Workshop on laboratory facilities for cloud research

Sponsored by:
UAE-NATURE project and Beijing Weather Modification Center

September 22 – 25, 2021
Beijing and virtual on gather.town

UAE-NATURE: Using Advanced Experimental – Numerical Approaches To Untangle Rain Enhancement

UAE-NATURE

Using Advanced Experimental – Numerical Approaches To Untangle Rain Enhancement

برنامج الإمارات لبحوث علوم الاستمطار
UAE Research Program for Rain Enhancement Science

HXCZ	BWMO	NUIST	UP	NYUAD	NCAR
华信创智 HUA XIN CHUANG ZHI SCIENCE AND TECHNOLOGY	Beijing Weather Modification Office	NANJING UNIVERSITY OF INFORMATION SCIENCE & TECHNOLOGY	PÉCSI TUDOMÁNYEGYETEM UNIVERSITY OF PÉCS	NEW YORK UNIVERSITY ABU DHABI	NCAR

المركز الوطني للأرصاد
National Center of Meteorology

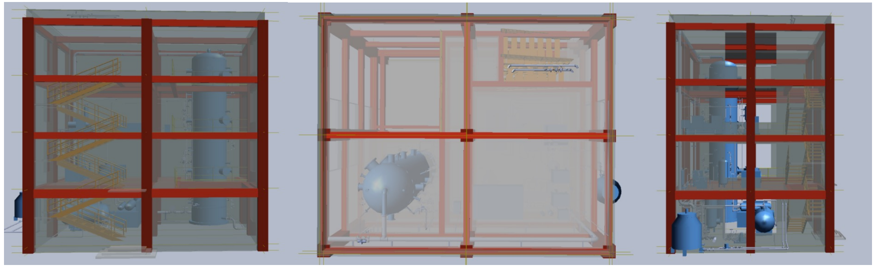
UAE-NATURE is sponsored by the UAE Research Program for Rain Enhancement Science (UAEREP)

Experimental component

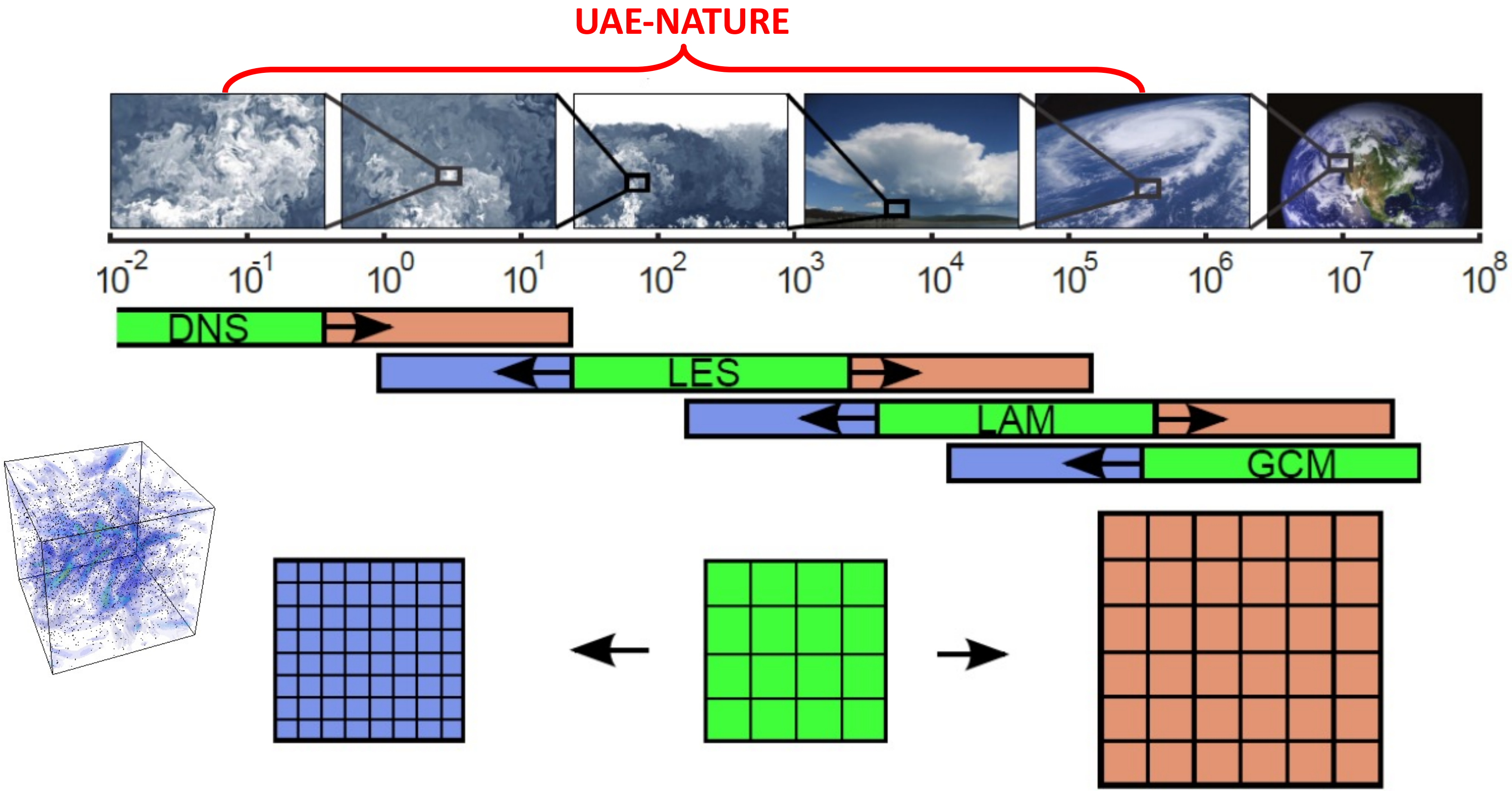
BMWO Aerosol Cloud Interaction Chamber (BACIC)

