letters

Study of 1919 eclipse sparks talk of terms and terminology

In "Testing Relativity from the 1919 Eclipse—A Question of Bias" (PHYSICS TODAY, March 2009, page 37), Daniel Kennefick makes synonyms of two words—observation and experiment—that traditionally have described different ways to gain knowledge of the physical world.

In his first paragraph, Kennefick describes Arthur Eddington's work on the 1919 eclipse as an observation, but elsewhere he usually calls it an experiment. He mentions "observation" or some form of it 5 times in that first paragraph and does not mention "experiment." Yet "experiment" or forms of it appear 19 times elsewhere in the text of the article where "observation" or forms of it appear 3 times.

In December 1919 Eddington wrote in the preface to the second edition of his *Report on the Relativity Theory of Gravitation* (Fleetway Press, 1920), "I think it may now be stated that Einstein's law of gravitation is definitely established by observation." Eddington appears never to have used the word "experiment" to describe results of the 1919 eclipse expedition, but he does use it to describe anticipated work on Fraunhofer lines, which agrees with traditional understanding of the word. And Albert Einstein himself, in early October 1919, reported that he had received provisional eclipse results of the "Beobachtung" (observation).[1]

Having spent 18 years doing experiments on water waves, I am aware, along with Kennefick, that measurement and insight—seeing the link between existing knowledge and the observed phenomenon—are forms of observation accompanying experiment. However, experiment differs essentially from observation by prescribing the values of variables believed to be relevant.

Although ongoing changes in dictionary definitions tend slightly to agree with Kennefick's usages, I think the traditional distinction between observation and experiment is logically necessary for the results of the 1919 eclipse expedition. The data obtained then are observations, as Eddington and his contemporaries called them.

Reference

1. A. Einstein, *The Collected Papers of Albert Einstein*, vol. 7, M. Janssen et al., eds., Princeton U. Press, Princeton, NJ (2002), p. 200.

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Two items interestingly coincide in the March 2009 issue of PHYSICS TODAY. Daniel Kennefick's article (page 37) on the 1919 eclipse observations to test predictions of gravitational light deflection vindicated the traditional conclusion in favor of general relativity and Arthur Eddington's role in the matter. Charles Day's Search and Discovery story (page 14) concluded that a cosmological term in Albert Einstein's equations can account for present data on the acceleration of cosmic expansion.

Eddington was a strong proponent of the cosmological term even after the discovery of the expansion of the universe removed Einstein's original rationale for it and many physicists had rejected it dogmatically. He argued that the term had a fundamental character because its "cosmical constant" Λ provided a universal standard of length, and he asserted in his picturesque way that *"to drop the cosmical constant would knock the bottom out of space."*[1] (Italics in the original.)

The speculative theories Eddington developed in later life have tended to prejudice physicists against his views, but he was surely right that the cosmological term should not be regarded as a mere fudge factor. If Einstein had not introduced it to make a static universe possible, someone eventually would have realized that it was a legitimate addition to the original field equations. There are even purely affine generalizations of Einstein's Riemannian theory, such as Schrödinger's, that not only allow but demand a cosmological term.[2] Wolfgang Pauli's rejection of Schrödinger's version precisely because it required a cosmological term is an example of the dogmatism I mentioned above.[3]

I hope present observations of the acceleration of cosmic expansion will convince physicists to be more open-minded. Eddington may once again be vindicated.

References

1. A. Eddington, *The Expanding Universe*, Macmillan, New York (1933), p. 148.
2. E. Schrödinger, *Space-Time Structure*, Cambridge U. Press, New York (1960), chap. 12.
3. W. Pauli, *Theory of Relativity*, G. Field, trans., Pergamon Press, New York (1958), p. 225.

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Interpretations of climate-change data

In the January 2009 issue of PHYSICS TODAY, Philip Duffy, Benjamin Santer, and Tom Wigley attempted (page 48) to rebut our argument that there is significant climate response to solar variability (PHYSICS TODAY, March 2008, page 50). We find their arguments unconvincing.

