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Reply on RC2

Carlos Corela et al.

Author comment on "The effects of deep ocean currents on different OBSs" by Carlos Corela et al., Nat. Hazards Earth Syst. Sci. Discuss.,
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The authors present the results of studying current induced noise in ocean-bottom seismometer data. They connect well-known noise generating mechanisms like short-period head-buoy strumming and long-period tilt and compare it to tidal recordings. The findings are definitely worth to be published, but the presentation is not sufficient enough yet. The discussion should be extended by information about the horizontal components and currents in the study area. I also recommend to show the spectrograms without normalization to allow a comparison of amplitudes.

General remarks on the content:

- There is no information about currents and tides in this area described in the text. The different directions of deep-water currents and tidal flows are essential for your conclusions, but how are they related at the OBS locations shown here? How does the sea floor topography affect the tides and currents, can this explain differences between the OBS? The maps shown in <https://doi.org/10.1016/j.ocemod.2018.08.003> suggests this. Can the pattern of currents explain, why only 3 out of 24 OBS are affected by this? Can you estimate current speeds out of the noise?

Considering two papers from Hernández-Molina. The first from 2011 (DOI:10.1007/s00367-011-0242-2) and the second from 2016 (DOI:10.1016/j.margeo.2015.12.008) is possible to highlight the circulation of water masses in SW Iberia and the influence of tides in the same study area. Both papers have details explanations how the deep-water masses and tides behave in terms of the topography, where their actions are more pronounce showing maps where the mean bottom-current speed are more relevant. I added this information and in Figure 2 of the manuscript I have the water masses directions and the directions of the tides. This added information is of great value and enhanced the value of this manuscript.

- Why is only the vertical component used for this study? The currents and most OBS structures discussed in the text (frame, flag pole, antenna) are not omnidirectional, therefore differences between the horizontal components might give additional insights. Also, should the orientation of the OBS be considered, especially for the discussion of the antenna and the flag pole. Are they oriented in a direction to the currents, that resonances can be excited at all?

In the new manuscript I added the spectrograms of the Y horizontal components. In 24 OBS only ten have all components with data and the OBS in focus (OBS01) has no data in X component. However, the cross-coupling due to tilt noise is very well pronounced in the vertical component. We designed the lobster in Solidworks software which have one fluid package simulation. When the speed flow is slow ($< 5\text{cm/s}$) the flow is laminar and we don't observe movement in the flag and radio antenna. However, when the speed flow increases and the flow became turbulent, the flag and radio antenna start to move and when the flow is in phase (0° or 180°) we observed vertical movement on the flag and antenna. If we increase the angle between the flow and the OBS (+/-) the movement became an ellipse and when we reach 90° or 270° the movement is horizontal. In every angle we detect movement in the flag and radio antenna, more or less energetic but it's there.

- The findings of this study are very interesting. Unfortunately, the manuscript does not emphasize the new findings enough. All mechanisms described here have been discussed before, long-period tilt as well as head-buoy strumming. The combination of this leads to new insights, but this needs a more detailed discussion considering all information available.

General editorial remarks:

- Title should be more specific, this is not a review article, but focuses on special effects of a special OBS design.

Ok. We will change the title to support the new OBS design and the findings.

- Please check references, several references mentioned in the text are missing in the list. Please check spelling of references, e.g. Stähler et al. was misspelled several times.

From the first reviewers we have already made all corrections regarding the references.

- Please check spelling, there are some mistakes. There are several very long sentences, which are difficult to understand.

We have already corrected hard sentences and streamline the most complicated sentences.

- The OBS were named "NT OBS..", this suggests that "NT" is an official FDSN network code, which it is not (it is the code for the US geomagnetism program).

I have named NT OBS just to differentiate from the new OBS. The FDSN code from the NEAREST project was That is correct with the new FDSN code from the NEAREST campaign.

