New Technology and the Political Economy of Geomorphology

Rob Inkpen

Introduction

The face of geomorphology is changing as revealed by a number of shifts in the characteristics of the science. There is a shift from data poor to data rich science (Piegay et al., 2015), a shift from analogue to digital technologies (Viles, 2016), a shift from analysing field to modelled reality coupled with local surveys (Piegay et al., 2105) and a shift towards miniaturization and portability of new technologies which have changed the nature and quantity of data collected from the field (Viles, 2016). Changes in publication patterns mirror these changes as outlined in Table 1 based on the cluster analysis of papers in fluvial geomorphology over the last 22 years (1987-2009) by Piegay et al. (2015). Clusters 2, 4 and 5 all show increases in publications over the period with cluster 2 emphasising the importance of new technologies for remote sensing and accumulating large datasets. Clusters 3 and 4 stress the focus on modelling high resolution data in complex ways. These clusters, however, also illustrate an increasingly narrow range of important journals hosting publications in these clusters as well as an increasing internationalization of authorships of publications.

Within these shifts new technologies have been highlighted as key to the development of geomorphology (e.g. Church, 2010, Wohl et al., 2016 and Viles, 2016) and in particular their importance for deepening our understanding of geomorphology and enabling new questions to be asked. New technologies undoubtedly do provide a major opportunity to explore and advance understanding and practice within geomorphology, but there has been a tendency to be relatively uncritical of these technologies and to analyse their impacts without considering the wider context of their operations. This is a surprise given the clear shifts in the international production of papers, the rise of interdisciplinarilty, the costs associated with acquiring, processing and interpreting 'big data' and the collection of qualitative different small-scale field data. The ramifications of the introduction of new technologies extend beyond the seemingly uncontroversial deepening of knowledge, expanding like ripples on a pool. New technologies, for example, affect the lives of the researchers using them through opening or closing of career opportunities, the lives of technical staff supporting technologies and changing work practices as well as the legitimacy of alternative techniques. It could be argued that these ramifications are incidental to the new technology and therefore not a legitimate focus for study. I would argue that the wide ranging socio-economic nature of the ramifications and the potential impact of new technologies on what is acceptable as knowledge in a subject is a critical issue for debate. Likewise, the significance of the ramifications of new technologies to the lives of researchers makes uncovering the wide ranging consequences an urgent issue for analysis and discussion. This paper is an initial attempt to identify and bring to light some of the impacts of new technologies on geomorphology as a scientific discipline situated within an evolving neoliberalist context.

Table 1

Cluster	Tools	Associations
1	'Classic' tools, e.g. literature review, conceptual models, mapping and vegetation dating	*Publications declined over time period* Channel scale and the present First authors tend to be African, Polish, Israeli and Dutch
2	Remote sensing and imagery techniques, mapping and spatial archives, physical and stochastic modelling, fractals and geostatistics	***Publications significantly increased over time period*** Decades, atemporal or Holocene focused Network focused scale and not upon channel or floodplain Publications focused in *Geomorphology* First authors tend to be Other European, Italian and Indian. UK, USA and Canada based authors tend to be less likely to be in this cluster
3	Hydraulic modelling	***Publications increased over time period*** Channel scale and the present and atemporal Publications focused in *ESPL* First authors don't tend to be African, Chinese, Other American or Spanish
4	Multivariate statistics and photogrammetry	***Publications increased over time period*** Channel scale and the present First authors tend to be from USA and less likely from Poland, Israel and Other Europe
5	Coring and dating tools for establishing evolutionary changes	*Publications declined over time period* Focused on terrace, floodplain and basin scales and centuries to Quaternary timescales First authors tend to be Australian/New Zealanders and Chinese and less likely to be Polish, Israeli and Other European
6	Field measurements focused on processes	*Publications declined over time period* Channel scale and the present Publications focused in *ESPL* First authors more likely to be Canadian and German and less likely to be Australian/New Zealander and Other Asian

Source: Based on Piegay et al. (2015)

