Skyscapes, Cosmology and Archaeology Module

Fieldwork in Archaeoastronomy
Part II - What and How to Measure

Fabio Silva

MA in Cultural Astronomy and Astrology
University of Wales TSD

March 2017

Summary

1. What needs measuring?

2. GPS -> Lat / Lon coordinates

3. Compass / Clinometer -> azimuth, altitude

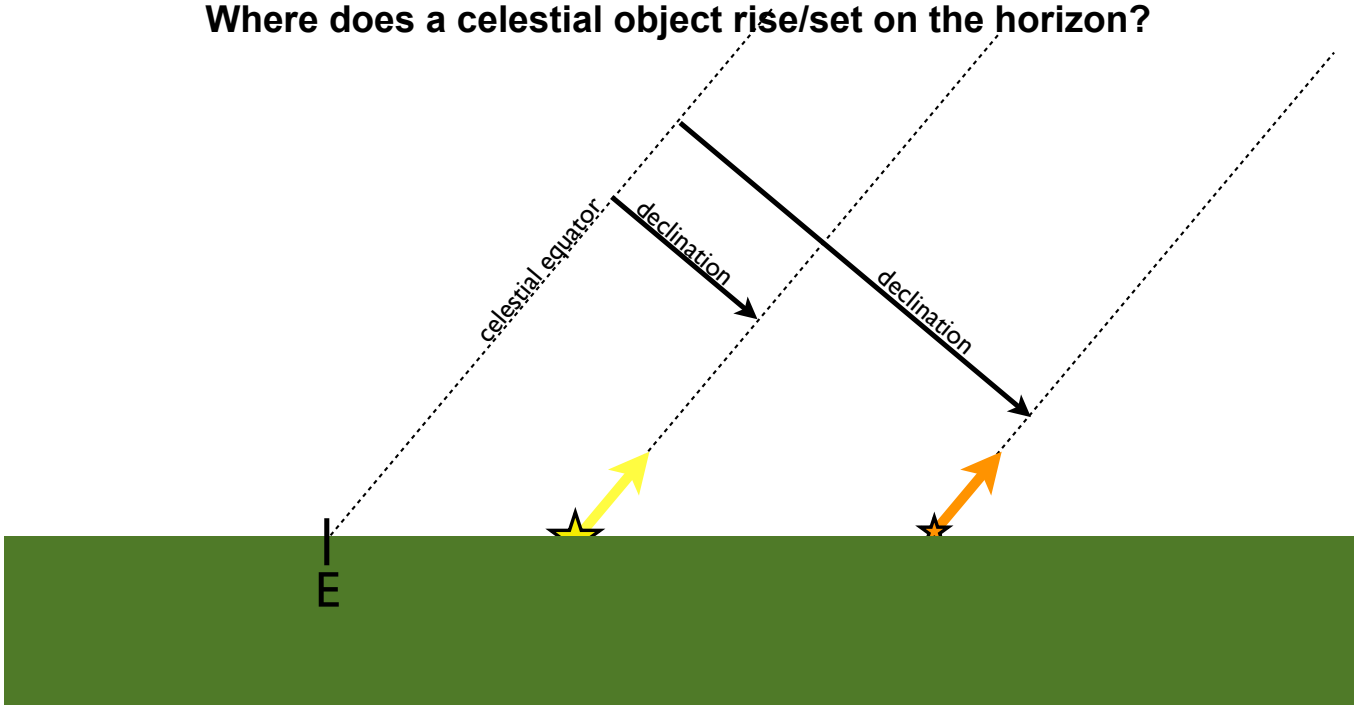
What needs measuring?

“Horizon Astronomy”

informal term used to describe an astronomy that is mainly concerned with events that occur at the horizon, eg. sunrise/set, moonrise/set, star-rise/set

Where does a celestial object rise/set on the horizon?

Where does a celestial object rise/set on the horizon?



There is a relationship between the declination of a celestial object and the position on the horizon where it rises.

Fieldwork in Archaeoastronomy II

Where does a celestial object rise/set on the horizon?

There is a relationship between the declination of a celestial object and the position on the horizon where it rises.

Eg. Objects with:

1) **declination 0º** have an orbit that coincides with the celestial equator and therefore **rise at East** and **set at West**.

2) **positive declination** rise and set **north of East and West**, respectively.

3) **negative declination** rise and set **south of East and West**, respectively.

What needs measuring?

There is no instrument to measure the declination on the field.

You can only measure quantities in the horizontal system (the “movable address” system.

You need to relate these to a value of declination in order to identify whether any celestial object rises or sets in the direction you are surveying.

What needs measuring?

The quantities you need to have to calculate a declination are:

azimuth (measured from True North)

altitude (more in the next slide)

latitude

What needs measuring?

The quantities you need to have to calculate a declination are:

Compass	azimuth (measured from True North)
Clinometer	altitude (more in the next slide)
GPS	latitude

