

Earth' s Shadow -Following the Gloaming-

*Aoi Ishimure¹

1. Yokohama Science Frontier High School

Introduction

The Earth' s shadow is the night. The lunar eclipse is observed when the moon enters into the shadow of the earth, but the Earth' s shadow appears everyday. This edge of the shadow, a border line of day and night which is projected to the atmosphere is called especially Earth' s shadow (Fig.1.). Before and after sunset or sunrise, in the sky opposite the sun, there are a blue belt and a pink belt (Fig.2.). Blue one is called Earth' s shadow (ES), pink one is Belt of Venus (VB). The purpose of this research is verifying whether the ES is really the shadow of the earth and what made the phenomenon occur as the ES and VB. Calculation and observation were done.

Methods

First, many calculation points (cal-points) was set to cover the sky above the observer at elevation angles, azimuth, and atmospheric altitude from the ground, of a certain interval (Fig.3.). It is judged whether or not light hits each point to change the size of calculation points in graphs of each azimuth by hit condition (Fig.4.). There is an observer at bottom left of screen and observer is looking right side.

Elevation Angle w1 : 0 ~ 45 deg. / 1 deg. Pitch

Azimuth w2 : 0 ~ 180 deg. / 10 deg. Pitch

Altitudes h : 0 ~ 15 km / 0.25 km Pitch

~ 20 km / 0.5 km Pitch

~ 30 km / 1 km Pitch

Next, the observation was carried out under following the conditions.

Day 2018. 1. 14

Time 6 : 31 ~ 7 : 03 (Sunrise at 6 : 50)

Photographing interval 10 Seconds

Place Nishiterao no oka Park, Yokohama city, Kanagawa ward

135degrees 38minutes 54seconds East, 35degrees 30minutes 02seconds North

(Get from Google Earth)

Equipments Nikon D7200 + AF-S NIKKOR 80-200mm f/2.8D

Finally, these results are compared.

Mt.Fuji is 80deg. west and elevation of about 2.2 deg. from observer, so the graph of 80 deg. and the pictures of Mt.fuji are compared and the atmospheric altitude affecting the ES and VB is estimated from the elevation of ES and VB and the distributions of cal-points that hit by lights. These graphs have long depth direction so their horizontal axis were changed to logarithmic axis.

Conclusion (Fig.5.)

The sky where the Earth' s shadow is visible is not hit by the light.

The Earth' s shadow is truly a shadow of the earth.

-> The Earth' s shadow is visible by projecting the shadow of the Earth onto the atmosphere.

When VB comes to the top of Mt. Fuji, the sunlight has already become pink,so the top of the mountain is dyed in pink (06:48)(Fig.6.).

-> The light scattered and turned pink shines on the atmosphere, like sunsets, it can be seen as VB.

In graph, the calculation points in elevation of 2 deg. altitudes of about 3km (elevation of top of Mt.Fuji from observer) change its size depends on time.

-> The graph could show change of actual phenomenon.

In the sky where the VB is visible, the lowest atmospheric altitude at which the light hits is 1 - 12 km.

-> It is lower than 12 - 50 km which is said in reference literature.

Future View

For the boundary between the shadow and VB, it is clearly defined by the brightness etc. in the image. In addition, Increase the range of azimuth in calculation and observation to find the approximate shape of the shadow. And, since the refractive index of the atmosphere is not taken into consideration this time, the errors must be generated in calculation and observation. The degree of this error is verified and made smaller.

References and Softwares

Yasuo, Takeda (2017). *“Chikyu wa hontoni marui no ka?”* (Is the Earth really round?) Japan: Soushisha.

