BACIC cloud chamber experiment and Ice nuclei observation in Beijing

Mengyu Huang

Ottmar Möhler, Ping Tian, Ruijie Li ,Kai Bi, Yaqiong Hu, etc

Email: huangmy@bj.cma.gov.cn

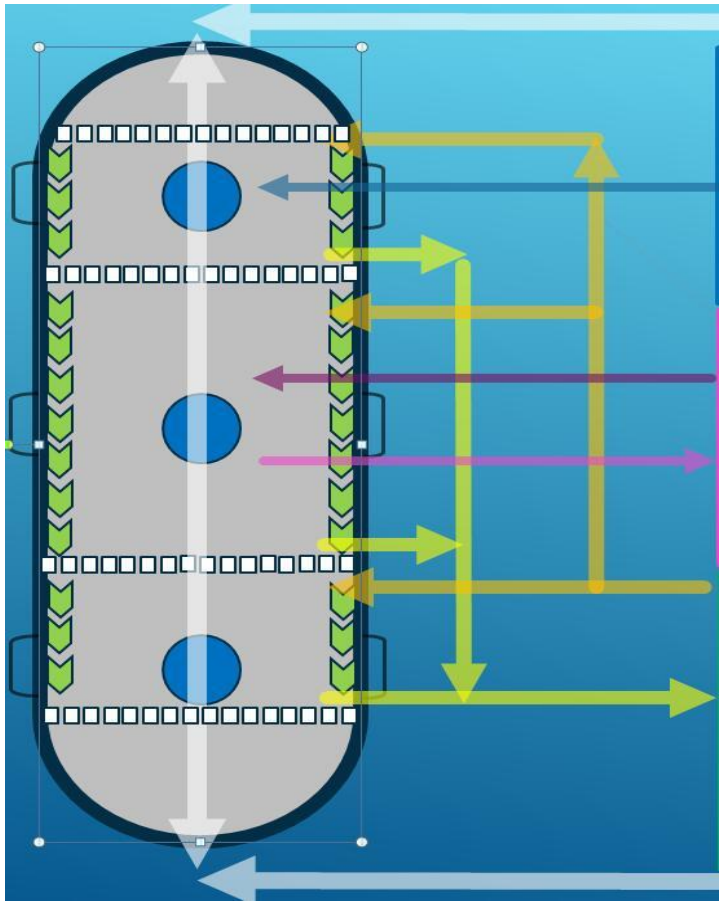
Beijing weather modification center

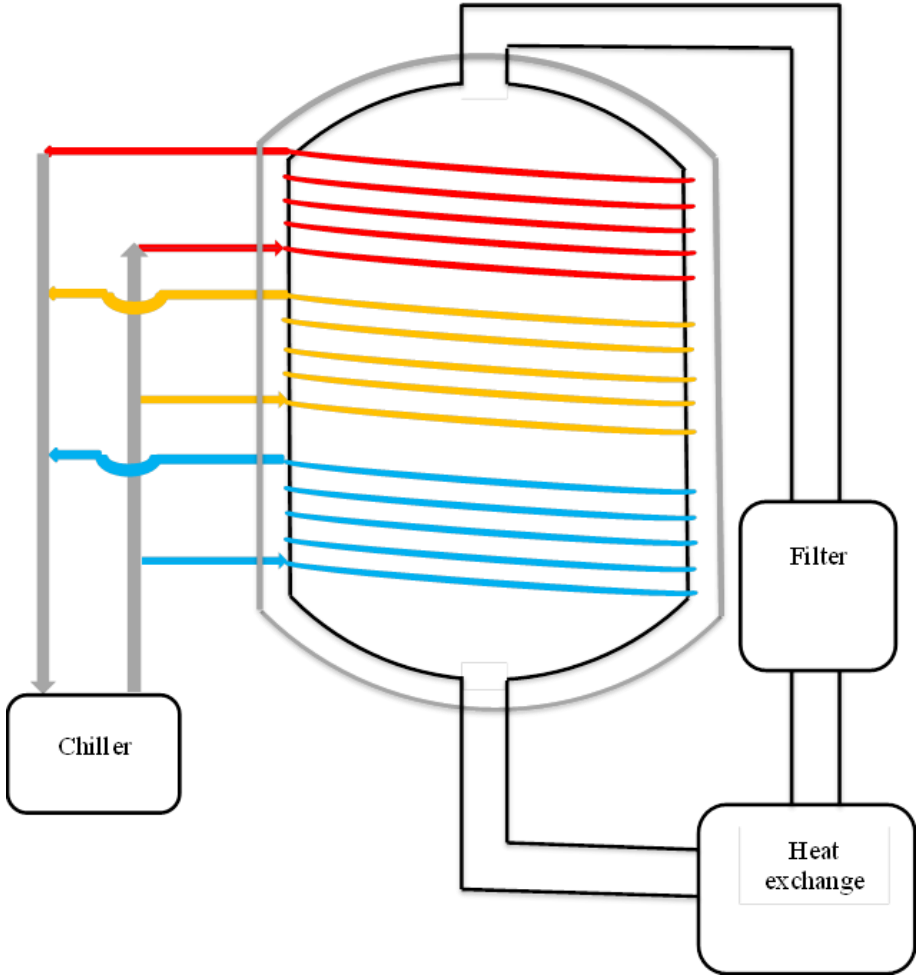
Outline

1. Experiment of BACIC cloud chamber

2. The observation of Ice nuclei particles in Beijing

1. Beijing Aerosol and Cloud Interaction Chamber (BACIC)





Properties	Parameters
Shape	cylinder
Size	diameter: 2.6 m height: 14 m
Volume/surface	70m^3 /118.4 m^2
Material	stainless steel
Temperature	223.5 K- 303.15 K
Pressure	1 hpa – 1013 hpa

The temperature of the top, middle and bottom of the BACIC can be controlled separately.

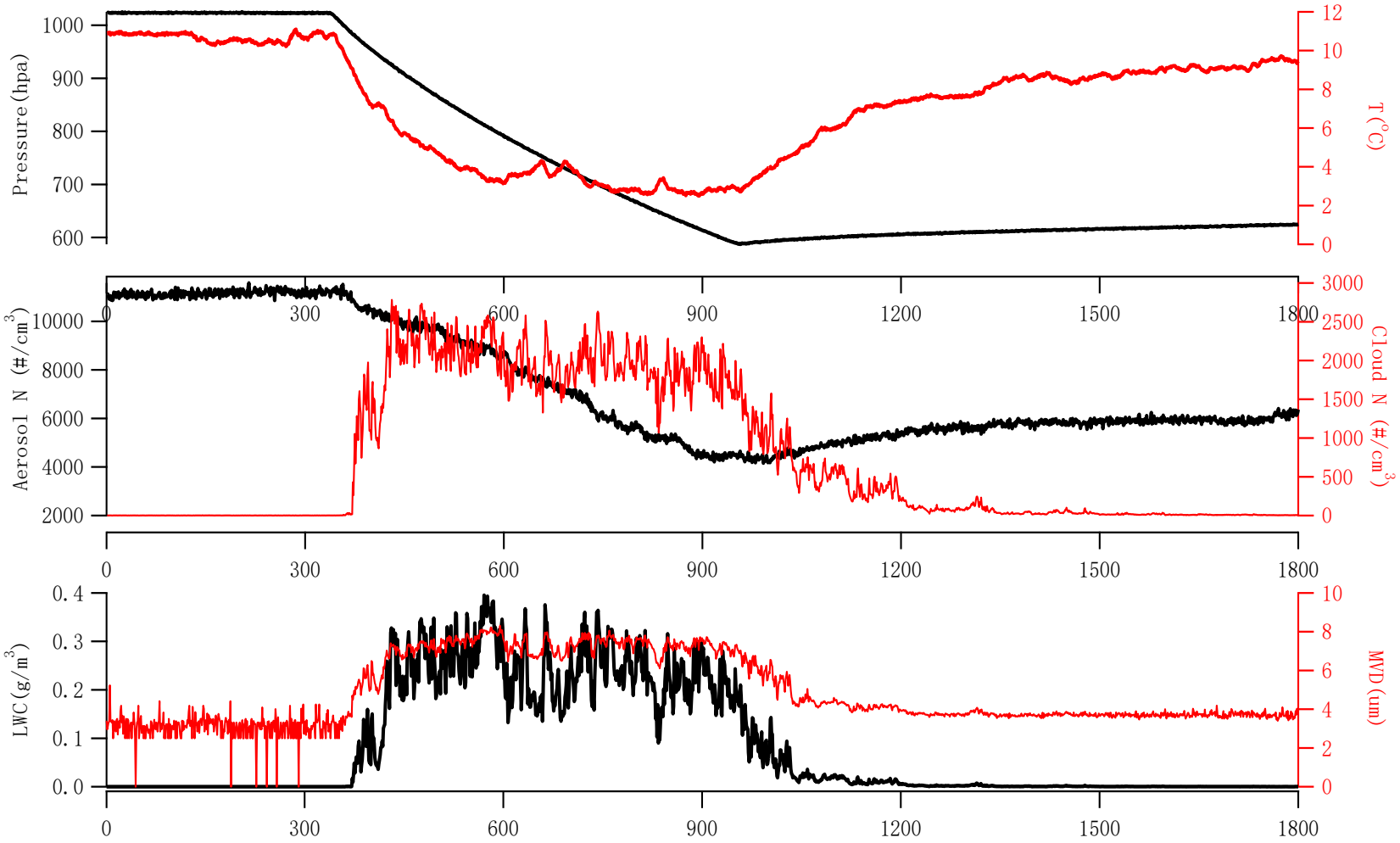
1. Beijing Aerosol and Cloud Interaction Chamber (BACIC)

BACIC: expansion chamber

aerosol activate to cloud droplet

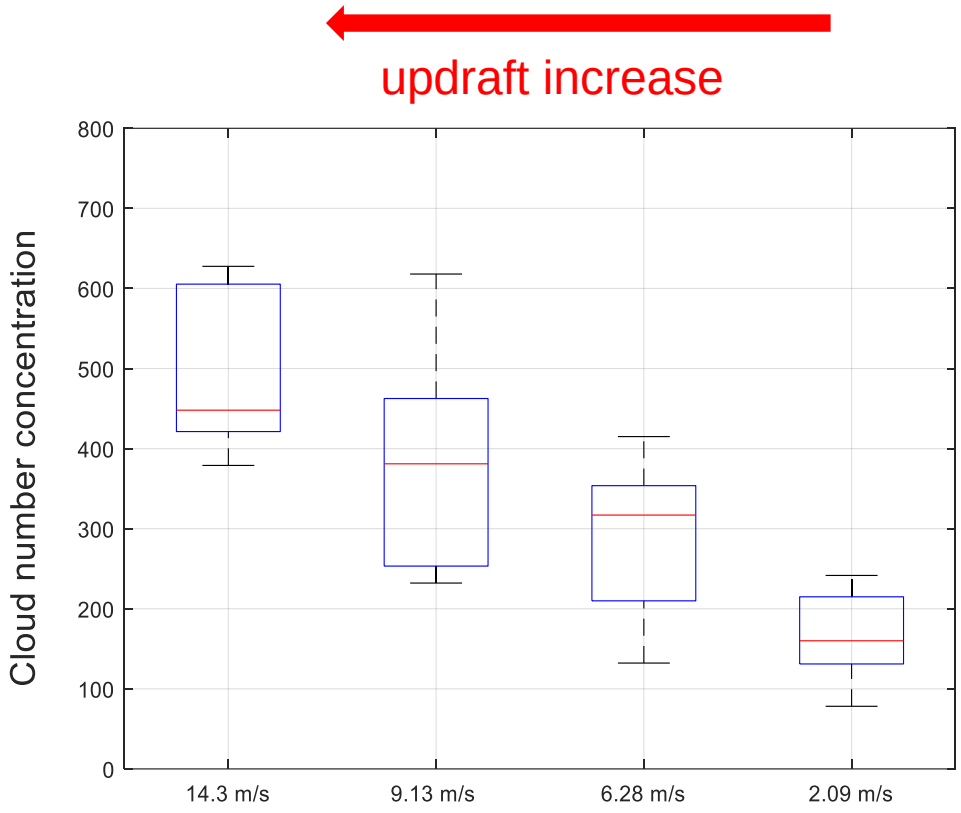
The updraft is calculated by the adiabatic expansion and can be control by the pumping rate

