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Contents

The reappearing Sun in Neolithic Orcadian culture

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Based on assay for the MA-CAA module Archaeoastronomy at University of Wales, Trinity Saint David, Lampeter.
Reworked on October 13th, 2012

Introduction

This Research Project investigates the horizon phenomenon of the reappearing Sun from several monuments part of Neolithic Orcadian culture in Scotland (Appendix A).

Within Maeshowe, a chambered cairn dating from between 3100 to 2700 BCE,[2] one can experience the Sun setting some 20 days before/after Winter Solstice day (WS) behind Ward Hill and reappearing for a few minutes at the right slope of Ward Hill (Figure 1).[3]

Figure 1 Horizon panorama seen from Maeshowe, Orkney.

Witnessing this phenomenon in 1998, not experienced in the recent past, was a very exciting and unforgettable event.

To an observer standing in front of Maeshowe; some 41 days before/after WS day, the Sun reappears from behind the right slope of Cuilags (Kame of Hoy), before it finally sets. This reappearance cannot be witnessed from within Maeshowe.[4]

As this reappearing Sun is a phenomenon of the horizon (foresight) due the steep slope of the hills; it can also be witnessed at other locations on Orkney. Based on computer prediction, Ness of Brodgar and Breckness were videotaped in 1999.[5] Did humans made here spatial foci (backsights)? Present day excavations at Ness of Brodgar and field walks at Breckness show that there might be artificial foci.

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Web: http://www.iol.ie/~geniet/eng/archaeocosmology.htm
[2] Patrick Ashmore, *Maes Howe*, ed. Christopher Tabraham (H.M.S.O., 1989), 4.
[3] Victor Reijs, "Maeshowe's Megalithic Month alignment," *3rd Stone*, no. Oct.-Dec. (1998).
[4] Victor Reijs, "The reappearing sun at Orkney," http://www.iol.ie/~geniet/maeshowe/eng/flashing.htm. and Euan W. MacKie, "Maeshowe and the winter solstice ceremonial aspects of the Orkney Grooved Ware culture," *Antiquity* 71, no. June (1997).
[5] Reijs, "The reappearing sun at Orkney".

The first aim of this Research project is to investigate the horizon at several Neolithic locations using theodolite and computer based horizon profiling: Maeshowe (chambered cairn); Ness of Brodgar (settlement); the Watch Stone (standing stone); Breckness (settlement); and the Bu on Hoy (field).[6] With this info one can determine when the reappearance of Sun would happen.

The second aim is to apply cultural interpretations to Neolithic Orcadian monuments and the interaction between the Sun and the horizon (like the reappearance).
This will be followed by an evaluation of the findings.

Methodology

A selection of monuments, with reappearing Sun on different days, has been measured with theodolite and photos. Due to multiple rainy days, this selection was biased towards known locations (like Maeshowe, Ness of Brodgar and Breckness).
To allow remote evaluation of locations in the future, computer based horizon profiles have been compared with theodolite measurements.

Unstructured interviews were held with landowners, an observer and an astronomer. An interview was broadcasted on April 4th 2012 by Radio Orkney to ask listeners for experiences around the reappearing Sun.

Cultural/anthropological literature is studied e.g.: John Hedges, concerning the Neolithic culture at Isbister chambered cairn; Euan MacKie on possible priest-elite in Neolithic times; Christopher Tilley relating phenomenological aspects; and Julian Thomas' views on understanding the Neolithic.

Measuring the landscape

This section will cover measurements and recordings done in the past and present based on visits to Orkney over the past 16 years. The last visit (Appendix B) was part of this Research Project.

Geography and geology of Orkney

Mainland, the biggest island of Orkney, is some 35 km north of Scotland: ~59º North and ~3º West. Mainland's geology consists of Stromness flag, which provides good building material.
Hoy is an island south of Mainland, separated by Hoy Sound. The Hoy hills are relatively high, barren, wet and they consist of Hoy sandstone, which is unstratified sandstone.[7]

Earlier research

A computer model of Maeshowe's passage, chamber and hoziron was constructed, based on my previous research from August 1996.[8] This provided the realisation that beside the broad WS Sun, the reappearing Sun of ~20 days before and after WS would be visible within the chamber. This was recorded on December 1st, 1998. The main reason why this might not have been witnessed in the past, is that the reappearing

[6] Reijs, "Maeshowe's Megalithic Month alignment.", Beverley Ballin Smith, "A new late Neolithic house at Brodgar Farm, Stenness, Orkney," (Glasgow: GUARD, 2003)., Sigurd Towrie, "The Ness of Brodgar excavations," http://www.orkneyjar.com/archaeology/nessofbrodgar/. M.M. Charleson, "Notice of the excavation of a chambered mound near Breckness, Stromness, Orkney," *Proc. Soc. Antiq. Scot* 37(1903). and Victor Reijs, "Views towards Ward Hill and Cuilags, Orkney," http://www.iol.ie/~geniet/maeshowe/eng/horizons.htm.
[7] J.L. Davidson and A.S. Henshall, *The chambered cairns of Orkney: an inventory of the structures and their contents* (Edinburgh University Press, 1989), 10.
[8] Victor Reijs, "Maeshowe," http://www.iol.ie/~geniet/maeshowe/eng/scot10.htm.

happens some 10 minutes after usual Sun light on the back wall and the faint reappearing Sun light would be drowned by the electric light.[9]

In 1997 MacKie described also Maeshowe's broad direction to WS Sun setting, and the reappearing Sun around 23 and 45 days before/after WS 2700 BCE.[10] He relates these events to Alexander Thom's Megalithic Month, which are 22 to 24 days long.[11] MacKie did not recognise that the reappearing Sun light can be seen on Maeshowe's back wall.[12]

If Maeshowe was built with such a horizon phenomenon in mind, there might be a chance that other monuments on Orkney were also related to such reappearances. As documented by Reijs, Ward Hill's and Kame of Hoy's steep slopes can be seen from several Neolithic monuments.[13]

The reappearing Sun would have occured near WS 3000 BCE at Ness of Brodgar (behind Ward Hill) and Breckness (behind Kame of Hoy).[14] In 1999 this was communicated with Historic Scotland and the local archaeologist, with the question: "Is there archaeology present at these locations, which could indicate a ceremonial environment?" According to their knowledge and the Canmore database, no significant archaeology was known.[15]

In 2002 a geophysical survey was done at Ness of Brodgar and when a notched stone was ploughed up, an excavation was performed in 2003.[16] Considerable archaeology was found and further excavations were done from 2004 and are still continuing.[17]

No major archaeological work has been done at Breckness, although the author has found considerable evidence of archaeological remains while walking ploughed fields in 2012.[18]

Measuring with theodolite

Before analysing the measurements, my first experiences with the theodolite (Jena THEO 020A)[19] are elaborated. Equipment was borrowed from Dublin Institute of Technology and ORCA, and I received excellent training from Frank Prendergast. Like with all equipment, it is important to practise beforehand to make sure one can handle it safely/promptly. Important one draws situation sketches so one can recall the measurement position.[20]

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[9] Victor Reijs, *Reappearing sun light in Maeshowe, Orkney* (CD-ROM private distribution, 1999).
[10] MacKie, "Maeshowe and the winter solstice ceremonial aspects of the Orkney Grooved Ware culture," 355, 57.
[11] Alexander Thom, *Megalithic Sites in Britain* (Oxford University Press, 1967), Chapter 9.
[12] MacKie, "Maeshowe and the winter solstice ceremonial aspects of the Orkney Grooved Ware culture," 351.
[13] Reijs, "Views towards Ward Hill and Cuilags, Orkney".
[14] Reijs, "The reappearing sun at Orkney".
[15] Historic Scotland, "Canmore," http://canmore.rcahms.gov.uk/.
[16] Ballin Smith, "A new late Neolithic house at Brodgar Farm, Stenness, Orkney."
[17] Towrie, "The Ness of Brodgar excavations".
[18] Victor Reijs, "Breckness fields," facebook, https://www.facebook.com/media/set/?set=a.3921814049613.170034.1407429736&type=3.
[19] G. Dombrowski, "THEO 020A." (Jena: Jenoptik Jena GmbH, 1971), http://www.meetcentrum.nl/files/Zeiss%20theo%20020A.pdf.
[20] Clive L.N. Ruggles, *Astronomy in prehistoric Britain and Ireland* (Yale University, 1999), Appendix.

A spreadsheet was made to evaluate the measurements, including: computation Sun/Moon azimuth/altitude and their semi diameters;[21] compensation of altitude scale; precision/accuracy analysis; and graphing to support sanity checking measurements.[22]

Computer based horizon profiling

Two computer based horizon profiling services have been evaluated: standalone software (Fernando Patat); and a Web Service (HeyWhatsThat from Michael Kosowsky).[23] HeyWahtsThat can export to Google Earth.[24] Not evaluated, but a standalone Windows program is called Horizon (Andrew Smith).[25] All use height-data gathered during the Shuttle Radar Topography Mission (SRTM).[26] For American locations the height is averaged over 30 m (SRTM30) and for the rest of the world it is averaged over 90 m (SRTM90), with an average-height precision of 2 to 8 m. In environments with steep hills, the accuracy of the average-height compared to the actual height can be low. Some STRM data is missing if surfaces were in the radar's shadow. The CGIAR initiative has tried to eliminate most of SRTM data limitations (but not all, see below).[27] Patat's and Horizon software uses CGIAR and HeyWhatsThat uses raw SRTM.

The horizon profile can be considerable off due to limitations of SRTM data. This can be seen in Figure 2: panorama photo taken from Sun Temple, Llactapata, Peru:[28]

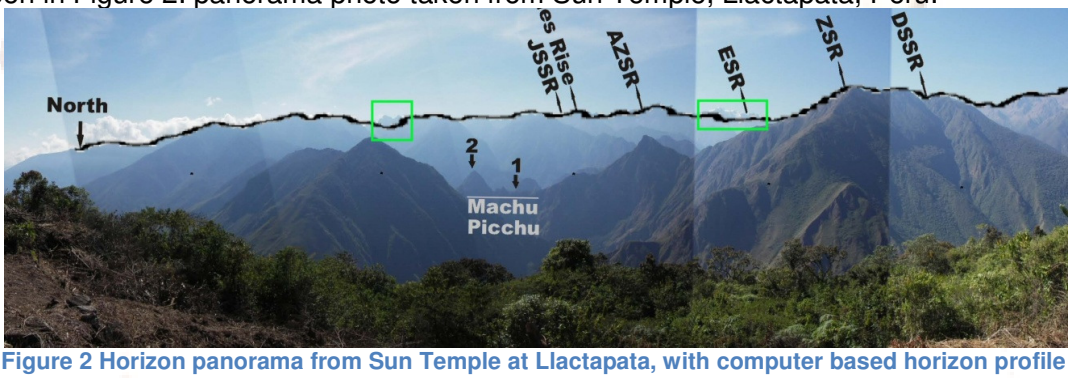

Figure 2 Horizon panorama from Sun Temple at Llactapata, with computer based horizon profile (Zawaski).

