UNIVERSITÄT BERN

GIS in Archaeology

12 - Visibility Analysis

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You can download a pdf of this presentation.

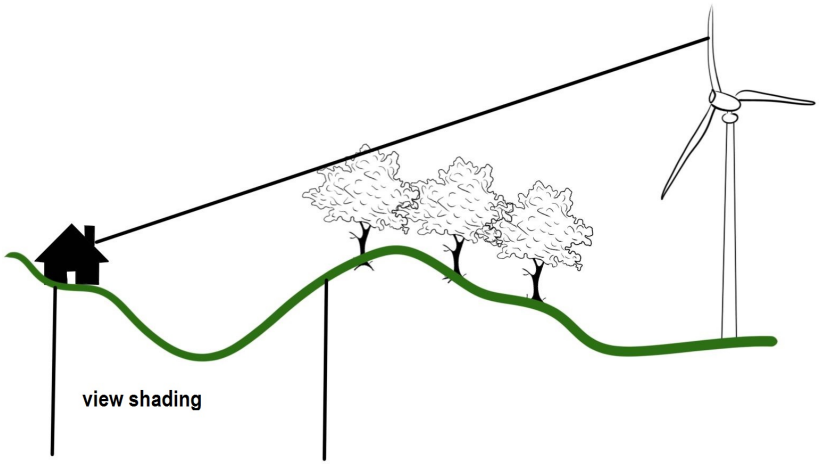
Before we start

Some had problems last time with:

- path names containing spaces:
  - make sure that while working with SAGA and GRASS that there are no spaces in the paths to your data
- zipped shapefiles
  - this time, everything should be possible without unzipping. But in general, you are more safe if you unzip the files and import them that way

What is Visibility Analysis

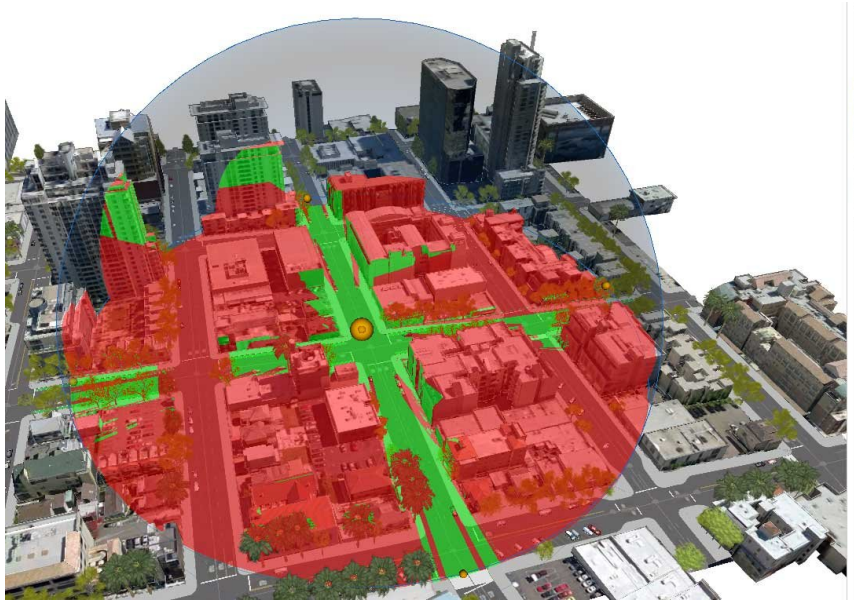
- determines which areas are visible from a certain point or - vice versa - from where a certain point or object can be seen.
- are based on the evaluation of elevation data in a digital terrain or elevation model (DEM)
- are particularly used in many approval procedures, for example in the planning of waste disposal sites, wind farms or freeway routes



Application of Visibility Analysis. Source: https://www.cloudeo.group/visibility-analysis

Why Visibility Analysis

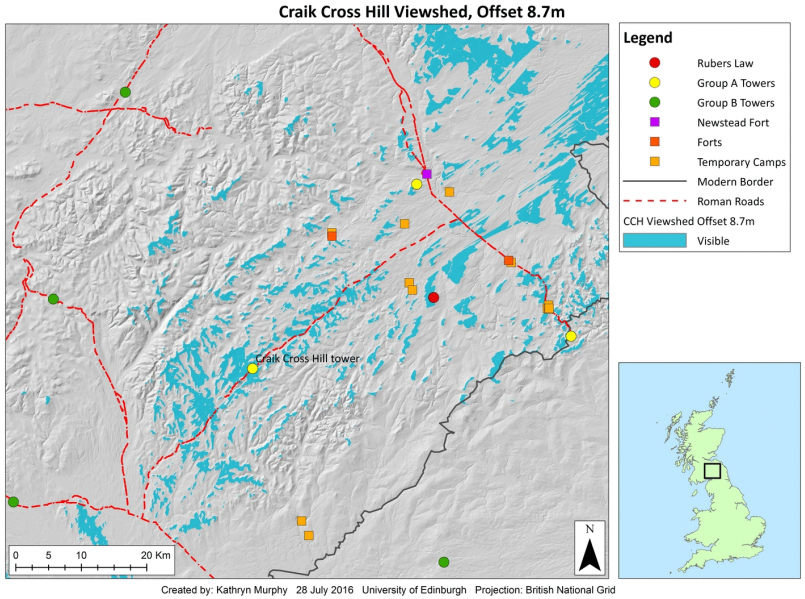
- Vision is one of the primary human senses
- therefore visibility is also a relevant factor in the interpretation of human behavior
- Visibility is
  - the basis of fundamental aspects of perception and orientation
  - of major importance to how humans relate to and interpret the landscape
- People often describe a place based on the visibility
- Visibility analysis is therefore an important element in the interpretation of the landscape for understanding past societies



Visibility analysis in modern city planning. Source: https://www.esri.com

Visibility Analysis in Archaeology

- explores the relationships of visibility and intervisibility between particular archaeological locations in the landscape
- can help analyse the spatial distribution of features in the landscape or help answer the question why a particular site was in a particular place
- certain sites might have been placed explicitly with vision in mind:
  - monuments
  - fortifications and watchtowers
  - ritual sites
  - hidden sites
- some interlinkage between sites may be made more plausible by intervisibility
  - eg. settlements and burial sites



Example of a binary viewshed analysis. Source: Murphy 2016

Visibility Analysis without GIS

- visibility analysis pre-dates GIS by at least two decades
- both formal studies (eg. Renfrew 1979) and anecdotal discussions about visual impressiveness or placement of monuments (eg. Devereux 1991)
- without a GIS difficult to produce and also to reproduce:
  - subjectivity of vision

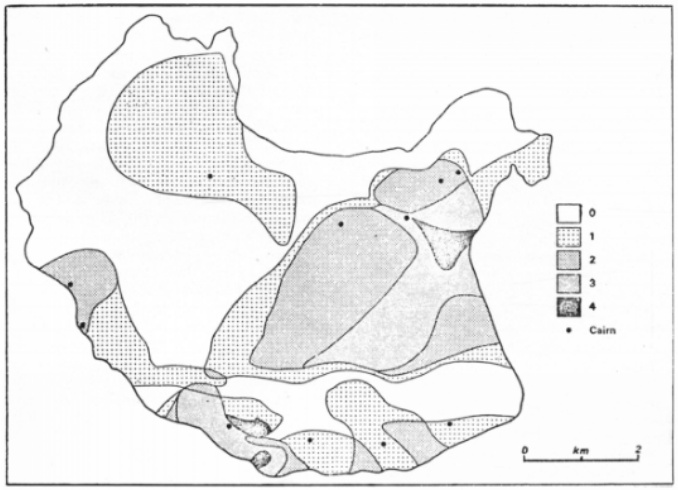


FIG. 2. Numbers of chambered cairns which are visible from different localities throughout Rousay (after Renfrew, 1979: fig. 5).

