

Real-time Airborne Determination of Aerosol Ionic Composition Using the PILS Instrument During the Texas 2000 Air Quality Study

Yin-Nan Lee and Zhiguang Song
Atmospheric Sciences Division
Brookhaven National Laboratory

Rodney Weber
School of Earth and Atmospheric Sciences
Georgia Institute of Technology

Outline

- Instrument description
- Examples of measurement results
- Evaluation of instrument performance
- Scientific insights
- Future directions

Principle of the PILS Technique

- Aerosol particles are grown to super micron size under super-saturated conditions created by mixing sample air with steam; particles of 100 nm diameter are activated with a >90% efficiency.
- The resulting super micron size droplets are collected by a single orifice jet impactor; 50% collection efficiency is at $\sim 1 \mu\text{m}$.

IC Analysis

- Liquid sample collected at the impactor surface is transported to the IC's sample loops using a constant carrier flow (ca. 0.2 mL min^{-1})
- Samples are injected into the IC for analysis every 3 minutes, which is the time required to elute the major ions.
- Sample integration time is governed by the carrier flow rate and the sample loop size; 70 s during the TexAqs 2000 study.

IC Analysis - continued

- A dual IC system allows both the cations, Na^+ , NH_4^+ , K^+ , and Ca^{2+} , and the anions, Cl^- , MeSO_3^- , NO_3^- , and SO_4^{2-} , to be determined.
- The limit of detection, based on the IC analysis (ca. $0.1 \mu\text{M}$) and a sample flow rate of 5.0 L min^{-1} , is estimated to be $\sim 0.1 \mu\text{g m}^{-3}$ for these ions.

Characteristics of the PILS Measurement

- Sample flow rate = 5.0 L min^{-1}
- Steam flow rate = 0.40 mL min^{-1}
- Limit of detection of IC $\sim 0.1 \text{ } \mu\text{M}$
- Limit of detection of aerosol mass $\sim 0.1 \text{ } \mu\text{g m}^{-3}$

A PILS System Outfitted on the DOE G1 Aircraft during TexAqs 2000



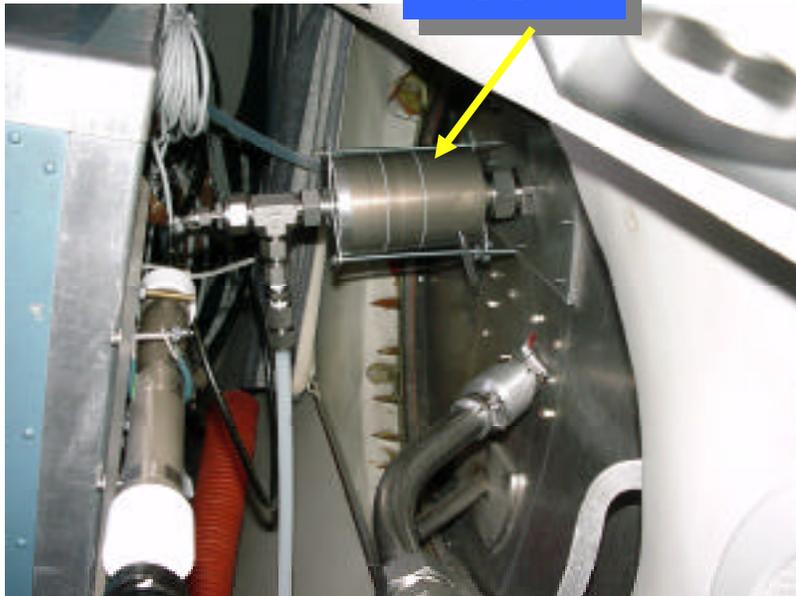
PILS

Inlet Arrangement

- Inlet nozzle with a 2.5 mm diameter opening for isokinetic sampling at a 30 L min^{-1} flow rate.
- 7 degree tapering to mate an 1" OD ss tubing.
- A MOUDI impactor for a $2.5 \mu\text{m}$ size cut.
- Glass annular denuders to remove gaseous SO_2 , HNO_3 , and NH_3 .

