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Place: The Physical Embodiment of Collective Information

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Abstract

Many classic landscape archaeology studies use GIS tools to create a 'god's-eye' perspective, where the images they produce are views from above the landscape looking down, like 2D-maps or viewsheds. Instead, this work uses software applications that recreate contexts from an individual's field of view. These are seen as investigative aids for examining archaeological problems about people rather than just illustrating newly gained knowledge from serious scientific investigations. The first application (*Horizon*) uses topographic data and 3D-rendering techniques to create landscape views with visual depth. The second application, *Stellarium*, allows us to insert new forms of output from *Horizon* as well as high resolution panoramic photographs taken at archaeological sites. This paper demonstrates the new informative digital outputs and their interpretive uses.

Keywords: visualisation, panoramic visions, place, *Horizon*, *Stellarium*

Introduction

Many classic landscape archaeology studies use GIS tools to create a 'god's-eye' perspective, where the images they produce are views from above the landscape looking down, like 2D-maps or viewsheds. By contrast, this project is inspired by 'individual immersion models'. These are tools used to recreate contexts from an individual's field of view, the 'point of view' perspective or 'egocentric' frame of reference (Higginbottom in preparation). These are seen as investigative aids for examining archaeological problems about people (Hermon 2008), and have been shown to be a more applicable way to discover something about the way landscape was used. This is done by recreating contexts from the point of view of people, rather than only "illustrating knowledge already gained once serious scientific investigations have been concluded" (Forte 2008: 22). Specifically, these software applications allow us to visualise how the sky and landscape appeared together to people in the past, viewed from any chosen point in a real landscape. The first application, *Horizon*, developed by Andrew G. K. Smith, uses topographic data and 3D-rendering techniques to create landscape views with visual depth (Smith 2013). The second application, *Stellarium* (Chéreau 2016) allows us to insert outputs from *Horizon* as well as high resolution panoramic photographs taken at archaeological sites. Significantly, both of these applications offer visual investigatory tools of the day and night skies combined with real landscape information. We applied this newest approach to case-study sites recently visited in Scotland on the isle of Mull. In this paper, we focus upon the digital methods and tools used for this extension of our project. By creating a number of land-skyscape models this paper endeavours to further understand the reasons behind erecting standing stone monuments and what was special about the locations in which we find such monuments.

Background

From the Late Neolithic onwards in Europe and the British Isles, regardless of the actual differences in dates, a form of megalithic structure that was essentially fully exposed and open to public view appeared (Bradley 1998; Burl 1993; Richards 2013). These standing stones appeared on their own or with other monuments. The variety of accompanying and associated monuments is great, including megalithic tombs, cairns, cists and earthworks (Bradley 2012; Burl 2000), and their forms are often well-known and/or regionally defined (Barnatt 1989; Brophy et al. 2013; Burl 1993, 2000; Richards 2013). The dates of the accompanying monuments are various, being built before, at the same time as, or after the standing stones. In Higginbottom (in press) it is argued that *the enwrapping horizon is a crucial factor* in the locational positioning of standing stones. The horizon, then, along with the megaliths, are all part of the creation and designation of place. This occurs through the enclosure and demarcation of visual space, creating close and far away views. This is related to Bradley and Richards' notions about stone circles and henges and their connections to nature. In his *Significance of Monuments*, Bradley (1998: 116-131) specifically argues that stone circles were created with links to the wider landscape, in contrast to the earlier henges, the circular mounds of which would have restricted visibility. Richards' himself, offering an example, states that "[the Deepdale stones'] situation on the downward slopes, effectively 'within' the confines of the surrounding hills, recreates the image presented by the stone circles within the henge. Here monument and landscape fuse in a series of transformations involving concentric order and representation of the natural world" (Richards 1996: 203).

The work in this paper concentrates on architecturally simpler standing stones sites, like single standing stones, stone pairs, short stone rows and small circles found in western Scotland. The original project was designed to unearth the locational choices of their builders, the reasons behind these choices, and what these reveal about the belief systems of these societies.