A framework for political economy of geomorphology

New technologies require the investment of both funds and researchers which means that they require justification within an increasingly neoliberalist university environment. Recent developments in Critical Physical Geography (e.g. Lave et al., 2010a, 2010b, Lave et al., 2014 and Tadaki et al., 2015) have highlighted the situated nature of physical geography, as an academic discipline deeply embedded within and structured by the general neoliberalist waves of change that have impacted institutions across the world. Identifying and tracing how the tendrils of new technologies extend through such neoliberalist constructs requires the application of concepts and frameworks that have been developed to explore this realm. Building on Harvey's work (1981), Lane (2017) reflects on the political economy of physical geography. Lane identifies two entities, academic physical geographers (labour) and resources (research questions and finances) both of which fuel the means of production (equipment, analytical procedures, and writing) to produce a surplus of scientific publications. This surplus is identified as an excess of knowledge over what previously existed. Consumption of this surplus has to be undertaken by the same labour that produced it forming a tight network of circulation. Lane identifies a crisis of underproduction in the rate of production of research ideas. The rate of publication increases, but the finite resource base of research ideas and the rate of innovation does not necessarily keep pace. Lane sees the 'fix' for this crisis as being the expansion into interdisciplinary research or the creation of a critical mass of researchers. Combined, these two actions result in an extension in the innovation space of research ideas that a researcher can search and so expand the nature of research questions that can be can be asked. Lane's initial analysis of the political economy of physical geography could be expanded and modified to scrutinise how the neoliberalism context is manifest in the multiple impacts of new technologies.

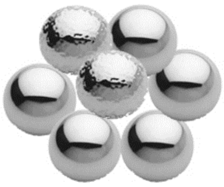
Analysis of neoliberalism and its uneven impacts has been a key research focus for David Harvey (Harvey, 2001, 2005, 2006, 2014). The inherent contradictions of neoliberalist policies and the geographical variations in the manifestation of these contradictions through flows of capital and their transformative power on different parts of the economy, society and nature has formed the central components of his analysis. In Harvey (2010), he introduces the idea of seven activity spheres to summarize and, to some extent visualize, the nature and impacts of capital flows through an ever more interrelated reality. The seven spheres are: institutional and administrative arrangement; technologies and organisational forms; production and labour processes; social relations; the reproduction of daily life; relations to nature; and mental conceptions of the world. Although the spheres maybe viewed as providing a convenient set of themes to guide thought, they provide much more than this. The interrelated nature of the spheres and their continual modifications by the differential flows and manifestations of capital that create and recreate them are an essential tool for tracing and analysing change. As Harvey notes (2010, p.123), no sphere dominates the others and no sphere is collectively determined by the others. Instead each sphere evolves according to its own internal dynamics but is always in a dynamic interaction with the other spheres that can reshape it. The relationships between the spheres are always in flux and are not necessarily harmonious resulting in the creation of tensions or crisis within and between spheres as changes in one sphere flow into and reshape others and are, in turn, reshaped by the reshaping.

The activity spheres are more than useful discussion themes as they identify key arenas for the circulation of capital and for the potential loci of changes in that circulation. Tracing the influence of new technologies through these spheres also traces out the diverse and differentiated impact pathways of the new technologies and highlights the constraints and contradictions involved in such changes. As Pelling et al. (2015) noted in relation to climate change adaptation, Harvey's activity spheres provide a means of identifying and tracing how actors within different spheres have the ability to affect structures and relations within and between activity spheres. Through such actions the relations between spheres as well as the internal dynamics of spheres reflect the interplay between actors and the, sometimes, unconscious, alignment their actions have upon these relations, which can reinforce the effects of particular actors. This power is manifest by the flows of capital as well as the blocking of capital as physical entities within each sphere. Within this framework the potential for new technologies to constrain and enable novel research questions and understanding becomes contextualised within the relationships inside and between the activity spheres. Novel research ideas do not merely appear they are fostered and hindered by the ever changing context of their political economy in which they emerge.

Figures 1a and b illustrates the nature of this co-evolution. If all the spheres were independent then each would only develop according to its own internal dynamics and their shape would remain perfect reflecting a lack of disruption to internal relations as in Figure 1a. Changes in one sphere could be visualized as a distortion that sets off a ripple throughout the network of relations that link the spheres causing distortion in others spheres of varying magnitudes as in Figure 1b. As the disruption permeates through all the spheres, the resultant changes feedback and alter the sphere that was the source of the original disruption thereby altering the configuration of internal relations and structure of each activity sphere but in different ways so each sphere could be altered at different rates. The activity spheres are always in a state of flux, co-evolving along unpredictable but constrained trajectories. It is within this framework that the multiple roles of new technology can be traced and analysed.

Figure 1a

Figure 1b



Technology and activity spheres

New Technologies and Institutional and Administrative Arrangements

Recent penetration of marketization into higher education institutions has been identified and analysed by a number of reseachers (e.g. Marginson, 2013, Pain, 2014, Montz et al., 2015, Chubb and Watermayer, 2016, Kallio et al., 2016), although the nature and pace of such penetration has varied from country to country (Krejsler, 2006, Czarniawska and Genell, 2002). From this process of marketization universities have increasingly become institutions that focus on competition and short-termism rather than collegiality and academic discussion (Kallio et al., 2016). Part of this process of marketization involves the growth and dominance of 'performance management', PM, in its broadest sense. Such a focus instils value into metrics which permit comparisons between institutions, between departments and individuals. Such metrics allow each individual entity to be compared and ranked externally and internally and their values on these measurement scales monitored over time (Marginson, 2008, Wedlin, 2008, ter Bogt and Scapens, 2012). As with any PM system improving your scores on the metrics becomes a focus for managers and for the academics and units being compared (Sousa et al., 2010).