The composite curve in their figure 1 is the PMOD composite of satellite data for total solar irradiance (TSI), which has no upward trend for the period 1980–2000. However, the second well-known composite, ACRIM, does show a significant upward trend during that period.[1] We find it curious that Duffy and coauthors cite the PMOD composite as the only one of consequence.

For the period before 1995, any TSI composite is constructed with data from ACRIM1, NIMBUS7, and ACRIM2 satellite experiments. The ACRIM composite uses these data as they are published by the experimental teams, while the PMOD composite is constructed by altering the published data on the basis of a TSI proxy model and the low-quality ERBS (Earth Radiation Budget Satellite) record. The ACRIM and NIMBUS7

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experimental teams have rejected the PMOD alterations as arbitrary.[2,3]

Recent work[3] that uses measurements of solar magnetic fluxes at Earth's surface establishes that a significant degradation of the TSI record from ERBS occurred during the gap in the ACRIM records (1989–92), as the ACRIM team has always claimed. That degradation invalidates the trust placed in the PMOD composite and its downward alterations of the NIMBUS7 record. Thus one is forced to select the ACRIM composite, which shows a TSI increase between 1980 and 2002, as we discussed in our Opinion piece.

Duffy and coauthors' choice of preferring an arbitrary TSI composite that shows no upward trend from 1980 to 2000 clearly undercuts their first major claim, that the Sun could not contribute to the warming observed since 1980, and consequently everything they deduced from it.

The second claim by Duffy and coauthors is that climate sensitivity to solar variability is low. To support that conclusion, they cite a 2004 study[4] by Gerald North and coworkers that summarizes findings obtained from simple energy-balance models. However, Duffy and coauthors omitted that study's major finding: that the empirical solar signature exceeds the energy-balance model predictions by a factor of two on average, implying that the climate is much more sensitive to solar changes than what climate models predict. Also, they do not realize that using a 10-year running average in their figure 2 suppresses the solar cycle's 11-year signature on climate.

The authors also ignore three other important points. First, our findings are consistent with secular paleoclimate temperature reconstructions that were recently made and confirmed.[5] Second, the glacial epochs were induced by small changes in the redistribution of sunlight due to the Milankovitch astronomical cycles—variations in the eccentricity, obliquity, and precession of Earth's orbit; that fact suggests significant climate sensitivity to changes in TSI inputs. And third, the oscillations of greenhouse gases observed between the glacial epochs were not induced by human activity but were a complex climate-dynamics response to the small redistribution of sunlight produced by Milankovitch cycles; that fact contradicts the assumption implicit in all climate models adopted in the Intergovernmental Panel on Climate Change 2007 report, that only humans can modify greenhouse gas concentrations.

Finally, the assumption underlying the piece by Duffy and coworkers is that the anthropogenic global warming theory is settled, those who claim otherwise are in error, and their studies should be dismissed. Yet an international team of scientists has published a comprehensive research review[6] disproving that claim by summarizing and organizing the findings of thousands of scientific papers; their review contradicts several conclusions of the IPCC 2007 report, which ignored many of the papers reviewed in *Climate Change Reconsidered*.[6] The review also lists more than 30,000 US scientists who have signed a petition stating that there is no convincing evidence to support the anthropogenic global warming theory. We remind readers about the dangers of dogma replacing science.

References

1. C. Fröhlich, J. Lean, *Geophys. Res. Lett.* **25**, 4377 (1998); C. Fröhlich, *Space Sci. Rev.* **125**, 53 (2006).
2. R. C. Willson, A. V. Mordvinov, *Geophys. Res. Lett.* **30**, 1199 (2003), doi:10.1029/2002GL016038.
3. N. Scafetta, R. C. Willson, *Geophys. Res. Lett.* **36**, L05701 (2009), doi:10.1029/2008GL036307.
4. G. R. North, Q. Wu, M. Stevens, in *Solar Variability and Its Effects on Climate*, J. M. Pap, P. Fox, eds., Geophysical Monograph 141, American Geophysical Union, Washington, DC (2004), p. 251.
5. A. Moberg et al., *Nature* **433**, 613 (2005); A. Eichler et al., *Geophys. Res. Lett.* **36**, L01808 (2009), doi:10.1029/2008GL035930.
6. C. Idso, S. F. Singer, *Climate Change Reconsidered: The Report of the Nongovernmental International Panel on Climate Change*, Heartland Institute, Chicago (2009), http://www.climatechangereconsidered.org.

