

## 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 measurement 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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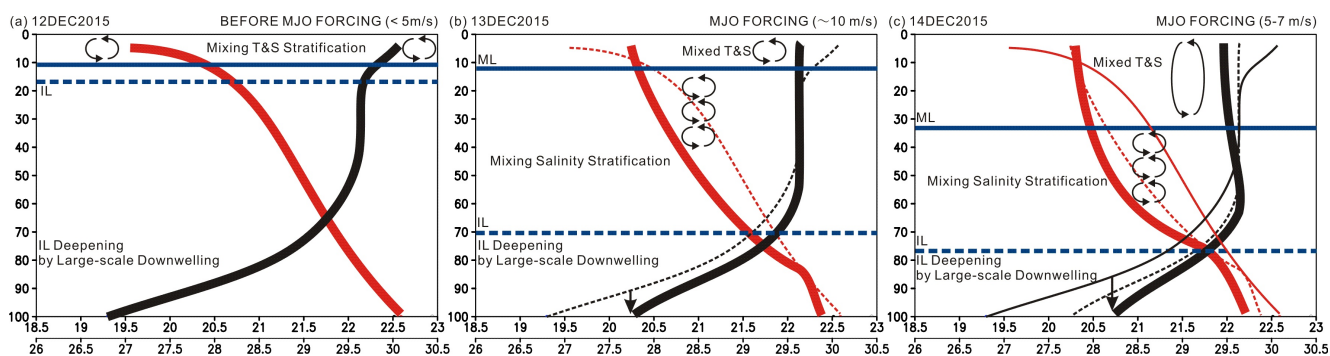
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Drastic deepening of the barrier layer off the western coast of Sumatra (4°S, 102°E, 800 m depth) due to the MJO passage observed during December 2015 is investigated. The Research Vessel Mirai observation captured the drastic increase of isothermal 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.

キーワード：バリアレイヤー、マッデンジュリアン振動

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 precipitation 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.

キーワード：日変化、MJO、ダウンスケーリング

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  $\sim 14$  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  $\sim 0.8$  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<sup>-1</sup>) 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 ( $\sim 1$  g kg<sup>-1</sup>) warm ( $\sim 1$  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 than in the inactive phases. During the pre-conditioning phases, both the low-frequency and high-frequency advectations 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  $\sim 0.6$  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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キーワード：全球非静力学モデル、予測スキル、水蒸気収支、マッデン・ジュリアン振動

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

## 水惑星実験で選択される熱帯季節内変動の発生過程: マッデン・ジュリアン振動の発生への示唆

### 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.

キーワード: マッデン・ジュリアン振動、赤道波、水惑星実験

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 observed before/after minimum brightness temperature is observed on the west/east coast of Sumatra 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 simulations by 27 global models. First, we found the commonly accepted perception 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 Continent 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 overall 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.

キーワード：熱帯低気圧、インド洋、マッデン・ジュリアン振動

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.

キーワード：安定同位体、降水、インドネシア海洋大陸

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.

キーワード : YMC、PALAU、季節内振動

Keywords: YMC, PALAU, Intra-Seasonal Oscillation