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# Percy Crowe: a forgotten pioneer climatologist and quantitative geographer<sup>1</sup>

Much of the written history of scientific disciplines focuses on the most influential items in their literature. Other work that could have had a substantial impact is largely ignored, raising questions as to disciplinary trajectories if it had gained greater attention. Such a situation is analysed here through the work of Percy Crowe, a British climatologist, the first geographer to advocate and deploy formal statistical procedures and who also had prescient views of the philosophy of human geography.

Climatology was for long a 'Cinderella science, languishing in the care of geography and looked down on by the practitioners of meteorology' (Hare and Sewell, 1986, 213; Kates and Burton, 1986, xiii). Compulsory courses in British degree curricula – 'No one is worthy of the name of geographer who has not a fairly detailed knowledge of climatic conditions in the different parts of the globe' (Newbigin, 1928, 418) – were rarely popular, and few geographers specialised in the field.

Percy Crowe did. With a BSc(Econ) in geography from the London School of Economics in 1925, taking several courses in statistics (very probably taught by A. L. Bowley, who emphasised the use of graphical methods: Bowley, 1910, 1920<sup>2</sup>), he then joined Glasgow's Department of Geography; a Commonwealth Fund Fellowship saw him spend 1928-1930 in the United States. His first papers (Crowe, 1927, 1929) were not on climatology, but with one notable exception he published nothing else thereafter; his 1940 PhD thesis was entitled 'New Methods in the Study of the Seasonal Incidence of Rainfall'. Although enlisted in the RAF, for much of the Second World War he worked in the Meteorological Office. In 1947 he was appointed Reader and Head of the Department of Geography at Queen Mary College, University of London (Sheppard, 1994) and in 1953 he became Professor and Head of the Department of Geography at the University of Manchester; he retired in 1971 and died in 1980 (Anon, 1981;<sup>3</sup> Musk and Rodgers, 1980).

Crowe's first climatological paper made him *the* British pioneer in the use of statistical methods in geography, as against the use of statistical data.<sup>4</sup> It was set, like all of his work, within the prevailing paradigm of earth description and regionalisation – descriptive climatology. By stressing the need to make precise descriptive statements and showing how to establish 'significant' differences between distributions he moved geographical description substantially forwards.

## The statistical study of variability and rainfall regimes

Crowe criticised using means to describe climatic conditions, quoting Newbigin (1928, 423) that any chosen indices should 'make clear both the normal sequence of events and the probable frequency

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<sup>2</sup> 'Diagrams do not add anything to the meaning of statistics, but when drawn and studied intelligently they bring to view the salient characteristics of groups and series; they show the various parts in relation to each other and to the whole, bring to light the unity that underlies the scattered figures, and suggest in what directions investigation is needed' (Bowley, 1910, 35).

<sup>3</sup> The anonymous obituarist was Prof H. P. White, a transport geographer who was a student of Crowe's at Queen Mary College and a staff member at what became the University of Salford, 1963-1982: <https://www.independent.co.uk/news/people/obituary-professor-h-p-white-1396091.html> (I am grateful to Dr Catherine Souch of the Royal Geographical Society who sought out this information for me).

<sup>4</sup> Steel and Watson (1972, 143) refer to him as a pioneer.

and extent of variations from the normal'. Few other geographers did this though Williamson and Clark (1931a, 1931b; Clark, 1932; also Taylor, 1920 and Andrews, 1932) used the mean variability around the mean expressed as a percentage of that mean – which Crowe (1933, 90) termed 'an approximation to probable error'.

Crowe followed Newbiggin's (1928, 418-419) contention that climatologists should appreciate that 'while even adjacent stations may not show identical mean conditions, certain groups show resemblances, as regards the nature and extent of the variations in the climatic elements which differentiate them from other groups, and that a classification of climates becomes possible': regions should be defined on that basis. His graphical method for depicting monthly rainfall data dismissed the mean and promoted the median, which is 'quite independent of a few very exceptional values', and the inter-quartile range – 'a good measure of mean dispersion' (p.77 – citing Bowley). He argued that '[t]he best way to appreciate the innate variability of rainfall is to plot the actual monthly totals' in what he termed dispersion diagrams. (Bowley's – 1910, 1920 – books did not include the dispersion diagram, however, although the latter did discuss quartile deviations.)

The goal was to identify discontinuities; 'many of the slighter differences between the monthly means must be of an entirely fortuitous character',<sup>5</sup> so establishing a significant difference in average rainfall between months involves 'a question of probability and as such must be stated in the form that "there is a fair presumption" that certain conditions will prevail' (p. 79). Significant changes in precipitation amounts between both adjacent and alternate months were 'relatively rare' (p.79) so it is 'usually quite impossible to point with definiteness to a wettest or a driest month'. When such changes occur, however, 'they are usually common to a whole group of stations as if illustrating some regional influence. Hence they give a new approach to the study of rainfall regime' (p.80). The reasons for such discontinuities were not explored, however: '[i]n the existing state of knowledge ... it would be rash even to hazard a guess. Our task is achieved if in place of the current conception of rainfall maxima and minima a good case has been stated for emphasis upon *rapidity of change*' (p. 85, his emphasis). His conclusion is thus modest (p.90):

We have thus outlined a method of handling rainfall statistics, in its essence perfectly simple. ... emphasis has been laid upon its behaviour in operation rather than upon abstract theory ... Of its merits or demerits others must be left to judge. If it has achieved nothing more than to provoke thought upon a somewhat neglected branch of climatology, it will have served its purpose.

Matthews (1936, 84) was 'inspired by Crowe's invaluable and stimulating discussion of rainfall variability' (see also Hogg, 1940, 1948), Crowe (1936) briefly responding (p.188) that:

The new method of rainfall analysis may now be regarded as having established itself in its two major objects: –

- (1) It has satisfactorily replaced the old one-point summary of monthly rainfall data by a more illuminating multiple-point summary.
- (2) It provides a method of exploring the significance of difference between monthly means [which appears to be eliding mean with median!].

In both cases it has been found possible to express abstract graphical relationships, at least in a general manner, in non-technical terms.

It should now be possible to go forward confidently to regional analyses on the new basis.

