Particle Hygroscopic Growth, Activation and Freezing:
Actual IfT Contributions to VI-ACI

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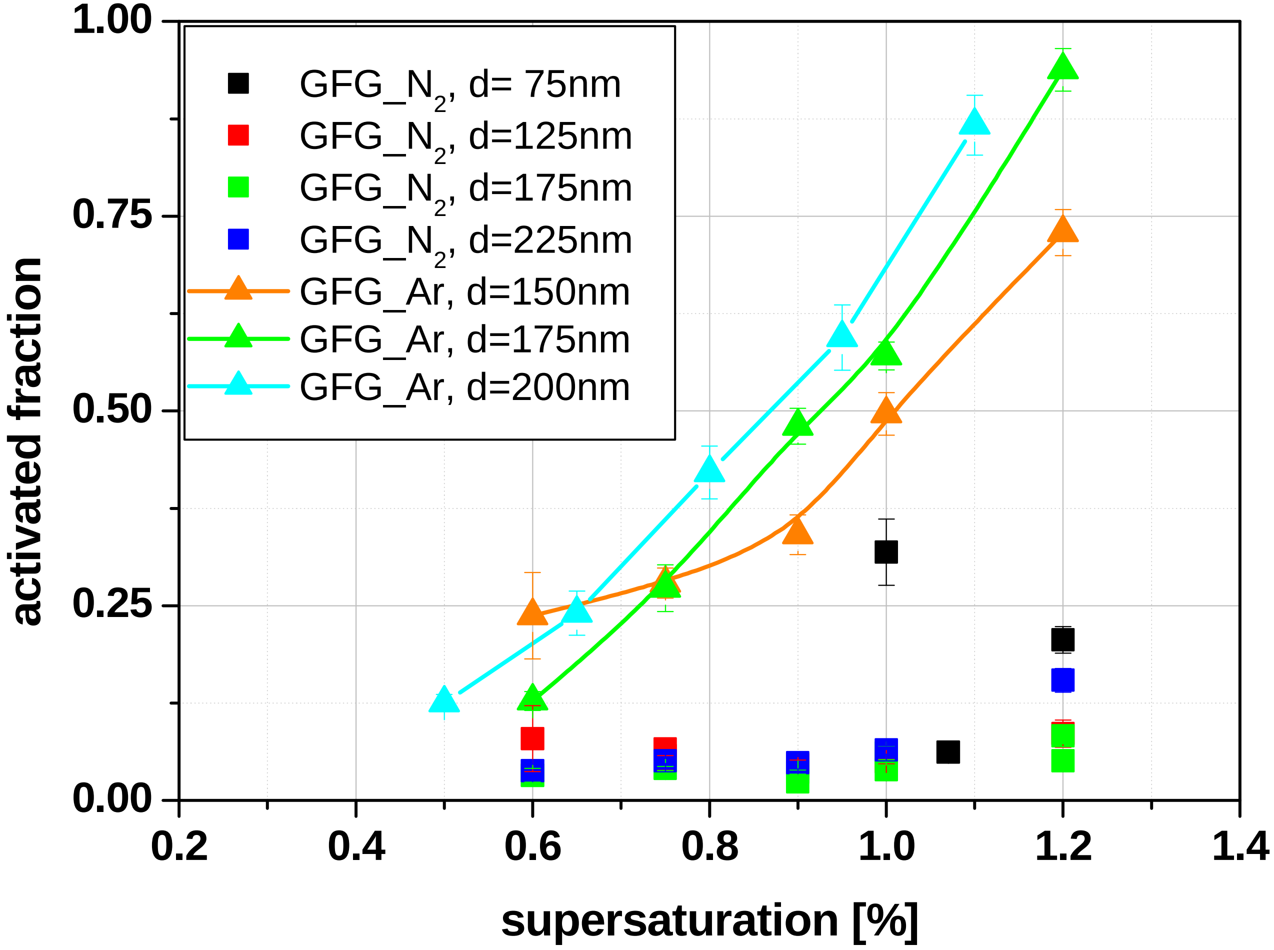
IfT-Contributions to VI-ACI

