Earth Surface Processes and Landforms
Earth Surf. Process. Landforms **27**, 667–672 (2002)
Published online in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/esp.345

SHORT COMMUNICATION

ANALYSIS OF GEOMORPHOLOGY CITATIONS IN THE LAST QUARTER OF THE 20TH CENTURY

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Received 16 August 2001; Accepted 15 November 2001

ABSTRACT

Three hundred and twenty-eight geomorphology articles published in the last quarter of the 20th century were cited 20 or more times in Institute for Scientific Information (ISI) indices, as of 15 May 2001. At the close of the 20th century, well-cited geomorphology is highly multidisciplinary and interdisciplinary with the most dominant fields being in biological, civil engineering, earth science, geography, geological, and soils disciplines. The very strong English-language bias of well-cited journal articles creates a geographical bias in study site selection, which may in turn bias geomorphic theory. Water-based research (fluvial processes and landforms, riparian, drainage basin) dominates well-cited papers, with the 'hottest' subfield in the 1990s being riparian research with a biological emphasis. Over 90 journals publish well-cited papers, but *Earth Surface Processes and Landforms* hosts the largest number of well-cited papers. Copyright © 2002 John Wiley & Sons, Ltd.

KEY WORDS: geomorphology; landform; earth surface processes; citation; bibliometric; temporal; time; trends

Garfield first proposed a citation index for analysing scientific literature (Garfield, 1955), leading to the creation of the Institute for Scientific Information (ISI). Bibliometric analyses, filtered through the ISI database, play important roles in faculty (Person, 2001; Reed, 1995), programmatic (Frohlich and Resler, 2001; Redman *et al*., 2001), and journal (Schwartz and Ibaraki, 2001) reviews. The question asked here is whether a bibliometric analysis of geomorphic literature complied by ISI might yield insights into trends not readily discerned by subjective expert reviews of the sort typically found in textbooks, review journals, and edited books.

I used ISI to compile a database of 328 articles published between 1975 and 2000 that were cited 20 or more times as of 15 May 2001 in the combined indices of Science Citation, Social Science Citation, and Arts and Humanities. All documents and all languages were searched for the following keywords: earth surface processes, geomorphic, geomorphological, geomorphology, landform, landforms, and their equivalent terms in non-English languages in the indices.

For each paper I tracked: affiliation of first, second and third author; year of publication; title; journal; whether a scientific society or private industry sponsors the journal; subfield of geomorphology; and primary location(s) of study. I purposefully exclude names of authors from this analysis, since this paper analyses trends in geomorphologic research and not peer approbation.

Bibliometric indicators of peer esteem and journal influence remain controversial. For example, two major metrics appeared to yield contradictory results in the UK: 'Urquhart's law' of interlibrary use of a journal being measure of its total use; and Garfield's 'law of concentration' whereby the information needs in science are satisfied by a few core journals. While these two indices may be reconcilable (Bensman, 2001), debate

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continues with such concerns as the validity of journal-based bibliometric analyses in light of the gradual migration of scientific communication to the Internet (Cronin, 2001). Table I presents concerns over analyses undertaken here, with a few of these limitations elaborated as follows.

Academic geomorphologists rightly emphasize the importance of books and monographs in creating capstone views, but keyword searching does not capture these projects. A book's impact certainly becomes evident in citation analyses of particular authors. For example, *Chemical Sediments and Geomorphology* (Goudie and Pye, 1983), *Desert Geomorphology* (Cooke *et al*., 1993), and *Hillslope Hydrology* (Kirkby, 1978) are cited more than 100 times in ISI indexed journals. However, author-by-author analyses of geomorphic books and monographs is a completely different project from an analysis of journal citations.

