



***A MASS EXPERIMENT
ABOUT LIGHT POLLUTION***

Tutorial and Background Material

Thank you for participating in the Star-Spotting Experiment!

In the citizen science initiative, known as the Mass Experiments, the Swedish science festival ForskarFredag (European Researchers' Night in Sweden), invites school classes and the public to contribute to a real research project. Participants get the chance to help scientists while learning more about the scientific process. For the researchers, this is a unique opportunity to collect large datasets that would not have been possible without help from the public. Mass Experiments have been run as citizen science projects on different topics every year since 2009.

In the Star-Spotting Experiment, the public are helping researchers to measure light pollution levels near their homes, using an ordinary paper tube. This new, low-tech method measures light pollution from the earth's surface, as opposed to using other land-based methods or satellites. To see if the method works, we need lots of data and that is where the researchers need your help. The researcher in charge of the experiment is Dr Urban Eriksson, a researcher and senior lecturer in physics, with a specialisation in astronomy education at Lund University and Kristianstad University in Sweden.

In this guide, you will find out more about the background of the project and instructions on how to run the experiment. The guide is designed to provide the necessary support for teachers who wish to participate in the Star-Spotting Experiment with their pupils but is also aimed at everyone, including leaders of social clubs, outdoor and recreation associations, scouts or individuals.

The Star-Spotting Experiment is created by the Swedish non-profit organisation Public & Science (Vetenskap & Allmänhet, VA), the National Resource Center for Physics Education (NRCF), Lund University, Kristianstad University Sweden, the Swedish National Space Agency, and the two science centres House of Science (Vetenskapens hus) and Umevatoriet, Sweden. The project is being run in collaboration with Fundación Descubre, Esciencia, La Palma Centre and Fundación Madri+d, Spain, University College Cork and Trinity College in Ireland and The Natural History Museum, London, UK.

The project is funded by the Research Council Formas, European Researchers' Night in Sweden (ForskarFredag) via EU research and innovation program Horizon 2020, (GA No 818421), and the Swedish National Space Agency.

The mobile app used to report the findings is called **Stjärnförsöket/Star-Spotting Experiment** and has been developed by the company SPOTTERON. It is available to download in the *App Store* and on *Google Play*.

NOTE: You can also participate in the Star-Spotting Experiment without downloading the mobile application.

Feel free to join the Star-Spotting Experiment Facebook group:
www.facebook.com/groups/starspotting/

Good luck!

Dr. Urban Eriksson, Researcher and Senior Lecturer in physics specialising in teaching astronomy, working at Lund University and Kristianstad University.

Lena Söderström, Project Manager for the Star-Spotting Experiment and ForskarFredag (European Researchers' Night in Sweden), Public & Science (Vetenskap & Allmänhet), VA.

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OBJECTIVE AND BACKGROUND

Light pollution is an environmental problem in the world that most people are not aware of. Street lighting, fluorescent signs, cars and many other sources light up our cities at night. This makes the night sky brighter and as a result it is more difficult to see the stars. Studies show that animals and insects are adversely affected by light at night and that it also has a negative impact on human health. Another consequence is that people's awareness of the stars and space is also decreasing.

The objective of the Star-Spotting Experiment is to test a new, simple method for measuring light pollution, and whether this new method is just as good (or better) for mapping light pollution as current methods such as satellite mapping, which measures light pollution from space.

The method being used in ForskarFredag's Mass Experiment¹ the Star-Spotting Experiment is low-tech and doesn't require any expensive equipment. Participants count the stars that they can see with the naked eye through a simple paper tube, angled in nine different directions towards the night sky (see Figure 1). You then report information about time, place, the number of stars and the weather conditions via a computer or through a mobile app. A formula is used to instantly calculate the total number of stars that you can see in the night sky from your location. You probably already have all the materials you need at home: a cardboard tube, string, tape, a weight (such as a nut) and a compass.

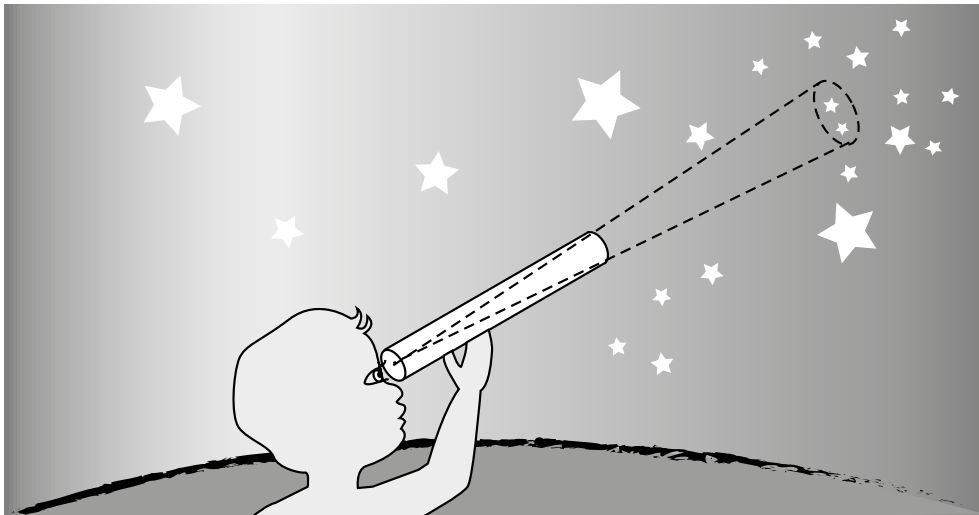


Figure 1. The method for the Star-Spotting Experiment 2019. A tube is held in nine different directions in the sky and the participant counts the number of stars they can observe in every direction. The results and weather conditions are then reported in the mobile app. *Illustration: Lotta Tomasson/VA CC BY-NC 2.0 (<https://creativecommons.org/licenses/by-nc/2.0/>)*

¹ ForskarFredag's Mass Experiment is part of the science festival ForskarFredag, which takes place throughout Sweden on the last Friday and Saturday of September each year. ForskarFredag is part of European Researchers' Night, an initiative of the EU Commission that is held in over 370 cities across Europe. ForskarFredag and ForskarFredag's Mass Experiments are coordinated by the Swedish NGO Public & Science (VA) – Vetenskap & Allmänhet).

The simplicity of the method allows everyone to make measurements wherever they are – in the school playground, on the balcony, in the garden or in the park. We are simply measuring the light pollution that people are experiencing in their everyday lives. This simple method could be crucial for combating the growing challenges caused by light pollution. This is the first time light pollution has been measured in this way on a large scale and you are a part of this unique research project!

Light pollution

Light – an environmental problem

Environmental problems have been documented on a large scale since the 1960s. Exhaust emissions, the use of DDT and PCBs, acidification and thinning of the ozone layer are examples of environmental degradation that have been recognised globally where societal changes have been made to try and combat the problems. What many people may not know is that one of the fastest growing environmental problems today is caused by electric lights.



Figure 2. Satellite image of light from major cities and densely populated areas in Europe. *Illustration: Craig Mayhew and Robert Simmon from data provided by Christopher Elvidge of the NOAA National Geophysical Data Center. Public domain, via Wikimedia Commons.*

Light created by humans is essential for modern society. Light provides us with security, safety and has allowed society to develop. However, artificial lights have also changed the environment in many parts of the globe.

