2018 ACSM Intercomparison at ACMCC in the frame of the ACTRIS and COLOSSAL programs

Part I

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The Aerosol Chemical Monitor Calibration Center (ACMCC)

Services: Calibration facility for on-line *in-situ* chemical analyzers (ACSM), intercomparison studies, best-practice, audit, training, exchange of knowledge, ..

Implication in EU programs:
- COST Action CA16109 COLOSSAL: WG1 co-leader with King’s College
- ACTRIS: unit of the Center for Aerosol In Situ measurements / European Center for Aerosol Calibration (CAIS/ECAC, led by Tropos)

Users: Research organizations, manufacturers, (French) regional air quality monitoring networks
Main instrumentation:

- **WG1**: Quality assurance of on-line chemical composition of non-refractory fine aerosol measurement
- **WG2**: Source apportionment of OA
- **WG3**: Refractory fine aerosol fraction

**Non-refractory fine aerosol**

**Fine aerosol**

- Sulfate
- Nitrate
- Chloride
- Organic matter
- Ammonium
- Black carbon

**WG4**: European overview of fine atmospheric aerosols

**Management Committee**

- **Chair**: María Cruz Minguillón
- **Vice-Chair**: André Prévôt

**33 countries**

**77 institutions**

**+230 participants**

**COLOSSAL**

CA16109 Chemical On-Line cOmposition and Source Apportionment of fine aerosol.
How to follow

- Twitter @cost_colossal
- http://www.costcolessal.eu/
- Research Gate

How to join

- http://www.costcolessal.eu/contact-us/
- https://www.cost.eu/cost-actions/how-to-participate/
  - Email: mariacruz.minguillon@idaea.csic.es
  - contact your COST National Coordinator (CNC)

March 2021
4 years duration
ACTRIS: European Research Infrastructure for Aerosols, Clouds and Trace Gases

Atmospheric processes relevant to ACTRIS:
ACTRIS Structure

European level
Central Facilities

- Head Office
- Data Centre

Centre for Aerosol In-situ measurements
Centre for Aerosol Remote sensing
Centre for Cloud In-situ measurements
Centre for Cloud Remote sensing
Centre for Reactive Trace gas In-situ measurements
Centre for Reactive Trace gas Remote sensing

National Facilities

Observational platforms
Exploratory platforms
ACTRIS Service Provision

- National Facilities
- Topical Centres
- Physical and remote Access
- Research Services
- Instrument calibration
- Industry Services
- Training services
- Data Centre
- Virtual Access
- ACTRIS data products
- ACTRIS VRE with tools and computing

- Instrument calibration
- NF aerosol, cloud and trace gas variables
ACTRIS Data

Provision of 83 atmospheric variables in the natural atmosphere
Provision of 24 atmospheric data products
Provision of Simulation Chamber Experiment data

• Cloud in-situ (15 Variables)
• Cloud Remote Sensing (25 Variables)

• Aerosol in-situ (12 Variables)
• Aerosol remote sensing (16 Variables)

• Trace Gases in Situ (5 Categories of variables)
• Trace gases Remote Sensing (10 Variables)

• A common specification in ACTRIS: high quality

ACTRIS controls the whole processing chain from production to dissemination
ACTRIS Agenda

- ACTRIS Implementation
- ACTRIS-Copernicus
CAMS projects: provision of real-time aerosol data
2018 ACSM COLOSSAL and ACTRIS workshop, meetings and intercomparison at ACMCC
2018 COLOSSAL and ACTRIS-2 campaigns at the ACMCC

Organization:
1. ACSM installation by ACMCC team using parameters recommended by owners
2. Pre-calibration intercomparison campaign
3. Meetings / Maintenance, tuning and RIE calibrations
4. Post-calibration intercomparison
5. Investigation of Pieber effect on 6 Q-ACSM + extended ambient air comparison + complementary RIE calibrations
5bis. Research activities on organic nitrate + complementary RIE calibrations

- **13 Q-ACSM + 4 ToF-ACSM**
  - Installed Nov. 13-16
  - Ambient measurements Nov. 16-19
  - Workshop / meetings Nov. 19-23
  - Ambient measurements Nov. 23-26
  - Installation, Nov. 26-30

- **6 Q-ACSM PM$_1$**
  - 1 Q-ACSM PM$_{2.5}$ SV
  - Extended amb. meas. Nov. 29 – Jan. 7