BACIC is located in the **Cloud Laboratory and Observational Utilities Deployment Base** (**CLOUD** Base) of Beijing weather modification office.

BACIC chamber	
Shape	Cylinder
Size	Diameter: 2.6 m / Height: 14 m
Volume / Surface	70 m^3 / 118.4 m^2
Surface to volume ratio	1.69 m^{-1}
Wall material	Stainless steel
Temperature	223.5 K- 303.15 K
Operating Pressure	1 hpa – 1013 hpa



Numerical modeling component



Workshops related to laboratory work

JAMES | Journal of Advances in Modeling Earth Systems

COMMISSIONED MANUSCRIPT
10.1029/2019MS001689

Confronting the Challenge of Modeling Cloud and Precipitation Microphysics

Hugh Morrison[1], Marcus van Lier-Walqui[2], Ann M. Fridlind[3], Wojciech W. Grabowski[1], Jerry Y. Harrington[4], Corinna Hoose[5], Alexei Korolev[6], Matthew R. Kumjian[4], Jason A. Milbrandt[7], Hanna Pawlowska[8], Derek J. Posselt[9], Olivier P. Prat[10], Karly J. Reimel[4], Shin-Ichiro Shima[11], Bastiaan van Diedenhoven[2], and Lulin Xue[1]

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Key Points:
- Microphysics is an important component of weather and climate models, but its representation in current models is highly uncertain
- Two critical challenges are identified: representing cloud and precipitation particle populations and knowledge gaps in cloud physics
- A possible blueprint for addressing these challenges is proposed to accelerate progress in improving microphysics schemes

Correspondence to:

1. *Sustained support for laboratory facilities to study microphysical processes*, addressing major gaps in cloud physics knowledge and providing data to develop physically based parameterizations and to support or refute cloud physics theories.

Workshops related to laboratory work

BAMS
Meeting Summary

Cloud–Aerosol–Turbulence Interactions

Science Priorities and Concepts for a Large-Scale Laboratory Facility

Raymond A. Shaw, Will Cantrell, Sisi Chen, Patrick Chuang, Neil Donahue, Graham Feingold, Pavlos Kollias, Alexei Korolev, Sonia Kreidenweis, Steven Krueger, Juan Pedro Mellado, Dennis Niedermeier, and Lulin Xue

Workshop to Explore Science Opportunities and Concepts for a Large-Scale Aerosol–Cloud–Turbulence Research Facility

What: More than 60 scientists from a wide range of fields overlapping with the chemistry and physics of aerosols and clouds in turbulent flows gathered to discuss scientific questions, priorities, and concepts for future laboratory research facilities and associated instrumentation.

When: 21–22 November 2019

Where: Boulder, Colorado

Workshops related to laboratory work

- We planned to host this “Workshop on laboratory facilities for cloud research” in April 2020 as a in-person event in Beijing. A lot of planning have been worked on. Serve as a following up international workshop to the previous one in Boulder. Unfortunately, COVID-19 hit right before the event.
- The plan B was to host it in April 2021 if COVID is no longer a problem. But…
- We are now on plan C: A virtual workshop on gather.town for international participants and an online meeting platform for Chinese participants.
- Thanks to Beijing Weather Modification Office for planning the workshop and working on the logistics continuously.
- Thanks to Ottmar, Raymond, Masataka, and Wojtek’s help in organizing this event.

