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TESTING LANDSCAPE AS CULTURAL EXPRESSION

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ABSTRACT

Traditional archaeological location modelling, whilst very informative about spatial patterns across a 2D spectrum, can be limited in its contribution to understanding human choice about location. On the other hand, projects combining statistical tests with models influenced by individual immersion techniques have a far better chance of understanding the choices people made in regards to place and confirming the likelihood of these apparent choices. In the past we have statistically tested and confirmed the likelihood that the points *on the horizon* as indicated by monument alignments as a regional group, were statistically different in terms of direction, altitude and distance from the monuments, compared to any other place on the surrounding visible horizon for monuments within particular regions. That is, the chosen points on the horizon indicated by the alignments do not appear to be random. We then tested the likelihood that monuments were erected with astronomy in mind in different locations across Scotland, using simpler standing stone monuments by region, and some complex monuments individually, like stone circles. We have also used 3D panoramas to view how things were seen at each site from the viewpoint of an individual. We have now created *new statistical approaches* to test different questions we might have of these panoramas. Most pertinently, we now have a test that can assess whether the two dominant horizon shapes found, which affect which astronomical bodies can be seen at these monuments, were likely chosen by their builders or if their shapes are likely determined by chance factors.

KEYWORDS: Landscape, Megaliths, Monuments, Astronomy, Horizons, GIS, Statistics

1. INTRODUCTION

This paper discusses the ways in which we have combined our visible models and new statistical approaches to help us better understand the locational choices made by prehistoric people. In this sense, this is a report on the ongoing improvements of our methodological approaches. Much of our work uses the computer program, *Horizon* (Smith, 2013). *Horizon* uses topographic, astronomical, and atmospheric data, along with information on human vision and 3D-rendering techniques, to create three main outputs: (i) 2-D, 360° visible horizon profiles, (ii) 360° models with visual topographic depth and layered astronomical information (3D panoramas), where a change in time accurately alters what can be seen astronomically, as well as the position of astronomical phenomenon in relation to the landscape and (iii) data files. These data files can contain data on the horizon shape only or the topography as a whole, surrounding a site. Such data outputs from *Horizon* contain some of the information used in our statistical tests in our broader project. For instance, when we were originally testing for a connection between the clustering in orientation of sites with an interest in viewing the horizon, we used data that contained information on the shape of the horizon only, expressed as a declination. Thus, when looking at those horizontal ranges or points *upon the horizon*, indicated by monument orientations, it was found for a number of separate regions across western Scotland that these indicated horizon areas were not due to chance (Figure 1). So this established that topographical places along the horizon itself were likely foci of monument orientations.

This was a graduated step in our overall assessment. Specifically, the *observed data* was made up of the declinations of the horizon 'points' in the direction indicated by the monument alignments. There were 276 declinations associated with the 276 alignments from 125 sites taken from Ruggles' 1984 study. These were divided by region such as Mull, Argyll and so forth (Figure 1 insert) and a declination distribution profile of observed data was created for each of these regions.

These files were then compared to the declination distribution profiles of the *expected data* that was created for each region by *Horizon*. These expected data provided information on the shape of the entire horizon at each monument in the study. *Horizon* created these files by extracting three pieces of information from the digital landscape data that we obtained from the Ordnance Survey, UK (Ordnance Survey 1:50 000 Landform PANORAMA map). Essentially the program extracted information every 0.01 of a degree for each 360° horizon. The pieces of information were: direction or azimuth (from 0.01 to 360°), the distance of the horizon from the site in the direction of each of these azimuths, and the elevation of the horizon in the direction of each azimuth, along with a calculated declination using these variables for each of these points. The number of files matched the number of site orientations; therefore some sites had more than one data file for the expected data. The declinations only were extracted from these files to make a new file for each location. These were then combined and the declinations averaged for each region so that now there was a single expected declination distribution for each region, with which to compare each regional observed declination distribution. Using the Kolmogorov–Smirnov test (K–S) to compare the expected and observed distributions revealed that, for the three regions of Mull with North Argyll, Coll and Tiree (Mull), Islay with Jura (Islay), and that of Argyll with Lorn (Argyll), the distributions of the indicated horizon declinations of site orientations were found to be statistically significant. The K-S test gave the following results: for Mull $p = 0.00817$ ($n = 25$ horizon distributions), Argyll $p = 0.00593$ ($n = 17$ horizon distributions), and Islay $p = 0.00105$ ($n = 25$ horizon distributions) (Higginbottom et al., 2000), where p is the probability that the observable distributions of the indicated horizon declinations found at our sites occur purely by chance. In each case, the probability that their occurrence was due to chance, then, is significantly low ($p < .01$). This tells us that for these regions the distribution of declinations found within each region are not due to chance. This was interpreted as an indicator of very particular locations being thoroughly searched for to create these places. We then used the azimuths and declinations of the original files to graph the observed and expected average profiles.

