Reply to comment by R. Blender and K. Fraedrich on "Volcanic forcing improves atmosphere–ocean coupled general circulation model scaling performance"

D. Vyushin,[1] I. Zhidkov,[2] S. Havlin,[2] A. Bunde,[3] and S. Brenner[4]

Received 30 July 2004; revised 22 September 2004; accepted 22 October 2004; published 27 November 2004.

INDEX TERMS: 0910 Exploration Geophysics: Data processing; 0370 Atmospheric Composition and Structure: Volcanic effects (8409); 3309 Meteorology and Atmospheric Dynamics: Climatology (1620); 4532 Oceanography: Physical: General circulation; 7538 Solar Physics, Astrophysics, and Astronomy: Solar irradiance. **Citation:** Vyushin, D., I. Zhidkov, S. Havlin, A. Bunde, and S. Brenner (2004), Reply to comment by R. Blender and K. Fraedrich on ''Volcanic forcing improves atmosphere–ocean coupled general circulation model scaling performance,'' *Geophys. Res. Lett.*, *31*, L22210, doi:10.1029/2004GL021155.

[1] The comment by *Blender and Fraedrich* [2004] (hereinafter referred to as BF) consists of 3 statements. All the statements are not new and appeared already in the work of *Fraedrich and Blender* [2003] and *Blender and Fraedrich* [2003]. As shown below, these statements are in contradiction with the observations.

[2] In the first statement, BF claim that the fluctuation exponent α is close to 1 over the ocean (corresponding to $1/f$ noise), varies between 0.6 and 0.7 for coastal areas, and is 0.5 (white spectra) in inner continents. The white noise statement is in marked contrast to direct measurements of α at the available long-term records from inner continental stations in North America and North Asia [*Bunde et al.*, 2004; *Eichner et al.*, 2003] and in Australia [*Kiraly and Janosi*, 2004].

[3] As has been shown in detail, the exponents are mostly around 0.65, similar to coastline stations, and there is no systematic dependence of α on the distance from the ocean. *Blender and Fraedrich* [2004] support their claims using the analysis of Australian stations by *Pattantyús-Ábrahám et al.* [2004]. We could not find support in this paper. However, a recent paper [*Kiraly and Janosi*, 2004] by the same two authors shows that α is mainly between 0.6 and 0.7 and there is no decline of α with increasing station distance from the ocean, i.e., no sign of a white spectra in the inner continents (see Figure 4c of *Kiraly and Janosi* [2004]).

[4] It was also pointed out by *Bunde et al.* [2004] that the white-noise claim is even not supported by the analysis presented by *Fraedrich and Blender* [2003], since a close inspection of the results presented in Figure la of *Fraedrich and Blender* [2003] shows an exponent α greater or equal than 0.6. In addition, the BF claim for the oceans (1/f-noise) neither agrees with their own work [*Blender and Fraedrich*, 2003] nor with earlier work by *Monetti et al.* [2003]. *Blender and Fraedrich* [2003] and *Monetti et al.* [2003] found that over the ocean α varies between 0.7 and 1, and only a minority of sites has exponents α close to one, i.e., $1/f$-noise.

[5] The second statement that AOGCM control runs without external forcings as well as with greenhouse gas forcing only reproduce the observed temperature variations is one of the main claims of *Fraedrich and Blender* [2003]. We fully disagree with this statement as shown in detail by *Govindan et al.* [2002] and *Vyushin et al.* [2004]. Only when volcanic forcing is included, the model simulations are able to reproduce the observed LFV (on land) nearly quantitatively. For the oceans, volcanic forcing also improves the model performance, but the agreement is not yet complete. Greenhouse gas forcing alone cannot at all reproduce the climate variability, and is even worse than the control run alone (for details, see *Govindan et al.* [2002] and *Vyushin et al.* [2004]).

[6] The third statement regards the error bars. As stated in the caption of Figure 3 of *Vyushin et al.* [2004], the error bars of the exponent α are not above 0.03 and have been calculated using the method described by *Peng et al.* [1993]. In contrast to the work of *Fraedrich and Blender* [2003] and *Blender and Fraedrich* [2003], details of the calculations and the fluctuation curves have been presented by *Vyushin et al.* [2004], so it is easy for a reader to estimate the quality of the conclusions. The error bars are considerably smaller than the α-variations between the different scenarios.