Today, 55 percent of the world's population is living in urban² environments³ with street lighting, shopping malls, fluorescent signs, cars and other lights that illuminate the night and prevent us from seeing the stars.

In recent years, the introduction of LED lights has brought about a lighting revolution. LED lights require less energy to shine equally bright as a traditional light bulb. However, although we are using less energy, we aren't reducing the amount of light that we are creating. In fact, the opposite is true. Scientific studies show that light from the earth's surface has increased in both area and intensity. Between 2012 and 2016, the illuminated part of the earth's surface increased by 2.2 percent per year, and existing illuminated areas were 2.2 percent brighter on average⁴. Over the past few decades, knowledge has increased on how the use of light is affecting the biology of organisms, with unexpected and worrying effects on ecosystems, biodiversity and human health. The problems with artificial light created by humans are collectively called light pollution.

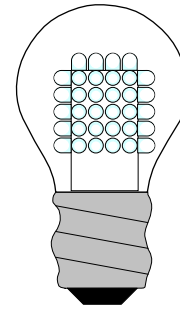


Figure 3. An LED light is a light made with one or more LEDs mounted in a standard base to be able to replace ordinary light bulbs. *Illustration: Pixabay*



Figure 4. New-born sea turtles making their way to the sea. *Photo: U.S. Fish and Wildlife Service, Public domain, Wikimedia Commons*

Light pollution and animals

Light pollution affects animals and plants in a variety of ways. Artificial lighting affects the biological clock of animals, circadian rhythms, positioning, and behaviour, but it also affects interactions between species, such as predators and prey. Examples of how light pollution affects biology are vast and span over a variety of species, including birds, frogs, reptiles, insects, crustaceans, fish, bats, and even large predators. An example of how light created by humans is affecting animals can be seen in sea-turtles. Many species of marine turtles lay their eggs on beaches, buried in the sand. Female turtles return to the same beach where they were hatched to lay their own eggs after a decade out at sea. Newly hatched turtles must then make their way down to the water. They do this at night when the sea is normally the only thing that they can see giving off light, as the stars and moon are reflected in the water's surface. They

² Large cities.

³ See: <https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html>

⁴ Kyba, C. C. M. et al. (2017). Artificially lit surface of earth at night increasing in radiance and extent. *Science Advances* 3, 1-8.

steer clear of the darkness and shadows on land, but ever since humans have started living next to the coast, the sea is no longer the brightest part of the horizon. Houses, street lamps, and cars all create light and the newly hatched turtles are now heading towards houses instead of into the water.

Night-active flying insects are often drawn to light sources such as lamps and street lights. Flying insects navigate using the moon, the stars and the bright horizon. Street lights distract the insects which start to swarm around the lamps instead of searching for food or a partner. If the light source generates heat it can also wound or kill the insects, and can also make them more visible to predators. Bats are another example. They are active during the dark hours of the day and choose their roosting spots with care to avoid light. Studies show that buildings illuminated with facade lighting can have devastating effects on bats. The bats sit during the day, hidden under the facade and roof, waiting for it to go dark so they can go out and hunt. When the building lights up it never gets dark and the bats never go out hunting, which means they die of starvation. However, bats can also benefit from this light. Flying insects are often seen flying around lights at night and make easy prey for the bats.



Figure 5. Common noctule
Photo: Mnolf CC BY-SA 3.0
(creativecommons.org/licenses/by-sa/3.0/, Wikimedia Commons)

Light pollution and the human body

For many years, researchers have studied how illumination at night affects animal behaviour and ecology, but we know less about how artificial light at night affects humans. In recent years, researchers have started to look into this as we need to know what risks light pollution pose to human health.

Like most biological creatures on earth, humans have a daily rhythm, technically called a circadian rhythm. The circadian rhythm acts as an intrinsic biological clock and splits the day into activity and rest. This rhythm also controls the production of one of the body's most important hormones, melatonin, which is produced in the dark and makes us tired. Melatonin (see Figure 6) controls many processes in our bodies, for example, our metabolism, how we eat and the balance between rest and activity. This internal clock is synchronised by light, to make sure our body is in sync with the environment. If we are exposed to a lot of light 24 hours a day, we risk interrupting several important functions in the body.

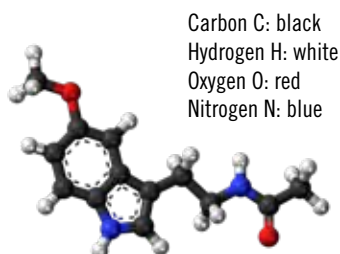


Figure 6. Molecular model of Melatonin.
A hormone that controls the circadian rhythm of animals.

Exposure to too much light during the dark parts of the day can disrupt our internal

biological clock and affect our melatonin production (see Figure 7). Melatonin plays a crucial role as an antioxidant⁵ and positively regulates the immune system. Although researchers do not yet fully understand the medical effects of light pollution on humans, there is some scientific indication that demonstrates a connection between light pollution and cancer⁶, which may be a result of decreased melatonin production.

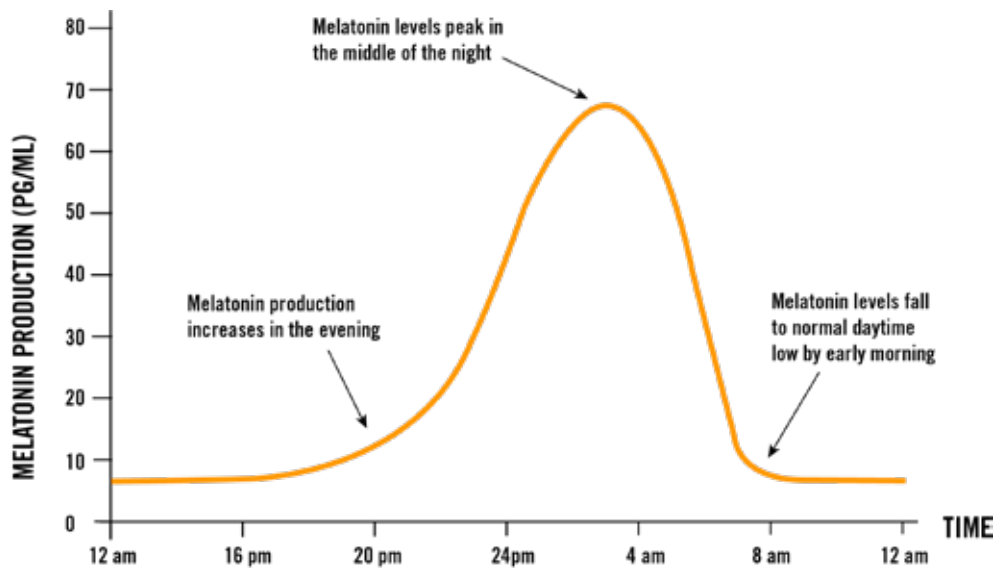


Figure 7. Graph of Melatonin production for 24 hours.

Illustration: Lotta Tomasson/VA CC BY-NC 2.0 (<https://creativecommons.org/licenses/by-nc/2.0/>)

Light pollution and urban planning

In order to reduce the harmful effects of light pollution and its impact on the environment, we need to think about light when planning and building our cities. It requires knowledge of how big the problems are and how lighting in cities and on roads can be adapted without losing the benefits, such as providing security for people out on the streets and reducing the risk of crime or traffic accidents. One solution is to minimise the light produced by programming lights that only come on when they are needed, and to ensure light is not directed upwards into the sky, see Figure 8.