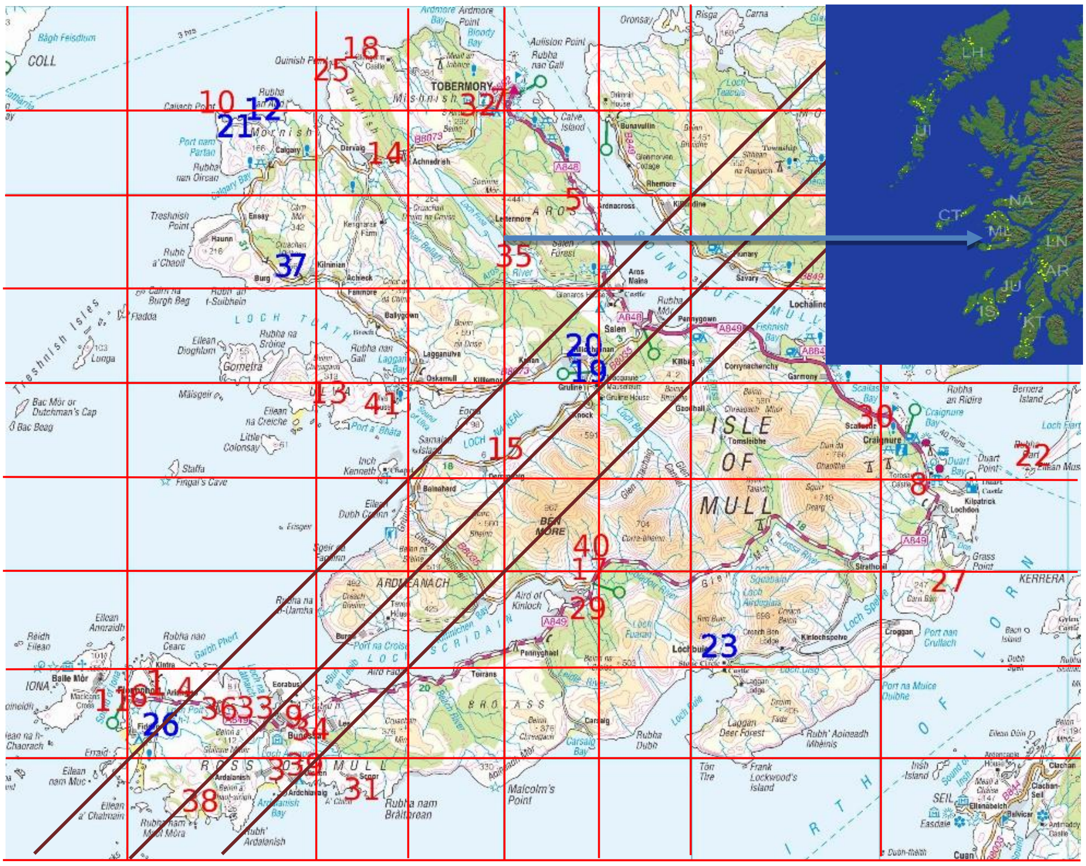

Figure 1. Map of the Isle of Mull with known sites & with inset of regions in western Scotland. Larger map adapted from 1:50.000 Ordnance Survey, UK Landranger Maps by Vincent Mom (site locations) and GH (author). One centimetre on the original map equals 50,000 centimetres (or 500 metres). The red lines highlight how we divided the latitude and longitude lines into half-degree intervals as part of our method (see 2. METHOD). The angled lines are examples of the direction of our numbered intervals, Each angles line was given an identifying letter. Where they crossed the junction of two red lines a number was added to the identifying letter. Map inset indicates where the Isle of Mull is located within western Scotland. Insert map legend: LH=Lewis&Harris; UI=North&South Uist; NA=North Argyll; LN=Lorn; AR=Argyll; ML=Mull; CT=Coll&Tiree; JU=Jura;IS=Islay; KT=Kintyre. For map inset: software and map created by Andrew Smith. Based upon the Ordnance Survey 1:50 000 Landform PANORAMA map with permission of the Controller of Her Majesty's Stationery Office © Crown Copyright.

