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Seasonal and diurnal variations of methane and carbon dioxide in the highly polluted Kathmandu Valley, Nepal

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Anthropogenic emissions of carbon dioxide and methane - key greenhouse gases (GHGs) - are primary causes of global warming and resultant impacts. The atmospheric warming is more pronounced and likely to cause more serious damage in vulnerable areas such as the Hindukush-Karakorum-Himalayan region (HKH). The HKH region is a data gap region according to the 5^{th} Assessment report of the intergovernmental panel on climate change (IPCC). In order to understand the mixing ratios and variability of the key GHGs in the foothills of the Central Himalaya, we carried out continuous measurements of CO_2, CH_4, CO, and water vapor at Bode (an urban site in the Kathmandu valley, Nepal) for a year (March 2013 – Feb 2014), and again at Bode and at Chanban (a background outside the Valley) for 3 months (July 15 – Oct 3, 2015), with two state-of-the-art cavity ring-down instruments (Picarro G2401). The measurements were carried out as a part of the international air pollution measurement campaign: SusKat- ABC (Sustainable atmosphere for the Kathmandu Valley - Atmospheric Brown Clouds). The annual average CO_2 and CH_4 concentrations at Bode were 419 $\pm$ 24 and 2.192 $\pm$ 0.224 ppm, respectively, which are notably higher than those observed at the background site at Mauna Loa Observatory in the same period. The CO_2concentration at Bode was high during the pre-monsoon period and low during the monsoon, while CH_4 was high in winter and lower during the pre-monsoon period. The monthly CO_2concentration was highest in April. Forest fires and agro-waste burning in the region, and the local emissions in the Kathmandu valley were the main sources of the high CO_2 in the pre-monsoon period. CH_4 showed a maximum in September due to additional emissions from paddy fields. Seasonally, winter has the highest CH_4 concentration which is due to brick production, which is a seasonal activity, and other local sources combined with the shallow mixing layer height in winter. The diurnal pattern of CO_2 and CH_4 showed a high morning peak (7:00-8:00 local time), a daytime low and a nighttime high in all seasons. CO showed similar diurnal patterns in the pre-monsoon and winter. The high concentrations of CO_2 and CH_4 from January to April were primarily due to emissions from brick industries located in the south-east and eastern side of the valley. The concentrations of CO_2, CH_4 and CO at the rural site outside the valley (Chanban) were 3.8%, 12% and 64% lower than corresponding concentrations at Bode (urban site) during 3 months of observations. The difference in CO_2, CH_4 and CO concentrations between urban and rural sites indicates that the the Kathmandu Valley is highly affected by local emission sources, which, if addressed with appropriate mitigation measures, can bring substantial benefits to both local air quality and GHG reduction.