KCIS APPs

Global Hydrodynamic's Prediction

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Prediction of tidal variations in water level is of importance in a wide range of practical applications such as: Navigation through inter-coastal waterways, and within estuaries, bays, and harbors; fishing, etc. This report provides a brief review of the basic theory for tidal prediction, an overview of how this theory is implemented, a step-by-step guide for developing and using a tidal prediction model.

KCIS Model is a general-purpose, state-of-the-art water levels prediction model. It is capable of estimating the water level variation due to tides at a number of stations in the Global waters. The KCIS model was validated with other model for water levels prediction it was and found to provide good results as shown in this report.

Introduction

The word "tides" is a generic term used to define the alternating rise and fall in sea level with respect to the land as shown in Fig 1, produced by the gravitational attraction of the moon and the sun. To a much smaller extent, tides also occur in large lakes, the atmosphere, and within the solid crust of the earth, acted upon by these same gravitational forces of the moon and sun. Additional nonastronomical factors such as configuration of the coastline, local depth of the water, ocean-floor topography, and other hydrographic and meteorological influences may play an important role in altering the range, interval between high and low water, an times of arrival of the tides.

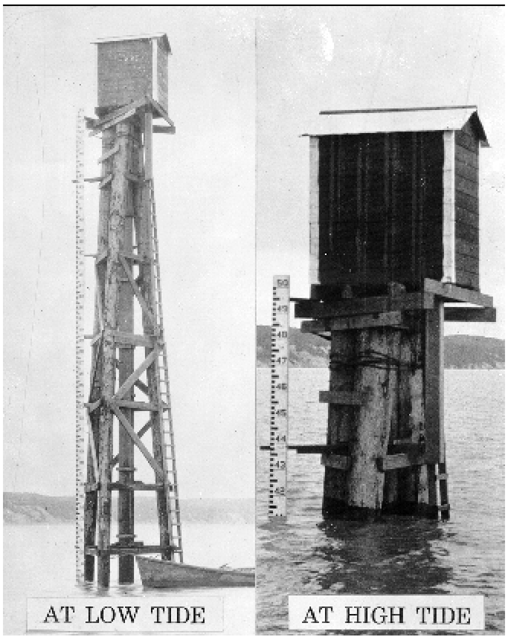

Fig. 1.Tide Gauge

The most familiar evidence of the tides along our seashores is the observed recurrence of high and low water – usually, but not always, twice daily. The term tide correctly refers only to such a relatively short-period, astronomically induced vertical change in the height of the sea surface (exclusive of wind-actuated waves and swell); the expression tidal current relates to accompanying periodic horizontal movement of the ocean water, both near the coast and offshore (but as distinct from the continuous, stream-flow type of ocean current). Knowledge of the times, heights, and extent of inflow and outflow of tidal waters is of importance in a wide range of practical applications such as the following: Navigation through inter-coastal waterways, and within estuaries, bays, and harbors; work on coastal engineering projects, such as the construction of bridges, docks, breakwaters, and deep-water channels; the establishment of standard chart datum's for hydrograph and for demarcation of a base line or "legal coastline" for fixing offshore territorial limits both on the sea surface and on the submerged lands of the Continental Shelf; provision of information necessary for underwater demolition activities and other military engineering uses; and the furnishing of data indispensable to fishing, boating, surfing, and a considerable variety of related water sport activities (Harris, D. L., 1965).

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Literature

Tide Producing Forces

The tide-raising forces at the earth's surface result from a combination of basic forces: (1) the force of gravitation exerted by the moon (and sun) upon the earth; and (2) centrifugal forces produced by the revolutions of the earth and moon (and earth and sun) around their common center-of-gravity (mass) or barycenter. The effects of those forces acting in the earth-moon system will be discussed, with the recognition that a similar force complex exists in the earth-sun system (Stacey, F., 1969).

