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A STUDY ON THE COMPARISON BETWEEN TWO DIFFERENT TIDE FORECASTING METHODS

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Abstract: In this study, a natural phenomenon tide has been predicted associated with the help of Discrete Fourier Transformation (DFT) and the storm surge model. There are some astronomical constituents has been used to forecast tide height approximately at some tide stations in Bangladesh. Tide generating forces are produced from the tidal potential which is derived from the idea of equilibrium tide. This work also associated with the comparison of tide heights form both the models. The comparison is capable of incorporating some stable data with a considerable accuracy. This comparison and the results are found to be satisfactory.

Key words: Numerical model, Storm surge, Tropical cyclone, Constituent, Fourier Transformation, Tide

1. Introduction

From the ancient era mankind are fascinated about the ocean not only for its prodigiousness but also for its bellowy surge. Innumerable kiss-curl has endless fluctuation. As sea level rises and falls, the edges of the tide slowly shifts landward and seaward daily, often destroying sand castles built during low tide. Knowledge of tides is important in many coastal activities, including tide pooling, shell collecting, surfing, fishing, navigation, and preparing for storms. Tides are so important that accurate records have been kept at nearly every port for several centuries. There is no doubt that early costal people noticed the tide yet the earliest written record of the tide is in about 450 B.C. Even the earliest sailors knew the moon had some connection with the tides; both followed a similar cycle, patterns. However a scientific explanation for the tidal phenomenon had to wait for Sir Isaac Newton and his universal theory of gravitation, which was published in 1687. He described in his “Principia Mathematica” how the tides arose from the gravitational attraction of the moon and sun on the earth. He also showed why there are two tides for each lunar transit, the reason why spring and neap tide occurred, why diurnal tides are largest when the moon was farthest from the plane of the equator and why the equinoxial tides are larger in general than those at the solstices. Thus the gravitational theory became established as the basis for all tidal science. Some important and useful references in tidal researcher: Moninet et al. [1], Phillips [2], and Turner [3]. Despite the appearance of the fundamental work by Whitham [4], Only a few fundamental publications are known which deal entirely with internal waves: Interne Wellen by Krauss [5]; Surface and Internal Waves [6] and Hydrodynamics of Surface and Internal Waves [7] by Cherkesov; Waves Inside the Ocean by Konyaev and Sabinin [8]; Munk’s Internal Waves [9] (an extensive literature review); and a more recent issue of Miropol’s sky’s Dynamics of Internal Gravity Waves in the Ocean [10].

In the present situation of this work a considerable work was done for the surge model. Some of them are Das [12], Dube et al. [13-14], Flierl and Robinson [15], Johns and Ali [16], Johns et al. [17-18] Roy [19-22]. According to Roy [19], but none of them can be use tide accurately. Rahman et al. [24], Paul and Ismail [23], first introduce the nonlinear interaction of tide and surge. The present study is the accuracy of both the models due to comparison.

2. Mathematical formulation

2.1 Discrete Fourier Transformation model

We first note that the data is sampled at $N$ equally spaced times
\[ t_n = n \Delta t, \quad n = 0, 1, \ldots, N - 1 \text{, where } \Delta t \text{ is the time increment. For a record length of } T, \text{ we have } \Delta t = \frac{T}{N}. \]  
We will denote the data at these times as \( y_n = y(t_n) \), so the DFT representation is

\[ y_n = \frac{1}{2} A_0 + \sum_{p=1}^{M} \left[ A_p \cos(\omega_p t_n) + B_p \sin(\omega_p t_n) \right], \quad n = 0, 1, 2, \ldots, N - 1. \]  

(1)

The trigonometric arguments are given by \( \omega_p t_n = \frac{2\pi pn}{N} \).

Note that \( p = 1, 2, \ldots, M \) thus allowing only for frequencies \( f_p = \frac{\omega_p}{2\pi} \frac{p}{T} \), or we can write \( f_p = p\Delta f \) for \( \Delta f = \frac{1}{T} \). We need to determine \( M \) and the unknown coefficients. As for the Fourier series, we will need some orthogonality relations, but this time the orthogonality statement will consist of a sum and not an integral. Let \( N \) equations for the unknown coefficients. Therefore, we should have \( N \) unknowns. For \( N \) samples, we want to determine \( N \) unknown coefficient \( A_0, A_1, \ldots, A_{N/2} \) and

\[ B_1, B_2, \ldots, B_{N/2-1}. \]  