To date, through the application of *Horizon* only, this project has discovered a quantity and persistence of two land-skyscape patterns at sites across western Scotland on the mainland and the Inner Hebrides. One pattern contains sites that have the closest and relatively highest horizons in the north. These are referred to as 'classic sites' because that was the first pattern recognized. This was the only pattern found on Coll and Tiree during the beginning of the landscape investigations (Higginbottom 2003; Higginbottom, G, Smith, A G K & Tonner, P 2015: 630-36). The second pattern has the closest and relatively highest horizons in the south. They are simply called 'reverse sites'. What is intriguing, is that these two patterns exist whether the sites are rows, pairs or single slabs or menhirs, or even small, low circles like Hough (CT7; Higginbottom 2015: 627). Further, as well as Coll and Tiree, such patterns have also been found to exist at likely Bronze Age sites on Mull and Argyll (Higginbottom in press; in preparation). More specifically, those sites with close horizons in the north, will have their most distant horizons in the south and vice versa for the reverse sites. Most importantly, it was repeatedly found across these regions, that the same astronomical phenomena could be seen to rise out of and set into the dominant mountains, hills or points, found in the same general compass directions at each monument (Figure 1). On top of this, it was statistically verified that the monument orientations towards these astronomical phenomena were not likely due to chance (Higginbottom et al. 2000). These analyses of orientation data supported an interest in the Moon at its most extreme rising and setting points that occurs every 18.6 years, both in the southerly and northerly directions, as well as the Sun at the winter solstice (WS) and around the midpoint between the solstices (Higginbottom et al. 2000).

Together, this evidence so far points towards ***consistent*** opinions ***about where and how to erect a standing stone monument***. The wide-spread application of these opinions indicates that something other than personal experience is at work. Or to put it another way, that the sum of such person-centred views typifies and illustrates the social or cultural view of a group or groups of people who erected standing stones.

The next step in understanding this creation of places through the locations and alignment of standing stones, was to determine the details of what people could actually see when standing at the monuments, concentrating on how astronomical bodies acted and specifically how the movements of the Sun and the Moon played out against the sky. Notably, for this, it