All these are measurable in the field

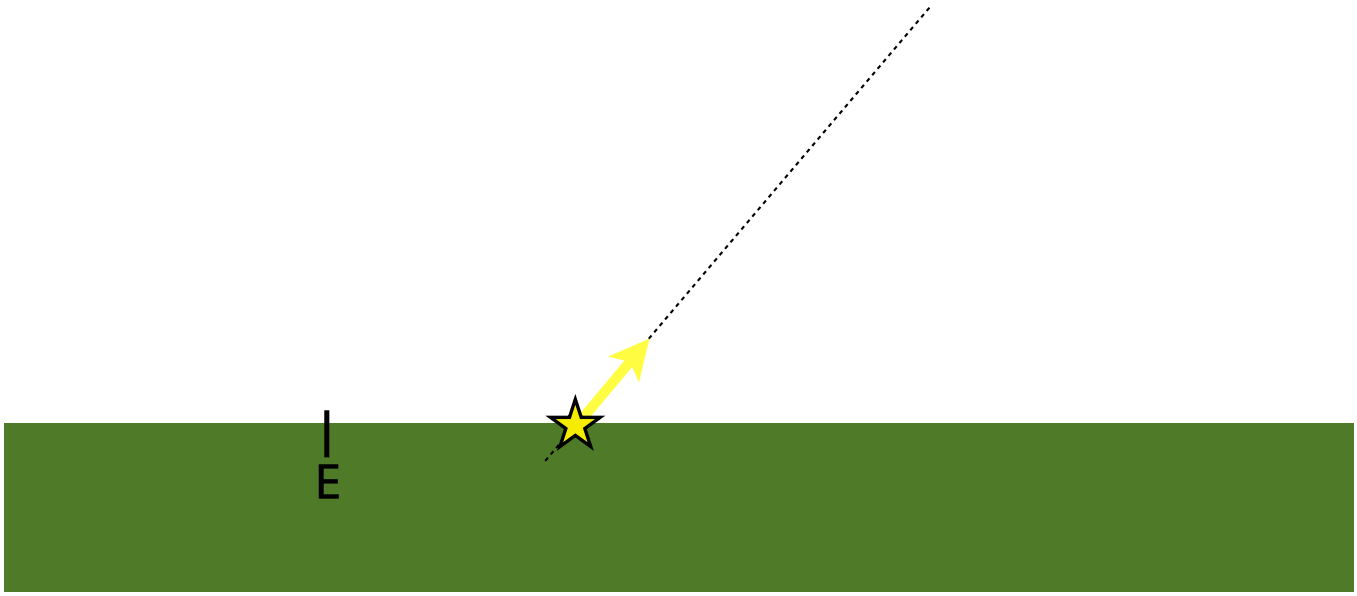
Why do I need the horizon altitude?

Why do I need the horizon altitude?

Fieldwork in Archaeoastronomy II

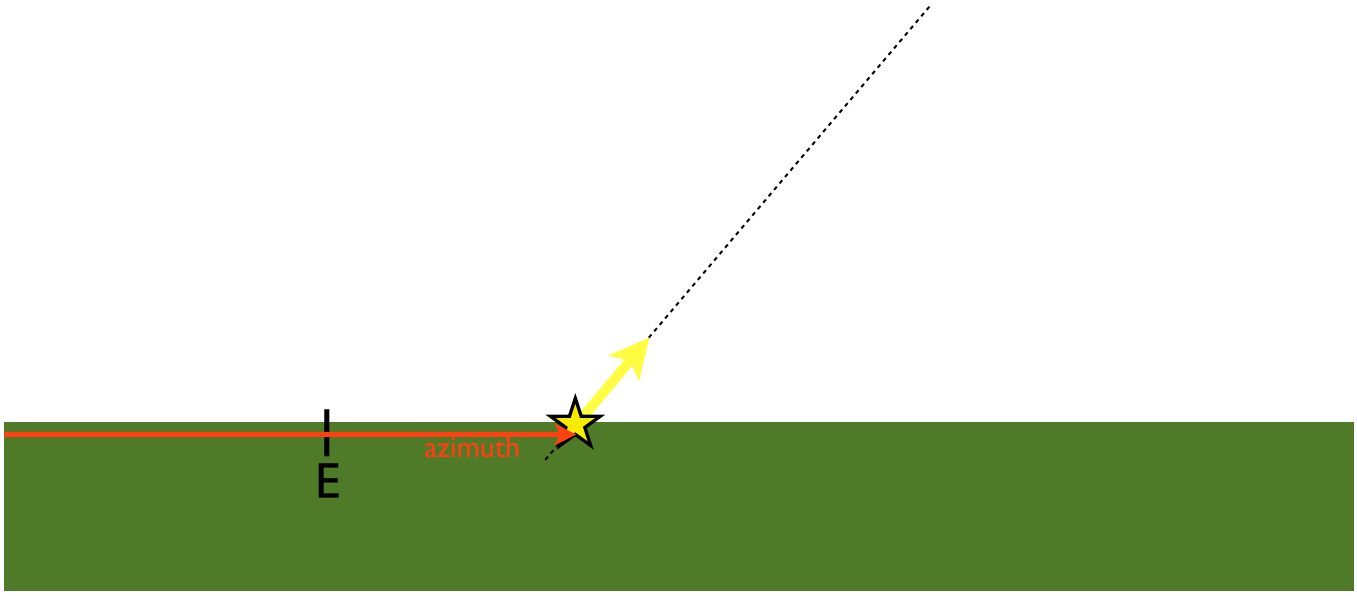
Why do I need the horizon altitude?

Why do I need the horizon altitude?

