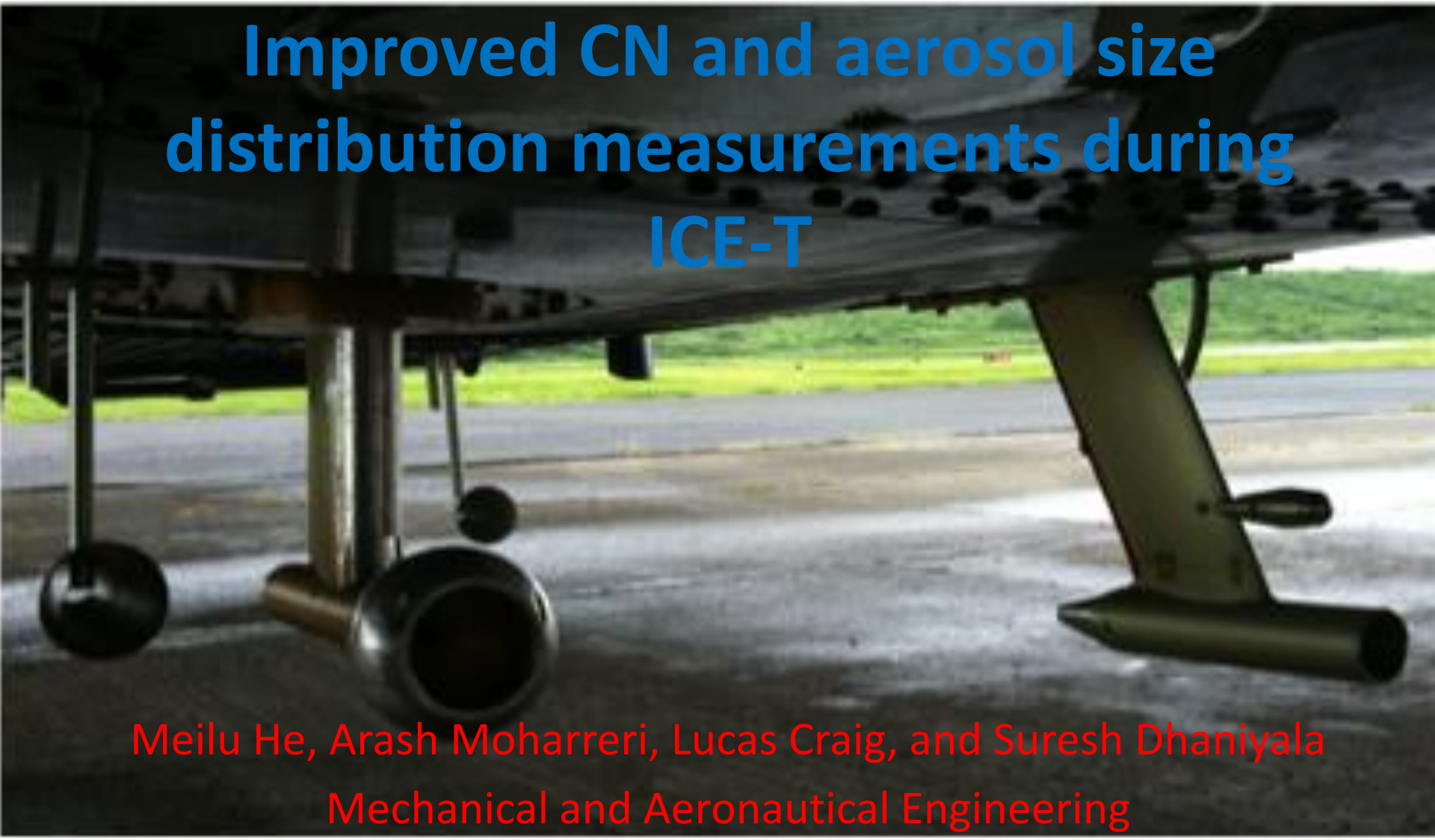
Improved CN and aerosol size distribution measurements during ICE-T



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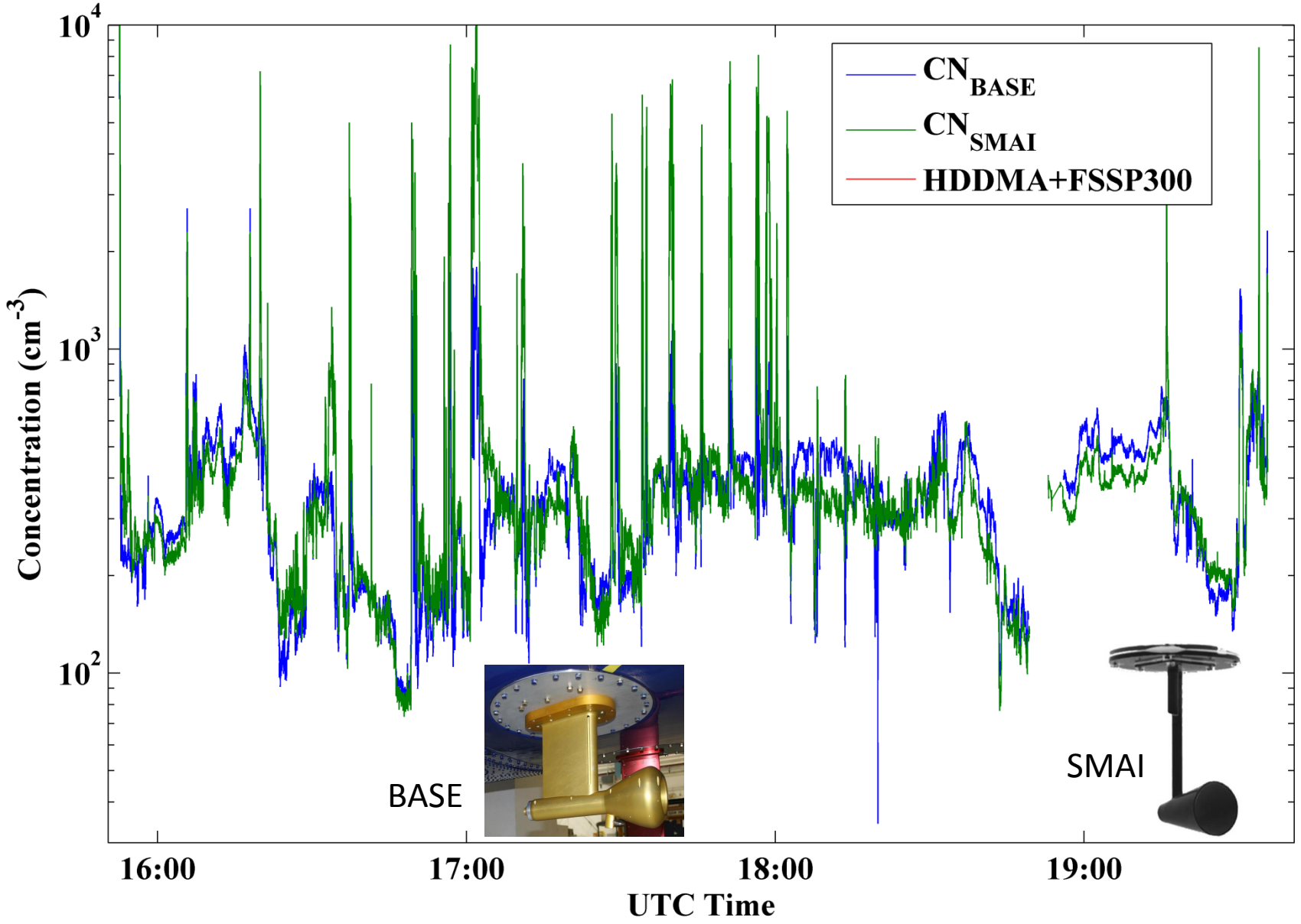
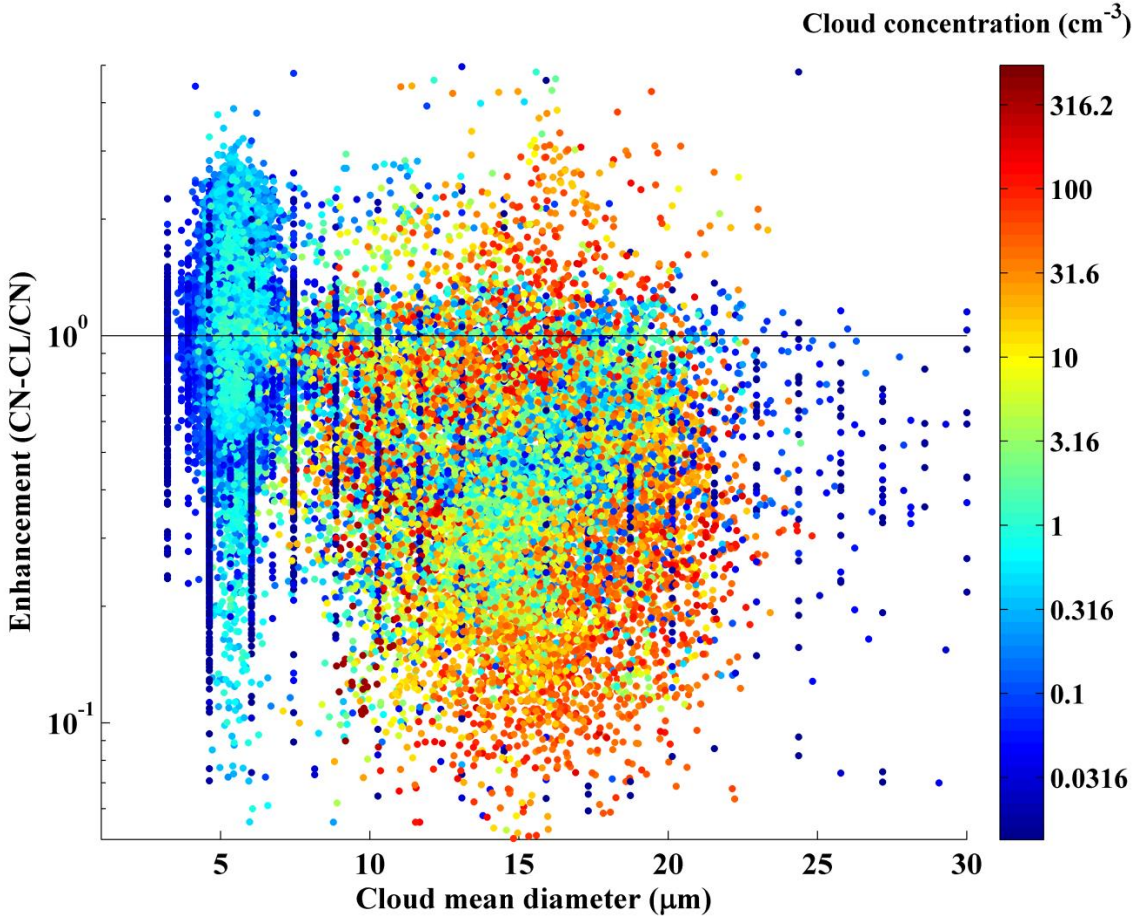
Clarkson Data Status

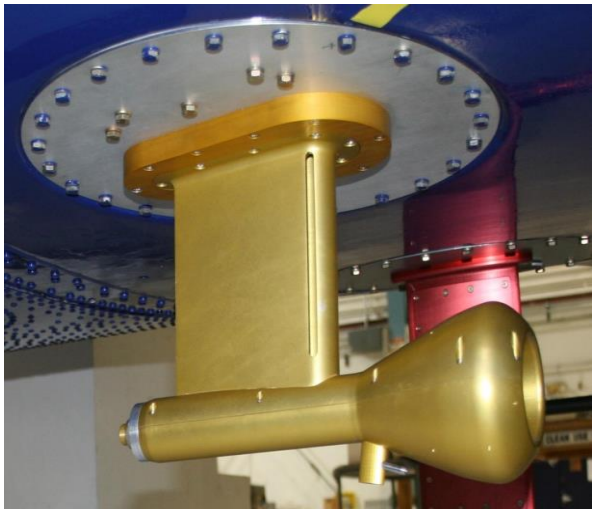
- CN measurements with several different aerosol inlets
  - Our primary CN measurement data (CONCN_CL) is integrated with the production data file
- CN size distributions (10-400 nm)
  - HD-DMA (and UHSAS)
  - HD-DMA submitted to the ICE-T archive
    - Two size distribution data sets
      - HDDMA-100 (10-100 nm)
      - HDDMA-400 (~ 30-400 nm)
- Scanning CCN measurements
  - CCN number concentration as a function of supersaturation
    - The data set is available upon request
    - Will be available for distribution soon

CN comparison (BASE vs SMAI)



Inlet comparison





Moharreri, A., Craig L., Rogers, D.C., and Dhaniyala, S. A Blunt-body Aerosol Sampler (BASE) for Interstitial Aerosol Sampling: Design and Wind Tunnel Testing, Aerosol Science and Technology, 47:8, 885-894, August 2013.

Craig, L., Moharreri, A., Schanot, A., Rogers, D.C., Anderson, B., Dhaniyala, S., Characterizations of shatter artifacts in airborne aerosol inlets, Aerosol Science and Technology, DOI:10.1080/02786826.2013.780648, 47:6, 662-671, 2013.

Craig, L., Schanot, A., Moharreri, A., Rogers, D.C., and Dhaniyala, S., Design and sampling characteristics of a new airborne aerosol inlet for aerosol measurements in clouds, Journal of Atmospheric and Oceanic Technology, 30:6, 1123-113 July 2013.