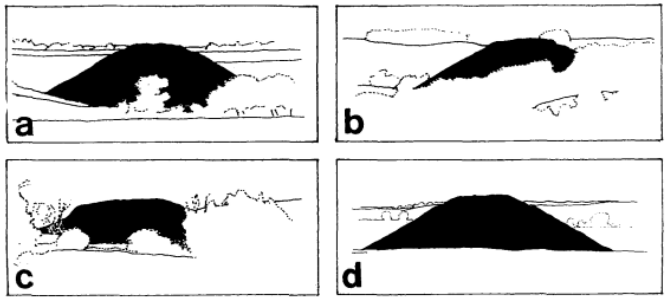
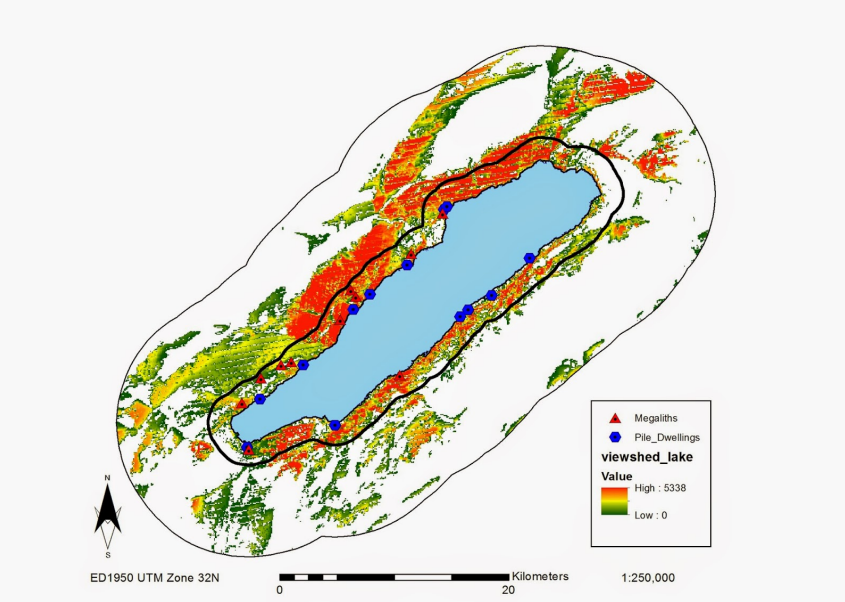


FIGURE 1. *The relationship of Silbury Hill (depicted in silhouette) with the horizon as viewed from (a) East Kennet Long Barrow; (b) the Sanctuary; (c) Beckhampton Long Barrow, and (d) West Kennet Long Barrow – in this instance the skyline is formed by Windmill Hill. It can be seen that the horizon intersects the profile of Silbury Hill between the monument's summit and ledge. (Depictions derived from telephotographs. Broken lines indicate foliage.)*

Example of an Visibility Analysis without GIS. Source: Renfrew 1979, Devereux 1991

Visibility Analysis with GIS

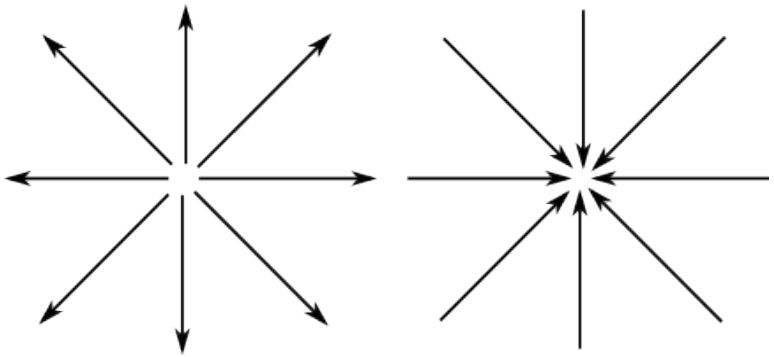
- Since widespread adoption in the 1990s GIS have increasingly been employed
- allow the user to
  - map the field-of-view from given viewpoint
  - determine lines of sight between locations
- viewshed has become a routine method in landscape archaeology
- crude in its basic application
  - simple binary map of zones in or out-of-view
- finessed through an on-going process
  - manipulation of view angles and parameters
  - fuzziness
  - visual acuity
  - visual prominence
  - horizon delineation
  - 3D visibility modelling



Viewshed from Lake Neuchâtel with megaliths and lakeshore sites.
Source: http://giannalogy.blogspot.com

Flavours of Visibility Analysis

- Visibility of the landscape from one point
- Visibility of a point from the landscape
- Intervisibility between two or more points
- Cumulative Viewshed
  - viewsheds from multiple points combined
- Total Visibility Index (i.e.: Total Viewshed)
  - viewshed from all points in the landscape combined
- ...

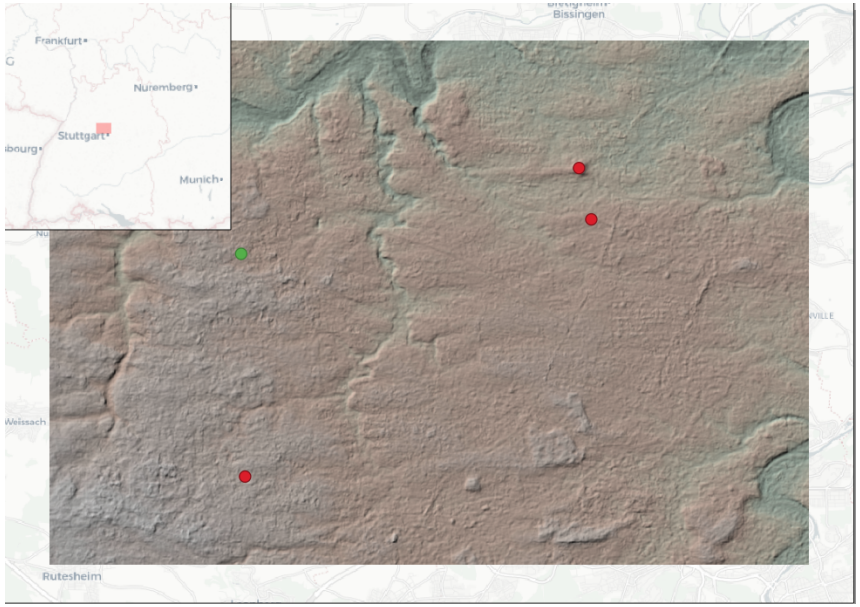


Visibility is not reciprocal. Source: https://landscapearchaeology.org

Prerequisites

- Observers point(s)
  - Hohenasberg - an Iron Age hill site
- Target point(s)
  - Iron Age Burial Mounds
  - (Hochdorf, Hirschlanden, Kleinaspergle)
- DEM
  - DEM of the region around the Hohenasberg
- a visibility analysis tool

