Atmospheric Humic-Like Substances (HULIS) Act as Ice Active Entities

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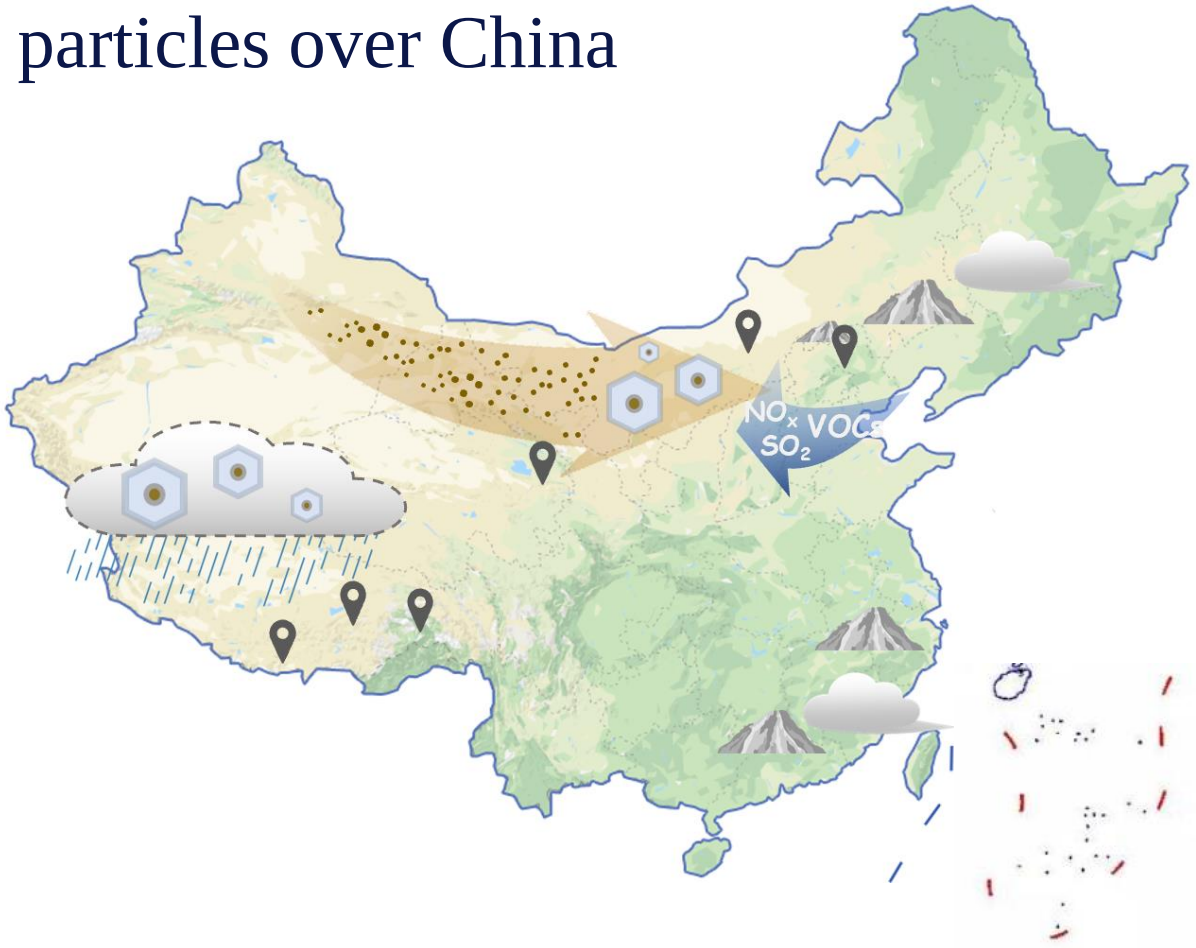
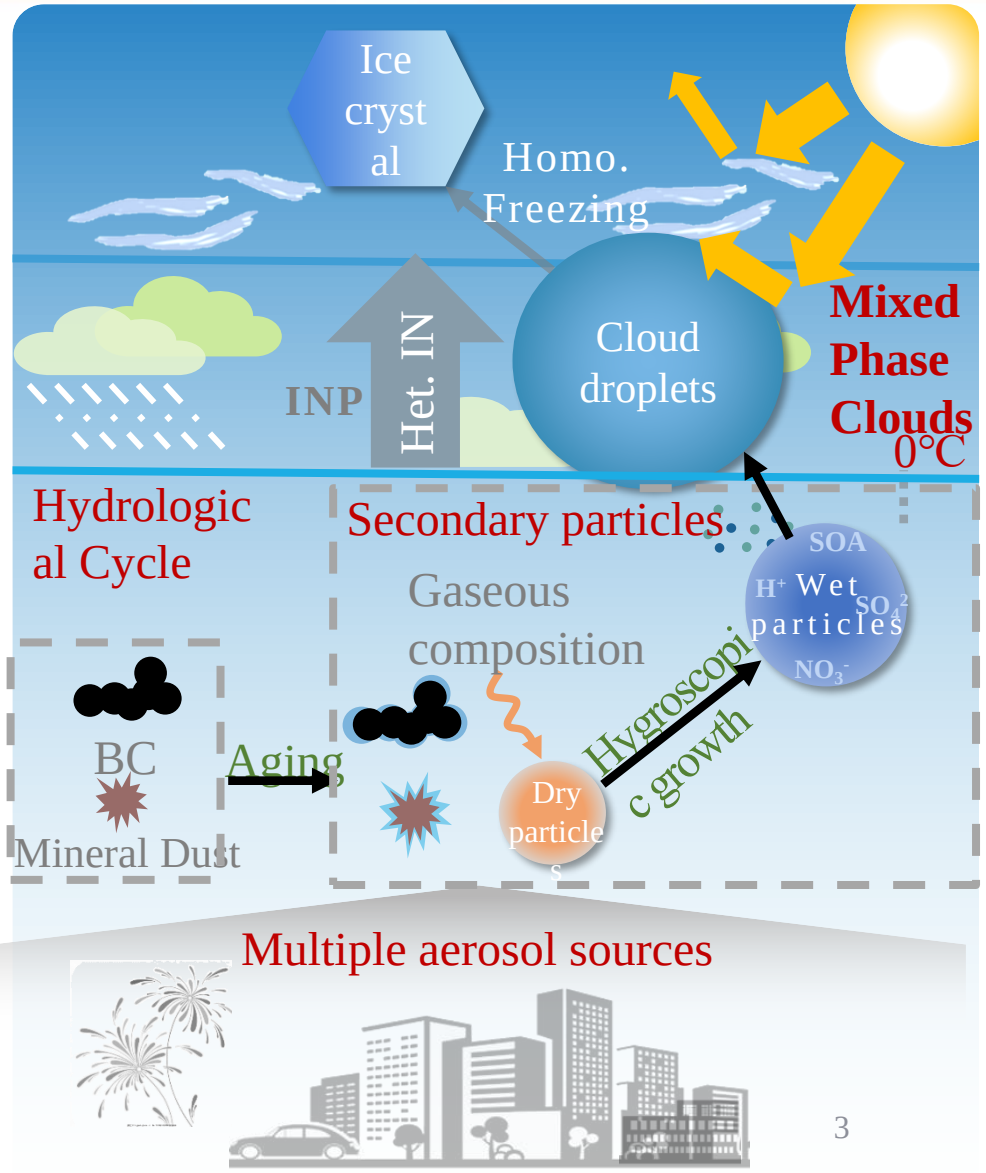
Outline

- **INP field observations in our group**
- **HULIS act as ice active entities**

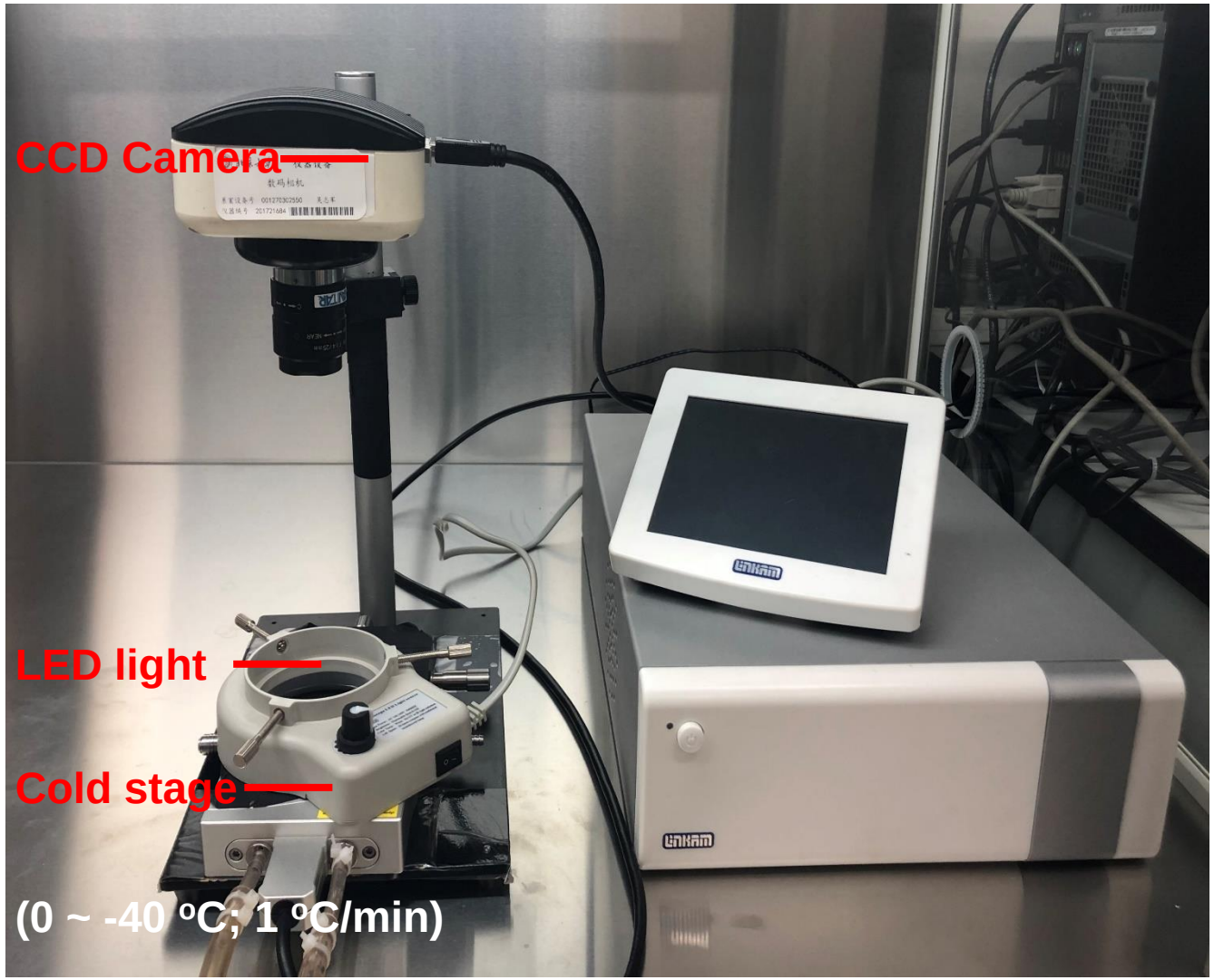
Natural particles mixed with anthropogenic-pollutants

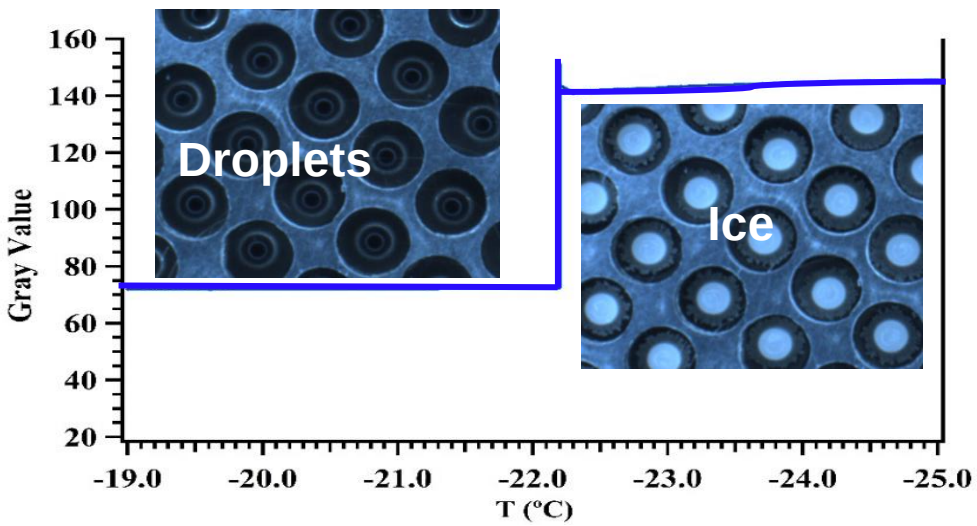
The sources and activities of ice nucleating particles over China