- Spectrograms: all spectrograms are normalized and, additionally, different color palette tables were used. This prevents the comparison of amplitudes, especially for the tilt noise. E.g. in Fig. 9, it seems that there is a very strong tilt noise all the time. Other signals like the microseisms look very different at the various spectrograms, this is very confusing. I strongly recommend to use real amplitudes and one common color palette table only.

Now we use the same color palette with real amplitudes.

- You discuss a large frequency range, switching between "Hz" and "seconds" is sometimes confusing. Please give both values, e.g.: "10 Hz / 0.1 s" .

When we work in ambient seismic noise we work in periods and for me was the natural way to do the figures to show linear scales. However, I will add the frequency as well. Stähler et al. used the spectrograms with the scale in frequencies and periods.

Text:

- Line 19ff: The references seem to be chosen very arbitrarily with emphasis on own projects. OBS are common instruments, so it is not necessary give references here.

Ok. We take out the references.

- Line 23ff: Please add the usage of hydrophones to this paragraph, which are important to understand noise. You refer to hydrophones (line 96) later, so it should be introduced before.

I add the hydrophone in the first lines of the manuscript.

- Line 35ff: The noise discussed in this paper is not "self-noise", it is noise generated by currents. Electronic self-noise is an important criterion for the performance of the seismometers. E.g. the Güralp CMG-40 seismometers have a very high self-noise below 10 seconds, this is clearly visible in the PPSD plots.

Corrected. The first attempt to describe OBS behavior in terms of current-generated noise was made near Hawaii.

- Line 105: A PhD thesis might not be the appropriate reference here. You might cite some papers resulting from this project instead.

This is my PhD thesis. I published in Ambient seismic noise which is one of my areas of study. However, in this work I write about the natural frequency of the OBS-sediment resonance behavior, the orientation of OBS in the sea-bottom, harmonic tremors, short duration events, tides, microseismic, infragravity waves, swell and local waves and surface wind, clock drift, all kind of signals recorded during the NEAREST campaign.

- Line 109/177: Is OBS03 located in the D. Henrique basin or at the Marques de Pombal plateau?

OBS03 is located in D. Henrique basin. In Marques de Pombal plateau is located OBS06. The sentence was corrected.

- Line 122: In this paper, only the behavior in currents is compared, "performance" includes much more, e.g. self-noise of seismometers, data retrieval, etc.

Ok. The term "performance" was not well used. The more correct term should be differences between OBSs data records showing spectrograms and PPSD for the all-time and some periods.

- Results and discussion: Please split this section into two parts. The discussion is so far not sufficient enough and should be separated from the pure results.

Ok. Already done.

- Line 188ff: Please move this paragraph to "Harmonic tremor structure".

Already corrected with the previous reviewer.

- Line 196ff: How did you determine the sources for the various frequencies? How do you know, which frequencies belong to the flag pole and the radio antenna? Essing et al. discussed this issue in detail. Please explain the "natural frequency of OBS-sediment coupling".

What is observed in the LOBSTER OBS components, between 0.5Hz until 7Hz in Harmonic tremors, is the rope, flag, radio antenna and the natural-frequency of the OBS-sediments coupling. The other components of the LOBSTER OBS doesn't do anything inside this frequency interval. When the strouhal frequency is close to the component resonant frequency the harmonic tremor, from this component, arise. For the radio antenna the stroudhaf frequency match the resonant frequency when the speed current is 5.7cm/s and that why the harmonic tremor of radio antenna shows up since the beginning around 6Hz. For the Flag the match between the frequencies happen when the current speed is around 15cm/s, and that is the reason why the harmonic tremor from the flag appears only when the current speed is at the maximum. This appears in the discussion section.

In the new introduction I have explain the work done in Hawaii in 1980's regarding the natural frequency of OBS-sediment coupling and the frequencies associated with OBS with the sensors attached to the structure. In my PhD thesis I explain this problem and illustrated spectrogram for the all-time campaign showing this persistent signal adjusting in the first few months of deploying (frequency gliding, until the connection to the sediment became rigid) and then maintain until the end of recording.

