Tropical Meteorology Meeting 2016

Hosted by: Tropical Meteorology Research Group, The Meteorological Society of Japan

Local host: Disaster Prevention Research Institute, Kyoto University

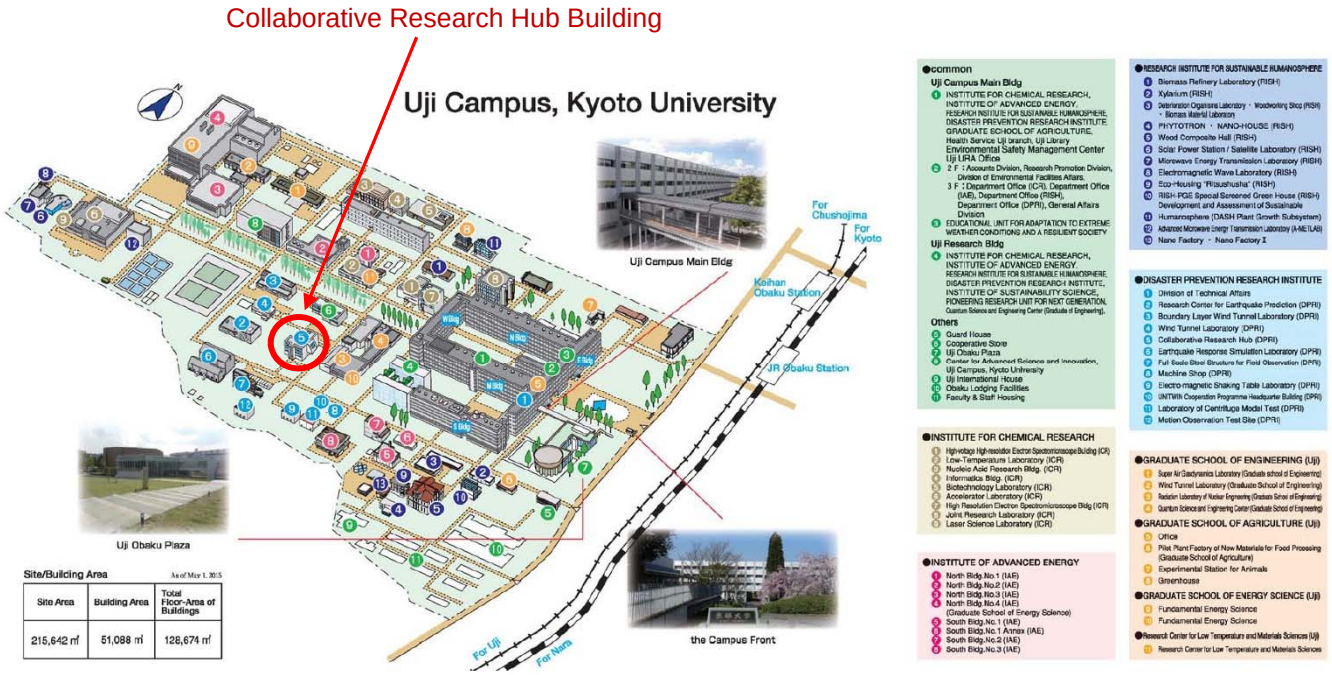
Venue: 3rd floor, Collaborative Research Hub Building, Disaster Prevention Research Institute

Uji Campus, Kyoto University, Gokasho, Uji, Kyoto

京都大学 宇治キャンパス 防災研究所 連携研究棟 3 階大セミナー室

(See the map below; the building #5 indicated by skyblue)

Date: 29－30 September 2016



Agenda

Thursday, September 29

13:00-13:10		Opening address	Yukari Takayabu	Atmosphere and Ocean Research Institute, the University of Tokyo

Session 1 (Chair: Tetsuya Takemi)

13:10-13:40	S01	The effects of inefficient congestus precipitation on tropical convective dynamics	Hirohiko Masunaga* and Yukari Sumi	ISEE, Nagoya University

13:40-14:10	S02	Gravity-wave class forced/trapped along maritime continent coastline: A quick look of Pre-YMC observation	M. D. Yamanaka*, S.-Y. Ogino, K. Yoneyama (1), Bengkulu Observation Team (1, 2, 3, 4) and Mirai Observation Team (1)	1 JAMSTEC, 2 TMU, 3 BPPT, 4 BMKG
14:10-14:40	S03	Diurnal cycle and its modulation by MJO observed during Pre-YMC field campaign	Satoru Yokoi*(1), Shuichi Mori(1), Masaki Katsumata(1), Kazuaki Yasunaga(1,2), and Kunio Yoneyama(1)	1 JAMSTEC, 2 Toyama Univ.
14:40-15:10	S04	How much is the precipitation amount over the tropical coastal region?	Shin-Ya Ogino*, Manabu D. Yamanaka, Shuichi Mori, and Jun Matsumoto	JAMSTEC

