Measurement of Ice Nuclei Number-Concentrations (SFB-641)

FRIDGE - FINCH

Holger Klein

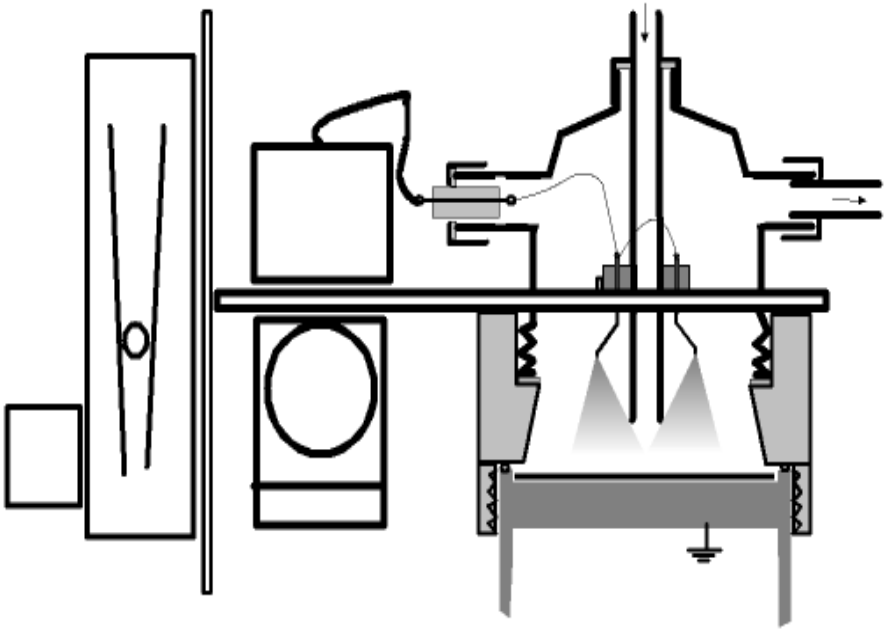
Heinz Bingemer, Ulrich Bundke, Bernd Reimann, Björn Nillius

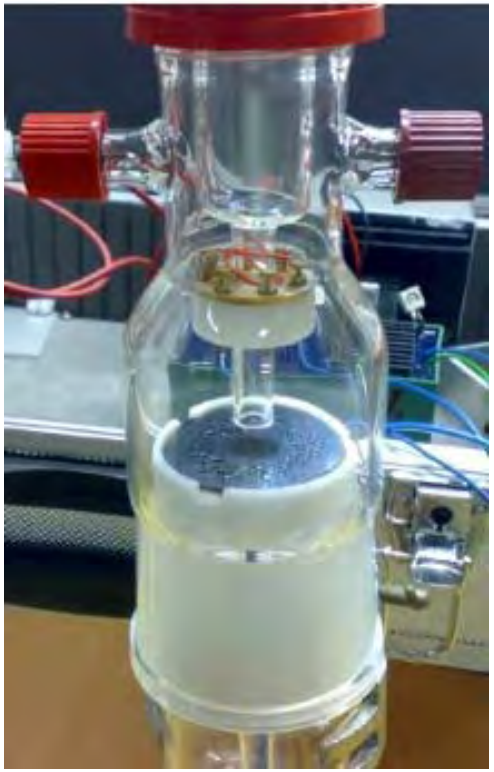
OVERVIEW:

- The New Aerosol Sampling Method for FRIDGE-Analysis
- Comparison-Measurements
- Ice-Nuclei Timeseries on Mt. Kleiner Feldberg
- Sahara Dust Episode / Model Comparisons
- First Test of Airborne Sampling
- Examples ACI-02 Results FRIDGE / FINCH
- Outlooks

- Report from Tel Aviv

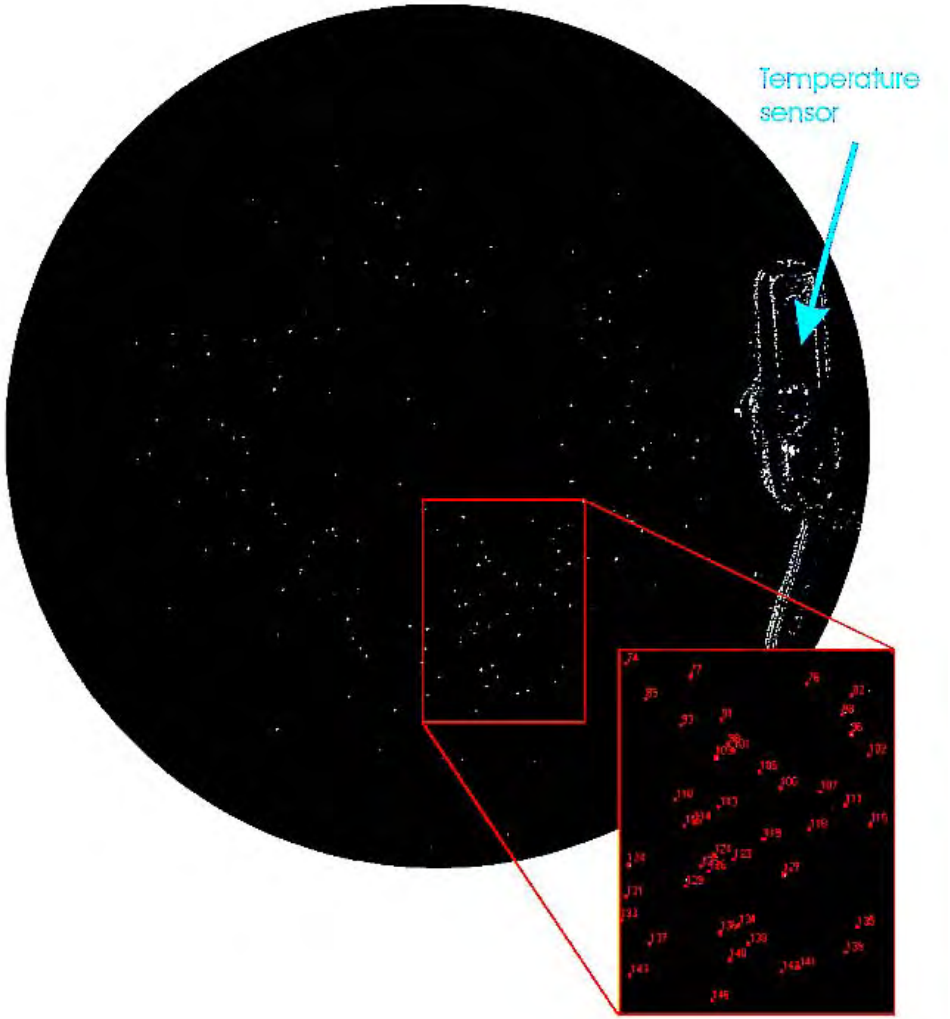
FRIDGE
Sampling with the new designed Electrostatic Aerosol Collector



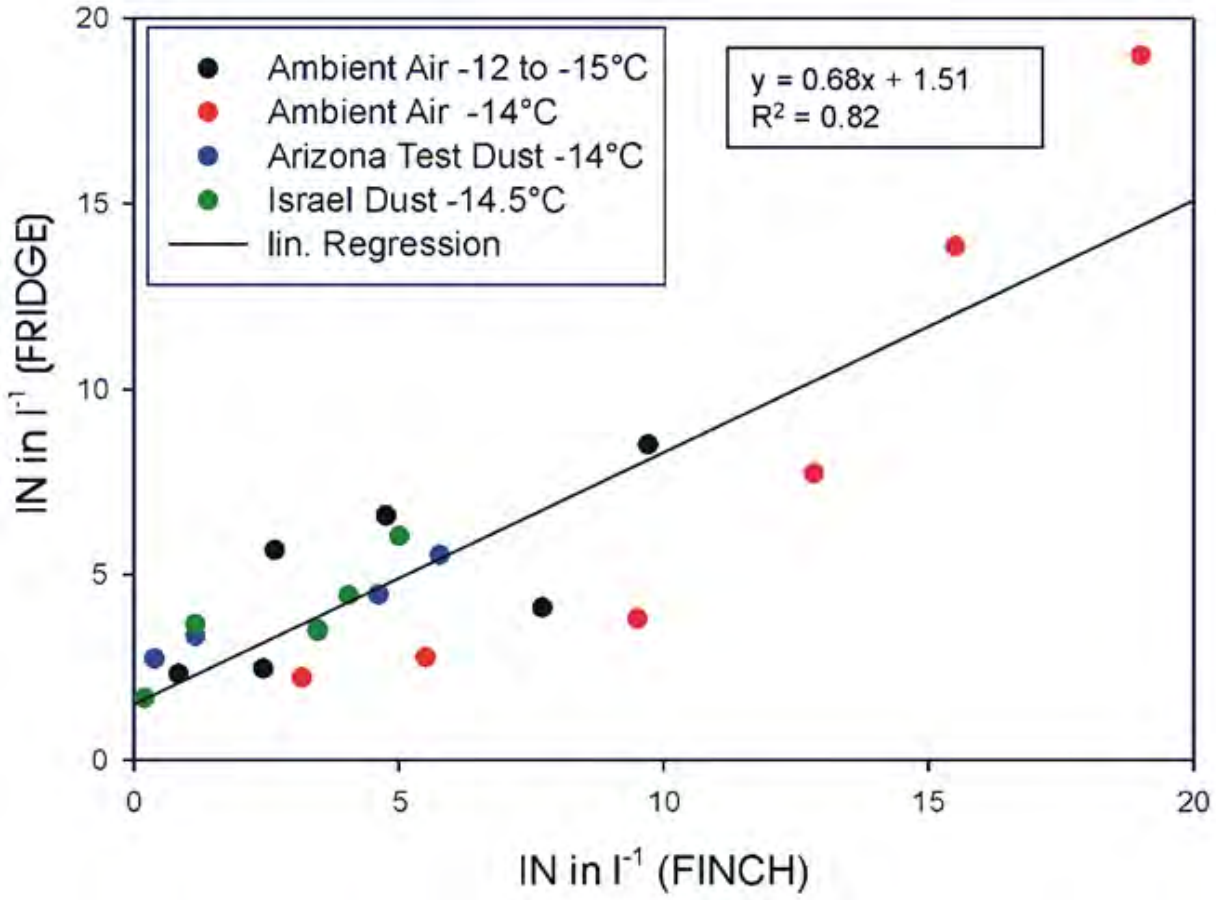


The FRIDGE-MAIN-Chamber

Activation of Ice-Nuclei inside the FRIDGE-CHAMBER



FRIDGE – FINCH Comparison



Timeseries of IN-concentrations at Mt. Kleiner Feldberg (50,22°N 8,45°O) (FRIDGE)

