NITech Lectures on Turbulence and Cloud
Program

March 8-9, 2018, Room 110, Building No. 4, Nagoya Institute of Technology

URL: http://comphys.web.nitech.ac.jp/cloudlec.html

March 8

9:00 - 9:25		*Reception*
9:25 - 9:30		*Opening*
9:30 - 10:30	Pumir	Collisions and aggregation of particles by turbulence in clouds
10:30 - 10:40		*Break*
10:40 - 11:40	Pumir	(continue)
11:40 - 13:30		*Lunch*
13:30 - 14:30	Shaw	Cloud droplet growth by vapor condensation in a turbulent flow
14:30 - 14:40		*Break*
14:40 - 15:40	Shaw	(continue)
15:40 - 16:00		*Break*
16:00 - 16:40	Ishihara	Motion of inertial particles in high-Reynolds-number turbulence
16:40 - 17:20	Sato	A grid refinement study on shallow cumuli using a large eddy simulation model
17:20 - 18:00	Watanabe	Large-scale simulation of monodispersed small solid particles in isotropic turbulence
18:30 - 20:30		*Banquet*

March 9

9:00 - 9:30		*Reception*
9:30 - 10:30	Yum	Cloud condensation nuclei distribution in East Asia Aircraft measurement of cloud microphysical relationships
10:30 - 10:40		*Break*
10:40 - 11:40	Yum	(continue)
11:40 - 12:00		*Photo Session*
12:00 - 13:30		*Lunch*
13:30 - 14:10	Suzuki	Linkage of cloud microphysics to climate: Satellite observations and global modeling
14:10 - 14:50	Matsuda	Numerical study on cloud radar reflectivity enhancement due to turbulent droplet clustering
14:50 - 15:30	Saito	Turbulence and cloud droplets in cloud micro-physics simulator
15:30 - 16:00		*Round Table Discussion*

Abstracts

March 8

Collisions and aggregation of particles by turbulence in clouds

Alain Pumir (Laboratoire de Physique, Ecole Normale Superieure de Lyon)

In clouds, aggregation of droplets and/of ice crystals plays an important role in the growth of particles to form rain drops or ice-graupels that eventually lead to precipitation. Turbulence creates relative motions between particles, which result in an enhancement of the collision rate between particles.

I will first review our current understanding of the role of turbulence in collisions of small droplets, viewed as small inertial particles. In particular, two main effects will been discussed. Droplets much heavier than ambient air, tend to accumulate in special regions of the flow; this effect is known as preferential concentration. If the inertia of the particles is large enough, particles may collide with a very large relative velocity; this is known as the " sling effect ". Both effects play an important role to understand collisions of droplets.

I will also discuss the problem of collisions involving small ice-crystals, focusing on crystals shaped approximately as oblate ellipsoids. I will first discuss collisions between these crystals, which is relevant to the formation of graupels/hail particles. In mixed phase clouds, ice-crystals, which coexist with small water droplets, can grow as a result of collisions with droplets. I will present new results on this process, known as " riming ".

Cloud droplet growth by vapor condensation in a turbulent flow

Raymond Shaw (Michigan Technological University)

Turbulence and mixing influence cloud droplet growth by vapor condensation, which in turn leads to implications for precipitation formation and cloud optical properties. Recent laboratory experiments and field observations support the view that the response time of water vapor resulting from droplet growth defines two growth regimes: fast response yielding relatively uniform cloud properties, versus slow response yielding broad droplet size distributions.

Motion of inertial particles in high-Reynolds-number turbulence

Takashi Ishihara (Okayama University)

Turbulence plays a key role in collision and coagulation process of droplets in cloud. Since turbulence in realistic cloud is at very high Reynolds number, our understanding of such processes in high-Reynolds-number turbulence is necessary. In this presentation, firstly vortical structures observed in high-resolution direct numerical simulations (DNSs) are reviewed. Next, the motions of inertial particles numerically tracked in the DNSs of high-Reynolds-number turbulence (the Reynolds number based on the Taylor micro-scale up to 730) are discussed.

