Japan Geoscience Union Meeting 2013
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ACG05-P01 Room:Convention Hall Time:May 24 16:15-17:30

Environmental conditions on the selection of MJO and moist Kelvin waves

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Moist Kelvin waves and Madden-Julian Oscillations (MJO) are dominant precipitation systems in the tropics which consist of mesoscale cloud clusters and move eastward along the equator. Not only have they different propagating velocity and convective profiles, but also they seem to prefer different environmental conditions. For example, observational studies show that moist Kelvin waves and MJO are strongly affected by different phases of the El Nino Southern Oscillation (ENSO). In this study, environmental conditions which select the development of moist Kelvin waves or MJO are examined, and then associated features of disturbances are discussed.

Intraseasonal perturbations of NOAA-OLR with eastward wave number 2 to 4 were divided into moist Kelvin waves and MJO, according to their equivalent depths. Environmental condition was defined with 3-months running mean variables of JRA reanalysis data. With regard to seasonal and zonal variations, MJO amplitude has a larger longitudinal dependency compared to seasonal variation; with local intensification from the Indian Ocean to the western Pacific Ocean, corresponding to the distribution of mid tropospheric relative humidity and vertical shear of zonal wind. On the other hand, moist Kelvin wave amplitudes and sea surface temperature (SST) show very similar intensifications from April to June at all longitudes in equatorial region. Correspondingly, in years with relatively stronger MJO amplitude compared to moist Kelvin waves, environmental midlevel relative humidity from the maritime continent to the western Pacific Ocean has high anomaly compared to an average year, indicating a La Nina pattern. In contrast, in years with relatively weaker MJO amplitude, there exist low relative humidity anomaly at midlevels in the Indian Ocean to the maritime continent and high SST anomaly in the central to eastern Pacific Ocean, indicating an El Nino pattern.

Comparing vertical profiles of the perturbations, MJO convection have deeper low level convergence than that of moist Kelvin waves. In addision, analysis of precipitation property about each continuous precipitation areas in the TRMM 2A25 PR data shows that stratiform rain ratio to total rain of mesoscale cloud systems embedded in MJO is higher than those in moist Kelvin waves. This suggests that MJOs consist of more organized mesosystems than moist Kelvin waves. These differences about convective characteristics seem to affect to the relationship between perturbations and environmental conditions such as mid tropospheric humidity or SST.

Keywords: MJO, moist Kelvin wave, ENSO

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ACG05-P02 Room:Convention Hall Time:May 24 16:15-17:30

Microstructure of Precipitation in Different MJO Phases over Sumatra

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1 Introduction

Natural variabilities of precipitation microstructure (e.g., DSD) substantially limit the accuracy of some DSD applications such as radar-derived rainfall. The aim of the present study is to investigate the intraseasonal variation of precipitation microstructure at Kototabang, west Sumatra, from long term precipitation data record.

2 Data and Methodology

The DSD observation was from a 2D-Video Disdrometer (2DVD), about eight years (end of 2002?2010). The vertical profile of DSD was from 24 GHz Micro Rain Radar (MRR). 1.3 GHz wind profiler data were used to determine the precipitating cloud type. Horizontal distribution of precipitation around 2DVD was observed by using 9 GHz X-band weather radar. Precipitation data were classified into three categories of MJO phase, i.e., (i) active, (ii) inactive/suppressed and (iii) weak MJO. Active and suppressed MJO are strong MJO phase in which the amplitude of MJO is greater than unity. For Kototabang, active convection was assumed when the MJO is during phases 2, 3, 4, and 5, and inactive/suppressed convection was assumed during phases 6-8 and 1. All cases with the amplitude of MJO being less than unity are assumed as weak MJO phase.

3 Results

During light rain, a slight difference in the DSD could be seen in which the DSD during inactive phase had more large drops than during active phase. The evidence of intraseasonal variation of DSD become more obvious during heavy rain in which the DSDs were much broader during inactive than active MJO phases, consistent with the previous study [1, 2]. Figure shows diurnal variation of percentage of rainfall contribution for several rain types during active and inactive MJO phases. During active MJO phase, shallow convective rain was dominant while deep convective rain was dominant during inactive phase. Detailed analysis regarding the intraseasonal variation of precipitation microstructure over Sumatra will be presented in the meeting.

