Evidence of Vertical Transport of CO from Biomass Burning Region as Observed from MOPITT

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SPARTAN

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1. Introduction

Atmospheric pollution in the troposphere is a global phenomenon in which local and regional scale surface emissions drive tropospheric chemistry on a hemispheric scale and directly impact on air quality.

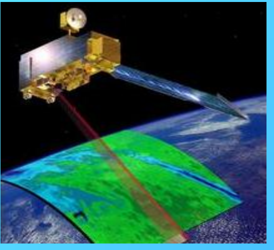
Human Activities - industrial, agricultural, residential, and transportation cause vast quantities of natural and synthetic chemical species to be emitted into the Earth's atmosphere. In developing countries such as China and India, the industrial and residential sectors, consisting of the combustion of coal, kerosene, and bio-fuels in stoves, cookers, and heaters, as well as gasoline in automobiles, generate the majority of the local surface emissions [*Streets et al.*, 2003].

One of these pollutants is carbon monoxide (CO), which is a primary component of incomplete combustion of fossil-fuel, bio-fuels, and biomass burning. CO is commonly used as an excellent maker of tropospheric pollution transport due to its life-time of approximately two months. Although it is mostly emitted at the surface, CO can be rapidly uplifted into mid and upper troposphere by convective systems, where it can be transported by global circulation systems. In addition to the emission at the surface, CO is also produced in the atmosphere through oxidation of methane (CH_4) and non-methane hydrocarbons (NMHCs) by the hydroxyl radical (OH). On long-term basis, CO plays a critical role in determining the oxidizing capacity of the atmosphere.

2. MOPITT Instrument

The MOPITT remote sensing instrument, onboard the NASA EOS Terra Satellite in December 1999, proved the feasibility of inferring tropospheric CO from measurements by a nadir viewing gas-correlation radiometry. The MOPITT instrument provides mixing ratios of CO at nominally 7 retrieval pressure levels from the surface to 150 hPa [*Deeter et al.*, 2003] to quantify surface CO emissions and track the transport of pollution.

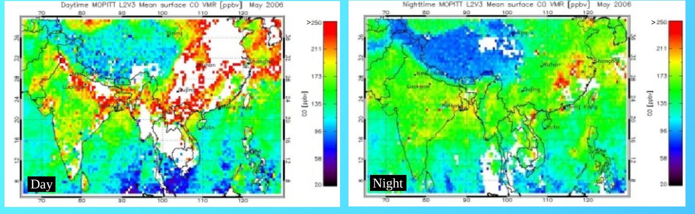
MOPITT measurements provide the opportunity to achieve global distributions of CO on a daily basis over long periods of time, however, the retrievals have limited vertical resolution but can generally distinguish between the lower and upper troposphere.



Here, emphasis is placed on identifying systematic effects of the vertical variations in the retrieved MOPITT CO profile (*Case study 1*) and the vertical transport of CO from biomass burning regions to the mid and upper troposphere (*Case study 2*).

3. Case Study 1: Emission of CO in the Indo-Gangetic Basin (May 2006)

MOPITT exhibits different vertical resolution and sensitivity between day and night time measurements over land. In particular, the averaging kernels for the lower retrievals levels exhibit a significant diurnal variation in sensitivity especially over land which have large diurnal surface temperature changes. Two measures can be used to differentiate vertical signal and to study information content of MOPITT CO profile. i) Day-Night differences and ii) 350hPa/850hPa CO ratio.



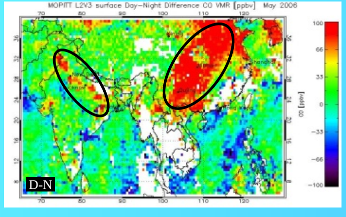
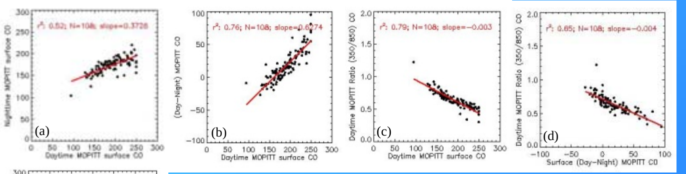


Figure 1. MOPITT day, night, day-night (D-N) difference 0.5 degree gridded monthly mean surface CO mixing ratios over China and India in May 2006. The (D-N) difference plot illustrate the improved sensitivity of the MOPITT retrieval to the lower troposphere and region of high surface CO concentrations (shown by oval shape).