Agenda

Days 1 and 2

Date	Time (BJ time)	Presentations	Presenter
2021/09/22	20:00-20:10	Opening notes (Lulin Xue)	Lulin Xue
	20:10-20:25	Introduction of research facilities and topics in BWMO (BWMO)	Deping Ding
	20:25-20:55	Recent developments and applications of stationary and mobile cloud simulation chambers called AIDAc, AIDAd, AIDAc2 and PINE	Ottmar Möhler
	20:55-21:00	Break	
	21:00-21:30	Insights from convection-cloud chamber experiments: aerosol activation, cloud droplet growth, and mixed-phase clouds in a turbulent environment	Raymond Shaw
	21:30-22:00	Key issues in contemporary cloud microphysics	Alexei Korolev
	22:00-22:05	Break	
	22:05-22:25	The moist-air wind tunnel LACIS-T: A laboratory facility to study aerosol–cloud–turbulence interactions	Dennis Niedermeier
	22:25-22:40	Model inter-comparison study of aerosol-cloud-turbulence Interactions in the Pi Chamber	Sisi Chen
	22:40-23:00	Comparison of convection cloud chamber simulations using various microphysics and advection schemes	Fan Yang

2021/09/24	09:00-09:30	Studies on Aerosol-Cloud Interaction and Weather Modification using MRI Cloud Simulation Chamber	Masataka Murakami
	09:30-10:00	Colorado State University Laboratory Facilities and Measurements Focused on Ice Nucleation	Paul DeMott
	10:00-10:05	Break	
	10:05-10:25	Adaptation of Ground-based and Airborne Cloud Condensation Nuclei Spectrometers to Wind Tunnel and Cloud Chamber Applications: Challenges and Opportunities	Darrel Baumgardner
	10:25-10:45	Construction of a new cloud physics experimental chamber (CPEC) in Korea	Joo Wan Cha/Seong Soo Yum
	10:45-11:05	Laboratory research from BWMO (BWMO)	Mengyu Huang
	11:05-11:10	Break	
	11:10-11:40	Predicting the morphology of ice particles in deep convection using the super-droplet method	Shin-ichiro Shima
	11:40-12:00	Discussion	
	14:00-18:00	Local meetings	

Agenda

Day 3

2021/09/25	09:30-10:00	Modeling studies of primary and secondary ice production in mixed-phase clouds	Huiwen Xue
	10:00-10:30	Atmospheric Humic-Like Substances (HULIS) Act as Ice Active Entities	Zhijun Wu
	10:30-11:00	Observational, Numerical and Theoretical Analysis of Entrainment/Detrainment Processes in Low-Level Clouds	Chunsong Lu
	11:00-11:30	Using a novel chamber to invesigate the evolution of single plume from biomass burning	Dantong Liu
	11:30-12:00	Construction of expansion cloud chamber	Zhengjun Su
	12:00-12:05	Break	
	12:05-13:05	Discussion (Key science questions and technical development of lab facilities to address them. How to organize and coordinate international efforts: category of lab facilities for cloud research and regular meetings or workshops)	Ottmar Möhler and Lulin Xue (moderators)
	13:05-13:10	Break	
	13:10-13:30	Summary	Lulin Xue

