WP3- NA3: In-situ chemical, physical and optical properties of aerosols
Deliverable D3.6: Expert workshop for CCN measurements

The expert workshop for CCN measurements was held at the European Commission's Joint Research Centre in Ispra, Italy, from 27-28 October 2011 as part of the ACTRIS WP3/WP4 technical workshop. The overall goal of this workshop was to develop standardized protocols for the measurement of cloud condensation nuclei (CCN) in order to ensure comparable CCN measurements at different monitoring stations of the ACTRIS network. Specifically, the following main topics were addressed during this workshop:

- Calibration procedures for CCN counters
- Standard operation procedures for polydisperse and monodisperse CCN measurements
- Data analysis procedures
- Format of data files for submission of CCN measurements to EBAS database

This workshop successfully boosted the transfer of knowledge between experienced and new users of CCNC counters and decisions relevant to achieve high quality and harmonized CCN data sets were made. Details of the discussion topics and recommendations are provided in the following.

Minutes of the first expert workshop for CCN measurements

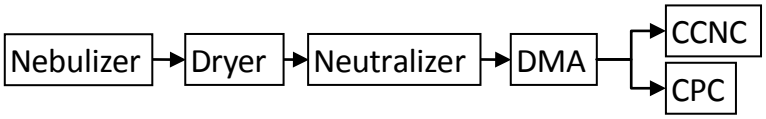
Calibration

- **temperature sensor "calibration"**
  - No calibration is required.
  - Differences between nominal/set and actual temperature values may occur ⇒ see recommendations.

  Recommendations:
  - Minimize differences between nominal/set and actual temperature values, if needed contact DMT. Note: a recalibration is required after adjusting the temperature gain parameter.
  - Users should be consistent in either using the nominal/set or actual temperatures.

- **SS calibration**
  - A target accuracy in supersaturation of ±10% (relative) is suggested at supersaturations above 0.2, for lower SS a different measure is needed (e.g. +/- 0.03 % SS).

  Recommendations:
  - Calibration setup should consist of nebulizer, dryer, neutralizer, DMA, CCNC, CPC:



  - Supersaturation calibrations should be performed at least every six month.
  - Particle number concentrations larger than 2000 #/cc should be avoided during calibration.
  - Calibration should be performed with ammonium sulfate particles.
  - Proper column temperature for calculating surface tension should be used (action item for M. Gysel).

- Size- and temperature dependent critical supersaturation values of ammonium sulphate should be taken from the thermodynamic model ADDEM should be used and/or compared with own activity models (2% deviation to ADDEM is acceptable).
- A linear calibration curve (with non-zero axis intercept) should be applied when relating critical supersaturation to temperature gradient.

Action items:

- *Emanuel Hammer (PSI):* Sends around calibration raw data and collects and compares calibration curves generated by CCNC operating groups.
- *All:* Generate calibration curve from raw data provided by PSI and send calibration curve to PSI.
- *Martin Gysel:* Sends around look-up table concerning droplet thermodynamics produced via ADDEM.
- *Frank Stratmann:* Provides calibration uncertainties from long term measurements.

- **Flow rate calibration**
  - Deviations between nominal and actual total and sample flows may occur if the differential pressure gages are not accurately calibrated.
  - Deviations in total flow rate affect the actual supersaturation.
  - Deviations in sample flow rate affect the measured droplet concentration. The plateau value of the activated fraction observed during calibration will be different from unity.

Recommendations:

- Total flow rate should be checked every time you are at site, at least every month.
- Sample flow should be checked at least every six month (this can be done by careful check of the plateau value of the activated fraction observed during calibration.

- **Counting efficiency / diffusion losses**
  - Diffusion losses occur at diameters below ~70 nm roughly.
  - The diffusion losses will be ignored for monitoring measurements.

- **OPC calibration**
  - OPC calibration is optional.

SOP

- **Flow rate**

Recommendations:

- No recommendation is made whether temperature gradient stepping at constant flow rate or flow rate scanning at constant temperature gradient is the preferred operation mode for polydisperse measurements (decision post-poned, to get Erik Swietlicki's opinion, see below).
- Choice of total flow rate is free with a minimum of 0.2 and maximum of 1 l/min.
- Default value for the ratio of sample to total flow is 1/10, however values ranging from 1/5 to 1/15 should be feasible.

Action items:

- *Erik Swietlicki:* Confirms minimum and maximum total flow rates.
- *Erik Swietlicki:* Is willing to share code illustrating how to scan CCNC-flows and therefore supersaturation.
- *Erik Swietlicki:* Volunteered to provide a summary concerning the pros and cons of scanning flow for adjusting supersaturation.

- **Temperatures**
  Recommendations:
  - It should be made sure that T1 it is below Tinlet and that T1 should be below 30°C.

- **Polydisperse vs. monodisperse measurements**
  - No preferred operation mode. Choice to be made by the station operators.

- **Polydisperse measurements**
  Recommendations:
  - Common supersaturations for polydisperse measurements should be: 0.1, 0.2, 0.3, 0.5, 1.0 (1.0 for test purposes every now and then).
  - If possible or desired a finer resolution can be considered: 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.5, 0.7, 1.0.
  - Duration of a complete measurement cycle should be one hour or shorter.
  - Enough time should be given concerning minimum duration per supersaturation to ensure good counting statistics.

  Remarks:
  - *Erik Swietlicki:* Equilibrium is not reached in scanning flow mode. Consequently the flow rate ramp has to be identical to that applied during calibration.
  - *Markus Fiebig:* Report values always for the same supersaturation, even if interpolation is needed.

