Borie has little confidence that we will ever have the ability to model climate properly. She argues that we ought to spend a lot of money, increase taxes and tell people what to do, even in the absence of observational data to show whether the climate is slowly getting warmer or colder. The world's people have already had enough trouble with command economies based on fallacious theories without embarking on worldwide economic changes based on a hypothetical cause and effect.

Alley suggests that more research and study would be "self-serving." I myself am retired and have no grants or proposals pending. He says we ought to tax gasoline to reduce greenhouse gases. We are already taxing gasoline heavily. Moreover, most proposals for political and economic action go much further than a simple tax on gas. We are now in a position, if we spend the money, to produce mass balances for the various ice sheets, and after we have assimilated and analyzed the data over a few decades we should have a sound basis for evaluating just when and if Alley's disaster might happen.

Bentley cites data from a paper presented after I wrote my letter. It has always proved difficult to consider unpublished information when you prepare a critique. I await Bentley's next paper with anticipation.

All of the robust observational data that I have been able to obtain indicate that the climate is getting colder, *not* warmer. The northern line of orange production in Florida has moved south over the past 20 years, not north. For those who enjoy anecdotal evidence, let me refer to chapter 39 of Mark Twain's *Life on the Mississippi*, concerning Natchez, Mississippi. Twain agreed with Mrs. Trollope's 1827 statement that "Natchez is the furthest point to the north at which oranges ripen in the open air or endure the winter without shelter." This is no longer true. Louisiana oranges were commercially grown south of New Orleans beginning in the early 1940s, but the last commercial grove was destroyed by frosts in the 1980s.

Finally there is the new "Plant Hardiness Zone Map" issued by the Department of Agriculture, which shows the low temperatures controlling plant survival: The 1990 map shows that the zones in the 1965 map are now 5–10 °F colder. At this rate, maybe we should be concerned about a new ice age and should promote the production of greenhouse gases to counteract the cooling. Let me emphasize that I do not advocate this—but we do need more research, and substantiated models, before the scientific community begins to advocate expensive restrictions on entire populations to avert a hypothetical anthropogenic climate change.

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Batting Around Ideas on Curveball Physics

Geoffrey F. Chew's review of *The Physics of Baseball* by Robert K. Adair (September 1990, page 103) led me to read and enjoy that delightful book. I was intrigued, but not entirely convinced, by Chew's reference to the mechanism of the curveball (the Magnus effect) as being "simpler than the Bernoulli effect." According to Georg Joos's *Theoretical Physics*,[1] from which I learned much of my physics, the Magnus effect is derived from the Bernoulli equation. Joos points out that this derivation assumes no separation of flow from the rotating surface, that is, it assumes no turbulence; and it follows from his discussion that *with* separation the lateral force is reduced by about half. Inclusion of turbulence, it seems to me, makes the mechanism more complex, though more realistic.

Adair expresses the Magnus effect in terms of the drag force due to flow separation and the experimentally derived drag coefficient, and he makes a point of distinguishing the Magnus and Bernoulli effects. He describes experimental results showing that the lateral (Magnus) force on a baseball varies with speed and reaches a slight maximum at about 60 miles per hour and a slight minimum at about 80 mph. The average magnitude in this speed range is roughly half of the inviscid-flow Magnus effect.

It seems to me that the inviscid-flow solution has unique conceptual and heuristic value, and that the experimental results might best be explained as departures from the inviscid-flow solution due to flow separation.

Reference

1. G. Joos, *Theoretical Physics* (trans. by I. M. Freeman), Hafner, New York (1934), pp. 197–199.

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ADAIR REPLIES: As another who learned much physics—and something of the Magnus effect—from Georg Joos's wonderful *Theoretical Physics*, I have no important disagreement with Robert G. Fleagle's physics. My use of Isaac Newton's simple description of the Magnus effect was based partially on pedagogical concerns: My book was addressed to the lay audience and the late baseball commissioner Bart Giamatti. The Bernoulli pressure–velocity relation that follows from the conservation of energy applied to irrotational laminar flows surely plays an important role in the Magnus effect, but the trailing vortices at low baseball velocities and the turbulence that follows Nolan Ryan fastballs generate effects outside of the Bernoulli conditions. And Joos's instructive calculation of the Magnus effect was derived from a model that did not account for the drag force.

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Geometric Phase's First Formulators

In an illuminating article (December 1990, page 34) Michael Berry writes about people whose work anticipated his discovery of the geometric phase. The earliest reference on his list is to the work by Sergei M. Rytov and Vassily V. Vladimirskii in the Soviet Union, to whom he attributes the discovery of the law of the parallel transport of the polarization vector in electrodynamics.

In fact, as we wrote in our paper on Berry's phase in the relativistic theory of spinning particles,[1] this discovery was made in 1926 by a mathematician, E. Bortolotti, who was working on the applications of the absolute differential calculus invented by Tullio Levi-Civita. In a very clearly written paper published in the proceedings of the Lincei Academy, Bortolotti described the propagation of linearly polarized light in an inhomogeneous refracting medium and found the correct propagation law for the polarization vector.[2] He ended his paper with the following conclusion: "The light vector of the linearly polarized ray Γ, propagating through a medium with a varying index of refraction $n(x,y,z)$, is transported along the ray Γ by a parallelism with respect to a metric connection (in the sense of Weyl) in $\mathbf{R}_3$, whose components are determined by the vector grad $\log(n^2)$."

Since B. L. Markovski and S. L. Vinitsky have already proposed the name "Rytov–Vladimirskii phase" for Berry's phase as it appears in the propagation of the polarization vectors in electromagnetism, I believe