Light Pollution Project and Lab-Activities

Activity III: Estimating "Sky Brightness" at location of interest using Satellite data

In this exercise, we are going to learn about ways to visualize and quantify light pollution by using data from the VIIRS satellite. The data from this satellite are accessible in a visual form on the https://www.lightpollutionmap.info/ website. One can go to any location on Earth and determine the sky brightness levels as measured by the VIIRS satellite[1].

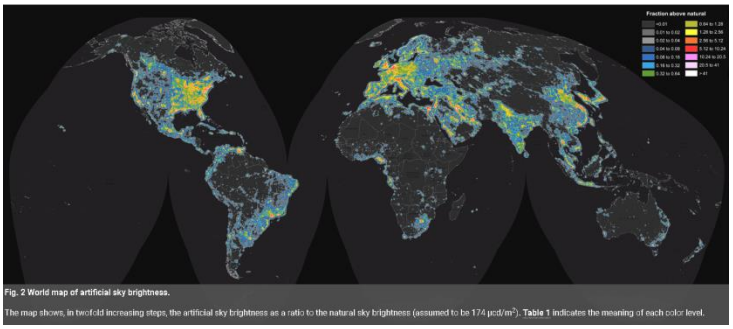


Fig. 2 World map of artificial sky brightness.

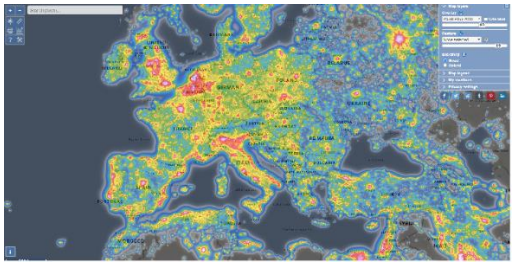
The map shows, in twofold increasing steps, the artificial sky brightness as a ratio to the natural sky brightness (assumed to be 174 μcd/m²). Table 1 indicates the meaning of each color level.

Materials:

a) Access to the internet and a desktop computer or tablet (hard to do on a smartphone)
b) Google-sheets or Excel (optional)

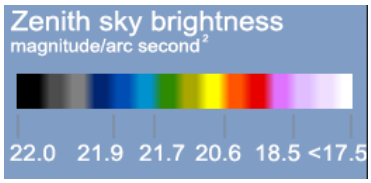
Procedure

1. Log in to the computer, then open a browser (Chrome, preferably) and click on (or copy-paste)https://www.lightpollutionmap.info/ in the address bar.

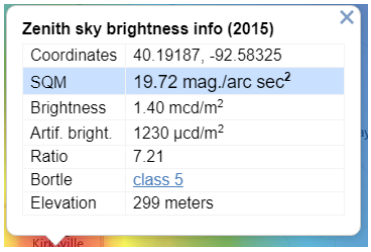


[1] https://advances.sciencemag.org/content/2/6/e1600377

2. Wait for a few seconds, and then enter in "Kirksville" in the 'search places' area on the top left of the webpage[2].
    a. The website should prompt you "Kirksville, Mo, US" at this point. If it does not, wait for a few seconds, and re-enter "Kirksville" and it should prompt you again as "Kirksville, Mo, US". Click on it and the map should zoom into Kirksville.
3. The map shows the light pollution contours, as measured by the VIIRS satellite. The data displayed by default are from light pollution world atlas of 2015, but you can change this (see top right of webpage) to other years if you wish. For our exercise, we will stick to the 2015 data.
4. There are other options on the top right panel on the webpage. For example, the "Map legend" option explains the color coding on the map in terms of "Zenith Sky Brightness".



5. On the top left of the webpage are tools one can use to "measure" sky brightness levels at any location. You can do this by clicking at any point on the map. For example, clicking on a point somewhere results in a "bubble" opening up with data on it:



6. The information in the window corresponds to the estimated sky brightness (in units of "mag/arcsec²") at the pointed location (latitude and longitude), and the corresponding Bortle scale.
7. You can click the cross at the top-right of the information window to close it.
8. Use the mouse-wheel to zoom in/out as needed. Let us zoom in in order to be able to identify individual buildings on the Truman State campus: Magruder hall, the SUB, Violette Hall, etc.

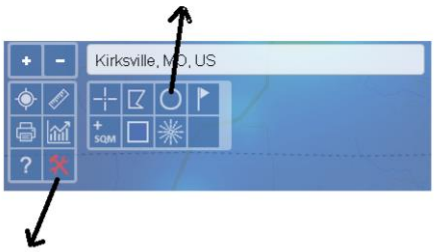
Part I: Sampling individual points

9. Click on a few places (about 8 separate locations in all) on the Truman Campus and note down your readings (Location, SQM reading and Bortle class) in the observation table provided below.
10. Repeat the same procedure for Thousand Hills State park, and for the other locations in the table. Feel free to repeat these measurements for a location of your choice (your hometown or a nearby park).

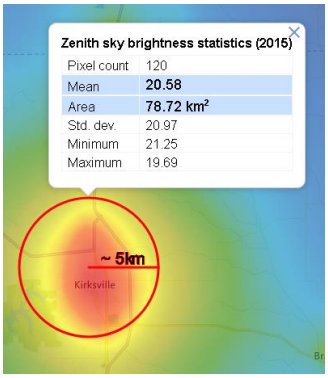
Part II: Averaging over an area

11. There is another way in which we can calculate the sky brightness in a given region: by averaging the readings over a certain area.
12. Click on the 'tools' button on the top left of the webpage (see figure)

[2] *We are using Kirksville, Mo as an illustrative example. You can enter any city or town, anywhere in the world or simply use the mouse to click, drag, and Zoom to any location of interest.*



13. Then click on the circle and move your mouse to the center of Kirksville.
14. Click and release the mouse. Now if you move your mouse away from Kirksville, you will notice a circle with text reading the distance from Kirksville. Move your mouse so that you form a circle of radius 5 km around Kirksville and click the mouse.



