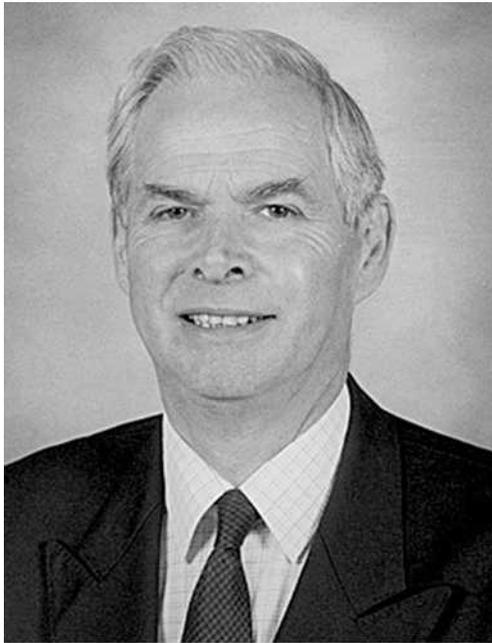


Editorial



Dr. John Lennox Monteith

Monteith symposium: topics in environmental physics

This issue of *Agricultural and Forest Meteorology* deals with various topics under the general heading of Environmental Physics. It is made up of selected papers presented at a symposium at the 1996 annual meeting of the American Society of Agronomy, held in Indianapolis, USA. One purpose of the symposium, and this issue, is to honor Dr. John L. Monteith. Dr. Monteith's distinguished career has spanned nearly five decades, and has largely defined the discipline of Environmental Physics. While the symposium and this issue cover a wide range of subjects, they still fall short of covering the range of topics to which John Monteith made substantial contributions.

The symposium featured contributions in the areas of evapotranspiration and plant water relations, carbon assimilation and allocation, and atmospheric transport, as well as applications in the areas of agroforestry and plant breeding. It is significant that John Monteith has had substantial influence on the science of each of these areas as well as several others. In these days of increased specialization in advanced studies it is interesting that no single scientific society has broad enough interests to cover all of the fields to which John Monteith made major contributions.

John Lennox Monteith was born on 3 September 1929 at Fairlie, Ayrshire, Scotland. He is the son of Reverend John and Margaret Lennox Monteith. He received his BSc in physics with first class honors from University of Edinburgh in 1951, and his PhD in Meteorology from University of London in 1955. In 1954 he became a Scientific Officer in the Physics Department of the Rothamsted Experimental Station. He served there as Scientific Officer, Senior Scientific Officer and Principal Scientific Officer until 1967. In 1967 Dr. Monteith was appointed to the Chair of Environmental Physics at the University of Nottingham. During his time at Nottingham he served twice as Head of Department, and also served as Dean of the Faculty of Agricultural Science.

In 1987, Dr. Monteith left Nottingham to become Director of the Resource Management Program at the International Crops Research Institute for Semi-Arid Tropics in Hyderabad, India, where he served until 1991. Since 1992 he has been Senior Visiting Fellow at the Institute of Terrestrial Ecology at Penicuik, Scotland.

Among the many ways in which John Monteith's professional accomplishments have been recognized are his appointments as Fellow of the Royal Society of London in 1971 and of Edinburgh in 1972. In addition he is Fellow (1951) and Honorary Fellow (1997)

of the Royal Meteorological Society, Fellow (1966) of the Institute of Physics, and Fellow (1976) of the Institute of Biology. He served as president of the Royal Meteorological Society from 1978 to 1980. He has served on many national and international scientific committees and on the editorial boards of prominent scientific publications. Notably, he has been a member of the Agricultural and Forest Meteorology editorial board since 1964!

Environmental Physics is not a branch of physics, like mechanics or solid state physics, it is the study of the physical interactions of living organisms with their environment. As such it involves analyses of mass and energy exchange between plants and animals and their surroundings, as well as continuity principles governing the conservation of energy and mass. The basic principles governing these processes were already well understood when Dr. Monteith started his career, but their application to biological Systems had barely begun. His PhD research, partially published in a paper simply titled *Dew* (Monteith, 1957), already gives a clear indication of the directions Monteith would take this new and emerging field. The formation of dew was easily observed (though, in the 1950s this involved some long nights for the scientist since field recording equipment was not available). However, the observations did not necessarily lead to understanding. They did not allow one to predict either the source of the dew or the amount of dew one might expect on some future night. Using a method of analysis that would become a characteristic of many future Monteith papers, he recognized that the energy balance of the surface controlled the amount of dew that could be formed. He showed that the amount of dew condensed could be computed from the isothermal net radiation. He computed the relative source strengths of atmospheric and ground sources using transport theory.