Figure 8. Street lamp lighting up the sky and nearby trees. Photo: Lamiot, CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>), Wikimedia Commons

⁵ Antioxidants are chemical compounds that counteract oxidation. Oxidation means that one or more electrons are moved from an atom, molecule or ion and transferred to another.

⁶ Chepesiuk, R. (2009). Missing the Dark: Health Effects of Light Pollution. *Environmental Health Perspectives*, 117 A20-A2.

Lights probably don't need to be lit all the time. Vegetation, trees and shrubs in the urban environment should be planted in areas without lighting, to protect the animals being drawn towards the vegetation. You can also reduce the effects of light pollution by choosing light sources that have less impact on the environment. Different light sources emit different types of light, in other words, they are different colours. Animals can have different sensitivity and attraction to different colours of light. If we select light sources with a colour that has the lowest impact on animals, this could reduce the effects of light pollution. A lot more information is needed about how different animals are affected by different kinds of light, and more research is required in the future.

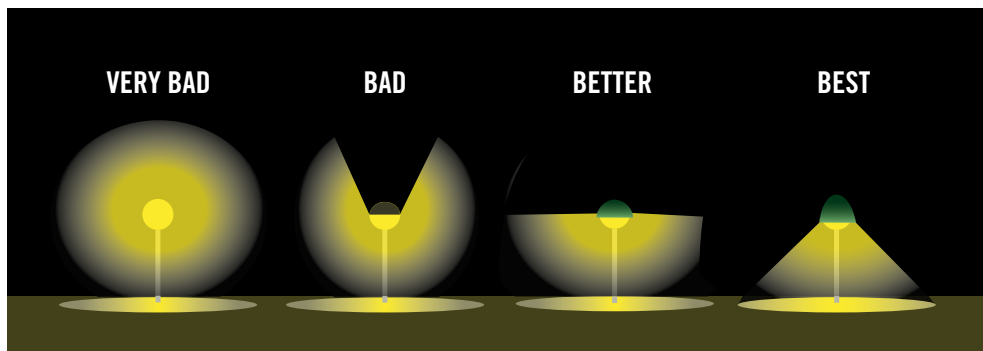


Figure 9. Examples of different types of street lighting and the effect on light pollution.

Illustration: Lotta Tomasson/VA CC BY-NC 2.0 (<https://creativecommons.org/licenses/by-nc/2.0/>)

Crucially, we still know relatively little about the effects of light on us and our environment. For this reason, the best thing we can do is to limit light as much as possible until we know more. This is sometimes called the principle of due diligence, to behave, plan and act in a way that mitigates risk.

Light pollution, humans, and space

Light pollution strongly influences our ability to study the universe in more detail. Astronomers all over the world are dependent on dark skies. There are many older observatories⁷ in cities that can no longer be used as the sky has become too bright. New telescopes are now being built in places where light pollution is minimal. However, these types of places are growing fewer as cities, towns, and villages expand and are modernised with more lighting. New technology doesn't always help either. The transition to LED lighting may seem like a good idea as it doesn't require as much energy as older light sources to produce bright light. For astronomers, however, this has negative consequences. Today's LED lights generate almost every colour. This makes the study of stars and astronomical bodies very difficult when starlight and light pollution are mixed with each other.

⁷ A facility where scientific observations of space are made, often by studying the night sky through telescopes.

In the past, street lighting was mostly sodium lamps, which produce almost only yellow light (see Figure 10)⁸. This meant that astronomers could put filters on their telescope that blocked the yellow light. Today, with LED lights generating all colours, we can no longer use this technique, which makes it difficult or impossible to make accurate observations of objects in the night sky. It also means that LED lights create more than 3-8 times as much light pollution than sodium lamps⁹.

Different kind of lamps have different light spectrum

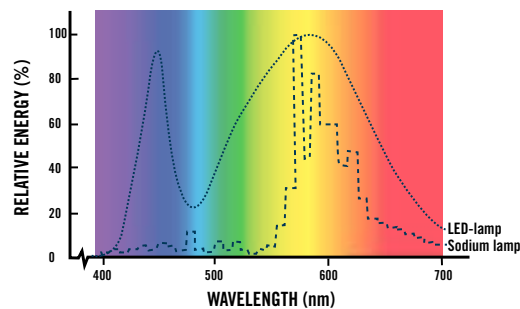


Figure 10. The graph shows the emission spectra of two different light sources. *Illustration: Lotta Tomasson/VA CC BY-NC 2.0* (<https://creativecommons.org/licenses/by-nc/2.0/>)

So how does the light from the lamps spread into the atmosphere and light it up? There is not just one, but several different mechanisms that contribute to this. Firstly, Airglow, where the air at high altitudes glows slightly green as a consequence of chemical reactions between oxygen and nitrogen, which become ionised. When these atoms recombine¹⁰ and react with each other, light is given off – airglow! You see it sometimes on images taken using a slow shutter speed or on images taken by astronauts, for example, on the International Space Station – ISS (see Figure 11).



Figure 11. This image clearly shows the phenomenon of Airglow as the green area above the curve of the Earth. *Photo: NASA [Public domain], Wikimedia Commons*

Light can also bounce off air molecules and particles. This is a completely natural process (visible when it is foggy) but the effect is amplified with increased amounts of pollutants (soot, exhaust fumes from cars etc). The colour of light and the size of the particles are important. Due to an increasing amount of particles in the atmosphere, along with more light in all colours being emitted through LEDs, the whole sky is much brighter today than it was in the past. There are various studies that provide evidence that the sky has become brighter. These show that between 1976 and 1988 the brightness of the sky was what astronomers call magnitude 0.5¹¹, which means that in 1988 you saw much less light-faint stars in

8 Pawson, S. M. & Bader, M. K.-F. (2014). LED lighting increases the ecological impact of light pollution irrespective of colour temperature. *Ecological Applications* 24, 1561-1568.

9 See: Luginbuhl, C. B. et al. (2014). The impact of light source spectral power distribution on sky glow. *Journal of Quantitative Spectroscopy & Radiative Transfer* 139, 21-26.

10 Recombining means that the atom captures one or more electrons and becomes neutral, or "whole" again.

11 Magnitude is a measure of the brightness of a star or other astronomical object.

the sky than some 10 years earlier¹². Recent studies show that this trend is continuing and has also become more serious¹³.

The sky becoming brighter has direct consequences not only for astronomers who want to study the sky but also for ordinary people. If we can't see the stars anymore, how does this affect the view of our place in the universe? Many people on Earth spend all of their lives in cities that are so light polluted, they never see the starry sky! Throughout the ages, humans have been dependent on the stars to keep track of time, the seasons, for sowing, harvesting, hunting etc. If we can no longer see the stars, there is the risk that this knowledge will slowly disappear.

Why is it important to study the universe? Humans are curious by nature and this attribute has brought us to where we are today. In our quest for understanding, we have developed instruments and knowledge that have taken us into space and resulted in technology that makes our lives easier. A good example of this are the satellites in the Global Positioning System (GPS) which are connected to most mobile phones. In addition, many people have existential issues that concern the universe. Are we alone or is there life on other planets? Space exploration has given, and will continue to give us answers to many questions, as well as raising new questions along the way. We are constantly developing new technology to help us learn more.