Following from this, we produced statistical evidence for alignments to the Sun and the Moon across Mull, Argyll and Islay with Jura (Higginbottom et al., 2000). This led us to further query what else might be special about the visualscapes in which the monuments were found as a whole. In particular, *how* the landscape might be connected to viewing astronomical phenomena. To do this, we used Smith's *Horizon* software to create 3D panoramas for every monument at the sites within these same regions of Mull, Argyll and Islay as well as Kintyre. A close study of these regions' sites showed that there were two major landscapes that dominated, or indeed, were the only forms of landscapes that were seen at all the standing stone sites (Higginbottom, 2003; Higginbottom et al., 2015; Higginbottom, in press). It was determined via visual assessment and the examination of raw landscape data that approximately half the sites have the same landscape locational variables as those found on the isles of Coll and Tiree ('classic sites'; Higginbottom, 2003; Higginbottom et al., 2015) and the other half are the topographical reverse (simply referred to as 'reverse sites'; Higginbottom, in press). Specifically, these two general landscape patterns were horizon-based, where, for the first type (classic), the observed southern horizon from a monument is usually both lower in altitude and farther in distance than the northern (Figure 2) and for the second (reverse), the southern horizon is usually both closer in terms of distance and higher in altitude than the northern (Higginbottom and Clay, 2016 figure 2). So the differences are relative comparisons. Whilst it is true to say there is some variation within these two horizon types, for example it is occasionally found that a section of the northern horizon at a reverse site may appear to be approximately the same relative height as parts of the southern (that is their altitudes are similar), the general model holds (Higginbottom, in press). What is striking about these patterns is that not only are they holding true across regions but these types of actual landscapes seem to be directly connected to the type of astronomical phenomena that are also the focus of monument orientation. Thus, for instance, the general pattern at a classic site had the Moon at the times of the major and minor standstills at its northern extremes and the Sun at the summer solstice, rising and setting out of the dominant northern chains or single peaks in the NE and NW (Higginbottom et al., 2015; Higginbottom, in press).

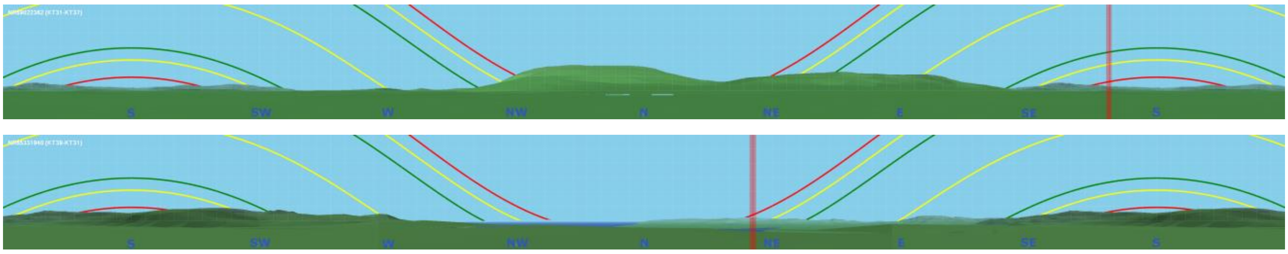

Figure 2. 3D renderings or panoramas of the landscape around a classic site (Craigs , KT31) and a reverse site (Mingary, KT39), along with the curved paths of the Sun & the Moon. The orange lines=Sun's path at the solstices; the yellow=the Sun's path at the equinox; the red lines=the Moon's path at the most extreme rising and setting points in the north & south (at the Major Standstill); the green=the Moon's path at the Minor standstill. The vertical redlines indicates horizon alignments. Both are intersite alignments. One from KT31 looking towards KT37 (Stewarton) and one from KT39 to KT31. Both alignments are on the Moon at the time of the major standstill. Software and 3D landscapes created by Andrew Smith. Note that the horizons are more than 360o; they wrap around for ease of viewing. The centre of the images are due north and due south is directly middle of the small red arc. Based upon the Ordnance Survey OS Terrain™ 50 DTM with permission of the Controller of Her Majesty's Stationery Office © Crown Copyright.

With so much evidence combined together across sites and regions we felt that such horizon shapes were deliberately selected. However, we had not tested specifically for this singular aspect. So to try to discern this particular kind of intentionality of horizon-shape choice, we asked 'are the landscape choices we are seeing - different to those found at random locations found in the same regions?'. In essence, we are only asking firstly about the two main shapes of the horizon profile to be found at the sites, the classic and reverse landscape shapes – not the interacting astronomical phenomena attached to these profiles.

2. METHOD

To find the answer to the above question, we created and applied a simple method, focusing on the Isle of Mull as our case-study area as an encapsulated geographical and topographical unit. We tested the location of 16 known sites in all, corresponding to the core sites of our initial landscape panorama study, which are labeled with red numerals in Figure 1. The remainder are sites more recently incorporated into our broader project. These 16 sites, and all of the orientation and location data, come from Ruggles' five-year field study in the late 1970s and into the early 1980s (Ruggles 1984). The sites were chosen according to very strict *a priori* criteria, such as those linked to the ruination-status of the site (Ruggles 1984 – all of his Chapter 2). Further, no circles from Mull were included in this initial data.