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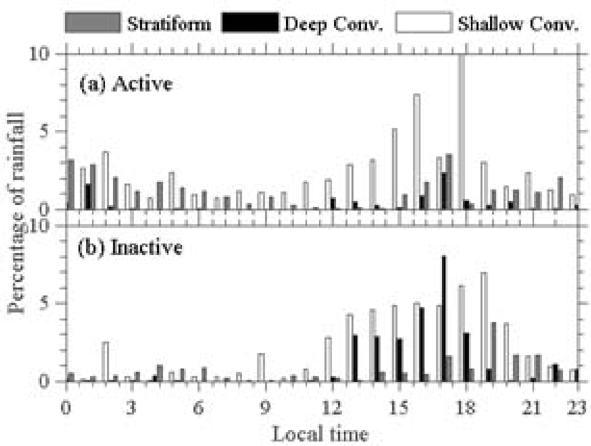
Keywords: Precipitation, MJO



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ACG05-P03 Room:Convention Hall Time:May 24 16:15-17:30

Variability of surface meteorology and air-sea fluxes during CINDY2011

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As a part of the CINDY2011/DYNAMO observation campaign, Research Vessel (R/V) Mirai was deployed at 8S, 80.5E in October and November of 2011. In this study, we investigate variability of surface meteorological variables and air-sea fluxes caused by atmospheric cumulus convective activity. Characteristics of convective systems observed by R/V Mirai in first half of October were quite different from those in second half of October and November.

In the former period, four mesoscale convective systems (MCSs) produced most of precipitation around R/V Mirai, associated with large-scale lower-tropospheric cyclonic circulation anomalies. Composite of the four events show that sensible heat flux was increased by approximately 20 W m^{-2} only during the passage of the MCS due to both increase in air-sea temperature difference and increase in surface wind speed. On the other hand, latent heat flux started to increase when the MCS reached the R/V Mirai, and continued to increase even after the passage of the MCS due solely to the increase in the surface wind speed. A difference in latent heat fluxes before and after the MCS events was approximately 70 W m^{-2} on average.

In the latter period, most of the observed convective events were sporadic sub-MCS-scale ones. By detecting sharp drop of surface temperature and its subsequent recovery period, we identify 22 events. Among them, 13 events consisted of only one temperature drop, while the other 9 events consisted of two times of temperature drops. We examine composite behavior of these two groups, as well as individual cases. We compare surface meteorological variables and radar reflectivity data, and find that minimum temperature is well correlated with maximum surface wind and ratio of radar echo area around R/V Mirai. Sensible and latent heat increases averaged for all the events were approximately 15 and 50 W m^{-2}, respectively.

Keywords: Surface meteorology, air-sea flux, cumulus convective activity, CINDY2011

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ACG05-P04 Room:Convention Hall Time:May 24 16:15-17:30

Persistence and the change of Baiu precipitation anomalies

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This work examines the persistence and the change of interannual Baiu precipitation anomalies during the Baiu season from late May to middle July around Japan. Atmospheric circulations affecting the Baiu precipitation are abruptly changed around late June. In the former period, the sea surface temperature anomalies (SSTAs) in the western North Pacific (WNP) associated with the El Nino/Southern Oscillation (ENSO) mainly controls the Baiu precipitation anomalies through the Pacific?East Asia teleconnection. The atmospheric circulations are characterized by specific surface pressure anomalies induced by the Rossby wave response of the SSTAs, which persist for the former period. On the other hand, the covariability of the SSTAs in the WNP and in the tropical Indian Ocean (TIO) through the ENSO is crucial for the Baiu precipitation anomalies in the later period. Anomalous atmospheric circulations are established through the Kelvin wave response from the TIO to the WNP. This response controls the Baiu precipitation anomalies in the only later period because this response needs a peculiar timing with the seasonal northward migration of the North Pacific subtropical high. Thus, the interannual variations of the Baiu precipitation in these two periods have insignificantly spatiotemporal correlations. These results suggest that detailed monitoring of SSTAs in both the WNP and the TIO can improve the predictability of the Baiu precipitation in the entire Baiu season.