[21] In this report the word *altitude* always means the *apparent altitude* (so including effects of refraction and Earth's curvature).
[22] Charles D. Ghilani, "Astronomical Observation Handbook." (The Pennsylvania State University, 2004), http://surveying.wb.psu.edu/sur351/CelestialCoords/ASTRO.pdf.
[23] Fernando Patat, "Horizon synthesis for archaeo-astronomical purposes," *Astronomische Nachrichten* 332, no. 7 (2011). and Michael Kosowsky, "HeyWhatsThat Testbed," http://www.heywhatsthat.com/main-0904.html.
[24] There seems to be a declination/RA accuracy bug (a kind of parallax) when exploring the Sky in Google Earth (6.2.2.6613), when looking with a small Field of View (<1º). This bug has been reported to Google Earth.
[25] Horizon Ver. 0.10a, Smith, Andrew.
[26] Jet Propulsion Laboratory, "The Shuttle Radar Topography Mission," http://www2.jpl.nasa.gov/srtm/.
[27] The CGIAR consoritum for spatial information, "CGIAR-CSI SRTM 90m Digital Elevation Data," http://srtm.csi.cgiar.org/.
[28] M.J. Zawaski and J.McKim Malville, "An astronomical survey of major Inca sites in Peru," *Archaeoastronomy: The journal of astronomy in culture* XXI(2007-2008). and J.McKim Malville, 29 May 2012.

The black horizon profile matches well the photo, except for two green squared regions. This is due to an SRTM/CGIAR error, where the radar was not able to measure the area (the white areas in Figure 3).

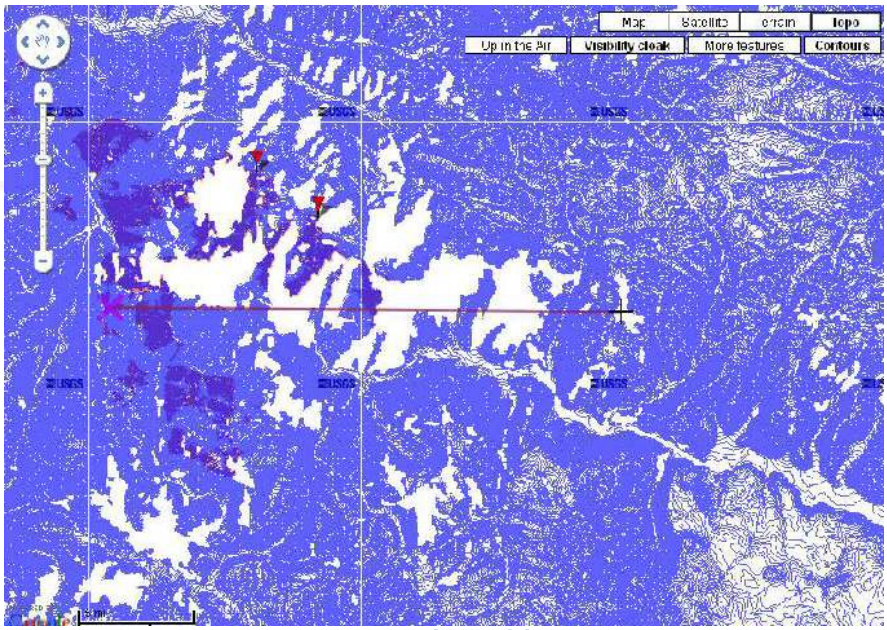

Figure 3 The white areas are missing SRTM/CGIAR data due to radar shadow.

Evaluation of tools

Comparing Maeshowe's horizon points measured by MacKie with author's measurements (Appendix C) gives average difference for azimuth ~0.03º and for altitude ~0.003º. The azimuth precision σ_{azi} ~0.005º (Appendix C) and the σ_{alt} is the theodolite precision: ~0.002º. The overall σ is for azimuth ~0.03º and for altitude ~0.004º. This translates into a declination[29] σ_{decl} ~0.01º, which is equivalent to ~80 years in obliquity change.[30]

The computer based horizon profiles have a σ_{az} ~0.8º/distance and σ_{alt} ~0.15º/distance (distance in [km]).[31] In the Orcadian environment (between 3 and 6 km horizon distance): the $\sigma_{az\,i}$ ~0.15º and σ_{alt} ~0.03º. This translates into a σ_{decl} ~0.07º, which is equivalent to ~540 years in obliquity change.

For comparison: measurements with a compass/clinometer would have an accuracy of around: $\sigma_{az\,i}$ ~1º and σ_{alt} ~0.25º.[32] This translates into a σ_{decl} ~0.5º, which is equivalent to ~4100 years in obliquity change.

The theodolite can just be used for dating: the theodolite σ_{epoch} ~80 years is close to the carbon dating σ_{epoch} ~50 years.[33]
Computer based horizon profiles are in most instances more accurate than compass/clinometers, **but** checking at the monument (ground-truthing) is essential![34]

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[29] *Declination* in this essay is the *Topocentric declination*; so it includes the effects of parallax.
[30] In 2012 the obliquity is 23.438 º (using Brtagnon) and this changes with +0.01º to 23.428º in 2089. See P. Bretagnon and J.-L. Simon, *Planetary Programs and Tables from -4000 to +2800* (Richmond: Willmann-Bell, 1986).
[31] Patat, "Horizon synthesis for archaeo-astronomical purposes," 791.
[32] Ruggles, *Astronomy in prehistoric Britain and Ireland*: 165. and Silva, "Silva Clino Master." (Sollentuna, Sweden), http://silva.se/sites/default/files/pro_clinomaster.pdf.
[33] S. Bowman, *Radiocarbon Dating* (University of California Press, 1990), 40.

Measurement locations and positions

Theodolite measurements were done at five Orcadian locations and at each location one or more positions were chosen to determine the effect of horizon parallax. The locations were: Maeshowe, a Neolithic mound (2 positions); the Ness of Brodgar, between the Loch of Harris and the Loch of Stenness (5 positions); the Watch Stone, near the Standing Stones of Stenness (1 position); Breckness area, directly opposite Hoy overlooking the Hoy Sound (5 positions); and the Bu on Hoy (1 position). Some details are given in Appendix D.

If a hill slope is steeper than the Sun's path (see also next section), three configurations of horizon and Sun can be recognised: a) Sun is so high in the sky that it does not touch the hill and thus keeps shining until it sets; b) Sun sets on summit and reappears somewhere from behind the slope; and c) Sun is so low in the sky that it sets on the summit and reappearing can't happen. For the investigated locations; the transition from b) to c) marks the lowest declination for a reappearing Sun.

This essay will not make a detailed numerical analysis, but some detail is given for four locations (Appendix D):

The right slopes of Ward Hill and Cuilags cause a reappearing Sun several days before WS day as seen from Maeshowe. These reappearings have been recorded for several years around 2000 CE.[35] Around its construction time (~2900 BCE) the reappearings would be respectively ~26 and ~45 days from WS;

Standing north-west of Ness of Brodgar's (lesser) wall, when it was just constructed after 3150 BCE, the Sun would reappear from behind the right slope of Ward Hill some 5 days before/after WS (Appendix E);

As Breckness is so close to the Cuilags' right slope, a large area will experience a reappearing WS Sun over many epochs;[36]

Measurements were done at Bu on Hoy, as Observer3 had witnessed a reappearing Sun from behind the right slope of Ward Hill close to 25 days before WS 2007 CE.

Interaction between hills and celestial objects

In the below sections some comparable phenomena, as seen on Orkney, are listed. The phenomena happen somewhere on the horizon (the foresight) and the phenomenon can be seen (best) from a certain position in the landscape (the backsight).

Slope steepness

As the steepness of the Hoy hills is larger than the set angle of the Sun's path, reappearing can happen.
The approximate rise/set angle of the Sun's path is: [37]

*Rise/set angle = arcos(sin(latitude) * cos(declination))*

At solstices, this rise/set angle would be ~20º in Orkney and ~30º in Ireland/England. The natural angle of repose for most granular natural material (sand, gravel, clay, etc.) is between 30º and 40º,[38] so naturally settled hills of such material can results in a reappearing Sun. Solid rock formations can of course have any slope angle.

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[34] Ruggles, *Astronomy in prehistoric Britain and Ireland*: 165.
[35] Reijs, "The reappearing sun at Orkney".
[36] Reijs, "The reappearing sun at Orkney".
[37] John D. North, *Stonehenge: Neolithic man and the cosmos* (HarperCollins, 1996), 563.
[38] R.L. Lowrie, *SME Mining Reference Handbook* (Society for Mining, Metallurgy, and Exploration, 2002), 12-13.

If the Sun's rise/set angle is close to the slope angle, a *Rolling* of the Sun along the slope can be witnessed. Examples are near Cough Patrick, Ireland (viewed from a decorated stone: Boheh stone, also known as St Patrick's Chair) and Silbury Hill, England (viewed from West Kennet palisades).[39]

Notches
The Sun or Moon can pass through notches in the horizon and this can result in a reappearing of the Sun/Moon. An example is Chimney Rock (USA), where the major lunar standstill rises between two rock spires when observed from the Great House, a ~1050 CE Chacoan structure.[40]

Sun-window
Another natural phenomenon is a gap/window in a mountain through which the Sun shines. One is the Martinsloch in Elm (Switzerland).[41] Like at other such locations, the Sun shines at certain times (mostly around WS or equinoxes) through a gap/window for several minutes onto e.g. a church or a cairn. Only for a few locations a church (mid 2nd century) was intentionally build at that focus. [42]

There is a sun-window in Cardenas Butte (Grand Canyon, USA) through which the WS Sun shines ~80 m from the Cardenas Hilltop Ruin (for the Sun to touch the monument, it needs to be ~7500 BCE). Cardenas Hilltop Ruin could have been a ceremonial monument of the Paleo-Indians. [43]

Reflections
To stay closer to Orkney, Sun reflecting on Ward Hill has been quoted by Sir W. Scott from Dr. Wallace's description of Orkney (1700 CE); who states that the Sun around summer months might reflect on Ward Hill's wet surface.[44]
A 2001 Radio Orkney interview resulted in finding Observer3, who witnessed in 1990s the phenomenon from Bu on Hoy.

Cultural interpretations

Beside the possible alignments, like the earlier mentioned reappearing Sun near Orcadian Neolithic monuments, both Keith Kintigh and Brad Schaefer mention that it is important to investigate the possible anthropological/cultural interpretations of such possible alignments.[45] This section will examine a few possible interpretations.