HD-DMA

- Size distributions – 10 nm to 400 nm
  - Two channels
    - 10-100 nm
    - 30-400 nm
  - Time resolution: 30 s
    - Multiple charge correction
      - He and Dhaniyala, AST 2013
    - New inversion algorithms
      - Dubey and Dhaniyala, AST 2013
    - New approach to account for smearing under low concentrations
      - Manuscript under preparation

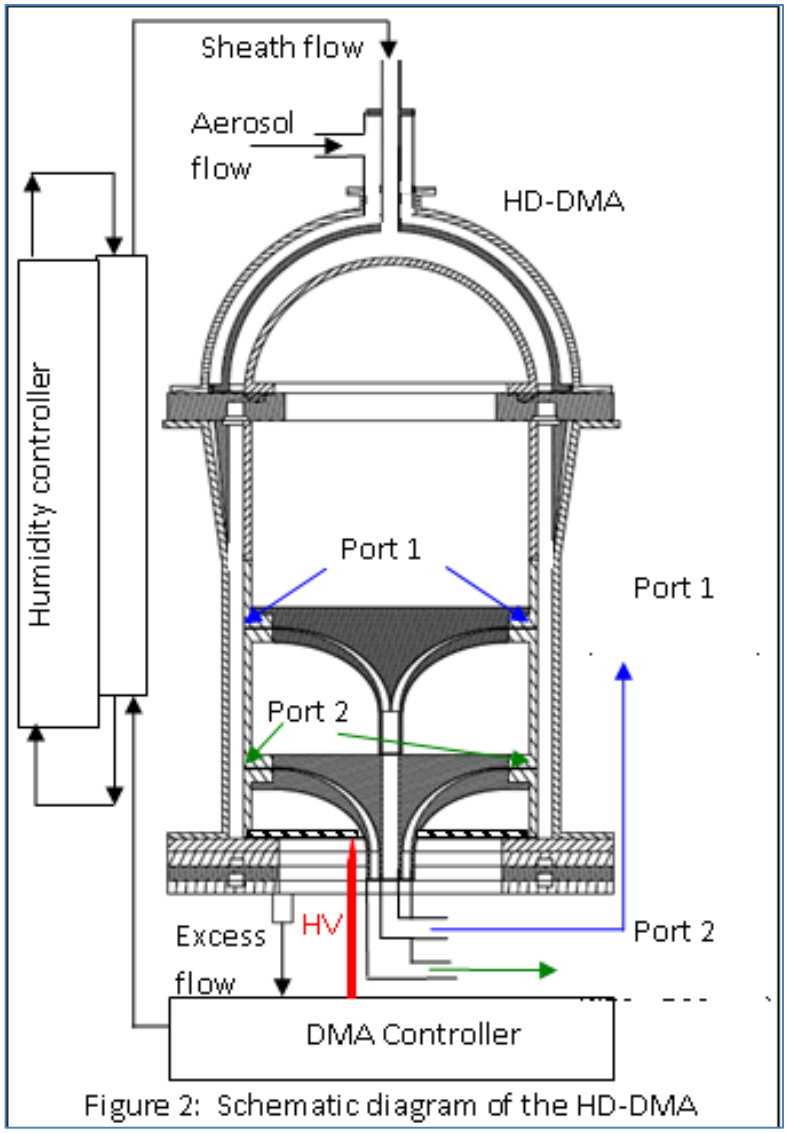
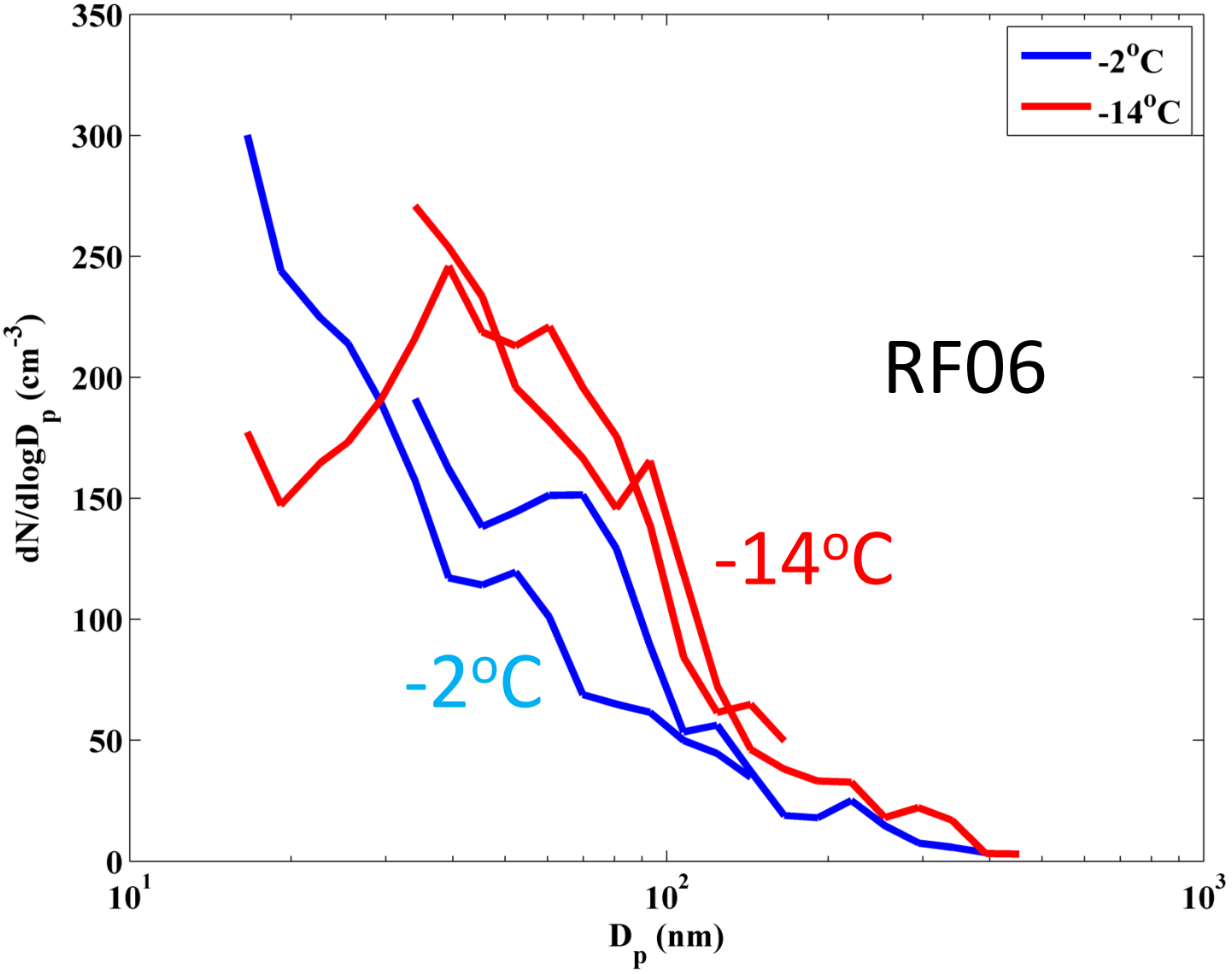
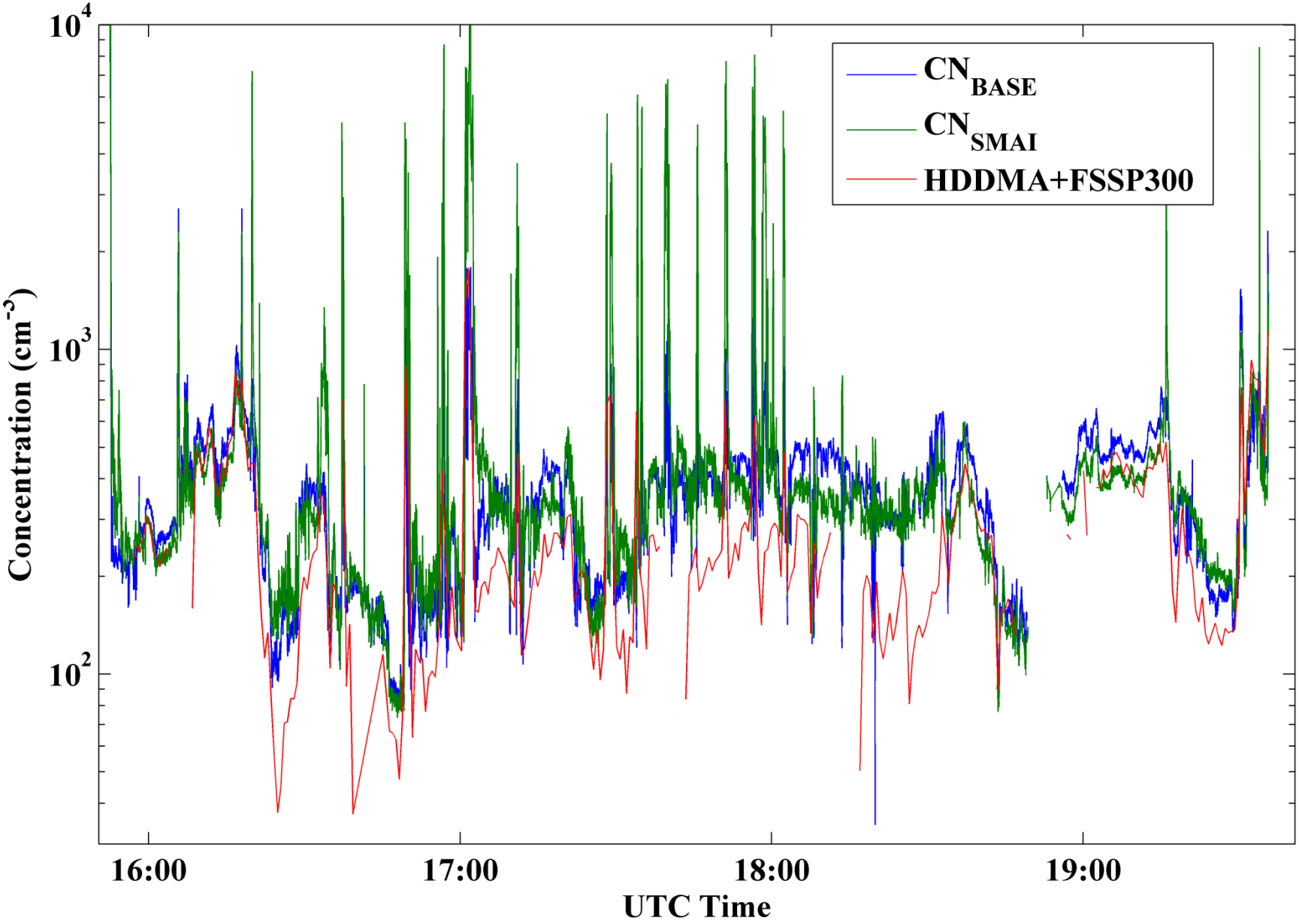


Figure 2: Schematic diagram of the HD-DMA

Size distributions



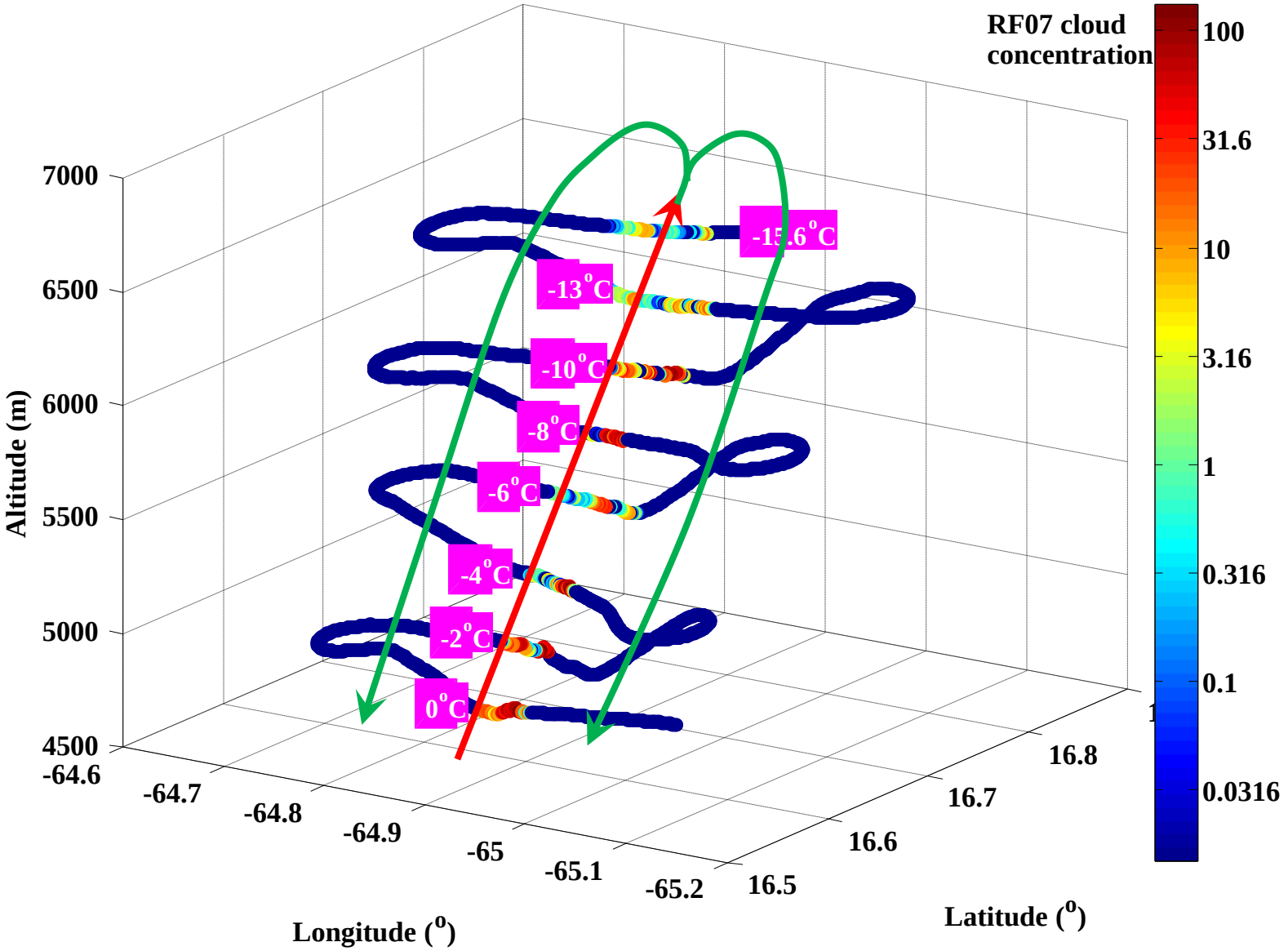
Total CN concentration (RF07)