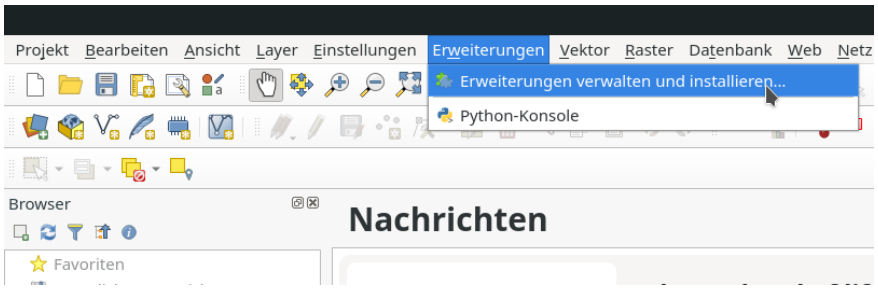
Download all layers and add them to the map.

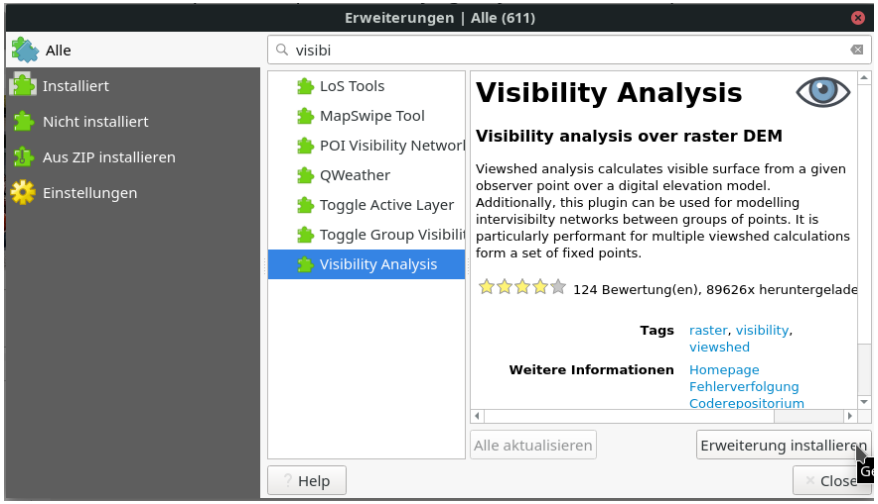


The working area. Green: Hochdorf. Red: Iron Age Burial Mounds and Hohenasberg. Background Map Positron by CartoDB.

Install the Plugin

- Go to 'Extensions > Manage and Install Extensions'
- Search for 'Visibility Analysis'
- Click on Install



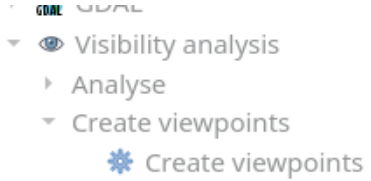


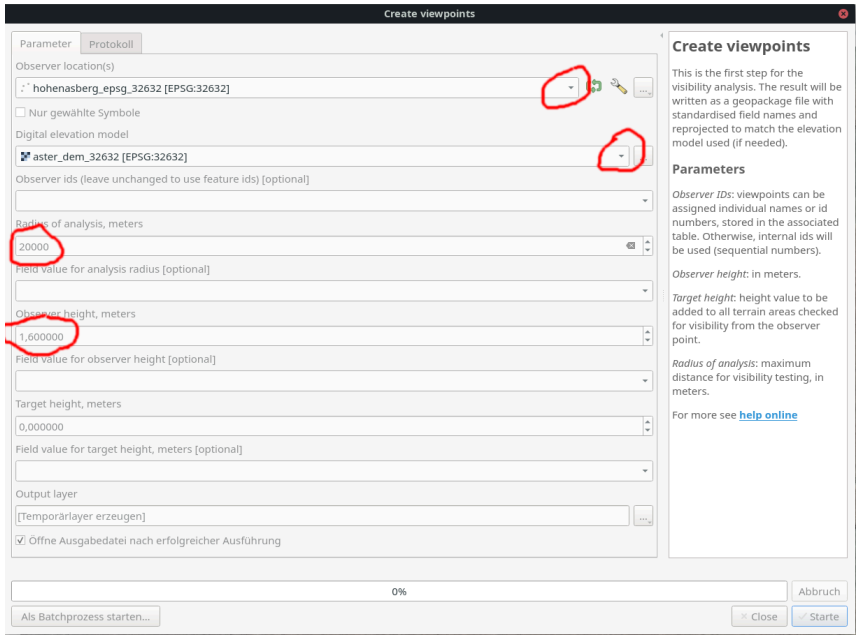
Viewshed from the Hohenasberg

Creating Viewpoint

At first, we will calculate the visible area from the Hohenasberg. To do so, we have to specify the observer location.

- Open the toolbox 
- Select 'Create viewpoints' from 'Visibility Analysis > Create viewpoints'
- Select 'hohenasberg' as Observer location
- Select 'aster_dem' as dem
- Specify 20000 m as radius of analysis
- you can specify an observer height different from 1.6 m, but we will not do it
- click on 'Run'
- You get a new layer, 'Output layer'. You might like to rename it to 'Viewpoint Hohenasberg'

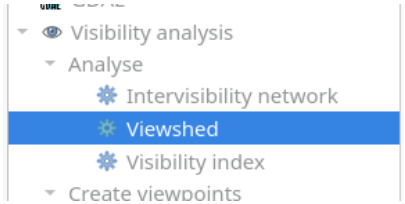


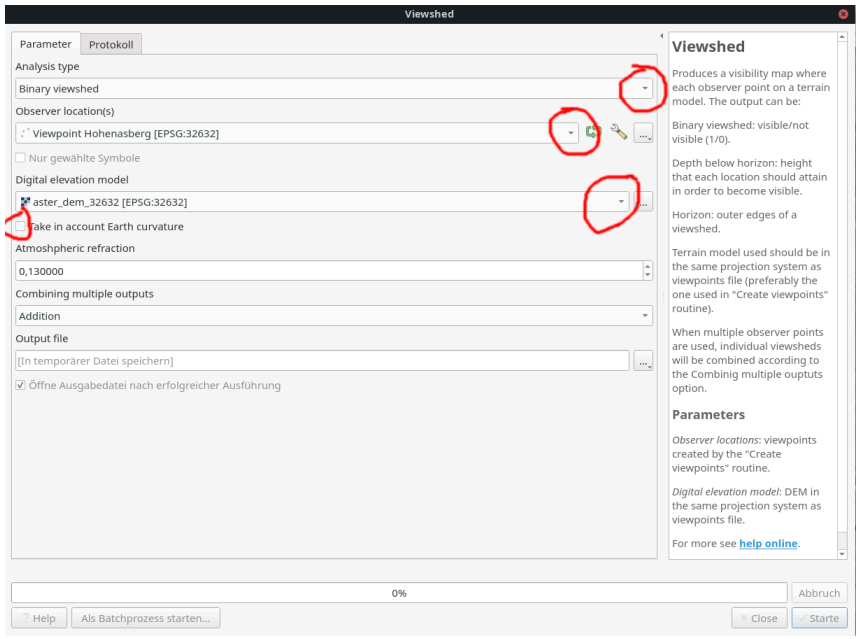


Viewshed from the Hohenasberg

Calculating Viewshed

- Select 'Viewshed' from 'Visibility Analysis > Analyse'
- Binary Viewshed is selected
  - other options are described in the box to the right
- Select the Viewpoint Hohenasberg as Observer location
- Select the aster_dem as DEM
- You could include the earths curvature (if you not belief in the flat earth)
- Click on Run