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[39] Gerry G. Bracken, "The 'Rolling Sun' Spectacle of Boheh," The Secret Island, http://www.carrowkeel.com/sites/croaghpatrick/reek3.html. and Steve Marshall and George Currie, "Investigation of a "Sun roll" effect in relation to Silbury Hill," *Time and Mind* 3, no. 3 (2010).
[40] J.McKim Malville, *A Guide to Prehistoric Astronomy in the Southwest* (Johnson Books, 2008), 88-94.
[41] W. Bäbler et al., *Das Martinsloch zu Elm: Die Region Elm/Glarus mit den Ereignissen im Martinsloch: Ihr touristischer Begleiter zum Elmer Phänomen: astronomisch, alpinistisch, geologisch, kulturhistorisch* (Verkehrsbüro, 1996).
[42] Thomas Baer, Andreas Schweizer, and Walter Bersinger, "Felsenlöcher," http://www.sternwartebuelach.ch/content/felsenloecher/felsenloecher.html.
[43] William H. Calvin, *Hoe de sjamaan de maan stal: een reis naar de oorsprong van de wetenschap*, trans. A. Konijnenbelt (Bakker, 1993), Chapter 9.
[44] Walter Scott, "The pirate," in *Waverley novels* (Edinburgh: A. & C. Black, 1871), 213-14.
[45] Keith W. Kintigh, "I wasn't going to say anything, but since you asked," in *Foundations of new world cultural astronomy: A reader with commentary*, ed. A. Aveni (Boulder: University Press of Colorado, 2008). and Brad E. Schaefer, "Case studies of three of the most famous claimed archaeoastronomical alignments in North America," in *Oxford VII* (Flagstaff Az.2004).

Thomas points out the existence of a multitude of readings of the landscape during Neolithic times itself:[46]

> *... as with any symbolic system, the essentially arbitrary nature of this way of attributing meaning to place meant that an endless series of alternative readings was always possible.*

And these readings can be seen in the different archaeological layers found at Ness of Brodgar, Maeshowe and many other places.[47] And such alternative readings intermingle with present day interpretations. And according to David Williams-Lewis and David Pearce, a tension is present between one form of cosmology "which arises 'spiritually' from within human beings ... and another that derives from people's observations of what they see and measure."[48]

In the case of ethnography (where we still can interact with the people) the difference of interpretation between the findings and the initial assumptions of the analyst is called alterity. And according to Martin Holbraad; the greater the level of alterity the more the analysts have to theorise.[49] For pre-historic studies ethnography is not really possible, so it is likely to have a range of possible interpretations of the Neolithic readings of the landscape.

Amiria Henare reasons as part of the *Thinking through things* concept that *thing* and *meaning* are not distinct: "things might be treated as *sui generis* meanings". So keep in mind that 'things' should be "encountered in the field as they present themselves, rather immediately assuming that they signify, represent, or stand for something else." [50]
So for instance "Thunder is the god Thor". And thus not saying that the thunder represents the god Thor and further analysing thunder and Thor on their own.

Several cultural interpretations around the reappearing phenomena will be investigated ranging from the perception of a phenomenon to a priest-elite managing events.

Perception of reappearing Sun

A natural phenomenon (like Sun appearing at a slope, a sun-window, a notch, etc.) just happens, regardless if a human perceives it or not. It is important to recognise that perception happens at least at two levels: unconsciously and consciously. The difference between the two is that for a human his/her attention has to be captured for a conscious perception of the phenomenon. As soon as ones attention is captured to e.g. the reappearing Sun, it almost looks so obvious; but it **needs** this essential attention. Arien Mack and Irvin Rock found that without this explicit attention a human does not perceive consciously a phenomenon. [51]
Mack and Rock found that they could increase the likelihood that a phenomenon gets attention, by positioning it relative to a spatial focus of attention.[52]

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[46] Julian Thomas, *Understanding the Neolithic* (Taylor and Francis, 2002), 61.
[47] Sigurd Towrie, "A millenium of activity on the Ness: Interview with Nick Card," *Islander 2012* 2012.and Colin Richards, "Maeshowe 1991 Phase 3 structures report," (University of Glasgow, 1991).
[48] David Lewis-Williams and David Pearce, *Inside the Neolithic Mind: Consciousness, Cosmos and the Realm of the Gods* (Thames & Hudson, 2009), 61.
[49] Martin Holbraad, "The power of powder: Multiplicity and motion in the divinatory cosmology of Cuban Ifa," in *Thinking through things; Theorising artefacts ethnographically*, ed. Amaria Henare, Martin Holbraad, and Sari Wastel (Abingdon: Routlege, 2007), 190.
[50] Amiria J.M. Henare, Martin Holbraad, and Sari Wastell, *Thinking Through Things: Theorising Artefacts Ethnographically* (Routledge, 2007), 2-3.
[51] Arien Mack and Irvin Rock, *Inattentional Blindness* (Mit Press, 2000), Chapter 11.
[52] Mack and Rock, *Inattentional Blindness*: 228.

Such a spatial focus can be a human or natural construction (aka backsight) as long as the focus in the landscape could be pointed out (also with attention) to others. If that spatial focus is not recorded in some way (verbally, written, rock art or construction), it will be very difficult to get proof beyond reasonable doubt that the phenomenon or not-pointed-out focus was consciously perceived/used.[53]

So there is always a chance that the phenomenon has not been perceived, even though it looks to be an (obvious) conscious perception. An example: when overlaying the excavation trenches in Google Earth and plotting in the directions to right slope of Ward Hill, these directions are within 1º of the trench grid (see Figure 4).

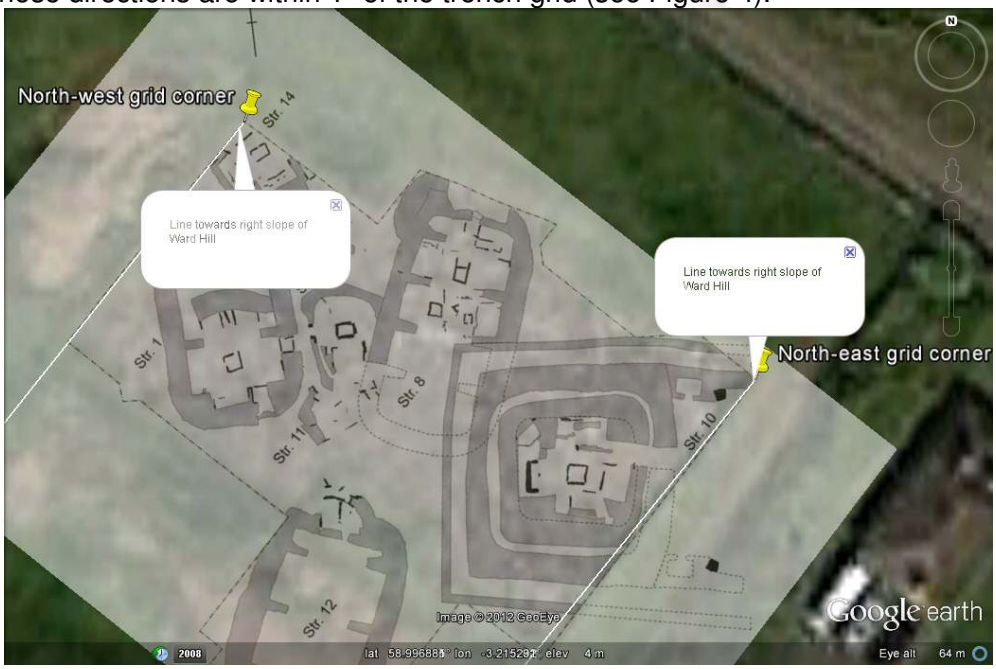

Figure 4 Excavation trenches and direction to right slope of Ward Hill

After checking with ORCA (excavators at Ness of Brodgar), there is no conscious link between Ward Hill and the excavation grid:[54]

> *To my knowledge, it was not determined on the basis of celestial factors, the grid would have been located on the basis of the size and length of the trench being excavated, combined with the lay of the land.*

But the fact remains that the lay of Ness of Brodgar's land is perpendicular to the line winter solstice set to summer solstice rise and that lay could have been a reason for Neolithic people to choice Ness of Brodgar for their ceremonial places/foci.[55]

The reappearing Sun could also have been experienced as an entity (thing/being) from another realm of existence and that such entities could interact with people in the material world. Shifts/alternations in the human consciousness can stimulate such experiences, according to Lewis-Williams and Pearce.[56]

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[53] Schaefer, "Case studies of three of the most famous claimed archaeoastronomical alignments in North America."
[54] Rosalind Aitken, 5 July 2012.
[55] Sigurd Towrie, "Resurrecting the Neolithic priesthood… Interview with MacKie," http://www.orkneyjar.com/archaeology/2012/01/10/resurrecting-orkneys-neolithic-priesthood/.
[56] Lewis-Williams and Pearce, *Inside the Neolithic Mind: Consciousness, Cosmos and the Realm of the Gods*: 46, 58.

Symbolic importance of Hoy hills

Tilley describes the likely deliberate spatial organisation of monuments around the Swedish's Álleberg mountain, which is enveloped in a wealth of mythology.[57] A similar spatial organisation might have taken place on Orkney. The many chambered cairns on Orkney[58] might have been placed at the boundary of visibility/non-visibility of the summits of Ward Hill and the Cuilags (see Appendix F).

Furthermore the type of sand stone on Hoy is different from the Mainland's: On the Mainland the stand stone can be split easily in flags (so good building material) while this is not the case for the unstratified sand stone on Hoy.[59] Future research is needed to determine if Hoy sand stone was used in a specific way in Orkney's Neolithic monuments. Beside the reappearing phenomenon that relates to the right slopes of the Hoy hills, there is also the midsummer phenomenon of the reflecting Sun on Ward Hill's wet surface.[60]
These different phenomena could provide an environment to perceive these Hoy hills as sacred.

A story reported by Sigurd Towrie could be related to reappearing Sun rays between Hoy and Breckness region:[61]

> *When the preaching of Christianity became too much for the trows/fairies, they decided to abandon the Mainland and head out to Hoy. To do this, they strung a straw rope from the Black Craig (2km North of Breckness) to Ward Hill of Hoy and began to climb across. Unfortunately, however, the rope snapped and they fell to their deaths. The one trow who was waiting for them on Ward Hill, upon seeing the others die, howled in anguish before casting himself into the sea.*

So, as discussed by Anthony Aveni, a symbolic link between periphery (Hoy hills) and centre (Mainland monuments) might be present.[62] The following two sections touch upon the centre.