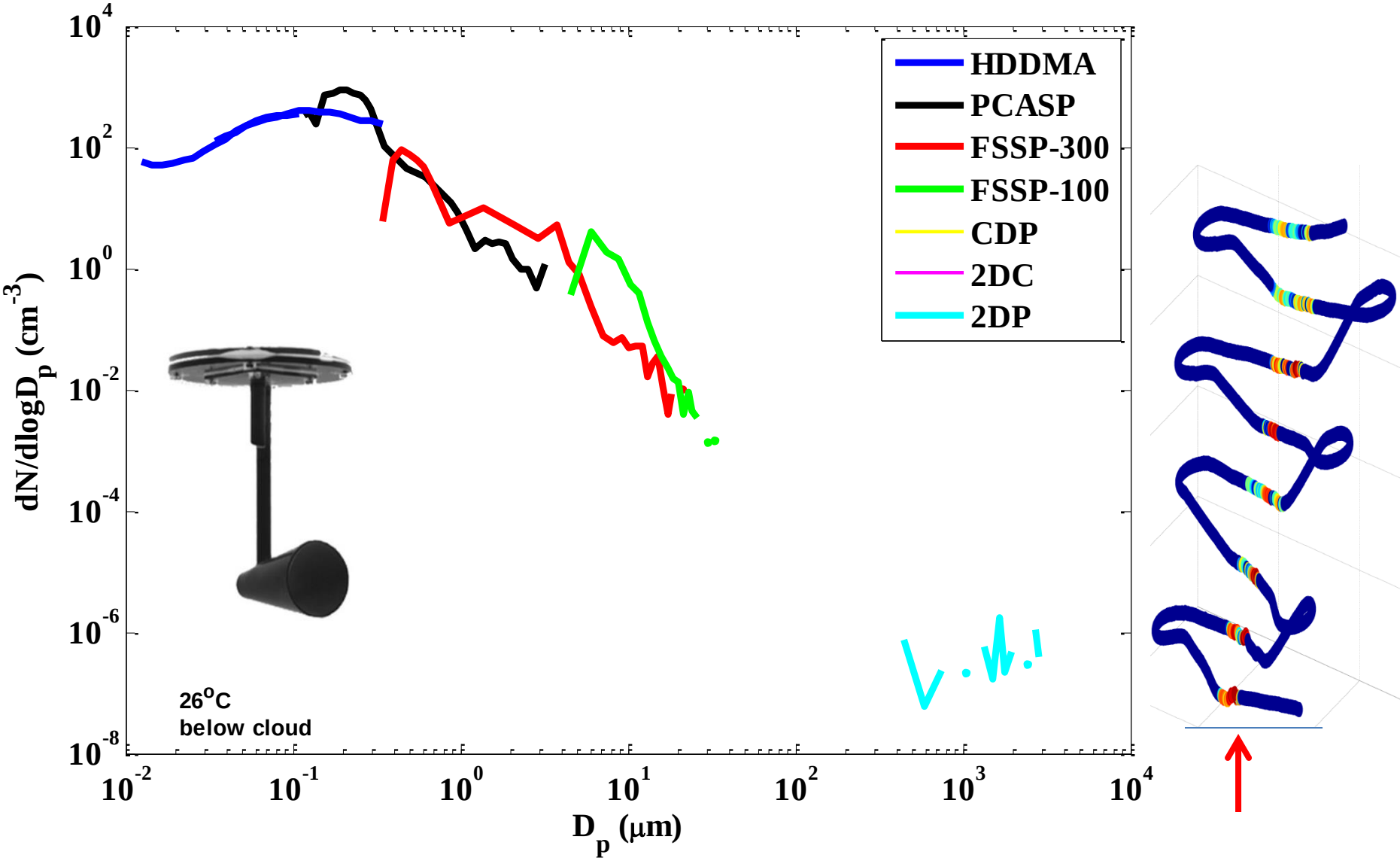
What can we do with this data?

- The combination of **the ability to sample interstitial particles and make fast size distribution measurements**, allows for analysis of **aerosol evolution in clouds**.
- Here, we investigate a convective cloud (RF07) that was sampled at multiple heights from the cloud base to the cloud top

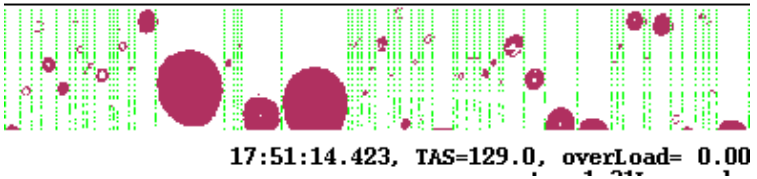
Flight passage of RF07 (17:50 to 18:23)

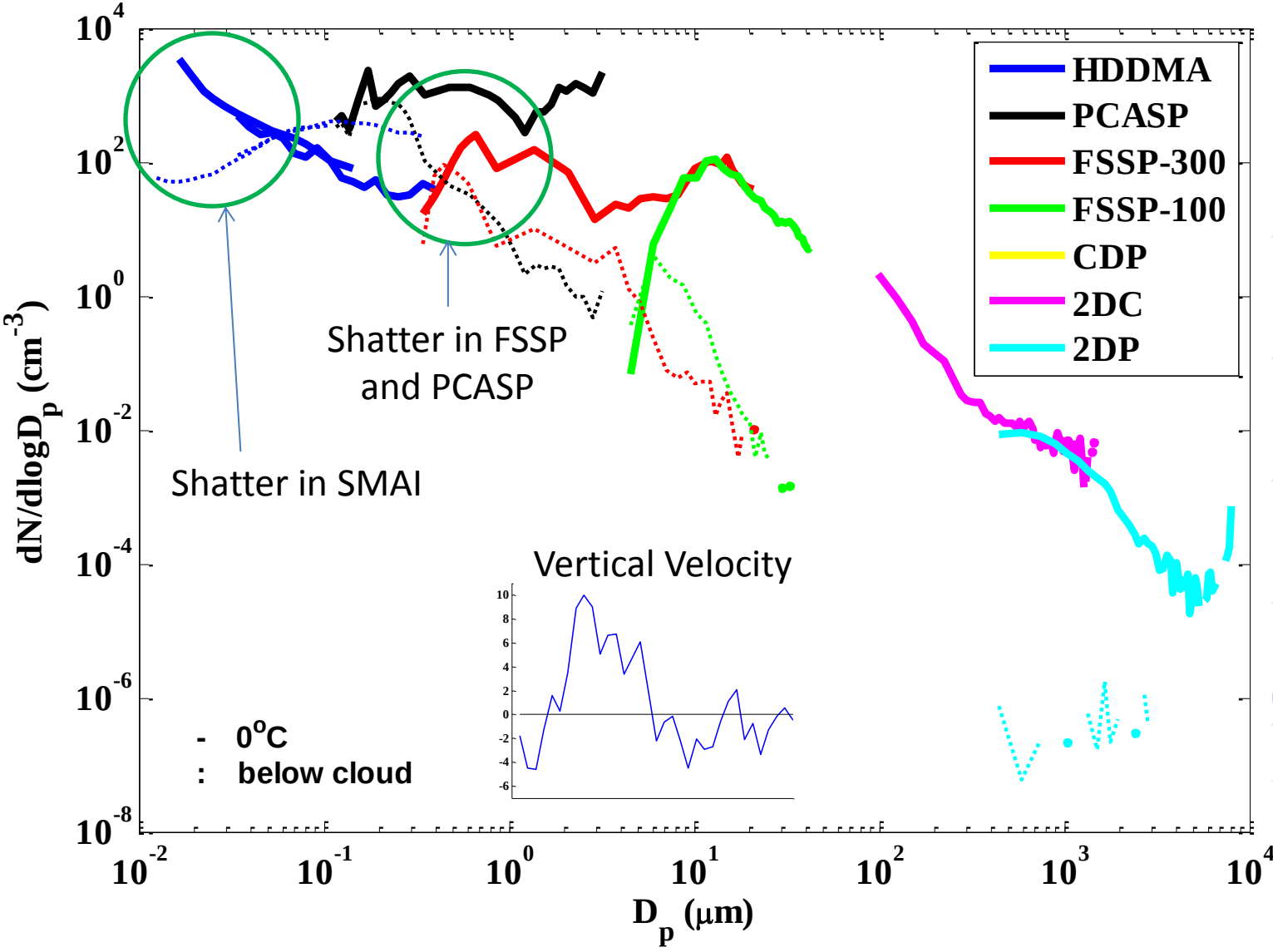


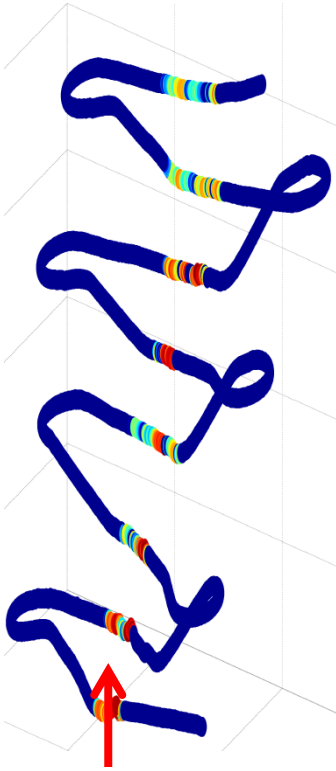
Particle size distribution at below cloud



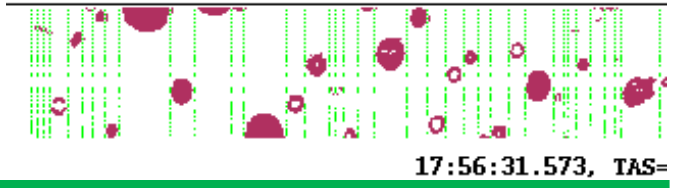
In-cloud (0°C)

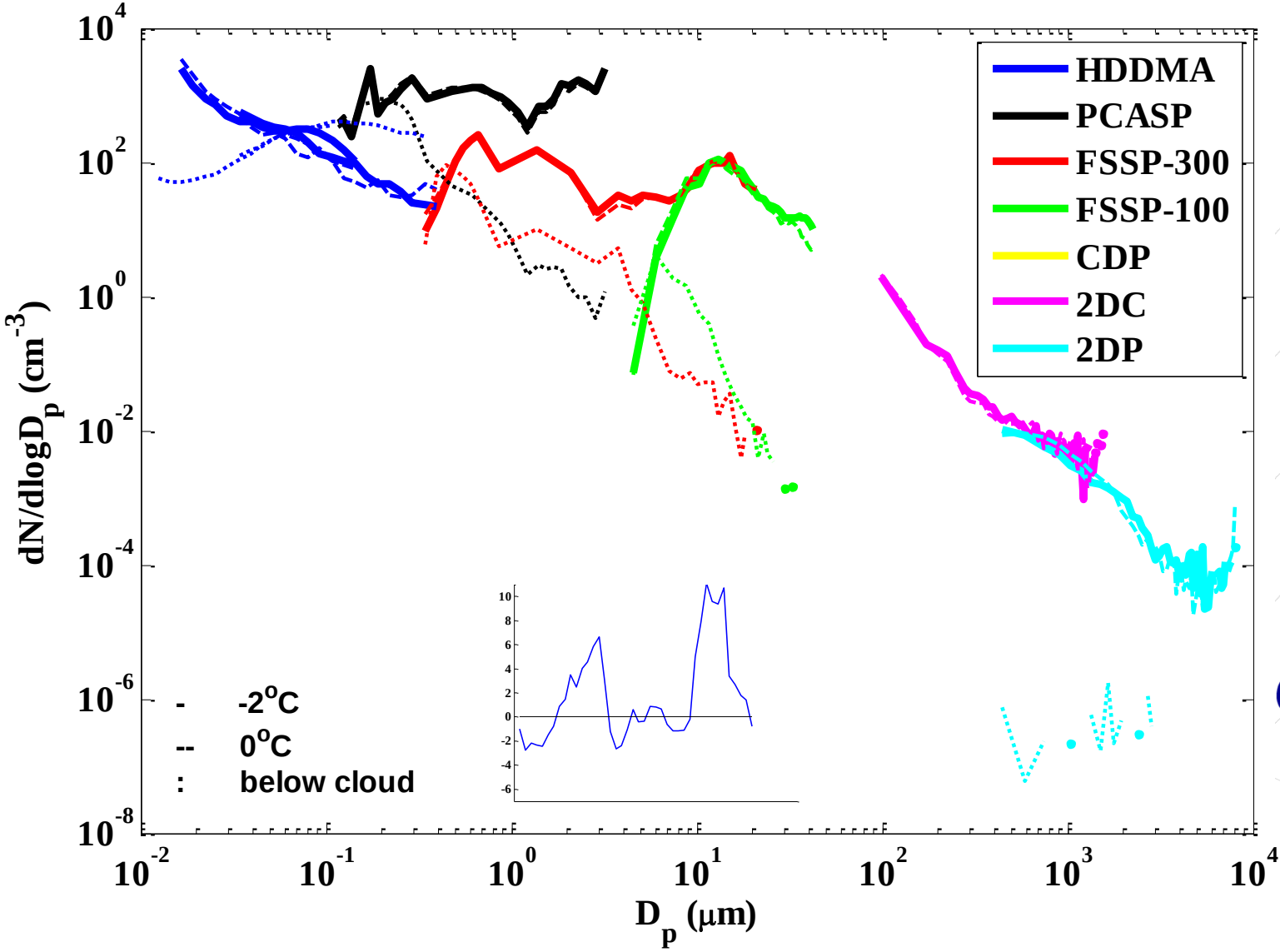

17:51:14.423, TAS=129.0, overLoad= 0.00

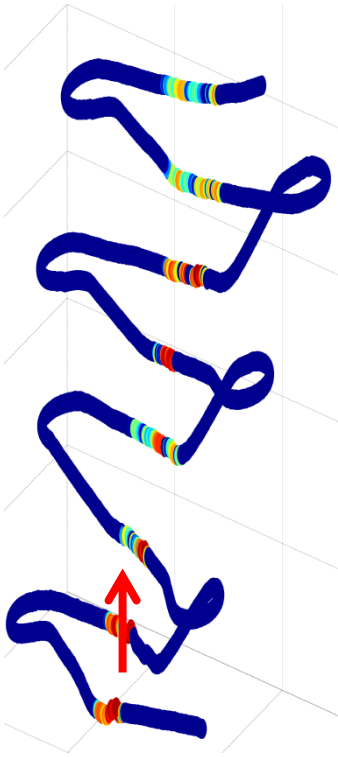

HDDMA
PCASP
FSSP-300
FSSP-100
CDP
2DC
2DP
Shatter in FSSP and PCASP
Shatter in SMAI
Vertical Velocity
- 0°C
: below cloud
dN/dlogD_p (cm^-3)
D_p (μm)



