Ocean Science

Discussions

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Interactive comment on "Temporal and spatial variations in three-dimensional seismic oceanography" *by* Zheguang Zou et al.

Kathy Gunn (Referee)

kathy.gunn@rsmas.miami.edu

General Comments

This paper makes a good contribution to the field of seismic oceanography, and presents interesting and useful analyses of 3D seismic data. The writing and figures are of a high quality.

I recommend Major Revisions as I have a number of comments. Most of my comments can be easily addressed. However, I do feel that this paper could benefit from a change of focus. Please see my comment below:

The paper is written in such a way that it is not immediately clear what the benefit is to an oceanographer. As you know, seismic oceanography is simply a tool that we can

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use to learn about the ocean. So, I think this paper could benefit from some re-direction toward the oceanographic aspects of its findings. In particular: - In the Introduction, there is little description of the oceanographic setting. What is it and what do you expect to see/resolve with seismic oceanography? Adding a paragraph along these lines would help place your findings in context later on. - In Section 3, you describe some seismic images in different orientations (i.e. inline, crossline, depth slices). Are the observations you describe typical across the survey? If so, can you comment further on what oceanographic implications these images have. For example, are the discontinuities in the crossline direction caused by heave of water masses? What sort of mixing processes could cause the degradation in Figure 5. Section 3 is presented as a way to guide the reader through the meaning of the images, but I think you could present them as some results (particularly if the images in Figs 5-7 are representative). Please see some related suggestions in 'Specific Comments'. - The discussion is dominated by seismic acquisition and processing thoughts. However, you could make some interesting discussion points about the oceanography related to Section 3 and 4. The authors may have a future paper that will address some of these points, and I understand that it is difficult to conclusively interpret seismic data without concurrent hydrographic information. Nevertheless, I think that the paper would be more impactful and have a wider scope if the authors address this general comment.

Specific Comments

Introduction: - In the Introduction, I think you should set up the expectation for this paper more clearly. For example, something like Line 331 would be useful at the end of the Introduction. - You (correctly) mention a few times that 3D seismic oceanography is not well-developed. However, I think it would be fair to devote a few sentences to the seismic oceanography studies that have used 3D data, and to what end, in the Introduction (I see they are signposted in the Discussion). As far as I am aware, these 3D studies are: (i) Gunn et al., (2020) who showed the evolution of a front, (ii) Dickinson et al., (2020) who explored the passage of an eddy, and (iii) Blacic and Holbrook (2010).

3D Seismic Processing - Why does the velocity model have to be calibrated with the CTDs and in what way did you do this calibration? In my experience, the seismic-derived sound speed models are poor when there is some unknown in the acquisition geometry (e.g. stretch in the streamer). Is that the case here? Another sentence to explain further would be useful. - You do not mention deconvolution in this section. I suspect it was too computationally expensive to apply? It would be good to describe what each reflection is in a bit more detail for those that are unfamiliar with seismic imagery (insert somewhere around Line 104). Then if you did/did not apply deconvolution becomes important for this description.

3D Seismic Volume - I understand your point about using the inline and crossline terms. However, can you add in a sentence about how the survey is orientated with regards to the oceanographic context. From the inset of Figure 1, the survey is a bit too far north of the Loop Current. Do you expect this section to have high eddy-kinetic energy or be quiescent? Perhaps it should be mentioned somewhere that you are in a continental slope setting.

Understanding 3D Seismic Water Column Images. - The observations you describe in this section are interesting and warrant further discussion here. Can you explain these qualitative observations further and link them with your inferences in Section 4.2? o Paragraph 2: I think that your observations are very interesting. Can you speculate on what might be driving the mixing of the water column? What are the typical processes in this area? o Paragraph 3: Again, this is very interesting. Can you expand on how you interpret these discontinuities? Heaving of the isotherms? Tides? Heaving can be more prevalent at different depths, so may explain why the discontinuities are not constant as a function of depth. o Paragraph 4: Again, an interesting observation. Can you comment on what this suggests in terms of timescales?

Theoretical Analysis - This thought experiment is useful, however I am not sure what you are trying to get at given your empirical analysis in Section 4.2. You mention the high-frequency aliasing in Lines 261-262, but that is your only direct comparison

between the two sections. Perhaps adding a few sentences to explain the purpose of this section in more detail, or removing it and expanding and improving upon Section 4.2?