Human interaction with Orcadian landscape

Tilley states that one can't see the landscape as just something natural and opposed to people, but better to see the landscape as totally socialised.[63] Landscape becomes intricately embedded in society:[64]

> *Humanised places become fashioned out of landscape through the recognition of significant qualities in that what has not in itself been culturally produced (rocks, rivers, trees, etc.) by association with current use, past social actions or actions of a mythological character.*

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[57] Christopher Tilley, "Art, architecture, landscape [Neolithic Sweden]," in *Landscape: Politics and perspective*, ed. B. Bender (Oxford: Berg, 1993), 77.
[58] Davidson and Henshall, *The chambered cairns of Orkney: an inventory of the structures and their contents*: Part Two.
[59] Davidson and Henshall, *The chambered cairns of Orkney: an inventory of the structures and their contents*: 10.
[60] Scott, "The pirate," 213-14.
[61] Sigurd Towrie, 4 June 2000.
[62] Anthony Aveni, "The role of astronomical orientation in the delineation of world view: A center and periphery model," in *Foundations of new world cultural astronomy: A reader with commentary*, ed. A. Aveni (Boulder: University Press of Colorado, 2008).
[63] Christopher Tilley, *A phenomenology of landscape: places, paths and monuments*, ed. B. Bender, J. Gledhill, and B. Kapfere, 1 ed., Explorations in anthropology (Oxford: Berg Publishers, 1994), 38.
[64] Tilley, *A phenomenology of landscape: places, paths and monuments*: 24.

As Thomas states, if humans construct monuments in their place, these monuments are "thoroughly bound up with human existence and we should be able to interpret them in social terms."[65] Such monument (a spatial focus) could have been build to mark a specific phenomenon. This phenomenon can now be seen in social terms, as the building of this spatial focus changed the way the place is or will be experienced.[66]

This links with Tilley's ideas that rhythms of land/sky will be part of the rhythms of lives/societies:[67]

> *A fundamental part of daily experiences in non-industrial societies is the physical and biological experience of landscape – earth, water, wood, stone, high places and low places, the wind, rain, sun, stars and sky. The rhythms of the land and the seasons correspond to and are worked into the rhythms of life.*

The Neolithic monuments in Mainland's landscape can have such linkage with the rhythms of the sky as several seem to have alignments with celestial events.

Enclosures, walls, platforms, doorways, passages and inner chambers regulated the way people can have access to these places.[68] When Ness of Brodgar settlement got a stone (lesser) wall after 3150 BCE, would there have been a platform at each of the entrances to observe the reappearing Sun (like assumed in Appendix E)? No excavations have been performed yet in this area.

Pilgrimage routes in Orcadian landscape

The Mainland landscape can be described as special/sacred as it is "a massive ceremonial complex, fragments of which are only now coming to light".[69] In such an environment pilgrimages could have happened. Peter Jan Margry gives a definition of pilgrimage:[70]

> *... a journey based on religious or spiritual inspiration, undertaken by individuals or groups, to a place that is regarded as more sacred or salutary than the environment of everyday life, to seek a transcendental encounter with a specific cult object for purpose of acquiring spiritual, emotional or physical healing or benefit.*

It is likely that possible pilgrimage routes existed between the major monuments in this area as there exist directions from Standing Stones of Stenness; Barnhouse Structure 8; and Ness of Brodgar's Structure 10 towards Maeshowe area.[71] The Standing Stones of Stenness might pre-date the Maeshowe cairn, but the four standing stones that make up Maeshowe's chamber pre-date Maeshowe cairn. The precise dates of all these

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[65] Thomas, *Understanding the Neolithic*: 45.
[66] Thomas, *Understanding the Neolithic*: 35.
[67] Tilley, *A phenomenology of landscape: places, paths and monuments*: 26.
[68] Thomas, *Understanding the Neolithic*: 48. and Geraldine Stout, "Monumentality and inclusion in the Boyne Valley, County Meath, Ireland," in *Round Mounds and Monumentality in the British Neolithic and Beyond*, ed. T. Darvill, J. Leary, and D. Field, *Neolithic Studies Group Seminar* (Oxbow Books, 2010).
[69] Richards, "Maeshowe 1991 Phase 3 structures report," 4-5.
[70] Peter Jan Margry, "Secular pilgrimage: A contradiction in terms?," in *Shrines and pilgrimage in the modern world: New itineraries into the sacred*, ed. Peter Jan Margry (Amsterdam University Press, 2008), 17.
[71] Sigurd Towrie, "The Ness of Brodgar Excavations – Maeshowe alignments," http://www.orkneyjar.com/archaeology/nessofbrodgar/excavation-background-2/maeshowe-alignments/.

monuments are not known,[72] but one could see the Standing Stones of Maeshowe contemporary with the Standing Stones of Stenness and Barnhouse Structure 8 and earlier than Ness of Brodgar's Structure 10.[73] These monuments could serve as 'stations' in the landscape for people's movement towards (the Standing Stones of) Maeshowe.[74]

Mortuary practices

According to Hedges, the individual's body was first excarnated outdoors and at some moment, perhaps annually, the bones were placed, possible with a public ceremony, into a chambered cairn like Isbiter, South Ronaldsay.[75] So the dead keep being important for the living, as they are given a new resting place inside their own territory.[76]
Thomas states the change from individual to ancestor,[77] and comparably Hedges reasons:[78]

> *... bones were considered and treated as being representative of a person, someone who was remembered by those that lived after. In time, however, their identity will have been forgotten – they will have simply become one of the ancestors.*

Hedges' reference of a possible annual event to place the excarnated bones inside a chambered cairn, could have happened at reappearing Sun: when that phenomenon happens, it signalled the burial of the ancestors.

Megalithic Calendar

Horizon calendars are reported in historic resources, like for the Pueblos of Southwest USA,[79] and, as shown above, the Hoy hills can act as a horizon calendar.
Thom proposed the Megalithic Calendar, where the year is divided in 16 months of 22 to 24 days.[80] The distribution of the calendar months was derived from Thom's measurements, assuming building epoch of 1800 BCE.[81] Thom's Megalithic Calendar is not generally accepted in archaeoastronomy.[82]

For Maeshowe at 2900 BCE, the right slope of Ward Hill (δ = -21.631º) is ~26 days from WS and the right slope of Kame of Hoy (δ = -17.066º) is ~45 days from WS (Appendix D). Thom's Megalithic Calendar transposed to 2900 BCE (Appendix G) would give: Megalithic Month11/13 ~23.5 days and Megalithic Month10/14 ~46 days from WS.
So these periods are comparable.
At other locations (Ness of Brodgar or Breckness) the Megalithic Months don't match up like at Maeshowe.

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[72] Towrie, "A millenium of activity on the Ness: Interview with Nick Card.", Richards, "Maeshowe 1991 Phase 3 structures report," 4. and Patrick Ashmore, "Dating Barnhouse," in *Dwelling among the monuments: the Neolithic village of Barnhouse, Maeshowe passage grave and surrounding monuments at Stenness, Orkney*, ed. Colin Richards (McDonald Institute for Archaeological Research, 2005).
[73] Patrick Ashmore, 6 July 2012.
[74] Thomas, *Understanding the Neolithic*: 64.
[75] John W. Hedges, *Tomb of the eagles: A window on stone age tribal Britain* (Oxford: Tempvs Reparatvm, 1984), 135.
[76] Hedges, *Tomb of the eagles: A window on stone age tribal Britain*: 130.
[77] Thomas, *Understanding the Neolithic*: 43.
[78] Hedges, *Tomb of the eagles: A window on stone age tribal Britain*: 136.
[79] Michael Zeilik, "Keeping the sacred and planting calendar," in *Foundations of new world cultural astronomy: A reader with commentary*, ed. A. Aveni (Boulder: University Press of Colorado, 2008).
[80] Thom, *Megalithic Sites in Britain*: Chapter 9.
[81] Thom, *Megalithic Sites in Britain*: Table 9.1.
[82] Clive L.N. Ruggles and Gordon Barclay, "Cosmology, calendars and society in Neolithic Orkney: a rejoinder to Euan MacKie," *Antiquity* 74(2000).

A priest-elite in British Isles

The existence of a possible priest-elite in megalithic Britain is a topic of some controversy between MacKie and Ruggles.[83] Thom started this idea by stating that his Megalithic Yard and Calendar were expected to be managed centrally in the British Islands.[84]

If such an elite was present in Neolithic times, is not known. The supporting argument of Mackie is that large settlements like: Ness of Bordgar; Barnhouse; and Skara Brae are labelled by archaeologist as ceremonial as they don't have much domestic artefacts. Mackie's standpoint is that such full-time professionals are needed to generate and protect knowledge and these groups utilised learning centres, which were stocked/supported by lay people. [85]

In other cultures such elites might have existed. There are recorded examples in the Pueblos of Southwest USA) where astronomical observations could be corrected by others people.[86] In Babylon vast amount of data was recorded and other people were consulted to audit first lunar crescent observations.[87] And according to Klaus Schmidt (paraphrased by Lewis-Williams and Pearce); Göbekli Tepe could have been a ritual centre for religious purposes.[88]

Death, resurrection and ascension

From a phenomenological and artist viewpoint according to Graves and Poray-Wilczynska:[89] While being in the air half way to Orkney, I was pondering if a reappearing Sun set could be symbolically related to death and subsequent re-birth,[90] coincidently my travel was two days before Good Friday (Jesus' crucifixion) and the measurements were made over the Easter days (Jesus' resurrection).[91] Elaborating this further:

1. Jesus' crucifixion (setting behind the summit): [92]

   > *Around noon the sky turned dark and stayed that way until the middle of the afternoon. The sun stopped shining, and the curtain in the temple split down the middle. Jesus shouted, "Father, I put myself in your hands!" Then he died. (Luke 23:44-46)*

2. Jesus' resurrection (first reappearing light):

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[83] Ruggles and Barclay, "Cosmology, calendars and society in Neolithic Orkney: a rejoinder to Euan MacKie."
[84] Thom, *Megalithic Sites in Britain*: 43.
[85] Towrie, "Resurrecting the Neolithic priesthood… Interview with MacKie".
[86] Zeilik, "Keeping the sacred and planting calendar," 206.
[87] Sacha Stern, "The Babylonian month and the new moon: sighting and prediction," *Journal for the History of Astronomy* 39, no. 1 (2008): 34.
[88] Lewis-Williams and Pearce, *Inside the Neolithic Mind: Consciousness, Cosmos and the Realm of the Gods*: 32.
[89] T. Graves and L. Poraj-Wilczynska, "Spirit of Place as process: Archaeography, dowsing and perceptual mapping at Belas Knap.," *Time and Mind* 2, no. 2 (2009).
[90] John Fraim, "The Place Of Time," in *Symbolism of place: The hidden context of communication* (2001).
[91] Scott P. Richert, "Roman Catholic liturgical calendar 2012," http://catholicism.about.com/od/holydaysandholidays/a/2012_Lit_Cal.htm.
[92] British Foreign Bible Society, *Contemporary English Version Bible* (Bible Society, 1997), Luke.