Thus, we need to fix \( M = \frac{N}{2} \). Often the coefficients \( B_0 \) and \( B_{N/2} \) are included for symmetry. So we claim that the DFT coefficients are

\[ A_p = \frac{2}{N} \sum_{n=0}^{N-1} y(t_n) \cos \left( \frac{2\pi pn}{N} \right), \quad p = 1, 2, 3, \ldots, \frac{N}{2} - 1 \]  

(2)

\[ B_p = \frac{2}{N} \sum_{n=0}^{N-1} y(t_n) \sin \left( \frac{2\pi pn}{N} \right), \quad p = 1, 2, 3, \ldots, \frac{N}{2} - 1 \]  

(3)

\[ A_0 = \frac{1}{N} \sum_{n=0}^{N-1} y(t_n). \]  

(4)

The derivation of the coefficient for the DFT is now easily done using the discrete orthogonally.

\[ A_q = \frac{2}{N} \sum_{n=0}^{N-1} y(t_n) \cos \left( \frac{2\pi qn}{N} \right), \quad q \neq \frac{N}{2} \]  

(5)

\[ A_{\frac{N}{2}} = \frac{1}{N} \sum_{n=0}^{N-1} y(t_n) \cos \left( \frac{2\pi \frac{N}{2} n}{N} \right) = \frac{1}{N} \sum_{n=0}^{N-1} y(t_n) \cos \left( \frac{\pi n}{2} \right) \]  

(6)

Similarly, \( \sum_{n=0}^{N-1} y_n \sin \left( \frac{2\pi qn}{N} \right) \) \( q = 1, \ldots, N - 1 \), these can be expanded as

\[ \sum_{n=0}^{N-1} y_n \sin \left( \frac{2\pi qn}{N} \right) = \frac{2}{N} \sum_{p=1}^{M} A_p \sin \left( \frac{2\pi qn}{N} \right) + B_p \cos \left( \frac{2\pi qn}{N} \right) \]  

\[ \sum_{p=1}^{M} \left[ A_p \cos \left( \frac{2\pi qn}{N} \right) + B_p \sin \left( \frac{2\pi qn}{N} \right) \right] \sin \left( \frac{2\pi qn}{N} \right) \]  

\[ \sum_{p=1}^{M} \left[ A_p + B_p \frac{2\pi}{N} \delta_{q,p} \right] \]  

\[ \frac{1}{2} B_{qN}. \]  

(7)

Where, \( B_q = \frac{2}{N} \sum_{n=0}^{N-1} y(t_n) \sin \left( \frac{2\pi qn}{N} \right) \),

(8) \( q = 1, \ldots, N - 1 \).

Thus, finally,

\[ y_n = \frac{1}{2} A_0 + \sum_{p=1}^{M} \left[ A_p \cos \left( \frac{2\pi qn}{N} \right) + B_p \sin \left( \frac{2\pi qn}{N} \right) \right] \quad n = 0, 1, \ldots, N - 1 \]  

(9)

using the Harman[11] algorithm, we may found the tide height in our desire tide station.

\[ \gamma(t) = \frac{1}{2} A_0 + A_1 \cos(\omega_1 t) + B_1 \sin(\omega_1 t) + A_2 \cos(2\omega_1 t) + B_2 \sin(2\omega_1 t) \]  

(9)

where, the speeds \( \omega_1 \) and \( \omega_2 \) are known. To predict tide height, we need to calculate the coefficients \( A_0, A_1, A_2, B_0, B_1, B_2 \). These can be
done easily by using equations (1), (2), (3), (4) and (9).

2.2 Storm Surge Model

The governing equations is

\[ \frac{\partial \xi}{\partial t} + \frac{\partial \tilde{u}}{\partial x} + \frac{\partial \tilde{v}}{\partial y} = 0 \]  \hspace{1cm} (10)

or, \[ \frac{\partial \tilde{u}}{\partial t} + \frac{1}{\rho} \frac{\partial \tilde{u} \tilde{u}}{\partial x} + \frac{1}{\rho} \frac{\partial \tilde{v} \tilde{u}}{\partial y} - \tilde{f} \tilde{v} \]

\[ -g(\xi + h) \frac{\partial \tilde{z}}{\partial x} + \frac{T_c}{\rho} - \frac{C_f u^2 + v^2}{(\xi + h)} \]  \hspace{1cm} (11)

