Geophysical Research Abstracts
Vol. 18, EGU2016-10980-1, 2016
EGU General Assembly 2016

The contributions of Lewis Fry Richardson to drainage theory, soil physics, and the soil-plant-atmosphere continuum

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The EGU Division on Nonlinear Processes in Geophysics awards the Lewis Fry Richardson Medal. Richardson's significance is highlighted in http://www.egu.eu/awards-medals/portrait-lewis-fry-richardson/, but his contributions to soil physics and to numerical solutions of heat and diffusion equations are not mentioned. We would like to draw attention to those little known contributions.

Lewis Fry Richardson (1881-1953) made important contributions to many fields including numerical weather prediction, finite difference solutions of partial differential equations, turbulent flow and diffusion, fractals, quantitative psychology and studies of conflict. He invented numerical weather prediction during World War I, although his methods were not successfully applied until 1950, after the invention of fast digital computers. In 1922 he published the book 'Numerical weather prediction', of which few copies were sold and even fewer were read until the 1950s. To model heat and mass transfer in the atmosphere, he did much original work on turbulent flow and defined what is now known as the Richardson number. His technique for improving the convergence of a finite difference calculation is known as Richardson extrapolation, and was used by John Philip in his 1957 semi-analytical solution of the Richards equation for water movement in unsaturated soil.

Richardson's first papers in 1908 concerned the numerical solution of the free surface problem of unconfined flow of water in saturated soil, arising in the design of drain spacing in peat. Later, for the lower boundary of his atmospheric model he needed to understand the movement of heat, liquid water and water vapor in what is now called the vadose zone and the soil plant atmosphere system, and to model coupled transfer of heat and flow of water in unsaturated soil. Finding little previous work, he formulated partial differential equations for transient, vertical flow of liquid water and for transfer of heat and water vapor. He paid considerable attention to the balances of water and energy at the soil-atmosphere and plant-atmosphere interfaces, making use of the concept of transfer resistance introduced by Brown and Escombe (1900) for leaf-atmosphere interfaces. He incorporated finite difference versions of all equations into his numerical weather forecasting model. From 1916, Richardson drove an ambulance in France in World War I, did weather computations in his spare time, and wrote a draft of his book.

Later researchers such as L.A. Richards, D.A. de Vries and J.R. Philip from the 1930s to the 1950s were unaware that Richardson had anticipated many of their ideas on soil liquid water, heat, water vapor, and the soil-plant-atmosphere system. The Richards (1931) equation could rightly be called the Richardson (1922) equation!

Richardson (1910) developed what we now call the Crank Nicolson implicit method for the heat or diffusion equation. To save effort, he used an explicit three level method after the first time step. Crank and Nicolson (1947) pointed out the instability in the explicit method, and used his implicit method for all time steps. Hanks and Bowers (1962) adapted the Crank Nicolson method to solve the Richards equation. So we could say that Hanks and Bowers used the Richardson finite difference method to solve the Richardson equation for soil water flow!