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AEROSOL BLACK CARBON MEASUREMENTS AT THE SOUTH POLE: INITIAL RESULTS, 1986-1987

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Abstract. In December 1986 an aethalometer was installed at the NOAA/GMCC South Pole Observatory to measure concentrations of the combustion effluent tracer species aerosol black carbon (BC) with a time resolution of one hour. We present data covering a 1-yr period from December 1986 through November 1987. The hourly data show infrequent events in which the concentrations increased greatly for periods of a few hours. We attribute these events to local contamination and identified them as such in the database. The remaining background data then yield daily average BC concentrations generally ranging from 50 pg m^{-3} to 5 ng m^{-3}, with a minimum in the early austral winter. The results imply long-range transport of this aerosol species, and suggest a minimum value of the order of 10 pg m^{-3} for its global background concentration.

Introduction

The primary global source of energy production is the combustion of carbonaceous fuels, with a geographic distribution strongly biased to the northern hemisphere [Marland et al., 1985]. This results in the discharge to the atmosphere of both the major species carbon dioxide and water vapor, and of minor or trace effluents. One of these trace effluents is graphitic or "black" carbon emitted as submicron aerosol particles: This material is a good tracer for combustion emissions: it cannot be produced in the atmosphere by secondary mechanisms from precursors, it is not significantly transformed by atmospheric reactions, and it can have a long lifetime against deposition processes. It has been found in all studies in urban and regional locations [Wolff, 1984] as well as in the Arctic haze [Rosen et al., 1981; Hansen and Rosen, 1984a; Hansen and Novakov, 1988] and in remote oceanic locations [Andreae, 1984]. Its detection in the Arctic implies transport paths exceeding 8000 km [Bridgman et al., 1988].

Aerosol black carbon is both a tracer for combustion emissions as well as a species of chemical and physical consequence in its own right. Its large optical absorption cross section may perturb the solar radiation balance, both in the general troposphere [Coakley et al., 1983] and especially over highly reflecting surfaces [Shaw and Stamnes, 1980; Cess, 1983]. It may act as a condensation nucleus, altering the size distribution and optical properties of clouds [Twomey, 1977; Pueschel et al., 1981]. Its surface may act as a site for the catalytic oxidation of SO_2 to sulfate [Brodzinsky et al., 1980] and for the destruction of ozone [Stephens et al., 1986]. Its widespread distribution in the troposphere may lead to its eventual presence in the stratosphere [Chuan and Woods, 1984].

Graphitic carbon has been measured in the Antarctic snowpack in the vicinity of the South Pole Observatory [Warren, 1987] with clear indications of the effects of local sources on the areas downwind of the station. In this work, we use the 1-hr time resolution of the aethalometer to distinguish between local contamination events and measurements of background air. Without this capability, single short-term events can easily dominate an average collected over a longer period.

Experimental Details and Results

The aethalometer draws the sampled airstream at a flow rate of approximately 20 standard liters per minute through a 1.1-cm^2 active area of a quartz fiber filter while monitoring the transmission of light through the filter [Hansen and Rosen, 1984b]. The accumulation of aerosol black carbon on the filter causes this transmission to slowly diminish relative to a reference beam intensity. This technique is insensitive to optical scattering by aerosol species and is specific to aerosol black carbon [Gundel et al., 1984; Rosen et al., 1978]. At the low concentrations encountered at the South Pole, the filter is changed approximately every two weeks. The instrument was installed in the Clean Air Facility at the South Pole Observatory and draws its sample from the common inlet stack feeding other gas and aerosol analyzers. Data were recorded during the last 20 minutes of each hour by an HP71B computer and HP3421 data acquisition system, and stored on magnetic tape. These tapes were returned to GMCC when transportation to the South Pole opened in the austral summer. The data were first checked for gross errors, and then reduced to a series of 1-hr concentrations expressed in units of nanograms of black carbon per standard cubic meter.

We first scanned the hourly data to identify abnormal events which were clearly evident above a threshold set at 25 ng m^{-3}. Thirteen such local contamination events were identified in the data during 1987 and were extracted for separate

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