Naked-eye Astronomy for Cultural Astronomers

J. C. Holbrook and Audra Baleisis

Abstract Cultural astronomy is an interdisciplinary field that attracts students from a variety of backgrounds. Many students have a background in astronomy, but even in astronomy departments students are not taught some of the most basic elements of the night sky needed for cultural astronomy research. For example, few students are taught constellation identification which is part of the foundation of cultural astronomy research. This paper seeks to introduce students to the information and skills needed to do cultural astronomy research effectively.

The Night Sky

The most difficult task for cultural astronomy students is to learn the night sky. Most students are familiar with the beautiful images taken with telescopes and satellites such as the Orion Nebula and the Andromeda galaxy. However, students are not as familiar with the night sky's stars and constellations visible without the aid of telescopes or binoculars. There are 88 constellations as set forth by the International Astronomical Union (IAU) (Table 1). However, knowing the names of the constellations is not as useful as knowing their locations in the night sky and their "shapes." It is useful to know what constellations are immediately adjacent to each other, as well.

For example, an informant points to a dim set of stars to the east of the constellation Cassiopeia. The constellations bordering the east side of Cassiopeia are Camelopardalis and Perseus, whose :"shapes" are markedly different with Perseus being composed of relatively bright stars but a less recognizable shape than Cassiopeia. Thus, the researcher first identifies Cassiopeia, then whether the informant is pointing to Perseus or Camelopardalis, then can identify a particular star, etc. Further, the informant may only be familiar with local names of asterisms – groupings of stars, which may not correspond in any way to the IAU constellations. The Big Dipper, for example, is one of the most famous asterisms, and is part of the formal

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Table 1 The names of the 88 constellations

Andromeda	Centaurus	Fornax	Monoceros	Scorpius
Antlia	Cepheus	Gemini	Musca	Sculptor
Apus	Cetus	Grus	Norma	Scutum
Aquarius	Chamaleon	Hercules	Octans	Serpens
Aquila	Circinus	Horologium	Ophiucus	Sextans
Ara	Columba	Hydra	Orion	Taurus
Aries	Coma Berenices	Hydrus	Pavo	Telescopium
Auriga	Corona Australis	Indus	Pegasus	Triangulum
Bootes	Corona Borealis	Lacerta	Perseus	Triangulum Australe
Caelum	Corvus	Leo	Phoenix	Tucana
Camelopardalis	Crater	Leo Minor	Pictor	Ursa Major
Cancer	Crux	Lepus	Pisces	Ursa Minor
Canes Venatici	Cygnus	Libra	Pisces Austrinus	Vela
Canis Major	Delphinus	Lupus	Puppis	Virgo
Canis Minor	Dorado	Lynx	Pyxis	Volans
Capricornus	Draco	Lyra	Reticulum	Vulpecula
Carina	Equuleus	Mensa	Sagitta	
Cassiopeia	Eridanus	Microscopium	Sagittarius	

IAU constellation, Ursa Major. Thus, it is very important that the researcher is able to identify both the constellation and the star of interest to be able cross list local names with the IAU standard names.

What is the Easiest Way to Learn the Constellations?

There are several ways to learn the constellations and their locations in the sky. Probably, the easiest is to get planispheres of the northern and southern hemisphere and start memorizing! A planisphere is a circular map of the night sky showing the stars and constellations. Planispheres are made for observing the night sky at different latitudes. For observing in the United States, a planisphere of latitude 40 degrees north is usually sufficient. Planispheres are usually available for purchase at planetariums and observatories, they can also be ordered online at “Shop at Sky”[2] and other shopping sites.

Paper star charts can be downloaded from the internet via “Your Sky” [3], “Starmaps.com” [4], “Sky & Telescope” [5], and “The Night Sky” [6]. Star charts without labels can be used to practice identifying constellations. Or star charts with the shapes of the constellations can be used for easier identification.

Having access to a good software program, that can recreate the night sky at any location and at anytime during the last 6000 years, is very important for cultural astronomy researchers. The software allows the user to adjust multiple variables to recreate what the sky looks like at a field site. Most researchers do not have the money or time to spend an entire year at a field site, so via the software they can explore the sky at other times during the year. For example: A researcher collected drawings from an informant of the positions of many stars rising in the east at sunset on the day of an important ceremony. The researcher can then use the night sky software to watch

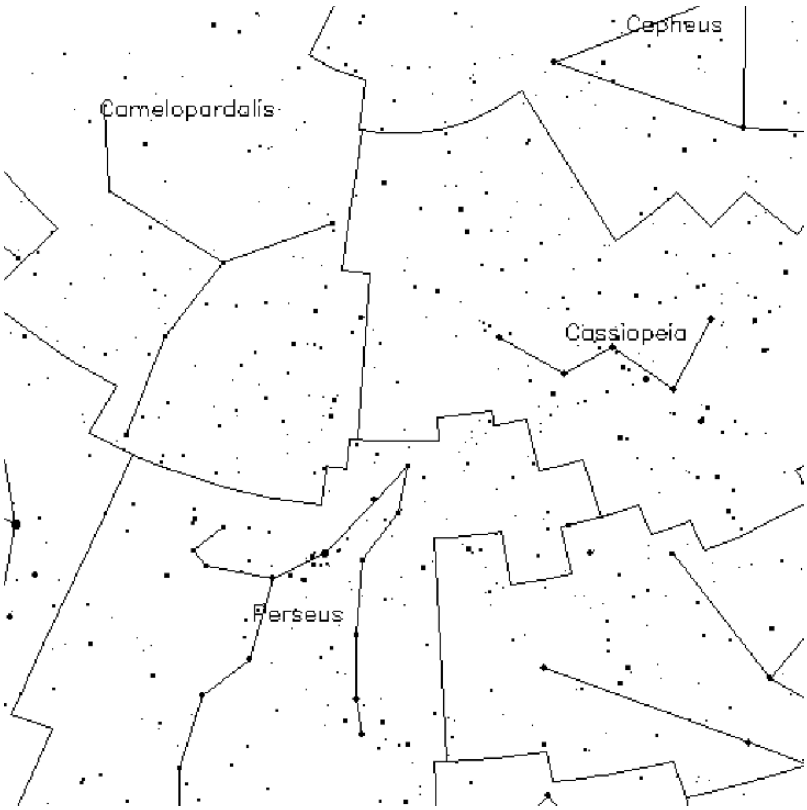

Fig. 1 HPLANET night sky image of Cassiopeia, Camelopardalis, and Perseus. With constellation borders
Source: Walker, J., Home Planet – HPLANET. 1994, Fourmi Laboratory. Software. http://www.fourmilab.ch/homeplanet/homeplanet.htm

the eastern horizon over time until the star positions match the drawing. Night sky software that is available free of charge is HPLANET [7] and Stellarium [8].

Another way to start learning your way across the night sky is to find someone who is already familiar with the constellations and is willing to give you an introduction. This is also a good way to bring the knowledge you gain from using a planisphere, a sky chart or with a software program, outside to the real sky. The actual night sky can look very different from anything on paper or a computer screen. It is very useful to learn to find a star that is shown on a chart also in the night sky and vice versa.

