TRACKING THE IMPACT OF EMISSION REDUCTIONS ON AIR QUALITY TRENDS AT WHITEFACE MOUNTAIN, NY

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Long term measurements of air pollutants provide the opportunity to track the progress and efficacy of implemented regulatory emission control actions. Over the past two decades primary air pollutants (SO_2, NO_x) have been reduced under regulatory programs including Acid Rain (Title IV), NOx SIP Call, Clean Air Interstate Rule (CAIR) and its subsequent replacement Cross-State Air Pollution Rule (CSAPR). These regulatory actions have resulted in estimated emission reductions of ~2.8% /yr in SO_2 and NOx since 1990. Measurements performed at Whiteface Mountain, which is situated predominantly downwind of the emission controlled regions, are analyzed to explore the atmospheric response to these emission changes.

Whiteface Mountain is located in the northern part of the Adirondack State Park in upstate New York (see Figure 1). The region is typically influenced by aged air masses that predominantly flow from the west and southwest transporting emissions from source regions in the Midwest. Less typical northerly flows are associated from clean air. Pollutant measurements at the Summit observatory (altitude 1,500m) (see Figure 2) include both primary (SO_2, NO_x, CO) and secondary (O_3, NO_2, NOy) air pollutants. A similar suite of gas phase as well as particulate matter (PM) mass and composition and chemical wet deposition measurements are carried out at Marble Mountain (altitude 600m) located to the northeast of the Summit and adjacent to ASRC's base of operations .

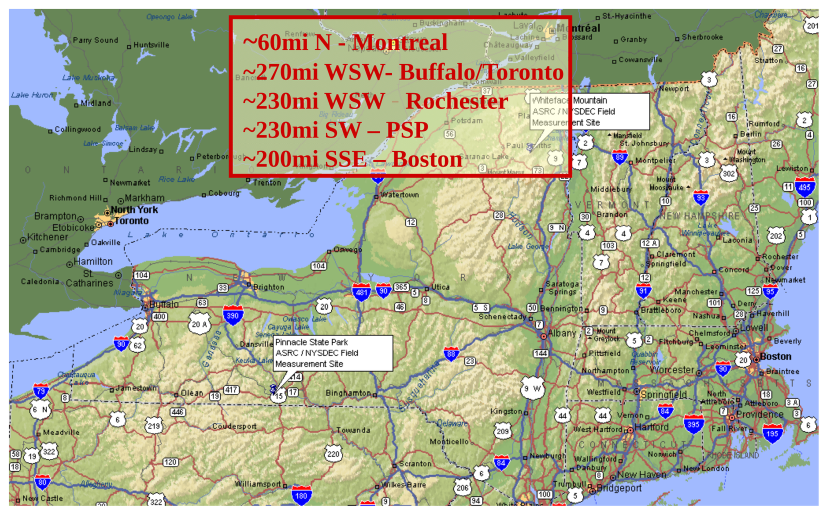


Figure 1. Map of northeastern U.S. and ASRC Summit and Pinnacle State Park monitor sites.

Figure 2. ASRC Summit Observatory (altitude 1,500m).

