Tightening of Hadley Ascent and Tropical High Cloud Region Key to Precipitation Change in a Warmer Climate

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The changes of global-mean precipitation under global warming and interannual variability are predominantly controlled by the changes of atmospheric longwave radiative cooling. Here we show that the tightening of the ascending branch of the Hadley Circulation is a key process coupled to the decrease of tropical-mean high cloud fraction when the surface warms. The magnitude of high cloud shrinkage is a primary contributor to the inter-model spread in the rates of tropical-mean outgoing longwave radiation (*OLR*) and global-mean precipitation change per unit surface warming (dP/dT_s) for both interannual variability and global warming. Compared to observations, most CMIP5 models underestimate the rates of interannual *OLR* and precipitation increase with surface temperature, consistent with the muted high cloud shrinkage. We find that the five models that agree with the observation-based interannual dP/dT_s all predict dP/dT_s under global warming higher than the ensemble mean dP/dT_s from the ~20 models analyzed in this study.

Keywords: hydrological sensitivity, high cloud shrinkage, tightening of Hadley ascent

Diagnostic relationships between precipitation and cloud types or regimes

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I will provide an overview of our group's recent work on obtaining diagnostics that expose the character of precipitation-cloud relationships mainly in tropical regions. The observational datasets on which our analysis is based are TMPA-3B42 precipitation rates and cloud types or regimes from ISCCP and MODIS. For comparisons with GCMs we use model cloud output from the CMIP5 archive that has been processed with the ISCCP simulator. Our investigation has focused on the following issues which I will address in my presentation: (1) Can we quantify the relationship between cloud types and precipitation events of particular strength and does the relationship change substantially between ocean and land? (2) Do Weather States or Cloud Regimes serve us well as a framework for distiguishing between different precipitation regimes? (3) Can we see evidence of aerosol effects on precipitation when the problem is decomposed by Cloud Regime? (4) Do models reproduce the observed dependence of tropical precipitation on Cloud Regime? The presentation will stress the value of spatiotemporally matched cloud and precipitation observations as a way forward for understanding their intricate connections.

Keywords: Cloud Types, Precipitation, Satellites, Cloud Regimes, Global Climate Models

The too fast, too frequent precipitation simulated in GCMs

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The cloud-to-precipitation transition process simulated by some state-of-the-art global climate models (GCMs), including both traditional climate models and a global cloud-resolving model, is evaluated against A-Train satellites observations. The models and satellite observations are compared in the form of the statistics obtained from combined analysis of multiple satellite observables that probe signatures of the cloud-to-precipitation transition process. One common problem identified among these models is the too-fast triggering of precipitation, before clouds are developed to a stage when cloud particle sizes are large enough to collide into precipitating particles. Another common problem closely related to the too fast triggering of precipitation is the overestimated (underestimated) occurrence frequency of precipitation (non-precipitating clouds).
The cloud-to-precipitation transition process is represented in GCMs by bulk auto-conversion schemes. A sensitivity test with two widely used auto-conversion schemes in the global cloud-resolving model shows that a more realistic auto-conversion scheme significantly improved the model representation of cloud-to-precipitation transition process: the typical cloud radius where precipitation occurs is shifted close to the observations. However, precipitation occurrence frequency is still overestimated, implying that the parameterization of cloud particle size, besides the auto-conversion scheme, also contributes to the model bias of precipitation occurrence.
Results here demonstrate that both auto-conversion and the growth of non-precipitating cloud particles need to be better represented to achieve realistic precipitation rate and frequency.

Keywords: cloud, precipitation, auto-conversion, GCMs, Satellites

An Investigation of Microphysics and Sub-grid Scale Variability in Warm Rain Clouds using The A-Train Observations and A Multi-Scale Modeling Framework

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Particle-growth processes (e.g. the cloud-drizzle-rain process) in warm rain clouds play a significant role in controlling the energy budget and hydrological cycle. However, the cloud-to-precipitation process is generally not well represented by models. A common problem in climate models is that they are likely to produce rain at a faster rate than is observed and therefore produce too much light rain (e.g., drizzle). Interestingly, the Pacific Northwest National Laboratory (PNNL) multi-scale modeling framework (MMF) whose warm rain formation process is more realistic than other global models, has the opposite problem: the rain formation process in PNNL-MMF is less efficient than the real world. To better understand the microphysical processes in warm cloud, this study evaluates warm cloud properties, subgrid variability, and microphysics, using A-Train satellite observations to identify sources of model biases in PNNL-MMF. Like other models PNNL-MMF under-predicts the warm cloud fraction with compensating large optical depths. Associated with these compensating errors in cloudiness are compensating errors in the precipitation process. For a given liquid water path, clouds in the PNNL-MMF are less likely to produce rain than are real world clouds. However, when the model does produce rain it is able to produce stronger precipitation than reality. As a result, PNNL-MMF produces about the correct mean rain rate with an incorrect distribution of rates. The sub-grid variability in PNNL-MMF is also tested and results suggest that the possible sources of model biases are likely to be due to errors in its microphysics or dynamics rather than errors in the sub-grid scale variability produced by the embedded cloud resolving model.