Very early on Sunday morning the women went to the tomb, carrying the spices that they had prepared. When they found the stone rolled away from the entrance, they went in. But they did not find the body of the Lord Jesus (Luke 24:1-3)
...
Same day two of Jesus' disciples were going to the village of Emmaus, which was about seven miles from Jerusalem. As they were talking and thinking about what had happened, Jesus came near and started walking along beside them. (Luke 24:13-15)

3. Jesus' ascension (last reappearing light):

   Jesus led his disciples out to Bethany, where he raised his hands and blessed them. As he was doing this, he left and was taken up to heaven. (Luke 24:50-51)

This sparked the idea that the reappearing Sun could be interpreted as a similar concept in Neolithic time; for instance a God of Light. No supporting literature has yet been found.

Conclusions

This Research Project has looked at two aspects of the reappearing Sun in Neolithic Orcadian culture.
First of all the horizon profiles were measured more accurate/precise with a theodolite. Computer based horizon profiles have been checked against these theodolite measurements and were found to be more accurate/precise than compass/clinometers readings; but one always has to verify by ground-truthing, certainly for nearby horizons.

The phenomenon of a reappearing Sun behind a slope that is steeper than the Sun's path has been analysed for a few Orcadian monuments/settlements (Maeshowe, Ness of Brodgar and Breckness) and this showed that reappearing does not always happen on specific celestial events (like equinox/standstill), but regardless of that; it happens. This reappearing could have been seen as a special phenomenon or entity/thing.

The reappearing phenomenon can be witnessed at many coordinates in the Orcadian landscape and Neolithic monuments are (still) unearthed at many coordinates. So what makes a Neolithic monument a human spatial focus for a reappearing phenomenon? Such interpretations are covered by the second part of this essay.

Several interpretations of the landscape with its build environment have been provided, from the possible conscious perception of the reappearing Sun and a symbolic link with the possibly sacred Hoy hills, through incorporating such foci into humanised space that links sky, land and humans with an annual rhythm. The journeys between the foci can be just as important as the foci themselves and these journeys might have been indicated by certain pointers included in the foci.

The reburial of ancestors' excarnated bones could be regulated by annual events and a (horizon) calendar could have been used to synchronise the different societies/tribes on Orkney. If this calendar was a formal calendar managed by a priest-elite, is not known, but non-utilitarian settlements could point to a class society.
The last interpretation compares the set-reappear-set phenomenon with a possible death-resurrection-ascension sequence.

This Research Projects left a lot of questions unanswered and new questions are added. Like: Were there platforms near the (lesser) walls at Ness of Brodgar?; What if other locations are analysed using computer based horizon profiles?; Was Hoy sandstone

used in Neolithic monuments on Orkney?; and Did humans made here spatial foci at Breckness (even though the horizon is so near)?

So on the journey of understanding Neolithic Orcadian culture, another small step has been placed. I am sure more steps will be placed.

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Bibliography

Rosalind Aitken. "My visit to Orkney." Pers. comm: 5 July 2012.

H.L. Andreson. "Metropolis, Monte Carlo and the MANIAC." *Los Alamos Science* 14 (1986): 96-108.

Patrick Ashmore. "Dating Barnhouse." In *Dwelling among the monuments: the Neolithic village of Barnhouse, Maeshowe passage grave and surrounding monuments at Stenness, Orkney*, edited by Colin Richards: McDonald Institute for Archaeological Research, 2005.

Patrick Ashmore. *Maes Howe*. Edited by Christopher Tabraham: H.M.S.O., 1989.

Patrick Ashmore. "Question on Maeshowe." Pers. comm: 6 July 2012.

Anthony Aveni. "The role of astronomical orientation in the delineation of world view: A center and periphery model." In *Foundations of new world cultural astronomy: A reader with commentary*, edited by A. Aveni, 253-72. Boulder: University Press of Colorado, 2008.

W. Bäbler, G.P. Bolze, M. Bischof, Kur- und Verkehrsverein Sernftal, Verkehrsbüro, and Bild und Botschaft. *Das Martinsloch zu Elm: Die Region Elm/Glarus mit den Ereignissen im Martinsloch: Ihr touristischer Begleiter zum Elmer Phänomen: astronomisch, alpinistisch, geologisch, kulturhistorisch*: Verkehrsbüro, 1996.

Thomas Baer, Andreas Schweizer, and Walter Bersinger. "Felsenlöcher." http://www.sternwartebuelach.ch/content/felsenloecher/felsenloecher.html, accessed on 2 July, 2012.

Beverley Ballin Smith. "A new late Neolithic house at Brodgar Farm, Stenness, Orkney." Glasgow: GUARD, 2003.

S. Bowman. *Radiocarbon Dating*: University of California Press, 1990.

Gerry G. Bracken. "The 'Rolling Sun' Spectacle of Boheh." The Secret Island, http://www.carrowkeel.com/sites/croaghpatrick/reek3.html, accessed on 5 July, 2012.

P. Bretagnon, and J.-L. Simon. *Planetary Programs and Tables from -4000 to +2800*. Richmond: Willmann-Bell, 1986.

William H. Calvin. *Hoe de sjamaan de maan stal: een reis naar de oorsprong van de wetenschap*. Translated by A. Konijnenbelt: Bakker, 1993.

M.M. Charleson. "Notice of the excavation of a chambered mound near Breckness, Stromness, Orkney." *Proc. Soc. Antiq. Scot* 37 (1903): 353-59.

J.L. Davidson, and A.S. Henshall. *The chambered cairns of Orkney: an inventory of the structures and their contents*: Edinburgh University Press, 1989.

G. Dombrowski. "THEO 020A." Jena: Jenoptik Jena GmbH, 1971, http://www.meetcentrum.nl/files/Zeiss%20theo%20020A.pdf.

John Fraim. "The Place Of Time." In *Symbolism of place: The hidden context of communication*, 2001, http://www.symbolism.org/writing/books/sp/4/home.html.
Charles D. Ghilani. "Astronomical Observation Handbook." The Pennsylvania State University, 2004, http://surveying.wb.psu.edu/sur351/CelestialCoords/ASTRO.pdf.
T. Graves, and L. Poraj-Wilczynska. "Spirit of Place as process: Archaeography, dowsing and perceptual mapping at Belas Knap." *Time and Mind* 2, no. 2 (2009): 167-94.
John W. Hedges. *Tomb of the eagles: A window on stone age tribal Britain*. Oxford: Tempvs Reparatvm, 1984.
Amiria J.M. Henare, Martin Holbraad, and Sari Wastell. *Thinking Through Things: Theorising Artefacts Ethnographically*: Routledge, 2007.
Martin Holbraad. "The power of powder: Multiplicity and motion in the divinatory cosmology of Cuban Ifa." In *Thinking through things; Theorising artefacts ethnographically*, edited by Amaria Henare, Martin Holbraad and Sari Wastel, 189-225. Abingdon: Routlege, 2007.
The CGIAR consoritum for spatial information. "CGIAR-CSI SRTM 90m Digital Elevation Data." http://srtm.csi.cgiar.org/, accessed on 30 June, 2012.
Keith W. Kintigh. "I wasn't going to say anything, but since you asked." In *Foundations of new world cultural astronomy: A reader with commentary*, edited by A. Aveni, 803-05. Boulder: University Press of Colorado, 2008.
Michael Kosowsky. "HeyWhatsThat Testbed." http://www.heywhatsthat.com/main-0904.html, accessed on 10 March, 2012.
Jet Propulsion Laboratory. "The Shuttle Radar Topography Mission." http://www2.jpl.nasa.gov/srtm/, accessed on 30 June, 2012.
David Lewis-Williams, and David Pearce. *Inside the Neolithic Mind: Consciousness, Cosmos and the Realm of the Gods*: Thames & Hudson, 2009.
R.L. Lowrie. *SME Mining Reference Handbook*: Society for Mining, Metallurgy, and Exploration, 2002.
Arien Mack, and Irvin Rock. *Inattentional Blindness*: Mit Press, 2000.
Euan W. MacKie. "Maeshowe and the winter solstice ceremonial aspects of the Orkney Grooved Ware culture." *Antiquity* 71, no. June (1997): 338-59.
Will MacNeil. "History of ancient Britain - Orkney special." http://willmacneil.com/new_site/?p=37, accessed on 30 June, 2012.
J.McKim Malville. *A Guide to Prehistoric Astronomy in the Southwest*: Johnson Books, 2008.
J.McKim Malville. "Llactapata panorama." Pers. comm: 29 May 2012.
Peter Jan Margry. "Secular pilgrimage: A contradiction in terms?" In *Shrines and pilgrimage in the modern world: New itineraries into the sacred*, edited by Peter Jan Margry, 13-48: Amsterdam University Press, 2008.
SkyMap Version 9.0.9. Marriott, Chris A., http://www.skymap.com/.
Steve Marshall, and George Currie. "Investigation of a "Sun roll" effect in relation to Silbury Hill." *Time and Mind* 3, no. 3 (2010): 291-302.
John D. North. *Stonehenge: Neolithic man and the cosmos*: HarperCollins, 1996.
Fernando Patat. "Horizon synthesis for archaeo-astronomical purposes." *Astronomische Nachrichten* 332, no. 7 (2011): 743-49.
Victor Reijs. "ARCHAEOCOSMO." http://www.iol.ie/~geniet/eng/archaeocosmoprocedures.htm, accessed on 5 July, 2012.

