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Interactive comment on "A monthly tidal envelope classification approach for semi-diurnal regimes with variability in S_2 and N_2 tidal amplitude ratios" *by* Do-Seong Byun and Deirdre E. Hart

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We are very grateful for this review as it has been useful in helping to improve our paper. Below we have copied each individual reviewer comment, and written below it a response. Almost all suggested changes have been adopted wholesale, but discussion and a couple of questions remain below regarding the link made to flooding hazard.

Individual reviewer comments and our responses

Abstract - if I had written this abstract I would have used the useful words on lines 206-214 of the Discussion. For example, I can see that the new form factor could inform about shoreline ecology as ecology depends on the tidal climatology. However, I cannot see that it is much use in discussion of inundation hazards and climate change; for that one would be interested primarily in the character of sea level extremes and not just on simple descriptions of the tide. Response: Thank you for this suggestion regards the discussion text – we have used some of this text to replace the original opening sentence of the abstract. Regards the inundation hazards and climate change link drawn here regarding perigean-spring tides, this comment relates our experiences in Christchurch (e.g. Allen et al., 2014; Hart et al., 2018). This city (marked by the Sumner gauge site in Fig. 2) experienced up to 1 m relative sea level rise in coastal and river proximal suburbs due to subsidence during the Canterbury Earthquake Sequence (CES, 2010-2011). This instantaneous sea level change was equivalent in magnitude to that which had been predicted (in absolute as opposed to relative terms) for the next 50 to 100 years due to anthropogenic climate change and accelerated sea level rise. We thus use Christchurch as a 'laboratory' to consider what 1 m of sea level rise might look and feel like in a delta city (of which there are many similar settings in seismically active areas worldwide), albeit with process-response timescales being rather different to those under climate change scenarios. One of the greatest effects has been enhanced flooding issues, much more so than other coastline hazards such as erosion. Since the city relies on river and estuary drainage conduits, in particular, when pronounced perigean-spring tides occur or combination with sustained rainfall events, inland riverside and low-lying coastal suburb flooding is widespread, deep and persistent. It would seem that around half of the city had little freeboard, and that buffer has been significantly reduced with the CES such that even monthly high tides pose issues for the lowest lying areas nowadays. The backwater effects of high tides combine with atmospheric low pressure and sustained precipitation events to extend the reach of flooding. We suspect that the latter will continue to be enhanced as the baseline mean sea level rises with climate change, meaning less ability to cope with perigean-spring tides. Since the CES, high tide alerts have become of wider public interest since they are now commonly associated with flooding. Understanding the frequency of such tidal alert days has been of use to those at the coal face of flooding, in terms of emergency responses as well as in making decisions about whether to stay or retreat from subsidence affected areas. We therefore see monthly tidal height patterns as intricately linked to questions of initial sea level rise effects in our city.

12 - remove 'database'. 'theoretical experiments' –> 'theoretical arguments' maybe. Response: Both changes have been made.

14 - the symbol Fsm is a clunky one and even impossible to write on an ascii keyboard. What is it supposed to mean? A form factor showing S2's influence on M2? But what about N2 i.e. Fnm? I would have invented a simpler symbol such as F-prime or maybe E for envelope? Response: As suggested, we have changed F_MˆS throughout the paper to the much simpler notation of E.

20 - I don't see that the first two references are really relevant to this sentence. Cartwright is a history of tidal science. D'Onofrio discusses Buenos Aires only and not spatial variation. The Nicholls reference is ok. Response: The first two references have been removed from the sentence: "Successful human-coast interactions in the world's low-lying areas are predicated upon understanding the temporal and spatial variability of sea levels". Please note that we meant the phrase 'temporal and spatial variability in sea levels' to encompass a wide range of processes including cyclical tidal height variations, and were not meaning mean sea level variations alone, a topic best highlighted using the third reference. We have added the reference Woodworth et al. (2019) to emphasise this wider meaning. This view of sea level variability was why we had Cartwright's book on tides here, because it covers the spatial aspect of sea level variability. Regards D'Onofrio et al. (1999), although this paper case studies just one place (Buenos Aries), it is a nice example of a low-lying coastal city study that combines analyses of storm surge and tidal height probability distributions, with consideration given to the importance of a robust temporal analysis of each element to predict the frequencies of future sea level extremes. This paper finishes by pointing out that the temporal dimension of these results will adjust in future with sea level rise.