15:10-16:10 Poster viewing and break

Session 2 (Chair: Hirohiko Masunaga)

16:10-16:40	S05	Role of orography, diurnal cycle and intraseasonal oscillation in the nature of summer monsoon rainfall over the western Ghats and the Myanmar coast	Shoichi Shige*, Yuki Nakano and Munehisa K. Yamamoto	Kyoto University
16:40-17:10	S06	The vertical modes and the effective stability of quasi-2-day waves	Yukari Sumi*(1), Hirohiko Masunaga(2)	(1) Graduate School of Environmental Studies, Nagoya University (2) ISEE, Nagoya University
17:10-17:40	S07	Reexamination of the concept of "Walker Circulation" --implication from the variety of large-scale tropical atmospheric response to equatorial SST anomaly in Aquaplanet Experiment --	Kensuke Nakajima*(1), Masahiro Kanda(1), Kotaro Takaya(2), Masaki Ishiwatari(3), Wataru Ohfuchi(5), Yoshiyuki O Takahashi(4) and Yoshi-Yuki Hayashi(4)	1: Kyushu University, 2: Kyoto Sangyo University, 3: Hokkaido University, 4: Kobe University, 5: JAMSTEC

18:30-20:30 Banquet

Friday, September 30

Session 3 (Chair: Kazuaki Yasunaga)

9:00-9:30	S08	Initiation processes and structures of intraseasonal variability simulated in an aqua-planet	Daisuke Takasuka*, Masaki Satoh	Atmosphere and Ocean Research Institute, the University of Tokyo
9:30-10:00	S09	Effects of the subtropical jet and lower-tropospheric convective instability on precipitation characteristics in the Baiu season	Chie Yokoyama* and Yukari N. Takayabu	Atmosphere and Ocean Research Institute, the University of Tokyo
10:00-10:30	S10	Evaluation of relationship between subtropical marine low stratiform cloudiness and estimated inversion strength in CMIP5 AMIP simulations using COSP	Tsuyoshi Koshiro*, Hideaki Kawai, and Seiji Yukimoto	Meteorological Research Institute
10:30-11:00	S11	A preliminary analysis of ENSO-Asian monsoon coupling on an interannual timescale in GCMs	Hiroshi G. Takahashi*(1,2), Nozomi Kamizawa(1)	(1)Tokyo Metropolitan University, (2)JAMSTEC

11:00-12:00 Poster viewing

12:00-13:00 Lunch

Session 4 (Chair: Shoichi Shige)

13:00-13:30	S12	The lack of westerly wind bursts in unmaterialized El Niño years and its relation to background wind states	Ayako Seiki*, Yukari N. Takayabu, Takuya Hasegawa, and Kunio Yoneyama	DCOP/JAMSTEC

13:30-14:00	S13	Role of stratospheric cooling on the tropical troposphere and the ocean	K. Kodera*(1), N. Eguchi(2), and R. Ueyama(3)	1: Nagoya University, Institute for Space-Earth Environmental Research, Nagoya, Japan 2: Research Institute for Applied Mechanics, Kyushu University, Kasuga, Japan 3: NASA Ames Research Center, Moffett Field, CA 94035, USA
14:00-14:30	S14	Impacts of vertical structure of convection on circulation change under global warming	Chao-An Chen*(1), Jia-Yuh Yu(2) and Chia Chou(1,3)	1: Research Center for Environmental Changes, Academia Sinica, Taipei, Taiwan; 2: Department of Atmospheric Sciences, National Central University, Taoyuan City, Taiwan; 3: Department of Atmospheric Sciences, National Taiwan University, Taipei, Taiwan
14:30-15:00	S15	High cloud size dependency in the applicability of the fixed anvil temperature hypothesis using global nonhydrostatic simulations	A. T. Noda*, T. Seiki, M. Satoh, and Y. Yamada	JAMSTEC
15:00-15:30	S16	Recent increase of early-winter precipitation in the Hokuliku area and its linkage with rainfall in the eastern Indian Ocean and western Pacific Ocean	Kazuaki Yasunaga* and M. Tomochika	University of Toyama
15:30-15:40	Closing address		Masaki Satoh	Atmosphere and Ocean Research Institute, the University of Tokyo