Finally, this introduction to the night sky is descriptive – we are pointing out facts about motions in the sky rather than spending much time explaining the underlying models of these motions. If you are interested in learning the underlying ideas about why the stars and planets move the way they do, we recommend you find an introductory astronomy book. A book for non-science majors in college may be a good place to start. If you have the time and resources, an introductory course

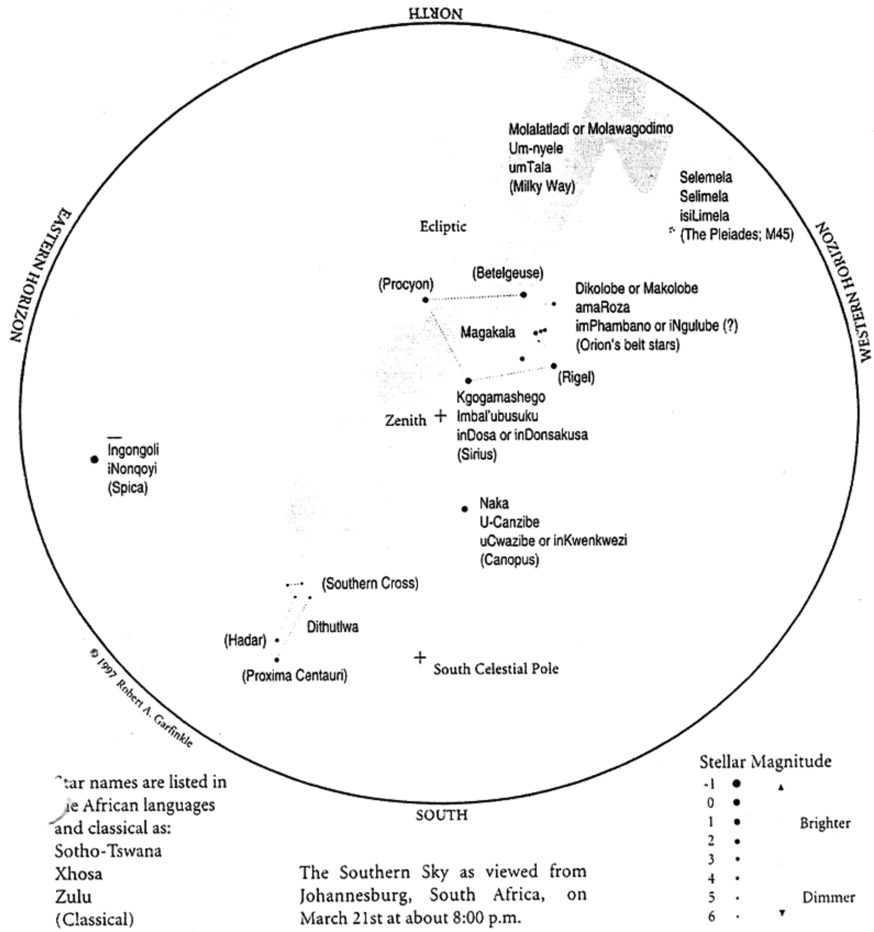

Fig. 2 Zulu night sky from Snedegar [1]

is even better. By learning about the space motions of Earth, the Sun, the Moon and the stars, you will better understand why the Sun does not always rise exactly East and set exactly West, why the stars visible in the night sky change throughout the year, and be able to bring that understanding with you to the field as an additional tool for cultural astronomy research.

The Bright Stars

Star brightness is measured in magnitudes, where the smaller the magnitude the brighter the star. Given low levels of light pollution, humans can see stars to a limit of about 6 magnitudes. At 5.5 magnitudes 2860 stars are visible [9]. However, not all of these have names nor are easily identifiable. Table 2 lists the thirty brightest

Table 2 Thirty brightest stars

Star	Name	M
alpha Canis Major	Sirius	−1.46
alpha Carina	Canopus	−0.72
alpha Centaurus	Rigil Kent	−0.01
alpha Bootes	Arcturus	−0.04
alpha Lyra	Vega	0.03
alpha Auriga	Capella	0.08
beta Orion	Rigel	0.12
alpha Canis Minor	Procyon	0.38
alpha Eridani	Archenar	0.46
alpha Orion	Beteigeuse	0.5
beta Centaurus	Hadar	0.61
alpha Aquila	Altair	0.77
alpha Taurus	Aldebaran	0.85
alpha Virgo	Spica	0.98
alpha Scorpius	Antares	0.96
beta Gemini	Pollux	1.14
alpha Piscis Austrinus	Fomalhaut	1.16
alpha Cygnus	Deneb	1.25
beta Crux	Mimosa	1.25
alpha Leo	Regulus	1.35
epsilon Canis Major	Adhara	1.5
alpha Crux	Acrux	1.58
alpha Gemini	Castor	1.58
gamma Crux	Gacrux	1.63
lambda Scorpius	Shaula	1.63
gamma Orion	Bellatrix	1.64
beta Taurus	El Nath	1.65
beta Carina	Miaplacidus	1.68
epsilon Orion	Alnilam	1.7
alpha Grus	Al Na'ir	1.74
epsilon Ursa Major	Alioth	1.77
gamma Vela	Regor	1.78
alpha Perseus	Marfak (Algenib)	1.79
alpha Ursa Major	Dubhe	1.79
delta Canis Major	Al Wazor	1.84
epsilon Sagittarius	Kaus Australis	1.85

stars in the night sky. It includes both northern and southern hemisphere stars and in which constellation they are located. Knowing the bright stars helps in the identification of fainter stars and their constellations.

Learning how to identify stars and constellations takes time, months and years, not hours. If you need help identifying constellations, again, check with your local amateur astronomy club. These clubs consist of astronomy enthusiasts who host "star parties" to which they bring their telescopes out for the public to use and to teach about the night sky. Members of these clubs can know a lot about the naked-eye night sky.

Fig. 3 Image of a northern hemisphere planisphere

Going Outside

Armed with your star chart or planisphere go outside and look up. It may take as long as 15 or 20 minutes for your eyes to adjust to the dark, and for you to see many stars. Only one flash of a white car headlight or misdirected flashlight can force you to start over! So, in order to read your starchart or find your way around, you need a red flashlight or red laser pointer. Using red light keeps your eyes dark adapted.

