patterns are also good, and this will be discussed elsewhere (*3*).

The motion associated with individual earthquakes is apparently incapable of maintaining the Chandler motion of the poles (*4*), although this is a matter of current spirited debate (*4, 5*). Preseismic and postseismic deformations, however, may be adequate (*3*). The large amount of elastic energy stored in the crust and upper mantle (*6*) due to rotational processes suggests that a small perturbation in the rotational parameters of the earth may trigger global seismic activity.

The main source of length of day variations appears to be related to changes in the zonal wind circulation patterns (*2*). Climatic changes, in turn, are affected by solar radiation modulated by volcanic dust in the atmosphere (*7*). A major volcanic eruption can lead to climatic variations that survive for periods of the order of 5 years or more (*7*). Explosive volcanic eruptions, more common in the last century than in the present one (*7*), may be the ultimate cause of the large change in the length of day at the turn of the century. The turn-of-the-century length of day peak also correlates well with the interval between the great decoupling and lithospheric earthquakes in Sanriku, Japan (*8*). After a great decoupling earthquake, the lithospheric plate motions can be expected to accelerate and to trigger earthquakes in adjacent portions of the arc. On the other hand, explosive volcanism in the 1830's and 1880's apparently triggered climatic changes, particularly atmospheric circulation patterns, that led to changes in length of day and may have triggered the global seismic activity that also occurred in these intervals. If the correlation between the length of day and the eccentric dipole motions is accepted (*9*), the lag in the magnetic field, if climatic changes are the causal phenomena, can be attributed to inertial and core viscosity effects, in addition to mantle electromagnetic phenomena.

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Thermal Blanketing: A Case for Aerosol-Induced Climatic Alteration

Abstract. *Long-term temperature records at Phoenix, Arizona, indicate the existence of a post-1946 warming trend that may be attributed to the buildup of pollution in the lower layers of the atmosphere. The causative mechanism appears to be an enhancement of the so-called "greenhouse effect," induced by the interaction of aerosol with long-wavelength thermal radiation in the lower atmosphere.*

In recent years there has been considerable discussion of the possibility of climatic alteration due to the particulate pollution of the atmosphere's lower layers by human activity. The most widely considered mechanism of alteration has been the interaction of aerosol with solar radiation. Several of the recent reports on this aspect of the problem have been rather indecisive, however, concluding that particulates in the lower atmosphere may either warm *or* cool the earth, depending upon the specific absorptive and scattering properties of the aerosol and the characteristics of the underlying surface (*1, 2*).

A second mechanism of alteration, one that has been seriously propounded only recently (*3*), deals with the interaction of aerosol with long-wavelength thermal radiation. It postulates that particulates in the lower atmosphere will always exert a warming influence at the earth's surface via an enhancement of the well-known "greenhouse effect." Neither one of these two mechanisms, however, has ever, to my knowledge, been demonstrated to have produced a real temperature trend on a localized scale that could definitely be linked to aerosol effects. Thus, in this report I attempt to fill that void by presenting evidence for a real aerosol-induced temperature trend at Phoenix, Arizona, that appears to be caused by the second of these two mechanisms, herein termed "thermal blanketing."

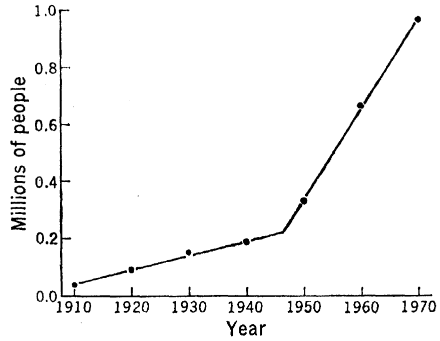

Fig. 1. Population of Maricopa County, Arizona, for the census record years 1910 to 1970.

Census figures for Maricopa County (composed preponderantly of the metropolitan Phoenix area) are plotted in Fig. 1. Two basically linear trends that meet at 1946 are indicated. Because of the sharp inflection point in population growth at 1946, that year was chosen as the pivotal point for the analysis of temperature trends.

Although several stations presently record temperature data in the Phoenix area, only two could be found that had continuous stationary-site records extending back as far before 1946 as between 1946 and the present. One of them, Litchfield Park, was located on the western edge of Phoenix and the other, the University of Arizona Experimental Farm, was located on the eastern edge.

