The impact of solar activity on tropical Pacific decadal variability

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It is no doubt that solar is one of the most important driving forcing for the earth climate. However, the impact of the solar activity for climate on interannual to decadal time scale is still on debate. Based on the detection for the solar signal in some critical components of climate system, we studied the sensitive response of atmospheric and oceanic system to solar activity variation. It is revealed that the tropical Pacific Ocean maybe the key region response to solar activity. As a quasi-period forcing, the features of the ocean heat content (OHC) anomaly and SSTA demonstrate opposite patterns in the tropical Pacific during the different phase of solar cycle. The impact of solar activity(F10.7)on tropical Pacific convection during the boreal summer(June–July–August, JJA) has been examined using reanalysis data, revealing a significant lagged(1–2 years) correlation between outgoing long-wave radiation(OLR) over the tropical western Pacific and the F10.7 index. As related to the influence of solar activity over the tropical western Pacific, a dipole convection anomaly pattern shows an eastward shift of the central position of deep convection. As in fact, this shift results in a feature more like an El Nino Modoki pattern. FGOALS-g2 is employed to simulate the atmospheric and oceanic system response to the constant and period solar forcing. The central Pacific response to solar activity variation is confirmed in these experiments.

Keywords: solar activity, ocean heat content, convection, decadal variability

Monitoring the Madden-Julian Oscillation with upper-level geopotential height gradient $\nabla_x z'$

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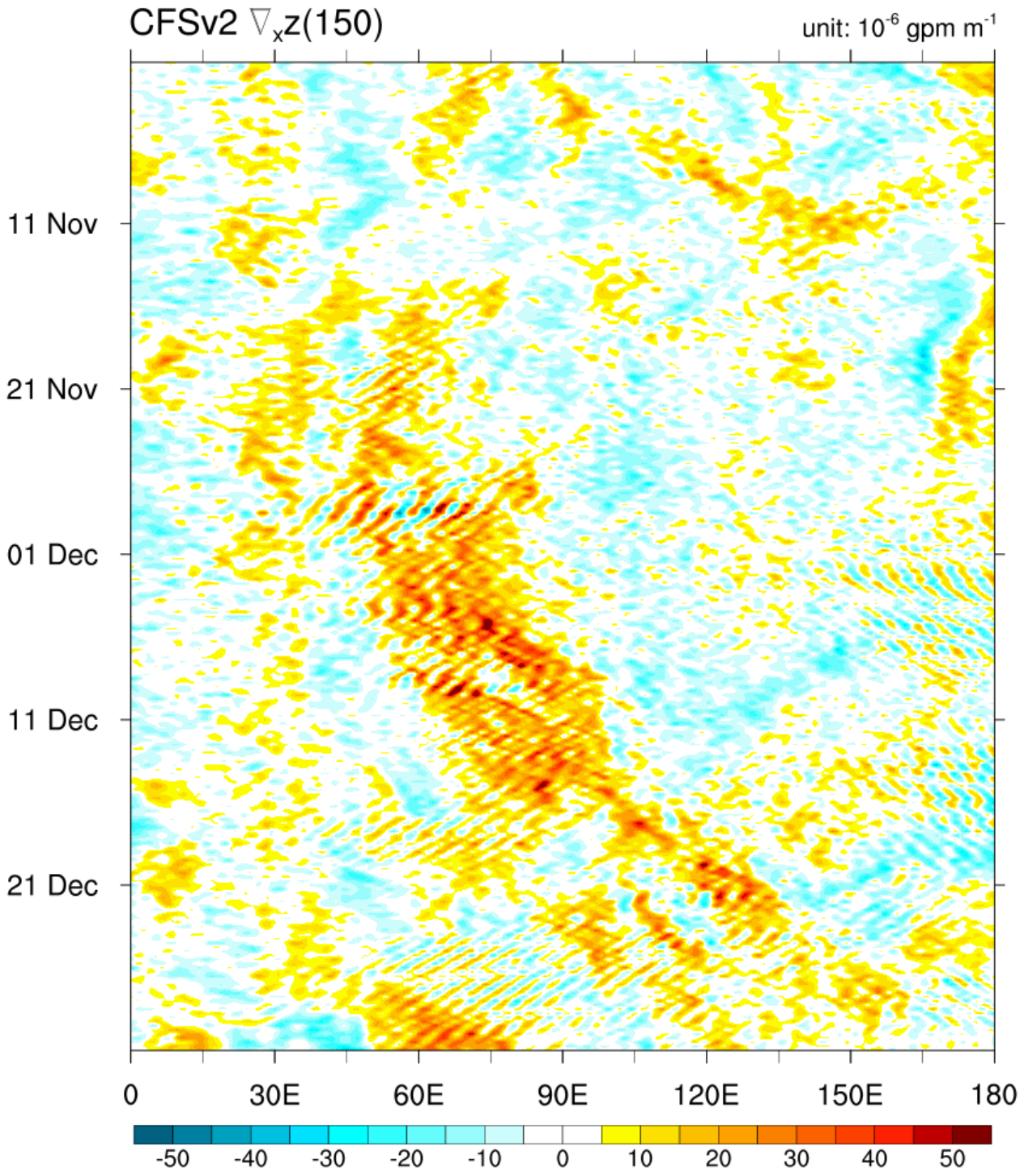
Given the dominant convection and circulation features of the Madden-Julian oscillation (MJO), its observation relies mostly on the measurements of convection, such as outgoing longwave radiation (OLR), and circulation-based measurements, such as zonal wind and velocity potential. For example, the Real-time Multivariate MJO (RMM) index, the most commonly used MJO index, is constructed from the combined empirical orthogonal function (CEOF) of OLR, 200-hPa and 850-hPa zonal winds. However, using OLR as a measurement of convection may have numerous shortages, such as the unavailability of data access before the satellite era and the calculation error of modeling output OLR.
This research explores an alternative MJO diagnostic parameter option, the 150-hPa zonal anomalous height gradient ($\nabla_x z'$), which may overcome the limitations of OLR. Statistical analyses of MJO events during extended winter (NDJFM) from 1979 to 2013 suggest that the 150-hPa $\nabla_x z'$ is highly correlated with OLR and shows a strong signal of MJO in the wavenumber-frequency spectrum. The 150-hPa $\nabla_x z'$ is also shown to be able to extract MJO signals from the version 2 of NCEP Climate Forecast System (CFSv2) output while OLR fails in a case study during the Dynamics of the Madden-Julian Oscillation (DYNAMO) field campaign in 2011. It is believed that 150-hPa $\nabla_x z'$ is a good alternative option of OLR for studying MJOs before the satellite era and in model evaluations.