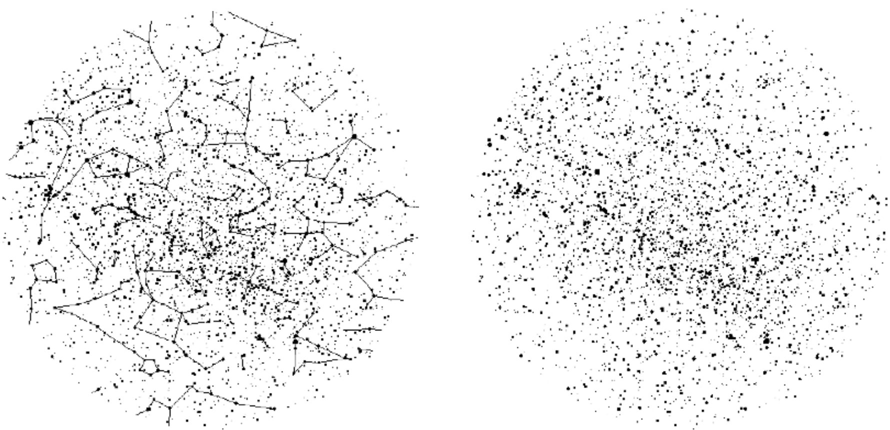

Fig. 4 Planisphere of the northern hemisphere with constellation shapes and without
Source: Walker, J., Home Planet – HPLANET. 1994, Fourmi Laboratory. Software. http://www.fourmilab.ch/homeplanet/homeplanet.htm

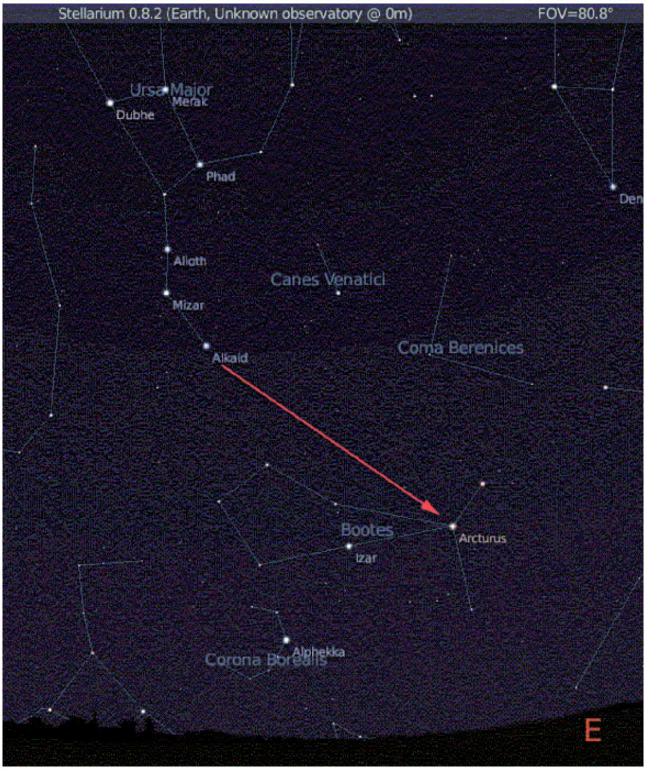

Fig. 5 Part of a Stellarium screenshot with an arrow inserted showing how to find Arcturus from the handle of the big dipper
Source: Chereau, F., Stellarium Software. 2001. http:// stellarium.sourceforge.net/

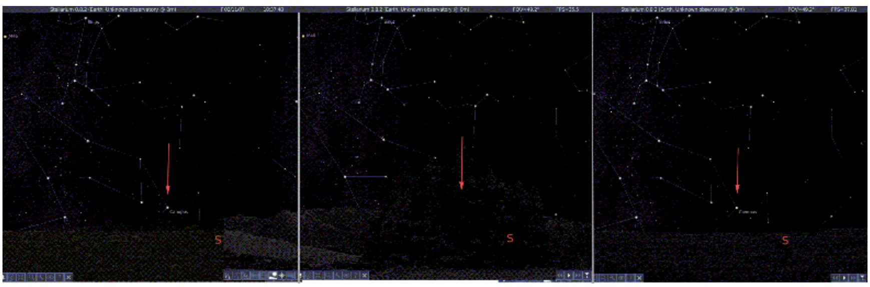

Fig. 6 Deciding when the star Canopus rises over a horizon may depend on what is on your horizon. Here there is (1) a farmland horizon, (2) a forest horizon, and (3) and ocean horizon, which is also the ideal horizon
Source: Chereau

Once your eyes are adapted to the dark, start looking up and noticing what you see. Finding stars and constellations in the sky does not just depend on your eyes being dark adapted – it also depends on how familiar you are with what you are looking for. The first time you go out may be frustrating, but remember it is part of a learning process, which means that you will get better with practice. If you can identify one constellation at first, you've begun. Next you might try to figure out some way to find a second constellation using a star chart, and the first constellation.

For instance, most Northern Hemisphere observers can find the Big Dipper. You can use this asterism to find a number of other stars and constellations. If you follow the curve of the handle of the dipper, away from the dipper itself, you "arc to Arcturus," the bright orange-tinted star in the constellation Bootes. Look on your map or chart first, see how this is done, and then try it outside.

Looking Around

If you were only interested in learning to identify constellations and didn't need to go further, you might stop here. But for doing cultural astronomy, there are a number of other important variables related to the sky. Considered here are the horizon, the cardinal direction, apparent distances, and direction angles.

The Horizon

To judge when a star (whether in the night sky, or you're looking for the Sun) or a planet rises or sets, you need to have a reference point, and this will depend on where you are when you are doing your observations. The first important reference point is the horizon. The horizon is the line at which the Earth's surface and the sky seem to meet. In real life, there might be mountains or forests or a city skyline in the distance from where you are standing. An extreme example of this is if you go out to look at the sky and stand very close to the building you just left. There will be part of the sky that is blocked by that building. Just keep in mind that where you stand (e.g. changes in distance of only a mile or so) might affect what your distant horizon looks like, and in turn, when celestial objects will rise or set past it. The ideal horizon, the one that you will be dealing with if you use any night sky software, is where the Earth's surface, at sea-level, would meet the sky if you could flatten all the mountains and remove all the trees. When you are looking out over an ocean or a sea, you can see an ideal horizon.

The Cardinal Points: N, E, S, W

The horizon is not the only reference system that is relative to you, the observer. There are also the cardinal points – the compass directions: North, East, South and West. It is important to know where these are along a horizon because they will help you interpret certain measurements like the rising and setting of objects in the sky. A compass can help you find these directions at a field site. Or ideally, you should learn which direction is north from the position of the constellations. The Big Dipper

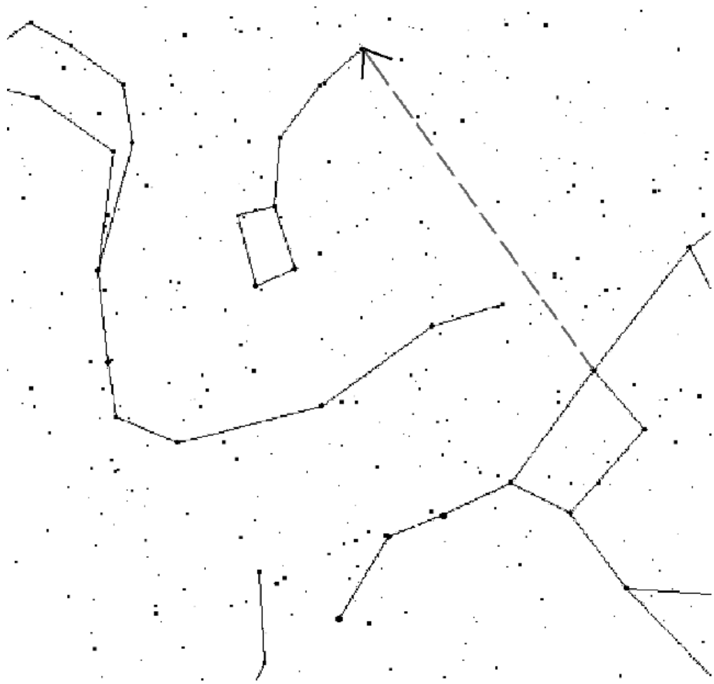

Fig. 7 Diagram of Ursa major and how to find Polaris
Source: Walker

and Cassiopea are two of the northernmost easily identified constellations. Both can be used to find Polaris, the star that marks north, also called the North Star.