It is within this neoliberalist context of marketization that the development and use of new technologies within universities needs to be addressed. New technologies could be viewed as the basis for the production of academic papers, the key product of the academic process identified by Lane (2017), and an important indicator for comparisons. The technologies themselves, however, could be viewed as essential positional goods (Chubb and Watermaeyer, 2016), central to the acquisition of research grants and papers through the competitive advantage the possession of such technology provide the individual, department and institution. In this sense, new technology can become the means to define the subject area and therefore the appropriate questions and approaches to be used to answer research questions. In this way new technology can act as a means of excluding researchers. Ownership of technologies acts to exclude other researchers either through the expense of capital investment in such technology or through the complex processing of data produced by the new technology. This could produce a situation where specific academics and institutions effectively own the academic ’market’ in specific forms of analysis.

Such technologies and the associated analysis of the data they produce become the ‘standard’ requirement when considering the methods used in publications. Likewise, possession of such technology could become ‘standard’ or expectation in the subject area without which researchers can not obtain a grant. The use of such technologies can also be used as a means of defining the quality of an output and act as a way of narrowing down the type of papers that become required reading in a specific subject area, partially at least overcoming the issue of overproduction that Lane identifies. Essential to this narrowing is the ability for such paper production to be indexed and accessed by researchers and the parallel development of publication databases and the ability to search these by individual institutions and technologies (e.g. Li et al., 2016 and Cheng et al., 2015). Developing such databases not only focuses what is appropriate reading material in a subject area but also enable managers to measure the impact of such technologies within the PM framework of emerging neoliberalist universities.

It is interesting to note, however, that new technologies can also be collaborative if they are ubiquitous enough. Frazier and Wilkle (2017) emphasized the interdisciplinary links of geography as being an essential part of its identity and survival strategy within the discipline and so collaboration has a vital role to play in the continuation of the discipline. Clusters 2-4 in Table 1 could require expensive and specialised technologies and restricted data to produce publishable research but the raw data/imagery could be relatively freely available such as with satellite imagery and the exploitation of freely available data archives. Likewise, statistical modelling methods can range from the complex and specialised to the relatively simple. The portability and miniaturization of the new technologies identified by Viles (2016) in relation to rock weathering, for example, could be viewed as enabling more researchers to enter that specific topic area. Even in such cases, however, there is a need to be able to post-process and analyse the data which will impact upon the nature of academic labour process and could become a means of exclusion.

The importance of such new technologies in defining the nature of a discipline can also impact upon management policies. Frazier and Wikle (2017), for example, highlight the rebranding exercise of geography departments in the US (1990-2014) aimed partly at realigning departments to teaching or research specializations in order to better survive in the face of budget challenges. Rebranding provides an opportunity to focus both internal and external audiences towards the research specialisms that the department feels it has ownership of and new technologies can become a focal expression of such specialisms. Concentrating branding on specific technologies and associated subject areas could force a trajectory to future department development in line with the specialism and its technological requirements.

New technologies and production and labour

New technologies within geomorphology tend to be modified from other disciplines as noted by Mol and Viles (2010), but often require adaption to field conditions to be of use within geomorphology. Importation of new technologies could also mean the importation of new labour practices and relations. An UAV, for example, requires a whole technical and analytical infrastructure to enable data to be processed and analysed as well as adherence to an emerging legal framework for its use. Although such activities may be allocated within an existing labour structure, for example, with technical staff taking on roles flying and maintaining an UAV, the new roles and responsibilities will require relocation of time and costs from other uses. Likewise, new software and analytical skills may be required to ensure data from the UAV can be processed as well as application of existing techniques such as establishing control points in the field that enable accurate data processing. The need to mix 'established' and 'new' technologies to obtain results is an aspect of the application of new technologies that is relatively poorly discussed in the literature.

Competition for limited labour resources within departments and institutions could affect existing labour and power relations and so the growth of new research areas could take labour away from other research areas. This will mean that some labour skills will be privileged over others and so direct the need for training and recruitment. Developing and using new technologies could, therefore, lock departments into specific technological infrastructures with the associated risks of such networks becoming obsolete if the new technology does not generate or answer research questions deemed to be important within the university's neoliberalist metrics.