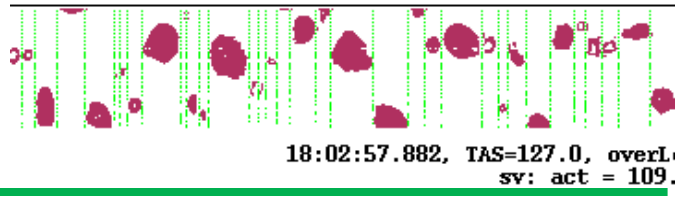
In-cloud (-2°C)

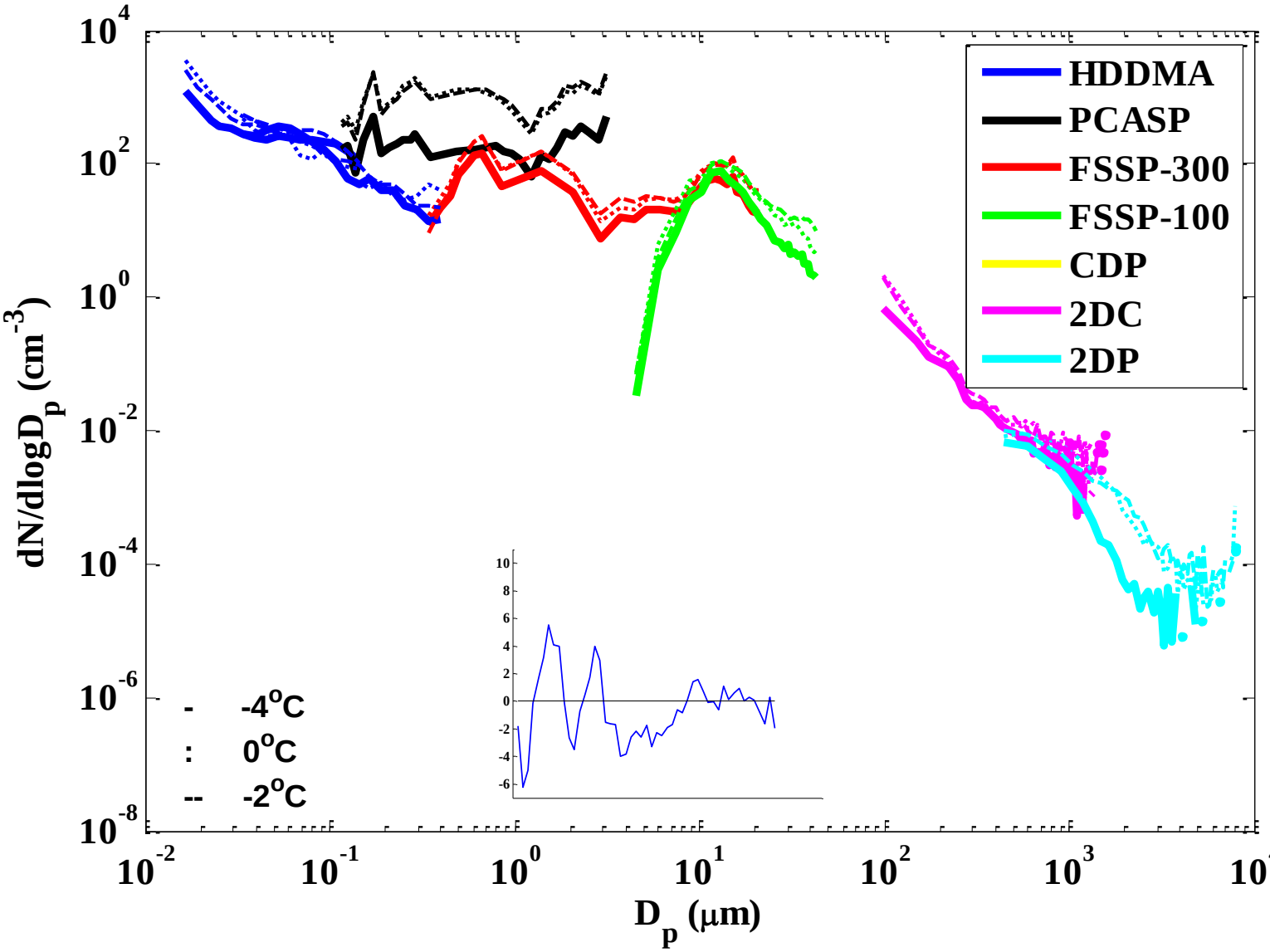

17:56:31.573, TAS=

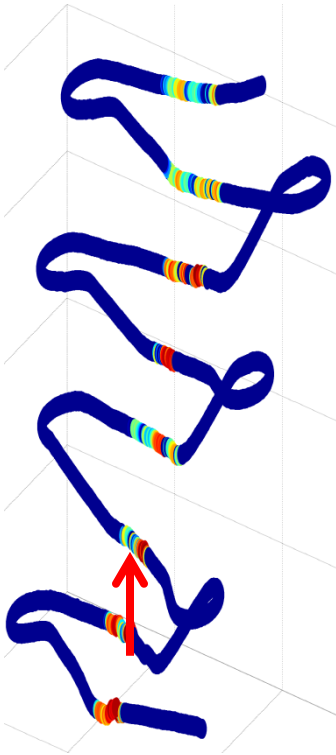

HDDMA
PCASP
FSSP-300
FSSP-100
CDP
2DC
2DP
- -2°C
-- 0°C
: below cloud
dN/dlogD_p (cm^-3)
D_p (μm)



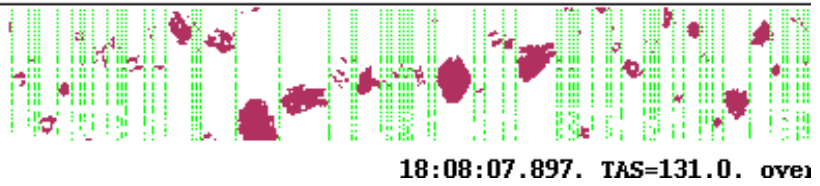
In-cloud (-4°C)

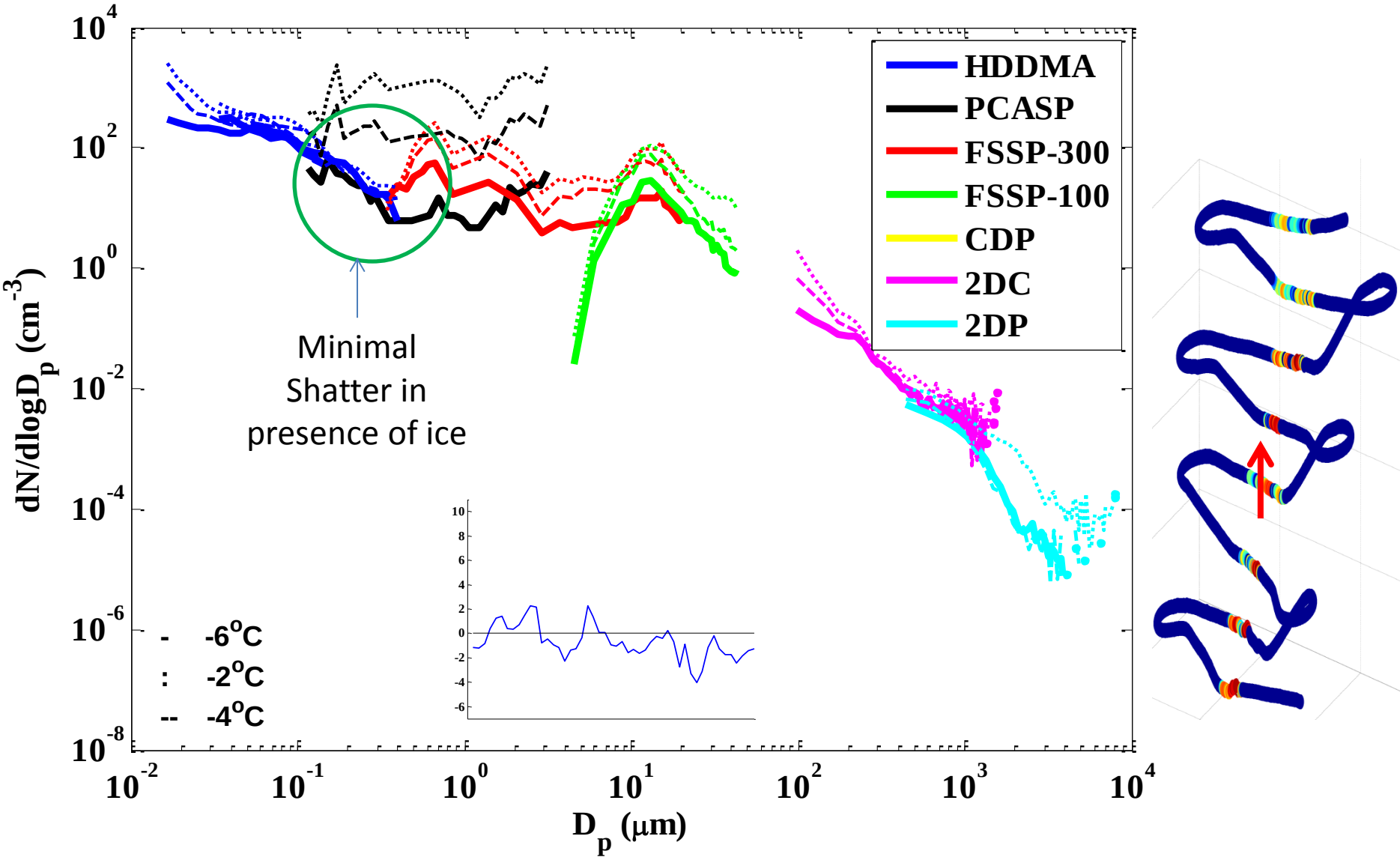

18:02:57.882, TAS=127.0, overL
sv: act = 109.


HDDMA
PCASP
FSSP-300
FSSP-100
CDP
2DC
2DP
- -4°C
: 0°C
-- -2°C
dN/dlogD_p (cm^-3)
D_p (μm)