Crowe (1936, 433) averred that climatology 'no longer confines itself to "average weather" but takes a keen interest in the frequency of exceptional weather'; if climates are not constant 'the search for

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<sup>5</sup> Crowe apparently used the term mean as a portmanteau term for any measure of central tendency, including the median, deploying arithmetic average whereas most authors now would use mean.

any valid mean expression would seem foredoomed to failure. Climatic statistics must therefore be examined in their entirety, and obsolete normal replaced by indices of probability'.<sup>6</sup>

Several papers developed the approach. He defined a hierarchy of rainfall provinces across the US Western Plains, briefly concluding that (Crowe, 1936, 484):

Such are the results of an objective study of precipitation on a purely relative basis. ... The statistical material has been allowed to yield its own results, and in a very real sense the discussion might have been summed up as "Rainfall Relativity". Precision has been given to the conception of a Plains type of rainfall, and it has been saved from a uniformity that was chaos.

The approach was extended to the south-eastern United States, presented as (Crowe, 1948, 71):

... purely descriptive in character. Its object is to establish a regional classification of rainfall types on an objective basis. Yet it is the work of a geographer seeking valid generalizations and not of a meteorologist for whom the study of rainfall is an end in itself.

Climatologists needed 'a disciplined method of describing the seasonal incidence of rainfall'.

A paper presented to the Royal Meteorological Society analysed rainfall at seventy British stations for 1881-1930. Climate is defined as 'average weather' but interpretation of long-period means involves three assumptions (Crowe, 1940, 285). First, the mean may be biased if the distribution is skewed. Second, the mean may not be a 'timeless normal' but vary over time. Finally:

... the outstanding characteristic of rainfall data is the very wide range of variability encountered and, under these conditions, small differences between means may be due entirely to chance factors. The question thus arises of how to recognise what elements of régime are significant and what ought rightly to be dismissed as fortuitous (p.286).

The standard method of testing for significant differences between means (he cites Bowley, Yule, and Fisher) makes assumptions about the data that may not be met; his method 'remains valid even when it is definitely known that some of them are not satisfied'.<sup>7</sup>

A short paper focused on the boundaries between two rainfall regimes, introducing the 'true normal' (or expected value) as 'no more than a hypothesis, a mental image ... the limit to which the average will tend as the record is extended over an indefinitely increasing number of years' (Crowe, 1941, 40-41). Many stations may have a single true normal but 'in transitional areas, at least, there may be two alternative normals' where reducing the record to a single average misrepresents the situation – as exemplified by Roswell, NM. His final sentence typifies the entire approach of his study of rainfall variability – 'Our present task has been to present the facts and state the problem' (p.47).

### *Impact*

These papers attracted little immediate attention and very few citations do more than note their existence. Lackey (1935, 1936, 1939), using dispersion diagrams, had promoted the median and percentile distributions to examine spatial variability; he agreed with and extended Crowe's promotion of the median and focus on variability (Lackey, 1937), later using a formula developed by two Indian scientists (Savur, 1937; Mahalingam, nd; Lackey, 1942); Crowe (1948) listed these but did not modify his method.

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<sup>6</sup> Some 40 years later Crowe still perceived the need to make that case. In a generally positive review of a climatology text he wrote that '... it is a little distressing to find that mean monthly rainfall is employed ... It has long been known that average rainfall is something that never happens!' (Crowe, 1975a, 278).

<sup>7</sup> This approach foreshadowed various non-parametric tests of establishing the probability of whether an individual value in one group is significantly different from one in another group, but these – such as the Mann-Whitney test – were only introduced in the late 1940s, after Crowe had finished his rainfall studies.

There was, however, a very important indirect impact. In 1947 Stanley Gregory enrolled for a geography degree at King's College London and took Crowe's inter-collegiate climatology courses, claiming that 'The intricacies and essential characteristics of statistical methods were first introduced ... [to me as a student] by Professor P. R. Crowe' (Gregory, 1963, ix). He joined the University of Liverpool, obtaining a PhD (1958) entitled 'Studies in Pure and Applied Climatology' comprising ten published papers, several using adaptations of Crowe's methods (Johnston, 2018). He taught descriptive statistical methods to climatology students and then, encouraged by colleagues, developed a compulsory course for all geography undergraduates. These were the first such courses on statistical methods taught by a geographer to geographers in the United Kingdom and were the basis of his textbook on the subject – the first by a geographer anywhere (Gregory, 1963).

Through later manifold activities within the Institute of British Geographers, the Geographical Association and the Northern Universities Joint Matriculation Board, Gregory played a major role not only getting quantitative methods adopted for research across much of geography but also widely taught in the country's universities and high schools (Johnston, 2018). He was one of the fathers of UK geography's 'quantitative revolution', and Crowe – referred to as 'one of the very few precocious harbingers of these later developments' (Gregory, 1983, 80) – was the grandfather.

Crowe introduced geographers to methods of studying spatial-temporal variations, deploying the median rather than the mean as the measure of central tendency and using dispersion diagrams and quartiles to identify variations. He was the first geographer to employ statistical significance tests of differences. Those more rigorous methods of 'geographical description' were taken up by only a small number of geographer-climatologists. (Barrett – 1964a, 1966 – for example, built on them for identifying regional patterns in rainfall variations.<sup>8</sup>) They were adopted by a leader of a new generation of climatologists, however,<sup>9</sup> who extended that research programme and, much more importantly, successfully introduced and promoted rigorous data analysis to geographers with a wide variety of specialist persuasions (Gregory, 1976, 1983).

Crowe's introduction of dispersion diagrams did have an impact, however, mainly through their introduction to later editions of a leading text on *Maps and Diagrams*: Monkhouse and Wilkinson (1963, 193) note that they were 'conceived' by Crowe and discuss their construction and use in mapping exercises, but not their use in statistical testing for differences. (Only Crowe's former student – Gregory, who worked at Liverpool with Monkhouse and Wilkinson – illustrated that usage in his pioneering statistics text: Gregory, 1963, 117-121.<sup>10</sup>) They were deployed in a number of descriptive climatologies (e.g. Dury, 1963; Farmer, 1956; Grove, 1956; Johnson, 1975) plus some research papers (e.g. Dury, 1964; Lewis, 1975; Ottaway, 1973) and introduced in a range of textbooks (e.g. Dickinson, 1963; Hammond and McCullagh, 1974; Matthews, 1981; Miller, 1953) – without reference to Crowe.<sup>11</sup> Later introductions for geographers to exploratory data analysis, with its emphasis on using diagrams to identify major features in a data set, noted the similarities

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<sup>8</sup> Eric Barrett – pers. comm. – reported that Crowe was a 'perceptive, thoughtful and kindly' external examiner of his Sheffield MSc on rainfall variations in the Macclesfield-Preston region and subsequently provided helpful comments and criticism on his paper based on that thesis (Barrett, 1964a).

