

One-dimensional interpolation of tides (ODIT)

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This paper presents a method for real-time tide interpolation in narrow confines where the tide propagation can be assumed to be one-dimensional. While rather restrictive, this type of configurations is often of interest for coastal hydrography as it covers river estuaries, channels and narrow bays. The bonus for the limited applicability is a method with a good accuracy that is very easy to set up.

Tide interpolation methods have been the object of many investigations with varying degrees of complexity and accuracies. At one end of the spectrum there are complete hydrodynamic models [3]. Using partial derivative equations and finite element methods, these models offer the most accurate results but force the user to specify complex boundary conditions and require a good knowledge of the bathymetry of the area. At the opposite end of the spectrum there are very simple zoning methods like the one recommended by [1]. Zoning methods are inadequate for automated data processing because they produce discontinuities at zone boundaries.

In the last few years NOAA began developing a different method called TCARI (Tide Constituents and Residual Interpolation) that tries to bridge the gap between the two ends of the spectrum. The principle behind TCARI is to decompose the tide value into an astronomic tide defined by its harmonic constituents and a ‘tide residual’

$$T = H + R$$
$$H = \sum_i A_i * \cos(K_i * t + \phi_i)$$

The method performs separate interpolations for each harmonic constituent and residual, combining them at the end to form an interpolated tide value. In order to perform the interpolation TCARI requires the user to define boundary conditions for the area of interest and then solves a (rather arbitrary) partial derivative equation to find the interpolated tide.

ODIT could also be called ‘the-son-of-TCARI’ because it uses the same principle but the application to a one-dimensional case makes for a much simpler setup. Fig 1 depicts a typical situation where ODIT could be applied.

The interpolation process takes into account only two tide stations: the one



Figure 1 – Typical ODIT application – St Lawrence River

upstream (A) and the one downstream (B) from the interpolation point (P). In order to use ODIT the following information is needed:

- Harmonic constituents at both tide stations
- Real time tide values at both tide stations
- Distance along the tide propagation line between the interpolation point and each tide station.

The concept of ‘tide propagation line’ is central to ODIT. It represents a segmented line along which it is assumed that tide changes occur. The basic assumption of the method (and the reason why we call it one-dimensional) is that if two points project to the same point along the tide propagation line they will have the same tide.

Figure 2 is a diagram of the calculation process.

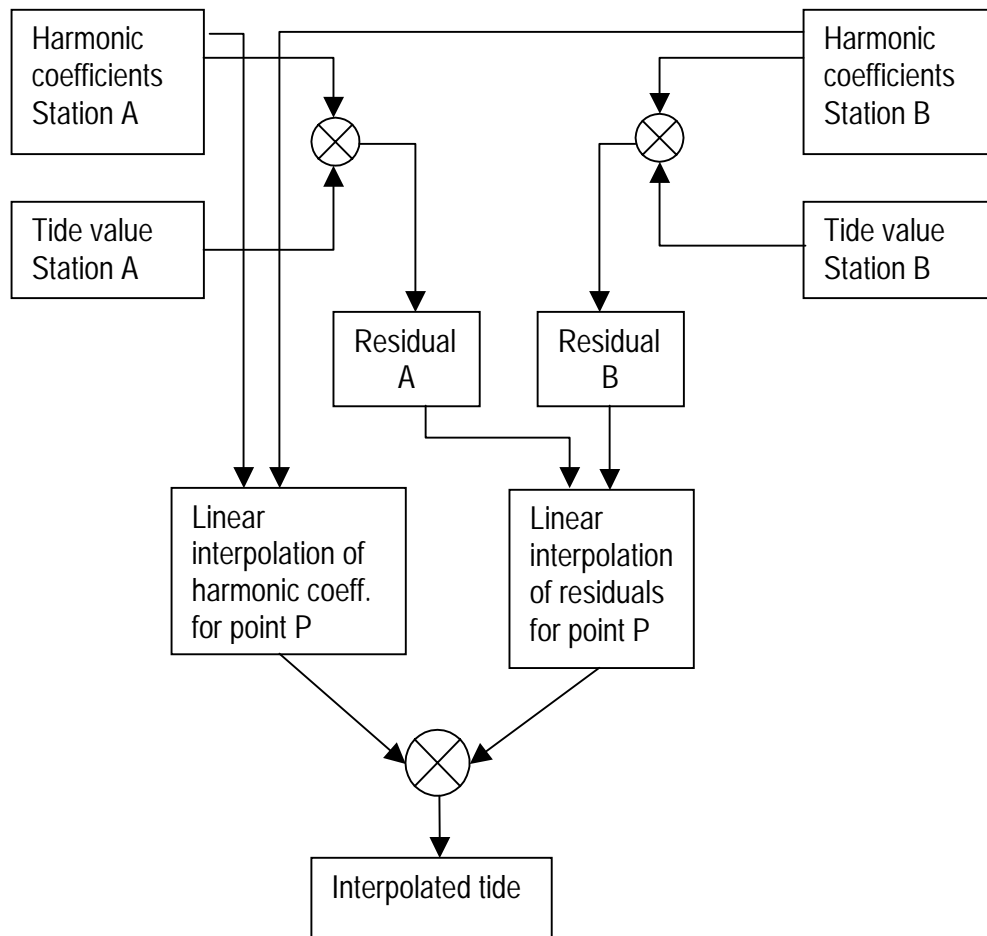


Figure 2 ODIT process diagram

Harmonic coefficients are used to calculate the astronomical tide and a residual tide at each tide station. The residual tides are then interpolated to give a residual tide at the point of interest. Harmonic coefficients are also linearly interpolated to produce harmonic coefficients at the interpolation point. These in turn are used to calculate the interpolated

astronomical tide. The sum between interpolated astronomical tide and interpolated residual tide gives the final interpolated tide value. With notations:

- D_A - distance of station A along the tide propagation line
- D_B - distance of station B along the tide propagation line
- D - distance of interpolation point P along the tide propagation line

We calculate the coefficient:

$$p = \frac{D - D_B}{D_A - D_B}$$

and harmonic coefficients:

$$A_i = p \cdot A_i^A + (1 - p) \cdot A_i^B$$

$$\varphi_i = p \cdot \varphi_i^A + (1 - p) \cdot \varphi_i^B$$

If V^A and V^B are real time tide values at stations A and B, the residual tide at each station will then be:

$$R^A = V^A - \sum_i A_i^A \cdot \cos(K_i \cdot t + \varphi_i^A)$$

$$R^B = V^B - \sum_i A_i^B \cdot \cos(K_i \cdot t + \varphi_i^B)$$

Interpolated residual tide is given by:

$$R = p \cdot R^A + (1 - p) \cdot R^B$$

And finally the interpolated tide is:

$$V = R + \sum_i A_i \cdot \cos(K_i \cdot t + \varphi_i)$$

Current status

China Harbor and Engineering Corporation asked Coastal Oceanographics to develop a real time tide interpolation method during the summer of 2000. They also provided data for Yangtze River that was used for method development and preliminary validation. Further testing was done using data provided by Canadian Hydrographic Service for the St. Lawrence River.

An initial ODIT implementation is scheduled to be available in the HYPACK® Max Hydrographic Survey Software package during this summer.

Bibliography

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3. Lyard F. and M.L. Genco, 1994: Optimization Methods for Bathymetry and Open Boundary Conditions in a Finite Element Model of Ocean Tides, *J. Comput. Phys.*, 114, 234-256