Keywords: Warm rain clouds, Microphysical process, Sub-grid scale variability, A-Train observations, Multi-scale modeling framework

The Bias of South China Sea Summer Monsoon Precipitation Associated With Physical Processes in Global Climate Models: The Multi-year Hindcast Approach

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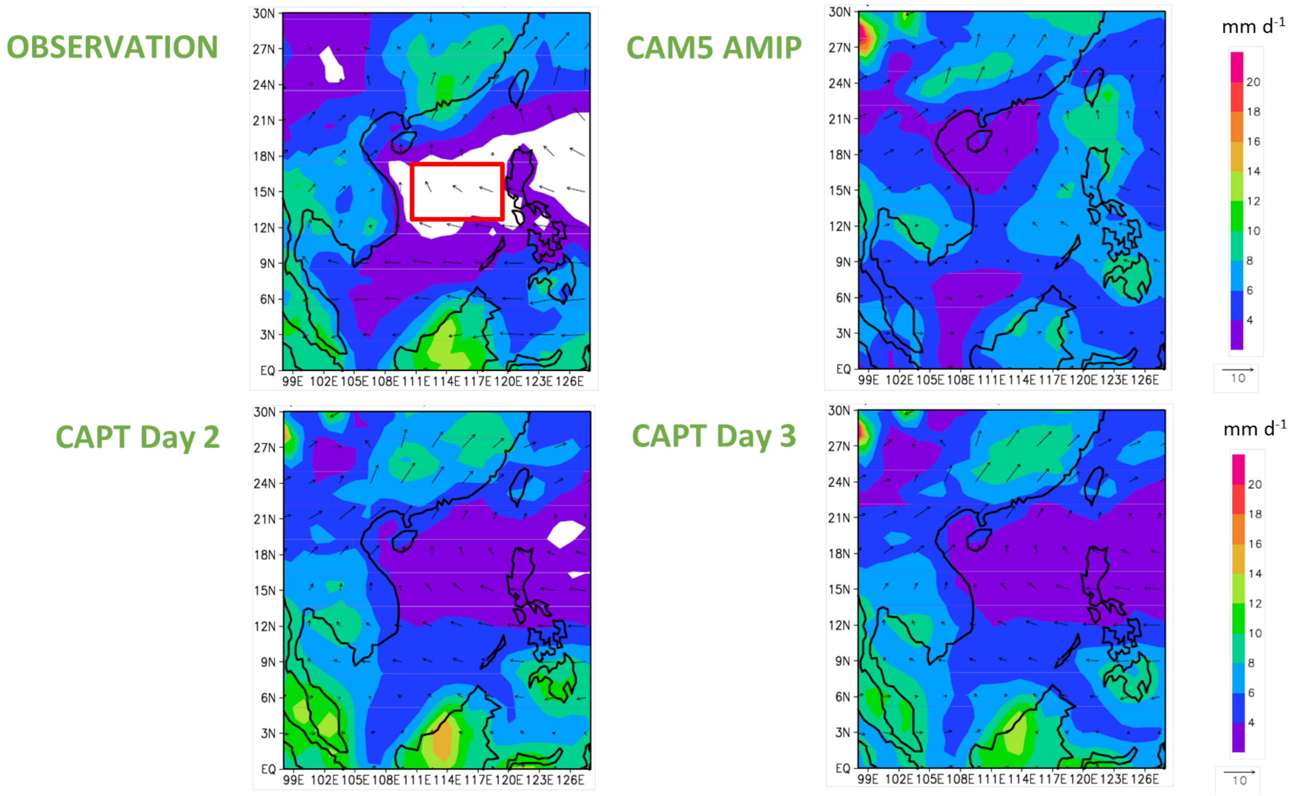
The multi-year hindcasts, initialized from the ERA-Interim reanalysis, allow for evaluating the simulated monsoon system given a well-constrained large-scale state at the exact period surrounding the abrupt onset each year over the South China Sea (SCS), a key precursor of the overall East Asia summer monsoon onset. With this experiment, one can better attribute model biases to interactions among parameterizations of fast physical processes, such as the boundary layer turbulence, shallow and deep convective parameterizations. Compared with the observation data, Community Atmospheric Model v.5 simulates excess convective precipitation over SCS and the western Pacific during the pre-onset period, where the environment is mostly suppressed by subsidence of the subtropical high ridge but with high sea surface temperature. The moisture tendency budget analysis reveals the existence of a wet tendency bias in the lower troposphere caused by the interactions among the fast physical processes. We hypothesize that this moist bias enhances the convective instability and produces the precipitation bias, hence the early onset of SCS monsoon. In the future, idealized cloud resolving model simulations will be carried out using the pre-onset, suppressed conditions, and the statistics from cloud resolving model simulations can then be compared with outputs of physical parameterizations in the global climate model to identify potential areas for improvement.