Figure 12. The constellation Orion, pictured on the left from dark skies, and on the right from an urban area with 500,000 inhabitants. Photo: Jeremy Stanley [CC BY 2.0 (<https://creativecommons.org/licenses/by/2.0>)], Wikimedia Commons

¹² Lockwood et al. 1990; Upgren 1991

¹³ Cinzano, P. & Falchi, F. (2014). Quantifying light pollution. *Journal of Quantitative Spectroscopy and Radiative Transfer* 139, 13-20.

HOW TO DO IT!

Materials

The method is based on estimating the number of stars that you can see from where you are positioned. The materials that you will need are:

- A simple **cardboard tube**, such as a kitchen or toilet paper roll. It is important that you know the **length** (L) and **diameter** (D) of the tube, see Figure 13.
- A **compass**, either on a mobile app or a classic analogue compass.
- An **Internet connection** and a **computer** or the **Star-Spotting Experiment app**, which is available for both mobile and tablet.
- **Protractor, string** and a **weight** (e.g. a nut).
- **Information** about what time the sun sets where you are. There are apps and websites which provide this information (eg the **Sunrise Sunset Lite app**).

Do your observations at least an hour after sunset, preferably later in the evening.

Implementation

Before the observation

- Measure the diameter and length of the tube (in mm) very carefully!, See Figure 13. This should be entered when you report your results.
- Make a protractor using the template on the following pages and attach it to the tube, see Figure 14.
- Learn to use the compass to find the cardinal directions (Figure 19). You can also print the compass rose (on page 21) and put it on the ground to work out the different directions.
- If you want to use the app, download the Star-Spotting Experiment app to see how it works.
- If you do not use the Star-Spotting Experiment app, you need to find out the exact position or address of the place where you are making your observations. For example, you can use the map function on your mobile phone – if you mark your location and scroll down the screen then will see the address and GPS-position (this is done automatically if you use the Star-Spotting Experiment app).
- Read all of the instructions and test it out in the daylight before you go out in the evening.

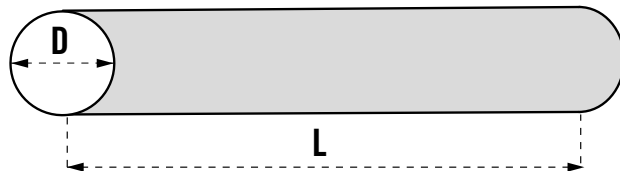


Figure 13. Measure the diameter and length of the tube with precision.

Construct the tube

1. Glue the paper protractor (see the template on the following pages) on a flat piece of cardboard and cut it out.
2. Attach the edge of the protractor to the far end of your paper tube with tape. Along the edge, not on the paper tube.
3. Next, pull a string through the hole you made in the black dot on the protractor template and attach a small weight to it such as a nut.

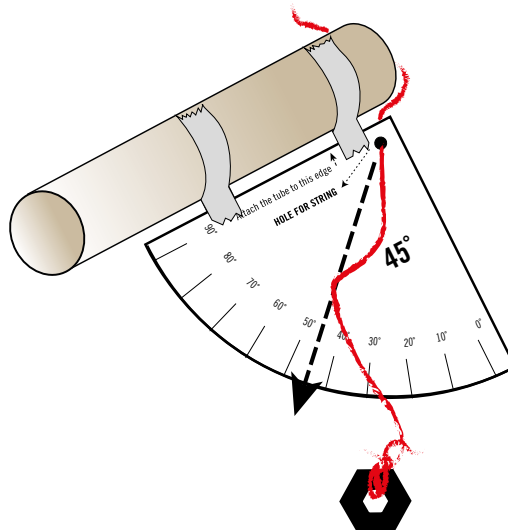
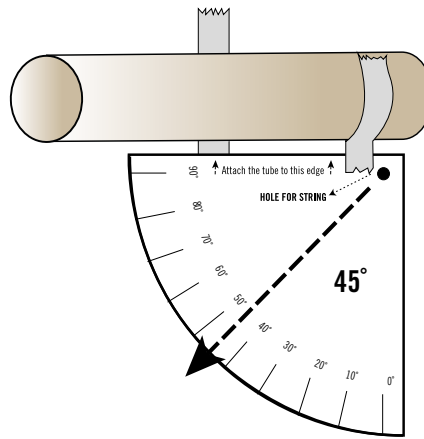
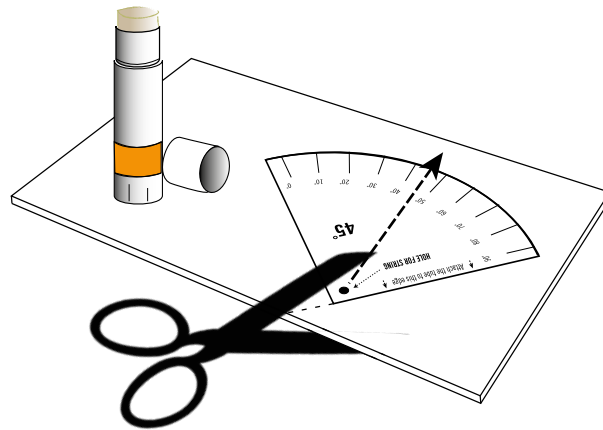
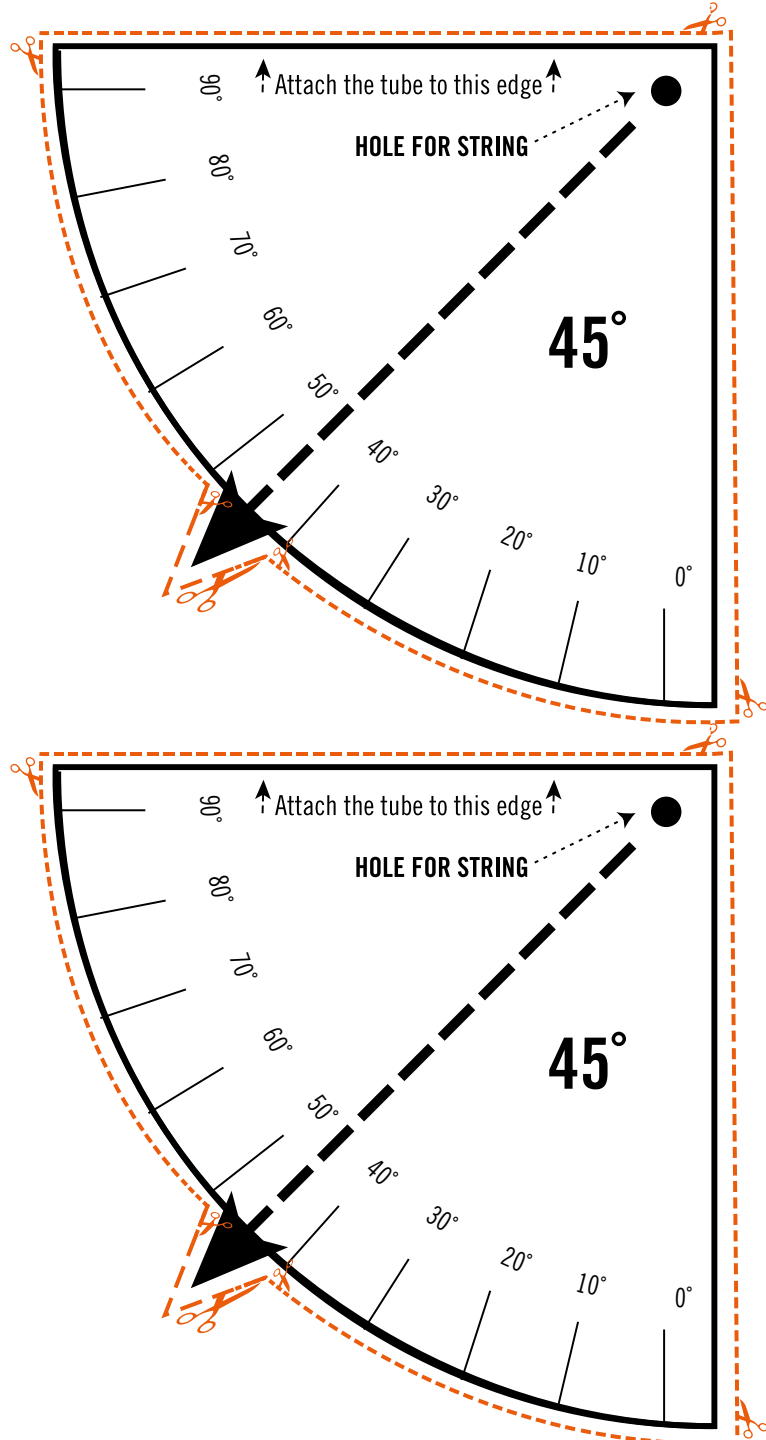