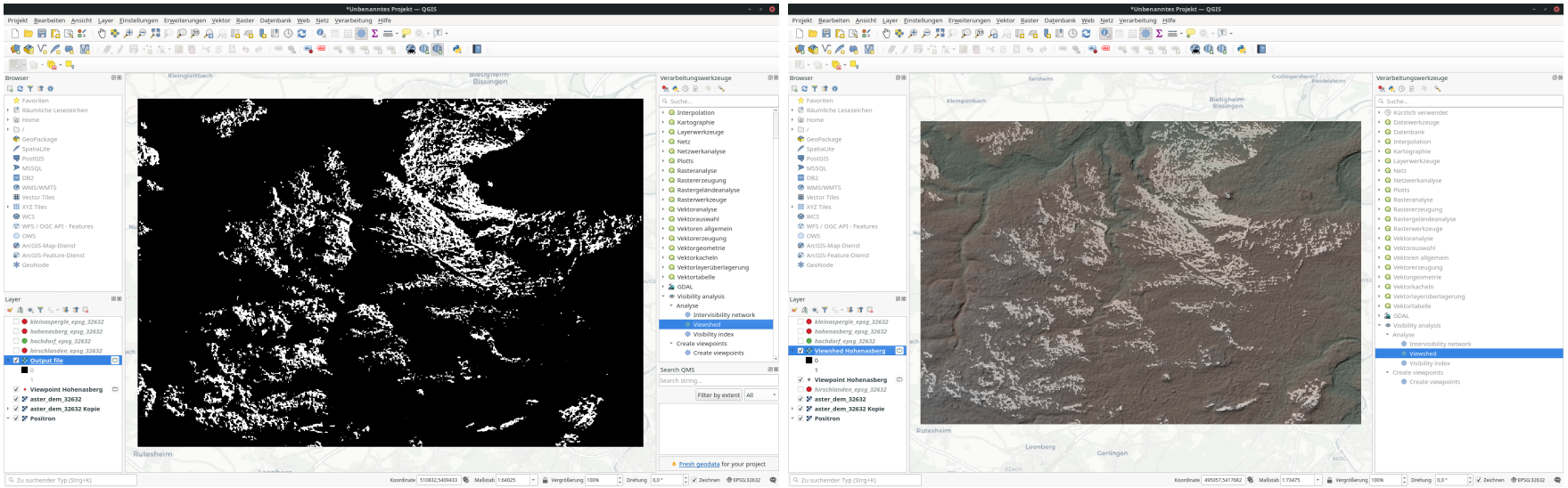




Viewshed from the Hohenasberg

Calculating Viewshed

- The result is a black and white image
  - black: not visible
  - white: visible
- You can improve the visualisation with transparency
- You can check if the burial mounds would be visible
  - **[keep in mind, that we selected heigth of 0, and observer heigth of 1.6]**



Result of the viewshed analysis from the Hohenasberg. Left: original result; Right: 33% Opacity.

Visibility of the burial mounds

Reciprocal Visibility

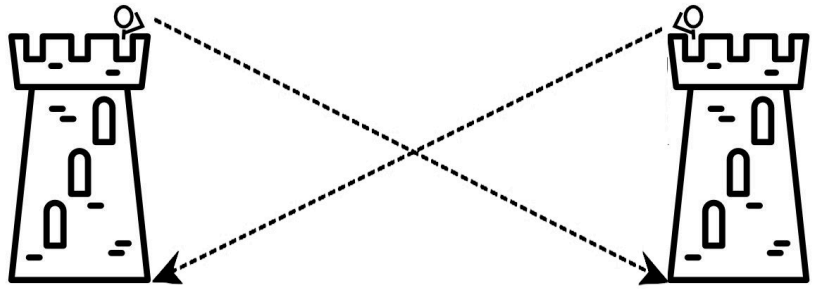
Line of Sight works in two ways. So what can be seen by an observer generally can also see the observer.

But:

The burial mounds are prominent themself. Their actual height might not be reflected in the (rather unprecise) DEM.

Also, the person on the Hohenasberg might be on an elevated position (eg. a rampart).

Lets assume the burial mounds where 6 m height. Lets repeat the procedure with an changed observer and target heigth.



The problem of reciprocity. Source: https://landscapearchaeology.org, modified.

Visibility of the burial mounds

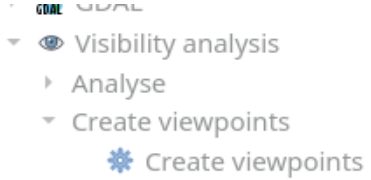
Creating a new Viewpoint layer

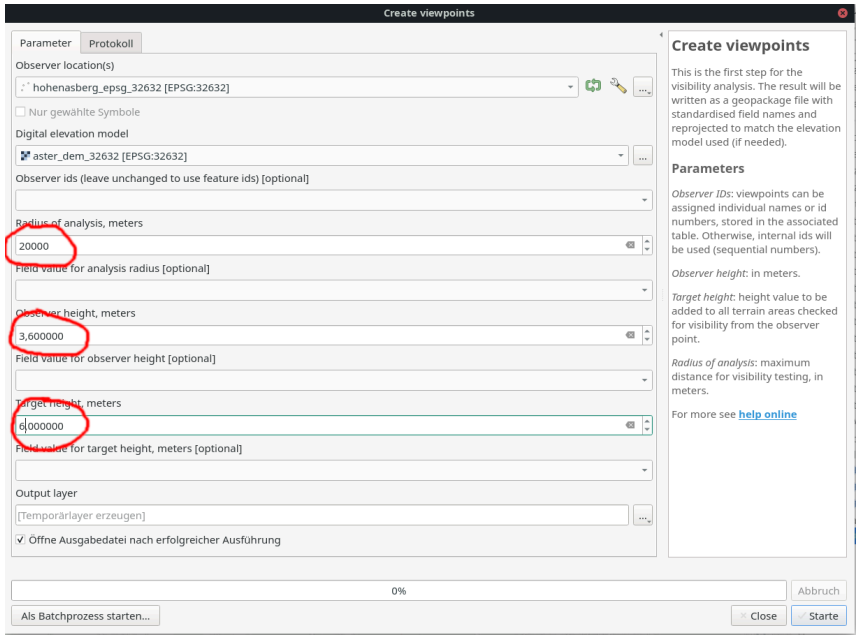
- Select 'Create viewpoints' from 'Visibility Analysis > Create viewpoints'
- Select 'hohenasberg' as Observer location
- Select 'aster_dem' as dem
- Specify 20000 m as radius of analysis
- Select 3.6 m as observer height
- Select 6 m as target height

