letters

Variations on Sun's role in climate change

In their Opinion piece "Is Climate Sensitive to Solar Variability?" (PHYSICS TODAY, March 2008, page 50), Nicola Scafetta and Bruce West draw attention to a "phenomenological solar signature" they find in preindustrial records of global temperature. Correlations between temperature proxies and solar activity have been reported since the 18th century; see, for example, reference 1. However, their significance cannot be judged without considering volcanism, which may account for much of the apparent correlation with solar activity over the past millennium.[2] Scafetta and West assume that the only secular influence on preindustrial climate is the Sun.

Scafetta and West also state that anthropogenic influence on global warming is overestimated if climate is as sensitive to solar activity as their studies suggest. But in their referenced work, they admit that such a high sensitivity requires more powerful couplings between solar activity and climate than have been identified so far. That is hardly news; for more than a decade, the big question has been whether such powerful Sun–climate coupling mechanisms exist. For reasons we reviewed recently,[3] variation in total solar irradiance (TSI) seems to lack the required power, and the solar UV flux variation—another candidate mentioned by the authors—seems to account for less than 10% of the variance in the 20th-century global temperature. Solar modulation of cosmic rays and their possible effect on cloud cover is the most complex candidate and remains hardest to test.

Letters and opinions are encouraged and should be sent by e-mail to ptletters@aip.org (using your surname as "Subject"), or by standard mail to Letters, PHYSICS TODAY, American Center for Physics, One Physics Ellipse, College Park, MD 20740-3842. Please include your name, affiliation, mailing address, e-mail address, and daytime phone number on your attachment or letter. You can also contact us online at http://www.physicstoday.org/pt/contactus.jsp. We reserve the right to edit submissions.

Additionally, Scafetta and West use solar flare statistics as a proxy for TSI variations to derive a similarity in the power law indices of solar fluctuations and Earth temperature variations. Their claim is puzzling since solar flares make a negligible contribution to TSI variation. Why not just analyze the widely available TSI record itself?

In summary, a solar effect on global temperature may well exist, and incisive correlation studies can play a role in its investigation. However, it is increasingly clear that deployment of improved radiometric and photometric instruments will be required to discriminate between suggested Sun–climate coupling mechanisms.

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I was rather disturbed to read the opinion article by Nicola Scafetta and Bruce West, which discussed the global surface temperature anomaly in relation to solar variability. Some important issues regarding their work should prompt readers to question their motivation and whether their conclusions come from an unbiased perspective. I offer those key concerns.

The authors use global temperature data that extend back only to 1890 and cover a short period of time, rather than data from other techniques, such as ice-core sampling, that cover a longer time span.

The authors claim that the increase in temperature, and the consequent change in climates, since 1900 is largely due to solar variability. Climates are often defined as average temperatures over 30 years—also a short time scale. However, if we are observing large temperature changes on time scales shorter than 30 years, it is certainly believable that those changes are due to human activity.

More fundamental, though, from a physical viewpoint is that if solar variability were to influence temperatures as much as Scafetta and West claim, that variability should exist over Earth's entire life span. It should be present in all possible temperature data from prerecorded times. If the Sun were truly having more variability in its output now than it ever has in its past, climate change is not our greatest worry.

More disturbing on a personal, moral level is that the authors are putting forth an argument that attempts to distance us from our responsibility for climate change. Ultimately, that gives readers—including politicians and the general public—justification to continue down the path we started with industrialization around 1900. Many people find that perspective very comforting because it means we don't have to change our ways of doing things.

The political perspective of Scafetta and West's opinion is disturbing because the current administration has repeatedly promoted policies that deny human-induced climate change. And the primary funding for the research in this Opinion piece came from the US Army Research Office. Furthermore, the majority of the references Scafetta and West cite are written by one or the other or both of them and have all been published during the current administration.

The authors are entitled to their opinion. Many other scientists, though, and the Intergovernmental Panel on Climate Change hold another opinion: that solar variability has had a negligible effect on climate. Surely, if solar variability were causing such drastic temperature changes, the IPCC would have incorporated it into its models and findings. Instead of trying to blame climate change on solar variability or other galactic events, we should rethink how we live our lives and whether our lifestyles are fundamentally compatible with the needs of other species on Earth. This is the only home we have; we can't use it up and throw it away in the same manner that we leave our trash at the curbside.

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In the March 2008 issue of PHYSICS TODAY, Nicola Scafetta and Bruce West show a graph (page 51) of global surface temperature and total solar irradiance. Two curves of TSI are shown. The red curve shows an increase of TSI since 1980 and is used to argue that global surface temperature is sensitive to TSI. The reference citation for the figure says that data for the red curve are from http://www.cru.uea.ac.uk and http://www.acrim.com.