With respect to the center of mass of the earth or the center of mass of the moon, the above two forces always remain in balance (i.e., equal and opposite). In consequence, the moon revolves in a closed orbit around the earth, without either escaping from, or falling into the earth - and the earth likewise does not collide with the moon. However, at local points on, above, or within the earth, these two forces are not in equilibrium, and oceanic, atmospheric, and earth tides are the result

The center of revolution of this motion of the earth and moon around their common center-of-mass lies at a point approximately 1,068 miles beneath the earth's surface, on the side toward the moon, and along a line connecting the individual centers-of-mass of the earth and moon as shown in Fig. 2. The center-of-mass of the earth describes an orbit (E1, E2, E3..) around the center-of-mass of the earth-moon system (G) just as the center-of-mass of the moon describes its own monthly orbit (M1, M2, M3..) around this same point.

1. The Effect of Centrifugal Force. It is this little known aspect of the moon's orbital motion which is responsible for one of the two force components creating the tides. As the earth and moon whirl around this common center-of-mass, the centrifugal force produced is always directed away from the center of revolution. All points in or on the surface of the earth acting as a coherent body acquire this component of centrifugal force. And, since the center-of-mass of the earth is always on the opposite side of this common center of revolution from the position of the moon, the centrifugal force produced at any point in or on the earth will always be directed away from the moon. This fact is indicated by the common direction of the arrows (representing the centrifugal force Fc) at points A, C, and B in Fig. 2, and the thin arrows at these same points in Fig. 3.

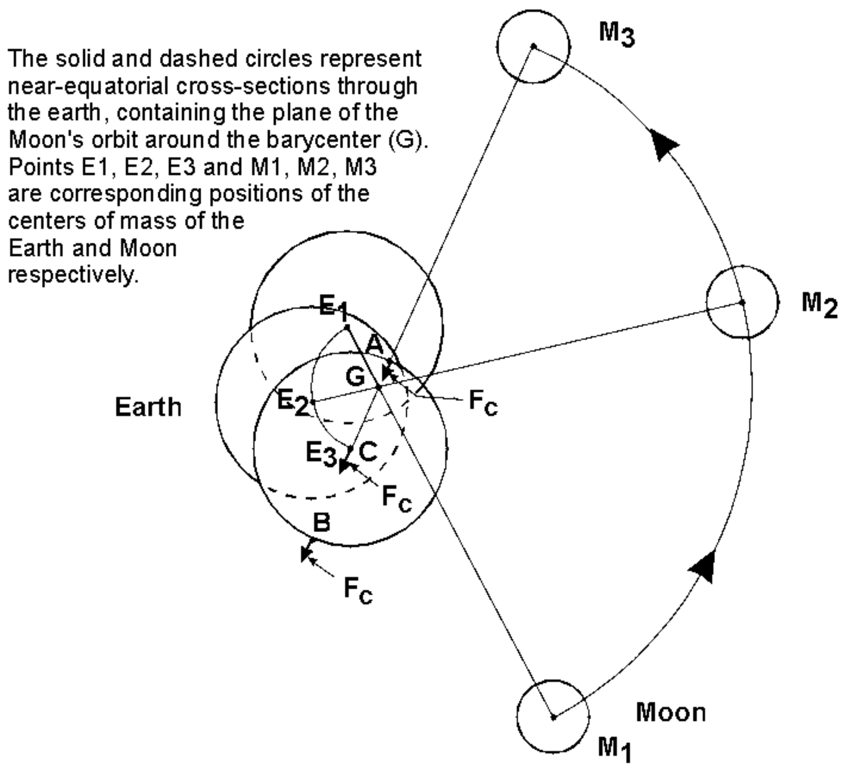
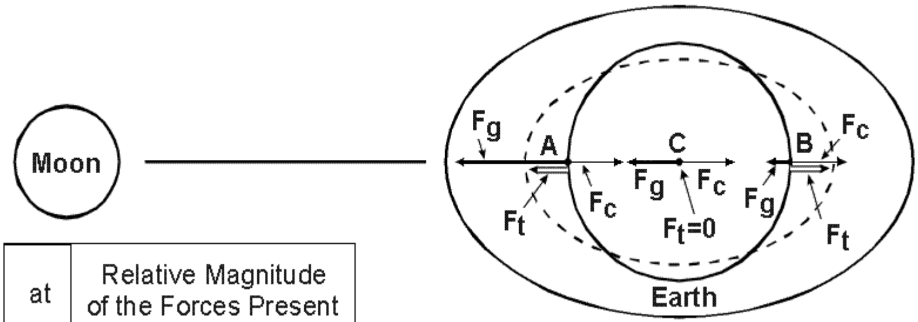


Fig. 2. The Monthly Revolution of the Erath and Moon Around the Barycenter of the Erath-Moon System.