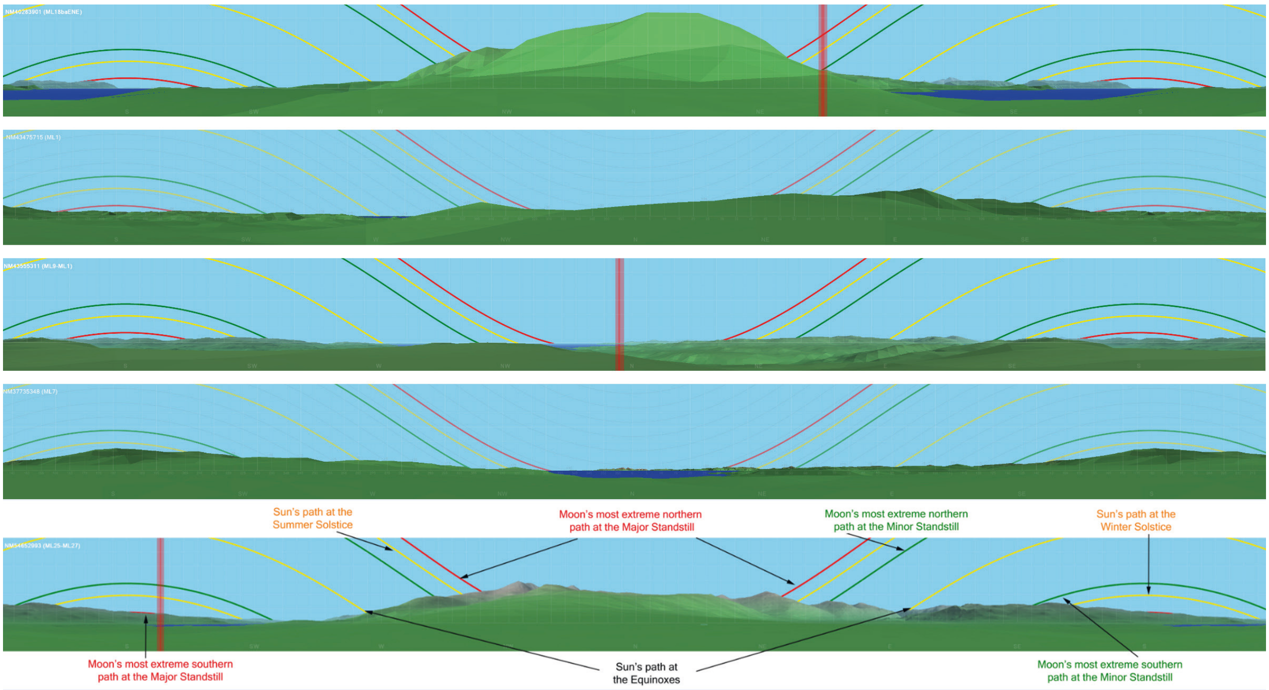

Figure 1. Examples of the two land-skyscape patterns found at sites across western Scotland. The top two and the bottom one are classic sites (Cragaig, Glengorm and Uluvalt), the third and fourth are reverse sites (Maol Mor and Cillchriosd). Each image also shows the representations of curved paths of particular celestial bodies seen from the location of the monument using coloured lines. The site of Uluvalt contains labels explaining which celestial path each line represents.

was important to know how the paths and phases of the Sun and Moon interacted, for the Moon's path is always within 5o of the Sun's path, and views of one affects the other, especially in terms of lighting and location. Whilst knowing such things provides more vital information on the visual experience of natural places, *comprehending* the visual experiences of each site requires more than this type of data. In the interests of greater comprehension and the communication of these things to others, creating a *narrative of first-person visual experiences* was chosen. It was found that using a narrative-based approach created revelatory texts and personal insight into the visions of the past. For example:

> It is summer … I can see that the differences between Sun's (and Moon's) rising and setting positions along the horizon are getting less and less each day. I now know that the great event of the summer Sun approaches, the summer solstice. Soft light is now continuous through the night and after the Sun drops below the horizon it is still light enough to carry out ordinary activities outside our family's dwelling for some hours. At this time, some of us travel to our designated place on our clan's western isle, to Gruline. At this place, we divide: some stand with the eternal Witness stone closest to sea (stone ML 16a), (some) with the mountain Witness stone (stone ML16b) and others stand nearby … On the marked day, all of us can see the Sun rising in the north-east and, with this, morning twilight passes. Those of us standing with the Witness of the Mountain (stone ML16b) can see the Sun *rise out of the dominant northern mountain chain and run along its edges for a short while* … As time goes by, … we later turn to face the west and northwards again to watch the Sun set *into the dominant range in the northwest*. However, it is only those of us standing with the Mountain Witness that are clearly directed *towards* the exact and appropriate setting position of the summer solstice Sun … by … the line that runs between the Witnesses of the Mountain and the Sea extending beyond the sea itself towards *the precise hilltop upon which the Sun will set* … (Higginbottom in press; technical corrections added here since draft of 'in press' paper, submitted and uploaded online to academia.edu).

We know, too, that the Sun and Moon's movements just below the horizon created various sky-light changes and glows and were clearly important parts of the visual landscape, though it is not really possible to comprehend exactly how they were seen or understood. It was further suggested that even these bodies' actions below the horizon were hypothesized by the builders of the monuments and the contrasts between that which was above and that which was below the Earth were relevant, primarily in terms of the concepts of nadir and zenith (Higginbottom in press). We will see that some of these unknown light qualities were clarified by our application of the digital tools below.

Digital Tools Used

For our reconstructions we use a combination of digital tools:

1. *Image Composite Editor*, a program to create panoramic (3600) images from sets of digital photographs (Microsoft Research Computational Photography Group 2015)

2. *Horizon*, which uses topographic and astronomical data along with 3D-rendering techniques to create landscape views with visual depth. Created by Andrew G. K. Smith of the University of Adelaide (Smith 2013).

3. *Google Earth* (Google Inc. 2017). Created by Keyhole, Inc. and further developed by Google Inc., it is essentially a navigable 3D GIS rendition of earth.

4. *Stellarium* (Chéreau 2016; Gates et al. 2016), a public domain astronomy software package that allows viewing day and night skies as observed from a given location on a particular date at a given time.

Image Composite Editor (ICE)

The procedure for creating panoramic photographs for each case-study monument runs as follows: first, a series of approximately 24 digital photographs is made at the site, spanning a full circle (camera: Olympus E-600, tripod equipped with a CamRanger turntable). The height of the camera was 1.50 meter above the ground, 2 meters from the standing stone in the direction of the alignment of the stone (if visually detectable). The series is stitched using ICE (version 2.0.3.0), resulting in panoramic images with a size of approximately 12.5 MB (22000x3000 pixels).

