The Use of Astronomical Observations to Determine Changes in Aerosol Concentrations within the Atmosphere.

The results of this study are important. By comparing future results to these, changes in aerosol concentrations within the atmosphere can be easily determined. These results may also be used to determine whether or not an astronomical event near the horizon will be visible, well ahead of the event.

3-1981

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## ABSTRACT

From 1978 through 1980, I conducted an overall study of the earth's atmosphere. This research consisted of measuring the effects of the atmosphere on deep sky objects, mainly faint galaxies. I also measured the refraction of the atmosphere by viewing stars that are below the horizon, but appear above the horizon due to refraction.

I made indirect measurements of the atmosphere's effect on faint celestrial objects in 1979. These experiments included a study of the colors near the horizon and the rate of light increase during twilight. These indirect experiments have yielded the relative thickness of the earth's atmosphere at all altitudes.

In September 1980, I initiated a long term study of the lower atmosphere. By measuring changes in the sun's oval appearance near the horizon, aerosol variations can be measured. This study is still in progress at the present.

Increases or decreases in atmospheric aerosols can be determined by comparing future results to the results concluded in this report. In addition, these results may be used to determine whether or not a future event occuring near the horizon will be visible. This determination may prevent an observer from wasting time in attempting to view an event not visible due to the earth's atmosphere.

## INTRODUCTION

An aerosol is defined as a colloidal system in which a gas, frequently air, is the continuous medium, and particles of solids or liquids are dispersed in it. Aerosol thus is a common term used in connection with air pollution control (Van Nostrand, 1976).

Air pollution control is becoming an increasingly important field of science because the increasing human population is bringing with it a greater demand for manufactured goods. The manufacturing process is causing an accelerated increase in the air pollution which may lead to serious health problems in the future.

In 1979, I linked the level of air pollution to my celestrial observations. I soon found that the air pollution was restricting my observations more than I had first thought. Therefore in 1980, I initiated a long term experiment in which the variations of the aerosols could be determined. This experiment is still continuing at the present.

## MATERIALS AND METHODS

In order to plan celestrial experiments, a basic knowledge of astronomy is necessary. I was first introduced to amateur astronomy in 1977 when I obtained a Celestron 8 telescope. I essentially learned the basic facts about astronomy during the next two years and by 1979, I had observed nearly 350 celestrial objects. I also began to recognize the effect of Knoxville's pollution on my observations and at this point, I decided to make an overall study of the earth's atmosphere by using my past observations.

My first experiment (conducted in the summer of 1979) consisted of plotting each observed object on a graph with the ordinate being the objects' true magnitude and the abscissa being the objects' angle from the horizon. As expected, objects appeared fainter near the horizon, hence light was lost.

On August 3, 1979, I executed another informative experiment. I measured the gradual light increase directly overhead during twilight. The measurement was made possible by viewing the faintest stars visible at selected times and comparing their magnitudes to the telescopes limiting visual magnitude at midnight. This experiment led to an outline of the earth's atmosphere.

In September 1980, I initiated an experiment which is still continuing at the moment. Once a month on an exceptionally clear morning, I make a photograph of the sun through my telescope when the sun is only one degree above the horizon. By comparing the minor and major axis of the sun, the refraction of the atmosphere near the horizon can be easily determined. Variations of this refraction are directly proportional to the aerosol levels in the lower atmosphere.

## RESULTS

Figures 1 and 2 are presented first because they are the basis of my experiments. It may be necessary to refer to them while studying the results of my experiments. Figure 1, shows a cross section of the atmosphere during twilight. This figure is the basis of the second experiment. Refraction of the atmosphere is the basis of my third experiment and two important facts are given in Figure 2.

The first experiment yielded the graphs in Figures 4 and 5. These graphs show that the nearer an object is to the horizon, the more light that is absorbed. The atmosphere does thicken when nearer to the horizon as shown in Figure 3 (see appendix for formula), especially the lower parts of the atmosphere. By comparing Figure 5 (measured curve) to Figure 3 (theoretical curves), it is apparent that the aerosols are mostly below one mile in altitude. A different interpretation is shown in Figures 7 and 8. These figures show a comparison of the pollution of Cedar Bluff and Knoxville to my home. However, the first interpretation tends to be more correct.

A general plot of the atmosphere was achieved by my second experiment. By measuring the magnitude of the faintest stars seen at different times during twilight, proportional background light increases were plotted (Figure 9). These results were replotted using "sunlight altitudes" instead of time as the abscissa (Figure 10). In Figure 11, the ordinate was changed from a proportional background light increase to the amount of light increase per mile. A more correct curve was made by studying the shattering effect of the atmosphere (Figure 1) and is also plotted in Figure 11.

In September 1980, a third experiment was started. This experiment has not yielded any significant results yet but variations of the atmosphere's refraction have been measured. This experiment will continue until some significant results are made.

## DISCUSSION AND CONCLUSION

The conclusion of the first experiment (Figure 6) shows that the aerosols effecting my observations are mostly below one mile in altitude. However, refraction has not been considered. Since the refraction (Figure 2) is only 35 minutes of arc, the measured curve will shift only slightly. The curve is still too low to be caused only from aerosols. In fact, it was found that the light from Knoxville was effecting my observations greatly. For example, it was found that the light coming from Knoxville causes an object seven degrees above the horizon to be twenty times fainter than the aerosols themself caused.

The first experiment has been concluded with two facts. First, most of the aerosols effecting my observations are less than one mile in altitude. Second, all objects seen within 30 degrees of the horizon are much fainted due to the light coming from Knoxville.