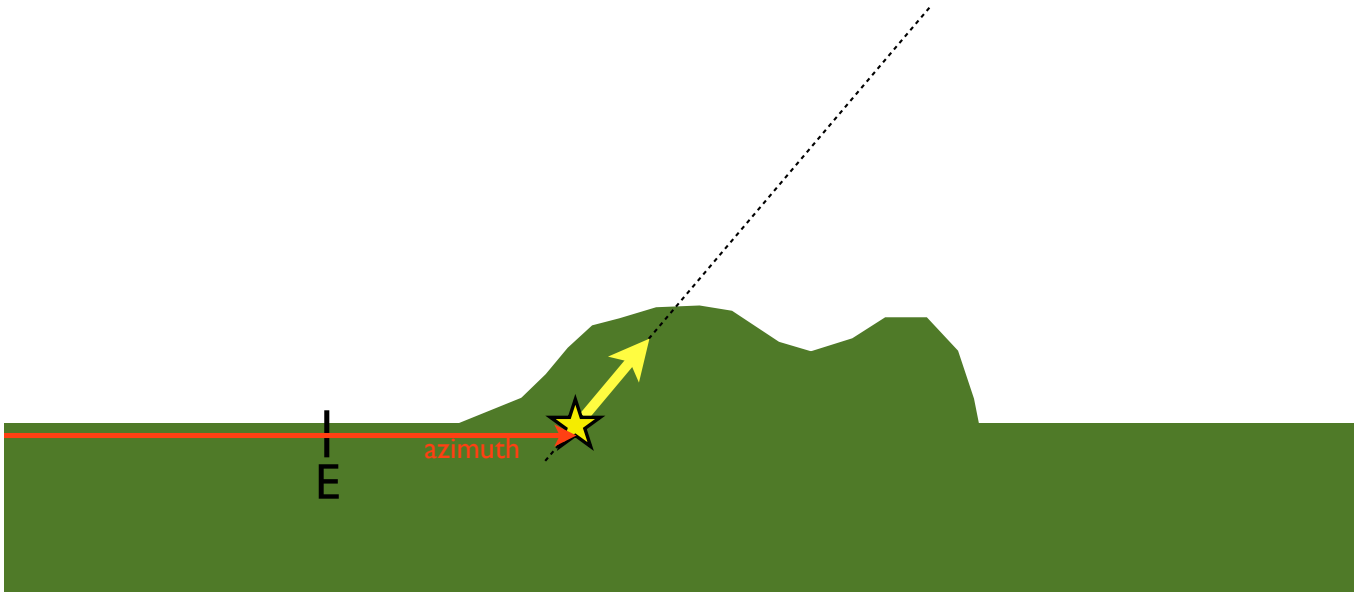


Fieldwork in Archaeoastronomy II

Why do I need the horizon altitude?

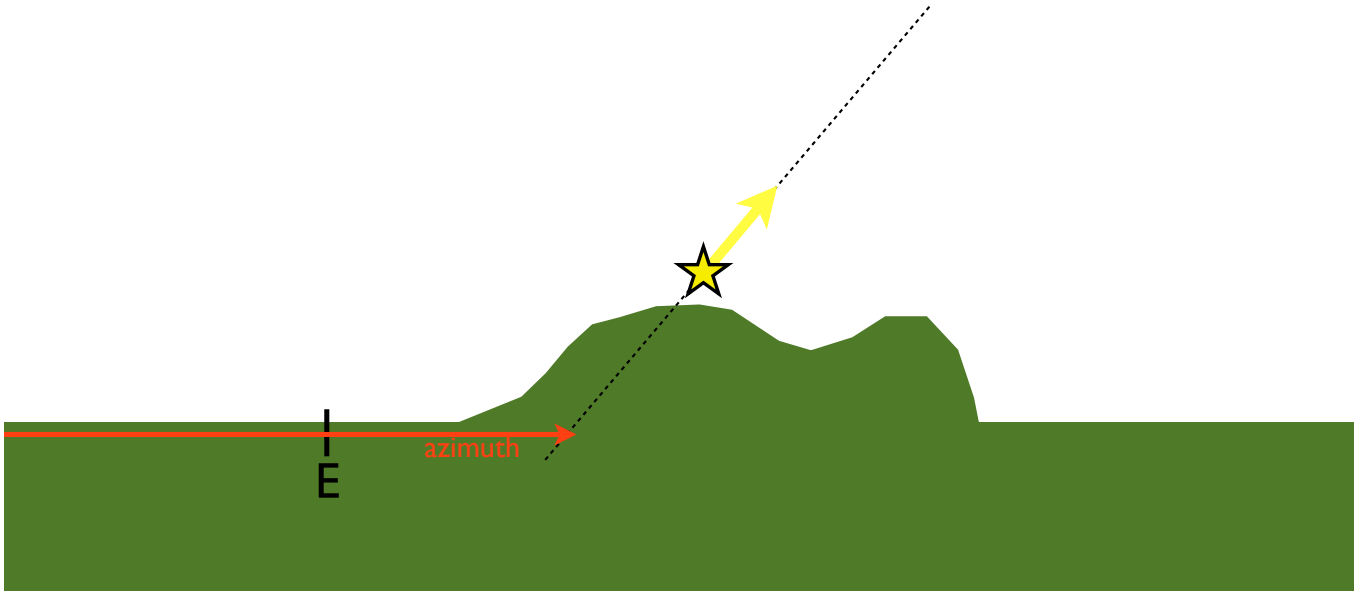


Why do I need the horizon altitude?

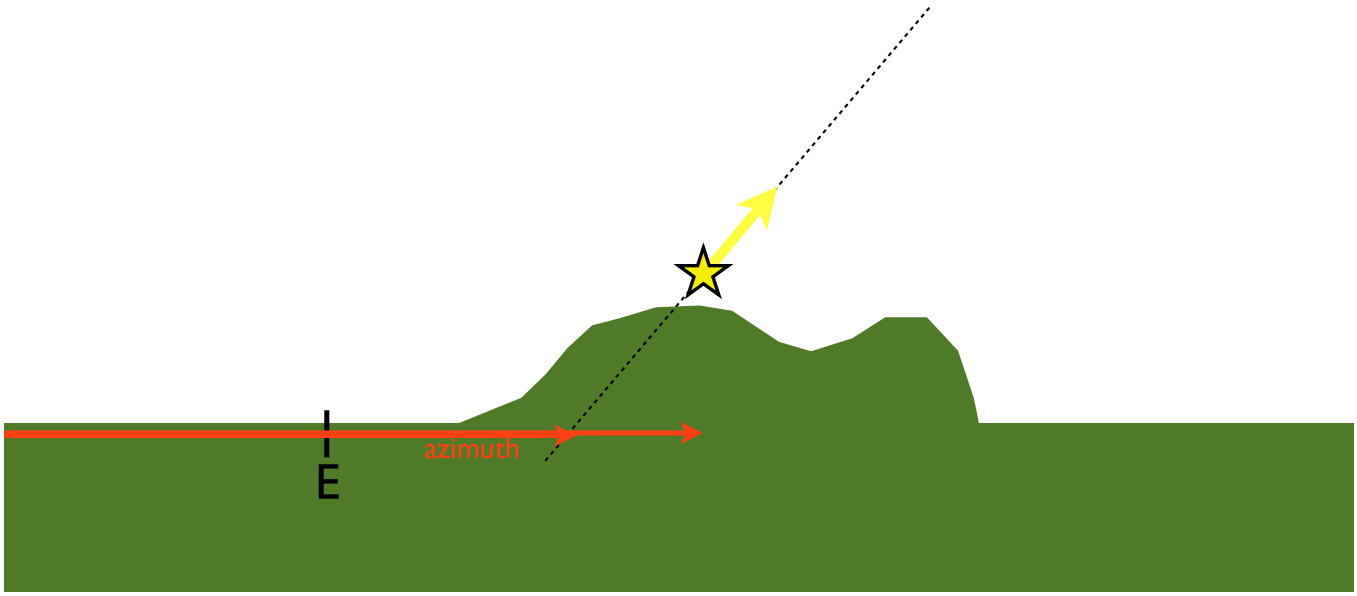


Fieldwork in Archaeoastronomy II

Why do I need the horizon altitude?

