Title:

Mapping liminality: Critical frameworks for the GIS-based modelling of visibility.

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Abstract

Since the widespread adoption of GIS by archaeologists in the early 1990s, analyses of visibility have steadily gained traction, becoming commonplace in landscape and regional analysis. This is in large part due to the routine way in which such products can be generated, bolstered by a raft of landscape-based studies that have placed varying degrees of emphasis upon human perception and direct bodily engagement in seeking to understand and explore the past. Despite this seeming popularity, two worrying trends stand out. The first is the lack of any coherent theoretical framework, applications preferring instead to seek justification in the very first wave of experiential landscape approaches that emerged in the early 1990s. Needless to say, the intervening 20 or so years have seen considerable development in the conceptual tools we draw upon in order to make sense of past landscapes, not to mention considerable finessing of the first-wave developments alluded to above. Second is the tendency to relegate viewshed analysis to certain types of predictable problem or question (i.e. viewshed analysis has become typecast). These trends have been compounded by a host of other issues. For example, whilst there have been refinements, tweaks and variations to the basic viewshed (and the frequency with which they are generated and combined), not to mention establishment of robust calibration criteria for controlling them and statistical approaches for assessing the patterns tendered, these have yet to be brought together in any coherent fashion and their veracity critically assessed. Likewise, a failure to establish an agreed vocabulary has resulted in a number of proverbial wheels being reinvented time and again. The argument presented here is that viewsheds have considerably more to offer archaeology but to realise this entails confronting these issues head on. That this is possible and desirable is illustrated through discussion of a new theoretical framework for visibility-studies that draws upon developments in assemblage theory and the author's own work on affordance and relationality. To demonstrate the value of this approach in encouraging different ways of thinking about what viewsheds are and how we might begin to draw creatively upon them, a case-study is described where viewsheds are folded into a detailed exploration of landscape liminality.

Highlights

- The paper highlights a number of key issues that are currently limiting the scope and value of GIS-based viewshed calculations to archaeological interpretation.
- It shows how developments in assemblage theory and other relational approaches can offer a much more flexible environment for conceptualising and applying viewsheds (as well as GIS more generally).
- It argues that the geodatabase can profitably be regarded as an assemblage with emergent properties.
- When treated less as end-products and more as means-to-an-end, viewsheds can be productively folded into the investigation of phenomenon that are notoriously hard to map.
- It demonstrates one such example of the above, combining viewsheds with geomorphometry to map liminality in a prehistoric monumental landscape.

Keywords

Viewshed, relationality, assemblage, liminality, emergence

1. Introduction

"The calculation of viewsheds can be used in lieu of thinking about the problem"
(Aldenderfer 1996: 2)

"Multiple viewshed analysis is more the product of the methodological possibilities of a GIS than of archaeological theory"
(Wansleeben and Verhart 1997: 61)

If a straightforward problem can be identified with the humble viewshed it is this. Whilst generating them has always been a relatively trivial task, knowing what to do with them once generated has proven to be far more difficult. As the opening quotes illustrate, this was realised some 20 years ago and perhaps explains the ubiquity of look-out points, watchtowers, prominent mounds and phenomenology in the practical case-studies that have followed. The aim of the present discussion is to confront this issue head on, and in so doing demonstrate that it is not only possible to use viewsheds in order to think about problems, but also to take an explicitly theoretical approach to their generation, propagation and analysis. In this way a series of enriched viewshed-based studies can emerge that not only foreground the profoundly relational qualities of looking and seeing, but position viewsheds as more a means to an end than an end in themselves. In keeping with the spirit of the introductory quotations, I will begin with two small aphorisms of my own.

Viewshed analysis has been typecast. Back to watchtowers. It is fair to say that viewshed analyses have become associated through repetition with particular kinds of archaeological structure. These tend to be either monumental, functional (lookout-posts and watchtowers) or communicative (e.g. serving as way-markers such as cairns). Whilst the applicability of viewsheds to the analysis of this kind of structure may seem uncontentious, the studies carried out have tended to settle on a simple binary in-view-of/out-of-view assessment centred upon the construction deemed to be either viewing or viewed (e.g. Gaffney and Stančič 1991; Risbøl et al, 2013; Kantner and Hobgood 2016). Whether broken down into distance bands or not, this is a rather blunt tool when we consider the vagaries and nuances of looking and seeing. It is also treated as the end-point of analysis. For example, having proven that inter-visibility between two watchtowers was theoretically possible, analysis stops there. It is rare indeed to see any detailed or sustained consideration of the precise character of signalling thought to have been carried out from the structure, or the degree of communication expected of the system employed (though see Van Dyke et al 2016). The danger of such type-casting is that it quickly becomes limiting and prescriptive.

Viewshed analysis has been shackled to an uncritical notion of Phenomenology. In the case of landscape phenomenology, there has been a tendency to establish the credentials of any given viewshed application by drawing a direct analogy to the wave of self-proclaimed phenomenological studies that followed in the wake of Tilley's seminal publication (1994), often positioning GIS-based work as a vital corrective. In so doing they have subscribed to at best a partial understanding of what Phenomenology offers (e.g. Thomas 2015: 1288) and there is certainly little evidence in the GIS literature of any concomitant obligation to consider the implications for simple, binary-viewshed generation, of subsequent developments in phenomenological thinking (a good example being the increasing importance of Merleau-Ponty in Tilley's oeuvre) or engage in dialogue with the practitioners and theorists effecting such (Gillings 2012). This intellectual laziness has reinforced the sense encapsulated in the opening quote from Aldenderfer, that viewshed analysis was simply a method looking for a problem and perhaps explains better the lack of enthusiasm for GIS on the part of theorists than the implication that some fundamental essence of modernity resides in the pixels of the computer screen (Tilley 2004; Thomas 2004; Brück 2005). It could also be argued that tacit acceptance of the assumption that the value of viewshed analysis lay solely in the realm of experiential landscape analysis resulted in perhaps the least helpful development in viewshed analysis; the notion that viewsheds (and viewshed-like analyses), if sufficiently finessed, could stand as proxies for human vision and through this perception as a whole (and thus satisfy the concerns regarding the validity of GIS-based studies on the part of researchers advancing the phenomenological agenda). Take for example the notion of visualscapes, and the implied gestalt that will eventually emerge from such studies in order to encapsulate how people perceive and experience their world in all of its nuanced complexity (e.g. Llobera 2003; Paliou 2013).