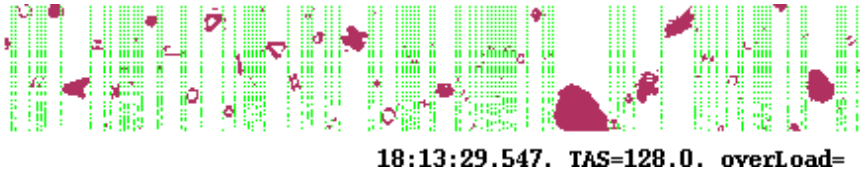


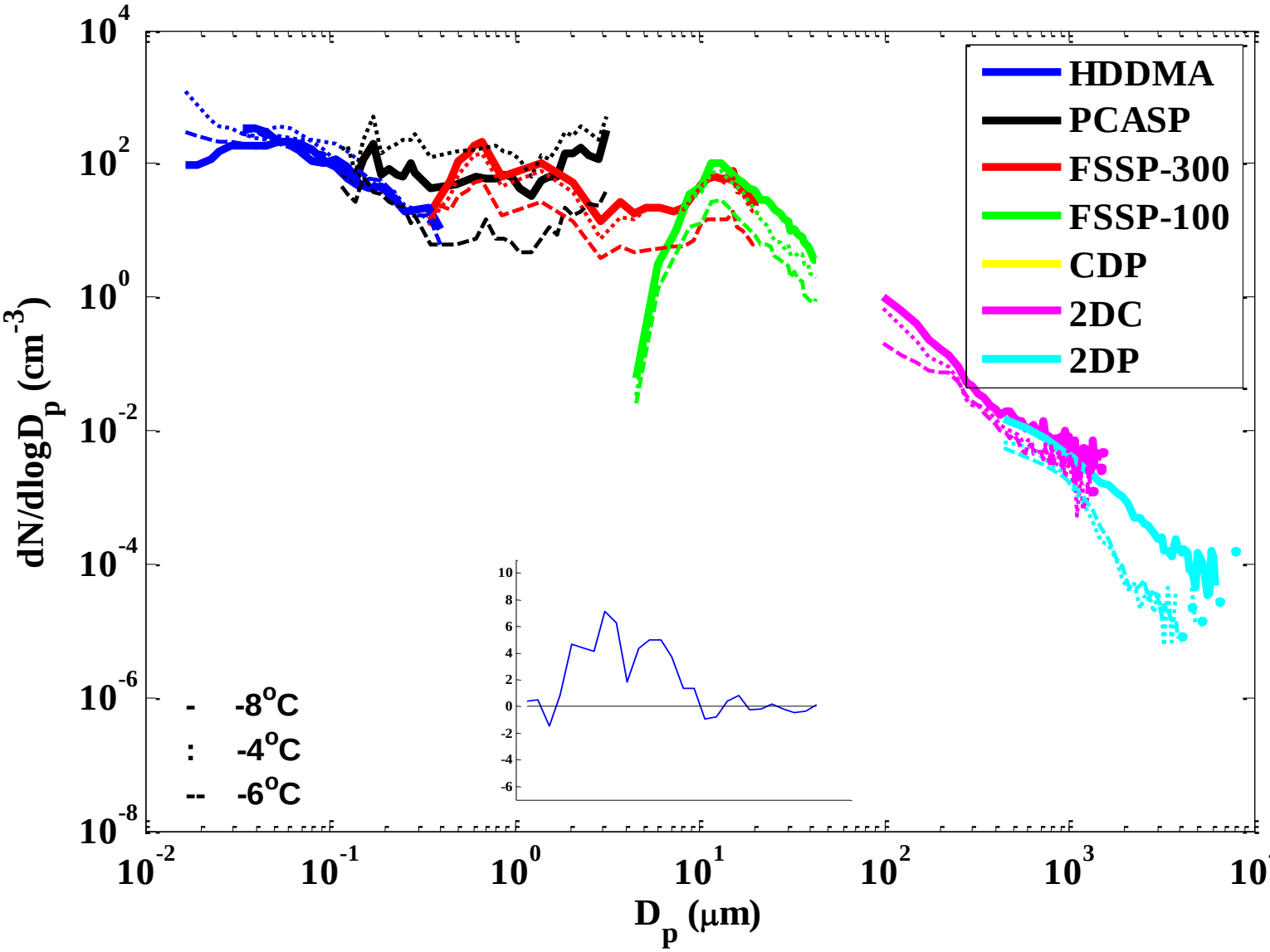
In-cloud (-6°C)

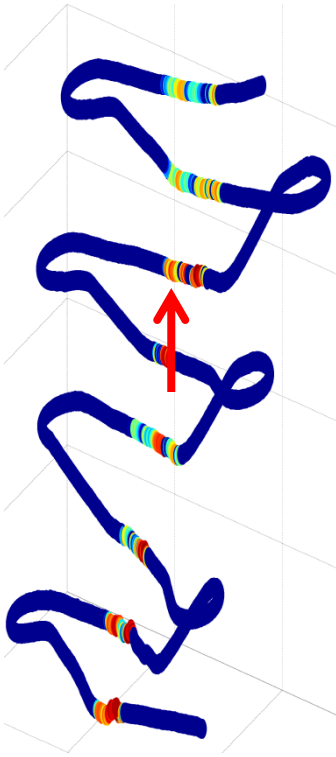

18:08:07.897. TAS=131.0. ove


HDDMA
PCASP
FSSP-300
FSSP-100
CDP
2DC
2DP
Minimal
Shatter in
presence of ice
- -6°C
: -2°C
-- -4°C
dN/dlogD_p (cm^-3)
D_p (μm)
10^4
10^2
10^0
10^-2
10^-4
10^-6
10^-8
10^-2
10^-1
10^0
10^1
10^2
10^3
10^4

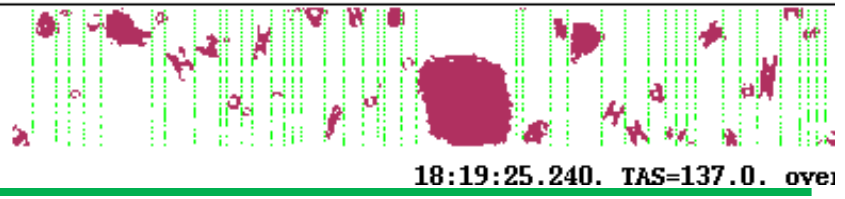
In-cloud (-8°C)


18:13:29.547. TAS=128.0. overLoad=


HDDMA
PCASP
FSSP-300
FSSP-100
CDP
2DC
2DP
- -8°C
: -4°C
-- -6°C
dN/dlogD_p (cm^-3)
D_p (μm)



In-cloud (-10 °C)

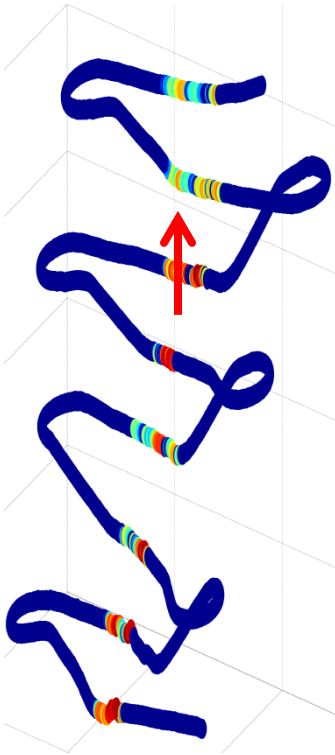


HDDMA
PCASP
FSSP-300
FSSP-100
CDP
2DC
2DP

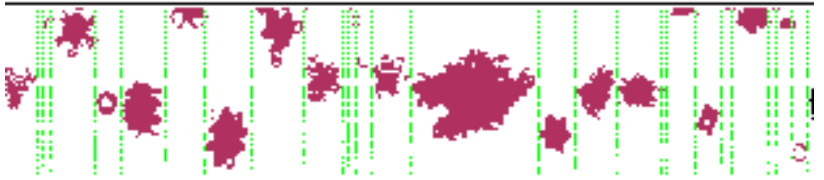
- -10°C
: -6°C
-- -8°C

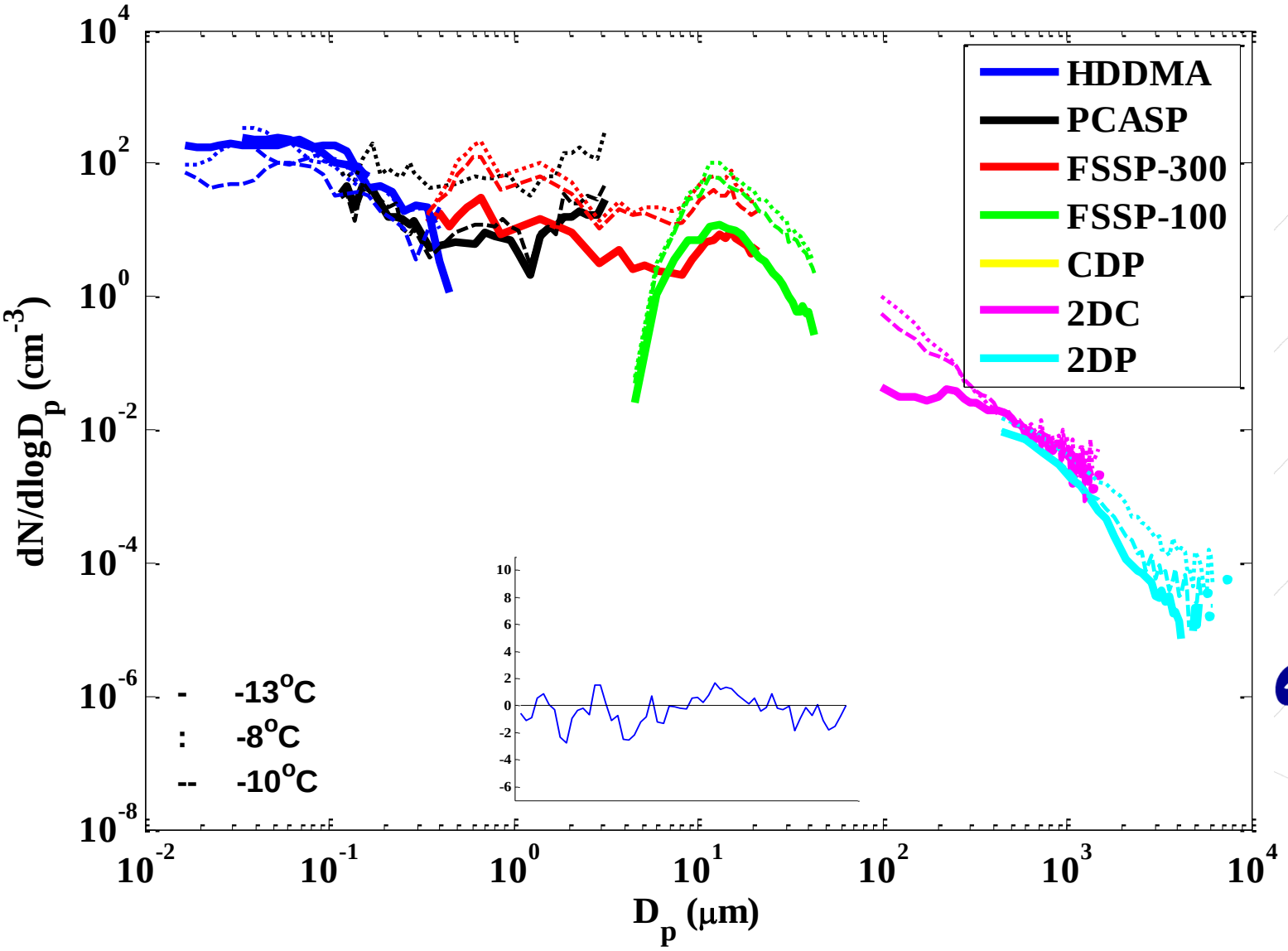
$dN/dlogD_p$ (cm^{-3})

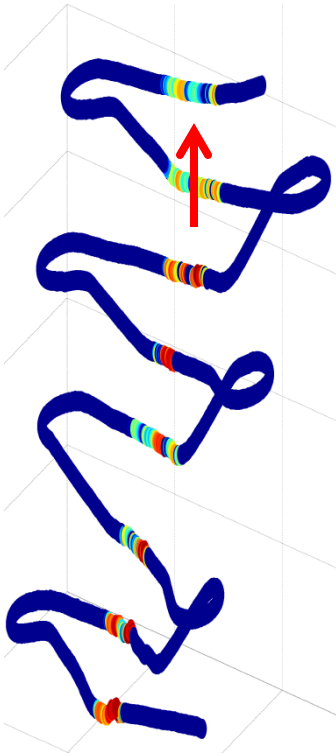
D_p (μm)



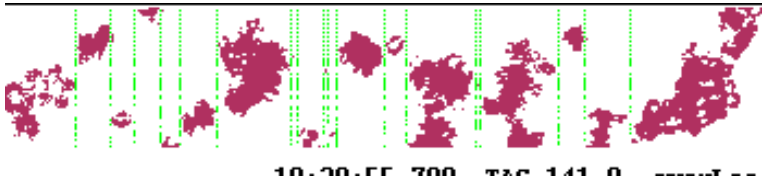
In-cloud (-13 °C)

