

## ***Interactive comment on “A mechanistic classification of double tides” by J. A. Mattias Green et al.***

**Anonymous Referee #2**

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### General Comments

This is a very poorly presented manuscript. It contains so many clumsy mistakes that I worry that there may be serious errors in the underlying calculations - errors that cannot be identified by a straightforward review process such as this. Some of the authors' arguments and discussions are so marred by inconsistencies and obvious errors that, in places, I got quite lost. An effective review of the scientific content is therefore not possible until most of these problems are resolved.

While the subject is of marginal interest, the authors do little to convince the reader that their findings have much use - the only statement I could find in this regard is on lines 223-234: "This has implications for mitigation purposes, because a prolonged high tide due to higher harmonics has the potential to increase flood risk due to storm surges".

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The authors could do a lot better in "selling" their work.

The manuscript would require substantial revision and thorough checking prior to any re-review.

### Specific Comments

Lines 31-33 ("The DT can be generated ..... low tide as well"): The logic of these two sentences isn't clear.

Lines 44-46: The criterion of Byrne et al. (2017) needs clarifying - there seem to be two semi-arbitrary constants (B and r) - I assume there must be a constraint on one of these constants - what is it?

Lines 44-45: The phrase "revised parameter" is curious, given that Equation (1) (Doodson's criterion) does not contain a parameter.

Line 55: I think "the semi-diurnal tide is reduced at neaps because M2 and S2 are about the same size" should be "the semi-diurnal tide is substantially reduced at neaps because M2 and S2 are about the same size" - by definition, "the semi-diurnal tide is reduced at neaps" by the interaction of M2 and S2, no matter what their relative size is.

Line 58: I don't understand the logic of "In the third class, M4 is amplified more than M2 inside an embayment and cant therefore generate a DT" - perhaps "cant" is meant to be "can"?

Lines 76-80: The criteria defining these Classes seem to come from nowhere - they need to be explained and quantitatively justified.

Lines 103-104: I'm confused by "the locations of these gauges are marked in Figure 1b". Presumably this refers to the seven gauges referred to in Table 1. If the white crosses are the DT locations identified from TPXO, where are the tide-gauge locations marked?

Lines 113-116: This explanation is confusing. What does a "tidal minimum" (line 114)

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mean? - presumably it means a minimum in M2 amplitude. Also, the location of Den Helder is most probably not at a "local minimum in M2 tidal amplitudes", because, by definition, the M2 amphidromes (one to the west of Den Helder and the other to the north-northeast) are points of zero M2 tidal amplitude (so the M2 amplitude at Den Helder must be larger than at either of the amphidromes - in fact, it looks as if it is near a local maximum, albeit a small one).

Line 116: I really don't see the point of Figure 2(c) - it certainly doesn't support the authors' case. While the blue curve (the observations) does indicate a weak double high tide (masked somewhat because the data is only hourly), the "reconstruction" (red curve), which includes M2 and M4, which supposedly give a double tide at this location, shows no such double tide - there is absolutely no explanation as to why this should be so.

Lines 124-125: I haven't a clue what is meant by "shows a flattened high tide during neaps, which M4 is able to modulate into the double low tide". For a start, M4 isn't "modulating" anything - it is just one harmonic component. Figure 3(a) doesn't show any double tide in either the observations (the blue curve) or the "reconstruction" (the red curve). There is a broadening of the observed high tide around day 3 but no actual double tide. Again, there is no explanation as to why the "reconstruction" shows absolutely no indication of a double tide.

Lines 126-128: the sentence "The mechanism is the same ..... the dominating diurnal tide" is unintelligible. And again, in Figure 3(b), there is no double tide in either the observations or "reconstruction" - the only deviation from a rather ordinary mixed semidiurnal/diurnal tidal curve are slight wiggles (presumably related to M4) in the observations just after days 275 and 276. There are just too much confusion for me to understand most of the paragraph in lines 124-129. If the authors want to be understood, they could at least indicate which of the points on the curves of Figure 3 that they consider to be double tides.

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Line 136: instead of just saying that a  $b/a$  ratio of 0.18 "is not enough to produce a double low tide", it would be helpful if the authors referred back to Equation (1) which indicates that " $b/a > 0.25$ " is the condition for the occurrence of double tides caused by an interaction of M2 and M4.

Lines 137-138: "This is because the annual fits ..... a double low in the Bay" is another inscrutable sentence.

Line 141: more detail is required here, concerning the "the fit on a 25-hour part of record". I assume (hope!) that, this was done only for one diurnal constituent, one semidiurnal constituent (presumably M2), M4, M6 and M8 - otherwise there would be a problem with splitting the constituent pairs K1 and O1, and M2 and S2.

Line 158: the word "supercritical" should be either defined or removed - in hydraulics, it has a quite different meaning to the meaning that is intended here - using the word in the present context only adds to the confusion.