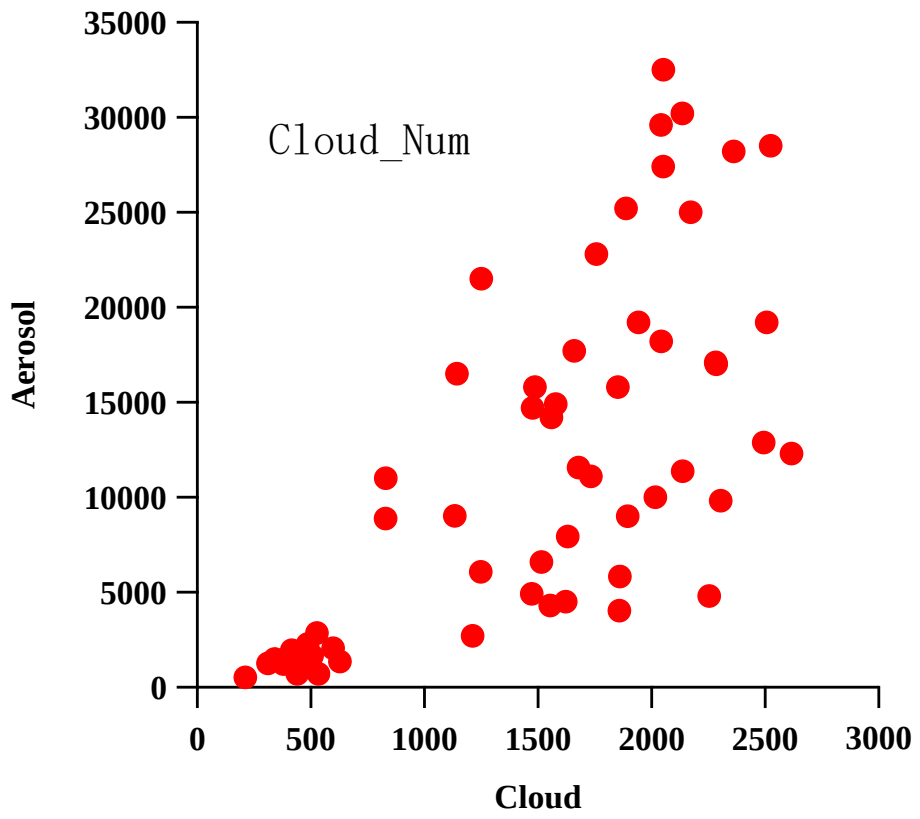
Typical BACIC experiment of liquid cloud



1. Beijing Aerosol and Cloud Interaction Chamber (BACIC)

The effect of aerosol number concentration and updraft on cloud number concentration:



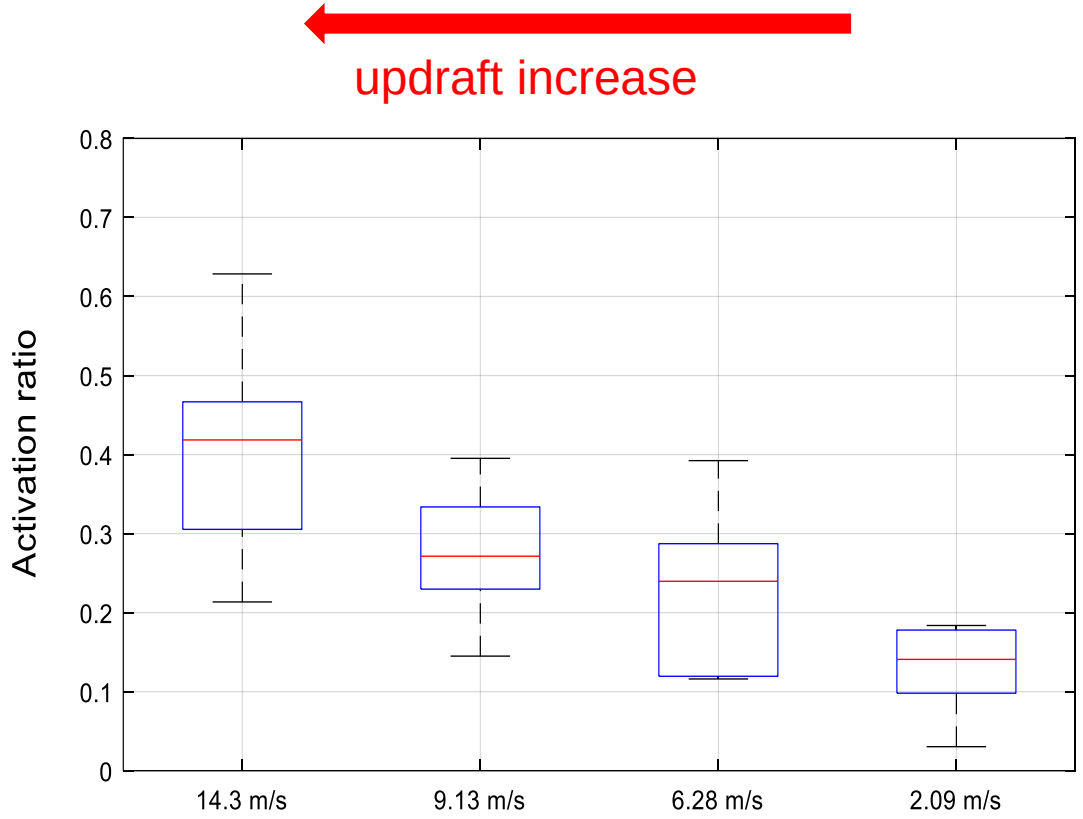


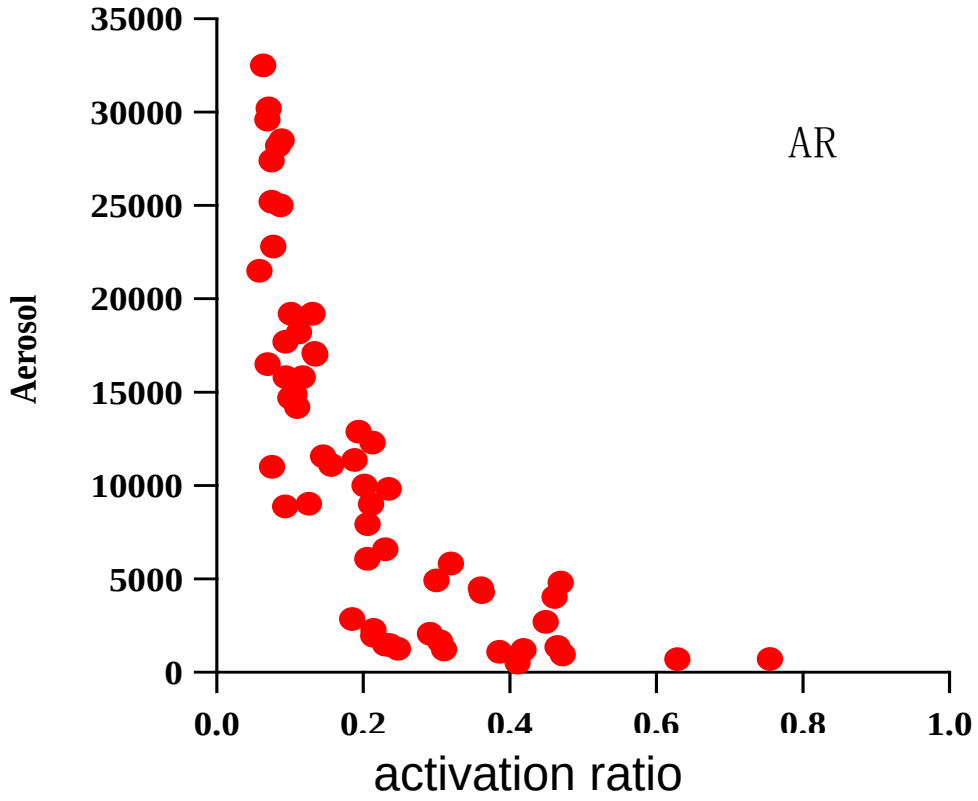
1. Same aerosol number concentration, the Cloud number concentration increase with the updraft (supersaturation).

2. Same updraft, the Cloud number concentration increase with aerosol number concentration.

1. Beijing Aerosol and Cloud Interaction Chamber (BACIC)

The effect of aerosol number concentration and updraft on activation ratio : with ambient aerosol





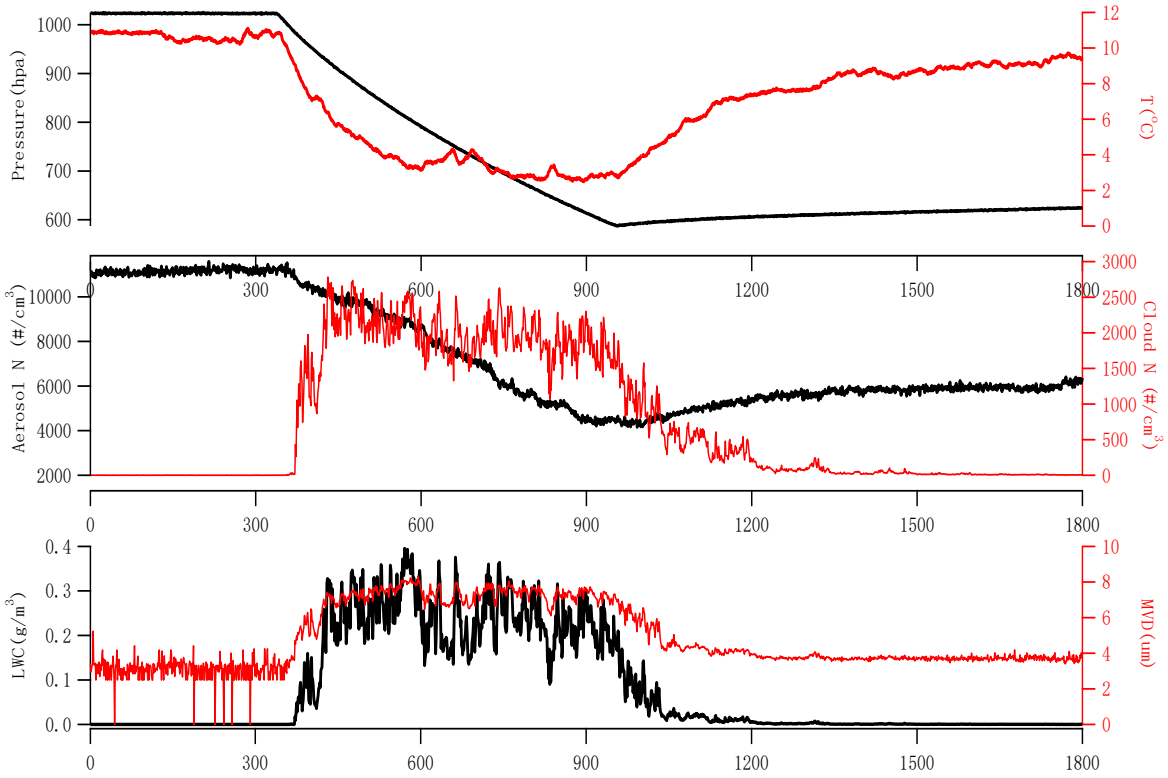
1. Same aerosol number concentration, the AR increase with the updraft (increase supersaturation).