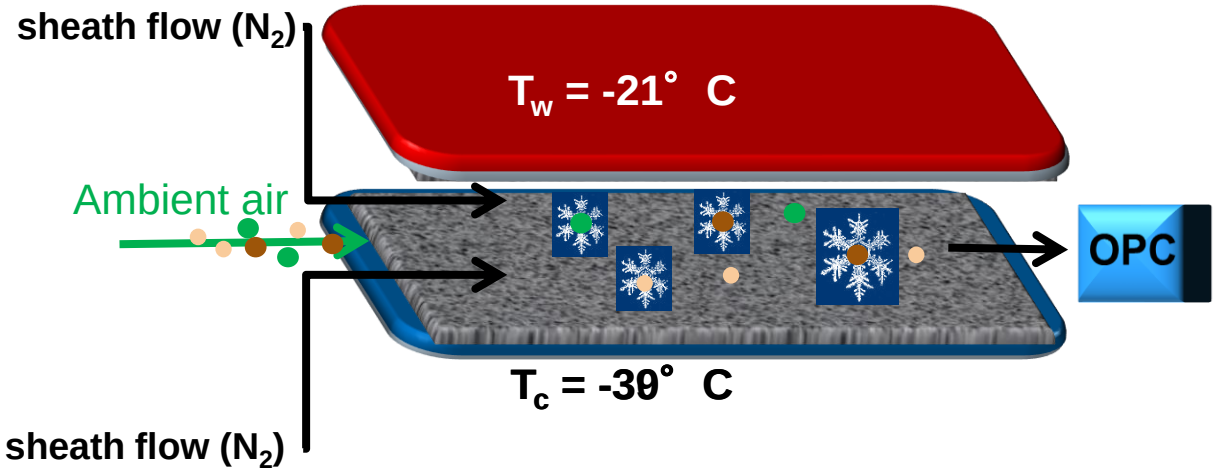
Ice Nucleation Array

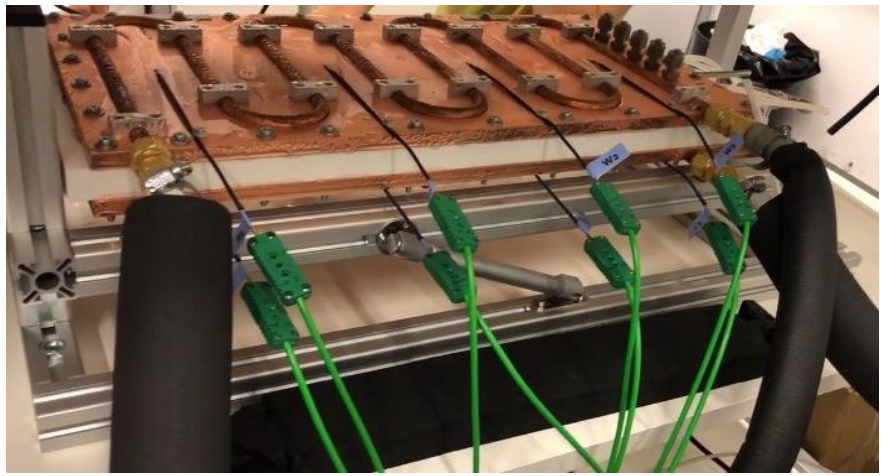




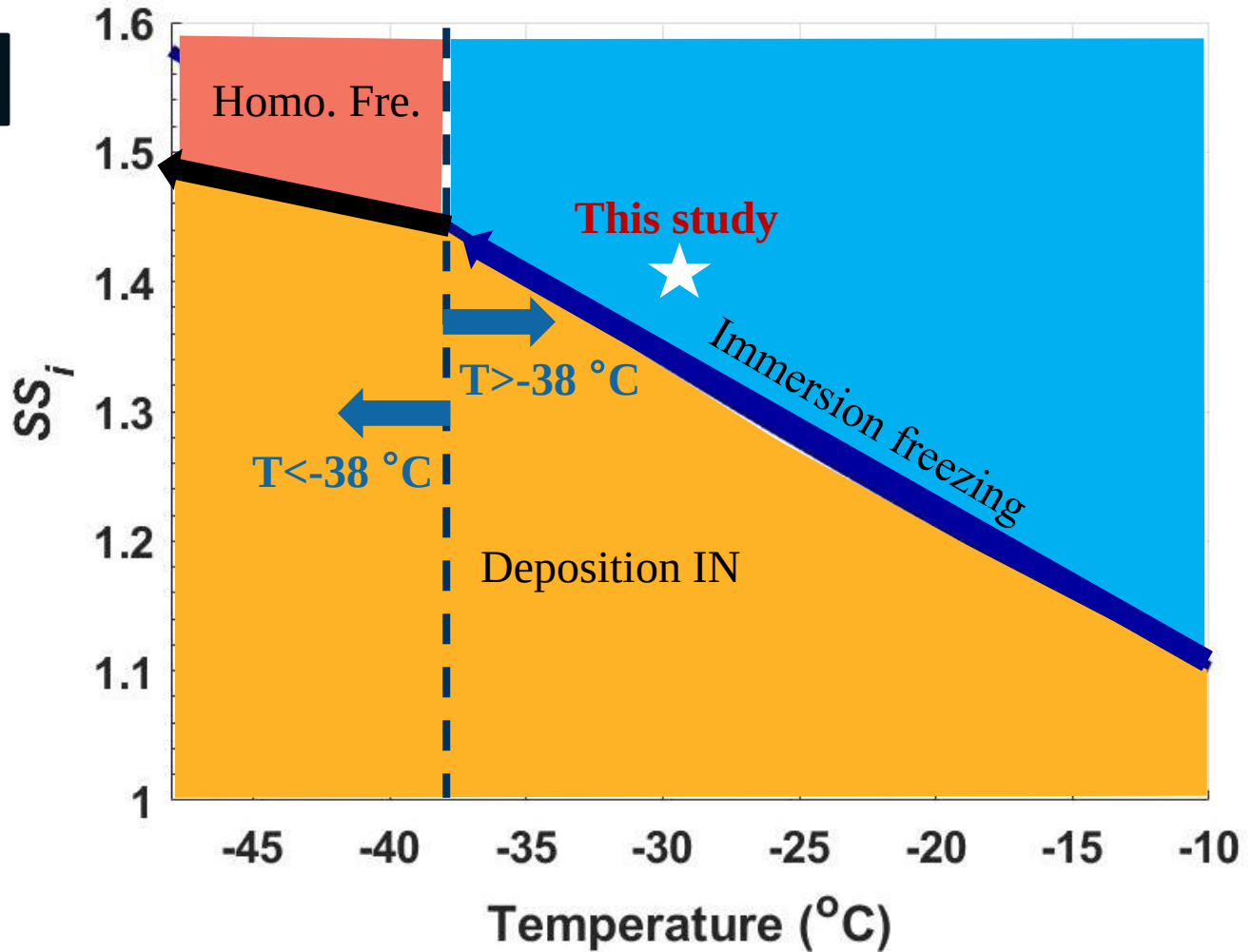
Chen et al., 2018, Atmosphere

Horizontal Ice Nucleating Chamber (HINC)