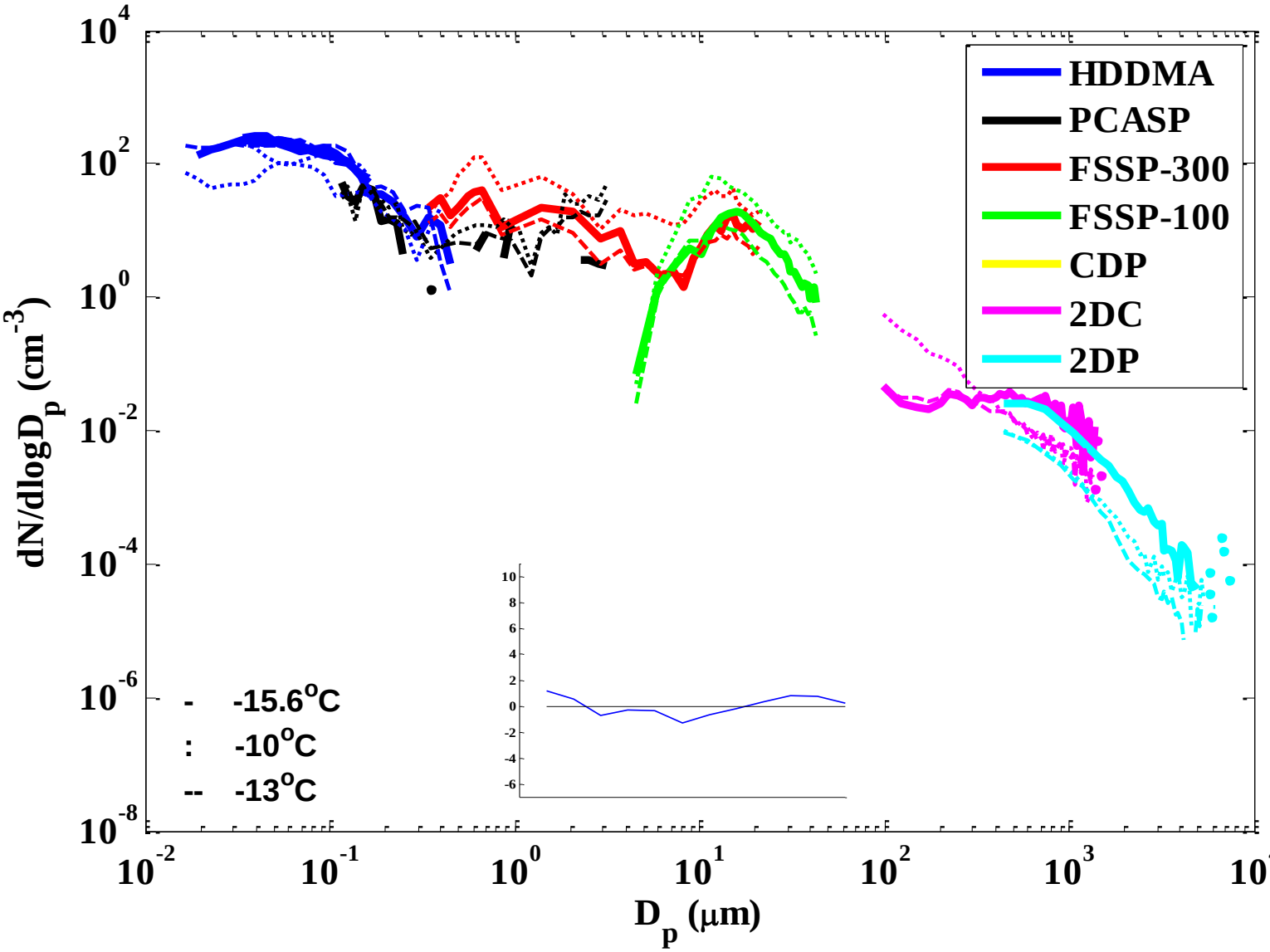


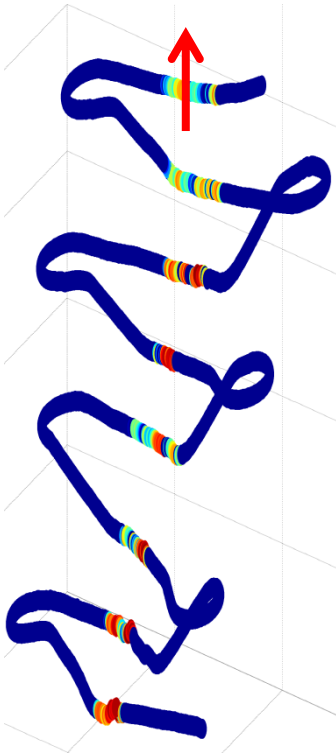

HDDMA
PCASP
FSSP-300
FSSP-100
CDP
2DC
2DP
- -13°C
: -8°C
-- -10°C
dN/dlogD_p (cm^-3)
D_p (μm)



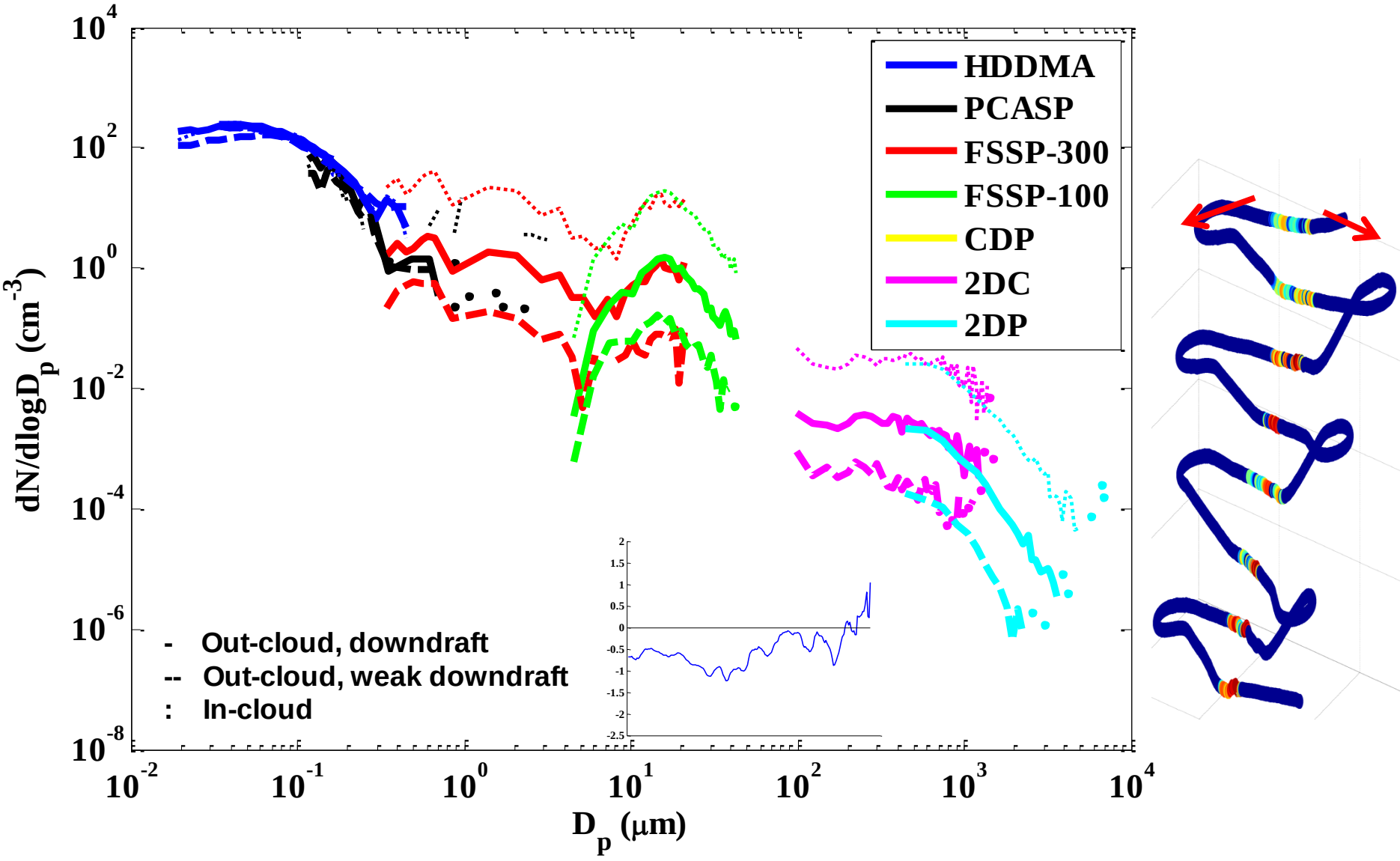
In-Cloud (-15.6 °C)



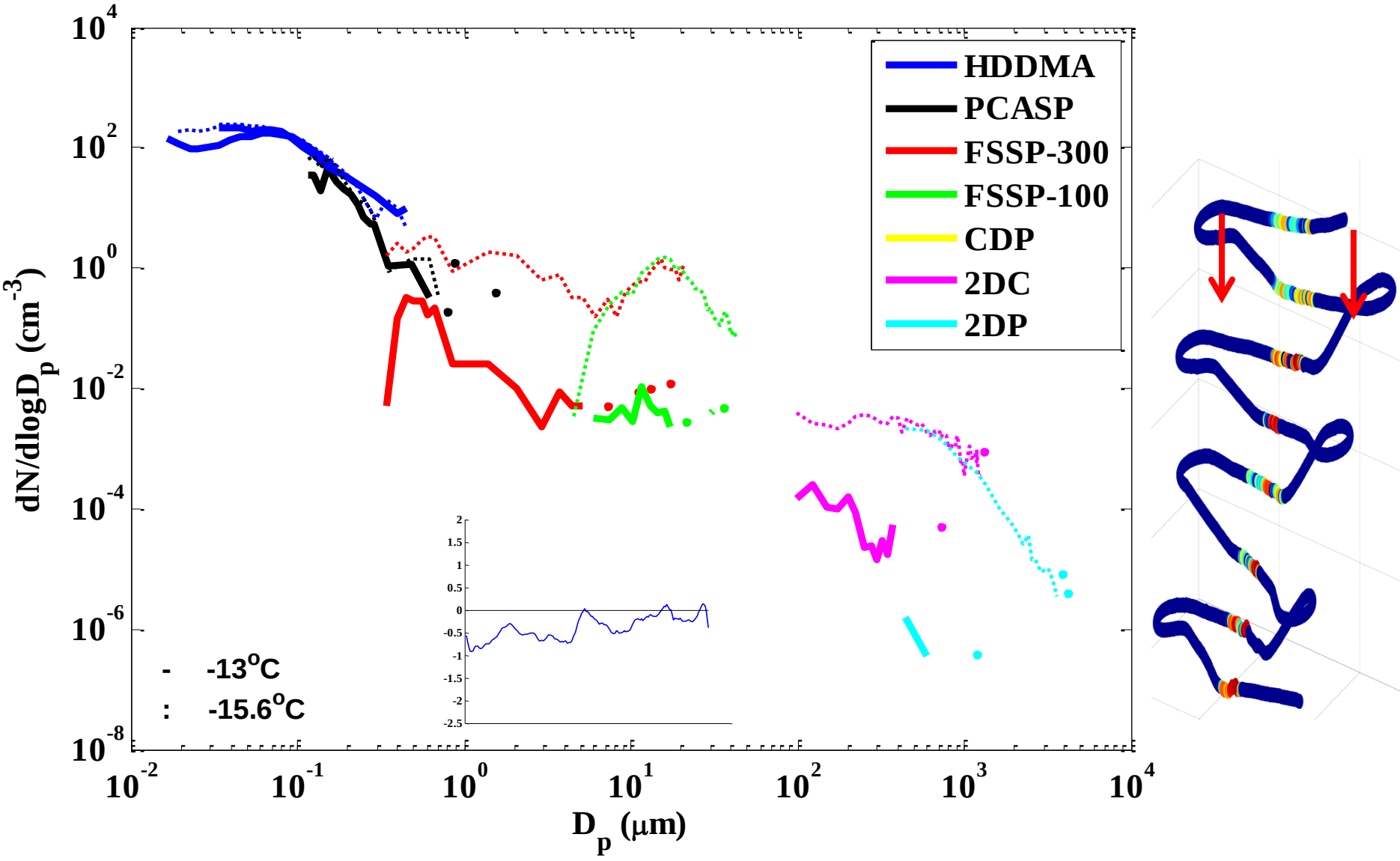




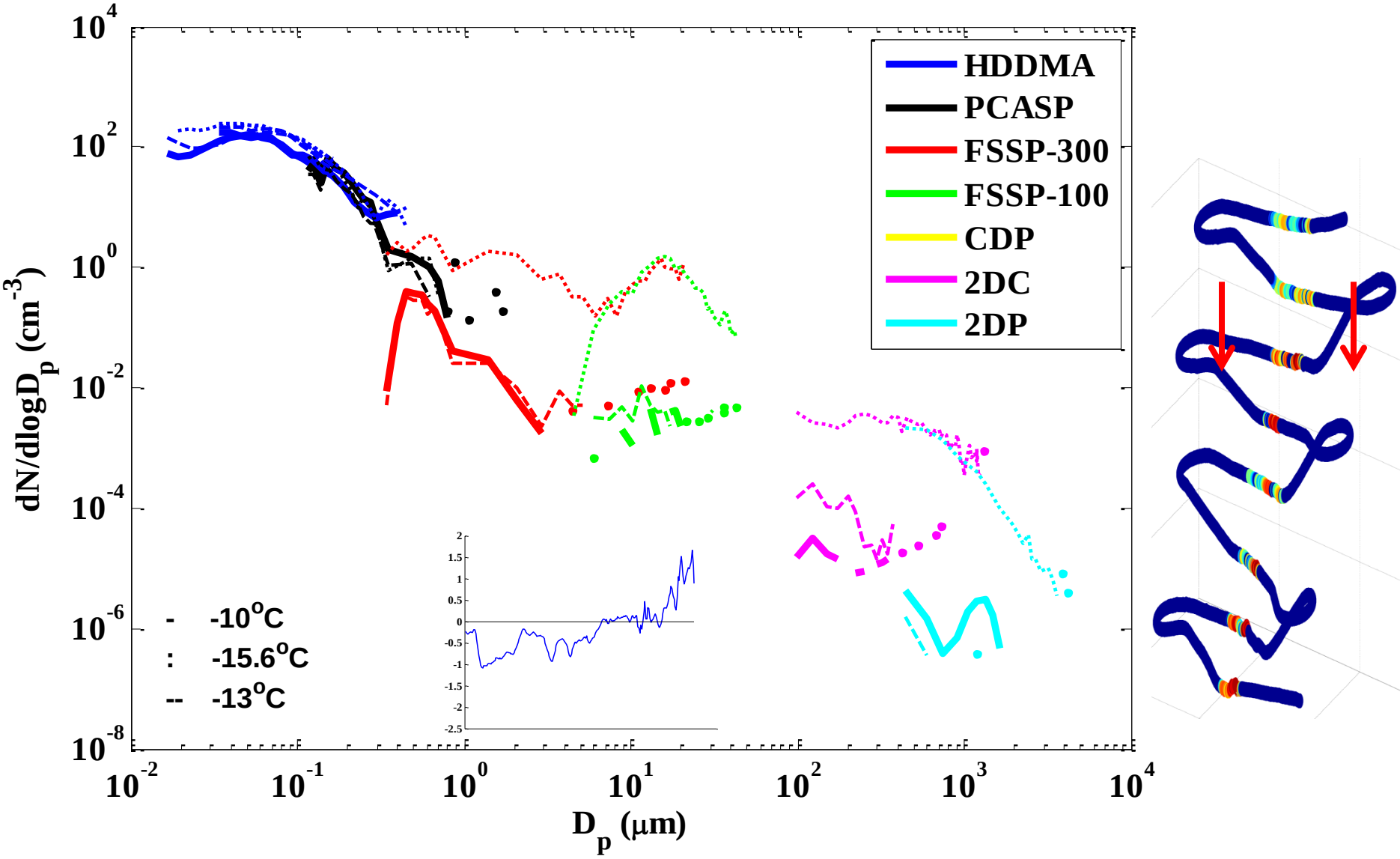
Cloudtop (-15.6°C)