2. Same updraft, the AR increase with decrease of aerosol number concentration.

1. Beijing Aerosol and Cloud Interaction Chamber (BACIC)

The effect of the aerosol number concentration on the size of cloud droplet

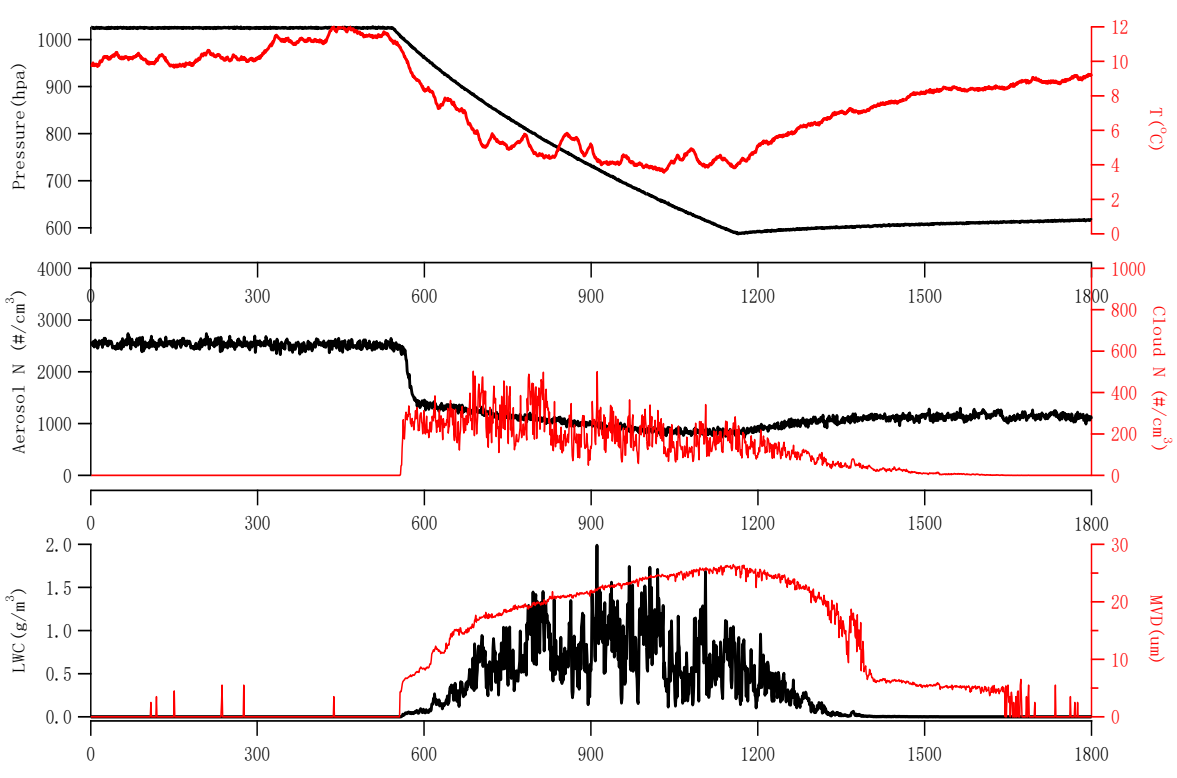
N_a = 10000 #/cm^3



d_c = 7 μm

N_c = 2000 #/cm^3

N_a = 2700 #/cm^3

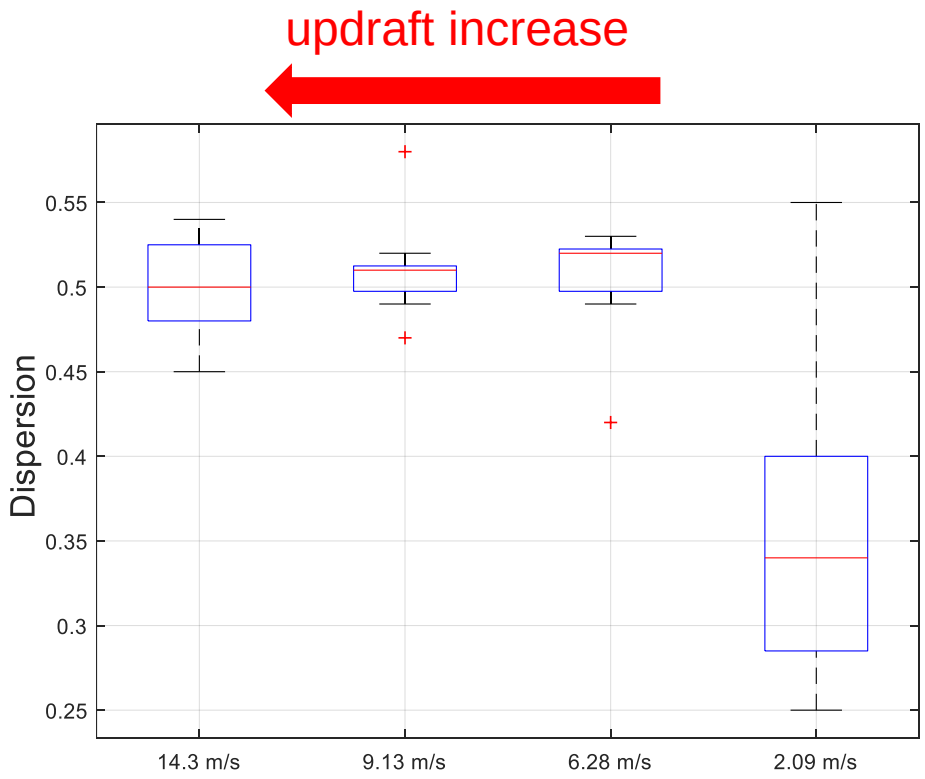


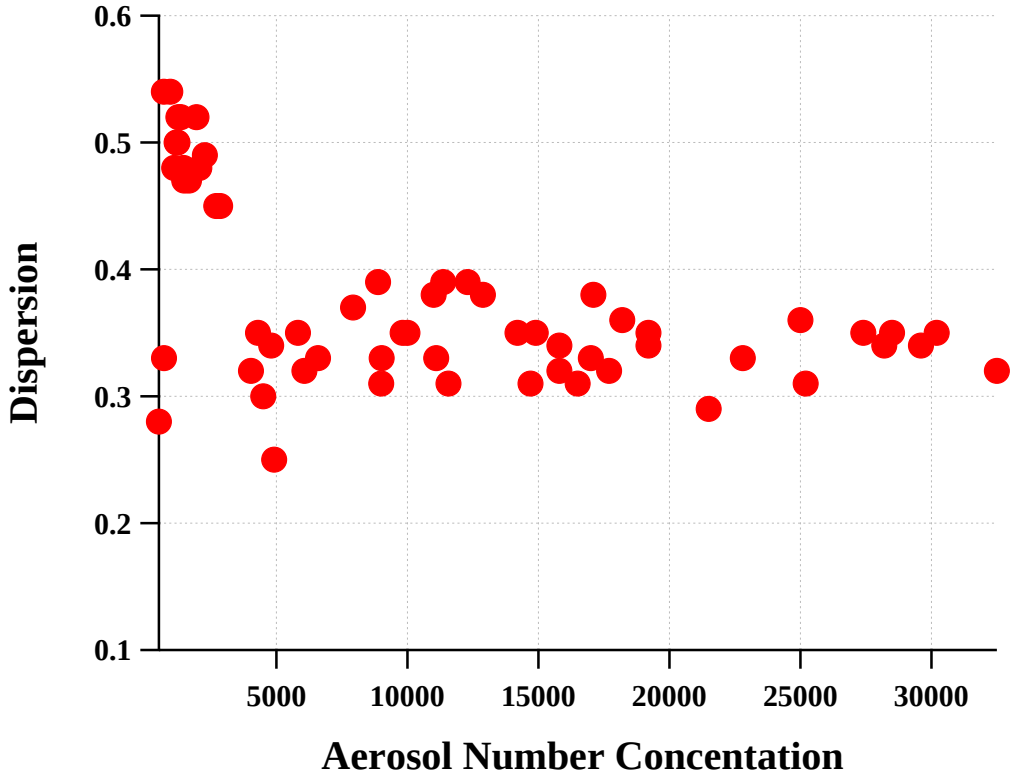
d_c = 25 μm

N_c= 300 #/cm^3

1. Beijing Aerosol and Cloud Interaction Chamber (BACIC)

The effect of the aerosol number concentration on the dispersion of cloud droplets





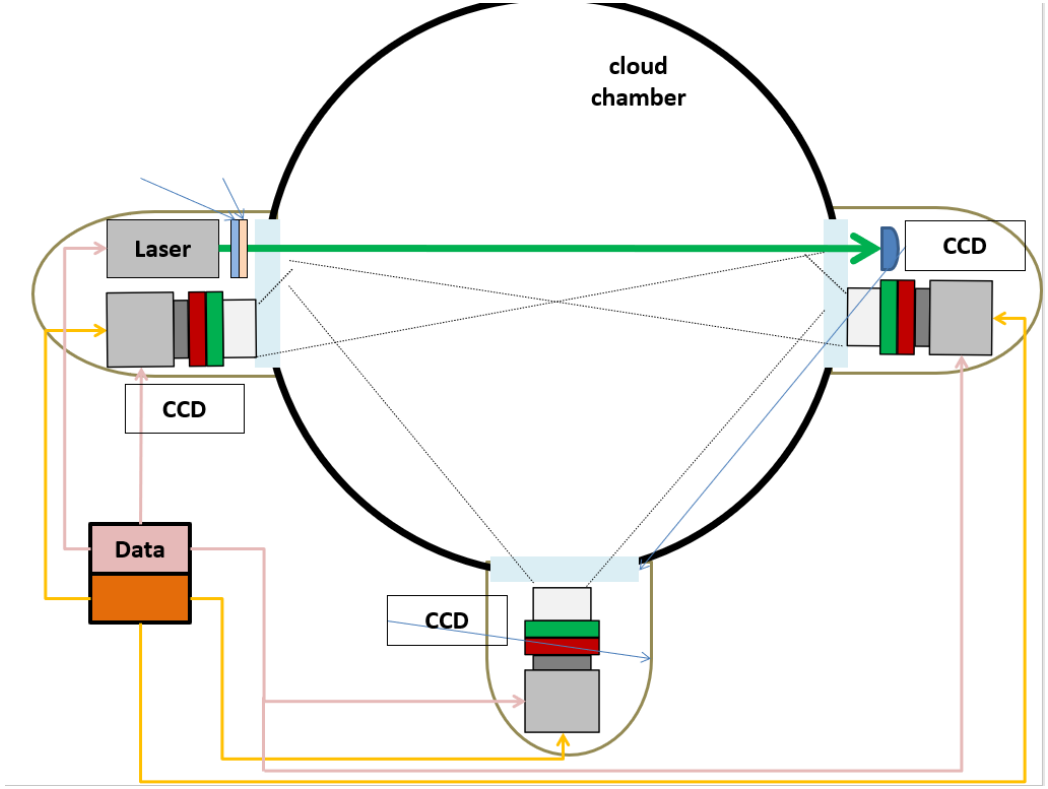
1. The dispersion of cloud increase with the updraft when N_a larger than 3000 #/cm^3.
2. The dispersion of cloud decline to 0.3 with the increase of the N_a.