Poster Presentations

P01	Characteristics of precipitation systems observed with the GPM DPR and their relationship with environmental moisture field	Marika Ono* and Yukari Takayabu	Atmosphere and Ocean Research Institute, the University of Tokyo

P02	A Statistical analysis of precipitation feature over oceanic areas adjacent to continents in the tropics from TRMM data	Miho Fujishima* and Yukari Takayabu	Atmosphere and Ocean Research Institute, the University of Tokyo
P03	The Difference of Vertical Profiles of Stratiform Precipitation in Tropical and Mid-latitude	Kazuki Kobayashi*, Shoichi Shige and Munehisa K. Yamamoto	Kyoto University
P04	Potential impact of sea surface temperature on Rainfall over the western Philippines	Julie Mae B. Dado*(1) , Hiroshi G. Takahashi(1,2)	1 Department of Geography, Tokyo Metropolitan University, Tokyo, Japan 2 Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan
P05	Convective cloud top vertical velocity estimated from geostationary satellite rapid-scan measurements	Atsushi Hamada* and Yukari N. Takayabu	Atmosphere and Ocean Research Institute, the University of Tokyo
P06	Use of operational meteorological data to reveal the characteristics and environmental properties of quasi-stationary mesoscale convective systems	Takashi Unuma and Tetsuya Takemi*	Disaster Prevention Research Institute, Kyoto University

Abstract

The effects of inefficient congestus precipitation on tropical convective dynamics

Hirohiko Masunaga* and Yukari Sumi
ISEE, Nagoya University

It is well known that vigorous tropical convection is fed largely by moisture convergence, producing heavy rainfall overwhelming the local moisture supply through surface evaporation. During such convective events, a substantial portion of moisture convergence often occurs above the lifting condensation level (LCL) and hence the condensation from any cumulus clouds rooted in the sub-cloud layer would seemingly account only for a minor fraction of the total precipitation even at the intensifying stage of convective organization. To address this question, DYNAMO/CINDY2011/AMIE sounding array data are analyzed to study the moisture and thermal budget of the tropical atmosphere with a vertical mode decomposition applied to the soundings. As expected, the variation of vertical motion is primarily governed by the first baroclinic mode. The second and higher modes, although minor in amplitude, also exhibit familiar features from time to time: a buildup of the "congestus mode" as convective intensifies, which gives way to the "stratiform mode" as convection dissipates. In this work, a simple diagnostic model is developed to interpret the observed behaviors. The “precipitation inefficiency”, or the fraction of the congestus-mode moisture convergence that goes into the vapor storage, appears to be a key parameter that characterizes the evolution of large-scale thermodynamics as convection develops and dissipates.

Gravity-wave class forced/trapped along maritime continent coastline: A quick look of Pre-YMC observation

M. D. Yamanaka*, S.-Y. Ogino, K. Yoneyama (1), Bengkulu Observation Team (1, 2, 3, 4) and Mirai Observation Team (1)

1 JAMSTEC, 2 TMU, 3 BPPT, 4 BMKG

Atmospheric waves of the first class (inertio-gravity and Kelvin waves, following classification by Matsuno, 1970) are analyzed from 3-hourly radiosonde data of the Pre-YMC observation (Nov-Dec 2015) at the both sides of the coastline near Bengkulu, Sumatera. Monochromatic analyses show (i) cloud convection (cf. Sakurai et al., 2005, 2009, 2011), (ii) diurnal-cycle sea-land breeze circulations (cf. Murata et al., 2002; Wu et al., 2003, 2008, 2009; Mori et al., 2004; Araki et al., 2006), (iii) whole tropospheric circulation longer than 1 day (cf. Okuda et al., 2002; Wu et al., 2013), (iv) tropopausal Kelvin (cf. Shimizu and Tsuda, 1997), and (v) thinner stratospheric inertio-gravity waves (cf. Yamanaka et al., 1983; Tsuda et al., 1994; Ogino et al., 1995). Vertical and temporal spectral analyses show dominant diurnal mode and stronger saturation level, both in particular in the land side. Discussions are made, for example, on the significance of bidirectional wave generation of (ii) for troposphere-stratosphere coupling.

