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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "Potential climatic impacts and reliability of very large-scale wind farms" *by* C. Wang and R. G. Prinn

**Anonymous Referee #1**

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Review of Wang and Prinn, "Potential climatic impacts and reliability of very large-scale wind farms"

General Comments

This is a well-written report of an interesting experiment, the first simulation of the global impact of extensive exploitation of wind power that includes a thermodynamically active ocean. In addition, because the forcing used differs from that used in Keith et al. (2004) and Kirk-Davidoff and Keith (2008), the results present an interesting contrast with those papers. In particular, the scaling of the vertically resolved temperature impact with increasing roughness is a puzzling new result, that calls for a more detailed presentation in the final paper.



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In order to aid in the interpretation of the results, the authors should present some of the wind fields corresponding to the presented temperature fields. A figure showing the change of wind speed with height, analogous to figure 3, would be helpful, and figures showing the change in wind speed in color, with vector direction changes shown with arrow superimposed with be a very helpful complement to figures 2 and 7. Could the change in the profile of temperature change with height from the H to the VH runs have to do with an advective temperature change aloft? Are the temperature change profiles similar over all continents or do they have a different character depending, say, on latitude? It would also be helpful to have more discussion of why the temperature change results for L and H in figure 3 are so similar- the relationship between temperature perturbation and wind energy generated seems otherwise reasonably linear.

Specific Comments

p. 19083: l. 27: "Legitimate interest" seems loaded. How about "substantial interest" or "vigorous efforts to harness".

p. 19084 l. 8: Thirteen million turbines to generate 4.4 TW implies 300 kW/turbine, which seems pretty small. If the bulk of the turbines were 2 MW turbines, and we assumed that they typically operated at 50% of capacity, we'd need 4.4 million turbines, rather than 13 million. What's the basis of this number? Barrie and Kirk-Davidoff (2009) present a methodology for relating a given density of wind turbines to a particular grid-scale roughness length; perhaps the authors could make use of this or another procedure.

p. 19085 l. 4: Confinement to shallow ocean regions is unlikely to be necessary-floating designs are in the works and likely to be deployed in a world that depends on wind for 10% of its total energy use.

p. 19087 l. 5: This sentence is puzzling: "The relevant model parameters were changed to remove the amount of near-surface atmospheric kinetic energy needed to match various energy production targets." Are the roughness lengths and displace-



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ment heights given on the previous page correct, reflecting these changes, or if not, what were the actual roughness lengths and displacement heights?

p. 19089 l. 3 ff: The discussion here should mention what kind of ocean model is used. If it's a slab, the authors should note that in a fully coupled run, changes in ocean fluxes might modulate the changes observed in the present experiments.

p. 19089 l. 20: It would be good to have more discussion of the change in precipitation shown in fig. 8. Is this due to change in wind direction, causing anomalous southerly winds over the Atlantic, and northerly wind over eastern North America? That would be consistent with the analysis in Kirk-Davidoff and Keith (2008), who argued that remote climate impacts of surface roughness changes were generally due to advection changes associated with the Rossby wave response to the rougness anomaly.

p.19090 l.1 ff: There are lots of references for the seasonal variability of wind power, most recently Lu et al. (2009).

References:

Barrie, D., D.B. Kirk-Davidoff: Weather response to management of a large wind turbine array. Atmos. Chem. Phys. Disc., 9, 2917-2931, 2009.

Keith, D.W., J.F. DeCarolis, D.C. Denkenberger, D.H. Lenschow, S.L. Malyshev, S. Pacala, P.J. Rasch: The influence of large-scale wind-power on global climate. {\em Proc. Nat. Acad. Sci.,} {\bf 101}:16115–16120. doi:10.1073/pnas.0406930101, 2004.

Kirk-Davidoff, D.B., and D.W. Keith: On the climate impact of surface roughness anomalies. J. Atmos. Sci, 65:2215-2234. DOI:10.1175/2007JAS2509.1, 2008.

Lu, X., McElroy, M.B., Kiviluoma, J.: Global potential for wind-generated electricity. PNAS, 10933-10938, doi: 0.1073/pnas.0904101106, 2009.

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