Both links show that TSI has not increased since 1980, but instead decreased during that period, so Scafetta and West's red curve disagrees with the cited data sources. That error is serious because it leads to the inaccurate conclusion in the last sentence of the article, that the report from the Intergovernmental Panel on Climate Change should not be trusted.

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Rest assured that the Opinion piece on solar contributions to climate change will find its way hastily into the policy—or should I say political—community and will be misused to stall efforts to limit greenhouse gas emissions. And on what scientific grounds? The work by Nicola Scafetta and Bruce West ignores decades of fundamental physical research and is roundly criticized on technical grounds.[1,2] More important, their basic approach to the question of how the Sun influences climate defies sound scientific logic.

Despite their sophisticated statistical treatments, the authors commit a fallacy by ignoring an established physical forcing (greenhouse gases) while trying to assess the contribution of a separate forcing (solar irradiance); both push the climate in the same direction, if one assumes that the questionable ACRIM satellite time series on solar irradiance is accurate. With IR-trapping gases omitted, the analysis by Scafetta and West must overestimate the contribution of total solar irradiance variations to surface warming. Is the contribution overestimated slightly or dramatically? The authors' work offers no insights.

Even if Scafetta and West take issue with the statistical treatments done by the Intergovernmental Panel on Climate Change, they should nonetheless appreciate the indispensable requirement to account for all relevant forcings, as the IPCC does in its analyses. If they hope to make an authentic contribution to our understanding of the Sun's role in climate change, they must build on an existing body of knowledge; ignoring more than a century of physical science will not help.

The policy community relies on professional scientific publications to provide sound information on relevant topics. When PHYSICS TODAY publishes opinions that are physically unsound and defy basic scientific logic, the policy community is misled. In my experience, once fundamental misconceptions about science are introduced to the policy community, they are difficult to correct. Moreover, confusion and embarrassment produced by the process of rooting out misconceptions can tarnish a policymaker's image of science.

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Publication of the recent Opinion piece by Nicola Scafetta and Bruce West struck me as potentially blurring the distinction between a peer-reviewed journal article and an opinion piece. Presumably, opinion pieces are held to a dramatically lower standard than journal articles are in terms of peer review, burden of proof, and weight of scientific evidence. Yet publishing something dubbed "opinion" that contains scientific declarations of fact or scientific assertions effectively blurs the crucial distinction between opinions and peer-reviewed research articles. PHYSICS TODAY's audience seems to have a broad focus and therefore to be less likely to evaluate the substance of the scientific claims raised in that or similar pieces.

As has been noted in journalism circles, from the perspective of the public and no doubt elements of the science community as well, "the distinction between reporting and commentary has seriously eroded."[1] The same may well be true for scientific journals; distinctions between opinions and research articles are largely meaningless to those outside science, and that blurring may misinform public perceptions.

The net effect is that the scientific community is more or less obligated to respond to scientific claims made in opinion pieces just as if they had met the standards of scholarly peer review. The burden of proof then switches from those making claims to the science community at large for disproving each and every such claim.

I urge the editors of professional science journals, including PHYSICS TODAY, to revisit their policies and procedures regarding what constitutes an article versus an opinion. Such distinctions are not without consequence.

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We enjoyed the article titled "Is Climate Sensitive to Solar Variability?" We commend Nicola Scafetta and Bruce West for their courage in publishing a scientific piece that presents a socially and politically unpopular position.

However, we are concerned about the article's placement in PHYSICS TODAY as an opinion piece. Considering the physical arguments, the reliance on observational and citable data sets, and the attention to mathematical rigor, we wonder what portion of the article is opinion.

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It is good that PHYSICS TODAY reported on the work of Nicola Scafetta and Bruce West. They have done by far the best work in relating solar variability to terrestrial climate, bringing sophistication and rigor to a field dominated mostly by unsupportable positions that the Sun's effect is negligible on the one hand, or is responsible for nearly all observed global warming on the other. That solar variability has appreciable coupling to Earth's climate becomes obvious when an observer notes the imprint of the Schwabe sunspot cycle on the climate temperature record.[1] The identical scaleless noise spectra for solar and terrestrial climate fluctuations provide additional support for coupling and for regarding the Earth–Sun network as a complex system.

Unfortunately, the Intergovernmental Panel on Climate Change clings to its position that solar variability effects are negligible, to the detriment of its credibility. Given known solar variability, the IPCC position can be rationalized only

if the so-called hockey-stick global temperature reconstruction,[2] which shows little natural variation, is valid. However, that reconstruction is at odds with natural history and has been shown to be statistically flawed;[3] more recent reconstructions[4,5] show much more natural variation. The fact that general circulation models do not give appreciable Sun–Earth coupling merely shows that they are leaving out essential physics—by no means their only serious shortcoming. Unfortunately, the phenomenological approach of Scafetta and West only informs us of the magnitude of the climatic impact of solar variability. It does not shed light on the actual physical mechanisms, so it points to the need for more research on physical coupling mechanisms between those interacting complex systems.

