Archaeoastronomy and Cultural Astronomy
by using arcAstro-VR

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Archaeoastronomy & Cultural Astronomy

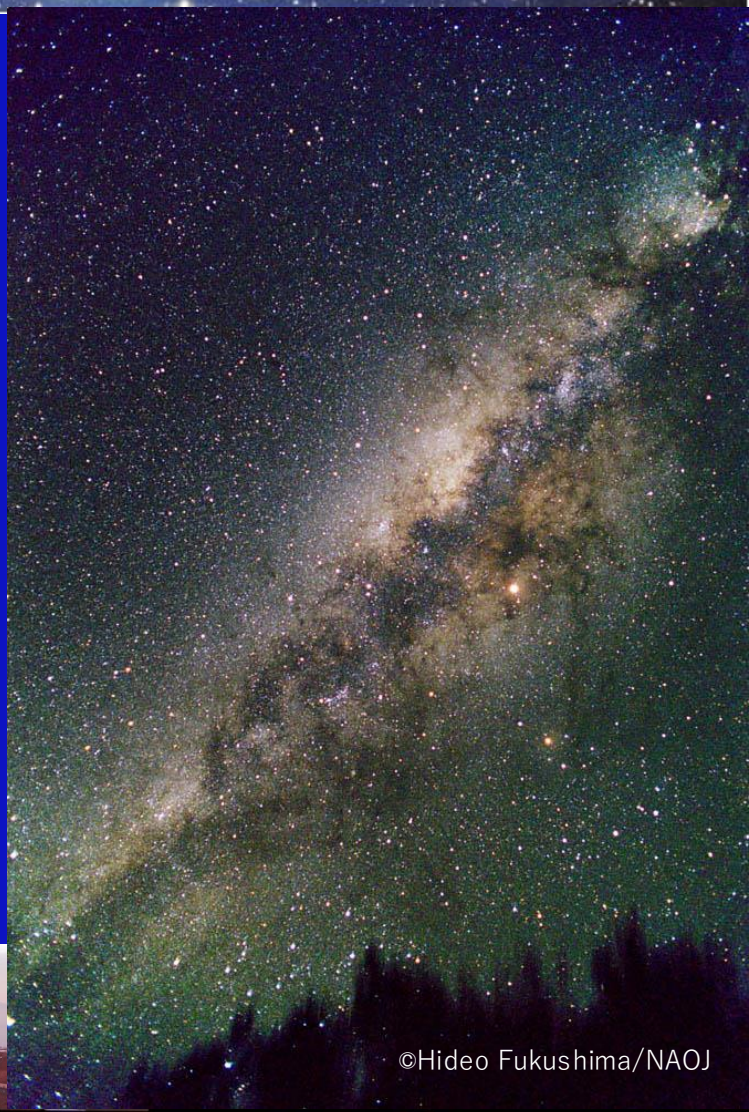
Archaeoastronomy is the interdisciplinary study of how people in the past understood and utilized celestial phenomena, and their role in culture, combining techniques and theories from archaeology, astronomy, anthropology, and history to interpret the astronomical practices, beliefs, and knowledge of ancient civilizations.

Cultural Astronomy is also the interdisciplinary study of how cultures, both ancient and modern, perceive celestial objects and incorporate them into worldviews. It combines archaeoastronomy and ethnoastronomy, which is the anthropological study of skywatching in contemporary societies.

The importance of astronomical observation in spatiotemporal cognition

The concept of the expanse of the universe and time :

Observation of celestial phenomena establishes concepts such as the extent of the world (universe) in which we live and the flow of time, and helps humans position their own existence within the universe and understand the scale of time.



Spatiotemporal Cognition

Temporal Cognition :
passage of time, scale and periodicity

Time is essential in all living things, and all psychological phenomena are related to time.

Spatial Cognition :
space, position and sense of direction

Understanding the relative positional relationship between oneself and space in three-dimensional space, which is essential for daily life.

Time concept: Perception and understanding of time

Sense of time passing :

Observation of celestial phenomena functions as a means of visually indicating the passage of time. For example, the rising and setting of the sun, the waxing and waning of the moon, etc. give us a visual sense of the time of day. This allows humans to sense natural rhythms and the passage of time, helping them adjust their daily lives.

Time concept: Perception and understanding of time

Understanding the passage of time and periodicity :
Celestial phenomena such as the position of the sun, the phases of the moon, and the length of day and night are important indicators of seasonal changes, and can be used to adjust activities such as agriculture. This allows humans to observe seasonal changes and understand natural cycles.