Horizon

The software was named *Horizon* after its original ability to calculate horizon profiles. Its primary aim is to combine topographical data with atmospheric and astronomical calculations to produce accurate three-dimensional landscape information to aid archaeoastronomical surveys and data analysis (Smith 2013). The two major functions of the *Horizon* software are 2D horizon profiles and 3D panoramas.

The horizon profiles are the apparent elevation of the horizon for a hypothetical observer located at a specified point within the landscape, sampled at regular intervals in azimuth around the full horizon, where the horizon is defined as the point with the greatest elevation in a given direction, which an observer would be able to see. Outputs of *Horizon* can be used for further analysis, which includes calculations of the distance and direction between the point of origin to all points on the horizon and the altitude of each of these horizon points.

The panoramas are rendered pictures covering a full 360 degrees from the viewpoint of an observer who is, as with the horizon profiles, located at a specified point within the landscape. Apart from the location, *Horizon* allows you to choose epochs, astronomical phenomena and dates far back in time. The results are far from photo-realistic, but they are ideal for visualising the topography of the landscape (Smith 2013: 5). Onto these landscapes are mapped the paths of astronomical phenomena like the sun on the longest day and the shortest day and those of the Moon at the times of its most extreme rising and setting points in its cycle. Relevantly, you can choose specific dates and time for the plotting of the paths of the Sun, Moon and even stars.

Google Earth

Through Google Earth one can view much of the earth in 3D. Google Earth produces landscape images of a somewhat less abstract nature than *Horizon*. Whilst the elevation data is not as accurate as that used with *Horizon* (see 'Data' below), it still produces some good basic visual models of landscape views. Its data includes elevation data including Shuttle Radar Topography Mission data, bathymetry data, as well as satellite and aerial images.

It is possible to use Google Earth to create 360-degree panoramic images from a location on Earth. Once you have chosen a location and are viewing it from 'above the Earth', you can 'zoom down' very close to the actual surface. When zooming in on such a point, Google Earth will automatically switch to 'horizontal view mode' so that you can create the panoramic images.

Taking screenshots at the chosen location every 150 results in a series of 24 images which are processed with ICE in the same manner as the digital photographs. This produces a final composite image of about 7500x900 pixels. The vertical height of the Google Earth images depends on the automatic switch and is more or less within a range of 50 m, but difficult to reproduce.

Stellarium

In its most basic form this astronomy software package enables one to view the night and day sky from any location on Earth (as well as bodies in our solar system). Essentially it renders 3D photo-realistic skies in real time, giving the option of choosing location, date and time. It is possible to pan around the landscape or to alter the field of view in terms of the amount of the horizon and sky that are seen.

Although most *Stellarium* parameters have mainly astronomical relevance, with *Stellarium* version 0.10.6 or later, the default landscape can be replaced. This feature enables the user to associate a specific panoramic image of a place with its set of geographical coordinates (i.e. the position from which the panoramic photograph was taken). When these coordinates are chosen, *Stellarium* will then show views of the sky combined with this panoramic image, resulting in a dynamic view with sunrise, sunset and night sky for the specific date and time chosen.

Most strikingly, the use of *Stellarium* can turn the whole observation exercise into an almost cinematographic experience through its video-like animation and 'frame rate' options. These create moving heavens over the landscapes from the point of *real time* motion to faster time frames, allowing to pick-up patterns of movement of astronomical phenomena more readily.

Stellarium supports several methods for describing landscapes. However, the *Stellarium* Dialog in *Horizon* currently only supports the Single Panorama (or spherical) method to export compatible 2D horizon profiles and 3D panoramas.

Combining Data and Software Outputs

What the current authors have done is to create a single comparative image for each site. This was done by stacking the 3D panoramas from *Horizon*, the panoramic photographs taken at standing stone monuments and the Google Earth panoramas, one under the other (Figure 2).

These simple stacked panoramas were much more informative overall as clear, easy comparisons and considerations could be made. Importantly, it was possible to line them up quite well in the horizontal axes, despite some minor differences in landscape feature placement.

