Measurements of chemical composition of submicron aerosols onboard NOAA WP-3D during TexAQS-2006
Roya Bahreini1,2, Middlebrook, A.M.2, Brock, C.A.2, Brown, S.S.2, DeCarlo, P.F.1, deGouw, J.A.1,2, Dunlea, E.1, Fahey, D.W.1,2, Flocke, F.3, Gallar, C.1,2, Holloway, J.S.1,2, Huey, G.4, Kimmel, J.1, Neuman, J.A.1,2, Nowak, J.B.1,2, Ryerson, T.B.1, Spackman, J.R.1,2, Schwarz, J.1,2, Tanner, D.4, Trainer, M.2, Warneke, C.1,2, Wollny, A.1,2, Zheng, W.3, Jimenez, J.L.1, Fehsenfeld, F.C.1,2
1 University of Colorado, CIRES, Boulder, CO 80309  2 NOAA ESRL- Chemical Sciences Division, Boulder, CO 80305  3 National Center for Atmospheric Research, Boulder, CO 80301  4 Georgia Institute of Technology, Atlanta, GA 30332  Contact email: Roya.Bahreini@noaa.gov

Methodology for Analysis

- Plumes’ Transects - Separated by Sources
  - Background
    - Data from 3 day-flights (Sep. 21, Sep. 26, Oct. 5) and a night-flight around Houston
    - Sep. 21: S-SW winds at 11 m/s, RH ~ 60-100%, cloudy
    - Oct. 5: S-NW winds at 3.6 m/s, RH ~ 60-80%, partly cloudy
    - Oct. 12: S-SW winds at 6.3 m/s, RH ~ 38-50%, clear
    - Only low-altitude data (i.e. <550 m for day flights and <800 m for night flight)

- Plume identification:
  - Ship Channel plumes
    - 3.9 m/s
  - Parish plant plumes
    - 3.6 m/s

Gas to Particle Conversion

- Increase in organic mass and contribution of SOA to organic mass (not shown for Sep. 21, but always >65%) as NOx oxidation and O3 concentration within the plumes increase (i.e. plume chemical processing)
- Indicates secondary organic aerosol (SOA) formation
- Similar organic fraction in ship channel and urban plumes, without significant change with plume processing
- Decreases in organic fraction in Parish plant plumes with increase in processing
- Faster sulfate formation than SOA or less SOA precursors present
- Increase in sulfate concentration and fraction of sulfur present in aerosols with plume processing
- Gas phase SO2 oxidation to H2SO4 and its subsequent condensation onto aerosols, and/or aqueous phase oxidation of SO2
- Only up to 40-60% of total sulfur present in aerosols
- Potential for more aerosol mass further downstream due to sulfate formation

Organics and Primary Emission Markers

- Increase in Organic/CO ratio with extent of processing
- Higher HOA/CO ratios in ship channel plumes
- Greater potential for SOA formation in ship channel plumes
- HOA/CO and HOA/BC higher in Houston compared to Pittsburgh (Sep. 2002)

Toblerone Mass Spectrometer (CToF-AMS)

- Aerosol measurement instruments sampled ambient air through a low turbulence inlet (LTI)
- AMS was downstream of the LTI, a 1 mm impactor, and a pressure controlled inlet (350 Torr)
- After a further pressure drop to ~1 Torr through a critical orifice, sampled air is drawn into the AMS vacuum chamber
- Particles are focused to a narrow beam by a system of aerodynamic lenses
- Upon impact on the vaporizer, non-refractory components of aerosols are vaporized and ionized under high vacuum by electron impact
- Ions are extracted at ~13 μs into the Time of Flight mass spectrometer (TofWerk, Switzerland)
- Signals from the multi channel plate (MCP) detector are amplified and sampled at 200 MHz
- Vacuum aerodynamic (DCl) and mass concentration of non-refractory aerosols are obtained
- Real-time data recorded every 10-15 s
- Uncertainty in mass concentrations: better than 25% for 14 flights (out of 17) and better than 50% for remaining flights
- Detection limits (DL, μg/m³): for reported species are:
  - SO2: 0.32 μg/m³ / COppbv = 0.0043
  - NO: 0.08 μg/m³
  - NO2: 0.05 μg/m³
  - O3: 0.15 μg/m³

Average Composition (includes all low-altitude data)

- Organics and sulfate most dominating components of aerosols
- DMS contribution to organic mass ~79%, consistent with Zhang et al.
- 83% in downwind of urban areas
- 95% in rural areas

- Aerosol sulfate and nitrate neutralized by ammonium, except in sulfate-rich plumes
- Aerosol nitrate present in appreciable amounts usually at night
- NOx, SO2 and SO4~2- present in some plumes
- Elevated nitrate during high NH3 concentrations
- High NOx, NO2, NH4NO3 formation likely, but NO2 hydrolysis to HNO3 (aq) not likely

References


Acknowledgements:
This work was supported by the Cooperative Institute for Research in Environmental Sciences (CIRES) with support in part from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce under cooperative agreement NA17RJ1229 and other grants. The statements, findings, conclusions, and recommendations are those of the authors and do not necessarily reflect the views of the National Oceanic and Atmospheric Administration or the Department of Commerce.

Disclaimer:
This poster was prepared by the Cooperative Institute for Research in Environmental Sciences (CIRES) with support in part from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce under cooperative agreement NA17RJ1229 and other grants. The statements, findings, conclusions, and recommendations are those of the authors and do not necessarily reflect the views of the National Oceanic and Atmospheric Administration or the Department of Commerce.