ACM 2017

ASIAN CONFERENCE ON METEOROLOGY 2017 (ACM2017)

Plenary Session
Key Note Talks

Key Note Talks - 1

Stratosphere-troposphere two-way dynamical coupling in the tropics through organization of moist convective systems

Shigeo Yoden (Kyoto University)

In the last decade or two, stratosphere-troposphere dynamical coupling has attracted much attention, such as the annular mode variability in both hemispheres and two-way coupling during extreme events as stratospheric sudden warming (SSW). The standard paradigms for interpreting and explaining stratosphere-troposphere coupling have been based on balanced dynamics; the non-local aspects of potential vorticity inversion, planetary wave propagation, and wave-mean flow interaction in both troposphere and stratosphere. Recently, we started a new international research activity on Stratospheric And Tropospheric Influences on Tropical Convective Systems (SATIO-TCS) under Stratosphere-troposphere Processes And their Role in Climate (SPARC) project of the World Climate Research Programme (http://www.sparc-climate.org/activities/emerging-activities/#c1880). It focuses on stratosphere-troposphere dynamical coupling in the tropics, where no comparable interpretive paradigm exists. Observational data analyses and global and cloud-resolving numerical-model studies all point to an important stratospheric influence on tropical convection and organized convective systems. Multi-scale dynamics of these systems is likely to play a vital role in determining the tropical response to such variations and change in the stratosphere.

There are some observational evidences that stratospheric variations associated with SSW events, the equatorial quasi-biennial oscillation (QBO), or anthropogenic cooling trend in the lower stratosphere and around the tropopause, do influence tropospheric variability in the form of moist convection and its large-scale organization into meso-to-planetary-scale systems. The organized moist convective systems include cloud clusters, tropical cyclones, the Madden-Julian Oscillation (MJO), annually varying monsoon systems, and interannual time-scale El Nino-Southern Oscillations. Some global general circulation models and regional cloud resolving models show similar features to these observed responses to the stratospheric variations, but such modeling studies are in a rather preliminary state.

In this talk, research progress on stratosphere-troposphere two-way dynamical coupling in the tropics is systematically reviewed for data analyses and theoretical and numerical model studies. Then, recent works of my group on the subject are summarized, including the following papers:

Yoden, S. et al., 2014: A minimal model of QBO-like oscillation in a stratosphere-troposphere coupled system under a radiative-moist convective quasi-equilibrium state. ***SOLA*, 10,** 112-116.

Nishimoto, E. et al., 2016: Vertical momentum transports associated with moist convection and gravity waves in a minimal model of QBO-like oscillation. ***J. Atmos. Sci.*, 73,** 2935-2957.

Bui, H.-H. et al., 2017: Downward influence of QBO-like oscillation on moist convection in a two-dimensional minimal model framework. ***J. Atmos. Sci.*,** in press.

Key Note Talks - 2

Development of a Lagrangian Cloud Model and Its Application to Cloud Microphysics Researches

Yign Noh (Yonsei University)

Lagrangian cloud model (LCM) has been developed based on the LES model PALM, in collaboration with Univ. Hannover, Germany. LCM is a fundamentally new approach of cloud simulation, in which the flow field is simulated by LES and droplets are treated as Lagrangian particles moving in the simulated turbulent flow field, while undergoing cloud microphysics. For this purpose, the concept of a superdroplet, which represents a large number of real droplets of the same radius, is introduced, and the number of contributing real droplets to a superdroplet is called the weighting factor. A novel algorithm of the collision process is developed, which calculates the collisional growth of each Lagrangian droplet based on the background droplet size spectrum (DSD), in a similar way to the spectral bin model (SBM), in terms of the modifications of radius and weighting factor of superdroplets. LCM is shown to reproduce successfully the realistic evolution of cloud dynamics and microphysics. Sensitivities to the collision kernel, the number of superdroplets, and the grid resolution are investigated.

LCM results are analyzed to clarify the mechanism of raindrop formation in a shallow cumulus cloud by tracking the history of individual Lagrangian droplets that grow to raindrops. It is found that the rapid collisional growth, leading to raindrop formation, is triggered when single droplets with a radius of 20 μm appear in the region near the cloud top, which is characterized by large liquid water content, strong turbulence, large mean droplet size, a broad DSD, and high supersaturations. Raindrop formation can always occur in time in the presence of turbulence-induced collision enhancement (TICE), unaffected by the broadening of DSD, but it is severely delayed without the broadening of DSD in the absence of TICE. TICE does not accelerate the timing of raindrop formation, but it enhances the amount of raindrop formation. Higher droplet concentrations increase the time for raindrop formation, and decrease precipitation.

Furthermore, LCM provides information how autoconversion and accretion appear and evolve within a cloud, which constitute critical parts in cloud microphysics parameterization. It is found that the conversion of cloud droplets to raindrops occurs initially by autoconversion near the cloud top, but it becomes dominated by accretion in the cloud core at the later stage. In particular, the calculation of autoconversion reproduces successfully for the first time the Kessler-type parameterization, which assumes the critical cloud water mixing ratio to trigger autoconversion.

Key Note Talks - 3

Weather conditions conducive to Beijing severe-haze more frequent under climate change

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The frequency of Beijing winter severe haze episodes has increased substantially over the past decades, and is commonly attributed to increased pollutant emissions from China's rapid economic development. During such episodes, levels of fine particulate matter are harmful to human health and the environment, and cause massive disruption to economic activities, as occurred in January 2013. Conducive weather conditions are an important ingredient of severe haze episodes, and include reduced surface winter northerlies, weakened northwesterlies in the midtroposphere, and enhanced thermal stability of the lower atmosphere. How such weather conditions may respond to climate change is not clear. Here we project a 50% increase in the frequency and an 80% increase in the persistence of conducive weather conditions similar to those in January 2013, in response to climate change. The frequency of severe haze between the historical (1950-1999) and future (2050-2099) climate was compared in 15 models under Representative Concentration Pathway 8.5 (RCP8.5). The increased frequency is consistent with large-scale circulation changes, including an Arctic Oscillation upward trend, weakening East Asian winter monsoon, and faster warming in the lower troposphere. Thus, circulation changes induced by global greenhouse gas emissions can contribute to the increased Beijing severe haze frequency.