Time concept: Perception and understanding of time

Understanding timescales

Observation of celestial phenomena not only allows us to understand cycles such as days/months/years and our sense of time, but also allows us to become aware of events on extremely long time scales that go beyond our everyday sense of time. This allows humans to think about their own actions and the development of civilization not only from a short-term perspective but also from a long-term perspective. Understanding broad timescales across the past and future provides insight into sustainable living and planning for the future.

Spatial Cognition

Position on the ground and sense of direction :

Observing celestial phenomena helps us understand our place in the world (universe). This understanding reinforces our sense of place and time on the ground and provides a sense of direction. Understanding the positions of stars and constellations is essential for long-distance travel and navigation, and contributes to developing geographical awareness.

Spatial Cognition

Spread of space and sense of scale :

Celestial phenomena involve events and objects beyond our terrestrial realm. Contemplating the vastness of the universe fosters an awareness of our own existence and insignificance, cultivating humility and respect for our environment. By recognizing the arrangement and immensity of celestial bodies, we can extend our thinking beyond Earth, enhance our spatial cognition, and appreciate different scales.

This understanding broadens our perception of distance and size within the universe.

Relationship with religion, culture, and science

Assignment of cultural and religious meaning :

Celestial phenomena have important symbolism and meaning in many cultures and religions. Celestial bodies such as the sun, moon, and planets are considered sacred and play a central role in religious ceremonies and festivals. Observations of constellations and celestial bodies are also associated with many legends and myths, which influence the formation of cultural identity.

Relationship with religion, culture, and science

Improving scientific thinking and observation skills :

The process of discovering laws from observational data of celestial bodies improves scientific thinking and observation skills. It helps humans understand things logically and effectively in daily life and problem solving. Because of these factors, observation of celestial bodies plays an important role in human spatial cognition. It has helped us understand the world more deeply, expanding our horizons in understanding the Earth's position and time, exploring outer space, and cultural implications.

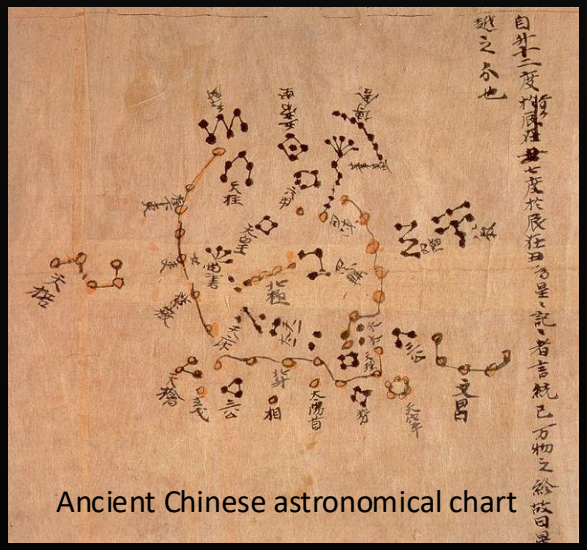
ancient chinese astronomical map

Archaeoastronomy

Egyptian Sun god “Ra”

In ancient societies, the celestial phenomena seen in the sky were part of everyday life. Our ancestors recognized them in connection with concepts about the relationship between nature and humans, especially the concepts of time and seasons.

Therefore, if we can visualize the positional relationship between astronomical phenomena and archaeological structures, we will know how the people of the ancient civilizations that built such structures perceived the celestial bodies, i.e., the concept of the universe and the world.



