Atmos. Chem. Phys. Discuss., 8, S10918–S10922, 2009
www.atmos-chem-phys-discuss.net/8/S10918/2009/

Atmospheric Chemistry and Physics Discussions

ACPD

8, S10918–S10922, 2009

Interactive Comment

Interactive comment on "Single ice crystal measurements during nucleation experiments with the depolarization detector IODE" *by* M. Nicolet et al.

Anonymous Referee #5

Received and published: 4 February 2009

This paper presents the fundamental theory and experimental setup of the Optical Ice DEpolarization detector "IODE". This detector is designed to distinguish between water droplets and ice crystals as part of the Zürich Ice Nucleation Chamber ZINC. Some experimental data were shown which were taken during the IN inter comparison Workshop ICIS. Because the focus is not on the experimental data, the title is somewhat misleading. The article may be better submitted to "Atmospheric measurement techniques" Summing up, this paper reports the status of the IODE detector development at a stage, which is far away from being operational. The question is, if this status merits publication! I would answer that question with yes but only with mayor (also experimental) changes!

General remarks of technical or scientific nature :

The authors present a newly designed detector to distinguish between ice crystals and water droplets for the ZINC counter. Also the theory of measurements is shown. But no information is given, where in terms of the depolarization ratio the separation between ice crystals and droplets is located. Even worse (with regard to fig.5.): In this picture the authors show a calculated probability density function (PDF) of the linear depolarization ratio for "cylindrical ice" crystals which are randomly orientated. On the right side of figure 5 the measured PDF using IODE is shown. Depolarization ratios less than 0.04 are ignored "because of the detection limit of the Photomultiplier (PMT)". From theory, water droplets are located at depolarization ratios close to zero. The maximum of the simulated ice crystal depolarization PDF is located at 0.04 which is the cut-off of the detection limit of the PMT. This picture lets me raise the question if it is possible to define such a threshold for the depolarization ratio to distinguish between ice crystals and water droplets. Moreover the authors demonstrate in this picture that the detector will not work with the necessary accuracy. IN are rare in the atmosphere (in the order of one per liter). Ignoring a majority of them because their depolarization is close to the detection limit is not suitable.

The authors cite the paper Bundke et al.2008 as reference for the IN chamber FINCH (Fast IN Chamber). This paper however also presents a phase discriminating detector measuring the circular depolarization ratio. It is surprising that no appropriate credit is given here with respect to an experimental solution of the problem that is the subject of the present paper.

Some remarks to the technical setup

I was astonished, that the detector is not mechanically coupled (P20979 Line 4) to ZINC. Thus, by misaligning (due to temperature changes of the chamber) the detection volume is located outside the "aerosol layer" resulting in an underestimation of the number concentration of IN and "a shift in the depolarization ratio" (false-positive ice detection?).

The authors report some "parasite light", thus they introduce a pinhole (P20972 L 25), and some band pass filter (P20973 L5). Where did this light come from? All these optical elements reduce the signal to noise ratio.

Especially for prototype equipment I would expect some more care on such details.

The general setup locating the detection volume in the cone area of ZINC (see fig. 1) is also problematic. First: The authors report some "coincidence" errors (e.g. 20978 L25). From my point of view this has two reasons.

1. The detection volume is too large. (12 cm length, 302 mm^3). This would be avoided if the detector is located at the bottom of the chamber close to the OPC.

2. The peak detection algorithm is not able to detect a second particle located on the shoulder/ tail of a former particle. This can be easily changed by using wavelet based peak detection algorithms also available for LABVIEW programming. (see www.Ni.com)

Second: I would expect that the aerosol layer is disturbed and particles are not focused well at the cone area (opening angle >6 degree) . This will result in an underestimation of the number concentration of IN. The authors give no reason why they place the detector in this critical region.

Some remarks to the experimental results

All experiments are done with ZINC, operating with a heating section to prevent droplets to enter the detector. Droplets are only present in IODE in a "water breakthrough" event- and in this case no single particle measurements are possible (and shown) because of "particle coincidence". For these cases the authors introduce a "hi-concentration" interpretation of their results (Fig. 9) which is not quantitative but qualitative!

The authors should add an experiment operating ZINC without this heating section to show the capabilities of the new device. They should add a figure analog to fig 5 which shows the depolarization ratio PDF for this experiment and indicates the threshold for ice detection.

The authors report an efficiency of 50-70% of the OPC. For single particle analysis this value results in enormous error-bars for ZINC measurements which are not shown.

Detailed remarks

- Page 20969 L 21: Equation 2) please write the 4x4 matrix complete and not in this short form.
- Page 20972 L16: Is it sure that a) the flow is laminar and b) all particles are located inside your detection volume. The cone has an opening angle larger 6-7 degrees, thus I would expect turbulences especially in the outer regions.
- Page 20972 L25: Where does the parasite light (with different wavelength) come from? Is the detector open to daylight? Is there fluorescence on optical parts? See also 20973 L5-6.
- 20973 L15: add "I" in following.
- P20973 L15- : A physical unit conversion is not necessary. All constants are eliminating each other. Only ξ has to be considered, which is different for the individual channels.

ACPD

8, S10918–S10922, 2009

Interactive Comment

- 20974 L3-4: The presented determination of the background signal (at the beginning of the experiment) has the disadvantages that PMT drift, laser adjustment drift and aerosol concentration variations are not considered. With focus on single peak detection a permanent determination of a "floating" baseline is the appropriated method.
- 20974 L25: "how long" is some time? See general remark to the peak algorithm.
- 20976 L20 What does the parameter "n" stand for?
- 20976 L13: In the sentence "The aerosol flow rate..." a word seems to be missing?
- 20978 25: please specify "particles" here: 70 IN or CN per cc?
- 20979 L5: What is the reason for the depolarization increase? (Baseline drift?)
- 20980: L1: Has the OPC a detection efficiency between 50-70% even for the large ice crystals? Really? Your error-bars for ZINC measurements have to be enormous! (Please add an error analysis!!)
- 20980 L 14: Are ice particles really randomly orientated? A 10 μm particle has a hydrodynamic relaxation time in the order of 1 ms. Why should not ice crystals (e.g. plates) come to a stable orientation in a laminar flow? Thus your difference in the PDF is caused by this! (And you are lucky because your detector will work in that case (see general comment!)
- 20981: L 1: 157% maximum rel. humidity: This is not consistent with Fig 6!
- 20981 L 9-10: Did you use the pre-impactor that ZINC normally operates with?

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 20965, 2008.

ACPD

8, S10918–S10922, 2009

Interactive Comment