Discussion

Key questions/Technology development/Future plans

Research area	Science questions	<1 m	1 m	10 m	100 m	1,000 m
	Number of science questions	9	12	22	15	5
Aerosol/cloud chemistry	Aqueous photochemistry (particle scale)	x				
Aerosol/cloud interactions	Do we know enough about heterogeneous ice nucleation?	x				
Aerosol/cloud interactions	Do we know enough about droplet activation? Influence of chemical (composition) and physical properties (charge, shape)?	x				
Mixed-phase/cold clouds	Rate of growth/evaporation of different types of ice crystals under constant and varying environmental conditions including metamorphosis	x				
Radiative transfer	Light scattering by single ice crystal and aggregates	x				
Turbulence-microphysics interaction	How does turbulence affect collision coalescence; sedimentation, orientation, and rotation of non-sphere (ice crystal) particles; ice process, diffusional growth?	x				
Aerosol/cloud interactions	What is the relationship between cloud/turbulence properties and aerosol scavenging?		x			
Mixed-phase/cold clouds	Aggregation–varying temperature and humidity conditions		x			
Mixed-phase/cold clouds	Terminal velocity of hydrometeors		x			
Mixed-phase/cold clouds	Secondary ice production	x	x	x		
Mixed-phase/cold clouds	Primary ice formation and its dependence on turbulence		x	x		
Radiative transfer	Radiative cooling at Sc cloud top with droplet growth (interface chamber)		x	x		
Radiative transfer	RT through electric field oriented ice particles		x	x		
Turbulence-microphysics interaction	How turbulence-induced fluctuation of concentration fields affects droplet size distribution (sedimentation/vertical velocity). Four main foci: 1) supersaturation, 2) fall speeds, 3) clustering, 4) collision–coalescence		x	x		
Mixed-phase/cold clouds	Aggregation of ice under varying relative humidity and temperature conditions, including effect of charge			x		
Mixed-phase/cold clouds	Rate of partitioning of phase in mixed-phase clouds, conversion of ice phase to mixed-phase clouds due to convection			x		
Turbulence-microphysics interaction	Coarse-grain microphysics at the 10-m scale (for coupling to LES, sampling measurements, etc.)			x		
Turbulence-microphysics interaction	What scales of fluctuations are most important for diffusional growth?	x	x	x	x	
Aerosol/cloud interactions	What are the optimal aerosol characteristics for inducing marine cloud brightening?		x	x	x	
Radiative transfer	Exploring emerging remote sensing techniques		x	x	x	
Aerosol/cloud chemistry	Aqueous photochemistry (cycling, parcel scale)			x	x	
Aerosol/cloud chemistry	Parcel scale dynamics of activation interacting with turbulence			x	x	
Aerosol/cloud chemistry	Interstitial scavenging			x	x	
Aerosol/cloud interactions	How are aerosols entrained/detrained at the cloud interface? How does turbulence influence aerosol entrainment into the cloud?			x	x	
Aerosol/cloud interactions	What is precipitation susceptibility as a function of aerosol properties?			x	x	
Radiative transfer	Imaging through turbulent clouds			x	x	
Radiative transfer	Depolarization by particle shape and multiple scattering			x	x	
Turbulence-microphysics interaction	Measure entrainment rates	x	x	x	x	x
Aerosol/cloud chemistry	Precipitation scavenging			x	x	x
Radiative transfer	Particle correlation inducing deviations from Beer–Lambert			x	x	x
Radiative transfer	Aerosol effect on cloud albedo (e.g., given heterogeneity in drop distance)			x	x	x
Radiative transfer	Signal propagation through an optically thick cloud				x	x

Key questions/Technology development/Future plans

1. Droplet spectra broadening
2. Collision-coalescence of small droplets (D<40mm)
3. Coalescence coefficients of droplets
4. Collective growth of droplets
5. Primary ice nucleation (heterogeneous and homogeneous ice nucleation in cirrus formation for example)
6. Collective growth of ice
7. Collective growth of cloud particles in mixed phase
8. Aggregation of ice, sticking efficiency
9. Necessary and sufficient conditions for secondary ice productions (6 mechanisms)
10. Entrainment and mixing (turbulent flow is needed)
11. Mechanisms of charge separation and electrification of clouds
12. Effects of the global and local electric fields on cloud microphysics
13. Chemical processes too.

Key questions/Technology development/Future plans

- New chamber design and construction should be determined or driven by the key science questions.
- Need to understand the requirements and limitations of the instruments for the phenomenon being observed. Design and development new instruments if necessary.
- For existing facilities, key science questions suitable to be addressed should be identified and pursued.
- Lab-scale numerical modeling tools and efforts should be an integrated component to all laboratory facilities (LACIS-T is a good example).
- Increase and improve the accessibility of the chambers and lab facilities for external users to enhance collaborative research and to use these facilities as platform for instrument test and development (Europe has a great platform for this point).

Key questions/Technology development/Future plans

- Share the recorded meeting video and presentation PDF files pending speakers’ approval.
- Try to submit a meeting summary to an appropriate journal.
- Organize another workshop in 2022 or 2023 on the technical aspects and details of the chamber engineering and science (following Seong Soo’s suggestion and request).
- Design one or more benchmark experiments to demonstrate the chamber interoperability and intercomparability (following Darrel’s suggestion, such as CCN activation experiments, chemical processes, aging, etc.).
- Meet in 2024 before or after next ICCP to share (following Alexei’s suggestion).
- Anything else? Need a working group focusing on instrumentation development for chamber observations such as the supersaturation measurements.
- Talk to Ottmar about international collaborations.

THANK YOU