Figure 7 and 8 show how a researcher uses these constellations to find north.

Similarly, there are the southernmost constellations. The Magellanic Clouds and the Southern Cross are used to find the general direction of south (Fig. 9). Unfortunately, there is no star like Polaris to mark south.

Distances in the Sky

There is one last basic reference system to consider. Think about answering the question, "how far west of the mountain peak did the star Canis Major rise?" This is not a question that can be answered with traditional distance units like miles, meters or kilometers. The reason is that the separation between objects in the night sky is measured in angles, not distances, because objects in the night sky only seem to all be located on a spherical shell around the Earth. In truth, the Moon is 384,000 km away from Earth, and the Sun is 150,000,000 km away. So, during a solar eclipse, the apparent separation in the sky between the Moon and Sun is almost zero, when in reality, they are 149,616,000 km apart from each other in space! Luckily, we are not worrying about how far they are from each other in space. We only need to learn the system of angles, where opposite sides of the sky – like North and South, or straight above and straight below – are 180° apart, and from the horizon to straight

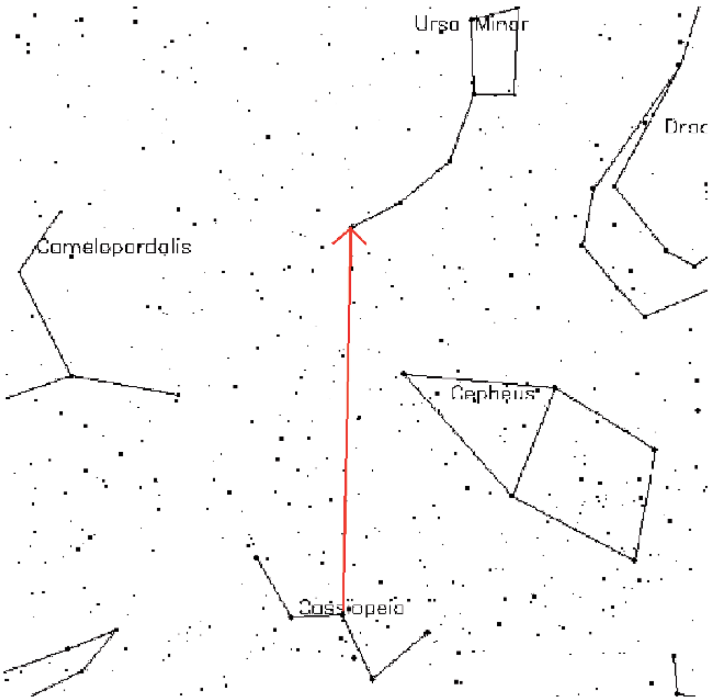

Fig. 8 Diagram of Cassiopeia and how to find Polaris
Source: Walker

above is 90°. This that lets us say that during a solar eclipse, the Moon and Sun are 0° apart in the sky, and during a Full Moon, they are 180° apart in the sky. To go from a point in the sky, all the way around the sky (in the largest circle you can draw) is 360°. From one cardinal point to the next, for instance from North to East, is 90°, as is from the horizon to the point directly above your head, the zenith.

When looking along the horizon you also note the rising and setting position of celestial bodies using angles. There is a convention of North as 0°, East as 90°, South as 180°, and West as 270°. Estimating the rising and setting positions using this convention will make finding the same positions in Stellarium or HPLANET easier.

But what about smaller separations? There happens to be one observing tool that most of us bring with us to any field site – our hands. It is a strange coincidence of human anatomy that the angular size of a person's hand, seen by them at arm's length is similar for most people. And there are rules of thumb, fist, and index finger, that help with angular separation measurement. At arm's length:

Your fist =10°
Your thumb to pinky outstretched = 20°
The width of your index finger = 1°

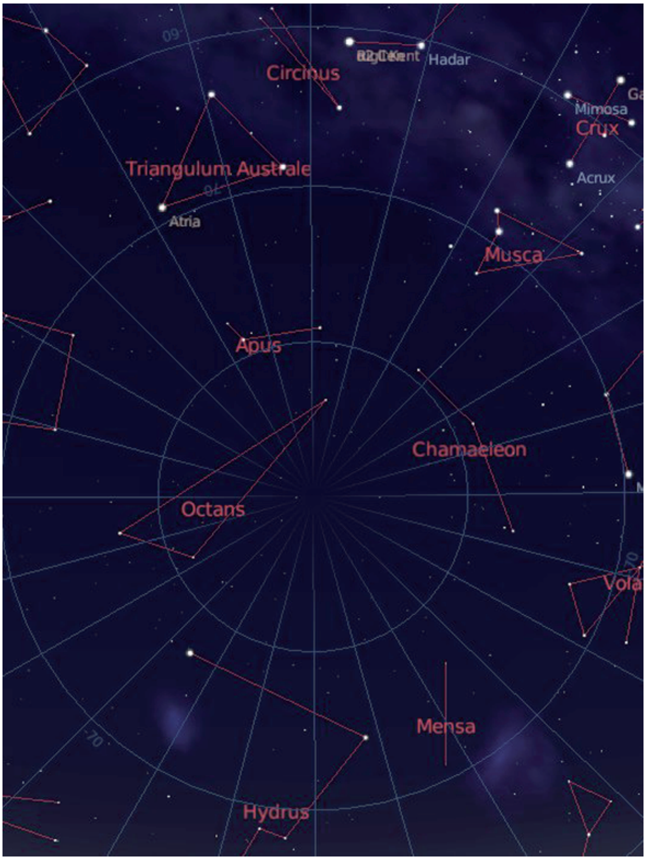

Fig. 9 Southern hemisphere constellations near the south celestial pole
Source: Chereau

A good way to check this for your own hand is to compare your fist, outstretched fingers and index finger to known angles on the sky. The distance between the two stars that mark the end of the Big Dipper is about 5° on the sky, which should be about half the width of your fist. The distance between the star Dubhe and Polaris, the North Star, is about 30°, which should be the width of one outstretched hand and a half. In the Southern Hemisphere, the long arm of the constellation Crux (the Southern Cross) is about 6° across.

