Ozone, Trace Gas, Particulate Matter and Key Indicator Measurements at ASRC's Rural Field Site in Addison, NY: 1995 - 2005

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INTRODUCTION

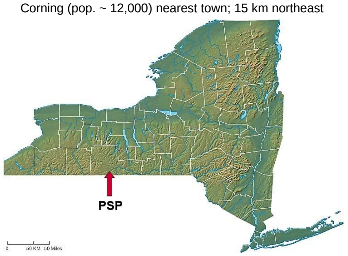
The linked issues of ozone and particulate matter pollution have been important problems in the field of tropospheric chemistry for many years. They are certain to remain important for many years into the future. Scientists have learned a tremendous amount about these topics, as illustrated by the assessment and review documents published on these topics. Still, there is much that remains to learn and understand. As with many problems facing the atmospheric science community, one is faced with the difficulty caused by the multiplicity of spatial scales required to fully describe the system and begin to unravel the processes involved. A regional or even larger outlook is required to describe transport, emissions, and many transformation processes; but local and even sub-local scales need to be included to describe variations in land use, point emissions, and micro-scale environmental conditions.

One important aspect of tropospheric chemistry research has been the surface measurement station. Stations with long term records of ozone and other trace gases have been cited extensively in the literature and in the numerous assessment documents. Continuous, long-term measurement records are generally available only from surface measurement stations. Surface stations can provide the opportunity to test and evaluate new and modified instruments deemed to be useful for the elucidation of important chemistry processes. We describe here one such research station, situated in a rural area of southwestern New York State, and give a glimpse of research results from this site.

SITE DESCRIPTION

Pinnacle State Park (PSP)

- Low population density rural village of Addison, New York
- Surrounded by parklands, and forested areas
- 42.09°N, 77.21°W, 504 m amsl
- Corning (pop. ~ 12,000) nearest town; 15 km northeast



Trace Gas Instrumentation

Trace Gas	Instrument Mfg. and Model	Measurement Method	Dates of Measurement	Data Frequency	Measurement Range	MDL (typical)
Ozone (O_3)	Thermo Model 49	UV Absorption	7/1/1995 – present	Minute/ Hour averages	1-1000 ppbv	2 ppbv
Nitric Oxide (NO)	Thermo Model 42S	Chemiluminescence (CL)	7/1/1995 – present	Minute/ Hour averages	0-50 ppbv	0.06 ppbv
Nitrogen Dioxide (NO_2)	Photolysis and Thermo Model 42S	Arc Lamp Photolysis of NO_2 followed by CL	7/1/1997 - present	Minute/Hour averages	0-50 ppbv	0.15 ppbv
Total Oxides of Nitrogen (NO_Y)	Moly Converter and Thermo Model 42S	Ambient heated moly converter followed by CL	7/1/1995 - present	Minute/Hour averages	0-50 ppbv	0.12 ppbv
Nitric Acid (HNO_3)	Denuder, moly converter and Thermo 42S	NaCl denuder, ambient moly converter and CL	12/16/1999 - present	Minute/Hour averages	0-50 ppbv	0.25 ppbv
Carbon Monoxide (CO)	Thermo Model 48S	NDIR gas filter correlation with native zeroing	7/1/1995 – present	Minute/Hour averages	0-1000 ppbv	10 ppbv
Sulfur Dioxide (SO_2)	Thermo Model 43BS	Pulsed Fluorescence	7/1/1995 - present	Minute/Hour averages	0-50 ppbv	0.06 ppbv
Hydrocarbons	Xontech Model 910A	Canister sampling / GC analysis	7/1/1995 – 8/27/2002	1-, 3-, or 6-hour samples	0-100 ppbC (minimum)	0.05 ppbC or better
Hydrocarbons	Perkin Elmer Ozone Precursor System	Automated sample thermal desorption GC analysis	Seasonal 1996-1998; 6/99-2/06	40 minutes samples every hour	0-100 ppbC (minimum)	0.2 ppbC or better
Formaldehyde (HCHO)	Alpha Omega MA100	Derivatization / liquid fluorescence	Various	10 minute averages	0-10 ppbv (varies)	0.15 ppbv