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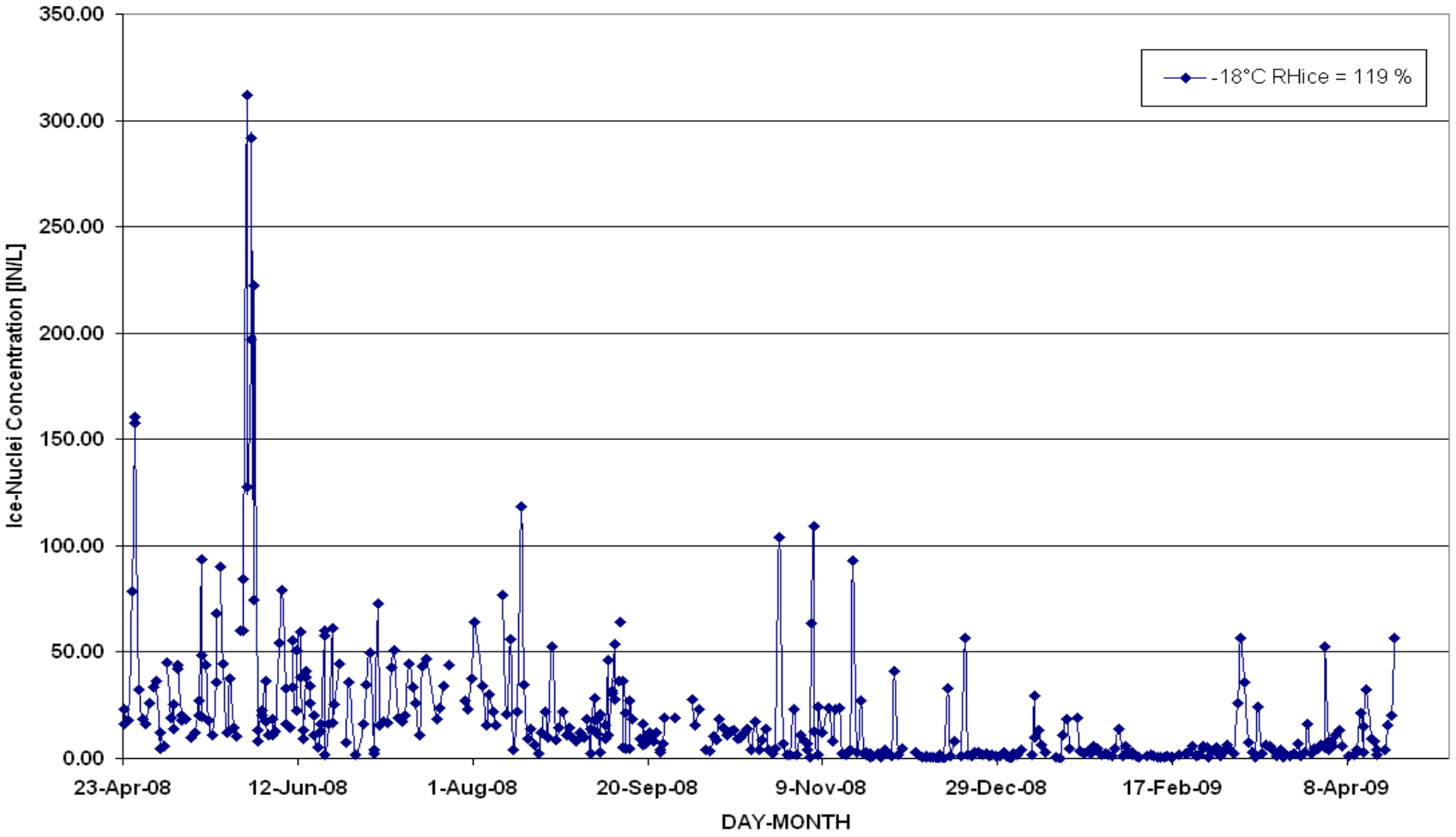
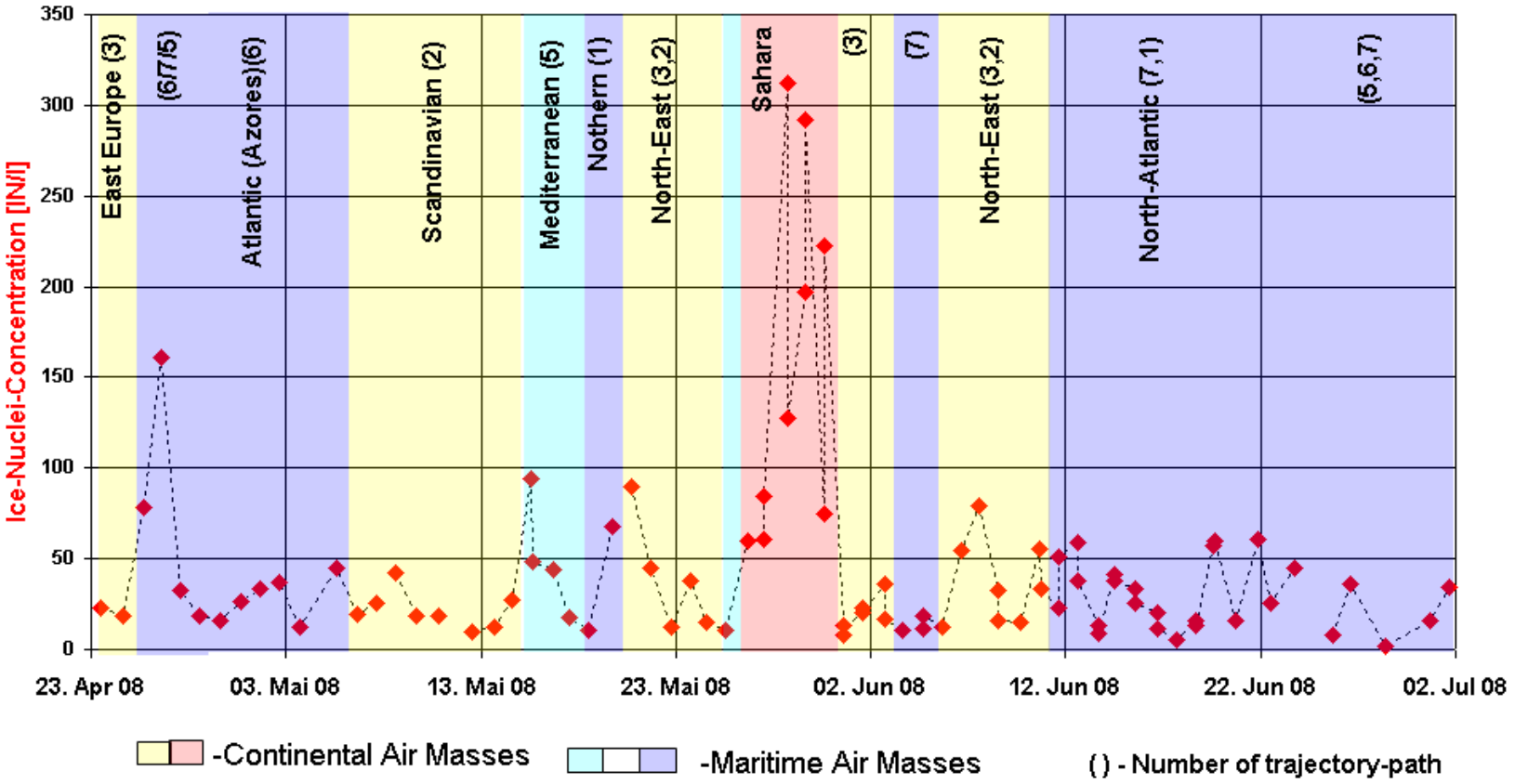
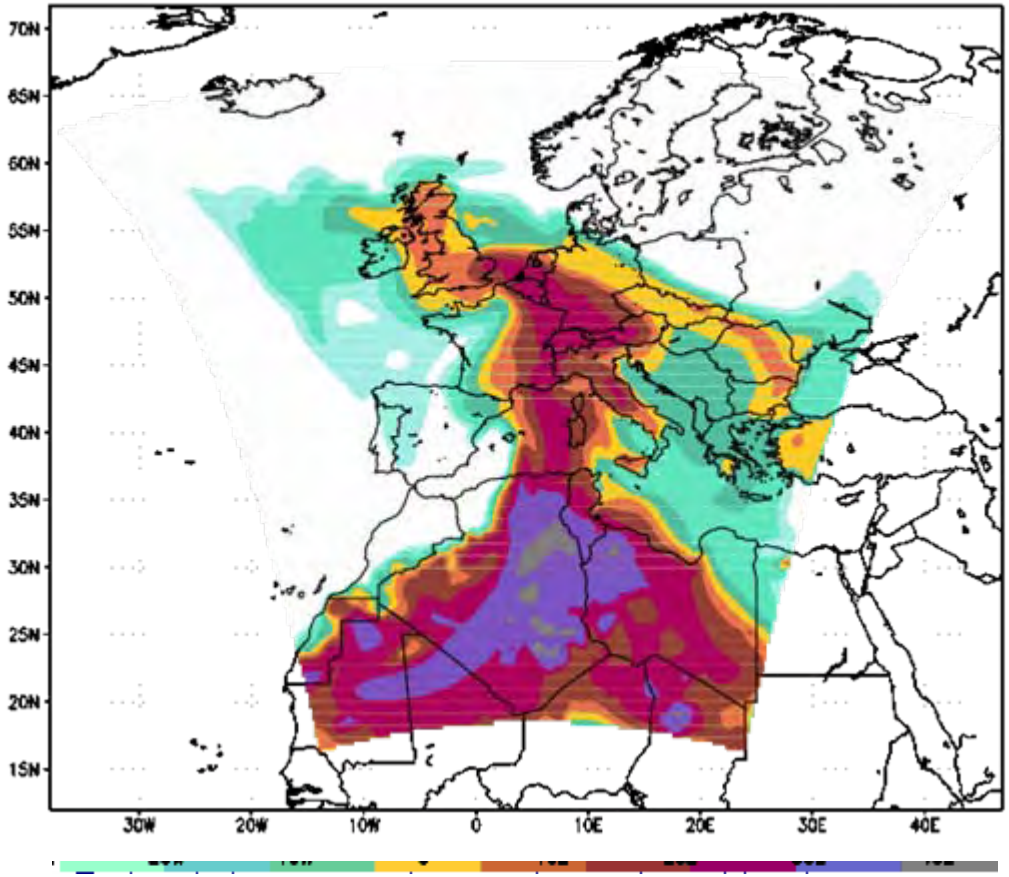


Timeseries April-July 2008 including Sahara-Dust

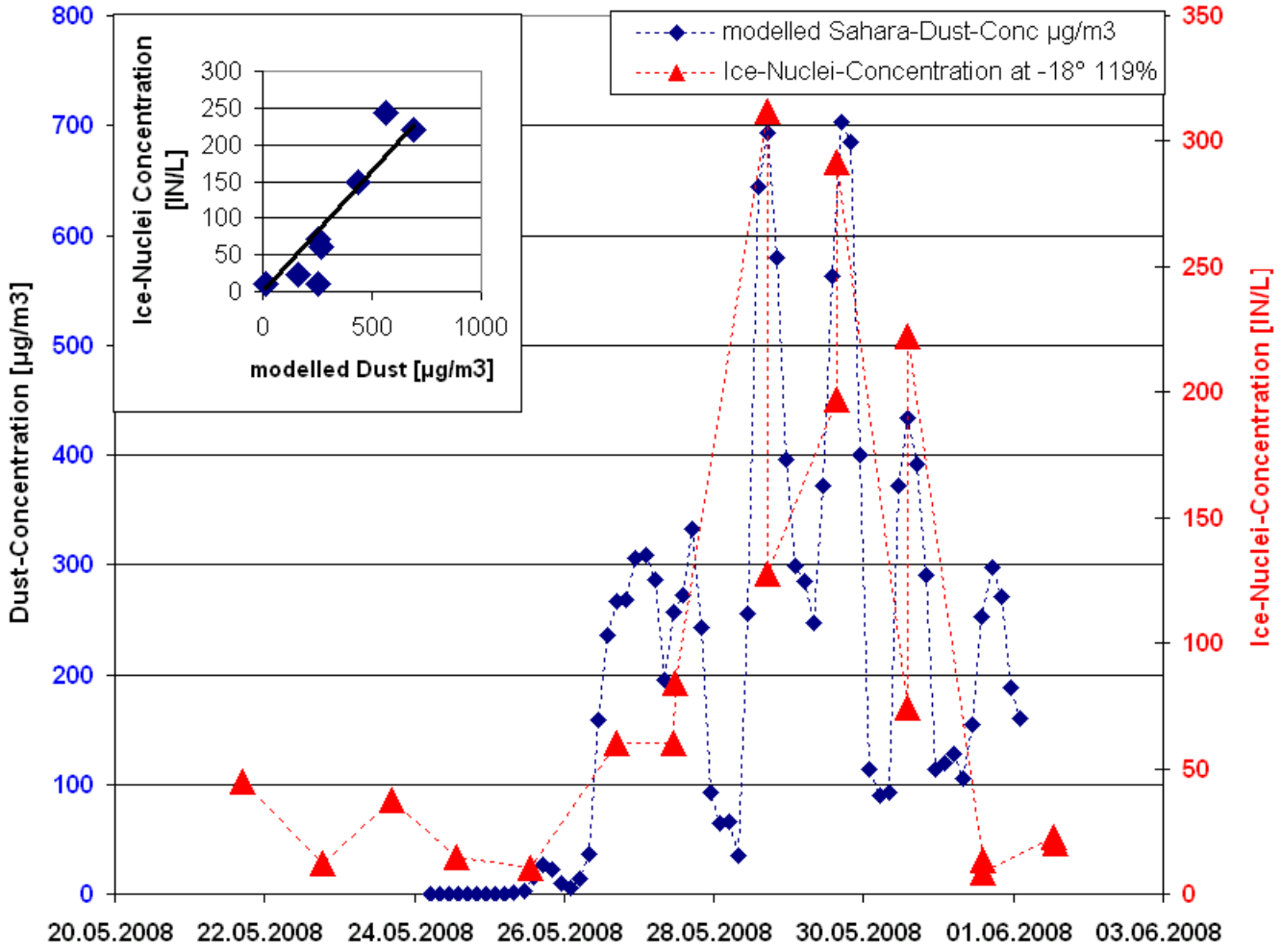


Modelled Dust Transport from Sahara-Region to Germany (28.5 12:00 UTC)

