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CO emissions from biomass burning in Southeast Asia in the 2006 El Nino year: Shipboard and AIRS satellite observations

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[Introduction]

During the dry season (October-November) in the 2006 ENSO year, we observed substantial CO enhancement over the western tropical Pacific by shipboard observations routinely operated between Japan and Australia/New Zealand. In this presentation, we present evidence of CO pollution episodes over the tropical Pacific due to intensive biomass fires in Southeast Asia and north Australia during 2006 El Nino year. We discuss locations of CO emissions from fires followed by long-range transport by combination of in-situ ship measurements, Atmospheric Infrared Sounder (AIRS) satellite observations, and Lagrangian particle dispersion model (FLEXPART).

[Method]

Beginning in November 2005, continuous monitoring of atmospheric trace gases has been initiated by using a commercial cargo vessel, M/V Transfuture 5 (TF5) (owned by Toyofuji Shipping Co. Ltd.). The ship takes regular service among ports of Japan, Australia and New Zealand with the 6 weeks interval, covering subtropical latitudinal region over North and South Pacific. The shipping route of TF5 is shown in Figure. Automated instruments were installed into an observation room for in situ measurements of CO, CO_2 and O_3.

[Result & Discussion]

Abnormal enhancements in CO were observed between 15N and the Equator during the southbound voyage (Episode 1), and around the Equator (Episode 2) during the northbound voyage, which had large impact on the seasonal variations of CO in the tropical Pacific. During Episode 1, AIRS satellite images and Global Fire Emissions Database version 2.1 (GFEDv2.1) suggested that the CO plume originated from biomass burning in Borneo and Sumatra followed by long-range transport to the tropical Pacific region. The amplitude of observed CO enhancement during Episode 2 was much smaller than that during Episode 1. Simulations by FLEXPART showed well consistent results with our analysis, which provides a reasonable interpretation of the data, complimenting in situ and satellite observations.

Correlations of CO to CO_2 and of O_3 to CO observed during two episodes were also examined. Scatter plots of CO versus CO_2 during Episode 1 showed significant correlation (R^2 = 0.60) with a steep dCO/dCO_2 slope (171 +/- 31 ppbv/ppmv at the 95% confidence interval). The dCO/dCO_2 ratio observed was higher than previously reported for savanna and grassland (63 +/- 20 ppbv/ppmv), tropical forest (103 +/- 21 ppbv/ppmv), and slightly higher that Indonesian peatland fires 142.7 ppbv/ppmv, indicating that Indonesian fires including peat soil burning are a dominant factor during Episode 1. Comparison between the dCO/dCO_2 ratio and CO/CO_2 emission ratios from GFEDv2.1 suggests the uncertainty in CO emissions of GFEDv2.1 in Southeast Asia region associated with peatland fires. Significant O_3-versus-CO correlation was observed only for Episode 1 (R^2 = 0.68). The dO_3/dCO ratio (0.05 +/- 0.01 ppbv/ppbv) was considerably smaller than values reported in previous observations in this region, which suggests that net O_3 production was not efficient in the burning plumes transported in the lower troposphere over the western tropical north Pacific. The reason for low dO_3/dCO ratio is not clear, but is likely associated with combustion properties of the peat and/or meteorological condition during the transport, both of which are specific to Southeast Asia region. Further research is needed to understand the low dO_3/dCO ratio in the long-range transport of the burning plumes over western tropical north Pacific in the lower troposphere.

Keywords: Carbon monoxide, Voluntary observing ship, AIRS, Southeast Asia, Biomass burning