It is important to note that the centrifugal force produced by the daily rotation of the earth on it axis must be completely disregarded in tidal theory. This element plays no part in the establishment of the differential tide-producing forces.

While space does not permit here, it may be graphically demonstrated that, for such a case of revolution without rotation as above enumerated, any point on the earth will describe a circle which will have the same radius as the radius of revolution of the center-of-mass of the earth around the barycenter. Thus, in Fig. 2, the magnitude of the centrifugal force produced by the revolution of the earth and moon around their common center of mass (G) is the same at point A or B or any other point on or beneath the earth's surface. Any of these values is also equal to the centrifugal force produced at the center-of-mass (C) by its revolution around the barycenter. This fact is indicated in Fig. 3 by the equal lengths of the thin arrows (representing the centrifugal force Fc) at points A, C, and B, respectively.

Type of Force	Designation
F_c = centrifugal force due to Earth's revolution around the barycenter	thin arrow
F_g = gravitational force due to the Moon	heavy arrow
F_t = the resultant tide-raising force due to the Moon	double shafted arrow



at	Relative Magnitude of the Forces Present
A	$F_g > F_c > F_t$
	$\vee \quad \parallel \quad \vee$
C	$F_g = F_c > 0$
	$\vee \quad \parallel \quad \wedge$
B	$F_g < F_c > F_t$

A north-south cross-section through the Earth's center in the plane of the Moon's hour angle; the dashed ellipse represents a profile through the spheroid composing the tidal force envelope; the solid ellipse shows the resulting effect on the Earth's waters.

Fig. 3. The Combination of Forces of Lunar Origin Producing the Tide

2. The Effect of Gravitational Force. While the effect of this centrifugal force is constant for all positions on the earth, the effect of the external gravitational force produced by another astronomical body may be different at different positions on the earth because the magnitude of the gravitational force exerted varies with the distance of the attracting body. According to Newton's Universal Law of Gravity, gravitational force varies inversely as the second power of the distance from the attracting body. Thus, in the theory of the tides, a variable influence is introduced based upon the different distances of various positions on the earth's surface from the moon's center-of-mass. The relative gravitational attraction (Fg) exerted by the moon at various positions on the earth is indicated in Fig. 3 by arrows heavier than those representing the centrifugal force components.

3. The Net or Differential Tide-Raising Forces: Direct and Opposite Tides. It has been emphasized above that the centrifugal force under consideration results from the revolution of the center-of-mass of the earth around the center-of-mass of the earth-moon system, and that this centrifugal force is the same anywhere on the earth. Since the individual centers-of-mass of the earth and moon remain in equilibrium at constant distances from the barycenter, the centrifugal force acting upon the center of the earth (C) as the result of their common revolutions must be equal and opposite to the gravitational force exerted by the moon on the center of the earth. This fact is indicated at point C in Fig. 3 by the thin and heavy arrows of equal length, pointing in opposite directions. The net result of this circumstance is that the tide-producing force (Ft) at the earth's center is zero. At point A in Fig. 3, approximately 4,000 miles nearer to the moon than is point C, the force produced by the moon's gravitational pull is considerably larger than the gravitational force at C due to the moon. The smaller lunar gravitational force at C just balances the centrifugal force at C. Since the centrifugal force at A is equal to that at C, the greater gravitational force at A must also be larger than the centrifugal force there. The net tide-producing force at A obtained by taking the difference between the gravitational and centrifugal forces is in favor of the gravitational component - or outward toward the moon. The tide-raising force at point A is indicated in Fig. 3 by the double arrow extending vertically from the earth's surface toward the moon. The resulting tide produced on the side of the earth toward the moon is known as the direct tide. At point B, on the opposite side of the earth from the moon and about 4,000 miles farther away from the moon than is point C, the moon's gravitational force is considerably less than at point C. At point C, the centrifugal force is in balance with a gravitational force which is greater than at B. The centrifugal force at B is the same as that at C. Since gravitational force is less at B than at C, it follows that the centrifugal force exerted at B must be greater than the gravitational force exerted by the moon at B. The resultant tide-producing force at this point is, therefore, directed away from the earth's center and opposite to the position of the moon. This force is indicated by the double-shafted arrow at point B. The tide produced in this location halfway around the earth from the sublunar point, coincidentally with the direct tide.