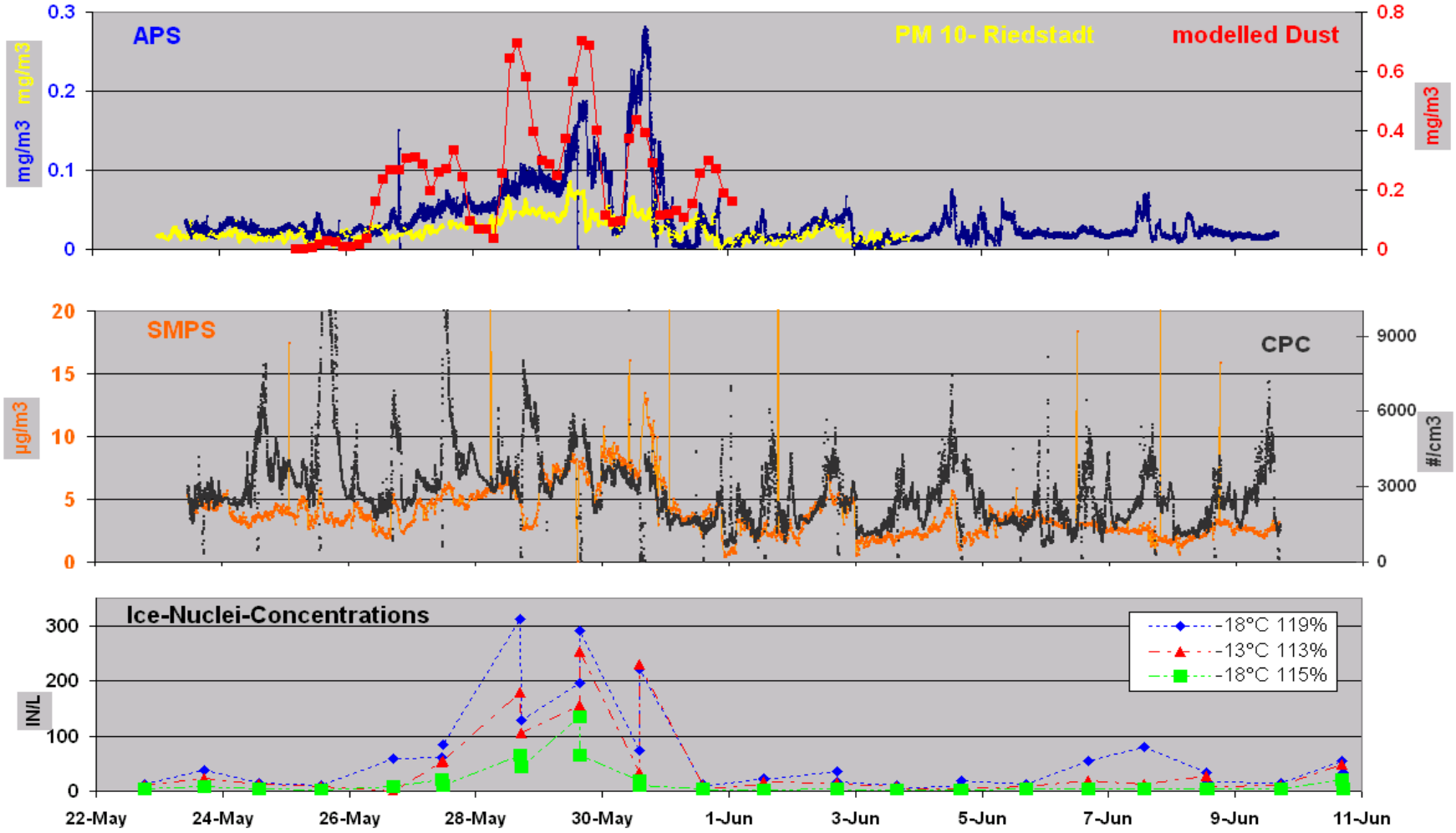


Slobodan Nickovic,
(WMO 2008)

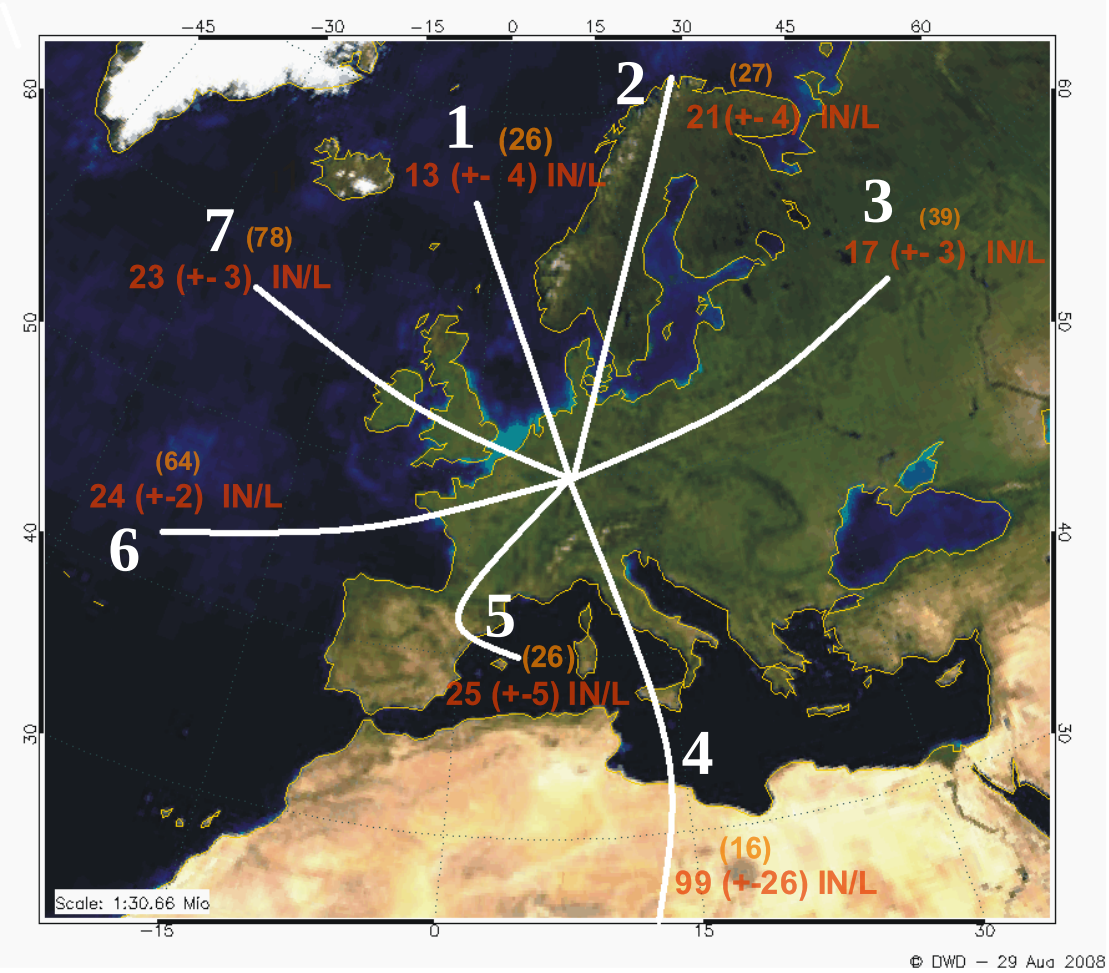
Comparison between modelled Dust / Ice Nuclei Concentration



