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Nonlinear Processes in Geophysics Discussions
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Interactive comment

Interactive comment on "On fluctuating momentum-exchange in idealised models of air-sea interaction" *by* Achim Wirth

Anonymous Referee #1

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In the present paper the properties of several linear models of idealized air-sea momentum exchange are discussed. Those models differ in the coupling type between air and sea variables, as well as in the forcing type. Analytical solutions for the covariances are presented and the energy budgets are discussed in terms of fluctuation dissipation relation. The fluctuation theorem is applied to the probability of energy fluxes.

I think the paper contains novel results, which are interesting in the context of modeling air-sea interaction. Using idealized models is one important way for approaching such a complex problem. I recommend the present paper for publication after the following comments are addressed.

Major comments:

In order to stress the relevance of the present work, I recommend in the introduction to discuss which features of the air-sea momentum interaction are captured by the linear models from the paper. The bulk parameterization is widely used in observational studies, but are there references for the linear model equations L1, L2 and L3 considered here? Several terms are neglected in these models, what is the justification. I understand that the linear form is analytically tractable, but for example the Coriolis term is missing in the model, which is also a linear term.

It seems to me that the L3 model corresponds to the model analyzed in Wirth 2018 and the models L1 and L2 are approximations to this model. This should be stated in the introduction. The differences of the present setup to the previous study of Wirth 2018 should be stressed.

Some models do not reach steady state. Can you give the growth rates in dimensional units for real air-sea configuration and estimate the relevance. In particular, some rates scale as 1/Mˆ2, where M is the total mass, suggesting very small growth. On this time scale probably other effects such as nonlinearity will become important.

Minor Comments

Abstract: replace:

The short term behaviour is similar, which ... with The short term behaviour is similar, with ...

p. 2 l.25: replace liaison with lesson

p.3. It is not clear to me the relevance of the 2D energy cascade dynamics discussed around line 20 to the present paper. Can you specify the connection with the work of Wirth 2018 and the lack of time scale separation between the forcing and atmosphere dynamics.

p.3. The analytic solution of linear model gives ... This sentence is confusing, rewrite.

p.3 It is shown in Wirth 2018, by solving the FPE ... Are you speculating that the linear models, discussed here, capture features of the nonlinear models? What is the exact connection between the linear/non-linear models in Wirth 2018 and the models discussed here.

p.5 eq. 1,2 Below it is stated that eq. 1, 2 represent a classical approach to implement air-sea interactions. Is this approach including only the linear eq.1,2 or other terms are included as well, can you give references.

p.5 below eq. 3,4 This model neglects the action of ocean currents, it is used ...

Can you provide references, are only eq.3,4 used in those studies?

p.7 paragraph above eq. 10: small omega is introduced to denote ensemble realizations. I found it confusing since it also denotes the frequency of the periodic forcing on p.6. line 6.

p.8 line 13: replace \mu « SM by \mu » SM

p.8 line 28: probably times t» SM**(-1) have to be considered.

p.9 line 15: A dot is missing before ”The total energy ...”

p.9 line 18: It is not clear why exactly this is a double FDR, can you please explicitly give the quantities exactly related.

p.13 eq.20: \chi is called response operator as well.

p.15. below eq. 23: When the interval ...., the FT holds when:

"When" appears two times in the sentence. Can you state under which conditions exactly the FT can be applied.

p.15. line 15: the time-averaged energy: probably time-averaged work?

p.18, line 7: The present calculations can be used to guide applications of the FDT to systems with large, but not infinite, time separation.

This I found very interesting conclusion, can you be more precise here. Sometimes the governing equations of the fast processes, hidden in the forcing are not known (or those processes have to be parameterized), will extending the phase space still work?

p.19, eq A4 replace: ADAˆ(-1) with: ADAˆ(-1)u

Is P always diagonalizable in applications?

p.20 below eq. A12 replace exp(Dt) with exp(D \Delta t)

same below eq. A19 and A26

p.24 Appendix B8 Is the definition of u_t and u_s required: the explicit form of u_a and u_o is given below anyway.

p.27 Title Appendix B11: change to L2W

p.28 Title Appendix B12: change to L3W

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