Keywords: Baiu front, ENSO, Indian Ocean, Western North Pacific, air-sea interaction

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ACG05-P05 Room:Convention Hall Time:May 24 16:15-17:30

Intraseasonal Mixed Layer Temperature and Salinity Variation in the Eastern Equatorial Indian Ocean

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Atmospheric forcing from Madden-Julian Oscillation (MJO) produces sea surface temperature (SST) variation on intraseasonal timescales in the tropical Indian Ocean. In this study, we investigate the ocean mixed layer temperature variation in the eastern Indian Ocean to clarify the processes that produced the intraseasonal SST variation. We used mooring buoy data from the Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction (RAMA) in the Indian Ocean, particularly on an eastern site at 1.5S, 90E. We focused on intraseasonal SST cooling events as an indicator of the intraseasonal variation. The buoy observation captured 14 MJO events in the Indian Ocean from November to May during 2002-2007. In general, the events accompany by large-scale SST decreases in the central and eastern Indian Ocean with the onset of atmospheric convection and westerly winds. Mixed layer temperature balance analysis demonstrated that the intraseasonal SST variation was mainly produced by surface heat fluxes, in which suppressed shortwave radiation and enhanced latent heat loss had major roles. Horizontal heat advection also acted to cool mixed layer temperature during the period, though the contribution was less than one third of the net surface heat flux. Deepening of mixed layer and low salinity signal were also observed during the events. Possible impacts of the ocean variability on the mixed layer heat content are discussed.

Keywords: Intraseasonal variation, Indian Ocean, RAMA buoy

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ACG05-P06 Room:Convention Hall Time:May 24 16:15-17:30

Indian Ocean Dipole Interpreted in Terms of Recharge Oscillator Theory

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In this paper we use sea surface height (SSH) derived from satellite altimetry and an analytical linear equatorial wave model to interpret the evolution of the Indian Ocean Dipole (IOD) in the framework of recharge oscillator theory. The specific question we address is whether heat content in the equatorial band, for which SSH is a proxy, is a predictor of IOD development as it is for El Nino and the Southern Oscillation (ENSO) in the Pacific. We find that, as in the Pacific, there are zonally coherent changes in heat content along the equator prior to the onset of IOD events. These changes in heat content are modulated by wind-forced westward propagating Rossby waves in the latitude band 5-10S, which at the western boundary reflect into Kelvin waves trapped to the equator. The biennial character of the IOD is affected by this cycling of wave energy between the equator and 5-10S. Heat content changes are a weaker leading indicator of IOD sea surface temperature anomaly development than is the case for ENSO in the Pacific though because other factors are at work in generating IOD variability, one of which is ENSO forcing itself through changes in the Walker Circulation.

Keywords: Indian Ocean Dipole, Ocean-Atmosphere Interactions, Climate Variability, Equatorial Waves, ENSO

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ACG05-P07 Room:Convention Hall Time:May 24 16:15-17:30

Seasonal prediction by SINTEX-F

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The SINTEX-F seasonal forecast system has demonstrated excellent performance of prediction on the ENSO and the IOD (Luo et al., 2005a, 2007, 2008a, 2008b, Jin et al., 2008). However, we found that the prediction skill is relatively low for the decay phase of the La Nina events, the IOD development phase, and the Atlantic Nino/Nina events. In particular, we would like to talk about the reason why the prediction of the 2012 positive Indian Ocean Dipole Modes was difficult. Also, we will present pre-results about the next generation of the seasonal forecast system on a basis of SINTEX-F2 (the atmospheric component (ECHAM5) has a resolution of 1.18 (T106) with 31 vertical levels and the oceanic component (OPA9) has 0.5*0.5 degree horizontal mesh with sea ice model).

Keywords: climate mode, tropics, seasonal prediction

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ACG05-P08 Room:Convention Hall Time:May 24 16:15-17:30

Simulation of tropical-temperate troughs over southern Africa: Impacts of convection schemes

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Southern African summer rainfall simulated in three versions of an atmospheric general circulation model differing only in the convection scheme is examined with a special focus on tropical temperate troughs (TTTs). All three versions provide satisfactory simulations of key aspects of the summer (November-February) rainfall, such as the spatial distribution of total rainfall and the percentage of rainfall associated with TTTs. However, one version has a large bias in the onset of the rainy season. Results from self-organizing map (SOM) analysis on daily precipitation data revealed that this is because the occurrence of TTTs is underestimated in November. This model bias is not related to westerly wind shear that provides favorable condition for the development of TTTs. Rather, it is related to excessive upper level convergence and associated subsidence over southern Africa, which is forced by strong convection in the far western tropical Pacific.

Furthermore, the models are shown to be successful in capturing drier (wetter) conditions over the southern African region in El Nino (La Nina) years. The SOM analysis reveals that nodes associated with TTTs in the southern (northern) part of the domain are observed less (more) often during El Nino years, while nodes associated with TTTs occur more frequently during La Nina years. Also, nodes with dry condition over southern Africa are more (less) frequently observed during El Nino (La Nina) years. The models tend to perform better for La Nina, because they are more successful in capturing the frequency of different synoptic patterns.