It is also unfortunate that PHYSICS TODAY chose to feature this work as an Opinion, rather than giving it the full-fledged article status it deserves. The readership should be informed in more detail about this important work.

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Scafetta and West reply: The purpose of an opinion piece is to stimulate debate, a function quite different from that of a research paper. However, for this topic, our piece required more than the usual scientific infrastructure to avoid being dismissed out of hand.

The letter writers, whose opinions are all important, tend to fall into three categories: Peter Foukal attempts a scientific critique of our research; Roger Cohen appears to have closely followed our research and has correctly understood its scientific framework; and the other readers do not seem to know the scientific details of the debate and question our work more from a political or ethical perspective. We limit our response to cover those issues we see as crucial.

Diedrich Schmidt argues that our research is politically tainted because it was partially supported by the US Army Research Office. That charge is as ridiculous as it is insulting. We speculate, without knowing Schmidt, that he would not level the same accusation at scientists reaching conclusions with which he is sympathetic, regardless of the funding source. In America's scientific community, there is freedom to investigate all sides of controversial issues without fear of political pressure from a funding agency.

Claiming that climate is sensitive to solar variability is not a message of despair, in part because solar activity is forecast to decrease during this century. Regardless of what the Sun may do, however, the scientific issue is what matters, and science must have priority over political correctness in this discussion.

Foukal claims that we are neglecting volcanism's contribution to climate change and cites the important work of Gabriele Hegerl and coworkers (see Foukal's reference 2). We did not neglect that effect. The green curve in our figure (page 51 of the Opinion piece) represents the temperature signal after the volcanic signal has been removed using a technique essentially equivalent to that of Hegerl and coworkers but applied to short time scales. The model simulations (blue and red curves), mistakenly interpreted by Wim Klaassen, have two inputs: the phenomenological signature of the 11-year solar cycle on the temperature, obtained after removing the volcanic signal, and a characteristic response of climate to external forcing of about a decadal time scale, which is essentially what many groups' energy balance models assume.

Hegerl and colleagues attempt to interpret some paleoclimate temperature reconstructions from AD 1000 to AD 2000 by means of a simple multilinear regression analysis constructor, which is essentially a linear fit of more than one variable to the data; in their fit are four components: the Sun, volcanoes, a greenhouse gas plus aerosol component labeled as anthropogenic, and noise (see their equation 2 and table 2). The multilinear fitting coefficients, as expected, strongly depend on the particular paleoclimate temperature reconstruction that is adopted.

A careful reader of that table would notice that for some paleoclimate temperature reconstruction, the fitting parameter referring to the solar forcing is negative. That means that if the paleoclimate temperature data and the model of Hegerl and coauthors are correct, every time the solar irradiance increases, the climate cools, and every time the solar irradiance decreases, the climate warms. That looks quite unphysical. At the other extreme, if another paleoclimate temperature reconstruction is adopted,[1] the multilinear fits give very different results according to the time period fitted, and the anthropogenic component vanishes when the temperature record is fitted from the years 1001 to 1925.

One crucial difficulty surrounding the climate change issue is the huge uncertainty in the paleoclimate temperature and solar reconstruction data and in the climatic effect of the forcing. For example, according to the 2007 Intergovernmental Panel on Climate Change (IPCC) report, a doubling of carbon dioxide would increase the global temperature between 1.5 K and 4.5 K—not a small range. The uncertainty makes quite problematic the application of the traditional climate model methodology, since it relies on having correct data and sensitivities and on knowing the correct physical mechanisms. Unfortunately, those data, sensitivities, and knowledge are not currently available.

For example, when the traditional climate model simulations are compared with the patterns observed in the temperature data, models significantly underestimate the solar signature: The 11-year solar cycle signature on the surface temperature has a peak-to-trough amplitude of 0.1 K, while the climate models predict an amplitude of 0.035 K (see the Goddard Institute for Space Studies ModelE simulations at http://www.giss.nasa.gov/tools/modelE). Thus the models appear to be missing important solar–climate linking mechanisms.

Arguing, as Foukal does, that the total solar irradiance and UV radiation do not have enough power to explain the strength of the link suggests that the physics of the solar–climate linking mechanisms should be further investigated, not that the mechanisms do not exist. To think otherwise would be a logical fallacy of scientific reductionism.

As Cohen correctly observes, one major reason the scientific community has believed that most global warming was anthropogenic is the so-called hockey-stick global temperature reconstruction,[2] which is based mostly on tree-ring data. It shows little preindustrial climate variability and significant warming since 1900. That pattern supports the theory of manmade global warming.[2,3] However, the latest studies have shown the limitation of the tree-ring temperature reconstructions and that, on the contrary, climate varied

substantially in preindustrial times.[2,4] The variability suggests that climate is strongly sensitive to solar change and more weakly sensitive to anthropogenic emissions than presently estimated. Thus our research and several new findings appear to indicate that the IPCC's conclusions need significant revision.