Figure 14. Attaching the protractor to the tube.

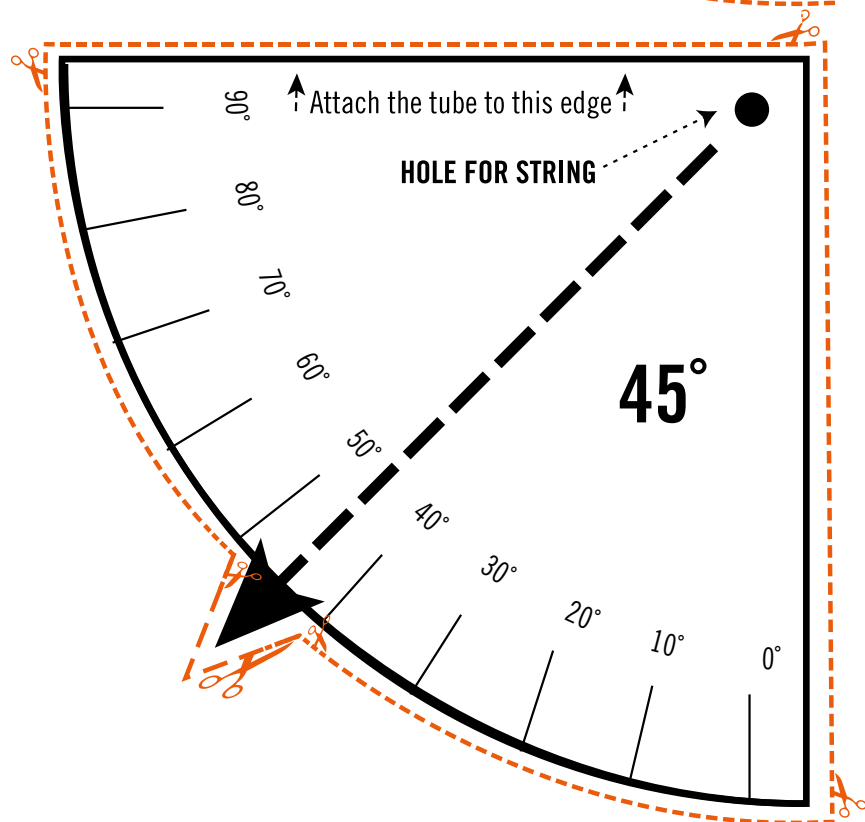
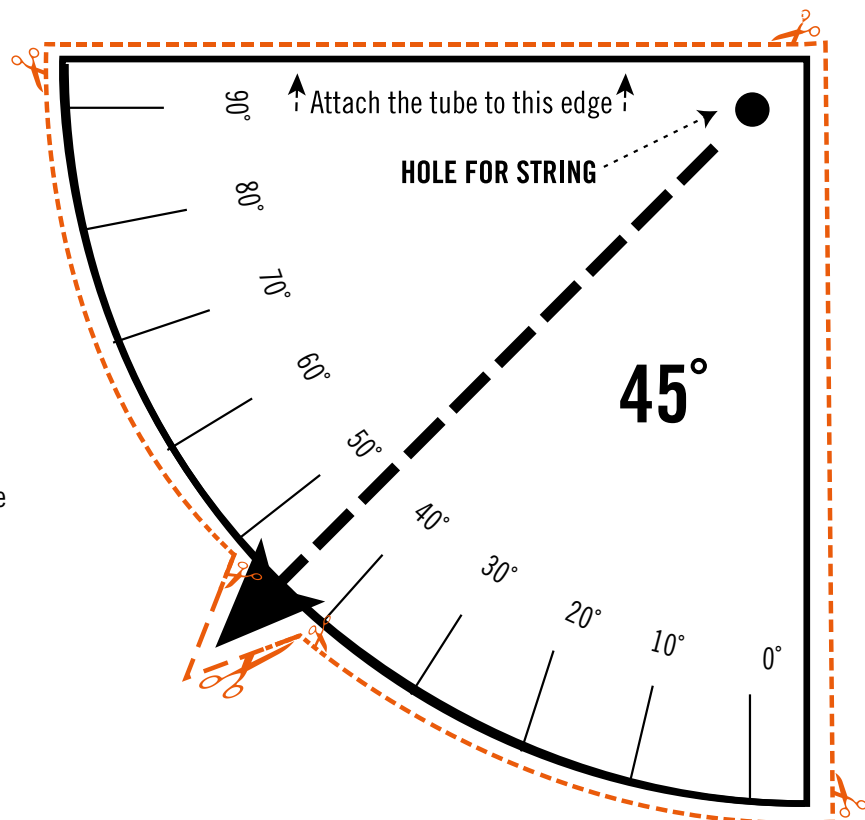
Template for protractor

Depending on the size of the tube, the protractor template is available in two sizes.