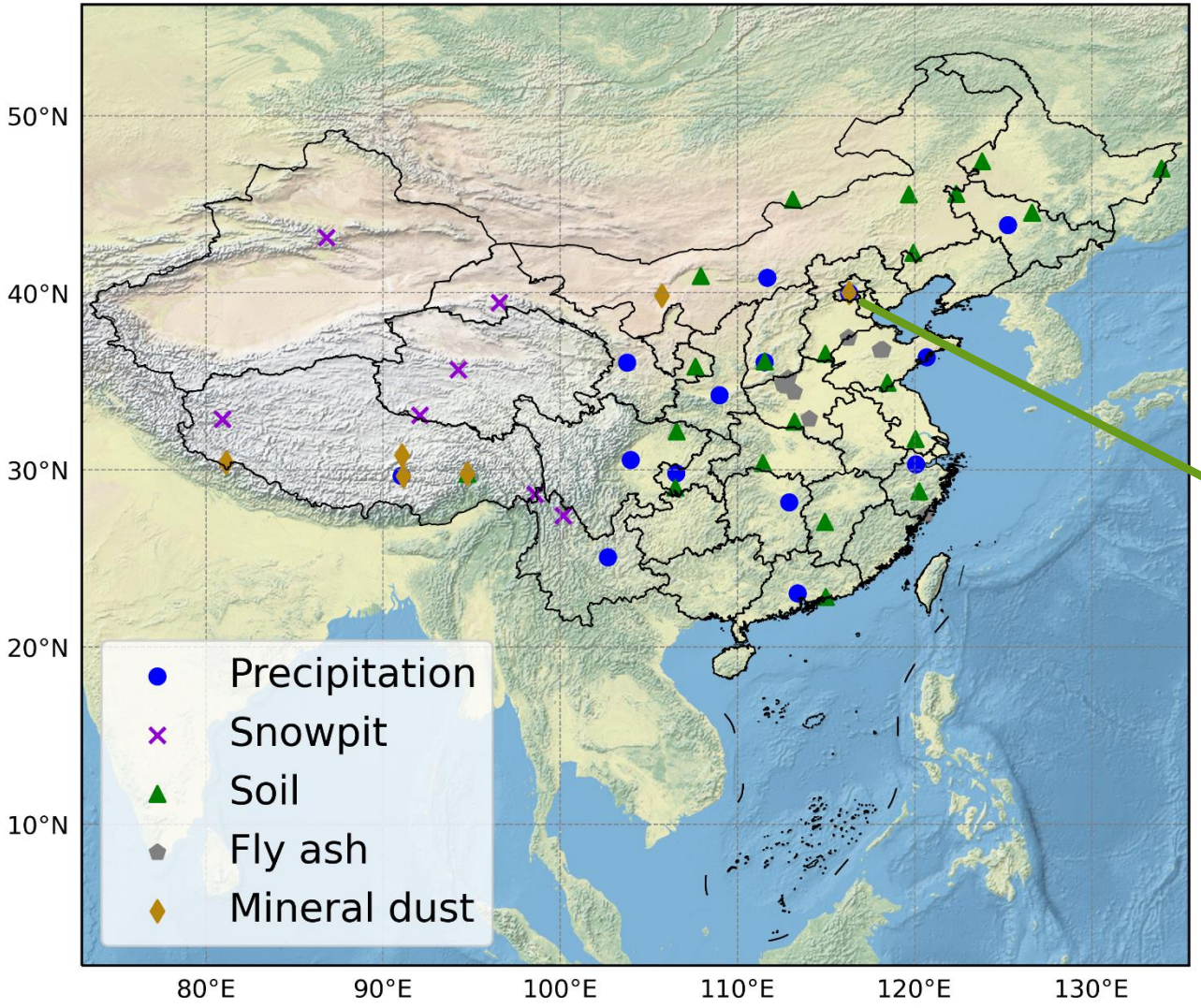




Lacher, et al., 2017, ACP

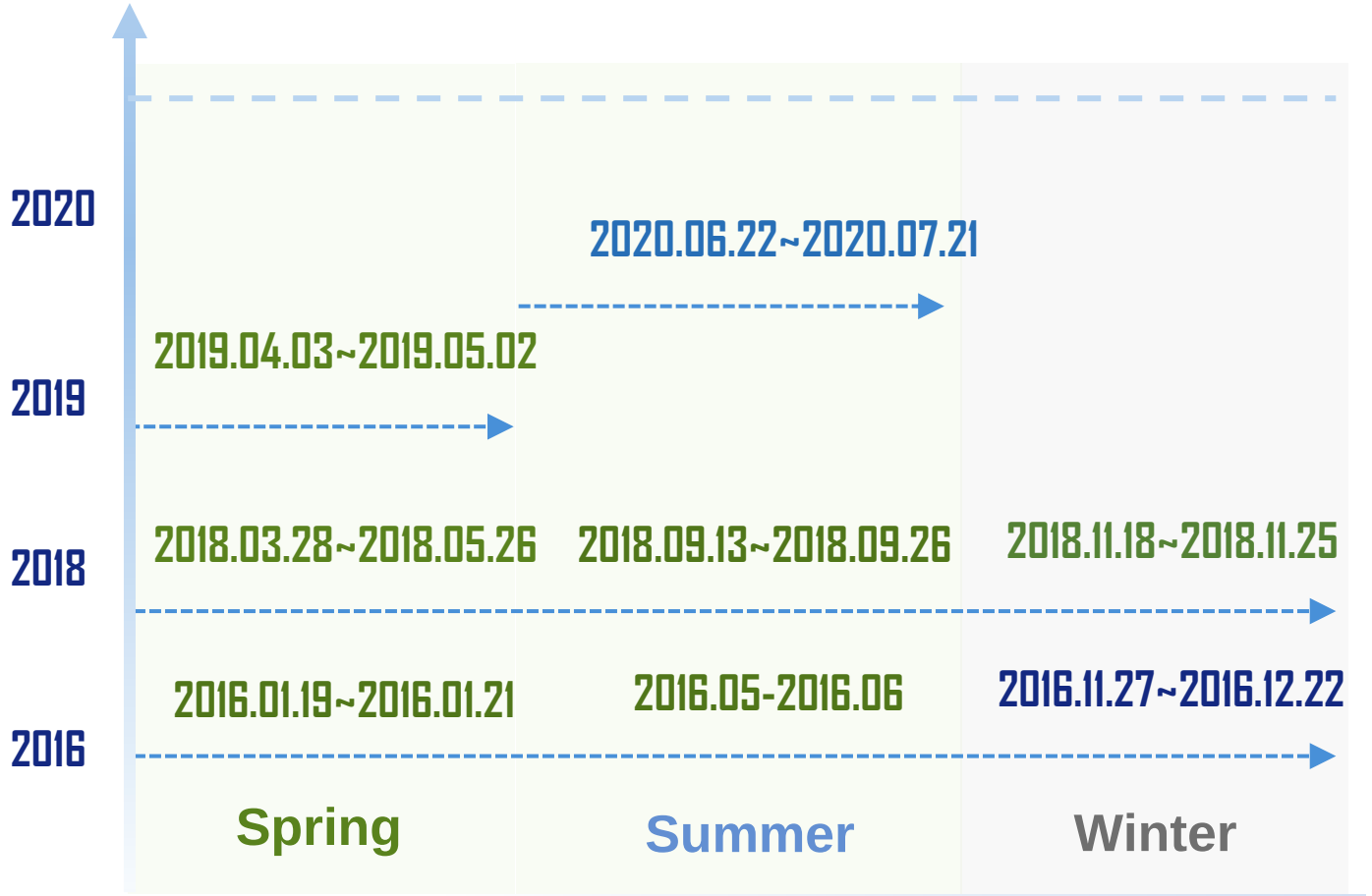


The locations for sample collection

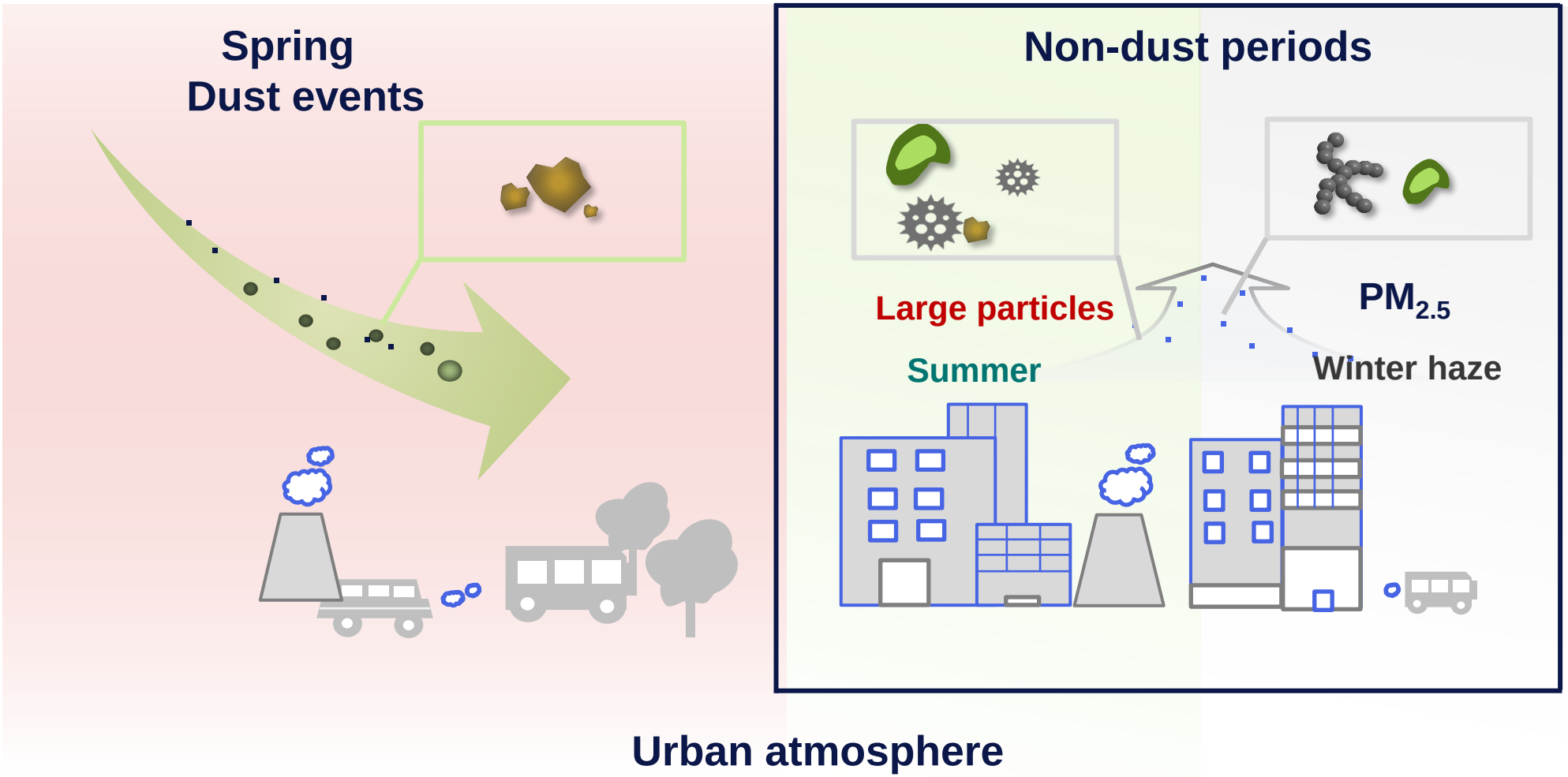


- **Urban aerosols**
- **Dust particles**
- **Agricultural soil**
- **Snowpit samples**
- **Precipitation**

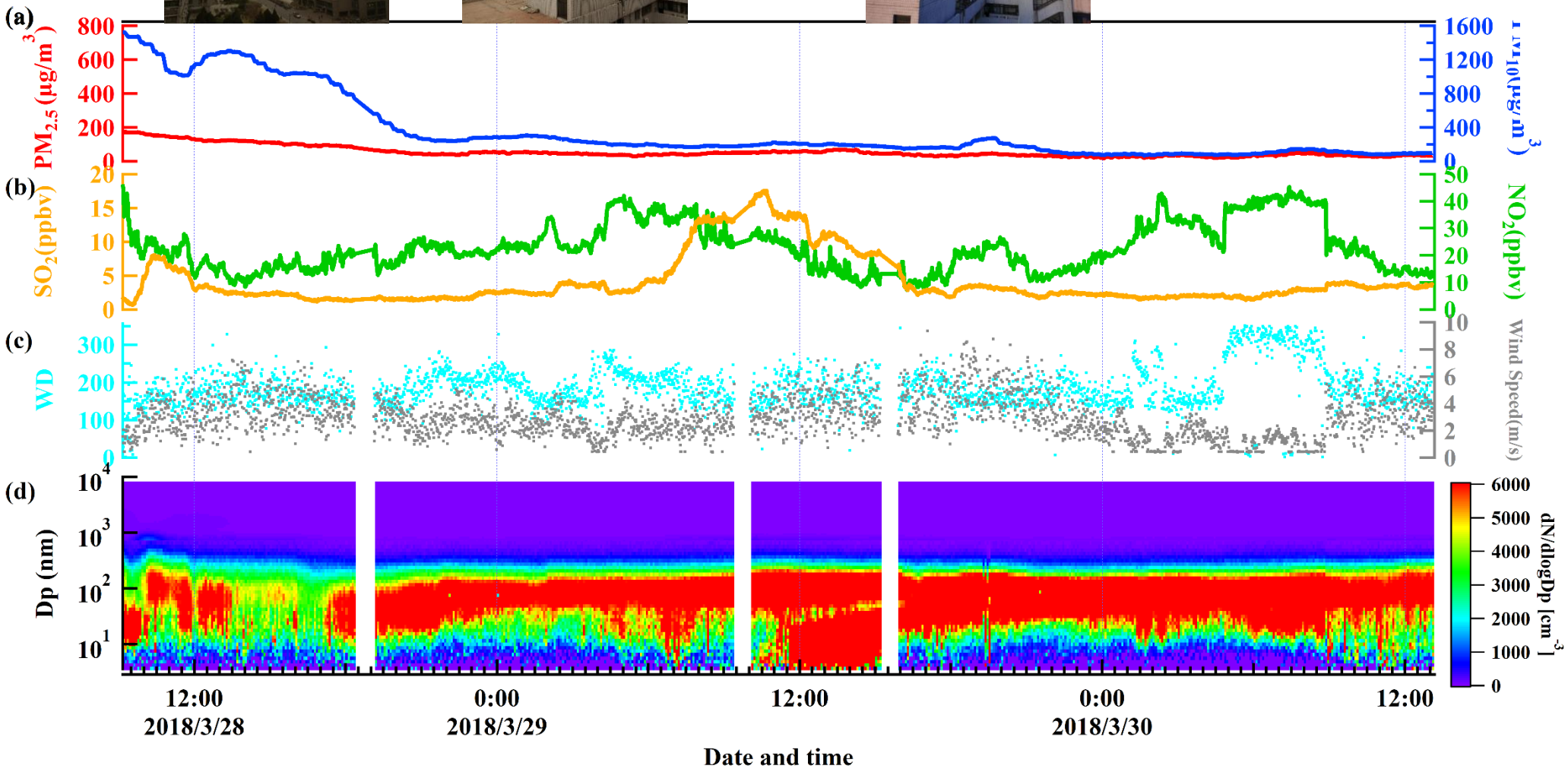
Samples collection in the urban atmosphere



