Analysis of Tropospheric Carbon Monoxide using MOPITT data

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Abstract

The Measurement of Pollution in the Troposphere (MOPITT) instrument is an eight-channel gas correlation radiometer launched on the Earth Observing System (EOS) Terra spacecraft in 1999. Its main objectives are to measure carbon monoxide (CO) and methane (CH4) concentrations in the troposphere. This work analyzes tropospheric carbon monoxide distributions using MOPITT data in East Asia and compared ozone distributions. In general, seasonal CO variations are characterized by a spring peak and decreased in the summer. Also, this work revealed that the seasonal cycles of CO are spring maximum and summer minimum with averaged concentrations ranging from 118ppbv to 170ppbv. The CO monthly means show a similar profiles to those of O3. This fact clearly indicates that the high concentration of CO in spring is caused by two possible causes: the photochemical CO production in the troposphere, transport of the CO in the northeast Asia. The CO and O3 seasonal cycles in northeast Asia are influenced extensively by the seasonal exchange of the different types of air mass due to the Asian monsoon. The continental air masses contain high concentrations of O3 and CO due to higher continental background concentrations and sometimes due to the contribution of regional pollution. In summer the transport pattern is reversed. The Pacific marine air masses prevail over Korea, so that the marine air masses bring low concentrations of CO and O3, which tend to give the apparent minimum in summer.

Key words: MOPITT, carbon monoxide, methane

1. Introduction

The troposphere is a region of great chemical diversity and activity, containing many important trace gases produced by natural and anthropogenic processes at the surface and the troposphere. These trace gases affect the chemistry of the entire atmosphere and directly impact the quality of the air we breathe, while also playing impartnat roles in the greenhouse effect and climate change [Wang et al., 1998].

Atmospheric carbon monoxide (CO) plays an important role in tropospheric chemistry through reactions with the hydroxyl radical (OH) [Logan et al., 1981]. CO has significant natural sourced from the oxidation of methane (CH_4) and other non-methane-hydrocarbons (NMHC), as

well as significant anthropogenic sources from fossil fuel combustion and biomass burning [Novelli et al., 1992]. Understanding the impact of CO on global tropospheric chemistry requires global measurements of the atmospheric CO distribution. The Measurement of Pollution in the Troposphere (MOPITT) has measured the spatial and temporal distributions of CO and CH_4.

2. Data

The Measurements of Pollution in the Troposphere (MOPITT) instrument [Drummond, 1992] is an eight-channel gas correlation radiometer designed to measure tropospheric carbon monoxide (CO) and methane (CH_4). The instrument launched on the Earth Observing System (EOS) Terra spacecraft in 1999. The measurement goals are global distributions of tropospheric CO and CH4 at 22km horizontal resolution and 3km vertical resolution.

The basic measurement technique that is used by MOPITT is remote sensing by means of infrared radiometry. The instruments measure infrared radiation (IR); gas concentrations in the atmosphere are inferred from the IR measurements [Smith M.W., 1999]. Its main objectives are to measure CO and CH4 concentrations in the troposphere using a CO thermal channel at 4.7 μm and reflected solar channels for CO at 2.3 μm and CH_4 at 2.2 μm.

Measurements of ozone (O_3) have been conducted continuously at Pohang station from January 1995 and December 1999. The ozone was observed using balloon-borne ozonesondes.

3. Results and Discussion

Figure 1 shows the seasonal distribution of CO (monthly mean) concentration from March 2000 to February 2001. Figure 2 shows the seasonal variation of O_3 and CO concentrations. The seasonal cycle of carbon monoxide is somewhat similar to that of ozone as shown in Figure 2(b).

Fairly constant concentrations, which range form 40 to 50 ppbv are observed during winter time. The ozone concentrations increase during spring with a maximum (60 to 70 ppbv) in April, May and June. The main reason for a spring maximum of ozone could be a gradual accumulation of ozone in winter [Liu and Trainer, 1988] and abrupt enhancement of photochemical build-up of ozone in spring.

The CO concentrations increase during spring with maximum ($\geq$ 160 ppbv). On the other hand, the CO has minimum value (100 to 120 ppbv) during summer. As shown in Figure 1, the CO distribution over East Asia reflects the direct influence of transport on CO mixing ratios. In summer, however, clean oceanic air is transported to continental Asia from the south-east. The east Asian Pacific region including Korea and Japan is strongly influenced by the Asian monsoon [Kajii et al., 1998]. Continental outflows prevail during winter, spring and fall. On the contrary a Pacific high pressure system associated with low concentration of ozone covers widely over Korea and Japan during summer [Ogawa and Miyata, 1985]. Thus, most of the data at their regions show apparently low CO and O_3 concentration in summer [Sunwoo et al., 1994;

Pochanart et al., 1998]. To explain the seasonal cycle, the origins of the air mass reaching Korea is required to study on the basis of the isentropic backward trajectory analysis.

