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THE "NONEFFECT" OF SOLAR ECLIPSES ON THE ATMOSPHERE

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Solar radiation, of course, provides not only the long-term driving force for the entire circulation of the atmosphere but is also responsible for the thermodynamic structure of the upper atmosphere. Absorption of solar ultraviolet radiation by ozone near 50 km provides the heat necessary to sustain the warm feature known as the stratopause, and absorption of extreme ultraviolet radiation at levels above 80 km gives rise to the structure known as the thermosphere. Thus, a solar eclipse presents an opportunity to examine the effect that a sudden removal of solar radiation would have on this structure. The effects of the eclipse that occurred on March 7, 1970, were explored with three pitot probe rocket soundings launched from Wallops Island, Va., at times during a 42-min period corresponding to 40, 80, and 100 percent totality.

Figure 1, which is a plot of the temperature profiles obtained during the course of the eclipse, indicates that the atmosphere was indeed disturbed. There were many small-scale features that appear to have persisted from one sounding to the next, especially below 90 km. At levels above 100 km, the changes were very large. At many levels, the progressive removal of solar energy was accompanied by warming, which eliminates the simplistic direct-heating viewpoint as an explanation of the changes.

Because radiative considerations alone could not account for these variations, dynamic explanations were sought. Figure 2 shows the temperature changes observed during the eclipse as a function of time for altitudes of 60, 80, 100, and 120 km. Note that at 60 km there was a 2 to 4 K continuous cooling as the eclipse progressed. At 80 km, cooling also occurred between the first two soundings, but a warming trend had begun at the time of the third sounding, when the eclipse was total. At 100 km, initial cooling was followed by a substantial 16 K warming at totality. The temperature history at 120 km indicates that a sharp warming of 65 K at 80 percent totality was followed by a temperature drop of 100 K during the final 15 min. preceding totality.

There was great temptation to attribute these large changes solely to the eclipse; however, it was recognized that soundings with this type of time and altitude resolution had never before been obtained at this latitude and time of year, so another series of soundings was conducted on a day about 1 yr later at the same place and at times identical to those of the eclipse day. The results of the second series are shown in Figure 3. Initially

