obtained even within 10 km from the coast.

Solvsteen and Hansen (2006) proposed two operational wave models; Mike21OSW (OSW) and WAVEWATCH-III (WW3), [19] as running at the Royal Danish Administration of Navigation and Hydrography (RDANH) were validated against wave height observations from satellite altimeter and buoys. Furthermore, Hirlam E15 wind forecasts (from the Danish Meteorological Institute, DMI) have been compared with wind speed observations from satellite altimetry. Satellite data cached from ERS-2 and Topex/Poseidon. The validation period covered the 14months from 01-01-1999 to 29-02-2000. The validation area corresponded to the wave model areas, i.e. The central and eastern part of the North Sea, the Skagerak, the inner Danish waters and the western part of the Baltic Sea.

To understand the nature of work to be done in the proposed model, action has been taken only after discussing with the scientists who have done a similar work to other parameters like temperature, salinity, wave heights and waves tides. The researcher had sufficient discussion to prepare a research design with senior scientist working in NIO-Goa, NIOT-Chennai, ADRIN, NRSC and INCOIS –Hyderabad.[20] to [28].

The Scope: The scientific community introduced various means of software for exactly evaluating the status of ocean parameters. However, wave height could not be approached accurately in view of the lack of technology development in applying to couple altimeter data with remote sensing images. As the altimeter readings, the necessity of applying the values of the altimeter to remote-sensing data, it brings many complications, which need not arise in this calibration.

This estimation enables to assess the significant wave height, supposed to be an indirect parameter, as accurate as possible from the ocean satellite images. Measuring the height using altimeter is reported to be highly expensive and laborious. It enables the database to get an increase of accurate estimation, to obtain practice of automation, time saving, to enhance the knowledge of computational exposure, easy digitization and a better understanding on Physio-chemical parameters like temperature, salinity and density.

The outcome of the research data is going to be used by the naval department activities, which is adopted with various inputs particulars obtained from the ocean satellite projections are put together with the actual data collected through the laborious field work in the study area, correlated, integrated and inter-predicted to produce the results. The successful predictions of the significant wave height's data are the base made available in the cases of other oceanographic parameters, which may join with the wave height's tabulation, so as to enable the mariner to g*et al*l oceanic parameters in one stroke.

The important aspect of the research is to submit the possible heights in the port and filling up the gap levels wherever out fails to record the height. The port authorities can presume the wave height using the formula if they are capable of collecting the wave height if they can to allow the sailing of the small and medium vessels. If the significant wave height can be supplied well ahead for the fisherman, authorities of sea ports, the tourism department and so on. They can be availed the wave atlas for the planning of forthcoming activities. For the navigation of the submarines, these data will be used.

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