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EDITORIAL

Climate Science: Drowned in the Noise

Climate change is a term that almost every educated person uses today. Hot days, as summer approaches, are quickly interpreted as tangible signs of global warming. Sudden, unanticipated events like torrential downpours and floods seem to immediately conjure up visions of a rapid change of the global climate cycle. Much of the discussion on climate change centres on policy issues. The recent summit in Copenhagen produced little by way of agreement on the commitments that need to be made by nations to mitigate 'global warming'. There will undoubtedly be more international meetings on the issue in the not too distant future. The public perception of the importance of climate change was suddenly enhanced a couple of years ago by the award of the Nobel Peace Prize in 2007 to former US Vice-President Al Gore and the Intergovernmental Panel on Climate Change (IPCC), a large body of scientists (close to 4000), who have over the years painstakingly prepared reports, that provide the evidence for climate change scenarios. The panel came into being in 1988 as a result of a UN General Assembly resolution, triggered by concerns about the rising levels of greenhouse gases, primarily CO_2 which could produce a warming effect. In seminar after seminar over the years the famous graph correlating global temperature with atmospheric CO_2 levels has been projected, establishing the connection between recent human activity and changing atmospheric composition. In the past few weeks controversy has dogged the IPCC report following the revelation that some alarmist scenarios, most notably the section on Himalayan glaciers, may have been based on somewhat flimsy grounds. The leakage of e-mails exchanged between scientists on issues of climate data has brought discussions about climate science, climate scientists and policy makers to the front pages of daily newspapers.

An interesting feature of a great deal of reporting on climate change issues is the almost complete absence of any discussion on the historical origins of climate science. 2011 will mark the 150th anniversary of the publication of John Tyndall's paper circumspectly titled: 'On the absorption and radiation of heat by gases and vapours, and on the physical connection of radiation, absorption and conduction' (*Philos. Mag.*, 1861, **22**, 169). This anniversary will undoubtedly be less celebrated than the recently concluded 'Darwin year' but is nevertheless an event that should refocus attention on the science of climate. The role of the atmosphere in maintaining global temperature was recognized in the early 1820s by Joseph Fourier. Nearly, four decades after Tyndall, Svante Arrhenius – immortalized in physical chemistry textbooks for his work on chemical kinetics – recognized that CO_2 emitted by human activity may warm the atmosphere. His paper entitled 'On the influence of carbonic acid in the air upon the temperature of the ground' (*Philos. Mag.*, 1896, **41**, 237) marks the formal starting point of the CO_2 theory of climate change. It would have been appropriate to mark the centenary of Arrhenius' initial attempts to connect climate and chemistry in 1996. For purists the Arrhenius paper is flawed; for the outside observer it may be prophetic. Years later, G. S. Callender returned to the issue with a paper succinctly titled 'The artificial production of carbon dioxide and its influence on temperature' (*Quart. J. R. Meteorol. Soc.*, 1938, **64**, 223). An interesting feature of the Tyndall, Arrhenius and Callender papers is the simplicity and clarity of the titles. There is no doubt that all three authors foresaw that global climate would be influenced by atmospheric composition. The CO_2 effect had few adherents even in the 1950s. Atmospheric science was a backwater and an unrewarding area of work. My curiosity about the history of the area was aroused when I read a 1956 article in *American Scientist* which was reprinted in the January–February 2010 issue of the journal. The article entitled 'Carbon dioxide and the climate' notes that 'it seems appropriate to reconsider the variations in the amount of carbon dioxide in the atmosphere and whether it can satisfactorily account for many of the world-wide climatic changes' (Plass, G. N., *Am. Sci.*, 1956).