Another substantive limitation rests in the selection of searching terms. Many important and well-cited geomorphic papers did not contain the search terms in the title, keywords, extended keywords or abstract. Consider, for example, that aeolian, climate geomorphology, economic geology, forestry, general geomorphology, lacustrine/marine, volcanic, and weathering subfields had six or fewer papers cited 20 or more times in the last quarter century, using the above search parameters. However, a great many untabulated geomorphic papers exceed the 20-citation threshold. For example, only four weathering papers emerged in this analysis; yet ISI tabulates 135 papers with 'weathering AND rock' and 'weathering AND mineral' as cited 20 or more times. Thus, if researchers consider their papers to be within the field of geomorphology, they should be careful to include 'geomorphology' in the title or as a keyword. This paper, however, does not open Pandora's Box by creating metrics for every term in geomorphology.

Table I. Limitations of this citation analysis of the geomorphic literature

Limitation	Anticipated impact on conclusions
Clustering of scientists	Institutes, centres, observatories and other clusters appear to create a disproportionate influence on citation indices (Salzarulo and von-Ins, 2001).
Institutional access	Identical searching parameters at different institutions on the same day yielded slightly different findings, suggesting a small bias imposed by different types of subscriptions.
Journals indexed by ISI are limited	Costs involved in ISI indexing result in biases on analyses of an individual paper's record (Reed, 1995).
Poor representation of non-English international literature	This 'drag effect' is greatest in non-medical fields (Grupp *et al*., 2001; Jimenez-Contreras and Ferreiro-Alaez, 1996).
Paper quality	Whereas the author of a literature review has the vital task of spotlighting both well-cited and little-cited works, computer-aided analysis does not address quality.
Publications not complied by ISI	Books, monographs, and papers in edited volumes are not directly computed by ISI citation algorithms; however, this information can be extracted from ISI in bibliometrics of individual scientists.
Search terms	Bias exists by excluding or including selected terms.
Self-citation	I did not eliminate self-citation, which is an excellent rhetorical strategy for emphasizing an author's contribution (Hyland, 2001) and for impacting indices (White, 2001).
Subfields and cognate fields	Not all geomorphologists use the searched terms in their title, keywords, or abstract.
Threshold of 20 citations	Extraordinarily prolific scientists can have great abundance of articles which may get cited, but their personal citation power is distributed in a way that their individual articles fall below the 20-paper threshold.
Timing of publication	A 'hump' in total citations for papers in the early 1990s probably represents enough time to reach the 20-paper threshold and an acceleration in the number of journals indexed by ISI.

Non-English papers provide vital geomorphic insights. However, the known English-language bias in ISI (Grupp *et al*., 2001; Jimenez-Contreras and Ferreiro-Alaez, 1996) emerges in this compilation through an examination of university affiliations of first authors. Universities hosting five or more well-cited papers all use English as the primary language: University of Washington (nine papers); Australian National University (seven); State University of New York, Buffalo (seven); University of New Mexico (seven); Arizona State University (six); University of Saskatchewan (six); University of Wollongong (six); University of California, Berkeley (six); University of California, Los Angeles (six); University of Arizona (five); Cambridge (five); and University of Edinburgh (five).

A potentially dangerous spin derives from the English-language bias in ISI. Are we creating bias in geomorphic theory by emphasizing studies of field sites in English-dominated countries? The most cited geomorphic research takes place in the USA (109 total papers focused on USA field sites: 78 western states; 24 eastern states; seven both), Australia (21), Canada (18), and UK (17). Only 1·5 per cent of papers cited more than 20 times focused on Africa, with only a single paper from a non-English speaking country. With well-cited papers representing such a small proportion of global geography, geomorphic theory building may suffer from geographic bias.

In comparison to a language bias, well-cited geomorphic papers do not appear to be biased by perspectives of any one dominant discipline. Considering only the department (or institute/centre) affiliation of the first author in universities, well-cited papers derive from the following fields: biological disciplines (33 papers); civil engineering (11), earth science (21), geography and physical geography (91), geology/geophysics/geological sciences/sedimentology (49), geosciences (eight), and soils (eight). Other represented academic fields include: astronomy, chemistry, environmental science, other multidisciplinary centres and institutes, landscape architecture, nuclear sciences, and oceanography. Thirty-two out of 137, or 23 per cent, of the well-cited papers were interdisciplinary in that co-authors showed affiliation with departments/suborganizations representing different disciplines.