Victor Reijs. "Breckness fields." facebook, https://www.facebook.com/media/set/?set=a.3921814049613.170034.1407429736&type=3, accessed on 30 June, 2012.
Victor Reijs. "Cuilagssummit." Kosowsky, Michael, http://www.heywhatsthat.com/main-0904.html?view=O8LA90U0, accessed on 2 July, 2012.
Victor Reijs. "Locations and positions measured on Orkney." http://goo.gl/maps/xC9p, accessed on 2 July, 2012.
Victor Reijs. "Maeshowe." http://www.iol.ie/~geniet/maeshowe/eng/scot10.htm, accessed on 30 June, 2012.
Victor Reijs. "Maeshowe's Megalithic Month alignment." *3rd Stone*, no. Oct.-Dec. (1998): 18-20.
Victor Reijs. "The reappearing sun at Orkney." http://www.iol.ie/~geniet/maeshowe/eng/flashing.htm, accessed on 4 March, 2012.
Victor Reijs. *Reappearing sun light in Maeshowe, Orkney*: CD-ROM private distribution, 1999.
Victor Reijs. "Refraction: Refraction calculation." http://ireland.iol.ie/~geniet/eng/refract.htm#Calculated, accessed on 2 July, 2012.
Victor Reijs. "Views towards Ward Hill and Cuilags, Orkney." http://www.iol.ie/~geniet/maeshowe/eng/horizons.htm, accessed on 4 March, 2012.
Colin Richards. "Maeshowe 1991 Phase 3 structures report." University of Glasgow, 1991.
Scott P. Richert. "Roman Catholic liturgical calendar 2012." http://catholicism.about.com/od/holydaysandholidays/a/2012_Lit_Cal.htm, accessed on 6 July, 2012.
Clive L.N. Ruggles. *Astronomy in prehistoric Britain and Ireland*: Yale University, 1999.
Clive L.N. Ruggles, and Gordon Barclay. "Cosmology, calendars and society in Neolithic Orkney: a rejoinder to Euan MacKie." *Antiquity* 74 (2000): 62-74.
Brad E. Schaefer. "Case studies of three of the most famous claimed archaeoastronomical alignments in North America." In *Oxford VII*. Flagstaff Az., 2004.
Historic Scotland. "Canmore." http://canmore.rcahms.gov.uk/, accessed on 30 June 2012.
Walter Scott. "The pirate." In *Waverley novels*. Edinburgh: A. & C. Black, 1871.
Silva. "Silva Clino Master." Sollentuna, Sweden, http://silva.se/sites/default/files/pro_clinomaster.pdf.
Horizon Version 0.10a. Smith, Andrew, http://www.agksmith.net/horizon/.
British Foreign Bible Society. *Contemporary English Version Bible*: Bible Society, 1997.
Sacha Stern. "The Babylonian month and the new moon: sighting and prediction." *Journal for the History of Astronomy* 39, no. 1 (2008): 19-42.
Geraldine Stout. "Monumentality and inclusion in the Boyne Valley, County Meath, Ireland." In *Round Mounds and Monumentality in the British Neolithic and Beyond*, edited by T. Darvill, J. Leary and D. Field, 197-210: Oxbow Books, 2010.
Alexander Thom. *Megalithic Sites in Britain*: Oxford University Press, 1967.
Julian Thomas. *Understanding the Neolithic*: Taylor and Francis, 2002.
Christopher Tilley. "Art, architecture, landscape [Neolithic Sweden]." In *Landscape: Politics and perspective*, edited by B. Bender, 49-84. Oxford: Berg, 1993.
Christopher Tilley. *A phenomenology of landscape: places, paths and monuments*. Edited by B. Bender, J. Gledhill and B. Kapfere. 1 ed, Explorations in anthropology. Oxford: Berg Publishers, 1994.
Sigurd Towrie. "A millenium of activity on the Ness: Interview with Nick Card." *Islander 2012*, 2012, 10.

Sigurd Towrie. "The Ness of Brodgar excavations." http://www.orkneyjar.com/archaeology/nessofbrodgar/, accessed on 4 March, 2012.

Sigurd Towrie. "The Ness of Brodgar Excavations – Maeshowe alignments." http://www.orkneyjar.com/archaeology/nessofbrodgar/excavation-background-2/maeshowe-alignments/, accessed on 20 June, 2012.

Sigurd Towrie. "[ORCADIA] Reaapearing light around Maeshowe, Brodgar, Breckness or Staney Hill." Pers. comm: 4 June 2000.

Sigurd Towrie. "Resurrecting the Neolithic priesthood… Interview with MacKie." http://www.orkneyjar.com/archaeology/2012/01/10/resurrecting-orkneys-neolithic-priesthood/, accessed on 2 July 2012.

M.J. Zawaski, and J.McKim Malville. "An astronomical survey of major Inca sites in Peru." *Archaeoastronomy: The journal of astronomy in culture* XXI (2007-2008): 20-38.

Michael Zeilik. "Keeping the sacred and planting calendar." In *Foundations of new world cultural astronomy: A reader with commentary*, edited by A. Aveni, 199-230. Boulder: University Press of Colorado, 2008.

Appendix A Research proposal

Separate file: RESEARCHRESEARCH-PROPOSAL-Archaeoastronomy-VR-06.pdf

Appendix B Orkney travel itinerary

Date	Day	Activity
April 4th, 2012	Wednesday	M(orning)&A(fternoon): Travel A: collect tripod at ORCA A Radio Orkney interview A: calibrating theodolite All evenings: review and plan
April 5th, 2012	Thursday	M: preparing, socialise, ask permissions from LandOwner1 and Custodian A: theodolite location Maeshowe
April 6th, 2012	Friday	M: visit sites inside/outside Maeshowe region A: visit Astronomer A: theodolite location Ness of Brodgar
April 7th, 2012	Saturday	M: ask permission from LandOwner2 M/A: theodolite location Breckness
April 8th, 2012	Sunday	M&A: enjoy Orkney A: theodolite location Ness of Brodgar
April 9th, 2012	Monday	M: theodolite locations Ness of Brodgar and Watch Stone M&A: visit Hoy and talk with Observer3 about reflecting sun A: theodolite location Bu on Hoy A: ask permission from LandOwner3 A: theodolite location Breckness
April 10th, 2012	Tuesday	M: goodbyes A: bring back tripod
April 11th, 2012	Wednesday	M&A: Travel

Appendix C Precision of theodolite measurements

When the Sun was shining, the σ_{azi} of the Reference Objects' azimuth was calculated:

Location, Position	Reference Object	σ_{azi} [º]
Maeshowe, PosA	Telcom tower	0.0033
Maeshowe, PosB	Telcom tower	0.0020
Maeshowe, PosB	Telcom tower	0.0040
Ness of Brodgar, Pos2	Telcom tower	0.0023
Ness of Brodgar, Pos2	Ward Hill pillar	0.0025
Ness of Brodgar, Pos3	Telcom tower	0.0070
Ness of Brodgar, Pos3	Ward Hill pillar	0.0047
Breckness, PosV	Hoy Low lighthouse	0.0032
Breckness, PosV	Hoy High lighthouse	0.0043
Bu on Hoy	Ward Hill pillar	0.0108

Comparison of MacKie and Zabriskie's azimuth/altitude measurements[93] with author's measurements at Maeshowe PosB:

Horizon point	MacKie		Reijs	
	Azimuth [º]	Altitude [º]	Azimuth [º]	Altitude [º]
Ward Hill left slope	216.98	1.283	217.09	1.291
Ward Hill right slope	222.88	1.000	222.85	1.002
Cuilags left slope	225.63	0.867	225.67	0.852
Cuilags right slope (Kame of Hoy)	235.65	0.333	235.64	0.327

[93] MacKie, "Maeshowe and the winter solstice ceremonial aspects of the Orkney Grooved Ware culture," 349.

Appendix D Measurement locations and positions

The below locations and positions have been surveyed using the theodolite.[94] At each position several specific horizon points have been measurements. Also the number of Sun shootings is mentioned, which gives an indication of cloudiness (as six shootings was the aim).

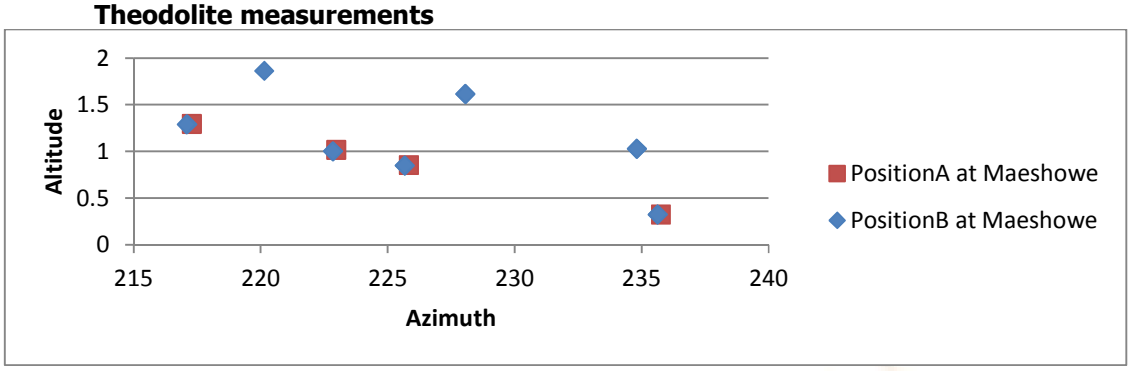
Location	Position	Longitude,Latitude	#horizon points	Sun shootings
Maeshowe	PosA	-3.18893,58.99627	68	6
Maeshowe	PosB	-3.18750,58.99641	9	9
Ness of Brodgar	Pos1	-3.21796,58.99809	9	0
Ness of Brodgar	Pos2	-3.21644,58.99751	9	6
Ness of Brodgar	Pos3	-3.21542,58.99683	9	3
Ness of Brodgar	Pos4	-3.21496,58.99673	6	0
Ness of Brodgar	Pos5	-3.21342,58.99662	7	0
Watch Stone		-3.21044,58.99518	5	4
Breckness	PosI	-3.34247,58.96531	5	0
Breckness	PosII	-3.33951,58.96647	5	0
Breckness	PosIV	-3.34365,58.96452	5	0
Breckness	PosV	-3.33946,58.96371	9	6
Breckness	PosVI	-3.33615,58.96461	6	0
Bu on Hoy		-3.32627,58.92511	4	6

In below sections:
For each location a graph is given of the theodolite measurements. And to give an idea of the landscape; for one position a panorama photo and computer based horizon profile is provided.

[94] Victor Reijs, "Locations and positions measured on Orkney," http://goo.gl/maps/xC9p.