The second experiment did little to study the aerosols effects on my observations. What it did conclude is that the upper limit of the atmosphere is between 80 and 100 miles in altitude. This altitude limit causes twilight to begin any time the sun is twelve degrees below the horizon.

The last experiment has not yielded significant results yet but should very soon. This experiment is capable of measuring changes in aerosol levels without having any correction factors. More important, light coming from Knoxville cannot effect this experiment since it only measures refraction and not the light intensity.

## SUMMARY

An aerosol is defined as a colloidal system in which a gas, frequently air, is the continuous medium, and particles of solids or liquids are dispersed in it. Aerosol thus is a common term used in connection with air pollution control (Van Nostrand, 1976).

By using two years of observations made with my Celestron 8 telescope, a study of the atmosphere was made. These observations led to the conclusion that the atmosphere is severely interfering with my astronomical observations.

The next step in studying the atmosphere is to determine how fast these aerosol levels are increasing or decreasing. This last step may take years to lead to any significant results, and an experiment to make these measurements is being made at the present.

LITERATURE CITED

Nostrand, Van, 1976, "Aerosol," Van Nostrand's Scientific Encyclopedia, Fifth Edition, page 51.

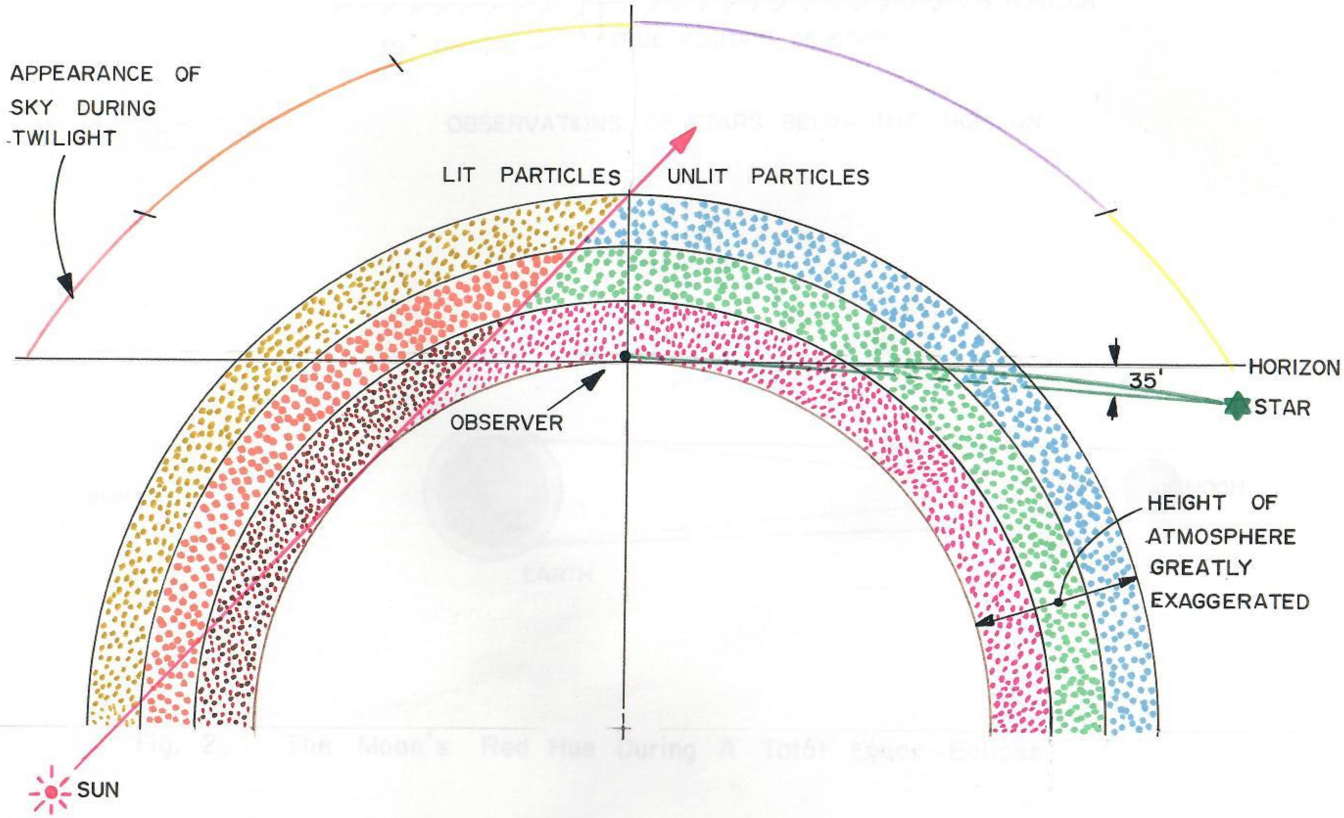
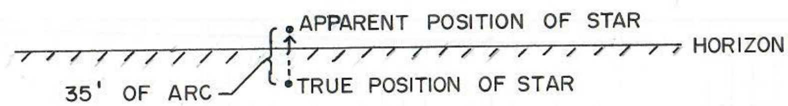