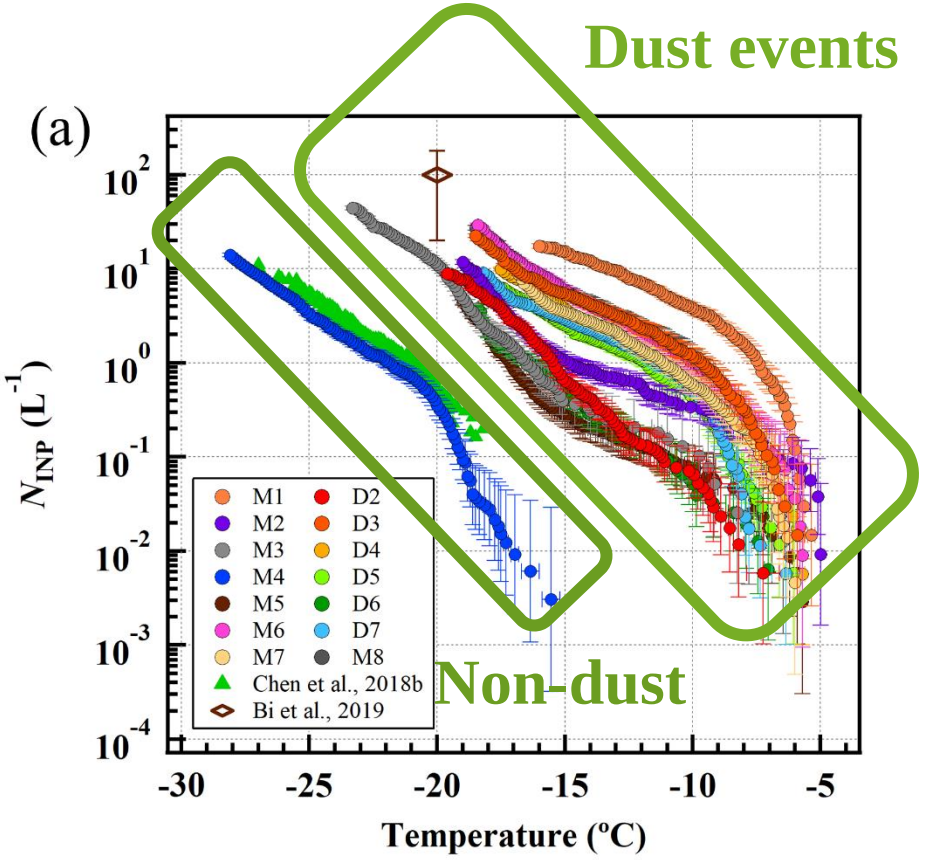
Foci in different seasons

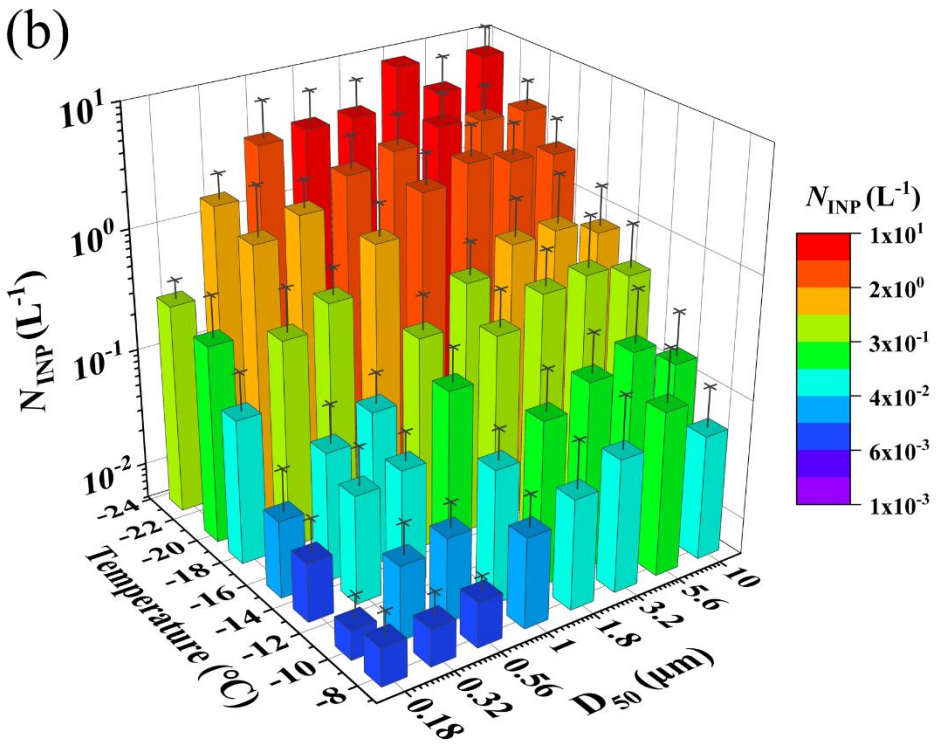


Dust events in the spring



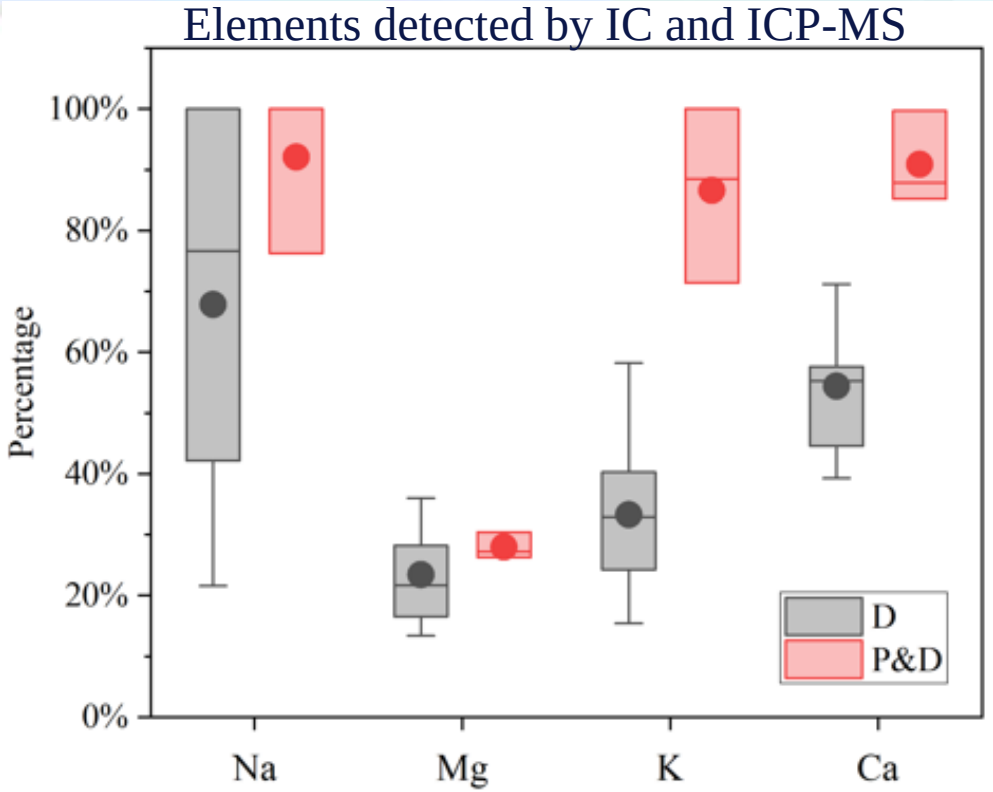
N_{INP} during dust and non-dust events

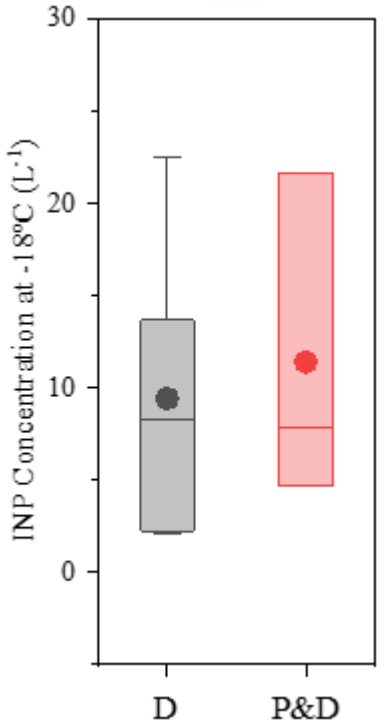


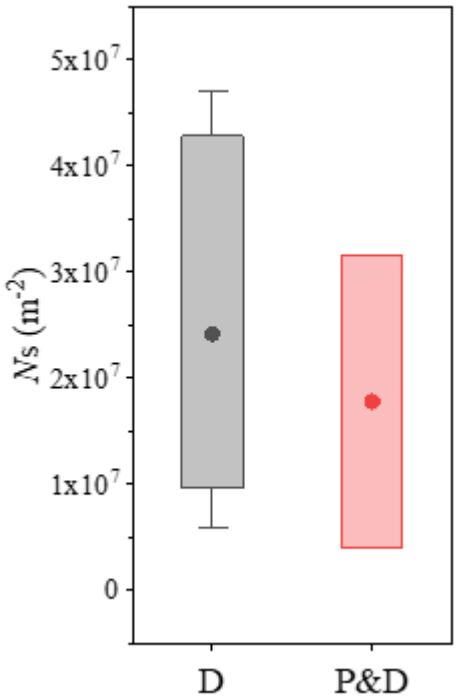


- Mineral dust particles are efficient INPs.
- N_{INP} ranged from 10^{-2} to 10^{2} L^{-1} at temperatures between -5 and -25 °C.
- Temperature- and size-dependence of N_{INP} was observed.

Comparisons between aged and non-aged dust particles





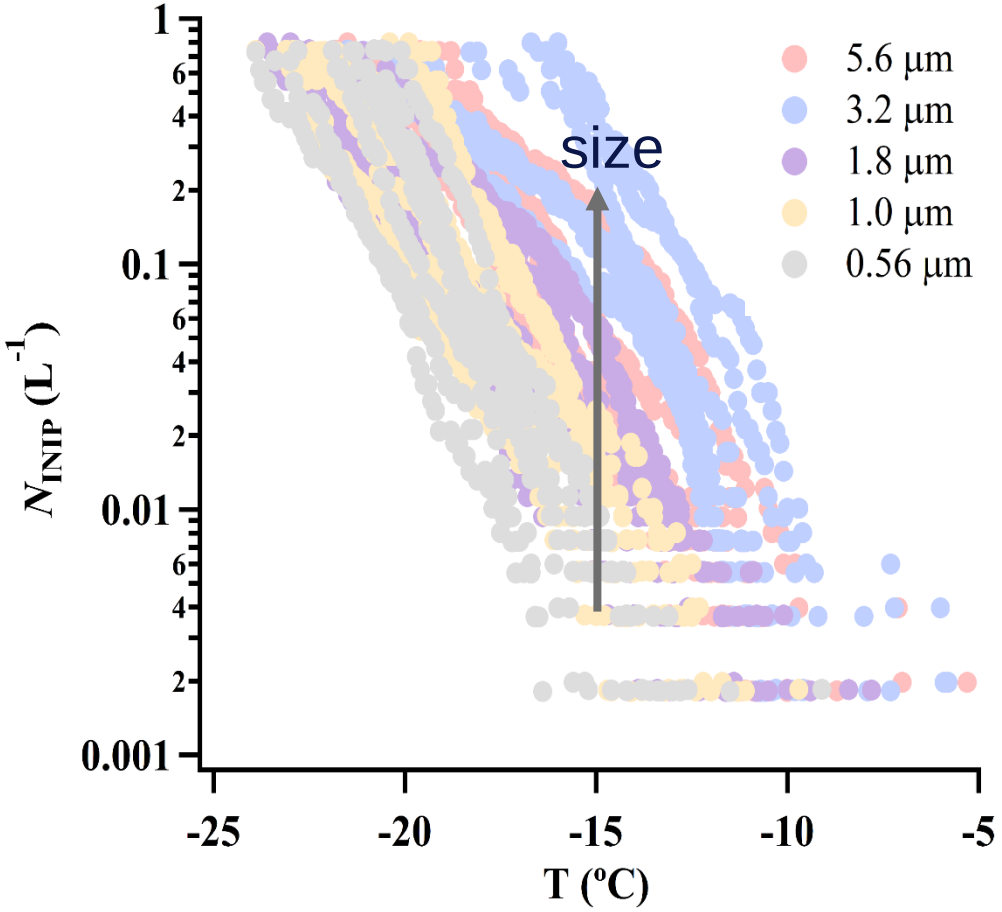


	Sample	mean	median	std
Ns	D	2.41E+7	1.82E+7	1.82E+7
Ns	P&D	1.78E+7	1.78E+7	1.78E+7
N_{INP}	D	9.42	8.32	8.32
N_{INP}	P&D	11.4	7.87	7.87

D: dust particles
P & D: Polluted and dust

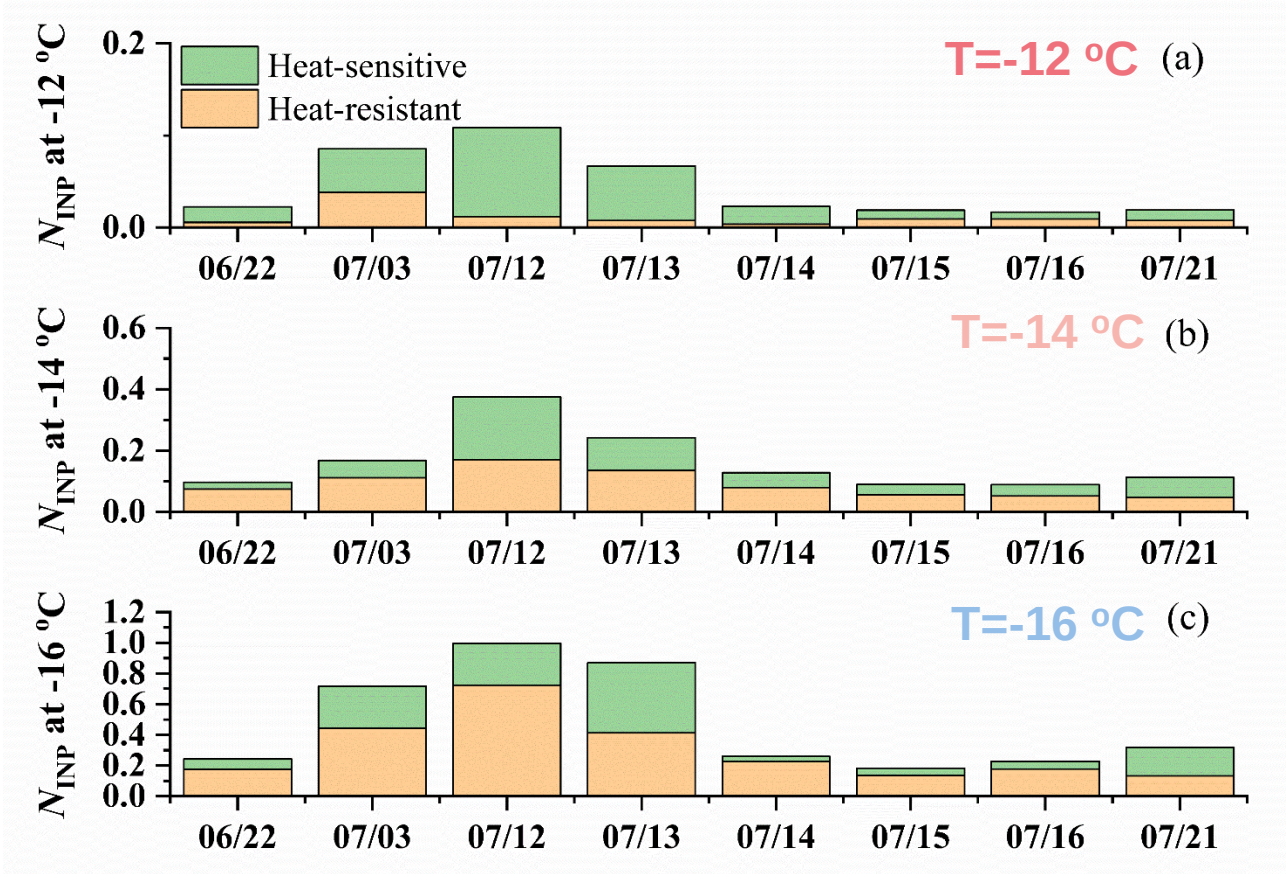
Chen et al., 2021, ACP

INPs during summertime



Large particles (>1 μm) contribute 90% of the N_{INP}

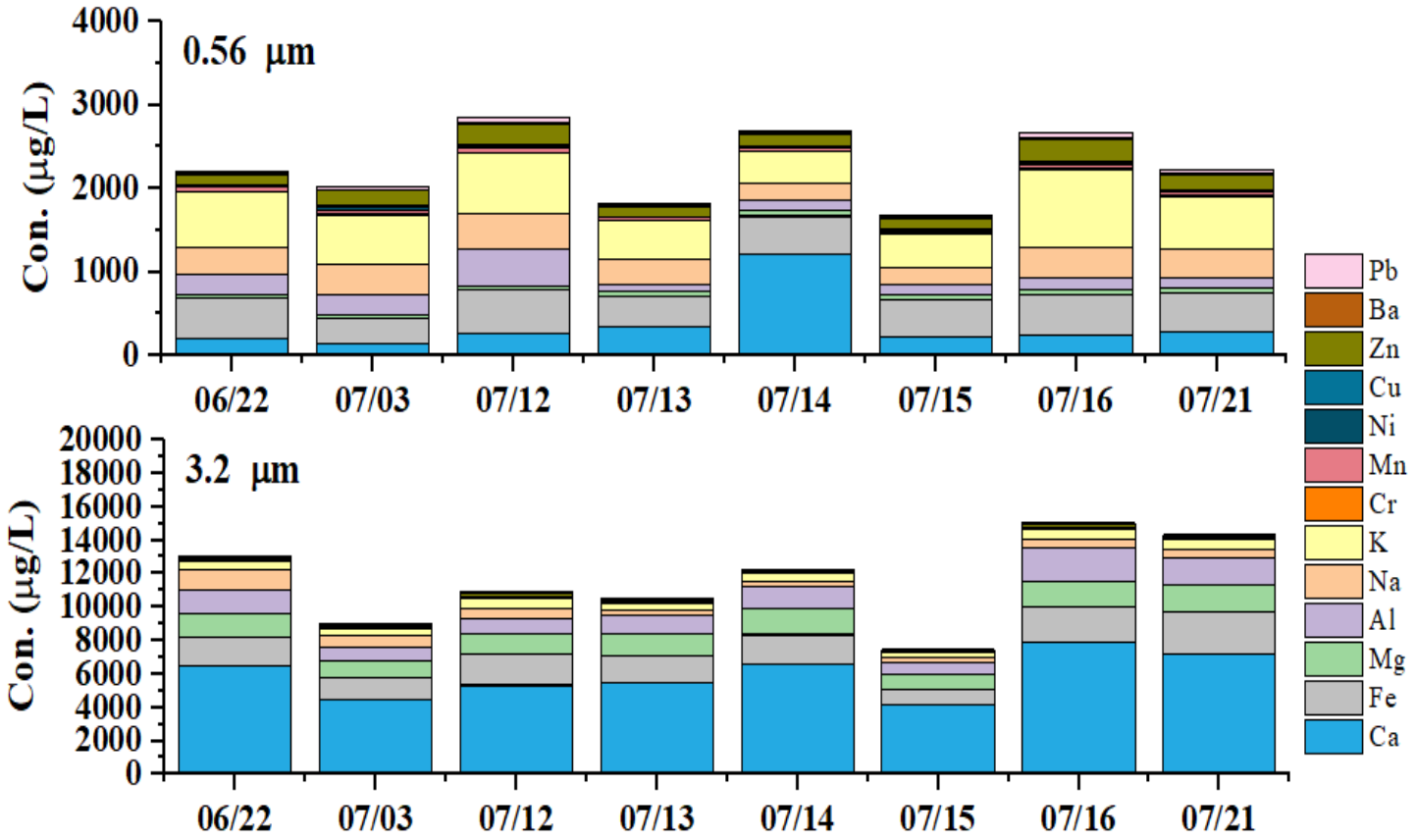
Heating samples to test biological proteinaceous INPs



