centration, and (ii) it carries everything that is embedded even in the most ancient ice to the surface as the ice sheet rides up the side of the barrier. Thus, in theory, the concentration occurs across an area and also back through time.

Other factors unique to the Antarctic environment undoubtedly act to favor preservation of friable and chemically less stable meteorites once they have fallen. Initial impacts may often occur in deep snow, favoring retention of meteorites as larger individuals. Chemical weathering is greatly retarded by low temperatures, low humidity, and the absence of plant-produced organic acids or inorganic soil acids. The low rates of chemical reaction and high degree of cleanliness on the Antarctic ice plateau would be particularly important in maintaining carbonaceous chondrites in their pristine states. Because of these factors the distribution of meteorite types in Antarctica may be different from that in other climatic zones and may more accurately reflect the original distribution in space.

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10. The work reported here resulted from a joint U.S.-Japan field project. The U.S. members were supported by NSF grant DPP76-10800. In addition, E.O. received partial support from the Field Museum of Natural History. K.Y. was supported by the Japan National Institute of Polar Research. We received very valuable preliminary advice on the field operations from W. MacDonald, D. Elliott, and C. Bull. Fruitful discussions on sections in the report were had with L. Rancitelli and P. M. Millman. We owe a special debt of gratitude to the pilots and aircrew members who helped ensure our success in the field by willing and intelligent application of their special skills. We thank all the institutions and individuals mentioned above.

15 August 1977

Planetary Radiation Balance as a Function of Atmospheric Dust: Climatological Consequences

Abstract. *An analysis of several atmospheric dust-loading events at Phoenix, Arizona, under background cloudless sky conditions, allowed determination of dust-induced changes in both the net solar and net thermal radiation received at the earth's surface. The resultant climatological forcing function for surface temperature change was plotted against the ratio of diffuse to normal-incidence solar radiation. It was found that initial increases in atmospheric dust concentration tend to warm the planet's surface. After a certain critical concentration has been reached, continued dust buildup reduces this warming effect until at a second critical dust concentration a cooling trend begins. This second critical dust concentration is so great, however, that any particulate pollution of the lower atmosphere by man will have a tendency to increase surface temperatures. Thus, anthropogenically produced tropospheric aerosols cannot be looked on as offsetting the warming tendency of increased carbon dioxide: their concurrent buildups must inexorably tend to warm the planet's surface.*

The climatological effects of atmospheric dust on the earth's radiation balance have been of great concern to scientists for many years. Interest centers chiefly on the question: Would an increase in the dust content of the atmosphere tend to warm or cool the earth?