Diurnal cycle and its modulation by MJO observed during Pre-YMC field campaign

Satoru Yokoi*(1), Shuichi Mori(1), Masaki Katsumata(1), Kazuaki Yasunaga(1,2), and Kunio Yoneyama(1)

1 JAMSTEC, 2 Toyama Univ.

In November-December 2015, we conducted Pre-YMC field campaign around western coast of Sumatra Island in Indonesian Maritime Continent, performing weather radar observation, 3-hourly radiosonde observation, etc., at Research Vessel Mirai deployed 50 km off the coast and at a coastal city, Bengkulu. In the first half of the campaign, well-known features of diurnal cycle of precipitation were observed, including afternoon heavy precipitation in land area and offshore migration of convective systems during nighttime. The purpose of this study is to examine mechanisms responsible for the offshore migration through analysis of observations.Composite analyses of radiosonde data over the vessel reveal that, before heavy precipitation tended to occur, temperature in lower free troposphere decreased earlier than that in the surface layer. Comparison between tendencies of

potential temperature and mixing ratio suggests that this temperature decrease was likely caused by ascent motion. Indirect evidence for the low-level ascent is also given by comparison of horizontal wind profile between the vessel and Bengkulu. We argue that this ascent was due to gravity waves which had propagated from the direction of land, and probably provided favorable condition for convection. These results suggest a possibility that the gravity waves played significant roles in the diurnal offshore migration.

How much is the precipitation amount over the tropical coastal region?

Shin-Ya Ogino*, Manabu D. Yamanaka, Shuichi Mori, and Jun Matsumoto

JAMSTEC

Motivated by observational evidence of rainfall concentration near tropical coastlines with diurnal cycle, we quantified annual mean precipitation amount in the tropics (latitudes lower than 37 degrees) obtained as a function of coastal distance, and compared them between land and ocean sides. The data is from the Tropical Precipitation Measurement Mission (TRMM). Precipitation amount peaks at the coastline and decreases rapidly over a distance of 300 km from the coastline on both sides of the coastline. The precipitation inside the “coastal region” (defined by distance <300 km from the coastline) accounts for approximately 34% of the total over the whole tropics, while that outside the coastal region accounts for 52% and 14% on the ocean and land sides, respectively. Since the coastal regions are about 29% of the total tropical areas, the precipitation per unit area inside the coastal regions is higher than that outside. Examining the grid number variation in the coastal regions with respect to the annual precipitation amount resulted in the finding that more than 90% of the annual precipitation with the amount of 3500 mm/yr or more occurs exclusively in the coastal regions, indicating that precipitation systems unique to coastal regions are needed for producing the highest annual precipitation on the Earth.

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

Shoichi Shige*, Yuki Nakano and Munehisa K. Yamamoto

Kyoto University

Rainfall in coastal ranges of western India (Western Ghats; WG) and Myanmar (Arakan Yoma; AY), heaviest rainfall regions of the Asian summer monsoon, are examined using a Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar (PR) data set of 16 years. Rainfall maxima occurs on the slopes of WG and the west coastlines of AY, in contrast to rainfall maxima offshore estimated by previous studies. Diurnal variations of rainfall in the WG and AY regions are very weak. Large rainfall amounts but small diurnal amplitudes are observed in WG and AY under strong environmental flow perpendicular to coastal mountains, and vice versa. Diurnal-driven mitigating systems are observed under weak environmental flow, but they are not major processes that determine the seasonal distribution of summer monsoon, explaining why rainfall maxima do not occur offshore. Composite analysis of boreal summer intraseasonal oscillation (BSISO) shows that rain anomaly over the WG slope is in isolation and lags behind the northward propagating major rain band. Orographic rainfall over the WG slope is enhanced with southwesterly anomalies of the cyclonic system associated with the BSISO. Diurnal variations of rainfall over the WG regions during the convectively inactive phase of the monsoon BSISO are stronger than those during the active phase.

The vertical modes and the effective stability of quasi-2-day waves

Yukari Sumi*(1), Hirohiko Masunaga(2)

(1) Graduate School of Environmental Studies, Nagoya University, (2) ISEE, Nagoya University

Quasi-2-day waves are tropical atmospheric disturbances with a period of about 2 days. Their dynamics are explained by a convectively coupled westward inertia-gravity wave (WIG wave) which has a shallower equivalent depth (or slower propagation speed) than the dry counterparts. The slowdown of convectively coupled equatorial waves is thought to be the result of a cancellation between adiabatic cooling and diabatic heating, which reduces the effective static stability in the convective atmosphere. In this study, the change in the equivalent depth of WIG waves due to convection is investigated by using satellite and reanalysis data. Different filter designs are adapted to separate WIG waves with different equivalent depths. Peaks of the WIG waves are defined as the local minima of filtered brightness temperature and then serve as the base points of the composite time series. The composite fields are further separated by vertical modes calculated with the mean sounding from reanalysis data. The large-scale dynamical fields associated with WIG waves are explained by a superposition of the first four baroclinic modes. The cancellation between adiabatic cooling and diabatic heating is larger in the first mode than in the second and third modes. The above results are discussed in terms of the effective stability and vertical modes.