Finally, the Moon is about 1/2° across, which is half the width of your index finger, held at arm's length. Testing this out at night is especially interesting when there is a full Moon, because often it can look much larger in the sky when it is near the horizon than when it is high in the night sky. Try to measure the angular size of the full Moon close to the horizon and then a few hours later, when it is higher in the sky. What do you find?

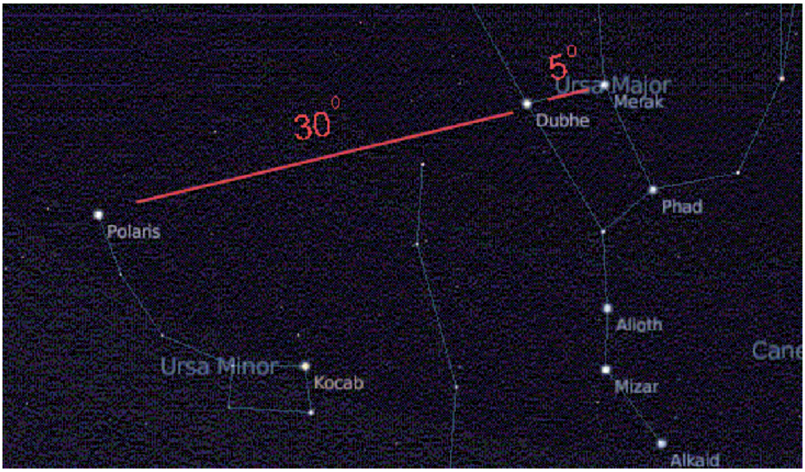

Fig. 10 Finding Polaris and measuring apparent angles
Source: Chereau

Directions in the Sky

There is a related complexity about judging position in the night sky, and that comes about when more than one person is looking up at an object. Try this at home – have a friend stand a few feet away and point at something at the other side of the room. You point at the same time. If you were to look where he/she is pointing, would you be observing the same object? How can you remedy this? Standing very close to the person is not always possible due to different customs and ideas about personal space. One way you might get around this is to use a flashlight with a strong, very straight light beam, try to locate an object you both agree on (like the Moon) and have the person direct you from there verbally and with compass directions, such as "the star I am looking at is 20° west of the Moon."

The Sun

CAUTION: You can cause permanent damage to your eyes if you observe the Sun incorrectly. Do not observe the Sun with your naked eye – always use a proper filter, obtained from a trusted source such as a local planetarium. Sunglasses or eyeglasses DO NOT provide enough protection to your eyes for looking directly at the Sun. NEVER look at the Sun through binoculars or a telescope that hasn't been professionally set up with a solar filter. Binoculars and telescopes do not just magnify an image, they concentrate light, which makes them potentially very harmful if you look through them when they are pointed at the Sun.

A wonderful alternative to getting a solar filter is to look at a projected image of the Sun. All this requires is a sheet of paper or cardboard with a pin hole in it. Use a second sheet of paper or light surface to project the image onto. By adjusting the distance between the two pieces of paper, you will adjust the size and focus of the image of the Sun. During solar eclipses, this is especially interesting, because as the Moon blocks out more of the Sun's disk, the projected image will look like more of a crescent. This technique works with any other medium that has small holes in it – leaves on trees, or holes between the fibers of a straw hat.

The Apparent Annual Motion of the Sun

As the Earth spins on its axis, the Sun and stars seems to move across the sky. There are many parts to this motion. The simplest one is that the Earth makes almost one complete turn around its axis every 24 hours – one day. But the path the Sun makes across the sky due to the Earth's spin looks different depending where on your latitude and what time of year it is. Where do you think the Sun will be tomorrow at noon if you go out to look? (Make a prediction now, and then check your prediction tomorrow).

Where you live is there a room that never gets sunlight? What direction do the windows in those rooms face? Is there a room that gets sunlight only in the morning or the evening? What direction do the windows in that room face?

For observers in the Northern Hemisphere, the Sun travels an apparent a path across the sky (remember, really the Earth is turning), that starts approximately in the East, ends approximately in the West, and arcs towards the South. This means that at local noon, even though the Sun is the highest it will be in the sky, and that it is halfway between rising and setting, it is not directly above your head. In winter, the path of the Sun is lower (reaches a lower maximum altitude above the southern horizon) than in summer.

In the Southern Hemisphere, the Sun still rises approximately in the East and sets approximately in the West, but its path is tilted towards the North. Near the equator, the direction of the Sun's path will depend on the time of the year. Near the equator, twice a year the Sun will pass directly overhead. Keep in mind, also, that winter in the Northern Hemisphere is summer in the Southern Hemisphere.

There are four important dates related to the Sun's path through our sky, that mark the beginning of Summer, Fall, Winter, and Spring. In the Northern Hemisphere, they are summer solstice, near June 21st, autumnal equinox, near September 21st, winter solstice, near December 21st, and vernal equinox, near March 21st. The summer solstice will be the longest day of the year, while the winter solstice is the shortest. The date of summer solstice in the Northern Hemisphere corresponds to winter solstice in the Southern Hemisphere. The equinoxes mark the days of the year that have equal hours of day and night, and when the Sun rises exactly in the East and sets exactly in the West, regardless of your latitude. There are many African cultures that have aligned structures to the solstices or have ceremonies associated with the solstices [10, 11, 12]. Cultural astronomy researchers should be sure to include asking about the solstices and equinoxes during their fieldwork.

Solar Eclipses

The rising and setting of the Sun are everyday events, even if they are shrouded in clouds or rain. But there are rarer events that involve the Sun, that are spectacular – solar eclipses. We live in a very special time in our solar system's history – the Moon orbits the Earth at just the right distance that it has about the same angular size in the sky as does the Sun. A simpler way of saying this is that the Moon and the Sun both appear to be about $^1/_2{}^\circ$ across. This would not be a very remarkable fact except that sometimes the Moon passes exactly between the Earth and the Sun and blocks out the Sun completely – a total solar eclipse. Total solar eclipses only happen every few years, are only visible for a maximum of 7 minutes (they can be as short as tens of seconds), and only visible from a small number of places on Earth each time. A map found at NASA Sun Earth Connection shows the path of recent and future solar eclipses (Fig. 11). This map shows the shadow of the Moon as it moves across the face of the Earth. A simple way to imagine this is to have a friend stand with you in a sunny place, and have them block the Sun from their eyes with their fist – when they say they can no longer see the Sun, you should see a shadow on their face, a kind of solar eclipse. The difference is that since the Moon is outside the Earth's atmosphere (which scatters sunlight and makes the daytime sky bright), when the Moon covers the Sun in a total solar eclipse, the sky gets very dark – like nighttime. It is an unforgettable event to witness: the air gets colder, some stars and planets may be visible, and even animals act differently during the short, unexpected night. During the eclipse that was visible from Cape Coast, Ghana, during this meeting, one college student who saw it broke into a smile after it was over saying "it was Wednesday before the eclipse, and I had an exam on Wednesday night, but since the Sun set behind the Moon, it should now be Thursday and there should be no more exam."