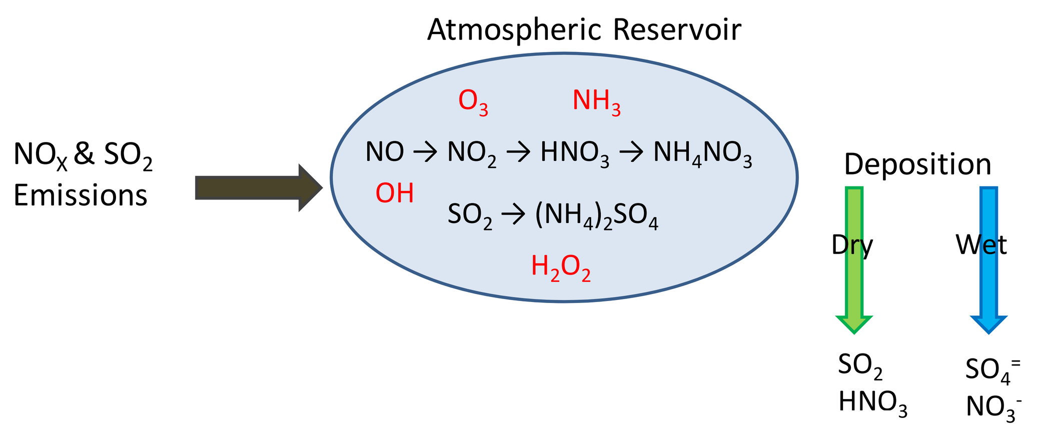
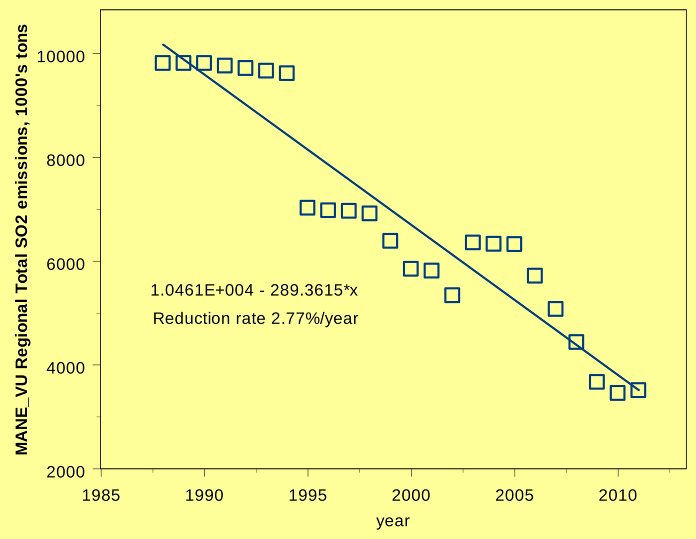
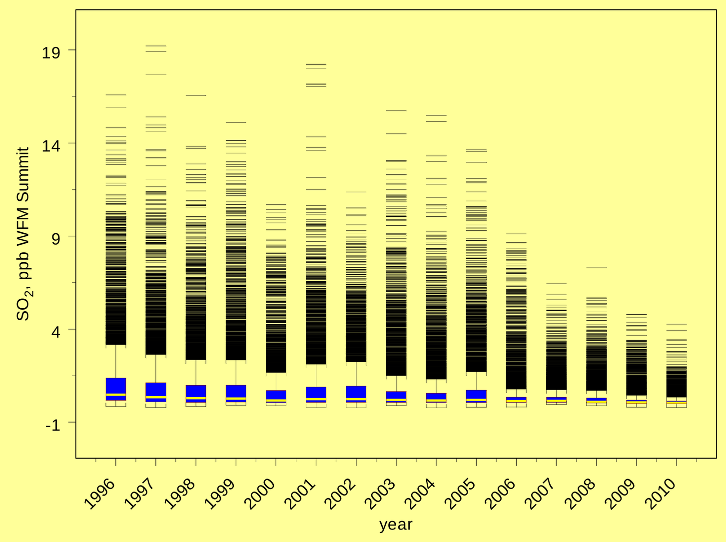
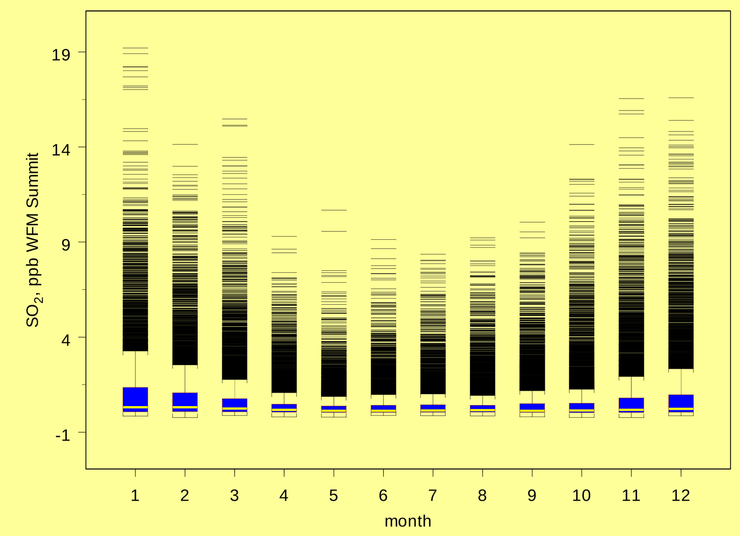