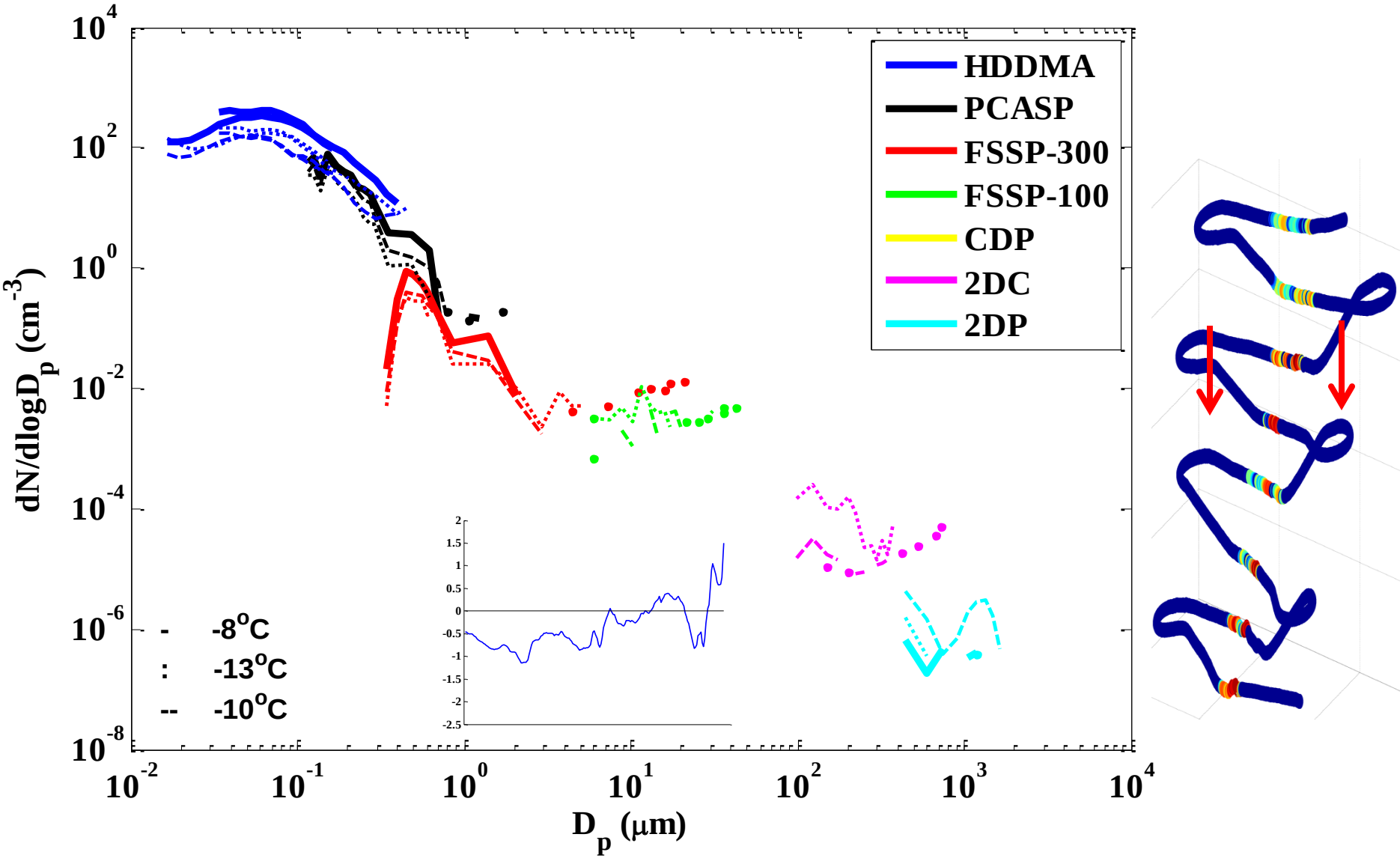
Out-of-cloud (-13°C)



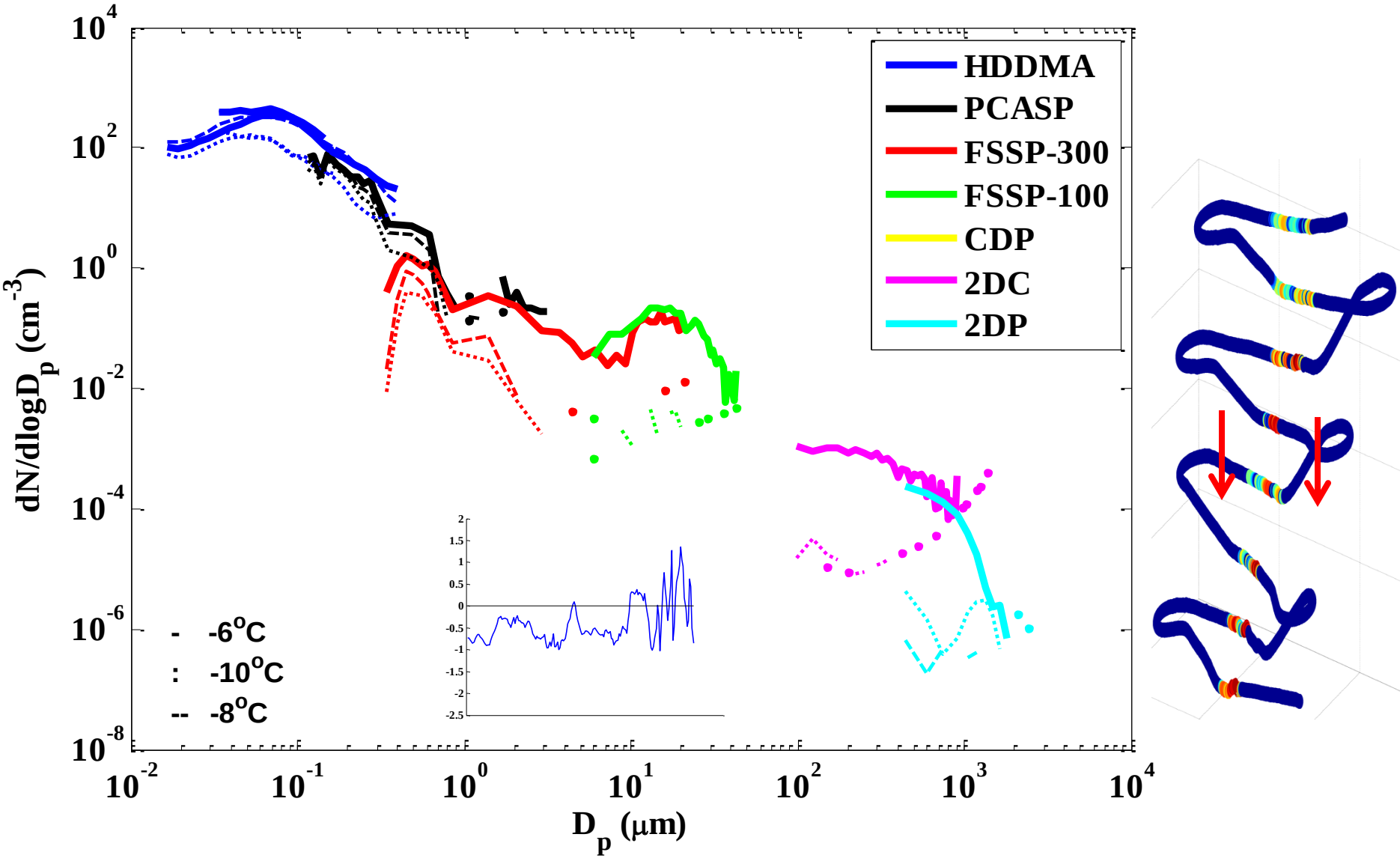
Out-of-cloud (-10°C)



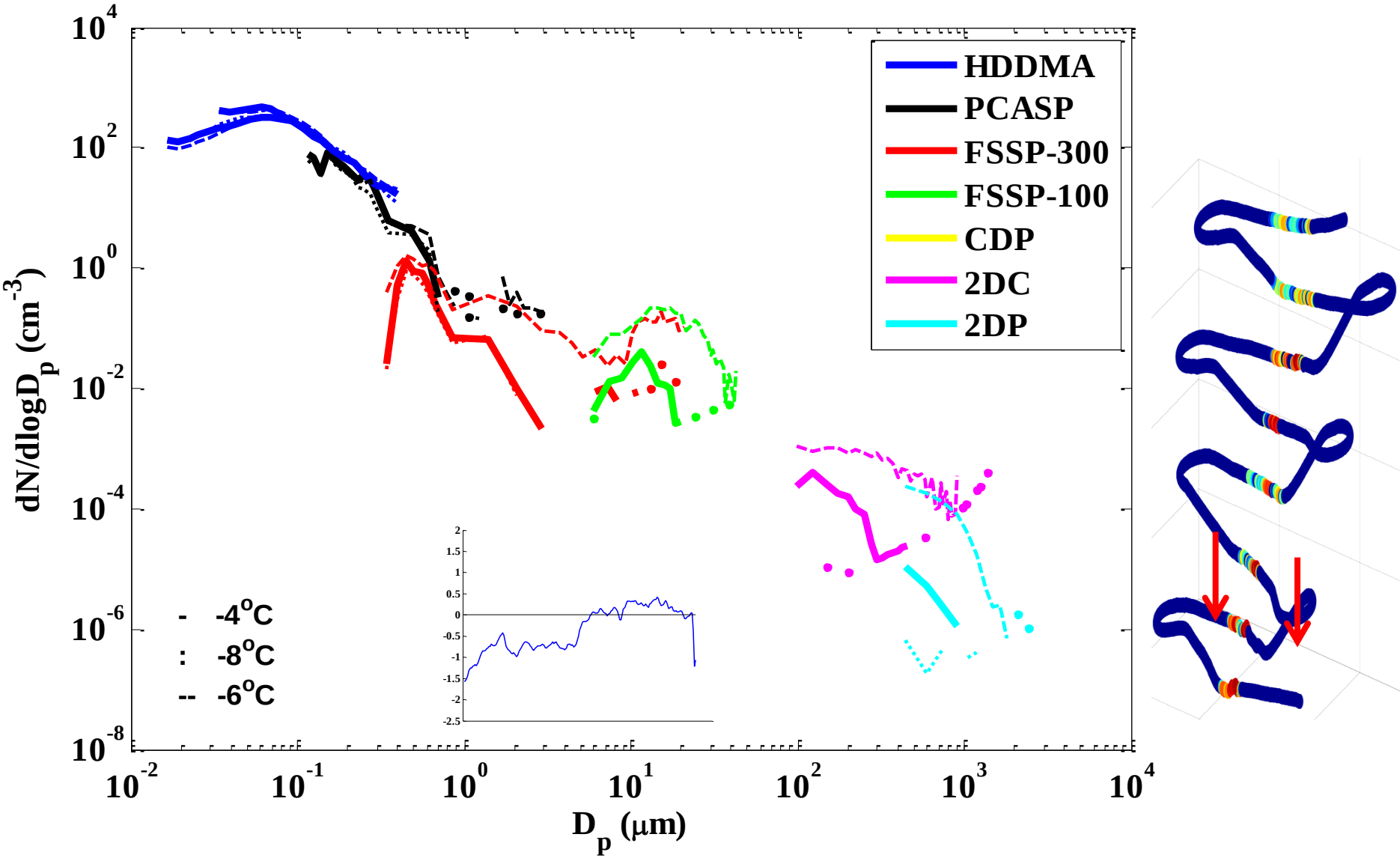
Out-of-cloud (-8°C)



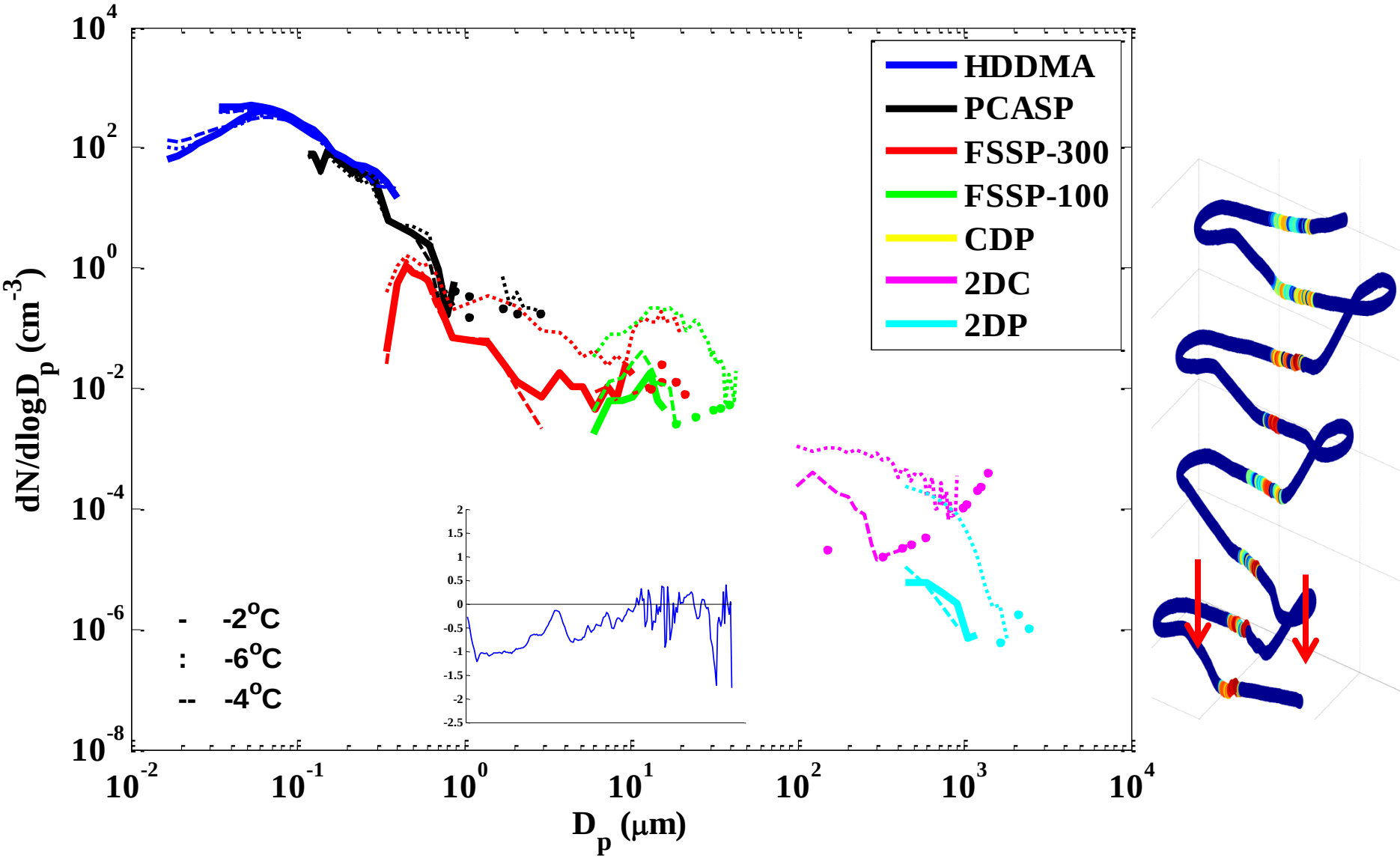
Out-of-cloud (-6°C)