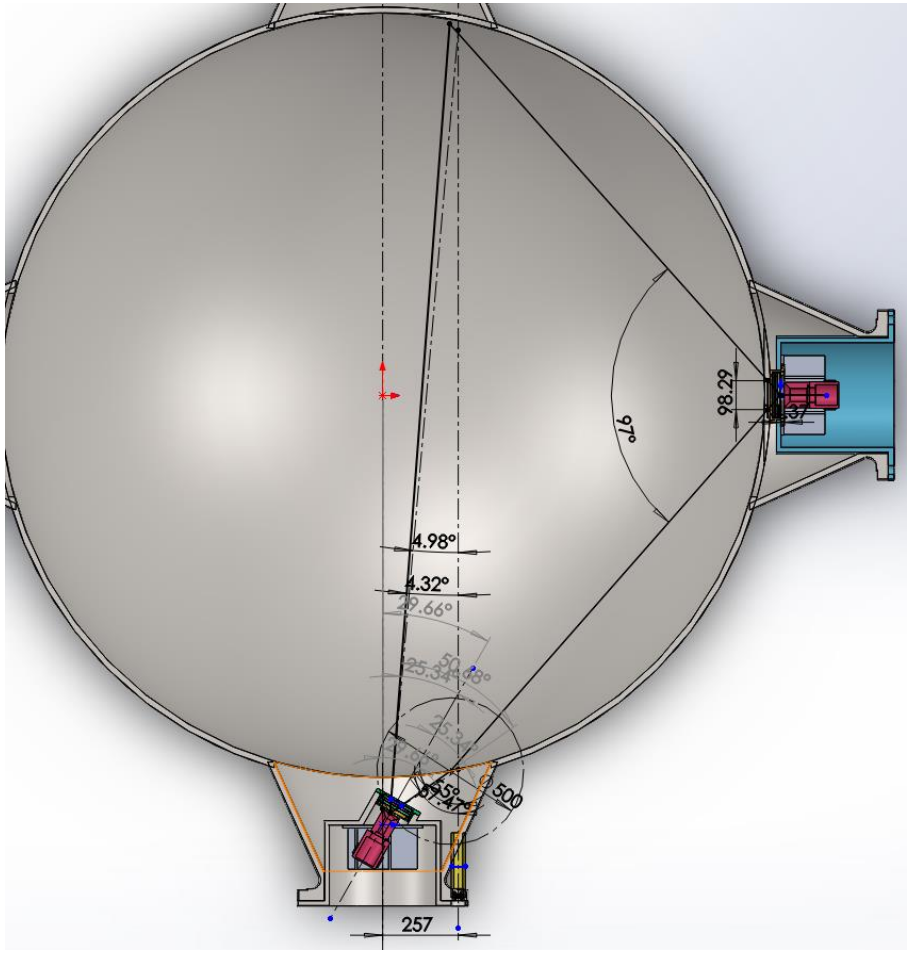
1. Beijing Aerosol and Cloud Interaction Chamber (BACIC)

development of new instruments:

measuring the scattering function of the cloud droplet and aerosol

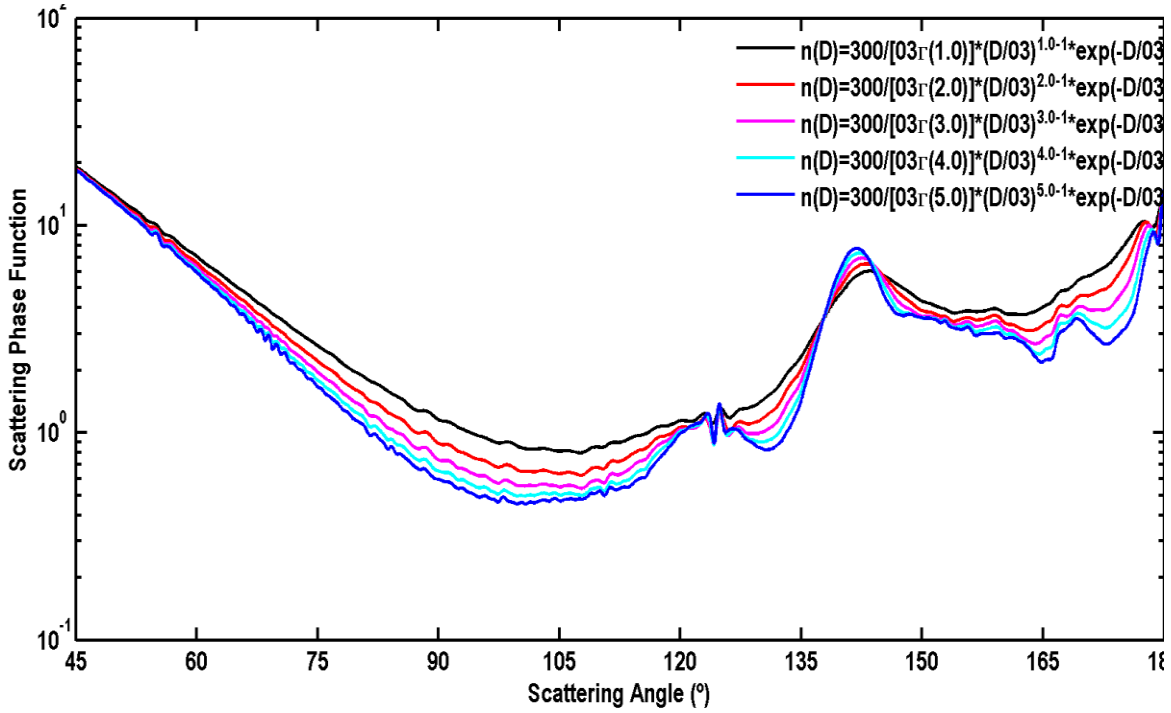
angle : 7° - 173°



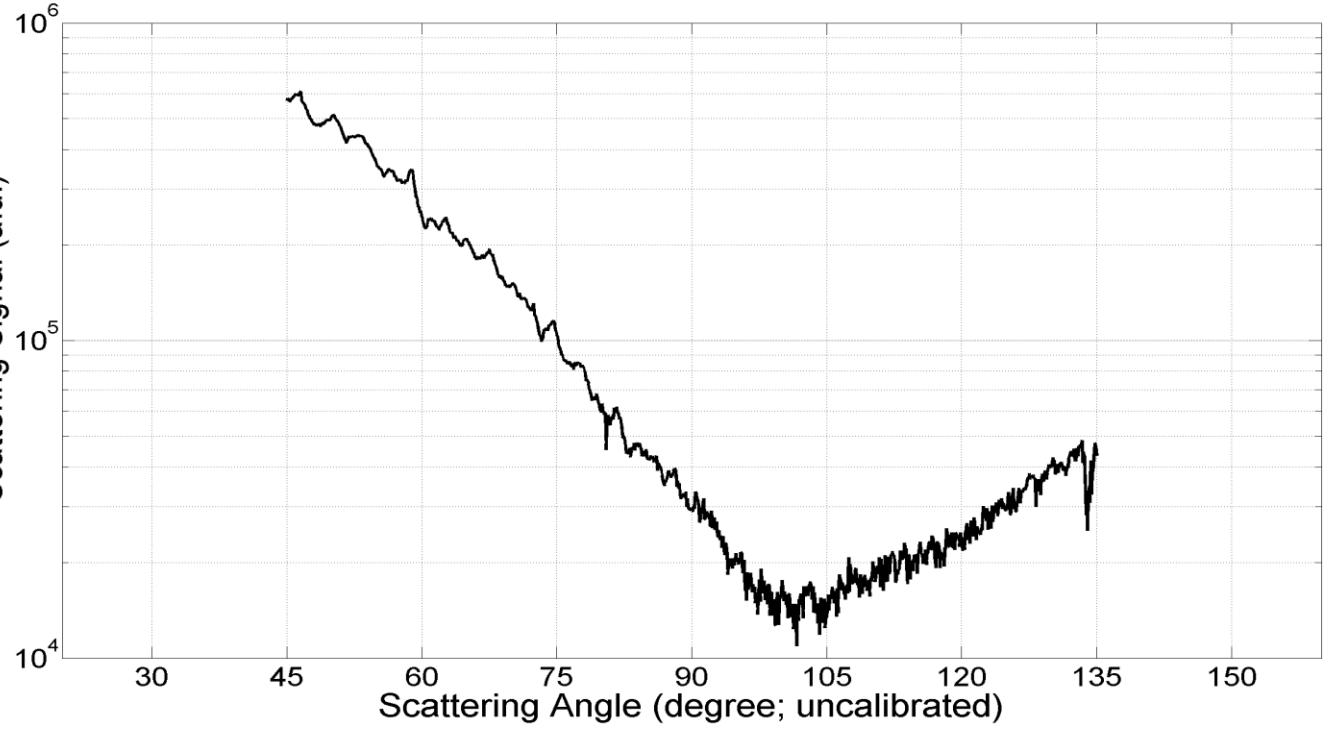


1. Beijing Aerosol and Cloud Interaction Chamber (BACIC)

Theoretical calculation

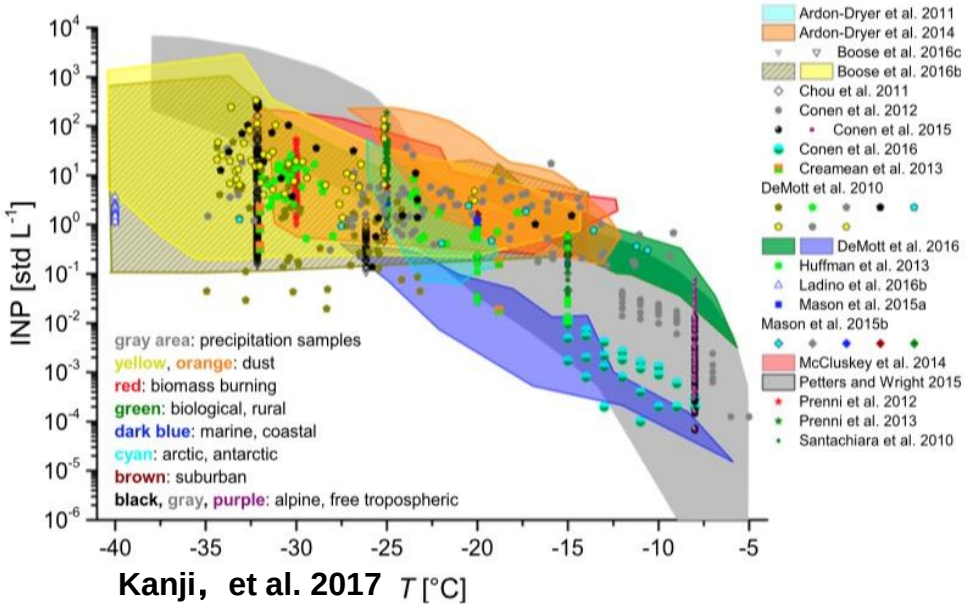


Observation



Using the scattering function to retrieve the cloud size distribution.