Having sketched out the background, I would now like to turn my attention to the question of critical frameworks. My aims here are twofold. First, I would like to highlight six interlinked issues that have emerged as a consequence of the above tendencies to type-cast and fall back on phenomenology when pressed on the issue of theoretical justification. This is not intended to comprise a critical review of the range of viewshed applications currently being carried out in archaeology or to offer a capsule history of such. Fortunately, a number of detailed reviews exist (e.g. Lake and Woodman 2003) bolstered by the curious tendency for authors drawing upon the viewshed function to feel the need to preface their accounts with summary histories of developments to date (e.g. Gillings 2009;

Risbøl et al. 2013; Kantner and Hobgood 2016). Nor is it intended to be exhaustive or prescriptive. Instead the aim is to draw attention to a series of themes, tendencies and circumstances that have a direct bearing on where viewshed analyses might go next. Needless to say, this list is personal, inevitably partisan and as a result undoubtedly partial. Second, I would like to demonstrate what a more productive trajectory may look like through a worked case-study that draws upon theoretical frameworks that explicitly acknowledge the profoundly relational character of looking and seeing.

2. Realising the potential of the viewshed

First, and as noted above, we currently lack a coherent and stimulating theoretical framework for the ongoing development of GIS-based visibility approaches. Instead we are still bound up in what might be termed the 'visualscape' phase and through it adherence to an often simplistic and impoverished notion of phenomenology. This in turn has generated an intellectual inertia that has manifested itself in the recurrent tendency to fall back on watchtowers, monuments and signal stations and has perhaps done more to stymie applications in this area than oft-cited issues such as DEM errors, vegetation and algorithm efficiency (see Wheatley and Gillings 2000 for a summary).

Second, at heart any given viewshed is a profoundly relational product. Something always has to be doing the looking and that act may be purposeful (deliberately seeking out or looking) or more discursive (unless vision is impaired, to have one's eyes open is inevitably to see). As a result generating viewsheds without careful control of the viewing parameters is an empty exercise, lest the past be characterised by an awful lot of generic 1.7m high 'average' humans with 20:20 vision rotating gently on the spot. Looking beyond visibility analyses, an explicitly relational approach can enrich GIS-analyses more generally. This is by focusing attention not on mapping static occurrences (soil type or flood zone) against which other layers can be arrayed, but instead upon the relational capacities such instances hold for the people, animals and things actively engaged with them (Gillings 1998; 2012); what might be termed *relational fields* (after Baires et al. 2013: 199).

Third, whilst a considerable range of suggested modifications and refinements to viewshed analysis have been suggested over the years these have yet to be drawn together into a single, coherent suite of methodological options with anything approaching an agreed terminology. The result has been to balance innovation against a tendency – inadvertent or deliberate - to repeat, re-discover and/or re-brand. Take for example summed viewsheds which are generated for every cell (i.e. viewing point) in a given landscape. For reasons no doubt arcane and esoteric these have variously been termed: Total Viewsheds (Llobera 2003), Inherent Viewsheds (Llobera et al 2010), visual exposure density (Berry 1993: 169), visibility index (Olaya 2009: 157), viewgrid, dominance-viewgrid (Lee and Stucky 1998: 893), cumulative viewshed analysis (Lake et al. 1998), affordance-viewshed (Gillings 2009), visibility fields (Eve and Crema 2014), visibility-surfaces (Caldwell et al. 2003). Another example involves the use of sensitivity analyses whereby the viewing height of a given observation point is incrementally raised in order to assess the impact upon viewable area (Lock and Harris 1996:224 & Kantner & Hobgood 2016: 1310-11). A good idea, repeatedly re-discovered. This lack of consistency and the urgent need to agree a common vocabulary may explain why researchers always feel hidebound to sketch out the history of viewshed approaches before commencing their own work.

Fourth, and linked to the above, the value of a more explicitly stochastic approach has also drifted in and out of fashion; stumbled upon anew by successive generations of GIS researchers. As was realised from an early stage (e.g. Fisher 1994; Loots et al 1999) the most economical way of encoding the myriad factors that can influence whether or not a given chunk of the landscape can be seen is to adopt a stochastic approach to viewshed generation. This has the added value of allowing the veracity of any claimed visibility patterns or relationships to be statistically tested (e.g. Lake et al. 1998). Rather than agonise over the precise placement of vegetation, viewer height, acuity and factors such as weather, probable viewsheds can be generated that effectively encompass all.

Fifth, when the question is one of intervisibility, inadequate consideration has been given over to the specific visual affordances of the thing being observed, insofar as appearances can be deliberately modified in order to accentuate their visual signature (i.e. to catch the eye) or camouflaged in order to effect the opposite. There may also be a temporal dynamic as initially striking visual statements weather and decay (e.g. Risbøl et al. 2013: 520). This goes beyond changes in contrast as deliberate activities such as movement can also ‘make-one-look’. The angle of incidence between viewer and target can also influence the ease with which a given object is seen. Put another way, just because a particular cell in raster surface model is deemed to be in-view does not automatically apply to the targets occupying it. Visual acuity (and the distinction between detection and identification (Aguilo & Iglesias 1995: 77) is only one part of the equation and visual contrast can exert a noticeable effect.