- Click on Run

- You get a new layer, 'Output layer'. You might like to rename it to 'Viewpoint Hohenasberg elevated'

- Repeat the viewshed analysis with the new observer location

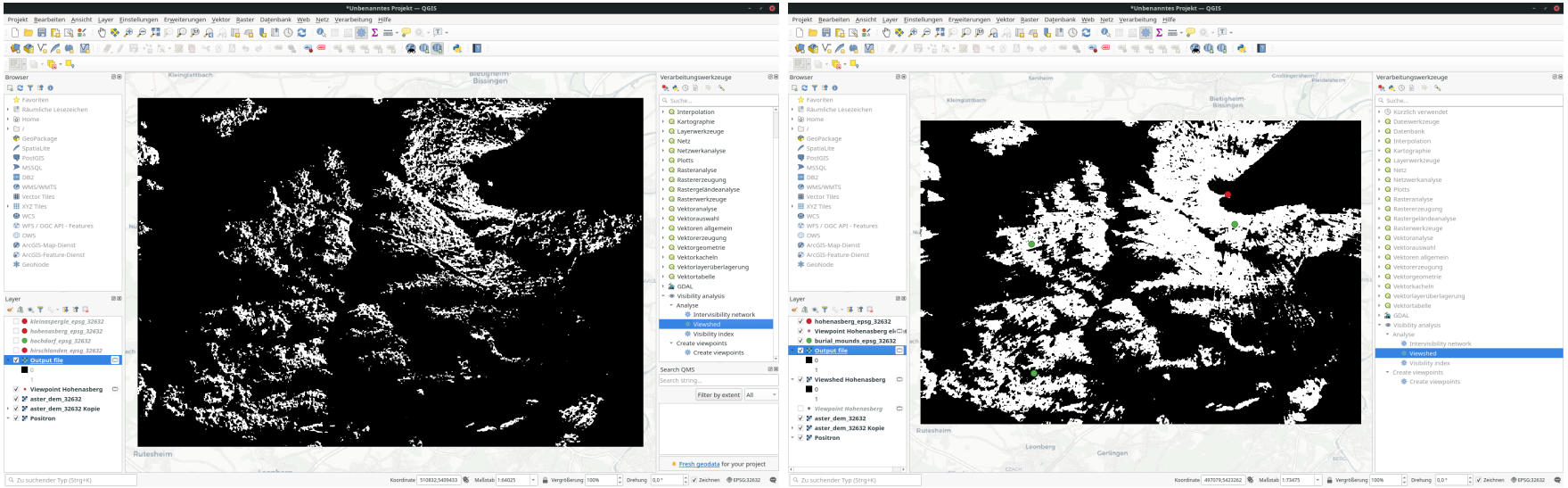




Visibility of the burial mounds

Result

- The result is a raster with more white (=visibile area) than before
- Compare with the visible area before
- You can check if the burial mounds would be visible now
  - [Kleinaspergle and Hochdorf would be visible, Hirschlanden not]



Result of the viewshed analysis from the Hohenasberg. Left: observer 1.6 m to ground; Right: observer 1.6 m to target 6 m.

What can be seen from the burial mounds

aka Cumulative Viewshed

We can combine multiple observation points in one analysis to calculate the total area that can be seen by any of the observers, rsp. how good an area can be observed by any of them.

We will try this out with the burial mounds

(admittedly, this does not make so much sense archaeologically, but think of the burial mounds as Roman Limes watchtowers)

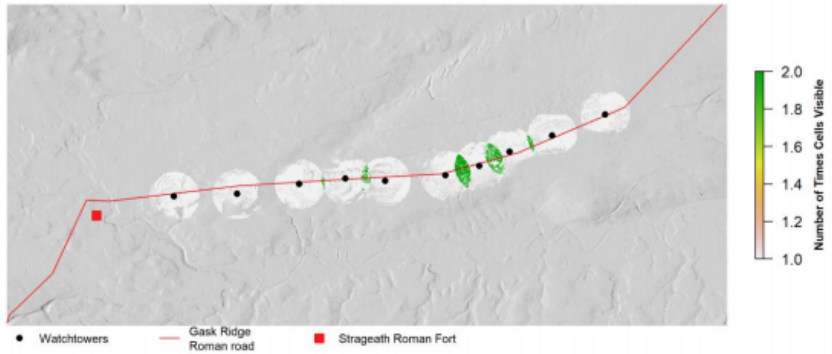


Fig. 3. Cumulative viewshed of the Gask Ridge Roman road from the watchtowers.

Source: Lewis 2020

What can be seen from the burial mounds

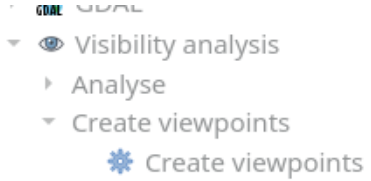
Viewpoints

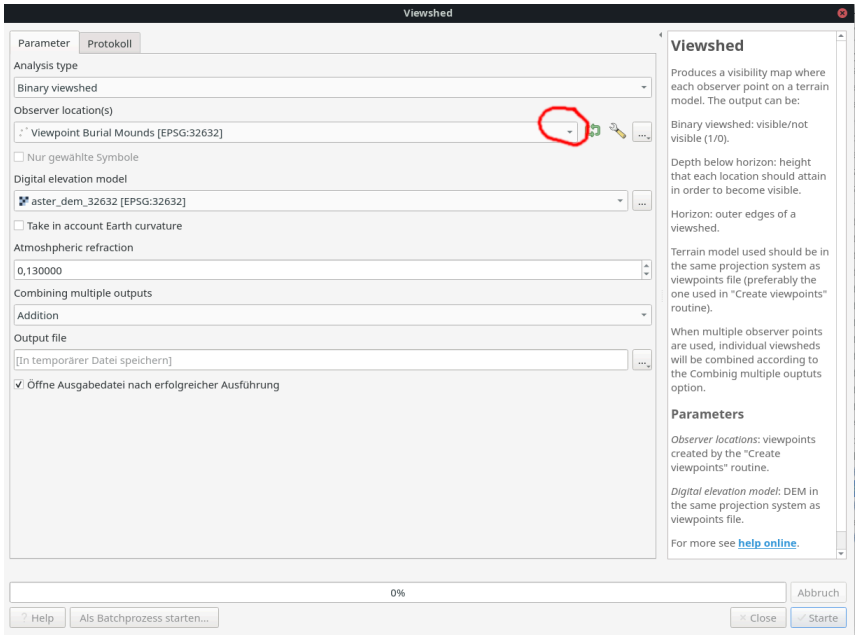
- Select 'Create viewpoints' from 'Visibility Analysis > Create viewpoints'
- Select 'burial_mounds' as Observer location
- Select 'aster_dem' as dem
- Specify 20000 m as radius of analysis
- Select 6 m as observer height
- Select 0 m as target height

- Click on Run

- You get a new layer, 'Output layer'. You might like to rename it to 'Viewpoint Burial Mounds'

