ROLE OF AMMONIA/AMMONIUM IN VISIBILITY ASSESSMENTS

Nitrate, nitrate, where is the nitrate?
ACKNOWLEDGMENTS

- Dr. Jeffrey Collett, Colorado State University
- IMPROVE and VIEWS Websites
VISIBILITY FOCUS

- Only consider visibility impairment associated with $\text{SO}_2$ and $\text{NO}_x$ emissions.
- Only consider that portion of those emissions that convert to sulfuric acid ($\text{p}$) and nitric acid ($\text{g}$).
- Discuss role of ammonia in neutralizing those acids.
- Discuss the resulting effect on visibility.
Causes of Visibility Impairment

In General

- Scattering and absorption of light by particles
- Scattering and absorption of light by gases

This discussion

- Emphasis on scattering of light by particles
IMPROVE Sampling

- 160+ sites in 2003
- Particle sampling
  - 24-hour samples every third day
- \( \text{PM}_{2.5} \) mass
  - Elemental analysis
  - Ions
  - Carbonaceous material
- \( \text{PM}_{10} \) Mass
IMPROVE Reporting

- Fine mass
  - Ammonium sulfate
  - Ammonium nitrate
  - Organic carbon
  - Elemental Carbon
  - Fine soil
- Undifferentiated Coarse mass
- “Reconstruct” Extinction
Mean Extinction Budgets on Haziest Days
1996-2001

Extinction (Mm⁻¹)

- Ammonium Sulfate
- Ammonium Nitrate
- Organics
- Soot
- Soil
- Coarse Mass

19 81 143 206
Mean Extinction Budgets on Clearest Days
1996-2001

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<th>Extinction (Mm⁻¹)</th>
<th>Ammonium Sulfate</th>
<th>Ammonium Nitrate</th>
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<th>Soot</th>
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So what can we notice?

- Particle extinction much greater in the eastern U.S.
- Sulfate (as ammonium sulfate) typically dominates the extinction in the east and is a major constituent elsewhere.
- Nitrate (as ammonium nitrate) is a major contributor in central and southern California, the northernmost tier of States.
- We need to fill in the gaps, but indications are the central U.S. may also experience high nitrate contributions.
**Why do we care about ammonia?**

- Free ammonia will tend to preferentially neutralize the sulfuric acid.
- The degree of neutralization may not be too important since ammonium sulfate, ammonium bisulfate, and letovacite all have similar hygroscopic properties.
- However, sulfuric acid has a greater effect on visibility because of its enhanced hygroscopic properties.
- In some locations, particulate nitrate may replace “controlled” sulfate since “freed” ammonia may become available when the temperature régime is favorable.
Confounding Issues

- Aerosol chemistry uncertainties
  - Assumption of fully neutralized sulfate is not correct for all sample days
  - Assumption of ammonium nitrate may not always be correct
  - IMPROVE configuration may not be suitable to determine ammonium concentrations
Nitrate Issues

- Nitrate may be present in both the fine and coarse modes
  - Usually ammonium nitrate in fine mode
  - In some locations, fine fraction may actually be tail of coarse fraction
  - Sodium nitrate in coarse mode
Nitrate Summary

- Eastern U.S.
  - Model studies show potential for aerosol mass increase as nitrate replaces sulfate in response to declining sulfate concentrations

- Western U.S.
  - Little known about potential for nitrate replacement of sulfate
  - Large uncertainties in current aerosol composition