ACTRIS Project
+
ACSM Best Practices

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ACTRIS Project – ACSM

→ Coordinated long-term (>1 year) aerosol chemistry (ACSM) measurements in Europe
→ Also coordinated with EMEP (1 month AMS measurements in summer 2012 and winter 2013)

www.psi.ch/acsm-stations/about-actris
ACSM Resources

• ACSM DAQ and Igor Manuals
• Aerodyne’s ACSM website
  – https://sites.google.com/site/ariacsm/home
• ToF-AMS wiki page
  – Focused on ToF-AMS, but many of the principles are similar
• Best practices document
  – Under construction, to be posted at ACSM website

Sampling Lines – Flow/Diameter

• PM$_{2.5}$ cyclone with metallic screen on inlet
  – Remove dust and large particles \( \rightarrow \) reduce clogging
  – Prevent (rare) supermicron particle transmission
  – PM$_{1}$ cyclones should be avoided at all costs because a double PM$_{1}$ size cut would be applied resulting in the underestimate of actual PM$_{1}$
  – Further, shrinking may occur after drying

• Limit residence time in lines to avoid sampling losses
  – Generally need a few L/min (1 to 10 L/min) to dryer inlet
    • Pump, e.g. split from Nafion dryer (discussed later)
    • Other instruments connected near ACSM inlet
  – Continuously monitor & record flowrate

• But maintain laminar flow (Re < 1000) in system to avoid turbulent flow losses
Sample Flow Controller Accessory

• Active flow control to pull major flow for ACSM
• Comes with cyclone, tubing, fittings…
• Analog output for flow rate incorporated into ACSM data stream

Sampling Lines - Material

• Conductive material only
• Stainless steel ideal for long-term sampling. If copper used, should occasionally check status
• Black conductive tubing (TSI) should NOT be used
  – Mass spectrum contaminated by siloxane peaks
  – m/z 73
    • Not good! (m/z 60 and 73 are important markers for biomass burning)
  – Others at higher m/z
ACSM Support Equipment

- On-line UPS (2000 kV)
- Spare Parts
  - Servo motor for inlet assembly
  - Filter for valve body assembly
    - Change when see pressure drop across filter (Analysis software diagnostics plot).
    - Negative airbeam may be a more sensitive diagnostic
  - SEM
    - Monitor voltage vs. time to predict failure
- Filaments (2 sets of 2)
- Critical orifice
- Turbo pump
- Diaphragms for backing pump

Maintenance/Calibration Schedule

The short version (for a well-characterized instrument)

- Continuously monitor (and look at!!):
  - Instrument flowrate
  - m/z 28 and naphthalene signals
  - Turbo pump speeds, currents, and temperatures

- Any significant changes? → Must understand why (on-site maintenance possibly needed)
## Maintenance/Calibration Schedule

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Task Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>- Monitor naphthalene signal and inlet pressure (~flowrate)</td>
</tr>
<tr>
<td></td>
<td>• Major changes in these parameter may indicate that maintenance is needed</td>
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<tr>
<td></td>
<td>• Monitor turbo pump speeds, currents, and temperatures</td>
</tr>
<tr>
<td></td>
<td>• Helps to anticipate pump failure</td>
</tr>
<tr>
<td>2x per week</td>
<td>- Check and record SEM gain, adjust if needed</td>
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<tr>
<td></td>
<td>- Monitor Faraday signal</td>
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<td></td>
<td>• Daily checks are best at start of a campaign or after venting the instrument, until stable operation is observed.</td>
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<tr>
<td>Every month</td>
<td>- Check inlet pressure/flowrate, clean orifice, check pressure/flow again</td>
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<tr>
<td></td>
<td>- Clean dust from turbo pump fan filters</td>
</tr>
<tr>
<td>Every 2 months</td>
<td>- IE calibration with NH₄NO₃</td>
</tr>
<tr>
<td></td>
<td>• This should be done more frequently (weekly) at the start of a campaign or after the instrument has been vented until stable results are obtained.</td>
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<tr>
<td>Every 3 months</td>
<td>- Collect data with valve closed for 1 hr to check instrument background</td>
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<td></td>
<td>- Record data in filter-minus-filter mode</td>
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<tr>
<td></td>
<td>- Update DAQ and Analysis software</td>
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<tr>
<td></td>
<td>- Users’ site</td>
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<tr>
<td>Other?</td>
<td>- m/z calibration and resolution (stable at PSI, but...)</td>
</tr>
<tr>
<td></td>
<td>- Flow calibration: record ambient pressure and temperature</td>
</tr>
</tbody>
</table>