- **Mixture Calibrations Nov. 26-29**

- **3 Q-ACSM PM$_1$**
  - 2 Q-ACSM PM$_{2.5}$ CV
  - 3 ToF ACSM
  - Organic nitrate PAM experiments Dec. 3-14
Participants to 2018 COLOSSAL & ACTRIS-2 ACSM intercomparison at ACMCC

Participating ACSMs (and station’s location):

- Norwegian Institute for Air Research (NILU, Norway)
- University of Helsinki (UHEL, Finland)
- Finnish Meteorological Institute (FMI, Finland)
- Estonian Environmental Research Institute (EERC, Estonia)
- Lund University (U. Lund, Sweden)
- National University of Ireland Galway (NUIG, Ireland)
- University of Manchester (U. Man., United Kingdom)
- King’s College London (KCL, United Kingdom)
- LSCE & INERIS (France)
- Deutscher Wetterdienst (DwD, Germany)
- Laboratoire de Météorologie Physique (LaMP, France)
- National Institute for Research and Development in Optoelectronics (INOE, Romania)
- Institute of Environmental Assessment and Water Research (IDAEA, Spain)
- Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT, Spain)
- National Centre of Scientific Research "Demokritos“ (NCSR Dem, Greece)
- Cyprus Institute (CyI, Cyprus)

+ Valuable participation of Aerodyne Res. Inc. (J. Jayne, P. Croteau, L. Williams & A. Lambe), ADDAIR (V. Crenn, G. Smith & A. Marpillat), Aerosol d.o.o. (M. Rigler & G. Lavric), CPST (V. Dudoitis), LISA (M. Cirtog, A. Féron & C. Gaimoz), ..
Experimental set-up: ACSM’s installation

4 groups of 4 ACSMs downstream same sampling heads designed for PM2.5 cut-off at 1m³/h (Total flowrate at each common inlet = 4 x 3 LPM = 12 LPM → Actual cut-off of sampling head = approx. 3.5 LPM):

- **Common inlet**
  - Q-ACSM, PM2.5/CV, LSCE
  - Q-ACSM, PM2.5/CV, UMan
  - Q-ACSM, PM1/SV, Cyl
  - Q-ACSM, PM1/SV, UHel
  - Q-ACSM, PM1/SV, CSIC
  - ToF-ACSM, PM1/SV, DEM

- **Common inlet**
  - Q-ACSM, PM2.5/SV, NILU
  - Q-ACSM, PM2.5/SV, IEPA

- **Common inlet**
  - Q-ACSM, PM1/SV, CSIC
  - Q-ACSM, PM1/SV, FMI
  - ToF-ACSM, PM1/SV, DEM
  - Q-ACSM, PM1/SV, KCL

- **Common inlet**
  - Q-ACSM, PM1/SV, CyI
  - Q-ACSM, PM1/SV, UHel

- **Common inlet**
  - Q-ACSM, PM1/SV, UHel
  - Q-ACSM, PM1/SV, CSIC
  - ToF-ACSM, PM1/SV, KCL
  - Q-ACSM, PM1/SV, EERC

Continuous operation since Summer 2011
Selected comments from the ACSM installation phase

- All instruments arrived in good shape and seemed able to operate accurately
- PM2.5 Q-ACSM needs adapted/bigger shipping boxes
- Some instruments had lack of o-ring and/or bad swadgelock fittings → leaks may be expected at stations
- Some sample line flow controller systems didn’t deliver the proper flowrate
- Some tricky drying systems (need to better define counterflow ? DeltaP ?)
- Some ScanData folders were quite heavy (e.g., up to one year datasets) → should be refreshed regularly
- A few instrument had very high AB signal after re-installation, whereas they were at about $10^{-7}$ just before being turned off for shipment / moving
- A wide range of used RIE values (e.g., up to over 20 for NH4)

Selected (preliminary) comments related to ambient air measurements

- A limited number of software crashes
- Seems like every system is not egal towards critical orifice clogging: some had to be cleaned frequently - e.g., every 2 weeks - while no pressure drop was observed on tablemate ACSM. Influence of previous campaigns / need for standardized cleaning procedures of ACSM sampling tubes ?
- A couple of ToF-ACSM displayed very high S/N ratio (e.g., NH4) and/or erratic behavior
- A few Q-ACSMs displayed negative chloride signals (see Evelyn’s talk)
(R)IEs calibration strategy

