CASTNET Ozone Measurements: Network Precision, Comparability, and Transitioning to 40 CFR Part 58, Appendix A

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Abstract:

Ground-level Ozone (O_3) is measured at over 1200 sites across the U.S. in both urban and rural areas. There are two main sources of surface-level ozone concentrations: data that is collected by the State and Local Ambient Monitoring Stations (SLAMS)* and data that are collected by the Clean Air Status and Trends Network (CASTNET). SLAMS ozone sites are mostly urban-based and data is stored and managed by the Air Quality System (AQS) whereas; CASTNET ozone measurements are regionally representative and data are managed by EPA and accessible on EPA's Clean Air Markets Division site: http://camddataandmaps.epa.gov/gdm/. Both networks have consistent and comprehensive quality assurance protocols with data extending back two decades. Understanding the comparability of the data from these two sources is important for assessment purposes and for uses of these data in evaluating emission control strategies, providing data for input to run and evaluate models, and for measuring overall progress of air pollution control programs. Combining data from both SLAMS and CASNTET provide greater spatial coverage and allows for assessment of transport from metropolitan areas to regional areas less impacted by local emission sources. Understanding the overall comparability of these two datasets and understanding any differences provide data users with the necessary information to perform more comprehensive ozone air quality assessments. CASTNET provides valuable information for evaluating various national and regional air pollution control programs and is the primary source for regionally representative, rural ozone measurements.

1) Comparisons of collocated pairs of ozone monitors operated by SLAMS and CASTNET are provided with information on overall precision estimates for each network.

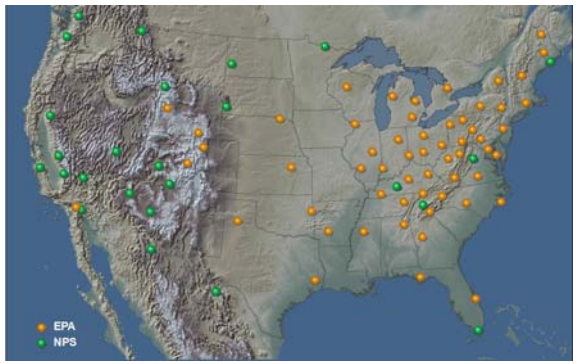
2) Results on accuracy from the CASTNET site audit program and evaluating single point precision checks for each network.

3) Progress and plans for transitioning CASTNET ozone monitoring operations to meet 40 CFR, Part 58 (Appendix A) requirements.

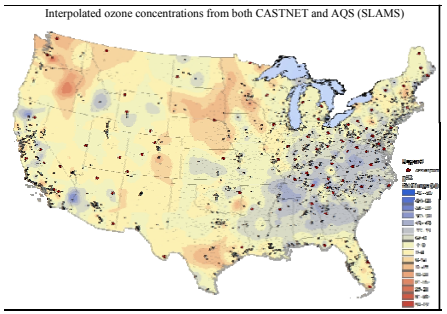
4) Interpolated map of using data from both CASTNET and AQS (SLAMS) sites.

* (SLAMS includes the subset of National Ambient Monitoring Stations (NAMS), proposed-NCore, and PAMS which measure ozone)

CASTNET: 84 Dry Deposition and Rural Ozone Monitoring Sites

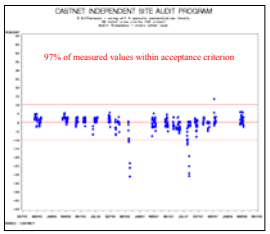


Interpolated ozone concentrations from both CASTNET and AQS (SLAMS)



CASTNET Site Audit Program

System and performance audits are performed at all network sites by an independent contractor (third-party) on a biannual basis. The CASTNET ozone inlet is sited at 10-meters with a particle filter. Each ozone analyzer is challenged with ozone-free air and four up-scale concentrations. Two challenges are in the range of 30-80 ppb, and one in each of 150-200 ppb, and 360-450 ppb. The ozone zero, span, and precision (zsp) calibration test gases are introduced at the ozone sample inlet, through all filters and the entire sample train. The ozone accuracy criterion for %difference is ≤ +/- 10% of the test gas concentration.