- Repeat the viewshed analysis with the new observer location

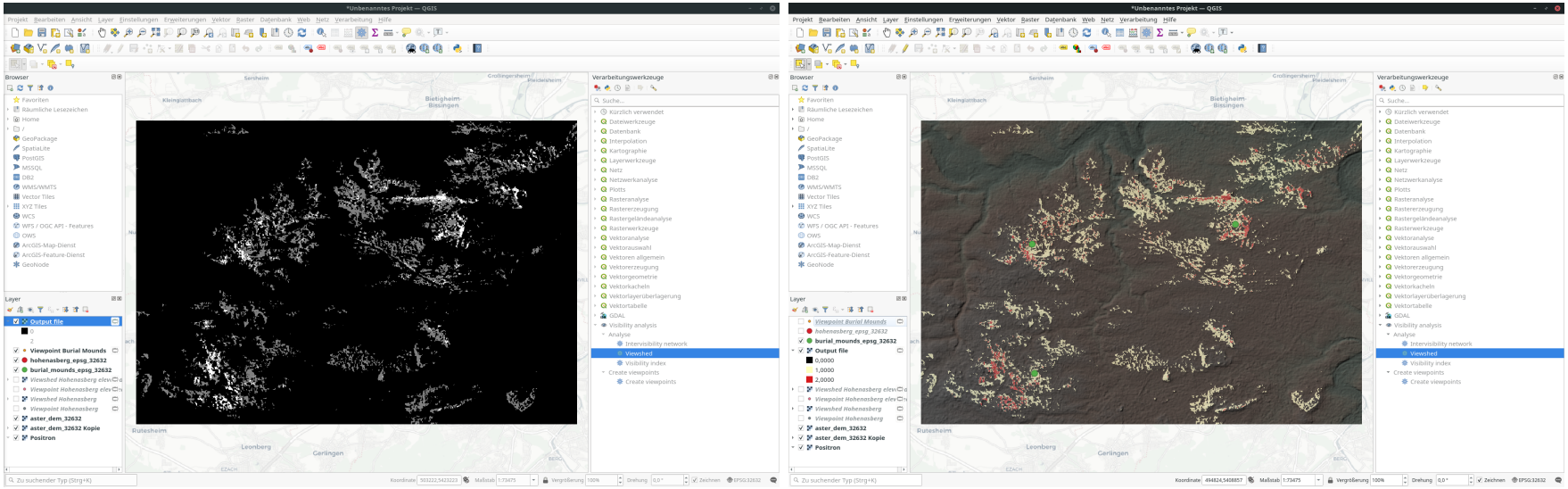




Visibility of the burial mounds

Result

- The result is a raster, where more white means visible from more locations (up to 2 here).
- You can use pseudocolor and transparency to make the result more appealing.



Result of the cumulative viewshed analysis from the Burial mounds. Left: original result; Right: styled using pseudocolor and transparency. Red mean, visible by two mounds.

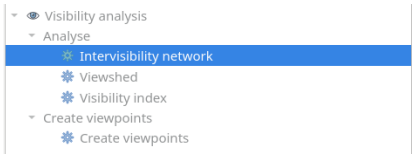
Making intervisibility more obvious

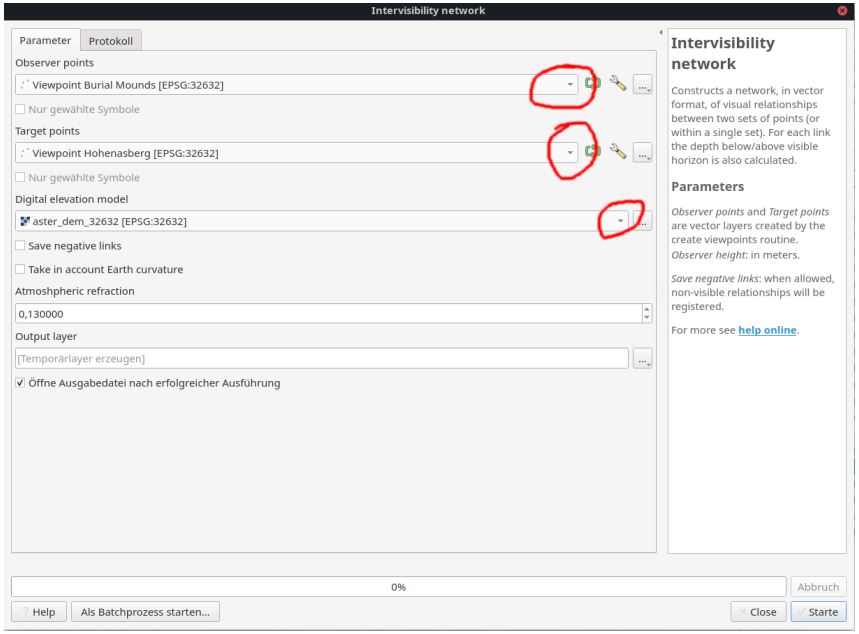
aka Intervisibility Network

The last analysis made clear that non of the burial mounds can see each other. We already saw that two of them might be visible from the Hohenasberg. To make this even more stand out, we can use the Intervisibility Network tool.

- Select the 'Intervisibility network' tool
- Select 'Viewpoint Burial Mounds' as observer
- Select 'Viewpoint Hohenasberg' as target
- Select the aster_dem as DEM
- Click on 'Run'

You need to select Viewpoint Layers as Observer and Target for this tool!



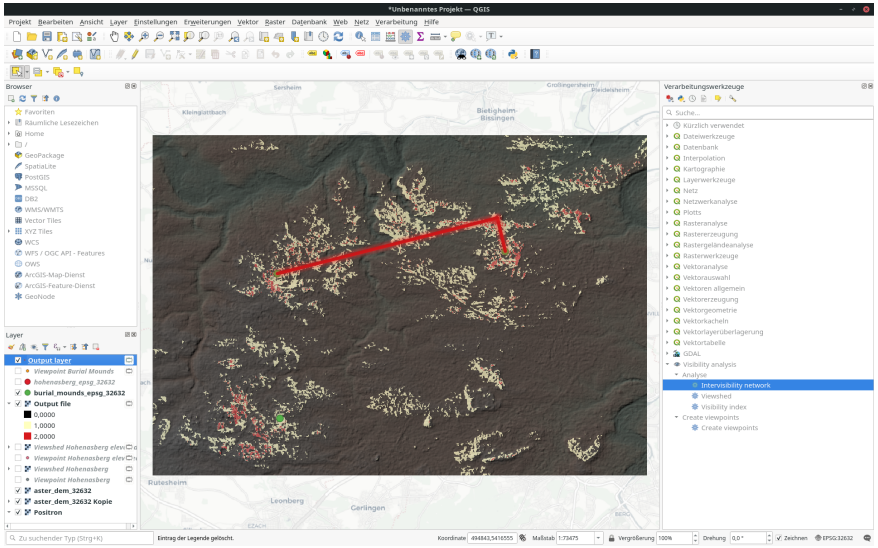


Making intervisibility more obvious

Result

The intervisibility is highlighted by lines connecting the lines of sight. You can make this stick out more using symbology.