Keywords: Madden-Julian Oscillation, diagnostic parameter, geopotential height, zonal anomalous height gradient, MJO index



Barrier Effect of the Indo-Pacific Maritime Continent on the MJO: Perspectives from Tracking MJO Precipitation

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Explanations for the barrier effect of the Indo-Pacific Maritime Continent (MC) on the MJO should satisfy two criteria. First, they should include specific features of the MC, namely, its intricate land-sea distributions and elevated terrains. Second, they should include mechanisms for both the barrier effect and its overcoming by some MJO events. Guided by these two criteria, we applied a precipitation-tracking method to identify MJO events that propagate across the MC (MJO-C) and those that are blocked by the MC (MJO-B). About a half of MJO events that form over the Indian Ocean propagate through the MC. Most of them (> 75%) become weakened over the MC. The barrier effect cannot be explained in terms of the strength, horizontal scale, or spatial distribution of MJO convection when it approaches the MC from the west. A distinction between MJO-B and MJO-C is their precipitation over the sea vs. land in the MC region. MJO-C events rain more over the sea than over land, whereas land rainfall dominates for MJO-B. This suggests that inhibiting convective development over the sea could be a possible mechanism for the barrier effect of the MC. Preceding conditions for MJO-C include stronger low-level zonal moisture flux convergence and higher SST in the MC region. Possible connections between these large-scale conditions and the land vs. sea distributions of MJO rainfall through the diurnal cycle are discussed.

Keywords: MJO tracking, Maritime Continent, barrier effect

Diurnal and MJO-scale variations in diabatic heating in the Maritime Continent

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Intraseasonal variability and the diurnal cycle have been shown to play a major role in modulating rain-rates over the land and sea in the Maritime Continent. Despite its important role in global heat and moisture transport, modelling convection in the Maritime Continent region remains challenging, partly due to the unresolved interaction beteween intraseasonal, mesoscale and diurnal variability brought about by the complex coastlines and steep topography. With the diurnal and intraseasonal variation in deep convection and cloudiness is an associated variation in diabatic heating.

In this work, we ran convection-permitting simulations over the whole Maritime Continent region using the Weather Research and Forecasting model with a horizontal grid-length of 4 km for 10 Austral summer seasons. The simulations cover the whole Maritime Continent region, and therefore include intraseasonal variations in convection and cloudiness such as that associated with the Madden Julian Oscillation as well as diurnal and mesoscale variability. In the simulations, the atmosphere is nudged towards the large scale weather patterns for wavelengths greater than 1000 km above the boundary layer, which facilitates direct comparison with observed rainfall variability from TRMM 3B42 and CMORPH satellite precipitation estimates. Comparison with satellite precipitation estimates and detailed examination of the diurnal cycle on and around the major Maritime Continent islands suggests that the simulations are able to capture the main physical processes controlling the intraseasonal and diurnal variation, despite a wet bias and errors in the timing of peak diurnal precipitation over the land.

We explore the diurnal and intraseasonal variation in diabatic heating using diabatic heating terms from the model's microphyics scheme, boundary layer scheme and radiation schemes. Diabatic heating terms are composited according to time of day and phase of the Madden-Julian Oscillation for land and sea areas and on cross sections through several Maritime Continent Islands. The simulated heating terms are used to examine the relationship between the diabatic heating associated with deep convection over the land and the incidence of diurnally varying, far-offshore precipitation. Furthermore, the aggregated variation in diabatic heating with the passage of the MJO is examined.

Keywords: Maritime Continent, Tropical Convection, Diabatic heating

Diurnal cycle over Jakarta as revealed by sounding-based thermodynamic budget analyses during HARIMAU2010 field campaign

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The diurnal cycle over Jakarta, Indonesia, was investigated by utilizing special sounding data during HARIMAU2010 field campaign. The 8 times/day radiosonde soundings at four sites surrounding Jakarta coastal area enable us to calculate thermodynamic budget in meso-beta-scale to reveal the mechanism to variate heat and moisture, with the precipitation morphology obtained by a C-band radar.
The obtained diurnal cycle basically resembles that in the previous studies; morning heating of the bottom of the troposphere, afternoon heavy rain, widespread night light rain. The further detailed processes were clarified by the present analyses. First one is the moistening in the lower troposphere around the noon to precede the onset of afternoon heavy rain. The plausible mechanisms are suggested as cumulus- and eddy-scale vertical transport, gravity wave from the preceding mountainous precipitation, and / or evaporation from the pre-existing cloud water. The second one is the "cloud storage" effects in the nighttime rain. Until midnight, the precipitation was maintained by both consuming local vapor and cloud storage. After midnight, water vapor was consumed more than precipitation to suggest to be stored as the cloud storage. The period-averaged vertical profiles of Q1 and Q2 are also shown to be the deep-convective type.

