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Monitoring of Atmospheric Carbon Dioxide ($C0_2$) at Maitri, Antarctica

Sachin D. Ghude, S.L. Jain and B.C. Arya

Radio & Atmospheric Sciences Division
National Physical Laboratory, New Delhi - 110012, India

Abstract

The changing behavior of the atmospheric greenhouse gases, which are very fundamental to climate change, can be understood with the coverage of global measurements. In light of this an automated gas chromatograph has been setup in January 2002 at Maitri (70° 46'S, 11° 45'E) Antarctica for the measurements of greenhouse gases, such as Carbon Dioxide ($C0_2$), and Methane (CH_4). Annual average $C0_2$ found out to be 368.5 ppm. The $C0_2$ concentration was found to vary in between 360 ppm to 377 ppm during observational period. Monthly average $C0_2$ concentration showed rising trend however no seasonal variation was observed during the year 2002.

Introduction

The possibility of global warming due to anthropogenic and natural variations of greenhouse gases has been debated increasingly in the last few decades[1-5]. The current important issues, which are dangerous for the survival of life on the earth, are global greenhouse warming, regional increase in tropospheric ozone, urban and regional atmospheric pollution and the decrease in stratospheric ozone and ozone hole over antarctica[6-8]. Carbon, in the form of $C0_2$, carbonate and organic compounds, is cycled between three main reservoirs, namely the atmosphere, the terrestrial biosphere and the oceans. The observed increase of $C0_2$ in the atmosphere has come largely from fossil fuel combustion and cement production[9]. Fossil fuel combustion and the deforestation are the sources of the atmospheric $C0_2$ but the atmospheric concentration of the $C0_2$ is affected only by exchange between atmosphere and ocean. The green house effect of $C0_2$ increase, which has been the subject of scientific studies since later half of the nineteenth century[10], has gained tremendous momentum during last two decades. $C0_2$ is the critical element in the greenhouse effect, with a current radiative forcing of 1.46 Wm^{-2}, and most important agent of

potential future climate warming because of its large current greenhouse forcing, its substantial projected future forcing, and its long persistence in the atmosphere. Various investigators "~[18] have reported measurements of $C0_2$ in the upper troposphere as well as ground level. The most of the observations for green house gases are being made on western longitudes and almost no regular measurements in our region. In view of the above, online measurements of various green house gases have been started during 21st Indian Antarctic Scientific Expedition at Maitri and Methane in 22nd Expedition. In the present communication experimental setup and the results obtained are discussed.

Experimental Setup

Various techniques have been used for the continuous in suite measurement of atmospheric greenhouse gases at various places over globe. Keeling et al. (1976) and Bacastow (1981) reported gas flasks sampling technique for continuous measurement of $C0_2$ using nondispersive infrared gas analyzer at South Pole, Antarctica[19,,20]. Francey (1996) Langenfelds (2001) reported analysis of air sample collected from the South Pole using Gas Chromatograph [21]. The instrumentation system for the online measurement of surface $C0_2$ and CH_4 using gas chromatograph during measurement period at Maitri, Antarctica is as shown in Fig. 1.