Maeshowe location

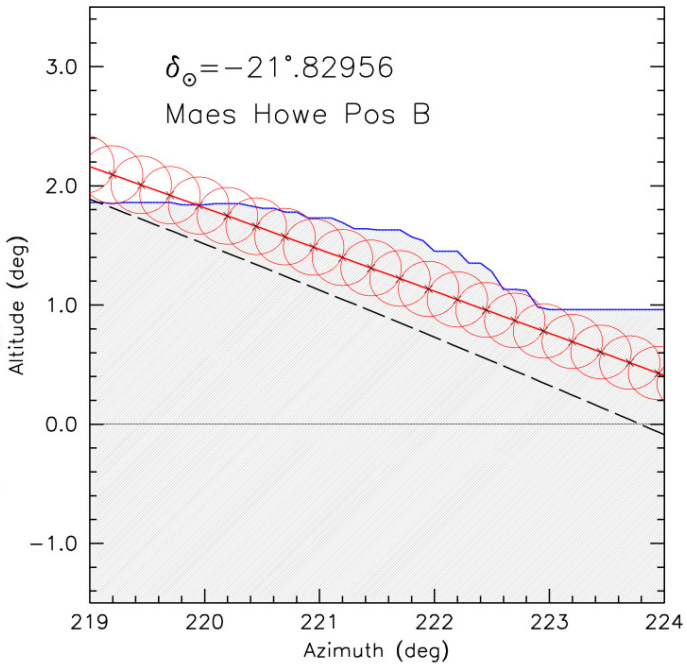
Theodolite measurements



PositionB panorama including computer based horizon profile

Horizon Point	Declination [º]	Days from WS 2900 BCE[95]
Ward Hill right slope	-21.631	~26
Cuilags right slope (Kame of Hoy)	-17.066	~45

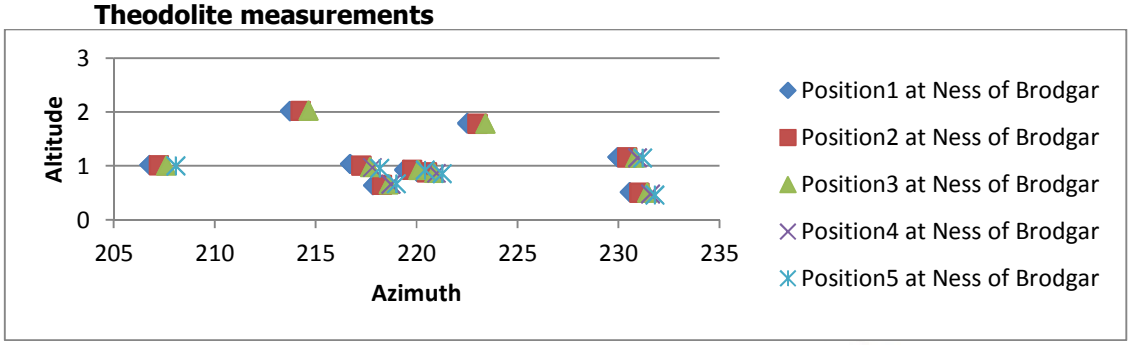
PositionB computer based horizon profile with Sun's path 20 days before/after WS 1999 CE



[95] SkyMap Ver. 9.0.9, Marriott, Chris A.

Ness of Brodgar location

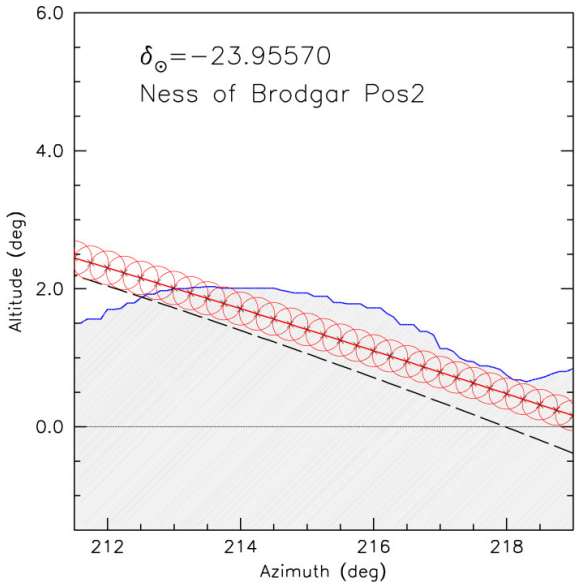
Theodolite measurements



Position2 panorama

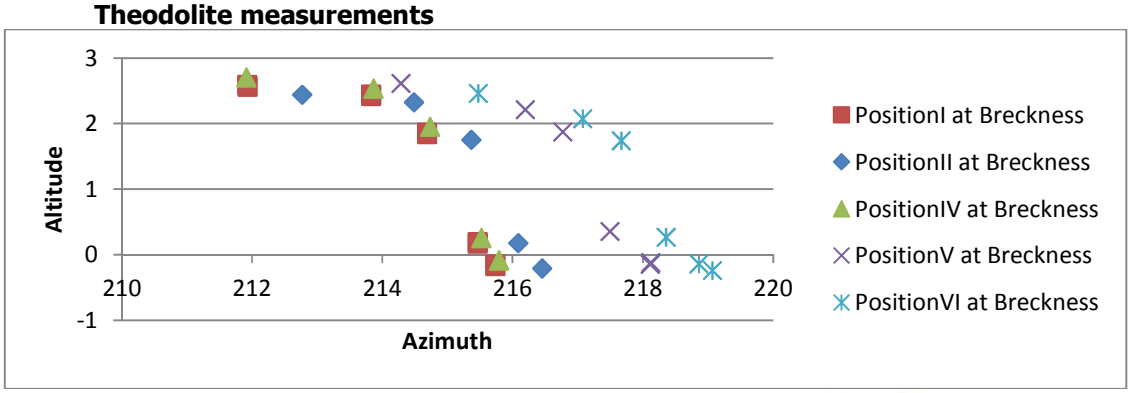
Horizon Point	Declination [º]
Ward Hill right slope	-23.639
Cuilags right slope (Kame of Hoy)	-18.877

Position2 computer based horizon profile with Sun's path on WS 2300 BCE

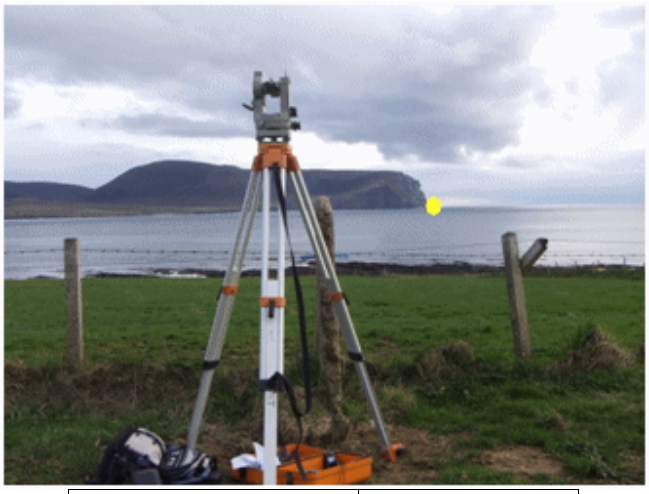


Breckness location

Theodolite measurements

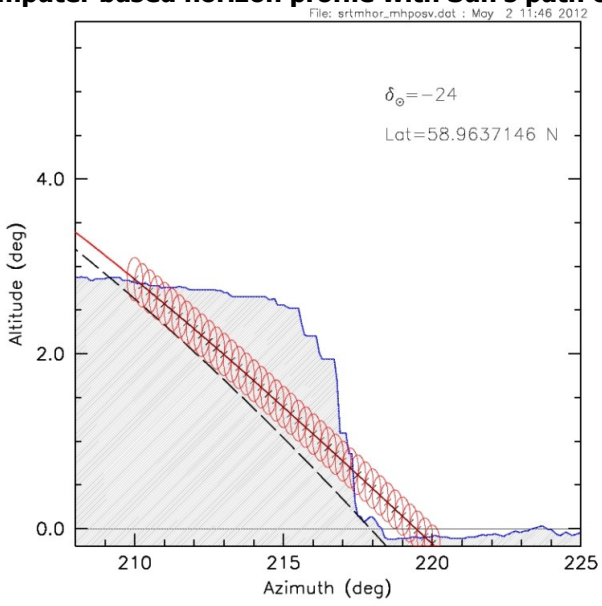


PositionV panorama



Horizon Point	Declination [º]
Cuilags right slope (Kame of Hoy)	-24.266

PositionV computer based horizon profile with Sun's path on WS 2750 BCE

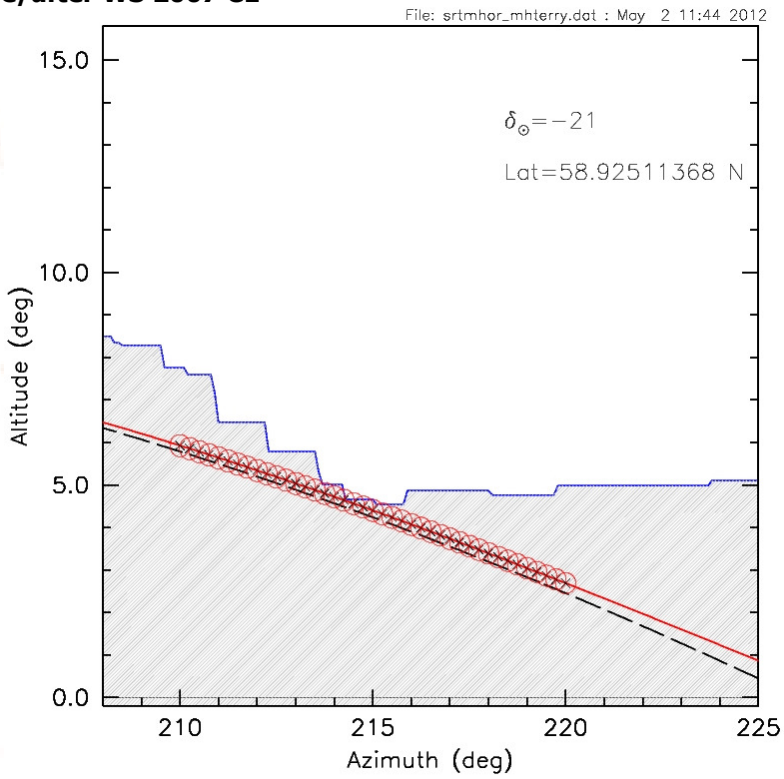


Bu on Hoy location

Position Bu panorama

Horizon Point	Declination [º]
Ward Hill right slope	-21.032

Position Bu computer based horizon profile with Sun's path on 25 days before/after WS 2007 CE