Keywords: diurnal cycle, thermodynamic budget analyses, maritime continent

Tropospheric turbulence over the tropical open-ocean: Role of gravity waves

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A large set of soundings obtained in the Indian Ocean during 3 field campaigns is used to provide statistical characteristics of tropospheric turbulence and its link with gravity wave (GW) activity. The Thorpe method is used to diagnose turbulent regions of a few hundred meters depth. Above the mixed layer, turbulence frequency varies from ~10% in the lower troposphere up to ~30% around 12km heights. GW are captured by their signature in horizontal wind, normalized temperature and balloon vertical ascent rate. These parameters emphasize different parts of the wave spectrum from longer to shorter vertical wavelengths respectively. Composites are constructed in order to reveal the vertical structure of the waves and their link with turbulence. The relatively longer wavelength GW described by their signature in temperature (GWT) are more active in the lower troposphere where they are associated with clear variations in moisture. Turbulence is then associated with minimum static stability and vertical shear, stressing the importance of the former and the possibility of convective instability. Conversely, the short waves described by their signature in balloon ascent rate (GWw) are detected primarily in the upper troposphere and their turbulence is associated with a vertical shear maximum suggesting the importance of dynamic instability. Furthermore, GWw appear to be linked with local convection whereas GWT are more active in suppressed and dry phases in particular of the Madden-Julian Oscillation. These waves maybe associated with remote sources such as organized convection or local fronts such as those associated with dry air intrusions.

Keywords: turbulence, gravity waves, observations

Overview of the Propagation of Intra-Seasonal Tropical Oscillations (PISTON) Field Program

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The boreal summer intraseasonal oscillation (BSISO) is associated with propagation of convection and associated large-scale circulation anomalies across the north Indian Ocean and South China Sea (SCS). Both eastward and northward propagation is observed, which contrasts with the primarily eastward propagation of the boreal winter MJO. The BSISO produces prominent variability in winds and precipitation in the Philippines Archipelago and other parts of the Maritime Continent (MC), although is also associated with other non-local effects such as active and break cycles of the south and east Asia monsoons, modulation of tropical cyclones in various parts of the tropics, and teleconnections to midlatitudes. The BSISO has been poorly simulated by climate and weather forecasting models, which limits the ability to forecast the various impacts of the BSISO.
This presentation will describe the upcoming Propagation of Intra-Seasonal Tropical Oscillations (PISTON) Field Program that will feature an observational campaign during the late summer of 2018 in the South China Sea. The goal of PISTON is to forge a better understanding of the multiscale, air-sea, and land-atmosphere interaction processes that regulate BSISO propagation and intensity, develop an observational dataset to benchmark model simulations of the BSISO, and use these models and observations to address the overarching PISTON hypotheses related to the multiscale atmosphere-ocean-land interactions of the BSISO. The observational campaign will entail about two months of shipborne measurements from the *R/V Thomas G. Thompson* off the West Coast of Luzon that will sample the northward-propagating BSISO and interactions with offshore-propagating convective disturbances and the upper ocean. A hierarchy of modeling tools will be employed in PISTON including large-eddy models, cloud-system-resolving models (CSRMs) that span local to regional domains, and climate simulations, forecasts, and reforecasts of global models. PISTON field observations and high-resolution models will foster process understanding that leads to improved model and predictions.

Keywords: Intraseasonal, Boreal Summer , Propagation

Interaction of convection over the Maritime Continent - SCS with large-scale flow

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The atmospheric Sciences community in Taiwan is carrying out an integrated project "Interaction of convection over the MC - SCS with large-scale flow”. The scientific issues and research approaches of all projects are organized and linked under three areas of study: convective processes, large-scale processes, observationas. The major observational task is the SCS Two-Island Monsoon Experiment (SCSTIMX) that includes field campaigns at Taiping and Dongsha islands along with the measurements by ocean research vessels (RV) and satellite observations. To prepare for the SCSTIMX, a pre-experiments has been completed during December 11-21, 2016, through the research cruise to Taiping Island by the NTU RV OR1 voyage 1156. The cruise took place during the La Nina phase following the warm winter of 2015/2016 El Nino/Southern Oscillation (ENSO) event. The equatorial eastern and central Pacific was about 0.5-2^{o}C colder than the climate mean. We developed a method of monitoring the climate background and high frequency (weather and intraseasonal) disturbances in time and applied it to Outgoing Longwave Radiation (OLR) data. Combining NCEP FNL assimilation (Wind, pressure, temperature, water vapor), surface observations at the two islands, ship soundings and satellite data, a preliminary analysis was conducted. The La Nina condition causes a warmer and more humid SCS-MC region, and colder and drier central and eastern equatorial Pacific. Accompanied by this background, synoptic and intraseasonal oscillations are more energetic in the SCS and NW Pacific warm pool area. The research team of the integrated project will continue to explore the multi-scale interaction processes and its impact on forecasts through analysis and modeling.