Such a careful multi-hazard approach is lacking in many studies, hence our desire to highlight this work.

24 - ’and gravimetry’. What does that refer to? Space gravimetry by missions such as GRACE? I would drop that. Then again the references are apparently random – Egbert et al. describes one particular model, while Stammer et al. describes many including Egbert. So why is Egbert here and not all the others? Response: We have removed “and gravimetry” and the Egbert et al. (1994) reference. This reference was in there as a succinct example of a research paper that focusses on removing tidal signals from sea levels, in their case from TOPEX POSEIDON altimeter data. We used this reference specifically as it was an example of tidal signal removal based on just the four main constituents that comprise F. Stammer et al. (2014, p243) stated the point, which we repeated in shorter form, that “An especially important application for accurate tide models is providing tide “corrections” to various measurements so that smaller nontidal signals may be studied. For example, barotropic tide models are used regularly to remove tidal variability from space geodetic observations; this is a critical necessity for successful satellite altimetry [e.g., Fu and Cazenave, 2001] and satellite gravimetry [Seeber, 2003; Visser et al., 2010], and in both cases improved tidal corrections lead to a reduction of aliased tidal “noise” in nontidal signals of interest”.

26 - I would have the equation here i.e. F=(K1+O1)/(M2+S2) and not just words, like your equation (1) below which would become (2) Response: We have added this equation explicitly, as suggested, and renumbered the other equation.

26-27 - if you have four you can’t add a fourth? Response: This has been clarified in the text. Originally van der Stok (1897) divided tidal regimes into three types using the F equation, while Courtier (1938) added a fourth (daily) tidal regime type.

28 - aren’t they the same form factor (singular)? Response: This has been corrected in the text.

I am not familiar with the van der Stok and Courtier references which are very old and

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I don't think many other readers will be either. How did you come across them? If in a more recent history of tides or a text book on tides then please add that. Response: Van der Stok (1897) was available to us via interlibrary loan. We borrowed an original 1897 large format book from California through the UC library – see available copies here: https://www.worldcat.org/title/wind-and-weather-currents-tides-and-tidal-streams-in-the-east-indian-archipelago/oclc/488220907. It is an interesting piece of work as it clearly outlines the F equation and three of the four tidal regime types in common usage today, in a work dating back over 120 years. We feel that it is best to leave this reference in our paper discussion of the origins and history of use of F, not least to give credit to this early author. We found out about van der Stok's work from its citation in Courtier (1938), which is available online, in a PDF English translation, from: https://journals.lib.unb.ca/index.php/ihr/article/download/27428/1882520184. We have added this web link in our reference list entry for Courtier (1938) to make it more accessible to readers. Both of these references were located via a Google search (in contrast our university library multi-search returned no useful results).

34-36 this is a garbled sentence. Could you please reword? Response: We have reworded this sentence into two shorter, clearer sentences as follows: The daily tidal form factor identifies the typical number (1 or 2) and form (equal or unequal tidal ranges) of tidal cycles within a lunar day (i.e. 24 hours and 48 minutes) at a particular site. In contrast, the term 'tidal envelope' describes a smooth curve outlining the extremes (maxima and minima) of the daily tidal cycles occurring at a particular site through a specified period of time.

45-47 This isn't right. You say yourself that NZ tides are unusual so the reviews of Andersen etc. cannot be blamed for focusing on the main constituents relevant to global studies. However, that does not mean those authors were disinterested in other constitents. In fact one main aim of such studies was to determine how well the total tide could be determined which necessitates accuracy in N2 etc. Response: We have deleted these lines.

