Preliminary results from the 2016 ACTRIS2 Q-ACSM intercomparison at the Aerosol Chemical Monitor Calibration Centre (ACMCC)

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Goal: Homogenous quality-controlled ACSM datasets at a European scale

- Intercomparison campaign took place March/April 2016. A total of 21 instruments.
- In order to accommodate all applications to the intercomparison exercise, two separate calibration exercises were organized.

### Participating stations:

**Intercomparison Spring 2016**

<table>
<thead>
<tr>
<th>Site</th>
<th>Intercomparison</th>
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<tbody>
<tr>
<td>Q-ACSM</td>
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<tr>
<td>ToF-ACSM</td>
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<tr>
<td>HR-AMS</td>
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<tr>
<td>Did Not Attend</td>
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**Map of Participating Stations**
2016 ACTRIS-2 ACSM intercomparison exercise at the ACMCC

Organization:
1. Three to four days pre-calibration intercomparison.
2. Calibration using single and mixed inorganic solutions
3. Three to four days post-calibration intercomparison (extended for ToF-ACSM).
Q-ACSM intercomparison

Quad-ACSM arrival

Ambient measurements
4th to 7th of March
11th to 14th of March

Calibration,
IE NO$_3$, IE SO$_4$
7th to 10th of March
Q-ACSM intercomparison
Quad-ACSM arrival
4th to 7th of March

Ambient measurements
11th to 14th of March

Calibration, IE NO$_3$, IE SO$_4$
7th to 10th of March

Q-ACSM intercomparison

![Graphs showing correlations and data trends for SO$_4$, NO$_3$, Org, and PM$_1$ with ACSM measurements over different periods.](image)
Q-ACSM intercomparison

Quad-ACSM arrival

Ambient measurements

4th to 7th of March

Calibration, IE NO₃, IE SO₄

7th to 10th of March

11th to 14th of March
1. ‘Standard’ Calibration set-up

Like normal ACSM Calibration Setup but with CPMA after DMA
CPMA selects particles by Mass/Particle
Combined with DMA, this eliminates Q2s
2. Mixture Calibration set-up

- Atomizer (4x)
- Dryer
- DMA

4x Solutions:
- Pure NH₄NO₃
- 2:1 NO₃⁻:SO₄²⁻ (by mass)
- 1:2 NO₃⁻:SO₄²⁻ (by mass)
- Pure (NH₄)₂SO₄

- ACSM 1
- ACSM 2
- ACSM 3
- ACSM 4

Calibration:
- IE NO₃⁻, IE SO₄²⁻
  - 7th to 10th of March

Ambient measurements:
- 11th to 14th of March

Run normal ACSM single scan mode, 1 set

ACSM sample flow
0.5LPM/ACSM
Quad-ACSM arrival 4th to 7th of March
Ambient measurements 11th to 14th of March
Calibration, IE NO$_3$, IE SO$_4$ 7th to 10th of March

Q-ACSM calibrations

Bar chart showing RIE$_{NH_3}$ values for different S/N values ranging from 140-145 to 140-139.
Quad-ACSM arrival
4th to 7th of March
Ambient measurements
11th to 14th of March
Calibration, IE NO₃, IE SO₄
7th to 10th of March
Q-ACSM calibrations
Q-ACSM intercomparison

Some examples of individual instrument comparisons

Comparison with reference instrument

BEFORE
Q-ACSM intercomparison

Some examples of individual instrument comparisons

Comparison with reference instrument

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Q-ACSM after-calibration intercomparison

Some examples of individual instrument comparisons

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Q-ACSM after-calibration intercomparison

Quad-ACSM arrival

Ambient measurements
- 4th to 7th of March

Calibration, IE NO$_3$, IE SO$_4$
- 7th to 10th of March

11th to 14th of March

Ambient measurements
Q-ACSM after-calibration intercomparison

- **Quad-ACSM arrival**
- **Ambient measurements**
  - 4th to 7th of March
- **Calibration, IE NO$_3$, IE SO$_4$**
  - 7th to 10th of March
- **Ambient measurements**
  - 11th to 14th of March

Instrument performance evaluated against the Median using the Z-score method
Collection vs. transmission efficiency

Evaluation criteria  (Error associated with instrument transmission and collection)

CE: Correction for collection efficiency of individual instruments depends on composition and phase.

Instruments are then corrected using a chemical dependant collection efficiency (CDCE).

Assuming that when particles contain a high fraction of ammonium nitrate that they are more efficiency sampled (more liquid)

The instrument to instrument variation in the CDCE = 5%
Collection vs. transmission efficiency

Evaluation criteria (Error associated with instrument transmission and collection)

Lens transmission efficiency

- For this exercise, standard AN calibrations were performed at various size of (relatively large particles) on different instruments
- The lens transmission efficiency ($E_L$) is calculated as the ratio between RFNO3 obtained for a given size and RFNO3 obtained at 300 nm

> If 50% of the mass > 400 nm ⇒ tot. mass may be off by up to 20%  

⇒ May induce much more bias than CDCE calculations
Evaluation criteria (Conclusion)

**Calibration repeatability**: Variation in calibration value (3 to 4 calibrations were performed on each instrument)
Max. Error of 15%

**TE: Transmission efficiency error**. Depending on the particle size measured the lens TE varies..
Max. Error of 25%

**CE: Collection efficiency correction**.
Depending on the particle chemical composition and morphology..
Error in CDCE based on chemical composition
Max. Error of 5%

**Propagation of errors**

\[
\sqrt{\sum \text{Error}_1^2 + \text{Error}_2^2 + \text{Error}_3^2}
\]

30% at max.
ACMCC: ACTRIS2_First intercomparison analysis and reporting

Instrument falls within ±30% of the «reference» instruments.

PM1 of all instruments compared with PM1 of SIRTA instruments. Dotted line indicates ±30% error. Light points represent TEOM-FDMS, black points represent ACSM data.
‘Pieber effects’

![Graph showing fractional intensity vs. mass values for \( \text{NH}_4\text{NO}_3 \text{mz44}/(\text{mz30+mz46}) \)]
‘Pieber effects’
Pieber effects

2013 Intercomp
‘Pieber effects’

Pieber et al., 2016
‘Pieber effects’

Total OA conc.:  

‘Pieber corrections’
‘Pieber effects’

ToF-ACSM calibration data

Might be worthy to check if m/z43 - related corrections could be needed in some cases
m/z 30 from pure $\text{(NH}_4\text{)}_2\text{SO}_4$

RIE $\text{SO}_4$ from standard calibration
Conclusions

- The ACSM is still a research instrument on which we have to keep performing research activities.
- The data acquired during the ACMCC intercomparison exercises will be used to further determine robust uncertainties for these instruments.
- Calibrations in acquisition mode (‘mixture calibrations’) significantly improved the accuracy of SO4 measurements.
- Tunning of ACSM (AMS) Analog Input used for CPC reading has to be checked.
- Encourage users to check for size dependent lens transmission efficiency of each individual instrument.
- Some more ‘Pieber effects’ to come .. (→ some more optimisation of the frag table ?)