Variations in the Range of the Tides: Tidal Inequalities

The situation gives rise to a twice-daily tide displaying unequal heights in successive high or low waters, or in both pairs of tides. This type of tide, exhibiting a strong diurnal inequality, is known as a mixed tide. See the middle diagram in Fig. 5. The resultant diurnal type of tide is shown in the bottom diagram of Fig. 5 is the difference in the height, in feet, between consecutive height and low tides occurring at a given place is known as the range. The range of the tides at any location is subject to many variable factors. Those influences of astronomical origin will first be described as:

1-Lunar Phase Effect: Spring and Neap Tides. It has been noted above that the gravitational forces of both the moon and sun act upon the waters of the earth. It is obvious that, because of the moon's changing position with respect to the earth and sun as shown in Fig. 4 during the monthly cycle of phases (29.53 days) the gravitational attraction of moon and sun may variously act along a common line or at changing angles relative to each other.

2-Lunar Declination Effects: The Diurnal Inequality.

3- Parallax Effects (Moon and Sun).

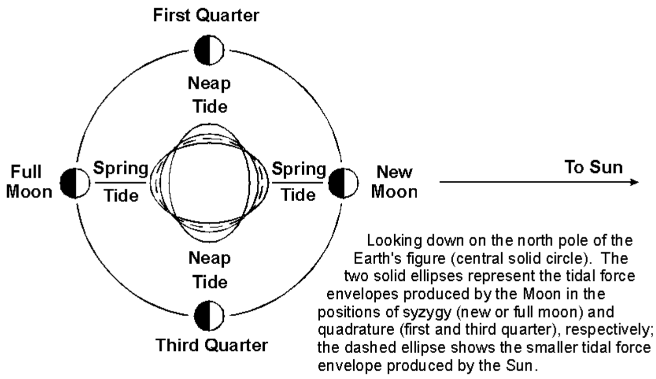


Fig. 4. Phase Inequality: Spring ,Neab Tides

Methodology

The model predict tides(water Level) from the following equation,

$$H(t) = H_o + \sum f_n H_n \cos\left[a_n t + \left(V_o + u\right)_n - \kappa_n\right] \qquad (1)$$

where

H(t)	=	Water level at time t (t is measured from start of the year)
H_o	=	Mean water level above some defined datum
H_n	=	Mean amplitude of tidal constituent n
f_n	=	Factor for adjusting mean amplitude (for each year)
a_n	=	speed of constituent n (2π / T where T is the tidal period)
$(V_o+u)_n$	=	Equilibrium argument (for each year)
κ_n	=	Phase shift of tidal constituent n

