1. INTRODUCTION

Nitric acid (HNO$_3$) was measured from an aircraft in the planetary boundary layer and free troposphere up to 7 km on 14 flights during the Texas Air Quality Study. The fast-response measurements of HNO$_3$ reported here were obtained between August 16, 2000 and September 13, 2000 aboard the NCAR Electra aircraft, which was based at Ellington Field, Texas.

By characterizing HNO$_3$ formation and loss in the troposphere, the fate of NO$_x$ emissions and the rate and yield of O$_3$ production can be better understood. HNO$_3$ measured here is formed from the oxidation of NO$_x$ and lost by wet and dry deposition.

Flight plans were designed to investigate the evolution of emissions from point sources (primarily power plants and refineries) and urban areas. The aircraft interrogated air masses both upwind and at various distances downwind from regions with high NO$_x$ or VOC emissions. When the aircraft intersected plumes from point sources, plume widths were typically on the order of a km when the aircraft was less than approximately 20 km from the point source. Since the aircraft speed was 110 m/s, the aircraft crossed these recently emitted plumes in several seconds. Hence, instruments with a rapid time response (approximately 1 s) are essential for capturing these rapid transients in the atmosphere.

2. MEASUREMENTS

Using a chemical ionization mass spectrometer (CIMS) with SiF$_5^-$ reagent ions, HNO$_3$ mixing ratios were measured at a 1 Hz sample rate. HNO$_3$ measurement using this highly selective ion chemistry is not degraded by large water vapor concentrations or interferences from other species. Rapid time response (1 s) is achieved using a heated Teflon inlet. In-flight standard addition calibrations from a HNO$_3$ permeation source were used to determine the instrument sensitivity of $1.1 \pm 0.1$ Hz/pptv. Contributions to the HNO$_3$ signal from instrument artifacts were accounted for by regularly performing in-flight instrument background checks, where HNO$_3$ was removed from the ambient air sample by diverting the sampled air though a nylon wool filter located near the inlet tip, shown in Figure 1.

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Measurement accuracy, which is determined from uncertainties in the standard addition calibrations and background measurements, is the sum of ±10% and ±130 pptv.

3. RESULTS

HNO₃ mixing ratios ranged from less than 100 pptv in the free troposphere to over 15 ppbv in the boundary layer downwind from Houston. Coincident in-situ measurements of other reactive nitrogen species are used to examine NOₓ partitioning and HNO₃ formation during this month-long measurement campaign. Rapid HNO₃ formation is frequently observed in pollution plumes from power plants, urban areas, and refineries. An example of these measurements (Figure 2) and the correlations between the measured reactive nitrogen species (Figure 3) are shown for a transect of a power plant plume.

![Figure 2](image_url)

**Figure 2.** Measurements recorded during a flight transect approximately 36 km downwind from the Parish power plant on August 28, 2000, at an altitude of 650 m.

![Figure 3](image_url)

**Figure 3.** 1 second measurements of HNO₃ (solid circles) and NOₓ (open circles) as a function of NOᵧ for the flight transect shown in Figure 2. Correlation slopes determined from linear least squares fits of this data give ΔNOₓ/NOᵧ = 0.75 and ΔHNO₃/NOᵧ = 0.25. In these plumes, a compact correlation between the reactive nitrogen species is typically observed, indicating a similarly rapid time response for each of the measurements.

Efficient HNO₃ formation from a power plant plume shown here is contrasted with the HNO₃ formation observed in plumes from urban and refinery sources. In photochemically aged power plant, urban, and refinery plumes, HNO₃ production is most favored in power plant plumes and least favored in refinery plumes.