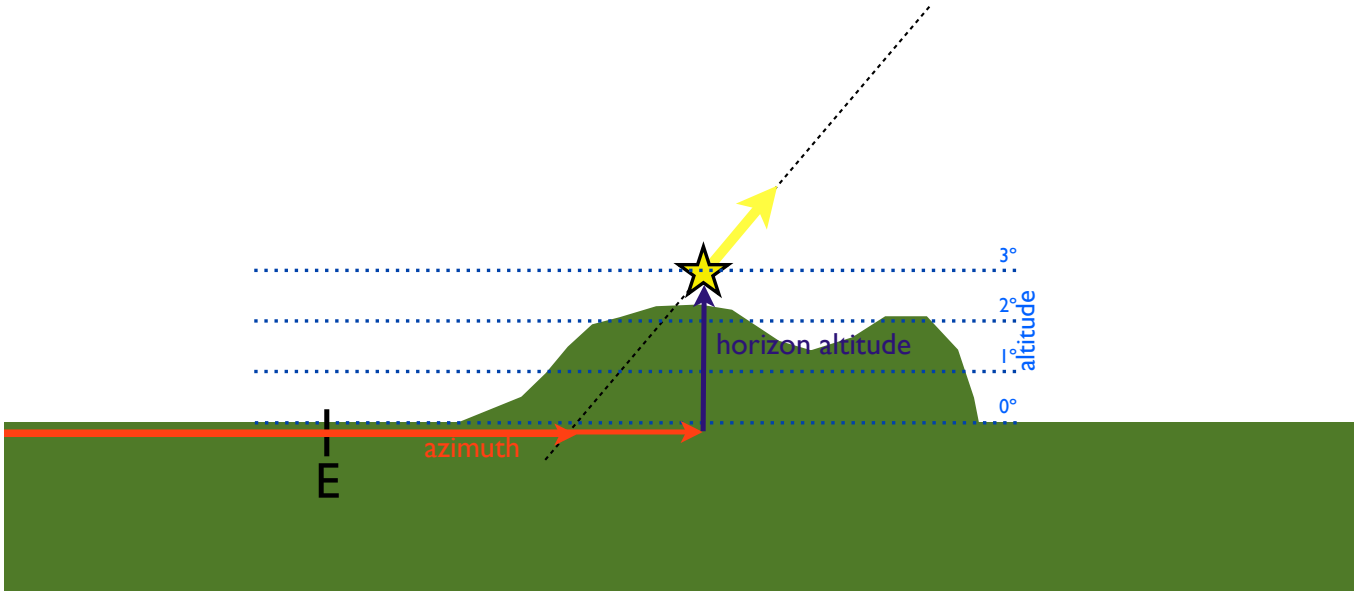


Why do I need the horizon altitude?

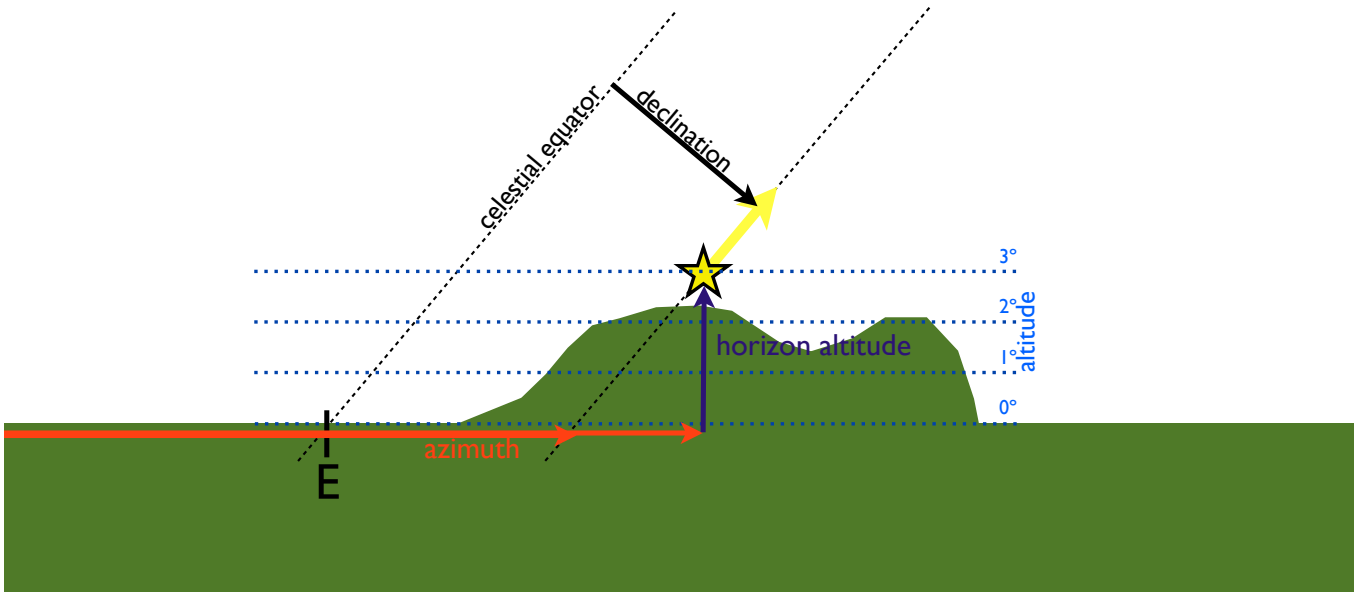


Fieldwork in Archaeoastronomy II

Why do I need the horizon altitude?