Sixth, linked to the above, despite the considerable computational overheads incurred, multiple viewshed products (whether stochastic; total or ideally both) offer entirely new heuristics that allow us to break free of any simple equation between a given viewshed and the human (and it is always human) act of seeing. Looking to total-viewsheds in particular, these can be combined with other modes of analysis to finesse and refine them as well as with individual viewsheds in a more iterative fashion, in order to drill down into a given research problem or domain – i.e. the viewshed as less an ‘end-product-of’ and more a ‘stage-in’ the analytical process.

3. Geodatabase as assemblage

If the relationship between GIS and developments in archaeological theory has to date been fraught (see Gillings 2012), the broad sweep of approaches that have been brought together under the banner of the new materialism (Thomas 2015), offer considerable potential in helping to open up the space for a provocative new conceptual framework for GIS applications; one that offers a different set of challenges and opportunities than the hypothesis-testing of spatial science, adaptive overlays of cultural ecology or naive landscape phenomenology alluded to earlier[1]. That the value of GIS in this regard is being acknowledged and pursued is one of the most important developments in GIS in two decades (e.g. Fowler 2013). Of particular importance is the emphasis that is placed upon relationality and, drawing on the work of Deleuze and Guattari (1992) filtered through De Landa (2006), the focus upon assemblage and concomitant move away from sole consideration of stable states to consider instead a world of flow, entanglement and emergence (see Harris 2014; Hamilakis and Jones 2017; Hamilakis 2017; Fowler 2017: 96 and Harris 2017). Whilst the potential of approaching the map as an assemblage has been tentatively broached (see Lucas 2012: 202), in the case of the spatial database this is far more than simply semantics or metaphor. It has long been argued that a great strength of GIS is its ability to generate new data, which means that the ‘whole’ of a given spatial database is always greater than the sum of its constituent parts. Through the notion of assemblage we can place this insight at the very heart of how we engage with the technology. From the motley of carefully constructed data layers that populate any given spatial database, specific assemblages emerge as a result of constraints and opportunities; comings-together and driftings-apart (in the language of assemblage theory territorialising and de-territorialising forces) some to appear fleetingly – occasionally upon the screen but more commonly as a means to an end – whilst others persist as new layers within the spatial database that in turn can become tangled up with other layers with sometimes expected, but often un-expected consequences. These in turn can stimulate new questions and engage elements of the GIS toolbox in unforeseen ways in order for other assemblages to be territorialised and de-territorialised. Take for example the map of liminality discussed below, which emerged not as the anticipated consequence of feeding carefully prescribed data into a tool called ‘liminal’ but instead through a complex, iterative chain of emerging datasets. This is not to argue for an entirely exploratory approach to data analysis but instead to recognise (and embrace) the possibility of emergence and focus attention on the territorialising/de-territorialising forces (whether in the form of specific research questions; data type limitations; papers such as this one advocating particular ways-of doing; data availability etc.) and lines of flight (following Bonta and Protevi's reading of the term (2004) the vectors that result in the transition between assemblages) that are brought to bear and emerge in any given circumstance. It is also to accept that rather than static end-products, the newly generated layers of data (e.g. viewsheds) are instead potential constituent-parts of a host of further assemblages (e.g. liminality; concealment) that may (or may not) emerge during the course of analysis. It also focuses attention on the myriad fleeting assemblages that come into being (and drift apart) as part of the process of analysis; the host of 'temporary' layers we clear from the system, the failures, the essential intermediary steps, and the fact that any given GIS-generated map layer has a history and genealogy[2].

It is the latter that forms the subject of the current paper – using multiple viewshed products (I will call them cumulative viewsheds for the sake of simplicity) as part of a broader assemblage of land-use parameters, ideas, data transformations and combinations, tools, trials and errors, assumptions, disappointments etc. in order to tease out notions of liminality in a strikingly split-level prehistoric landscape. In this it seeks to build directly upon pioneering studies into more explicitly heuristic approaches to spatial analysis (e.g. Kintigh and Ammerman 1982), as well as earlier work by the author into questions of concealment, hiding, visibility and invisibility as relational capacities of specific animal-landscape engagements (Gillings 2012; 2015a; 2015b).

4. Liminal zones?

The study area is a small portion of the upland wilderness of Exmoor and the archaeological context a group of unusual standing stone arrangements thought to date to the later Neolithic-early Bronze Age (c.2,400-2,200 BC) (Figure 1). It is not my intention to discuss in detail the archaeological background to this study, as this has been covered in a range of recent publications to which interested readers are directed (Gillings et al 2010; Gillings 2015a; Gillings 2015b). Instead, my express aim is to demonstrate how simple viewsheds can be woven into broader investigations of landscape phenomena; phenomena traditionally regarded as both inherently un-mappable and falling outside of the ambit of quantitative GIScience. In short how unexpected (and highly useful) data layers can emerge from a complex assemblage of ideas, hunches, datasets and algorithms, all stirred up and cooked in the crucible of the geodatabase; layers that can then go on to take part in new assemblages.