As well as the boundary condition is given by equation

\[ u + \left( \frac{g}{h} \right)^{\frac{1}{2}} \xi = 0 \]  \hspace{1cm} (i)

\[-u - \left( \frac{g}{h} \right)^{\frac{1}{2}} \xi = 0 \]  \hspace{1cm} (ii)

\[-v - \left( \frac{g}{h} \right)^{\frac{1}{2}} \xi = -2 \left( \frac{g}{h} \right)^{\frac{1}{2}} \sin \left( \frac{2\pi}{T} + \phi \right) \]  \hspace{1cm} (iii)

These equations are discretized by finite difference (forward in time and central in space) by considering the discrete points in the xy-plane define by

\[ x_i = (i - 1)\Delta x, \hspace{0.5cm} i = 1, 2, \ldots, m(\text{even}) \]

\[ y_j = (j - 1)\Delta y, \hspace{0.5cm} j = 1, 2, \ldots, n(\text{odd}) \]

where, \( \Delta x \) and \( \Delta y \) are grid increments. A sequence of time instants is defined by \( t_k = k\Delta t, \hspace{0.5cm} k = 1, 2, 3, \ldots \), where \( \Delta t \) represent the increment in time, the grid must be \( m \) (even) and \( n \) (odd) respectively.

The details of the finite difference method are as follows:

Any variable \( \xi \) at a grid point \((i, j)\) at time \( t_k \) is represented by

\[ \xi(x_i, y_j, t_k) = \xi^k_{i,j} \]

\[ \frac{\partial \xi}{\partial t} = \frac{\xi^k_{i,j} - \xi^{k+1}_{i,j}}{\Delta t} \]  \hspace{1cm} (13)

\[ \frac{\partial \xi}{\partial x} = \frac{\xi^{k}_{i+1,j} - \xi^{k}_{i,j}}{2\Delta x} \]  \hspace{1cm} (14)

\[ \frac{\partial \xi}{\partial y} = \frac{\xi^{k}_{i,j+1} - \xi^{k}_{i,j-1}}{2\Delta y} \]  \hspace{1cm} (15)

Averaging operations (for any variable \( U \)) are defined as

\[ \overline{U^x_{i,j}} = \frac{U^k_{i+1,j} + U^k_{i-1,j}}{2}, \hspace{1cm} \text{[From equation (13)]} \]

\[ \overline{U^y_{i,j}} = \frac{U^k_{i,j+1} + U^k_{i,j-1}}{2}, \hspace{1cm} \text{[From equation (14)]} \]

And \[ \overline{U^{xy}_{i,j}} = \frac{U^k_{i+1,j+1} + U^k_{i+1,j-1} + U^k_{i-1,j+1} + U^k_{i-1,j-1}}{4} \]

Also, the last term in the right of each of Eq. (10) and (11) is discretized in a manner so that the scheme becomes semi-implicit in nature for example, from Eq. (12) the term \( \tilde{u} \sqrt{(u^2 + v^2)} \) is discretized as \( \tilde{u}^{k+1} \sqrt{(u^2 + v^2)} \), where the subscript \( k+1 \) indicates that \( \tilde{u} \) is to be evaluated in advanced time level. Thus the finite-difference form of the Eq. (10) can be written as follows:
\[ \xi_{i,j}^{k+1} = \xi_{i,j}^{k} - \Delta t [TL1 + TL2] \]

Where

\[ TL1 \left( \frac{u_{i+1,j}^{k} - u_{i-1,j}^{k}}{2\Delta x} \right) \]

\[ TL2 \left( \frac{v_{i,j+1}^{k} - v_{i,j-1}^{k}}{2\Delta y} \right) \]

In Equation (10) \( \xi_{i,j}^{k+1} \) can be computed at \( i = 2, 4, 6, \ldots, M - 2 \). And \( j = 3, 5, 7, \ldots, N - 2 \).