Ancient Chinese astronomical chart

Astronomical Alignments

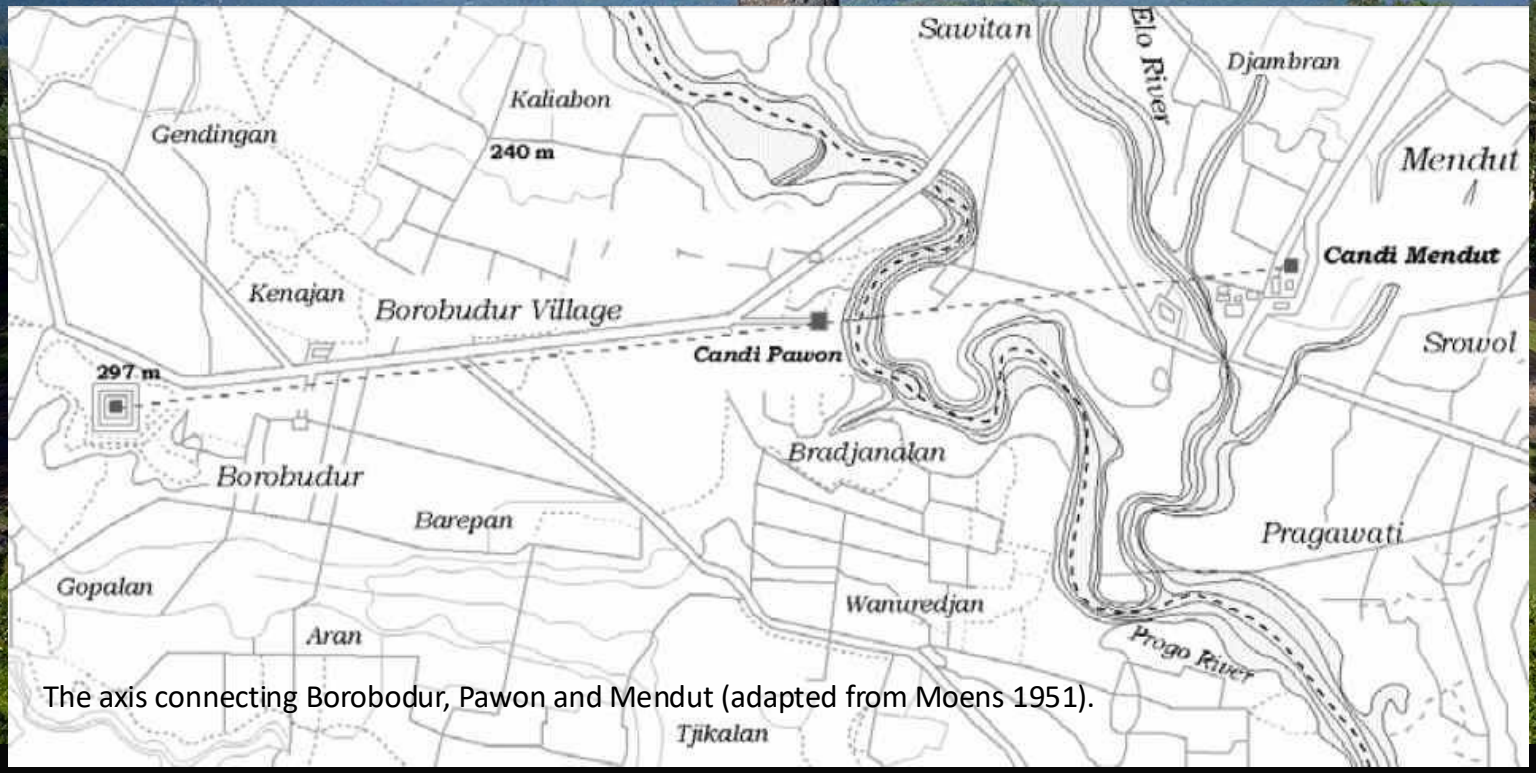
Investigates how ancient structures are aligned with celestial bodies (e.g., the sun, moon, stars).

Examples include Stonehenge in England, which is aligned with the solstices, and the pyramids of Giza in Egypt, which are oriented to cardinal points and possibly stellar constellations.

The solar alignment of the equinox at Angkor Wat

The sunrise on Angkor Wat during the equinox is such that someone standing in front of the western entrance can see the sun rising directly over the central lotus tower.

Borobodur



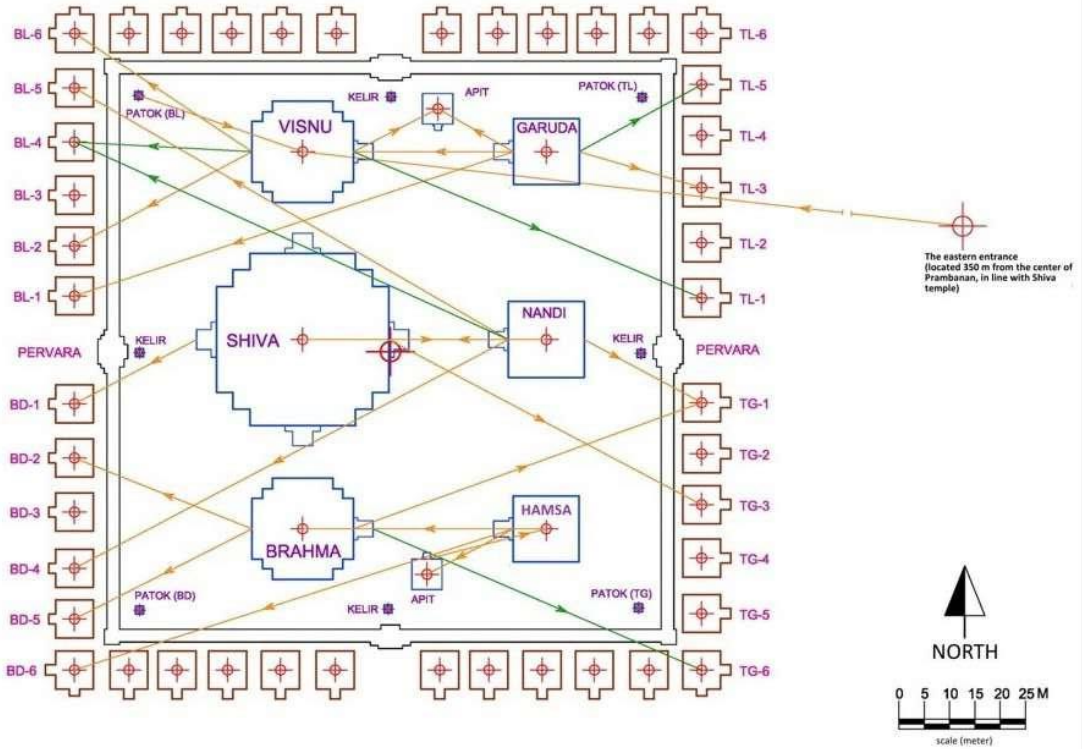
The axis connecting Borobodur, Pawon and Mendut (adapted from Moens 1951).