The growing research clusters identified by Piegay et al. (2015) are likely to require an analytical infrastructure to match the technological infrastructure needed to support new technologies. The volume of data collected, its storage and interpretation will require a range of skills that may not be found in a single individual and so research teams, whether within or across departments and institutions, will be required to make sense of the data. Aside from potential conflicts concerning the value of each individual's contribution to this collaborative process, the advent of new technologies does suggest that paper and grant production will increasingly require joint application of a team's analytical and interpretative skills with the need for a cooperative and communal production process. Within a neoliberalist context this means a potential contradiction in that the funding rewards for new technologies will become spread across research teams and institutions implying a potential conflict within institutions about the value of such collaboration.

Interdisciplinarity is often explicitly encouraged by funding bodies but the potential for misunderstanding increases as different approaches, philosophies and terminologies need to be negotiated to ensure each contributor understands the analysis. Such negotiation of meanings is not necessarily straightforward (e.g. Bracken and Oughton, 2006) and the process may result in a compartmentalization of knowledge such that no single individual in a research team understands the whole process of knowledge production manifest in the final paper. This implies the team needs a high level of mutual trust in the expertise of the individuals involved to produce the final paper. This would suggest that as well as the formal academic relations within the team, additional social relations important to creating and maintaining trust will be important, factors that are not usually considered within the research process.

Increase portability and transferability of new technologies also have the potential to impact upon the labour process. A portable NIR (near infrared) probe, for example, embodies technology and labour that was previously only available in the laboratory and enables the individual researcher to undertake NIR analysis of rock surfaces. It could be argued that transferring and standardizing the data collection and analysis process has deskilled the task, placing it in the hands of the researcher in the field. This transfer has, however, produced a new set of issues that the researcher needs to consider around the accuracy and repeatability of the measurements they take, issues that would previously have been controlled and incorporated into laboratory practices and protocols.

Although the portability of equipment may mean that more data can be collected in the field and, as it is in the field, provides the illusion of being 'real' data, there may be stringent conditions associated with the use of equipment. These conditions are often designed to provide 'control' in equipment use that eliminates variability that would have previously been removed by the using the instrument within controlled laboratory conditions. These operational constraints required in the field highlight that decisions about control and calibration have been transferred from codified laboratory protocols to decisions by a researcher in the field. This introduces the potential additional and new sources of variability, an observation made by Salmond et al. (2017). Researchers may attempt to overcome these issues but trying to relate field measurements to their equivalent in the laboratory to ensure objective and standardized measurements between the field and the laboratory. Such a translation may not be as straightforward as applying a single and simple correction factor as noted in trying to correct micro-erosion meter measurements for environmental conditions (e.g. Spate et al., 1985).

New technologies do seem to hold the promise of democratizing science such as through crowdsourcing research which is enabled by advances in social media platforms (e.g. Raddick et al., 2007, Newman et al., 2012). As noted below, however, such democratization may be based on a foundation of a specialised analytical infrastructure post-data collection. The labour of data collection is distributed across the public and is possible though the use of equipment such as personalised pollution monitors or through techniques such as form identification. These methods are calibrated without the intervention of the user or require only a minimal level of user training. Although such crowdsourcing can produce lots of data it also has data quality problems associate with it, some of which may only emerge as the data derived from diverse individuals is collated and compared and so may require a novel understanding of the nature of data from traditional expectations and procedures (e.g. Nov et al., 2014).

New technologies and social relations

Frazier and Wikle (2017) note that universities have been viewed as '*socially constructed places for creative interaction and exploration among likeminded students and faculty.*' (p.12). Within the neoliberalist context outlined above, new technologies have the potential to disrupt the social relations that construct this academic space. The flows of resources and prestige associated with the successful use of new technologies could create a shift in power relations within the social networks of a department or institution. A clear hierarchy of successful and unsuccessful academics with the associated implications for career progression could flow from new technologies. This would be accompanied by a shift in power relations between individual staff members. If the university included workload metrics as part of its PM, this could result in a reallocation of teaching and research time thereby disrupting the daily routines of staff within and beyond the research team.

The potential for changing the spatial dynamics in a department that aid the recreation of social dynamics may also be affected by new technologies. New and expensive laboratory equipment often requires specialised and separate workspaces. These can transform into new social spaces for interactions amongst the individuals involved operating the instruments and using the instruments for research and so create a new and strong set of social relations based on work practices. As the new social network is tied to a workspace for the technology this can become a mechanism for excluding individuals who do not use that space.

