Concentration of Ozone in Surface Air over Greater Boston in 1965

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1. Introduction

The global ozone budget has been studied in detail by Junge (1962) and one of his conclusions was that further systematic measurements of surface ozone at a number of sites over the globe would be of great value in consideration of stratospheric-tropospheric exchange processes. Such studies could provide information about where and when stratosopheric air reaches the lower troposphere; the vertical mixing in the lowest 1.5–2 km during the day essentially provides a short-circuit between the surface and 1.5 km. Combined with ozone sounding data such as that gathered over North America (Hering, 1964; Hering and Borden, 1964, 1965), it is not unreasonable to hope that eventually the quantity of stratospheric air passing into the troposphere can be estimated. An objection often raised to Junge's proposed network of surface ozone stations is that measurements made near a city can be contaminated with ozone produced locally by the action of sunlight on automobile and industrial exhausts. There is some direct evidence of such production in the controlled experiments of Ripperton (1965) and in the existence of high ozone values in the polluted air of a relatively unventilated city like Los Angeles. This may account for the fact that the only surface ozone measurements added to the literature since Junge's paper are apparently those from the Antarctic reported by Aldaz (1965). Thus, the question of the feasibility of the network suggested by Junge has not really been decided. In view of our interest in the general circulation of ozone in the atmosphere and its possible use as a tracer of the vertical transfer of energy from the troposphere to the stratosphere (Newell 1961, 1964), we decided to monitor surface ozone in the relatively well-ventilated region of Greater Boston. This note represents the gross results for a one-year period.

2. Procedure

An ozone recorder designed by Brewer (Brewer and Milford, 1960) and built by the Mast Development Company of Davenport, Iowa, was used. It was allowed to operate continuously for a 14-month period and did not require any attention other than renewal of solutions. A chromium trioxide filter was fitted to the air inlet to remove sulphur dioxide which interferes with the ozone measurement. In a one month sampling program of Boston air by the Public Health Service, sulphur dioxide had a maximum concentration of 0.34 ppm. The odor is sometimes detectable from the roof of M.I.T. buildings as the plumes from nearby power stations are intercepted. It has been pointed out that there is an average 70 per cent reduction in ozone recorded when the filter was removed (Brandli, 1965). No systematic change in the ozone reading was observed when the existing filter was replaced by a new filter. Filters were changed every month. During November 1964 and March–December 1965 the instrument was operated on the roof of the Green Center for Earth Sciences, at a height of 100 m, located on the M.I.T. campus in Cambridge, Massachusetts. For certain practical reasons the site could not be used in the intervening months. During December 1964 and January 1965, air was sampled in Roslindale, approximately 15 km southwest of the M.I.T. campus. The instrument was placed in a second floor room 8 m above ground level with the inlet tube protruding from the window. For February 1965, the sensor was moved to Braintree, some 25 km south-southwest of the campus. Here the window used was only one meter above the ground.

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3. Results

Fig. 1 shows a plot of the monthly means,[2] which were computed by averaging one hour means for the entire month. Also plotted are the average daily maximum values, which should give a more representative value for the lower troposphere since the effect of ozone destruction near the ground is minimized. The maxima usually occurred early in the afternoon. Ozone concentrations are a maximum in late spring as would be expected if the ozone had arrived in the troposphere from the lower stratosphere. The maximum in May is one to two months later than the maximum in total ozone which occurs mainly through a build-up of ozone in the lower stratosphere. The rate of stratospheric-tropospheric mass exchange, the rate of dispersion of ozone in the troposphere, and the rate of ozone loss to tropospheric aerosols and the surface and in reactions with the oxides of nitrogen (Kawamura, 1965) are all factors that enter into the time delay, and without a network of stations it is practically impossible to sort them out. The minimum in November in 1965 is likewise about one month later than the average minimum in total ozone. The general form of the annual variation is the same as that reported for Arosa (see Junge's summary, *loc. cit.*). The amplitude of the variation is somewhat greater. Until records for several years have been accumulated it is not possible to attach any significance to this finding. Instrument response, presence of the filter, and year to year variations are all factors that may be involved.

The annual variation observed is consistent with a stratospheric source of ozone. It has not been possible to assign a fractional contribution to the local pollution; indeed, the photochemical smogs that could be tasted occurred mainly in the fall months. Thus, at present pollution levels, it appears that ozone of stratospheric origin can be monitored in a reasonably well-ventilated city. Junge's proposed network, therefore, seems quite feasible, with many potential sites offering much less pollution than Boston. There are numerous plans for new highways and garages and a general encouragement for an expansion of vehicular traffic in and around the present observing site and the Greater Boston area. An increase in pollution levels is therefore anticipated. We plan to continue observations for several years and have recently obtained a portable Mast instrument to compare values measured at 100 m at M.I.T. with those measured close to busy streets in an effort to distinguish stratosopheric and local sources of ozone. A number of case studies and correlations with climatological studies have been made and will be reported elsewhere.

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[2] Values in parts per hundred million, pphm.

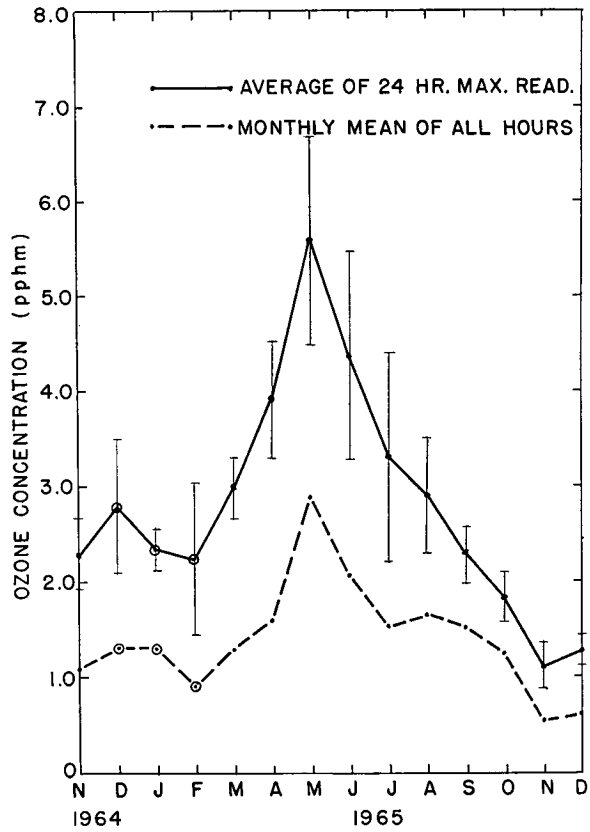

FIG. 1. Ozone concentration over Greater Boston in pphm where bars represent one standard deviation. No. of days per month instrument was in operation were: 1964—23, 25; 1965—24, 24, 19, 20, 30, 30, 31, 17, 22, 28, 28, 11.

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