A grid refinement study on shallow cumuli using a large eddy simulation model

Yousuke Sato (Nagoya University)

The effects of grid resolution on the simulated shallow cumuli was investigated using a large eddy simulation (LES) model coupled with an Eulerian cloud microphysical model (ECM) and a particle-based Lagrangian cloud microphysical model (LCM). We swept he horizontal/vertical grid resolution from 100 m/80 m to 6.25 m/5 m. Cloud cover was increased with fining the grid resolution, and it was numerically converged with a horizontal/vertical grid resolution of 12.5 m/10 m. The turbulent structure in the subcloud layer was critical to the cloud cover. Using the fine grid resolution, the roll convection was clearly simulated in the sub-cloud layer, but it became obscure with coarsening the grid resolution. The dependency of the grid resolution was commonly seen in both LCM and ECM.

Large-scale simulation of monodispersed small solid particles in isotropic turbulence

Takeshi Watanabe (Nagoya Institute of Technology)

We investigate modifications of isotropic turbulence due to the monodispersed small solid particles using the large-scale direct numerical simulation. Although the particle diameter is comparable to the Kolmogorov length l_K, the flow around each particles is accurately resolved by computing the incompressible Navier-Stokes equations with volume penalization. It is found that the far dissipation range of kinetic energy spectrum is strongly modified by particles, and the effect of particles becomes stronger when increasing the volume fraction of particles. However the body of spectrum in $kl_K < 1$ is not affected by particles as far as the particle concentration is not so large. Turbulence modulation is also examined by changing the mass density of particle, where it is found that the kinetic energy spectrum is strongly modified over whole wavenumber range when the mass density of particle is larger. These properties are also discussed by examining the behavior of transfer function originated from the interaction between particles and turbulence.

March 9

Cloud condensation nuclei distribution in East Asia

Seong Soo Yum (Yonsei University)

Cloud condensation nuclei (CCN) are a subset of atmospheric particles that can serve as nucleus of cloud droplet. It means that cloud microphysics (number concentration and sizes of cloud droplets) is largely determined by CCN, which in turn determine radiative properties of clouds. Therefore, an important climatic implication is that change of CCN distribution can alter earth radiation budget. Nevertheless, information on CCN is still lacking in many parts of the world and especially in East Asia. Shown in this lecture are the results of CCN measurements in and around the Korean Peninsula on various platforms, ground, ship and aircraft, which may represent the CCN distribution in East Asia.

Aircraft measurement of cloud microphysical relationships

Seong Soo Yum (Yonsei University)

Cloud microphysical relationships are initially determined by adiabatic condensational growth of embryonic droplets formed on CCN but are being modulated by entrainment and mixing of clear air from the surrounding that lead to evaporation and/or new cloud droplet activation on CCN from the entrained air. Importantly, depending on how entrained air is mixed with cloudy air, further development of cloud droplets is affected. To estimate what type of mixing process is dominant in clouds of different thermodynamic and dynamic conditions, cloud microphysical relationships are examined for stratocumulus and cumulus clouds measured in several aircraft field projects. Some important results are highlighted in this lecture.

Linkage of cloud microphysics to climate: Satellite observations and global modeling

Kentaroh Suzuki (University of Tokyo)

This presentation highlights our recent studies that combine satellite observations and global modeling to explore how cloud microphysics is linked to climate and to expose a fundamental gap in our understanding of the linkage.

Numerical study on cloud radar reflectivity enhancement due to turbulent droplet clustering

Keigo Matsuda (Japan Agency for Marine-Earth Science and Technology)

Cloud droplets form a nonuniform spatial distribution in turbulence, which is referred to as turbulent clustering. The cloud radar reflectivity factor can be enhanced by turbulent clustering of cloud droplets. The quantitative influence of turbulent clustering on radar reflectivity factor is investigated by using a direct numerical simulation of particle-laden homogeneous isotropic turbulence.

Turbulence and cloud droplets in cloud micro-physics simulator

Izumi Saito (Nagoya Institute of Technology)

Cloud micro-physics simulator is a DNS model developed for the seamless simulation of turbulence and the evolution of cloud droplets to rain drops in a turbulent cloud environment from a first principle. In this talk, I provide an overview of the recent progress and result of cloud micro-physics simulator, including the effect of turbulence on condensation and collision growth of cloud droplets and the effect of droplets on turbulent fluctuations.