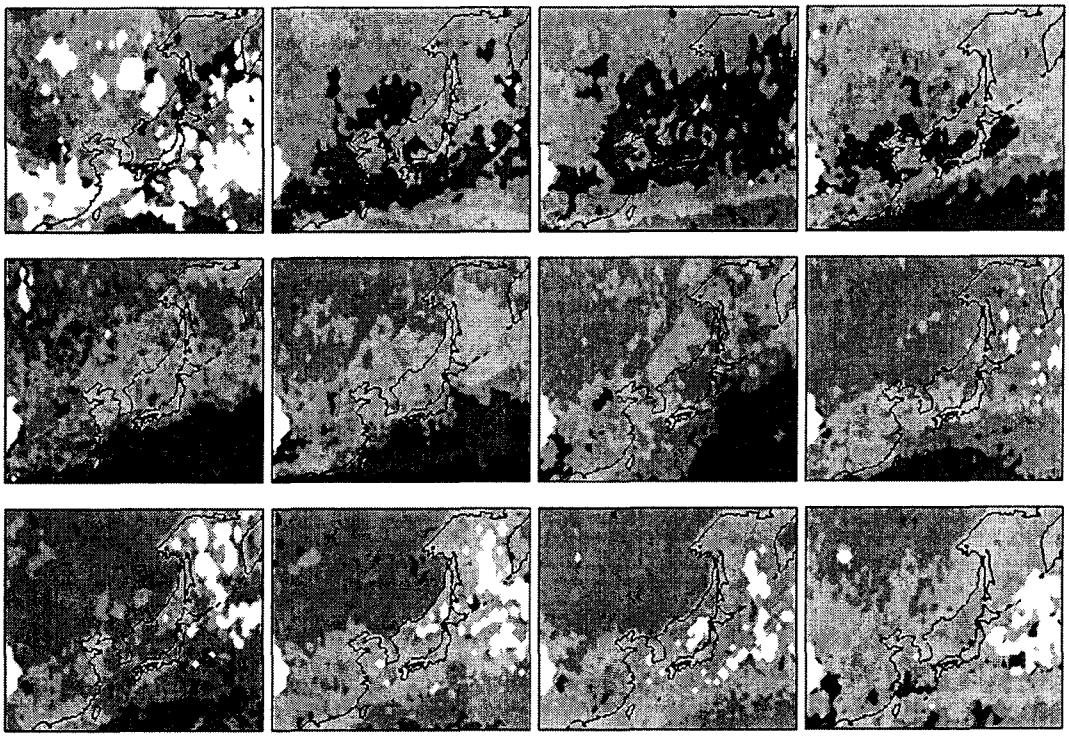

Figure 1. Monthly mean distribution of carbon monoxide concentration using MOPITT data (at 700hPa) from March 2000 to February 2001 (100E-160E, 10N-60N).

Since CO serves as a good tracer of combustion, correlation between CO and O_3 is often used for evaluation photochemical O_3 production [Parrish et al., 1993; Andreae et al., 1994]. The CO seasonal cycles are same with O_3 ones. These results suggest photochemical production is relatively well reproduced in the region of East Asia.

The sources of atmospheric CO are variable. Direct production by biological activity contributes substantially to the CO atmospheric budget. The CO is also produced in large quantities by burning of fossil fuels and by biomass burning. Although quite uncertain, the contribution of the latter could be very important.

The lifetime of CO (approx. 3 months) is long enough that it will be susceptible to atmospheric transports. However, its lifetime is also sufficiently short it is not completely mixed.

We will make a comparision between satellite CO and surface CO. It is expected to advance our understanding of global tropospheric carbon monoxide.

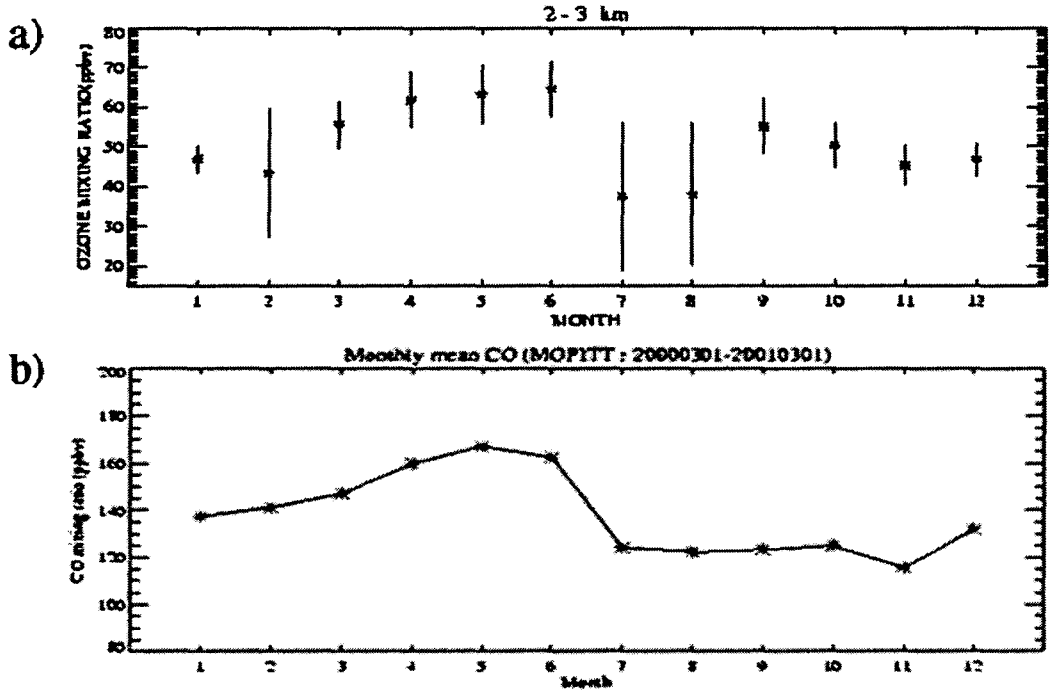

Figure 2. Seasonal variations of (a) ozone and (b) carbon monoxide (at 700hPa) concentration observed over Korea. Vertical bars on the observational data indicate standard deviation.

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