- WP L2: LACIS laboratory experiments at IfT Leipzig
  - Measurement of CCN properties (ongoing continuous and campaign measurements)
  - Measurement of ice nucleation properties (ongoing continuous and campaign measurements)
- WP M1:
  - Evaluation of microphysical expressions and parameterizations inside a coupled CFD-particle dynamic model (ongoing model development and application)

Campaigns

- IN 11 (19. – 30. Nov. 2007)
  - IfT-Goal: Quantify hygroscopic growth and activation of coated soot particles
- FROST (31. March – 18. April 2008)
  - Topic: Hygroscopic growth, activation and freezing of coated Arizona Test Dust (ATD) particles
  - Participants: FZ Jülich (AMS), Universität Mainz (AMS), Universität Wien (CCNc), IfT (LACIS, CCNc, H-HTDMA, AMS,…)
  - Goal: Size resolved quantification of hygroscopic growth, activation and freezing behavior of ´monodisperse´ coated ATD particles

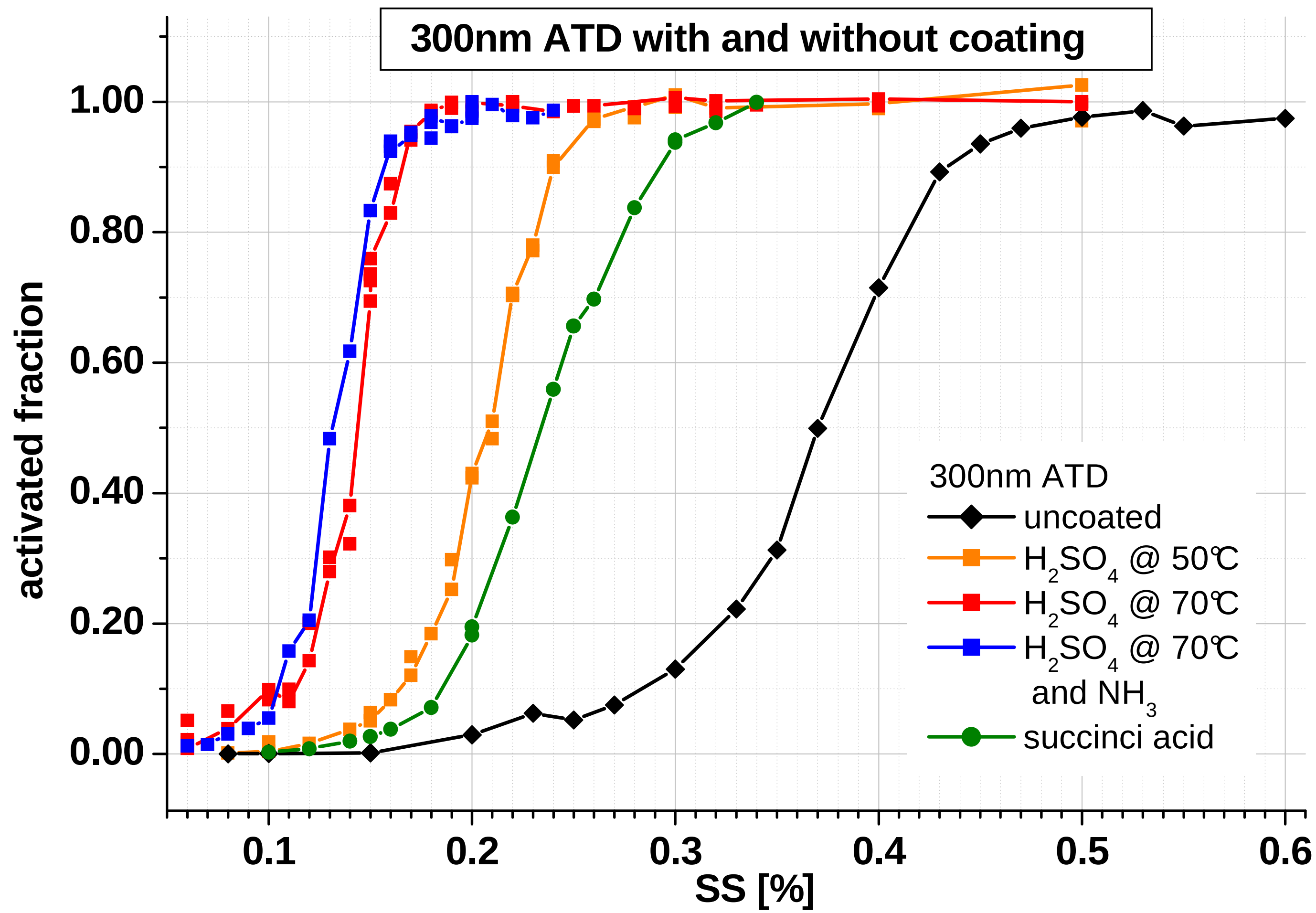
AIDA IN11: Activation of GFG-soot with argon or nitrogen as carrier gas (DMT-CCNc)