<sup>9</sup> Gregory's near-contemporaries at King's College London at the time included: Tony Chandler, who had taught meteorology to pilots during the war and himself became a distinguished climatologist (cf. Chandler, 1965); Eric Brown, a leading geomorphologist who had audited the climate and meteorology course – taught then by a geologist, J. F. Kirkaldy – in the year before Crowe moved to London; and Clarence Kidson, another leading geomorphologist. (I am grateful to Hugh Clout – pers. comm. – for this information.)

<sup>10</sup> Monkhouse and Wilkinson (1963, 195) do refer to Hogg's (1948) argument that 'discontinuities for the same pair of adjacent months is not always a satisfactory criterion for distinguishing between rainfall zones' but without indicating how Crowe deployed them in that context.

<sup>11</sup> The exception was Farmer (1956, 237) who noted their use in the 1922 *Atlas of American Agriculture* and Crowe's 'pioneer work'. Ottaway refers to Monkhouse and Wilkinson.

between box plots, part of the arsenal of techniques promoted by Tukey (1972, 1977 – Tukey terms them box-and-whisker plots), and ‘the dispersion diagrams once popular in geography, particularly for climatic data’ (Cox and Jones, 1981, 136).

### Later work

Three papers – the equivalent of a short monograph – on the Trade Winds, stimulated by his wartime work at the Meteorological Office (Crowe, 1949, 39),<sup>12</sup> involved the collection, cartographic representation and analysis of large volumes of data (some of it using Hollerith punchcards, probably also pioneering). These had similar goals to the rainfall variability studies (Crowe, 1949, 39):

In so far as it is indeed one of the objects of Geography to achieve ‘earth description’, it would appear necessary at an early stage to establish objective definition of its primary concepts.

Having established a ‘statistical technique’ for mapping the Trades’ extent, with their seasonal migration and pulsation (Crowe, 1950, 25) he turned to the measurement of wind strength: again –

... this paper has as its chief aim the analysis and presentation of fact with as great a degree of objectivity as the nature of the material permits. If the few more speculative passages do not find favour, the facts remain and demand alternative explanation.

The third paper focused on the ‘zone of light and variable winds intermediate between the systems ... and seeks to relate the character and movement of this zone to the annual sequence of equatorial and sub-equatorial weather as it is reflected in long-period rainfall statistics’ (Crowe, 1951, 23). He revisited these data in analysing seasonal variation in monsoon strength in parts of the Arabian Sea and the Bay of Bengal, using diagrams and tables which ‘must be left to speak for themselves’ (Crowe, 1951, 187) and concluding that ‘A better example of the beauty of statistical processes [finding order within noise] given ample records it would be hard to find’ (p.188). Again, citation statistics suggest that these papers had very little impact.<sup>13</sup>

Crowe then turned his attention to climatic classification. Most descriptive climatologists produced climatic classifications resting heavily on qualitative assessments, whereas Thornthwaite’s (1931, 1948) system used more complex, relatively objective, techniques ‘whereby the boundaries between classes could be determined by the data... This is no easy task’ (Crowe, 1954, 44). Thornthwaite failed to appreciate his data’s statistical limitations, Crowe pointing to the variation in mean values across a 36-year record (the issue of the ‘timeless normal’ again), which inevitably introduces a degree of error to any calculations.

A further essay proposed an alternative method which he regretted ‘is not less empirical than Thornthwaite’s nor is it really more streamlined’ (Crowe, 1957, 67) but gave a direct estimate of the concept, was simpler ‘and its flaws and assumptions are thus more self-evident an open to correction’. His criticisms of Thornthwaite were accepted by some (e.g. Chang, 1955, 1959) and the search for a solution extended (e.g. Sibbons, 1962; Mather and Ambroziak, 1989) but got only a passing mention in a later review of the study of evapotranspiration (Ward, 1971; Haggett, 1964, had applied Thornthwaite’s 1931 formula despite Crowe’s warnings, arguing that it had empirical

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<sup>12</sup> In his survey of the roles British geographers played during that conflict Balchin (1987, 174) notes that Crowe ‘gave valuable assistance to the Naval Meteorological Service’.

<sup>13</sup> Eric Barrett, one of the early users of satellite data (Barrett, 1964b) – including a paper on the inter-tropical convergence zone (Barrett, 1970) – reports (pers. comm.) that it was reading Crowe’s ‘clear, classical and fascinating’ first two Trade Wind papers that was ‘very definitely among the most significant events that befell me as a student, triggering thereafter a life-long fascination with things climatological and meteorological. Without those particular stimuli I might well not have advanced in the direction I did’. Crowe (1975b) wrote a favourable review – calling it ‘heroic’ – of Barrett’s (1974) early textbook on *Climatology from Satellites*.

advantages over the meteorological criticisms, and was also most likely to be reliable in mid-latitude temperate zones). Crowe published no further research papers after 1957.<sup>14</sup>

Crowe's IBG presidential address noted that over the preceding three decades whereas geomorphology had 'so elaborated its techniques, sharpened its concepts and acquired so vast a band of devotees, that its independence of its mother-science [geology] is assured' for climatology: Its devoted adherents are few and forward progress ... has not been noteworthy. Indeed it could be said that climatologists have abandoned their cycles before equipping themselves with an attractive band-wagon. ... In our well-intentioned efforts to retain the 'Ge' in geography have we not all been guilty of concentrating too much on the earth's solid and liquid elements at the price of, at least relative, neglect, of its all-embracing gaseous envelope? (Crowe, 1965, 2)

Climatology's four-dimensional field – including time – is not readily accessible, and meteorology, unlike geology, was not a compulsory subsidiary subject for most undergraduate geography students. He was personally attracted to it because of its intrinsic interest, its relative neglect, and 'the scope it gave for statistical measurement' (p.2). Few did more than note the address's existence. Within a decade, the growing interest in climate change stimulated a wealth of interdisciplinary scholarship in which geographers played a substantial role (Thornes and Randalls, 2014). Randalls (2017, 5) reviews this shift, after presenting descriptive climatology – with no reference to Crowe – as:

... a soft, descriptive topic and with limited scientific content, a view that secured (and was reinforced by) its placement within geography, the descriptive science. The location of climatology within geography significantly shaped and potentially tarnished the reputation of climatology due in particular to the propensity of geographers to also focus on cultural aspects in the spirit of Huntingtonian environmental determinism. In other words, meteorology (for physicists) needed to be clearly insulated from what geographers did in climatology.