Saharadust event 26 May – 1 June 2008

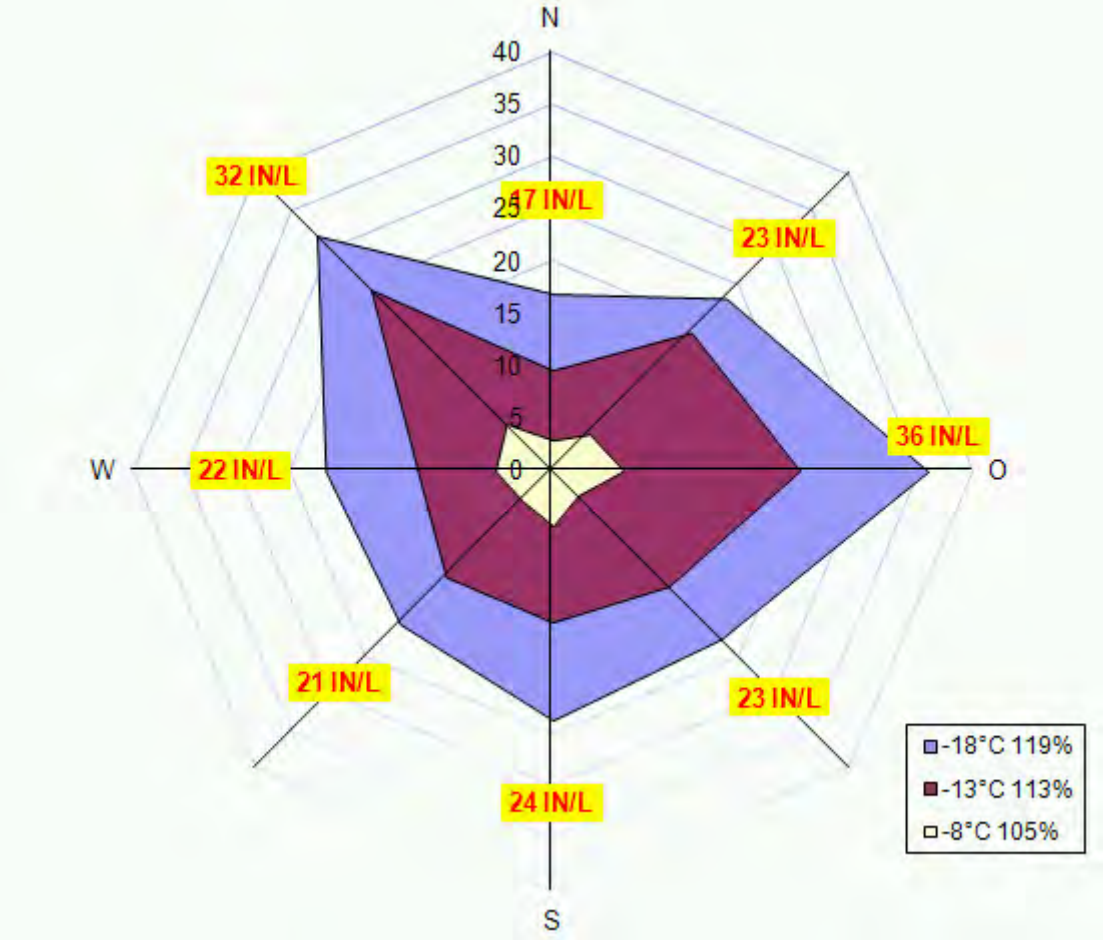


Averaged Ice-Nuclei Concentrations for various trajectory pathways

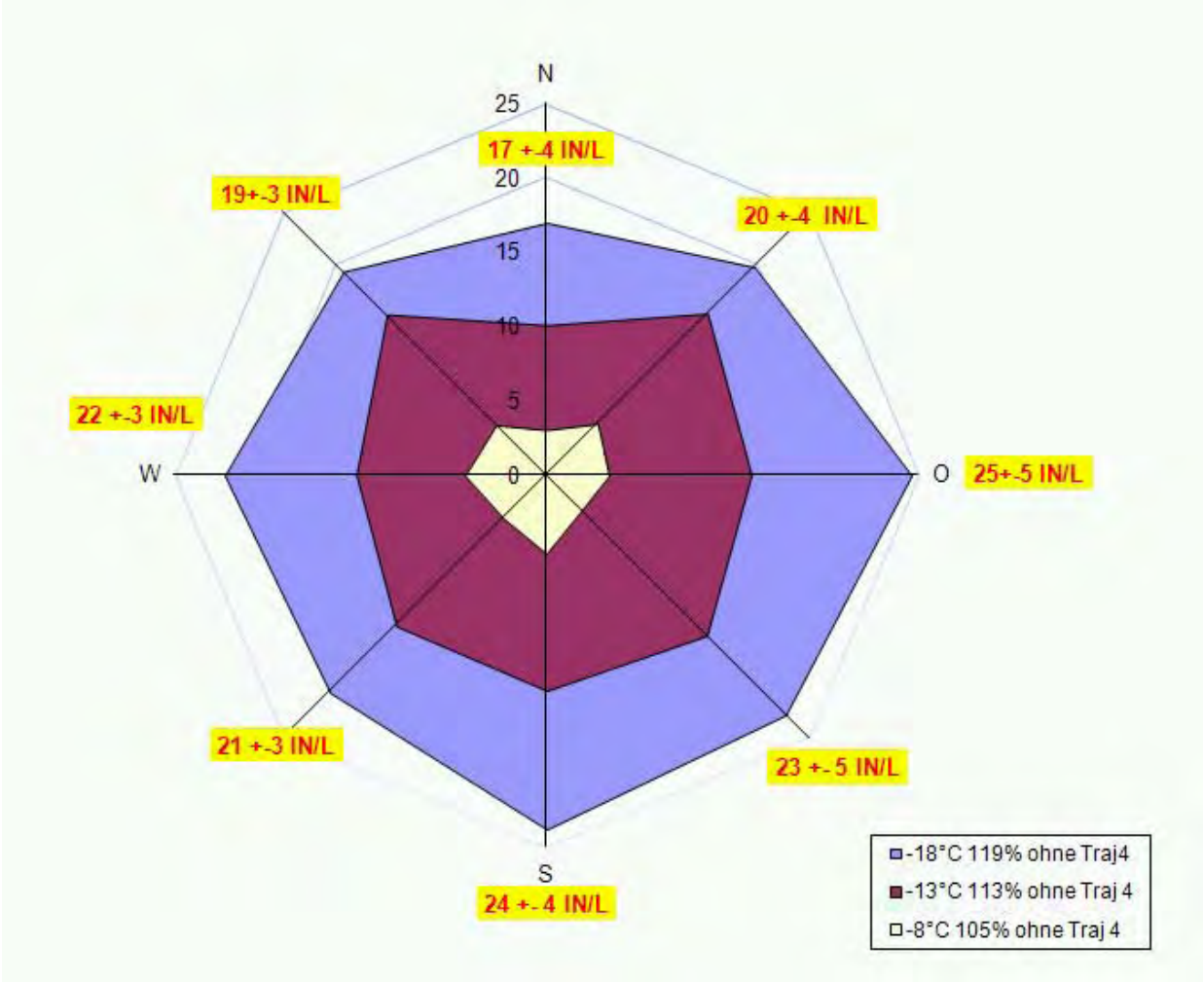


(underlying Map from DWD)

IN-Concentrations with respect to local wind



IN-Concentrations with respect to local wind (without Dust-Events)



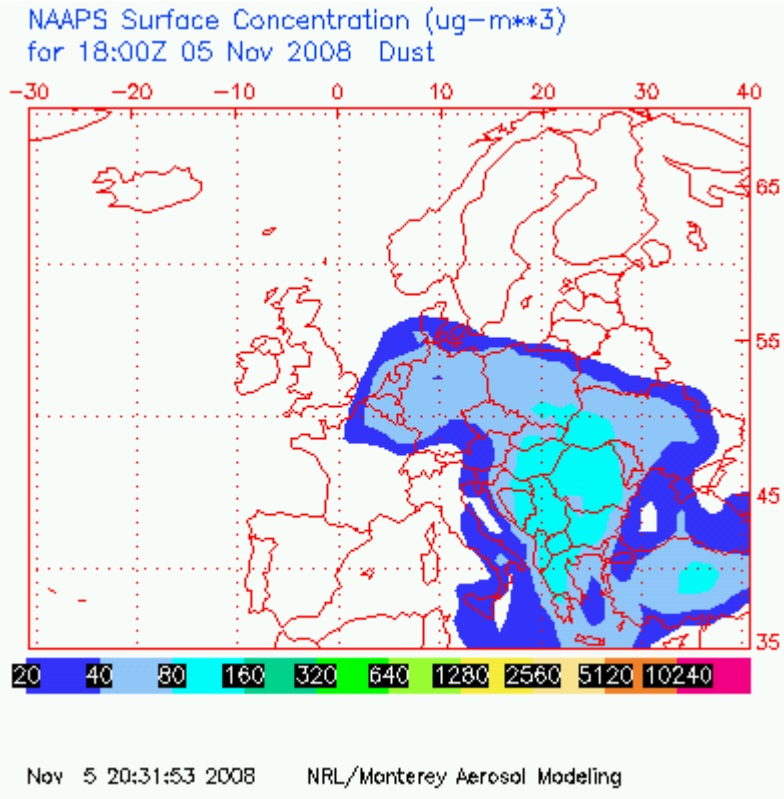
Dust-Event in November 2008

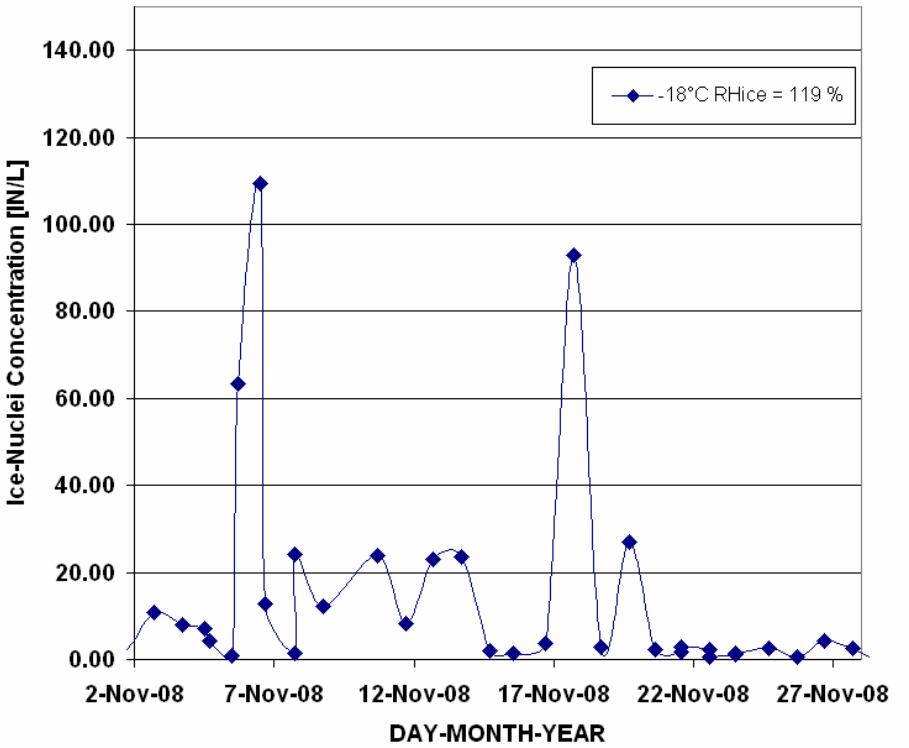
NASA image courtesy MODIS Rapid Response, NASA Goddard Space Flight Center. Caption by Michon Scott.

Instrument:
Aqua - MODIS

Date Acquired:
November 1, 2008

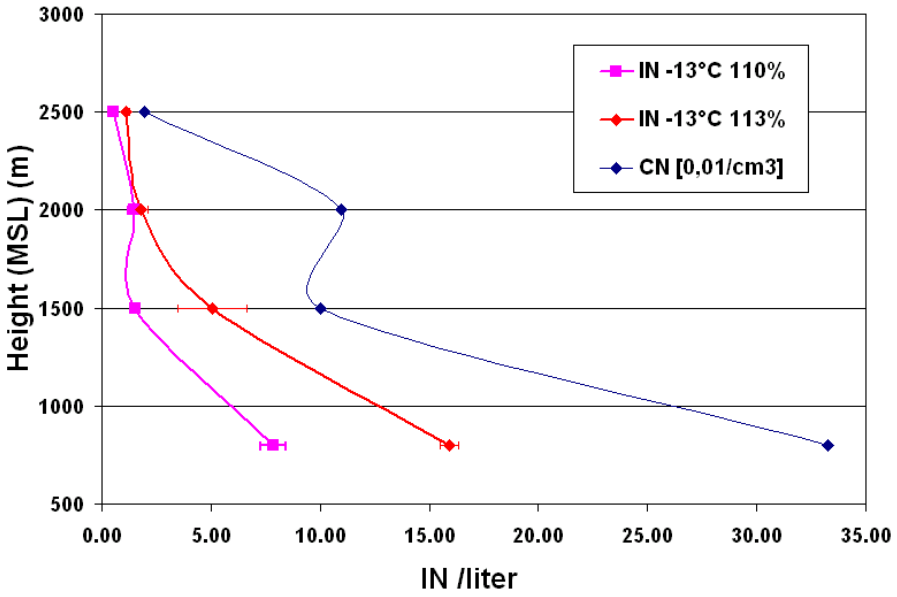
Dust-Event in November 2008

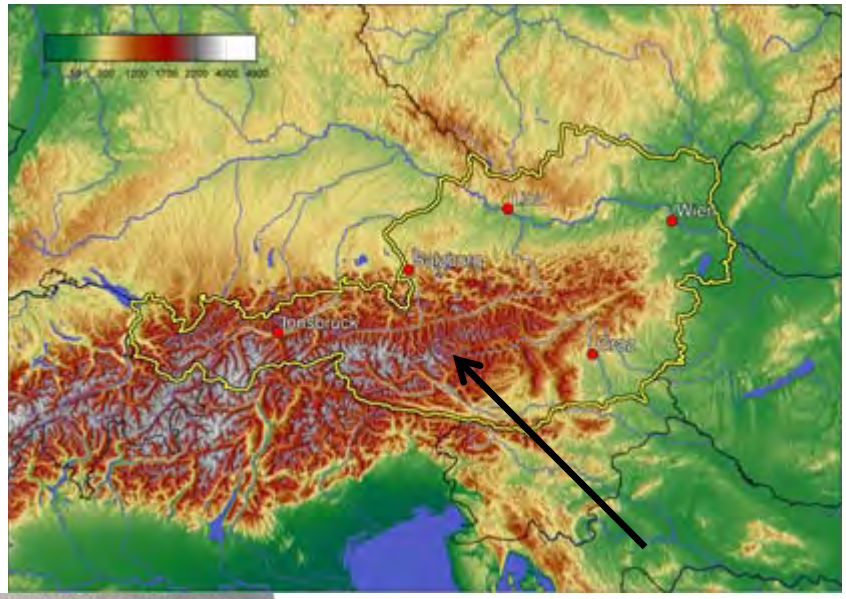


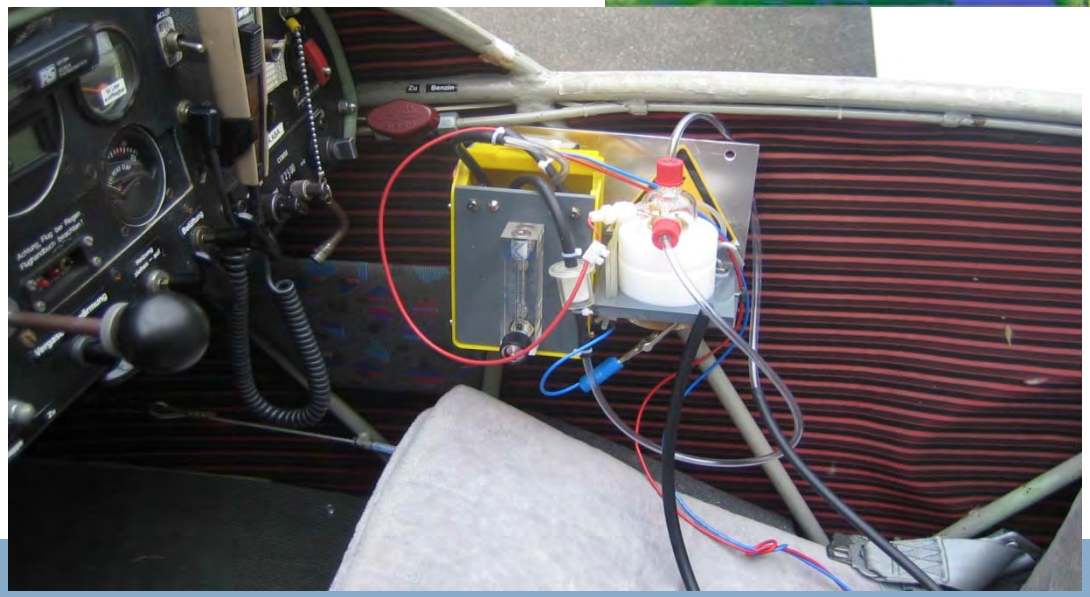


(2008, from NRL Website)