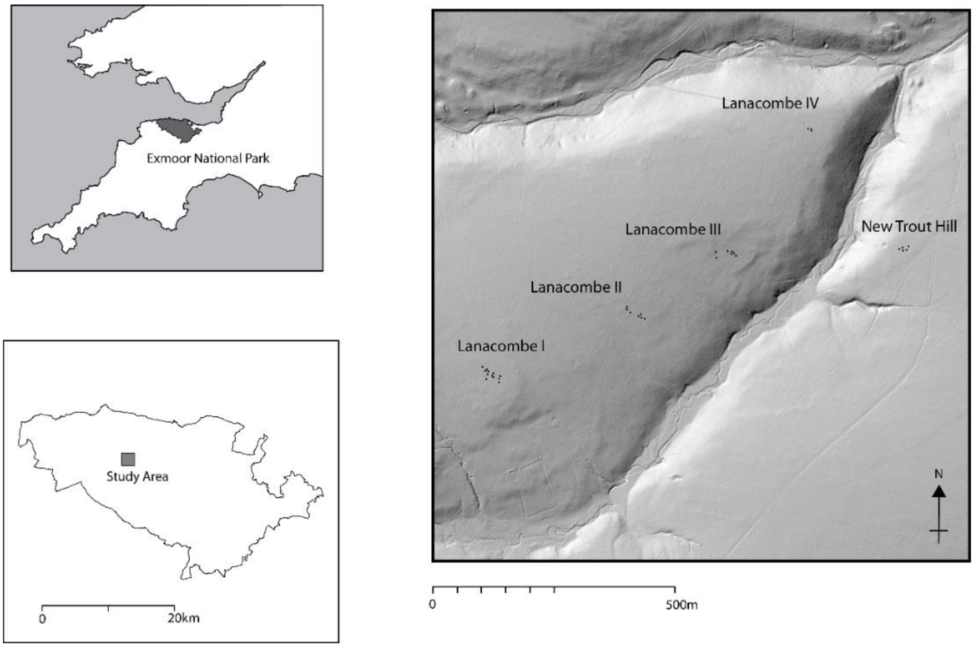

Figure 1 – Location of the study area.

The landscape of Exmoor operates on a split level; broad, slightly domed plateaus cut by deeply inscribed valleys (called coombes). When on the plateau tops, all one is aware of are the plateaus whilst in the bottom of the coombes the opposite is true. From walking the landscape it became apparent that many of the prehistoric monuments appeared to occupy liminal zones, the liminality manifesting itself in the form of distinctive 'shoulder' locations in the local topography, where the domed plateau tops meet the steep coombe edges. These were quite literally transitional zones where one could have a foot in both worlds – neither fully plateau nor coombe (or alternatively a little bit of both). As well as the physical sense of the landscape flexing, another key manifestation of the feeling of being betwixt and between was visual, insofar as some locations clearly afforded a direct visual connection with both the plateau tops and coombe bottoms. How common are such zones and was there really a direct association between monuments and areas of marked transition? Like visibility, liminality is a profoundly relational property insofar as something has to be actively perceiving landforms and visual fields as 'in-between' two (or more) states for any liminality to manifest. That transitionary states were important to the prehistoric communities of Exmoor and were marked and/or recognised as such, has been suggested not only by the apparent spatial association between monuments and the landscape zones noted above; it is also apparent in the physical fabric of the monuments themselves. Recent excavations at the site of Porlock Stone Circle revealed a surprising complexity (Gillings 2015c). Rather than a simple circle of upright stones, we have two circles carefully interleaved with one another and sharing the same circumference. One comprised standing stones raised upwards (i.e. with the bulk of the elongated stone sitting above ground). The second was more overtly chthonic insofar as the stones appeared to point down (i.e. the bulk of the elongated stone was beneath the surface). Spaced between these two distinct megalithic manifestations were deliberately angled stones that appeared to be bridging these two states; clearly, and materially, marking the transition between up and down (Gillings 2015d).

To investigate this sensed relationship further required careful delineation of these liminal zones. The first challenge in identifying (and ultimately mapping) such areas was to extract from the DEM those portions of the landscape that manifested the morphometric characteristics of 'shoulders'. Curvature provides a useful proxy, with areas of marked convexity potentially indicative of precisely the bridging landforms I was interested in extracting. Curvature is a second order derivative of terrain morphology and a range of different functions exist for its quantification which differ both in the directions along which curvature is determined and the polynomials used to extract it (Olaya 2009: 149-155; Jenness 2012: 63-89). In the analysis below, Profile (or Vertical) curvature has been calculated using the Evans polynomial (as implemented in the DEM Surface Tools extension to ArcGIS). Profile curvature can be equated to the flow of water across a given surface recording where the flow would accelerate (convex) or slow (concave) as it traverses a given cell. This, I felt, best captured the shoulder properties I was interested in, though in practice General Curvature could equally be applied (compare figures in Jenness 2012).