15. A box opens up with the mean sky brightness values for the area covered by the circle. Note the mean, minimum and maximum values in the table below.
16. Now move the mouse back to the (approximate) starting point at the center of Kirksville, and draw a circle of 10 km, again noting down the mean, min and max values of sky brightness.
17. Repeat this process for successively large radii around Kirksville.

Observations

Part I: Sampling Individual Points

Location	Measurement 1	M2	M3	M4	M5	M6	M7	M8	Average
Kirksville, Mo (Truman State)									
Thousand Hills State Park									
Eminence, Mo									
Echo Bluff State Park									

Part II: Average Measurements

City or town or park: _____

Radius of sample area	Mean sky brightness	Minimum	Maximum
5 km			
10 km			
15 km			
20 km			
30 km			
50 km			
100 km			
150 km			
200 km			
250 km			

Analysis

1) What is the average sky brightness around the Truman State campus? Compare these values with those measured at the farm and at Thousand Hills. Are these measurements consistent with your expectations? Explain.

2) What is the sky brightness in-and-around our home (or the location you chose as the 4th location for part I)? Compare these values with those in-and-around Kirksville.

3) What happens when you increase the size of the circle you are averaging the sky brightness over in Part II?

4) What is the minimum and maximum value reported in a 250-km radius around Kirksville? Can you figure out where these locations might be (approximately)?

5) [If you have time and are so inclined]: Using google-sheets or Excel ®, make a plot of the average sky brightness as a function of averaged radii. What can one conclude from the plot?

Activity V: Using the handheld SQM to measure Sky Brightness

In this exercise, we are going to learn about ways to quantify light pollution by using a handheld light meter called a "Sky Quality Meter" (SQM). This meter essentially measures the amount of light that is entering into its sensor when it is pointed in a certain direction (usually, we will point the SQM to the zenith). The sky brightness is measured in "mag/arcsec^2" – the same "magnitude" we have learnt about in class. Also, recall that 1arcsec = 1/3600th of a degree is a measure of the angle. Essentially, the sky brightness measures the amount of light (i.e. the brightness measured in magnitude) there is, in square arc-second of the sky.You will make at least 10 measurements and then record your measurements and calculate the average sky brightness. You then have the option of submitting your measurement to the "Globe at Night" program by using the "Loss of Night" smartphone app.

Materials:

1. *Unihedron*'s handheld Sky Quality Meter,
2. Red Headlamp,
3. Printer (optional),
4. Clipboard, pencil,
5. Dog.

Procedure

The handheld "Sky Quality Meter" is relatively easy to use.

1. Identify the button and make sure you are able to operate it in the dark. Practice running your fingers over the SQM so you can feel the "bump" of the button and press it to operate it in a well-lit room first.
2. Point the SQM straight up and raise your hand straight over your head. Again, practice a few times and get your mechanics worked out (are you pointing straight up? Can you find the button and click on it, and then read the display? Etc.). Remember it will be dark when you make your measurements, so you want to practice and be absolutely sure how you will take and record your measurements in the dark.
3. Decide on a spot to make your measurements during day time. Look for any holes or ditches and make a mental note of these so you can look out for these at night.
    a. Make sure that you are away from any overhanging lights and trees, and also any buildings or walls that might interfere with your measurement. Remember you are trying to measure the brightness of the sky, so your sensor should have an unobstructed view of the sky.
4. Check you have all supplies you need (headlamp, clipboard, pencil, paper, phone, SQM etc.) and go to your measurement location.
5. Practice a few times before you start your "science run". Let the SQM settle to the ambient temperature.
6. Start collecting your data. Make sure no lights are 'on' (even your red headlamp should be off). Ideally, you can have a partner with you who can record the readings on paper (if your smartphone has an audio recorder, you can simply dictate your readings into it along with time of measurement, location etc. and transcribe your data on paper or the GaN app later).
7. Log into the 'loss of night' app. Make sure your phone is connected to a wireless network (4G or 5G or home network).
8. Click on the "Submit data from SQM" and enter in your average SQM reading. If your phone is connected to wireless, the app will take a GPS fix on your location and submit your data to the GaN database.

Safety:

1. Always scout out a location during the day before venturing there at night.
2. Always be aware of your surroundings and be safe whilst doing nighttime measurements.
3. Make sure someone knows where you are at any given time. Have a protocol about periodic check-ins (text message or phone callevery 15 minutes etc., especially if you are going to a relatively new location).

Observations:

Enter in your data below. Additional tables are provided for multiple locations (for example, one set of data could be your backyard, another set could be from the local park, or an open space.

Date:
Time:
Location:
Conditions:
Limiting magnitude (from GaN chart/data):
Table I: SQM Readings

Observer	Trial I	Trial II	Trial III	Trial IV	Trial V	Trial VI	Trial VII	Trial VIII	Trial IX	Trail X	Average
										Grand Average	

Date:
Time:
Location:
Conditions:
Limiting magnitude (from GaN chart/data):
Table I: SQM Readings

Observer	Trial I	Trial II	Trial III	Trial IV	Trial V	Trial VI	Trial VII	Trial VIII	Trial IX	Trail X	Average
										Grand Average	