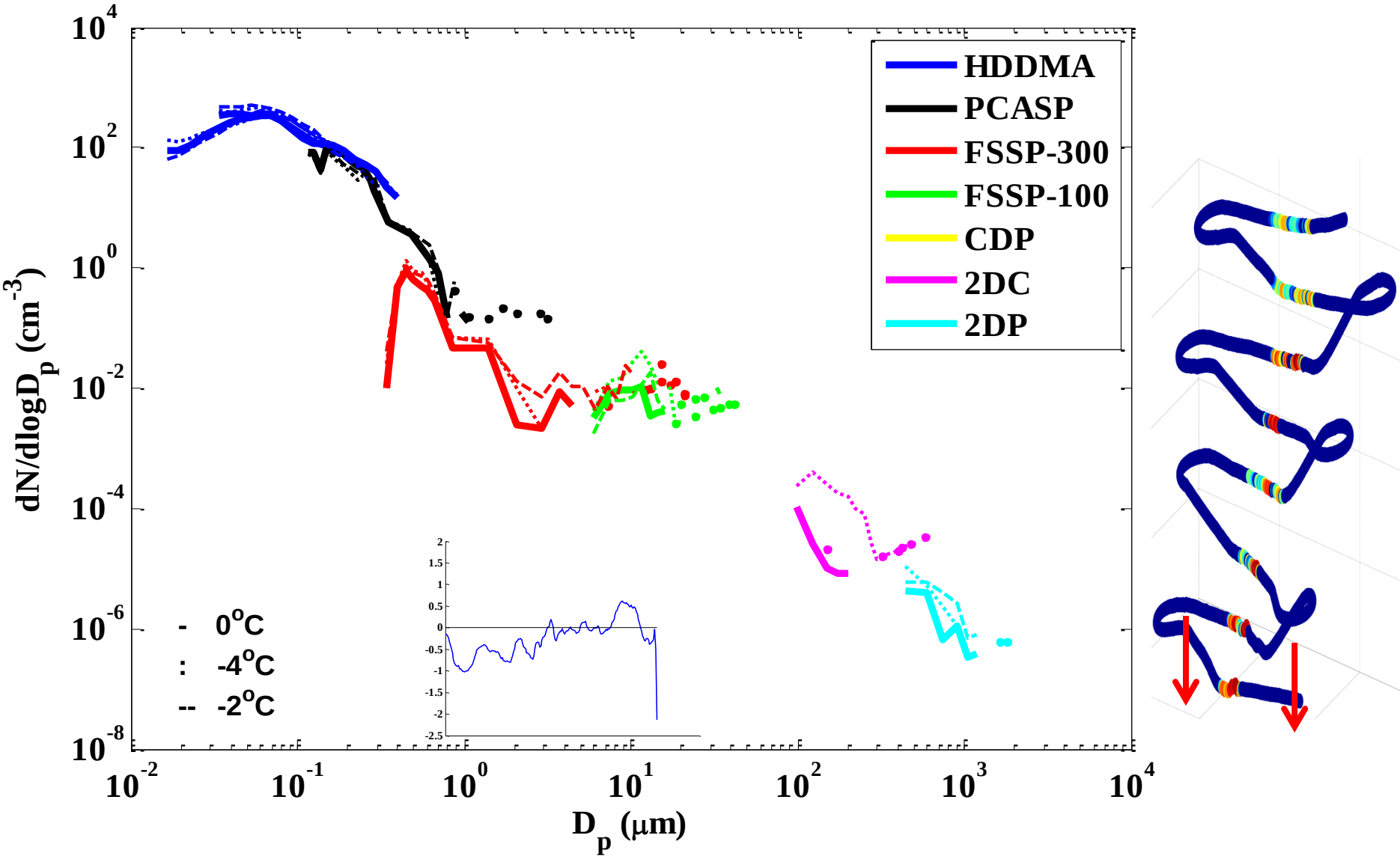
Out-of-cloud (-4°C)



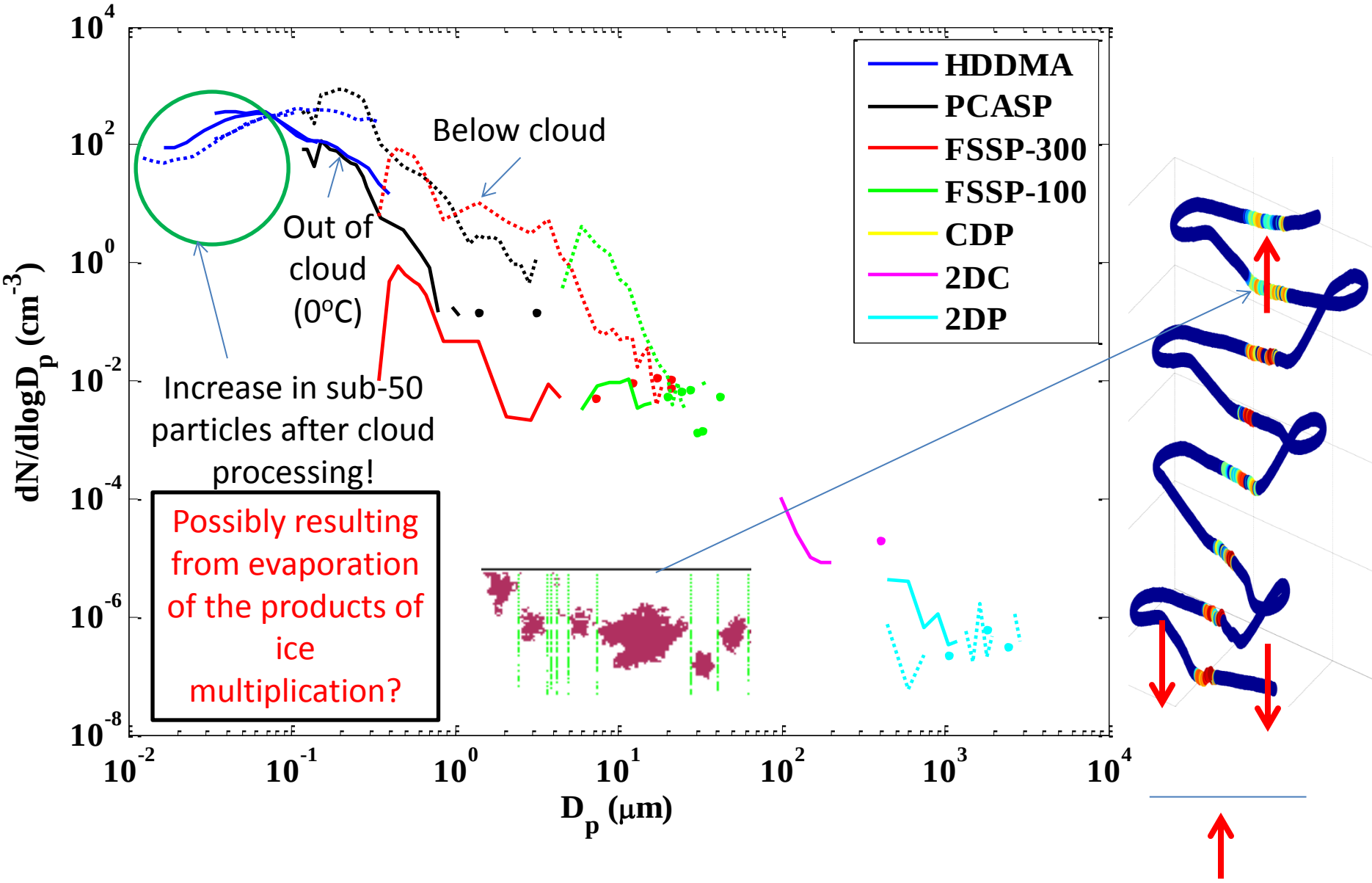
Out-of-cloud (-2°C)



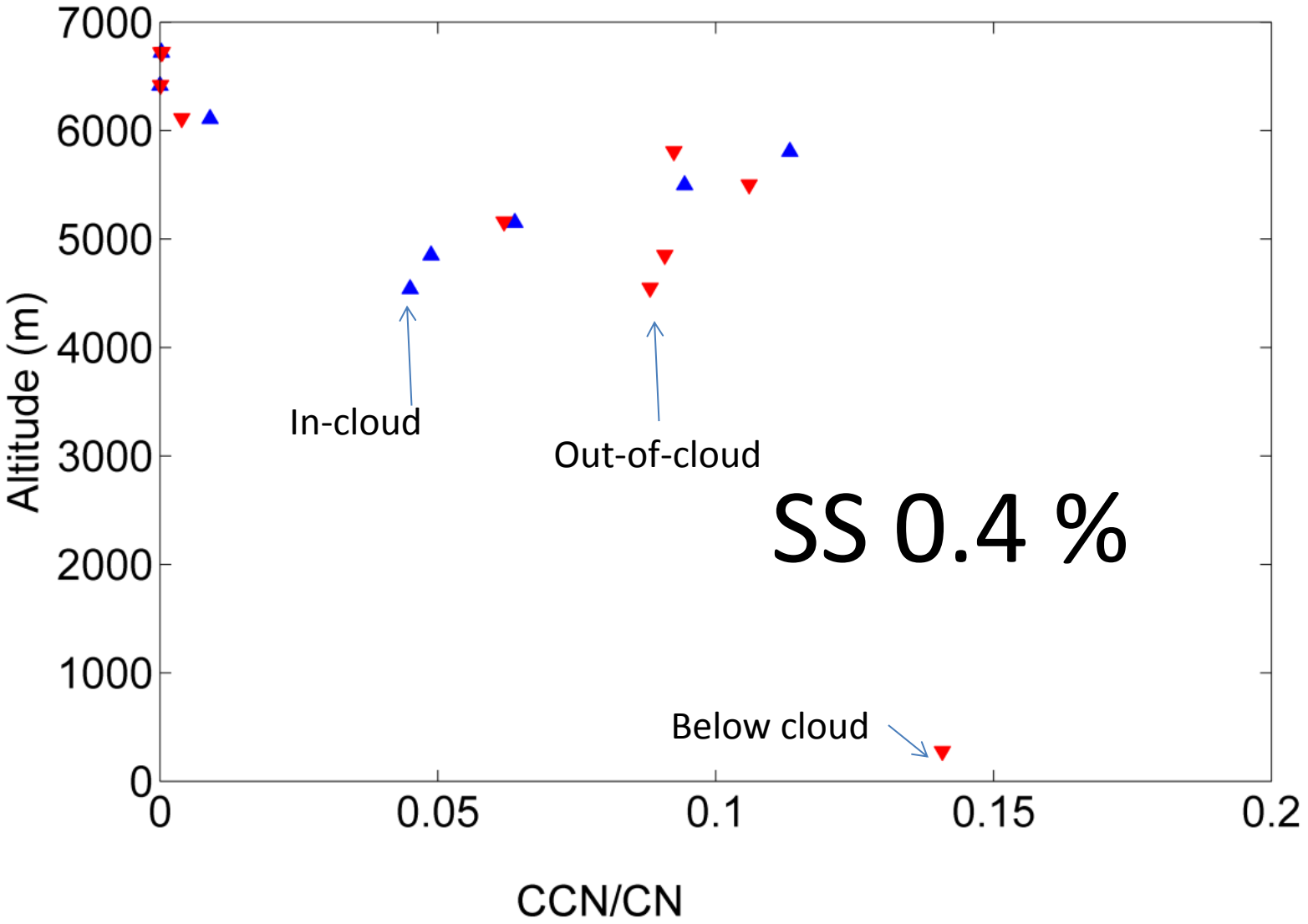
Out-of-cloud (0°C)



Out-of-cloud vs below-cloud



CCN evolution in clouds



Cloud processing results in modifying the particles – as evidenced in the CCN fraction at a SS of 0.4 %

Summary

- The combination of interstitial aerosol sampling and fast size distribution measurements allows for investigation aerosol evolution in clouds
- Is the evolution in aerosol size distribution largely a result of the Hallet-Mossop process?
- Can we identify the products of Wegener–Bergeron–Findeisen process?
  - Evaporation of liquid droplets will result in increase of particle populations in the CCN-active size range (> 80 nm)

Size distributions