Modification of Network Sampling Systems for Measurement of NH$_3$

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MOTIVATION

Ammonia (NH$_3$) is the most important basic gas in the atmosphere and recent studies have shown that concentrations are steadily increasing. NH$_3$ contributes to particle formation by reaction with sulfuric and nitric acids thus has important implications for visibility impairment. Ammonia also is an important component of nitrogen deposition and has been shown to have deleterious affects on ecosystems as varied as pine forest to alpine tundra. Although the importance of NH$_3$ is well documented, no national network currently measures it on a routine basis. One way to alleviate this obvious discrepancy is to add additional filter media for absorption of NH$_3$ gas using existing network sampling systems as discussed below.

The CASTNET sampling system, shown below, is an open face filter-pack consisting of an array of filters designed to collect various airborne species, related to deposition.
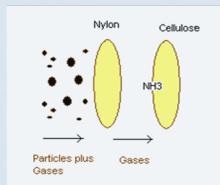

CASTNET Filter-Pack
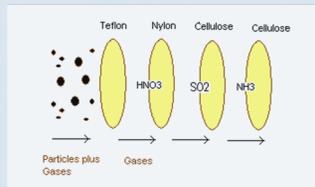
Schematic of filter-pack array

The IMPROVE Sampler utilizes a denuder to remove HNO$_3$, a cyclone to limit sample collection to PM$_{2.5}$ aerosol, and a filter-pack.
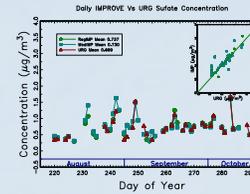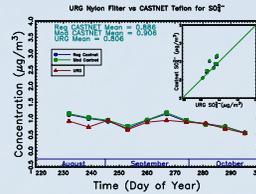

Inlet with denuder   Cyclone   Filter-Pack

Schematic of filter-pack array

The URG system utilizes a nitric acid denuder, an ammonia denuder, a filter pack, then a second ammonia denuder.

This sampling system collects gases first, then particles, and last the NH$_3$ gas volatilized from the filter.

Results of Initial Field Study

The plots of sulfate show that the addition of cellulose fiber filters, for collection of ammonia, to the CASTNET and IMPROVE filter-packs do not alter the concentration of other important species. The few CASTNET data points, which are slightly higher than the URG data points could be course sulfate, an artifact do to the lack of a cyclone on the CASTNET system.
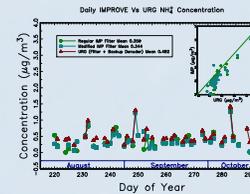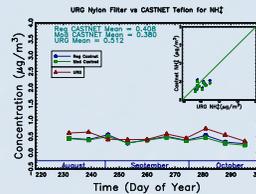
The plots of particulate ammonium ion show CASTNET and IMPROVE filter NH$_4$ versus the sum of URG filter NH$_4$ and URG backup denuder NH$_4$. This may be an example of the loss of particulate NH$_4$ from the IMPROVE nylon filter probably due to the volatilization of NH$_4$NO$_3$.
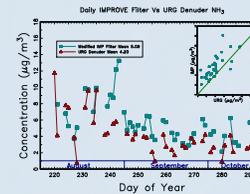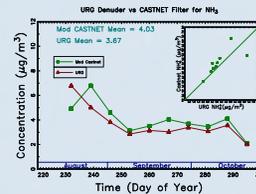
In general, the comparison of NH$_3$ between the URG denuder and impregnated cellulose fiber filters for CASTNET and IMPROVE show reasonable agreement between the samplers. It is expected that the URG sampler would exhibit slightly lower concentrations because the filter based systems would collect both NH$_3$ gas from the atmosphere and that volatilized from the filter. The discrepancy between the filter and denuder data is larger than can be explained by volatilization alone. Other explanations such as URG denuder efficiency, loss of NH$_3$ in the HNO$_3$ URG denuder, and contamination of impregnated filters are being investigated.
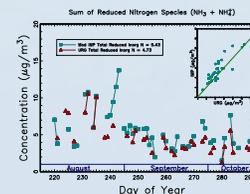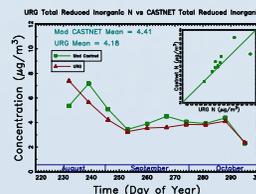
The plot of total inorganic nitrogen closely mimics the plot of NH$_3$ shown above because NH$_3$ dominates the total reduced N mass. The difference in the mean for CASTNET and URG of about 6 percent is very reasonable. The difference of 15 percent observed for the IMPROVE system and the URG is somewhat higher than we would like but not excessively poor. Again, these discrepancies are being investigated in current work.