The available records of both of these stations consisted of mean monthly values of maximum and minimum temperatures from 1918 to the present. The data were averaged for the two sites for the summer period May through August and the winter period November through February. Then, 3-year moving averages were computed for each of these four sets (mean maximum summer, mean maximum winter, mean minimum summer, and mean minimum winter). Separate linear regressions of temperature on time were carried out for each of these data sets for the periods before and after 1946. The resultant slopes (warming trends) with their associated standard errors of estimate (in units of degrees Fahrenheit per year) for the period prior to 1946 were as follows: maximum summer, 0.100 ± 0.020; maximum winter, 0.019 ± 0.019; minimum summer, 0.019 ± 0.018; and minimum winter, 0.059 ± 0.023; the values for the period after 1946 were as follows: maximum summer, 0.039 ± 0.020; maximum winter, 0.048 ± 0.023; minimum summer, 0.083 ± 0.026; and minimum winter, 0.175 ± 0.021.

In relating these results to air pollution, reference was made to the study by Idso and Kangieser (*4*), wherein it was shown that there is a large diurnal and yearly vertical redistribution of dust over Phoenix. In winter, inversions and shallow mixing heights confine the surface-generated aerosol to a layer only 500 to 800 m deep, whereas in summer the less frequent inversions and greater mixing heights allow the aerosol to daily mix to heights on the order of 2500 m. In both seasons the aerosol is distributed to greater heights in the afternoon as compared to the morning, as a result of the degradation of the inversions with time through the day.

From detailed data in (*4*) on the occurrence and persistence of inversions, I calculated the percentage of the total time that inversions existed at the times of the four temperature measurements (midafternoon, summer; midafternoon, winter; early morning, summer; and early morning, winter). The first instance (midafternoon, summer, or mean maximum summer) showed no indications of inversions at all. Thus, it was not expected to exhibit any dust-induced greenhouse effect; and indeed it did not. Its mean warming trend since 1946 was actually less than that prior to 1946, in good agreement with the general world cooling trend observed by Mitchell (*5*) to have begun at about the same time as the pivotal year used here.

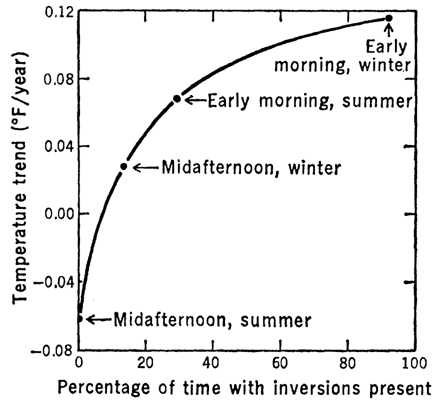

Fig. 2. Mean rate of temperature increase at Phoenix, Arizona, after 1946 relative to that prior to 1946 as a function of the percentage of the total time that inversions existed at the specific times and seasons represented by the four data points.

The changes in warming rates after 1946 relative to those prior to 1946 for all four periods are plotted as a function of the percentage of time of inversion existence in Fig. 2. A good curvilinear relation is seen to result, where the relative warming trend increases with the increasing percentage of time of inversion existence. Thus, the restriction of aerosols produced by human activity to low levels of the atmosphere does indeed appear to directly affect the climate at the earth's surface, causing mean air temperatures to rise significantly.

The final question, then, concerns the mechanism involved: Is it the solar or the thermal radiation interaction that is responsible for the apparent aerosol-induced warming effect? Two facts point to the latter mechanism. First, it has been shown experimentally that the thermal radiation interaction can indeed occur (*3*), whereas the solar radiation interaction that would cause a warming has only been theorized. Second, in postulating the solar radiation effect, Mitchell (*2*) has noted that it would be least likely to occur in "arid and urban areas," both of which conditions aptly describe Phoenix and its environs. Thus, both experiment and theory point to the thermal radiation interaction mechanism as the one responsible for the temperature effects described in this study.

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The Spiral Interplanetary Magnetic Field: A Polarity and Sunspot Cycle Variation

Abstract. *Spacecraft observations near the earth of the average direction of the interplanetary magnetic field during the sunspot maximum year 1968 showed a deviation from the spiral field of Parker's classical description. The included angle between the average field direction when the field polarity was away from the sun and the average direction when the field polarity was toward the sun was 168°, rather than 180° as predicted by Parker. This effect appears to have a sunspot cycle variation.*

The solar magnetic field is stretched out away from the sun by the solar wind plasma. Parker (*1*) has pointed out that the resulting interplanetary magnetic field should, on the average, have the form of an Archimedean spiral because of the combined effects of the radially flowing solar wind and a twisting induced by solar rotation. Near the earth the average radial solar wind velocity is approximately 400 km/sec, which is approximately equal to the azimuthal velocity of the solar rotation ΩR, where Ω is the sun's angular velocity and R is the distance from the sun to the earth, so that the average spiral angle α is about 45°.

Early spacecraft observations [reviewed by Wilcox (*2*)] showed that, on the average, the interplanetary magnetic field configuration was close to that described by Parker, and this theoretical picture is now widely accepted. In a recent investigation utilizing the several years of spacecraft observations of the interplanetary mag-