FIG. I. A Cross Section Of The Atmosphere During Twilight




OBSERVATIONS OF STARS BELOW THE HORIZON


Fig. 2. The Moon's Red Hue During A Total Lunar Eclipse

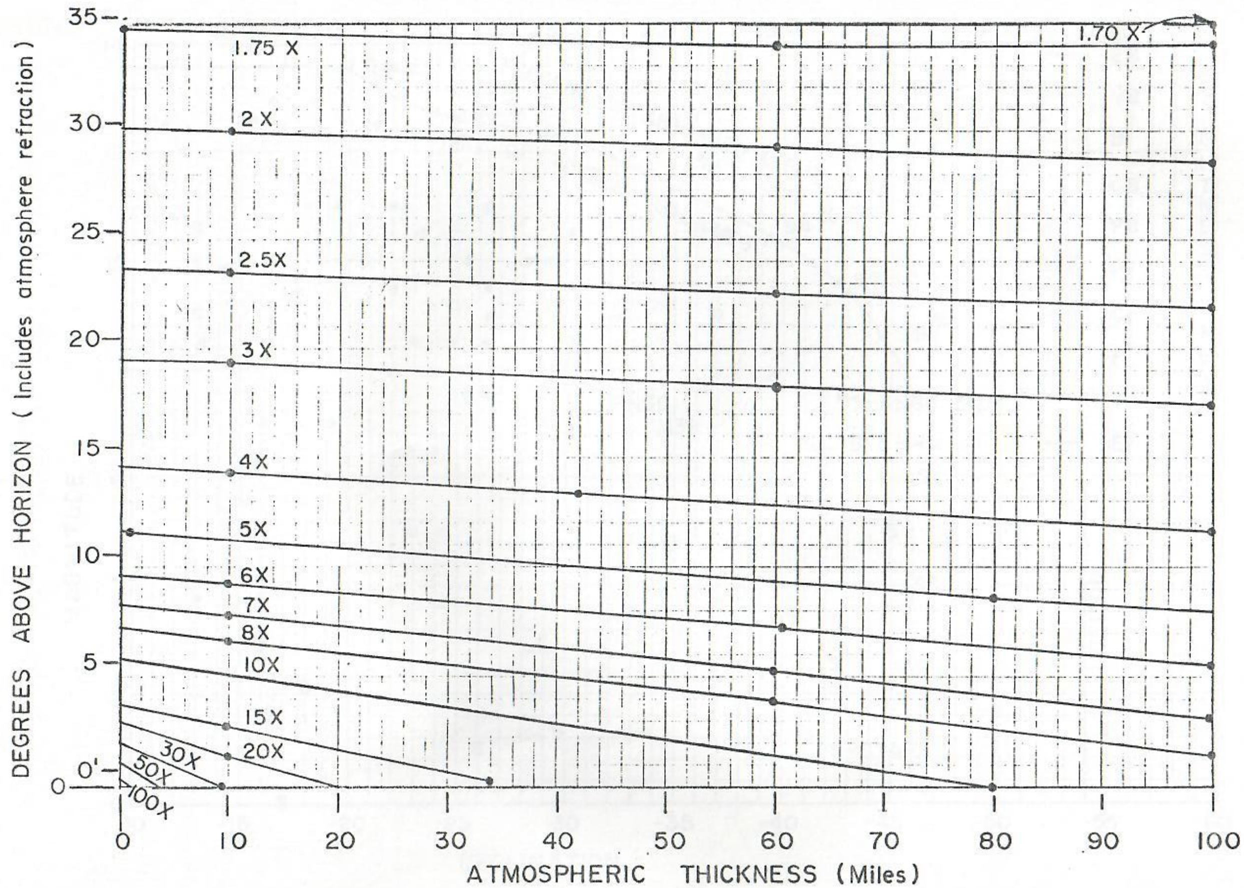



Fig 3. No. Of Times Thicker Than Normal Atmosphere