Use of CPMA to avoid double-charged particles

Full scan calibration mode, which is now recommended for Q-ACSMs (see Evelyn’s talk) ... but takes longer.
Ambiant air nitrate concentration obtained using initial IE value provided by participants (CE 0.5)

Ambiant air nitrate concentration obtained using IE value obtained at ACMCC after workshop (CE 0.5)
**Intercomparison results**

Pre-calibration campaign (16-19 Nov.):
- Using calibration/tuning parameters recommended by the users.
- 8 instruments (on 15) delivering ‘suspicious’ data

Second intercomparison campaign (23-26 Nov.):
- After tunnings and considering new (R)IE values
- 3 instruments (on 17) delivering ‘suspicious’ data: 2 ToF-ACSMs which have been maintained by ARI + 1 PM2.5 Q-ACSM misaligned
Clues on Lens transmission efficiency

Example of Irish EPA/Jurgita Q-ACSM with PM$_{2.5}$ lens:

IE/N2 normalised = f(size)

Data:
- 1/14/2019
- 1/15/2019
2018 COLOSSAL and ACTRIS-2 campaigns at the ACMCC

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   (See Evelyn’s talk)

5bis. Research activities on Organic-Nitrate
**Motivation**

Need for a sound methodology (if any possible one) to quantify particulate Organic-Nitrate using ACSM, as this compound seems to be ubiquitous in Europe

**Objectives**

- Characterization of selected pON compounds:
  - 4 ON precursors
    - Biogenic: Limonene & b-pinene
    - Anthropogenic: guaiacol & acenaphthalene
Objectives

• Characterization of selected pON compounds
  ➢ pON RIE (generation of monodispersed pON, multipoint *calibration curves*, CE=1 using LSCE PM$_{2.5}$ / capture vaporizer system)
  ➢ pON densities
  ➢ Optical properties (multi-wavelength aethalometer)

• Comparison of the responses (e.g., Org:NO$_3$ ratio, m/z30 vs. m/z46) of the different MS systems and configurations:
  ➢ 3 PM$_1$ Q-ACSMs (standard vaporizers): IDEAE-CSIC, UHEL, FMI then EERC
  ➢ 2 PM$_{2.5}$ Q-ACSMs (capture vaporizers): U. Man, LSCE (Corsica)
  ➢ 3 PM$_1$ ToF-ACSMs (standard vaporizers): U. Lund, DEM, LaMP
  ➢ 1 Long-ToF-AMS: UHEL

• Accurate methodology to estimate pON concentrations using ACSM?
Particulate Organic-Nitrates (pON) ACSM intercomparison 2018

Some preliminary results
OM-NO3 ratio (usual frag tables)
mz30 / mz46 ratio

Default $R_{pON}$ used in Kindler-Scharr et al., GRL, 2016 (HR-ToF-AMS and C-ToF-AMS)
mz30 / mz46 ratio

Q-ACSM (std vap.) Q-ACSM (cap. vap.) ToF-ACSM LongToF-AMS

Capture vaporizer

Standard vaporizers

Limonene β-Pinene (-) Guaiacol Acenaphthylene
mz30 / mz46 ratio

~ 6.0 ± 0.5 (NO⁺/NO₂⁺)
RIE ‘calibrations’

PM2.5 Q-ACSM capture vap.

$\rightarrow$ CE=1

- Rather low RIEs, except for limonene’s pON

AMS user’s meeting #20
Particle density

- No significant change following particle size
- Anthropogenic pON > Biogenic pON
Examples of pON mass spectra (CSIC Q-ACSM, PM1 Std vaporizer)
**ANGSTROM EXPONENT**

Normalized $B_{abs}$ so that $B_{abs}(950) = 1 \text{ Mm}^{-1}$

- $\alpha_{acenaph.} = 3.25 \pm 0.23$
- $\alpha_{guaiacol} = 8.16 \pm 0.94$
- $\alpha_{limonene} = 1.01$
- $\alpha_{\beta-pinene} = 2.08$

AMS user’s meeting #20
Next ACSM intercomparison at ACMCC is planned for June 2020 ...

... still in the frame of COLOSSAL and ACTRIS programs

(Agenda to be decided during the COLOSSAL Riga meeting in Oct. 2019)