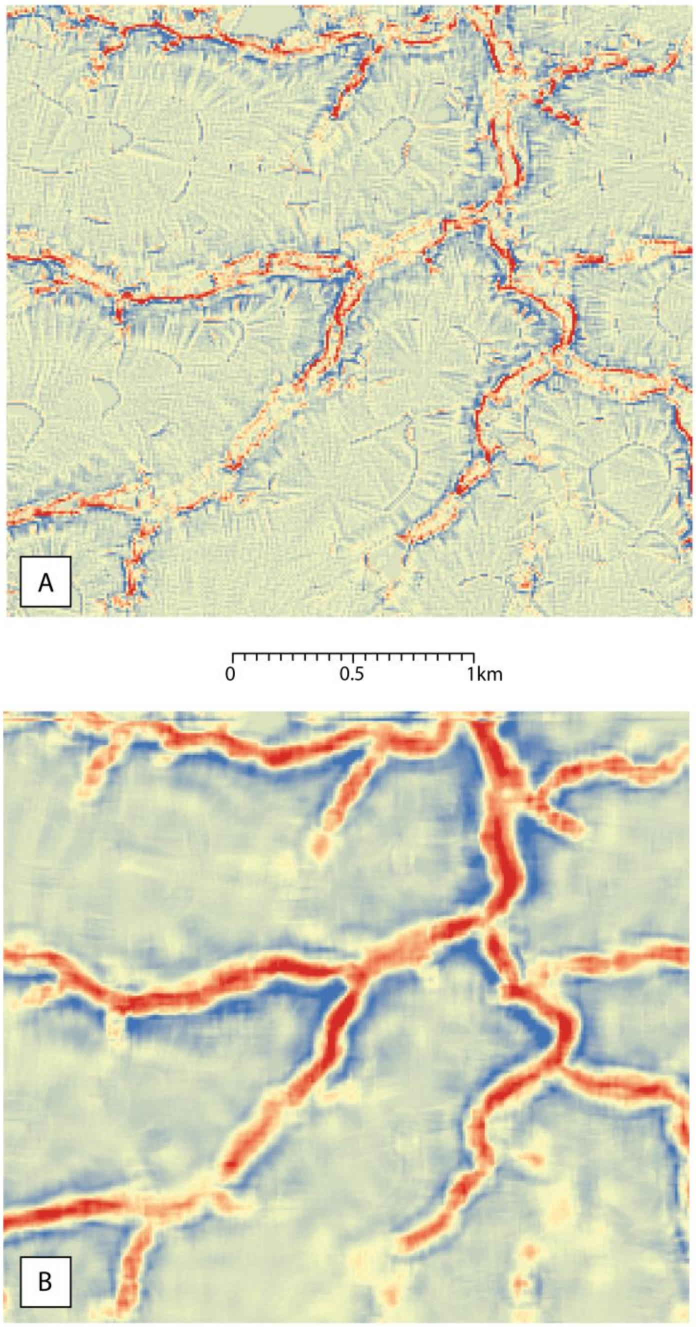

Figure 2 – the impact of DEM smoothing on the calculation of curvature (red = concave; blue = convex).

It rapidly became clear that curvature determinations on the original 10m resolution DEM were badly affected by artefacts in the dataset (most obviously the contours that had been interpolated to generate the DEM – see Figure 2a) [3]. As a result, prior to analysis the DEM was smoothed using focal statistics with a 5 cell window, the latter decided on the basis of trial and error in seeking to achieve a balance between too much and too little smoothing (Figure 2b). Profile curvature was then extracted, the resulting raster layer successfully encoding the gentle doming of the plateau tops as well as the more pronounced shoulder zones marking areas of maximum convexity. Quartile values for the curvature layer were calculated in R and reclassification carried out in order to create a mask of areas falling within the lower quartile (convexity in Profile curvature being marked by negative values). This was the first ingredient in the liminal layer (Figure 3).

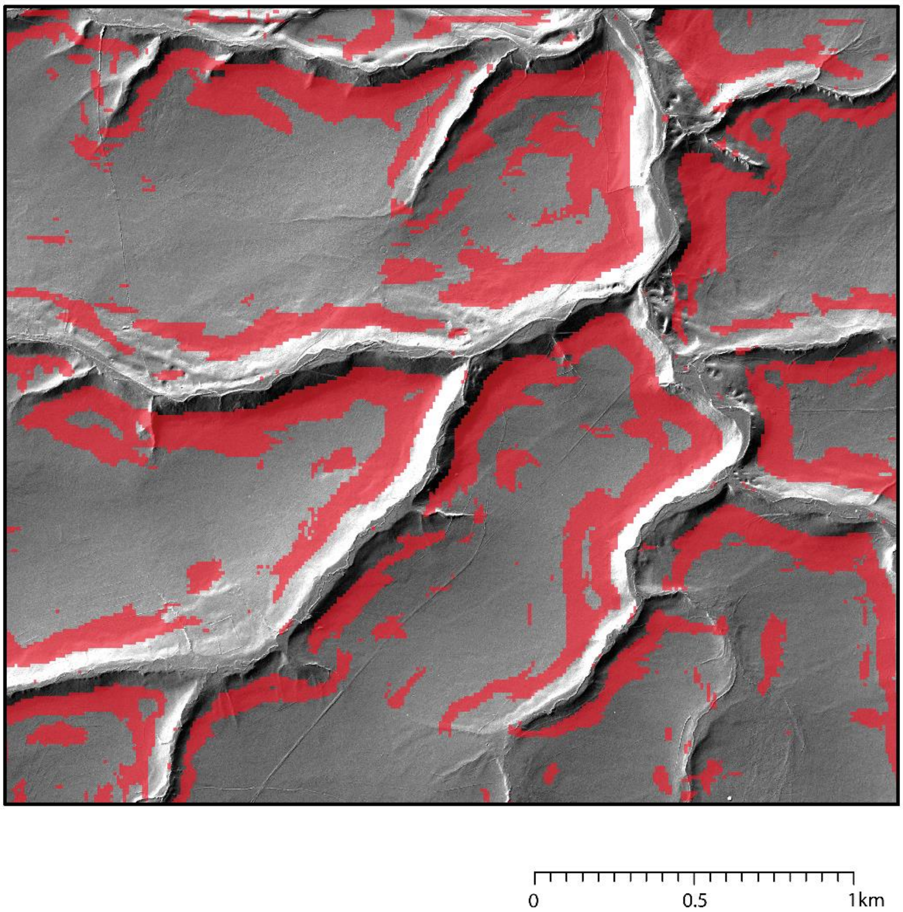

Figure 3 – 'shoulder' areas defined by curvature.