Why do I need the horizon altitude?

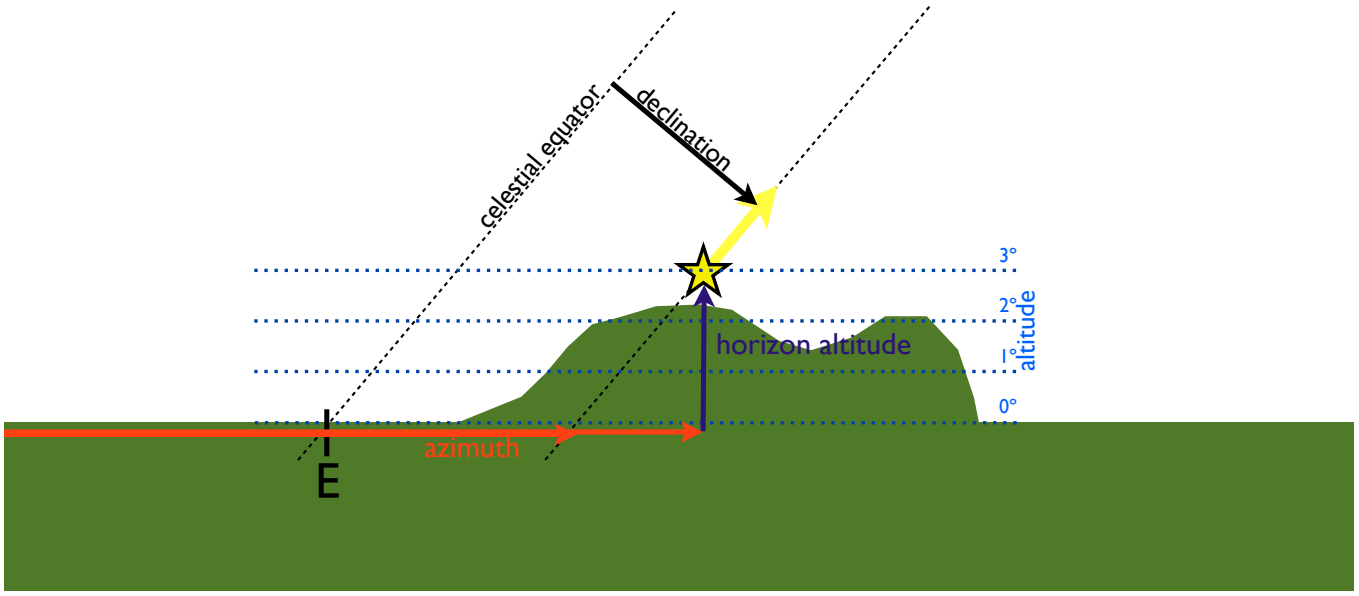


azimuth

horizon altitude

Fieldwork in Archaeoastronomy II

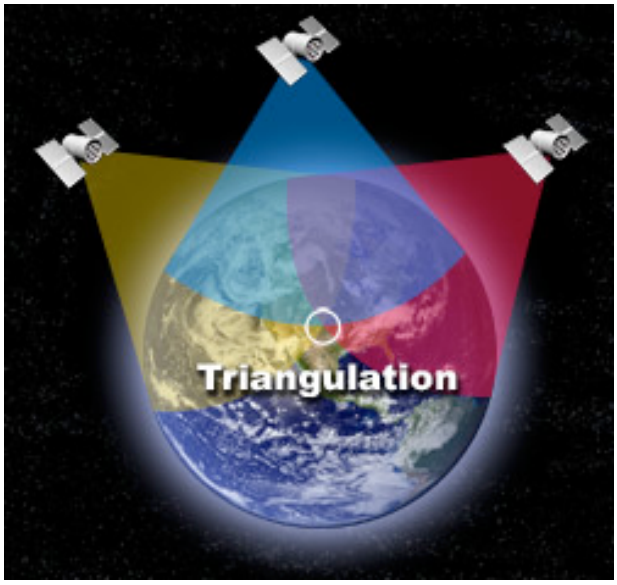
Why do I need the horizon altitude?



azimuth
latitude } declination
horizon altitude

Using a handheld GPS

How does it work?



Using a handheld GPS

Garmin 12
black and white
accuracy: 15 metres

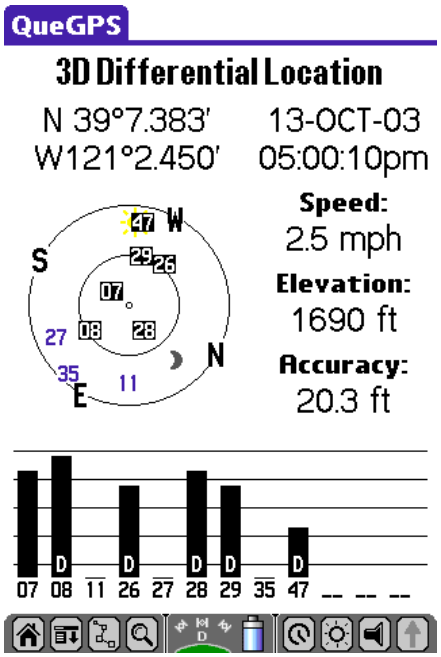
Garmin 76
colour
accuracy: 5 metres

Garmin eTrex 30
colour
accuracy: 5 metres

Car ('satnav') GPS receivers not good enough.