Similarly, as noted above, the need to engage in interdisciplinary research to justify the acquisition of new technologies, will rely upon forming new social networks of trust amongst teams across institutions. Often these social networks develop from existing professional and personal networks within a subject area and the stresses such close collaboration puts upon the development and maintenance of personal and virtual networks is relatively poorly researched.

The trend to portability and miniaturization and democratization of science through new technologies could, however, aid the formation of social networks beyond academia. Using new technologies to inform public debate and even to advance the involvement of groups within environmental decision making could result in academics becoming part of and central to the development of the social networks of interest groups. Such crowd sourced information, however, only becomes academically valid and of use value to those providing the information if it has been transformed to and analysed as a datascape. Within a datascape the limitations of the accuracy of the data can be analysed and provide a basis for judging the value of the information for academic use. Likewise, patterns and trends in behaviour can only be identified and analysed once an aggregate set of information from individuals is produced. This is the information that is feedback to those providing the data enabling them to contextualise the information they provided. Involvement in such crowd sourcing groups could, however, clash with the neoliberalist imperatives of governments and private companies setting up a potential funding conflict. It could also be argued, however, that the aggregating the data to enable analysis provides the additional market value for crowd sourced research which is created and appropriated by the researcher.

New Technologies and Reproduction of Daily Life

Acquiring and implementing new technologies imply role accumulation for academic and technical staff that can offer an enrichment of their work environments. Role accumulation can also, however, have the potential to increase the nature and volume of work demands and so has implications for the mental health of individuals (Kinman, 2016) and hence their ability to maintain the routines of their daily lives. It is through these daily routines that social and institutional norms are constructed and reproduced almost automatically and so any potential disruption to them can become an important issue within an institutional PM. Potential increases in training and skills required to operate new technologies as well as deskilling through transference of skills to the technology itself could affect how individual's work and so disrupt their daily routines. The use of UAVs, as noted above, requires the need to obtain appropriate licenses, at the time of writing (October 2017) this is a permissions for commercial operations licence (PfCO) to fly a drone in the UK. This requires licensed operators to produce an Operations Manual as well as manage insurance and legal issues that arise from flying a drone. This means that the individual or individuals tasked with operating this equipment need to undertake training and then produce management systems that cover activities such as legal concerns that may not have been part of their daily remit before. There is potential for disruption to their established work routines to incorporate these new practices plus their need to engage with new sections of an institution relevant to legal issues.

There is also the potential to disrupt daily routines if the advent of new technologies involves increasing interdisciplinary research. This will involve research teams in collaborating in terms of co-ordination and aligning their work practices as well as their research. If work load allocation models are part of the institution's PM policy then such disruption as well as allocating time to the use of any new technologies will need to be negotiated and allocated, a process which could highlight differential powers within the research team to minimize disruptions to daily routines. Where the new technologies also mean the engagement with stakeholders outside of academia, it is probable that the stakeholders operate to different daily routines and goals and, in the neoliberalist context within which new technologies will be used, there is likely to be severe pressures to adapt academic work practices to the stakeholder requirements so potentially disrupting the daily routines and work practices of a research team.

New technologies and relation to nature

New technologies also impact upon the relations to nature activity sphere as they constrain the manner in which the researcher interacts with the natural world. Within fluvial geomorphology, for example, the development of technologies such as the acoustic Doppler current profiler (aDcp) provide a vast increase in the volume and spatiotemporal resolution of dimensional velocity data for river flow. The resultant velocity profiles could be seen as just an extension of existing understanding of the fluvial system, but it could also be that the nature of the data shifts the researcher's perception of the entity they are researching. Previously, velocity data would be available as discrete and limited measurement points, but the aDcp provides a more spatiotemporally detailed and finely differentiated entity. Williams et al. (2013), for example, use the aDcp to collect field measurement to validate and advance the understanding of hydrodynamic simulations in braided rivers. Combining the aDcp with high resolution terrestrial laser scanning they are able to model data at a spatial density beyond anything previously possible. To draw out the relevance of the data to hydrodynamic processes, however, required processing techniques that enabled the identification of statistical flow structures and the inference of generalities from the particularities of the field site.

Viles (2016) notes that the use of new technologies could enable researchers to analyse geomorphology across scales. This view is based on the assumption that the phenomenon being researched have an expression across a number of scales that can be identified and quantified. Additionally, it is assumed that the phenomena has an existence independent of the measurement system being used (Rhoads and Thorn, 1996, Inkpen and Wilson, 2013). This assumption is essential if there is to be confidence that 'old' and 'new' technologies are measuring the same phenomena. Using this assumption, explanation can be developed that encompass both the 'old' phenomenon and the 'new' phenomenon that emerges from the new technologies. Trying to confirm this assumption and the potential impact, if any, on explanation is a relatively unexplored topic within the literature.