Dr. Monteith is perhaps best known for the Penman–Monteith equation (Monteith, 1965) for computing evaporation from crop and soil surfaces. Penman had already successfully combined the energy balance and aerodynamic equations for evaporation into a single equation which eliminated the need for a measured surface temperature. The Penman equation, however, made no explicit allowance for non-infinite canopy and soil surface conductances. Since canopy and soil surfaces generally do not have infinite conductance, the Penman form of the equation gave incor-

rect values for evaporation, and had an incorrect wind speed dependence. Monteith showed how to explicitly account for surface conductance, and produced a new equation that more correctly accounts for wind and surface effects. The Penman–Monteith equation has become the basis for the new FAO world guidelines for estimating irrigation water requirements (Allen et al., 1994). Applications of the equation, however, go well beyond prediction of evaporation from agricultural crops. It is a fundamental statement about the behavior of any system involving radiative, sensible and latent heat exchange. For example, it has been used in animal energetics to analyze the energy balance of sweating endotherms and wet ectotherms (Campbell and Norman, 1998), and to predict the canopy temperature of water stressed crops (Jackson, 1982). The impact of the Penman–Monteith equation has been profound and far-reaching.

As was mentioned earlier, this issue, and the symposium from which it came, covers a wide range of topics. All relate directly to research contributions made by Dr. Monteith. The first article is by Monteith, and shows again his brilliant insights into the workings of nature. In a world where computers now allow scientists to multiply the complexity of simple systems almost without bound, he is able to look at a complex system (a crop) and reduce it to simple and understandable terms. What a difference it would make to science if more scientists possessed that talent.

John Sperry's article on plant water relations is not an outgrowth of Monteith's work, but complements it nicely. One of the first projects undertaken by Dr. Monteith at Rothamsted was the measurement of plant and soil-water potential with a thermocouple psychrometer (Monteith and Owen, 1958). Considerations of water supply and demand are critical for correct predictions of evaporation, and were discussed at length in several of Monteith's papers (Monteith, 1986, 1999) and incorporated into his RESCAP model. Sperry's models of water transport in plants provide the physiological insight needed to understand the field observations that are in Monteith's models of plant response to water.

The papers by Chin Ong and Cohn Black, and by Jonathan Williams come fairly directly from Monteith's work, and are good examples of the applications that have been and can be made of Monteith's

science. All three of these scientists worked extensively with John Monteith in overseas development efforts both at Nottingham and at ICRISAT. As these two papers show, there is much to be gained by applying the principles and methods of Environmental Physics to practical problems in agriculture, forestry and environment. Indeed, this may be the only possible way forward in the future.

The final papers go in an entirely different direction, but, again, represent an area where Dr. Monteith did significant early work. All three papers deal with the measurement of heat and mass transport in the atmosphere, an extremely important topic in Environmental Physics. Transport processes involving heat and water vapor are, of course, an important part of the Penman–Monteith equation. In addition Monteith made some of the earliest measurements of CO₂ transport in the atmosphere (Monteith and Szeicz, 1960; Monteith et al., 1964). John Baker's paper discusses a relatively new method which is useful for directly measuring the fluxes of CO₂ and other trace gasses. The papers by Tom Denmead and Lowrey Harper test a very promising application of Lagrangian dispersion analysis that not only models fluxes, but gives information about the locations of sources and sinks in the canopy. The ability to measure and model at this level were only dreams of the environmental physicist of the 1960s. These achievements have been made possible because of the pioneering work of scientists like John Monteith.

If the symposium and this issue had included papers in all of the fields to which John Monteith contributed, it would have produced a very thick book. Other areas where he made major contributions include radiation climatology, animal-environment interaction, and instrumentation.

While scientists from various disciplines worked on problems in Environmental Physics in the 1960s and 1970s, the subject really became established as a defined field of study with the Publication of *Principles of Environmental Physics* in 1973 (Monteith, 1973). I first saw the book when one of my students showed me a copy soon after it was published. I was able to borrow the book overnight, and sat up all night reading it. I occasionally find novels exciting enough to keep me awake through the night, but that is the only science book ever to keep me awake. It is now in its second edition (Monteith and Unsworth, 1990), has

been translated into several languages, and is known, used, and loved around the world.

Contributions through papers, books and lectures by scientists are easily traced and tallied. Contributions to science through commercialization of instrumentation are often not cited or credited, but can play an extremely important role in the advancement of science. Some of John Monteith's contributions in these areas should also be mentioned. While at Nottingham, Monteith and his colleagues developed and used diffusion porometers and tube solarimeters. Other scientists saw this equipment in use at Nottingham, and wanted to make those same measurements in their research programs. Ed Potter, an engineer at a small company called Delta T Devices, at Burwell near Cambridge, undertook the production of these instruments. Monteith and others at Nottingham gave advice and direction. From that start, Delta T Devices has become a major supplier of instrumentation for environmental physics research throughout the world. Monteith was also one of the founders of Campbell Scientific Ltd., another major supplier of research instrumentation for Britain and Europe. The president of CSL began his career as a technician in Monteith's laboratory at Nottingham. Much of our progress in Environmental Physics in recent years is the direct result of the availability of good field instrumentation like that provided by these companies.

Even harder to quantify is the influence Monteith has had on science through his impact on the lives and minds of the people who have worked with him. Many students as well as colleagues had their careers shaped and altered by that association. Students who either trained at Nottingham or were strongly influenced by Monteith's teaching now hold important and responsible positions in many places in the world, and themselves are training students.

It is hoped that this issue will recognize, in some small way, the important contributions made by John Monteith to the science of Environmental Physics over the past half century.

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