Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS23-P01 Room:Convention Hall Time:May 22 17:15-18:30

Role of Vertical Mixing Induced by Small Vertical Scale Structures above and within the Equatorial Thermocline in a CGCM

SASAKI, Wataru[1*], RICHARDS, Kelvin J.[2], LUO Jing-Jia[3]

[1]Japan Agency for Marine Earth Science and Technology, [2]International Pacific Research Center/SOEST, University of Hawaii, [3]Centre for Australian Weather and Climate Research

Recent measurements of ocean currents available at high vertical resolution capture vertical scales down to the order of O(10m). These new measurements showed numerous small vertical scale structures (SVSs) are present in and above the thermocline in the western equatorial Pacific [Richards et al., 2012]. The estimated vertical diffusion coefficient was found to vary from 10^{-5} to 10^{-3} m^2s^{-1} from the core of the thermocline to the base of the surface mixed layer. This is in stark contrast to the estimated diffusion coefficients below the thermocline in equatorial waters, which is found to be as low as 10^{-6} m^2s^{-1} [Gregg et. al, 2003].

The vertical scale of the SVSs is such that they are unresolved in ocean general circulation models with conventional vertical resolution. The vertical mixing originating from the SVSs, therefore, needs to be parameterized and its impact investigated. In this study, as a first step towards gaining an understanding of the likely role of SVS induced mixing in the dynamics of the equatorial ocean we employ a simple method for parameterization of the SVS mixing, and focus on the impacts of the SVS mixing on the climatological state and El Nino/Southern Oscillation (ENSO) in the equatorial Pacific.

We have performed a total of three simulations with and without parameterized SVS mixing by using a coupled general circulation model. Only the elevated background vertical diffusivity coefficients which represent the SVSs are different between the simulations. For the control run (CTL: without SVS mixing), the background vertical diffusivity coefficient is set to be a constant 1.0x10^{-6} m^2s^{-1} throughout the water column in the whole computational domain. In the runs with SVS mixing, the enhanced mixing induced by SVSs in the equatorial Pacific is represented as the elevated background vertical diffusivity coefficient. To reflect the observations that the SVS enhanced mixing appears to occur in the upper water column down to the center of the thermocline [Richards et al., 2012], we introduce a run with SVS enhanced mixing (SVS_C: stratification-independent SVS mixing) in which background diffusivity in the upper water column down to the 20C isotherm is set to be a constant 5.0x10^{-5} m^2s^{-1}. Below the 20C isotherm, the background vertical diffusivity is set to the control value of 1x10^{-6} m^2s^{-1}. The enhanced diffusivity is applied to the tropical Pacific (5S-5N, 140E-70W). We perform an additional run with SVS enhanced mixing, SVS_N2 (stratification-dependent SVS mixing), in which the level of the enhanced mixing is inversely proportional to the square of the buoyancy frequency. This parameterization is prompted by the observation that variation of the level of the vertical diffusivity is caused by variation in the stratification [Richards et al., 2012].

It is found that the SVS-induced mixing leads to a reduced stratification above the thermocline. The reduced stratification leads to an increase in the vertical diffusivity which feeds back to further reduce the stratification and tighten the thermocline. The sharpened thermocline limits the exchange of heat across the thermocline and traps the surface heating above the thermocline. As a result, SST in the eastern equatorial Pacific is warmed by the SVS enhanced mixing. Furthermore, the warming of the SST is strengthened through the ocean-atmosphere feedbacks in the coupled system: Bjerknes feedback [Bjerknes, 1969] and SST-shortwave feedback [Klein and Hartman, 1993]. We also find that the SVS-induced mixing changes a few characteristics of ENSO. There is a reduction in the amplitude of ENSO brought about by a deepening of the thermocline. Moreover, stratification-independent SVS mixing reduces the skewness of ENSO, while stratification-dependent SVS mixing leads to a warming of the cold tongue and deepened thermocline during La Nina conditions, which increases the skewness of ENSO.

Keywords: small vertical scale structures, vertical mixing, coupled general circulation model, El Nino

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS23-P02 Room:Convention Hall Time:May 22 17:15-18:30

Impacts of the South China Sea Throughflow on the tropical Pacific

TOZUKA, Tomoki[1*], Tangdong Qu[2], YAMAGATA, Toshio[1]

[1]The University of Tokyo, [2]International Pacific Research Center

Impacts of the South China Sea throughflow (SCSTF) on the tropical Pacific are investigated using the University of Tokyo coupled general circulation model. It is found that the period of ENSO becomes longer when the SCSTF is blocked. Since no large difference is seen in the phase speed of Kelvin waves when vertical mode decomposition is conducted, the differnce is not due to the change in stratification of the equatorial Pacific. Rather, it is more related to the larger discharge of heat through the Indonesian Throughflow.