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56 - as mentioned above I can't see form factors (of whatever kind) being directly relevent to coastal flooding hazards work, but if I am wrong please give references. Response: You are absolutely right to question the unusual link drawn in our paper between form factors and coastal flooding hazards work, and we cannot provide you with a published tidal reference that neatly encapsulates this idea directly and fully. However, I would like here to offer some explanation for why we think this link exists for some places (delta cities) and is relevant, then to seek your expert advice on whether it would be best to delete the link from our current paper, or to try to express the idea more clearly for our readers. Again using Christchurch city as an example - this city is situated towards the centre of Aotearoa New Zealand's east coast region of strongly perigean-apogean influenced tides. The city is constructed (like Tokyo, Jakarta, Charleston NC and many other delta cities) on a low-lying, formerly swampy, coastal progradation and river delta plain in a seismically active area. This physical setting, combined with imprudent development, has influenced the flood hazard: major flooding occurs when periods of sustained heavy (as opposed to high intensity) rainfall produce river and overland flows which fail to drain efficiently through the city's distributed, gravity-based and sea level connected drainage network (Hart et al., 2018). One of the key factors that determines whether or not a sustained rainfall event will result in widespread and severe flooding, or not, is the tides. Flooding is more likely during perigean tides, since these times feature periods of more than a week with particularly high tidal ranges. As illustrated in the Fig. R1 (top), unlike in spring-neap dominated areas, periods of high tidal ranges in Christchurch can last for well over a week with short duration periods of smaller range tides between, when flooding is less likely. This means that high tide 'red alert' days (Fig. R1 (below)) can last for more than a week, and there is an increased chance that these might coincide with sustained rainfall events, than in more spring-neap dominated regions which feature the distinct and regular punctuations of the lower range neap tides. This is a subtle but genuine reason why we believe it is important for 'delta cities' like Christchurch to consider their monthly tidal pattern when considering the multiple factors that influence

flooding. An additional aspect of this idea relates to how we quantify future flood risks and return periods under changing climate (not to mention in the multi-hazard context of future seismic activity, e.g. Allen et al., 2014). The tidal height patterns will not be hugely influenced by climate change, so we can already produce accurate frequency histograms and probability distributions for future high tide levels, like that conducted by D'Onofrio et al. (1999) for Buenos Aries. Future rainfall and storm surge statistics are harder to predict under changing climate and need to be combined with the more predictable tidal water level contributions to establish accurate flooding and inundation risk predictions. In the past we in ANZ focussed on flood return periods established using historical water level records, but this is no longer a robust practice since the more predictable tidal water level probabilities need to be combined with the changing atmospheric components to produce altered flood risk estimates for the future. All this is in a relatively newly colonised country where hydrological data records are short. Our point is partly that amongst all this uncertainty, at least the tidal pattern component of these hazards is nicely predictable, so we encourage colleagues to take tidal patterns into account in their flood hazard predictions (something that has been lacking in past analyses). We hope to make the case for the connection between tidal envelope pattern and flood hazards in an upcoming ASCE (2020) monograph paper on flooding and inundation multi-hazards, but realise that this idea is only hinted at in a very truncated manner in our current paper. Please do recommend if we should delete text making this link in our current paper, or if we should leave it in, albeit as a fleeting mention, or some other suggestion.

61 - why don't you just have a simple map here for the reader to refer to i.e. Figure 2, and not wording such as 'latitudinal gradient' - you mean range of latitude. Having the Type information in the figure is ok but you have to return to that later (see below about that) Response: We have corrected the word 'gradient' to 'range' and added a citation pointing the reader to Fig. 2 at this point in the text. Also, in Results section 3.1 we have added another mention of Fig. 2, highlighting at this stage the observation station colour coding of their identified monthly tidal envelope types.

62 - what are ’absolute tides’? Response: We have amended the sentence to read “. . .micro through to macro tidal ranges”.

68-69 - this business of a pair of amphidromes to the NW and SE is not easy for the reader to appreciate from your wording alone, and the amphidromes are in fact a long way NW and SE and off the maps of Figure 3. So you have to point the reader to where he can see a map of M2 in the SW Pacific - ideally a map from FES2014 as you have focused on that. Or see Fig 5.1 of Pugh and Woodworth (2014) which was provided by Richard Ray - i.e. a wider area than you have used for Fig.3. Anyway I don’t think it is right to say S2 has a single wavefront and amphidrome in the SE. Take a look at Figure 4 of Walters et al. (2001) and you will see a pair of them close together in the SE. And I would drop mention of the Coriolis effect and simply say that they rotate anticlockwise. Response: Regards the description of the M2, we have added a citation Pugh and Woodworth (2014) Fig. 5.1 – thank you for this suggestion. We have amended our description of the S2 and K1 tide amphidromes in line with Walters et al. (2001; 2010). Mention of the Coriolis Force has been removed as suggested.