Piegay et al. (2015) identified a shift towards site specific studies that analysed how phenomena interact and how such interactions alter the phenomena under study. This could help identify how specific combinations of earth surface processes produce scale dependent variations in outcomes. A focus on site and its particularity, however, will stress the significance of local context for understanding whereas the neoliberalist tensions identified will be focused on solutions that are general and transferable. New technologies will provide data at greater spatiotemporal resolution and complexity through integration of techniques for an individual site but this will always be in tension with the standardizing tendencies of neoliberalist pressures. This sets up an interesting contradiction between the potentially increasingly complex and site-specificness of intellectual enquiry through new technologies and the scale destroying tendencies for explanation of the neoliberalist context within which such research is carried out. Lave's analysis (2012) of the experience of stream restoration suggests that this paradox may not necessarily be resolved through new technologies but rather by a shift to a market-focused research and set of methods that privilege application over exploration of explanation.

New technologies relations to mental conceptions

New technologies can provide a deeper understanding of existing research questions, where 'deeper' means either more complete within the terms of current concepts or novel with respect to the development of new conceptual or explanatory frameworks. The difference is an important one to make. If 'deeper' understanding refers to refining existing concepts then there is an intensification of an existing explanation, a stabilization of current thinking. This could mean a clearer identification of the scientific principles underlying the phenomenon being studied or an increase in the volume of data that can be used to test the main concepts or confirm existing assumptions. Either way, new technologies are being used within a framework of existing concepts; they are not being used to develop novel or new conceptual understandings. It could be argued that the use of new technologies to extend the scope of existing concepts, and indeed a gradual, evolutionary view of developing explanation could be appropriate particularly if that extension included applying existing concepts to new phenomenon or in a new context. If, however, new technology helps to redefine the entities or phenomenon being researched then this is a transformative change in understanding.

New technologies have produced a vast amount of data often referred to as 'big data'. Salmond et al. (2017) have noted that this affects how data is handled as well as how science is done which has ramifications throughout the seven activity spheres. Salmond et al. (2017) discuss the impact of 'big data' on our understanding of environmental sciences pointing out that big data is seen by some as moving the way that science is done from theory-driven to an iterative process through the analysis of big datasets. Whilst new technologies may seemingly push scientific investigation towards detailed analysis of the field, the production of big datasets could be as likely to mould questions to fit the available data. Instead of being 'question-driven', it will become increasingly adapted to suit the big datasets available which have often been produced at large costs to funding councils, databases in search of a purpose collected by scientists and the public will begin to constrain research (Shearmur, 2015).

Kitchin (2014) notes that this shift to big data emphasises large scale, quantitative and positivist analysis and so a return to positivist forms of explanation. Big data is concerned with generalising relationships and often with identifying them automatically though algorithms (Peters et al., 2014). Datascapes emerge as the focus of analysis and the source of explanation rather than the physical entities from which the datascapes are derived. As Salmon et al. (2014) note:

'If landscapes can be converted into datascapes, then what is needed is not analysis of landscapes but analysis of datascapes. Further, these changes in observational and methodological priorities could lead towards the prioritization of reanalysis of open source/public datasets over field science, triggering the "rise of the data scientist" (Levy 2015) and the death of the environmental expert (Death 2015).'

Salmond et al. (2014) p.59.

The detachment of a datascape from the physical landscape, however, constrains the understanding that the physical geographer can derive as each analysis, each conclusion requires a translation back to the physical landscape, assuming a direct one-to-one translation from datascape to landscape is even possible.

New technologies and the resultant production of big data could severely limit the generation of research ideas in geomorphology. They can act as barriers to entry into a research area and so limit research ideas to those associated with the new technologies. Likewise, the advent of big datascapes focuses research ideas on the extraction and manipulation of this datascape and so potentially limits research questions to those that interrogate these datascapes. Collaboration between disciplines may be required to interrogate these spaces and so research ideas in geomorphology became entwined with the development of research ideas and agendas in other disciplines. The distinctive nature of geomorphology, if it exists, could be eroded as the generation of its research questions becomes merged with other disciplines. Within the context of political economy, this may be expected, as both new technologies and big datascapes represent heavy capital investments and so act as attractors for activities in different activity spheres, pulling and distorting the spheres to reflect the capital flows they control and solidify.