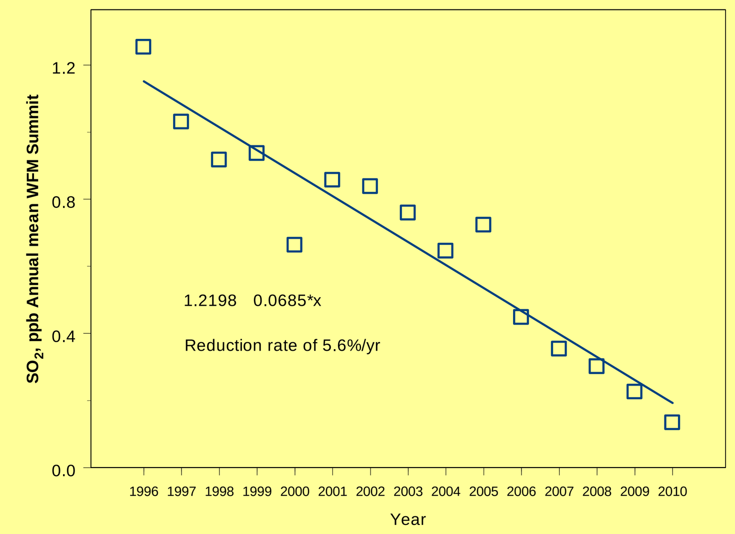
Figure 3. schematic of the processes affecting the transformation and partitioning of primary pollutants (SO_2 and NOx).

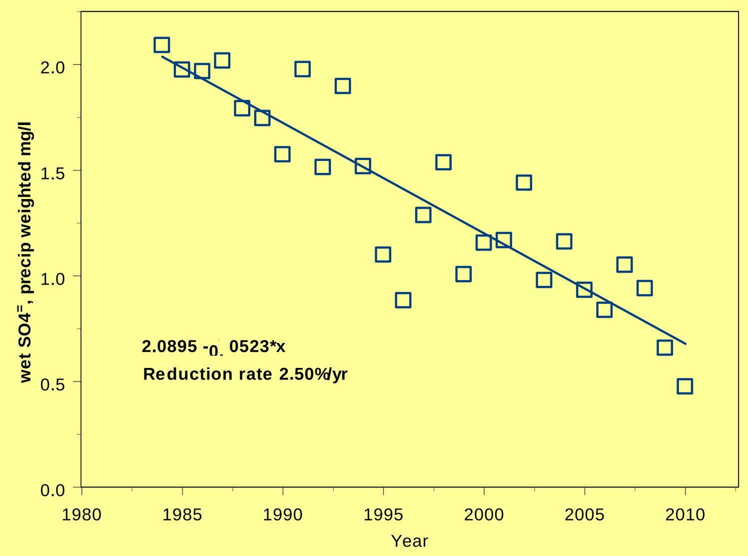
The chemical and physical pathways that affect the fate of SO_2 and NOx emission in the atmosphere are illustrated in Figure 3. These processes result in atmospheric lifetimes ranging from ~1/2- 3 days (the shorter lifetimes associated with NOx) and transport scales in the range of 200 to 1000 km. Trend analyses of these primary pollutants and their oxidation products are compared with emission trends to determine their consistency with implemented regulatory emission control actions.