By implication, Crowe – to some extent correctly – is associated with this rejection of geographical descriptive climatology: but the absence of close scrutiny of his innovations in the presentation and analysis of spatio-temporal data fails to recognise the foundations he laid for statistical analysis in climatology. His overview of his sub-discipline, *Concepts in Climatology* (Crowe, 1971), included a substantial appendix on climatological statistics followed by a section on comparison and correlation 'intended to illustrate a few of the challenges that face the budding climatologist'.<sup>15</sup>

### **Crowe and geography**

Crowe said little on the nature of climatology, and even less on geography – with one substantial exception. The origins of 'On progress in geography' are obscure: according to a footnote 'It is difficult to make full acknowledgements. A debt is owed to all colleagues and friends at Glasgow, London and Chicago who have allowed me to argue with them' (Crowe, 1938, 18).

He wondered whether there is 'less community of aim and aspiration among British geographers than among any equivalent group abroad'. Mackinder had promoted geography as a 'bridge subject' spanning arts and sciences but apparently believed – 'still', Crowe (p.18) refers to a discussion at a 1937 meeting in Glasgow which Mackinder attended – that 'research in its analytical

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<sup>14</sup> He did produce a long essay on the descriptive climatology of the Manchester region in the book provided to delegates to the British Association for the Advancement of Science 1962 annual meetings in Manchester (Crowe, 1962).

<sup>15</sup> The book, promoted as a text, had little apparent impact, reflecting the absence of much student interest in advanced climatology courses, despite some relatively favourable reviews (e.g. Brooks, 1972; Unwin, 1974; Giles, 1981).

sense is scarcely possible in geography' (p.1). For Crowe, 'Knowledge, as distinct from person knowing, comes into existence when for consciousness we substitute measure' (p.2). Measurement in geography can never reach observational science's precision but the more measurements obtained the better. Unfortunately, many geographers were not of this view:

It has been the uncomfortable experience of geography that, as soon as measures have been devised – such as, for example, the geological time scale, erosion estimates, climatic statistics – they have led to the rise of daughter studies which have robbed the patriarch of much of its glory. ... The idea that Man's social reactions are measurable finds every inch of the way contested. This is perhaps the reason why modern geography shows a tendency to retreat upon *things*, to become a morphological analysis of all sorts of objects that nobody has previously thought worthy of study. (p.2; his emphasis)

Many geographers presented their discipline as the science of distributions, seeing these as unique rather than outcomes of general laws. Much of their work involved regionalisation, but 'The ultimate scientific synthesis possible of attainment is the synthesis into principle' (Crowe, 1938, 16). Human geographers should focus on motion rather than static morphology ('[i]t is not adequate to regard man and his works as so many more landscape features to be classed with slopes and rivers and trees' and mapping population distributions is 'largely a statistical abstraction'; 'regional organisation must result from a system of human circulations' – p.11). Their principles would have to 'take the form of statements of tendencies similar to those of the social sciences' – but geographers had identified few, which were trite. His paper would succeed if it had:

... drawn attention to the widespread tendency of modern geography to crystallise itself upon the distribution of inanimate objects and the morphology of static patterns. This behaviour is cryptozoic, it is fleeing from the glare of human truths. Observation is a fundamental part of the study, but we must be in quest of essentials. ... Geographical momentum is not a conception to be introduced when ordinary geographical intuition fails; it is continuously in operation throughout the whole field and must be constantly reviewed and assessed. In some aspects, it is freely admitted, this will bring geographical work into close contact with the field of sociology; but emphasis will always be on the space-dimension rather than upon systems of human relationships. How else can we construct a science of Man in Nature, unless its roots are set deep in the physical world while its head is ultimately lost among the vapours of sociological speculation? (Crowe, 1938, pp.16-17)

Dickinson's (1939) response defended the centrality of the landscape concept to much contemporary geography. Daryll Forde (1939) set the debate within a wider context provided by other disciplines, especially history and sociology. Geographical research comprises two fields: 'the historical explanation of natural features observed on the surface of the earth and the formulation of scientific laws of which the particular relations of such features are special cases' (p.230); and 'historical explanation of certain classes of human activity and the formulation of sociological laws applicable to them'. Human geography analyses the spatial forms resulting from social processes interacting with the physical environment and every study of human activities 'should include a consideration of physical conditions, space relations, and regional divisions'.

If Google Scholar citations are a valid measure of impact, Crowe's essay attracted much more attention than his research papers: 78 are recorded.<sup>16</sup> Some merely noted his general argument (as in Fisher, 1970; Lewis, 1970; Rimmer, 1978); others (such as Finch, 1939) debated with it. Hartshorne's (1939) *The Nature of Geography*, gave it considerable coverage but it was not recognised in a British volume that essayed a similar task (Wooldridge and East, 1951). Hartshorne largely supported Crowe against Dickinson; Ullman (1954) favourably noted his suggested emphasis on things moving; and Haggett (1965, 31) cited him in justifying placing movement before morphology in the creation of regional spatial structures. For Emrys Jones (1956), Crowe's statement

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<sup>16</sup> Google Scholar, 3 January 2019.



that generalizations in human geography should take the form of tendencies similar to those of the social sciences was a harbinger of his own claim that ‘however broad the generalization, it might fail in strict application to any single phenomenon. Any pattern which emerges does so as the statistical mean of the behavior of a mass of human individuals, and any generalization which the human geographer might find useful must be based on this behavior’ (Jones, 1956, 373). Jones and Crowe were before their time, however. Human geographers who launched their quantitative and theoretical revolutions in the 1950s-1960s believed they could identify laws in the same way that physicists do (or they thought physicists did!); only after the first phase of that revolution had run its course did human geographers adopt the position Crowe and Jones adumbrated (Johnston et al., 2018) – though they have never stated it as clearly as Goldthorpe (2016) has for sociology.<sup>17</sup>

Crowe’s opinions about those contemporary developments appeared in reviews of two path-breaking books. *Models in Geography* provided evidence of ‘colossal activity’ but he could identify no clear purpose or audience, concluding that the authors were writing for each other, occasionally in ‘barbarous and repulsive jargon’ (Crowe, 1968, 424): ‘a new faith is hardly likely to be attained by a frenzied search throughout the realms of physical and social science for gadgets which might conceivably be turned to geographical ends. The nature of those ends still calls for solid thought, a task which cannot be delegated to computers’. ‘[T]hese young workers do indeed share a common faith though they do not openly declare it. It is an apparently unbounded confidence in the efficacy of “regression” and related statistical procedures. The intellectual load now being placed upon this little bit of mathematical sleight-of-hand might well have appalled its inventor’ (Crowe, 1968, 424).<sup>18</sup> For someone whose scientific publications pressed for rigour in measurement and description this criticism seems odd! The second review was of *Progress in Geography Volume 1* (Crowe, 1970) in which Gould’s essay on methodological developments ‘follows a bleak pattern already much too familiar. It is an exercise in non-communication in the very real sense that, if you can follow him, there is little point in doing so and, if you cannot, you are none the wiser’.