Keywords: convection, tropical waves, MJO

Observational study of diurnal offshore migration of precipitation area over the Indonesian Maritime Continent

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The Pre-YMC (Years of the Maritime Continent) field campaign conducted in the western coastal area of Sumatra Island during November and December of 2015 successfully observed typical diurnal cycle of precipitation over coastal waters characterized by nighttime offshore migration of heavy precipitation zone, with 3-hourly radiosonde soundings and weather radar at the research vessel *Mirai* deployed at about 50 km off the coast. Through analysis of these observational data, this study examines mechanisms responsible for the offshore migration. We find that the static stability of the offshore atmosphere decreases a couple of hours before the arrival of the precipitation zone, which is due mainly to cooling in the lower free troposphere. We further find that the cooling is due mainly to ascent motion, which is presumably a component of shallow gravity waves excited by convective systems over land. As the cooling rate is significantly correlated with offshore precipitation amount during nighttime, we can conclude that these gravity waves and the resultant destabilization play significant roles in the offshore migration of the precipitation zone via enhancement of the convective activity.

Keywords: precipitation diurnal cycle, the Indonesian Maritime Continent, gravity waves

Videosonde observations in the Pre-YMC field campaign

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For the better understanding of microphysics in tropical precipitating clouds, videosonde observations were carried out as a part of the Pre-YMC field campaign, which was a pilot study of the Years of Maritime Continent (YMC).
18 videosondes were launched at Bengkulu weather station located in the southwestern coastal land of Sumatera Island, Indonesia from November 24 to December 15, 2015. Videosonde is one of strong tools to measure precipitation particles in clouds directly. It has a CCD camera, a strobe and an infra-red sensor inside. A precipitation particle interrupts the sensor, it triggers the strobe and the particle image is then captured by the CCD camera. Recorded particle images are classified as raindrops, frozen drops, graupel, ice crystals, or snowflakes on the basis of their transparency and shape. Videosonde observation will give us information on the number, size, and shape of precipitation particles in vertical. After the launch of a videosonde, the RHI scan by a C-band dual-polarimetric radar installed on the R/V Mirai, which was approximately 50 km off Sumatera Island, were continuously preformed, targeting the videosonde in the precipitating cloud.
On 30 November 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.
In another case of November 25, a strong convection occurred 10 km away from our observation site. The RHI scan of R/V Mirai radar showed a tall convective tower and an anvil cloud. We launched a videosonde into a weak convective cloud formed by the convergence of the outer flow from the strong convection. A lot of graupel were observed in the upper layer, which is supposed to be formed by riming of uplifted supercooled droplets. This solid precipitation particle distribution was different from that in a typical stratiform cloud observed on December 15.

Keywords: Videosonde, Pre-YMC, Precipitation process, Cloud microphysics

Tropo-Stratospheric Wave Activity near Western Maritime-Continent Coast during MJO Landing and QBO Modification

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"Pre-Years of the Maritime Continent" 3-hourly radiosonde and weather radar observations were carried out both at and off Bengkulu in the southwestern coast of Sumatera in November-December 2015. The station on the sea side was the R/V *Mirai* staying at a 50 km distance from the coastline. Frequency and vertical wavenumber spectra of radiosonde wind and temperature showed generally-known red noise-like features. There were four types of disturbances categorized as the gravity-wave class: (i) lower-tropospheric sea-land breeze circulations (land- and sea-ward propagating cells composed of up- and down-ward waves); (ii) taller circulations with middle/upper-tropospheric nodes; (iii) few-day-period tropopausal Kelvin waves (only in zonal wind and temperature); and (iv) thinner lower-stratospheric inertio-gravity waves (with elliptic polarizations of horizontal winds). When an MJO landed around December 13, radar-observed diurnal-cycle rainfall associated with (i) was modified, and amplifications of (iii) and (iv) produced a strong vertical shear between the upper-tropopsheric easterly and the whole lower-to -middle stratospheric westerly. The middle-stratospheric zonal wind remains westerly since early 2015 even now (January 2017) with a modification of QBO. Subsequent observations might be discussed, upon the budgetary situation in after Japanese FY2017.

Keywords: Indonesian maritime continent, tropo-stratosphere, atmospheric gravity-wave class , convective clouds

Investigating the component of the eastward shift of the MJO explained by the seasonal transition of SST though a case study on the pre-YMC MJO

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The Madden-Julian Oscillation (MJO) is the dominant mode of intraseasonal variability in the tropics characterized by slow eastward propagation of convective active region from the equatorial Indian Ocean to the equatorial Western Pacific (Madden and Julian 1972). However, its complex composition of interacting convective activities of various space and temporal scales has made it difficult to determine the principal dynamical mechanism explaining the phenomenon. Therefore, here we investigate for a component of the MJO which is independent from the atmospheric dynamics that can be explained solely by the lower boundary condition given by the sea surface. In Neelin and Held (1987; NH87), they make a simple two-layer model of climatological tropical convergence and precipitation diagnosed from sea surface temperature (SST) and surface latent heat flux. As the NH87 model is intended to estimate climatological precipitation means from the SST, by making an assessment of an MJO event in the NH87 framework we investigate for a component of the MJO dominated by the seasonal transition of the SST. The event assessed here is the observed MJO event during the pre-YMC observation campaign from Nov. to Dec. 2015.
During the pre-YMC campaign, an MJO event was observed as an outburst of low level westerlies around Dec. 13, 2015 from radiosonde observations from R/V Mirai stationed at 4-04S, 101-54E. This MJO is observed to initiate over the Indian Ocean around Dec.12, 2015 and propagate to the Western Pacific in around 30 days. Following NH87, we estimated the low level moisture and precipitation means using NOAA OISST V2 and latent heat flux values from NCEP NCAR reanalysis1. The NH87 model succeeds in capturing buildup of low level moisture before the MJO initiation, and the following eastward propagating precipitation pattern of the MJO with a major event at the end of December to some extent. The results suggests that the seasonal warming of the Western Pacific SST is preconditioning region eastward of the Maritime Continents favorable for MJO convection, and that there are indeed components of the MJO that can be at least partially explained by the seasonal change of the sea surface conditions.

