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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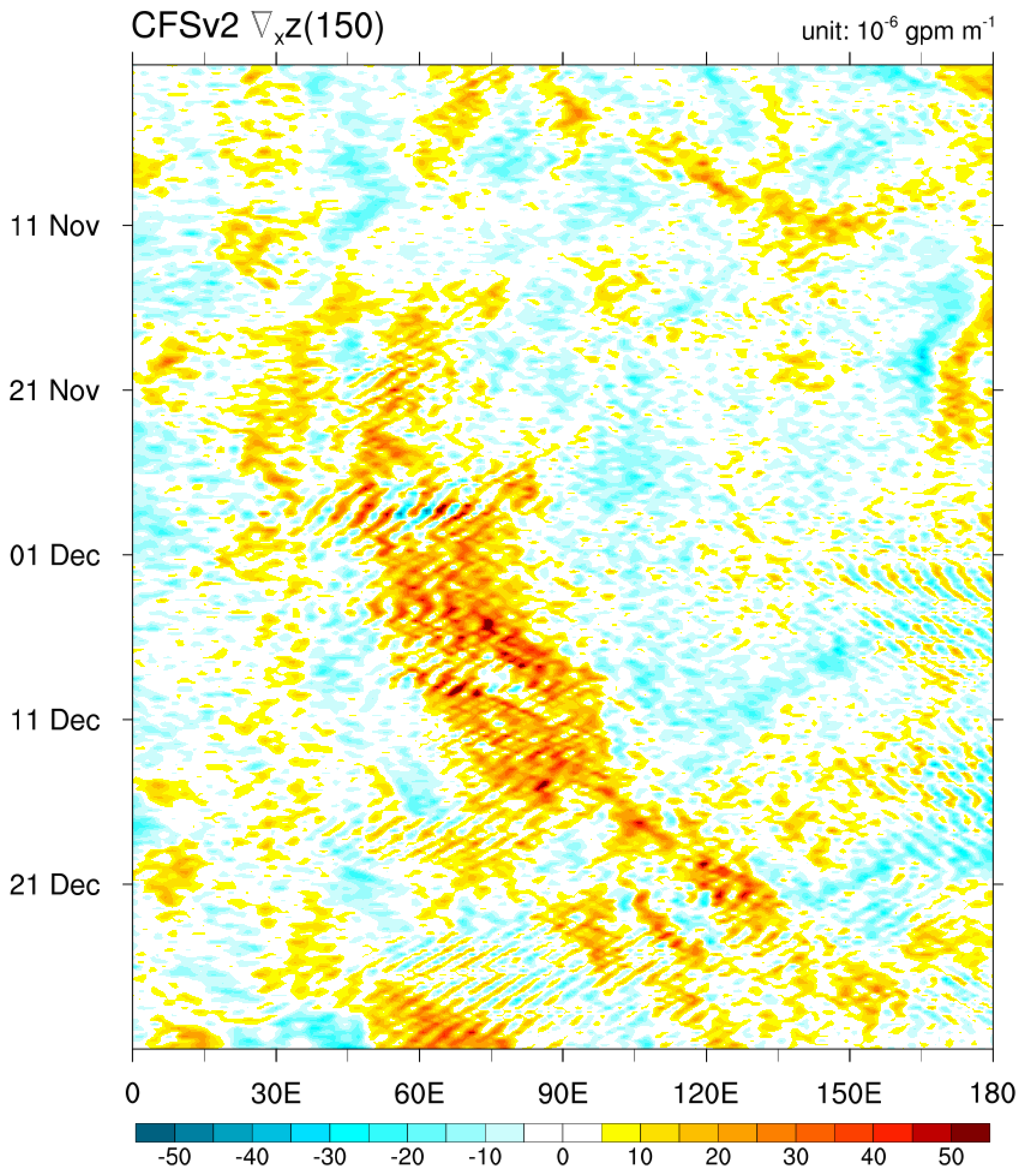
Given the dominant convection and circulation features of the Madden-Julian oscillation (MJO), its observation relies mostly on the measurements of convection, such as outgoing longwave radiation (OLR), and circulation-based measurements, such as zonal wind and velocity potential. For example, the Real-time 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


CFSv2 $\nabla_x z(150)$
unit: 10^{-6} gpm m^{-1}
11 Nov
21 Nov
01 Dec
11 Dec
21 Dec
0
30E
60E
90E
120E
150E
180
-50
-40
-30
-20
-10
0
10
20
30
40
50

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