77 - ’years’ is misleading as it suggests you have used many years per station whereas Table A1 shows you used only one year for each. Have the amplitudes and phase lags in Table A1 been adjusted for nodal variations according to equilibrium relationships? Or are they the observed amplitudes for the years shown? See below for other comments on this table. I would have prioritised the FES2014 model over the tide gauge data as the main aspects of what you are trying to show are best done with the model. Then at the end of the paper you can show your findings from FES2014 are consistent with those from the tide gauge positions. 80 - you mean ’in comparison with values obtained from the tidal potential or Equilibrium Tide’ Response: We have added the adjective “individual” to highlight that an individual year was analysed for each of the 27 observation stations, with the text now reading “an individual year of good quality hourly data was selected for analysis per site from amongst the multi-year records. The 27 individual year sea level records were then harmonically analyzed using T_Tide

(Pawlowicz et al., 2002) with the nodal modulation correction option, to examine spatial variation in the main tidal constituents' amplitudes, phase-lags, and amplitude ratios between regions (see Table A1 for raw results) and to compare them with values obtained from the tidal potential or Equilibrium Tide". In our paper we have chosen to initially employ the analysis of observational data, later on using the FES2014 model data to check our findings and extend our spatial coverage. Although the observational data does not have the same uniform coverage of the FES214 data, we prefer to initially use the observational data since it represents real in situ records that are accurate at the coast, while the FES2014 data is helpful for our final classification around the whole country (i.e. Figure 7).

81 - 'amplitude data' –> 'amplitudes'. 'was sourced' –> 'was obtained' 82 - days' length or days in length 83 - tides are the strongest 85, 242 and 268 - Carrere has an accent over the first e 86 - dataset –> model. experimental plots –> studies (maybe) 88 - siderial –> diurnal. 92-93 - mapped spatial variability Response: All changes made as suggested. The accent has been added everywhere that Carrère's work is cited.

94-95 - .. those from the Equilibrium Tide (Defant, 1958). It was not Defant's theory. Anyway you might better refer to Cartwight and Tayler (1971) for example. Response: We have altered the misplaced reference to Defant (1958) to indicate that this was the source from which we obtained the Equilibrium Tide data, and not the source of Newton's Theory itself, and we have also deleted the reference to Defant (1958) from the table (now numbered Table 1) since it is now clearer in the text.

95 - 'data results' –> results 98 - reinforces –> shows 101 - .. amplitude (Figure 3c). 102 - in the text and tables and figures it would be much simpler if you dropped the 'a' and have M2 for example to refer to its amplitude. All the a's make things messy. You would have to say you were doing that of course. 103 - drop relatively The two bullets below. Could you mention them as determining Type 1 and Type 4. 109 - surely that is not referring to Figure 1, you can't see Cook Strait in that at all 110 - 75 to 90% of what? What are the adjacent coasts? 114 - 'anomalistic timeframes' –> 'a month' and drop

the 27.5546 four decimals –> 27.6 will do Response: All changes made as suggested, Figure 1 has been corrected to Fig. 2, and for 110, the text has been amended to “compared to on the western coasts both north and south of this central ANZ area”.

116 Chatham Rise and Castle Point are not in Figure 2. Response: The text read: “This type of regime occurs, for example, around the northern Chatham Rise near Kaikoura, and as far north as Castle Point on the east coast of the South Island”. We have left this text and the Fig. 2 map unchanged regards these labels as both Castel Point and Kaikoura were on this figure (see north and south of Cook Strait on the central east coast). Other labels that were missing from Fig. 2 as pointed out below (e.g. North/ South/ Stewart Island) have been now added though.

121 sentence ’By examining’. I would drop this sentence. You repeat yourself a lot. Response: Deleted – thank you, we really appreciated your suggestions for shortening our text and removing repetition.

126 - I would say spring-neap and then perigean-apogean as that is the order elsewhere Two bullets. Can you mention them as Type 2 and 3 133 - amplitudes being only Response: All changes made as suggested.