Particulate Matter Instrumentation

PM Property Measured	Instrument Mfg. and Model	Measurement Method	Dates of Measurement	Data Frequency	Measurement Range	MDL (typical)
$PM_{2.5}$ Mass	R&P Partisol Model 2025	Filter Collection – gravimetric analysis	8/1/1999 – present	Daily – 24-Hr averages	0-1000 µg/m³	0.5 µg/m³
$PM_{2.5}$ Mass and Species	R&P Partisol Model 2300	Filter Collection – various analyses	2/1/2001 – present	Every 3rd day – 24-Hr avg.	Varies with species	Varies with species
$PM_{2.5}$ Mass and Species	IMPROVE Sampler	Filter Collection – various analyses	4/1/2001 - present	Every 3rd day – 24-Hr avg.	Varies with species	Varies with species
$PM_{2.5}$ Sulfate and selected trace elements	R&P ACCU Sampler	Filter Collection – various analyses	7/1/2001 – 2/15/2005	Daily – 24-Hr averages	Varies with species	Varies with species
$PM_{2.5}$ Mass	R&P Model 1400AB TEOM	Inertial microbalance (IM), sensor at 50ºC	8/1/1999 - present	Minute/Hour averages	0-1000 µg/m³	1.5 µg/m³
$PM_{2.5}$ Mass	R&P Model 1400AB SES-equipped TEOM	IM, nafion dryer, sensor at 30ºC	3/25/2000 – 10/1/2003	Minute/Hour averages	0-1000 µg/m³	1.5 µg/m³
$PM_{2.5}$ Mass	R&P Model 8500 FDMS	Differentially switched IM	2/20/2003 - present	6 Minute/Hour averages	0-1000 µg/m³	2 µg/m³
PM_{10} Mass	R&P Model 1400AB TEOM	IM, sensor at 50ºC	7/1/2005 - present	Minute/Hour averages	0-1000 µg/m³	1.5 µg/m³
$PM_{2.5}$ Sulfate	Thermo Electron Model 5020	Reduction oven conversion – SO_2 detection	7/12/2004 – 11/2/2004; 10/25/2005 -	15-min or 1 Hr averages	0-100 µg/m³ sulfate	0.2 µg/m³
$PM_{2.5}$ Carbon	Sunset Labs RTECOC Analyzer	Sample collection on quartz filter – NDIR analysis	7/15/2004 - present	47 minute samples every hour	0-100 µg/m³ EC/OC/TC	EC: 0.2 µg/m³ OC: 0.2 µg/m³
$PM_{2.5-}$ scattering (dry)	OPTEC NGN-3 Nephelometer	Light scattering – heated sample	7/1/2001 - present	Minute/Hour averages	0-1000 Mm⁻¹	0.24 Mm⁻¹

Meteorological Instrumentation

Parameter	Instrument Mfg. and Model	Measurement Method	Dates of Measurement	Data Frequency	Measurement Range	MDL (typical)
Wind Speed	Met One 010	Cup Anemometer	7/1/1995 – present	Minute/Hour averages	0-60 m/s	0.28 m/s
Wind Direction	Met One 020	Balanced vane	7/1/1995 – present	Minute/Hour averages	0-360º	n/a
Temperature	Rotronic MP101A	Platinum Resistance Temperature Detector (RTD)	7/1/1995 - present	Minute/Hour averages	-40 to 60 ºC	0.2ºC
Relative Humidity	Rotronic MP101A	Humicap – variable capacitor	7/1/1995 – present	Minute/Hour averages	0-100%	1%
Barometric Pressure	Met One 090	Silicon Solid State Transducer	7/1/1995 - present	Minute/Hour averages	600-1000 millibar	0.1 millibar
Precipitation	Climatronics or Sierra Misco	Tipping Bucket	6/1/1996 - present	Minute/Hour averages	n/a	0.01 inch
Solar Radiation (total)	LICOR LI-200	Silicon photovoltaic detector – cosine corrected head	7/1/1995 - present	Minute/Hour averages	0-3000 W/m²	~ 2 W/m²
UV Radiation	Eppley 100TUVR	Selenium barrier layer photocell	8/1/1995 – 1/12005	Minute/Hour averages	0-70 W/m²	~0.2 W/m²

Data Products (Data Sets Generated)

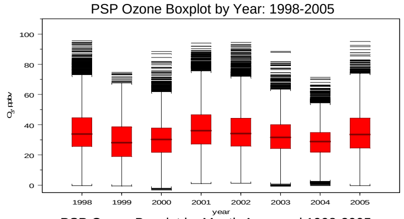
- Minute and Hour Data for continuous gas analyzers and met instruments - (1995 – JAS; June 1996 – present)
- Non-polar hydrocarbons (VOC's) – separate databases for canister samples and hourly AutoGC measurements
- Minute and hour data for TEOM monitors – August 1999 – present; for nephelometer – July 2001-present
- Hour data for sulfate and carbon PM analyzers – from installation to present
- Filter PM data – FRM and STN from NYSDEC; IMPROVE from web site; ACCU from NYSDOH
- Special studies – 1998, 2002, 2004