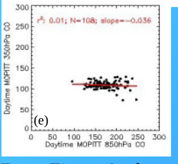
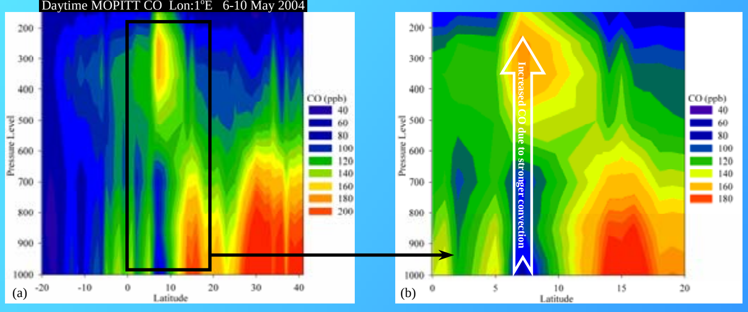


Figure 2 shows correlation between (a) daytime and nighttime MOPITT surface CO, (b) daytime MOPITT surface CO and (D-N) difference, (c) daytime MOPITT surface CO and ratio (350/850) CO (d) (D-N) difference and ratio (350/850) CO, and (e) daytime MOPITT 850 hPa and 350 hPa CO for Indo-Gangetic basin in the region 20-30ºN and 75-88ºE in May 2006.

From Figure 2, the strong correlation between the daytime and nighttime surface CO mixing ratios, their differences, and ratio (350/850) are observed. However, 850 and 350 hPa MOPITT CO mixing ratios are poorly correlated. This suggests that there is not much evidence for vertical transport of CO in the upper troposphere whereas it provides some information on CO in the lower troposphere.

4. Case Study 2: Vertical Transport of CO in African Biomass Burning region (May 2004)

In this section, we have used daytime MOPITT retrieved CO data to examine the case of vertical transport of CO from enhanced surface source regions to the upper troposphere. Estimates of outgoing longwave radiation (OLR) from National Oceanic and Atmospheric Administration (NOAA) polar-orbiting satellites are often used to distinguish areas of deep tropical convection and to examine the Earth's radiation budget. The pre-monsoon season in the tropics is characterized by a strong convergence at the lower troposphere and a divergence in the upper troposphere. The later associated monsoon circulation result in rapid vertical transport of polluted boundary layer air in this region.



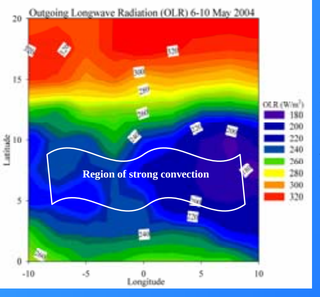


Figure 4 shows 5-day averaged 2.5 gridded NOAA interpolated OLR in the region 0-20ºN and 10ºW-10ºE. The OLR values less than 240 W/m^2 represent the region of strong convection.

Figure 3 (a) shows pressure-altitude cross-section plot of MOPITT retrieved CO data for 6-10 May 2004 in the region 20ºS-40ºN and 1ºE (b) represents the extended part of (a) for latitude 0-20ºN and shows the greatest CO mixing ratios in the upper troposphere (~250 hPa).

5. Summary

We have presented MOPITT retrieved CO data in May 2006 and 2004 with a focus on i) the surface CO emissions from industrialized regions and ii) to examine the vertical transport of CO from the planetary boundary layer to the mid and upper troposphere respectively. The following conclusions can be made from this study;

- The day, night, and (day-night) differences plots demonstrate the useful information about CO in the lower troposphere and hence surface fluxes.
- MOPITT CO retrievals show signatures of deep convection over biomass burning regions (e.g. Central Africa) result in the large surface emissions being uplifted to upper troposphere. This suggests some information on vertical transport of CO and its magnitude which is important for future predictions.

6. References

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7. Acknowledgment

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