139 - Sumner not in Figure 2 Equations 1 - drop the a’s (see above). Also drop the ’more stable’ words. I guess you mean similar locally? But the same situation would apply if the constituents varied a lot spatially. These are just simple algebraic relationships at a particular position – they have nothing to do with spatial scale or ’stability’. 161 Table 4 should be 3? Response: For 139, Sumner is in Fig. 2, on the central east coast of the south island (just above the peninsula – this is a gauge site for Christchurch city). For Eqs. 2, 2a and 2b (formerly 1, 1a and 1b), all ‘a’s have been deleted and it has been specified in the text that these ratios refer to amplitudes. All references to stability have been dropped. Re ‘161’, both Tables 3 and 4 now seemed superfluous after re-arranging Table 1 and with removal of the experiments, so these two tables (3 and 4) have been deleted, as has all mention of them, shortening our paper nicely

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(thank you for those suggestions).

173 - it is strange to read of M2, which is the largest, moderating something smaller. I think this paragraph needs rewording. Also I don't understand (i) and (ii). What are the 'annual' and 'subsequent' things? I guess the R in MTR is ratio? Not clear. But note that MTR stands for Mean Tidal Range in usual tidal studies. Anyway I found these experiments at lines 180-204 somewhat unconvincing, although I do understand why you felt the need to inject some rigour into the choice of boundary values between Types. But the experiments do not cover the whole space of possibilities for amplitude and phase lag of all constituents concerned. The main thing to me is Figure 6 which shows nicely how Fsm varies with x and y. Why don't you then just define the boundaries between Type 1 etc. in an ad hoc way, similar to the way as F is divided in an ad hoc way for 'semidiurnal' etc. After all, in the end all these form factors are just handy coarse descriptive subdivisions for the tide. Anyway lines 180-204 need rewriting - see my comment at line 173 also. It is just not clear what you are doing. Response: The "moderating influence of" has been replaced by "strong influence of". The whole section on the experiments, including Figure A1, has been deleted. As suggested, simplified ad hoc (and less repetitive) explanations for selecting the boundaries between the different E types has been used instead as follows: "Below we explain how we set boundaries between the different E types around ANZ, using our case study data, and as summarised in Fig. 6. Firstly, in any semi-diurnal tidal regime (F<0.25) anywhere in the world where the amplitude ratio N_2/S_2 < 1, spring-neap cycles will feature clearly in the tidal height records. Thus, the boundary separating Types 1 and 2 from Types 3 and 4 occurs at N_2/S_2 = 1. Type 1 and 2 areas of the ANZ coast are characterized by relatively larger S2 amplitudes (19-40 cm) than areas with stronger perigean-apogean influences (2-18 cm) (Table 1). Secondly, tidal regimes with stronger spring-neap signals include places where spring-neap cycles occur as consecutive fortnightly cycles of similar magnitude (Type 1 or 'spring-neap' type regimes), and places where spring-neap signals dominate but with noticeable variability in the magnitudes of consecutive cycles due to subordinate perigean-apogean influences (Type 2 or 'in-

termediate, spring-neap' regimes). In ANZ the strongest spring-neap influence occurs in the Cook Strait to Kapiti area, where harmonic analysis revealed an amplitude ratio of N_2/S_2 = 0.35 and an E value of 0.79 (Table 1). Examining the shapes of tidal height plots showed that Kapiti had the only completely spring-neap dominated tidal envelope amongst the case study sites. Hence the boundary between Type 1 versus 2 was set as E = 0.8 for ANZ, just greater than that of Kapiti and below the next strongest spring-neap influenced site, Nelson, where E = 0.9 (Fig. 6). Lastly, to set a boundary between 'perigean-apogean' and 'intermediate, perigean-apogean dominant' regimes (i.e. Types 3 versus 4), we again examined tidal height plots to determine a boundary value of E = 1.15, between the 'intermediate, perigean-apogean dominated' type regime of Napier (E = 1.147) and the 'perigean-apogean' type regime of Kaikoura (E = 1.162) (Table A1; Fig. 6)."

203 - see below. mention the other red blob. Response: The following text has been added: "As shown in Fig. 1c, such regimes unusual internationally, also occurring in limited areas of the Cook Islands and northeast of Pitcairn Islands in the Southwest Pacific Ocean; in Alaska's Bristol Bay, Canada's Hudson Bay and offshore of the North Carolina to Virginia coast in North America; on the north coast of the Bahamas in Central America; and in the Gulf of Ob in Russia".