Microsoft Excel 2010

Graph-R version 2.41

Adobe Photoshop Elements 14

AstroArts Stella Navigator Ver.9.2c

Keywords: Earth' s Shadow

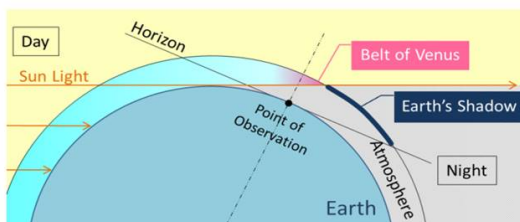


図1. 地球影の模式図

Fig.1. Schematic diagram of Earth's shadow

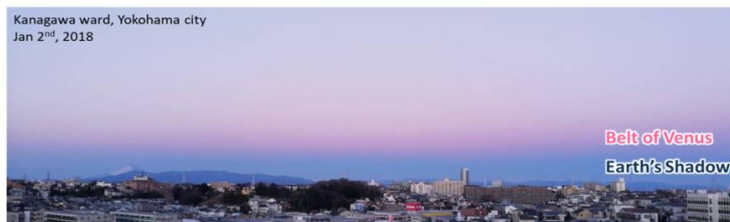


図2. 地球影とビーナスベルト

Fig.2. Earth's shadow and Belt of Venus

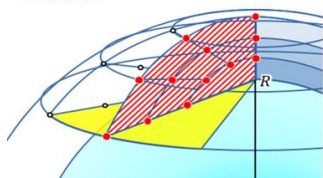


図3. 計算点の模式図

Fig.3. Schematic diagram of cal-points

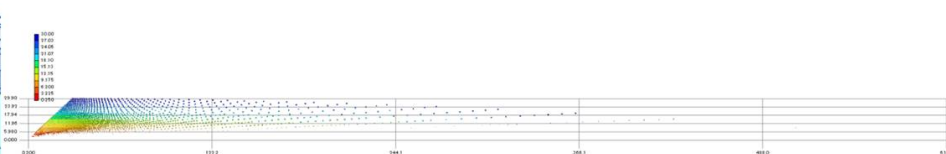


図4. 仰角80°の計算点

Fig.4. Cal-points in azimuth of 80°

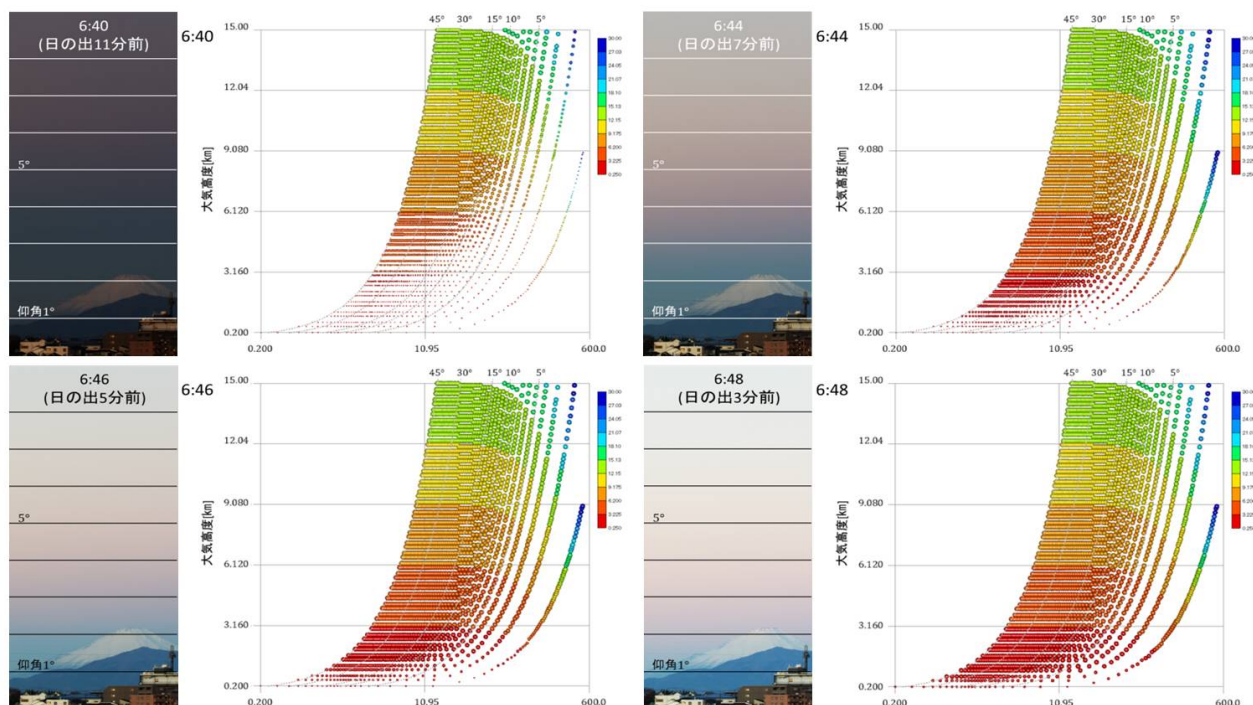


図5. 観測写真と計算結果の比較

Fig.5. Comparison of observation and calculation

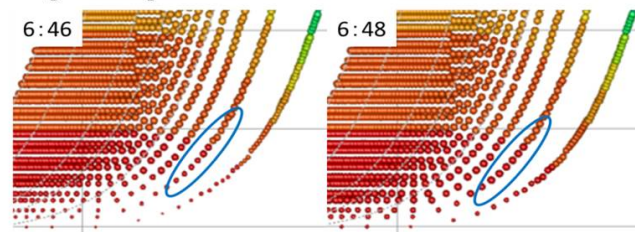


図6. 6:46と6:48での仰角2°・高度3kmの比較

Fig.6. Comparison of elevation of 2°, altitudes of 3km of 6:46 and 6:48