Keywords: precipitation, monsoon, GCM, CRM

Pre-onset bias: Day2 → Day3 → AMIP



Cloud, Precipitation and Radiation over the Tibetan Plateau and its Neighboring Areas

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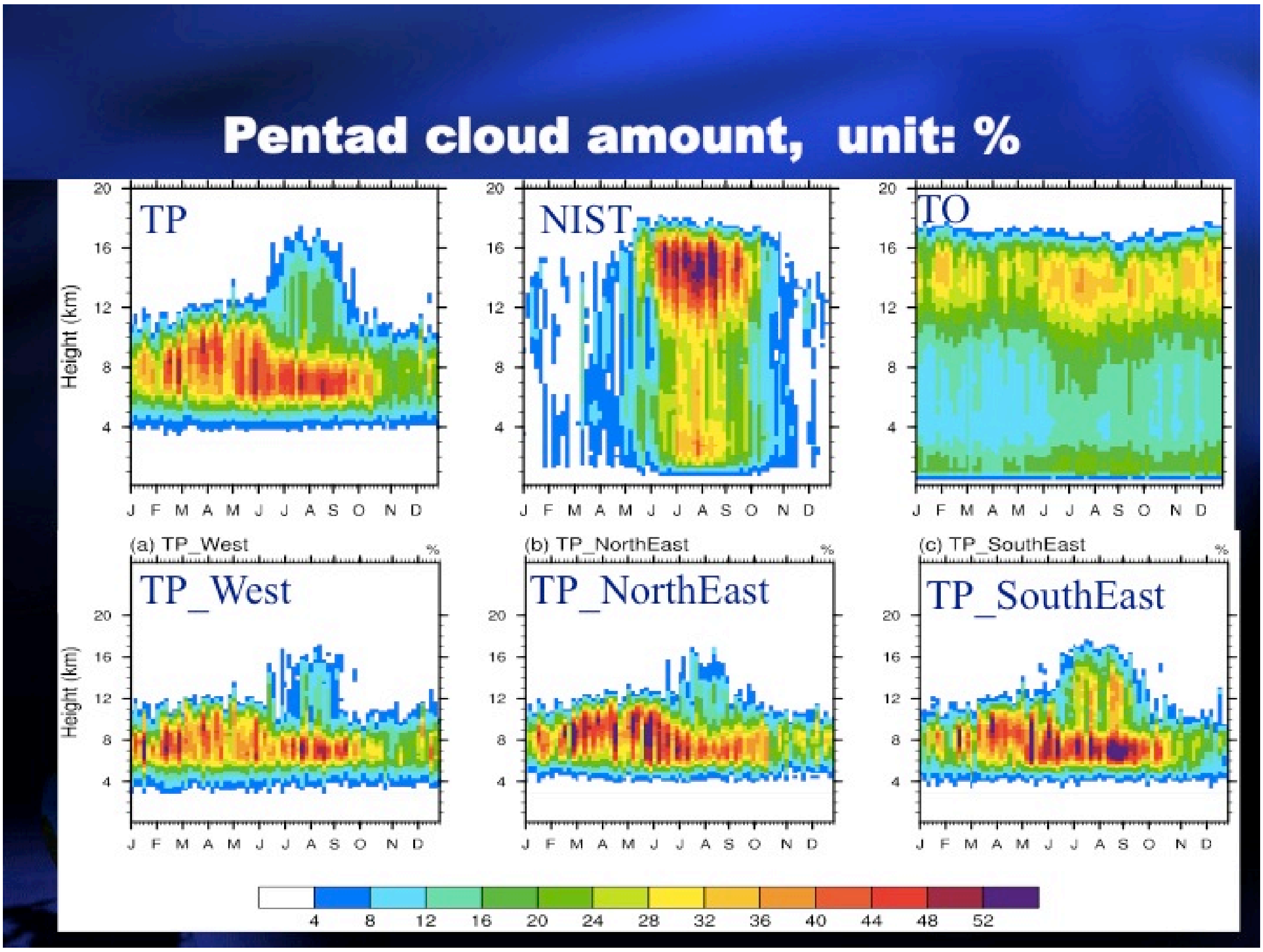
By using CloudSat/CALIPSO and TRMM data, the characteristics of cloud vertical structure over the Tibetan Plateau (TP), its southern adjacent land (southern region) and the tropical region are comparatively analyzed. The cloud vertical structure over the TP and its southern region shows significant seasonal variation. In the TP, the cloud amount presents a single peak in January-April, while two peaks after mid-June, and resumes one peak after mid-August. In the southern region, the cloud occurs rarely from October to April, and the cloud amount is mostly below 4% ; while from May to September, the cloud is located at 10-17.5 km and the amount are more than 44%, which is the largest among the three regions. In the tropical region, the cloud is located stably through whole year. Due to the TP restrictions on moisture supply in lower level, there is a significant compression of cloud thickness, cloud layers, as well as cloud top height, so the possible precipitation intensity is smaller over the TP than the other two regions. The variation range of cloud thickness, cloud layers number and cloud top height corresponding to different precipitation intensity is significantly smaller over the TP than the other two regions. In summer, deep convection cloud, which can reach 12-16 km altitude, is significantly smaller over the TP than the other two regions, while the relatively shallow cloud, located in 5-8 km and corresponding to mixed phase cloud water content, appears much more than the other two regions. These significant differences of cloud microphysical characteristics over the TP and other regions may have impacts on the radiation and precipitation. Our results can be applied on the improvements of model simulation on the cloud characteristics and precipitation.

