

Interactive comment on “On the tides and resonances of Hudson Bay and Hudson Strait” by D. J. Webb

Anonymous Referee #2

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This paper explores the resonances of Hudson Bay, Foxe Basin and Hudson Strait which are shown to have multiple resonances close to the main semi-diurnal tidal frequency. This area has only relatively recently been shown to have the second highest tidal range in the world and to be the most important area of tidal energy dissipation in the world. The paper addresses this important topic in a very interesting way which sheds light on the fundamental mechanisms of tidal physics of shelf seas and is thus of general interest and worthy of publication. There are a few points which it would be good to clarify or discuss further (see below).

This is part of a series of papers using a linearised tidal modelling by same author (Webb, 2011, 2012, 2013a, b). Each of these has elucidated some further aspect of tidal resonances. It is necessary to read the series of papers, especially Webb (2012),

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as some of the earlier material is not fully reviewed in the present paper and this is one criticism of the present work. One important modification of the model included here is the use of a radiation open boundary condition, which allows for energy to be radiated back to the ocean.

General Comments

Areas of near-resonance to the dominant tidal frequency are also generally important for tidal energy dissipation and this is an important component of the numerical model used here. The near-resonance in some locations enhances the tidal response and hence the tidal friction, which in turn limits the tidal response and ultimately affects the Earth's rotation. The friction is known to be non-linear i.e. the larger the current the more dominant the friction. This makes it difficult to quantify the resonance and disentangle the effect of friction, Webb has simplified this by linearising the friction (and neglecting other non-linear terms), which allows for a solution of the Laplace tidal equation, using finite differences to deal with the complicated geometry of the real ocean basins. Thus the resonance behaviour can be examined more directly, although at the expense of possibly over-simplifying the friction. If the system is frictionless, the resonant response is on the real axis, but if friction is present, the resonant peaks move off the real axis into the negative imaginary half of the complex plane. The real component of the response is related to the tidal amplification, whereas the imaginary part is related to the decay of the response. The distance from the real axis then equals the decay rate of the resonances (Webb, 2012).

The method has been developed and applied to other sea areas in earlier papers. The Hudson Bay area is unique in being unusually deep and so friction is less important than other areas, such as the Bristol Channel and Bay of Fundy, which are known to be near-resonant at a quarter-wavelength of the dominant semidiurnal tide. It would be good if the author would discuss how the linearisation of friction may limit the solution. It is mentioned that a spatially varying friction coefficient could be applied but this has not been done, although different constant values were tested. Presumably the coefficient

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would be proportional to the current amplitude so a first solution with a constant value could be used to get the magnitude of the currents to calibrate the friction coefficient for a second iteration. This might elucidate some of the rather intransigent points of disagreement of tidal phase. Near amphidromes the current amplitude will be at a maximum and the tuning of friction might perhaps move these locations.

Another interesting question is the sensitivity of the model to the location of the open boundary. Also, despite using a Flather radiation boundary condition, it is not clear whether tidal current amplitude and phase were specified at the open boundary as well as the tidal elevation. Could the author please comment on this?

Overall, a few points of physical interpretation of the method could usefully be added, with reference to the earlier work. In some places it would greatly add to the readability.

Specific Comments

It is known that the GEBCO bathymetry is not very accurate in shallower areas nearshore and probably this area is particularly unknown and inaccessible to survey. The model sensitivity to changes in the water depth could be tested more thoroughly (this is done in a limited way in section 3). Discuss resonances as response to periodic tidal forcing. Technical Corrections 1. Multiple miss-spellings of 'amphidrome', Foxe Basin.

2. Explain how to read figure 4, this type of figure was introduced in Webb (2012).
3. P 8 – explain how cycles per day correspond to rads per day – stay with one set of units. Indicate what is planetary angular velocity at this latitude.
4. P 11 line 19 – energy flux plots not shown
5. P 12 lines 5-6 – what does this mean?
6. P 12 line 11 'single wavelength wave' – what is this?
7. P 12 line 24 – what is symmetry term?

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8. P14 lines 1-3 – narrowness of Hudson Strait compared to openness of English Channel/Irish Sea to Atlantic tidal energy flux?
9. P14 lines 16 Explain resonance/impedance analogy briefly, give reference
10. P15 lines 5-6 – how much is ocean basin tide affecting by absorbing shelf?
11. Appendix A – bit obscure, requires reading Webb (2013a)
12. P 8 line 22, insert 'it' before 'has a minimum'
13. P 8 line 25 replace 'maxima' by 'maximum'
14. IHB (1954) not referred to in the text. Overall this is an excellent paper which should be published, after some minor revision.

References

Webb, D. J.: Notes on a 1-D Model of Continental Shelf Resonances, Research and Consultancy Report 85, National Oceanography Centre, Southampton, <http://eprints.soton.ac.uk/171197>, 2011. Webb, D. J.: On the Shelf Resonances of the Gulf of Carpentaria and the Arafura Sea, *Ocean Science*, 8, 733–750, 2012. Webb, D. J.: On the Shelf Resonances of the English Channel and Irish Sea, *Ocean Science Discussions*, 10, 393–433, doi:10.5194/osd-10-393-2013, 2013a. Webb, D. J.: On the Impact of a Radiational Open Boundary Condition on Continental Shelf Resonances, National Oceanography Centre, Internal Document 06, National Oceanography Centre, Southampton, available at: <http://eprints.soton.ac.uk/349401>, 2013b. 5, 17

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