Latest smartphone GPS receivers are very good, however you'll need to buy an app that tells you the latitude and longitude

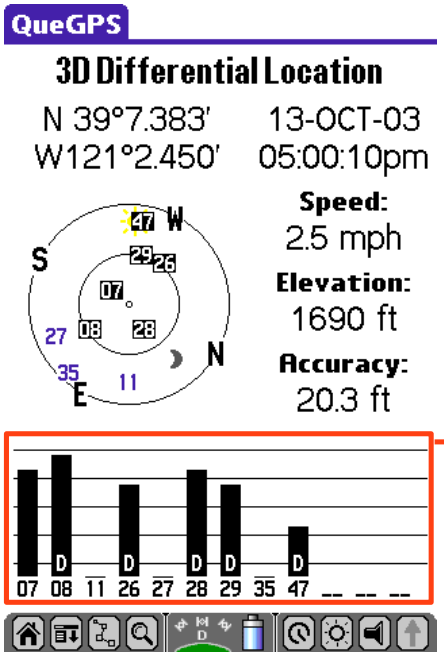
Using a handheld GPS



Typical GPS screen

Fieldwork in Archaeoastronomy II

Using a handheld GPS



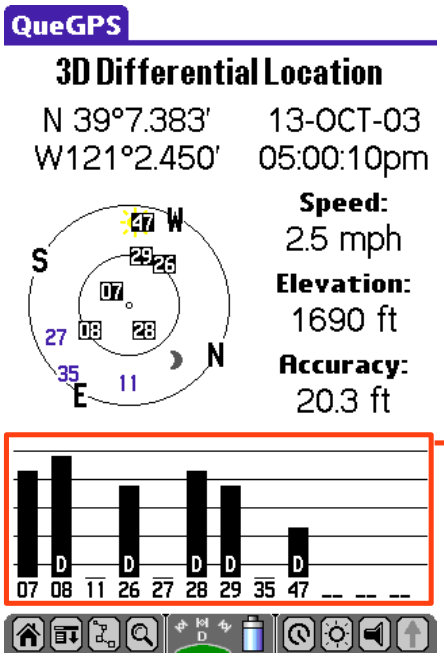
This shows the satellites
you are connected to

each bar is a satellite

"the more the merrier"

Typical GPS screen

Using a handheld GPS



Typical GPS screen

Turn the GPS on as soon as you reach the site and leave it on while you take photos and measurements

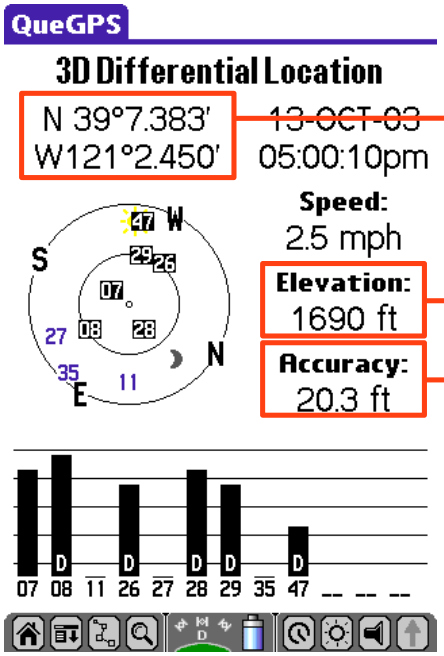
This show the satellites you are connected to

each bar is a satellite

"the more the merrier"

Fieldwork in Archaeoastronomy II

Using a handheld GPS



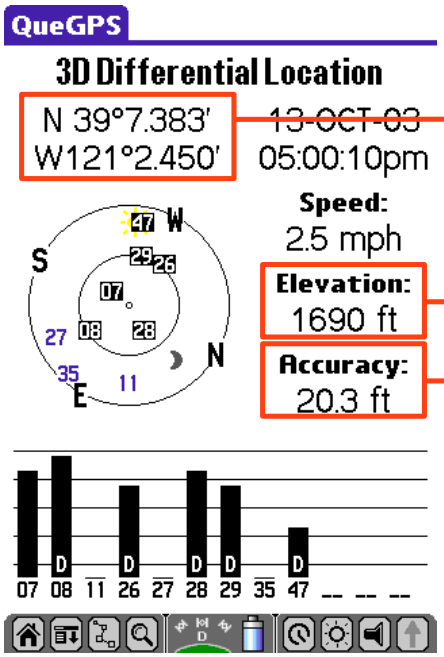
latitude & longitude

elevation above sea level

current precision

Typical GPS screen

Using a handheld GPS



latitude & longitude

elevation above sea level

current precision

Typical GPS screen

If handheld has averaging facility and/or WAAS, turn those on as they can dramatically increase the accuracy.

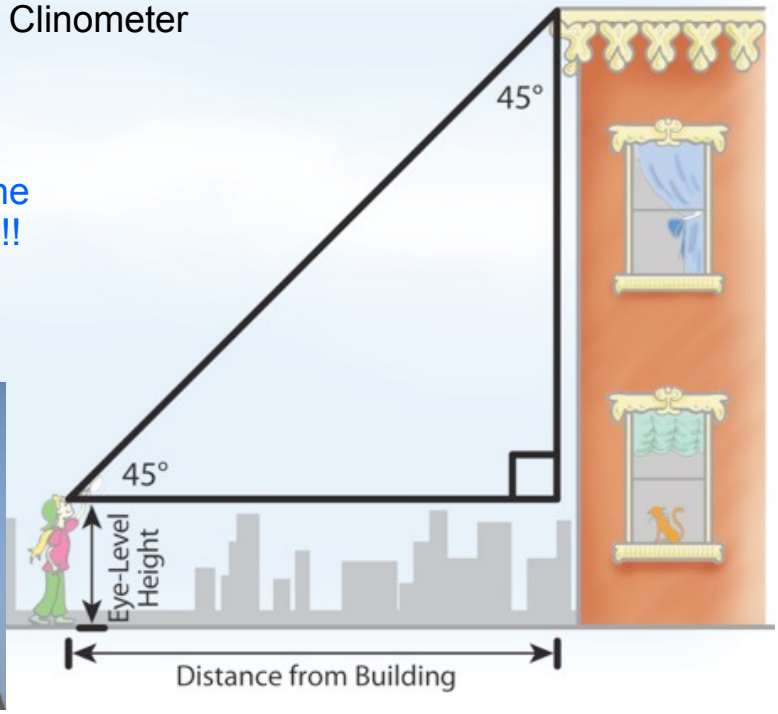
Using a compass / clinometer

Clinometer

Using a compass / clinometer

Clinometer

Make sure you are reading the
º scale and not the % scale!!!!



