Research on light pollution by using a sky quality meter
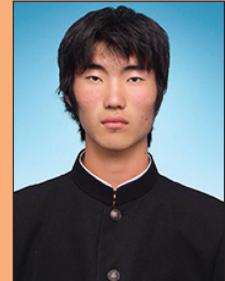
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ABSTRACT

Visible from space, the light from our cities pollutes our night skies. Sobue decided to measure the light levels at night around Japan using a Sky Quality Meter (SQM). He tried to determine the reliability of SQMs and accuracy of his results by comparing the measured light pollution levels with electricity consumption statistics and light pollution guidelines. He then calculated the altitude at which the majority of light causing light pollution is reflected: Between 2-3 km above ground level and verified that light pollution is greater near heavily populated areas.

Introduction

Light pollution is an environmental problem caused by artificial light. It brings about some problems, for example, the decrease in number of light sensitive species and bad effects to star gazing. We researched the present levels of light pollution through observation with a Sky Quality Meter (SQM) [Figure1] and prediction by using our simulation.

Experiments

Research 1

Preliminary experiment
We did preliminary experiments to check if the measurements from SQMs were reliable.
1. Comparing measurements between cooled-CCD camera and SQMs
2. Finding the variance among SQMs
3. Finding the effect of the moon and season

Research 2

Making the "Brightness map" [Figure 2]
We gave SQMs to elementary/high school students and made observations.

When: 8pm~9pm, July 30~August 13, 2010.
8pm~10pm, July 25~August 4, 2011.
Where: 2010, 19 places across Japan. 2011, 25 places across Japan.

Research 3

The simulation of the night sky's brightness
Hypothesis: We proposed that the main light which causes light pollution was at the city hall, and the brightness of places was proportional to the population.

The formula is[1]:

$$L = \frac{L_0}{D^2} e^{-D\sigma}$$
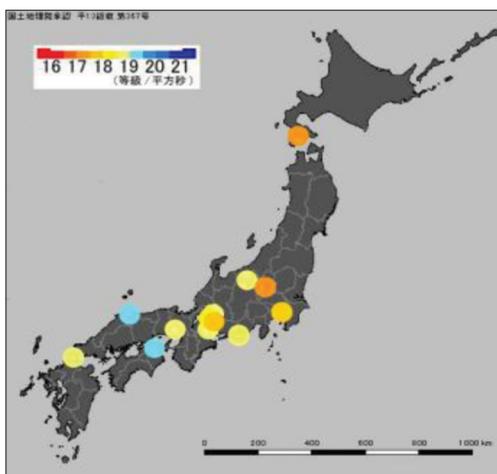
Figure 1: Sky quality meter

Figure 2: Brightness map

L: The brightness, L_0: The brightness of the light, e: The natural logarithm, D: The distance from cities, σ: The extinction coefficient (6×10^{-5}).

We used the formula above, considering the effects from the cities near the observation place and simulated the brightness from it.

Results and Discussion

Research 1
The measurements of SQM and that of cooled-CCD were proportional. So, we regarded the SQM as a reliable device. Measuring the variances among SQMs, we are able to compare the measurements from different SQMs under the same standard.

We also found that the effect of the moon can be ignored if the moon is darker than the half moon. So we carried out the observation when the moon was darker than the half moon.

Research 2
The nearer the observation place is to a large city, the brighter it gets.

Research 3
We were able to predict the night sky brightness accurately.[2,3] Also, we changed our estimate of the altitude at which the light is reflected and found out from the formula that lights are reflected at the altitude of 2~3 km.

Conclusion

From research 1, we found the reliability of SQMs and its character. With these experiments, we found the most accurate way to research light pollution. Hereafter, we would like to observe at more places in a wider area than those of research 2. In research 3, our results were close to the true value. Also, we found out the altitude of where the light reflects. Using a similar method, we would like to find out each weather factor effects the night sky and finally make our own forecasts of the starry skies.

Acknowledgments

References

1. The way to value the measures from SQMs. Ichinomiya Senior High School; 2008.
2. Guideline of Light Pollution "Ministry of the environment".
3. The data of the usage of electricity. Federation of Electricity Power Companies.

About the Author

Sobue Hideaki likes to take photographs and to read books, especially any related to History. This meant that he was very excited to see historical architecture when he came to England and visited the British Museum. He is currently studying Astronomy and Physics and hopes to major in Physics at University. He loves Science and believes in its potential, so he would like to become a Scientist to be able to use Science to protect our civilization.