The major underlying benefit of the 3D panorama models is that the shape of the horizon and the topography of the landscape can be seen all the way around the site, something photographs can rarely do, either due to tree or cloud cover. Overall, then, including a comparative 3D panorama is particularly useful when research requires detailed horizon or topographic detail. Further, it is likely that much of Mull was covered in open forest and that the horizons could be seen in the Neolithic and Bronze Ages (Tipping *pers. comm*. 2015, in relation to his work Tipping 1994)

However, the photographs are essential to understand something of the natural aesthetics of a place. The photographs give a sense of human scale and a comprehension of this, even though this is a panorama and does not represent an immediate human field of view. This is due to our general familiarity with objects (trees, fences, walls) in the photograph, as well as the objects allowing for height comparisons and possibly depth considerations (Kaufman and Kaufman 2000), letting us understand something of the scale of the place.

The second step involved the creation of 3D pan-

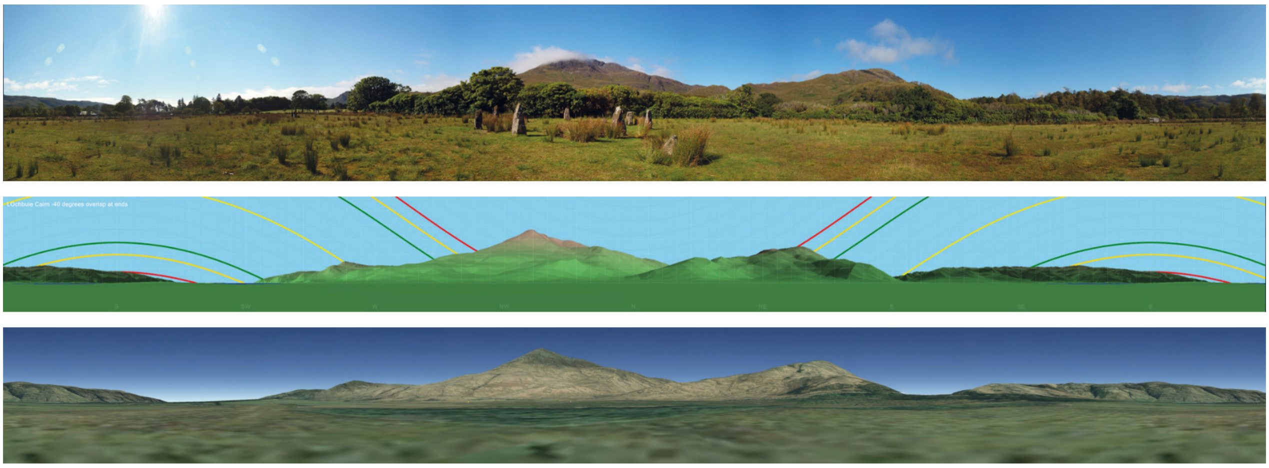

Figure 2. An example of stacking landscapes from different software outputs for cross-comparison purposes. This site is the stone circle of Lochbuie, Mull.

orama files in *Horizon* that work with the spherical projections in *Stellarium*, as well as the creation of panorama landscape photographs, from a series of photographs using ICE. Various conversion processes were required for their use in *Stellarium*. The panoramas, originally jpg format, had to be converted to png format because the upper part of the image must be transparent in order to show the sky from *Stellarium*, a feature that the jpg format does not offer. Standard photo processing software was used to do this, including the required scaling and aligning. These two digital outputs, then, allowed for two types of integrations with *Stellarium* – one a 3D digital model and the other a photographic capture of landscape.

Without a doubt, the import of panoramas into, and the running of, *Stellarium*, has transformed our understanding as researchers of place. Whilst *Horizon* can now produce stills of night skies on particular dates and at specific times, through *Stellarium* we can more fully comprehend what could actually be seen from these monuments with its moving pastiche of 24-hour skies that roll on continuously from one day to the next, in slow motion or real or accelerated time.

Having already gathered visual information from a combination of astronomical knowledge, the alignments of the standing stones and using the 3D landscapes, along with narrative, we already knew something of what could be seen at sites on Mull and other places in western Scotland in the past. With this combination we concentrated on the Sun and Moon (Higginbottom in preparation, in press; Higginbottom et al. 2015). Whilst our focus has remained on these bodies, the lightening effects in the sky and upon the land are much more fully realised by using *Stellarium* and even the paths of other highly visible celestial phenomena come into play.