Having chosen our observed sites, we obtained a number of random site locations. We did this using an Ordnance Survey 1:50,000 Landranger map and dividing the latitude and longitude into half-degree intervals and labelling the points where the longitude and latitude overlapped, e.g. A1, A2 and so forth. Each longitude and latitude line that intersected became our random location (Figure 1). All locations found in water were eliminated from consideration. Horizon profiles were created for each of the remaining locations so that ultimately we could compare the observed (monument location) with the expected (random location) horizons by creating average distribution models of both groups.

Remember from above, that to compare the ´shape´ of a horizon profile of an individual location, we have to know the information about the points along the entire 360 degree horizon, where each horizon point is a record of the distance, direction and altitude of that point in relation to the viewing position (location). So, as for our observed locations, we extracted this information for every expected location every 0.01 degrees along the horizon, making 36,000 points for each profile. Again, each file also contained the calculated declination of each horizon point, which were later extracted to create a new file for each expected location. We then created declination distribution models of each location using these new files, where the declination values were mapped against the real horizon azimuths (Figure 3).

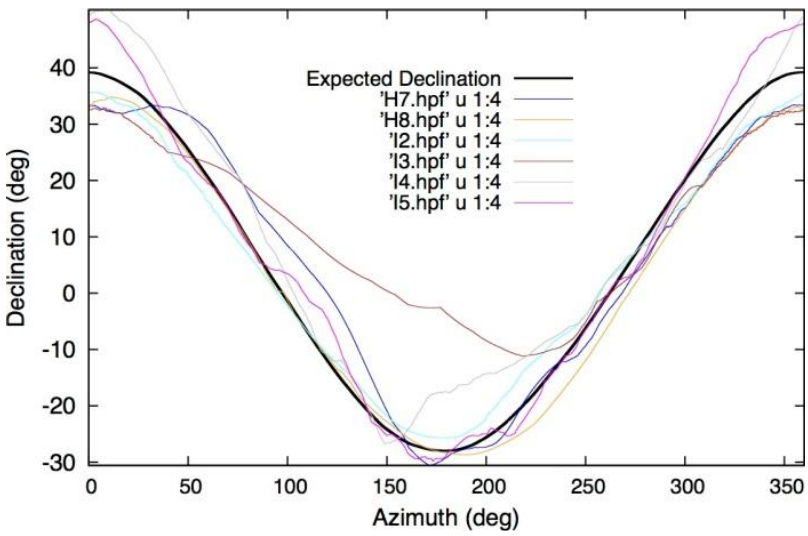

Figure 3. These are examples of the expected declination distribution models for individual random locations. Each profile's location (map co-ordinate) was given an unique identifier, like A1, A2 and so forth. On the figure we can see the legend made up of the vertically listed file names of each corresponding horizon profile, like H7.hpf. The coloured line next to the name indicates the corresponding profile on the graph. The data for the profiles were based upon the Ordnance Survey OS Terrain™ 50 DTM with permission of the Controller of Her Majesty's Stationery Office © Crown Copyright.

The next step was to create the average distribution profile for the real sites or monument locations (observed data), and one for the random sites (expected data), to test for any significant difference between them (Figure 4). A statistical comparison was made between the average declination distribution for all real selected sites and that for the random sites. The comparison was made on the basis of a chi-square test using the spread in the background site data to estimate a standard error of the mean for the individual measurements. Deviations of the selected site data (at 20 degree intervals) from the expected (random site) data were then used to find a value for the reduced chi-square. To derive this, it was assumed, conservatively, that the spread of the selected site data was similar to that of the random site data so that an appropriate standard error of the mean for each dataset could be estimated.

Finally, once the statistical test was completed we used the azimuths and declinations of the original horizon profile files to graph the average expected and observed profiles together for visual comparison (Figure 4). We also graphed these for all observed sites only (n=16), separating classic sites and reverse sites along with all their concomitant profiles that were used to create the average profile (Figures 5a & 5b). Note that the actual number of observed horizon profiles is greater than the number of observed sites. This is because each monument at every site has its own viewing position/location and therefore its own horizon profile. There are eight sites (n=8) and nine (n=9) horizon profiles for each horizon category, resulting in a total of 18 profiles for the observed data.

When we applied a reduced Chi Square to the data (Figure 4), a significant difference was found. The resulting reduced chi-square for a comparison between the random site data and the selected site data was 4.3. Here we have much less than 0.0001 chance probability that the observed distribution from the real sites is from the background distribution.