Sampling from a sailing plane







MEASUREMENTS WITH FRIDGE AT AIDA ACI-02

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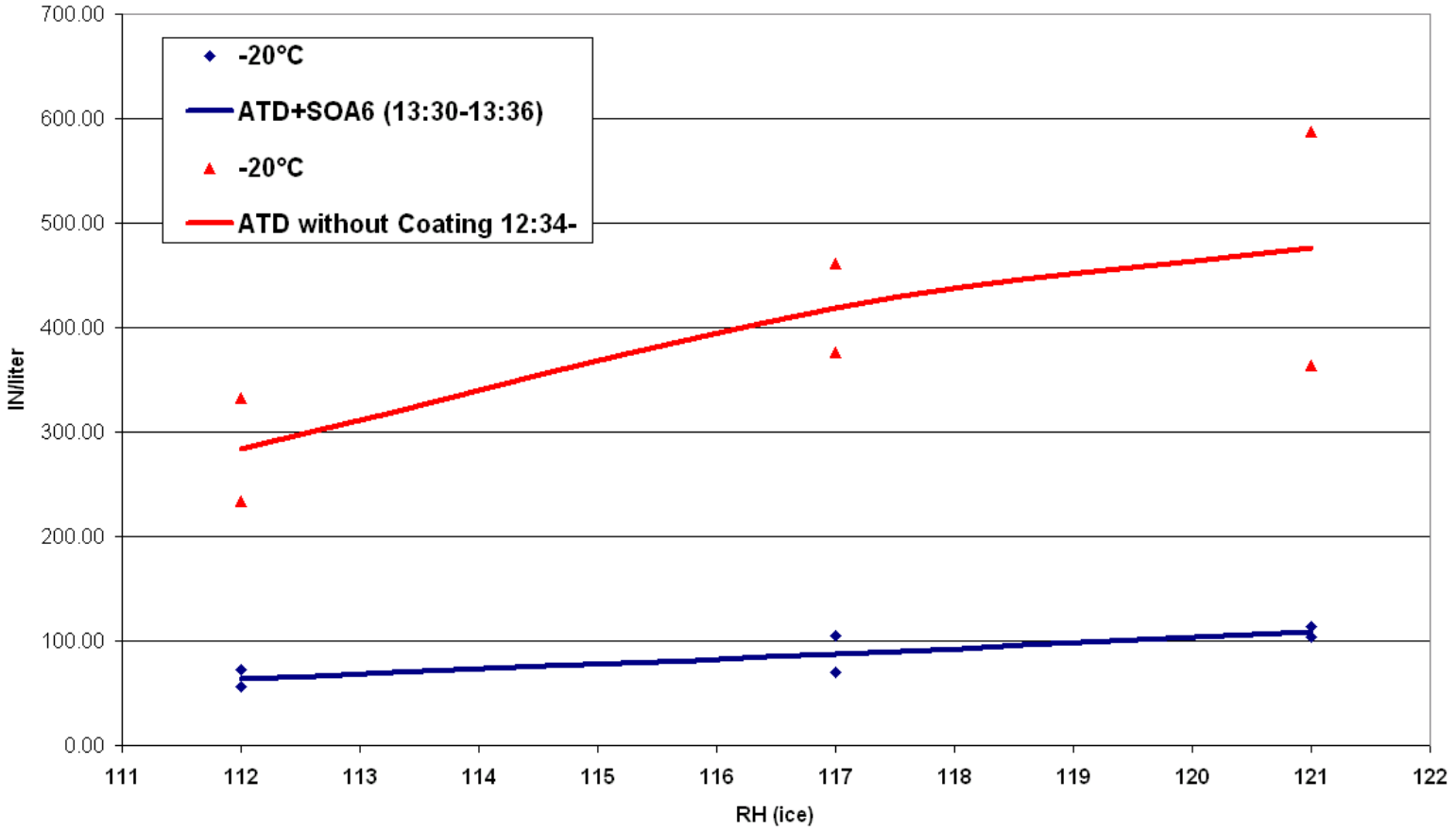
FRIDGE-Analysis
Arizona Test Dust Experiment NAUA Exp. 14/15



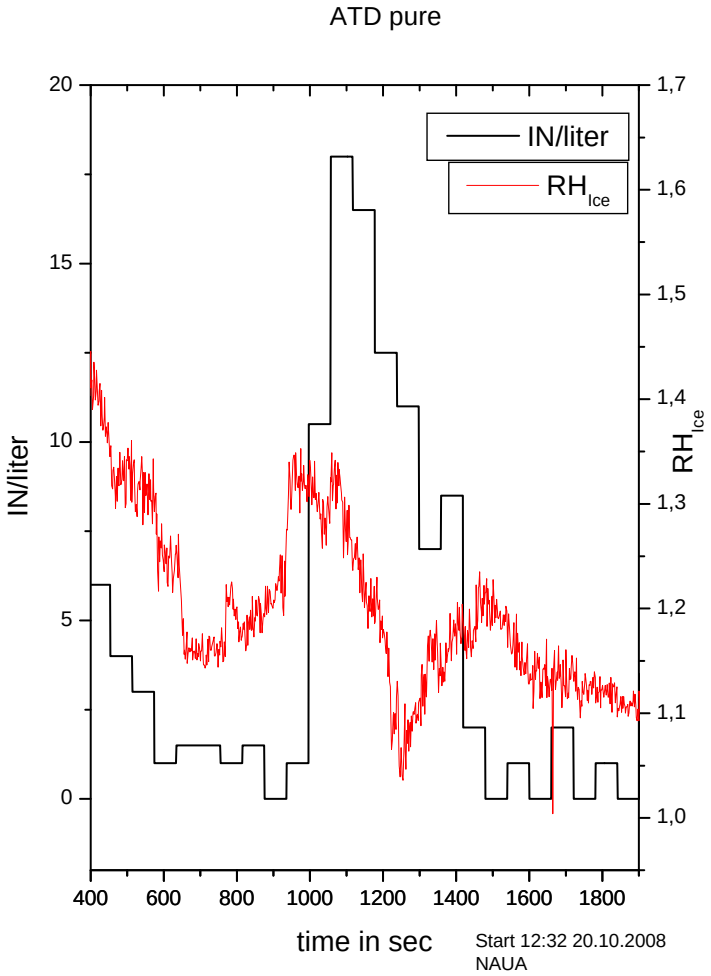
The continuous flow mixing chamber FINCH at AIDA/NAUA experiments during October 2008

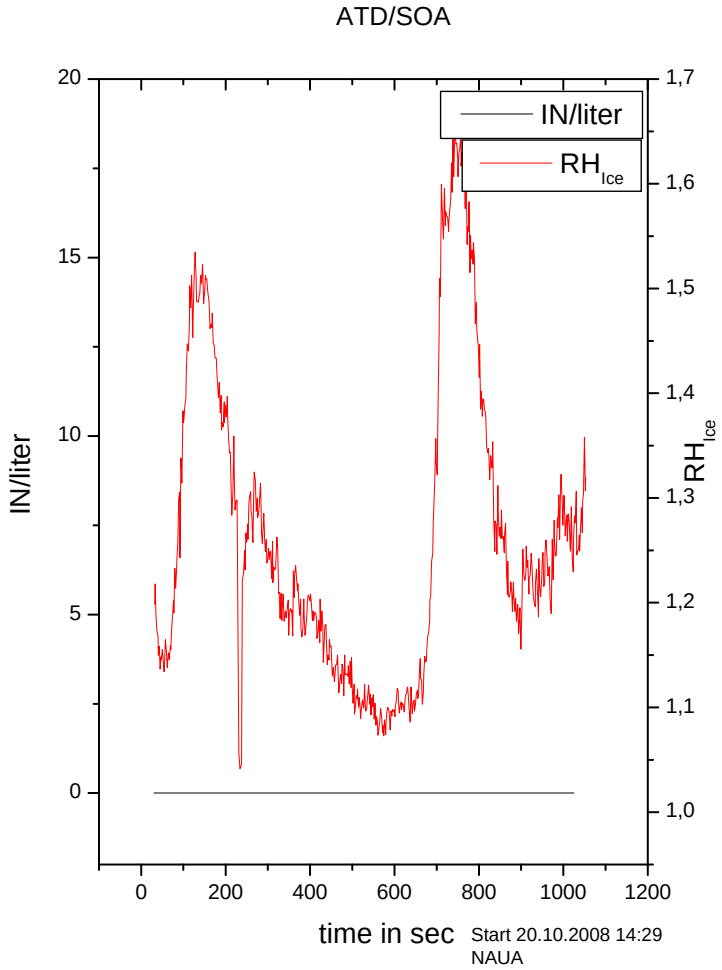
U. Bundke, B. Nillius, T. Wetter, B. Reimann

Institute for Atmospheric and Environmental Sciences
Goethe-University, Frankfurt/M., Germany

… just two examples …

FINCH at NAUA in October 2008:
Effect of SOA coating on IN activation

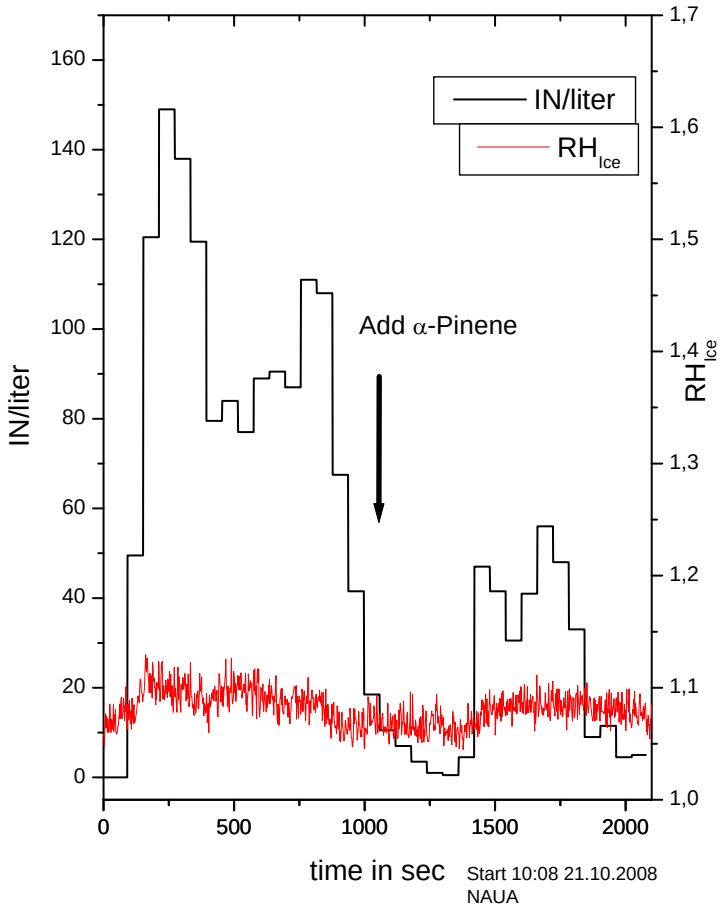




FINCH at NAUA in October 2008:

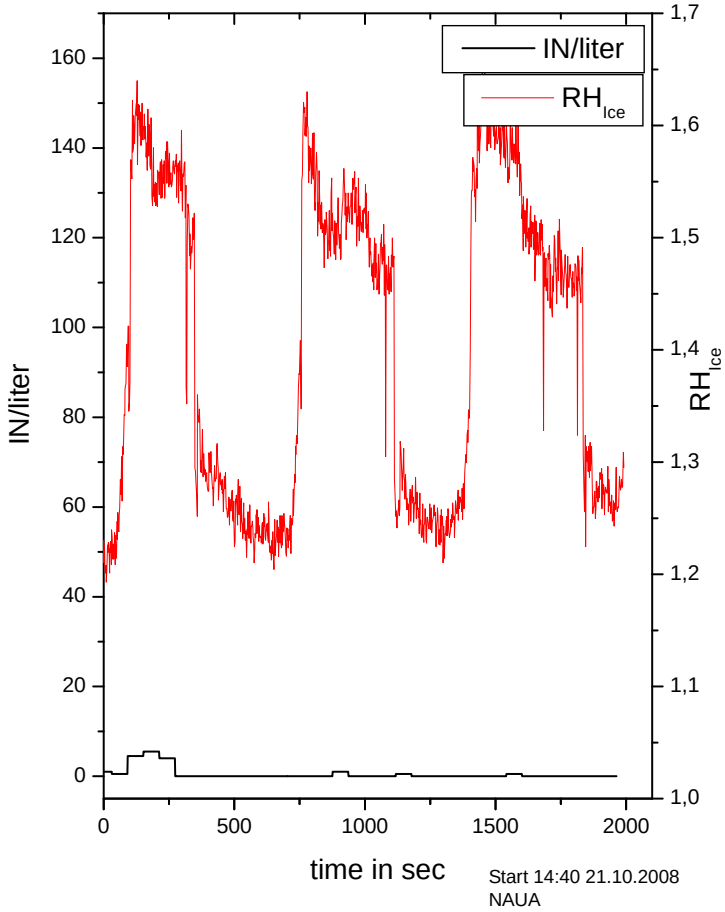
Effect of SOA coating on IN activation

ATD pure



-20°C

ATD/SOA



-22°C

OUTLOOKS:

- Analysis of the timeseries with model results
- Development of an automated multi-sample Aerosol Collector
- Further Comparison-Measurements
- Cooperation with the Electron Scanning Microsocope – Darmstadt
- Measurements of Dust-Events in Europe at higher levels (Jungfraujoch)
- Improved Dust-sampling from an airplane in Israel

Measurements on Immersion freezing and on Condensation and Deposition freezing on samples of Near East ambient aerosol

Methods:

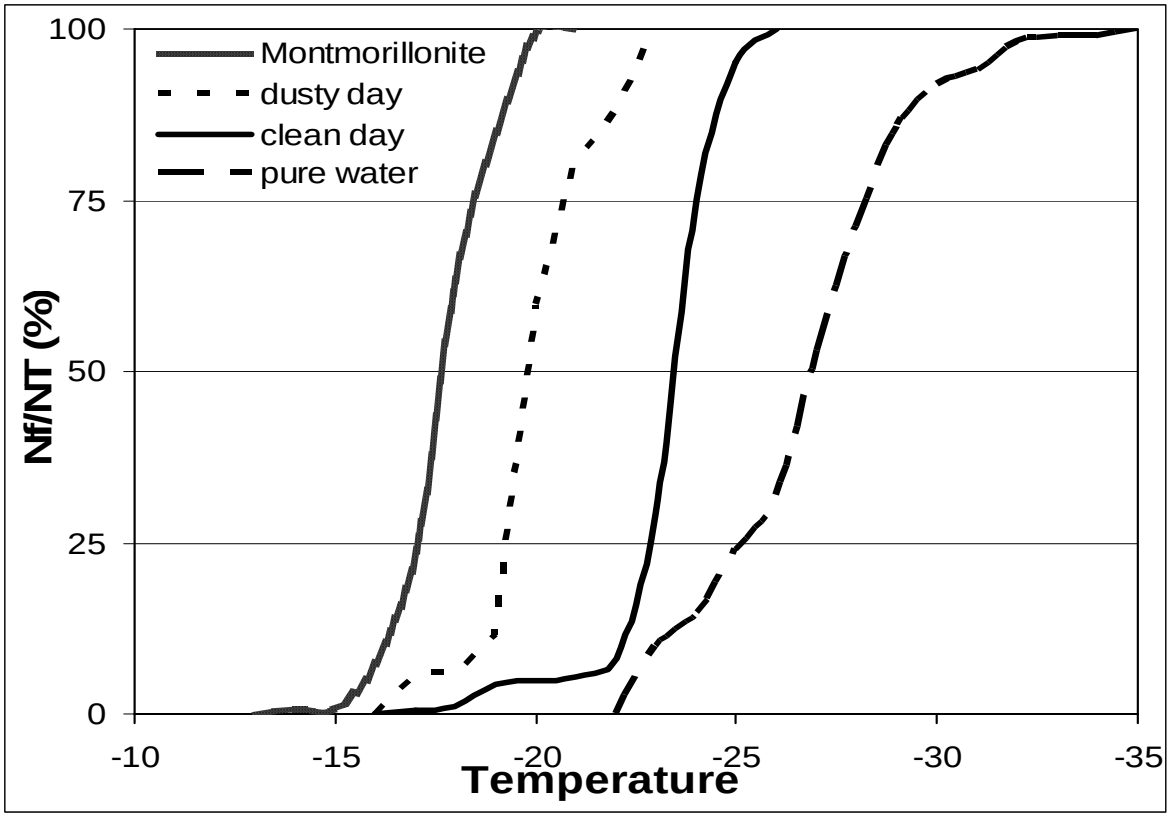
Aerosol samples were collected at TAU building roof on filters and on silicon discs.

In the Static Vapour Diffusion Chamber FRIDGE-TAU ice is grown on the nuclei and ice crystals are counted

- *for immersion freezing:* drop freezing method (Vali, 1985, Levin et al. 1987):

  dissolve aerosol on fliters in 10 ml DIW, spray ~ 200 droplets of 2µl each on FRIDGE substrate, cooling substrate, record number of drops frozen at T (CCD camera)

- *for deposition freezing:* run FRIDGE at normal mode: cooling plus 1-2 HPa H_2O vapour, count ice crystal number at T, S



clean: East. Europe / Mediterr. Air

dusty: Saudi Arabia / Red Sea air

Figure 2: Temperature dependence of the relative percent of frozen drops (Nf) to the total drops (NT) containing Montmorillonite particles, clean day and dusty days.

1. Pure Montmorillonite has highest freezing temperature: -16.5 C
2. Dust (34% Illite, 66% Kaolinite, no Montmorillonite: -19.5° C
3. Clean day sample: ~ -25° C
4. ➔ Pure Montmorillonite is nucleating more effective than Illite and Kaolinite

3.2 Deposition and Condensation freezing in FRIDGE-TAU:

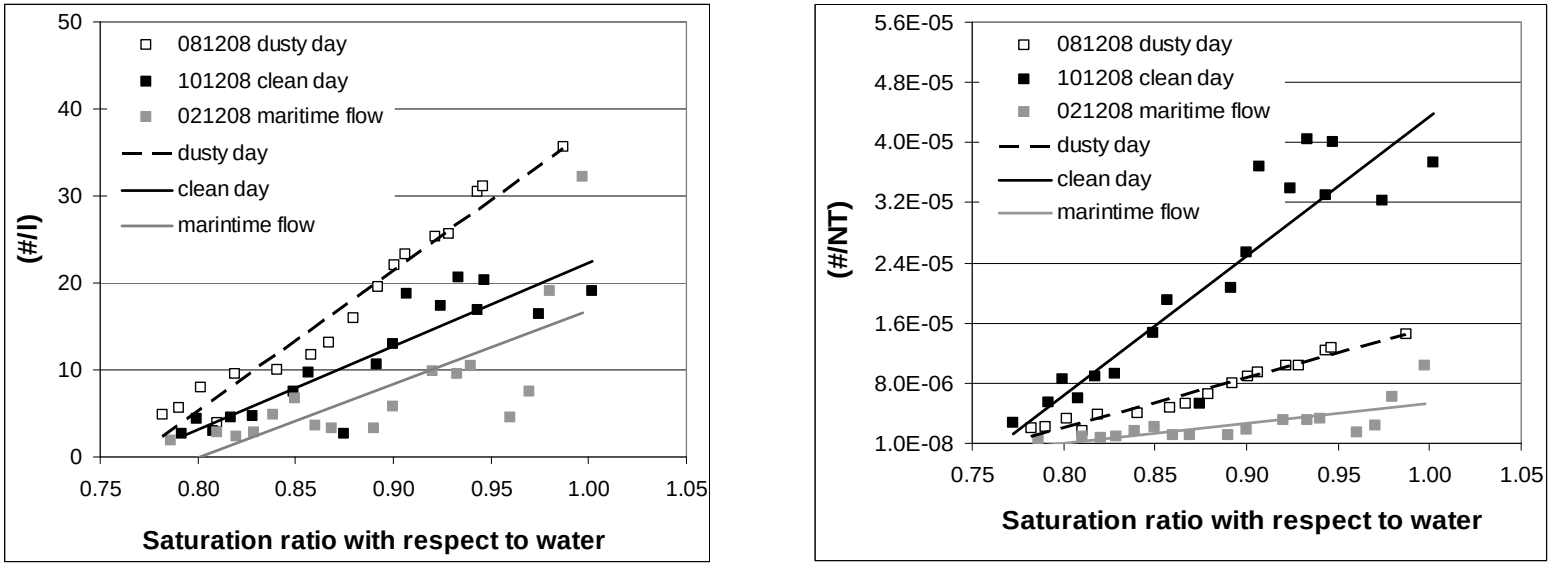
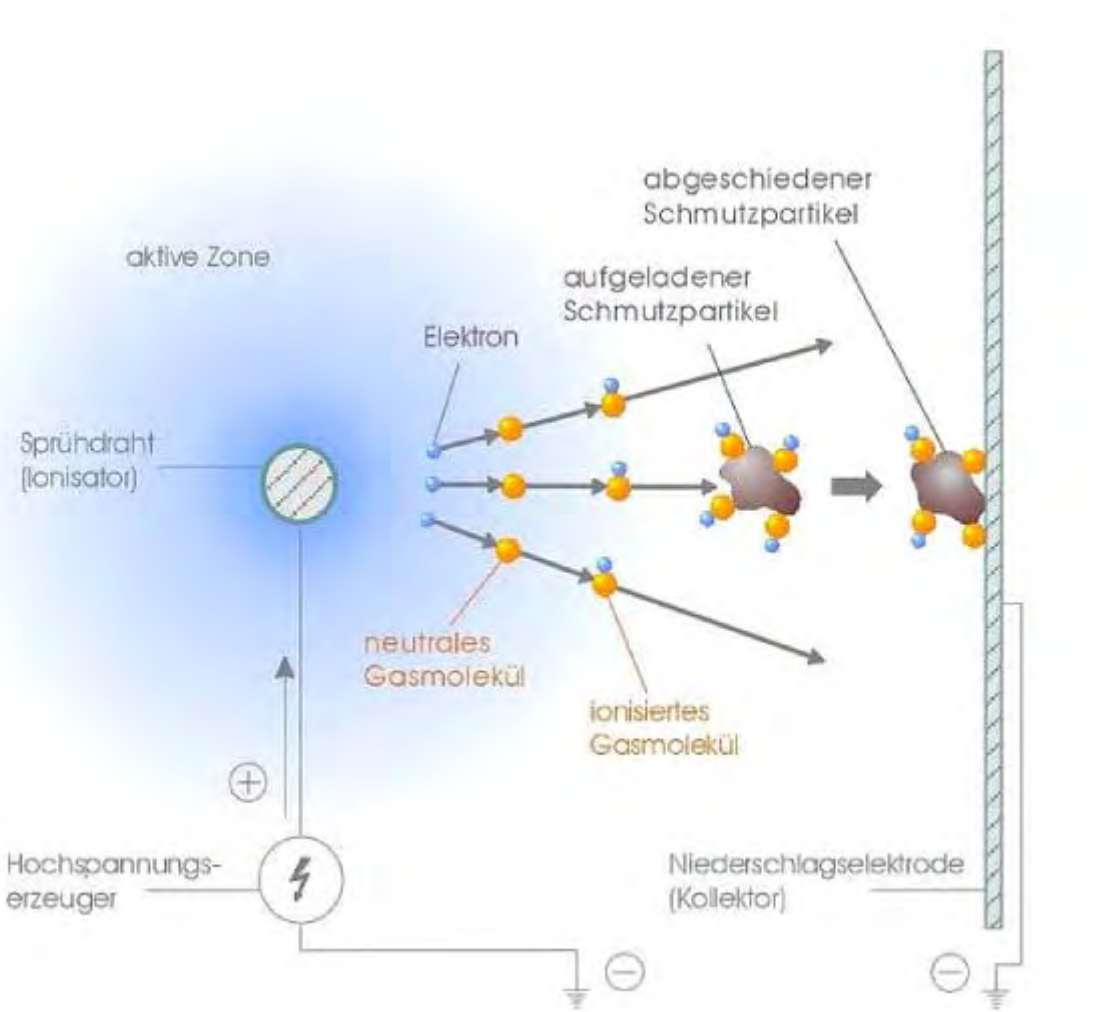
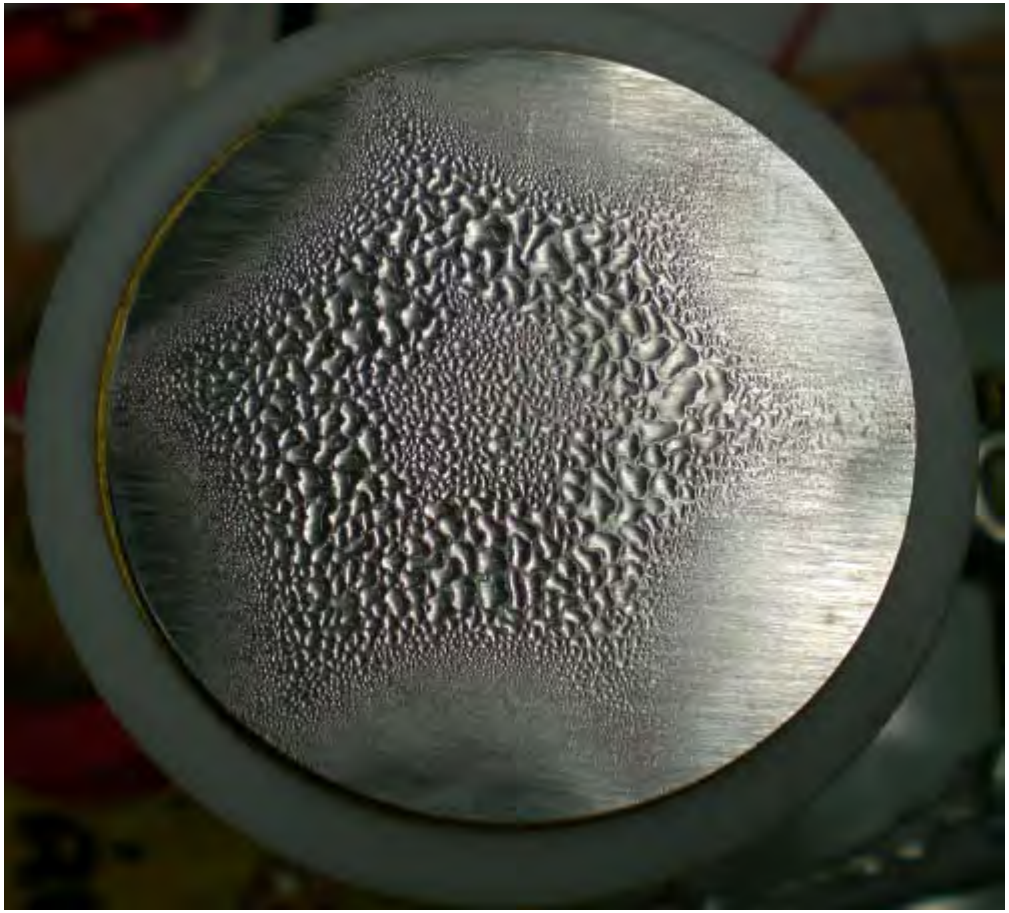