217 - if you agree then drop 'theoretical experiments' here. Response: Yes – all mention of them, and the experiments themselves, have been dropped.

220 - these three do not all operate at 'synodic anomalistic timescales'. Why not just '..three key constituents (M2, S2 and N2).' At this point it occurred to me that a similar exercise could be conducted for areas of predominantly diurnal (but a bit mixed) tides. Could you speculate in this Discussion which parts of the world could benefit that way? Response: 3 key constituents change made. Using the FES2014 model for a similar exercise, we explored predominantly diurnal tidal regimes and found a possible area, the Ross Sea, Antarctica, where there are extremely weak (F>15), very weak (F>8) and weak (F>5) M2 and S2 amplitudes along with the areas of M2>S2, S2>M2, N2>S2

and S2>N2 amplitudes. Thus, our approach to classifying monthly tidal patterns can be applied to the Ross Sea diurnal tide area, but it is not as simple as the application in this paper to semi-diurnal ANZ regimes.

230 - this isn't necessarily true. Figure 1c shows where S2 is small compared to M2. It doesn't necessarily follow that perigean influences dominate. Response: We checked the results for all 'red blob' areas and in all the N2 is at least five times greater than the S2.

239 - what is 'low-frequency coastal flooding'? Response: This unhelpful descriptor has been deleted.

Table A1. Line 1 - you don't show tidal ranges, this will be confusing for most people. What you show on the last line are ranges of amplitudes and phase lags in your data set. Also the 'ranges' shown are crazy for some as shown e.g. see 6-360 for K1. But 360 degrees is the same as 0 degrees! Line 2 - values. Also the header should mention you show Types. Say if the phase lags shown are in Greenwich Mean Time or local time? if Greenwich then they are usually denoted by G. Response: Corrections to caption and number values (360 –> 0) made as suggested, and line 2 deleted. Phase lag reference added and notation amended to G. Also the columns in this table have been re-ordered in line with the suggested re-ordering of the Table 2 (now Table 1) columns.

Figure A1. I don't understand the 'under conditions summarised in Table A1'. Surely all one needs to know is which stations were used for these 3 examples. Response: Since the experiments have been deleted, this figure has also now been removed.

261 - doesn't matter much but Figure 2 looks like a simple coastline map to me that one could make with GMT or Matlab, so where do the fancy 'map layers' come in? And with an undesirable national coordinate system to boot instead of lat/lon? Response: The coordinate system and map outline were supplied as CorelDraw map layers. The coordinate system has been amended to internationally understandable Lat/Long, and

the Acknowledgement note has been simplified to ‘map layer’.

Table 1. Line 1. The word ’interval’ in tides refers to the times of high tide since passage of the moon. What you are showing here are not intervals but the periods of beating of the shown pairs of constituents. And personally I would abandon columns 3 and 4 - you are not writing a text book here - certainly drop column 3 (and in M2/S2 – drop ’axial’. M2/N2 - drop ’relative’. line 3 ’during the siderial month’ –> during a month). And I would drop the Note which doesn’t add anything. Response: Taking on board these comments, we have completely deleted Table 1 (and also Tables 3 and 4 as per your comments below) and re-ordered the remaining table.

Table 2. I would have a column 1 showing Type. And I would move Example Sites to be a column 2. First line of that: Equilibrium Theory (no footnote and no Note – you have already mentioned Defant in the text). Response: Table columns re-ordered and changes made as suggested (note – now Table 1 as per change above).

Table 3 - I guess this does no harm but it just repeats what has been given in the text. I would drop it. Response: This table is now deleted – it was superfluous with clearer formatting of Table 2 (now Table 1).

Table 4 - I don’t understand this table. It is tied up with mention of the experiments, see comments above. I would drop this table as well. Response: This table is now deleted, in line with removal of the experiments as commented on above.

Figure 1 - just a suggestion but perhaps all panels could be made the same size. You have (a) large but that is for the normal F which is not the subject of this paper and can be found in many text books. Also for this, and also for the other colour maps in Figs 3,4 etc. could you have an arrow on the max colour as you have points on the maps with values which are in overflow. As for Figure 1 (c), you should mention somewhere in the text where the other red blob is. Near Tahiti? line 4 of caption ’.... monthly tidal envelope using criteria described in section 3.’ Then for (c) see my comment for line 230. Response: All 3 maps are now the same size. The overflow issue has been

eliminated from this figure. The red blobs in 1 c have now been described in the text more fully, as indicated above. For Fig. 1c, see reply above. The caption for 1 c has also been adjusted.