The sources and the spatial distribution of INP in Beijing



Kanji，et al. 2017

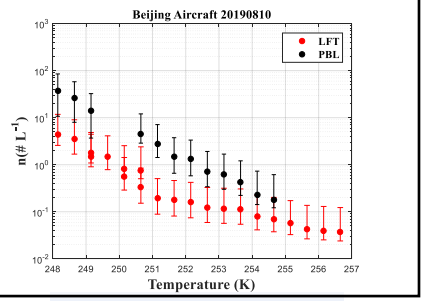
The aerosol number concentration was larger than 10000 #/cm^3 during pollution.

The INP concentration vary several order of magnitude at certain T

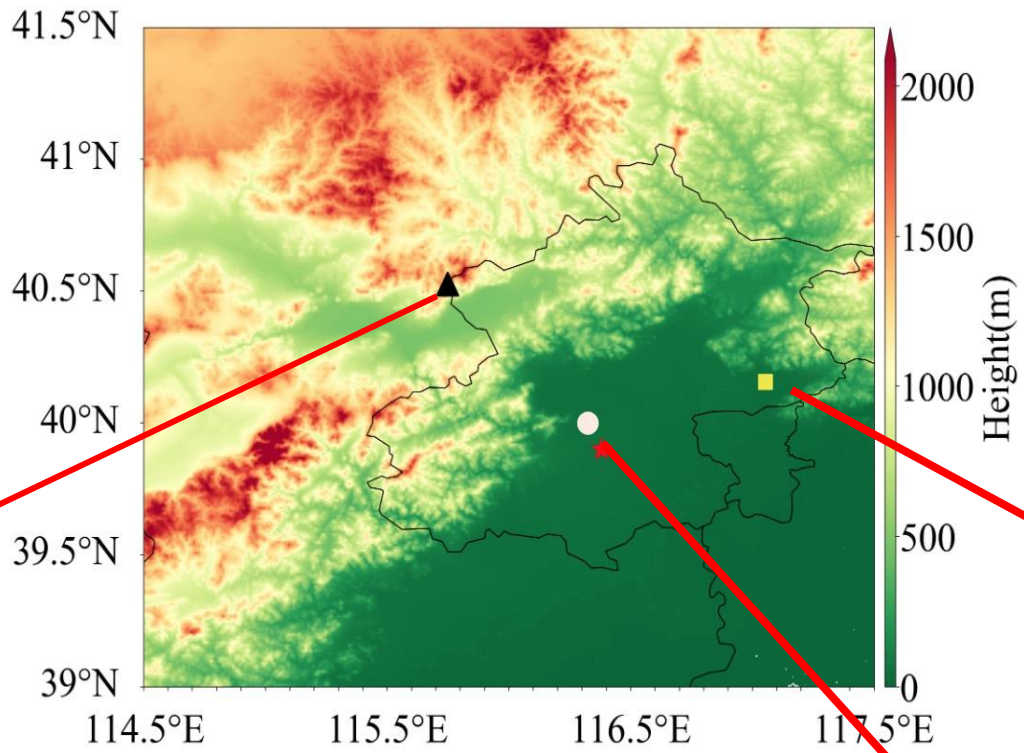
Whether the anthropogenic aerosol could contribute to the INPs ?

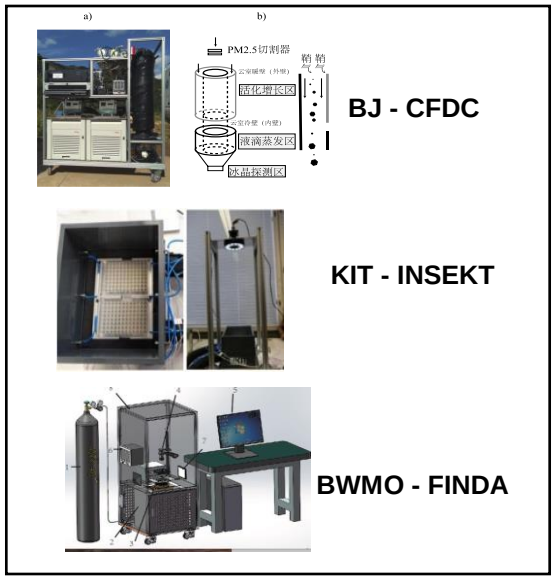
- “Ice-nucleating particle concentrations **unaffected** by urban air pollution in Beijing, China” —— Chen, et al., ACP, 2018
- “The concentration of **INPs increases** significantly when air pollution is severe” —— Che, et al., AE, 2018

INPs Comprehensive Observation Project in Beijing

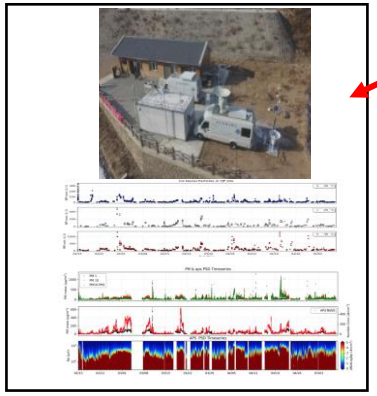


Aircraft platform

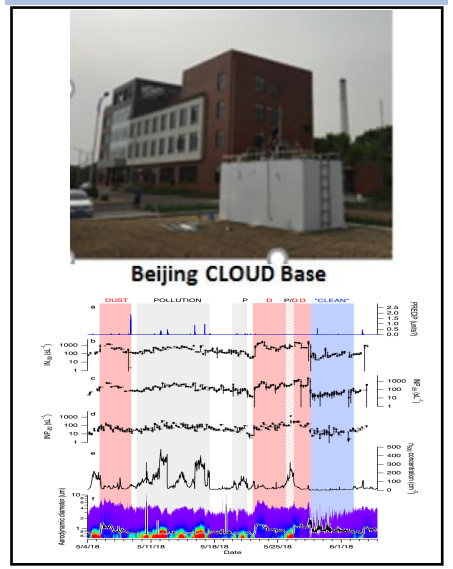




YJP Mountain



CB Suburban site



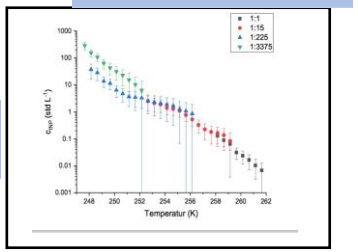
different emission source backgrounds

Long-term observation

anthropogenic influence

inside and outside the boundary layer

Urban site



Characteristics of INPs in Beijing

INPs Comprehensive Observation Project in Beijing

Time	2016	2017	2018	2019	2020	2021
	11 12	1 2 3 4 5 6 7 8 9 10 11 12	1 2 3 4 5 6 7 8 9 10 11 12	1 2 3 4 5 6 7 8 9 10 11 12	1 2 3 4 5 6 7 8 9 10 11 12	1 2 3 4 5 6 7 8 9 10 11 12
Mountain						
Suburban						
Urban						
Aircraft						

CFDC
GRIMM
APS

CFDC
GRIMM
APS

CFDC
CCN
GRIMM
APS
SMPS
AMS

Filter
GRIMM

CFDC
GRIMM
APS
ion chromatograph

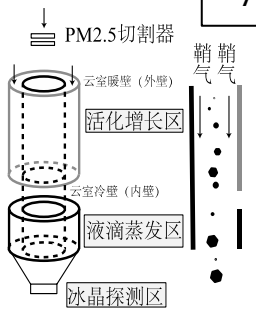
CFDC
GRIMM
APS
Ion
chromat
ograph

Filter
GRIMM
AIMMS

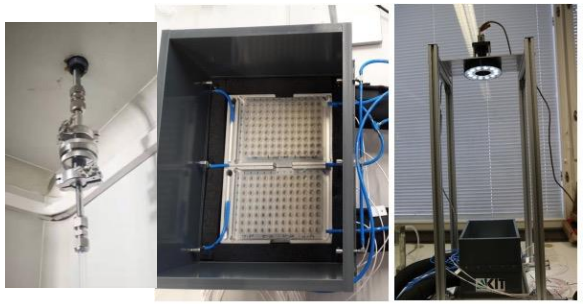
BJ – Bigg mixing chamber

a)

b)



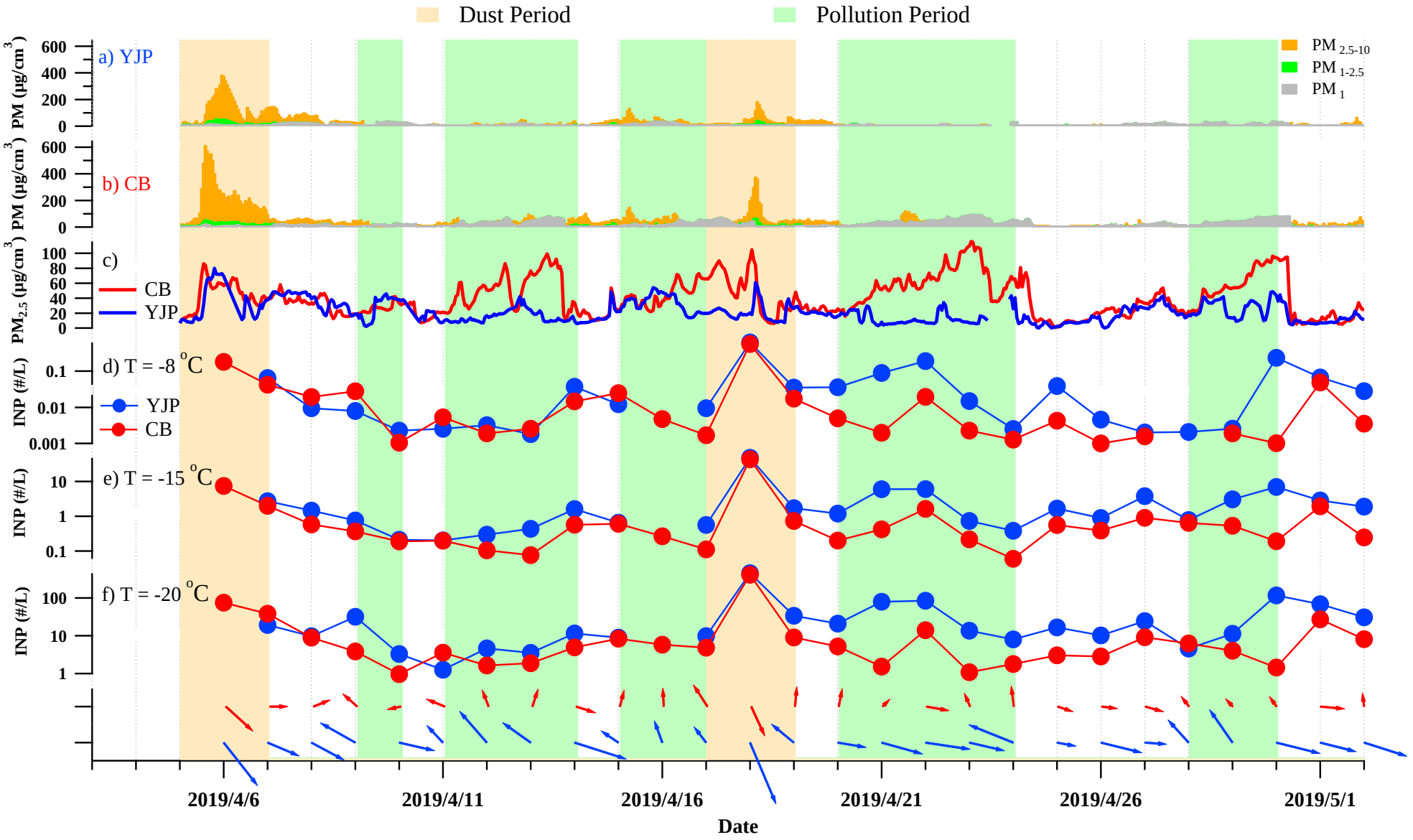
CFDC-IAS



KIT - INSEKT

The spatial distribution of INPs in Beijing

Spring season



Red line : Urban polluted site

Blue line : Clean mountain site

Though the aerosol loading of urban polluted sites was higher, but the **INP concentration of clean mountain site was higher**

