README: Trace-gas instrument info during SPIFFY

# Summer 2016:

## A common inlet was used for all three measurements.

A pumped bypass inlet is constructed of 45 feet of 3/8” o.d. PFA tubing operating at a flow rate of ~7 lpm. The inlet tip is positioned roughly 20 feet above ground near the second platform of the tower. Short segments (< 12” long) of ¼” o.d. PFA tubing and PFA tees are used to connect each analyzer to the pumped bypass inlet line. No external filters were used.

## NOx

Nitrogen oxides (NOx=NO+NO2) were measured using a commercial NO-O3 chemiluminescence (CL) analyzer (Thermo Scientific, model 42i-TL) operating in NO and NO2 sampling mode. The analyzer employs a heated molybdenum converter (325 ˚C) and is located inside the analyzer box for converting NO2 to NO prior to NO-O3 CL detection. Operated in this configuration, the NO2 measurement is known to have interferences from PANs, HNO3, and other reactive nitrogen species (Dunlea et al., 2007). The analyzer switches between measuring NO and NO2 every 10 seconds. Measurements are reported on a 1 minute averaged timescale given an instrument response time of 60 seconds. The analyzer is housed inside a trailer located at the base of the MEFO tower. The analyzer is calibrated in the field at the beginning, middle, and end of the deployment to a few known concentrations of NO over the range of the analyzer (0-100 ppbv). The calibration mixture is produced by standard addition of a NIST traceable (21.67 ppmv NO in N2 mixture, Airgas) to a flow of synthetic ultrapure air introduced at the back of the analyzer; the total flow of the calibration mixture is sufficient to overflow the analyzer. Known concentrations of NO2 are used to test the efficiency of the molybdenum converter. NO2 is generated by gas-phase titration of the NO standard with ozone. An LOD of 50 pptv is specified by the manufacturer of the commercial analyzer; uncertainties are ±5% for NO and ±8% for NO2 calculated from the quadrature sum of the individual uncertainties associated with the analyzer, calibration standard, and flow measurement devices.

## O3

Ozone was measured via UV absorption using a commercial analyzer (2B Technologies, Inc., model 202), which was calibrated with a NIST-traceable ozone calibration source (2B Technologies, Inc., model 306) over a 0-400 ppbv range. The manufacturer specifies the LOD (2 sigma) for the O3 measurement as 3 ppbv with an uncertainty of ±2% for the O3 analyzer.  Including an uncertainty of ±2% in the O3 generated by the calibrator unit and ±2% uncertainty in the NIST transfer standard, the total uncertainty calculated by quadrature sum is conservatively reported as ±5%. The 2B website is a good resource for the O3 monitor (model 202) and calibrator (model 306);<http://www.twobtech.com/model-202-ozone-monitor.html>.

## SO2

SO2 was measured using a commercial analyzer (Teledyne, model T100U) employing UV absorption. The analyzer was calibrated over a 0-100 ppbv range by standard addition of a NIST traceable (9.2 ppmv SO2 in air mixture, Matheson) to a flow of synthetic ultrapure introduced at the back of the analyzer; the total flow of the calibration mixture is sufficient to overflow the analyzer. An LOD of 50 pptv is specified by the manufacturer of the commercial analyzer; the uncertainty is ±5% for SO2 calculated from the quadrature sum of the individual uncertainties associated with the analyzer, calibration standard, and flow measurement devices.

# Fall 2016:

## Separate inlets were used for individual measurements.

## NOx

Nitrogen oxides (NOx=NO+NO2) were measured using a commercial NO-O3 chemiluminescence analyzer (Thermo Scientific, model 42i-TL) located in a trailer at the base of the MEFO tower and operating constantly in NO measure mode. A 395 nm LED-based converter (Air Quality Designs, Inc., model BLC), positioned as close to the inlet tip as possible, is used to convert NO2 to NO by UV photolysis (Dunlea et al., 2007). The resultant NO is then detected by the CL analyzer. The LED converter achieves chemically-selective photolysis of NO2 and >90% conversion to NO (Pollack et al., 2011). The LEDs in the NO2 converter are switched on and off every 1 minute, allowing for measurements of NO only when the LEDs are off and measurements of (NO+NO2converted) when the LEDs are on. Ambient NO2 is determined by subtracting a 2-minute average of measured NO from the corresponding 2-minute average of measured (NO+NO2converted) divided by the fraction of NO2 converted; measurements are reported on a 2 minute averaged timescale. A single sample line (~10 feet of ¼” PFA tubing) connects the inlet box, which was affixed to the roof of the trailer and positioned ~ 6 m a.g.l., to the detector located inside the trailer. The inlet line is protected by a light-blocking sleeve, preventing additional photolysis by sunlight in the tubing. A flow rate of 1 LPM through the detector corresponds to a plug flow residence time of approximately 6 s through the inlet tubing and converters; no filters were used. The analyzer is calibrated in the field at the beginning, middle, and end of the deployment to a few known concentrations of NO over the range of the analyzer (0-100 ppbv). The calibration mixture is produced by standard addition of a NIST traceable (21.67 ppmv NO in N2 mixture, Airgas) to a flow of synthetic ultrapure air introduced at the back of the analyzer; the total flow of the calibration mixture is sufficient to overflow the analyzer. Known concentrations of NO2 are used to test the efficiency of the molybdenum converter. NO2 is generated by gas-phase titration of the NO standard with ozone. An LOD of 50 pptv is specified by the manufacturer of the commercial analyzer; uncertainties are ±5% for NO and ±8% for NO2 calculated from the quadrature sum of the individual uncertainties associated with the analyzer, calibration standard, and flow measurement devices.

## O3

Ozone was measured via UV absorption using a commercial analyzer (2B Technologies, Inc., model 202). The inlet was constructed of ¼” PFA tubing and outfitted with a 47 mm diameter PFA filter housing equipped with a 5 μm PTFE filter membrane (Savillex) positioned at the inlet tip; membranes were changed weekly.  The analyzer was calibrated with a NIST-traceable ozone calibration source (2B Technologies, Inc., model 306) over a 0-400 ppbv range by overflowing the calibration mixture at the inlet tip. The manufacturer specifies the LOD (2 sigma) for the O3 measurement as 3 ppbv with an uncertainty of ±2% for the O3 analyzer.  Including an uncertainty of ±2% in the O3 generated by the calibrator unit and ±2% uncertainty in the NIST transfer standard, the total uncertainty calculated by quadrature sum is conservatively reported as ±5%. The 2B website is a good resource for the O3 monitor (model 202) and calibrator (model 306);<http://www.twobtech.com/model-202-ozone-monitor.html>.

## SO2

SO2 was measured using a commercial analyzer (Teledyne, model T100U) employing UV absorption. The inlet was constructed of ¼” PFA tubing and outfitted with a 47 mm diam. PFA filter housing equipped with a 5 μm PTFE filter membrane (Savillex) positioned at the inlet tip; membranes were changed weekly.  The analyzer was calibrated over a 0-100 ppbv range by standard addition of a NIST traceable (9.2 ppmv SO2 in air mixture, Matheson) to a flow of synthetic ultrapure introduced at the inlet tip; the total flow of the calibration mixture is sufficient to overflow the inlet. An LOD of 50 pptv is specified by the manufacturer of the commercial analyzer; the uncertainty is ±5% for SO2 calculated from the quadrature sum of the individual uncertainties associated with the analyzer, calibration standard, and flow measurement devices.