Keywords: Madden-Julian Oscillation , Air sea interaction

Evaluation of Routine Based Radiosonde Data Obtained in Indonesia for the Precise Observation during the YMC Field Campaign

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During the 2-year field campaign of the international project Years of the Maritime Continent (YMC) starting from July 2017, several intensive observations will be conducted to study weather and climate systems over the MC region. Since coordination with the local meteorological agencies is a key to establish adequate observation network, those routine based data sets should also be well evaluated for their scientific use. Currently Meisei radiosonde is used at the 16 radiosonde stations in Indonesia. Thus, we evaluated those data quality focusing on the humidity based on the intercomparison with other radiosonde and independent measuremwent system such as GPS-derived water vapor. This time we performed quality control procedure to the data of Meisei RS-11G, and confirmed that some known errors such as discontinuity of RH at 0 deg-C level, which was found in RS-06G, have been removed. Since new sensors iMS-100 will be used in the BMKG stations, continuous evaluating procedure is required. Therefore, in this study, not only current correction scheme but also the basic strategy of quality control is discussed.

Keywords: YMC, radiosonde humidity data correction

Drastic deepening of the barrier layer off the western coast of Sumatra due to the MJO passage during the Pre-YMC

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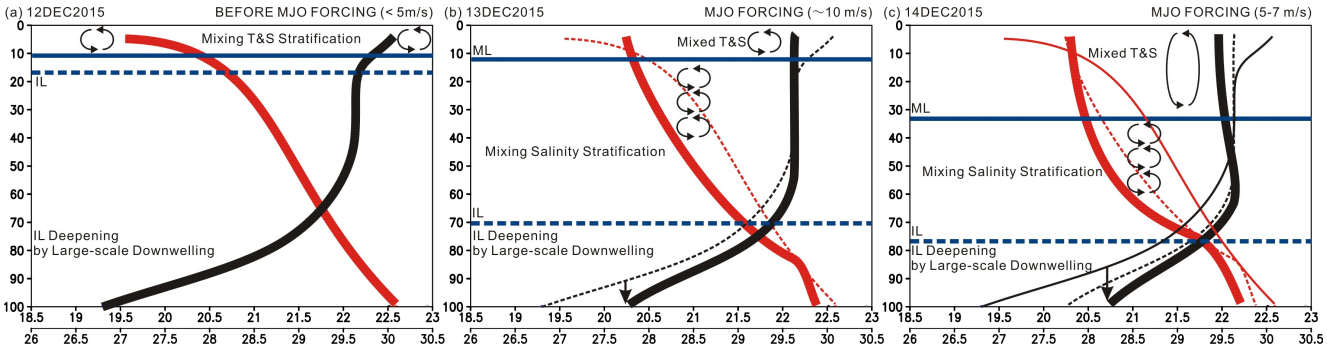
Drastic deepening of the barrier layer off the western coast of Sumatra (4˚S, 102˚E, 800 m depth) due to the MJO passage observed during December 2015 is investigated. The Research Vessel Mirai observation captured the drastic increase of isothermal depth from 20 m to 100 m for only 4 days due to the westerly burst (5-9 m/s) associated with the MJO. While, the mixed layer was deepened from 10 m to 40 m because of the strong stratification of the salinity in the ocean surface layer. As a result, the barrier layer depth was deepened from 10 m to 80 m. This drastic deepening of the barrier layer was associated with the increase of turbulent energy dissipation rate. Because the current speed in the surface layer off the western coast of Sumatra was very slower (less than 20 cm/s) than that over the open ocean (more than 50 cm/s), the vertical mixing due to the westerly burst could be a main factor for the barrier layer deepening.

Keywords: barrier layer, MJO



Diurnal and intraseasonal lightning activities over the western maritime continent during the pre-YMC observations in 2015

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Lightning activities over the western Indonesian maritime continent are investigated by using worldwide lightning location network (WWLLN) data for the pre-YMC observations in 2015 (November-December, 2015).

As described in previous studies, diurnal cycle of lightning with clear island-sea contrast is predominant over the region. Frequent lightnings are observed in the mountainous region of Java/Sumatra in the afternoon/evening, whereas the night/early morning lightnings are predominant in the off coastal region of southern Sumatra and Malacca straight. Intraseasonal lightning variations with the phases of MJO convection are also observed. In the inactive (active) phase of MJO convection over the maritime continent, lightnings are more active in the western (eastern) side of the steep mountains of Sumatra under low-level easterly or weak (westerly) wind conditions.

We will discuss a link among the temporal/spatial variations of lightning activities, atmospheric stability and development of convective cloud system in the coastal region of Sumatra by using the in situ sounding and radar observation data.