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Constraining potential bomb builders

According to Alisa Carrigan's Opinion piece, "Learning to Build the Bomb" (PHYSICS TODAY, December 2007, page 54), to prevent proliferation of nuclear weapons, knowledge of nuclear power should be kept from scientists and engineers of potentially rogue countries. I would like to comment on her line of reasoning.

First, nuclear weapons are not the only threats to world peace. Chemical and biological weapons are as dangerous as nuclear weapons. So the restriction should not be limited to nuclear physics and related areas of knowledge; various fields in chemistry, chemical engineering, pharmaceutical and biological sciences, physics, and mechanics must also be off limits. After that come certain fields of mathematics—for example, number theory—and software engineering because they have applications in cryptography. Just imagine some terrorist hacking into a computer that is controlling, for instance, airplane traffic. Even quantum computation is dangerous because it has applications in deciphering. Where should one stop?

Carrigan distinguishes between explicit and tacit knowledge. But there is no permanent sharp line between the two. For example, Carrigan mentions the need to use fabric gloves to assemble centrifuges; since that information has now been published, it has been transformed from tacit to explicit. Since people have access to explicit knowledge through books and journals, it is not sufficient to monitor the sources of tacit knowledge. To prevent proliferation of the required knowledge, the flow of explicit knowledge must be controlled as well. That requires establishing a system of censorship.

I think the logical consequence of accepting Carrigan's idea is a kind of "knowledge nonproliferation treaty." Such a system, if implemented, simply means that people are divided into two categories: those who have the knowledge of making nuclear, chemical, and biological weapons and those who do not. The first category, by this system, has the right and responsibility to block the second group's access to the required knowledge and technology. I think that is simply a variant of apartheid. It would force people in the second category—the "have-nots"—to invoke dirty tricks to get that knowledge. Scientific apartheid doesn't work and is not a suitable means to establish a sustainable peace.

Today, contrary to, say, 100 years ago, even people in developing countries have access to the basics of the scientific method and the fundamentals of science. From those foundations it is, in principle, possible to produce the forbidden knowledge, just as scientists in the developed countries have done. So a knowledge nonproliferation treaty does not help. Because knowledge is not only transported but also produced, it is now almost impossible to impose a knowledge blockade.

Let us consider that problem from another point of view. The case of South Africa's nuclear program is worth discussing. Why did South Africa make weapons and then destroy them? I think the answer is that four decades ago South Africa was having trouble with its neighbors—and with its own people as well. After the apartheid era, the troubles being greatly diminished, South African officials no longer saw the need for nuclear weapons.

Which other countries have made nuclear weapons? North Korea, because of its standoff with South Korea; Israel, because of trouble with all its neighbors; Pakistan and India, because of their long-standing animosity. Carrigan points out that all those nations were able to obtain the required knowledge, and from nonmilitary activities. My conclusion is that if some nation has enough motivation to build a dangerous weapon, it probably can obtain the knowledge to do so. If we want to build a sustainable peace, why not try to reduce the nations' motivation to have weapons?

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Carrigan replies: Ahmad Shariati makes several valid points in his letter, but most of them are not logical extrapolations from my argument.

For example, he writes that any branch of science or mathematics could be implicated in the process of building nuclear, biological, chemical, or conventional weapons or of hacking into computer systems. That is true: Whatever can be used can be misused, and every branch of science is therefore potentially at risk of being hijacked for malevolent purposes.

Shariati thinks that condition must necessarily lead to a "knowledge nonproliferation treaty" to keep the people that do not possess knowledge to create nuclear, biological, or chemical weapons from obtaining it. But that is in direct contrast to my own conclusions. I wrote, and still believe, that "it is unlikely that the international community can stop the dissemination of nuclear weapons knowledge altogether," or stop the spread of any other type of scientific knowledge. My research indicated that a driven state will find ways to acquire the tacit and explicit knowledge it needs. For precisely that reason I proposed not a knowledge nonproliferation treaty but several steps that might help the international community better track the spread of nuclear weapons knowledge and thereby have a better understanding of who is working on what.

On Shariati's final question, I agree most completely. Attempting to stop proliferation is simply treating a symptom; the disease itself—the political and security drivers motivating states to acquire nuclear weapons—must also be addressed. But I think it is wise to treat both the symptom and the disease simultaneously, especially in this case. I am well aware that nonproliferation policies do not present a final solution to the problem of nuclear weapons, but I also believe it would be negligent to ignore proliferation entirely to focus on quelling states' desires for nuclear weapons.

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