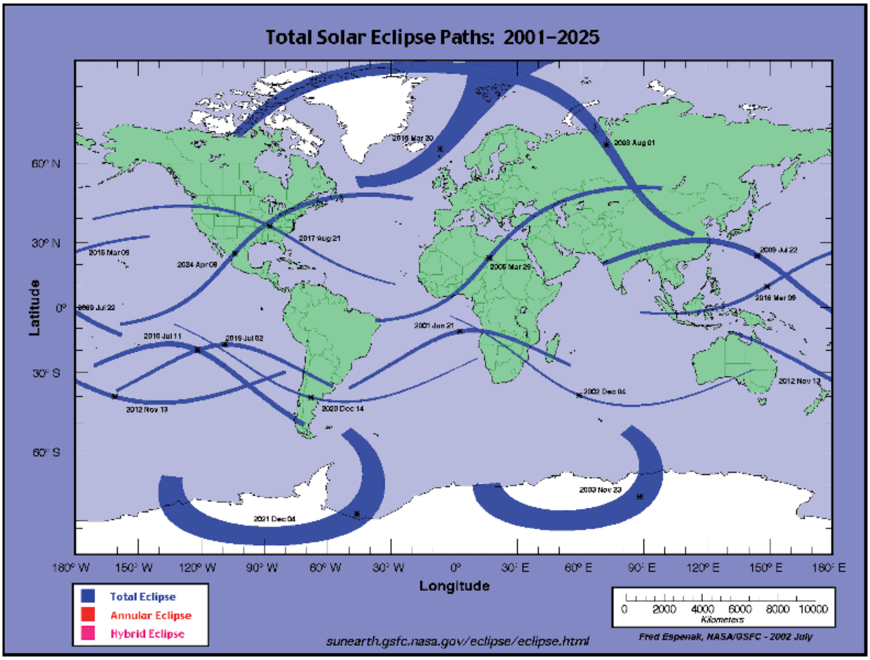

Fig. 11 Solar eclipses: 2001–2025 [13]

There are times when the Moon is a bit farther from Earth, but still directly between Earth and the Sun. When this happens, it is not large enough (in the sky) to completely block the Sun, and an annular eclipse happens. The name refers to the fact that the Sun's rays show around the edges of the Moon in a ring, or annulus, shape. Finally, at times the Moon is almost exactly between the Earth and the Sun, and it will only cover part of the Sun's disc, which is called a partial eclipse.

The Sun and the Constellations

One final point to make about the apparent motion of the Sun through the sky is relevant to nighttime. As the Earth travels around the Sun throughout the year, making one trip every 365 days or so, different stars are visible at night, and the Sun appears to travel through different constellations. If the Sun were an important character in the sky to cultures that noticed it, the constellations it went through would also be significant. Can you guess which constellations these might be? They are listed in many magazines and newspapers – the Zodiac constellations. Because of the shape of our solar system (all of the planets orbit the Sun in a plane and the Moon orbits Earth in approximately the same plane), the planets and the Moon also move through the Zodiac constellations. So, the bright light you observe in Orion or the Big Dipper or Crux, which are not Zodiac constellations, cannot be a planet, it must be a star (or an airplane!). As mentioned, the standard constellations and boundaries are set forth by the IAU. Because of this, there are 13 constellations that the Sun travels through not twelve (Table 4).

Table 3 Major meteor showers for 2007 [24]

Shower	Activity Period	Maximum		Radiant		Velocity	r	ZHR	Class	Moon
		Date	S. L.	R.A.	Dec.	km/s				
Quadrantids (QUA)	Jan 01–Jan 05	Jan 04	283°16	15:20	+49°	41	2.1	120	I	15
Lyrids (LYR)	Apr 16–Apr 25	Apr 22	032°32	18:04	+34°	49	2.1	18	I	5
Eta Aquarids (ETA)	Apr 19–May 28	May 06	045°5	22:32	−01°	66	2.4	60	I	18
Delta Aquarids (SDA)	Jul 12–Aug 19	Jul 28	125°	22:36	−16°	41	3.2	20	I	12
Perseids (PER)	Jul 17–Aug 24	Aug 13	140°	03:04	+58°	59	2.6	100	I	00
Orionids (ORI)	Oct 02–Nov 07	Oct 21	208°	06:20	+16°	66	2.5	23	I	9
Puppid/Velids (PUP)	Dec 01–Dec 15	Dec 07	255°	08:12	−45°	40	2.9	10	I	27
Geminids (GEM)	Dec 07–Dec 17	Dec 14	262°2	07:28	+33°	35	2.6	120	I	5
Ursids (URS)	Dec 17–Dec 26	Dec 23	270°7	14:28	+76°	33	3.0	10	I	13

Table 4 The Path of the sun through the zodiac constellations

Constellation	Dates in Constellation (2007 CE).
Aries	April 19–May 13
Taurus	May 14–June 19
Gemini	June 20–July 20
Cancer	July 21–August 9
Leo	August 10–September 15
Virgo	September 16–October 30
Libra	October 31–November 22
Scorpius	November 23–November 29
Ophiuchus	November 30–December 17
Sagittarius	December 18–January 18
Capricornus	January 19–February 15
Aquarius	February 16–March 11
Pisces	March 12–April 18

The Moon

Phases of the Moon

When is the Moon in the sky and what does it look like? For some people, who have spent a lifetime looking at the sky and noticing changes, this may be fairly easy to answer. But for those of us who find ourselves surrounded by buildings or by many cloudy nights, the answer may not be so obvious. The phases of the Moon are due to the relative positions of the Earth, Moon and Sun. This means that the phase of the Moon is directly related to how close it looks to the Sun in the sky.

Simply reading the previous two sentences is not a good way to learn about Moon phases, however. Over the course of a month, look for the Moon in the sky every day, and note in a journal when you saw it and sketch how it looked. Be sure to look for the Moon during the day, as well. At the end of your month, you should find that you never saw a thin, crescent Moon high in the sky, and that a full Moon was not visible during the day. There are names for the different phases of the Moon, and they cycle over about 29 days. So if you have a Full Moon tonight (when the Moon is in the opposite part of our sky from the Sun), in two weeks there will be a New Moon (when the Moon is very close to the Sun in the sky, an thus not visible). In between Full and New Moon are phases called Gibbous (more than half lit), Quarter (half lit), and Crescent (less than half lit). For these in-between phases, there is also added information about if they occur when the Moon is getting more (waxing) or less (waning) lit on future nights.

Figure 12 is an example of what you might see when you observe the Moon over two weeks. From left to right, these represent what phase the Moon was in on March 15, 2007, March 23, March 25, and March 29. Keep in mind that the different phases of the Moon will be up in the sky at different times.