Conclusion

Viewing new technologies in geomorphology through the lens of political economy highlights the importance of tracing the impacts of new technologies on the flows of capital and resources through the seven activity spheres identified by Harvey (2010). New technologies have impacts that ripple and distort these activity spheres and which feedback on each other to produce a complex and inter-related web of changes. The neoliberalist context within which universities operate is the overriding context that permeates through the new technologies and their impacts. New technologies often focus and reinforce the neoliberalist agendas within departments and institutions, but counter currents of impacts through the potential for the democratization of science and scientific practices could also be outcomes.

Central to the neoliberalist justification for new technologies is the drive for high quality papers and grant funding, key metrics within university's PMs. Undoubtedly, such new technologies do contribute to advancing knowledge and understanding but this specific neoliberalist context could also constraint the nature of the research questions as well as the relation of the researcher to reality. This could mean that geomorphogical research is set off on a particular research trajectory which will be accentuated through the flow of resources and the alignment of work practice with that trajectory. The dependence on specific technologies can become self-reinforcing.

This aim of this paper was to illuminate some of the implications of new technology within the neoliberalist context that universities and academic research now finds itself. I have outlined one potential analytical framework for tracing the ramifications of new technologies. Selection and analysis is never a complete process and I am sure others will find my discussion either too pessimistic or too opportunistic in its outlook. More important than agreeing with the analysis presented here is that the complex and intricate nature of the consequences of undertaking academic research in a neoliberalist context are recognised and seen as legitimate issues for academic discussion.

References

Bracken, L.J. and E.A. Oughton, 2006. 'What do you mean?' The importance of language in developing interdisciplinary research. *Transactions of the Institute of British Geographers* 31: 371-382.

Cheng, Q., X. Lu, Z. Liu and, J. Haung. 2015. Mining research trends with anomaly detection models: the case of social computing. *Scientometrics* 103: 453-469.

Chubb, J. and R. Watermayer, 2016. Artifice or integrity in the marketization of research impact? Investigating the moral economy of (pathways to) impact statements within research funding proposal in the UK and Australia. *Studies in Higher Education* Doi: 10.1080/0375079.2016.1144182.

Church, M. 2010. The trajectory of geomorphology. *Progress in Physical Geography* 34: 184-192.

Czarniawska, B. and K. Genell, 2002. Gone shopping? Universities on their way to the market. *Scandinavian Journal of Management* 18: 455-474.

Frazier, A.E. and T.A. Wikle, 2017. Renaming and rebranding within U.S. and Canadian Geography departments, 1990-2014. *The Professional Geographer* 69: 12-21.

Harvey, D. 1981. The spatial fix – Hegel, von Thunen and Marx. *Antipode* 13: 1-12.

Harvey, D. 2001. *Spaces of capital: Towards a critical geography*. Routledge, London.

Harvey, D. 2005. *A brief history of neoliberalism*. Oxford University Press, Oxford.

Harvey, D. 2006. *Spaces of global capitalism: Towards a theory of uneven geographical development*. Verso, London.

Harvey, D. 2010. *The enigma of capital*. Oxford University Press, Oxford.

Harvey, D. 2014. *Seventeen contradictions and the end of capitalism*. Profile Books, London.

Inkpen, R. and G. Wilson. 2013. *Science, philosophy and physical geography*. Second edition. London, Routledge.

Kallio, K-M., T.J. Kallio, J. Tieenari, and T. Hyvonen, 2016. Ethos at stake: Performance management and academic work in universities. *Human Relations* 69: 685-709.

Kinman, G. 2016. Effort-reward imbalance and overcommitment in UK academics: implications for mental health, satisfaction and retention. *Journal of Higher Education Policy and Management* 38: 504-518.

Kitchin, R. 2014. Big data, new epistemologies and paradigm shifts. *Big Data and Society* April-June: 1-12.

Krejsler, J. 2006. Discursive battles about the meaning of university: The case of Danish university reform and its academics. *European Educational Research Journal* 5: 210-220.

Lane, S.N. 2017. Slow science, the geographical expedition, and Critical Physical Geography. *The Canadian Geographer* 61: 84-101.

Lave, R., M. Doyle and M. Robertson. 2010. Privatizing stream restoration in the US. *Social Studies of Science* 40: 677-703.

Lave, R., P. Mirowski and S. Randalls. 2010. Introduction: STS and neoliberal science. *Social Studies of Science* 40: 659-675.

Lave, R. 2012. Bridging political ecology and the STYS: A field analysis of the Rosgen Wars. *Annals of the Association of American Geographers* 102: 366-382.

Lave, R., M.W. Wilson, E.S. Barron, C. Biermann, M.A. Carey, C.S. Duvall, L. Johnson, K.M. Lane, N. McClintock, D. Munroe, R. Pain, J. Proctor, B.L. Rhoads, M.M. Robertson, J. Rossi, N.F. Sayre, G. Simon, M. Tadaki and C. Van Dyke. 2014. Intervention: Critical physical geography. *The Canadian Geographer* 58: 1-10.