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The rather passionate rebuttal of the Scafetta and West solar variability hypothesis by Philip Duffy, Benjamin Santer, and Tom Wigley seems to clearly show some weaknesses in the Scafetta and West model. Nevertheless, Duffy and coauthors ignore a data trend that weakens the argument for climate change based almost solely on greenhouse gas emissions. Their own figure 2 clearly illustrates that although GHG emissions have continued to increase at an enormous rate, global temperatures have not increased over the past decade and have actually slightly decreased overall since the record-setting warmth of the 1998 El Niño maximum. Also, last year's apparently anomalous low temperatures occurred during a year of extremely low solar activity (and a possibly weak La Niña), despite the aforementioned increase in GHG emissions and without a significant volcanic eruption.

Although the various current climate models are getting better at re-creating the past, they still fail in accurately predicting the future, especially with their emphasis on GHG emissions. So it certainly doesn't hurt to examine other models such as Scafetta and West's. If there exists a single climate model from a decade ago that based climate change predominantly on GHGs and that predicted the past 10 years of cooling, I would love to see a reference to it.

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Duffy, Santer, and Wigley reply: Solar irradiance measurements have been made by a number of satellites covering different time periods. Several investigators have stitched together the multiple records into composites, correcting for small instrumental differences (for a comparison, see the online version of this letter). Nicola Scafetta and Bruce West make much of the fact that our figure showed the PMOD composite rather than their favorite, ACRIM. The differences between the two, however, are insignificant in terms of implications for climate; neither produces anything close to the observed late-20th-century warming, even if one assumes a climate sensitivity much greater than the most commonly accepted value. Furthermore, the superiority of the ACRIM composite is not established.[1]

Scafetta and West's characterization of the 2004 paper by Gerald North and coworkers (reference 4 in Scafetta and West's letter) contradicts that paper's abstract. Far from finding that "the climate is much more sensitive to solar changes than what climate models predict," North and coworkers find "a faint response to the solar cycle" with amplitude "roughly what we would expect (a few hundredths of a degree) based on simple energy-balance model estimates." That finding contradicts Scafetta and West's argument that the climate is mysteriously hypersensitive to solar variations.

We used a 10-year running mean in our figure 2 precisely because it masks the 11-year solar cycle; our point was that there is no significant multidecadal trend due to solar variability.

Scafetta and West's discussion of glacial and interglacial cycles does not support their assertion that climate is exceptionally sensitive to solar variations. As is well established, glacial and interglacial temperature differences result from extremely large changes—not "small" ones as Scafetta and West claim—in the spatial and seasonal patterns of incoming solar radiation, which trigger two powerful but slow feedbacks: changes in atmospheric carbon dioxide and changes in surface reflectivity resulting from the advance and retreat of land ice sheets. Certainly, neither feedback can be responsible for late-20th-century warming.

Although this is irrelevant to the main point of contention, climate models do not assume that "only humans can modify greenhouse gas concentrations." Naturally occurring CO_2 variations are included either by prescription or through modeling of climate and carbon-cycle feedbacks.

Finally, a recent paper[2] explains in detail the serious flaws in the work of Scafetta and West. Primarily, multicollinearity between different climate forcing agents makes it impossible to unravel their relative effects by considering only a single forcing, as Scafetta and West attempt. Reference 2 further shows that the statistical method they used leads to grossly incorrect results; when applied to a situation with a known solar contribution, it gives a greatly and unrealistically enhanced solar effect.

In response to Benjamin Jordan, we note that observed temperatures reflect both natural variability and the effects of forcings such as greenhouse gases and solar variability. So in an era of increasing greenhouse gases, each year need not be warmer than the previous, even as temperatures trend generally upward. Climate models correctly predict that phenomenon.[3] However, because climate simulations are not initialized from observations in the same way that weather forecasts are, they are not expected to predict the *timing* of natural variations, including cooling episodes. Hence, the lack of any warming trend since 1998 is not cause for concern about climate models.