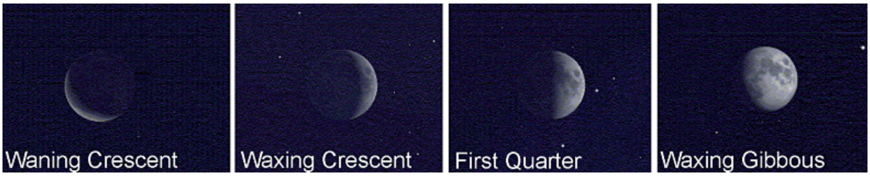

Fig. 12 The phases of the moon.
Source: Chereau

Apparent Motion of the Moon

The Moon is in orbit around the Earth and it does appear to rotate around the Earth. However, the Moon takes 28 days to complete one orbit around the Earth. The daily motion is due to the Earth rotating on its axis, the same as with the apparent daily motion of the Sun. To make things more complicated, the phases of the moon which are determined by the angular distance between the Sun and the moon repeat after 29.5 days. This is because over the course of a "month" the Earth moves within its own orbit taking the moon with it.

The path the moon takes through the stars is close to the ecliptic which is the path the Sun takes through the stars. The Moon stays within five degrees of the ecliptic. But over a month it usually spends half the month above the ecliptic and half below because of the tilt of its orbit around the Earth compared to the Earths orbit around the Sun. Nonetheless, the Moon remains close enough to the ecliptic to pass through the same constellations as the Sun (Table 4).

Metonic Cycle

The Moon appears in a particular location in the sky with a specific phase only once every 19 years. Thus, a full moon near a particular star in Leo only occurs in that exact same location and also as a full moon nineteen years later. Thus, far no scholars have explored knowledge of the Metonic cycle among Africans except in the literate cultures. In our society, nineteen years is close to when children become legally adults and thus noting the Metonic cycle could have possible significance. But, research on African adult initiation rites place initiation ages much younger, between twelve and fifteen years old.

Lunar Eclipses

If a solar eclipse happens when the Moon blocks the Sun from reaching a part of the Earth's surface, what is a lunar eclipse? It is not very logically named – a lunar eclipse happens when the Earth blocks the Sun from reaching a part of the Moon's surface.

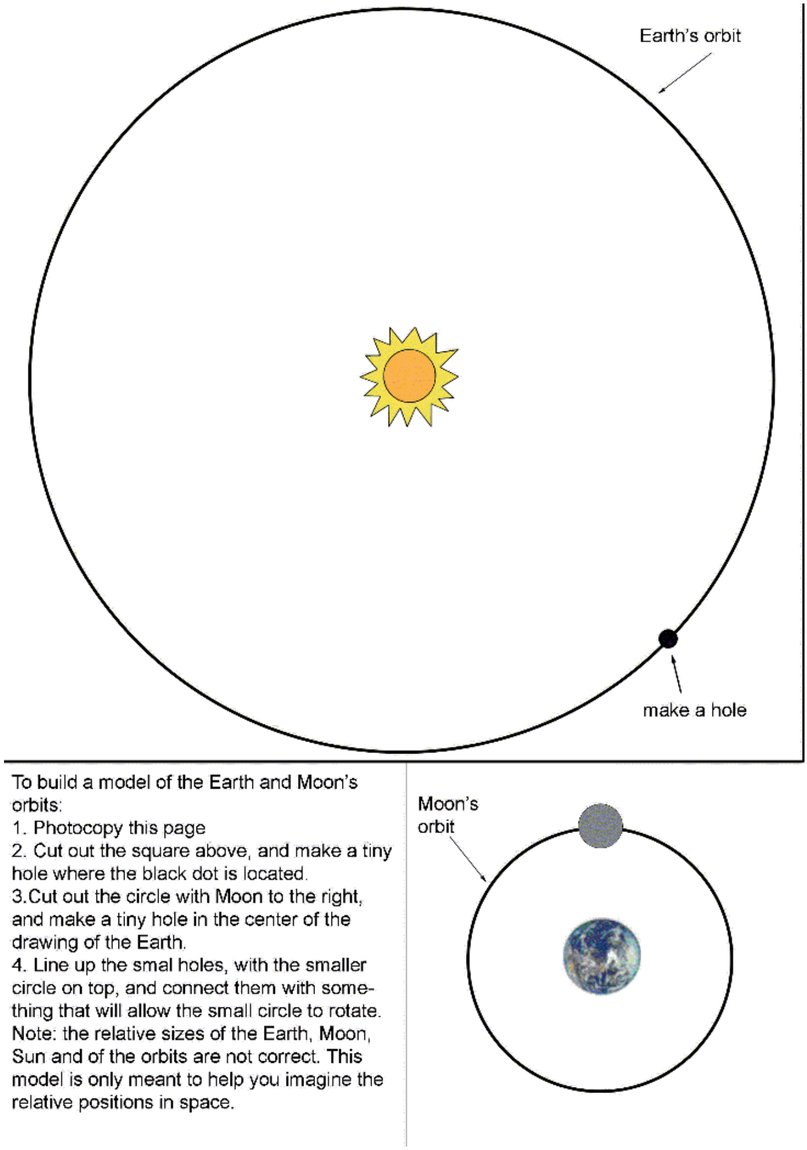

Fig. 13 Create a model of the Earth – Moon – Sun system. (Designed by A. Baleisis)

Because the Earth has to come between the Moon and the Sun, a lunar eclipse can only happen during a Full Moon. Because it is safe to look at a Full Moon with the naked eye, it is also safe to look at a lunar eclipse with the naked eye. As the Moon moves into the Earth's shadow, its surface will get darker – ranging from dark grey to a deep red, depending on conditions in the Earth's atmosphere. Also because of the Earth's atmosphere, its shadow does not make a sharp curve on the Moon. Lunar eclipses occur more frequently than solar eclipses do, due to the fact that from the Moon, the angular size of the Earth is much bigger than the angular size of the Sun – so it is easier to get a lunar eclipse and they last longer (up to 3 hours). They take place one to two times per year, and are visible by everyone for whom it is night.

Field Research

After learning the night sky at home, learning how to use the night sky software, and armed with star charts and planisphere the researcher is prepared for field research. Upon arriving at the research site, the researcher should begin learning the night sky at that location. Ultimately, the research should be able to identify an object that an informant points to. But, there are two techniques that are also helpful for identifying stars and constellations in the field: photographing the night sky and creating sketches of the night sky. But as a cultural astronomy researcher what are you looking for? What are you trying to learn? Ruggles suggests three broad areas – 1. To document and analyze how people use the sky. 2. To learn how people perceive and think about the sky. 3. To determine how competent people are at observing the sky [14]. But, these skip an essential first step which is collecting the local names for celestial bodies. Collecting myths and legends about celestial bodies compliment learning the names. And, a new area of research for African cultural astronomy is highlighted: to look at the interplay of light and shadows.