- Line 230/231: The microseisms appear also in other spectrograms, please mention them also there.

Ok, already done is the new version.

- Line 232ff: This explanation is not sufficient enough. Why are you sure, that the 3.8 Hz signal is the sediment coupling? What should the reader see in the figure? The 3.8 Hz signal is hardly visible.

The first iteration of the new OBS was made with the sensors attach to the OBS structure. When this happen the natural frequency of OBS-sediment coupling will be inside our interesting interval between 1 and 8 Hz. In the new manuscript I have one figure in the supplementary file showing this resonant frequency for the all time recording.

- Line 273: Essing et al. described the results of an experiment, where the head buoy was fixed and the harmonic tremor disappeared. This is not the best final sentence for a paper, maybe you add some more words about the consequences of your findings.

Ok. In discussion I will remark the Essing et al. results. In the UPFLOW campaign we have prepared all the LOBSTER OBS with the rope attach to the OBS.

Figures:

- Fig. 1: The different scaling for upper and lower part of the spectrogram is confusing. Maybe you should use "frequencies" on the left side and "periods" on the right side. Please mark and mention all features visible in the spectrograms, e.g. whale calls, microseisms, etc. Is the noise gap at 1 Hz real or an artefact? Which parameters (Window length, etc.)

were used for calculating the spectrograms? Caption: consider to write "Spectrogram instead of "Noise domain". First sentence is too long and confusing.

Ok. The new figures have all signals mentions and how the spectrograms are made.

- Fig. 2: The OBS locations and annotations are very difficult to see and read. Maybe the map section should be chosen differently. Please remove all annotations, which are not mentioned in the text, most geographic features are not relevant for this paper. Some arrows or similar showing the main bottom currents should be added, see <http://dx.doi.org/10.1016/j.margeo.2015.09.013> for an example.

Done, with the Antarctic bottom water (AABW) and the North Atlantic Deep Water (NADW). These two masses are the ones that could influenced the OBS and the directions are in concordance to what is observed in the OBS records. The tides movement are as well mention in this Figure 2. I added colors for the OBS saying what are the OBS with harmonics tremors and the ones that doesn't show any signal and correlate with the water masses and tides. In the supplementary material I had the PPSD of all stations in the spring tides.

- Fig. 3: I do not think, using pictures from web sites is a good idea. Are there no own photographs from the NEAREST experiment available? Caption: Why is the caption "NEAREST" when just some OBS are shown?

Ok. I will try to use photos from the NEAREST campaign.

- Fig. 4: Caption: The description of seismometer and hydrophones should be moved to the text. Or add the same information to Fig. 3. The last sentence is incomplete.

Ok. I will remove the description of seismometer and hydrophone from the figure. I have the same information on the text.

- Fig. 5: Why is there an abrupt change in amplitude at 1 Hz, is this an artefact? Please provide a scale for the Sines curve. Caption: The last sentence can be deleted. The nature of tides is already explained in the text.

No, it's not an artefact. It's the color scale. I will add below the Tide Sines curve with the proper units.

- Fig. 8: Why are the amplitudes normalized? A comparison of amplitudes at the different stages would be very interesting, e.g. is C constant all the time? How was the lower part of the figure calculated? - Fig. 11: Are these spectrograms also normalized?

With the normalized amplitudes the color scales are easier to make and with more resolution. I will add the amplitudes. No the signal C, which means natural frequency OBS-sediment coupling, increase amplitude during the harmonic tremor (flow is turbulent during this time) however, the amplitude of the antenna, rope and flag are higher when compared with that signal. The lower part of the Figure 8 is the vertical line at the different hours of the frequency window of the upper figure. The first figure is at 7h30m, the second at 09:30m and so on.

- Supplement: Are the seismograms also normalized or do they have the same scaling? In some spectrograms, e.g. 2017-09-12 12:00, are strong noise amplitudes ("red blobs") visible below 1 Hz. What is this?

It's a distant earthquake from Sumatra with magnitude Mw 8.4