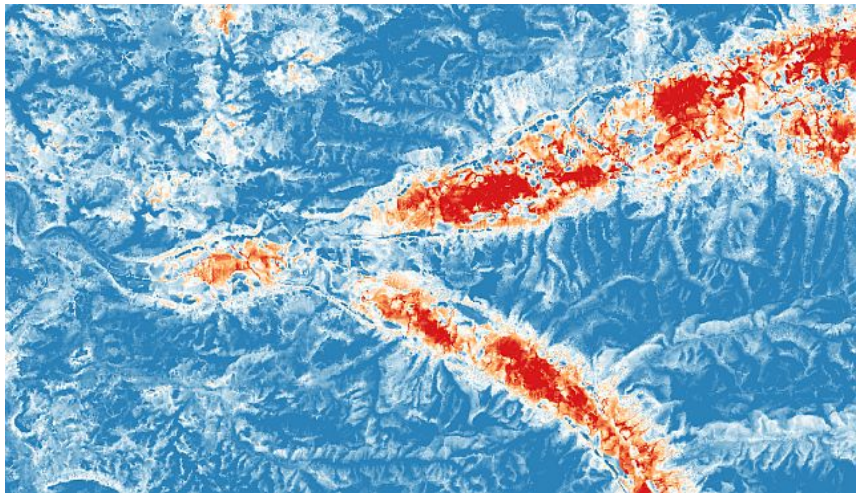
We can also use this tool specifying Observer and Target points the same, calculating intervisibility within one set of points.



Visibility Index

aka Total Viewshed

- Essentially a cumulative viewshed for every pixel
- Used to find very exposed places in the landscape
- calculation is rather time consuming

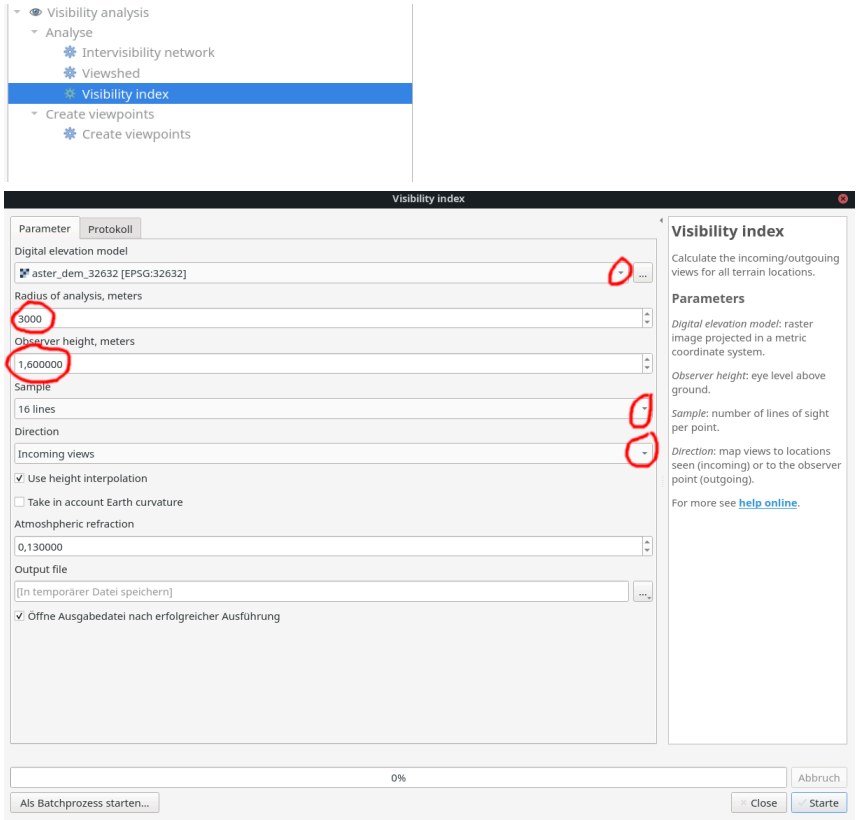


Example of a total viewshed/Visibility index for two river valleys: note high exposition of valley bottoms. Source: https://landscapearchaeology.org

Visibility Index

Calculation

- Select the 'Visibility Index' tool
- Select the aster_dem as DEM
- You can specify how far each raster cell should 'see'
  - higher values mean more calculation time
- You can specify observers height
- You can specify observation directions
  - more means more calculation time, but more precise results
- You can specify if to see (Incoming) or to be seen (Outgoing)
- Click on 'Run'



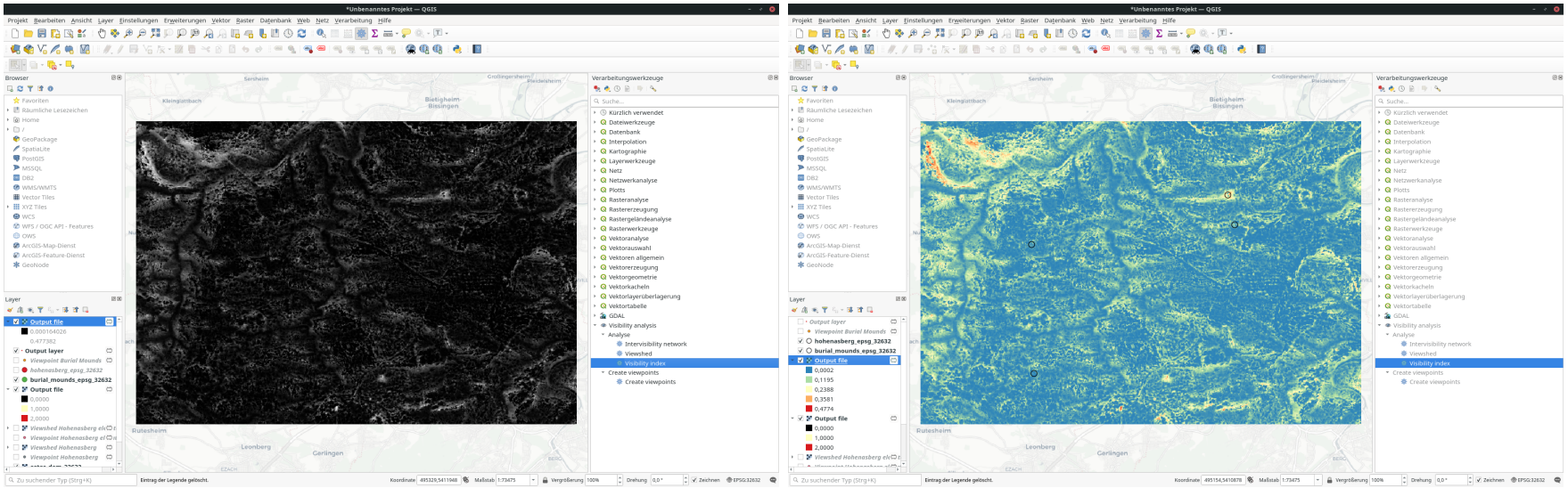
Visibility Index

Result

The result shows prominent locations in the landscape

Note that the Hohenasberg is rather prominent and can be seen from many places.

On the other hand, the burial mounds are not that prominent...