Reexamination of the concept of "Walker Circulation" --implication from the variety of large-scale tropical atmospheric response to equatorial SST anomaly in Aquaplanet Experiment --

Kensuke Nakajima*(1), Masahiro Kanda(1), Kotaro Takaya(2), Masaki Ishiwatari(3), Wataru Ohfuchi(5), Yoshiyuki O Takahashi(4) and Yoshi-Yuki Hayashi(4)

1: Kyushu University, 2: Kyoto Sangyo University, 3: Hokkaido University, 4: Kobe University, 5: JAMSTEC

Walker circulation is understood as a zonal-vertical circulation over the equator, and it is generally considered that heating anomaly is acompanied by low-level zonal convergence. However, in the SST anomaly experiments in the Aquaplanet Experiment (Neale and Hoskins, 2000), weak or negative zonal convergence is found in warm SST area (Nakajima et al, 2013). In this presentation, we will examine the sensitivity of tropical response to SST anomaly to the basic state meridional SST profile in a series of aquaplanet AGCM experiment. Results will be discussed in terms of equatorial Rossby wave dynamics in addition to Kelvin wave that has been considered to be the dynamical agent.

Initiation processes and structures of intraseasonal variability simulated in an aqua-planet

Daisuke Takasuka*, Masaki Satoh

Atmosphere and Ocean Research Institute, the University of Tokyo

Initiation processes and structures of the Madden-Julian Oscillation (MJO) are investigated thorough aqua-planet experiments by the Nonhydrostatic Icosahedral Atmospheric Model (NICAM) with 56-km mesh. In spite of the coarse resolution, the explicit cloud physics scheme is used to generate an MJO-like disturbance. MJO-like disturbances are internally produced in the zonally asymmetric fixed-SST distribution (±2K amplitude), though moist-Kelvin waves are dominant in the zonally uniform SST. It is confirmed that MJO-like disturbances frequently initiate over the western side of the warm pool. Lagged-composite analysis of MJO-like disturbances identified using only outgoing long-wave radiation anomalies suggests that initiation of MJO-like disturbances is triggered by the convergence in the boundary layer associated with negative sea level pressure anomalies, which seems to be circumnavigating Kelvin-wave signals radiated from previous MJO events. The moisture budget analysis shows that moisture accumulation in the mid-troposphere caused by horizontal advection is obvious before the realization of convective activities that lead to MJO-like disturbances, which contributes to making a favorable condition for the onset of deep convections. The horizontal advection of moisture is related to the Rossby response to negative diabatic heating. The feedback process of convective organization during the onset and the results of other experiments will also be discussed.

Effects of the subtropical jet and lower-tropospheric convective instability on precipitation characteristics in the Baiu season

Chie Yokoyama* and Yukari N. Takayabu

Atmosphere and Ocean Research Institute, the University of Tokyo

In this study, we examine how precipitation characteristics during the Baiu season are determined by large-scale environments such as the subtropical jet (STJ) and lower-tropospheric convective instability (LCI), using the Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar data. First, two types of mesoscale rainfall events (REs, contiguous rainfall areas) are identified; moderately stratiform REs (stratiform precipitation ratios of 0-80%) and highly stratiform REs (80-100%). Highly and moderately stratiform REs are found to represent mid-latitude precipitation systems associated with extratropical cyclones and tropical organized precipitation systems, respectively. As the STJ becomes strong, rainfall from both types increases, with a distinct eastward extension of a mid-tropospheric moist region. It is suggested that the STJ moistens the mid-troposphere due to updrafts associated with a secondary circulation to the south of the STJ around the jet entrance. In such a preferable condition in terms of the STJ, tropical organized precipitation systems are found in higher LCI region than mid-latitude mesoscale precipitation systems. Further study on effects of the STJ and LCI shows that mid-latitude mesoscale precipitation systems are strongly influenced by the STJ, while small precipitation systems are highly dependent on the LCI. Interestingly, tropical organized precipitation systems appear not only with high LCI, but with relatively low LCI when the STJ is strong.

Evaluation of relationship between subtropical marine low stratiform cloudiness and estimated inversion strength in CMIP5 AMIP simulations using COSP

Tsuyoshi Koshiro*, Hideaki Kawai, and Seiji Yukimoto

Meteorological Research Institute

Subtropical marine low stratiform clouds (LSCs) simulated in AMIP experiments by the CFMIP Observation Simulator Package (COSP) implemented in nine CMIP5 models are evaluated in terms of the relationship with the estimated inversion strength (EIS). In this study, the ISCCP middle+low cloud amounts, corrected with the random-overlap assumption, with optical thickness >3.6 are defined as the LSC amount. We found that most models failed to simulate observed linear relationship between the LSC amount and EIS. The EIS is well simulated in all models, compared with reanalysis data. However, the LSCs are quite different among models; although some models can produce similar distributions to the observations, their amounts are not in good agreement quantitatively. Further analysis using the CALIPSO observations with its simulator outputs and layered EISs suggests that information on the vertical structure of the LSC amount and the related inferred inversion levels can help improve the simulated relationship.