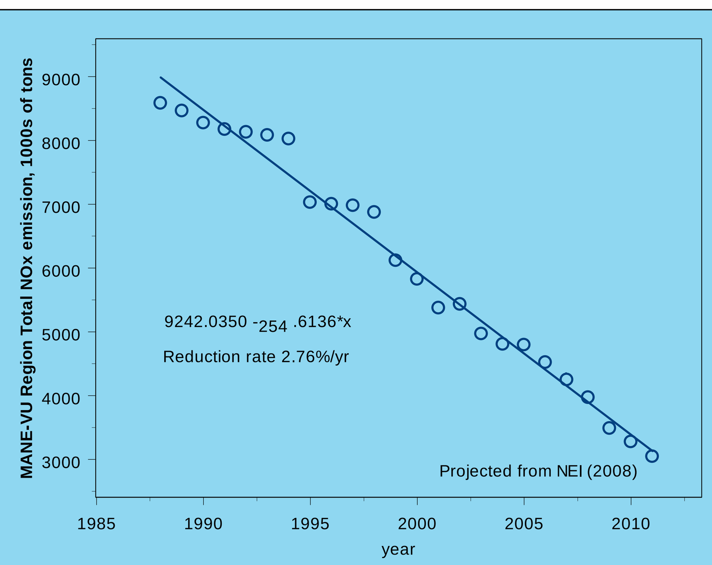


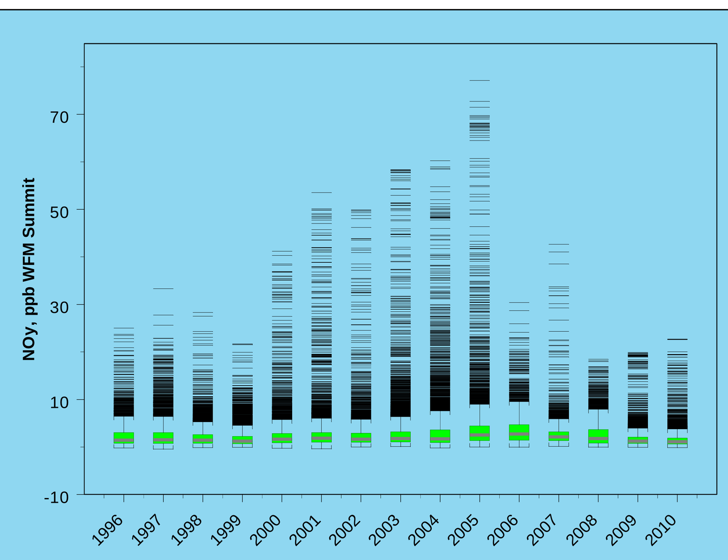


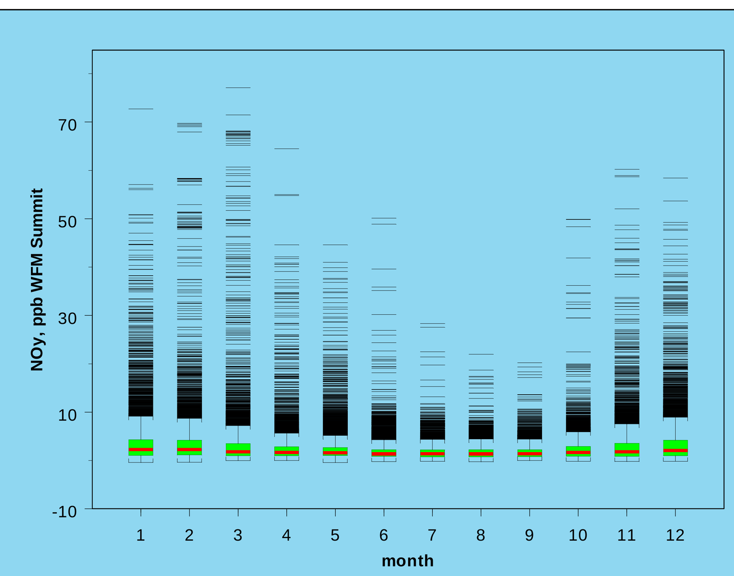


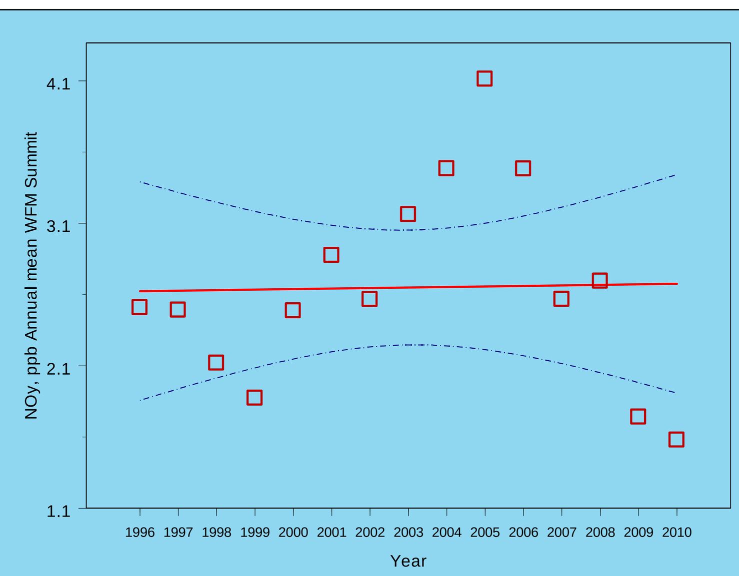


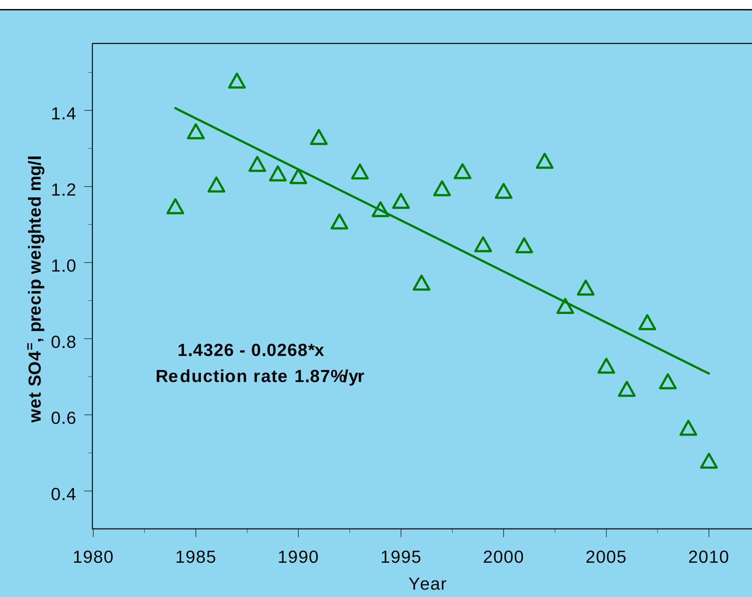
The sequence of graphs above from left to right show temporal trends in SO_2 emission estimates in the northeast (OTAG) region (1988-2011), Whiteface Mountain annual boxplots of hourly SO_2 measurement, monthly boxplots, annual mean linear regression of these data for the period 1996-2010. The final graph shows the annual mean linear regression of sulfate wet deposition measurements taken at the lodge level. The rate of reduction of the annual mean concentration of ambient SO_2 is 5.6 % /yr, while that for annual mean precipitation weighted wet sulfate deposition is 2.5% /yr . The wet rate of reduction is comparable with SO_2 estimated emissions reduction rate of 2.8% /yr, but less than that observed for ambient SO_2. The EPA National Trends Network (134 sites) reports an annual mean reduction in ambient SO_2 of 2.5 %/yr. The explanation for the factor of 2 difference between the national mean trend and that observed at Whiteface Mountain is not immediately apparent, but is likely due to enhanced SO_2 processing occurring in aged air parcels typically sampled at Whiteface.