Results

We will now describe and discuss what was actually seen in *Stellarium* at sites on Mull using example sites to demonstrate consistent or specific phenomena observed. This will be done via screen grabs that record screen animation, as *Stellarium* does not have any output capacity. Please note that the views we describe are at the times of the WS or summer solstice (SS) for 1500 BC, seasonal times of interest that were confirmed as relevant through previous research (Higginbottom 2003; Higginbottom et al. 2015; Ruggles 1984), but we could have chosen other times. The epoch of 1500 BC is in-line for the earliest dates of simple standing stone sites such as these in Scotland.

One of the most visually intriguing shared visions to be found at sites through *Stellarium* is the way prominent features on the horizon are backlit from the Sun just prior to rising or just after setting at the solstices, this is more prominent at the SS. More striking at some sites than others, this back lighting causes the entire horizon about prominent or distinct topographic forms at the ordinal directions of the northeast, northwest, southeast, southwest to glow, setting up the horizon area in one direction 'at a time' as a focal point, in stark contrast with the rest of the darker landscape. Watching as the Sun slowly vanishes in the northwest at classic sites like Lochbuie and Uluvalt, the intensity of the halo increasing about the northwest mountain as night pulls in, is very striking (Figure 3). Relevantly, it has already been shown that that these distinct topographic features placed in ordinal directions around the standing stones is likely to be a deliberate consideration (Higginbottom in press, in preparation, Higginbottom et al. 2015). This is because, at the times of the Moon's most extreme rising and setting, and those of Sun, these same bodies are seen to rise out of and set into these ordinal features from the purview of the standing stones. Remembering, too, that the orientation of the monuments to these same rising and setting points are statistically supported (Higginbottom et al. 2000).

As the night of the solstice continues, and the Sun moves further below the horizon, the halo of light above the horizon almost vanishes, then there is soft glow evenly distributed at and either side of true north (Figure 4). At sites like Lochbuie and Uluvalt, this is accentuated by the fact that north has 'been positioned' in the middle of a dip between two significant single, or sets of, peaks, as viewed from the monument (Figs. 3 & 4); Poit na h-I has a distinct change in slope at north. Notably, when at north, the Sun is at its maximum distance below the horizon. As midnight passes we can see the amount of sunlight increase and as we move towards dawn the entire mountain or hill in the northeast is backlit, and the rest of the landscape is still relatively much darker as the mountain or hill takes pride of place as the visual focus. This is the feature out of which the SS Sun will rise.

Another shared vision involves the brightest group of stars in Ursa Major (UMa). At this epoch, these stars of Uma sat within the circumpolar region of the sky as they do today, never rising or setting. This means, that almost no matter where you are at these latitudes you will see them. They are arranged in a curving shepherd's crook (Figure 4). There are distinctive views of these stars that occur at the WS and SS when you are standing at a monument. For example, at midnight at the SS these stars are positioned as a group horizontally low in the sky in the north, with Merak, the second star in the chain from the 'right', immediately above true north (Figure 4). At the WS, UMa is directly overhead of the viewer, at the zenith, but the group of stars making up Ursa Minor (UMi) – also a shepherd's crook-like but small-