When looking at these *average* profiles, we can see that this difference is primarily expressed in the southerly declinations, where real sites as a group see further to the south, especially SSE to WSW, with some possibility of being able to see more to the north. The latter though may not be a statistical difference. So most of the differences between the average observed and the expected profiles in the chi-square comes from the southerly directions.

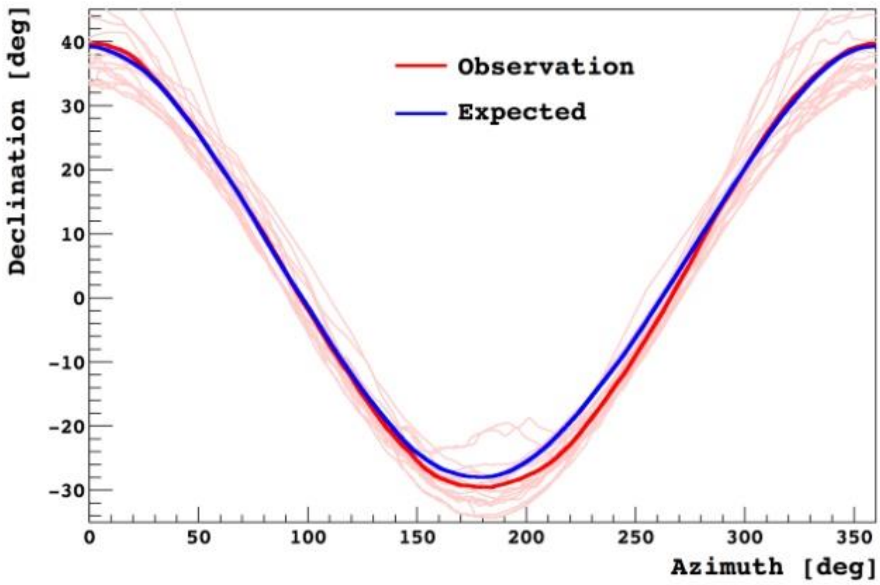

Figure 4. The average expected profile compared with the average observed profile. The fine lines are the profiles from the observed sites. The data for the profiles were obtained from the Ordnance Survey OS Terrain™ 50 DTM with permission of the Controller of Her Majesty's Stationery Office © Crown Copyright.

Comparing the *average* horizon profiles of both classic and reverse sites side-by-side, along with all their concomitant individual profiles, and focusing upon the declination of +35º in the north, we can see there are clearly different things going on in the north at the classic sites versus the reverse (Figures 5a & 5b). Every classic site's horizon profile is above +35° in declination and the majority appreciably so. However, at least half of the reverse sites appear below this declination, and only two of these can be considered to be appreciably above +35º. Thus, it seems that when they have been combined to create the average profile of all observed sites, the impact on the difference from the expected average profile in the north is lessened. Also, when we look in the south we see that ALL of the classic sites most distance points are *below* 30 degrees south (i.e. below -30º), and all of the reverse sites sit above this line, except for one site. So the strength of the signal to indicate a difference from random is likely to have been weakened even here. This can only mean that the signal of difference between the real sites versus random, whilst clearly significant, could well be underestimated.

When examining all the individually placed classic profiles on one graph and all the reverse profiles on another (along with their concomitant averages and expected profiles), we can see that, for the classic sites, the horizons deviate appreciably in relation to both True North and True South, *but particularly in the south* (Figure 5a). Thus we can say that classic horizons dominate the southerly direction found in the average observed profile and are likely responsible for the majority of difference found in the expected and observed profiles in this direction. Relevantly, a non-statistical observation is that a couple of sites clearly have a much more distinct hill than the rest of the classic sites, these straddle True North with their middle of their highest peaks located due-north (ML18 &ML11), with a third monument (ML25) similarly placed, though its mid-peak is slightly shifted west. Thus not only do we have generally distinct relatively higher horizons in the north than the south, but these two sites could even just have *very close* low hills in the north thus increasing the altitude of a horizon profile dramatically and thus, too, its declinations.

