March 8, 2014

Jeffrey Puschell

Associate Editor

Journal of Applied Remote Sensing

Dear Dr. Puschell:

Thank you and your referees for considering my Letter “Fossil turbulence and fossil turbulence waves permit remote sensing of submerged submarines” for publication in JARS.

I have extensively revised the manuscript in Microsoft Word according to your comments and the many constructive comments of the reviewers, and hope they like the result. My responses are included below in red.

Dear Prof. Gibson,

I have received the reviewers' comments on your paper entitled "Fossil turbulence and fossil turbulence waves permit remote sensing of submerged submarines." and regret to inform you that we cannot accept your manuscript for publication without major revisions and re-review.

The reviewer's comments on your paper are copied below. If you wish to address these comments and submit a revised paper, I would be happy to give it further consideration. Note that it is JARS policy that, under normal circumstances, only one major revision is allowed and if the manuscript still requires significant changes after the revision, a reject decision will likely be rendered (with possibly encouragement to re-submit at a later point in time when all issues have been satisfactorily addressed)."

Please submit the revised manuscript by March 4, 2014. If you need more time to complete your revision, please contact the editorial office for an extension.

Go to the URL below to submit the revised version:

http://jars.msubmit.net/cgi-bin/main.plex

In a "Response to Reviewer Comments", please address the reviewers' comments and describe in detail the changes you have made to the manuscript on a point-by-point basis. You should also justify any instances in which you feel that the criticism is not valid. I will then have the paper re-reviewed and will let you know the outcome.

Please be sure to adhere to the folloiwng formatting requirements when submitting your revised manuscript:

Please submit your revised manuscript in either Microsoft Word or LaTeX/RevTeX. These are the only file formats that are usable for the composition process.

Include a list of figure captions at the end of your manuscript file.

Please upload individual figure files in TIFF, PostScript, EPS, PNG, or PDF. This will ensure optimal quality of your figures in the final published article, as well as expedite the processing of your article during production. When preparing your figures, make sure there is only one figure per file. All parts of the figure should be submitted as one file [e.g., Fig. 1(a), 1(b), and 1(c) should all be combined into a single file called Fig. 1.] The only data in the file should be the figure itself (do not include the caption or figure number). Set the graphic for 600 dpi resolution for line art, 264 dpi for halftones, and 600 dpi for combinations (line art + halftone). Save line art as black/white bitmap; not grayscale. Save halftones and combinations as grayscale, not black/white bitmap. Set the bounding box to image to avoid excess white space around the image.

Manuscripts should include a brief professional biography not to exceed 75 words. Please do not include photos.

If you have any questions, feel free to contact the journal staff at jars@spie.org.

Sincerely,

Jeffrey Puschell

Associate Editor

Journal of Applied Remote Sensing

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Editor's Comments:

Reviewer Comments:

Reviewer #1 (Reviewer Comments Required):

This short article proposes that the turbulent wakes of submerged vehicles operating in the stratified portion of the oceanic water column can develop a remotely detectable signature by virtue of the internal wave (IW) field radiated by their wakes. Although the author's proposal is not that outlandish and indeed a very interesting one, I find that there is not sufficient support for it. There need to be more references on turbulence-generated IWs and the fate of IWs as they propagate through variations in the background stratification and shear fields. Moreover, these references should be by other researchers not just the author himself.

Alas, the oceanographic community has chosen to ignore or reject all these concepts. In my opinion, microstructure studies without hydrodynamic phase diagrams are virtually meaningless. Imberger and Ivey have explored the HPD concept with their lake and sometimes ocean studies, but have failed to recognize the extreme persistence time of fossilized turbulence remnants. Jorg buys the ¼ buoyancy period claim of Van Atta et al. Diamessis has shown persistence to 1000. Fernando and his students have nicely tested all of them in the laboratory, but needs to keep his funding so he can’t be confrontational about it.

There are also some logical gaps in the author's primary proposal that make it highly conjectural. Key concepts are not defined, especially that of "fossil turbulence". The author might also want to also identify other more recent studies on high Reynolds number stratified turbulence that indeed indicate that the turbulence does not die out immediately, although a mechanism distinct to fossil turbulence might be operative. There is a great imbalance in the reference list, overall. Finally, some of the figures are very hard to read.

