Review of

Wirth et al.: *"Empirical evidence of a fluctuation theorem for the wind mechanical power input into the ocean"*, submitted to NPG

The paper reports on the application of a thermodynamical law, namely a fluctuation theorem, to the exchange of mechanical power at the ocean surface. Necessary measurement data were obtained from 24 years of global satellite observations.

The reasearch described in the paper is highly interesting and relevant to geophysics. Fluctuation theorems (FT), especially the one discussed in the paper, represent newer results from thermodynamics of non-equilibrium systems. Originally derived for and applied to discrete, microscopical systems, their application to macroscopic systems obeying a continuous description is currently a very active field of science. As FTs extend the second law of thermodynamics from an inequality to an exact equation, strong conclusions can be drawn for systems which allow their application. This is also the case for the paper under review.

The reviewer is not an oceanographer and can not evaluate the oceanographic aspects of the paper. However, the exchange of mechanical energy or power at the interface between atmosphere and ocean appears to be a good candidate for an investigation of thermodynamical aspects. As FTs are valid in a very fundamental sense (comparable to, e.g., energy conservation), the detailed processes in both ocean and atmosphere might even not affect the thermodynamics at the interface very much.

After an introduction, the paper first explains the FT under investigation, namely a Galavotti-Cohen fluctuation theorem, frequently also called a "Detailed Fluctuation Theorem" in contrast to an "Integral Fluctuation Theorem". Next, the derivation of the mechanical power input at the sea-air interface is described, followed by the data used in the study. Results are presented in the next section, showing that the FT is fulfilled in two of the four investigated ocean regions. The discussion section finally draws conclusions from the results.

The methodology and the reasoning of the paper are scientifically sound and well performed. The conclusions drawn in the discussion section highlight the potential of FTs in the applied sciences, such as geophysics. Namely the last two paragraphs of the paper discuss the high relevance for assessment of extreme event statistics (and thus, e.g., climate modelling) and general properties of dynamical systems.

The paper in general, and especially the conclusions, have already benefitted substantially from the previous review process. Publication is recommended. My recommendations for improvements are restricted to few technical remarks, which do not affect the scientific contents:

1. p.2 l.25 Put a comma after "fluctuations"; end the sentence after "state" and begin the next one with a capital "Weather".
2. p.3 l.5 "data" is plural, not singular. Therefore it should be "data come" instead of "data comes". Please also check this in the rest of the paper.
3. p.3 l.31 "chonvergence" → "convergence"
4. p.4 l.9 Consider adding "in turbulence" to the end of the last sentence of the paragraph, as this conclusion is probably restricted to turbulence.
5. p.4 l.30 The mentioned "vector product" is, to my understanding, actually a *scalar product*, which is quite a difference. The power $\mathcal{P}$ should be a scalar quantity.
6. p.10 l.18 "form" → "from"
7. p.10 l.22 "a phenomena" → "a phenomenon", the singular form