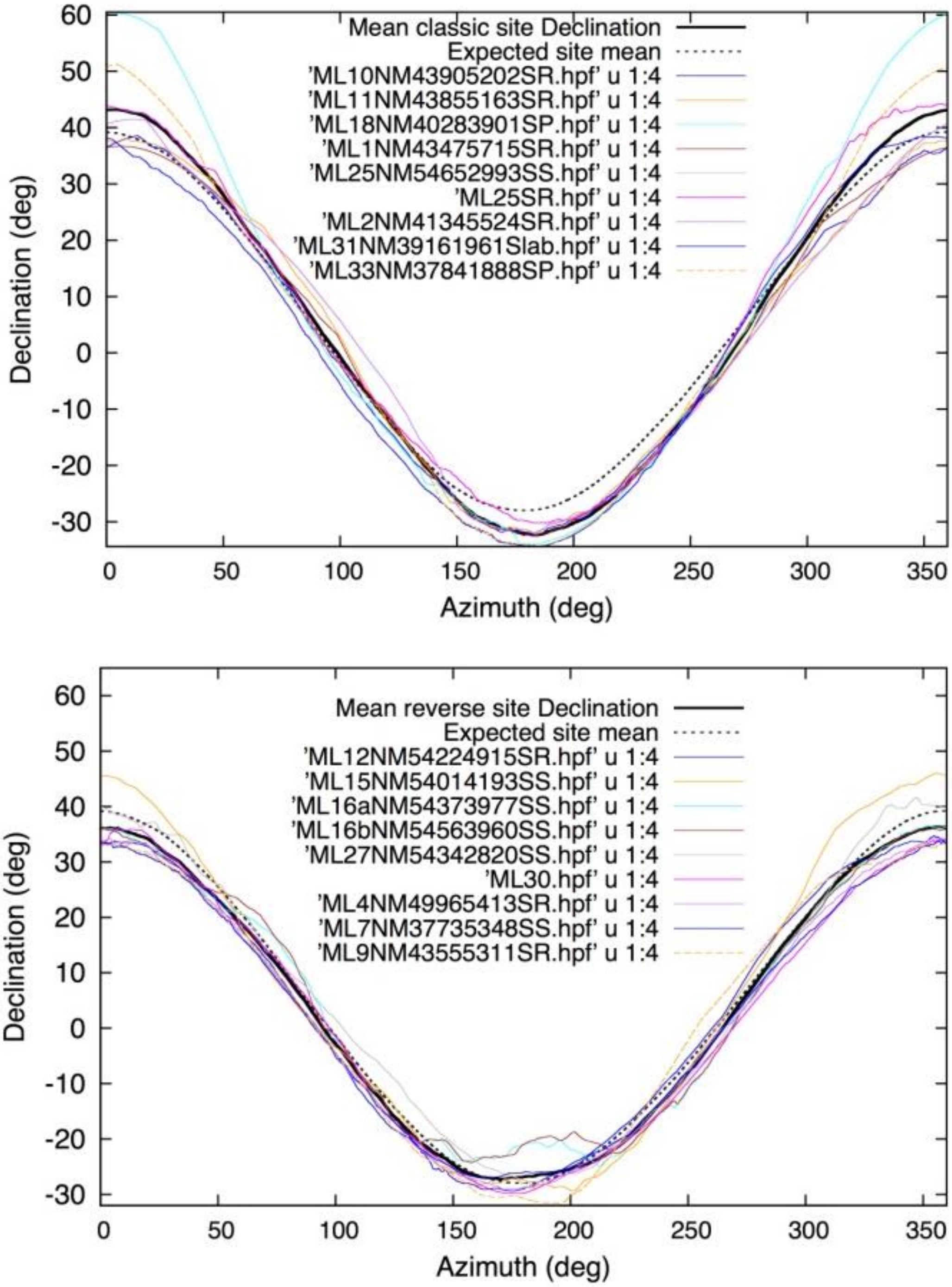

Figure 5. (a) Average and expected declination profiles along with all the individual monument declination profiles for classic sites (n=9 profiles; top); (b) The same as for (a) for reverse sites (n=9 profiles; bottom). Again we can see that the legend is made up of the vertically listed file names of each corresponding horizon profile. The file names here correspond to the site code given by Ruggles (1984), like ML12, and the majority also have their national grid reference (location). The coloured line next to the name indicates the corresponding profile on the graph. The data for these profiles were taken from the Ordnance Survey OS Terrain™ 50 DTM with permission of the Controller of Her Majesty's Stationery Office © Crown Copyright.

Some things are clearly different for the reverse sites. For instance, their average northern horizons are sitting lower in declination than the average of the random sites', which is opposite to that of the classic sites (Figure 5a & b). Being lower in declination indicates that the northern horizons of the reverse monuments are located towards a more southerly declination than those of the random site locations. This means that *on average* the northern horizons are lower in altitude and/or farther away than those of the random sites. The same can be said for a comparison with the average profile of the classic sites – this being the one of the observations made prior to testing. (Figures 5a & 5b).