Figure 3: The dependence on saturation ratio with respect to water of a) the number of ice crystals (#/L) formed at -25C and b) the relative number (#/total aerosols >0.1 μm), on dusty, clean and maritime flow

4. CONCLUSIONS

- Dusty days have higher absolute concentrations of effective IN as compared to days with little dust or days with flow from the sea.
- The relative concentrations of IN with respect to total aerosol concentrations (d>0.1 μm) is frequently lower on dusty days than on the other days.
- smooth increase of ice crystal conc. as water saturation ratio approached ➔ nucleation below saturation is mainly due to condensation freezing.
- Samples containing Kaolinite and Illite less effective as freezing nuclei than pure Montmorillonite particles.


abgeschiedener Schmutzpartikel
aktive Zone
aufgeladener Schmutzpartikel
Elektron
Sprühdraht (Ionisator)
neutrales Gasmolekül
ionisiertes Gasmolekül
Hochspannungs-erzeuger
Niederschlagselektrode (Kollektor)



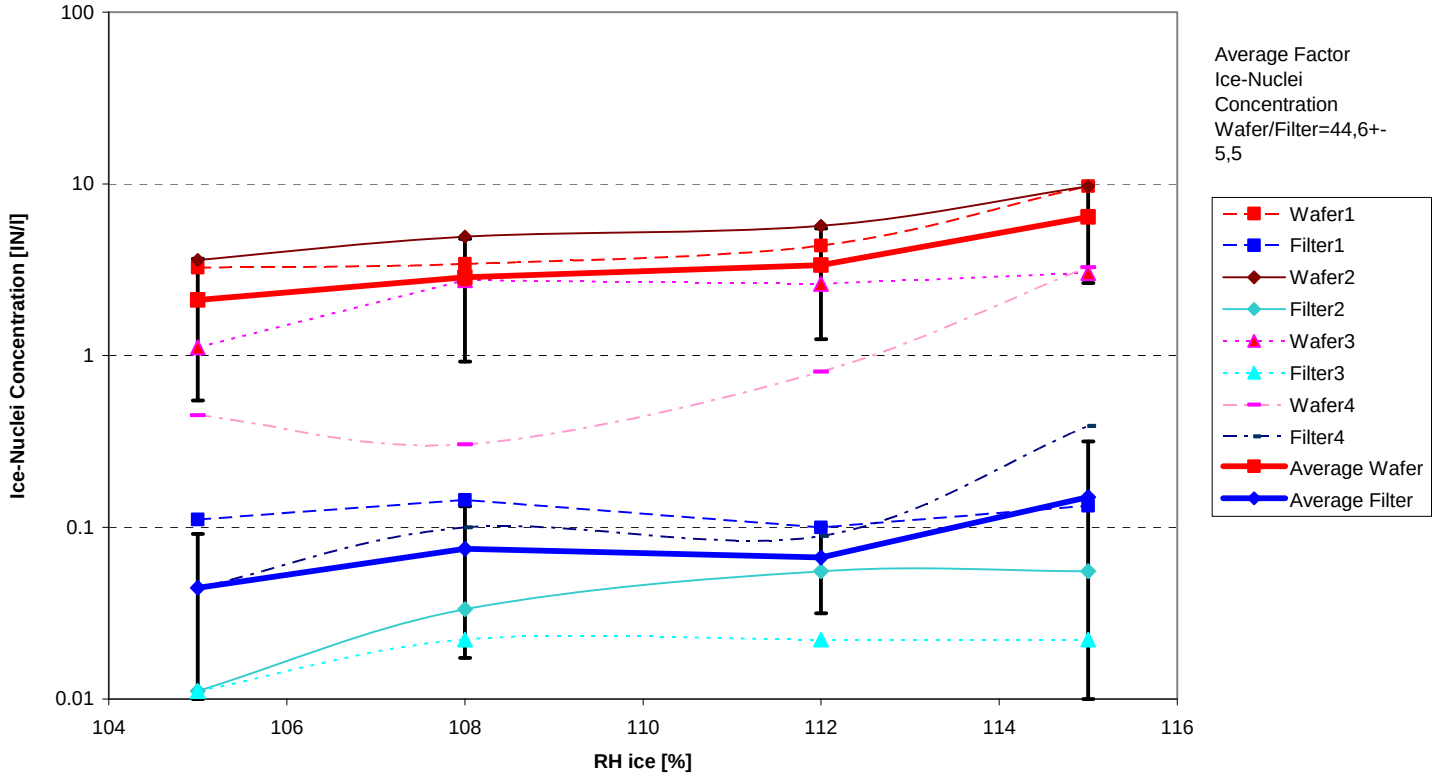
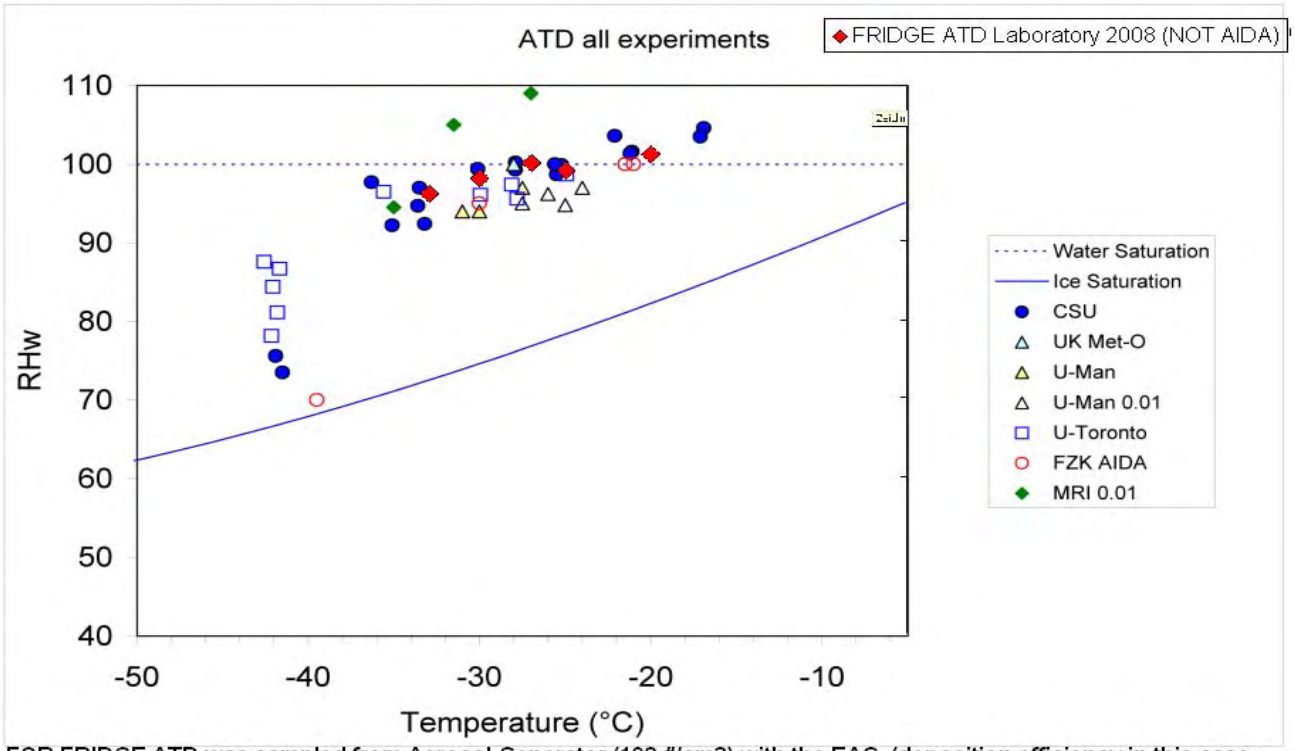


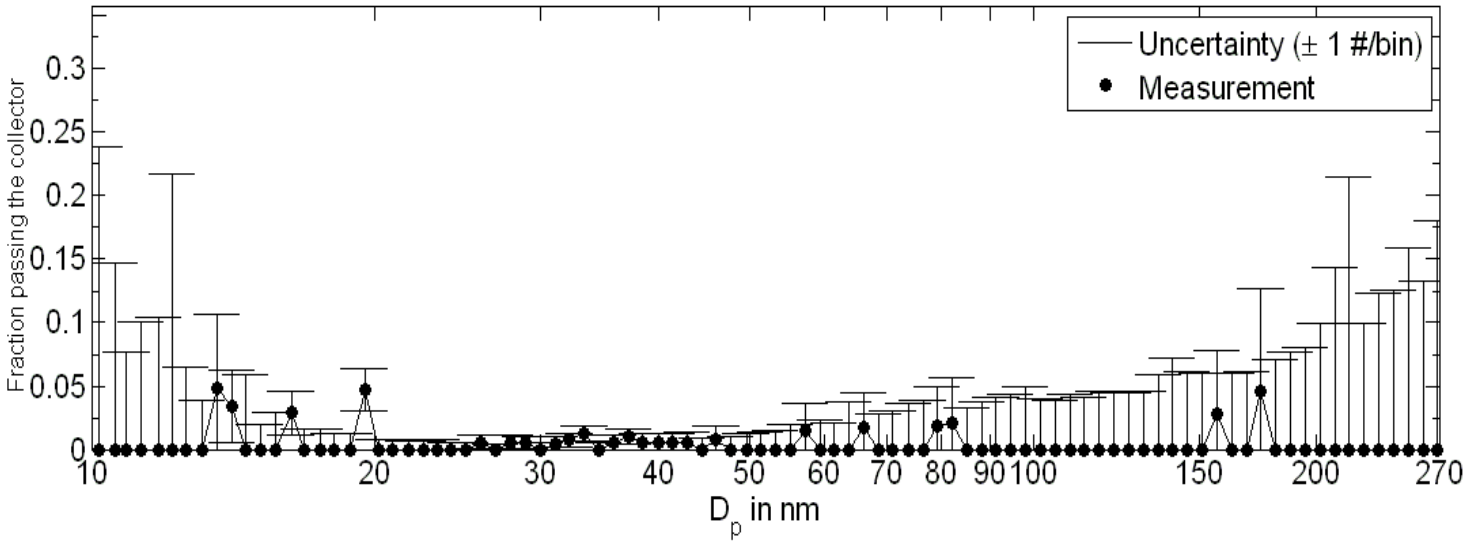
Figure 3: Analysis of Parallel-Sampled Probes Wafer/Filter (30 l) at -14°C. Results of the Filter-Analysis are shown in blue while results of the Wafer-Analysis shown in red. Thick lines represent average values, with standard deviation (black bars). The sampled aerosol is ambient aerosol from Frankfurt.