Numerical simulations of a diurnal cycle of precpitation during Pre-YMC field campaign

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Diurnal cycles of precipitation over the Maritime Continent (MC) are investigated, making use of a cloud resolving models (Scale and WRF). Some numerical simulations were conducted to reproduce the diurnal cycle observed during the “Pre-YMC” field campaign in late November- December 2015. In the earlier period of the campaign, the background zonal wind was easterly, because the Madden-Julian Oscillation (MJO) stayed over the Indian Ocean, and the precipitation system migrating to the west was frequently observed. After the middle of December, the MJO passed over the MC region, and the background zonal wind turned to westerly. Following the change of the zonal wind direction, the precipitation system migrating to the east was dominant. Numerical simulations successfully captured the diurnal cycle of precipitation over the land and the migration of the precipitation systems was well reproduced during both periods in term of the direction. However, the migration speed was different among the simulations. From some sensitivity tests, it is concluded that the horizontal resolution of the model is most critical to reproduce the realistic migration speed.

Ensemble downscaling of diurnal convection in the Maritime Continent associated with MJO during Pre-YMC 2015

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The diurnal convection and its amplitude around the Maritime Continent associated with MJO activity were investigated with the global ensemble forecast data. In the Pre-YMC period, the diurnal migration of clouds over the Sumatra Island toward the Indian Ocean is frequently observed, and the amplitude of diurnal cycle was associated with the particular MJO phase as reported in the previous studies. To investigate the relationship between diurnal amplitude and MJO activity statistically in the specific environmental fields in the Pre-YMC, we performed the dynamical downscaling with the data of global ensemble forecasts by NCEP. For the diurnal convection in regional scale, it is necessary to downscale these data to capture the interaction between the environmental field by MJO and the diurnal convections. The downscaled convections and precipitation tend to have large amplitude of diurnal cycle when the MJO activity was classified as strong by the MJO index. We will show the difference of diurnal structure that varies with the MJO’ s environmental fields.

Keywords: Diurnal variation, MJO, Downscaling

Evaluation of global nonhydrostatic simulations for the recent field campaigns over the tropical Indian Ocean

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In order to gain our understanding of the interactions between local phenomena and the large-scale intraseasonal variability (e.g., Madden-Julian Oscillation; MJO) over the tropical warm pool region, field programs were conducted in recent years, such as the CINDY2011/DYNAMO (October 2011-January 2012) and Pre-YMC (November-December 2015). Currently, the Years of the Maritime Continent (YMC) project (2017-2019) is launching. Global nonhydrostatic simulations are useful to the project goal and to the field operation. In this study, we evaluate the overall performance of the near real-time forecasts using Nonhydrostatic Icosahedral Atmospheric Model (NICAM; Satoh et al. 2014) for the field campaigns (Nasuno et al. 2017, in revision).

In the CINDY2011/DYNAMO campaign, week-long forecasts were daily conducted using the regionally stretched NICAM (Tomita 2008), with the finest horizontal mesh size of ~14 km. The moist convection was explicitly represented without using the cumulus parameterization. The forecasts fairly simulated the two prominent and one marginal MJO events; the real-time multivariate MJO index (Wheeler and Hendon 2004) skill score ~0.8 for the week-long integrations (Nasuno 2013). On average, the precipitation amount was overpredicted by 30% than in TRMM 3B42v7, with overprediction of strong (> 40 mm day^{-1}) precipitation and underprediction of weak precipitation. This suggests that the excessive occurrence of the very strong precipitation events was the major source of the overprediction of the total precipitation amount. The evaluation of atmospheric soundings using the radiosonde data revealed growth of lower to middle tropospheric dry (~1 g kg^{-1}) warm (~1 K) biases. The moisture and energy budgets during the CINDY2011/DYNAMO period were investigated using the 6-hourly (unfiltered) and 7-day mean (low-pass filtered) forecast outputs. The 7-day mean diagnosis well represent the observed profiles of the apparent moisture sink and apparent heat source, and the variation in the moisture budgets associated with the MJO phase. As a merit of using the high-resolution forecast outputs, the high-frequency effects were directly quantified as the difference between the 6-hourly and 7-day mean diagnosis. A significant amount of upward transport of moisture was found in the NICAM forecasts, which accounted for the excessive condensation in the upper troposphere and the resultant heavy precipitation events, as well as the dry and warm biases in the lower troposphere due to the compensating subsidence. Thus, the high-frequency effects were rather diffusive to the growth of the MJO on average, and more pronounced in the active phases of the MJO events then in the inactive phases. During the pre-conditioning phases, both the low-frequency and high-frequency advections had a tendency to enhance the moistening in the lower to middle troposphere.

In the Pre-YMC campaign, the forecasts were conducted using the global 7-km and 14-km mesh NICAM on the Earth Simulator. During the campaign, a MJO was intensified around the observational site (southwest Sumatra). The RMM skill score in 14-km mesh month-long forecasts was ~0.6 at the three-week lead time. The budget analysis and high-frequency effects in these forecasts, and the plans for the YMC campaign will be also discussed.

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Keywords: Global nonhydrostatic model, forecast skill, moisture budgets, Madden-Julian Oscillation

Initiation processes of the tropical intraseasonal variability simulated with aqua-planet experiments: Implication for the onset of the Madden-Julian Oscillation.