A list of the 'top ten' cited geomorphic papers further illustrates the multidisciplinary nature of well-cited geomorphic research, as tabulated by first author department affiliation: 220 citations from Zoology (Hoolings, 1992); 219 citations from Oceanographic Institute (Milliman and Syvitski, 1992); 145 citations from Earth Science (Jackson *et al*., 1982); 145 citations from Environmental Studies (Moore *et al*., 1991); 141 citations from Biogeography and Geomorphology (Bowler, 1976); 131 citations from Geography and Environmental Engineering (Wolman and Gerson, 1978); 113 citations from Geochemistry Institute (Barsukov *et al*., 1986); 113 citations from Geoscience (Baker *et al*., 1991); 110 citations from Center for Streamside Studies (Naiman *et al*., 1993); and 95 citations from Geography (Mark and Aronson, 1984).

A surprising comparison rests in the meagre difference between well-cited papers derived from government and those from private industry. With little incentive to publish in academic journals, private industry generated four well-cited papers. Government agencies with a primary task of publishing findings generated only 27: Canadian Geological Survey (two papers); NASA (two); USA state geological surveys (three); Topographic Survey of Nepal (one); and US Geological Survey (19). A bibliometric index of dollar investment per well-cited paper may very well have political funding implications.

What journal sponsors the most cited geomorphic papers? Although well-cited journal research rests in more than 90 different journals, the five most dominant serials are *Earth Surface Processes and Landforms* (22 papers), *Geological Society of America Bulletin* (18), *Water Resources Research* (17), *Nature* (14), and *Geology* (12). Of these top five journals, private industry sponsors only *Nature*. Figure 1 illustrates a strong association between well-cited papers and publication in journals sponsored by a scientific society.

Well-cited papers peak in the early 1990s (Figure 1), perhaps an artifact of two trends. First, the number of journals indexed through ISI grew over time, accelerating the total number of papers cited in the dominant geomorphic journals (Figure 2). Second, since it takes time for papers to reach the threshold of 20 citations, a precipitous citation drop-off occurs in the last five years. Temporal trends in subfields of geomorphology mirror the peak of the early 1990s seen in the entire compilation (Figure 2).

Of all of the different subfields of geomorphology, stream-related research dominates well-cited geomorphic papers (Table II). Three of the top four subfields focus on streams: fluvial processes; riparian studies emphasizing biological (plant, animal) issues; and studies of drainage basins. Of the 32 well-cited drainage

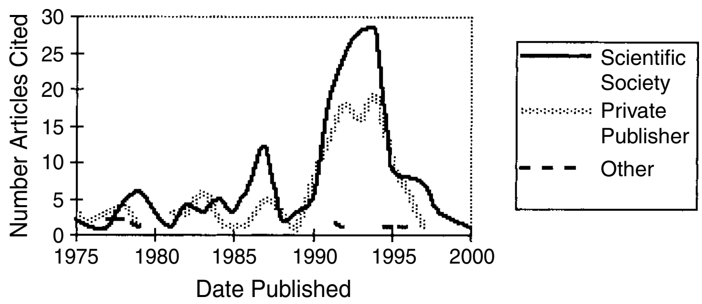

Figure 1. Time trends in publication of the most cited geomorphic papers by scientific societies, private publishers, or another publisher such as a governmental agency or public university