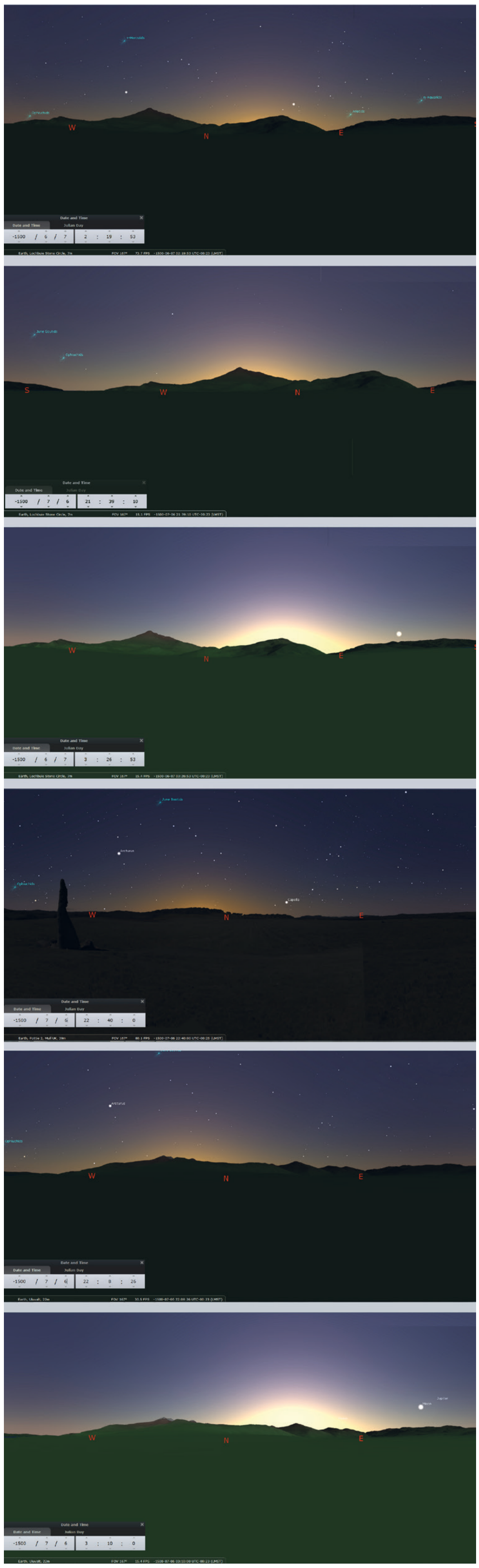

Figure 3. Illustrations of landscapes prior to sunrise and sunset at the summer solstice, where prominent features on the horizon are backlit from the Sun causing the entire horizon about prominent forms to glow. Sites names from top to bottom: the first three are from inside the circle of Lochbuie; the fourth is Poit na h-I. The last two show the highlighted mountain edges of Uluvalt. The Mercator projection in Stellarium was used for the creation of these images.

Figure 4. Striking instances of the sky lit at dead north. Note the dips in the horizon at North to accentuate light given out by the Sun at this time. The sites in order from top to bottom are: Uluvalt, Ardnacross, Poit na h-I, and Lochbuie.

Figure 5. Light and celestial displays at the reverse stone row site of Ardnacross (ML12) at the summer solstice as described in the main text.

Figure 6. Light and celestial displays at the site of Ardnacross at the winter solstice as described in the main text.

er, now sit low in the sky in same position that UMa occupies at the SS. At classics sites like Uluvalt and Lochbuie, this means that UMa phenomena at the SS will be located between the two prominent peaks of the northwest and northeast, which create a focal range. Other notable visions at the WS for all sites include the travels of Betelgeuse, where it sits right alongside or matches the Sun's path of the Equinox for this epoch. Similarly for Pollux, as it travels along the most extreme path of the Moon in the North. These travels can be seen for the entire period of 1550 to 1200 BC, which overlap those known dates for the erection of these simple standing-stone monuments.

As we can see from these examples, monument horizons shared particular traits affecting the shared views of the skies and the astronomical bodies. However, what *Stellarium* also demonstrated so well was how the individual nature of a site horizon would affect the overall astronomical show seen at each separate site: like what bodies are blocked in which direction and by which landscape and when. Therefore, these following examples are about the individuality of place within a shared system of collective information. As with the shared views above, these views are linked to particular epochs and times of the year. Due to the limits of space we will use just one example site, Ardnacross.

At midnight on the SS, as the Sun sits below the horizon at true north, the full Moon rises in the southeast slowly increasing the light of the midsummer night skies (Figure 5a). Standing two metres away from and in alignment with the southeast stone row, one can see this row *aligned to the Sun under the horizon* in the north *soon after midnight* (1:30 am; Figure 5b), the glow of the SS Sun's rays lights up the stone from behind. As the SS Sun rises higher towards the horizon in the northeast, more easterly, Venus has risen out of the slopes of the highest hill in the northeast (Figure 5c).

