SC1
Some comments on 'Bardsey – an island in a strong tidal stream Underestimating coastal tides due to unresolved topography' by Green and Pugh

I am not the topical editor or one of the reviewers for this paper, but I gave it a read and have some detailed comments that I hope are useful. I thought it was an interesting paper but the text is not very good and there are many minor problems, especially in the first half. I list these below. I will leave the official reviewers to comment more on the science.

19, 21, 24, 25 and many other places in the text - there are often mentions of 'altimeter data' or 'altimetry database' but the authors do not use that but instead use the outputs of a hydrodynamic tide model (TPXO9) in which altimeter data (and possibly tide gauge data) have been assimilated. There is a difference between these things and 'altimeter data' is a complete misnomer. On the other hand, sometimes the language is correct e.g. line 18 'altimetry constrained product'. Fine.

- **Corrected to "altimetry constrained product" or, more specifically, "TPXO9" throughout.**

Also everyone knows that altimetry has a coarse spatial (and temporal) sampling and provides elevations and not currents. But on line 14 we read about tidal streams and next line says they will be unresolved by altimetry. Well, yes, of course they will, whatever the spatial resolution.

- **This sentence (on line 19) has been rewritten: "…**and that even in this latest [TPXO9] altimetry constrained product the derived tidal stream is seriously under-represented due to the island not being resolved.**"**

So I think the text has to be gone through and the misleading language corrected. I suggest that first time you refer to 'altimeter-derived tide model information' (or similar) and thereafter just refer to TPXO9, which is what you mean anyway.

- **Done when we discuss our results. We have kept "altimetry constrained product" or similar when discussing the general usability.**

18 – observations

- **Corrected.**

31 - ... constituents have been mapped using altimetry

- **Corrected.**

32-34 - it is reasonable (or essential) to say e.g. TPXO here, but pointless to refer to FES and give a web site as you don't use the FES2014 model in the paper and there is no further mention of it below. I suggest that you reword to say e.g. TPXO and several other models and give a reference to Stammer et al. (2014) which the authors will be familiar with.

- **Rewritten: "**Scientific understanding of global tidal dynamics is well established. Following the advent of satellite observations, up to 15 tidal constituents have been mapped using altimetry constrained numerical models, and the resulting products verified and constrained further using in situ tidal data – see Stammer et al. (2014) for details.**"**

Define TPXO acronym

- **As far as we are aware TPXO isn't an acronym – it is the name of the database – and there is not a full name given on the product page.**

Also you can add that, because TPXO9 is a model and not a simple altimeter database, it provides tidal currents as well as elevations.

- **We have added "**Because many of the altimetry constrained tidal database are models, and not just altimeter databases, they also provide tidal currents as well as elevations. This is true for TPXO9 (see Egbert and Erofeeva, 2002 and https://www.tpxo.net/ for details), the altimetry constrained product used here."

35, 38 - again, there isn't an issue with altimetry products but rather with the models that have used altimetry.

- **This is clarified in the new text: "**…"invisible in altimetry constrained products".

39 - define GEBCO

- **Done**

50, 51 - ditto the above. I rest my case.

- **Corrected in all cases as mentioned above.**

53 - We will make a ..

- **Included**

54 - .. for tide gauge (TG) locations ..

- **Done**

55 - in situ is Latin and has no hyphen, as you use correctly somewhere lower down. You could put it in italics as you do below.
... of the in situ tide gauge measurements).

- **All six instances in the text corrected.**

Figure 1. There are many problems with this:
(i) In (a) can you please change the political Eire and UK to the geographicial Ireland and Great Britain. If you insist on the former then I will insist on you showing the border with Northern Ireland.

- We do not insist – corrected.

(ii) In (b) there is no (b) shown

- **Added**

(iii) (b) shows longitudes but not latitudes. Also the caption says 'map data from GE' but there is no bathymetry shown (that would be essential I would have thought, surely you can get bathymetry to 50 metres or so from recent European databases) or land topography so I don't see where GE comes into this.

- **Updated with bathymetry.**

(iv) in the box for location East, the two sets of amplitudes and phases run into each other with no space.

- Fixed.

(v) line 1 of caption meters should be metres as most of the paper has UK English spelling. line 3 - locations. line 3 - drop 'les' line 3 - I can't see any blue crosses. It may be that there are both green and blue dots, I can't tell, but they overlap and you can't see them separately and some people will also have problems telling green from blue.