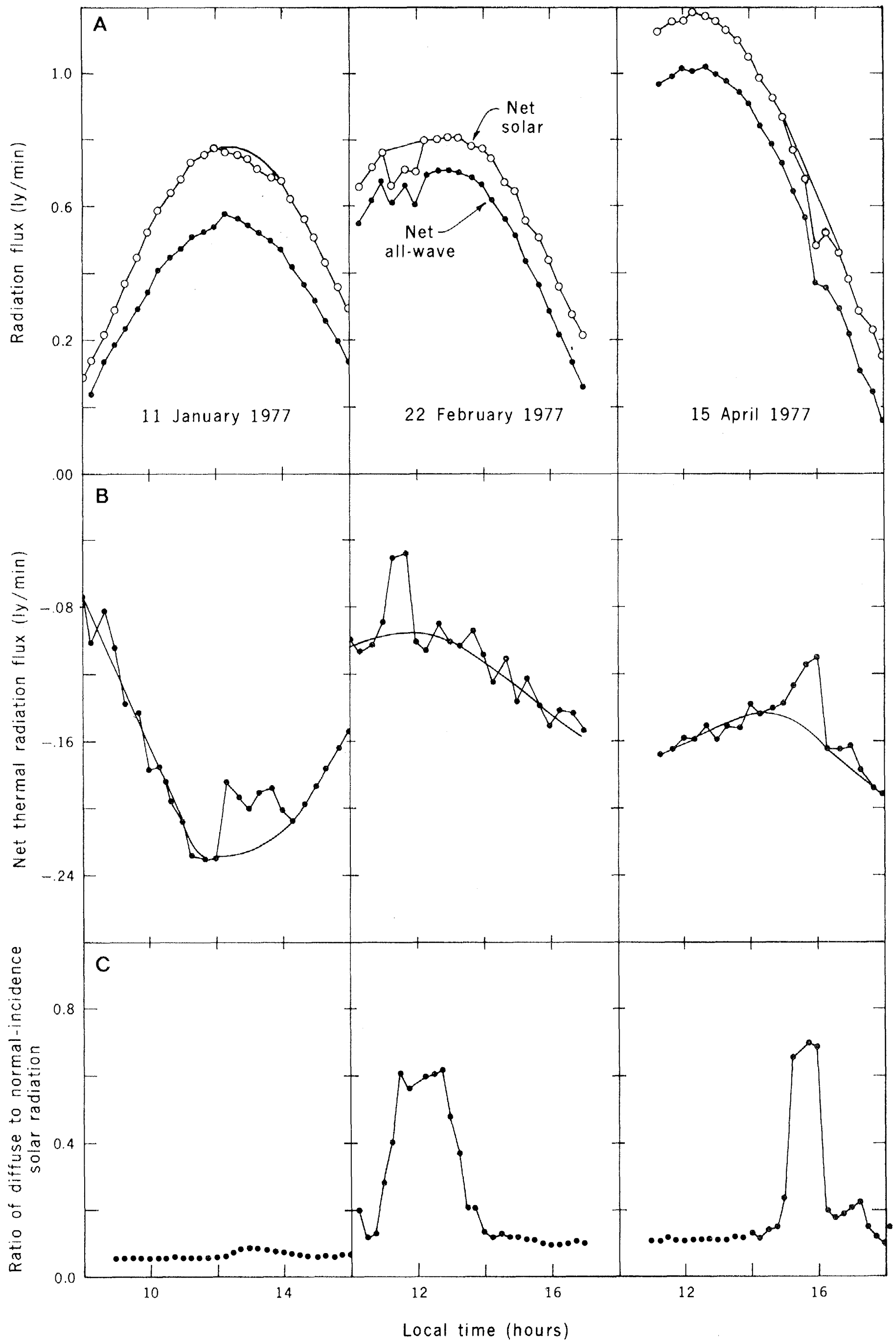
Most research on this subject has concentrated on effects of airborne particulates on solar radiation. These studies, practically all theoretical, have dealt with absorption and forward- and back-scattering characteristics of different aerosol types with different numbers and size distributions over different surfaces, such as forest, farmland, desert, snow, and water. A sampling of results is highly ambivalent; many studies have predicted cooling trends for increases in atmospheric dust concentrations, while many others have predicted warming trends.

A second research effort, somewhat more experimental, has concentrated on effects of airborne particulates on atmospheric thermal radiation. These studies have not been as equivocal as the solar radiation studies, as almost all of them have predicted a warming trend with increasing atmospheric dust concentration. However, they have not been completely unambiguous either, yielding somewhat different heating rates for different experimental conditions. Thus, we felt that a more unified and systematic approach to the problem was needed, consisting of an experimental study of both solar and thermal radiation interactions with atmospheric dust as a function of dust loading of the atmosphere.

Our primary data were obtained from two intensive, long-term radiation balance studies conducted at Tempe and Phoenix, Arizona, over the period December 1976 to May 1977. The Tempe study involved a characterization of incoming solar radiation. Normal-incidence and diffuse solar radiation were measured every 20 minutes with an Eppley normal-incidence pyrheliometer on a motorized equatorial mount and an Eppley precision 180° hemispherical radiometer equipped with a shadow band appropriate for our latitude, respectively; both were atop a 9.2-m tower at the Laboratory of Climatology on the Arizona State University campus. Altitude and azimuth angles of the normal-incidence pyrheliometer and the position of the shadow band about the hemispherical radiometer were checked every other day.

The Phoenix study, carried out 4 km southwest of the Tempe study site at the U.S. Water Conservation Laboratory, included a characterization of incoming and reflected solar radiation and net all-wave radiation over a wheat crop. Three hemispherical solarimeters (Eppley, Spectran, and Lambda Instruments) recorded incoming global (direct plus diffuse) solar radiation, 24 inverted Spectran solarimeters recorded reflected solar radiation, and 24 Fritschen-type net radiometers recorded net all-wave radiation—all on an every-20-minute basis. These instruments were checked daily.