Fieldwork in Archaeoastronomy II

Using a compass / clinometer

Different styles of compass

Plate Compass

good for reading maps,
bad for surveying

Prismatic Compass

better

Sighting Compass

best

Using a compass / clinometer

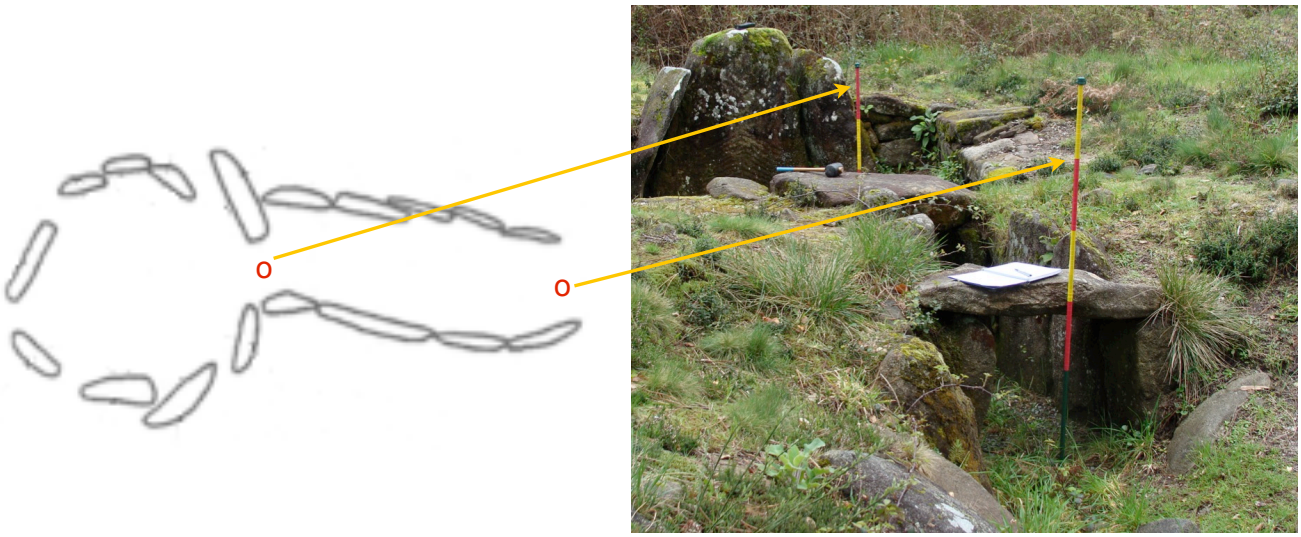
Different compass/clinometer precision

Compasses and clinometers have different levels of precision
(even two similar compasses can be quite different)

Get one that has, at least, 1º of precision. The
smaller this number the better!

How to measure an orientation accurately?

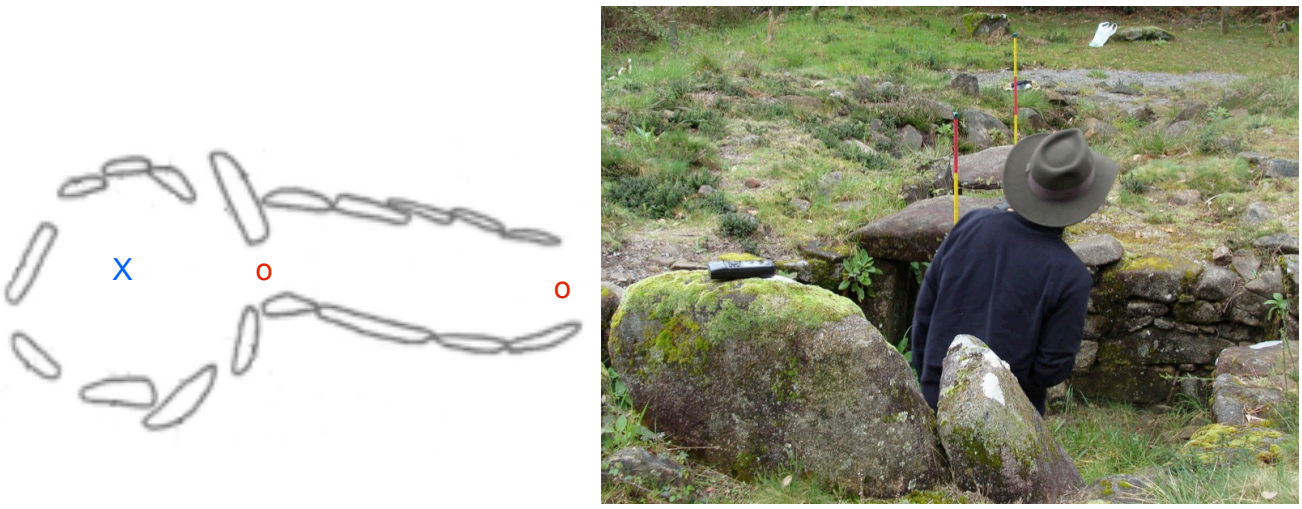
How to measure an orientation accurately?



1) You need a foresight and a backsight, forming a line, along which you'll measure an azimuth and horizon altitude

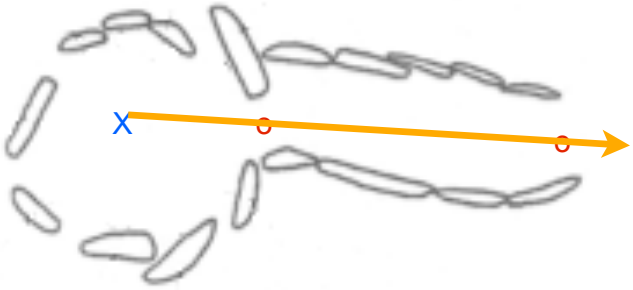
Eg. two surveyor's rods can be inserted into the ground at key points (decide which ahead of fieldwork)

How to measure an orientation accurately?