The sequence of graphs above are similar to those for SO_2 above, but for nitrogen oxide species, where from left to right show temporal trends in NOx emission estimates, Whiteface Mountain annual boxplots of hourly NOy measurement, monthly boxplots, and annual mean linear regression of these data from1996-2010. The final graph shows the annual mean linear regression of nitrate wet deposition measurements. The rate of reduction of the annual mean concentration of ambient NOy shows no trend, while that for annual mean precipitation weighted wet nitrate deposition is 1.9% /yr . This is in comparison with NOx estimated emissions which indicate a reduction rate of 2.7% /yr. The EPA National Trends Network (151sites) reports an annual mean reduction in ambient NO_2 of 2.0 %/yr.

Conclusion:

Emission trends of SO_2 and NOx in the northeast over the past 20 years have been estimated to have very similar (i.e., ~2.8%) annual rates of reduction . The chemical lifetime of the SO_2 and NOx affects their transport and fate, which in turn affects sensitivity to detect emission changes in ambient reservoirs and atmospheric sinks.

Longer lived SO_2 shows trending in ambient SO_2 concentrations and sulfate wet deposition that is consistent with emission reduction rates, while trends in ambient NOy were not observed, likely due to NOx's very short lifetime and the significant distance between source and receptor (Whiteface Mountain).

These trend analyses demonstrate the utility of long-term environmental measurements in monitoring the efficacy of emission controls in achieving anticipated environmental/air quality outcomes, elements fundamental to establishing an "accountable" air quality management system.

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