The second key ingredient involved viewsheds; identifying those parts of the landscape that had a visual connection to both landscape zones which in turn required careful delineation of 'plateau tops' and 'coombe bottoms'. Whilst this could be addressed through curvature or multiscale surface characterisation (e.g. Wood 2009) in the current analysis slope was derived from the smoothed DEM and reclassified to identify flatter areas of the landscape (in practice those with a slope value of less than 5 degrees).

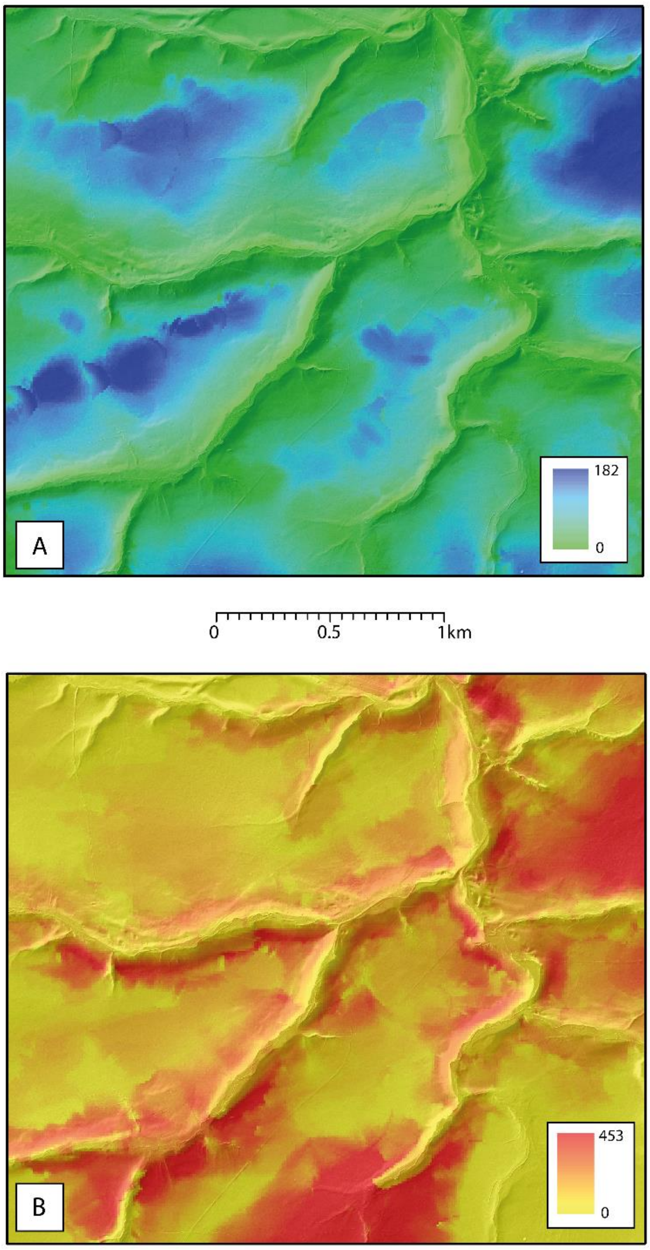

Figure 4 – cumulative views of the plateaus (A) and coombes (B) – in each case the values indicate frequency of view.

The result was a series of raster regions that could be combined with elevation in order to distinguish higher flattish zones (plateau tops) from low ones (the coombe bottoms). These raster zones were then converted into a 10 x 10m grid of vector viewing points corresponding to the centres of the raster cells – 28,385 plateau points and 2,576 coombe. Cumulative viewsheds were then generated for each discrete set of points (placing 1.65m high observers at each cell location in the study area to ensure views-to were being calculated[4]) that encoded how frequently plateau or combe locations could be seen (Figure 4). The two zones were then normalised to values ranging from 0 to 1 and the coombe cumulative viewshed subtracted from the plateau to generate the final viewshed product. Here negative values (red) indicate a dominant coombe aspect to the shared view and positive (green) an emphasis upon the plateaus. Values around zero (orange-yellow in Figure 5) indicate more balanced views. Map algebra was also carried out in order to identify areas without any overlap at all to ensure that these false '0' values were not confused with the above (hatched in Figure 5).

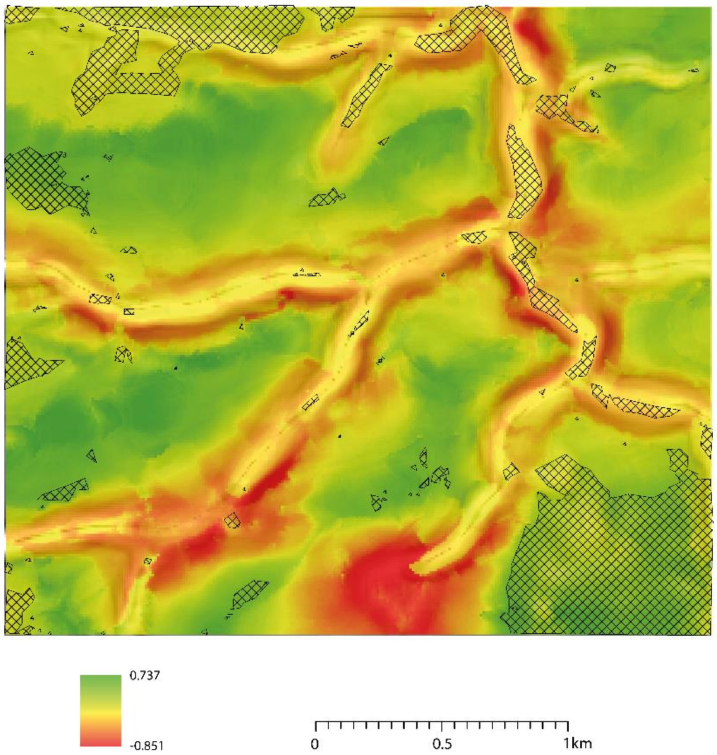

Figure 5 – visual liminality (negative values indicate views dominated by coombe and positive values plateau; the hatched areas are those where no visual overlap was observed)