It appears that the declination of the Pawon-Mendut-Borobodur direction – which was also the direction of the sun's setting on the days of the zenith passages (11 October and 28 February).

Giulio Magli, 2017, Archaeoastronomy of the Sun path at Borobudur, History and Philosophy of Physics, https://api.semanticscholar.org/CorpusID:119545578

Prambanan

Possible lunar (yellow) and solar (green) alignments at Prambanan.



The Sun and the Moon play an important role in the construction of the mandala. Prambanan has 23 lunar alignments and five solar alignments, most of which used Pervara as their observing points. Apart from its religious purpose, Prambanan was built as a lunar observing site.

Sitti Attari Khairunnisa, Taufiq Hidayat, Wayne Orchiston and Nok Nikeu, "Astronomical Aspects of the Prambanan Temple in Central Java, Indonesia", In Orchiston, W., and Vahia, M. (eds.), 2020. Exploring the History of Southeast Asian Astronomy: A Review of Current Projects and Future Prospects and Possibilities. Cham (Switzerland), Springer. Pp. 487–502.

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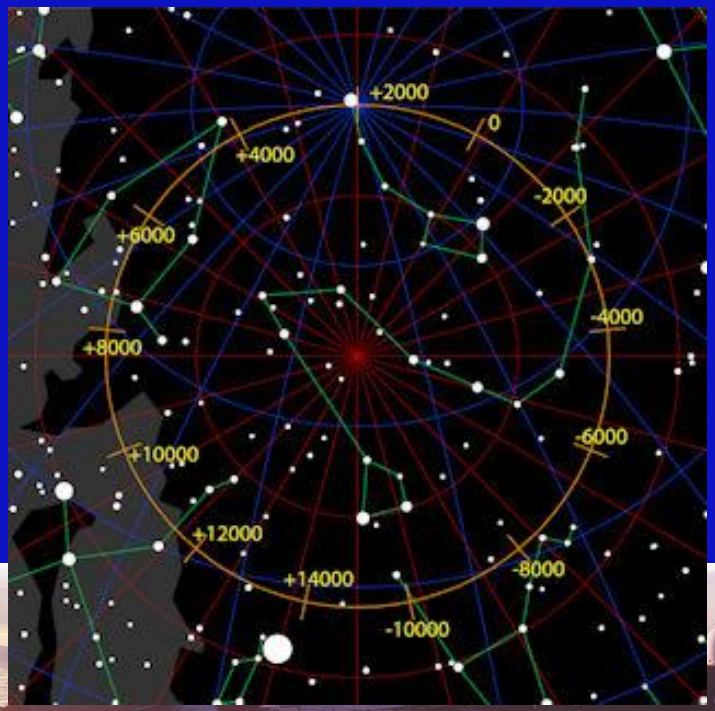
Reproducing ancient space-time landscapes