Keywords: Cloud, Precipitation, Radiation, the Tibetan Plateau


Pentad cloud amount, unit: %
TP
NIST
TO
Height (km)
J F M A M J J A S O N D
(a) TP_West
TP_West
(b) TP_NorthEast
TP_NorthEast
(c) TP_SouthEast
TP_SouthEast
4 8 12 16 20 24 28 32 36 40 44 48 52

Ensemble super-parameterization for subseasonal-to-seasonal prediction

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The sub-seasonal forecast timescale, which has long been known as the “predictability desert”, is receiving more interest from most weather forecasting centers in the recent decade. A major reason is due to improved representation of climate modes of variability that act as important potential sources of predictability at these timescales, such as the Madden-Julian Oscillation (MJO) and other tropical modes. Convection and cloud processes play a key role in the dynamics of the tropical atmosphere, especially in the MJO. Despite significant improvements in global modeling over the last three decade, our shortcomings in parameterising convection in global climate models (GCMs) are limiting our ability to simulate and understand the climate and weather of the planet. Recent innovative ideas on convection parameterisation such as super-parameterisation (embedding cloud resolving models within the GCM grid) or stochastic-parameterisation implemented in the ECMWF climate model has helped improve the model’s representation of the climate and weather systems. These two approaches in convection parameterisation have emerged as new paths forward and complement the conventional approaches rather than replace them. We study the impact of these two approaches and a combination of the two on forecasts from weather to sub-seasonal timescales with ensemble forecasts over a 20-year time period. Results from evaluation of forecast skill in the Tropics and for organized convective systems such as the MJO will be presented. We show that the combination of the two approaches helps improve reliability of forecasts of certain tropical phenomena, especially in regions that are mainly affected by deep convective systems. We will also present studies on how these new approaches impact the forecast of clouds and precipitation processes and their interaction with the dynamics. This has implications on improving conventional convection parameterisation using hybrid approaches for probabilistic earth system forecasting as we await the exascale computing systems of the future to resolve convective processes in climate models.

Keywords: convection, precipitation, weather forecasting

Improvements of the Eastward Propagation of the MJO in MIROC6

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A new version of the atmosphere–ocean general circulation model cooperatively produced by the Japanese research community, known as the Model for Interdisciplinary Research on Climate (MIROC6), has recently been developed. Many aspects of the Madden Julian Oscillation (MJO) simulations are improved compared with its previous version MIROC5. For example, MJO amplitudes underestimated in MIROC5 are enhanced; the MJO convective envelopes over the Indian Ocean, which often decays too early around the Maritime Continent in MIROC5, propagate farther to the Central Pacific; the vertical structure of the MJO related humidity shows more realistic stepwise moistening associated with the transition from shallow convection to deep convection. Our preliminary analyses indicate that these improvements are associated with a newly implemented shallow convection scheme. The shallow convection in MIROC6 transports the boundary layer moisture to the lower free troposphere, mitigating dry biases around 800hPa over the Western Pacific. MIROC6 also shows improvements in climatological mean precipitation and shallow cloud distribution.