Inlet arrangement for the PILS - continued

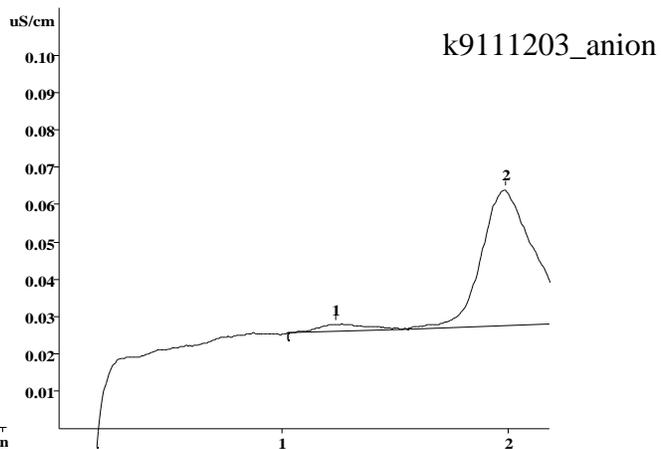
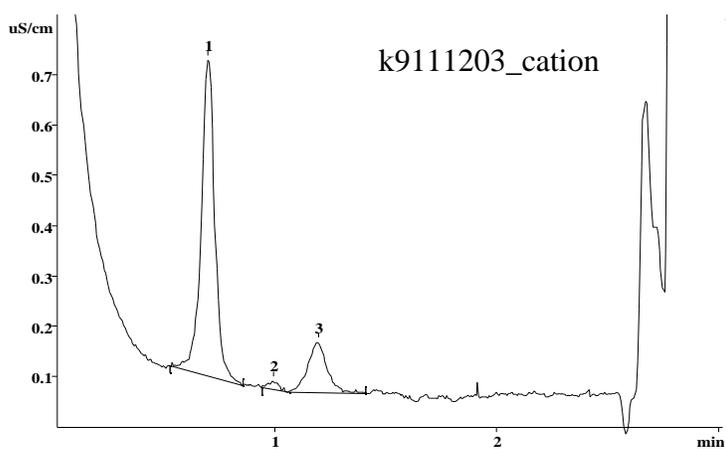
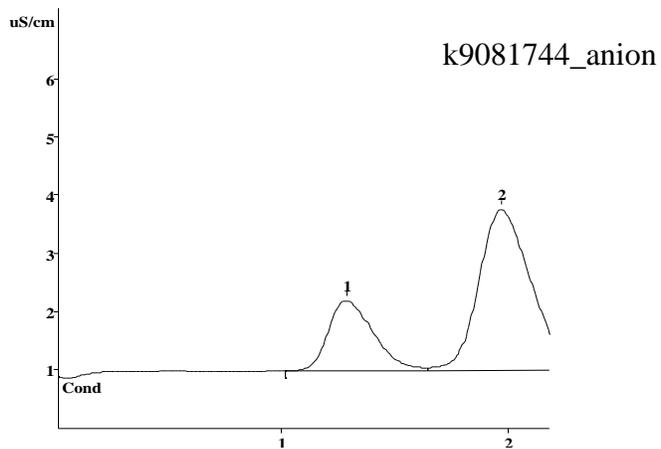
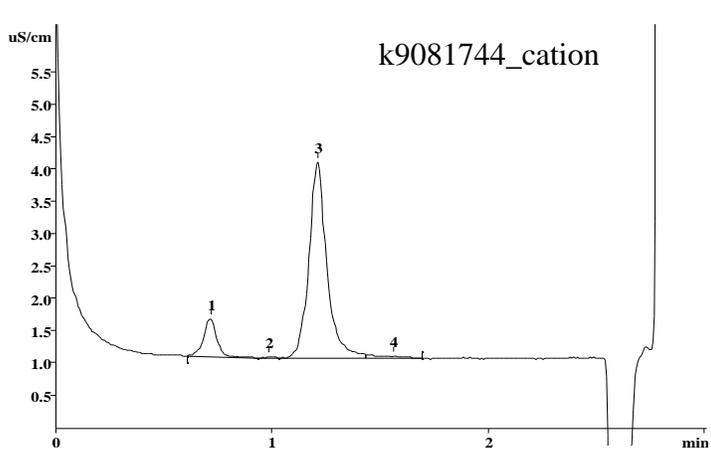
MOUDI