## Conclusions

Crowe ended that second review with ‘Perhaps this geographer has led too sheltered a life!’. Geographers were certainly sheltered from him. He was a pioneer in the graphical and statistical study of frequency distributions, introducing significance testing; he provided a clear definition of a major climatic belt; and he essayed a more precise formula for identifying climatic regions. All was set within an approach – earth description through regionalisation – rejected by subsequent generations of geographers, let alone just climatologists, for whom he provided no research agenda. And yet in one essay he clearly foreshadowed not only a major shift in the focus of human geography – from the morphology of things and static regions to the dynamism of changing spatial structures – but also in its philosophical protocols. For the last two decades of his career – at the end of the period in which most British university geography departments had a single professor who carried permanent, increasingly heavy, administrative responsibilities – he was publicly almost entirely silent (Anon, 1981). In other circumstances, he may have made considerable contributions to a rapidly-changing and -expanding discipline, which faced a richness rather than a paucity of data and an increasingly powerful set of tools for their analysis and display. The context and infrastructure for climatological research changed markedly towards the end of Crowe’s career; he and a few others dug the foundations for some of that work but, as with so many foundations, they have disappeared from sight under later edifices. He did not build a graduate school but ensured a continued solid presence for climatology at Manchester, with two lecturers – Leslie Musk and David

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<sup>17</sup> Crowe was also well ahead of his time in his rejection of means: see Rose (2016).

<sup>18</sup> Unwin (1989) used quotations from that review as epigrams introducing the major sections of his critical appraisal of modelling in physical geography.

Tout – appointed during his last two years in post,<sup>19</sup> and in 1973 another distinguished climatologist – Tony Chandler – was appointed to a chair in the department (Clout and Atkinson, 2009).

The careers of many twentieth century geographers are now largely forgotten and their publications rarely cited; their immediate impact has long ago dissipated and few identify their indirect impact, substantial though it may have been – perhaps still is. This fate may have befallen climatologists more than other geographers because of their minority status so it is instructive, as Rohli and Bierly (2011) assert, to revisit their work occasionally, elaborating on their contributions and examining why they are no longer as celebrated as perhaps they could/should be. Percy Crowe – described by his obituarists (Musk and Rodgers, 1980, 388) as a rugged, perhaps even stubborn, individualist who ‘never minded forming a minority of one’ and who ‘had too much moral courage to ignore his own judgement and hide behind the consensus view’ – is certainly one of ‘the forgotten’, in part because, unlike Gregory, he didn’t proselytise the case for statistical methods, though, as his obituarist claims, he was a stimulating and admired teacher (Anon., 1981).<sup>20</sup>

Indeed, one could argue that he was hardly ever remembered. He is not mentioned in Pacione’s (2014) historiography of Scottish geography;<sup>21</sup> Atkinson’s (1980) review of British writing on climate in a volume celebrating the Royal Geographical Society’s 150<sup>th</sup> anniversary mentioned his presidential address in passing and referred to his 1971 book as a ‘reflective piece’ (p.119) but cited none of his research papers; and his Manchester colleague Freeman’s (1961, 1980) histories of British geography entirely ignored him. In a volume on British geography between the two world wars, Freeman (1987, 18) devotes a paragraph to the Crowe-Dickinson debate but ignores Crowe’s climatology and Steers’ (1987, 139) chapter on physical geography merely notes that at Glasgow ‘P. R. Crowe introduced some climatology and elementary meteorology’ (p.143). His research papers get no mention, nor do they in any editions of most popular immediately post-war climatology texts (e.g. Hare, 1961; Miller, 1961): Stringer’s (1972) chapter on ‘Interpreting the observations’ in *Techniques of Climatology* similarly ignores Crowe’s pioneering work – as did an earlier methodological handbook (Brooks and Carruthers, 1953). Many refer only to his 1971 book as a detailed discussion of certain themes (e.g. Barry and Chorley, 2003; Lockwood, 1974: his obituarist, however, claims it ‘will remain a classic’ – Anon., 1981, 138). Further, in the multi-volume *World Study of Climatology*, Crowe gets no citations in the volume on statistical analysis (Essenwanger, 1986) and just one reference to his North American analyses (Bryson and Hare, 1974); the sole citation of his UK work is to his essay (Crowe, 1962) on the Manchester region’s climate (Wallén, 1970). Perhaps even more surprisingly, there are no references to his three Trade Wind papers in the volume on ‘Climates of the Oceans’ (van Loon, 1984). The first two of those papers are mentioned in Beckinsale’s (1965) review of recent trends in climatology and are briefly cited in Barry’s (1967) review of models in climatology and meteorology, where his presidential address gets a passing citation because of his mention of Hadley’s pioneering work.

Few followed Crowe’s example in the statistical analysis of rainfall variability but one did, and he was central to later developments in British geography. Stan Gregory not only adopted and adapted his methods but also, and very significantly, stimulated the teaching of rigorous statistical

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<sup>19</sup> Musk published widely within climatology, specialising on applied studies – such as fog hazards – on which he published five surveys for *Progress in Physical Geography* between 1983 and 1988 (e.g. Musk, 1988: see Rodgers, 1990). Tout specialised on biometeorology (e.g. Tout, 1980).

<sup>20</sup> In her history of the geography department at Queen Mary College, Sheppard (1994, 14-16) records that Crowe was ‘remembered with affection by students ... not least for his somewhat irreverent approach to authority’.

