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Quantification of atmospheric formaldehyde by near-infrared cavity ring-down spectroscopy

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Formaldehyde is an important species in atmospheric chemistry, especially in urban environments, where it is a photochemically driven decay product of methane and volatile hydrocarbons. In addition, it is a toxic, carcinogenic compound that can contaminate ambient air from incomplete combustion, or outgassing of commercial products such as adhesives used to fabricate plywood or to affix indoor carpeting. Formaldehyde has a clearly resolved ro-vibrational absorption spectrum that is well-suited to optical analysis of formaldehyde concentration. We describe an instrument based on cavity ring-down spectroscopy for the real-time quantitative analysis of formaldehyde concentration in ambient air. The instrument has a precision (1-sigma) of about 1 ppb at a measurement rate of 1 second, and provides measurements of less than 100 ppt with minutes of averaging. The instrument provides stable measurements (drift < 1 ppb) over long periods of time (days). Because it is based upon high resolution optical absorption spectroscopy, it does not suffer from cross-talk with other aldehydes or other carbonyl containing compounds. The instrument has been ruggedized for both mobile applications or for unattended operation at ground monitoring stations, and with a fast response time of a couple of seconds, it is suitable for either for multipoint indoor air quality sampling, or for ground-based vehicle deployments for fenceline monitoring of formaldehyde emissions. The instrument also reports high quality measurements of water vapor and methane. We report the results of eight months of outdoor ambient atmospheric measurements at a 10 m urban tower. We observe diurnal, synoptic, and seasonal patterns in the data set, with daily peak concentrations ranging from about 1 ppb or less to more than 30 ppb for some intense pollution episodes.