With this large data base available, we decided to search the records of the nearby Phoenix National Weather Service Office for days that had blowing dust events under cloudless skies. Out of the entire 6-month study, only 3 days met these two criteria: 11 January, 22 February, and 15 April 1977. For these 3 days, the results from the 24 inverted solarimeters were averaged and subtracted from the average incoming solar radiation determined from the three upright solarimeters at the U.S. Water Conservation Laboratory to yield the net solar radiation over the wheat plot (Fig. 1A). This result was then subtracted from the aver-



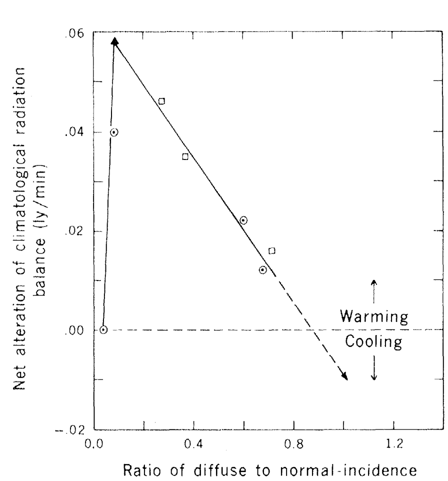


Fig. 1 (top). (A) Traces of net solar and net all-wave radiation above a wheat crop at Phoenix, Arizona, for 3 days of blowing dust events under cloudless sky background conditions. (B) Traces of net thermal radiation for these days derived from the net solar and net all-wave radiation curves. (C) Traces of the ratio of diffuse to normal-incidence solar radiation measured on these days. Fig. 2 (bottom left). Calculated net change in the global net radiation balance at the earth's surface for different dust events characterized by, and plotted as a function of, the ratio of diffuse to normal-incidence solar radiation. The data points are (⊙) from this study, (□) from (*3*), and (▲) from (*2*).

age net all-wave radiation over the wheat, as determined from the 24 net radiometers (also Fig. 1A), to yield the net thermal or long-wave radiation over the wheat (Fig. 1B). Lastly, as a characterization of the degree of dust loading of the atmosphere, the ratio of diffuse to normal-incidence solar radiation measured at Arizona State University was also plotted (Fig. 1C).

The plots of the ratio of diffuse to normal-incidence solar radiation clearly delineated two quite dramatic dust events and one very mild one. This helped us to confidently locate the aberrations in the net solar and thermal radiation traces that were clearly attributable to the dust loading of the atmosphere. We then determined from the plots of Fig. 1A the reductions in incoming solar radiation caused by the injection of dust into the atmosphere, and from the plots of Fig. 1B the increases in incoming thermal radiation due to the "thermal blanketing" effect (*1*) of the increased atmospheric dust. To put both the solar and thermal effects on an equal climatological basis, the solar radiation reductions were divided by a factor of 4, since on a global basis solar radiation is only intercepted by a disk with an area equal to one-fourth the surface area of the planet, while atmospheric thermal radiation is ever present over the globe. The algebraic sums of the adjusted solar radiation reductions and the thermal radiation increases represent the net climatological effects of the increased atmospheric dust concentrations on the days of the dust events we investigated. All of them indicated a net warming.

To determine the trend of this net radiational warming as a function of atmospheric dust loading, we plotted the three climatological heating rates just determined as a function of the ratio of diffuse to normal-incidence solar radiation measured during the dust events (Fig. 2), since this ratio is very responsive to atmospheric dust concentration. Then, since there can be no change in the radiation balance attributable to dust if there is no dust event, we plotted a zero base value radiation point for a nominal base value for the ratio of diffuse to normal-incidence solar radiation of 0.04—the lowest value we characteristically measured on the clearest days.

Four other points were added, based on previously published work from the U.S. Water Conservation Laboratory. Idso (*2*) had determined the warming effect of a very diffuse dust event (15 May 1973) that did not reduce the incoming solar radiation by any measurable amount. Thus, that warming rate was plotted at a value for the ratio of diffuse to normal-incidence solar radiation of 0.085—the same value as for 11 January, when the incoming solar radiation was reduced by only a very small amount—with probably less error of location than that associated with the points for 22 February and 15 April.

Finally, the study by Idso (*3*) yielded our last three points. It dealt with a several-hours-long dust storm on 3 February 1971, during which radiation measurements had been made every 10 minutes. Throughout this event an upright Eppley pyranometer had been alternately shaded and unshaded with a small blackened paddle, so both diffuse and direct solar radiation were determined. Thus, on the basis of geometrical considerations, the normal-incidence solar radiation was calculated and the diffuse/normal-incidence ratio obtained. The results for all ratios between 0.2 and 0.3 were averaged together, as were results for all ratios between 0.3 and 0.4. Then, three peak ratios above 0.7 were averaged to yield the last of three points.