The finite difference from of equation (11) can be written as,

\[ \Rightarrow \tilde{u}_{i,j}^{k+1} - \Delta t ((TR1 + TR2) - (TL1 + TL2 + TL3)) \]

\[ = \tilde{u}_{i,j}^{k} - \Delta t (1 + FR3) \Delta t \]

Now we let,

\[ TL1 \left( \frac{U_{i+1,j}^{x} - U_{i-1,j}^{x}}{2\Delta x} \right) \]

\[ TL2 \left( \frac{\tilde{V}_{i,j+1}^{x} - \tilde{V}_{i,j-1}^{x}}{2\Delta y} \right) \]

\[ TL3 \left( \tilde{f}_j \tilde{u}_{i,j} \right) , \]

\[ TR1 \left( -g(\xi_{i,j}^{k+1} + h_{i,j}) \frac{\xi_{i,j}^{k+1} - \xi_{i,j}^{k-1}}{2\Delta y} \right) , \]

\[ TR2 \left( \frac{\tau_{y}}{\rho} \right) , \]

\[ FR3 \left( \frac{C_f}{\xi_{i,j}^{k+1} + h_{i,j}} \right) \]

Averaging operations for any variable \( U \) are defined as

\[ U_{i,j}^{x} = \frac{U_{i-1,j}^{k} + U_{i+1,j}^{k}}{2}, \quad U_{i,j}^{y} = \frac{U_{i,j-1}^{k} + U_{i,j+1}^{k}}{2}, \quad \text{an} \]

\[ \text{d}U_{i,j}^{xy} = \frac{U_{i,j}^{x} - U_{i,j}^{y}}{2} \]

For example, from Eq. (12) the term \( \tilde{u} \sqrt{u^2 + v^2} \) is discretized as \( \tilde{u}_{i,j}^{k} = \sqrt{(\tilde{u}_{i,j}^{k})^2 + (\tilde{v}_{i,j}^{k})^2} \), where the subscript \( k+1 \) indicates that \( \tilde{u} \) is to be evaluated in advanced time level. Thus the finite-difference approximated form of the Eq. (10) is as follows:

\[ \xi_{i,j}^{k+1} = \xi_{i,j}^{k} - \Delta t [TL1 + TL2] \quad (16) \]

where, \( TL1 \left( \frac{u_{i+1,j}^{k-1} - u_{i-1,j}^{k-1}}{2\Delta x} \right) \) and

\[ TL2 \left( \frac{v_{i,j+1}^{k-1} - v_{i,j-1}^{k-1}}{2\Delta y} \right) \]

\( \xi_{i,j}^{k+1} \) in Eq. (17) is computed at \( i = 2, 4, 6, \ldots, M - 2 \). And \( j = 3, 5, 7, \ldots, N - 2 \).

Similarly, the finite-difference form of the Eq. (12) as follows

\[ \tilde{v}_{i,j}^{k+1} = \tilde{v}_{i,j}^{k} - \Delta t ((TR1 + TR2 + TL3) + \Delta t (TR1 + TR2)) \]

\[ \text{(17)} \]

where, \( TL1 \left( \frac{\tilde{u}_{i+1,j}^{k-1} - \tilde{u}_{i-1,j}^{k-1}}{4\Delta x} \right) \),

\[ TL2 \left( \frac{\tilde{v}_{i,j+1}^{k-1} - \tilde{v}_{i,j-1}^{k-1}}{2\Delta y} \right) \]
\[ TL3 = -f_i\tilde{v}_{i,j} \]
\[ TR1 = -g \left( \zeta_{i,j} + h_{i,j} \right) \frac{\zeta_{i,j+1} - \zeta_{i,j-1}}{2\Delta x} \]
\[ TR2 \frac{\tau_x}{\rho} \]
\[ FR3 \frac{C_f}{\zeta_{i,j} + h_{i,j}} \left( \sqrt{U_{i,j}^k + V_{i,j}^k} \right)^2 \]
\[ \tilde{\tilde{v}}_{i,j}^{k+1} \text{ in Eq. (18) is computed at } i = 2, 4, 6, \ldots, M - 2 \text{ and } j = 2, 4, 6, \ldots, N - 1 \]

From the boundary conditions the elevations at \( j = 1, j = N \) and \( i = M \) are computed respectively in the following manner.

\[ \zeta_{i,1} = \zeta_{i,3} - 2\sqrt{h_{i,3} / g} \quad V_{i,2}^k \]  \( \ldots \) (19)
\[ \zeta_{i,N} = \zeta_{i,N-2} + 2\sqrt{h_{i,N-1} / g} \quad V_{i,N-1}^k \]  \( \ldots \) (20)
\[ \zeta_{u,j} = \zeta_{u,j+2} + 2\sqrt{h_{u,j+1} / g} \ U_{u,j}^k + 4a \sin \left( \frac{2\pi k}{T} \right) \]  \( \ldots \) (21)