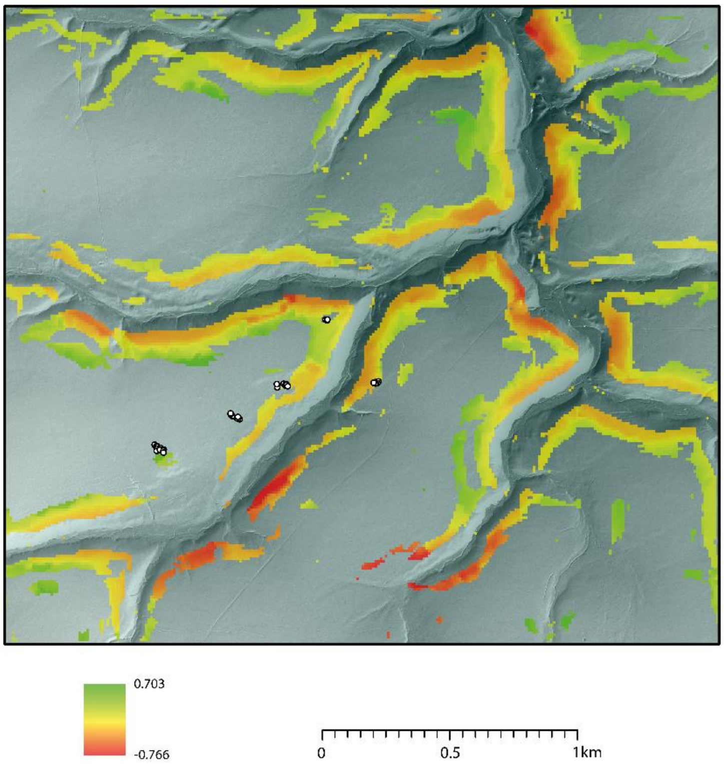

Figure 6 – liminality (the dots indicate the locations of prehistoric standing stone monuments)

The final stage was to use map algebra to combine the two sets of results in order to highlight areas which both felt and looked liminal with regard to the plateaus and coombes (Figure 6). When compared to the location of the prehistoric monuments it is interesting to note that the latter consistently fall adjacent to but outside of the mapped liminal zones, in some cases occupying small pockets of ground that are defiantly not liminal according to the definitions that have informed the current analysis. They seem to have been directly accessible from these in-between zones but not part of them (Figure 7). This is clearly something that warrants further sustained investigation and to do this I will be able to draw upon other elements of the geodatabase (see invisibility and concealment layers discussed in Gillings 2015a) to begin the process of folding the newly created 'liminality' data into a host of other assemblages[5]. The layer has also been converted to Google Earth format (see attached KML file) so that other researchers and fieldworkers can take a look and even use it in order to navigate this part of Exmoor; returning it to the landscape and walking along and within the mapped liminal zones.

5. Conclusion

One of the strengths of an assemblage-based approach is how it stresses the inherent relationality, contingency and emergent qualities of the data layers we generate – whether distribution maps, predictive models, or, as has been discussed here, viewsheds. We can see the resultant 'liminality' layer as an end-product; one more discrete data layer in the file geodatabase. We can also see it as encoding a static landscape metric; an ingredient that in due course can be combined with other such ingredients in order to produce a model – another static end-product. Alternatively we can see it as the highly contingent mapping of a profoundly relational engagement; a specific assemblage emerging out of fieldwork, digital data, the science of geomorphometry, the ethnography of van Gennep, the ArcGIS toolbox, trial and error, the Python programming language, insights gained from teasing other such assemblages into being, the possibilities afforded by the digital environment within which it has been created and so on (Barad 2007). Rather than done, its work is just beginning, as the layer itself enters a host of new relationships as it is drawn into the ongoing processes of interpretation and interrogation. This is a layer that can be folded – or may indeed fold itself - into new assemblages within the confines of the spatial database of which it is now part. But it is also a layer that can be quite literally taken for a walk, entering wholly new spheres of relational engagement as it is taken into the field and used to encourage wholly new physical engagements between the fieldworker and landscape. It can also exert its own agentive presence by taking *us* for a walk, through provoking and encouraging certain reactions and responses[6]. The GIS, and the spatial database that lies at its heart, produce the creative space needed in order to do this.