Figure 2 - please use conventional lat/lon and not a national coordinate system no-one else will understand. As mentioned above there are places in the text (e.g. Stewart Is.) not shown. '&' –> 'and'. When Figure 2 is first mentioned in the text there is no mention of the Type 1, 2 etc. So you have to returrn to this figure after you discuss Figures 6 and 7 and mention the Types in Fig.2, and then please also use the same colours for the Types here as in Fig 6. Response: All changes made as suggested.

Fig 3 - arrows needed on colour scales e.g. for the overflow top-left of 3(d). The contour annotation bottom right of 3(f) is messy, please thin out the annotations. Also drop 'Unit' in 'Unit mm'. line 1 of caption - 'Amplitudes for'. Drop 'horizontal'. Line 2 - drop 'derived and'. Drop 'database'. 'at a scale of' –> 'on a grid of' Response: The scale of 3f has been changed to eliminate the overflow issue. The contours have also been thinned out as recommended. 'Unit' has been deleted from the scale bar. All caption changes have been made as suggested.

Fig 4 - as mentioned I would drop the a's in the headers and captions. Arrows on colour scales. line 1 of caption - drop 'horizontal'. Line 2 - drop 'database'. 'at a scale of' –> 'on a grid of' Fig 5 - drop a's Response: The overflow area in Fig. 4c has been clearly delineated and labelled, and the suggested caption changes are made, including removal of 'a's.

Fig 6 - this is actually a useful plot. Use another colour instead of pink which is too much like red. drop a's. Use same colours for the Types as in Fig 2. Add dotted or dashed lines also for the Fsm boundary values chosen to define Types 1-4. Also what would be useful also would be to have values from FES2014 for the whole NZ coastline - that might be a fiddly computing exercise but is obviously possible. Response: Color, dashed line boundary, and 'a' changes made as suggested. We decided not to made a

FES2014 model based version of this diagram for the whole ANZ coast due to our focus on observational data in this diagram (including the Walters et al. data comparison) and also since we use the FES2014 data to do this task (albeit in map rather than plot form), classifying the whole ANZ coast into E type categories, in our newly expanded Figure 7.

Fig 7 - overflow arrow. could roughly the same colours be used as for Fig 6 as far as possible? That has red-green-blue-pink for types 1-4 whereas this has green-yellowred more or less (the blue is not used). line 2 - .. see Figure 5 for definitions and examples of .. Response: All colour and caption changes made as suggested. Figures 2, 5, 6 and 7 now have the same colours for all E types.

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Interactive comment on Ocean Sci. Discuss., https://doi.org/10.5194/os-2019-122, 2019.