If AB is stable, ACSM probably stable →

**BUT STILL IMPORTANT TO CHARACTERIZE YOUR INSTRUMENT**

## Calibrations

<table>
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<tr>
<th>Calibrations</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Calibration</td>
<td>- Record ambient pressure and temperature</td>
</tr>
<tr>
<td>IE Calibration</td>
<td>- Always perform SEM calibration immediately before</td>
</tr>
<tr>
<td></td>
<td>- Confirm particles are <strong>dry</strong></td>
</tr>
<tr>
<td></td>
<td>- Maximum concentration 5 mM</td>
</tr>
<tr>
<td></td>
<td>• Check atomizer performance by varying solution concentration</td>
</tr>
<tr>
<td></td>
<td>- Measure 32 and 40 but not 28 (shortens SEM lifetime). 28 can be recorded during SEM gain calibration.</td>
</tr>
<tr>
<td></td>
<td>- Log and look at <strong>28-to-IE ratio</strong></td>
</tr>
<tr>
<td>RIE Calibrations (NH₄⁺, SO₄²⁻, MSA?, Org?)</td>
<td>- NH₄ from mass balance with NO₃</td>
</tr>
<tr>
<td></td>
<td>- Then SO₄ from mass balance with NH₄ (atomize (NH₄)₂SO₄)</td>
</tr>
<tr>
<td></td>
<td>- MSA in marine-influenced sites</td>
</tr>
<tr>
<td></td>
<td>- Can/should we select some organics for RIE measurements?</td>
</tr>
</tbody>
</table>
Fragmentation Diagnostics

- Consistency of fragmentation patterns
  - (e.g., are my plots linear?)
- Sanity checks: NH$_4$, NO$_3$, SO$_4$, Org
  - (e.g., Do the ratios make sense?)
  - (e.g. #2, Do I have good zeros?)

(Bounce) Collection Efficiency

- Nitrate content
- Acidity/neutralization
- Organic liquid content
- Particulate water content
  - Depends on relative humidity at the ACSM inlet
Should I dry?

(#1): Strongly time-varying CE (temperature-controlled indoors, varying humidity outdoors)

(#2): Time series corrupted by massive water condensation

(Bounce) Collection Efficiency

- Nitrate content
- Acidity/neutralization
- Organic liquid content

- Particulate water content
  - Depends on relative humidity at the ACSM inlet

Solve this by drying particles at the ACSM inlet
Nafion Dryer

• **Strongly recommended!**
  – Install upstream of filter

• Less maintenance than for silica gel dryers (may require daily gel changes)

• Dryer models
  – Aerodyne

\[ E_b \text{ depends on…} \]

- Nitrate content
- Acidity/neutralization
- Organic liquid content
- Particulate water content
  – Depends on relative humidity at the ACSM inlet

How do we address these factors?
E_b: Composition Dependence

- Two approaches:
  - 1. Estimate E_b from the chemical composition (Middlebrook et al., )
  - 2. Estimate E_b from comparisons with other instruments (e.g. SMPS, PILS, nephelometer, TEOM…)

Which to use? …BOTH!
→ Strongly recommended to compare with multiple instruments
→ E_b should not be a catch-all for instrument disagreement!

Risk of estimating CE from individual intercomparisons (every time)

- Official intercomparison of nominally identical instruments by same group in 2 airplanes
  - AMS is very often intercompared with this instrument
- Scaling to another single instrument can be extremely risky

From Gao Chen, NASA

Jose Jimenez, 2010
Eb from Inter-comparison

- Inter-comparisons are tricky…
- Example: ACSM vs. SMPS
  - Particles should be dried for both instruments
  - Refractory species (e.g. BC, dust, sea salt) must be negligible or independently measured
  - Synchronize instrument transmission size range, especially for large particle sizes.

- Note that other instruments have their uncertainties, too. Eb should not be a catch-all for instrument disagreements…