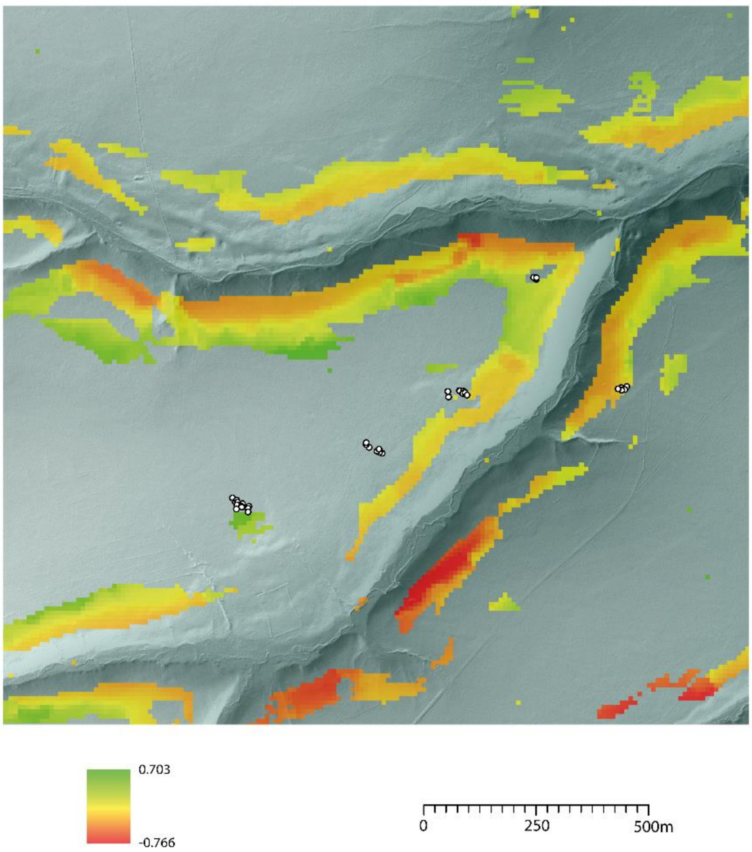

Figure 7 – relationship between sites and liminal zone

To return to the concerns that prompted this paper, I have a nagging sense that we could, and should be doing more with viewsheds and that these problems are less to do with ever more refinement of the viewsheds we produce - their quantity or the speed and with which we generate them - and everything to do with why we generate them in the first place. This is not to deny the considerable body of original, insightful and stimulating work that has been (and continues to be) carried out with regard to visibility analyses (e.g. Wheatley 1995; Llobera 2003; Eve and Crema 2014; Bernardini et al. 2013; Lake and Ortega 2013 to name but a few). Nor is it to claim that researchers have not begun to explore the ways in which viewsheds can be folded into other analytical procedures in order to enrich and extend them, for example using of viewsheds as a form of perceptual friction in the establishment of cost-surfaces (Lee and Stucky 1998; Lock et al. 2014). It is merely to note the lack of any coherent, and persuasive theoretical rationale for generating and analysing viewsheds that has stymied innovation or prevented those innovations that have taken place from gaining traction. This has inevitably resulted in a situation where history is repeating itself (albeit masked by a confusing set of labels). The challenge we face with viewshed analysis is to start doing something thought-provoking and stimulating with it and if we continue to restrict ourselves to the playbooks of landscape phenomenology and cultural ecology this will become increasingly harder to effect. I have argued here that with its explicit emphasis upon relationality, motley and emergence, the *chapbook* offered by assemblage theory may offer a different way forward for thinking about what viewsheds are and how we might begin to draw creatively upon them. To this end recent work on the concept of the relational field, as a dynamic web of relationships, may serve as a model for the type of data layer we should be striving to create (Baires et al. 2013)

Whilst the assemblage-based approach followed here may seem to some to be little more than an issue of semantics, it does encourage a radically different approach to not only viewsheds, but the role of GIS in archaeological enquiry. To conclude, we are fortunate to be working during a period of intense and productive theoretical development, as researchers begin to explore and negotiate the many and diverse strands of thought that fall within the ambit of what has been termed the New Materialism (Witmore 2014; Thomas 2015). Rather than seek solace in phenomenology or cultural ecology, or worse wait to ride the coat-tails of these new developments, the GIS community has the unique chance to fully engage from the outset. In this way we can play a dynamic role in forging new conceptual frameworks for GIS analysis; frameworks that will enable us to realise as yet unsuspected potentials and possibilities in the data and tools we assemble.

Endnotes

[1] A key plank in the argument that is developed in this paper is that GIS practitioners have an enormous amount to gain by engaging directly with theoretical ideas (rather than working with particular – and inevitably partial – readings of such). As a result the discussion of relationality/assemblage included here is merely intended to highlight the existence of this theoretical work; note the crucial emphasis it places upon notions of flow, emergence and relationality; and to provide interested readers with a clear and detailed set of references so that they can further pursue these themes.

[2] I am indebted to Steve Stead for this important insight (and for raising the possibility of not only tracking but also mapping the developmental steps involved in the creation of a GIS data layer) in order to better understand what Lucas has termed the residues of prior assemblages, that any object (e.g. data layer) brings to the new assemblages it participates in (Lucas 2012: 204).

[3] All of the raster layers used in the analyses comprise Ordnance Survey Landform Profile DTM data which has a 10m horizontal resolution and a vertical accuracy of +/- 2.5m. It is interpolated from 5m interval contour data taken from 1:10,00 scale mapping (Ordnance Survey 2012). © Crown copyright and database right 2015.

[4] Given the earlier discussion, I fully acknowledge the irony of then populating *my* landscape with precisely the same nameless, standardised entities I railed against earlier. In hindsight I should have at the very least generated probable viewsheds for each viewpoint (i.e. based on a range of viewer heights) and combined those.

[5] Looking beyond my own current work, there are a host of types of analysis (each involving its own particular assemblages) that the liminality result could be brought into dialogue with. Two examples, mapping directly onto established forms of GIS analysis, concern movement and locational preference. Looking to the first, the fact that the sites are consistently adjacent to the liminal band could suggest that it represented a channel of preferential movement. As a result, it could be factored as a beneficial friction in the creation of a cost surface (and any least-cost pathways derived from it). Second, it could be used as a variable in a predictive or total landscape model (e.g. Brouwer Berg 2013). If we know that sites preferentially cluster on the very edges of these liminal zones we could create buffer strips around the edges and incorporate the latter into such formal models.

[6] I am indebted to Emily Banfield for this observation.

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