FROST

- Instrumentation
  - TSI Fluidized bed generator for dispersing ATD
  - Coaters for H_2SO_4, ammonium sulfate, and succinic acid
  - DMA for size selection
  - H-HTDMA for hygroscopic growth up to 98 % RH
  - DMT-CCNc and Vienna CCNc for particle activation
  - 3 AMS for particle chemical analysis and aerodynamic size distribution
  - Various off-line chemical analysis
  - LACIS for freezing
- Modelling
  - Coupled CFD-particle dynamics model for determining temperature, water vapor mass fraction and saturation ratio (liquid and ice), and particle / droplet hygroscopic and dynamic growth in LACIS

FROST: ATD Activation Behavior

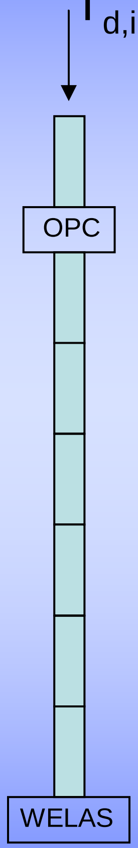


FROST: ATD

- ATD is not completely insoluble as it activates at lower SS than expected (300nm: 0.37% instead of 0.71% corresponding to about 0.5-1% per volume of soluble material).
- 200nm ATD particle show a “shoulder” at activation, indicating an “external mixture” (chemically different? doubly charged? (“large” fraction, some tens of percent – persistent also in coated ATD particles).
- Coating techniques work reproducibly.
- Silicone was found in ATD particles (m/z 73 and 147).
- Silicone did NOT come from the MOUDI, black tubing, or stainless steel tubes connecting the generator to the AMS. This suggests that silicone might have been added during the production process of the desert dust.