<sup>21</sup> Michael Pacione (pers. comm.) told me that Crowe was ‘less well known north of the border’; he ‘did not leave a significant mark on Scottish geography, nor make a major contribution to the development of the discipline here’.

description through a pioneering textbook and promoted it throughout British universities and high schools (Johnston, 2018). As Unwin (1977, 186; 1999, 2) has recorded, those who think that ‘UK quantitative geography ... was all to do with Haggett and Chorley on a supposed “Cambridge (Chorley) to Bristol (Haggett) axis” should note that there was also another axis from Manchester to London with two unsung and largely forgotten influences from climatologists Crowe and Gregory’. The counterfactual – without Crowe and Gregory how might British geography have developed in the 1950s-1960s? – is unanswerable, but there can be no doubt of their importance. Reading and re-assessing their works reminds us of that inheritance and, as so many essays into disciplinary past do, shows that many seemingly novel arguments were foreshadowed by earlier authors whose work has sadly since been ignored (on which see also Johnston and Jones, 2019).

## References

- Andrews, J. (1932) Rainfall reliability in Australia’, *Proceedings of the Linnean Society of New South Wales*, 57 (1): 95-100.
- Anon. (1981) Obituary: Percy Robert Crowe (1904-1980). *The Geographical Journal*, 147 (1): 138-139.
- Atkinson, B. W. (1980) Climate. In E. H. Brown (ed.) *Geography: Yesterday and Tomorrow*. Oxford: Oxford University Press, 114-129.
- Balchin, W. G. V. (1985) United Kingdom geographers in the Second World War. *The Geographical Journal*, 153 (2): 159-180.
- Barrett, E. C. (1964a) Local variation in rainfall trends in the Manchester region. *Transactions of the Institute of British Geographers*, 35, 55-71.
- Barrett, E. C. (1964b) Satellite meteorology and the geographer. *Geography*, 49 (4): 377-386.
- Barrett, E. C. (1966) Regional variations of rainfall trends in northern England, 1900-1959. *Transactions of the Institute of British Geographers*, 38, 41-58.
- Barrett, E. C. (1970) A contribution to the dynamic climatology of the equatorial eastern Pacific and central America based on meteorological satellite data. *Transactions of the Institute of British Geographers*, 50, 25-53.
- Barrett, E. C. (1974) *Climatology from Satellites*. London: Methuen.
- Barry, R. J. (1967) Models in meteorology and climatology. In R. J. Chorley and P. Haggett (eds.) *Models in Geography*. London: Methuen, 97-144.
- Barry, R. J. and Chorley, R. J. (2003) *Atmosphere, Weather and Climate (8<sup>th</sup> edition)*. London: Routledge.
- Beckinsale, R. P. (1965) Some recent trends in climatology. In R. J. Chorley and P. Haggett (eds.) *Frontiers in Geographical Teaching*. London: Methuen, 39-60.
- Bowley, A. L. (1920) *Elements of Statistics (4<sup>th</sup> edition)*. London: P. S. King and Son.
- Bowley, A. L. (1910) *An Elementary Manual of Statistics*. London: McDonald and Evans.
- Brooks, C. E. P. and Carruthers, N. (1953) *Handbook of Statistical Methods in Meteorology*. London: HMSO.
- Brooks, E. M. (1972) Review of *Concepts in Climatology*. *Monthly Weather Review*, 53, 890.
- Bryson, R. A. and Hare, F. K. (eds.) (1974) *World Survey of Climatology. Volume 11 Climates of North America*. Amsterdam: Elsevier.

- Chandler, T. J. (1965) *The Climate of London*. London: Hutchinson.
- Chang, J.-H. (1955) The climate of China according to the new Thornthwaite classification. *Annals of the Association of American Geographers*, 45 (3): 393-403.
- Chang, J.-H. (1959) An evaluation of the 1948 Thornthwaite classification. *Annals of the Association of American Geographers*, 49 (1): 24-30.
- Clark, K. G. T. (1932) The vicissitudes of the summer rainfall of the Indo-Gangetic Plain and the Assam Valley. *Geography*, 17 (4): 286-292.
- Clout, H. D. and Atkinson, B. W. (2009) Professor T J Chandler 1928-2008. *The Geographical Journal*, 175 (1): 82-83.
- Cox, N. J. (2009) Speaking Stata: creating and varying box plots. *The Stata Journal*, 9, 478-496.
- Cox, N. J. and Jones, K. (1981) Exploratory data analysis. In N. Wrigley and R. J. Bennett (eds.) *Quantitative Geography: a British View*. London: Routledge & Kegan Paul, 135-143.
- Crowe, P. R. (1927) The population of the Scottish lowlands, *Scottish Geographical Magazine* 43 (2):, 147–167.
- Crowe, P. R. (1929) The Scottish coalfields. *Scottish Geographical Magazine*, 45 (4): 321-337.
- Crowe, P. R. (1933) The analysis of rainfall probability: a graphical method and its application to European data, *Scottish Geographical Magazine*, 49 (1): 73–91.
- Crowe, P. R. (1936a) The rainfall regime of the western plains, *The Geographical Review*, 26 (4): 463–484.
- Crowe, P. R. (1936b) A new view of some familiar Indian rainfalls. *Scottish Geographical Magazine*, 52 (2): 187-188.
- Crowe, P. R. (1938) On progress in geography, *Scottish Geographical Magazine*, 54 (1): 1–19.
- Crowe, P. R. (1939) Note. *Scottish Geographical Magazine*, 55 (1):, 14–15.
- Crowe, P. R. (1940) A new approach to the study of the seasonal incidence of British rainfall, *Quarterly Journal of the Royal Meteorological Society*, 66 (3): 285–316.
- Crowe, P. R. (1941) The dual rainfall regime of Roswell, New Mexico. *Monthly Weather Review*, 79 (1): 40-47.
- Crowe, P. R. (1949) The trade wind circulation of the world. *Transactions and Papers of the Institute of British Geographers*, 15, 39-56.
- Crowe, P. R. (1950) The seasonal variation in the strength of the trades. *Transactions and Papers of the Institute of British Geographers*, 16, 25-47.
- Crowe, P. R. (1951a) Wind and weather in the equatorial zone, *Transactions and Papers of the Institute of British Geographers*, 17, 23–76.
- Crowe, P. R. (1951b) Rainfall regime in the south-eastern United States, in L. D. Stamp and S. W. Wooldridge (eds.) *London Essays in Geography: Rodwell Jones Memorial Volume*. London: Longmans Green, 71–90.

