Interactive comment on “The First Evaluation of Formaldehyde Column Observations by Pandora Spectrometers during the KORUS-AQ Field Study” by Elena Spinei et al.

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Received and published: 18 July 2018

We thank the reviewer for his/her thoughtful and constructive comments/recommendations.

< The description of the ground-based measurement technique (Sections 2.2) is insufficient. The Hottle et al. (2009) reference is for the LIF technique, which was not used here. Please include a more relevant reference and a more detailed description. More information on the instrument accuracy should be included, similar to the discussion of the CAMS measurement (page 13, lines 5-8). >

- We have expended the in-situ surface measurement description and added more appropriate reference: "Surface HCHO concentrations were measured at Mt. Taehwa and Olympic Park by tunable infrared laser direct absorption spectroscopy (Li et al., 2013) at mid-IR wavelengths (QC-TILDAS from Aerodyne Research, Inc). In situ HCHO measurements were conducted by the U.S. Environmental Protection Agency (EPA) at the Olympic Park Research Site, and by the Aerodyne Research, Inc. at the Mt. Taehwa Site.

Light from 1765 cm⁻¹ (Olympic Park) and 2831.6 cm⁻¹ (Mt. Taehwa) quantum cascade lasers were passed through a 0.5 liter absorption cell with an effective path length of 76 m. Air was sampled at 12 liters per minute from a heated glass inertial inlet system located at a height of around 10 and 15 meters above ground level for Olympic Park and Mt. Taehwa sites, respectively. The inertial inlet kept particulate matter greater than 100 nm out of the absorption cell in the instrument. A critical orifice controlled the instrument flow rate. The pumping speed dictated the cell pressure (35-45 torr). All tubing between the inertial inlet and the measurement cell was Teflon and heated to 30°C.

Absorption measurements were made relative to a zero air background gas obtained from an ultra-high purity zero air gas cylinder. Backgrounds were taken through the same inertial inlet that samples were measured. A 30 second background (with a 15 second flush time) was taken every 10 – 15 minutes. Nitrogen (N2) was flowed constantly through a permeation tube heated to 50°C to provide a reference gas. This was added to the sample stream for 90 seconds every 15 minutes as a standard addition to monitor instrument stability over time.

Spectra were averaged for 1 second intervals and fit using a non-linear least squares fitting algorithm, with parameters based on the HITRAN database (CITE). 1-second HCHO data was averaged to 10-second and 60-second averages to improve precision. Allan deviation (estimate for precision) for 10-second HCHO data is 0.100 ppb and for 60-second data is 0.060 ppb. Estimated accuracy is approximately 10%.”
The following sentence was deleted: "but varied by 20% in HCHO ∆SCD. The selected fitting scenario was in the middle of the spread."

The following sentence was modified: "Pinardi et al. (2013) reported that for multi-axis DOAS geometry (336.5-359 nm), error due to σ(O3) selection (Bogumil et al., 2003 vs. Malicet et al., 1995) can result in HCHO ∆SCD error of 13% (ΔSCD); σ(NO2) selection (Vandaele et al., 1998 vs. Burrows et al., 1998) - up to 5%, and σ(BrO) selection (Fleischmann et al., 2004 vs. Wilmouth et al., 1999) - about 2%, totaling 14%. Uncertainty in HCHO cross section is 9%.

The following was added: "Figure 2(b) shows an example of common optical depth residuals calculated by the DOAS fitting algorithm of 4537 cloud/spatial stray light free DS measurements and scaled by DS AMF. Figure 2(c) illustrates the effect of this residual spectrum on the retrieval of 0.5 DU (background levels) of HCHO. Some of this common residual spectrum is potentially due to ESS. At this point we estimate that the error due to ESS is on the order of 0.025 DU."

The following was added: "Pinardi et al. (2013) reported that for multi-axis DOAS geometry (336.5-359 nm), error due to σ(O3) selection (Bogumil et al., 2003 vs. Malicet et al., 1995) can result in HCHO ∆SCD error of 13% (ΔSCD); σ(NO2) selection (Vandaele et al., 1998 vs. Burrows et al., 1998) - up to 5%, and σ(BrO) selection (Fleischmann et al., 2004 vs. Wilmouth et al., 1999) - about 2%, totaling 14%. Uncertainty in HCHO cross section is 9%.

Page 30, final conclusion: It is worth noting here that the Pandora instrument performed about as well as an in-situ measurement combined with measured mixing layer heights (Table 3).

The reviewer’s recommendation is addressed in conclusion No. 9: "Comparison between Pandora and ‘ground-up’ columns over Olympic Park suggested that profile
shape (4) with measured MLH and exponential decay produced the best agreement (slope = 1.03 ± 0.03, intercept = 0.29 ± 0.02 DU and R2 = 0.78±0.02). The source of the offset bias is not clear at this point. These results suggest that reasonable estimation of the surface concentration can be done from the total column HCHO and MLH data.


Fig. 1. Figure 1 (see text for caption)