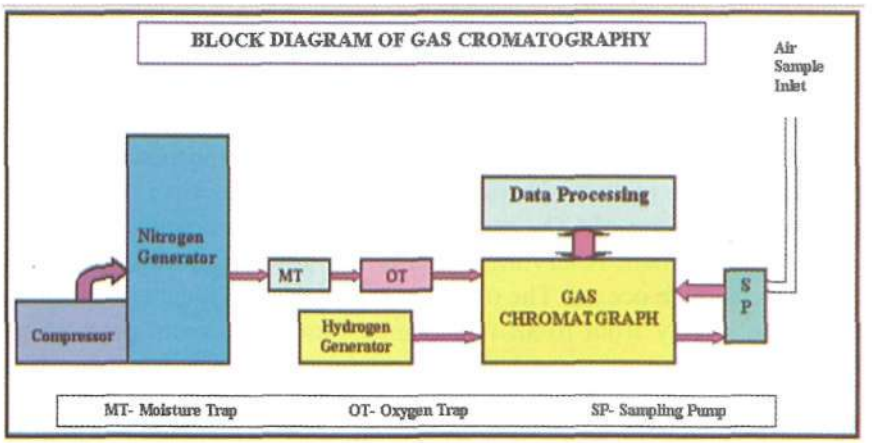

Fig. 1: Block diagram of gas chromatography

The instrumentation system has an independent nitrogen generator producing ultra high pure nitrogen as carrier gas at site that transports the

sample components through the column to the detector. The system also has separate Hydrogen Generator and inbuilt air compressor which is needed to produce flame for FID (flame ionization detector). The samples from ambient air are injected into the column by an online sampling pump for known interval of time. The entire process of online sample collection from ambient air and sample injection is handled by computer-controlled software. To achieve optimum separation, good accuracy and precision, good regulation of pressure and flow rate of mobile phase and temperature programming of the column is done using dedicated computer controlled software. Additional regulation for the gas supplies to FID is also done by same technique.

The switching of carrier gas is achieved using ten port switching valve already integrated in GC. Column switching is used to switch the carrier gas through sample loop and injects sample into the column at different interval of time, and also for venting, back-flushing, dual column operation and two achieve column switching. Two separate columns are incorporated to determine surface concentration of CH_4 and $C0_2$ respectively. As FID is less sensitive to $C0_2$, Methanizer is included which converts $C0_2$ into methane. The signal from FID is amplified and conditioned by a high input impedance amplifier needed for computer interface. Further it is processed by computer analytically to determine surface concentration of the interested species.

Results and Discussions

Under the present investigations the online measurements of $C0_2$ from air sample was carried out using automated gas chromatography at Maitri, Antarctica. Data was collected cyclically every day on half hourly basis during daytime and occasionally night times after accurately stabilization of the system. Once a week 24 hourly data were also taken. To obtain an error free data the system was calibrated on regular basis with 303-ppm standard $C0_2$ gas of M/S Scott Specialty Gases, USA.

Carbon Dioxide

The daily averaged concentration of atmospheric $C0_2$ at Maitri from February 2002 to February 2003 is depicted in Fig. 2. The gaps in data are due to the inability to conduct measurements during Antarctica blizzards. The concentration of carbon dioxide was found to vary from 360 ppm to 377 ppm during observational period. The annual average $C0_2$

during the year 2002 was found out to be 368.56 ppm. The values of $C0_2$ observed over Maitri are comparable to present Global $C0_2$ values.

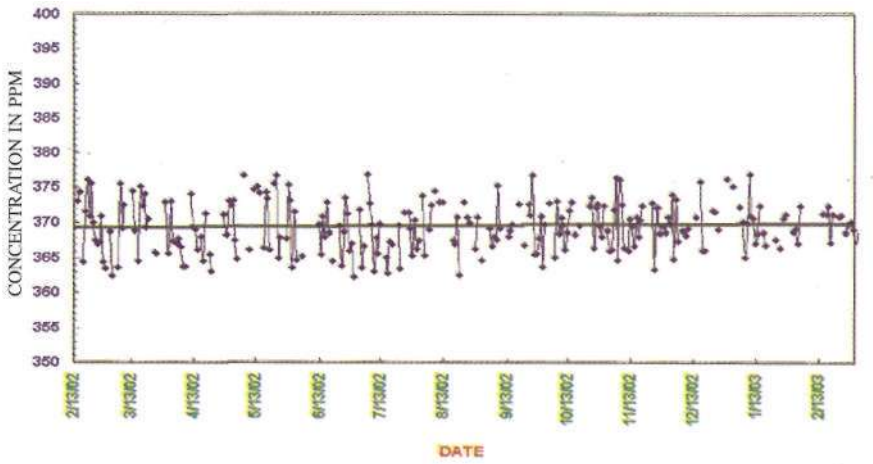

Fig. 2: Daily averaged $C0_2$ concentration during February 2002 to February 2003 at Maitri, Antarctica