Our resultant eight data points of Fig. 2 define two essentially linear trends, which we have connected and extrapolated somewhat with a dashed line. The first data set shows an increased warming influence with increasing dust loading of the atmosphere, while the second data set shows a decrease in the warming influence. Apparently, when small amounts of dust are injected into the atmosphere, the net income of solar radiation to the planet's surface is only slightly reduced (11 January 1977), if at all (15 May 1973). However, this minor addition of particulates seems to have a great effect on the net thermal radiation balance, acting, so to speak, to significantly "close" the atmospheric "window" that otherwise allows a good deal of the terrestrial thermal radiation of the earth to escape to space. Thus, a peak warming influence is manifest at a critical dust concentration characterized by a relatively low diffuse/normal-incidence ratio, on the order of 0.1. In addition, the curve turns downward from that point as dust loading increases, and, assuming a linear extrapolation, at a second critical dust concentration characterized by a diffuse/normal-incidence ratio on the order of 0.9, a cooling influence begins. Beyond this second point, solar radiation reductions are hypothesized to continue, but no additional heating influence caused by thermal blanketing is expected. The atmosphere has long since become a virtual blackbody in the thermal infrared region of the electromagnetic spectrum—that is, the atmospheric window has been shut, and it can be shut no tighter. Idso (*4*) described an experimental situation in which this actually happened. It could not be plotted as a point on Fig. 2, however, since diffuse and normal-incidence solar radiation were not measured on that day, and solar radiation was somewhat reduced.

What do these results portend for the earth's future climate? Since our data only apply to aerosols contained within the lower troposphere, we are not yet in a position to comment on the greatest potential source of atmospheric particulates—volcanoes—since volcanism generally injects large amounts of particulates into the stratosphere. However, we can comment on the climatological consequences of man's industrial pollution of the atmosphere—that is, the "human volcano," postulated by Bryson (*5*) to have a great cooling influence. If, and when, this source of tropospheric particulates ever becomes climatologically significant, our findings imply that the resultant surface temperature trend will definitely be one of warming, not cooling. Thus, whereas many groups assigned to assess the problem have looked on this aspect of intensified industrialization as acting as a "brake" on the warming influence of increased carbon dioxide production, just the opposite is actually the case—the two phenomena complement each other. It is time that we face this fact and consider its many ramifications.

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11 July 1977; revised 26 August 1977

Simultaneous Effects of Erythropoietin and Colony-Stimulating Factor on Bone Marrow Cells

Abstract. *Erythropoietin or colony-stimulating factor, or both, were added to rat or mouse marrow cell cultures, and the responses to each inducer were measured. Colony-stimulating factor caused the suppression of erythropoietin-stimulated hemoglobin synthesis, and erythropoietin caused the suppression of the granulocyte-macrophage colony formation that is dependent on colony-stimulating factor. The extent of suppression by each inducer was dose-dependent. Marrow cells from plethoric rats were more sensitive to suppression of erythropoietin action by colony-stimulating factor than were normal marrow cells. These findings suggest that either (i) the receptors for erythropoietin and for colony-stimulating factor have overlapping specificities and that the "wrong" inducer may bind without having an inductive effect, or (ii) the target cells for erythropoietin and colony-stimulating factor are very closely related or are the same.*

Evidence suggests that competitive demands can influence erythroid and granulocytic lines of hemopoietic differentiation (*1, 2*). Normally, erythropoiesis and granulopoiesis occur simultaneously, and modest stimulation of one line of differentiation does not affect the other. Under conditions of a greatly increased requirement for red cells, however, erythroid differentiation is increased, and this increase is accompanied by a decline in granulopoiesis (*2*). The stage in the developmental pathway of the blood cells at which this competition occurs is not known. A current model of hemopoietic cell differentiation postulates a developmental level of unipotent cells which are derived from pluripotent stem cells but, unlike them, are sensitive to specific inducers such as erythropoietin and a putative granulopoietin (colony-stimulating factor, CSF) (*3*). In an alternative view, specific inducers act on the pluripotent stem cell itself to regulate differentiation (*4, 5*). Much of the evidence supporting the former model comes from studies in vivo where the complexity of whole animals makes unequivocal interpretation difficult. Appropriate assays in vitro for erythropoietin and CSF now exist (*6*), and the hypothesis that the presence of one inducer influences the response by bone marrow cells to the other factor can be examined.

We tested the action of CSF under conditions where erythropoietin added to marrow cells from normal rats caused