Keywords: MJO, climate model MIROC6, convection

Impacts of entrainment model in cumulus parameterization on atmospheric general circulation

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Entrainment model is a key parameterization in cumulus parameterization since entrainment affects structure and formation of convective clouds, and thus has influences on atmospheric general circulation. In the past studies, several entrainment models have been proposed based on observation and results of cloud-resolving model simulations. However, there still coarse and inconsistent assumptions exist in those modeling. Considering drawbacks in the modeling procedures, long-range cloud-resolving model simulation was performed and detailed, statistical convective cloud structure was analyzed. Based on the analysis, entrainment model which can represent statistical structure of convective clouds and can be used with detrainment model in cumulus parameterization was proposed.
The new entrainment model was implemented into a spectral cumulus parameterization, and was compared with one of the recent entrainment models used in some cumulus parameterizations. The physical performance of the models was examined using AMIP experiment. The results indicated that the new model could simulate better climatology in terms of the annual mean states of atmospheric circulation. Significant difference in simulated results between two models appeared in vertical profiles of entrainment. Since existing model parameterized entrainment so that it is directly proportional to in-cloud buoyancy, the entrainment especially in low altitude was overestimated, resulting in too much low cloud amount. The new model suppresses the trend due to the consideration of detrainment effect into estimation of entrainment. Finally, further analysis revealed that the new formulation of currently proposed model also could contribute to the improvement of atmospheric variability.

Keywords: entrainment, cumulus parameterization, atmospheric general circulation

A study on Cloud Microphysics for Remote Sensing Data Assimilation

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A new km-scale hybrid-4DVar data assimilation system is being developed to improve short-range precipitation forecasts at the Japan Meteorological Agency. One of the purposes of developing this system is to enable the assimilation of observations related to hydrometeors. For the assimilation of such observation, a new simplified 6-class 3-ice 1-moment bulk cloud microphysics scheme suitable for the tangent linearization has been developed. This cloud microphysics scheme is tuned to reduce the forecast bias of hydrometeors profile by updating the assumption of ice and snow particles. In this revision, the shape assumption of ice and snow is changed from spherical particle to non-spherical particle, and the particle size-distribution of snow is changed from negative-exponential distribution to negative-exponential and+ modified gamma distribution. The unbiased attribution of hydrometeors is very important for the appropriate assimilation of the observation as well as the improvement of precipitation forecast.
A traditional 4DVar uses climatological background error covariance. However, the errors of hydrometeors are correlated each other, and the error correlation depends strongly on meteorological situations. To consider such flow-dependency, the background error covariance of hydrometeors is constructed using ensemble perturbations in the new hybrid-4DVar data assimilation system. Using this km-scale hybrid-4DVar data assimilation system, the impact of space-borne radar and radiance data was investigated. The results of this investigation will be presented.

Convective cloud-top vertical velocity estimated from geostationary satellite rapid-scan measurements

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We demonstrate that the development rate of cumulus clouds, as inferred from so-called geostationary satellite "rapid-scan" measurements, is a good proxy for convective cloud-top vertical velocity related to deep convective clouds. Convective cloud-top vertical velocity is estimated from the decreasing rate of infrared brightness temperature observed by the MTSAT-1R satellite over the ocean south of Japan during boreal summer. The frequency distribution of the estimated convective cloud-top vertical velocity at each height is shown to distribute lognormally and is consistent with the statistical characteristics of direct measurements of cumulus updrafts acquired in previous studies. We have commenced a follow-up study using data from a new Japanese geostationary satellite (Himawari-8), which is capable of routine full-disk observations with 10-minute interval and 2-km spatial resolution.

Keywords: cumulus, vertical velocity, geostationary satellite, rapid scan

Spatial variability of summer monsoon raindrop size distribution over Western Pacific Ocean.