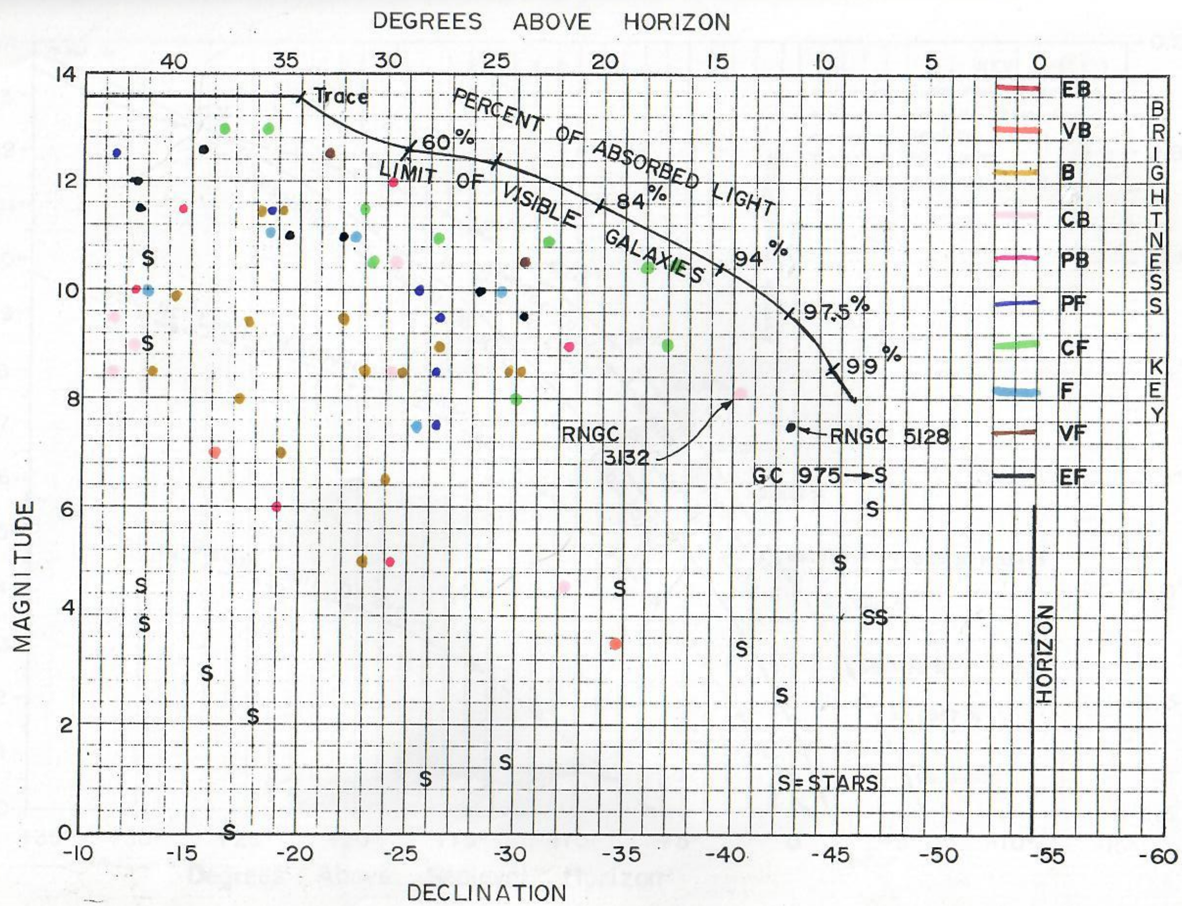



Fig. 4. Observations In The Lower Atmosphere Until Mid-1979

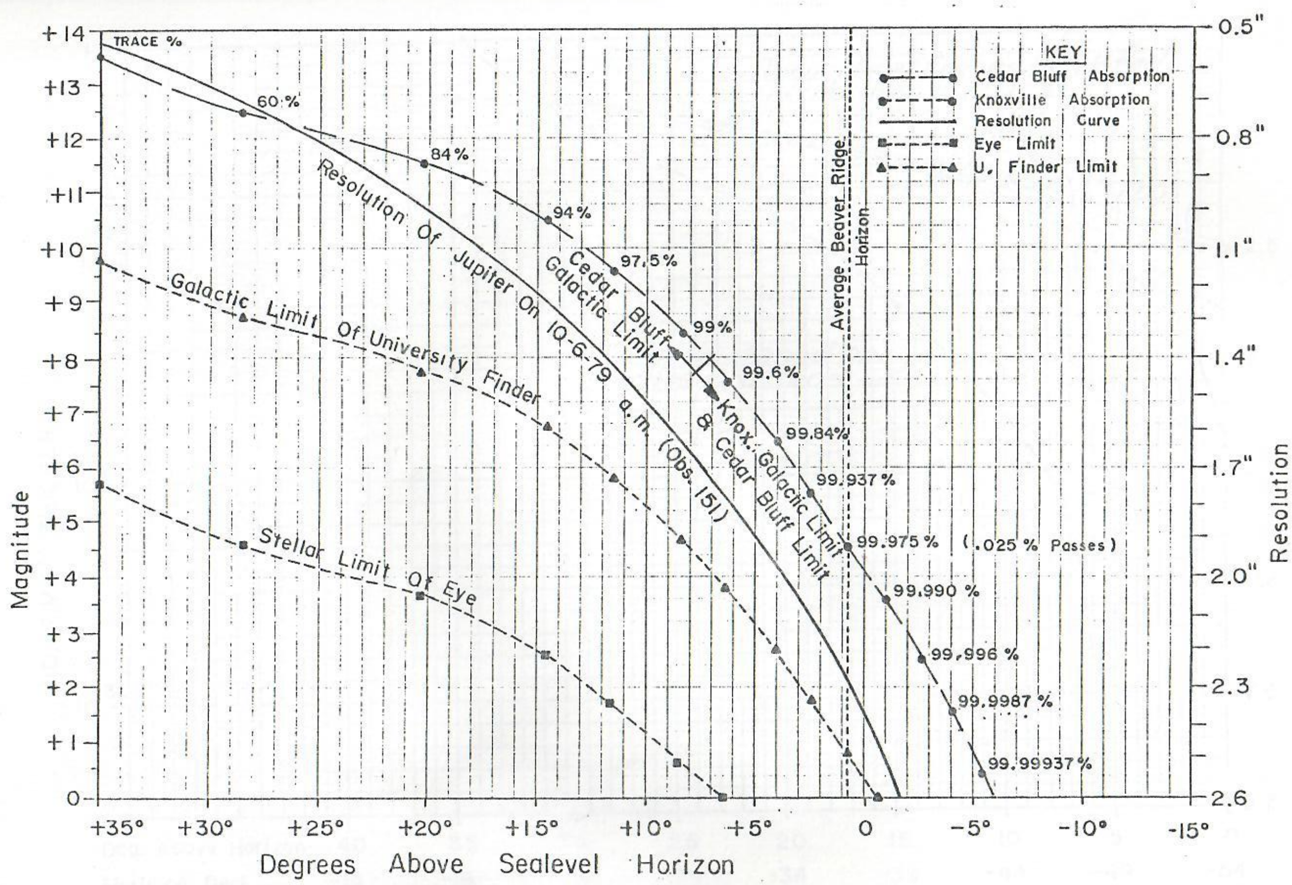



FIG. 5. Minimum Absorption In The Lower Atmosphere Of Knoxville Under Favorable Conditions