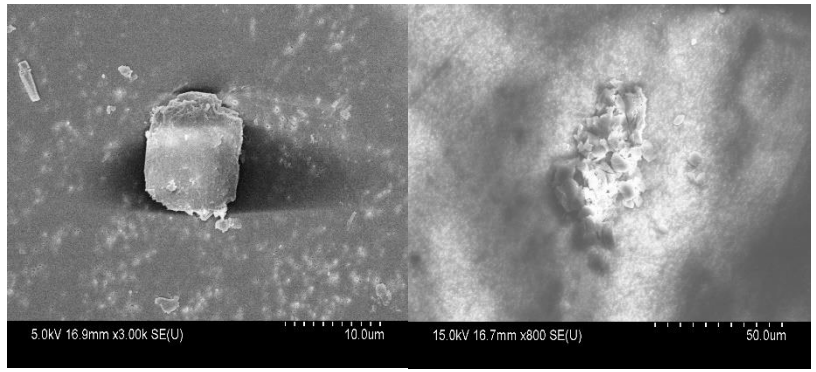
T>-15 °C, biological INPs contribute more than 70% of N_{INP}

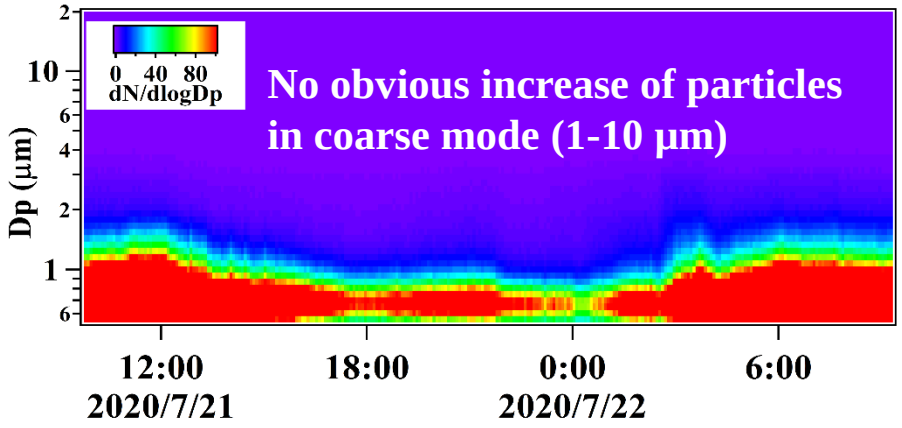
Anthropogenic dust: potential source of INPs

High content of crustal element in large particles (Ca, Al, Fe, Mg)