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Raindrop size distribution (RSD) characteristics in summer monsoon (June to August) rainfall of two observational sites [Taiwan (24° 58’ N, 121° 10’ E), Palau (7° 20’ N, 134° 28’ E)] in Western Pacific region are studied by using four years of impact type disdrometer data. In addition to disdrometer data, TRMM, MODIS, ERA-Interim data sets are used to illustrate the dynamical and microphysical characteristics associated with summer monsoon rainfall of Taiwan and Palau. Significant differences between raindrop spectra of Taiwan and Palau rainfall are noticed. Palau rainfall is associated with higher concentration of small drops when compared to Taiwan rainfall. RSD of Taiwan and Palau rainfall are fitted to gamma distribution. RSD stratified on the basis of rain rate showed higher mass weighted mean diameter (D_m) and lower normalized intercept parameter ($log_{10}N_w$) in Taiwan than Palau rainfall. Even after classifying the precipitation in stratiform and convective regimes, Taiwan rainfall showed higher D_m values than Palau rainfall. Furthermore, the mean value of D_m is higher in convective precipitation as compared to stratiform precipitation for both the locations. Radar reflectivity (Z) and rain rate (R) relations ($Z= A*R^b$) derived for Taiwan and Palau showed a clear variations in the coefficient with less variation in exponent values. Terrain influenced clouds extended to higher altitudes over Taiwan resulted with higher (lower) D_m ($log_{10}N_w$) values in Taiwan rainfall as compared to Palau.

Keywords: Raindrop Size Distribution (RSD), mass weighted mean diameter, Normalized intercept parameter.

Characteristics and Environmental Properties of Warm-Season, Quasi-Stationary Mesoscale Convective Systems in Japan

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1. Disaster Prevention Research Institute, Kyoto University

Mesoscale convective systems (MCSs) are one of the major mesoscale disturbances and sometimes spawn heavy rainfall/snowfall and high winds locally. MCSs occur over the various regions of the world in any season and take various forms such as a circular shape and a linear shape. Because of their potential impacts on the human society, diagnosing and predicting the development of MCSs are very important. For this purpose, it is required to obtain basic understandings on the characteristics and environmental properties of MCSs. We conducted statistical analyses by using operational radar and radiosonde data in order to reveal the characteristics and environmental properties of stationary or slow-moving MCSs during a warm season in Japan from a climatological point of view (Unuma and Takemi 2016a, 2016b). The analysis period was from May to October, referred to as the warm season here, during 8 years of 2005-2012. It was found that the MCSs in Japan have smaller spatial scales than those in midlatitude continental regions. We call such warm-season, stationary MCSs as quasi-stationary convective clusters (QSCCs). The environmental conditions for the development of QSCCs were described through a comparison with those for no-rain cases. With the use of an automated QSCC identification method by Shimizu and Uyeda (2012), 4133 QSCCs were extracted over the Japanese major islands. It was found that QSCCs are typically meso-β-scale phenomena. From the analyses of the shapes of QSCCs with the use of an automated shape-determining algorithm, it was shown that most of QSCCs have an elongated structure with the southwest—northeast orientation. The environmental analyses indicated that low-level moisture content controls the stability condition for the development of the QSCCs, and that the differences in the magnitude and directional shear of horizontal winds in the lower troposphere characterize the kinematic environments for QSCCs. An increased amount of the middle-level moisture was found for the QSCC environments, suggesting that atmospheric moistening is an important factor for the development of QSCCs. The vertical shear in the lower troposphere also controls the shape of QSCCs: circular mode versus elliptical mode. From the examination of the relationship between radar precipitation intensity and environmental conditions, it was found that the precipitation intensity has a higher correlation with the convective instability, whereas the precipitation area with the shear intensity. From the analyses, it was indicated that a stability condition plays a role in determining intensity of QSCCs while a shear condition tends to control the shape of QSCCs. This feature led us to conclude that a parameter combining shear and stability, i.e. bulk Richardson number, clearly distinguishes between the organization modes. It is suggested that the back-building process is one of the key factors in determining the organization mode. We have shown that the operational meteorological data are quite useful in studying the characteristics of MCSs. With the further advances of observation techniques and numerical modeling in accuracy and spatio-temporal resolution, the analyses on the characteristics and environmental conditions of MCSs and their precipitation characteristics are expected to be extended to MCSs for various regions of the world.

Keywords: convection, precipitation, environmental condition

Role of orography, diurnal cycle, and intraseasonal oscillation in summer monsoon rainfall over Western Ghats and Myanmar coast

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1. Kyoto University

Rainfall over the coastal regions of western India (Western Ghats; WG) and Myanmar (Arakan Yoma; AY), two regions experiencing the heaviest rainfall during the Asian summer monsoon, is examined using a Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar (PR) dataset spanning 16 years. Rainfall maxima are identified on the windward slopes of the WG and the coastlines of AY, in contrast to the offshore locations observed in previous studies.