- Rectified, they are now black stars.

Also Bardsey Island has no space.

- **Fixed**

line 4 - Phases should be phases to be consistent with elsewhere. line 5 – amplitudes should be M2 amplitudes, and then it should say 'the black numbers show ...', phases should be Greenwich phase lags and two minutes should be approximately 2 minutes, and 'for each tide gauge' should be 'for each

tide gauge record'. Somewhere in the caption one should also refer to Table 1 and the caption should also mention the arrows. It is important to refer to phase lags instead of phases as (i) they are lags anyway, and (ii) you also use the word phase to refer to a set of measurements.

- All suggested corrections done; the caption now reads "Figure 1: a) Map of the European shelf showing M_2 amplitudes in meters, from TPXO9.
b) details of local topography and tidal characteristics in the vicinity of Bardsey Island. The symbols mark the TG location, with green ellipses denoting phase 1, black stars phase 2, and red triangles phase 3. Note that East was occupied twice, during Phases 1 and 3. The red numbers in the text boxes are the amplitudes (in meters) and the phase lags on Greenwich (in degrees, one degree is almost two minutes in time) from the harmonic analysis for each tide gauge. The bathymetry comes from EMODnet (https://www.emodnet-bathymetry.eu/)."

88 - I don't think 3.2-16.5 is consistent with 'a few tens' which to me means a much larger number.

- **This has been clarified – we are referring to the lateral distance as a few tens. It now reads "**The other instrument deployments were bottom mounted a few tens of metres laterally offshore, and in depths between 3.2 m and 16.5 m**"**

91 - this should read 'using the Tidal Analysis Software Kit of the National Oceanography Centre (NOC, 2020)' and then add NOC (2020) with the web reference to the reference list.

- **Corrected**

98 - say when Ophelia was

- **Added: "..**hurricane Ophelia, which had maximum local wind speeds on 16 October 2017.**"**

99 - in situ

- **Corrected as mentioned above**

I don't think a reader will automatically understand why the consistency of tidal age (and will he know what that is anyway?) and S2/M2 ratio is important. It could do with some extra words and a reference to Pugh and Woodworth (2014). Also I felt at this point that there should be a para describing Table 2. The table sort of stands alone and is not really mentioned in the text although there are occasional mentions of it. But a para here would be justified. For example, why did you choose just to show M2, S2 and M4. Then, you are inviting the reader to compare the tide gauge and model values, but S2 is not strictly comparable as the measurements will come from pressure sensors and so include the air tide. You need to mention points like this before the reviewers do.

- **We have expanded this section to cover all of these points: "**A good indication of the internal quality of the *in situ* observations and analyses is given by the consistency in the tidal ages and S_2/M_2 amplitude ratios . The tidal age is the time after maximum astronomical tidal forcing and the local maximum spring tides, or approximately the phase difference between the phases of S_2 and M_2 in hours, whereas the amplitude ratios are related to the spring-neap amplitude cycle. These are given in the final columns of Table 2. The effects of the storm were not noticeable in the tidal signals, as they were at very different natural frequencies. The subsurface pressure measurements at Bardsey include atmospheric pressure variations, and any tidal variation therein. However, at these latitudes the atmospheric pressure S_2 variations are very small. At the equator the atmospheric S_2 has an amplitude of about 1.25 mb, which decreases away from the equator as $cos^3(latitude)$, so at 53^0 N the amplitude is reduced to 0.26 mb, a sea level equivalent of 2.5 mm. In Table 2 the three constituents listed are the two biggest , M_2 and S_2 , and as an indicator of the presence of shallow water tides, M_4 the first

harmonic of M_2 . These shallow water effects are enhanced around the island because of curvature on the directions of current flow.**"**

104 - 1 minute

- **Corrected.**

Table 1 - column 3 should say East Longitude, 4 should be Time and Date Deployed (hour (GMT), day, month, year), 5 should be Time and Date Recovered (hour (GMT), day, month, year), 6 should be Mean Depth It is important to spell out the date convention as there is often ambiguity between US and UK conventions.
Phase 2 deployed times have an extra /

- **All corrections done.**

108 - for the reasons explained above I think the title should be Tide Model Information and then the first sentence should read 'The tide model used in this paper is that of the TPXO9 ATLAS which is derived from assimilation of both satellite altimeter and tide gauge data (Egbert and Erofeeva, 2002).' Actually I was surprised to learn lower down that you say TPXO9 included some tide gauge data as well as altimetry. Well, ok, if that is case the above sentence is needed.