The monthly average values of $C0_2$ showed no seasonal variation as seen in Fig. 3. These measurements indicate a rise in monthly average atmospheric $C0_2$ concentration from 367.82 ppm in Feb 2002 to 369.018 ppm in Feb 2003. Fig. 4 depicts the $C0_2$ measurement during May 2002. As high as has been 377 ppm observed and as low as 360 ppm of $C0_2$ during may 2002.

Methane

We could not measure methane concentration during 2002 due to masking of Methane peak by negative peak. We tried various options, however could not resolve the problem. The only Change in the system tested at NPL and at Maitri was that we had setup a dedicated nitrogen generator at Maitri to be used as a carrier gas to avoid carrying heavy cylinders from India. However during summer phase of 22nd expedition problem was rectified replacing Nitrogen Generator with pure nitrogen cylinder. Few chromatographs were also collected and analyzed and found that the methane concentration at Maitri Antarctica was about 1.7 ppm. The results on CH_4 will be discussed in detail in scientific report for 22nd expedition.

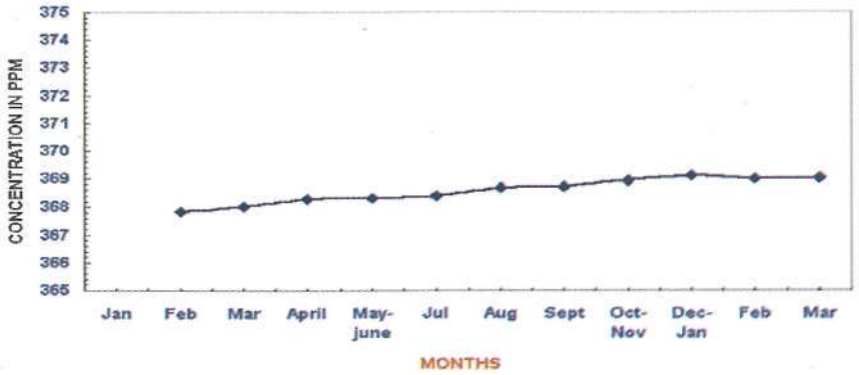

Fig. 3: Monthly averaged $C0_2$ concentration during 2002 at Maitri, Antarctica

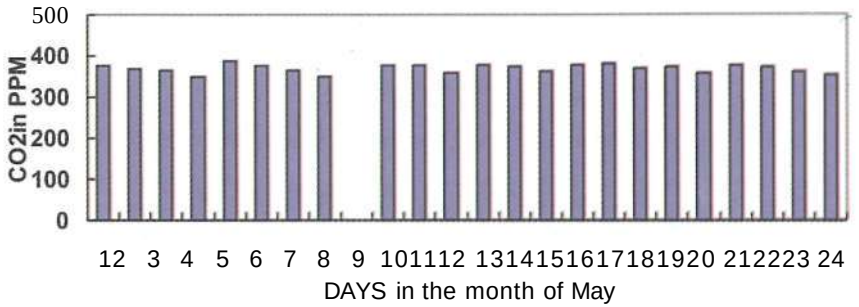

Fig. 4: Variation of atmospheric $C0_2$ during May 2002 at Maitri, Antarctica

The issues of global change are complex and the systematic observations of green house gases ($C0_2$, CH_4 N_20, CFC's, tropospheric ozone), reactive gases (CO, NOx, $S0_2$, VOCS), will aid in understanding the changing chemical composition of the atmosphere and related physical characteristics and will be useful in framing national and international policy decisions affecting the environment. The observations, made at high latitude like Antarctica will help to understand photochemical, heterogeneous and dynamical processes that control the distribution of atmospheric trace gases and hence the climate change.

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