The rainfall in the WG and AY regions exhibits low diurnal variability, implying that the rainfall is not primarily driven by thermal convection, but by mechanical convection. Large rainfall amounts with small diurnal amplitudes are observed over the WG and AY under strong environmental flow perpendicular to the coastal mountains, and vice versa. Diurnal-driven mitigating systems are observed over the WG under weak environmental flow, but do not determine the seasonal distribution of summer monsoon rainfall, explaining why the rainfall maxima are not observed offshore.

Composite analysis of the boreal summer intraseasonal oscillation (BSISO) shows that the rain anomaly over the WG slopes lags behind the northward propagating major rain band. The cyclonic systems associated with the BSISO introduces south-west wind anomaly behind the major rain band, enhancing the orographic rainfall over the WG, and resulting in the phase lag. This lag is not observed in the AY region where more closed cyclonic circulations occur. Diurnal variations in rainfall over the WG regions are smallest (largest) during (preceding) the strongest BSISO rainfall anomaly phase.

Observational and Numerical Study on Terrain-induced Heavy Rainfall in Mt. Jiri, Korea

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During a summer monsoon season every every, severe weather phenomena caused by front, storm, mesoscale convective systems (MCSs), or typhoons influence the Korean Peninsula. Especially mountains that cover a large part of the Korean territory play an important role in controlling formation, amount, and distribution of rainfall. As convective systems move over mountains, they tend to intensify more and produce locally heavy rainfall. Observation data in mountainous areas is essential for studying terrain effects on the rapid development of rainfall.

In order to understand developing and decaying mechanisms of precipitation systems that pass over the mountain, we performed Orographic Rainfall Experiment (OREX) around Mt. Jiri (1950 m above sea level) during summertime on June and July 2015-2016 in the southern Korean Peninsula. Observation data from seven Parsivel disdrometers, three ultrasonic anemometers (measuring winds), and radiosondes were analyzed during periods of Typhoon Chanhom on July, 2015 and the heavy rain event on 1 July 2016. A dual-Doppler analysis was also conducted to retrieve three-dimensional wind fields in this mountain area. Vertical structure of radar reflectivity and winds (especially vertical velocity) within the precipitation systems moving over Mt. Jiri was examined. For comparing with retrieved vertical velocities, we developed a technique to derive vertical velocities from fall velocity and drop size spectra measured by the Parsivel disdrometers. From the comparison of vertical velocities between the Parsivel and anemometer, we found that upward motions were dominant in the windward side and the areas of upward motions were nearly coincident to those of a large amount of rainfall accumulation. During the periods of updrafts, rainfall rates and mean drop diameter were larger than those during the periods of downdrafts. We digitized these updraft periods as percentage, dividing them by the total rainfall period and these percentage values would be useful for inducing an area of updrafts around the mountain. Also, variances of Parsivel-measured fall velocities per each diameter bin, which are related to turbulent air intensity, were found to be larger when surface winds were stronger.

To find important atmospheric factors affecting the orographic rainfall enhancement we performed numerical study by assimilating observation data to a model. For validating model results with better accuracy, surface measurements as well as rainfall data from the field observations were used.

Acknowledgements

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Keywords: Orographic rainfall, Atmospheric factors

Observational and Numerical Study on Terrain-induced Heavy Rainfall in Mt. Jiri, Korea

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[2]Department of Environmental Atmospheric Sciences, Pukyong National University, Korea
[3]HM&Co, Ecole des Ponts ParisTech, Marne-la Vallée, France.

Abstract

During a summer monsoon season each every, severe weather phenomena caused by front, storm, mesoscale convective systems (MCSs), or typhoons influence the Korean Peninsula. Especially mountains that cover a large part of the Korean territory play an important role in controlling formation, amount, and distribution of rainfall. As convective systems move over mountains, they tend to intensify more and produce locally heavy rainfall. Observation data in mountainous areas is essential for studying terrain effects on the rapid development of rainfall.

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Three-dimensional analyses of initial stage of convective precipitation using two X-band polarimetric radars

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Convective precipitation rapidly develops and often brings about localized torrential rain which cause flooding and landslides. The polarimetric radar is one of the key instruments for precipitation study, since it provides kinematic properties of precipitation developments as well as information on microphysical process in the precipitation. The present study uses two X-band polarimetric radars to understand the initiation process of convective precipitation. However, the volumetric data of X-band radar currently available is 5 min interval data which is not enough for studying initial stage of developing convective cell. In this study, to investigate three dimensional structure of convective cell in early stage, we developed an algorithm based on the interpolation method in both space and time. The algorithm produces three dimensional high spatio-temporal resolution CAPPI data using two X-band polarimetric radars (3D CAPPI). The mosaic of two radars has an advantage to construct whole images of precipitation compared to single radar analysis. The algorithm is applied a localized convective precipitation observed in Kanto area of Japan on 19 July 2012. The 3D CAPPI gives us detailed structure of rapidly developing convective cell and provides quantitative information on echo top height, maximum reflectivity, and first observation time of each cell. Using mosaic 3D CAPPI information, the present study clearly shows the back-building process at the initial stage of convective precipitation. In initial stage, the three dimensional analyses of convective precipitation could be helpful to detect the first core of cell and develop a short-term forecasting model.