- Crowe, P. R. (1951c) The seasonal variation in the strength of the monsoons. In G. Kuriyan (ed.) *Indian Geographical Society Silver Jubilee Souvenir and N. Subrahmanyam Memorial Volume*. Madras: University of Madras, 181-188.
- Crowe, P. R. (1954) The effectiveness of precipitation: a graphical analysis of Thornthwaite's climatic classification, *Geographical Studies*, 1 (1): 44-62.
- Crowe, P. R. (1957) Some further thoughts on evapotranspiration: a new estimate, *Geographical Studies*, 4 (1): 56-76.
- Crowe, P. R. (1962) Climate. In C. F. Carter (ed.) *Manchester and its Region*. Manchester: Manchester University Press, 17-46.
- Crowe, P. R. (1965) The geographer and the atmosphere, *Transactions, Institute of British Geographers*, 36, 1-19.
- Crowe, P. R. (1968) Review of *Models in Geography: the Second Madingley Lectures*, *Geography*, 53 (4): 423-424.
- Crowe, P. R. (1970) Review of *Progress in Geography: International Reviews of Current Research, Volume 1*, *Geography*, 55 (4): 346-347.
- Crowe, P. R. (1971) *Concepts in Climatology*. London: Longman.
- Crowe, P. R. (1975a) Review of Lockwood, *World Climatology*. *The Geographical Journal*, 141 (3): 278.
- Crowe, P. R. (1975b) Review of Barrett, *Climatology from Satellites*, *The Geographical Journal*, 141 (3): 279.
- Dickinson, G. C. (1963) *Statistical Mapping and the Presentation of Statistics*. London: Edward Arnold.
- Dickinson, R. E. (1939) Landscape and society. *Scottish Geographical Magazine*, 55 (1): 1-14.
- Dury, G. H. (1963) *The East Midlands and the Peak*. London: Thomas Nelson.
- Dury, G. H. (1964) Some results of a magnitude-frequency analysis of precipitation. *Australian Geographical Studies*, 2 (1): 21-34.
- Essenwanger, O. M. (1986). *World Survey of Climatology. Volume 1B Elements of Statistical Methodology* Amsterdam: Elsevier.
- Farmer, B. H. (1956) Rainfall and water supply in the dry zone of Ceylon. In R. W. Steel and C. A. Fisher (eds.) *Geographical Essays on British Tropical Lands*. London: George Philip & Son, 225-264.
- Finch, V. C. (1939) Geographical science and philosophy. *Annals of the Association of American Geographers*, 29 (1): 1-28.
- Fisher, C. A. (1970) Whither regional geography. *Geography*, 55 (4): 373-389.

- Forde, C. Daryll (1939) Human geography, history and sociology. *Scottish Geographical Magazine*, 55 (3): 217-235.
- Freeman, T. W. (1961) *A Hundred Years of Geography*. London: George Duckworth.
- Freeman, T. W. (1980) *A History of Modern British Geography*. London: Longman.
- Freeman, T. W. (1987) Geography during the inter-war years. In R. W. Steel (ed.) *British Geography 1918-1945*. Cambridge: Cambridge University Press, 9-24.
- Giles, B. D. (1981) Meteorology +/- climatology: climatology +/- meteorology textbooks for teaching climatology to geographers. *Journal of Geography in Higher Education*, 5 (1): 86-94.
- Goldthorpe, J. H. (2016) *Sociology as a Population Science*. Cambridge: Cambridge University Press.
- Gregory, S. (1963) *Statistical Methods and the Geographer*. London: Longmans.
- Gregory, S. (1976) On geographical myths and statistical fables. *Transactions of the Institute of British Geographers*, NS1 (4): 385-400.
- Gregory, S. (1983) Quantitative geography: the British experience and the role of the Institute. *Transactions of the Institute of British Geographers*, NS8 (1): 80-89.
- Grove, A. T. (1956) Soil erosion in Nigeria. In R. W. Steel and C. A. Fisher (eds.) *Geographical Essays on British Tropical Lands*. London: George Philip & Son, 77-112.
- Haggett, P. (1964) Towards a statistical definition of ecological range: the case of *Quercus suber*. *Ecology*, 45 (4): 622-625.
- Haggett, P. (1965) *Locational Analysis in Human Geography*. London: Edward Arnold.
- Hammond, R. and McCullagh, P. S. (1974) *Quantitative Techniques in Geography: an Introduction*. Oxford: Oxford University Press.
- Hare, F. K. (1961) *The Restless Atmosphere*. London: Hutchinson.
- Hare, F. K. and Sewell, W. R. D. (1986) Awareness of climate, in R. W. Kates and I. Burton (eds.), *Geography, Resources and Environment. Volume II. Themes from the Work of Gilbert F. White*. Chicago: University of Chicago Press, 207-239.
- Harter, L. H. (1974) The method of least squares and some alternatives: part II. *International Statistical Review*, 42 (2): 235-264.
- Hartshorne, R. (1939) *The Nature of Geography*. Lancaster, PA: Association of American Geographers.
- Hogg, W. H. (1940) A note on the rainfall régimes of the western United States. *Quarterly Journal of the Royal Meteorological Society*, 67 (4): 439-441.
- Hogg, W. H. (1948) Rainfall dispersion diagrams: a discussion of their advantages and disadvantages. *Geography*, 33 (1):, 31-37.