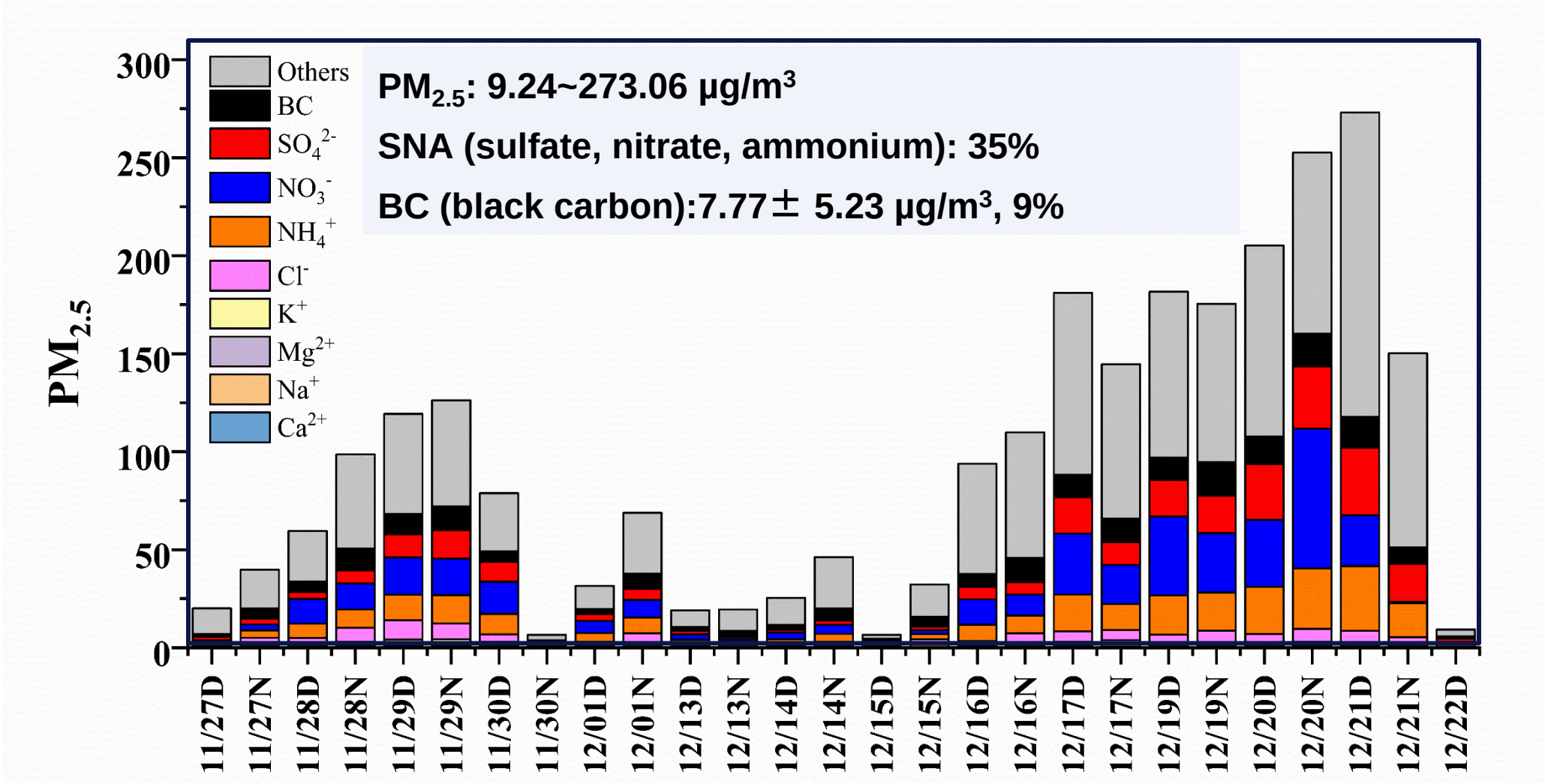


Presence of dust in collected samples

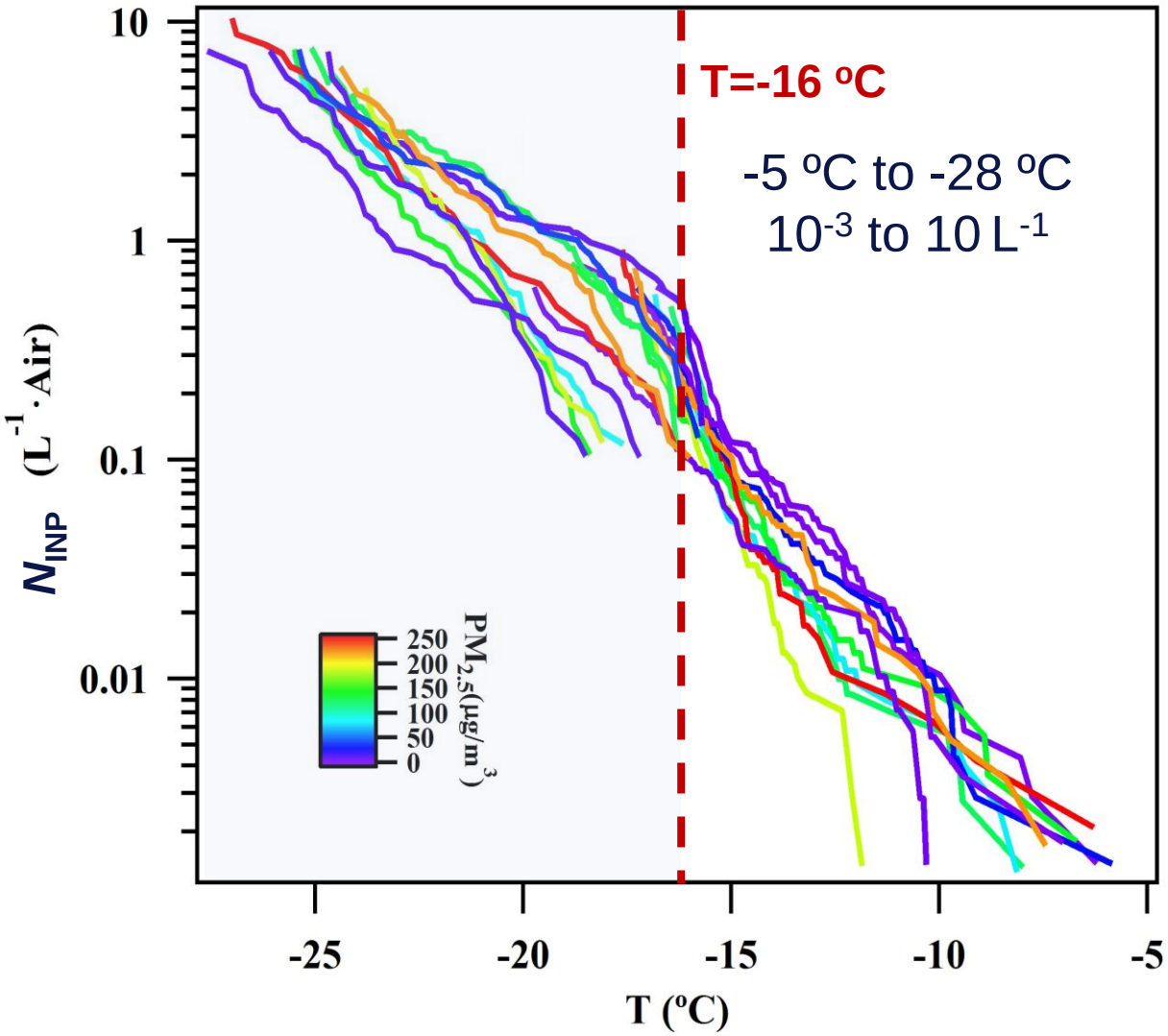


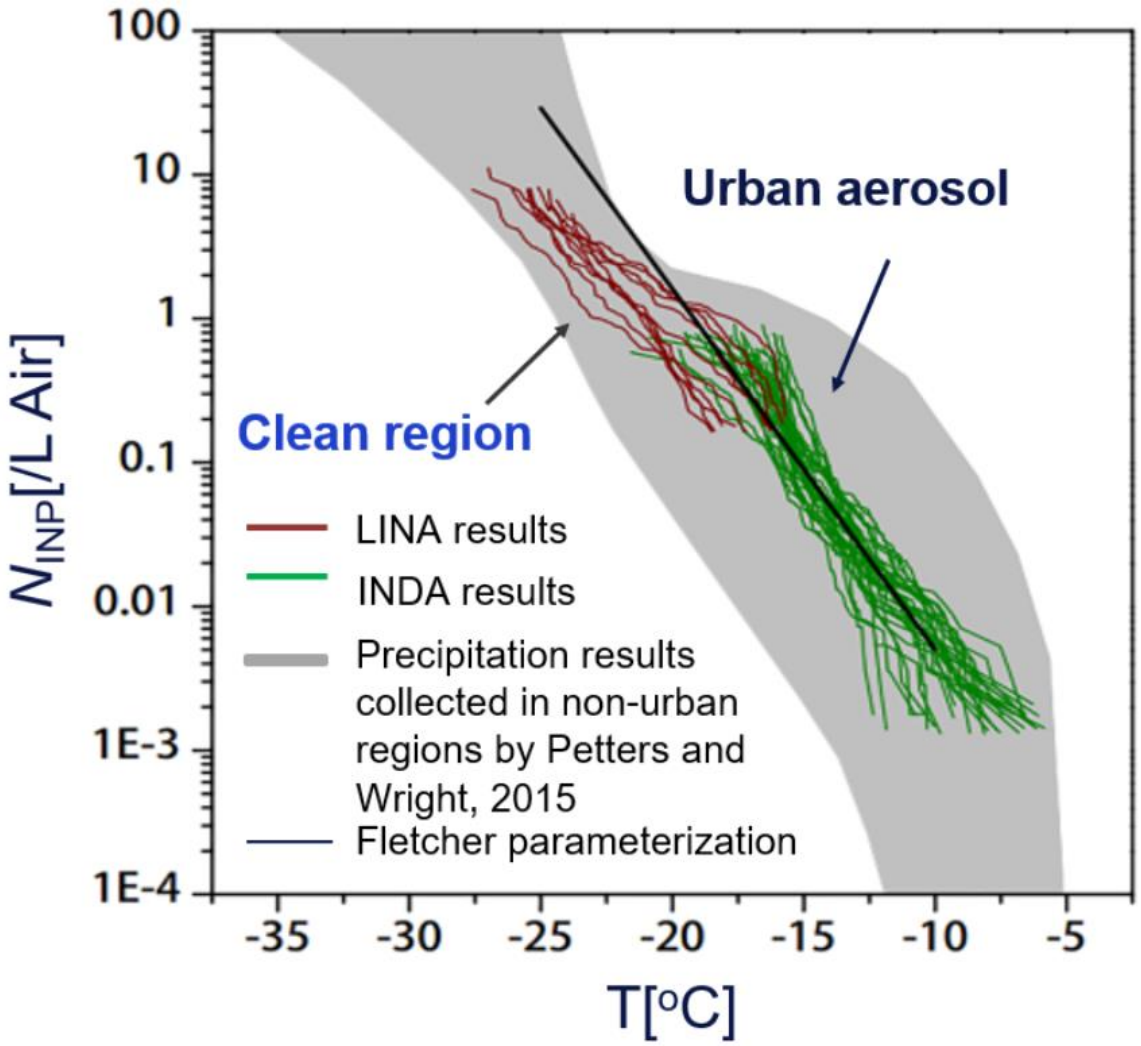


INPs during wintertime



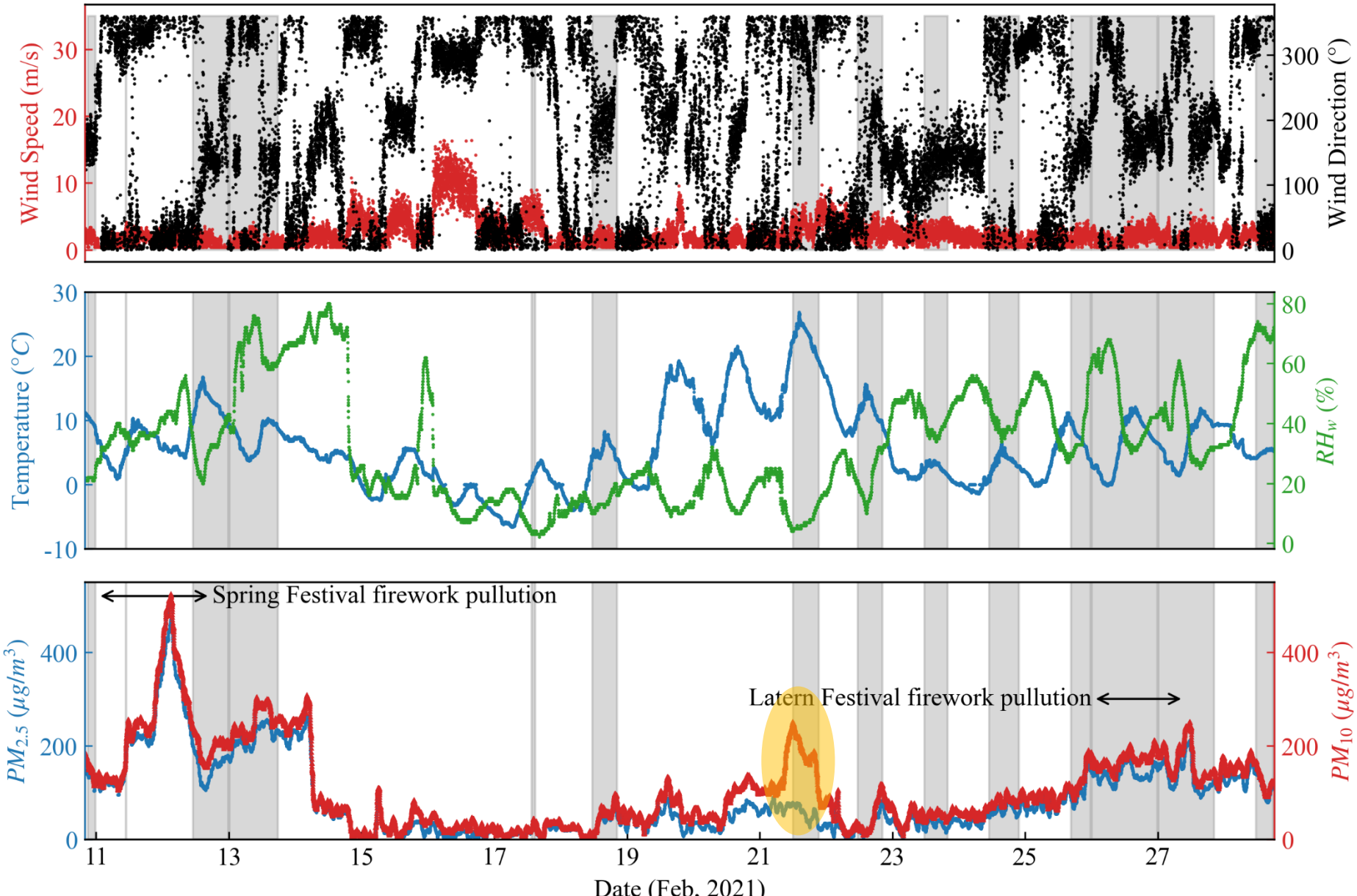
Comparable N_{INP} with results in clean region



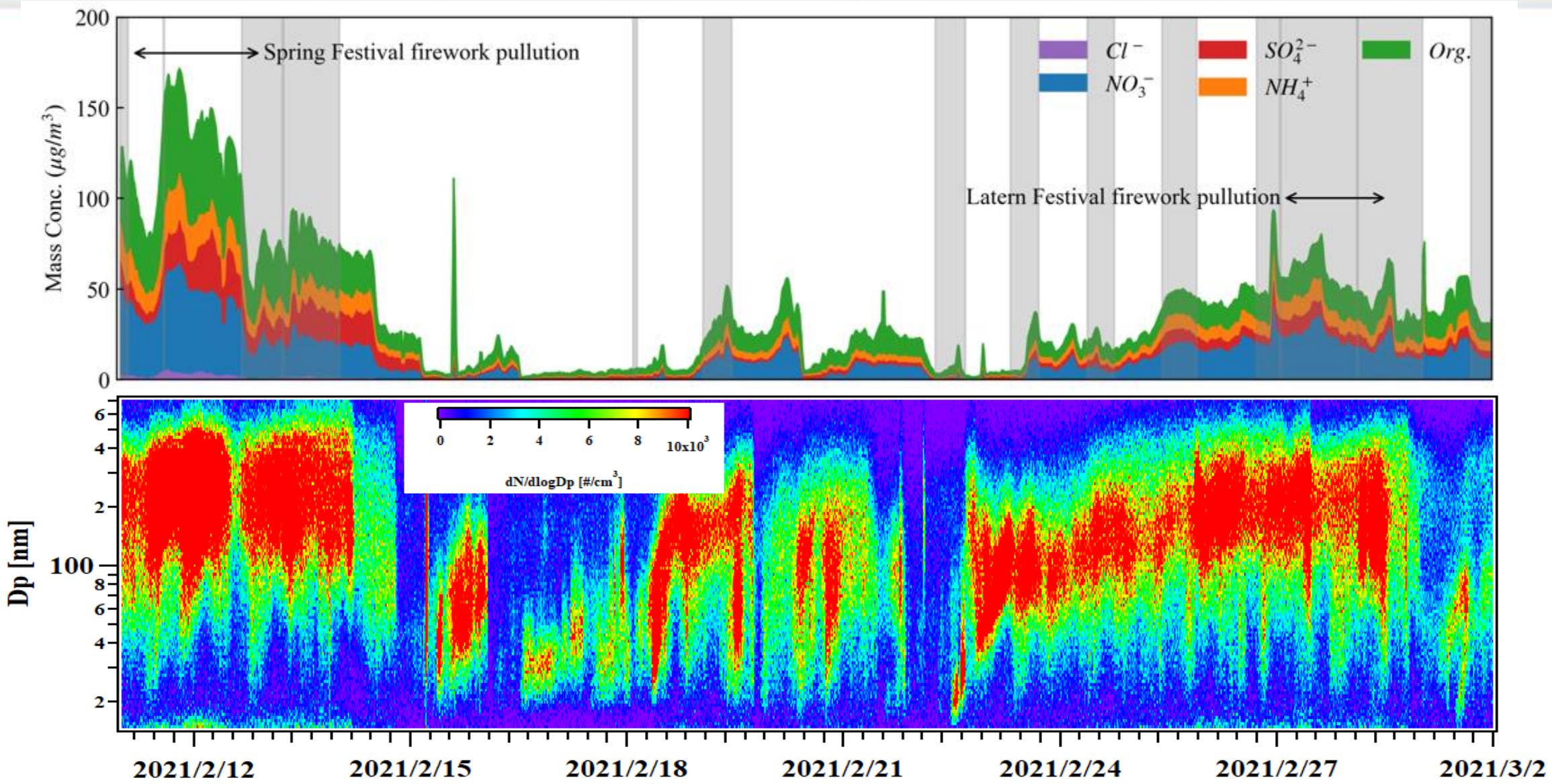


Chen et al., 2018, ACP

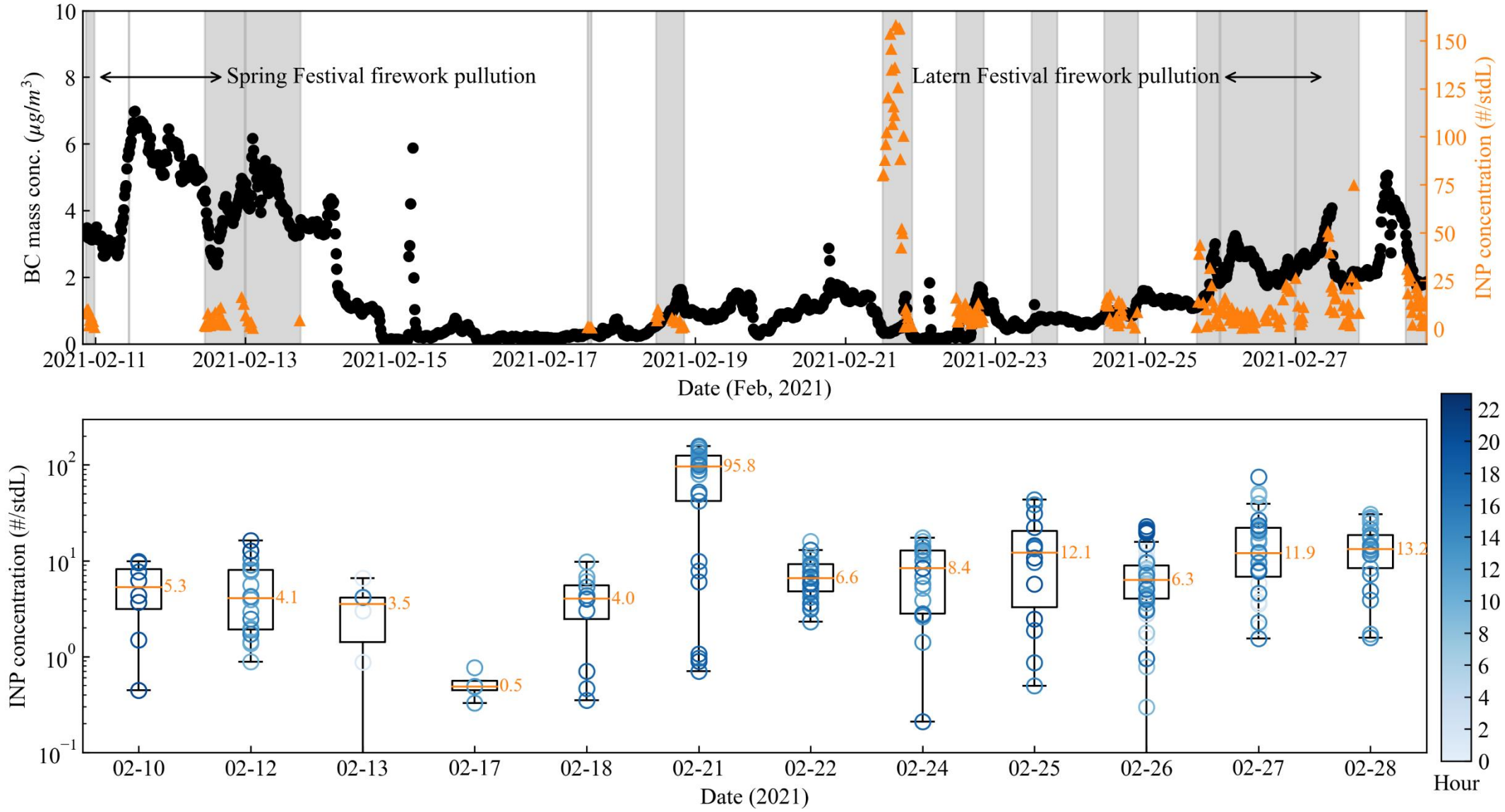
Meteorology data during February



Particle chemical composition and size distribution



INP and BC mass concentration



Outline

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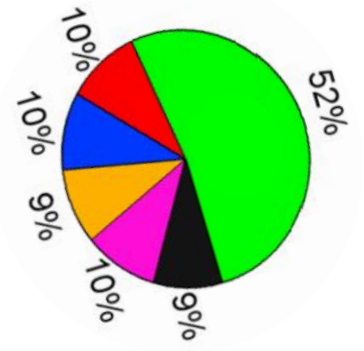
- **HULIS act as ice active entities**