[1]Department of Physics, University of Toronto, Toronto, Ontario, Canada.
[2]Minerva Center and Department of Physics, Bar-Ilan University, Ramat-Gan, Israel.
[3]Institut für Theoretische Physik III, Justus-Liebig-Universität Giessen, Giessen, Germany.
[4]Department of Geography, Bar-Ilan University, Ramat-Gan, Israel.

0094-8276/04/2004GL021155$05.00

References

Blender, R., and K. Fraedrich (2003), Long time memory in global warming simulations, *Geophys. Res. Lett.*, *30*(14), 1769, doi:10.1029/2003GL017666.

Blender, R., and K. Fraedrich (2004), Comment on "Volcanic forcing improves atmosphere–ocean coupled general circulation model scaling performance" by D. Vyushin, I. Zhidkov, S. Havlin, A. Bunde, and S. Brenner, *Geophys. Res. Lett.*, *31*, L22213, doi:10.1029/2004GL020797.

Bunde, A., J. F. Eichner, S. Havlin, E. Koscielny-Bunde, H. J. Schellnhuber, and D. Vyushin (2004), Comment on "Scaling of atmosphere and ocean temperature correlations in observations and climate models," *Phys. Rev. Lett.*, *92*, 039801, doi:10.1103/PhysRevLett.92.039801.

Eichner, J. F., E. Koscielny-Bunde, A. Bunde, S. Havlin, and H. J. Schellnhuber (2003), Power-law persistence and trends in the atmosphere: A detailed study of long temperature records, *Phys. Rev. E.*, *68*, 046133, doi:10.1103/PhysRevE.68.046133.

Fraedrich, K., and R. Blender (2003), Scaling of atmosphere and ocean temperature correlations in observations and climate models, *Phys. Rev. Lett.*, *90*, 108501, doi:10.1103/PhysRevLett.90.108501.

Govindan, R. B., D. Vyushin, A. Bunde, S. Brenner, S. Havlin, and H. J. Schellnhuber (2002), Global climate models violate scaling of the ob-

served atmospheric variability, *Phys. Rev. Lett.*, *89*, 028501, doi:10.1103/PhysRevLett.89.028501.
Kiraly, A., and I. M. Janosi (2004), Detrended fluctuation analysis of daily temperature records: Geographic dependence over Australia, *Meteorol. Atmos. Phys.*, in press.
Monetti, R. A., S. Havlin, and A. Bunde (2003), Long term persistence in the sea surface temperature fluctuations, *Physica A*, *320*, 581.
Pattantyús-Ábrahám, M., A. Király, and I. M. Jánosi (2004), Nonuniversal atmospheric persistence: Different scaling of daily minimum and maximum temperatures, *Phys. Rev. E*, *69*, 021110, doi:10.1103/PhysRevE.69.021110.
Peng, C.-K., S. V. Buldyrev, A. L. Goldberger, S. Havlin, M. Simons, and H. E. Stanley (1993), Finite-size effects on long-range correlations: Implications for analyzing DNA sequences, *Phys. Rev. E*, *47*, 3730.
Vyushin, D., I. Zhidkov, S. Havlin, A. Bunde, and S. Brenner (2004), Volcanic forcing improves atmosphere–ocean coupled general circulation model scaling performance, *Geophys. Res. Lett.*, *31*, L10206, doi:10.1029/2004GL019499.

S. Brenner, Department of Geography, Bar-Ilan University, Ramat-Gan 52900, Israel. (sbrenner@mail.biu.ac.il)

A. Bunde, Institut für Theoretische Physik III, Justus-Liebig-Universität Giessen, Heinrich-Buff-Ring 16, 35392 Giessen, Germany. (armin.bunde@theo.physik.uni-giessen.de)

S. Havlin and I. Zhidkov, Minerva Center and Department of Physics, Bar-Ilan University, Ramat-Gan 52900, Israel. (havlin@ophir.ph.biu.ac.il; zhidkov@shoshi.ph.biu.ac.il)

D. Vyushin, Department of Physics, University of Toronto, 60 St. George Street, Toronto, Ontario, Canada, M5S 1A7. (vyushin@atmosp.physics.utoronto.ca)