

Butterfly effects

We have read Tim Palmer's article "The real butterfly effect and maggoty apples" (PHYSICS TODAY, May 2024, page 30) with much interest. He writes that the popular conception of the butterfly effect, in which "the flap of a butterfly's wings in Brazil can set off a tornado in Texas a week later," is "folklore" that "isn't quite correct."

We recently published a relevant paper on this topic.¹ We conclude that a butterfly in Brazil cannot cause a tornado in Texas because of its tiny spatial scale and the dominant role of molecular dissipation at that scale.

The notion of a butterfly's flap causing a tornado is distinct from that of a sensitive dependence on initial conditions affecting the solutions to the equations of motion. Our paper offers a scientific discourse that the former effect is not at all plausible for the real atmosphere. In our chaos studies,² we have focused on finite predictability in Edward Lorenz's models of 1963 and 1969³ and on three kinds of butterfly effects within those models.

We offer more comments at the online version of Palmer's article.

References

1. R. A. Pielke Sr, B.-W. Shen, X. Zeng, *Weatherwise* **77**(3), 14 (2024).
2. B.-W. Shen et al., *Encyclopedia* **2**, 1250 (2022).
3. E. N. Lorenz, *J. Atmos. Sci.* **20**, 130 (1963); *Tellus* **21**, 289 (1969).

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► **Palmer replies:** While plausible, of course, the model of Roger Pielke, Bo-Wen Shen, and Xubin Zeng is nevertheless heuristic: As mentioned in my article, no rigorous proof or disproof of the real butterfly effect exists. Indeed, in contrast with the paper by Pielke and his coauthors,¹ recent published work² on spontaneous stochasticity in high Reynolds

number flows (see reference 7 in my article) suggests that not only may macroscopic circulations be sensitive to flaps of butterflies' wings in finite time, but they may also be sensitive to the motions of individual molecules.

References

1. R. A. Pielke Sr, B.-W. Shen, X. Zeng, *Weatherwise* **77**(3), 14 (2024).
2. D. Bandak, A. A. Mailybaev, G. L. Eyink, N. Goldenfeld, *Phys. Rev. Lett.* **132**, 104002 (2024).

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Where physics students find community

It was with the joy of recalling fond memories that I read the recent article by Hannah Means about the In-

ternational Association of Physics Students (PHYSICS TODAY, June 2024, page 28). I became acquainted with IAPS in