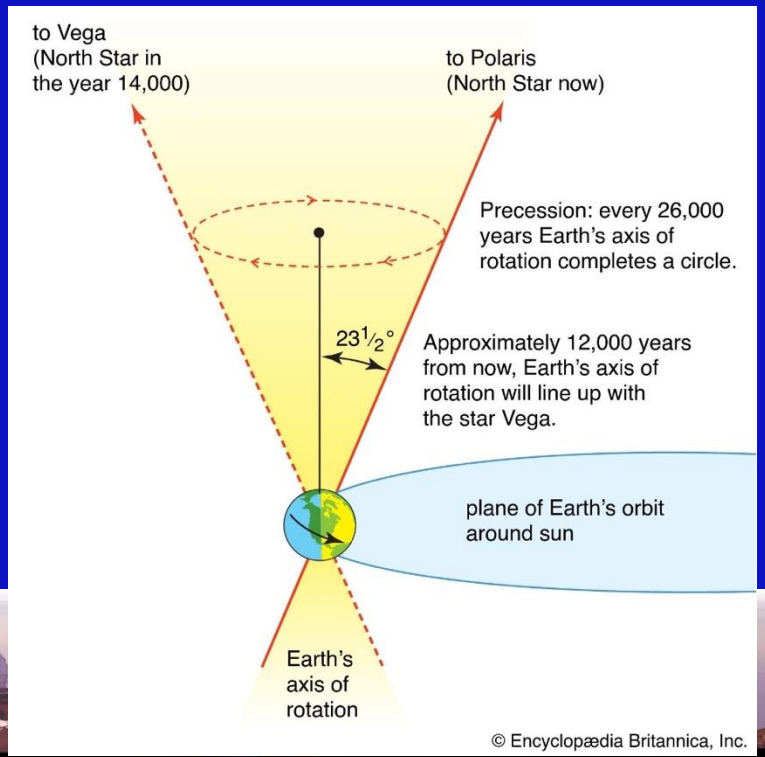
The "artificial landscape" that embodies our perception of space and time mirrors the fundamental structure of human consciousness, including elements like religious rituals, myths, and architectural layouts.

To test this hypothesis, it is necessary to reproduce and verify the relationship between the background topography and the positions of the sun, moon, planets, and stars on the celestial sphere at a specific date and time (time) and place (position) in the past.

Reproducing ancient space-time landscapes

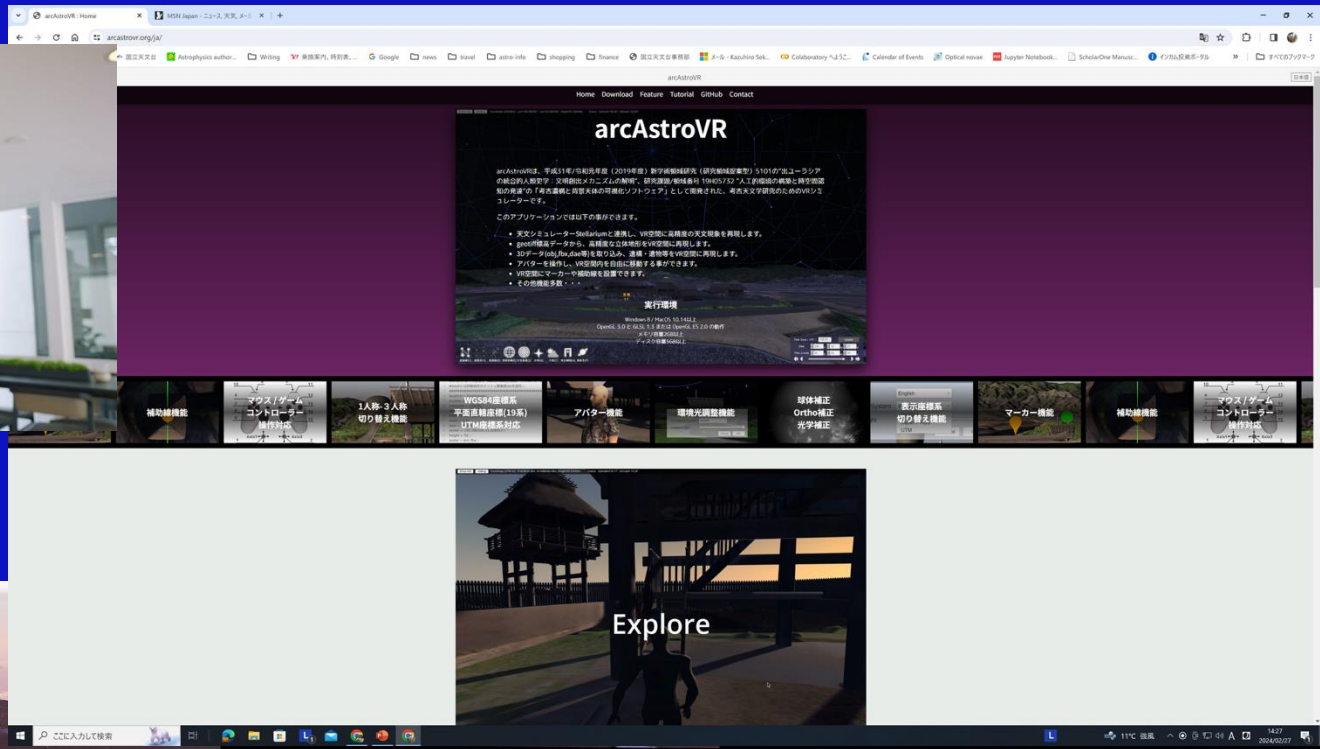
However, due to the effects of the Earth's precession and other factors, the positions of celestial bodies we see today are not the same as those seen by ancient people. Therefore, it is necessary to go back in time and visually represent and verify the positional relationship between celestial bodies and the terrestrial landscape, including ruins.