Results of the Visibility index calculation. Left: original result; Right: restyled using Symbology. More yellow-red means more visible

Challenges

Visibility analysis is complex. Wheatley and Gillings (2000) classify the issues relating to visibility analysis into three categories:

- Pragmatic - pragmatic issues are those which apply to both GIS and non-GIS based visibility studies
  - e.g. vegetation, human perception and temporal changes
- Procedural – procedural issues refer to concerns that arise as a product of using GIS for visibility analysis
  - e.g. DEM accuracy and the undifferentiated nature of the viewshed (binary output)
- Theoretical – theoretical issues are those which arise from debates in the humanities (e.g. geography)

More on Visibility analysis

Axel Posluschny, Sehen und gesehen werden – Sichtbarkeitsanalysen als Werkzeug archäologischer Forschungen. In: D. Krausse (Hrsg.), Frühe Zentralisierungs- und Urbanisierungsprozesse. Zur Genese und Entwicklung frühkeltischer Fürstensitze und ihres territorialen Umlandes. Forsch. u. Ber. Vor- u. Frühgesch. Baden-Württemberg 101 (Stuttgart 2008) 367–380, 2008

Free available via academia.edu

Also: https://landscapearchaeology.org of Zoran Čučković, the maker of the QGIS Plugin

Sehen und gesehen werden

Sichtbarkeitsanalysen als Werkzeug archäologischer Forschungen

AXEL POSLUSCHNY

Die Untersuchungen des Projekts „Fürstensitze" & Umland[1] werden im Wesentlichen mit Hilfe geographischer Informationssysteme (GIS) als Arbeitswerkzeug durchgeführt.[2] Da Sichtbarkeitsanalysen einerseits eines der bekanntesten Analyseverfahren in einem GIS sind, andererseits in der landschaftsarchäologischen Forschung in Deutschland bislang eher selten eingesetzt wurden, sollen im Folgenden in einem methodisch orientierten Überblick die Möglichkeiten und die methodischen Fallstricke aufgezeigt werden.[3]

Die Bedeutung des Sehens

Sehen ist einer der primären Sinne des Menschen, daher ist Sichtbarkeit auch ein relevanter Faktor bei der Interpretation menschlicher Verhaltensweisen. So ist Sichtbarkeit die Basis grundlegender Wahrnehmungs- und Orientierungsaspekte, die einen direkten Bezug zu landschaftsarchäologischen Fragestellungen haben.[4] Neben dem direkten Erkennen und Auffassen der Umgebung und der Orientierung in der Landschaft gehören dazu auch übergeordnete Gesichtspunkte wie die Dichotomie von Natur und Kultur oder das Erkennen von Richtungen, Bewegungen u.ä. sowie darauf basierend das Erkennen von Zeit durch das Erkennen von Veränderungen (jahreszeitliche Veränderungen in der Natur, tages- und jahreszeitliche Veränderungen in der Position der Gestirne usw.).

Grundlagen des Sehens

Die menschliche Fähigkeit des Sehens wird von verschiedenen Faktoren beeinflusst. Dazu gehören die Sehschärfe, die Auflösungsschärfe, die Erkennungsschärfe/"Trennschärfe" und auch Faktoren der Umwelt wie Licht, die Atmosphäre sowie selbstverständlich auch Hindernisse wie Vegetation, Bebauung, usw. die die Sicht beeinflussen können.[5]
Dadurch, dass gerade der Faktor Vegetation, d. h. im Wesentlichen die Bewaldung bzw. Nichtbewaldung, für vorgeschichtliche Zeiten nur in Ausnahmefällen zu rekonstruieren ist, ergeben sich entscheidende Einschränkungen bei der Bewertung von Sichtverbindungen. So sind die in den verschiedenen GIS-Programmen enthaltenen Algorithmen abhängig von der Geländehöhe, können aber Waldflächen nur indirekt berücksichtigen, wenn diese bekannt sind und deren Höhen zu den Geländemodellen an den entsprechenden Stellen addiert werden. Das Ergebnis einer Sichtbarkeitsanalyse sollte also eher die Aussage sein, unter welchen Bedingungen ein Objekt, ein Gebiet oder eine Landschaft *theoretisch sichtbar oder einsehbar gewesen sein konnte* bzw. noch entscheidender, ob eine Sichtbarkeit auch bei postulierter fehlender Bewaldung *in keinem Fall möglich war*.[6]

Grundlagen des Erkennens

Neben den erwähnten Grundlagen des Sehens sind – abhängig vom „Ziel" des Sehens – vor allem die Größe des zu beobachtenden Objekts, der Kontrast des

1 Geringfügig erweiterte Fassung des anlässlich des 3. Plenarkolloquiums des DFG-Schwerpunktprogramms gehaltenen Vortrags, Blaubeuren, 9.–11.10. 2006.
2 Zur Einführung in die Fragen und Arbeitsweisen des Projekts „Fürstensitze" & Umland siehe Posluschny 2005.
3 Eine gute Übersicht bietet u.a. Wheatley/Gillings 2002, 201–216. – Soweit es sich um technische Abläufe und Verfahren innerhalb eines GIS handelt sind die meisten Fachtermini englischsprachig, da ein wesentlicher Bestandteil der entsprechenden Fachliteratur auf Englisch publiziert ist. Gelegentliche Anglizismen sind daher nicht zu vermeiden.
4 Einführend zu landschaftsarchäologischen Fragestellungen Hodder/Orton 1976. – Bei Tilley 1994 liegt ein Schwerpunkt auf Fragen der Landschaftsauffassung und -betrachtung (perception of landscape), wobei die grundsätzliche Herangehensweise aufgrund der postprozessualen Ausrichtung des Autors nicht immer von einer ein subjektiven auf eine – zumindest annähernd – objektive Ebene überführt werden kann (s. auch Eichfeld 2005, 106 Anm. 77 sowie Fleming 2006).
5 Ogburn 2006. – Letztlich wirkt auch die Erdkrümmung limitierend auf die maximale Sichtweite, doch sind solche Überlegungen eher theoretischer Art. Immerhin berücksichtigen GIS-Programme normalerweise den Faktor der Erdkrümmung bei ihren Berechnungen.
6 Zur oft mangelnden Berücksichtigung der (meist nicht rekonstruierbaren) vorgeschichtlichen Vegetation bei Sichtbarkeitsanalysen in der Archäologie Gillings/Wheatley 2001.

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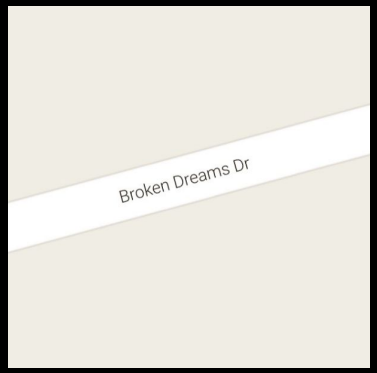
Homework

- Get a DEM of a location of your choice (tip: make it not too big! And have it in projected coordinate/meter based)
- Make a vector point layer with one position in the landscape
- Make a viewpoint layer from it
- Calculate a viewshed from it
- Send me a screenshot of the result

Any questions?



You might find the course material (including the presentations) at

https://github.com/BernCoDALab/gia

You can see the rendered presentations at

https://berncodalab.github.io/gia

You can contact me at

martin.hinz@unibe.ch

Source: https://www.instagram.com/sadtopographies