A preliminary analysis of ENSO-Asian monsoon coupling on an interannual timescale in GCMs

Hiroshi G. Takahashi*(1,2), Nozomi Kamizawa(1)

(1)Tokyo Metropolitan University, (2)JAMSTEC

The coupling between the El Nino-Southern Oscillation (ENSO) and the Asian monsoon is one of the noticeable climate systems on the Earth. The ENSO-Asian monsoon coupling may be a key component of the seasonal prediction of the Asian monsoon climate. In this presentation, we have preliminary investigated the interannual variability of ENSO-Asian monsoon system in the Coupled Model Intercomparison Project Phase 5 (CMIP5), comparing with that of observed datasets (55-year Japanese Reanalysis; JRA55, Global Precipitation Climatology Project; GPCP). In Northern summer, the ENSO-Asian monsoon coupling is likely to be weak in the observation. However, the majority of coupled global climate models (CGCMs) showed a very strong coupling. Particularly, the strong coupling over the Indian Ocean were simulated, which was not observed. This difference may

be a systematic bias in the CGCMs. We will also discuss the simulated coupling in Northern winter.

The lack of westerly wind bursts in unmaterialized El Niño years and its relation to background wind states

Ayako Seiki*, Yukari N. Takayabu, Takuya Hasegawa, and Kunio Yoneyama

DCOP/JAMSTEC

The strong El Niño in late 2014 was predicted by many climate scientists based on high ocean heat content and successive equatorial westerly wind bursts (WWBs) in early 2014. However, it turned out to be a weak El Niño and developed again in 2015. One of the reasons addressed is the lack of WWBs after boreal spring. In this study, we examine what caused the lack of WWBs in unmaterialized El Niño (UEN) years such as 2014 focusing on background wind states.
Both in El Niño years and in UEN years, there were several MJO events throughout the year. However, few WWBs accompanied the MJO convection in UEN years. Focusing on boreal summer/autumn, background zonal wind convergence, which facilitates the development of synoptic disturbances including WWBs, was retracted westward and did not reach the equatorial central Pacific. Unchanged background states can be a reason for the lack of WWBs even with several MJO events in UEN years.
In addition, the contribution of zonal SST gradients both in the equatorial central Pacific and in the Philippine Sea on the background wind states will be discussed.

Role of stratospheric cooling on the tropical troposphere and the ocean

K. Kodera*(1), N. Eguchi(2), and R. Ueyama(3)

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2: Research Institute for Applied Mechanics, Kyushu University, Kasuga, Japan
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Large changes in circulation have occurred around the end of 1990's in the troposphere as well as in the lower stratosphere, such as an advancement of the onset of Asian summer monsoon, cooling of the equatorial eastern Pacific connected to the hiatus, and cooling in the tropical lower stratosphere. Whether or not a causal relationship exists among these phenomena, is an interesting yet challenging question.
We, therefore, investigate a transient phenomenon to gain insight into the relationship between changes in the stratosphere and the ocean. For this, we select a sudden cooling event in the tropical lower stratosphere during the boreal summer. Stratospheric temperature decreased in association with an increased upwelling induced by an enhancement of planetary wave activity in the SH in July 2010 and 2016. Increase of the upwelling is particularly apparent in the UTLS region of the summer hemisphere around 15° N-25°N, where the ascending branch of the Hadley circulation in line with the upwelling branch of the Brewer-Dobson circulation. Because this connected zone is situated poleward of the climatological center of the ascending branch of the Hadley circulation, enhancement of the upward velocity in this region shifts the Hadley circulation poleward.