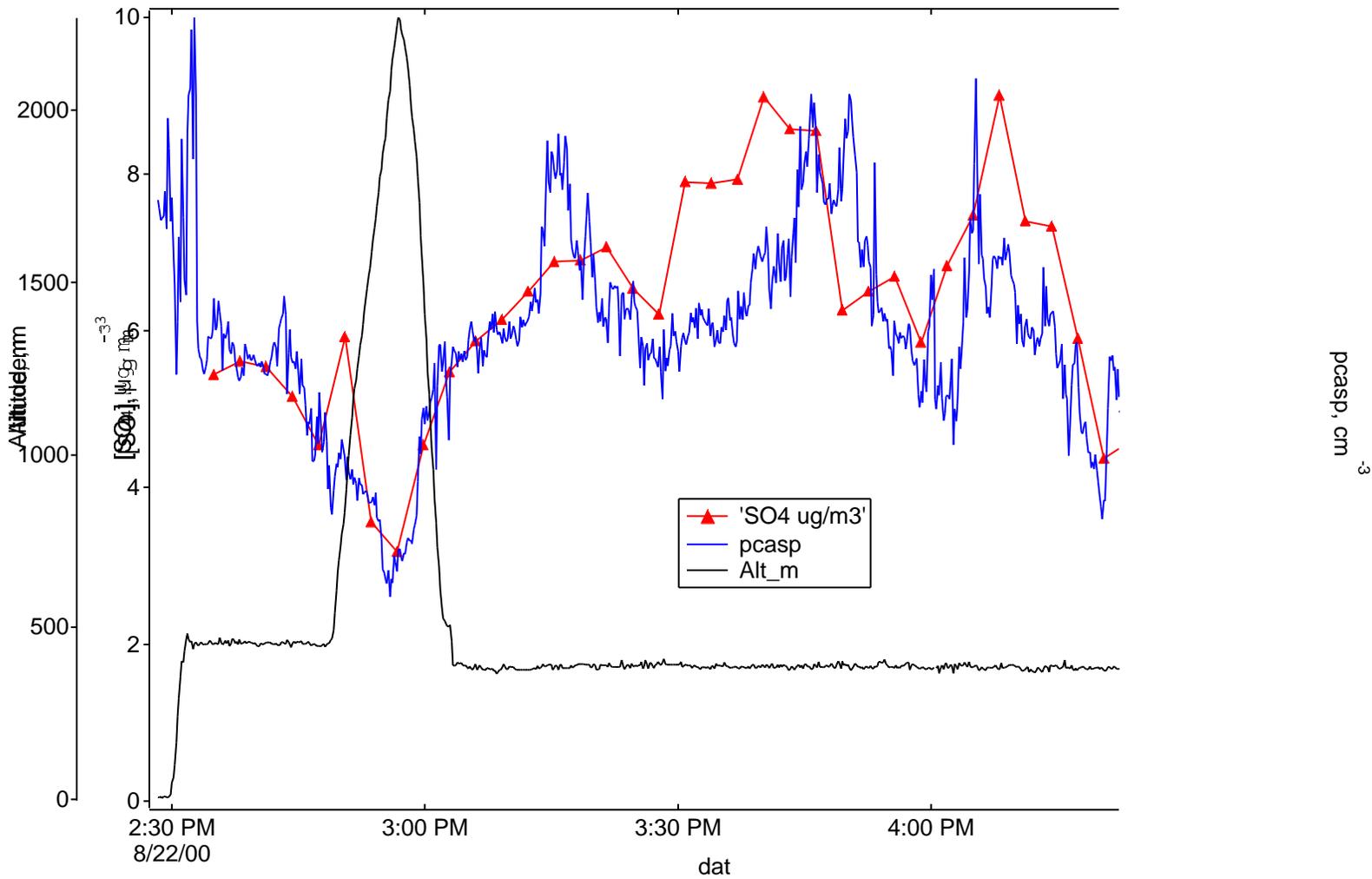
Denuders



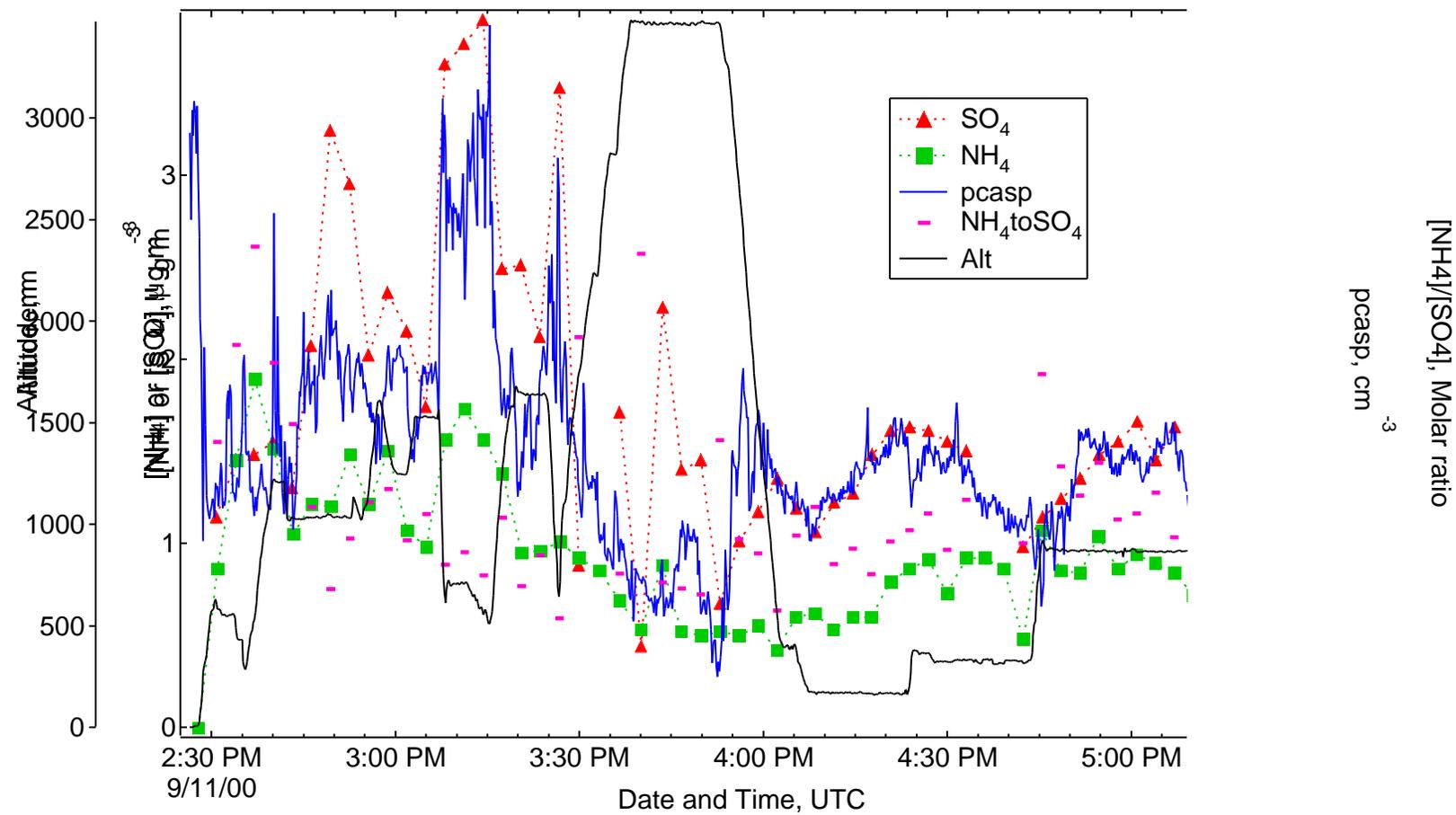
IC Chromatograms: Aerosol Standards (top) and Ambient Samples (bottom)