Whilst there was an obvious visual difference between the *average* southerly declinations in the profiles of the classic sites and the expected sites, no such difference was seen for the reverse sites, in fact their average declination profile sits side-by-side with the average of the random landscape profile in the southerly directions. Nevertheless, there are important outcomes for the reverse sites. The horizon declination patterns at reverse sites confirm that their southerly horizons are closer and/or higher in altitude in the south (below -30 degrees) compared with their own northerly horizons (which reach above +32°). And we can see that two of the nine monuments have a local hill in the south to make the declination *less southerly* and thus ensuring the horizon is much closer to the monuments than the average landscape profile and even than those found at other reverse sites (ML16a&b). Also, two monuments have a hill in the north, which will affect the same outcome (ML15, ML27). These visions have been attested in the field (see below for the example of our most recent work on Gruline (ML16a&b). Importantly, in reality, most of the hills at reverse sites (6/9) are lower and/or further away in the south than the average expected horizon profile (ML9, ML7), ML15, ML27, ML4, ML30). Interestingly, four of these profiles have their lowest declinations in the south just east of due-south (closer to 175°) and two just to the west of due south (190° - 200°), whereas for the classic sites they are actually due south.

3. DISCUSSION

We now have further combinative statistical evidence for the previously hypothetical stance that the horizon forms surrounding the monuments were likely chosen by the builders of the megalithic sites to enhance the astronomical displays seen from the purview of the monuments. This statistical outcome, then, is seen to support our other positive statistical outcomes that have shown (i) the monument orientations cluster significantly in similar directions in azimuth; (ii) the declination ranges on the horizon to which the monuments are oriented is significantly different from all the other declination ranges around those same horizons and (iii) declinations significantly cluster together and they coincide with specific astronomical phenomena.

The outcomes of viewing the new declination graphs of the individual as well as the average horizons allowed us to comprehend a little more of the comparative nature of the two horizon forms that we believe are in evidence. For instance, remembering that one of the original 'definitions' of the horizon/site types was that the classic *southern horizons were further away* from the monuments <u>than their own</u> *<u>northern horizons,</u>* whilst the reverse was true for the reverse sites. But in actual fact the difference seems greater than just these two variables, for the classic sites *also* actually *have more distant horizons in the south* <u>than the reverse sites.</u> Thus we can say more firmly that there *are likely more variables considered by the builders* of the monuments *in the choice for the locations of their monuments.* In particular, there are clearly *on-site differences* between the north and south horizons as well as inter-site differences, and together these were likely chosen to create and observe significant astronomical effects.

To some degree this is another way of saying what we already have already stated in the past, but without the statistical support we were unable to quantitatively qualify it. Namely that people are choosing places with horizons that are higher or lower in particular directions and it is likely that they were doing so to effect a particular astronomical view. Many of the shared views relating to the extreme paths of the Sun and Moon seen along the horizons and in the sky at classic and reverse sites have already been discussed in detail in Higginbottom et al (2015), Higginbottom (2003; in press) and our previous SEAC proceedings paper (Higginbottom and Clay 2016). With the new statistical results presented in this paper, we can here state that the particular shared views within the classic and reverse site groupings, as detailed and argued for in these previous works, are indeed significantly supported. The shared views from these previous works included, for instance, the consistent association of the northern extreme rising and settings of the Moon (every 18.6 years) and Sun (summer solstice) with the tops or slopes of the highest topographical features of the *entire* horizon at classic sites (Higginbottom et al 2015; Higginbottom in press), and the relatively higher southern horizons (than their northern) at reverse sites. At the latter sites it was found that the southern extreme phenomena were blocked from view during their travels, sometimes several times at one event or even in their entirety, that is for the entire day/night/ plus a few days either side for the Sun at the winter solstice (Higginbottom and Clay 2016). The phenomena blocked most often included the Moon at the times around its extreme rising and settings in the south and the winter solstice Sun. Relevantly, these blocking events occurred many more times at these reverse sites than at classics sites on Argyll and Mull (Higginbottom and Clay 2016). For the reverse sites of Argyll and Lorn, six out of ten (6/10, 60%) contain 22 southern blocking events, and more times at these reverse sites on Mull, whereas we only find four (4) such events at three out of ten (3/10) classic sites in Argyll (Higginbottom and Clay 2016). The majority of these events were major blocking events as defined within the 2016 work, so, whilst 21 events were actually found at classic sites on Mull, this is only *35% of the total events for Mull* and the majority of these are made up of small occlusions of part of the astronomical body for the first minutes when rising or setting (n=12/21; Higginbottom and Clay 2016). These blocking events occur in the south at reverse sites because of the following combination of events: (i) builders of the megalithic monuments choosing horizons that have their highest altitude in the southerly directions and (ii) the southern phenomena of the Sun at the winter solstice along with the Moon at its most extreme southerly rising and settings, travel very close to the horizon during these times, at these latitudes. To further accentuate the truth of choice and focus upon the comings and goings of the southerly phenomena on Mull and Argyll is the statistical support for southern alignments: the alignment to the Moon at the southern major standstill on the isle of Mull (with Coll & Tiree), p= 0.025 (Higginbottom et al 2002, table 1). A few of these alignments are focused upon the sole gleam or a glimmer of the Moon when travelling below, but at its closest point to, the horizon (Higginbottom in press). Argyll's focus on the winter solstice Sun's rising and settings also has some support (p = 0.062; Higginbottom et al 2002, table 1).