Please see the new reference 17, which is to Mike Gregg’s 1991 paper, reproduced in Volume 21(60) of the Journal of Cosmology with the topic “Studies of Stratified Turbulence in the Ocean”. Gregg’s paper captures the attitude of Western oceanographers to Russian oceanographic and fluid mechanical research: utter contempt. The editorial comment attached to Gregg’s paper is “This paper illustrates the appalling lack of sensitivity among oceanographers to the importance of fossil turbulence and fossil turbulence waves to mixing in the ocean, not to mention submarine detection.” Cosmologists and astronomers are equally guilty of this foolishness, and have vastly better data than the oceanographers that is fairly shouting about the existence of fossil turbulence. For example, see Volume 23 with the topic “Fluid Dynamics in Cosmology”. The frontispiece figure shows how turbulence cascades from a small cigar shaped source in less than 10^-5 of Kolmogorov space-time, from Tony Leonard’s 2013 analysis of the Johns Hopkins turbulence archive. The CMB spectra at big bang turbulence and plasma epoch scales dispel the myth of the acoustic peak of LCDMHC cosmology in favor of fossil turbulence patterns.



These generic turbulence patterns have persisted as fossils of turbulence for 13.7 billion years, clinching the universal similarity hypotheses of Kolmogorov and Batchelor for turbulence and turbulent mixing based on an inertial vortex force definition of turbulence where the direction of the kinetic energy cascade is always from small scales to large.

I feel that all these issues need to be addressed before I can recommend this paper for publication. My specific comments below should offer further guidance and I hope the author will fully take them into consideration.

SPECIFIC COMMENTS

Top of page 2 and Fig. 1: Please include this in the reference list. Are there no other claims that submerged turbulence can be remotely detected through its internal wave field ? I'm aware of work on the corresponding signature of internal tidal beams (see the studies by New and Pingree in the Bay of Biscay) and the numerous studies on surface signature of internal solitary waves (e.g. www.internalwaveatlas.com ).

<http://www.internalwaveatlas.com/Atlas2_PDF/IWAtlas2_Pg057_BayofBiscay.pdf> is now included as a reference. The data is great, but the origin of the surface manifestations is left as a mystery. The first astronauts noticed they could see bottom contours from space, but no one believed them. We now know how this works, from the RASP experments in journalofcosmology.com volume 21. It is beamed zombie turbulence maser action mixing chimneys in action. The same atlas shows internal waves radiating from seamounts on the mid Atlantic ridge. See, for example,

http://journalofcosmology.com/JOC21/GBKL.IJDF.06.proof.pdf

and

http://journalofcosmology.com/JOC21/115GibsonPhysicaScripta10.pdf

That said, turbulence generates IWs that are of much higher frequency and wavenumber that the above examples. I believe that there is some work by Zappa & Jessup (IWs of 25-35m wavelength) and also Marmorino (remote sensing of municipal outfall, JARS 2010) that touch upon this topic. Please add some more references of this kind to balance out your literature search.

The Marmorino reference 18 is included as requested. It is a nice contrast to the Sand Island outfall at Honolulu which never surfaced, but manifested only through fossil turbulence waves. The Sand Island buoyant plume stops rising at about 50 meters depth where the turbulence fossilizes (meaning that the inertial vortex forces cease to dominate other forces) and internal wave (fossil turbulence waves) take over. This was shown by direct microstructure measurements, shown in the J of C Vol. 21 collection of papers. This is the only detailed study of stratified turbulence processes ever undertaken in the ocean. We did the study in Hawaii to avoid kelp oils on the surface and to have continuous strong vertical stratification.

Middle of page 2: What is N here ? Presumably, the Brunt-Vaisala frequency. Define it to help the non-expert reader. Moreover, is it defined in rad/s or Hz units here ? My feeling is that it is rad/s in terms of the particular study

referenced.

Yes, it is the BV or stratification frequency in rad/s. It could just as easily be in Hz because the question is whether the persistence time is in seconds or in days. The answer, as the Russians know very well, is days. The amazing thing is that they have finally decided to leak this information (fig. 1).

I also do not feel that it is appropriate technical writing for a journal article to include a personal communication that the 2011 JFM study of Diamessis was delayed in publication because of the use of the "fossil turbulence" concept. I strongly recommend deleting these two sentences.

The reviewer is right. The discussion is gone in the revision.