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The onset of the Madden-Julian Oscillation (MJO) is characterized as large-scale convective organization over the warm pool at the intraseasonal time scale. Although various kinds of mechanisms focusing on dynamic and thermodynamic environments have been proposed for MJO initiation, it seems to be difficult to understand what processes are essentially important for its onset due to the diversity of MJO behavior related to seasonality or land-sea distribution. Aiming to get an intrinsic insight into initiation processes of the MJO, we investigated the realization mechanism of convective activities associated with the tropical intraseasonal atmospheric variability (MJO-like disturbances) simulated in 10-year aqua-planet experiments using the Nonhydrostatic Icosahedral Atmospheric Model (NICAM) with a 56-km horizontal mesh. A zonally non-uniform fixed-SST distribution and explicit cloud microphysics can lead to the generation of MJO-like disturbances. We constructed the detective method of MJO-like disturbances in terms of convective activities and grasped their initiation processes continuously with a lagged-composite analysis. It is found that the horizontal moisture advection associated with a Rossby response to suppressed convection and a mixed-Rossby gravity wave can help moisten the mid-troposphere on the western warm pool about 10 days before the initiation, which makes a favorable condition for deep convective activities. After that, active convection of MJO-like disturbances is triggered by large-scale boundary layer convergence caused by the intrusion of a circumnavigating Kelvin-wave with negative sea level pressure anomalies into the moist region. It is also clarified that surface latent heat flux (LHF) and cloud-radiation feedbacks play a role in organization of triggered convection. Furthermore, sensitivity experiments suggest that a circumnavigating Kelvin-wave can efficiently determine the period of MJO-like disturbances and that the LHF feedback contributes to rapid convective organization. These results may provide us with important clues about an interpretation of the real MJO.

Keywords: Madden-Julian Oscillation, equatorial waves, aqua-planet experiments

Modulation of the diurnal cycle of precipitation over the Maritime Continent by the Madden-Julian Oscillation

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It is well known that the diurnal cycle of precipitation is dominant over the Maritime Continent. There have been disputes on the impact of the diurnal cycle of precipitation by the Madden-Julian Oscillation (MJO). Many studies used cloud top height observed by infrared radiation (IR) or outgoing long-wave radiation (OLR) as a proxy for precipitation. Peatman et al. (2014), however, claimed that IR and OLR are not good proxy for the rainfall over Maritime Continent. In this study, modulation of diurnal cycle of precipitation by the MJO is examined using a Tropical Rainfall Measuring Mission Precipitation Radar (TRMM PR) dataset spanning 16 years.

Composite analysis of the MJO shows that mean daily precipitation and the diurnal precipitation have a strong correlation. It is also shown that distribution of precipitation observed by PR does not agree with that of IR brightness temperature. It is remarkable that they differ from each other over land. Especially, maximum precipitations are obserbed before/after minimum brightness temperature is observed on the west/east coast of Sumatera and Borneo. Examining diurnal propagation the coast precipitation of these islands shows that the west coastal propagation gets much stronger before MJO large convection locates on the Maritime Continent while the east coastal one gets slightly stronger after that. Thus, it is likely that west coastal propagation of diurnal precipitation have a great effect on propagation of MJO large convection.

Barrier effect of the Maritime Continent on the MJO in global models

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Using a method of tracking individual MJO events, we diagnose MJO simuations by 27 global models. First, we found the commonly accepted perseption that some models produce the MJO and other do not is incorrect. All diagnosed MJO produce the MJO, but some do frequently, others infrequently. Second, we found all models suffer from a common bias: their simulated MJO events starts evenly over the Indo-Pacific region, while the observed MJO start mostly over the Indian Ocean. Third, the barrier effect of the Maritime Contiment on the MJO is very different among the models. The "exaggerated barrier effect" is found only in some models. In other, there is no barrier effect. The exaggerated barrier effect is evident in models that produce weak overal statistical signals of the MJO. These results suggest that the mean state is a key factor for MJO simulations and barrier effect in them. This, however, may not be the reason for the barrier effect in observations.

Keywords: Madden-Julian Oscillation (MJO), Maritime Continent, Barrier effect, global model simulations

Impact of the diurnal cycle on the propagation of MJO convection across the Maritime Continent

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Influences of the diurnal cycle on the propagation of the Madden-Julian Oscillation (MJO) convection across the Maritime Continent (MC) are examined using cloud-permitting regional model simulations and observations. A pair of ensembles of control (CONTROL) and no-diurnal cycle (NODC) simulations of the November 2011 MJO event are performed. In the CONTROL simulations, the MJO signal is weakened as it propagates across the MC, with much of the convection stalling over the large islands of Sumatra and Borneo. In the NODC simulations, where the incoming shortwave radiation at the top of the atmosphere is maintained at its daily mean value, the MJO convection signal propagating across the MC is enhanced. Examination of the surface energy fluxes in the simulations indicates that the surface downwelling shortwave radiation is larger in the presence of the diurnal cycle (CONTROL simulations) because clouds preferentially form in the afternoon. The diurnal co-variability of surface wind speed and skin temperature results in a larger sensible heat flux and a cooler land surface in the CONTROL runs compared to the NODC simulations. An analysis of observations indicates that ahead of and behind the MJO active phase, the diurnal cycle of cloudiness enhances downwelling shortwave radiation and hence land-locked convection over the MC. Enhanced land-locked convection competes with convection over the water, which is the main convective signal of MJO events that propagate through the MC. The propagation of MJO across the MC is thus disrupted.