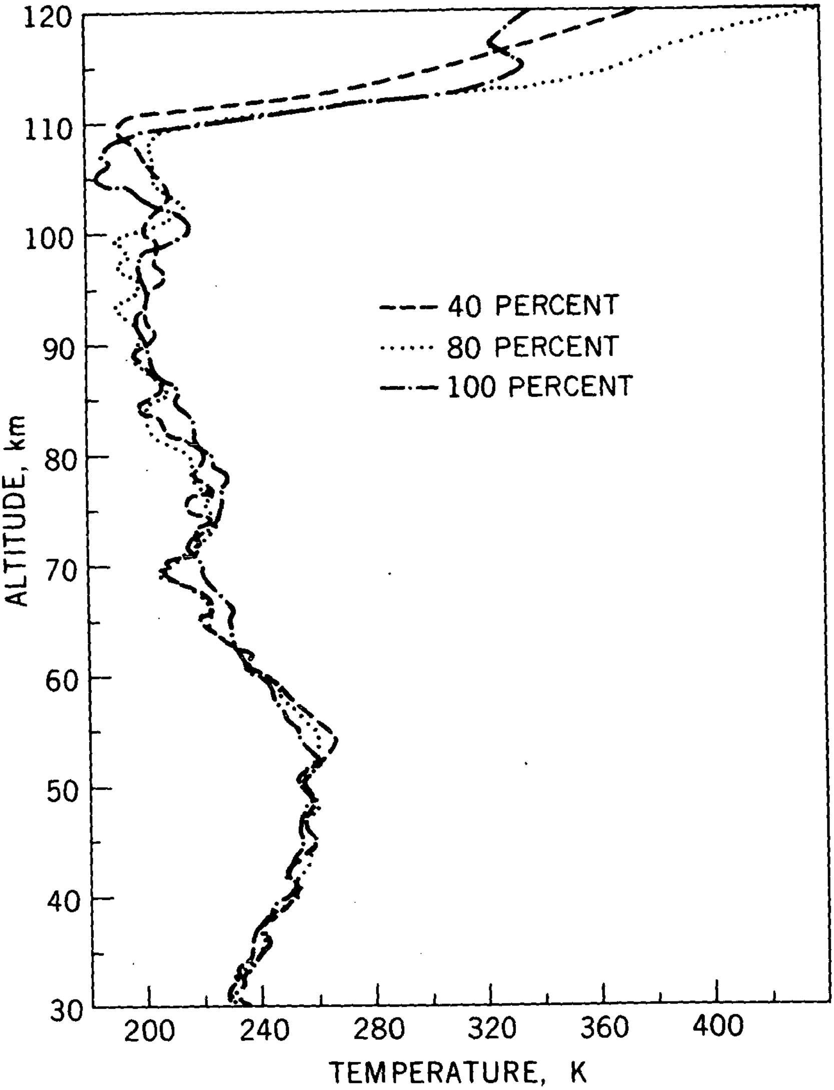

Figure 1–Temperature profiles of upper atmosphere obtained during the solar eclipse.

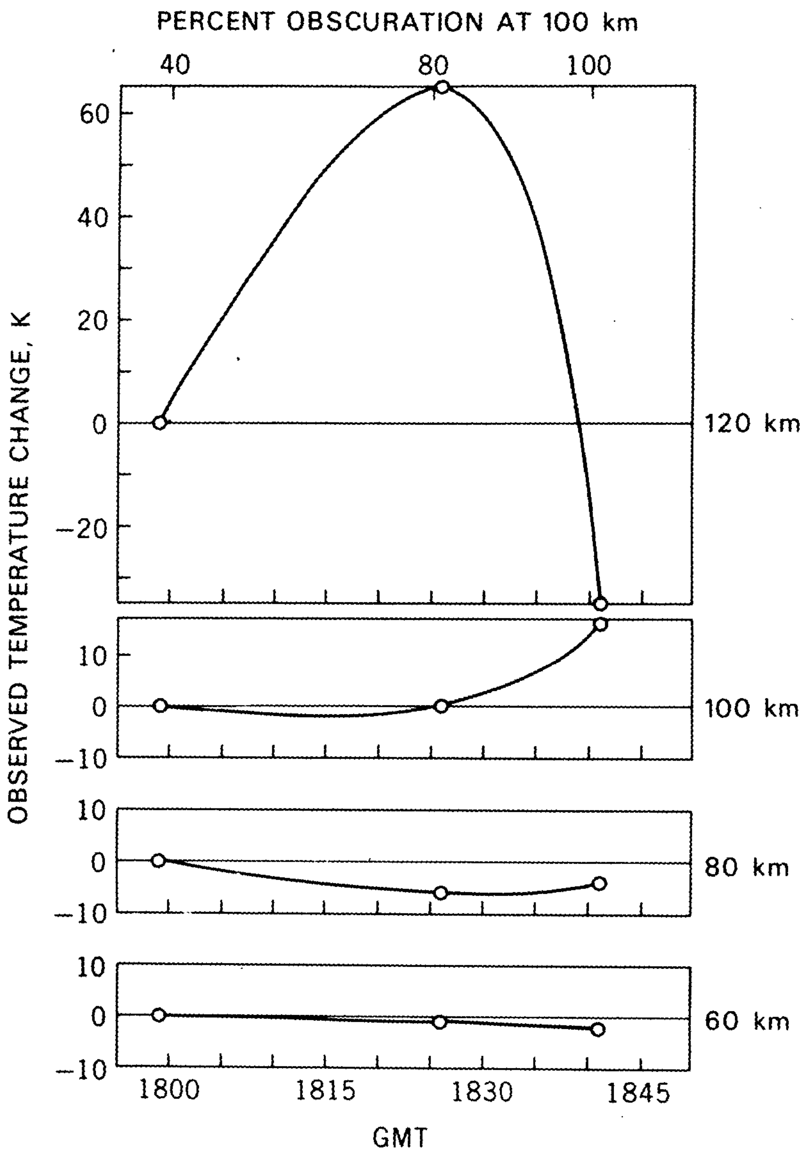

Figure 2–Temperature changes of upper atmosphere as a function of time during the solar eclipse.