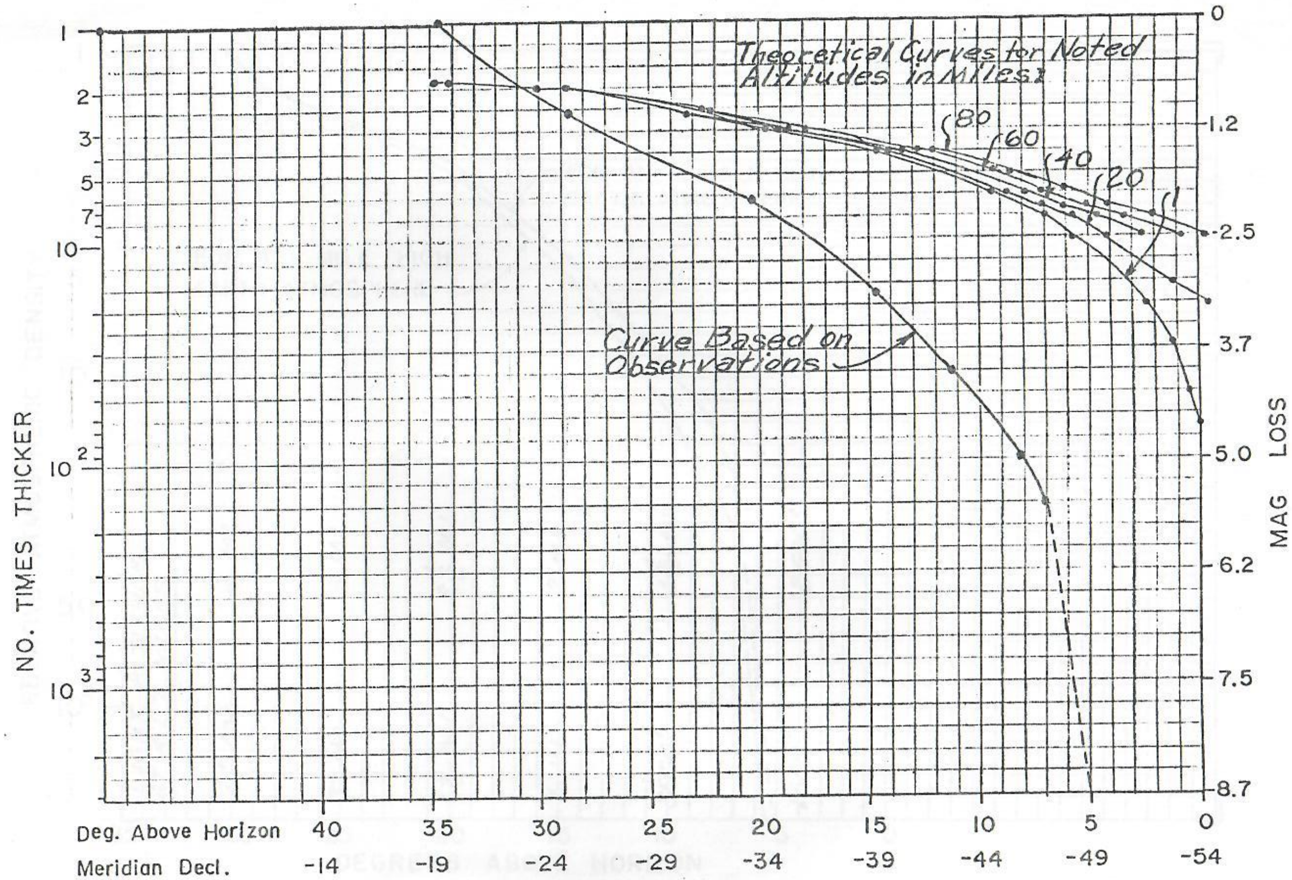



FIG. 6. Comparsion of Theoretical to Observed Data

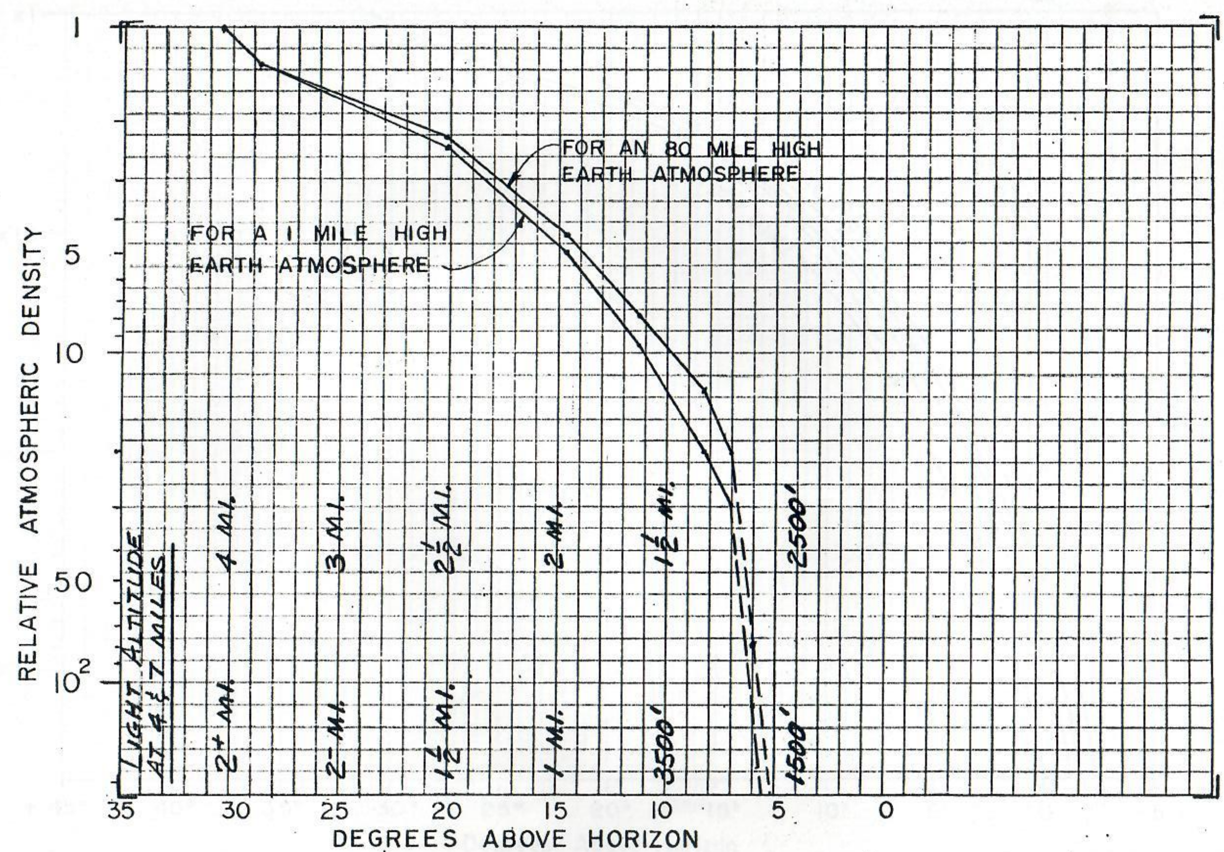



Fig. 7. Pollution Density of Cedar Bluff Compared to Home Location

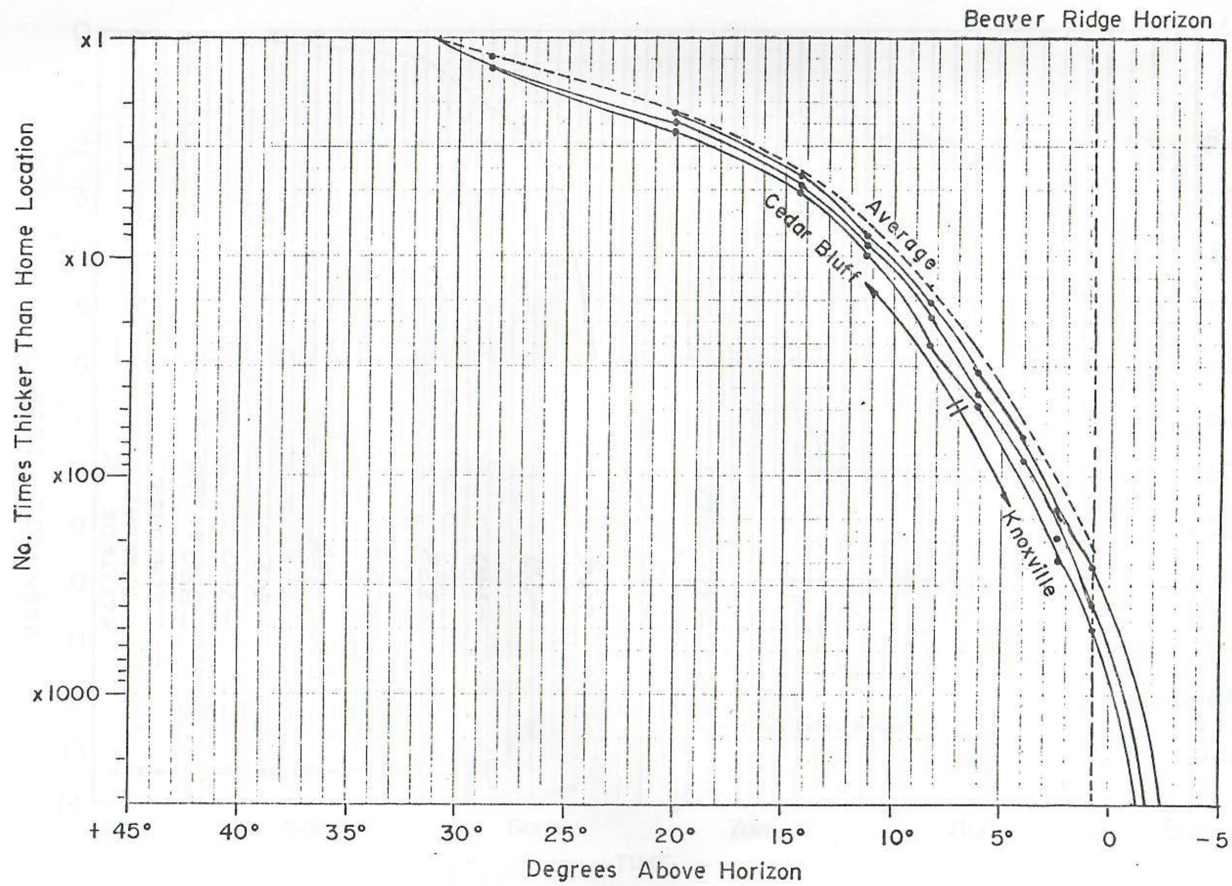



FIG. 8. Pollution Density of Cedar Bluff Compared to Home Location