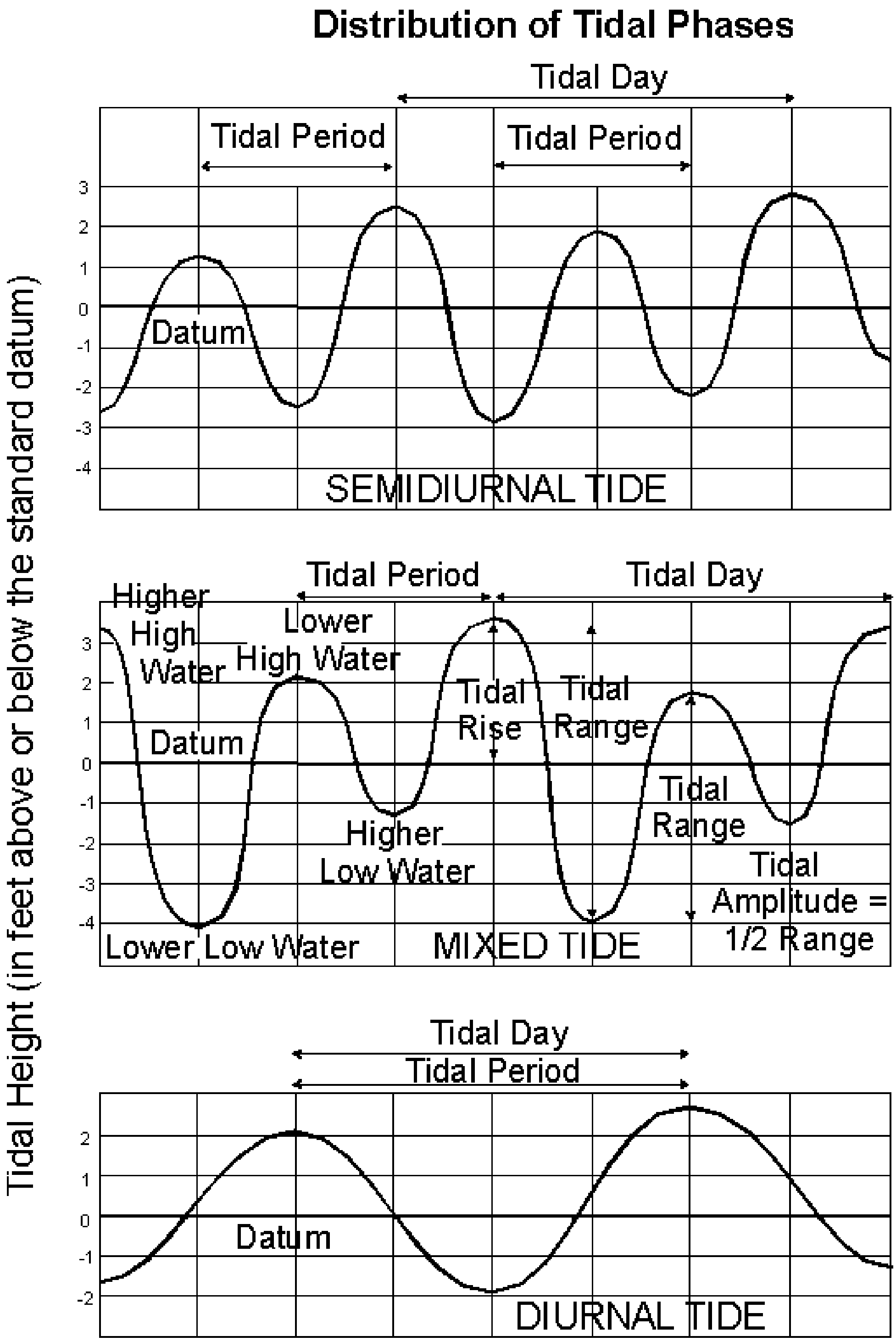


Fig. 5. Principal Types of Tides.

Result Validation

Data were Extracting from Admiralty Tide Chart for different City in The World will Compared with the output results from **KCIS APPs**.

Data Information.

Start Date : May 25 2011

End Date : May 31 2011

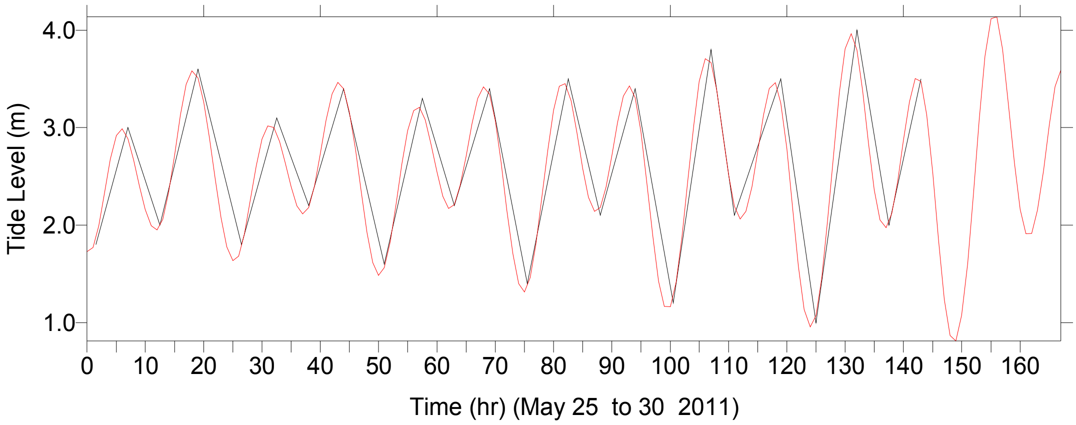
Red Line Results From (**KCIS APPs**)