CASTNET/SLAMS Collocated Pairs

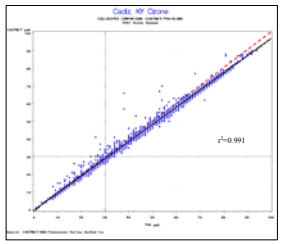


Figure B

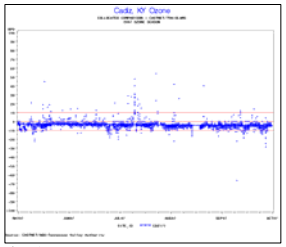


Figure A

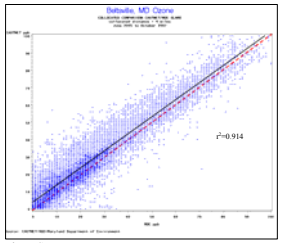


Figure C

The Tennessee Valley Authority (TVA), State of Kentucky, and EPA CASTNET have been cooperatively supporting monitoring at Cadiz, KY (CDZ171) for over two years. Cadiz has collocated ozone analyzers one run by CASTNET and the other by TVA/KY DEP (as a SLAMS site). The relative percent differences are plotted for the 2007 ozone season (figure A). The data tends to be within the precision criterion of +/- 10%, but indicates a negative bias. A regression is also presented for the 2007 ozone season with a 1:1 line (figure B).

Another relatively close ozone CASTNET/SLAMS pair is in Beltsville, MD. The sites are approximately four miles apart. A simple linear regression with a 1:1 line is provided for the time period June 2005 to October 2007 (figure C). Greater variance in the data can be partly attributed to the 4 miles distance between sites and their proximity to metropolitan activities.

Part 58, Appendix A Transition

CAMD is planning to transition CASTNET ozone monitoring operations to fully meet those outlined in 40 CFR, Part 58. This has required purchasing all new analyzers (Thermo 49i's) and data loggers (CR3000's) for each EPA sponsored CASTNET site. In addition prior to data submission to EPA's Air Quality System (AQS), data collected at compliant sites, will adhere to the appropriate data validation procedures, calibration and audit frequencies. This transition is underway and will be complete by the fourth quarter of 2010.

Currently, the ozone analyzers are not able to meet the strict criteria detailed in Part 58. Therefore, CAMD and the CASTNET contractor are exploring additional options for using the current monitors to meet the precision and accuracy checks required for compliance monitoring.

CAMD is testing the feasibility of using methods other than external ozone transfer standards at each site for to meet the quality assurance criteria. Currently, tests using alternative air compressors, external pressure regulators and an external ozone generator are being explored by the CASTNET contractor. A method that proves to be successful in the laboratory will then be tested in the field at a current CASTNET site(s) for 6-months or more measure the feasibility of long-term deployment throughout the network. At this time, EPA feels the network will be ready for compliance monitoring by the fourth quarter of 2010 provided the funding and resources are available to meet the QA criteria. In addition, if one of the methods being tested as a work-around for using the current 49i ozone analyzers proves to be successful, EPA has a goal of running 5 to 10 pilot sites meeting all Part 58 compliance requirements by March 2010.

All EPA CASTNET sites are scheduled to have the full independent audit in 2009. The funding of the additional audits required by compliance monitoring is being taken from the CASTNET budget at this time.

Collocated Pairs and Network Precision

CASTNET has operated collocated monitoring at eleven sites for network precision since its inception in the late 1980s. Currently, two collocated sites are maintained with identical sampling system configurations. The systems are located at Mackville, KY (MCK131/231) and Rocky Mountain NP, CO (ROM206/ROM406).