Impacts of vertical structure of convection on circulation change under global warming

Chao-An Chen*(1), Jia-Yuh Yu(2) and Chia Chou(1,3)

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2Department of Atmospheric Sciences, National Central University, Taoyuan City, Taiwan
3Department of Atmospheric Sciences, National Taiwan University, Taipei, Taiwan

Global-warming-induced changes in regional tropical precipitation are usually associated with changes in tropical circulation,

which is the dynamic contribution. This study focuses on mechanisms of the dynamic contribution that is related to the partition of shallow convection in tropical convection. To understand changes in tropical circulation and the associated mechanism, 32 coupled global climate models from CMIP3 and CMIP5 were investigated here. The study regions are convection zones with positive precipitation anomalies, where both enhanced and reduced ascending motions are found. Under global warming, an upward-shift structure of ascending motion is observed in the entire domain, implying a deepening of convection and a more stable atmosphere, which leads to a weakening of tropical circulation. In a more detailed examination, areas with enhanced (weakened) ascending motion are associated with a more (less) import of moist static energy by a climatologically bottom-heavy (top-heavy) structure of vertical velocity, which is similar to the rich-get-richer mechanism. In a warmer climate, different climatological vertical profile tends to induce different change in atmospheric stability: the bottom-heavy (top-heavy) structure brings a more (less) unstable condition, and is favorable (unfavorable) to the strengthening of convective circulation. The bottom-heavy structure is associated with shallow convection, while the top-heavy structure is usually related to deep convection. In other words, shallow convection tends to strengthen tropical circulation and enhances upward motion in future warmer climate. This study provides a linkage for projecting and understanding future circulation change from current climate.

High cloud size dependency in the applicability of the fixed anvil temperature hypothesis using global nonhydrostatic simulations

A. T. Noda*, T. Seiki, M. Satoh, and Y. Yamada

JAMSTEC

Hartmann and Larson (2002, GRL)は上層雲の雲頂温度は地球の地表面温度が上昇してもほぼ一定に保たれるとする仮説(固定アンビル(FAT)仮説)を提唱した。このことは地球が温暖化しても赤外放射による効率的な熱の解放は行われないことを示唆している。全球非静力学モデルを用いて固定アンビル(FAT)仮説の適応可能性を調べた結果、この仮説は主に小さなスケールの雲について有効に働くことがわかった。

Recent increase of early-winter precipitation in the Hokuliku area and its linkage with rainfall in the eastern Indian Ocean and western Pacific Ocean

Kazuaki Yasunaga* and M. Tomochika

University of Toyama

In winter, strong north-westerly wind prevails over Japan, which is known as the East Asian winter monsoon. The cold and dry air-mass is pushed by the wind from the Eurasian Continent to the Sea of Japan (SJpn), and the air-mass absorbs a lot of sensible and latent heats while passing over the warm surface there. Eventually, it brings about heavy snowfall along the northwest coast of Japan. It is found that early-winter precipitation amounts gradually increase around the Hokuliku area after 1990. It is a well-known fact that sea-surface temperature (SST) exhibits an increasing trend over almost entire regions of SJpn, and it can be considered that warmer SSTs (and enhanced heat fluxes) are responsible to the precipitation increase. On the other hand, the monsoonal flow gets stronger in recent years, and our analysis indicates that such enhanced flow is more important to the precipitation increase. Furthermore, it is also indicated that variations of the monsoonal flow are significantly correlated with the rainfall around the tropical eastern Indian Ocean (the Bay of Bengal) and western Pacific Ocean (South China Sea and Philippine Sea), and that the enhanced circulations in early-winter around Japan are interpreted as the heat response to the rainfall increase in the tropics.

Characteristics of precipitation systems observed with the GPM DPR and their relationship with environmental moisture field

Marika Ono* and Yukari Takayabu

Atmosphere and Ocean Research Institute, the University of Tokyo

Characteristics of precipitation systems in various column moisture conditions are examined over tropical oceans and land (30N-30S) using the GPM DPR (Global Precipitation Measurement Dual-frequency Precipitation Radar). Previous studies reported a rapid increase of precipitation amount and area beyond a critical value of column moisture value over tropical oceans (e.g. Ahmed and Schumacher, 2015). We made a precipitation system database based on precipitation event observed with Ku-band radar. The database includes the precipitation characteristics information (e.g. volumetric precipitation per precipitation event, precipitation area and maximum precipitation intensity) of each system. The characteristics of precipitation systems in relation to the column water vapor are examined. Over tropical oceans, a positive correlation between conditional mean precipitation and column water vapor is observed in this study. On the other hand, precipitation amount and area over tropical land show no increase with increasing column water vapor. These results suggest the environment favorable for organization of precipitation systems over tropical land regions is different from that over tropical oceans. We will also present results for mid-latitude regions to compare with those in tropical regions.

