Update on SMPS/CPC comparisons at BEACHON-RoMBAS 2012

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1. Deployed 5 different SMPSs and 3 stand-alone CPCs at RoMBAS
   • SMPS: TSI-Kr, TSI-Xray, Custom BMI, Grimm
   • Often only 1 SMPS at a field site, used to “determine” CE
   • Opportunity to see how well that may work out
   • Basic check: compare total number concentrations

2. Reminder of where we stood at the end of campaign
3. Identification of some of the problems
4. Moral of the story

As shown at 2011 AMS Users Mtg

Factor of x5 between instruments
None of SMPS agree with CPC!
As shown at 2011 AMS Users Mtg

Three different CPC models match ➔ taken to be “true” int. number density

Compared to CPCs:
- SMPS #4 and #5 are too high
- SMPS #1 matches except for afternoons
- SMPS #2 and #3 are too low

SMPS#1: CPCs have a lower size cutoff
Nucleation during afternoons
Small particle losses in SMPS explain afternoon deviations
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Investigating SMPS #2: dN/dlogDm scans compared to SMPS #1
- Three different (and stable in time) size distributions on 8/12/11
- Residence time in SMPS #2 inlet was much longer than in SMPS #1 inlet → large losses of small particles in inlet
Empirical Correction Function for SMPS #2 $dN/d\log D_m$

SMPS #2: After size-dependent correction
Integrated Number after SMPS #2 size-dependent correction

Integrated Volume after SMPS #2 size-dependent correction
As shown at 2011 AMS Users Mtg

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Direct Comparisons of SMPS #1, #3-5 w/ CPC

- Compare CPC counts to integrated SMPS counts
- Compare DMA-selected particle size to measured SMPS size
**SMPS #1 vs. CPC**

- Decent agreement in size and integrated number

**SMPS #4 vs. CPC**

- Selected vs. measured size matches, but integrated number density does not match.
As shown at 2011 AMS Users Mtg

Three different CPC models match ➞ taken to be “true” int. number density

Compared to CPCs:
- SMPS #4 and #5 are too high
- SMPS #1 matches except for afternoons
- SMPS #2 and #3 are too low

SMPS #5 vs. CPC

- Neither size nor integrated number density match
- Known problem: a TSI X-Ray neutralizer was used, which produces a more symmetrical equilibrium charge distribution (see next slide). This means the software inversion is wrong, resulting in ~15-40% higher particle number density measured
- Unknown problem: why do selected and measured particle sizes not match?
**Concentration Correlation**

No indication of ion depletion at any of the experimental test conditions.

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**Y = 1.17 X ??**

- SMPS uses a fixed table of charge probabilities. Apparent concentration differences between the 3077A and the 3067 are due to differences between the actual single positive charge probability and that assumed in the data analysis.
- Our experiments show that the probability of single positive charge is consistently a few percent higher for the soft X-ray device than for the Kr-85 device.
- Further tests showed that the probability of single negative charge is lower by a similar amount.
- The particle charge distribution with soft X-ray gas ionization is thus more symmetrical than the Fuchs distribution calculated with Wiedenschnier’s ion parameters.
- Published literature corroborates this difference...
SMPS #3 vs. CPC
Still working on this comparison, but there was definitely a software or user error in converting dN/dLogDp to integrated number. More to come...

What’s going on?

• Nobody gets funded to bring an SMPS to a field campaign, or gets excited about its data (e.g. good luck recruiting a good PhD student to do SMPS measurements!)
• In a field study, people tend to take SMPS out of the box, set it up, and not pay much attention to it as they work on the more scientifically interesting instrument they really care about
  - Unfortunately SMPSs can have many problems and still produce reasonably-looking concentrations and size distributions. Most users won’t even notice!
  - I’d estimate the probability of a problem is ~90% for unattended SMPS
• AMS users need to be the exception because of the need of high-quality SMPS measurements for comparison

Moral of the Story

• Always use 2+ independent measurements to compare to AMS (especially if trying to determine CE).
• Need to ALWAYS compare number and calibrate size on SMPS
• Even “routine” instruments are wrong more often than not.
Summary
• 5 SMPSs from 5 experienced groups at same location
  – 1 working OK (not seeing nucleation particles, as expected)
  – 1 losing particles < 200 nm due to both long inlet and CPC issues
  – 1 likely has error in inversion software
  – 1 has too many particles due to TSI X-Ray charging efficiency, also unknown sizing problem
  – 1 unclear, but maybe software / user error

• Moral of the story: you always want TWO independent measurements to compare to AMS
Volume Comparison #1 vs #2

SMPS #2 now matches CPCs and SMPS #1

What about SMPS #3, #4, #5?
Asymmetry of charging by alphas vs soft X-rays

from Lee et al. (2005)