Bottom of page 3: It seems that the concept of fossil turbulence is paramount in importance to the author's thesis but do we really need this 2-paragraph tangent on the role of this phenomenon in cosmology ? In it place, I strongly recommend offering some more fundamentals on fossil turbulence and why one expects to see IW radiation from it. To this end, what is a "fossil-turbulence internal wave" ? Give some of its characteristics ! Its role in cosmology could be limited to 2 sentences.

All the information about beamed maser action is astrophysical. The beaming also occurs for vertical transport in the ocean, as we showed in RASP. It is like lightning. Once an ionized path is established by the first lightning bolt, numerous lightning bolts follow along the same path.

In this regard, there are no references on investigations of the radiation of IWs by stratified turbulent wakes. Please give a few, e.g. Gilreath and Brandt (AIAA 1985), Bonneton et al. (JFM 1993) and the more recent work by Abdilghanie and Diamessis (JFM 2013). There is also work on IW generation by well-mixed regions of turbulence, predominantly by Sutherland and co-workers but also the Sarkar group at UCSD. These merit a couple of references.

These papers are all fatally flawed by reliance on the standard definition of turbulence, with its assumption that the cascade of turbulent kinetic energy is from large scales to small. This is never true. Diamessis knows better, but can’t be confrontational about it to preserve his funding. Sutanu Sarkar believes his advisor John Lumley about this. Lumley got an APS/DFD prize for calculating the time for the cascade from large scales to small, and published this nonsense in the Physics of Fluids. Alan Brandt believes the source of energy of fossil turbulence waves is wake collapse. It is not.

Page 4, Theory Section: This is a very interesting section but there are some gaps in understanding for me. What is exactly "fossil turbulence" ? Why is the direction of the turbulent energy cascade so critical in this discussion and how does it exactly drive the generation of IWs ? I'm assuming that the turbulence produces these waves at its largest scales, as this is where buoyancy first impacts it. Nevertheless, is there any evidence for this in the literature ? Moreover, why should the energy of the large scales originate from the small ones and it can't come from larger-scale external forcing ? Please clarify.

Turbulence is defined as an eddy like state of fluid motion where the inertial vortex forces of the eddies are larger than any other forces that tend to damp the eddies out. Fossil turbulence is defined as a perturbation in any hydrophysical field that was produced by turbulence that persists after the fluid is not longer turbulent at the scale of the perturbation. Thus the turbulence must begin at the Kolmogorov length and time scales and cascade to larger scales by the vortex dynamics of inertial vortex forces. The cleanest evidence is recently emerging from the Herschel and Planck space telescopes. See journalofcosmology.com volume 23 where the big bang turbulence fossils and the plasma epoch fossils both demonstrate the turbulence patterns expected, and a connection is made to the analysis of the Johns Hopkins archive of forced turbulence numerical simulations by Tony Leonard of Caltex.

In this regard, numerous recent studies by the groups in KTH (Lindborg) and LadHyX (Chomaz, Billant, Augier) have studied high Reynolds number stratified turbulence and have determined that there is very likely to be a "forward" energy cascade. This occurs due to the formation of highly unstable shear layers (as proposed by Lilly in 1983) that prolong the "life-span" of the turbulent burst in a highly anisotropic state of multiple horizontal layers. My point is that the author should indicate that the longer-living turbulence, very different from its original incarnation, sends out the waves ; whether this is fossil turbulence or something closer to the Lilly paradigm remains to be seen.

The Lilly paradigm if fine as far as it goes. It does not extend to BZTMA mixing chimneys. In my opinion, the data is in and the question is settled. This is why we did the RASP experiment.

Bottom of page 4: I agree that turbulence in the stratified ocean is intermittent. Especially in pelagic waters it should be tough to find an event that is turbulent at all scales. However, once again, what is a "fossil" and why should we expect it to radiate waves.

The reviewer is quite right. You can determine whether a patch of microstructure is turbulent using a hydrodynamic phase diagram. Before RASP only about 200 of these existed. We needed about 40,000 HPDs to do RASP. At the equator, the mean to mode ratio for the dissipation rate is about 30,000! The reason fossils can radiate so much energy is that they can extract energy from the powerful fossil turbulence waves coming up from the bottom. These narrow band internal waves tilt the high density gradient layers existing at the top and bottom surfaces of a fossil density turbulence patch and generate vorticity, which bring the turbulence remnant back to life. Hence the “zombie turbulence” terminology. The 50 kw of power required to pump the wastewater out to sea were amplified to the megawatts needed to mix Mamala Bay by this mechanism.

