Korean Journal of Remote Sensing, Vol.19, No.3, 2003, pp.217~221

Analysis of Tropospheric Carbon Monoxide in the Northeast Asia from MOPITT

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Abstract : The Measurement of Pollution in the Troposphere (MOPITT) instrument is an eight-channel gas correlation radiometer that 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 study analyzes tropospheric carbon monoxide distributions using MOPITT data and compare with ozone distributions in Northeast Asia. In general, seasonal CO variations are characterized by a peak in spring and decrease in summer. Also, this study revealed that the seasonal cycles of CO are maximum in spring and minimum in summer with average concentrations ranging from 118ppbv to 170ppbv. The monthly average of CO shows a similar profile 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, or the transport of the CO in the northeast Asia. The CO and O_3 seasonal cycles in the 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 O_3 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 O_3, which tend to give the apparent minimum in summer.

Key Words : MOPITT, Carbon Monoxide, Methane, Ozone.

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 troposphere. These trace gases affect the chemistry of the entire atmosphere and directly impact the quality of the air we breathe, while also playing important 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 sources from the oxidation of methane (CH_4) and other non-methane-hydrocarbons (NMHC), as well as significant

Received 25 February 2003; Accepted 20 May 2003.

anthropogenic sources from fossil fuel combustion and biomass burning (Novelli *et al.*, 1992). Understanding the impact of CO on the global tropospheric chemistry requires measurements of the global CO distribution. The Measurement of Pollution in the Troposphere (MOPITT) measures the spatial and temporal distributions of CO and CH_4.

The ozone measurements for this study were obtained from a balloon-borne ozonesondes.

2. Data

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

The basic measurement technique of MOPITT is remote sensing using infrared radiometry. The instruments measure infrared radiation (IR); gas concentrations in the atmosphere are inferred from the IR measurements (Smith, 1999). Its main objectives are to measure CO and CH_4 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. Regional Distribution of Carbon Monoxide

Fig. 1 shows the seasonal distribution of CO (monthly average) concentration from March 2000 to February 2001 (100°E-160°E, 10°N-60°N). Red pixels show relatively high levels of carbon monoxide and blues are relatively low values.

Fig. 2 shows the seasonal variation of O_3 and CO concentrations. The seasonal cycle of carbon monoxide is somewhat similar to that of the ozone, as shown in Fig. 2(b). Fairly constant concentrations, which range form 40 to 50 ppbv are observed during winter. The ozone concentrations increase to a maximum (60 to 70 ppbv) during spring in April, May and June. The main reason for a spring maximum in the ozone could be due to 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 to a maximum ($\geq$ 160 ppbv) during spring. On the other hand, the CO has minimum value (100 to 120 ppbv) during summer. As shown in Fig. 1, the CO distribution over Northeast Asia reflects the direct influence of transport on CO mixing ratios. In summer, however, clean oceanic air is transported to continental Asia from the southeast. 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 of those regions show apparently low CO and O_3 concentrations 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.