Black Line Results From (Admiralty Tide Chart)

Case 1 : Asia Region

MUMBAI (BOMBAY), India West Coast

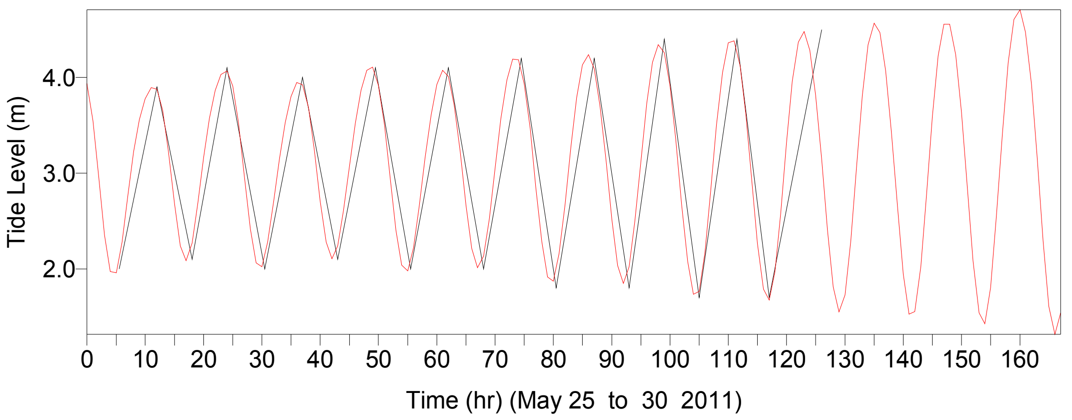
Longitude:E72.833298 / Latitude:N18.916700 deg



