

Interactive comment on “Jarzynski equality and Crooks relation for local models of air-sea interaction” by Achim Wirth and Florian Lemarié

Anonymous Referee #2

Received and published: 15 February 2021

The manuscript addresses the applicability of the Jarzynski equality and the Crooks relations from non-equilibrium statistical mechanics to study the exchanges of momentum between the ocean and the atmosphere. A hierarchy of local models is employed. Two more idealized models are solved analytically, which include a time-varying (white-noise) external forcing with and without Coriolis. Finally, a more elaborate model considering the interaction between atmospheric and oceanic boundary layer is integrated numerically. This is a relevant contribution, employing modern concepts of non-equilibrium statistical mechanics to deepen the understanding of large-scale geophysical fluid flows. The manuscript is well-structured, the methods and results are clearly described, despite the complexity of the problem. In my opinion, the manuscript is acceptable for publication after minor changes.

C1

- The study focuses on the air-sea exchange of momentum. This should be clearly stated in the abstract and conclusions, since air-sea interactions encompass a much broader range of processes.
- The discussion of the Figures must be improved in the text. The authors should better guide the reader through shown the results, namely for Fig. 3, but also for Fig. 2. Moreover, Figure 5 is not mentioned in the text. The authors should either discuss this figure or remove it
- Page 23 line 14: “This is key in understanding the energetics of the climate system”. I believe that providing the a few sentences explaining the implications for the energetics of the climate system and the future directions of research would be important and could broaden the interest of the present manuscript to a wider audience.
- Page 1 line 1 “We show using a hierarchy of local models of air-sea interaction that the most prominent of the work theorems, the Jarzynski equality and the Crooks relation can be applied to air-sea interaction”. This provides an important summary of the manuscript. Maybe improve the clarity of the sentence by re-phrasing to something like “We show that the Jarzynski equality and the Crooks relation can be applied to air-sea interaction using. . .”
- Page 22 Line 13: “We started by introducing the concept of work theorems in a simple model of air-sea interaction” – Provide a few words describing (summarizing) this simple model.
- The notation when referencing figures in the text should be consistent throughout the text (Fig. our figure, e.g. Page 10 line 12 and Page 20 line 2)

Interactive comment on Earth Syst. Dynam. Discuss., <https://doi.org/10.5194/esd-2020-82>, 2020.

C2