Gilbert Plass (1920–2004) was a physicist who published extensively in the 1950s on atmospheric infrared radiation. His seminal paper entitled 'Effect of carbon dioxide variations on climate' noted that 'physicists are somewhat partial to the carbon dioxide theory since all the relevant experimental and theoretical work that is needed in order to determine the magnitude of the effect is in their field'. Plass was emphatic in his conclusion: '. . . we can be sure that the atmospheric carbon dioxide amount has changed many times and by large factors during the geologic history of the earth and that these variations have had their influence on the climate'. Plass was clear that in order to relate CO_2 changes to climate variation 'the carbon dioxide content of past epochs should be known'. He was prescient in noting that 'in order to determine these variations we must collect evidence from diverse fields as geology, oceanography, biology and meteorology' (Plass, G. N., *Am. J. Phys.*, 1956, **24**, 376). Plass based his work on the sound knowledge of the infrared absorption and emission properties of the gaseous constituents of the atmosphere. In a paper entitled 'Infrared radiation in the atmosphere', Plass noted: 'From the surface of the earth up to heights of 80 km or more the temperature is usually in the range from 200 K to 320 K. The blackbody radiation that corresponds to these temperatures is largely in the spectral region from 5 to 100 microns. In order to influence the infrared flux in the atmosphere, a gas must have an absorption band in this range of frequencies'. He then added that the common constituents of air, oxygen and nitrogen do not absorb these frequencies but ozone and carbon dioxide do, clearly identifying the latter as the principal actor in determining infrared flux and consequently global temperature. Although in Plass' time the problem of global warming had not heated up, he observed with remarkable foresight: 'The accumulation of carbon dioxide in the atmosphere from continually expanding industrial activity may become a real problem in several generations. If at the end of the century measurements show that the carbon dioxide content of the atmosphere has risen appreciably and at the same time the temperature has continued to rise throughout the world, it will be firmly established that carbon dioxide is an important factor in causing climate change' (Plass, G. N., *Am. J. Phys.*, 1956, **24**, 376–387). Plass' initial calculations were oversimplified; curiously some of his numbers coincide with those obtained with more realistic models. In his 2010 commentary that accompanies the reprinting of the Plass article in *American Scientist*, Gavin Schmidt points out that more accurate calculations carried out subsequently have 'been all but forgotten' since the author 'incorrectly concluded that CO_2 could not play a role in climate change'. Schmidt adds: 'In 50 years time if someone reviews my work, I would hope to have been as lucky as Gilbert Plass.'

The *American Scientist* issue drew me, inevitably to the internet and there I discovered a treasure; a website 'The discovery of global warming' by Spencer Weart (http:www.aip.org/history/climate, June 2007). The author, a historian of science has created a wonderful collection of essays, an ocean of information for those interested in climate change. He provides a fascinating insight into the 'scientific process, as seen in climate studies'. Weart observes that groups of scientists who work in an area do not 'look like an exploring team aiming into new territory'. Rather, 'it looks more like a crowd of people scurrying about, some huddling together to exchange notes, others straining to hear a distant voice or shouting criticism across the hubbub. Everyone is moving in different directions, and it takes a while to see the overall trend. I believe this is the way things commonly proceed not only in geophysics but in most fields of science'. Weart adds that he attempts to capture this process in climate science in his essays, 'by connecting the dots among roughly a thousand of the most important papers in the science of climate change'. This is clearly a formidable task in a rapidly expanding field; one which Weart accomplishes in compelling fashion. Two of climate sciences major figures emerge in these pages, Roger Revelle (1909–1991) and Charles Keeling (1928–2005). In a 1957 paper that he coauthored with Hans Suess, Revelle argued that the rates of absorption of CO_2 by oceans would be far slower than its production by anthropogenic activity, laying the foundation for much of modern discussion on ocean geochemistry. In retrospect, the bicarbonate chemistry that Revelle introduced to the field of climate science seems both obvious and simple; a clear sign of its importance. Revelle's leadership abilities propelled him to the position of the most articulate spokesman for the field. Charles Keeling, whom I have written about on an earlier occasion (*Curr. Sci.*, 2008, **95**, 291), began his painstaking measurements of atmospheric CO_2 in 1957. Weart's essay 'Money for Keeling: Monitoring CO_2 levels' must be read by all those who discuss ways of funding science. Keeling's persistence in the face of funding difficulties is a lesson in the virtues of committment, dedication and resilience. Weart notes that 'some officials would have preferred to pursue CO_2 monitoring without Keeling himself'. 'Keeling's a peculiar guy', Revelle later remarked. 'He wants to measure CO_2 in his belly. . . And he wants to measure it with the greatest precision and the greatest accuracy he can'. It is these measurements of Keeling, together with the work of Plass and Revelle that provide the foundations of present day climate science. The road to Copenhagen was laid a long time ago and the builders have faded into history. A call to Stockholm when the IPCC was being set up, when all three were still alive, may have attracted many more to the area of the science of climate, rather than the politics of climate change.

Is climate science in danger of being drowned by the noise of climate change controversies? James Lovelock in his latest book, *The Vanishing Face of Gaia: A Final Warning* (Allen Lane, 2009; Penguin, 2010) provides a sombre assessment: 'We seem to have forgotten that science is not wholly based on theory and models: more tiresome and prosaic confirmation by experiment and observation plays just as important a part. Perhaps for social reasons, science has in recent years changed its way of working. Observation in the real world and small-scale experiments on the Earth now take second place to expensive and ever-expanding theoretical models. . . . Our tank is near empty of data and we are running on theoretical vapor'. Climate science must carve an identity distinct from climate change policy issues. Only then will the science of the Earth be heard above the cacophony of controversy.

P. Balaram