Case 1 : Europe Region

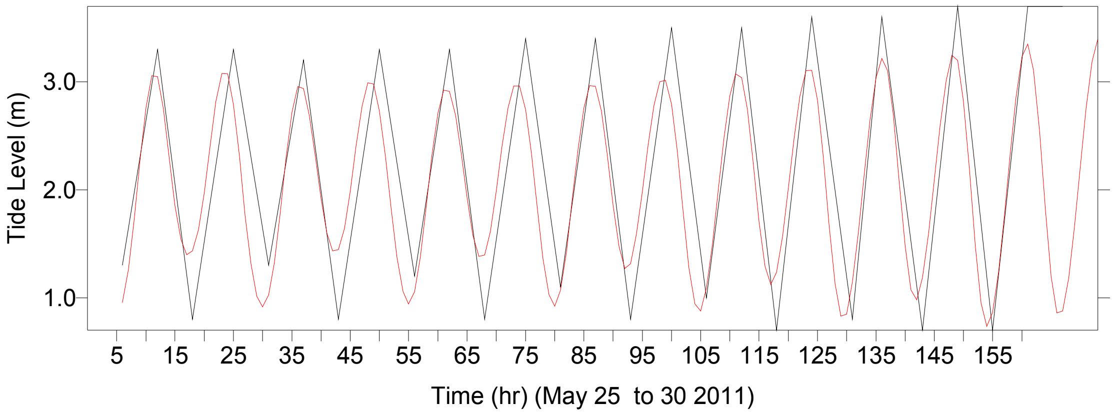
Sables D'olonne, France

Longitude:E-1.800000 / Latitude:N46.500000 deg



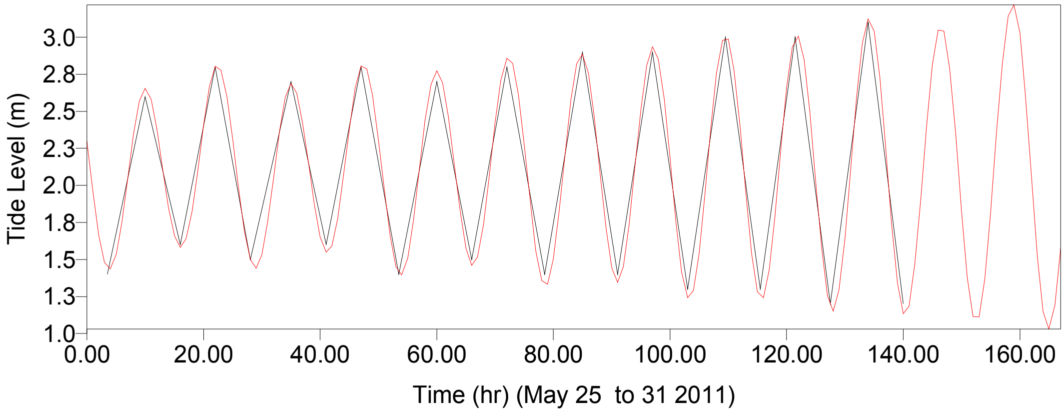
HARWICH, England

Longitude:E1.283300 / Latitude:N51.950001 deg



Cascais, Portugal

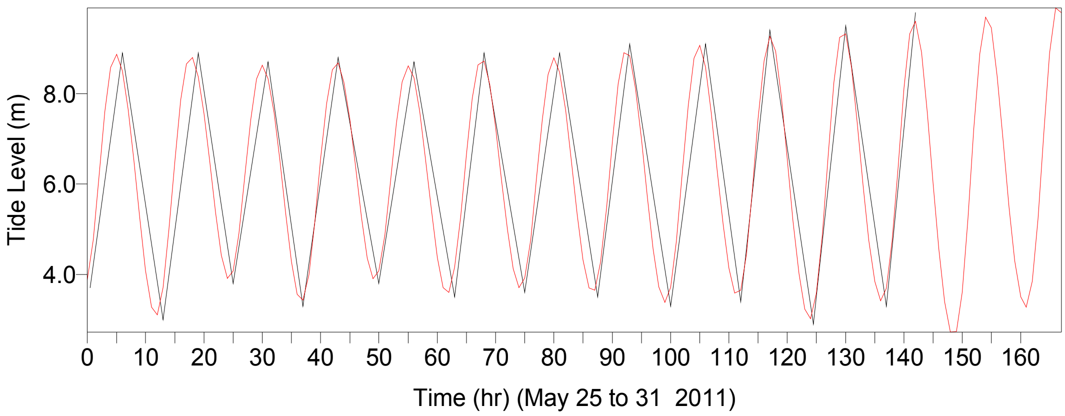
Longitude:E-9.416700 / Latitude:N38.683300 deg



Case 3 :South America Region

Punta Quilla, Argentina

Longitude:E-68.416702 / Latitude:N-50.116699 deg



KCIS APPs Description

KCIS apps is divided into to two applications as follows:

1- Setup hydrodynamic's station inside Arabian Gulf to generate the following:

   -1D Tidal Current

   -Water Level

   -Extract the station hydrodynamic's Consteinut prediction value.

   -Time Serious Prediction Cover (1970 to 2035 hourly data)

2- Global Water Level Prediction from (1970 to 2035) hourly.

To Start Hydro APPs for 1 Option.

If user interest to setup new hydrodynamic's station inside Arabian Gulf as in Fig.1 the following information needed as (longitude and latitude in deg) of the station location must be decided.

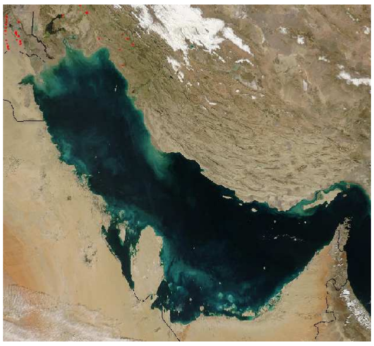


Fig.6 Arabian Gulf

Fig.7 Main Apps Page

Start the APPs As shown in Fig.7. By Selecting from Fig. 7 **Arabian Gulf Button** Fig.8 Will display For user to setup the station location.

User will Find two Map Button in Fig x2 top Map button for user to Post the station location On the Map. The Lower **Map Button** for user to Zoom in the Arabian Gulf Map by two method as:

1- By touch on the screen for Lower Left Coordinate and the second Screen touch for upper right coordinate. New Map Scale will be setup
2- Manual Input in Map Scale Textbox for Scale Coordinate.

User Enter Station Name

User Enter Name files (File I/O Save) where the Station Information Will Store for Later to Reload.