- **This is now more specific than suggested and called "**TPXO9 data**". The regional TPXO Atlas products include some TG data (whereas some is used for validation and error quantification). TPXO9 is a conglomerate including the regional solutions, so the text has been amended to "**The altimetry constrained product used in this paper is that of the TPXO9 ATLAS which is derived from assimilation of both satellite altimeter and tide gauge data (Egbert and Erofeeva, 2002).**".**

112 - using the word 'astronomical' in this way is a bit strange. But as you say you are making some kind of analogy with Highest Astronomical Tide. But I wonder if it would better to define some acronym here such as GA to mean 'Greatest Astronomical'. Also, many times below you refer to astronomic and not astronomical which must be the same thing. Use an acronym instead.

- **We have opted to rewrite this as "**In the following calculations, we approximate the largest tidal current speeds or amplitudes as the sum of the amplitudes of the above four tidal constituents. Of course this is only a crude estimate of the full Highest and Lowest astronomical tides. Note that we are not allowing for M_2 to M_4 phase locking, and the relatively small diurnal tides are ignored. We refer to this as the GA (Greatest Astronomical) in the following.**"**

114 - drop 'we discuss'. reword 'This term is thus analogous to'

- **Done, see above.**

119 - give a reference to SNAP 7.0

- **Done: "**were created with SNAP 7.0 **(**Sentinel Application Platform; https://step.esa.int/main/toolboxes/snap/)**"**

123 - why was this hour chosen and not an hour later for example?

- **Because this was when the satellite passed over the region; Clarified in the text: "**The images used were taken between 11:00 and 12:00 UTC, when the satellite passed over the area.**"**

129 - reword. Summary of findings for M2, S2 and M4 from harmonic tidal analysis of tide gauge and TPXO9 model data. The latter were ... locations given ... drop 'to ease reading'

- **Done and the caption now reads "**Table 1: Results of the tidal (TASK) harmonic analyses. "H" is amplitude (in m) and the phases "G" (degrees relative to Greenwich) are given in italics. The TPXO9 data was interpolated to the TG locations and the resulting data given to 0.01 m. The *in situ* RBR data results are given to 0.001 m and 1.0 degrees. However, for regional comparisons we assume confidence ranges of 1% for amplitudes and 1.0 degrees for phases. RBR constituents are adjusted for nodal and seasonal variations.**"**

Good to have in situ in italics and no hyphen.
Top left of table should be Station

- **added**

You have TPXO here and in places in the text. It would be best to use TPXO9 throughout. line 1 of phase 2 has TPXO9 phase to 4 decimal places instead of 2

- **Corrected to TPXO9 throughout. Decimal places amended.**

135 - phase lags

- **This is now "*In situ* observations"**

137 - .. (west) (Table 2).

- **Included**

I struggled to understand some of the numbers in this para. For one thing why do -14 and -9 have minus signs as you don't specify by difference whether it is east-west or west-east. Then surely at springs the amplitudes will be larger in the east by 16 cm (8 from M2 and 8 from S2), compared to spring total amplitude of about 1.8 m, which gives 9% to me and not 14.
Then I don't see where the 9% comes from along-island as you don't have a sensor in the south anyway. So please can you spell out things so there is no confusion? Also I don't see where 30 cm comes from - do you mean +/- 16 cm?

- **We have corrected and clarified the paragraph: "**The results of the tidal harmonic analyses are shown in Table 2. A spring-neap cycle of parts of the data from the East and West gauges in Phase 1 is plotted in Figure 2a. The TG data show amplitudes of 1.210 m (North), 1.347 m (East) and 1.139 m (West, see Table 2). These give pressure gradients around the island. The narrowest part of the island, some 300 m separates the East and West sites. Here, across-island difference in amplitude give, on spring tides a level difference across 300 m of up to 0.5 m. There is also 6.5^{o} (13 minutes) phase difference for M_2 across the island between the east and the west, with the east leading, consistent with the tide approaching the island from the south and east and then swinging north and east around the Llŷn Peninsula headland. Figures 2 b, c show the across island level difference plotted against the measured level at East for two representative days of spring and neap tides. Obviously, the differences are smaller for neap tides. The plots show that the East levels are some 0.5 metres higher in the East than on the West, at High Water on spring tides. On neaps the excess is only about 0.3 m. The differences on the ebb tide are slightly reduced, probably because the direction of flow is partly along the island, steered by the Llŷn Peninsula.**"**

150, 151 - phase lags. altimetry data again!