Protractor – small

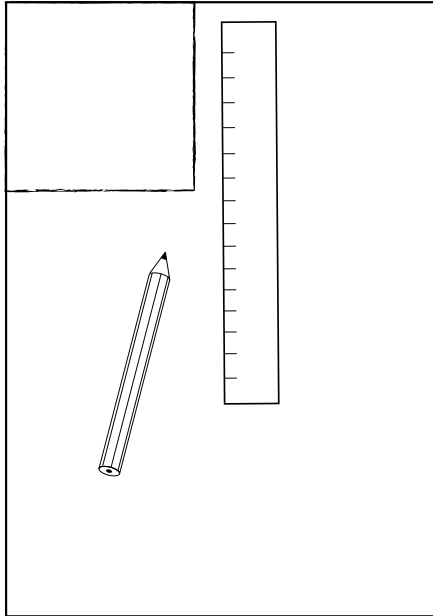


Protractor – large

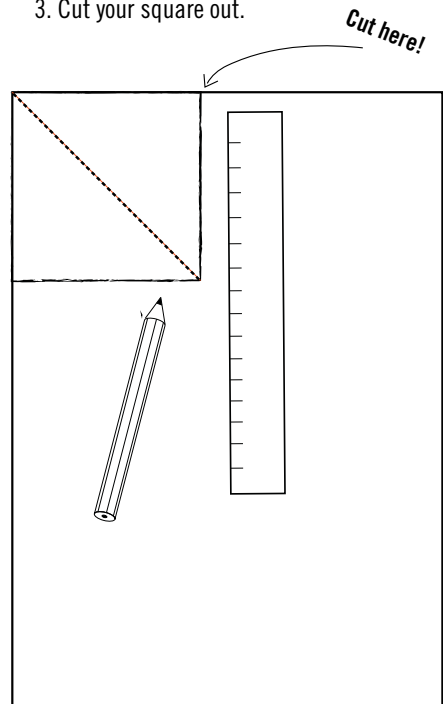


How to make a protractor without a printer

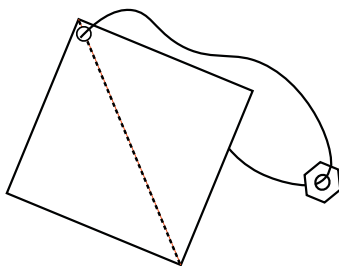
1. Draw a square. All sides should be the same length and each corner should have an angle of 90 degrees.



2. Draw a diagonal line.
3. Cut your square out.



4. Attach the thread by one of the corners that meets the diagonal line.



5. Attach the square on your cardboard tube.
You are looking in a 45 degree angle when the thread hangs straight along the diagonal line.

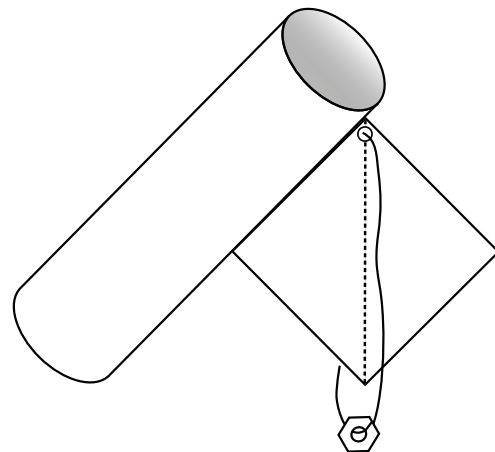


Figure 15. You can draw your own protractor if you don't have access to a printer.

Outside

Start your observations at least **one hour after sunset** when it is dark enough, preferably later.

- Go out and wait for **at least 10 minutes** to allow your eyes to get used to the darkness by looking at the sky, not another light source.
- Take the tube and point it towards the sky at a 45° incline straight towards North (N).
- Use a compass to find the right direction, see **Figure 16**.
- Use the protractor to get the right angle, see **Figure 15**. Try to be as accurate as possible.
- Hold the tube still to your eye and count the number of stars you can see through the tube. Record the number in **Table 1** or directly in the app.

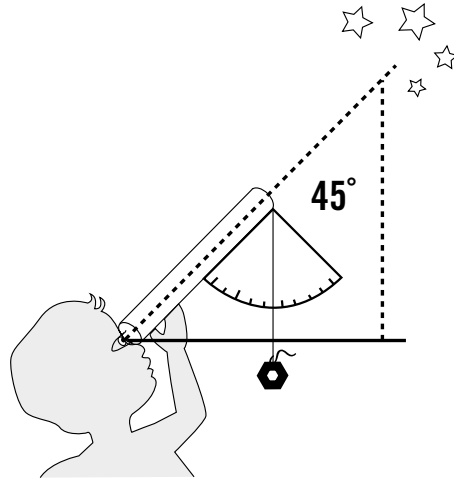


Figure 16. How to use the protractor and tube. Note that the string should hang down at a 45 degree angle. Illustration: Lotta Tomasson/VA CC BY-NC 2.0 (<https://creativecommons.org/licenses/by-nc/2.0/>)

Please double check your position mark so that your observation site is recorded at the correct spot on the map.

- Turn to the Northeast (NE) and repeat the observation.
- Continue with observations towards East (E) Southeast (SE), South (S), Southwest (SW), West (W) and Northwest (NW).
- Finish by pointing the tube **straight up in the air** (at the zenith) and count the number of stars there as well. (The string with the weight will hang at 90° , i.e. straight down)
- In total, this gives nine values for the number of stars that you can see from your location.
- If you can't see the sky in one of the directions (e.g. if a house, wall, or a tree is in the way) simply **leave the box empty**. Make a note of why a direction has not been recorded in the comment field of your observation.
- Write **zero (0)** if you can see the sky but do not observe any stars. Zero is **a result – not a failure!**
- Fill in information about the weather, the moon phase, the tube diameter, and length, as well as the date and time of the observation directly in the app or in table 2.

Reporting

You can report data directly in the Star-Spotting Experiment app or record in on paper using the table provided. See table 1 and 2 below to report data at a later stage via the Star-Spotting Experiment reporting webpage. For further details, see the “practical instructions” handbook.

When you report your data, you get an immediate calculation of the light pollution at your location, and the number of stars you can see overall in the sky in that particular place. This information is also available when you go into your observation afterwards. You can also go in and see the results of other people’s observations on the map.

Figure 18. The view of the Star-Spotting Experiment reporting webpage at spotteron.com/stjarnforsoket where you can edit your spot and put in time and date manually afterwards.

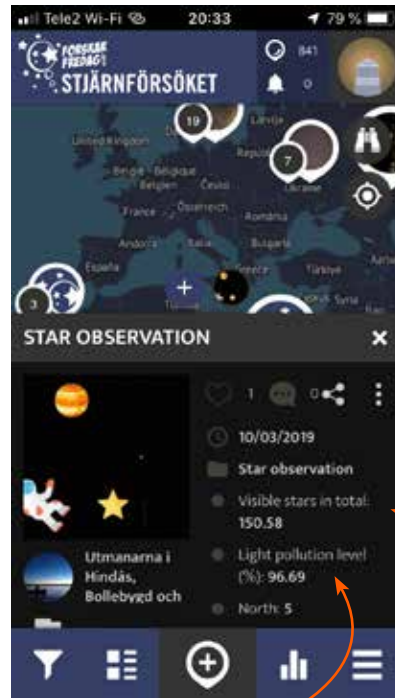


Figure 17. The light pollution level where you are, is calculated directly, where 0% means that there are no light contaminants at all, and 100% means that it is so light-purified in that place that it is impossible to see any stars at all.

You also get a calculation of the number of stars you can see in total over the entire sky in that particular location.

Input / change of date and time

In the web reporting you must enter the time and date of the observation (*this is done automatically in the mobile application*).

On the web you can also edit the time and date afterwards for an observation you made in the app (*eg if you have entered the observation a different time than when you did the measurement*).