HULIS account for a large fraction of WSOC



Water soluble organic carbon

HULIS(~60%)

Insoluble organic carbon

Feczko et al., 2007

Sources of HULIS

Biomass burning

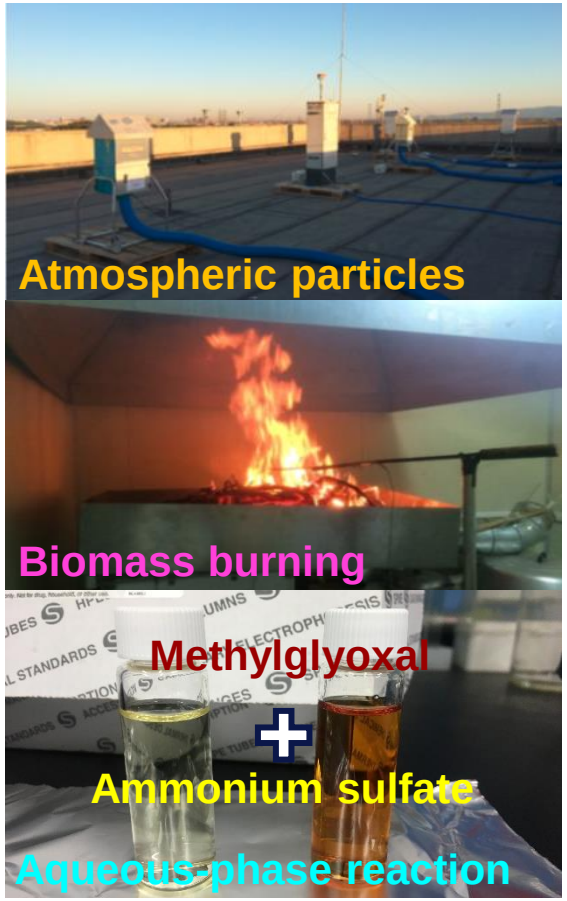
HULIS

Secondary formation

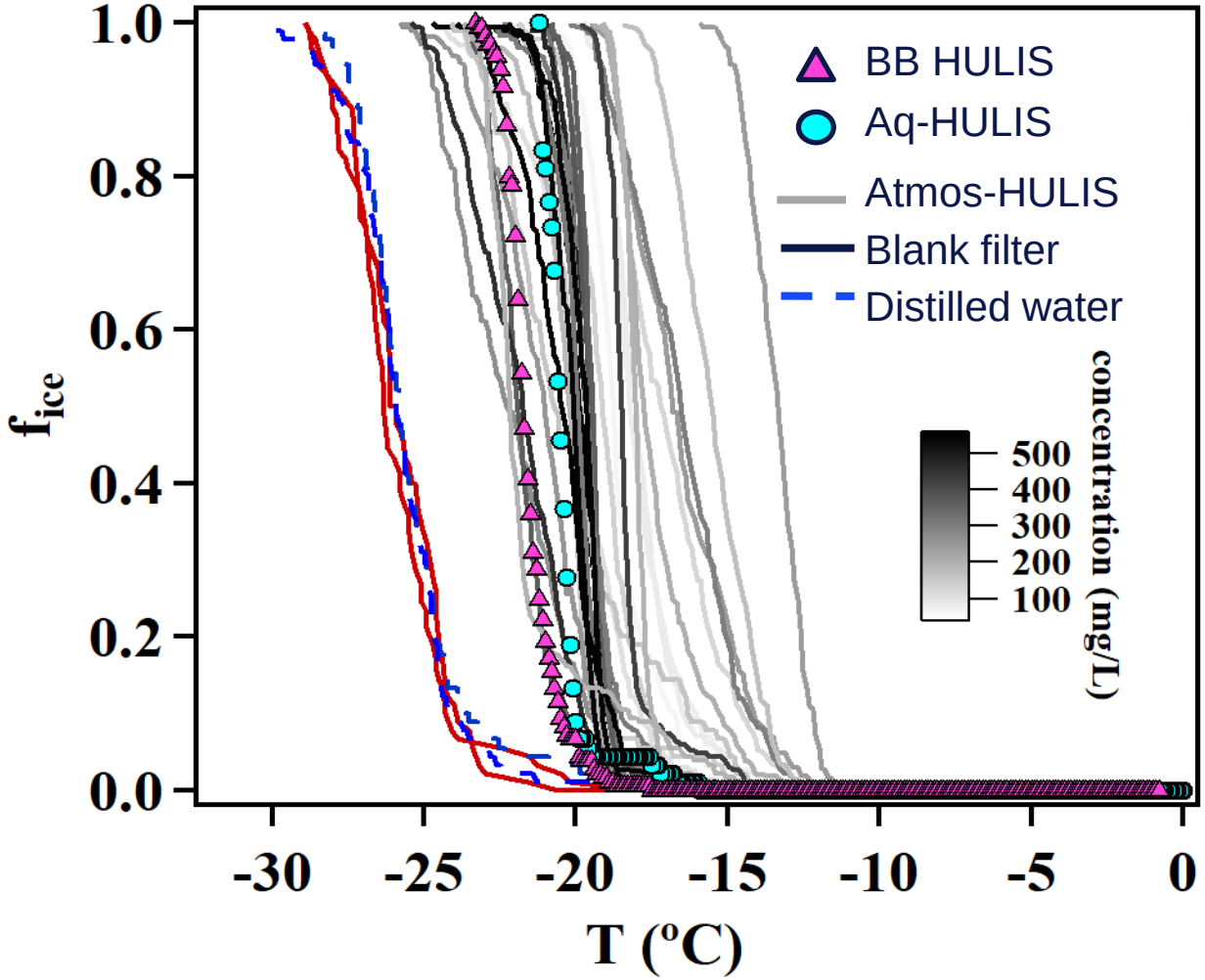
VOCs, NO_x, SO_2, etc.

Humic substances has been proved to act as INPs

HULIS containing Ice Active Entities (IAE)

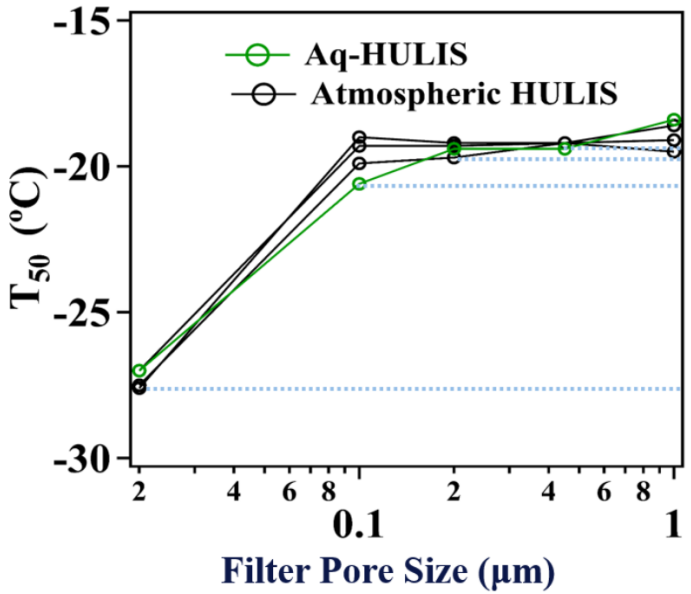


Chen et al., 2021, GRL



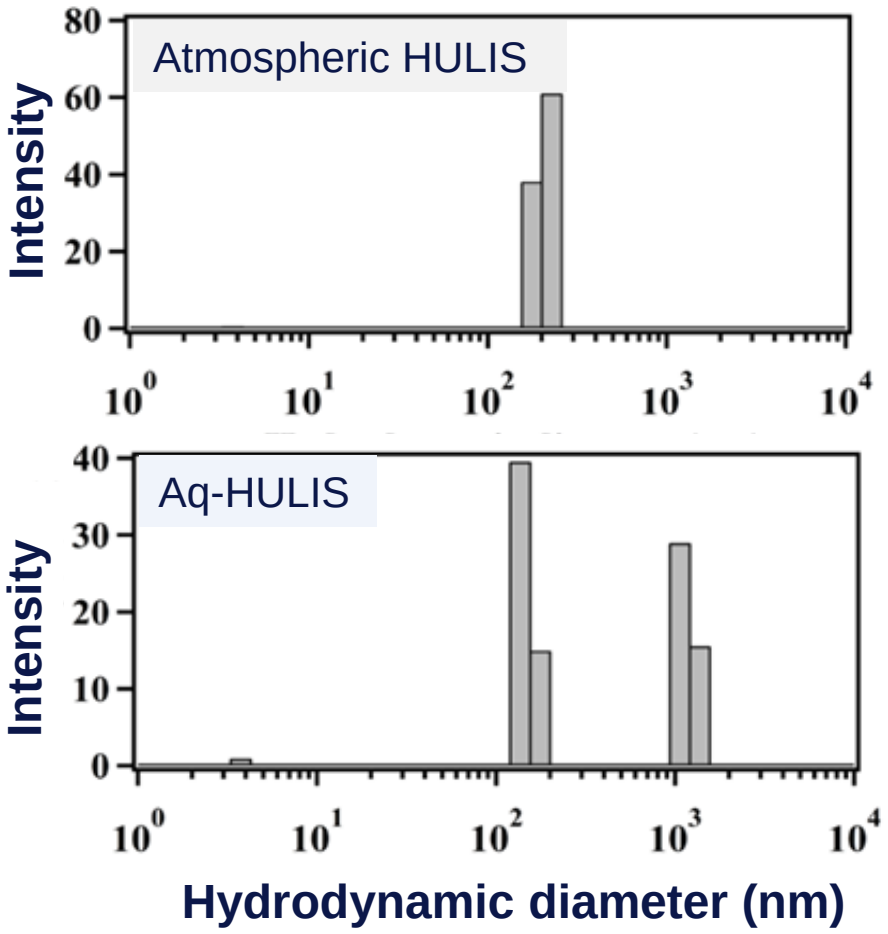
Micelles/aggregates present in the HULIS extracts