Freezing experiment for 300nm uncoated ATD

$T_{d,in}$ = -7℃



$T_{w,1}$ = 20℃

$T_{w,2}$ = 0℃

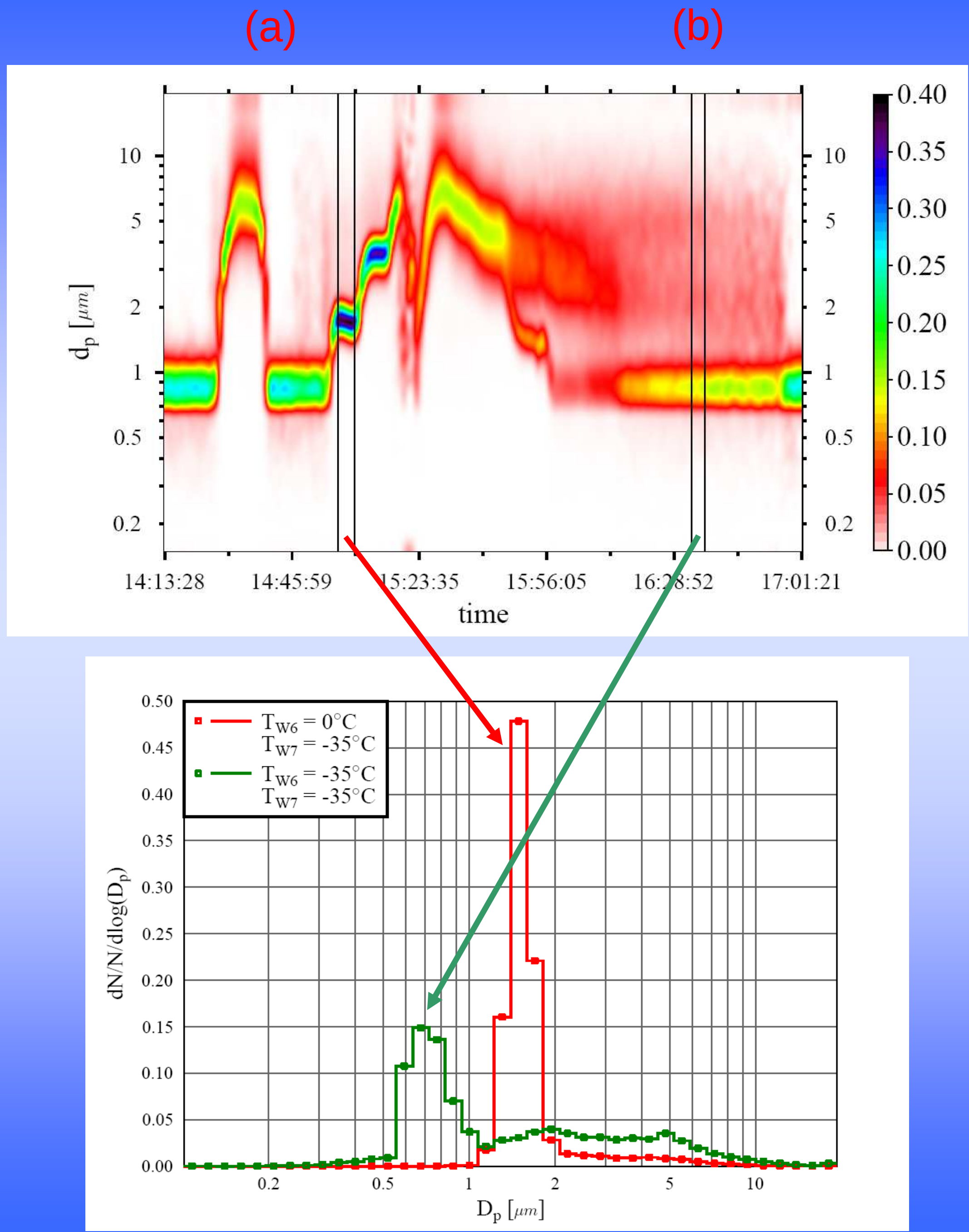
$T_{w,3}$ = 0℃

$T_{w,4}$ = 0℃

$T_{w,5}$ = 0℃

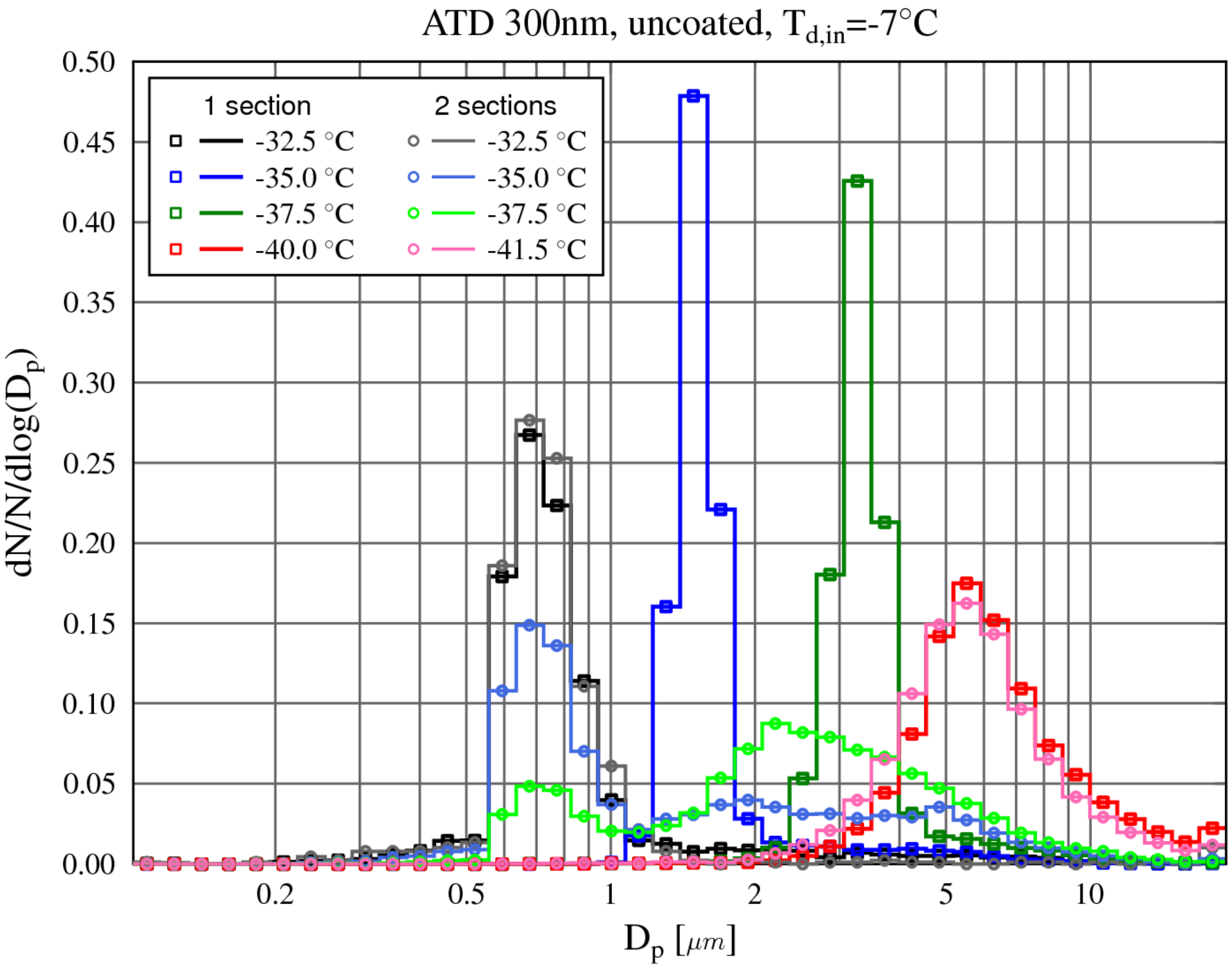
$T_{w,6}$ = 0℃ / variable

$T_{w,7}$ = variable

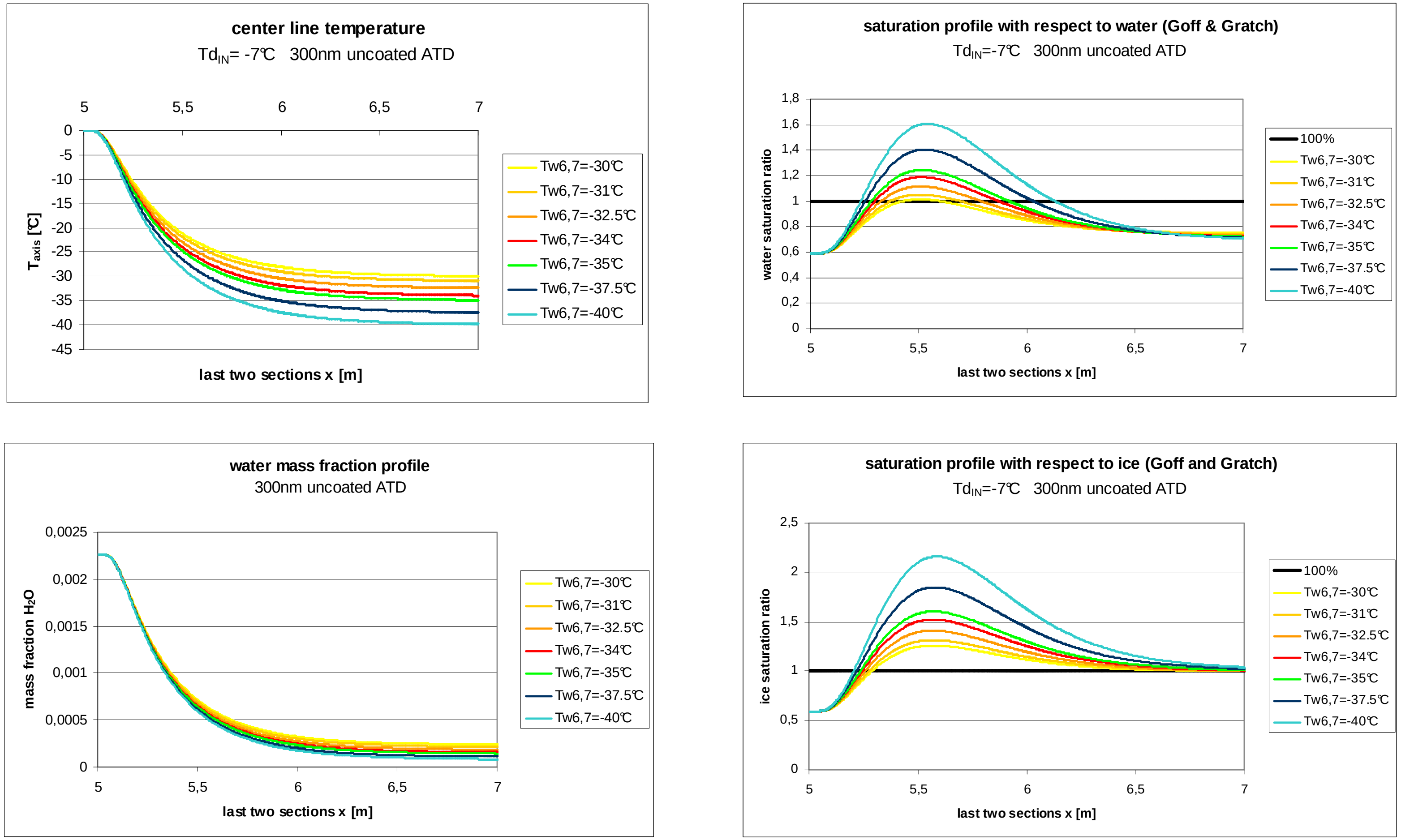


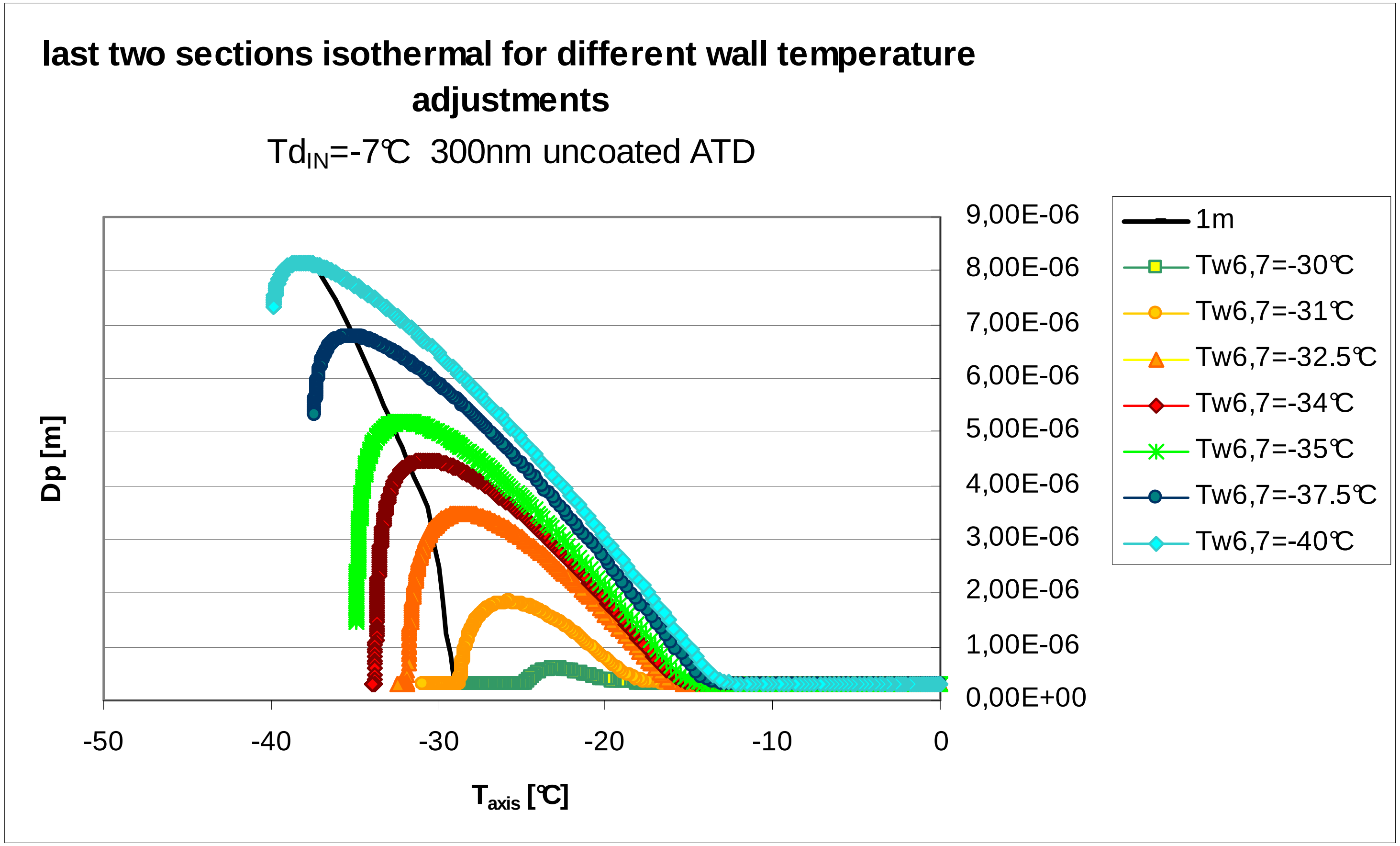
(a) $T_{w,6}$ = 0℃; $T_{w,7}$ = -35℃

(b) $T_{w,6}$ = $T_{w,7}$ = -35℃


ATD 300nm, uncoated, $T_{d,in}$=-7°C
1 section