Users Then Start simulates the Apps for Setting up Station by enter (Setup Button).

Now the station is ready to Predict Hydrodynamic's Information.

User must Select CIS Button for hydrodynamic's page As shown in Fig.9.

Fig.8 Station Setup Page

To start 1D hydrodynamic prediction user inter in Fig.9 the following information as :

1-File Name where the station data stored in.

User must input station name to reload the station parameter if the user forgot the name. User can must select **More button** a number of option will be display for user. Select Station Button to Display all name for Station File that user Created before.

Then press **Reload Button** .

User will see a selected location Datum value displayed on the textbox. This value for station adjustment.

2-User must Enter starting Date And Ending Date As Fig 10.

3-User must select the **Start Button** to simulate.

Fig.9 Hydrodynamic's Page

Fig.10 Date Display

Fig.11 Simulation display

Fig.11 will display for user to select a number of output list as:

1- **Plot Button**. For Plot Output Results Fig.12.
2- **Hydro. Table Button**. Display Output Result in Table (hourly) Fig.13
3- **Constituents Button**. Display the predicted hydrodynamic's Constituent for the station selected Fig.14.

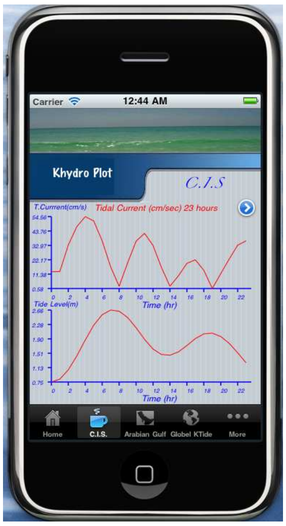


Fig.12. Plot Display

Fig.13. Table Display

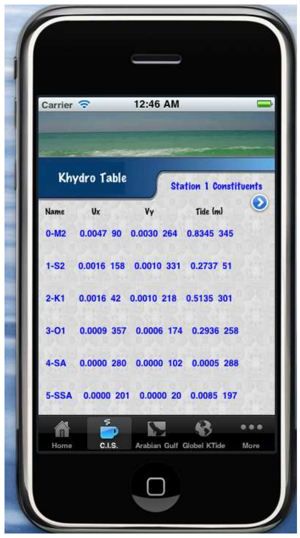


Fig.14. Constituent Display

To Export the Results User Select **More Button** then select **Contact Button** for data Export as shown in Fig 15 as follows:

1- User Can Email the hydrodynamic's results file and the Plot Image.
2- User Can Email the hydrodynamic's Constituent file and Plot Image

Fig.15. Export Data

To Start Hydro APPs for 2 Option.

Global Tide Level Prediction

If user interest to extract water level from Global station must select from Fig.7.
(**Global Tide Button**). Fig.16 will Display for user a number of Continents Icon as follow:

1- Asia Region
2- Africa Region
3- Europe Region
4- North America Region
5- South America Region

Fig.16. Global Tide Page

In Fig.16. Each of Continents Icon has different Option for user to select as:

1- Station Piker for User to Select Any City Fig.17.
2- Station List Page for user to Select the Station Index Number Fig.18.
3- Manual Input Box for Station Index Fig.19.

Fig.17. Station Peker

Fig.18. Station List Page

Fig.19. Manual Index Station

When User select the station name/index Fig.20 will Display for user to select the station starting Date to End Date for Model simulation.

Fig.20. Date Input Page

When simulation finish Fig.21 will display for user to select a number of output list as:

4- **Plot Button**. For Plot Output Results Fig.12 but only Tide Level Plot.
5- **Hydro. Table Button**. Display Output Result in Table (hourly) Fig.13.
6- **Constituents Button**. Display the predicted hydrodynamic's Constituent for the station selected Fig.14.

Fig.21. Output Display Option

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ANANGA, N., COLEMAN, R. & RIZOS, C., 1994. Establishing a unified vertical datum for tide gauge positioning. Proc. *Conf. on Recent Crustal Movements*, Kobe, Japan, 6-11 December, 203-207.

Harris, D. L., N. A. Pore, and R. A. Cummings, 1965. Tide and tidal current prediction by high speed digital computer, *International Hydrographic Review*, Vol. XLII, No. 1, 95-103.