- Johnston, R. J. (2018) Stanley Gregory 1926-2016. In E. Baigent and A. Reyes Novaes (eds.) *Geographers: Biobibliographical Studies Volume 37*. London: Bloomsbury, 69-104.
- Johnston, R. J. and Jones, K. (2019) A classic that wasn't: *Statistical Geography* and paths only later taken. *Progress in Human Geography*,
- Jones, E. (1956) Cause and effect in human geography. *Annals of the Association of American Geographers*, 46 (4): 369-377.
- Kates, R. W. and Burton, I. (1986) Introduction, In R. W. Kates and I. Burton (eds.) *Geography, Resources and Environment. Volume II. Themes from the Work of Gilbert F. White*. Chicago: University of Chicago Press, ix-xvi
- Lackey, E. E. (1935) Annual variability maps for Nebraska. *Monthly Weather Review*, 63 (1): 79-85.
- Lackey, E. E. (1936) A variability series of isocrymal maps of Nebraska. *The Geographical Review*, 26 (1): 135-138.
- Lackey, E. E. (1937) Annual-variability rainfall maps of the Great Plains. *The Geographical Review*, 27 (4): 665-670.
- Lackey, E. E. (1942) The reliability of the median as a measure of rainfall. *The Geographical Review*, 32 (3): 323-325.
- Lewis, C. R. (1975) The analysis of changes in urban status: a case study in Mid-Wales and the Middle Welsh Borderland. *Transactions of the Institute of British Geographers*, 64, 49-65.
- Lewis, P. W. (1970) Measuring spatial interaction. *Geografiska Annaler, B: Human Geography*, 52 (1):, 22-39.
- Lockwood, J. G. (1974) *World Climatology: an Environmental Approach*. London: Edward Arnold.
- Mahalingam, L. S. (nd) An analysis of Indian rainfalls using the median as a statistic. *Scientific Notes of the Indian Meteorological Department*, 8.82.
- Mather, J. R. and Ambroziak, R. A. (1986) A search for understanding potential evapotranspiration. *The Geographical Review*, 76 (3): 355-370.
- Matthews, H. A. (1936) A new view of some familiar Indian rainfalls. *Scottish Geographical Magazine*, 52 (1): 84-97.
- Matthews, J. A. (1981) *Quantitative and Statistical Approaches to Geography: a Practical Manual*. Oxford: Pergamon.
- Miller, A. A. (1953) *The Skin of the Earth*. London: Methuen.
- Miller, A. A. (1961) *Climatology*. London: Methuen.
- Monkhouse, F. J. and Wilkinson, H. R. (1971) *Maps and Diagrams: their Compilation and Construction (third edition)*. London: Methuen.

- Musk, L. and Rodgers, H. B. (1980) Percy Robert Crowe, 1984-1980. *Transactions of the Institute of British Geographers*, NS5 (3): 388-389.
- Musk, L. F. (1988) Applied climatology. *Progress in Physical Geography*, 12 (4): 421-434.
- Newbigin, M. I. (1928) The geographer and the study of climate. *Geography*, 14 (4): 417-427.
- Ottaway, B. (1973) Dispersion diagrams: a new approach to the display of carbon-14 dates. *Archaeometry*, 15 (1): 5-12.
- Pacione, M. (2014) *Scottish Geography; a Historiography*. Glasgow: Royal Scottish Geographical Society.
- Randalls, S. (2017) Contributions and perspectives from geography to the study of climate. *Wiley Interdisciplinary Reviews: Climate Change*, doi 10.1002/wcc.466
- Rimmer, P. J. (1978) Redirections in transport geography. *Progress in Human Geography*, 10 (1): 76-100.
- Rodgers, H. B. (1990) Leslie F. Musk, 1948-1989. *Transactions of the Institute of British Geographers*, NS15 (3): 374-375.
- Rohli, R. V. and Bierly, G. D. (2011) The lost legacy of Robert DeCourcy Ward in American geographical climatology. *Progress in Physical Geography*, 35 (4): 547-564.
- Rose, T. (2016) *The End of Average. How to Succeed in a World that Values Sameness*. London: Penguin Random House.
- Savur, S. R. (1937) The use of the median in tests of significance. *Proceedings of the Indian Academy of Sciences, A*, 5 (4): 564-576.
- Sheppard, J. A. (1994) *A Century of Geography: a History of the Geography Department of East London College (to 1935), Queen Mary College (1935-1989), Queen Mary and Westfield College (1989-)*. London: Department of Geography, Queen Mary and Westfield College.
- Sibbons, J. L. H. (1962) A contribution to the study of potential evapotranspiration. *Geografiska Annaler*, 44 (3): 279-292.
- Smith, M. W., Cox, N. J. and Bracken, L. J. (2011) Modeling depth distributions of overland flows. *Geomorphology*, 125, 402-413.
- Steers, J. A. (1987) Physical geography in the universities, 1918-1945. In R. W. Steel (ed.) *British Geography 1918-1945*. Cambridge: Cambridge University Press, 138-155.
- Stringer, E. T. (1972) *Techniques of Climatology*. San Francisco: W. H. Freeman.
- Taylor, T. G. (1920) *Australian Meteorology*. Oxford: The Clarendon Press.
- Thornes, J. E. and Randalls, S. (2014) Applied meteorology and climatology. *Progress in Physical Geography*, 38 (4): 389-391.



- Thorntwaite, C. W. (1931) The climates of North America. *The Geographical Review*, 21 (4): 633-655.
- Thorntwaite, C. W. (1948) An approach towards a rational classification of climate. *The Geographical Review*, 38 (1): 55-94.
- Tukey, J. R. (1970) *Exploratory Data Analysis*. Reading, MA: Addison-Wesley.
- Ullman, E. L. (1954) Transportation geography. In P. E. James and C. F. Jones (eds.) *American Geography: Inventory and Prospect*. Syracuse: Syracuse University Press, 310-333.
- Steel, R. W. and Watson, J. E. (1972) Geography in the United Kingdom, 1968-1972. *The Geographical Journal*, 138 (2): 139-153.
- Tout, D. G. (1980) The discomfort index, mortality and the London summers of 1976 and 1978. *International Journal of Biometeorology*, 24 (4): 323-328.
- Unwin, D. J. (1974) Review of *Concepts in Climatology*. *Geography*, 59 (1): 83.
- Unwin, D. J. (1977) Statistical methods in physical geography. *Progress in Physical Geography*, 1 (2): 185-221.
- Unwin, D. J. (1989) Three questions about modelling in physical geography. In B. Macmillan (ed.) *Remodelling Geography* (Oxford: Basil Blackwell), 53-60.
- Unwin, D. J. (1999) Euroquant at 21: "coming of age". *Cybergeo; European Journal of Geography*, 114 - <https://journals.openedition.org/cybergeo/563>
- Van Loon, H. (ed.) (1984) *World Survey of Climatology: Volume 15 Climates of the Oceans*. Amsterdam: Elsevier.
- Wallén, C. C. (ed.) (1970) *World Survey of Climatology: Volume 5 Climates of Northern and Western Europe*. Amsterdam: Elsevier.
- Ward, R. C. (1971) Measuring evapotranspiration: a review. *Journal of Hydrology*, 13 (1): 1-21.
- Williamson, A. V. and Clark, K. G. T. (1931a) The variability of the annual rainfall of India. *Quarterly Journal of the Royal Meteorological Society*, 57 (1): 43-56.
- Williamson, A. V. and Clark, K. G. T. (1931b) The rainfall regions of India. *Geography*, 16 (2): 98-108.
- Wooldridge, S. W. and East, W. G. (1951) *The Spirit and Purpose of Geography*. London: Hutchinson.