- **Monodisperse measurements**
  Recommendations:
  - ACTRIS recommends D-scans.
  - A neutralizer must be used in front of the DMA.
  - The DMA should be operated as outlined in SOP for size distribution measurements.
  - Diameter range to be covered during D-scans should be 40 – 300, or from zero activation to 300 nm (covering diameters larger than 300 nm is appreciated but not mandatory).
  - Common supersaturations for monodisperse measurements should be 0.1, 0.2, 0.3, 0.5, 1.0 (1.0 for test purposes every now and then)
  - Duration of measurement cycle should be around 1 to 1.5 hours.
  - CCN-size distributions should be reported (rather than diameter dependence of activated fraction).

- **Data analysis procedures**
  Recommendations:
  - Which temperature difference should be used as a reference for the supersaturation, e.g. T2-T1 or T3-T1? (Martin Gysel will get in contact with Thanos Nenes in order to make a recommendation.)
  - No recommendation was made concerning which temperature should be used for calculating the surface tension (Martin Gysel will get in contact with Thanos Nenes in order to make a recommendation.)
  - Diffusion losses, which become important below ~70 nm, should be ignored for now. Correction of polydisperse CCN measurements for diffusion losses would only be possible if parallel SMPS measurements are available. (A sensitivity study should possibly be performed).

Action items:

- *Martin Gysel:* Gets in contact with Thanos Nenes in order to identify the relevant temperature difference determining the SS.
- *Martin Gysel:* Gets in contact with Thanos Nenes concerning the temperature at the centre of the CCN's column at point of CCN activation.
- *Volunteer:* Perfoms a sensitivity study regarding the potential importance of considering the diffusion losses.
- *Groups possessing a code for inversion of monodisperse measurements:* It would be good to share the inversion code (in transparent form) with those groups that still need an inversion code for their monodisperse measurements.

Remarks:

- *Martin Gysel:* Stopping D-scans at D=300 nm implies that size distributions measured independently by an SMPS have to be used to estimate the number concentration of CCN above 300 nm.
- *Martin Gysel:* Verification of consistency between the calibrations of the SMPS and CCNC can be achieved as follows: polydisperse pure ammonium sulphate should be provided to the main inlet and the SMPS and CCNC should be operated in standard "monitoring" configuration. A closure study between SMPS and (polydisperse) CCNC can be done by integrating the SMPS above the critical diameter calculated for pure ammonium sulphate for the supersaturation applied in the CCNC.

EBAS Data format

Data filtering (open questions):

- Tolerance for deviations of total flow rate from nominal setpoint?
- Tolerance for actual supersaturation?

- **Level 0**
  - Standard deviations for flow rate should be provided for later quality checks.
  - Standard deviation for temperatures should be provided for later quality checks.
  - Quality flags should be applied for flow rates (if flow is off during one set point, data should be rejected for level 1 and 2!). Acceptable tolerances: flow rate bias <±5%; relative standard deviation <10%. Instruments operated in scanning flow rate operation will have to find their own reasonable quality criterion (corresponding to less than 10% relative uncertainty in the precision of the applied SS). Note, the flow rate control is susceptible to disturbance from other applications with high memory/CPU usage such as e.g. remote desktop login.
  - Quality flags should be applied for the CCNC's flow ratio (sample : total): values between 1:5 and 1:15 should be acceptable.
  - Quality flags should be applied for the maximum CCN number concentration (coincidence and water vapour depletion effects). Upper limit remains to be identified.
  - Stable supersaturation should be assured (if SS is stepped). This can be achieved in different ways. A first option is filtering a sufficiently long time interval after setpoint changes based on careful tests of the equilibration times. A second test is to use the temperature readings to filter transient periods. The maximum temperature tolerance should correspond to less than 10% relative uncertainty in the precision of the applied SS. The type of stability criterion applied should be stated in the header of the file. Note, the CCNC's flag "temperatures stabilized" is not always sufficient.
  - Nominal set point of total flow rate is missing in the instrument output and needs to be added by users when loading the raw data.
  - Set points for supersaturation should be reported (either set point or reading should be indicated and used CONSISTENTLY).

- CCNC calibration data should be reported (requires flag marking data as "ambient" or "calibration").
- Monodisperse CCN data should contain the same quality parameters as SMPS data.
- Providing results for different supersaturations in one or different files? (In the former case, which time stamp should be used, in the latter native time should be used). Markus Fiebig will take a decision.

Action items:

- *Markus Fiebig:* Instructions concerning the level 0 data format will be distributed by the end of the year.
- *Frank Stratmann:* Check literature for upper limit CCN number concentration below which coincidence and water vapour depletion effects are negligible.

- **Level 1**
  - Difference between level 0 and level 1 is mainly averaging
  - Averaging time should be 1 hour.
  - Monodisperse data must be inverted data and the inversion result must be quality checked.
  - "Inversion" means at least correction for multiply charged particles, while considering effects of DMA transfer function is optional.
  - Providing results for different supersaturations in one or different files? (In the former case, which time stamp should be used, in the latter native time should be used). Markus Fiebig will take a decision.
  - If calibrations are different before and after a measurement period, those two calibrations should be averaged. 20 % difference is acceptable for now, if difference is larger, data should be flagged by provider.
  - Calibration data are not included in level 1.

- **Level 2**
  - Conversion to STP should be performed.
  - Averaging time should be 1 hour for polydisperse and 3 hours for monodisperse measurements. (Time stamp refers to the end of the interval).
  - The results for all supersaturations are provided in a single file.
  - No information on variability will be provided, as the sampled subset is too small to provide statistically relevant information on the variability.