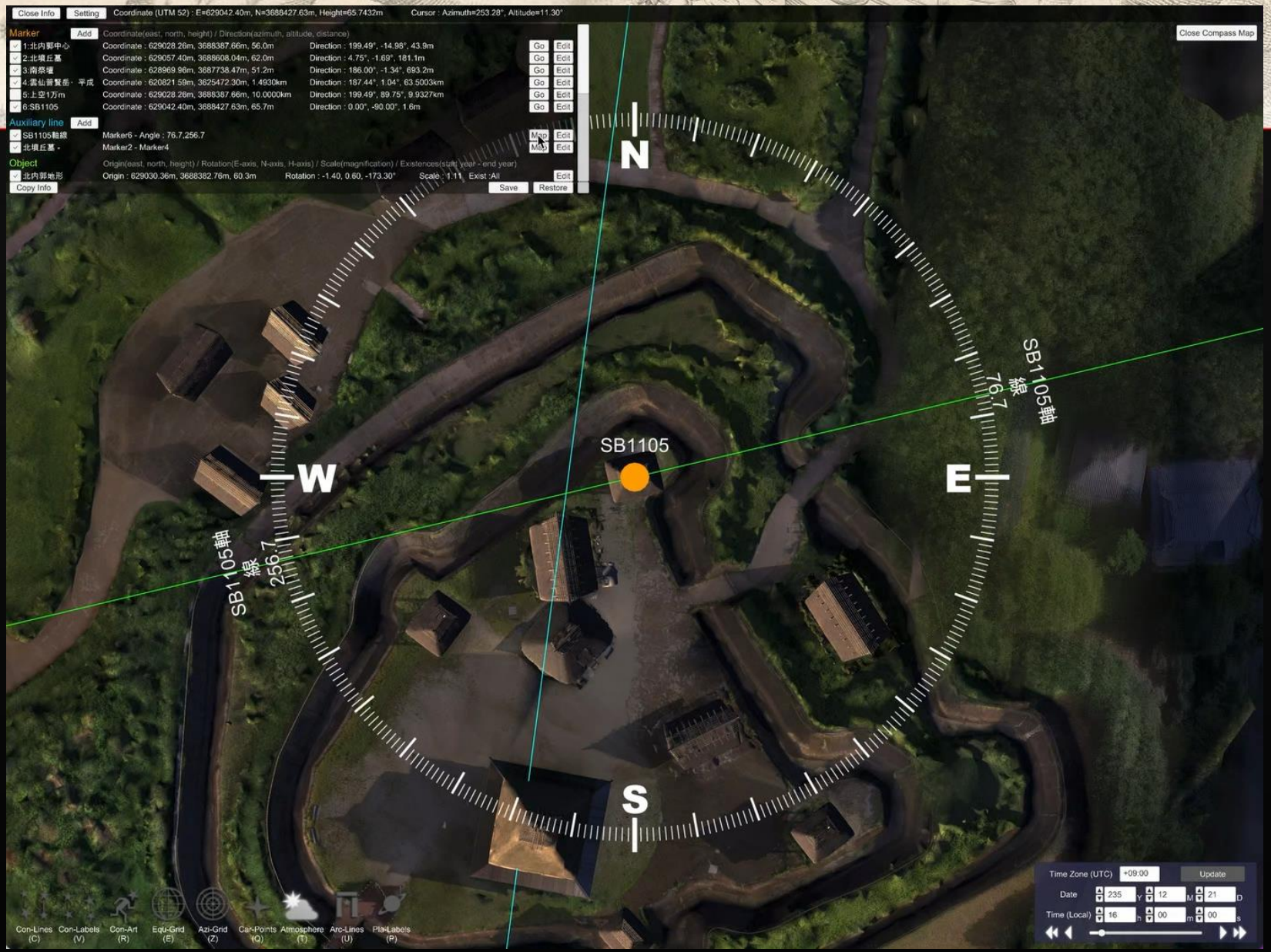




Reproducing ancient space-time landscapes

arcAstro-VR (https://arcastrovr.org/ja/) was developed as a system for visual analysis in archaeological and cultural astronomical investigations. It recreates the precise placement and movement of archaeological structures, surrounding landscapes, and their corresponding past celestial bodies as a virtual 3D space.