In the deep night of the WS, when the Sun is far below the horizon, the combined effect of dark skies and bright bodies in the sky is striking. A travelling full moon does little to diminish this night sky display whilst it is high in the sky, yet it is bright enough to lighten the landscape and the standing stones emerge from the darkness (Figure 6a). As the Sun then moves towards the horizon to rise in the southeast, the Moon moves towards the west-northwest to set and Capella sits at dead north (7:20 am; Figure 6b). Soon after this, the Sun rises out of a clear hill in the southeast. Standing in alignment with the stone row, this time looking south, *one is exactly aligned with the stones and the Sun as it sets at the WS*. Soon after the WS Sun has set (approximately 16:30), with the bright sun-rays remaining, Mars, Jupiter and Venus are heading westward, and the bright stars of Orion's belt rise in the east-southeast. At 16:40, and all at the same time, Mars sits above the cardinal point of south, Procyon sits above east and Altair sits directly west on the horizon itself. A little arc of stars line up with the arc at the top of the stone. Merak and Duhbe of UMa sit above the top of the stone, with much of UMa low in the sky at this time of day. Having such a number of prominent bright features close to the horizon draws the eye towards the horizon itself and when it is completely dark, at 17:30, Arcturus sits dead south and the full Moon rises in the northeast (Figure 6c). All this time UMa has been slowly turning and at 21:00, it sits vertically above the stone with the star Phecda of UMa sitting most centrally (Figure 6d; the projection for all these views, Mercator, has been used in order that both a higher and wider sky-view can be observed). The full Moon has lit up the land. These distinct views at an individual site occur at the same times as all of the other *shared visions* described earlier. Here we are seeing the marking out of the land and the marking out of astronomical phenomena. These inextricably linked goals create very specific visual effects.

Conclusion

This work explicitly uses the interaction and navigation of the spatial, temporal and thematic components of archaeological data to demonstrate how visualisation facilitates deeper insights into archaeological phenomena. The combined effect of these programs is to integrate quantitative capabilities along with different forms of visual interrogation. Whilst *Horizon* does not yet have photo-realistic visuals and time-lapse frame-by-frame animation, it has several advantages over *Stellarium*, including output facilities for data and images. On the other hand, *Stellarium* has allowed us to see visions in the landscape that are clearly linked to these latitudes and more narrowly, specific sites. For each monument horizon, whilst we already know them to strongly share some values in terms of general shape and the positions of the rising and setting Sun and Moon, are at different relative altitudes and not always in the exact same place. For those who have no or little knowledge of astronomy, and, therefore cannot imagine how the Sun and Moon's paths and cycles interact to create a narrative as that found in Higginbottom et al. 2015, *Stellarium* is invaluable.

The important thing, though, is not to apply *Stellarium* to one site and make conclusions about possible astronomical connections, without having done research into probable patterns with more certain data, such as the orientations of the same groups of site types, for instance. Otherwise, naturally, conclusions arising from the former approach will not be sound.

Through our use of new tools and our new use of available software we have come to a greater understanding of place as it was seen and experienced more than three millennia ago. The views of some of these natural phenomena may well have occurred by 'chance', that is they were not easily blocked out by a horizon as they were so high in the sky (such as the view of UMa). However, the fact that the monuments were located in areas that gave them clear views of skies in various directions meant these sights would be included; they clearly weren't located in crevices or narrow, steep-sided valleys. Also, those phenomena at the cardinal points, like the sun glow evenly spread above due North at midnight at the SS, are much more likely to have been deliberately included through the choice of the height of horizons in these directions. We surmise this because we already know that monuments were aligned to particular phenomena on the horizon and that other stone monuments were also often set up with a north-south axis, like the circles of Callanish and Stenness (Higginbottom and Clay 2016a). Further, we can see that sites were chosen with mountains or hills either side of north and south or with the same straddling north or south, with north or south sitting roughly centrally (Higginbottom et al. 2015; Higginbottom and Clay 2016b; Figs. 1,3,4).

The knowledge contained in locating, cutting, working and moving stone, in the understanding of the day and night sky and how the Sun and Moon behave together over time, and the two millennia over which they were built, point to a great deal of collectively held knowledge and activity. Past people related *notions of time* to the locations of the planets and the stars, effectively dividing up, and connecting, the night and seasons, with place. There is a natural inter-dependency recognised by the builders. It seems, then, that standing stones are landmarks for people in the past (MacKie 1988). They embody information about the landscape as these people saw and understood it, and therefore information is specific to the local setting and may not be applicable to any other setting or location (Higginbottom et al. 2015: 632, 634, 636). Standing stones are thus proxies for a single point of view but are a constructed physical embodiment of complex collective information (Higginbottom et al. 2015: 632, 634, 637, 640), similar to other monumental sites (Atakuman 2014: 6, 19).

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