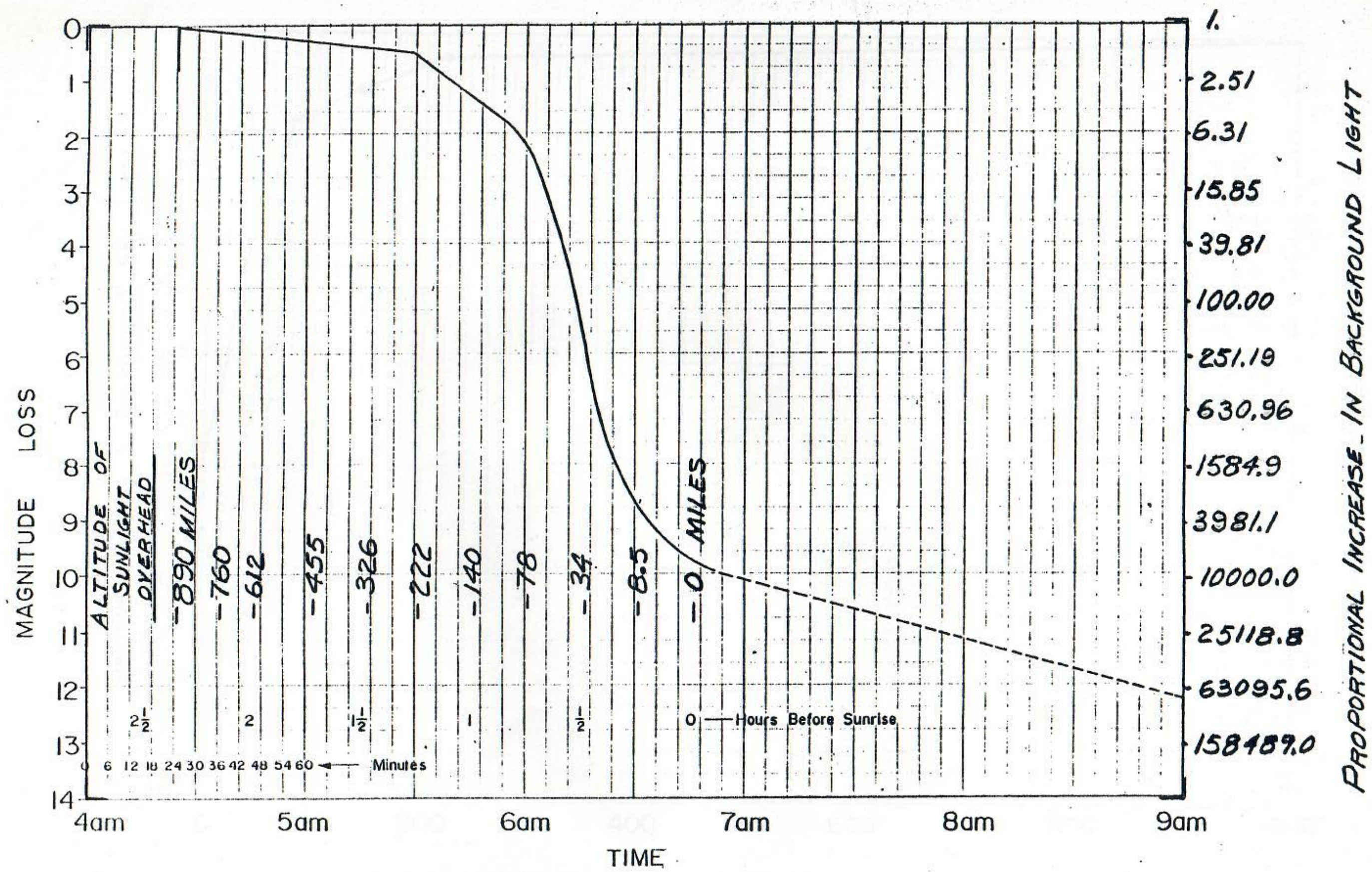



FIG. 9. Twilight Test

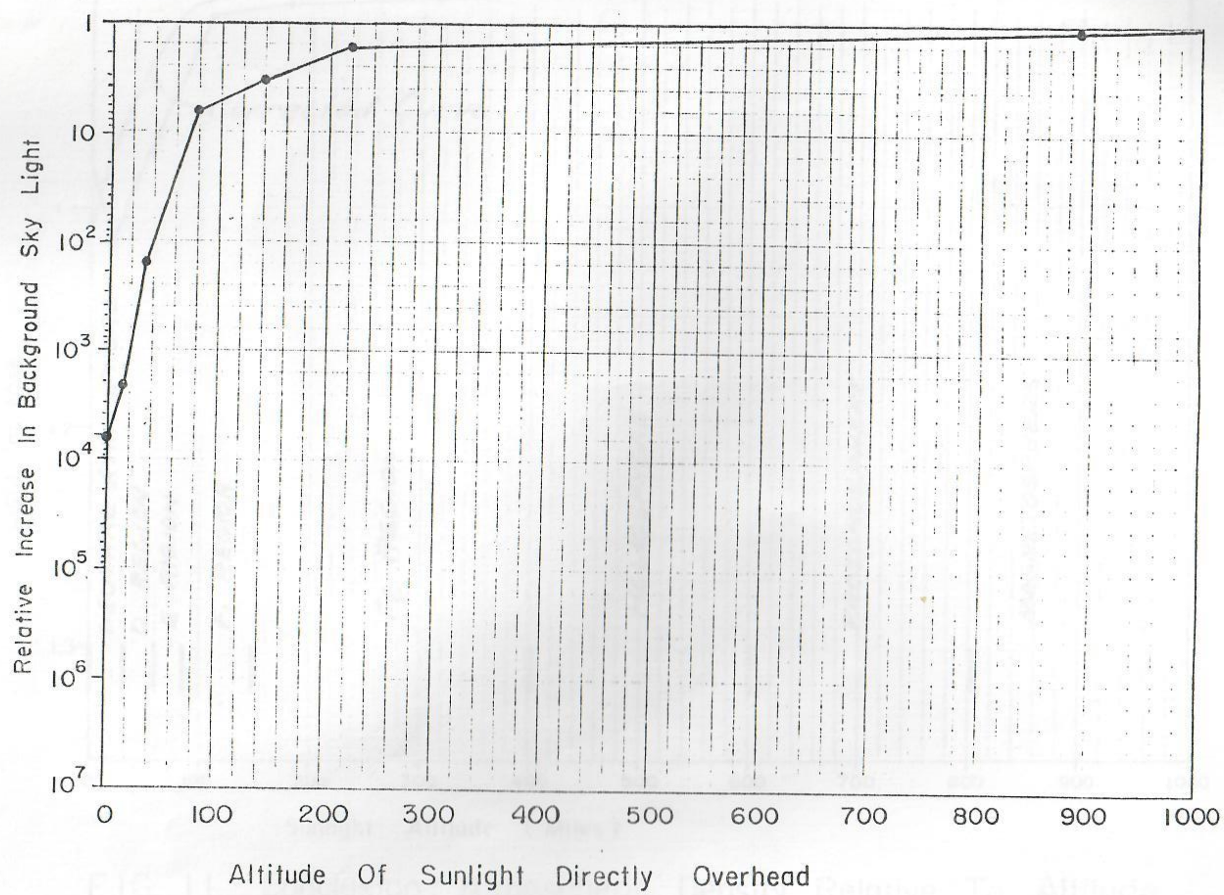



FIG. 10. Atmosphere Particle Density At 36.00° Lat. & 84.111° Long.

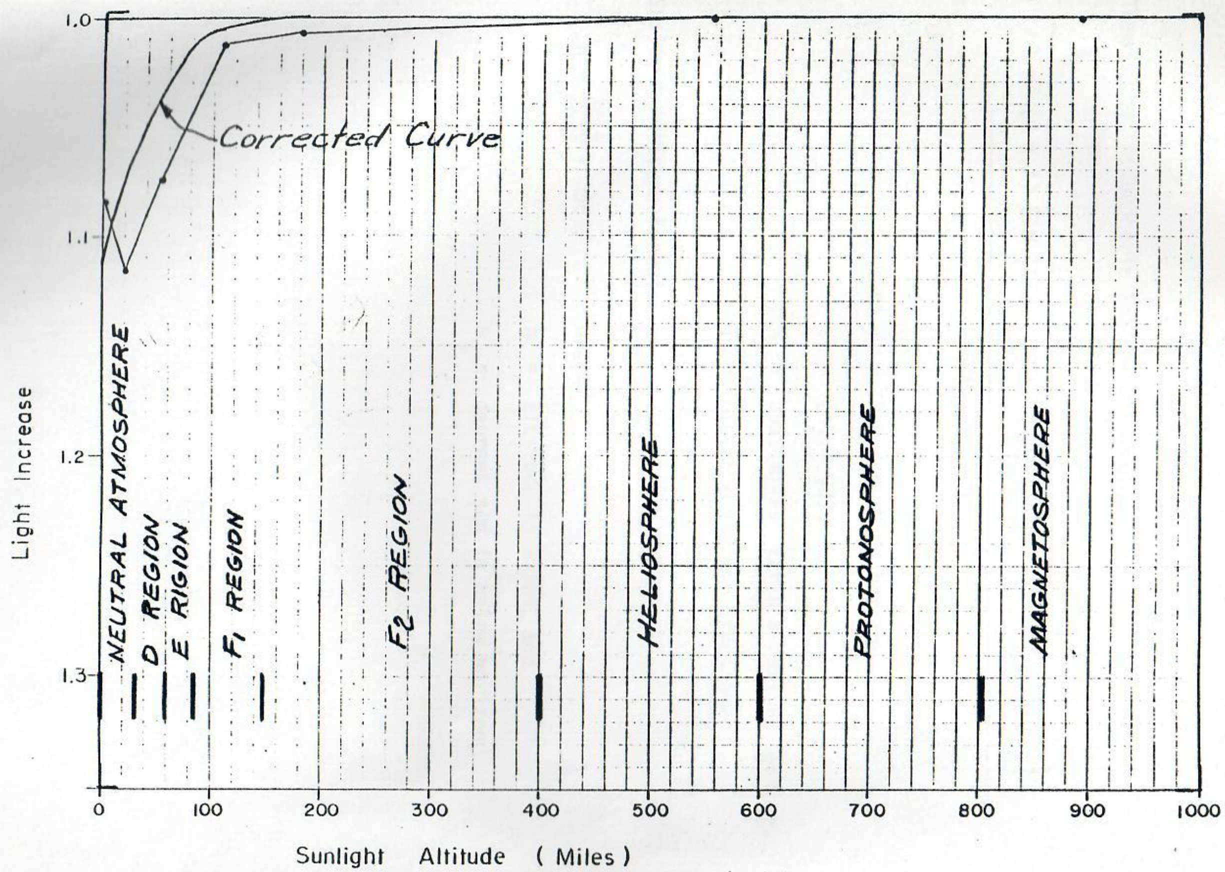



FIG. 11. Conclusion: Atmospheric Density Relative To Altitude
(For Lat. 36.000° - Long. 84.111°)

# APPENDIX

Theoretical Atmospheric Thickness Formula:

$$T = \frac{(R + A)\ \text{SIN}\left\{180 - \left[\text{Sin}^{-1}\left(\frac{\text{Sin}\ (\Theta_1 + 90)\ \ R}{R + A}\right) + (\Theta_1 + 90)\right]\right\}}{\text{SIN}\ (\Theta_1 + 90)},$$

where $\Theta_1$ = Degrees above horizon,

$\Theta$ = $(\Theta_1 + 90)$,

$R$ = 3959 miles (Earth's radius), and

$T$ = Distance through atmosphere.

Sunlight Altitude Formula:

$$h = \frac{3959}{\cos\Theta} - 3959,$$

where

$h$ = altitude in miles, and

$\Theta$ = degrees sun is below horizon.