Figure 6. A still from Stellarium animations of Taolsin, a reverse site. The Sun's glow is seen due-north at midnight 6/7 1500BC at midnight on the summer solstice.

That people are choosing places with horizons that are higher or lower in particular directions to effect a view, is in no doubt. The extent to which the entire view is orchestrated is unknown, but the fact that the landscapes of the monuments shared certain traits whilst also containing individual or unique elements, is certain. These discussions and discoveries have been underscored by other recent work that uses the software Stellarium. Here we used 3D panorama outputs from *Horizon* or panoramic photographs taken at strategic locations at sites (e.g. in line with a stone row within two metres of the monument) to create movie-like shows of the movement of all visible astronomical bodies as seen from a specific location at a particular time/epoch (Higginbottom and Mom, 2018). As well as nicely illustrating visual effects we had already known, Stellarium also assisted us to uncover new astronomical shows that were shared across sites and those which were unique to a particular site, all affected by the horizon shape (Higginbottom and Mom, 2018; in preparation). Examples of shared views include a glowing arc of light at due north at the summer solstice at midnight, which is actually the light of Sun below and closer to the horizon (than in winter; Figure 6; Higginbottom and Mom, 2018 figure 4) and where prominent features on the horizon are backlit by the Sun (Higginbottom and Mom, 2018 figure 2). Site-unique spectacles were essentially layered onto or included within these shared views such (Higginbottom and Mom, 2018 - Ardnacross; in preparation - Gruline). The work found in this paper adds to this knowledge. For instance, the results above highlighted that Gruline had a local hill in the south to make the declination less southerly, ensuring that the southern horizon would be closer to the monuments even than at most other reverse sites (ML16a&b). Whilst we were previously aware of the shape of the horizon at Gruline, understood the individual movements of the Sun and Moon and had access to horizon distances, the uniqueness of this horizon's distance in the south compared with other sites wasn't as clear. The new statistical and graphic work found in this paper emphasises to us the unique value of Gruline's horizon and therefore its possible relative importance in the history of standing stones for the prehistoric people on Mull. This is further verified by archaeological knowledge of two near-by cairns (**RCAHMS,** 1980) and our new work with Stellarium. The latter showed us that a unique affordance was created by the builders of the standing stones whereby the dominant ranges in the south were used to effect the rising and setting of a number of notable visible bodies at the winter solstice such that they all rise, travel very close to the horizon of this southern hill for their entire travels, and then set at the foot or just beyond, one after the other through the long night. (Figure 7; Higginbottom and Mom, in preparation).

Figure 7. A still from Stellarium animations of Gruline. As the winter Sun sets at Gruline, Venus and Jupiter are revealed to be above yet close to the horizon in the south and continue their journey across this dominant range. Later Rigel rises out of the peak of the small hill left of east of the dominant range; then as Venus sets, Sirius and the full Moon rise, Sirius and Rigel make their way across the sky hugging the tops of the same dominant range that Venus and Jupiter also travelled along. A 3D panorama from Horizon was used for the creation of the animation. Horizon software created by Andrew Smith. Based upon the Ordnance Survey OS Terrain™ 50 DTM with permission of the Controller of Her Majesty's Stationery Office © Crown Copyright. A still from our Stellarium animations with a panoramic photograph taken at the site can be found in Higginbottom and Mom, in preparation.

4. CONCLUSION

Our final word is that whilst we apply statistics in our analyses we haven't forgotten that the point of our study is people and the places that people inhabit. As part of this broader project we have chosen to focus on 'visualscapes' and where the visual landscape is not that which only contains the land but all that can be seen. We are slowly incorporating each element as we go. Whilst the current vegetation knowledge been incorporated in prior discussion (Higginbottom, *in press*) there is not enough detail in much of the study region for close mapping as yet. Further, all other known prehistoric sites, up until 2002, have most certainly been incorporated into detailed *quantitative* viewshed or alignment analyses on Mull and other regions (Higginbottom, 2003; Higginbottom et al., 2002) but these too have not yet been incorporated into our 3D panoramas. Further research will incorporate new field work to gather data on past vegetation on Mull as well as the location of all other monuments in the area of each site into our 3D viewsheds to gain a better understanding of the visual world that surrounded the people that erected these monuments on Mull.

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