Reply to Anonymous Referee #1

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"The rate of information transfer as a measure of ocean-atmosphere interactions"
D. Docquier, S. Vannitsem, A. Bellucci

We would like to thank the reviewer for his/her helpful comments. Below we present the reviewer's comments (in black) **and our point-by-point replies (including changes in the paper) (in bold blue). Line numbers correspond to the revised version.**

Comments

In physical oceanography it is believed that wind stress drives the ocean, while in dynamical meteorology the ocean surface is treated as a bottom boundary that influences the atmosphere. The interaction between the sea surface temperature (SST) and wind stress, respectively characterizing the sea and the atmosphere at the interface, has become of enormous interest. In this paper, the authors applied a causality analysis which is built on a firm physical ground, in contrast to other statistical formalisms, to the study of this problem, and obtained intriguing new results. Specifically, they found that that the ocean surface (SST and SST tendency) strongly drives changes in the lower atmosphere (THF) and that the lower atmosphere also has an important influence on the ocean surface in many regions of the world, different from the traditional view that ocean-driven regimes largely exist in western boundary currents and atmospheric-led regimes dominate in the open ocean. In recognition of the importance of the finding, I hence recommend publication of this manuscript. The following are just some points that the authors may pay some attention.

We thank the reviewer for the very positive comment. We have taken all comments from the reviewer into account and have revised our paper accordingly.

l.1 & l.13, True. But in this paper, the usage of information transfer/information flow (IF) in studying the interaction is actually more fundamental. It is the exchange of entropy/information rather than energy. In statistical physics, entropy plays a role in distributing energy.

In the beginning of the abstract and introduction, we refer to the general physical relationship between the ocean and atmosphere, rather than the statistical relationship (based on entropy). In order not to have any confusion between information transfer and "physical" energy exchanges, we changed the terminology "exchanges of energy" by "exchanges of mass, momentum and energy" (L1 and L14).

l.97, the last term may also represent the effect from unobserved processes.

This is correct, we have now clarified this in the paper (L101).

l.100, While mathematically this is correct in terms of Shannon entropy, you may want to be more cautious in interpreting the sign, as it actually may not be explained using the well-known physics.

We agree with the reviewer that we need to be cautious with this interpretation, but this is the interpretation provided by Liang (2014), so we prefer to keep this terminology in the paper. As stated in Liang (2014), a positive (negative) value of $T_{j \to i}$ means that the variability in X_j

makes the variability in X_i more uncertain (certain); we have added reference to Liang (2014) in this sentence (L104). We also make reference to Appendix A and Figure A1 in the paper (L105), where we show that when $T_{j\to i}$ increases, the variance in X_i also increases.

ll. 130-135.). “This suggests that SST variability generally increases THF variability, while THF variability mainly constrains SST variability.” This is good. But be cautious.

We thank the reviewer for the word of caution. Please see our response to the previous comment.

ll.189-190. To include more additional variables, make sure they are not nearly parallel; otherwise the singularity of the covariance matrix could numerically deteriorate the result.

We thank the reviewer for this comment and have added it to the paper (L194-195).

Section 3.3. In studying lagged transfer of information, be careful that only the IF in one way makes sense—Causality cannot be from the future to the past.

We agree with the reviewer and that is exactly why we checked the other direction to verify the robustness of the method. We found that the rate of information transfer from SST / SST tendency to THF(-1) is statistically not significant (Fig. B5). This information is provided at L210-212.

ll.226-229. Indeed ocean-atmosphere interactions become more pronounced at larger time scale. So these results do make sense.

We thank the reviewer for this comment.