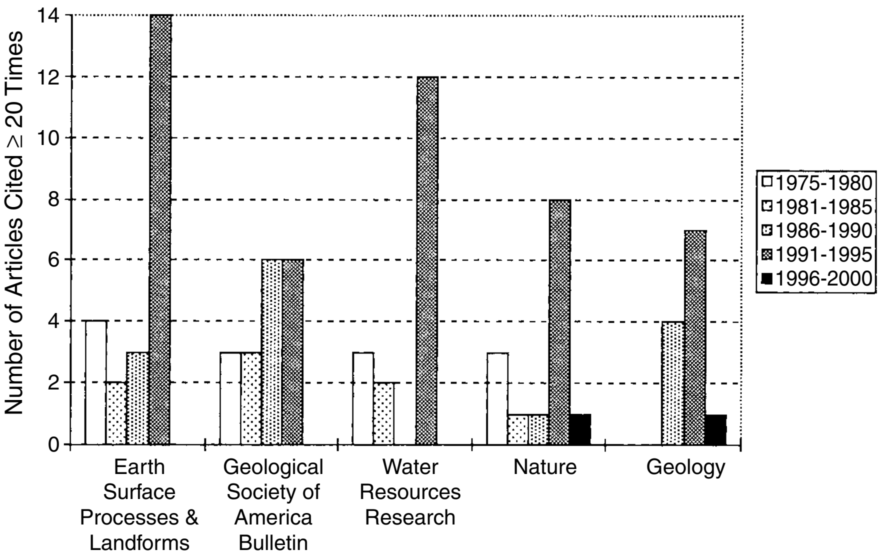

Figure 2. Time trends in article citation of the most cited geomorphic journals

basin studies, 22 focused on modelling using digital elevation model datasets. Examined another way, of the 29 well-cited papers with a modelling emphasis, 22 focused on drainage basins. Although fluvial processes yielded the highest number of well-cited papers, riparian research with a biological emphasis appears to host the 'hottest' research arena (Table II).

Planetary geology emerged in the period of study as a cohesive group of well-cited papers related to geomorphology. The three Venus papers appear to be driven by specific sensor packages. The remaining well-cited planetary papers focus on ground water or surface water as Martian geomorphic agents.

A surprising trend was the absence of well-cited glacial or glacial geomorphology papers written during 1975–1990, and then its sudden re-emergence in the 1990s. Without further bibliometric analyses it is difficult to discern whether this is a real trend or an artifact of indexing factors such as the way glacial geomorphologists wrote abstracts, keywords, and titles.

In conclusion, bibliometric analyses please very few scientists, for their papers and their subfields are usually slighted. Citation analyses, however, offer a somewhat more objective window on the extremely subjective topic of what research is important enough for others to use. As such, this ISI-based analysis of the geomorphic literature yields new insights where the highly multidisciplinary and interdisciplinary field of English-language geomorphology rests at the close of the 20th century.

Table II. Citation trends over time, organized by subfield

Subfield	Subfield total	1975–1980	1981–1985	1986–1990	1991–1995	1996–2000
Fluvial processes and landforms	47	13	11	4	18	1
Riparian – biological emphasis	42	0	2	7	25	8
Landscape evolution	39	4	3	11	18	3
Drainage basin studies	32	3	4	1	22	2
Tectonics	31	0	3	3	22	3
Slope	27	5	3	8	10	1
Glacial	19	0	0	0	17	2
Coastal	18	2	1	4	11	0
Planetary	15	0	0	2	10	3
Soil	14	1	0	2	11	0
Dating methods	11	1	0	1	0	9
Biogeomorphology	10	1	0	3	5	1
Aeolian	6	2	0	2	2	0
Climate change emphasis	4	1	0	0	2	1
Weathering	4	1	1	0	2	0
Forestry	2	0	0	0	1	1
General geomorphology	3	1	1	0	0	1
Lacustrine and marine	2	0	1	0	1	0
Volcanic	1	0	0	1	0	0
Economic geology	1	0	0	0	1	0

REFERENCES

Baker VR, Strom RG, Gulick VC, Kargetl JS, Komatsug G, Kale VS. 1991. Ancient oceans, ice sheets and the hydrological cycle on Mars. *Nature* **352**: 589–594.

Barsukov VL *et al*. 1986. The geology and geomorphology of the Venus surface as revealed by the radar images obtained by Veneras-15 and Veneras-16. *Journal Geophysical Research – Solid Earth and Planets* **91B4**: D378–D398.