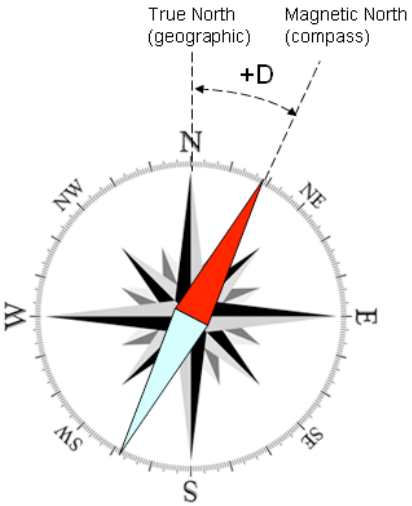
2) Position yourself behind the backsight

How to measure an orientation accurately?



3) Align your compass with the back- and foresight and take a reading

Magnetic Declination



True North and Magnetic North are not the same! Hence *true azimuth* and *magnetic azimuth* are not the same

The difference between the two is called *Magnetic Declination*

When using a compass you are taking magnetic azimuth readings. You need to correct then for True North.

The Magnetic Declination varies from site to site and from year to year. You can measure it in the field (talk to Kim or Fabio) or get an estimate online (link on handbook).

Usually expressed as 3ºE or 4ºW or +3º or -4º

E (east) means you need to add this value to your compass azimuths,
W (west) means you need to subtract it.

Local Magnetic Anomalies

Not to be confused with Magnetic Declination!

This is a local variation of magnetic North due to magnetic fields in the surroundings.

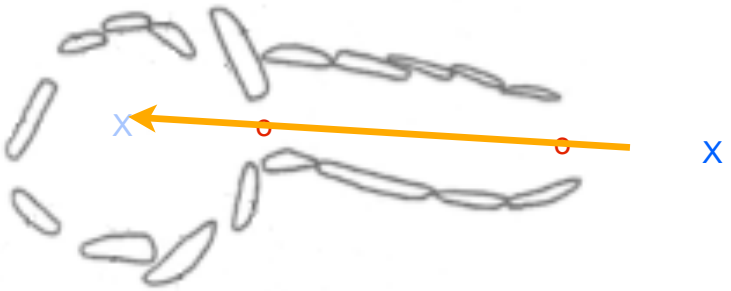
Eg. ferromagnetic rocks, nearby power stations, power lines…

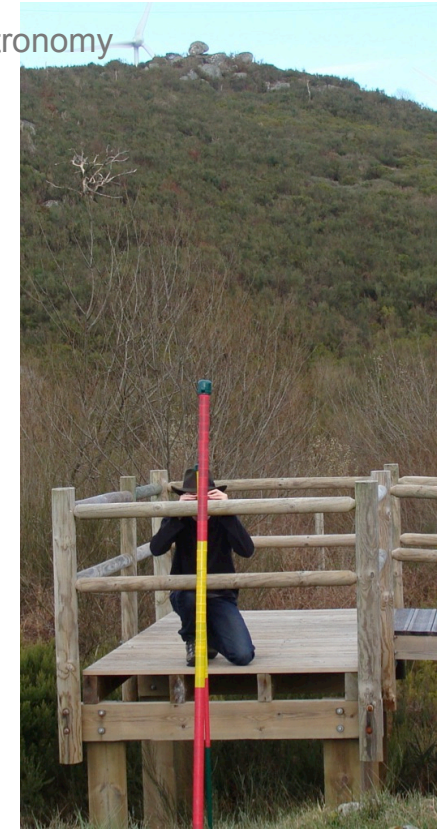
<u>But also due to the batteries in your smartphones, cameras, laptops, etc.</u>

There are no accurate models.

Hence, you need to check it out in the field.

Local Magnetic Anomalies





It's easy to check: just measure the azimuth from both directions and compare the two values

If there is no local magnetic anomaly, the two values should be different by 180º, give or take 1º (for the precision of the compass).

It's good fieldwork practice to do this for every single direction you are measuring and write down both azimuths!

Converting field measurements to Declination

FINDING DECLINATIONS

An easy-to-use spreadsheet to calculate the declination given the azimuth, altitude and latitude

Fabio Silva 10 Feb 2011

Instructions:

1) Insert your AZIMUTH data in the cells of the PURPLE column

2) Insert your ALTITUDE data in the cells of the BLUE column

3) Insert your LATITUDE data in the cells of the YELLOW column

4) The DECLINATION will be AUTOMATICALLY CALCULATED and shown on the GREEN column

5) If you wish to tag or LABEL each row to know which measurements you are using you can do so in the GREY column

NOTE: All values should be in degrees. Use spreadsheet to convert from ° ' " into degrees and vice-versa if needed.

NOTE: Do not write anything on the GREEN column as it will delete that cell's equations preventing it from calculating the proper value

Labels	AZIMUTH	ALTITUDE	LATITUDE	DECLINATION
example 1	85	3	43	5.701589564
example 2	110	0.5	43.1	-14.10845228

Spreadsheet on Moodle!!

Declination Tables

The Sun's declination varies throughout the year from two extremes at the Solstices.

Date	Summer Solstice	Winter Solstice
2000 CE	23.45	-23.45

Declination Tables

These extremes vary slowly through time, as the obliquity of the Earth changes.

Date	Summer Solstice	Winter Solstice
2000 CE	23.45	-23.45
1000 BCE	23.8	-23.8
1500 BCE	23.85	-23.85
2000 BCE	23.95	-23.95
2500 BCE	24	-24
3000 BCE	24.05	-24.05
3500 BCE	24.05	-24.05
4000 BCE	24.1	-24.1
4500 BCE	24.15	-24.15

The stars have fixed declinations, but these also slowly change through time due to precession (and proper motion).

In sum

Ahead of fieldwork you should:

1. Read the manual and/or play with the GPS handheld so you learn how to use it

2. Learn how to use your compass and clinometer to take azimuths and altitudes

3. Plan your field methodology: how are you going to lay out the directions you want to measure

In sum

On the field you should:

1. Identify the direction you want to measure

2. Measure its azimuth

3. Measure the horizon altitude along that direction

4. Obtain the latitude of the site

In sum

After fieldwork you should:

1. Convert your magnetic azimuths to true azimuths

2. Calculate your declinations

3. Compare them to known values

4. Interpret them!