Aerosol sulfate concentration and accumulation mode particle concentration measured on 8/22/00



Aerosol sulfate and ammonium concentrations and accumulation mode particle concentration measured on 9/11/2000

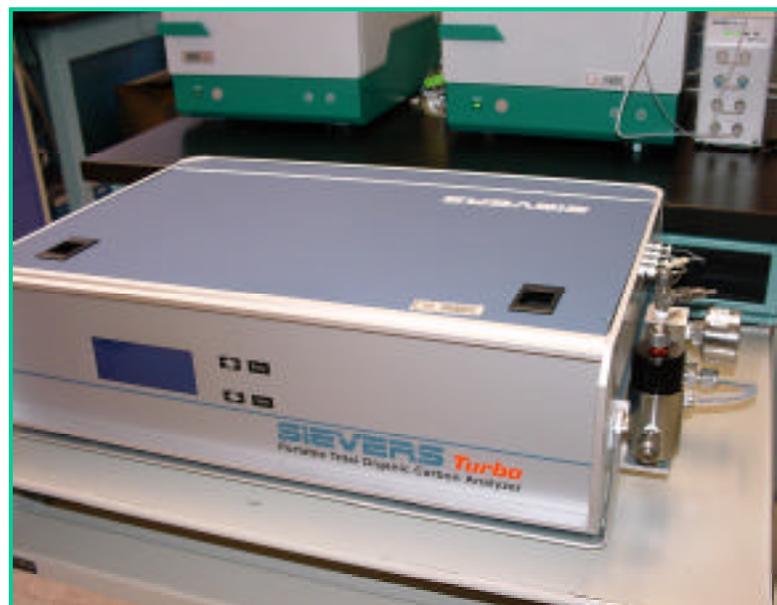


Preliminary Observations

- The PILS system on the G1 aircraft measured aerosol ionic species at a 3 min time resolution with a LOD of $\sim 0.1 \mu\text{g m}^{-3}$.
- NH_4^+ and SO_4^{2-} were the dominant inorganic ionic species.
- $[\text{NO}_3^-]$ is typically small, $< 0.5 \mu\text{g m}^{-3}$, with infrequent excursions reaching half as $[\text{SO}_4^{2-}]$.
- The measured mass concentrations of aerosol ionic components are consistent with a pcasp data corrected for refractive index.
- The ratio, $[\text{NH}_4^+]$ to $([\text{NO}_3^-] + 2[\text{SO}_4^{2-}])$, was rarely 2, suggesting the presence of other ionic species.
- With the relatively fast aerosol ionic concentration data measured by the PILS, interesting periods in terms of acidity and mass balance may be identified for detailed investigation.

Determining Aerosol Total Organic Carbon

- An Ionics Instrument will be used to analyze the TOC content.
- Principle: organic compounds are oxidized to CO_2 by UV irradiation aided with $(\text{NH}_4)_2\text{S}_2\text{O}_8$.
- The CO_2 produced is measured conductometrically following migration across a gas-permeable membrane.
- Detection Limit: 0.1 ppb TOC ($\sim 0.05 \mu\text{g m}^{-3}$)
- Time Resolution: ~ 5 min



Advantages of the PILS Technique

- High temporal resolution
- Real-time, on-line, continuous
- Quantitative mass determination
- Reduced interference and artifacts
- Reduced labor cost
- Small size and weight
- Relatively inexpensive

Characterization and Improvement of PILS

- Sample flow rate
 - volumetric
 - particle growth
 - impactor collection efficiency
- Steam generation
 - Köhler curve
 - mixing
- Temperature control
 - particle size grower
 - G1 environment

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