To conclude my comments on the theory I offer a very important question: How do we know that these higher-frequency/wavenumber waves reach the surface and have enough strength to even strain it ? These are not internal solitary waves, although there is ongoing discussion of local generation of internal solitary waves by internal tidal beams (see Mercier et al. JFM 2012).

The RASP measurements were done carefully, with ample funding and the best microstructure instruments and their designers on the same ship to make sure they worked. I was there too. You could see the slick produced by the fossil turbulence waves at about 45 degrees from the tip of the diffuser pipe, just where they should be. No smell, no discoloration. BZTMA mixing chimneys at work.

IWs coming from the deeper ocean will encounter changes in the stratification profile and shear and will be absorbed and dissipated, will generate mean flows and will scatter energy into higher harmonics. In some cases, they'll break into turbulence. The author should offer a cautious remark in this regard and should reference at least a couple of papers that study IWs going through variable stratification and shear.

Like I keep saying, we are talking about a solved problem. The data is in. It would be misleading to offer cautionary remarks.

The question that ultimately arises, are the turbulence-generated IWs energetic enough to survive these encounters with varying background conditions so that they can meaningfully strain the surface ? In other words, is there any investigation that demonstrates to us that stratified wakes can send out IWs with significant enough energy content ?

Yes, plenty. Alas, most of the best data is not available to the public.

Section 3 on Observations: Figure 3 is impossible to read all across the board ! Something larger with better quality graphics is needed. It is unclear to me why one sees the signature of turbulence-generated IWs from below based on this mix of figures.

Each component of Fig. 3 is detailed by reports with better graphics in Volume 21 of the Journal of Cosmology. This figure is an overview of the Remote Anthropogenic Sensor Program (RASP) 2002, 2003 and 2004 results.

The results conflict with numerous expectations and claims of the fluid mechanical, oceanographic, and national defense communities that submerged sources of turbulence, such as wastewater plumes and submarines, are invisible to remote sensing. They are not.

At the end of this section, the author mentions this exotic "Beamed Zombie Turbulence Maser Action Mixing Chimney" mechanism. Beyond this entertaining title, could he tell us what are the essential ingredients of this mechanism ? Is there evidence in more controlled environments (lab, numerical modeling) for it ?

The key idea is that turbulence must be defined by the inertial vortex force. The associated vortex dynamics can be understood by good undergraduate fluid mechanics classes. The cascade mechanism from small scales to large is that adjacent vortex lines with the same direction induce inertial vortex forces that cause the vortices to merge. Think of a thickening boundary layer approaching critical Reynolds number at 5 Kolmogorov scales. Add buoyancy forces and you get vertical fossilization at the Ozmidov scale. Add Coriolis forces, etc. and you get fossilization other universal critical scales, etc. Standard linear models rapidly fail if you attempt to extend them from mathematical and numerical simulations to natural fluids of oceans, atmospheres, astrophysics and cosmology. See volumes 22 and 23 for the latest attempts to connect with direct numerical simulations.

Conclusions: This probably sets the record for the shortest conclusions section I've ever seen. Please a) Give an overview of your proposed mechanisms, b) indicate how new deployments or remote sensing, lab, numerical studies might provide further evidence for your conjectures.

I suggest these interpretations of the behavior of natural fluids have gone beyond the conjectural stage. The standard models of turbulence and turbulent mixing in the ocean, atmosphere and astrophysics are simply wrong and must be replaced. Failure to publish this message is the usual response, and is expensive to the public and even dangerous.

References: I've already stated that there are several references by other authors that need to be included here. That said, it feels quite imbalanced as a reference list when one sees that out of 16, only three are by other authors. Furthermore, are is the majority of the author's work on stratified turbulence published in the J. of Cosmology which doesn't not even come up on the Web of Science ?

The Journal of Cosmology will not come up on the web of science until its new ideas are absorbed by the standard models. Just because most people believe that turbulence cascades from large scales to small does not make it true. Just because most oceanographers believe turbulence is not intermittent and vanishes at the equator and can be characterized by a handful of dropsonde samples does not make it true. Tell this to the relatives of Air France 447 victims that crossed the equator on the first day of hurricane season and passed directly through a thunderstorm region to keep a schedule.