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Nonlinear Processes in Geophysics
Discussions
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Interactive comment on "Evidence of a fluctuation theorem for the input of mechanical power to the ocean at the air-sea interface from satellite data" *by* Achim Wirth and Bertrand Chapron

Anonymous Referee #2

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This paper aims to provide observational support in favour of the idea that the wind power input satisfies a fluctuation theorem (FT) in some regions of the ocean. FTs have only appeared recently in the literature and have been useful to justify the physical character of (rare) violations of the second law of thermodynamics. In this paper, it is the wind power input that is treated as the dominantly positive quantity and the analogue of the positive entropy production predicted by the second law, while the negative power input events are seen as the analogue of the rare events seemingly violating the second law. Review of the literature on the subject is pedagogical enough that it can be read and understood with little background on the part of the reader. Overall, the paper is relatively clear and easy to follow, while the analysis appears to

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be competently done although short on practical details. The main weakness of the paper, however, is that it appears to devote much time explaining why FTs are useful or important in general, without ever really explaining why they are useful or important in the particular case considered by the paper, namely ocean energetics. The negative power input events are presented as 'extreme' events, but it is unclear to what extent this is justified. Are these events related to the passing by of low- pressure systems that result in occasional reversal of the winds relative to prevailing conditions? The authors emphasise that extreme events are often 'key' for the systems considered (by others), but do not explain why these are key for the system they consider. The paper needs to improve on those aspects as well as on the specific points outlined below before it can be accepted for publication.

General comments

Title: A more concise title would be: Empirical evidence of a fluctuation theorem for the wind mechanical power input in the ocean. I suggest using empirical because the estimation of the power input does not just involve satellite data. The authors need to explicitly state that the mechanical power input is due to the wind, as surface buoyancy fluxes also contributes to powering the ocean.

Aim: Could the authors clarify the precise aims of the paper? Is it intended to contribute to the literature about ocean energetics? If so, the authors should provide some review of the literature about ocean energetics. Is it intended to provide a constraint and metric by which to constrain ocean models? If so, the authors should expand on this some more and explain how one should go about it. Even better would be to repeat the calculations using model outputs where the authors find evidence for a FT to establish whether this would be useful metric to assess models. As written, it is difficult to understand what issues of interest to the oceanographic community the present results are useful for.

More specific comments

1. Abstract, line 3: ‘global satellite observations’ may be more specific . Scatterometer wind observations and surface current derived altimeter data.

2. Page 1, lines 15-17: The wind stress also includes a form stress component due to the wind blowing creating negative and positive pressure anomalies on the surface waves

3. Page 1, lines 20-21: The energy exchange is not conservative and most of the mechanical energy is dissipated. I don’t understand what that means. Clearly, momentum is conserved and energy is transferred from the atmosphere to the ocean. Part of it goes into avaialbel potential energy to push down isopycnals or suck up isopycnals. Does it go into heat rapidly? Ultimately, sure. What are you trying to say here?

4. Page 2, line 5. ‘measure’ -> ‘estimate’ or ‘evaluate’. The power input is clearly not measured.

5. Page 2, line 12: ‘spacial’ -> ‘spatial’

6. Page 2, lines 16-17: and conversely, turbulent motion depend also on the mean. Does it matter for the arguments developed here?

7. Page 3, line 7: ‘existence of a FT was shown empirically’. ‘Shown’ sounds like a strong word. Suggested sounds more accurate

8. Page 3, line 13. ‘Satellite measurements’ not onl. ‘discuss their relevance’ it is not clear to me that this has really been achieved satisfactorily. This needs to be improved.

9. Page 4, line 21: I find reference to ‘shear’ somewhat confusing, since power is best understood as the product of a force times displacement by unit time. Why not refer to the wind stress rather than the shear? Moreover, the wind stress is not just due to the shear, it also includes a form stress part due to the wind blow creating pressure positive and negative pressure anomalies on the upwind and downstream sides of sea surface waves.

10. Line 25. May be indicate the value of Cd used for the calculations.

11. Page 4, linear 29. ‘goestrophic’ - > ‘geostrophic’

12. Page 4-5, Lines 31-33. What does it mean physically? Is the power converted into available potential energy or is it dissipated into heat? How does this result justify estimating the wind power input proposed by the authors? Are the overall results sensitive to using the surface velocity or 15 m velocity? The calculations seem easy enough to do that the authors should describe both.

13. Page 6, Lines 19-20: ‘This indicates the existence of a large deviation principle’ What does that mean? What does that imply? Why is this important or useful?

14. Page 8. Lines 6-8. Why is this useful?

15. Page 8. Lines 7-8. ‘Extreme events are often key for the system [. . .]’ What does that mean? To what extent are negative wind power input ‘extreme’ and ‘key’ for the understanding of ocean energetics.

16. Page 9. Lines 14-26. These last three paragraphs are particularly vague and abstract and not really related to any issues pertaining to ocean energetics. Is it possible to link these to ocean energetics in some way? This paper does not contribute to the theory of FT, so it is unclear why it should speculate on it.

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