FIRST COMPARISON OF FRIDGE - LABORATORY EXPERIMENTS (ARIZONA TEST DUST) WITH ICIS 2007 RESULTS

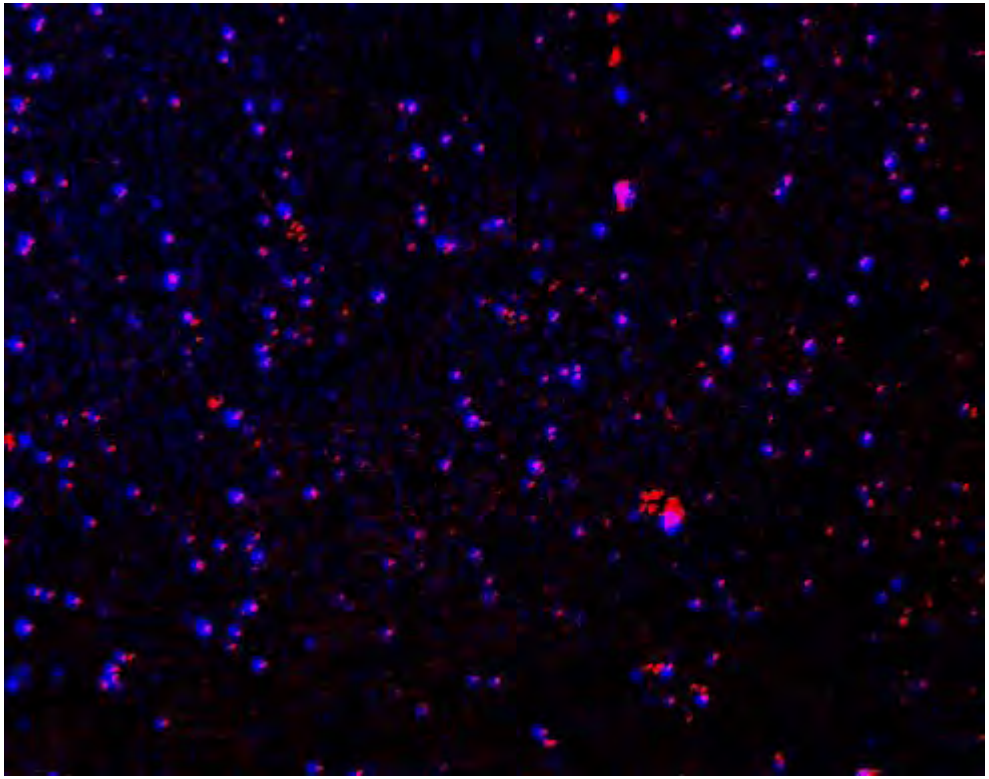
SHOWN IS THE 0,1 % ACTIVATED FRACTION OF ATD.

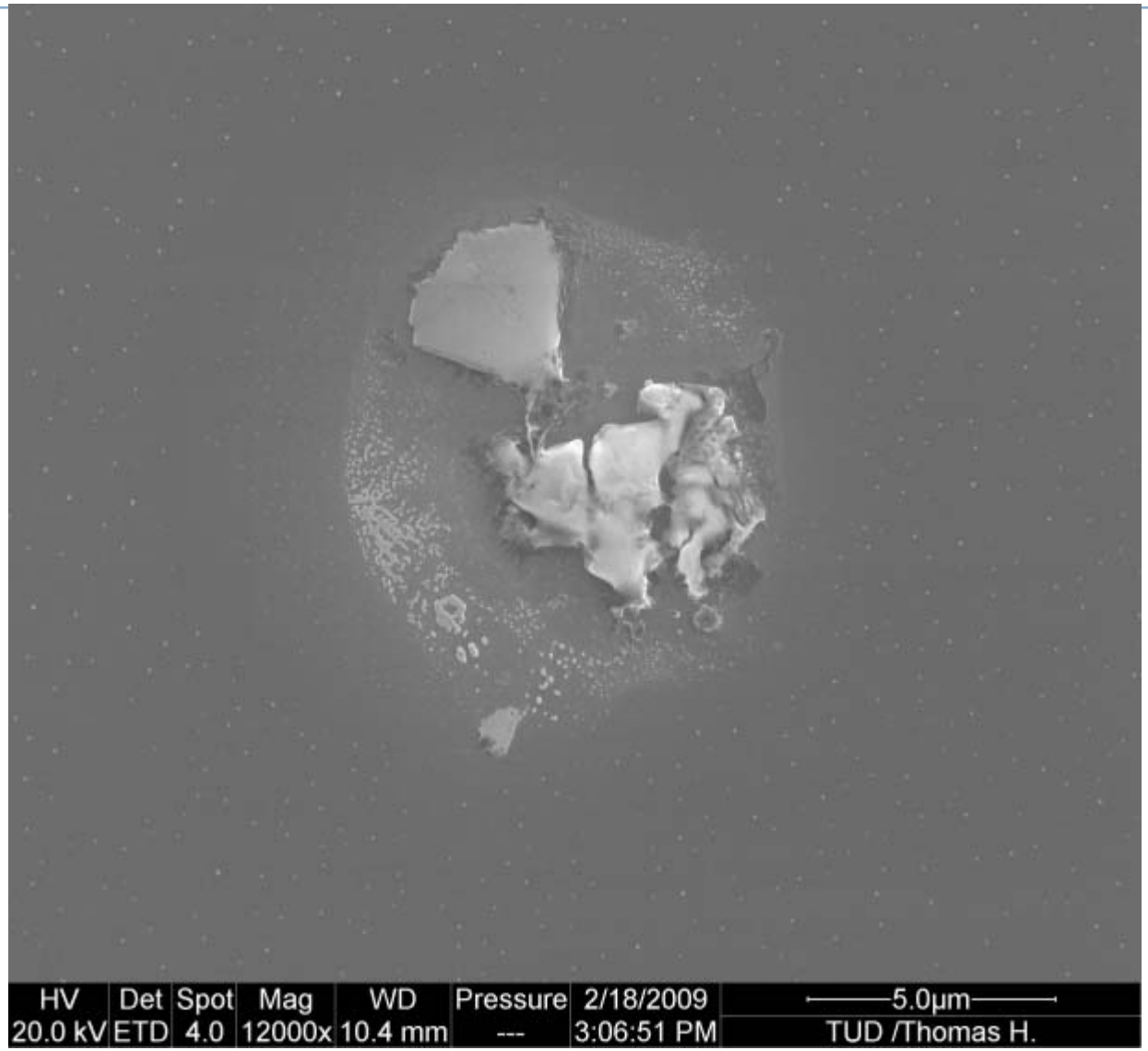


FOR FRIDGE ATD was sampled from Aerosol-Generator (102 #/cm3) with the EAC (deposition efficiency in this case ~ 74%) Please be aware that the Size Distribution of the Aerosol-Generator ATD was with a max. at 1 µm - shifted to larger particles than AIDA/NAUA experiments . Sample Volume was 8 l at 2l/min

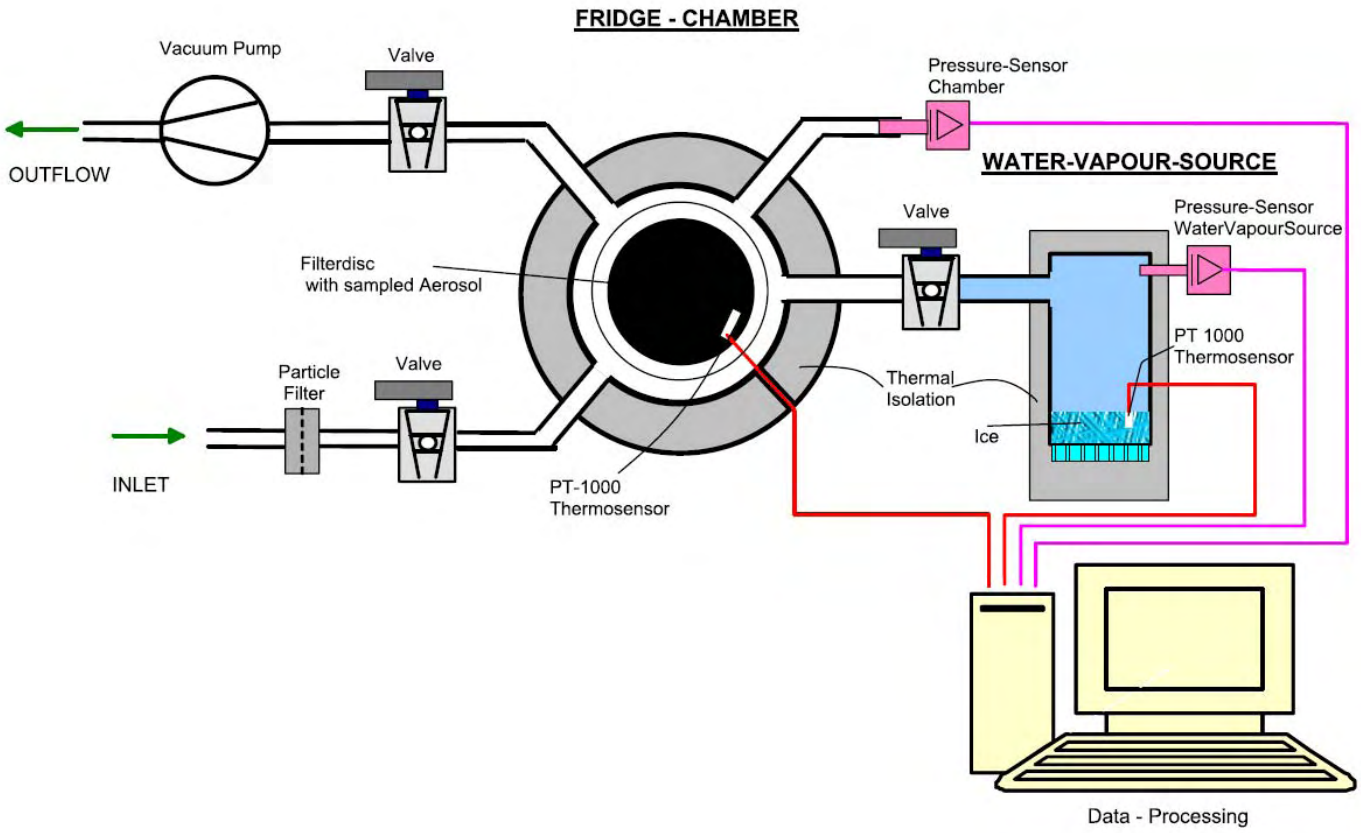

Uncertainty (± 1 #/bin)
Measurement
Fraction passing the collector
0
0.05
0.1
0.15
0.2
0.25
0.3
10
20
30
40
50
60
70
80
90
100
150
200
270
D_p in nm

Tel Aviv Sample Activated with FRIDGE TAU(blue) and later with FRIDGE (red) at -13°C 113%




HV
20.0 kV
Det
ETD
Spot
4.0
Mag
12000x
WD
10.4 mm
Pressure

2/18/2009
3:06:51 PM
5.0µm
TUD /Thomas H.


FRIDGE - CHAMBER
Vacuum Pump
Valve
Pressure-Sensor Chamber
OUTFLOW
WATER-VAPOUR-SOURCE
Valve
Pressure-Sensor WaterVapourSource
Filterdisc with sampled Aerosol
PT 1000 Thermosensor
Particle Filter
Valve
Thermal Isolation
Ice
INLET
PT-1000 Thermosensor
Data - Processing