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Cursor : Azimuth=253.28°, Altitude=11.30°
Marker
Add
Coordinate(east, north, height) / Direction(azimuth, altitude, distance)
1:北内郭中心
Coordinate : 629028.26m, 3688387.66m, 56.0m
Direction : 199.49°, -14.98°, 43.9m
2:北壇丘墓
Coordinate : 629057.40m, 3688608.04m, 62.0m
Direction : 4.75°, -1.69°, 181.1m
3:南祭壇
Coordinate : 628969.98m, 3687738.47m, 51.2m
Direction : 186.00°, -1.34°, 693.2m
4:雷仙菅賀岳・平成
Coordinate : 620821.59m, 3625472.30m, 1.4930km
Direction : 187.44°, 1.04°, 63.5003km
5:上空1万m
Coordinate : 629028.26m, 3688387.66m, 10.0000km
Direction : 199.49°, 89.75°, 9.9327km
6:SB1105
Coordinate : 629042.40m, 3688427.63m, 65.7m
Direction : 0.00°, -90.00°, 1.6m
Go
Edit
Auxiliary line
Add
SB1105軸線
Marker6 - Angle : 76.7,256.7
北壇丘墓 -
Marker2 - Marker4
Map
Object
Origin(east, north, height) / Rotation(E-axis, N-axis, H-axis) / Scale(magnification) / Existences(start year - end year)
北内郭地形
Origin : 629030.36m, 3688382.76m, 60.3m
Rotation : -1.40, 0.60, -173.30°
Scale : 1.11
Exist :All
Copy Info
Save
Restore
Close Compass Map
N
W
E
S
SB1105
SB1105軸線 76.7
SB1105軸線 256.7
Con-Lines (C)
Con-Labels (V)
Con-Art (R)
Equ-Grid (E)
Azi-Grid (Z)
Car-Points (Q)
Atmosphere (T)
Arc-Lines (U)