Lines 158-159: what on Earth does "the phase is not right between the M2 low tide and the M4 high tide" mean?

Line 170: I don't understand how the fact that "the M6 amplitude in providence is  $\sim 0.3ab$ " is consistent with M6 being "proportional to the product  $ab$  of M2 and M4 tides". All the authors have apparently done is to divide the M6 amplitude by the product of the amplitudes of M2 and M4, resulting in a value of about 0.3. This DOESN'T show that M6 is "proportional to the product  $ab$  of M2 and M4 tides" - all it does is show that, at a single location, the amplitudes  $M6/(M2 \cdot M4)$  are about 0.3.

Lines 183-185: an important point is missing in the sentence "the reason is quite simply ..... potential to generate DTs". The criterion for DTs is primarily based on ratios between the amplitudes of tidal components (e.g.  $M4/M2$ ). However, the overtides, M4 and M6, are generated by nonlinear processes acting on the motions produced by pure lunar and solar forcing. Therefore, as M2 is reduced, so too are the ratios  $M4/M2$  and

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M6/M2, and the "potential to generate DTs" becomes smaller. Therefore, anything that reduces the amplitudes of major constituents tends to reduce the nonlinearities which produce the overtides which, in turn, tends to reduce the occurrence of DTs - which raises the question as to why, in this instance, the number of DTs isn't reduced.

Table 1: I don't know why the phases are given as "the phase ..... measured relative to the starting point of the time series". As such they are almost meaningless unless the date and time of each "starting point of the time series" is known; the phases given cannot be checked against existing estimates and the difference between the phases of different constituents only has any meaning when the constituents are harmonically related. The phases should, instead, be given in relation to the equilibrium tide (i.e. as the conventional harmonic constant, "g").

Figure 5 caption: it cannot be correct to say that "the b/a ratio is plotted with an orange x" because the vertical axis is sea level in metres - i.e. it can't be a ratio. "b" is the M4 amplitude and "a" is either the M2 amplitude or the semi-diurnal neap amplitude - so I can't understand how plotting "b", or "a", or "b/a", or some critical value of "b/a", on top of the observed sea level makes any sense.

#### Technical Corrections

Line 32: "higher harmonics" should be "higher harmonic".

Line 46: "For" should be "for".

Line 58: "cant" should be "cannot" or "can't" (but see earlier comment on Line 58).

Line 78: "ration" should be "ratio".

Line 99: "where" should be "were".

Line 103: "Table 2" should be "Table 1".

Line 107: "amphidromie" should be "amphidrome" or "amphidromic point".

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Line 113: "to" (at right-hand end of line) should be "two".

Line 122: "at" should be "in".

Lines 146-147: the sentence "This further stress .... a double low tide" needs rewriting.

Line 170: "providence" should be "Providence".

Line 189: "Table 2" should be "Table 1".

Table 2 is not referred to in the text (except incorrectly when the authors mean "Table 1").

Figures showing maps: it is a pity that these are all bitmaps rather than vector graphics (e.g. Postscript or PDF), as the relatively poor resolution of the present figures does not allow much in the way of zooming in on specific features.

Caption to Figure 1: Presumably the white circles in (a), the white crosses in (b) and the red dots in (c) are the identified DT locations - if so, the caption should say so. Also, most of the "140 potential class 2 locations" seem to have disappeared from (b), presumably underneath the black triangles. The "the locations of these gauges ... marked in Figure 1b" (lines 103-104) also seem to be missing from both the figure and this caption.

Figure 2a and its caption, Table 1 and four places in the text (lines 36, 102, 109 and 111) : Should the location be called "Den Helder" or "den Helder"? - the authors need to be consistent.

Caption to Figure 2(a): this includes a reference to Figure 2(b) (the "right" panel). The captions to Figures 2(a) and 2(b) need to be rewritten to remove the confusion.

Figures 2(a) and 2(b): these maps are almost unreadable - for example, the M4 cotidal lines are very indistinct, especially in the region around Den Helder. Also, the scales for latitude and longitude severely distort features on the map (i.e. it is distinctly non-conformal) because one degree of longitude is mapped to a greater distance than

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one degree of latitude, which is opposite to the way required for a conformal projection (such as a Mercator projection). It isn't very hard to make the shape of the land features roughly correct.

Figure 3: it is a pity that some of the curves are truncated at the maximum and minimum levels.

All figures of time series: some key colours are incorrect. For example, in Figures 2(c), 3, 4 and 6(b), the key shows O1 as orange but the O1 curve is in fact purple. In Figure 6(a), the key shows M2 as orange but the M2 curve is in fact purple.

All figures of time series: the vertical axis is marked "sea-level", which is an adjective - the noun, "sea level" (without a hyphen) should be used instead.

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