Where, \( i = 2, 4, 6, \ldots, M - 2 \) and \( j = 1, 3, 5, 7, \ldots, N \)

Along the northeast corner of the VFMS, river discharge is considered. To take into account river discharge, velocity component \( bU \) at a grid point \((1, j)\) is computed from the river discharge condition in the following way:

\[ (U_b)_{1,j}^{k+1} = U_{3,j}^{k+1} + \frac{Q}{B \left( \zeta_{3,j} + h_{3,j} \right)} \]  \( \ldots \) (22)

The initial values of \( \xi, u \) and \( v \) are taken as zero. The time step is taken as 60 seconds that ensures stability of the numerical scheme. In the solution process, the values of the friction coefficient \( C_f \) and the drag coefficient \( C_D \) are taken uniform throughout the physical domain, which are 0.0026 and 0.0028 respectively.
3. Result and discussion

We opine based on our research that the observed result and the model results are in good agreement. The following figure represents the agreement accuracy.

Figure 1. shows the tidal data agreement at Chittagong at the time of 28 April to 30 April 1991

Figure 1: Combined data representation at Chittagong tide station

Figure 2: Data representation at Chittagong tide station for DFT analysis data

Figure 3: Data representation at Chittagong tide stations observed data

Figure 4: Comparison represent at Coxbazar tide station.

Figure 5: Data representation at Coxbazar tide station for DFT

Figure 6: Data representation at Coxbazar tide station for surge model data

Figure 7: Data representation at Coxbazar tide station observed data
4. Conclusion

After finishing all discussion we may conclude that the results are found to be satisfactory and make a good agreement with observed data. We have used two models for compute tide at two different tide stations in Bangladesh. First model is surge model and other one is harmonic analysis. The first model is capable of incorporating bending of the coastline and island boundaries with a considerable accuracy and the second model justify the amplitude and phase of tide. Finally the model data and observed data make us satisfactory output.

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Digital Environment in University Libraries: Challenges and Opportunities

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Abstract: The latest developments in Information and Communication Technology (ICT) have made the concept “Libraries without walls” into a practical reality. This has posed several challenges to the information workforce and the information users. Developments in computers, microelectronics and communication technologies have dramatically changed the library and information environment. In this regard, the information environment is changing greatly throughout the world. Digital libraries are emerging as an important area of research and number of other related disciplines for information science in information age. The information technology has made a profound impact on availability and accessibility of e-resources. The concept of digital libraries and its objectives in university digital system and challenges has been discussed in digital libraries environment. This research paper is highlighted infrastructure and technology as challenges facing and parameters of digital environment. With the application of IT university libraries could gradually overcome such challenges and opportunities in consideration of users’ perspective. University librarians are facing difference challenges which have been focused in this study. It is also mentioned users’ expectation and requirements for digital environment in university libraries. The paper focuses its opportunities in digital environment in university libraries.

Keywords: Digital Environment, Challenges, Opportunities and Infrastructure, Accessibility.

1. Introduction

Digital libraries are emerging as an important area of research and number of other related disciplines for information science in information age. The information technology has made a profound impact on availability and accessibility of e-resources. As we are approaching the new millennium, we can look back and last decade has been characterized by the development of the new information sources known as digital libraries, libraries without walls or virtual libraries. The foundation of these new information sources is human knowledge organized according to some principle in form of digital collections. These digital collections can be later used in a local environment for various purposes (mostly for education) and eventually grow in size and combine into larger clusters of knowledge with other local collections thus creating global network of knowledge.

Furthermore, recent scientific works agree upon the fact that the future of the knowledge organization will be in form of highly organized structures of knowledge, based on indexed digital collections. On the local level such knowledge structures will share their resources by use of local area networks, while on the global level they will probably use the Internet which has already become a new paradigm for interconnectivity among various information sources in the world today. As it is self-evident, during the last few years, the explosive growth of the Internet has given immense contribution to the development of digital collections by giving opportunity to authors of such collections to communicate and share their experiences with their colleagues around the world thus creating another type of global network, network of experience and specific problem solving knowledge applicable to the creation of future knowledge structures.

2. Review of Related Literature

There is no sole explanation for digital libraries. The definition evolves as research progresses. Within the context of libraries, digital libraries may be viewed as technical services performed electronically with an entirely electronic application. The e-libraries are “a set of electronic resources and associated technical