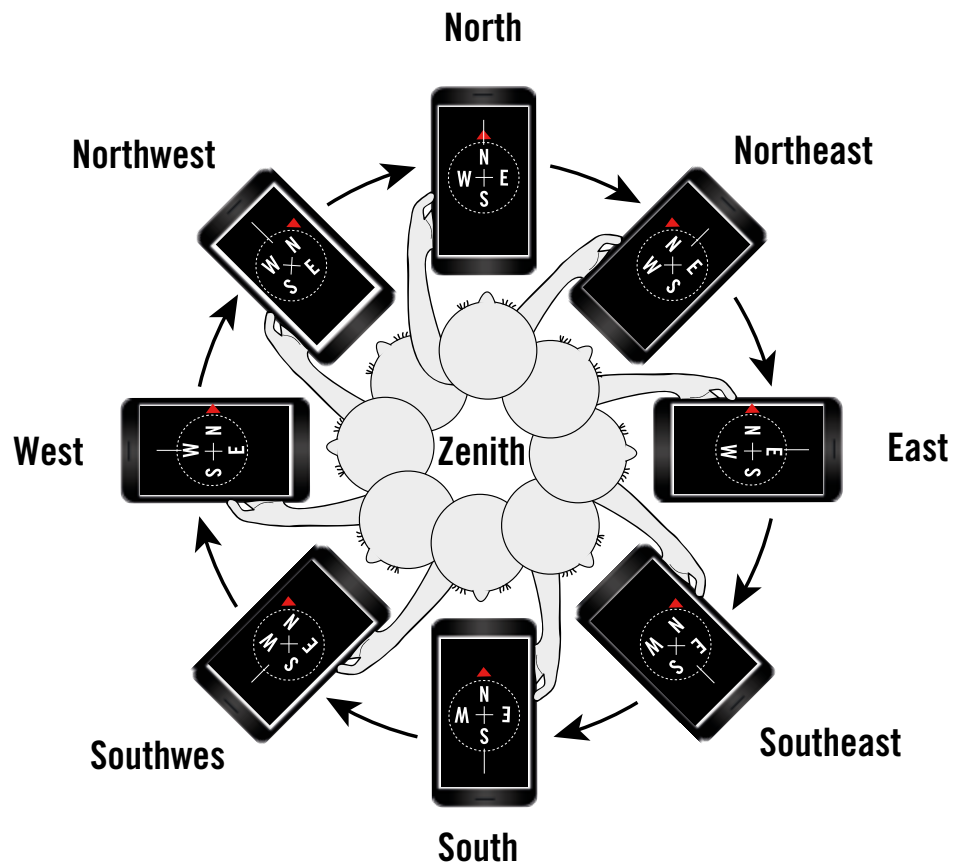


Figure 19. How to use a compass in the Star-Spotting Experiment. Turn eight times and then straight up into the zenith. *Illustration: Lotta Tomasson/VA CC BY-NC 2.0 (<https://creativecommons.org/licenses/by-nc/2.0/>)*

Table 1.

Direction	Number of stars
North (N)	
Northeast (NE)	
East (E)	
Southeast (SE)	
South (S)	
Southwest (SW)	
West (W)	
Northwest (NW)	
Zenith – Straight up	

Table 2.

Tell us what the sky looks like, (put a cross in the box)

Yes, the sky is cloudy	No, the sky is clear.
------------------------	-----------------------

If you can, try to estimate how much of the sky is covered with clouds:









(put a cross in the box)

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Can you see the moon? (put a cross in the box).

Yes	No
-----	----

If yes, what does the moon look like?(put a cross in the box)

							
NEW MOON	1/4	HALF MOON	3/4	FULL MOON	1/4	HALF MOON	1/4

Tell us about the tube you are using for your measurements. (What dimensions does the tube have?)

Diameter (D) of your tube in millimeters (mm):	
Length (L) of your tube in millimeters (mm):	

Date and time:

--

Things to think about

It is best to do the observations during new moon. If you do this experiment in a group, everyone in the group can individually make and report their own observations. You are encouraged to help one another, especially with angling the tube as this is difficult to do on your own. Everyone can use the same account and login.

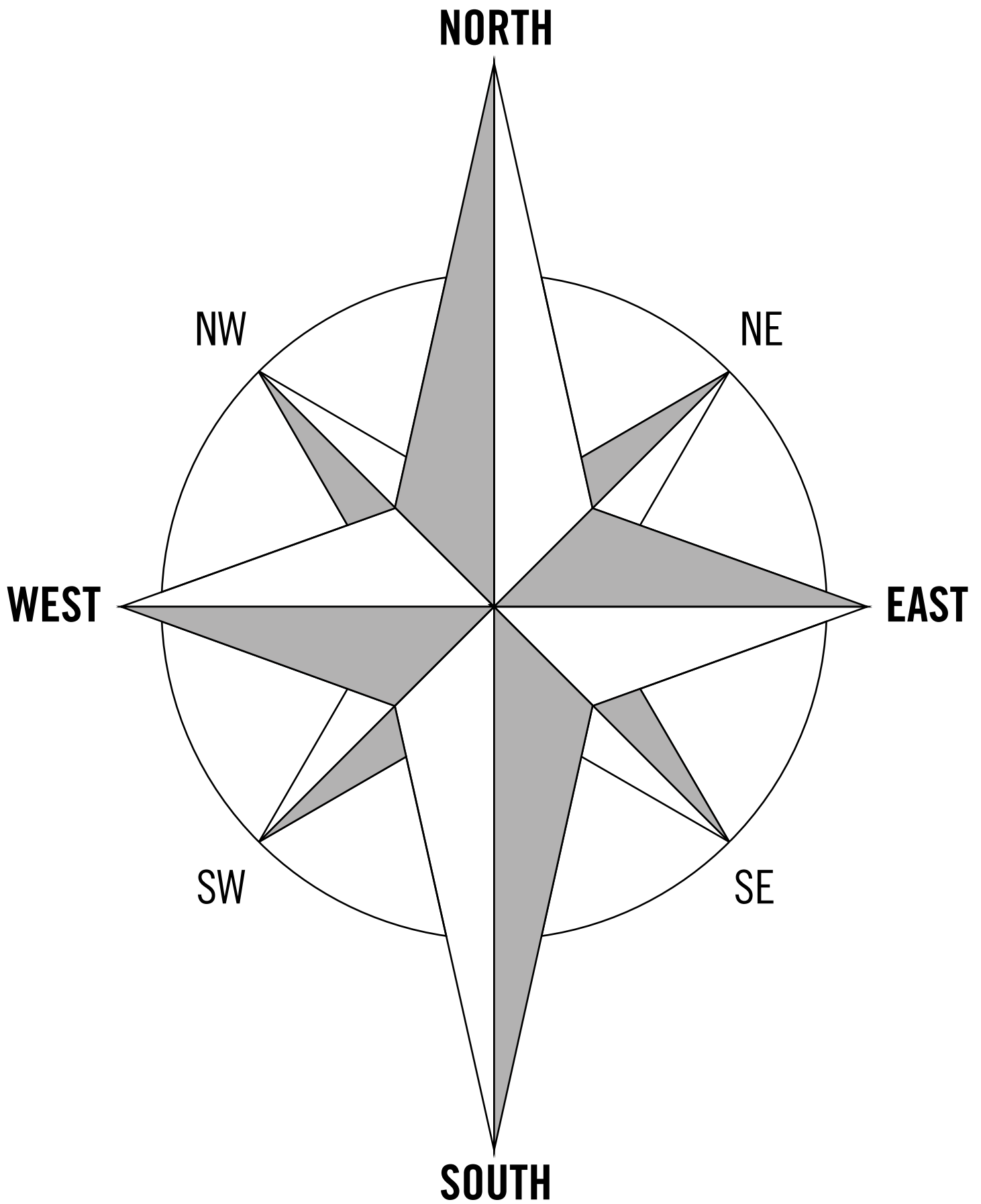


Figure 20. You can print this compass rose if you want and put on the ground to help you find the right position for the observations.