HULIS IAEs are in size between 0.02~ 0.1 μm

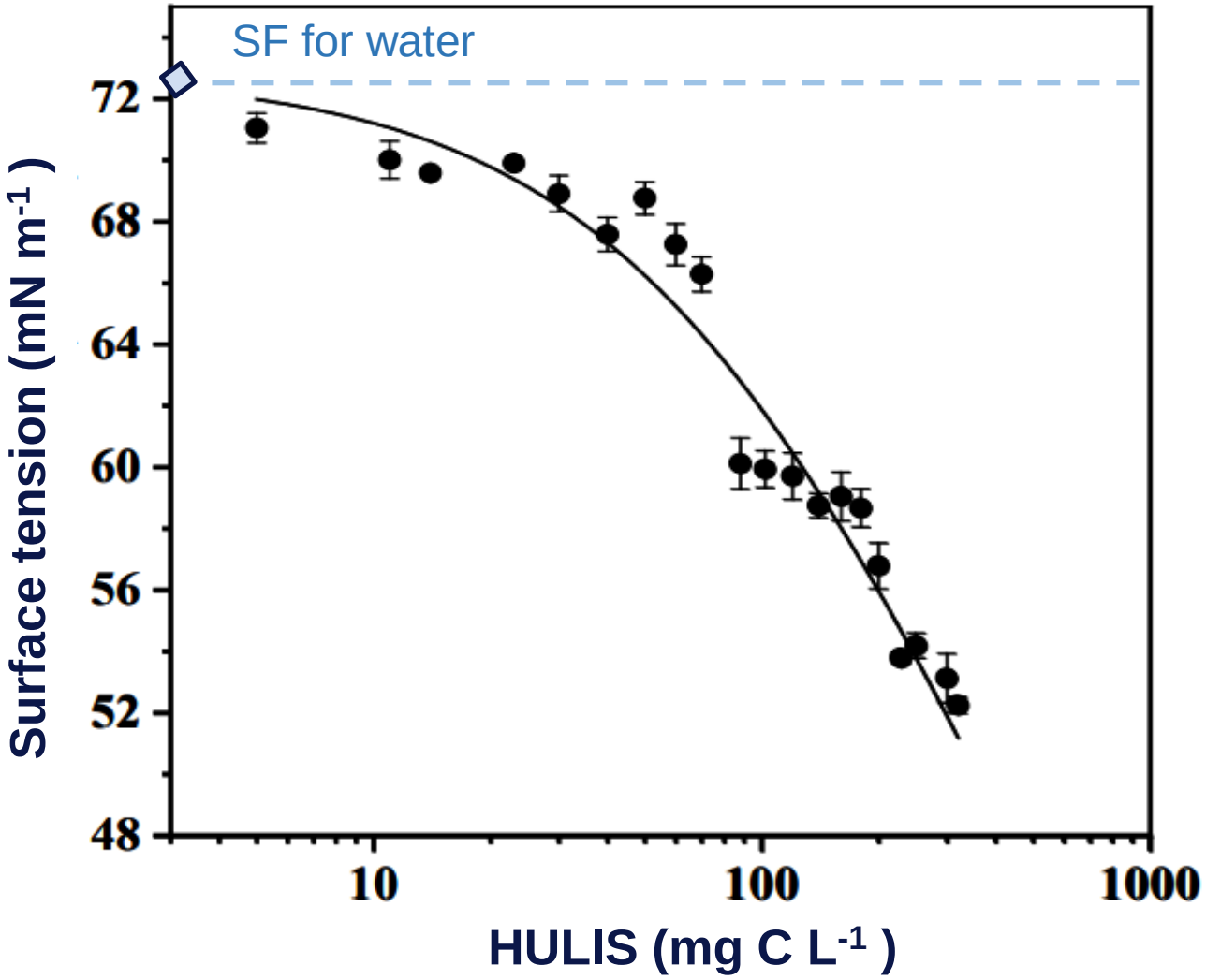


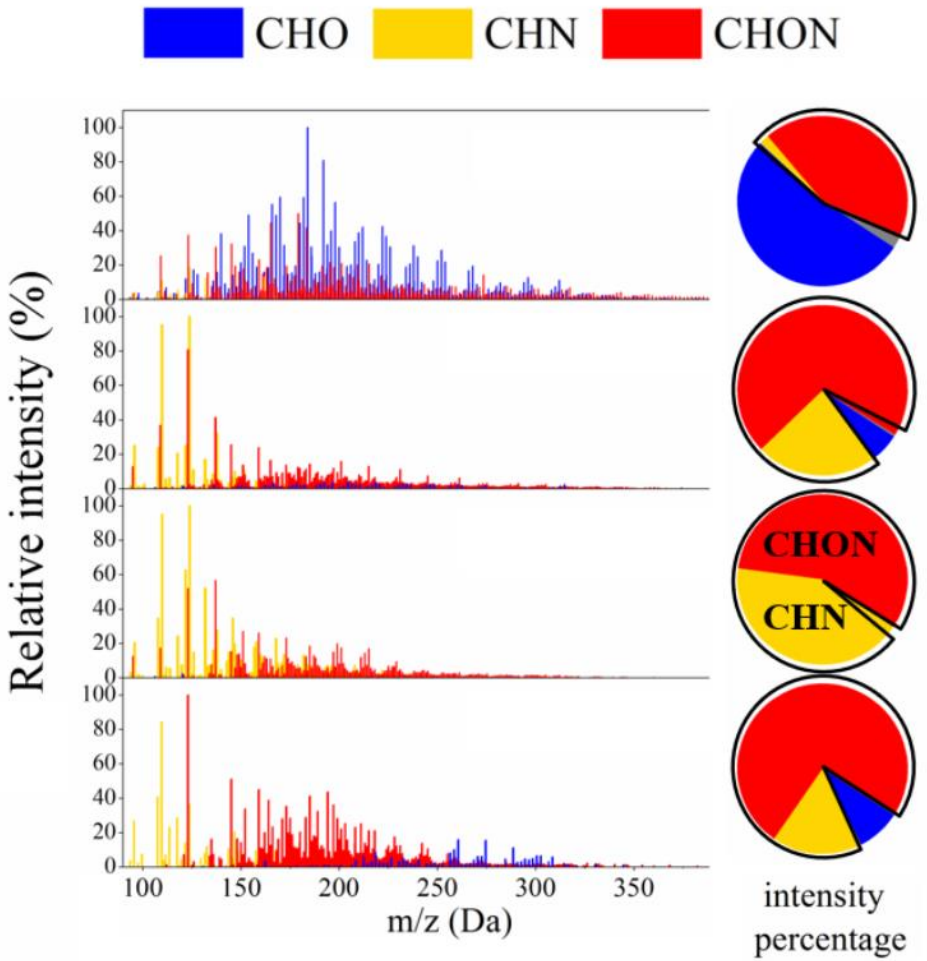
Tyndall effect of HULIS extracts

Size distribution measured by dynamic light scattering (DLS) instrument



HULIS are surface active materials

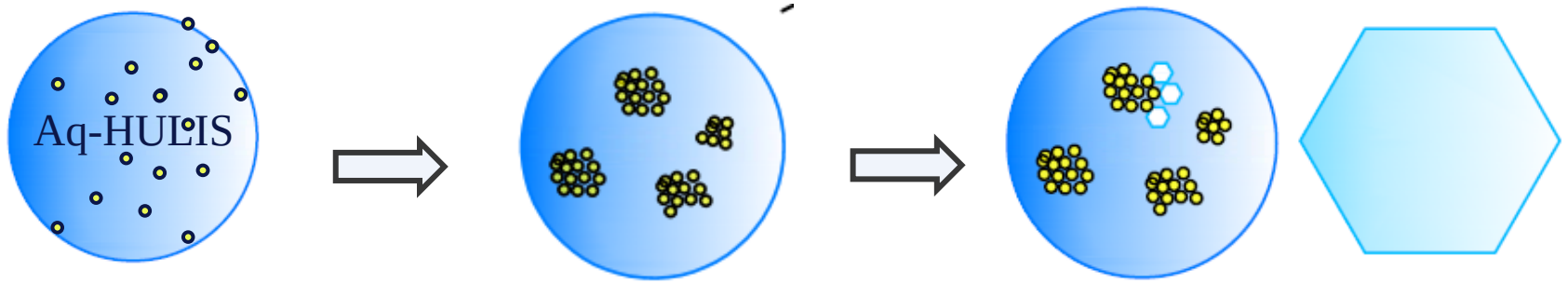




Organic sulfate and organic nitrate

Possible formation mechanism of HULIS IAE

Surface tension	DLS/Filtration measurement	INP measurement



HULIS surface active macromolecules

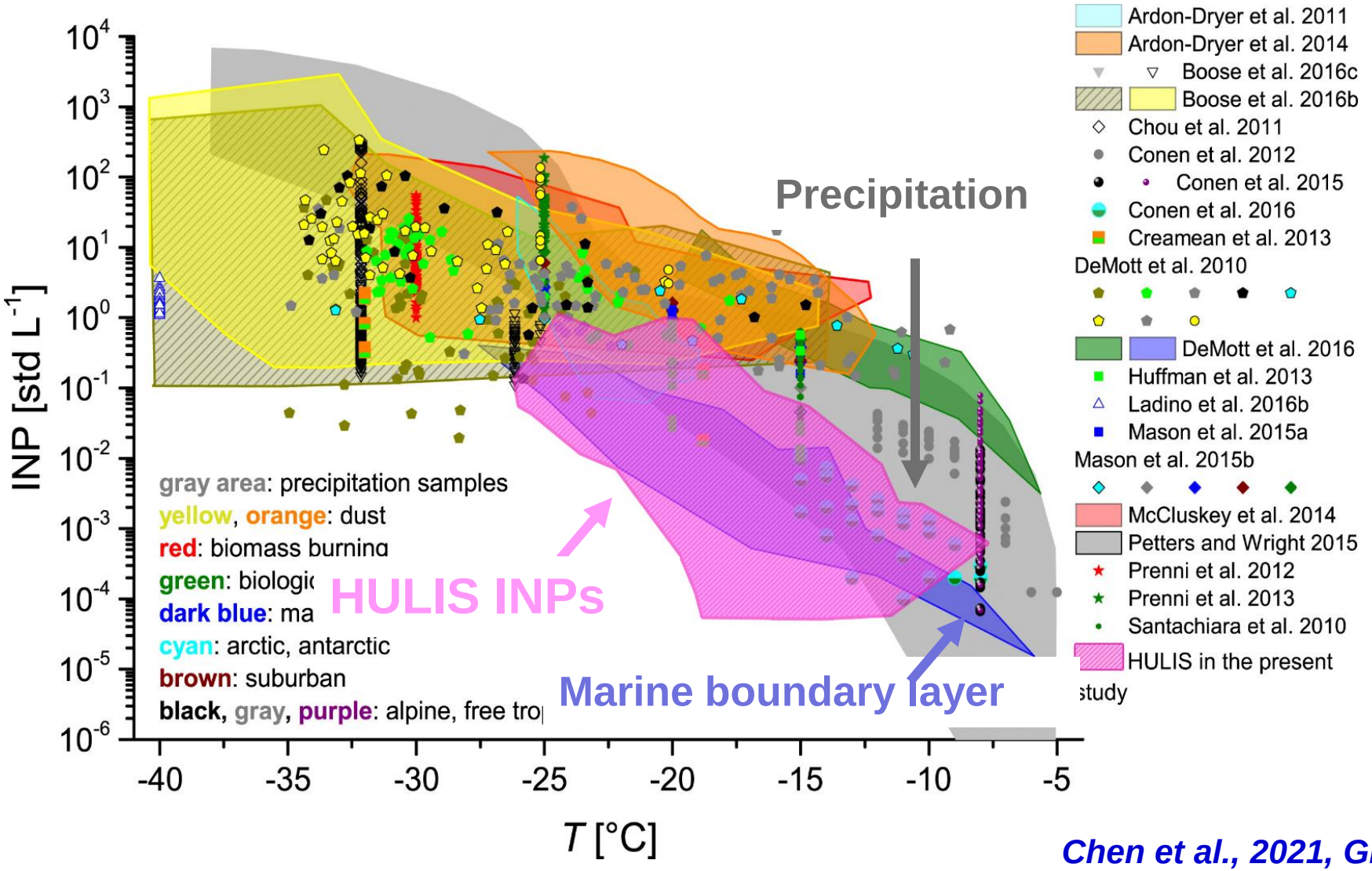
HULIS aggregates

Ice crystal

Chen et al., 2021, GRL

HULIS micelles formed through aggregation provided the required ice active surfaces

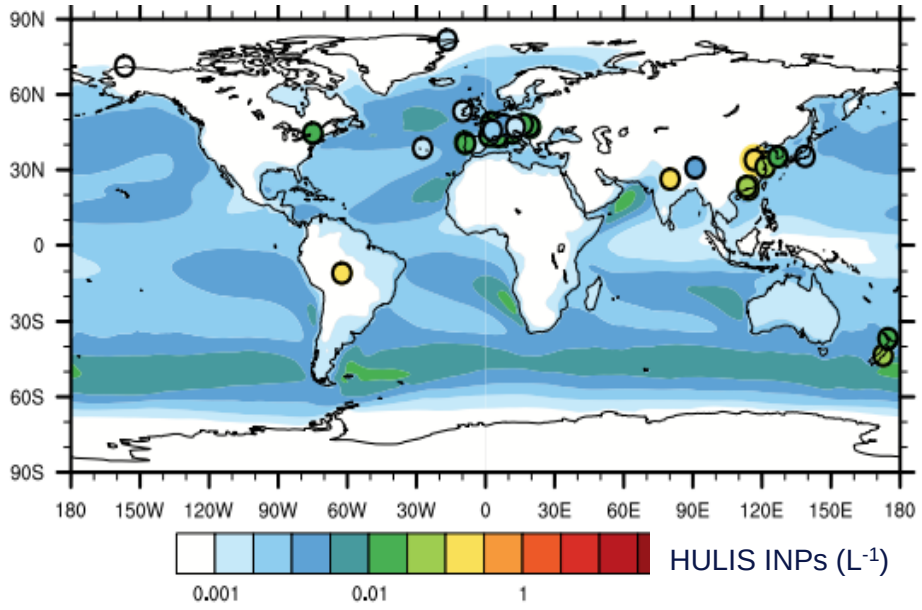
HULIS IAE have comparable air concentration with INPs from other sources



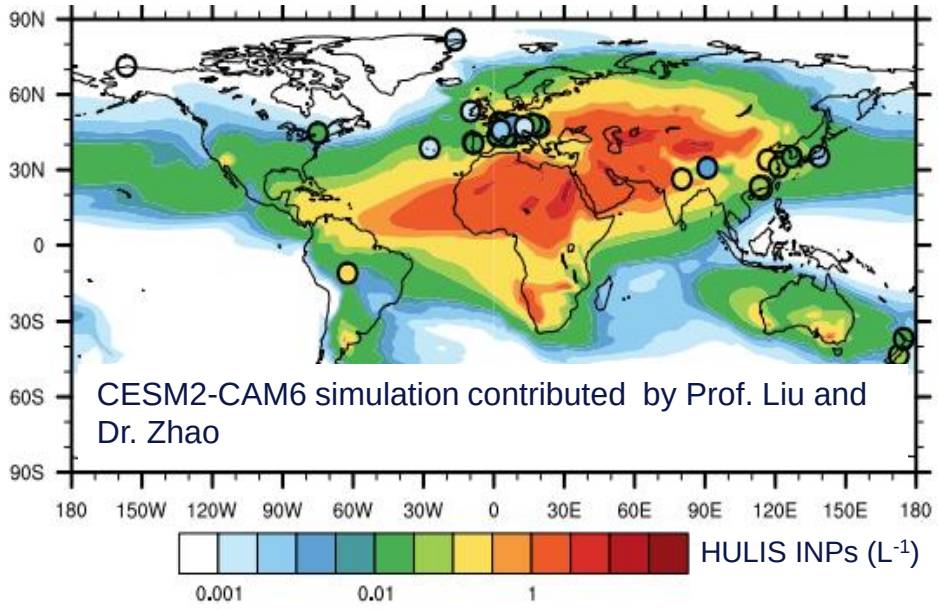
Chen et al., 2021, GRL

HULIS IAE concentrations on a global scale

- HULIS IAE vs. SSA INPs



- HULIS IAE vs. dust INPs



CESM2-CAM6 simulation contributed by Prof. Liu and Dr. Zhao

Chen et al., 2021, GRL

HULIS could be an important IAE contributor where dust INP are either low in concentration

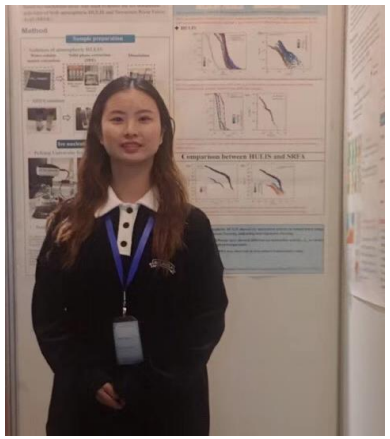
Summary

- Size-resolved atmospheric ice-nucleating particles parameterizations during East Asian dust
- Ice-nucleating particle concentrations unaffected by urban air pollution in Beijing, China
- Atmospheric Humic-Like Substances (HULIS) Act as Ice Active Entities

Thanks

Dr. Cuiqi Zhang

Dr. Jie Chen



Now at ETH

Jingchuan Chen