Data Collection Aids

Photography

Taking images of the night sky takes practice and patience. However, to take images of the alignments of moon and sun rises and sets is easy and instantly offers concrete proof that such alignments exist. For example if an informant says that a temple is aligned such that sunlight enters the main door on the summer solstice. A researcher should make an archaeological map of the temple with north indicated and using accurate scale lengths and correct angles. Then, the direction of the temple main door (using the latitude and longitude of the temple, plus the direction angle of the door) can be checked using the astronomy software for the June 21st sunrise location on the horizon. However, such confirmation is easier if on June 21st, the researcher takes pictures from inside the temple facing the main door as the sun rises. The proof is if the pictures capture the alignment. Such a process is the same for moonrises. Both the sun and moon are bright and easy to photograph. Photographing the stars is significantly more difficult.

In order to take pictures of the night sky for reference is it useful to include some of the horizon features. Thus, it is best to photograph target parts of the sky while rising or setting. For example, to capture Orion in December in the northern hemisphere, it is easiest to capture it when it rises a couple of hours after sunset.

For taking images of the stars in addition a tripod and a cable release are needed in addition to the camera. With digital cameras, a good image can be taking in about 40 seconds. For film cameras, it takes several minutes. The cable release allows the researcher to take images without jostling the camera. Most cable releases can be used with the open shutter function called "bulb." The earth continues to rotate while pictures are exposing, if longer exposures are necessary a clock drive tripod will be needed. Having a clock drive tripod will prevent star trails because it compensates for the earth's rotation.

Photographing daily life and people's faces at your research site will provide context for your research. You will use these photos in presentations, articles, and books which will enable you to better convey what life is like for the people from whom you are learning about the sky. Also, it is important to record what technology is available at your field site and how such technology effects sky knowledge. For example, is there lighting outside at night that may contribute to less stars being visible? Or are printed calendars available that compete with the traditional sky calendar. A picture of these will allow you to show these technologies to audiences.

Photographing the night sky is difficult and requires a lot of equipment. As a researcher, you may not want to take expensive equipment with you. Disposable cameras can be substituted for more expensive ones for daytime photography, but not for night photography. In certain countries, there are restrictions as to what kind of information can be recorded and taken out of the country. Nonetheless, nights of photographing the sky can be interspersed with nights working with informants identifying objects. Doing both on the same night is usually not possible and makes for a long night.

Sketching

When photographing the night sky is not an option, a sketch of the horizon, the relative positions of stars and familiar constellations may be helpful. In some instances, it may be easier to make a quick drawing than to set up camera equipment. On a drawing, a researcher can label familiar stars and constellations and mark unfamiliar ones for later identification. It is also useful to have informants make sketches of what they are talking about. You may need to instruct the informant to put in familiar horizon features. Such sketches may be useful for identifying stars and constellations by comparing to a star chart or planisphere.

Data Content

Names

In order to begin to talk with local informants about the sky, you must learn basic terminology such as the works for sky, star, moon, and sun. This is part of creating a common language for communicating with local informants. Other important terms are the times of the day, seasons, months or moons, years, and the names of individual celestial bodies and phenomenon. It is possible that a dictionary of the local language contains many celestial terms, it is worth checking. But, terms such as the names of individual planets and less bright stars are often not recorded. Thus, cultural astronomy researchers often record names for celestial bodies for the very first time. Creating a star chart of local names is equally significant. However, recording the names is usually just the first step of more sophisticated cultural astronomy research projects.

Myths and Legends

Oftentimes, people have myths or legends associated with celestial bodies. These two should be recorded with the names of individual celestial bodies. Most people have an accepted origin myth or cosmogony that may also be connected with the sky. Sometimes, these myths and legends include factual information about the physical properties of celestial bodies, or factual information about migration from one place to another. The latter falls in ethnohistory. Other myths of powerful figures or elites may claim a celestial origin or a connection to temporary celestial events such as comets or eclipses [15, 16, 17, 18]. One area of naming and myths and legends that is understudied is meteor showers [19]. Meteor showers occur when the Earth enters the path of a comet. As comets travel the solar system, they leave behind bits of dust and ice particles. It is these small particles that burn up in the Earth's atmosphere during meteor showers. There are five major meteor showers a year in the Northern Hemisphere: The Lyrids, Perseids, Orionids, Geminids, and the Ursids. There are four major Southern Hemisphere meteor showers and the Orionids can be seen in the Southern Hemisphere as well. A researcher can strategically choose to do research during a meteor shower or around another major celestial event such as a solstice or eclipse. Researchers can ask about celestial events, but being there during a celestial event can result in much deeper explanations and stimulate more recollections.

Light and Shadows

Cultural astronomy research in the United States has revealed that Native Americans created petroglyphs in locations such that shadows and spears of light fell onto the patterns only on certain days of the year. A film that shows the phenomena is "The Sun Dagger" [20]. Thus far, no researcher has studied the combination of rock art and light and shadow interactions in Africa. Given the extensive rock art sites in East, South, and North Africa, there are plenty of places for researchers to begin studying. The creation of such sites required much though about both the placement of the glyph and the possible modification of surrounding rocks and earth to create the desired pointing effect on specific days. The NASA Sun Earth Connection provides resource on the web that shows the serpent shadow descending along the central temple on the spring equinox in the Mayan town of Chichen Itza in the Yucatan Pennisula, Mexico, among other light and shadow phenomena see http://www.traditionsofthesun.org/ and http://sunearthday.nasa.gov/2005/index.htm. The Sun Dagger is an example of a natural environment being modified for marking a celestial event, while Chitchen Itza is an entirely built complex aligned for making a celestial event. Examples of these types have not been explored in Africa.

Deeper Questions

After gathering the basics of names, myths and legends, usually a researcher moves on to the core of their research. The core question is usually researcher specific. Some projects have looked at navigation by the stars, architecture and alignments, archaeological sites, rock art, contemporary tribal art, symbolism in literature, and ritual. However, some standard issues should be a part of every study just like learning celestial names, myths and legends. These include gender, acquisition and transmission of sky knowledge, lost knowledge, and social status. Gender begins with which celestial bodies are male, female, both or neither, to what do men or women know about the sky and how they use the sky. For example, many women around the world use the moon to keep track of their menses and fertility. Or when are women or men initiation ceremonies. The acquisition and transmission of sky knowledge answers the question of how people learn about the sky and who is being taught about the sky and why. Lost knowledge reminds the researcher to ask about what people think that their grandparents knew about the sky that they don't know now [21]. What is the social status of the people who know about the sky? Is certain knowledge commonplace and other parts only known by a few elites or non-elites? Is sky knowledge being used to maintain a social caste system [22, 23]?

Conclusions

This paper explores the naked-eye astronomy that needs to be mastered by cultural astronomy researchers but includes field data collection methods and areas of inquiry that should always be considered. To summarize, the cultural astronomy researcher needs to know the constellations, many of the brightest stars, the Sun and its annual apparent motion, the Moon and its phases, and how to measure angles in the sky and along the horizon. Once in the field, a common language for discussing the night sky needs to be established through learning the local names for celestial bodies, angles, and the cardinal directions. Only then can deeper questions and the core of the research project be approached. This paper should help the cultural astronomy researcher, but ultimately each person should design their own unique project with core issues to explore. Thus, this paper is not meant to be exhaustive in scope but merely suggestive.

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