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Keywords: localized convective precipitation, X-band polarimetric radar, high resolution, initial stage

Precipitation processes revealed from hydrometeor measurements by videosondes

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Videosonde is one of strong tools to measure hydrometeors in clouds directly. It is a balloon-borne radiosonde that acquires images of precipitation particles via a CCD camera. The system has a stroboscopic illumination that provides information on particle size and shape. Interruption of the infrared beam by particles triggers a flash lamp and particle images are then captured by the CCD camera. Precipitation particles are classified as raindrops, frozen (or partly melted) drops, graupel, ice crystals, or snowflakes on the basis of transparency and shape. One of the advantages for the videosonde is to capture images of precipitation particles as they are in the air because the videosonde can obtain particle images without contact.
Videosonde observations of Baiu monsoon clouds have been conducted from 2007 to 2016, as part of the in-situ campaign observation by a C-band polarimetric radar synchronized with videosonde, which were carried out at Okinawa Electromagnetic Technology Center of National Institute of Information and Communications Technology (26º29′N, 127º50′E). In the case of May 20, 2012, a Baiu stationary front was located over the Okinawa Island, and we experienced heavy rain of 71.1 mm from 09 JST to 13 JST. Six videosondes were launched into the different developing stages of the rainband. In the cases of the developing stage, frozen drops were observed from 0ºC to -15ºC. Graupel were also detected in the same altitude. On the other hand, in the mature stage, we observed them between 5ºC and 0ºC layer, and graupel were dominant in between 0ºC and -5ºC. It was supposed that freezing processes and graupel formation processes near the 0ºC was different in the different developing stages.
We also carried out the videosonde observation at Bengkulu (3.86ºS, 102.3ºE), Indonesia from November 24 to December 15, 2015 for the better understanding of microphysical precipitation processes of tropical convection, which were conducted as a part of Pre-YMC field campaign. In the case of November 30, 2015, we experienced a strong rain associated with diurnal variation with convection along the coastline of Sumatera Island. A videosonde was launched into this convective cloud with cloud top 9 km. It transmitted images of large raindrops up to 6 mm in diameter in the lower level, and nearly round frozen drops and graupel above the freezing level. This was a typical tropical convective cloud characterized by the warm rain and freezing process.

Keywords: precipitation process, cloud microphysics, videosonde

Thundercloud electric field fine structure and lightning initiation

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It is well known that the amplitude of the electric field measured in a thundercloud, is an order of magnitude less than the threshold value, which is necessary for the conventional electrical breakdown of air. This fact turns the lightning initiation question in one of the most intriguing problem of thunderstorm electricity. In this work, initiation of lightning in a thundercloud is regarded as a noise-induced kinetic transition. As a source of the noise we consider the collective stochastic electric field of charged hydrometeors. The intensity of the noise is equal to the product of hydrometeors concentration with the variance of their charge magnitude. Above-critical bursts of the stochastic field provide the appearance of elevated-conductivity areas and turn the cloud medium into a strongly inhomogeneous random mixture of highly conductive areas with poorly conducting, almost dielectric regions. Thus we reduce the consideration of lightning initiation to the dielectric breakdown problem in random conductor-insulator composites. The sensitivity of the dielectric breakdown field on the conductor fraction in the material is caused by the formation of conductive percolation clusters which act as equipotential for an applied quasi-static electric field. For a given applied field, a larger and larger local field is concentrated across the space between relatively large conductive clusters. The breakdown field is of order the inverse of the linear dimension of the largest of these percolation clusters. Since the size of the clusters diverges as the volume fraction of conductor tends to the percolation threshold value, the breakdown field tends to zero in this limit. In addition, the average breakdown electric field decreases logarithmically with the linear dimension of the system when the volume fraction of good conductor is below the percolation threshold. The proposed kinetic mechanism of the initiation of the lightning discharge provides both amplification of the local electric field in a thundercloud, and self-consistent support of the discharge process under the conditions when the free electrons attachment dominates over their production in ionization process.

Keywords: thundercloud, lightning initiation, charged hydrometeors