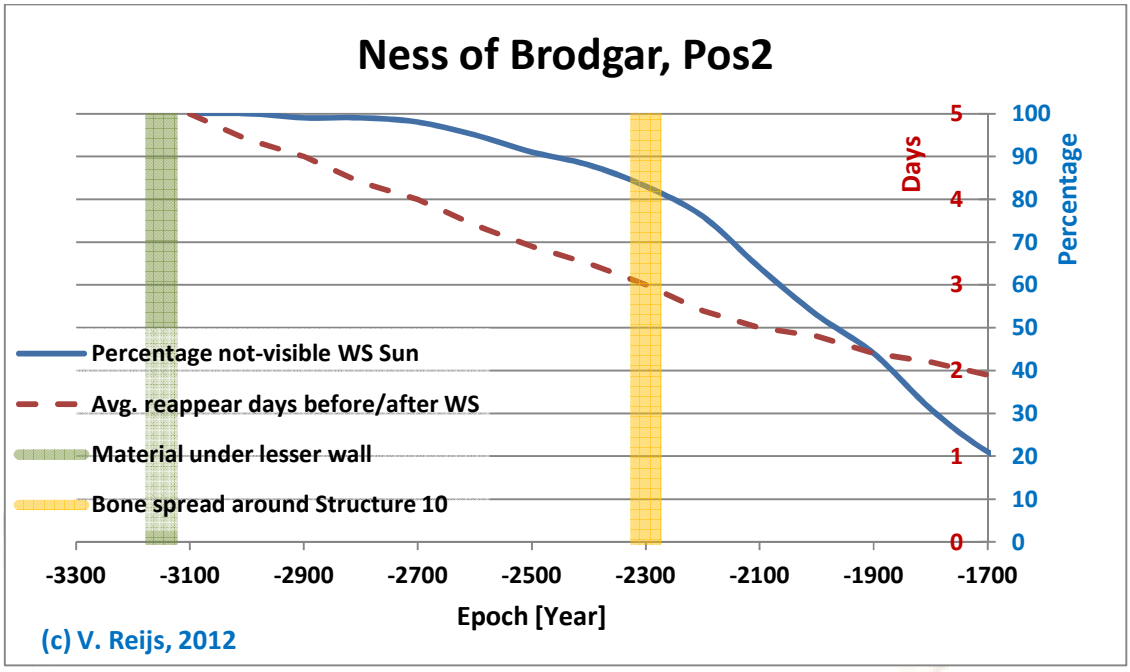
Appendix E Monte Carlo analysis on Ness of Brodgar's reappearing Sun

An analysis has been done using the Monte Carlo method[96] to get an idea when the Sun will reappear behind right slope of Ward Hill in the centuries around 3000 BCE.
The Ness of Brodgar location looks as follows:

This picture is a composition of Google Earth; a geophysical survey including an stylised depiction of a wall; and several theodolite positions. [97]

Pos2 is taken as the average observer position, standing outside (on a platform?)[98] and on the north-west side to the stone (lesser) wall. The observer's position is varied in a Gaussian way around this Pos2 (σ_{pos} = 16 [m]). The 'right slope of Ward Hill' horizon point is varied in the following way: its altitude is varied due to atmospheric stability class[99] (Gaussian: σ_{alt} = 0.025 [º]); and its azimuth is varied due to parallax of the observer's position. The year of the observation is varied in a random way (+/- 50 years) around a central epoch.
One now calculates the declinations of the horizon point and the WS Sun's position for some 1500 runs (with each run; new input values are chosen based on above statistical behaviour).
The difference of these two declinations determines if the WS Sun is visible (west of the horizon point) or not-visible (east of horizon point, so behind Ward Hill) from the observer's position. And if not-visible; one can calculate how many days before or after WS the Sun will visible/reappear.

[96] H.L. Andreson, "Metropolis, Monte Carlo and the MANIAC," *Los Alamos Science* 14(1986): 96.
[97] Will MacNeil, "History of ancient Britain - Orkney special," http://willmacneil.com/new_site/?p=37., Figure 4 and Reijs, "Locations and positions measured on Orkney".
[98] Stout, "Monumentality and inclusion in the Boyne Valley, County Meath, Ireland."
[99] Victor Reijs, "Refraction: Refraction calculation," http://ireland.iol.ie/~geniet/eng/refract.htm#Calculated.



In the above graph the central epoch has been varied from 3500 BCE to 1700 BCE, which is a period overlapping the assumed occupation period of Ness of Brodgar settlement. No official excavation report on Ness of Brodgar has been published yet.[100]

How to read this graph

Example one: at an epoch ~3150 BCE ("*Material under the lesser wall dates from 3200 – 3100BC. As such this is probably the earliest material we have so far encountered*")[101] the observer will never see a reappearing WS Sun. The Sun will, on average, reappear some 5 days before/after WS.

Example two: at epoch 2300 BCE, which might coincide with the decommissioning with Structure 10 ("*the bone spread around Structure Ten yielded a date of around 2300BC. This was much later than expected*...")[102] there is an 83% chance that the observer will not see a reappearing WS Sun. And if not-visible at WS, the Sun will, on average, reappear some 3 days before/after WS.

Could it be that Ness of Brodgar was 'slowly' decommissioned as the reappearing Sun became more and more visible on WS day, aka Winter Solstice was sometimes not a 'dark' day anymore and thus the 'darkness' could not be chased away by a ceremony?

[100] A pers. Communication reference needed
[101] Towrie, "A millenium of activity on the Ness: Interview with Nick Card."
[102] Towrie, "A millenium of activity on the Ness: Interview with Nick Card."

Appendix F Visibility of Ward Hill and Cuilags

An investigation has been performed to determine where on Orkney the two hills of Hoy (Ward Hill and Cuilags) can be seen. The computer programs can determine the visibility of a topographic feature in an easy way. HeyWhatsThat can provide such a *Visibility cloak* in a Google Earth/Map environment. An example of Cuilags summit's visibility on Orkney can be seen in Figure 5:[103]

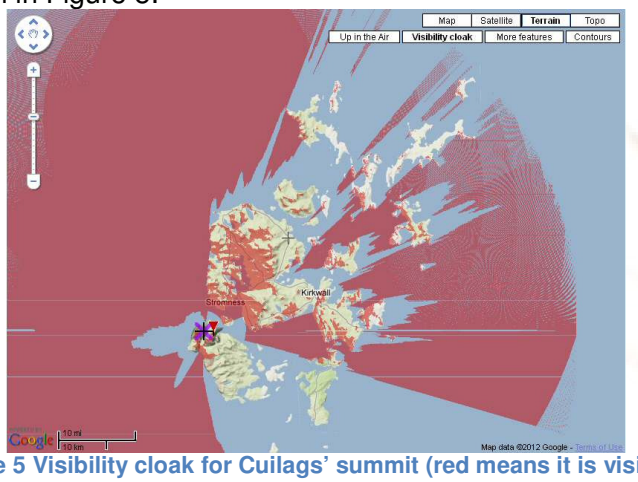


Figure 5 Visibility cloak for Cuilags' summit (red means it is visible).

We can combine the Orcadian soil type map with the distribution of Orcadian chambered cairns (as catalogued by J.L. Davidson and A.S. Henshall).[104] According to Davidson and Henshell, the cairn builders seem to have had a preference to build their chambered cairns at locations with a visibility between 1 and 5 km and that the cairn builders lived/farmed close to their cairns.[105]

If the above soil type and chambered cairn distributions are mapped on the visibility cloaks of Ward Hill and Cuilags summits, Figure 6 emerges:

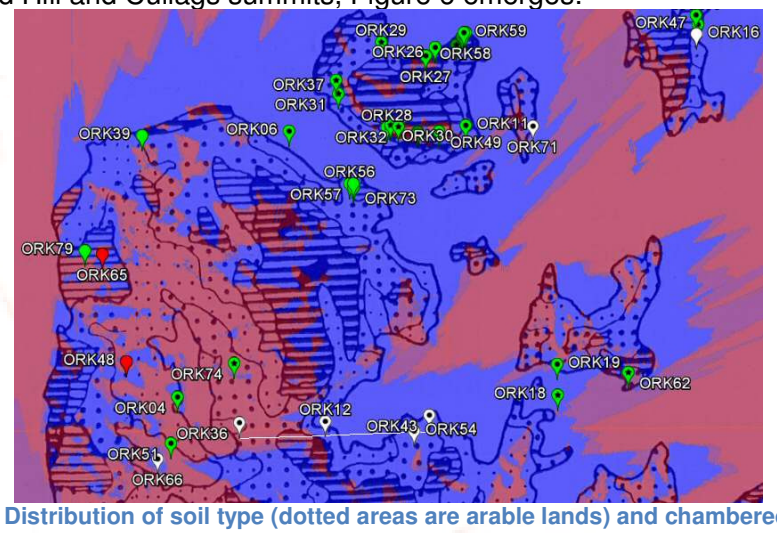


Figure 6 Distribution of soil type (dotted areas are arable lands) and chambered cairns on visibility cloaks (red) of Ward Hill and Cuilags summits.

[103] Victor Reijs, "Cuilagssummit," Kosowsky, Michael, http://www.heywhatsthat.com/main-0904.html?view=O8LA90U0.

[104] Davidson and Henshall, *The chambered cairns of Orkney: an inventory of the structures and their contents*: 16, Part Two.

[105] Davidson and Henshall, *The chambered cairns of Orkney: an inventory of the structures and their contents*: 15-17.

As Davidson and Henshall state, most of the chambered cairns are close to arable lands (dotted areas). Furthermore it looks that the chambered cairns are also close to the boundaries of the visibility/non-visibility of Ward Hill and/or Cuilags.
An initial Monte Carlo analysis[106] on the above has shown some significance of the visibility of summits, but a more detailed statistical analysis needs to be performed.

[106] Andreson, "Metropolis, Monte Carlo and the MANIAC," 96.

Appendix G Transposing Thom's Megalithic Calendar

Thom derived a Megalithic Calendar for 1800 BCE.[107] As most of the Orcadian construction dates are from around 2900 BCE, an attempt has been made to transpose Thom's calendar to 2900 BCE.

This has been done in the following way: it is assumed that Thom's declination distribution (made up of some 250 sites) can still be used; and that the Sun's declination in 2900 BCE can be proportionally compensated to obliquity of 1800 BCE (but still acknowledging the influences of eccentricity, perihelion, tropical and anomalistic years). Below Table 1 has been generated by ARCHAEOCOSMO software.[108] The differences with the 1800 BCE table don't look to be significant.

Month Number	Days in 'month'	Nominal days elapsed from SS	Nominal days elapsed from WS	Avg δ_s	Compensated Avg δ_s
0	23	0	272	0.39	0.39
1	23	23	249	9.07	9.03
2	24	46	226	16.62	16.55
3	23	70	202	22.11	22.01
4	23	93	179	24.01	23.90
5	23	116	156	22.08	21.98
6	22	139	133	16.89	16.81
7	22	161	111	9.29	9.25
8	22	183	89	0.41	0.41
9	22	205	67	-8.57	-8.53
10	22	227	45	-16.40	-16.32
11	23	249	23	-22.05	-21.95
12	24	272	0	-24.01	-23.90
13	23	296	24	-21.80	-21.70
14	23	319	47	-16.23	-16.16
15	23	342	70	-8.47	-8.43
16		365	93	0.29	0.29

Table 1 Transposed Thom's Megalithic Calendar declinations for 2900 BCE

[107] Thom, *Megalithic Sites in Britain*: Table 9.1.
[108] Victor Reijs, "ARCHAEOCOSMO," http://www.iol.ie/~geniet/eng/archaeocosmoprocedures.htm.