Keywords: Maritime Continent barrier effect, MJO propagation, cloud permitting simulations, radiation, surface fluxes

Environmental conditions for tropical cyclone genesis in the Indian Ocean and implications for the MC influences

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This study investigated the seasonal environmental characteristics for tropical cyclone genesis (TCG) over the Indian Ocean during the Cooperative Indian Ocean Experiment on Intraseasonal Variability in the Year 2011 and the Dynamics of the Madden–Julian Oscillation (MJO) (CINDY/DYNAMO) field experiment and compare them with long-term climatological features. It was found that the spatial pattern of an empirical environmental index for TCG over the tropical Indian Ocean in 2011 is very similar to the feature composited over the years with high activity of MJO. The analyses of the contributions from each environmental factor indicated that relative humidity, absolute vorticity, and vertical velocity contribute to generate positive influences on the conditions for TCG in 2011. The influences of La Niña appear only through a shear effect over the Indian Ocean in 2011. Under the influences of active MJO events during the CINDY2011/DYNAMO period, the environmental conditions for TCG over the Indian Ocean are determined more strongly by MJO than by La Niña, through modifications of some environmental properties favorable for TCG. The environmental characteristics during CINDY2011/DYNAMO seem to be quite typical of the MJO active years; in such a case, the influences of El Niño/La Niña would not appear in determining the environmental conditions for TCG over the Indian Ocean. The MJO variation is significantly correlated with the variation of genesis potential index (GPI) for TCG over the northwestern and southwestern parts of the Indian Ocean, while over the northeastern and southeastern parts of the Indian Ocean there is no significant correlation between the GPI variation and the MJO variation. The different features found in the eastern and western parts of the Indian Ocean suggest that the environmental conditions in the eastern part of the Indian Ocean are partly affected by the atmospheric variability induced by the Maritime Continent. The analysis for the CINDY/DYNAMO period is compared with the climatology obtained from the statistical analysis for 33-year period.

Keywords: tropical cyclone, Indian Ocean, Madden-Julian Oscillation

Stable isotopes in precipitation over Indonesia observed for 2010-2013

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There are a lot of paleo-climate studies that analyzed stable isotopes in ice cores, corals, speleothems, tree-rings, and others over the Indonesia Maritime Continent (IMC). Stable isotopes are good indicator of climatic change, such as temperature and/or precipitation amount. Factors controlling stable isotopes in precipitation are various, therefore, it is necessary to investigate them in the present climate. Previous observational studies found three types of seasonal pattern in stable isotopes across the IMC, namely annual, semi-annual and anti-monsoonal type based on monthly data from only six stations. However, spatial resolution is not enough to investigate spatial and temporal variability of stable isotopes in precipitation over the IMC. The objectives of this study are to show the spatial distributions of stable isotopes in precipitation and to classify the regions based on their seasonal patterns. Stable isotopes in precipitation were observed weekly at 33 observation stations over the IMC belong to Indonesia Agency for Meteorological, Climatological and Geophysical (BMKG) from October 2010 to March 2013. The Cluster analysis was used to distinguish the spatial grouping of seasonal variability of monthly mean Oxygen-18 in precipitation from the BMKG dataset. As a result, the clusters 1 and 2 had similar seasonal patterns with the highest in the dry season (June–November) and the lowest in the wet season (December–May). These clusters were widely distributed over the IMC regions. The cluster 3 had a semi-annual pattern with two peaks in January-February and May-July, which were located only in Sumatera Island. The cluster 4 was only one station located in the Papua Island, which had an opposite type of the monsoonal pattern with the lightest in May–July. To examine the relationships between Oxygen-18 and precipitation amount, a negative correlation (that is amount effect) was found in the clusters 1 and 2. This should be a main factor controlling seasonal variability of Oxygen-18 in these regions. Meanwhile, the amount effect was observed only in transition months (March-August) and could not be seen in the cluster 3 and cluster 4 regions, respectively.

Keywords: stable isotopes, precipitation, Indonesia Maritime Continent

Intra-seasonal oscillation and typhoon activity obtained by long-term observational project around warm pool region

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The warm water pool region in the tropical western Pacific is a key area for the global climate system, as strong atmospheric convective activity in this area is the driving engine of the atmosphere. However, there are many processes between meso-scale convective activities and the global-scale climate, and these are not fully understood yet. To understand the mechanism of cloud-precipitation processes and air-sea interactions over the warm water pool in the tropics, there are in need of further investigation on the western Pacific monsoon and the tropical-extratropical interactions. Toward these objectives, we have continued a long-term observational project named PALAU (Pacific Area Long-term Atmospheric observation for Understanding climate change) around the tropical western Pacific near the Republic of Palau. The main target of this project is to describe multi-scale interactions of cloud systems to intra-seasonal oscillations affected by monsoon activities.

Since November 2000, we have been continuously operating surface weather observation sites in Palau. We also have conducted several intensive field campaigns targeted for various phenomena. During the campaigns, Research/Vessel Mirai and G-II aircraft were used as plathome for atmospheric and oceanic observations. Doppler radars were utilized to obtain the internal structure of cloud systems. To capture monsoon activity with wide area, we constructed intensified sounding network from Philippines, Palau, and Yap to Guam. Quasi-real-time forecasts were also executed by using numerical models.

From the results of PALAU observations, it is indicated that the variability of monsoon activity and ENSO are strongly affected to the structure of convections over the warm water pool region. Formation of the initial stage of tropical cyclones are frequently observed around Palau. In the case of PALAU2013 which is one of the intensive observation campaigns, three events of the early stage of tropical cyclones were captured in one month. All of the initial disturbances corresponded to a kind of easterly waves with vortical structures, and after passing through Palau, they developed to the typhoons on the Philippine Sea. Because these typhoons caused strong surface westerly winds in the formative period, they represented a close relation with the monsoon onset and the intensification of the activity of intra-seasonal oscillations over the tropical western Pacific.

Currently, we also have a plan of intensive observation around Palau in the boreal summer of 2018, as a part of YMC (Years of the Maritime Continent) campaign.

Keywords: YMC, PALAU, Intra-Seasonal Oscillation