Li, R.T., K. Khor and L.G. Yu. 2016. Identifying indicators of progress in thermal spray research using bibliometrics analysis. *Journal of Thermal Spray Technology* doi:10.1007/s11666-016-0445-1.

Marginson, S. 2008. Academic creativity under new public management: Foundations for an investigation. *Educational Theory* 58: 269-287.

Marginson, S. 2013. The impossibility of capitalist markets in higher education. Journal of *Education Policy* 28: 353-370.

Mol, L. and H. Viles, 2010. Geoelectric investigations into sandstone moisture regimes: Implications for rock weathering and the deterioration of San Rock Art in the Golden Gate Reserve, South Africa. *Geomorphology,* 118: 280-287.

Mountz, A., A., B. Bonds, J.M. Mansfield, J. Lloyd, M. Hyndman, R. Walton-Roberts, R. Basu, R. Whitson, T. Hawkins, T. Hamilton and W. Curran, 2015. For slow scholarship: A feminist politics of resistance through collective action in the neoliberal university. *ACME: An International E-Journal for Critical Geographies* 14: 1235-1259.

Newman, G., A. Wiggins, A. Crall, E. Graham, S. Newman, K. Crowston, 2012. The future of citizen science: emerging technologies and shifting paradigms. *Frontiers in Ecology and the Environment* 10: 298-304.

Nov O., O. Arazy, D. Anderson, 2014. Scientists@Home: What drives the quantity and quality of online citizen science participation? *PLoS ONE* 9: e90375.

Pain, R. 2014. Impact: Striking a blow or working together? *ACME: An International E-Journal for Critical Geographies* 13: 19-23.

Pelling, M., K. O'Brien, and D. Matyas, 2015. Adaptation and transformation. *Climate Change*, 133: 113-127.

Peters, D.P.C, K.M. Havstad, J. Cushing, C. Tweedie, O. Fuentes, and N. Villanueva-Rosales. 2014. Harnessing the power of big data: Infusing the scientific method with machine learning to transform ecology. *Ecospher*e 5: 1-15.

Piegay, H., G.M. Kondolf, J.T. Minear and L. Vaudor, 2015. Trends in publications in fluvial geomorphology over two decades: A truly new era in the discipline owing to recent technological evolution? *Geomorphology* 248: 489-500.

Raddick, J., C.J. Lintott, K. Schawinski, D. Thomas, R.C. Nichol, D. Andreescu, S. Bamford, K.R. Land, P. Murray, A. Slosar, A.S. Szalay, and J. Vandenberg, 2007. Galaxy Zoo: An Experiment in Public Science Participation. *Bulletin of the American Astronomical Society* 39: 892.

Salmond, J.A., M. Tadaki, and M. Dickson, 2017. Can big data tame a 'naughty' world? *The Canadian Geographer* 61: 52-63.

Shearmur, R. 2015. Dazzled by data: Big data, then census and urban geography. *Urban Geography* 36: 965-968.

Sousa, C.A., W.F. De Nijs, and P.H. Hendriks, 2010. Secrets of the beehive: Performance management in university research organizations. *Human Relations* 63: 1439-1460.

Spate, A.P., J.N. Jennings, D.I. Smith, M.A. Greenway, 1985. The micro-erosion meter: Use and limitations. *Earth Surface Processes and Landforms* 10: 427-440.

ter Bogt, H.J. and R.W. Scapens, 2012. Performance management in universities: Effects of the transition to more quantitative measurement systems. *European Accounting Review* 21: 451-497.

Viles, H. 2016. Technology and geomorphology: Are improvements in data collection techniques transforming geomorphic science? *Geomorphology* 270: 121-133. doi:10.1016/j.geomorph.2016.07.011.

Tadaki, M., G. Brierley, M. Dickson, R. Le Heron, and J. Salmond, 2015. Cultivating critical practices in physical geography. *The Geographical Journal* 181: 160-171.

Williams, R.D., J. Brasington, M. Hicks, R. Measures, C.D. Rennie and D. Vericat, D. 2013. Hydraulic validation of two-dimensional simulations of braided river flow with spatially continuous aDcp data. *Water Resources Research* 49: 5183-5205, doi: 10.1002/wrcr.20319.

Wohl, E., P.R. Bierman and D.R. Montgomery. 2016. Earth's dynamic surface: A perspective on the past 50 years in geomorphology. *Geological Society of America Special Paper 523*: SPE523-01.