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

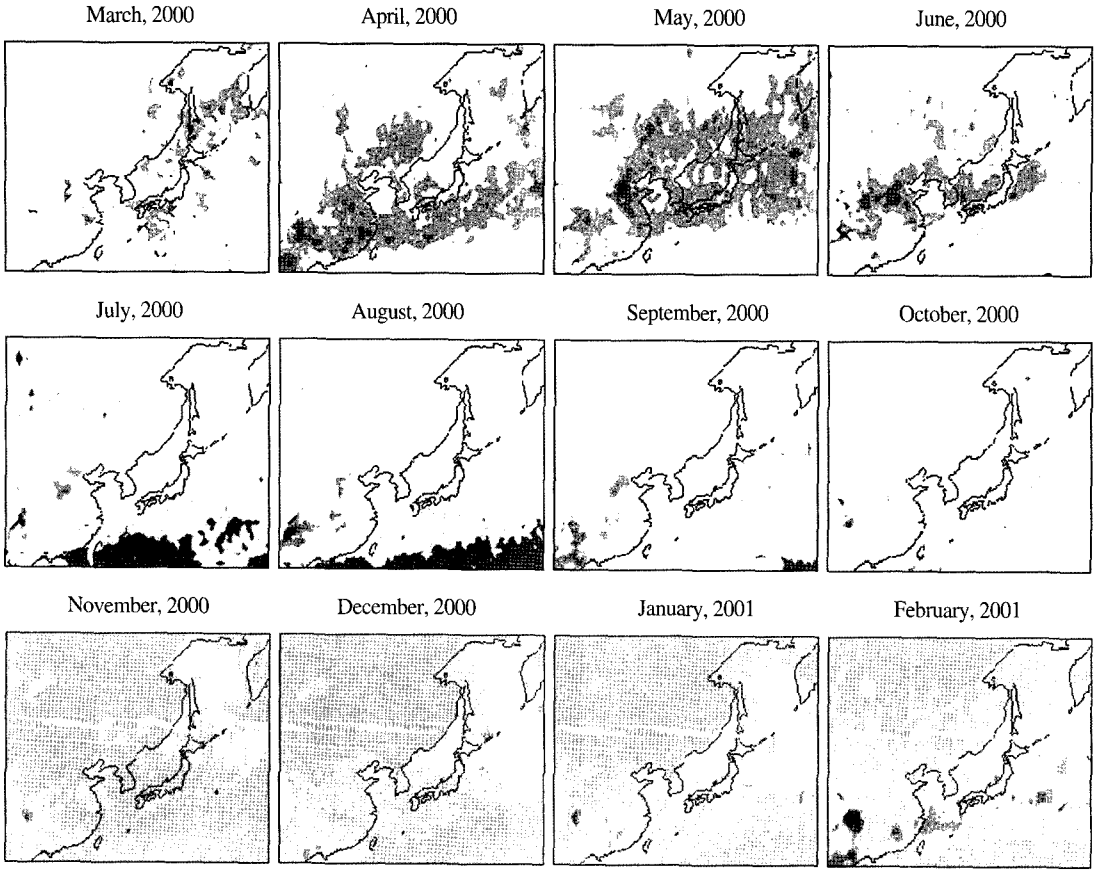

Fig. 1. Monthly average distribution of carbon monoxide concentration using MOPITT data (at 700hPa) from March 2000 to February 2001 (100(E-160(E, 10(N-60(N). Red pixels show relatively high levels (near 250ppbv) of carbon monoxide and blue pixels are relatively low values.

same as the O_3 cycles. These results suggest photochemical production is relatively well reproduced in the region of Northeast Asia.

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

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

4. Conclusions

Through this study, the global and regional morphology of carbon monoxide distributions have been generated.

The seasonal variation in the tropospheric carbon monoxide concent-rations shows a primary peak during spring. This suggests that the spring maximum may be caused by biomass burning and anthropogenic pollutants.

However, it is difficult to explain the source of origin of the spring maximum over Northeast Asia. Therefore, studies to analyze these origins, through the back

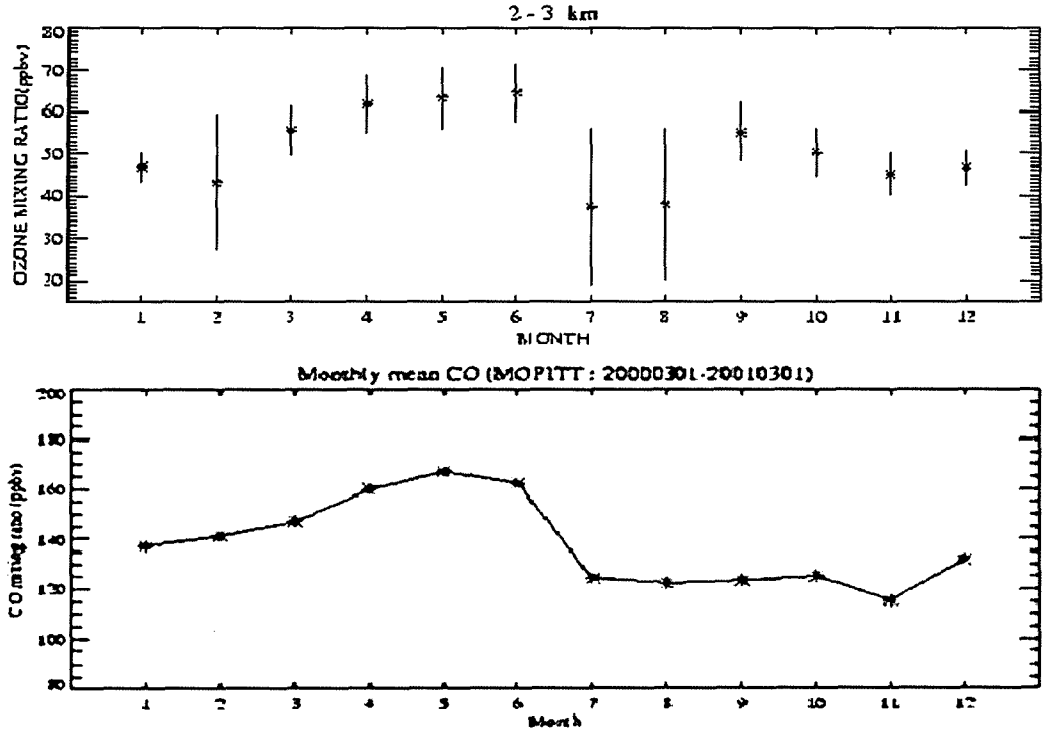

Fig. 2. Seasonal variations of (a) ozone and (b) carbon monoxide (at 700hPa) concentration observed over Korea. Vertical bars on the observational data indicate the standard deviation. 700hPa is equal to about 3 kilometer.

trajectory modeling. There is also a need for the daily analysis CO concentrations, and make a comparison between CO and measured by satellite and CO measured by surface. These studies are expected to advance our understanding of global tropospheric carbon monoxide.

Acknowledgements

This study has been supported by Advanced Environmental Monitoring Research Center/ KwangJu Institute of Science. The MOPITT data were obtained from the NASA Langley Research Center/ Atmospheric Sciences Data Center.

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