The comparison of the INPs between mountain and urban site in Beijing

air comes from the **same sources**

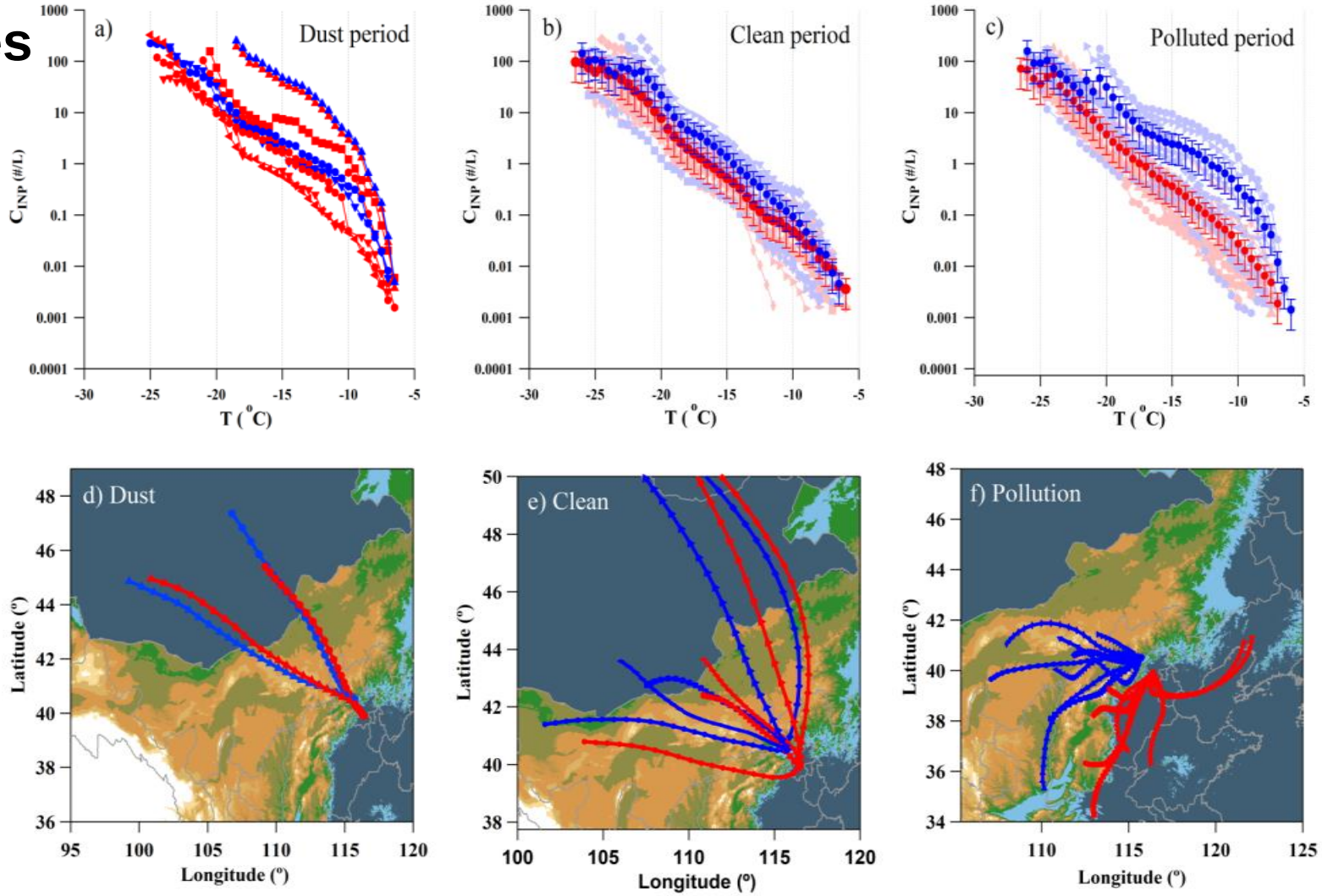
Dust and Clean period

→ **Similar INP temperature spectra** and INP concentrations at YJP and CB sites

under a stable weather system

Polluted period

→ Higher INP was found at Mountain site



2. The comparison of the INPs between Spring and Summer

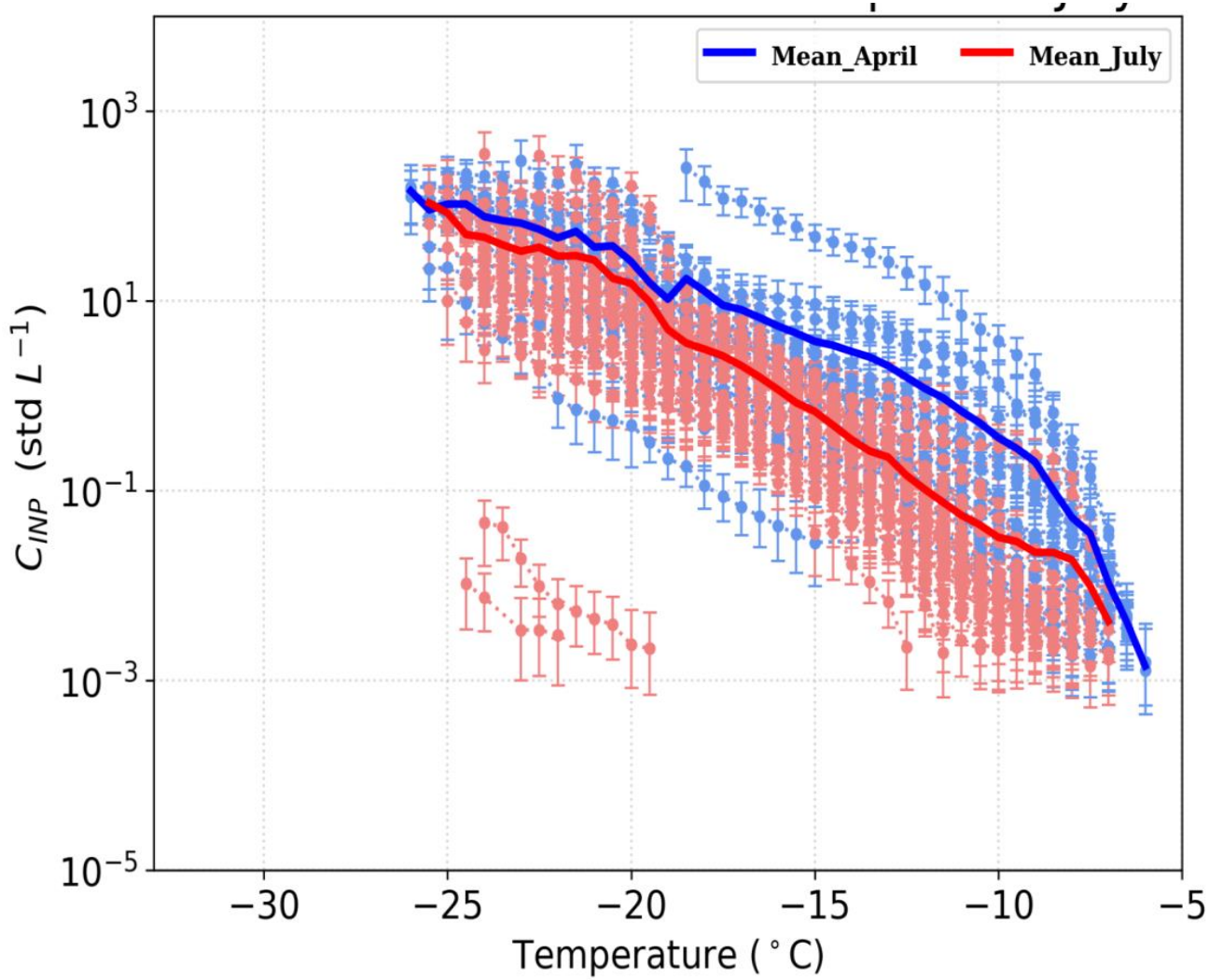
Mountain

INPs concentration:

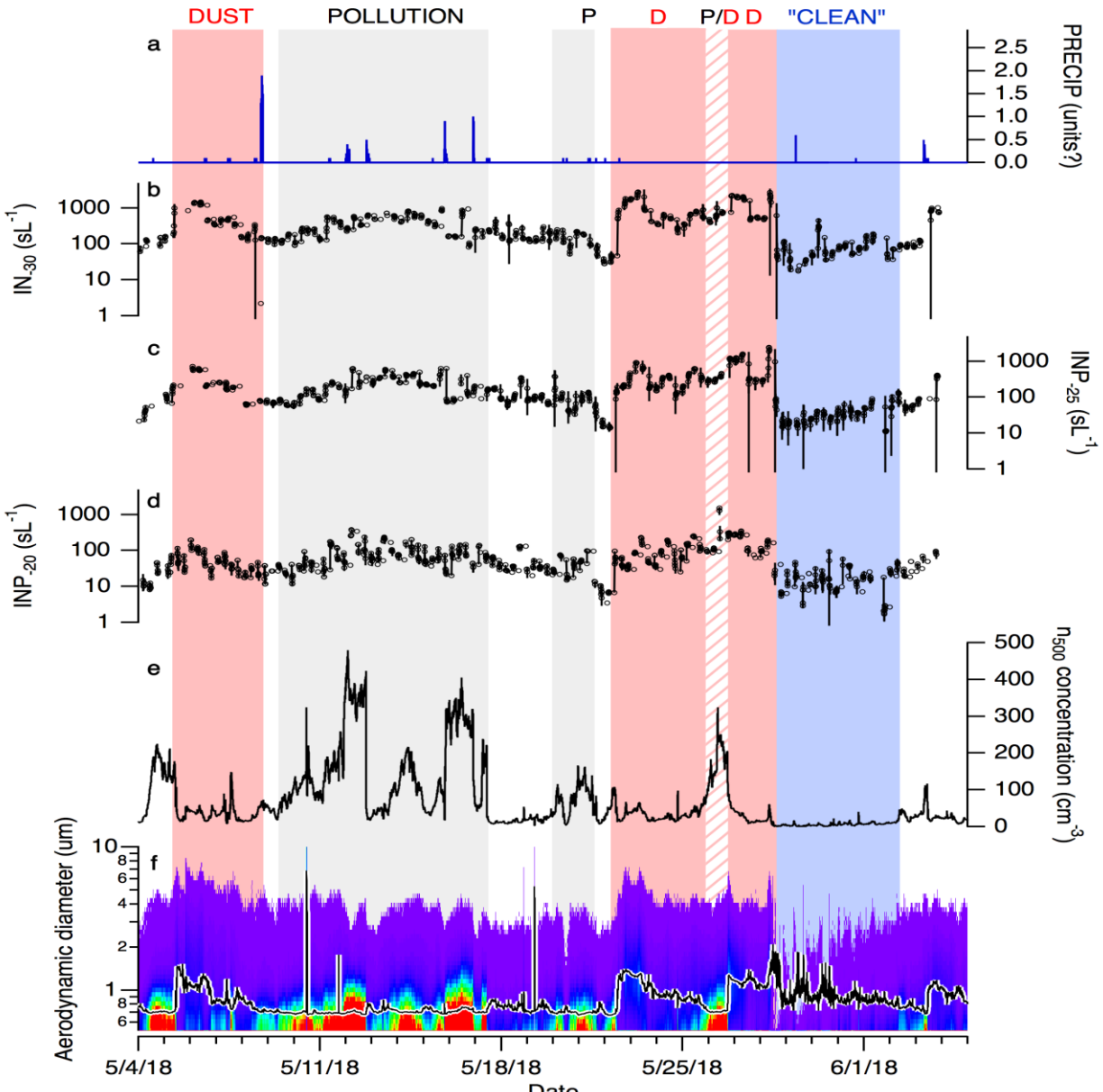
Spring > Summer

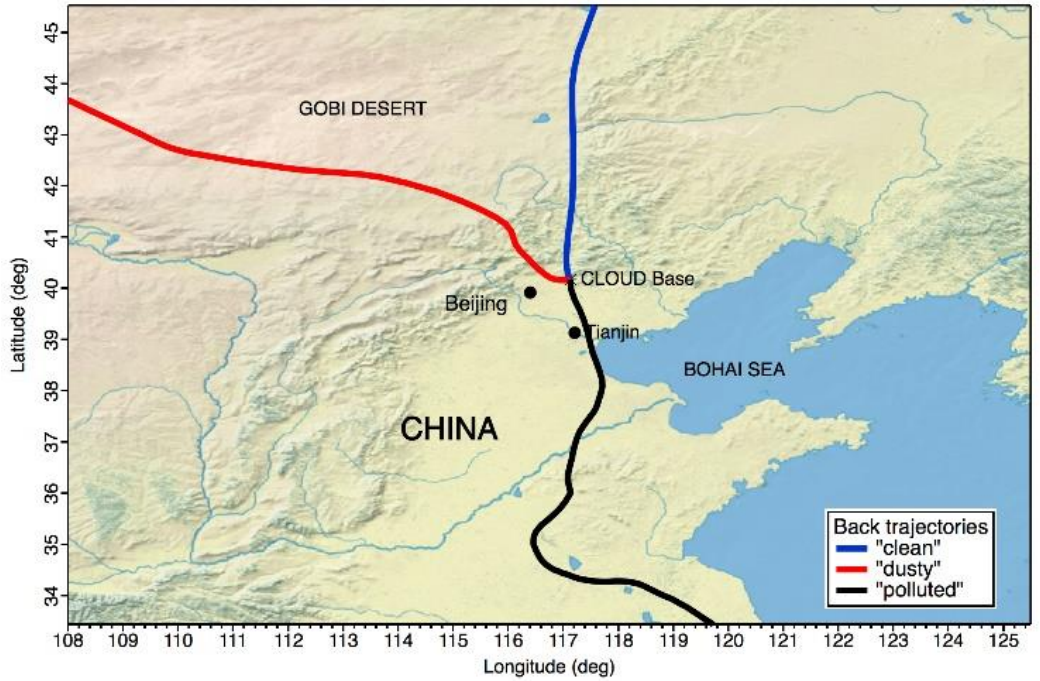
Especially -17℃~-6 ℃

INPs exist at higher temperatures in spring than in summer



First CFDC measurement in North China Plain

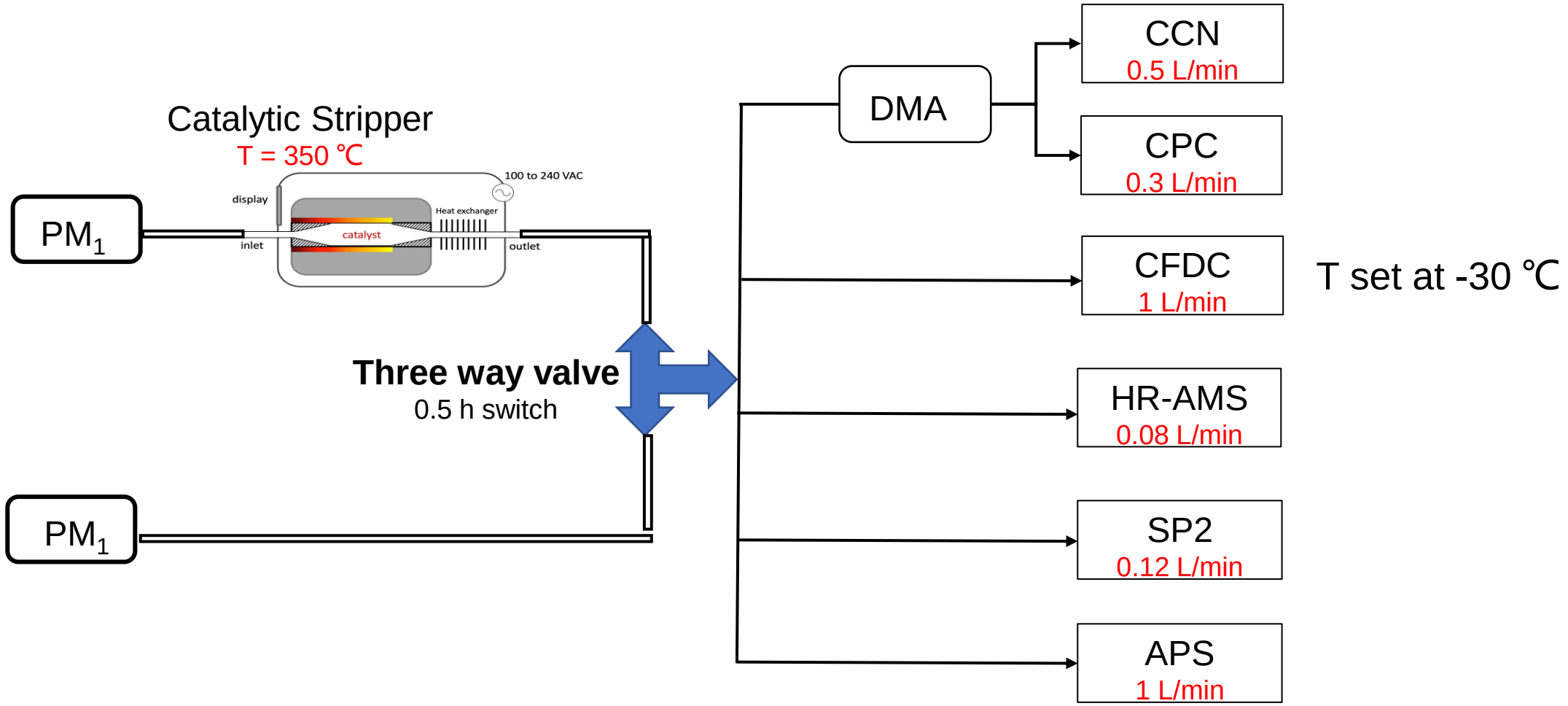




1. During periods dominated by the dust transport pathway, INP_{-25} and INP_{-30} concentrations increased sharply and were strongly correlated with super-micron aerosol concentrations.

2. There is no clear relationship between the anthropogenic pollution and INPs.

First CFDC measurement in North China Plain



The ambient aerosol was separated into :

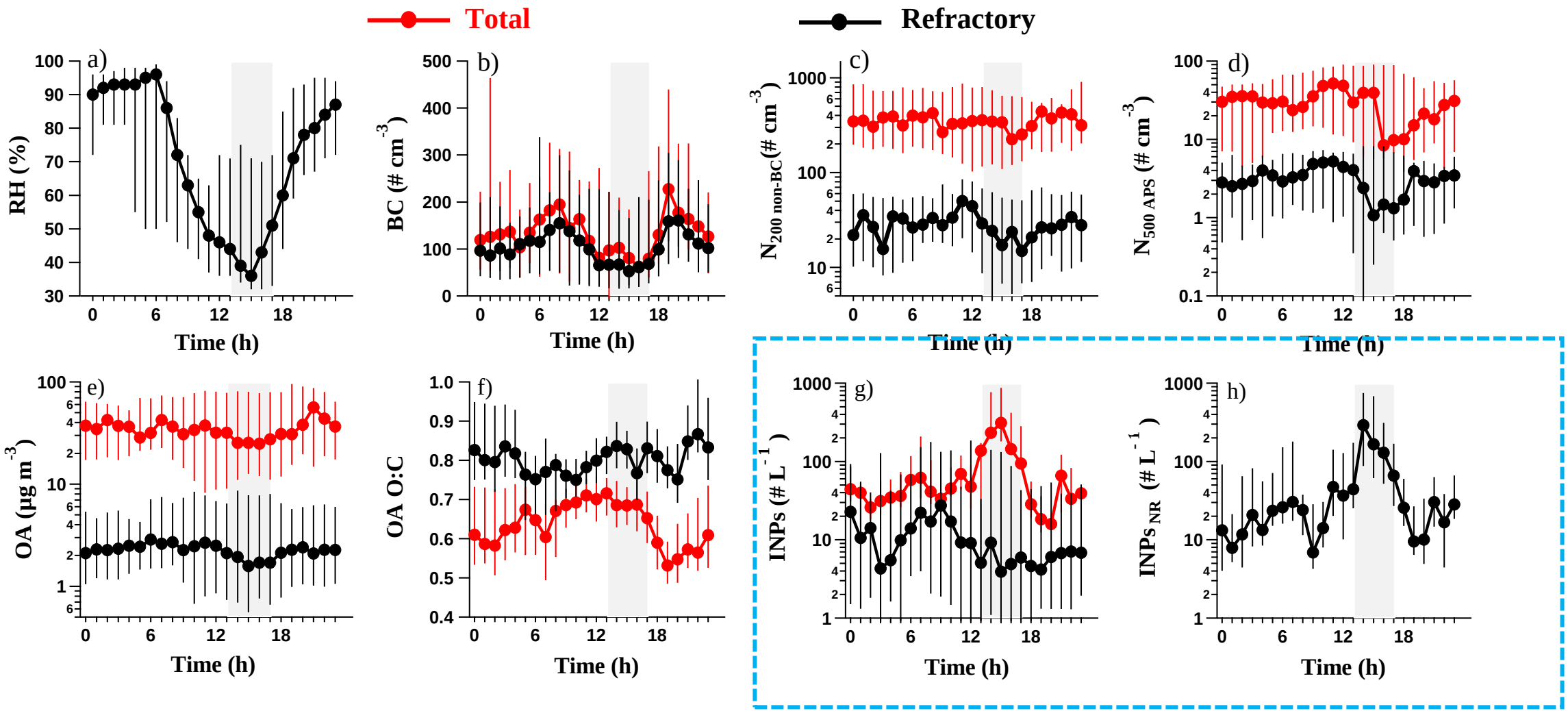
(1) 350 ℃ Refractory :