2 sections
-32.5 °C
-35.0 °C
-37.5 °C
-40.0 °C
-32.5 °C
-35.0 °C
-37.5 °C
-41.5 °C
dN/N/dlog(D_p)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.2
0.5
1
2
5
10
D_p [μm]

Thermodynamic Profiles inside LACIS





last two sections isothermal for different wall temperature adjustments
Td_{IN}=-7℃ 300nm uncoated ATD
Dp [m]
9,00E-06
8,00E-06
7,00E-06
6,00E-06
5,00E-06
4,00E-06
3,00E-06
2,00E-06
1,00E-06
0,00E+00
-50
-40
-30
-20
-10
0
T_{axis} [℃]
1m
Tw6,7=-30℃
Tw6,7=-31℃
Tw6,7=-32.5℃
Tw6,7=-34℃
Tw6,7=-35℃
Tw6,7=-37.5℃
Tw6,7=-40℃

FROST Preliminary Summary

- LACIS is a useful tool for performing freezing experiments in the immersion *and deposition mode*.
- ATD is not as simple as we thought !
- *CCNc is suitable tool for determining the amount of known soluble materials on solid particles such as ATD*.
- Liquid droplets containing 200 to 400 nm ATD particles do exist down to temperatures below – 35 ℃.
- *´Interesting´ influences of coating thickness and type are visible in freezing experiments but further data evaluation and measurements are needed.*

Outlook

- Continue size resolved freezing experiments for coated ATD particles
- Continue model development:
  - include ice mode and ice nucleation processes
- Second measurement campaign FROST II (fall 2008 or spring 2009):
  - possible topic: immersion/evaporation freezing
  - particle material: simpler or more complex ?
  - instrumentation: SID-3, IN counter, single particle, MS