In summary, we do not claim that the climate is insensitive to solar forcing, only that the sensitivities to different types of forcing appear to be very similar. We are open to the possibility that unknown feedbacks might amplify solar forcing; however, Scafetta and West have provided no evidence of such and no reason to discard an explanation of late-20th-century warming that is consistent with theory, models, and observations—namely, increased greenhouse gases.

References

1. See, for example, M. Lockwood, C. Fröhlich, *Proc. R. Soc. A* **464**, 1367 (2008).
2. R. E. Benestad, G. A. Schmidt, *J. Geophys. Res. D* **114**, 14101 (2009), doi:10.1029/2008JD011639.
3. See, for example, D. R. Easterling, M. F. Wehner, *Geophys. Res. Lett.* **36**, L08706 (2009), doi:10.1029/2009GL037810.

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Other climate-change inputs

A vigorous round of correspondence appeared in PHYSICS TODAY (October 2008, page 10) regarding the Opinion piece "Is Climate Sensitive to Solar Variability?" by Nicola Scafetta and Bruce West (PHYSICS TODAY, March 2008, page 50). One letter writer, Peter Foukal, pointed out that neither total nor UV solar irradiance can account for most of the climate variance that correlates with solar activity. In view of the quantitative problems in using irradiance to account for the correlated climate variations, the question can be asked, Are the cosmic-ray variations, which are mostly due to solar activity, themselves drivers of climate change, or are they—as generally assumed—merely proxies for irradiance variations?

Not mentioned in the discussion was observational evidence for greater long-term and short-term climate sensitivity to solar activity than irradiance can account for. Proxies for climate change on the centennial and millennial time scales—proxies such as glacier-carried debris and the oxygen-18 isotope—show strong correlations with the cosmic-ray-generated cosmogenic isotopes carbon-14 and beryllium-10 in stratified geological repositories.[1]

One little-known mechanism coupling solar activity to the atmosphere has been shown to respond to cosmic-ray changes as well as to other inputs, as documented and reviewed in recent publications.[2,3] Clear evidence of meteorological responses, including changes in cloud cover, has been reported for five disparate short-term solar or terrestrial inputs that modulate the flow of the downward electric current density J_z of the global electric circuit through the atmosphere. For example, recent analysis of measurements in both the Antarctic and Arctic high-magnetic-latitude regions shows correlations between surface pressure and the north–south component of the interplanetary electric field. Changes in J_z due to low-latitude thunderstorms produce a similar effect on polar surface pressure.[2] There are other consistent, statistically significant atmospheric responses to the effects of cosmic-ray, solar-proton, and relativistic-electron precipitation on J_z.[3]

The J_z flow deposits electric charge on droplets and aerosol particles in gradients of droplet concentration, humidity, and, therefore, resistivity in clouds in accordance with Ohm's law and Gauss's law. Such charges could affect clouds through the scavenging rates for cloud-condensation and ice-forming nuclei. Consequent changes in the concentration of such nuclei and in ice-nucleation rates can affect droplet concentration, precipitation rate, and cloud cover and can potentially explain the observations. But to model the effects of the cloud changes on global mean temperature on the century time scale, it will be necessary to separately evaluate the effects of solar-induced J_z changes on clouds at low and high altitudes, at high and low latitudes, over ocean and land, by day and night, and for stratus versus cumulus clouds. Such work has not been done, but uncertainties appear much larger than those shown for the solar irradiance effect in the reports of the Intergovernmental Panel on Climate Change, and can thus accommodate the observed changes in global temperature that correlate with solar activity.

References

1. G. Bond et al., *Science* **294**, 2130 (2001), and references therein.
2. G. B. Burns et al., *J. Geophys. Res.* **113**, D15112 (2008), doi:10.1029/2007JD009618.
3. B. A. Tinsley, *Rep. Prog. Phys.* **71**, 066801 (2008).

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Complexities of cell differentiation

In his Reference Frame (PHYSICS TODAY, March 2009, page 8), Leo Kadanoff discussed how the function of biological