BC, Mineral, and OC

(2) Semi volatile :

OC and Biological

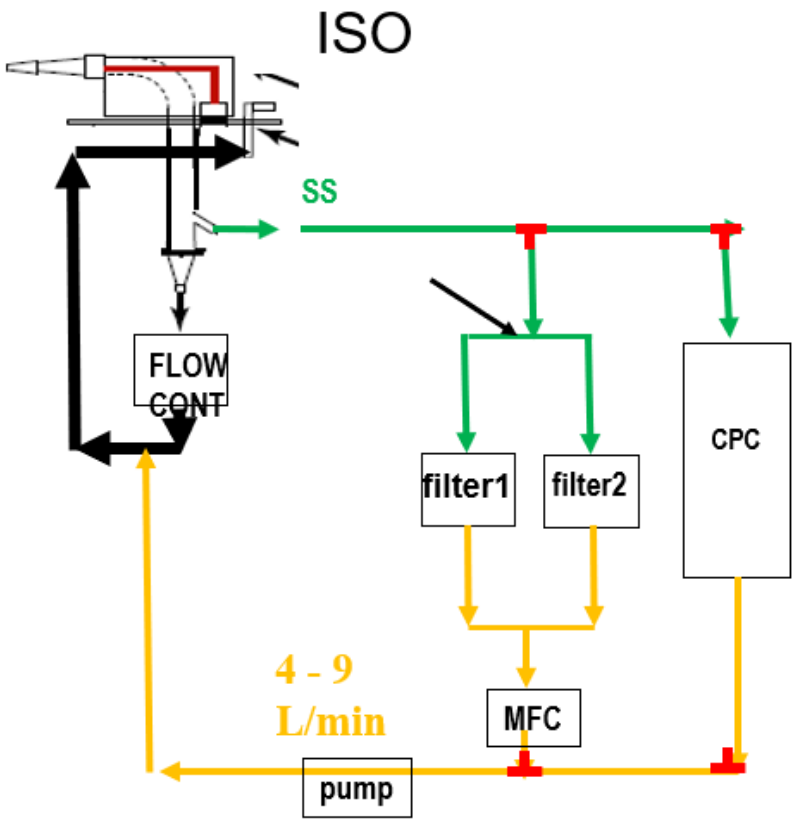
Diurnal variation of the INP and aerosol



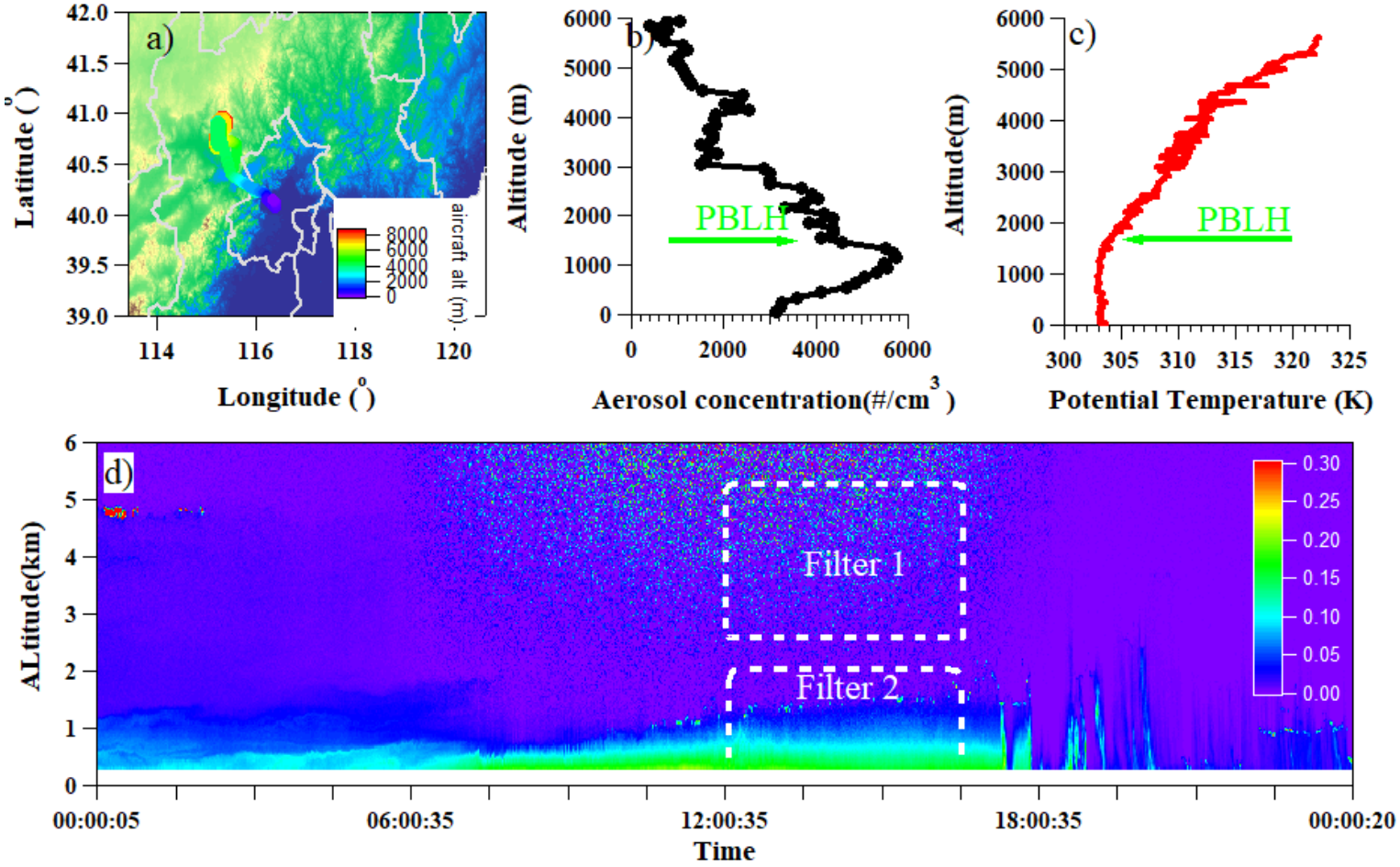
Higher non-refractory INP concentration was found at noon when the RH was lowest and photochemistry SOA form

The vertical distribution of INPs over Beijing

aircraft filter sampling

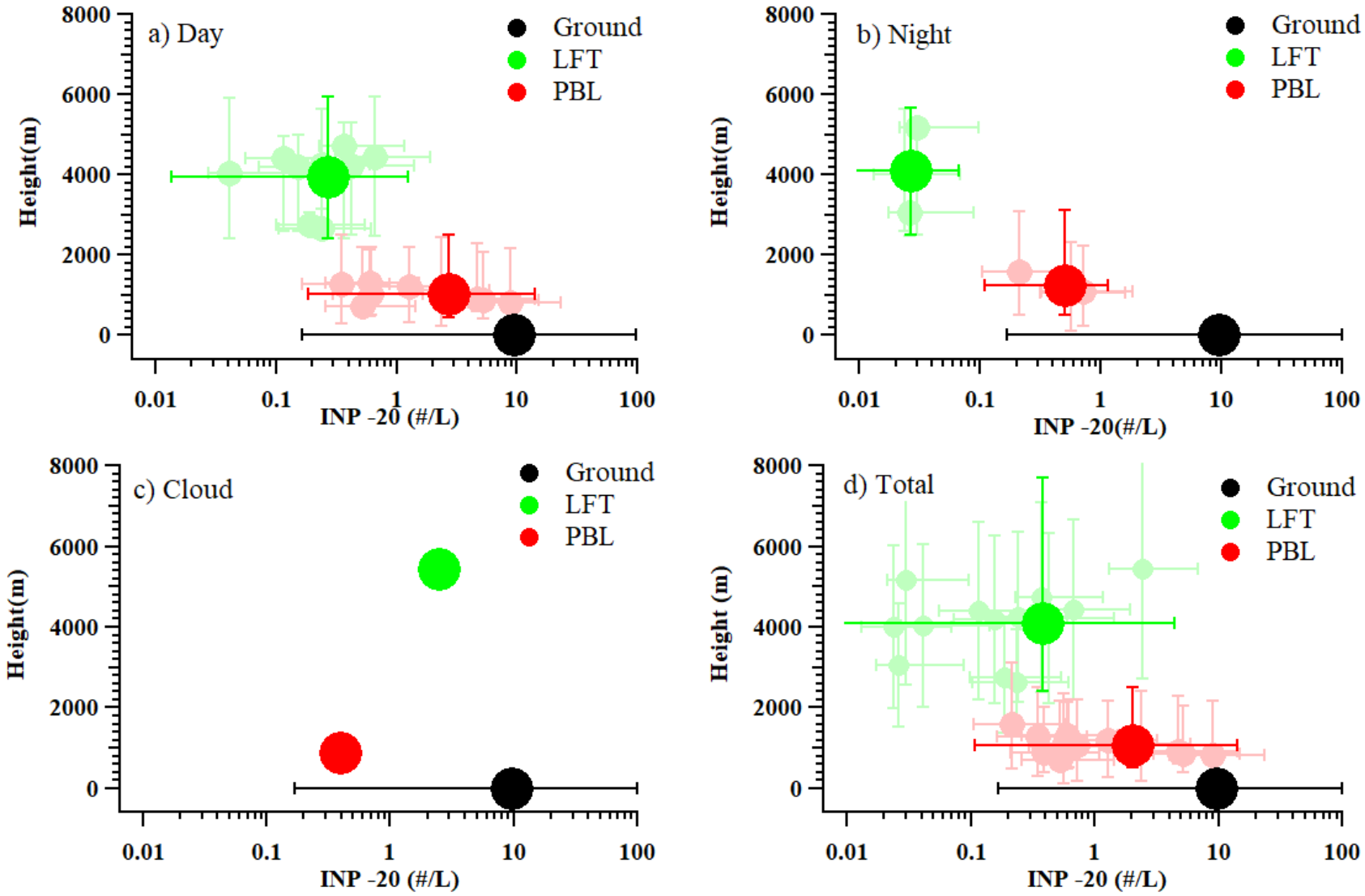


determine the PBLH



filters was analyze at KIT using the INSEKT

The vertical distribution of INPs over Beijing



1. The vertical distribution of the INP indicate that the near surface observation can not represent the troposphere.

2. Higher INP concentration was found at top of the cloud top.

Conclusion：

1. Warm cloud can be formed using expansion method of the BACIC.

2. The anthropogenic pollution could contribute to the INP but when the RH was lower.

3. The INP have high spatial distribution and seasonal variation, long-term INP needed.

4. The aircraft INP results show clearly the surface observation can not represent the troposphere condition.