Plan-Labels (P)
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Date
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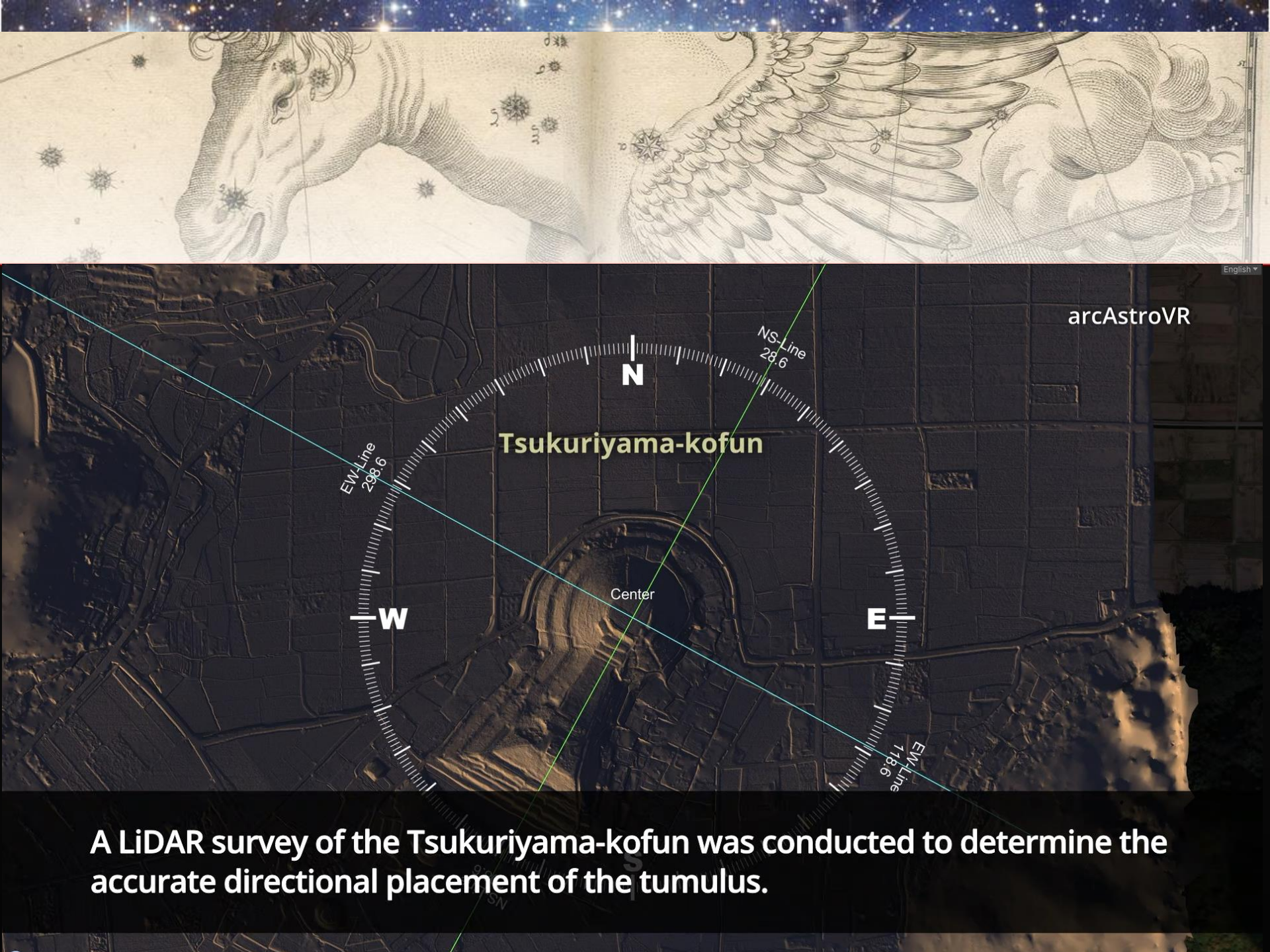
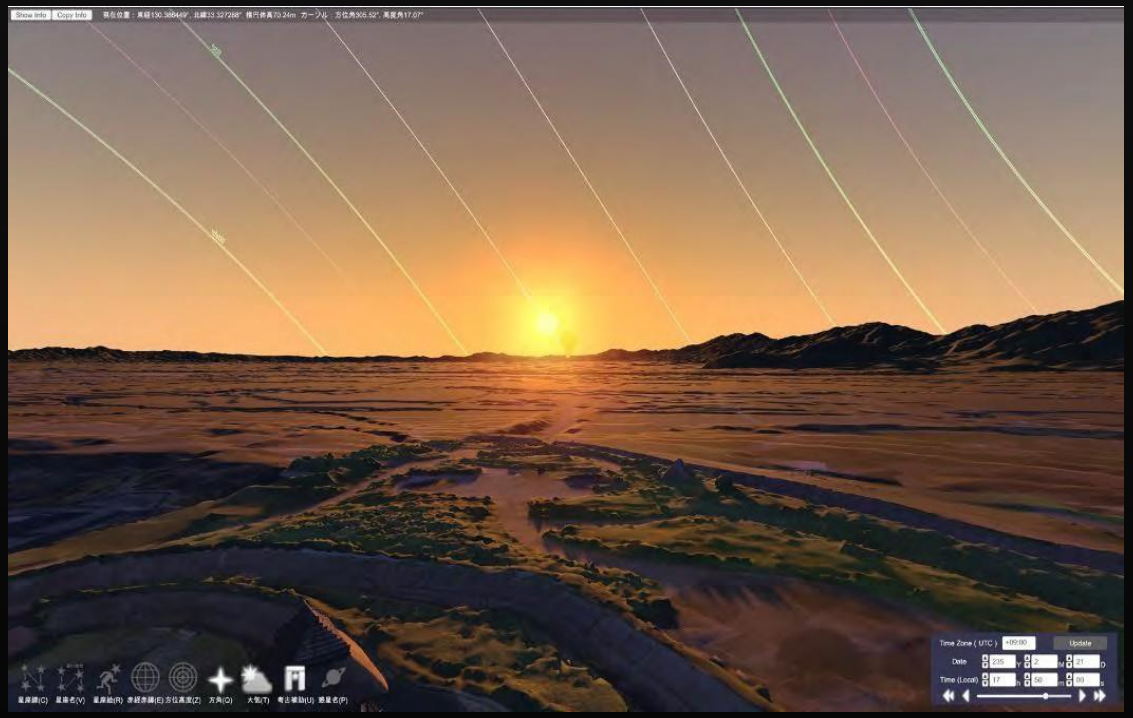

English
arcAstroVR
N
NS-Line
28.6
Tsukuriyama-kofun
EW-Line
298.6
Center
W
E
EW-Line
118.6
A LiDAR survey of the Tsukuriyama-kofun was conducted to determine the accurate directional placement of the tumulus.

What is arcAstro-VR?

Introducing arcAstro-VR

- An application that reproduces topography, 3D data, and astronomical phenomena on a PC in VR.
- Data surveyed by LiDAR and photogrammetry can be visualized in 3D.
- You can move freely in the VR space and change the settings to perform various verifications.



PC monitor display example of arcAstro-VR

What you can do with arcAstro-VR

- Importing 3D model data prepared by yourself
- Display/hide and move 3D models, set markers, set auxiliary lines
- Free movement in VR space (mouse, keyboard, game controller, etc.)
- -2,000 B.C. to 6,000 A.D. Highly accurate reproduction of astronomical phenomena
- Verification of sunlight, shadows, and water surface reflections using the sun and moon as light sources
- For details, please refer to https://arcastrovr.org/en/.