Keywords: El Nino/Southern Oscillation, Atmospheric general circulation model, Self-organizing map

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ACG05-P09 Room:Convention Hall Time:May 24 16:15-17:30

Possible remote influence on pacific decadal variability and predictability

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We explore causes of less skills in hindcasting recent decadal climate changes, such as the Pacific decadal variability and the so-called hiatus of global warming tendency in the 2000s. As the hiatus forms a negative Pacific Decadal Oscillation (PDO)-like spatial pattern, together with the warming tendency in the extratropical North Atlantic relating to the Atlantic Multidecadal Oscillation and the strong temperature rising in the Indian Ocean, here we focus on the sea surface temperature (SST) tendency in the Pacific and on possible remote influences from other oceans. The Pacific decadal variability is generally regarded as an internal fluctuation in the climate system and, when statistically analyzing sets of initialized decadal hindcasts for recent decades, errors in initial state of the tropical Pacific SST can control skills in predicting extratropical SST variability relating to the PDO. By performing some sensitivity experiments using global climate models, in addition, we also find small but significant impacts of the other oceans on some stages of the Pacific decadal variability. While our ability to predict decadal variations in each ocean is limited at this stage, except for the high latitude of the North Atlantic, further understanding of these remote influences in addition to the inherent decadal fluctuations over the Pacific Ocean can help us to enhance the predictability of decadal climate changes.

Keywords: climate prediction, decadal variation, initialization, climate model

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ACG05-P10 Room:Convention Hall Time:May 24 16:15-17:30

Low-frequency variations of the zonal dipole sea surface temperature pattern in the South Indian Ocean

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Temporal variations of monthly sea surface temperature (SST) anomalies from 1951 to 2012 are investigated using observational dataset (ERSST: Smith et al., 2008). To explore large-scale SST patterns, we perform an empirical orthogonal function (EOF) analysis in the South Indian Ocean [20E-120E, 55S-Equator]. The first EOF mode (35%) represents an increasing tendency and the second EOF mode (13%) presents the Indian Ocean subtropical dipole (IOSD) pattern, as shown by Behera and Yamagata (2003). The third EOF mode (9%) has an east-west seesaw pattern, whose boundary lies at 90E: the centers of action are located around [70E, 30S] in the positive area and [110E, 30S] in the negative area. The time coefficient tends to have low-frequency variations: positive phases in the 1970s and 2000s, and negative phases in the 1960s and 1990s.

We specifically focus on the third EOF mode. We propose an zonal dipole index (ZDI) showing an activity of the third EOF mode based on the SST anomalies: the ZDI is defined as the SST anomalies averaged within the central South Indian Ocean [65E-75E, 35S-25S] minus SST anomalies averaged within the eastern side of the basin [110E-120E, 35S-25S], and then the ZDI is normalized using a standard deviation. Because the correlation coefficient between the ZDI and the time coefficient of the third EOF mode is 0.80, results obtained using the ZDI are not substantially different. We investigate temporal feature of the ZDI by applying a power spectral analysis. Result shows that the dipole SST pattern has a low-frequency variation on decadal (about 15 years) timescale. In addition, we investigate monthly dependence of the zonal SST pattern using the root mean square. Result shows that the SST pattern is dominant during austral summer (January to March).

We investigate causes of the zonal dipole SST pattern by applying a correlation analysis for various variables such as SST, sea level pressure (SLP), sea surface wind, and vertical velocity through the troposphere. Here, we use the JFM mean values. The correlation analysis with the ZDI shows existence of positive SLP anomaly with the downward anomaly located around [90E, 20S]. Therefore, we can point out that the zonal dipole SST pattern results from changes in surface wind related to the SLP variations. Interestingly, the ZDI shows significant correlations in the western equatorial Pacific: positive SST pattern, negative SLP pattern, and upward anomaly throughout the troposphere. The SST spatial structure resembles the El-Nino Modoki: an obtained coefficient between the ZDI and the Modoki index is 0.30 (0.54 of 1981-2012). Therefore, we expect that changes in zonal atmospheric circulation, that is, Walker circulation, associated with the western equatorial Pacific SST variations can form the zonal dipole SST pattern in the South Indian Ocean.

Keywords: subtropical Indian Ocean, low-frequency variability, sea surface temperature, tropical atmosphere