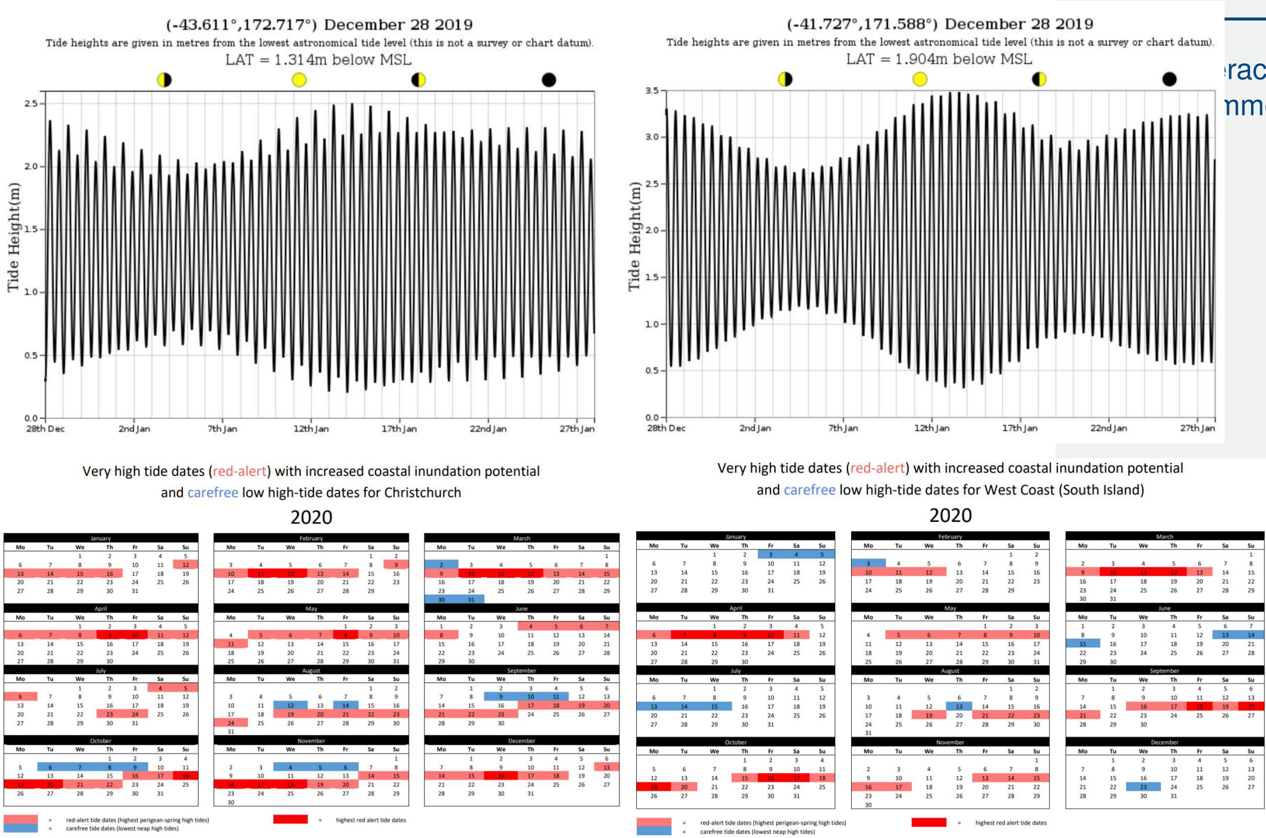

Figure R1. (Top) One month of tidal heights for Christchurch on the South Island's east coast (left) versus Westport on the South Island's west coast (right); and (Below) 2020 predicted tidal 'red alert' days for Christchurch (left) and the South Island West Coast (right), Aotearoa New Zealand (generated using NIWA, 2019).

Interactive comment

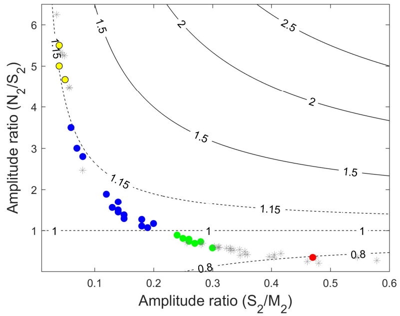

Figure 6. Plot of the relationship between the $\frac{N_2}{S_2}$ and $\frac{S_2}{M_2}$ amplitude ratios (y and x axes respectively) versus *E* values (shown as plot contours), with data points corresponding to Aotearoa New Zealand waters Type 1 sites (red dots); Type 2 sites (green dots); Type 3 sites (blue dots); and Type 4 sites (yellow dots), all from Table A1; and tidal data representative of the greater Cook Strait area (grey crosses) from Walters et al. (2010, Tables 1 and 3).

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Fig. 2. Figure 6. Plot of the relationship between the N_2/S_2 and S_2/M_2 amplitude ratios (y and x axes respectively) versus E values (shown as plot contours), with data points corresponding to Aotearoa N

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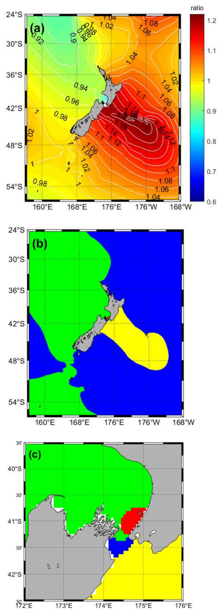

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Fig. 3. Figure 7. Distribution of monthly tidal envelope factor (E) values (a); and types (b); in the waters around Aotearoa New Zealand, including in the Cook Strait area between the two main islands (c); ca

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