DOWNLOAD THE APP

Search for and find the app in the GooglePlay store or the Apple App store. Alternatively you can also enter your observations on the project's website.

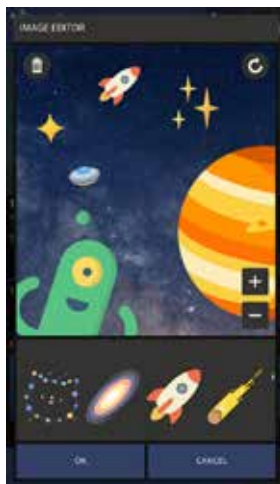
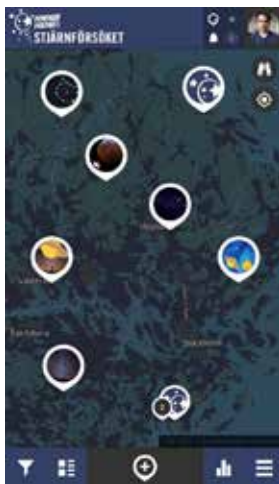


REGISTER AN ACCOUNT + LOGIN



When first opening the app, register a SPOTTERON account with your eMail address, your username with ≥ 6 letters and a password with ≥ 8 letters. You can start right away and put observations on the map. If you logged out or were inactive for a long time, you can always log back in with your eMail address and the chosen password.

OVERVIEW IN THE APP

The app starts at your location and you can see spots and stacks that were already put on the map. In the upper right corner you can see the current number of observations made, new notifications and your user profile. On the bottom you can find the filter function, the newest entries, statistics and the menu.



ADD NEW SPOT


To add a new spot, you simply click on the icon with the plus. You can use the  symbol, to jump to your current location if your GPS is turned on. You can also use the  address search or move the map to your location manually. The positional mark shows you where on the map your spot will be placed. If the positional mark is at the right location, fill in all fields of the questionnaire from top to bottom.

> ADD A PICTURE TO THE OBSERVATION



Take a nice picture to make your observation visible to other users. You can also use a picture from your gallery to add to your observation.

> SAVE OBSERVATION

After you clicked on „Save“ the spot will be added to the map. With the  symbol on the bottom right, you can also add your observation to the waiting spots and upload it later in case you don't have an internet connection when making the observation. After the upload is completed, you will get a message saying that it was successfully added to the map and you will see all information in an overview.

In case you upload from the waiting spots, it will always be added with the date you entered the observation, not the date you actually got to upload it. If necessary you can change the date later on the website.



EDIT SPOT

If you made a mistake when first adding or updating your spot, you can edit your observation with the pen symbol later.



DELETE SPOT

In case you want to delete an observation, click on the icon with three points above each other and choose „delete spot“. If it's a spot with updates, it will only delete the chosen entry.

YOUR OBSERVATION

When you report your data, direct feedback is obtained in the form of a calculation of the number of stars you can see in total over the entire sky in that particular location.

Even how large the light pollution is where you are, is calculated, where 0% means that there are no light contaminants at all, and 100% means that it is so light-purified in that place that it is impossible to see any stars at all.



FILTER

Here you can filter the featured spots by the time frame in which they were entered and/or category. On the map, you can only see the desired spots now. Don't forget to set back the filter, to be able to see all spots again.

NEW SPOTS

By clicking on the new spots icon, you can see the most recently added spots.

RANKING

The ranking shows you the ten users who added the most observations.

MENU

In the side bar menu you can find (among other things) further information on the project, the „waiting spots“ you didn't upload yet as drafts, notifications, your profile, personal settings (for example language and map background), the intro-manual, the search function to find other users and a button to log out.

PROFILE & OTHER USERS

By clicking on your own profile in the upper right corner, you can get to your own user profile. There you will find a timeline of activities of other users you follow and an overview of the spots you added and also your own profile. You can edit your profile by clicking on the pen symbol. On the very right you can also find lists of the users you follow and who follow you.

>> LIKING SPOTS & COMMENTS

If you really like another user's observation, you can show that by clicking on the heart to like it.

>> COMMENTING SPOTS

You can comment on others user's spots. This way you can ask questions or for help if needed.

>> SHARE SPOTS

By clicking on the share symbol, you can share your spots via Facebook, Twitter and Google+. If you copy the link, you can also share it via your medium of choice, for example via eMail.

>> FOLLOW / UNFOLLOW USERS

If you don't want to miss new entries by certain users, you can follow them. All you need to do is click on one of the user's entries and „follow“. In the menu you can also search for users by name.

FIRST AID, IF SOMETHING DOESN'T WORK!


>> ERROR MESSAGE: NOT LOGGED IN



If an error message like „you are not logged in“ comes up while saving your spot, save your observation as draft first. You can find it again in the „waiting spots“ and load it up after you logged in again.

>> NO DATA CONNECTION WHEN OBSERVING

You can still make an observation and save it as draft for later. You can find it in the sidebar in „waiting spots“ and load it up whenever you have an internet connection again. It is definitely good and important to collect the observation when you make it. In this case it will save the actual date you made the observation and not the date of the upload.

>> GPS-LOCATION DOESN'T WORK

If the reticle doesn't jump to your current location, you can also use the address search  to find it or move the map to your current location manually.

If you want to be located automatically, you can turn on GPS  (if it wasn't turned on already) and open the app again, wait a few seconds and click on the  symbol (see „add new Spot spot“).

LINKS TO THE SCHOOL CURRICULUM

Different for each participating country

MORE INFORMATION

Scientific Literature

Chepesiuk, R. (2009). Missing the Dark: Health Effects of Light Pollution. *Environmental Health Perspectives*, 117, A20-A27.

Gaston, K. J. et al. (2013). The ecological impacts of nighttime light pollution: a mechanistic appraisal. *Biological reviews*, 88, 912-927.

Kyba, C. C. M. et al. (2017). Artificially lit surface of Earth at night increasing in radiance and extent. *Science Advances* 3, 1-8.

Longcore, T., & Rich, C. (2004). Ecological light pollution. *Frontiers in Ecology and the Environment* 2, 191-198.

Popular Science Literature and Reports

Calluna (2011). Vägbelysningens påverkan på djur och växter samt rekommendationer för val av ljus.

Eklöf, J. & Rydell, J. (2018). Det dödliga ljuset. *Forskning & Framsteg* 8, 26-33.

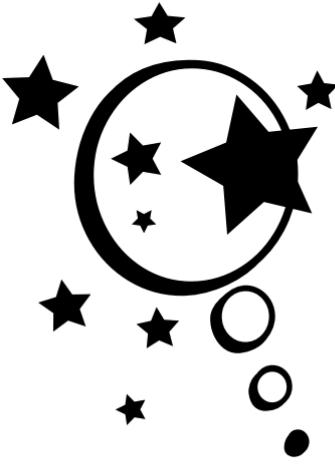
Other web resources about light pollution

www.darksky.org

www.globeatnight.org

www.darkskiesawareness.org

www.lightpollutionmap.info



**THE STAR
SPOTTING
EXPERIMENT 2019**

GOOD LUCK!



FORSKARFREDAG
— En del av European Researchers' Night —

Many thanks for your participation!

www.forskarfredag.se/star-spotting