Analyses Performed

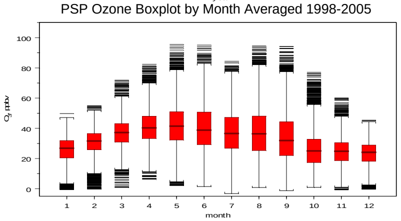
- Continuous data – averaged to hour (day), month, and year – standard deviations calculated for month and year averages
- Box and whisker plots for O_3, CO, SO_2, NO_x and NO_y. Plots done as annual averages, by month averaged over all years, monthly by year, and by hour by season in some cases.
- VOC data from AutoGC – monthly averages of hourly data
- Regression slopes of O_3 vs. NO_y and NO_z by month
- SO_2 and NO_y as a function of wind direction and season
- Frequency distribution of daily maximum hour averaged ozone
- Continuous $PM_{2.5}$ mass vs. filter-based (FRM) mass
- Continuous $PM_{2.5}$ sulfate and carbon vs. filter-based (STN, IMPROVE, and ACCU) concentrations
- Sum of sulfate and carbon (adjusted for ammonium and non-carbon organic mass) vs. continuous $PM_{2.5}$ mass
- Analyses linked to special studies

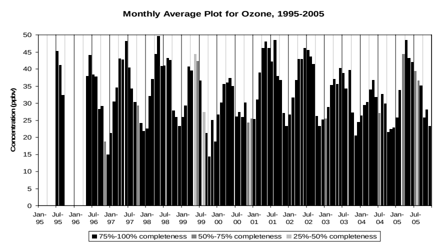
Data Examples

PSP Ozone Boxplot by Year: 1998-2005

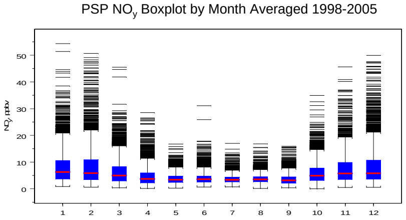


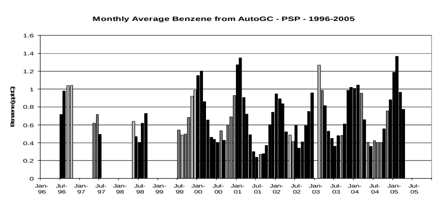
PSP Ozone Boxplot by Month Averaged 1998-2005

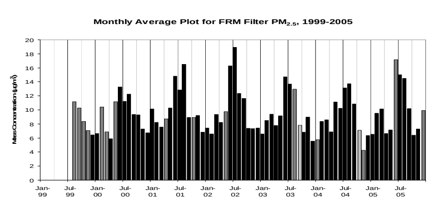




PSP NO_y Boxplot by Month Averaged 1998-2005

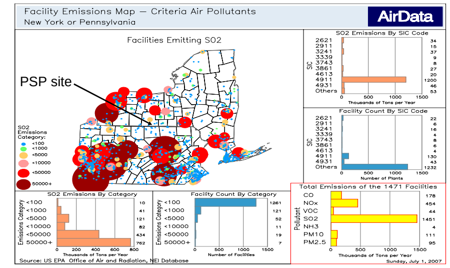




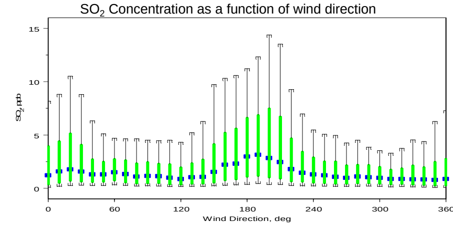


Analysis Examples

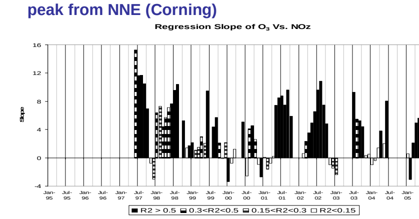
SO_2 Emission Sources



SO_2 Concentration as a function of wind direction



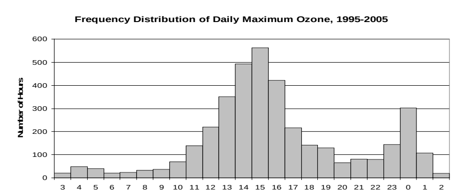
Highest SO_2 is from SSW (Pittsburgh), with a secondary peak from NNE (Corning)



Ozone Production Efficiency (OPE) = $\Delta O_3/\Delta NO_z$

$NO_z = NO_y - NO_x$ = products of photochemical oxidation of NO_x

Most years show summertime OPE's of 7-10, consistent with other measurements in North America (ref. NARSTO)



Secondary peak in frequency distribution around midnight confirms designation of PSP as a "transport-dominated" site.

Work In Progress – Future Work

- Complete (and refine as necessary) analyses discussed above
- Verify nephelometer data and compare aerosol scattering to $PM_{2.5}$mass, sulfate, and carbon
- Study regional particle production events – compare and contrast with our data from Queens and other studies in the region
- With continued support, continue and expand measurements and address issues related to air quality and atmospheric chemistry

Acknowledgements

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