Empirical Analysis - Your cross-correlation analysis is very interesting; however the structure of this section is confusing and I think you need further explanation and quantification in some places. o You define the terms 'inline variation' and 'crossline variation', but then do not use them very often. You could use them in some places in the main text which would make the writing sharper (e.g. Line 260). o After the equation, can you include the portion about 1D and 2D cross-correlation (i.e. Line 236-242). Following that, can you describe what these cross-correlations mean (i.e. Lines 230-235). Finally, discuss the results of Figure 9 and 10. o Having read this section a number of times, I am confused by why there is no temporal variation in 9a. Does the cross-correlation not compare multiple inlines that are separated by a few hours? I think the description in Line 236-242 could be clarified by removing the use of alternating brackets to describe two things in the same sentence, e.g. 'inline (crossline)..', and by including some descriptive examples. o What is the level of noise here? Are you sure some of the fluctuations in 9a are real? What is a significant R value here? Can you include an uncertainty and/or level of significance on Fig 9? o Line 250-252: I'm not sure I follow this conclusion from Figure 9. I agree with you, but not based on Figure 9. Furthermore, I think you should specify that the lack of temporal variation in the inline direction is specific to this region, as this conclusion will not be relevant everywhere (also specify at Line 264). The reason there is little temporal variation in the inline direction here is because of the setting of the seismic survey with respect to the oceanographic context.

Discussion - The discussion is coming from a seismic point of view, there is little discussion of the oceanography. Please see my general comment.

Figures - Figure 1 is excellent. It might be useful to add the average time between each inline on the figure, as you mention the temporal aspect several times in the main

text. However, this change is up to the authors. - Figure 2. In this figure, you have the vertical resolution as 5 m, but in the text you mention 6-7 m. Whichever it is, be consistent. - Figures 5-7: Interesting figures. Are they representative? Why did you choose them? If they are typical, you could replace 'example' with 'representative'. - Figure 9-10: Can you add some indication of the uncertainty?

Technical Corrections Line 7: missing 'the' before 'crossline direction' Line 9: delete 'allow to' Line 29: not sure if 'indeed' is necessary. Line 30: change 'primary' to 'and are primarily' Line 31: the placing of the commas makes the sentence sound weird. How about 'This new cross-discipline, between . .... oceanography,. . ..'. Or start a new sentence after 'known as seismic oceanography'. Line 101: I am not familiar with the term 'chair cut display'. Do you mean the display in Fig. 2? If so, please can you add a signpost to Fig. 2 at the end of this sentence. Line 109: 'water columns' sounds a bit odd. What about 'shows only the portion of the water column below 200 m'? Line 112: please be more specific about the average hours between the inlines. Line 115-116: Great sentence. Line 136: Do you need a new paragraph here? Line 138: You could delete 'Again' before 'We emphasize' Line 143: You could just cite Klaeschen, as you have already given the name of the assumption earlier. Line 150: the 'indeed' chops up the sentence. I would delete. Line 151: missing 'to' after 'We refer' Line 124: You do not use 'i' in the equation, just 1 and 0. 'i' and 'i+1' in the equation would be useful. Also, I think the 'medium' at the end of the sentence should be 'layer'. Line 154: delete 'here' before 'we present' Line 161: I would delete the 'mostly, but not completely'. I believe you are trying to say that it is temperature and salinity gradient that controls the reflections. However, by stating this caveat now, you make the latter part of the sentence weaker. Can you re-word slightly so that the conclusion (i.e. the change is real, not an artefact) is clear? I suggest removing this caveat entirely, as you explain a few sentences later. Line 162: delete 'the acquisition' and 'an' Line 163: 'amplitude of seismic reflection is' should be 'amplitude of seismic reflections are' Line 165: Colon should be a full stop. Line 167: Why is there emphasis on 'time-varying'. I think this is either obvious, or may need more explanation if I am not following your

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meaning. Line 177: I would change 'at shallow. . . deep one' to 'in shallower portions of the water column'. Line 178: I would delete 'the seafloor is associated . . .scale and' as I do not think it is necessary to state. Then the sentence would be '. . .because there is no temporal variation. . .' Line 182: replace the second 'representation' with 'view' Line 182: Missing 'a' between 'observe similar' Line 183: delete 'the' before discontinuity Line 200: missing 'a' before '1-km inline' and '1-km crossline' Line 205: replace 'being' with 'the' Line 228: 'note' rather than 'noted' L231-232: I think the sentence needs a bit of re-wording, something like 'The obtained cross-correlation is plotted as a function of spatial distance and temporal shift'. Line 232: 'correlation lengthscale' is more common in the literature I believe. Line 246: 'dominated' not 'dominant' Line 248: again, 'correlation lengthscale' Line 250: I disagree that the inline direction is 'only' associated with spatial variation. How about 'mostly'? Line 255: The sentence starting 'This decreasing trend' is unfinished. Line 266-268: A good point to state here. You cannot be expected to interpret every single thing. Line 293-294: Can you replace the first set of brackets with commas to avoid the double bracketing?

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