Collocated precision for CASTNET ozone measurements is calculated here using equation 10 of 40 CFR Part 58, Appendix A for each collocated pair to provide a relative percent difference (RPD) d_i. The coefficient of variation CV% is calculated using equation 11 (figures 1 and 2). Pairs with values less than 10 ppb were removed from collocated analysis.

x = primary analyzer
y = collocated analyzer

Equation 10

$$d_i = \frac{X_i - Y_i}{(X_i + Y_i)/2} \cdot 100$$

The Mackville systems are both operated by common site operators and calibrators and provide intra-system comparison while the Rocky Mountain N.P. systems are operated by independent site operators and calibrators and providing inter-system comparison between EPA and NPS sponsored sites.

CASTNET historic (1990-2006) network precision for Ozone from collocated pairs is estimated to be 5%. This is typically calculated using a mean absolute relative percent difference (MARPD) at quarterly and annual aggregations.

Network precision for SLAMS sites is determined primarily from on-site NIST traceable precision point checks that are run at least bi-weekly. Comparison between SLAMS and CASTNET regarding single point precision is limited due to differences in quality assurance protocols of QC checks therefore; a CV was not calculated for CASTNET precision point checks. Results from 2006 are presented for all analyzers in each network as percent differences using equation 1 and 2 of 40 CFR Part 58, Appendix A (figures 3 and 4).

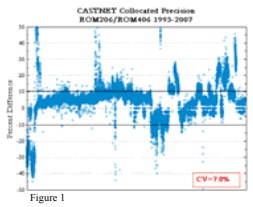


Figure 1

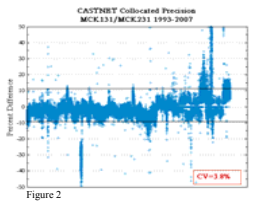


Figure 2

Note: concentrations pairs ≤ 10 ppb were removed from analysis in figures 1 and 2

Analyzer Precision Checks

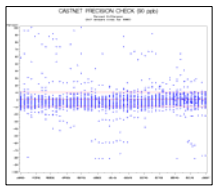


Figure 3

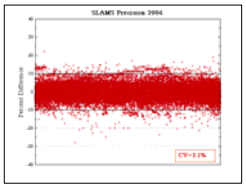


Figure 4

Conclusions:

Network Precision

- Collocated pairs of CASTNET sites provide a relatively good measure of network precision and is estimated to be 4-7% over 14 years (low concentration pairs, ≤ 10 ppb, were removed from analysis). More than two collocated sites are recommended for larger (over 50 sites) networks. Based on QA precision check data, SLAMS ozone monitor precision is estimated to be 3.1% for the year 2006.
- Despite differences in how each network (CASTNET and SLAMS) determines precision and the significantly larger number of SLAMS sites in AQS the coefficient of variance (CV) as derived is rather comparable.
- Where CASTNET and SLAMS sites are collocated together (physically at the same site) the data indicate very good correlation and low RPDs as demonstrated at by the Cadiz, KY site. However, monitors located just 5-6 km apart indicate more variability as demonstrated by the Beltsville, MD comparison.

CASTNET Accuracy Audit Results

- CASTNET ozone measurement accuracy as determined by CASTNET's independent site audit program provides evidence that network monitors are operating consistently with no bias compared to audit test gas concentrations. All sites will be audited annually beginning in 2009.

CASTNET Transition to 40 CFR Part 58, Appendix A

A subset of EPA-sponsored CASTNET ozone monitors will meet SLAMS/AQS audit requirements this year and all ozone operations and quality assurance will meet 40CFR Part 58, Appendix A by the end of 2010.

A more rigorous analysis of the two networks is necessary to further demonstrate the comparability of the two networks and understand the quality of each dataset however; based on the estimated network precision and direct collocated comparisons there is evidence of good overall comparability with regard to ozone measurements.