A statistical analysis of precipitation feature over oceanic areas adjacent to continents in the tropics from TRMM data

Miho Fujishima* and Yukari Takayabu

Atmosphere and Ocean Research Institute, the University of Tokyo

It is known that characteristics of precipitation are different between land and ocean in the tropics. Land-sea difference also appears in the difference of the Rain-yields per flash (RPF) values which is the rainfall amount divided by the number of lightning flashes (Williams et al., 1992; Zipser, 1994). The global distributions of RPF values calculated with Tropical Rainfall Measuring Mission (TRMM) PR and LIS data indicate a significant contrast in over land and ocean. In addition, intermediate values over oceanic areas adjacent to continents are found (Takayabu, 2006). This region is being referred to as 'Transition Zone (TZ)'. It is not clear how this TZ is formed. On the other hand, in some regions the systems like squall-line systems which propagated from coast to offshore were observed (Houze et al., 1981; Zuidema, 2003; Miyakawa and Satomura, 2006).
The purpose of the present study is to clarify the process of this TZ formation. Here, we assume that the systems having continental characteristics like squall-line systems exist in the TZ. We use the TRMM dataset produced by the University of Utah which is based on TRMM PR 2A25 data. We examine precipitation features which were observed in the TZ and compare them with those over oceans and over lands. To start with, we show the frequency distribution of several precipitation characteristics observed in land, ocean and TZ. We will also examine their environmental field, as well as diurnal variations.

The difference of vertical profiles of stratiform precipitation in tropical and mid-latitude

Kazuki Kobayashi*, Shoichi Shige and Munehisa K. Yamamoto

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Operating the GPM Core Observatory, an observable area of a spaceborne precipitation radar extended from tropic and subtropic regions (~35°N-35°S) by TRMM/PR to middle and high latitude (~65°N-65°S). In the stratiform region of tropical Mesoscale convective systems (MSCs), raindrops evaporate in mesoscale downdraft below melting layer (Houze 1982 , JMSJ). On the other hand, Houze et al. (1981, JAS) observed that the mesoscale updraft generated clouds below melting layer and that rainfall rate increased by scavenging cloud water below melting layer in the stratiform region of warm-frontal rainband, using ground

radar. Therefore, it is likely that precipitation process and rainfall profiles are different between stratiform rain associated with MCSs in tropics and extratropical cyclone or front in mid-latitude, even though these rainfall cases are classified into the same rain type by a satellite algorithm. In this study, we used a GPM Ku-band precipitation radar (KuPR) product and investigated characteristics of radar reflectivity profiles classified into stratiform rain by this product, focusing on precipitation systems and regions.

Potential impact of sea surface temperature on Rainfall over the western Philippines

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This study uses a 5-km- resolution regional climate model (WRF-ARW; the Advanced Research Weather Research and Forecasting Model) to quantify the potential impact of sea surface temperature (SST) west of the Philippines on the summer monsoon rainfall on the western coast the country. A set of control simulations (CTL) driven by ERA Interim reanalysis and monthly NOAA OISST dataset is performed from June to August for the years 1982-2012. A second set of simulations driven with climatological SST values is also done for the same time period. The difference between these two sets of simulation is analyzed to determine the sensitivity of rainfall to the interannual variations of SST. Spatial and temporal variation of rainfall was well simulated with the CTL simulations yielding realistic rainfall values of high correlation with observed monthly rainfall. Results showed that positive SST anomalies west of the Philippines induced positive rainfall anomalies in the western region of the country through the increase of latent heat fluxes from the sea surface, which implies that rainfall in the western Philippines is being modulated by the interannual variation in SST west of the Philippines. The SST impact on latent heat flux and rainfall exceeded the 7% approximation of the Clausius–Clapeyron formula, which can be mainly explained by the enhancement of low-level winds and the weak warming of surface air temperature over ocean.

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

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We demonstrate that the rate of development of cumulus clouds, as inferred from the 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 Multi-functional Transport SATellite-1R (MTSAT-1R) 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 it is consistent with the statistical characteristics of direct measurements acquired in previous studies.

Use of operational meteorological data to reveal the characteristics and environmental properties of quasi-stationary mesoscale convective systems

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The morphology and environmental properties of warm-season quasi-stationary convective clusters (QSCCs) in Japan were statistically investigated using operational weather radar and upper-air sounding data from May to October during 2005-2012. 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, 4133 QSCCs were extracted over the Japanese major islands. It was found that QSCCs are typically meso-β-scale phenomena. 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 speed and directional shear of wind in the lower troposphere characterize the kinematic environments for QSCCs. The vertical shear also controls the shape of QSCCs: circular mode versus elliptical mode. 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 precipitation intensity has a higher correlation with the convective instability, whereas the precipitation area with the shear intensity. A comparison between slower- and the faster-moving CCs indicated that the precipitation intensity of the slower-moving CCs is stronger. This feature is related to a higher convective instability for the slower-moving ones.