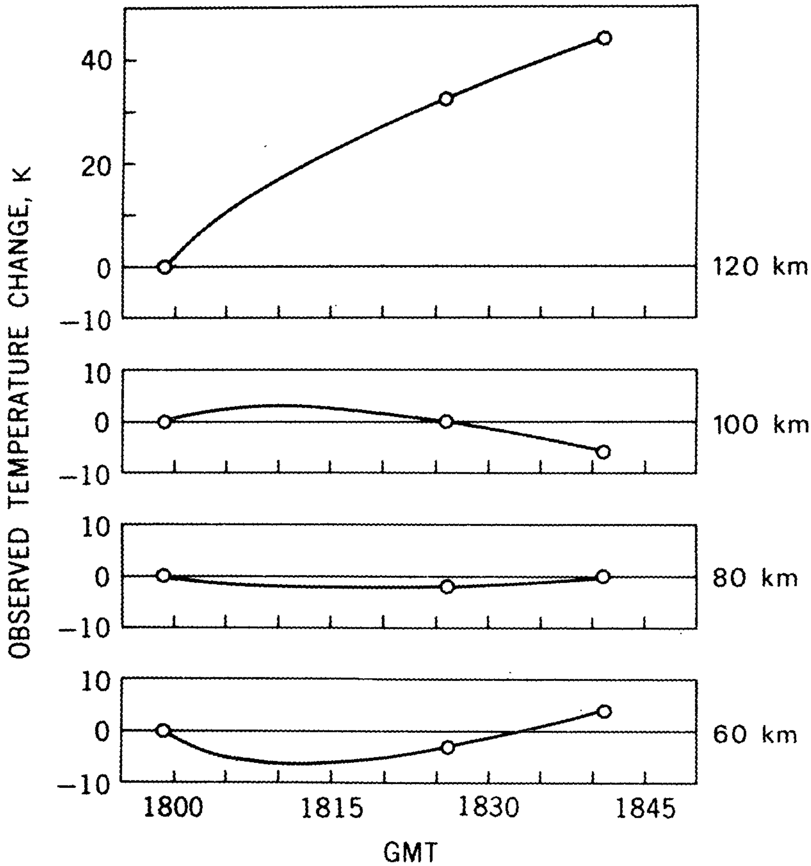

Figure 3–Temperature changes of upper atmosphere as a function of time under normal solar conditions.

there was cooling at 60 km, larger in magnitude than that observed during the eclipse, followed by a warming of about 10 K. At 80 km, the eclipse day and the normal day were almost identical. At 100 km, there was first warming, then cooling similar in amplitude, but opposite in phase to the changes observed on the eclipse day. At 120 km, a continuous warming of approximately 45 K occurred during the 42-min period, demonstrating that the thermosphere was in a disturbed state during both series of soundings. At 120 km, the 45 K warming on the normal day is comparable to the 65 K warming observed during the eclipse, and it is not possible to determine whether cooling comparable to that observed on eclipse day occurred on the normal day. These two series of soundings clearly demonstrate that there are large and rapid variations in the structure of the upper atmosphere which must be of dynamic origin, but that these phenomena, be they tides or gravity waves, are not uniquely generated by a solar eclipse as some theoreticians had predicted. Therefore, caution should be exercised when interpreting measurements made during an eclipse unless measurements made under normal conditions are available for comparison.