Bensman SJ. 2001. Urquhart's and Garfield's laws: The British controversy over their validity. *Journal of the American Society for Information Science and Technology* **52**: 714–713.

Bowler JM. 1976. Aridity in Australia – age, origins and expression in aeolian landforms and sediments. *Earth Science Review* **12**: 279–310.

Cooke R, Warren A, Goudie A. 1993. *Desert Geomorphology*. UCL Press: London.

Cronin B. 2001. Bibliometrics and beyond: Some thoughts on web-based citation analysis. *Journal of Information Science* **27**: 1–7.

Frohlich C, Resler L. 2001. Analysis of publications and citations from a geophysics research institute. *Journal of the American Society for Information Science and Technology* **52**: 701–713.

Garfield E. 1955. Citation indexes for science: A new dimension in documentation through association of ideas. *Science* **122**: 108–111.

Goudie A, Pye K (eds). 1983. *Chemical Sediments and Geomorphology: Precipitates and Residua in the Near Surface Environment*. Academic Press: New York.

Grupp H, Schmoch U, Hinze S. 2001. International alignment and scientific regard as macro-indicators for international comparisons of publications. *Scientometrics* **51**: 359–380.

Hoolings CS. 1992. Cross-scale morphology, geometry, and dynamics of ecosystems. *Ecological Monographs* **62**: 447–502.

Hyland K. 2001. Humble servants of the discipline? Self-mention in research articles. *English for Specific Purposes* **20**(3): 207–226.

Jackson JA, Gagneipain J, Houseman G, King GCP, Papadimitriou P, Soufleris C, Virieaux J. 1982. Seismicity, normal faulting, and the geomorphological development of the Gulf of Corinth (Greece) – the Corinth Earthquakes of February and March 1981. *Earth and Planetary Science Letters* **57**: 377–397.

Jimenez-Contreras E, Ferreiro-Alaez L. 1996. Publishing abroad: Fair trade or short sell for non-English-speaking authors? A Spanish study. *Scientometrics* **36**: 81–95.

Kirkby MJ. 1978. *Hillslope Hydrology*. Wiley: Chichester.

Mark DM, Aronson PB. 1984. Scale-dependent fractal dimensions of topographic surfaces – an empirical investigation, with applications in geomorphology and computer mapping. *Journal of the International Association for Mathematical Geology* **7**: 671–683.

Milliman JD, Syvitski J. 1992. Geomorphic tectonic control of sediment discharge to the ocean: The importance of small mountainous rivers. *Journal of Geology* **100**: 525–544.

Moore ID, Grayson RB, Ladson AR. 1991. Digital terrain modeling – a review of hydrological, geomorphological, and biological applications. *Hydrological Processes* **5**: 3–30.

Naiman RJ, Decamps H, Pollock M. 1993. The role of riparian corridors in maintaining regional biodiversity. *Ecological Applications* **3**: 209–212.

Person O. 2001. All author citations versus first author citations. *Scientometrics* **50**: 339–344.

Redman J, Willett P, Allen FH, Taylor R. 2001. A citation analysis of the Cambridge Crystallographic Data Centre. *Journal of Applied Crystallography* **34**: 375–380.

Reed KL. 1995. Citation analysis of faculty publication – beyond science-citation-index and social-science-citation-index. *Bulletin of the Medical Library Association* **83**: 503–508.
Salzarulo L, von-Ins M. 2001. Bias, structure and quality in citation indexing. *Scientometrics* **50**: 289–299.
Schwartz FW, Ibaraki M. 2001. Hydrogeological research: beginning of the end or end of the beginning? *Ground Water* **39**: 492–498.
White HD. 2001. Authors as citers over time. *Journal of the American Society for Information Science and Technology* **52**: 87–108.
Wolman MG, Gerson R. 1978. Relative scales of time and effectiveness of climate in watershed geomorphology. *Earth Surface Processes and Landforms* **3**: 189–208.