- **Corrected.**

152 - .. is a substantial model deficiency in representing the role of the island due toits limited resolution, resulting in ..

- **Corrected: "**is a substantial deficiency in the TPXO9 model in representing the role of the island due to its limited resolution, resulting in a 13% difference in amplitude between the TPXO and TG data at station East. "

159 - drop the comma
I must say I don't find this para very surprising.

- **Comma corrected and the lack of surprise noted.**

162 - you mean 'As a representation of the shallow-water harmonics, ..'

- **Indeed, rewritten as suggested.**

168 - altimetry alone. Ditto again.

- **Corrected.**

173 - you have this the wrong way round. East is on the x-axis so you plotting the difference versus east.

174 - what does 'the first data point of the day' mean? Do you mean 0 hr on the day.

The caption is rewritten; "Plots of the East-West elevation difference *vs. the* elevation at East for springs (b, day 147) and neaps (c, day 154). The red stars show the data point for 0000 hours on the day. The progression is clockwise.**"**

Figure 3: (i) the colour scale says current amplitude but the caption says current magnitude. I suggest use magnitude for both. Then line 185 says they are spring flood and neap flood but the caption says neap ebb and spring flood. And then because (b) looks to have smaller values anyway I guess that is for neaps? Anyway this is all inconsistent.

- **We opted to change the caption to** "amplitude". **The figures show spring flood and neap ebb and the text has been corrected. The full caption is now** "Figure 2: The current amplitude (colour) and vectors at spring flood (a) and neap ebb(b) from TPXO9. The white circle shows the location of Bardsey – note that it is not resolved in the TPXO9 data and has been added for visual purposes only. "

184 - perhaps it would be best to also have the Admiralty chart in the reference list.

- **Added.**

194 - strait. You have called it a sound elsewhere

- **Corrected.**

199, 201 and elsewhere - astronomic - see above

- **Corrected throughout to "**GA tide**" as suggested above.**

244 - this is not a suitable heading for a science paper. I suggest you have something like 'Island Tidal Wakes' and by all means express your reservations in the text.

- **We disagree with this, and the formal reviewers have not raised concerns, so we will keep it as it is.**

245 - altimetry data again

- **Corrected.**

246 - computation of what

- **Changed to "…**so our computations of the energetics and non-dimensional numbers are conservative.**"**.

253 - this sentence has no verb

- **Now it does – rewritten as "**The Simpson-Hunter parameter is $X = h/u^3 \approx 70$ for Bardsey Sound (Simpson and Hunter, 1974).**".**

266-269 - this sentence needs rewording. Makes no sense

- **Rewritten as "**This means that fully developed eddies can be generated at the higher flow rates, because our tidal period (12.4 hours) is longer than the vortex shedding period a few hours). However, at neap flows there is no time to develop a fully separated vortex within the timeframe of a tidal cycle.**"**

Figure 4: needs (a) and (b) adding.

- **Added**

272 - mentions Landsat 8 twice. 273 - is halfway. 274 - 3b should be 4b.

- **Corrected: "**Figure 4: Landsat 8 images from October 5, 2017 (a) and September 13, 2018 (b) from Landsat 8. The tidal phases are halfway through the tidal cycle on the neap flood in a) and just after spring high tide in b)….**"**

278 - 3a should be 4a

- **Corrected**

You say here 4a and 4b are neaps and springs but in the caption says halfway between and after springs. Also I had to read this twice as from the caption I originally understood that to mean just after a particular spring tide (say an hour after) whereas what I think you mean is after a period of springs (like a day later). Anyway, can you please make this clearer?

- **Clarified, see above.**

286 - altimetry-constrained models
'where the bathymetry is unresolved' - you mean unresolved in these models. There are in fact decent bathymetry databases available - I suggest you use them for Figure 1(b).

- **Rewrtitten: "…**highlight the limitations of altimetry-constrained models near coastlines where the bathymetry used in the model is unresolved…**".**

292 - one is not 'relying solely on altimetry' for the reasons above. You are relying on the models.

- **Corrected to "**…altimetry constrained models…**"**

301 - sea level

- **Corrected**

302 e.g. –> for example

- **Our preferred use is e.g., and we have kept that.**

reference - please check that you have included them all. Pugh and Woodworth (2014) for example is missing.

- **Corrected**