Keywords: South China Sea, El Nino/Southern Oscillation, Coupled general circulation model, Indonesian Throughflow

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS23-P03 Room:Convention Hall Time:May 22 17:15-18:30

Mechanism for the asymmetry in ENSO transition and duration

OHBA, Masamichi[1*]

[1]Central Research Institute of EPI

The El Nino-Southern Oscillation (ENSO), which consists of a quasi-periodic (3-7-yr timescale) warming (El Nino) and cooling (La Nina) of the tropical central and eastern Pacific Ocean (CEP), is the most dominant driver for Earth interannual climate variability. ENSO prediction is of practical interests, in addition to scientific, because of its large environmental and societal impacts. To predict and understand the variability of ENSO, a number of investigators have suggested conceptual theories, providing a comprehensive idea regarding the cyclic nature of ENSO. The mechanisms in these conceptual theories effectively capture the observed phase transition from El Nino to La Nina and successfully reproduce the linear oscillation of ENSO. However, several studies have reported that a type of break in the ENSO cycle occurs when La Nina shifts to El Nino. The air-sea coupled system over the Pacific somehow remains in a weak La Nina state for up to two years, while El Nino tends to turn rapidly into La Nina after the mature phase. Recent studies (Ohba and Ueda 2009; Ohba et al. 2010; Okumura et al. 2011) have reported that the nonlinear atmospheric response to the CEP sea surface temperature forcing is a fundamental cause of the asymmetry in the transition. Because the duration of an ENSO episode can cause severe drought, for example, the 1999-2001 drought in central Asia from, and this duration is difficult to reproduce in most coupled general circulation models, understanding of the ENSO asymmetry is important for improving seasonal climate forecast skills (Ohba et al. 2010; Ohba and Watanabe 2012). Therefore, the asymmetry of transition/duration is an important aspect of ENSO. In the presentation, these recent studies will be introduced with the discussion of its long-term change and asymmetry in the ENSO predictability.

Keywords: El Nino/Southern Oscillation, Indian Ocean, Pacific Ocean, Sea surface temperature

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS23-P04 Room:Convention Hall Time:May 22 17:15-18:30

Sea surface heating in the central North Pacific associated with La Nina and intensification of the subarctic front

NAGANO, Akira[1*], HASEGAWA, Takuya[1], KAWAI, Yoshimi[1], Hiroyuki Tomita[1], Masanori Konda[2]

[1]Japan Agency for Marine-Earth Science and Technology, [2]Kyoto University

Japanese only

Keywords: El Nino, La Nina, Sea surface temperature, Sea surface heat flux, North Pacific subarctic front

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS23-P05 Room:Convention Hall Time:May 22 17:15-18:30

Interdecadal variability of western North Pacific summer monsoon through the PJ pattern

KUBOTA, Hisayuki[1*], Yu Kosaka[2], Shang-Ping Xie[2]

[1]JAMSTEC, [2]University of Hawaii IPRC

Pacific-Japan (PJ) pattern is known as a basic pressure pattern during summer over the western North Pacific and is correlated to hot and cold summer in Japan (Nitta 1987, Koasaka and Nakamura 2006). PJ pattern is also known as a remote response from interannual variability of warm anomaly of summer Indian Ocean after the El Nino which suppresses the convection over Philippines and enhances Baiu/ Meiyu activity (Xie et al. 2009). In this study, we defined new PJ pattern index using station data and reproduced PJ pattern from 1897 to 2009, and investigated the interdecadal variability of summer monsoon activity over the western North Pacific.

The first mode of EOF analysis using 850hPa vorticity during summer and PJ pattern using the difference of both major pressure seesaw points of Yokohama and Hengchun during summer are correlated well of 0.80. Therefore PJ pattern is defined as a difference of surface pressure data between Yokohama and Hengchun.

PJ pattern and the preceding ENSO have high correlation after 1970s. However this correlation becomes unclear before 1970s. It is interesting to convey that the correlation between PJ pattern and ENSO is also high before 1910. The relation with PJ pattern and summer temperature in Japan and summertime tropical cyclone activity will be also discussed.

Keywords: monsoon, interdecadal variability, western North Pacific

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS23-P06 Room:Convention Hall Time:May 22 17:15-18:30

Phase reversal and periodicity of the decadal and bi-decadal ENSO-like variabilities controlled by South Pacific Ocean

Hiroaki Tatebe[2], MORI, Masato[1*], Yukiko Imada[3], Masahide Kimoto[1], Hiroyasu Hasumi[1]

[1]Atmosphere and Ocean Research Institute, University of Tokyo, [2]Japan Agency for Marine-Earth Science and Technology, [3]Graduate School of Information Science and Engineering, Tokyo Institute of Technology

Phase reversal mechanisms of the Pacific ENSO-like variability on decadal timescales are investigated based on a pair of the climate model experiments consisting of the control run (CTRL) and the partial blocking run (PB) where model temperature and salinity are restored to their climatological values near 10 degrees south in the South Pacific. In CTRL, positive anomalies in the tropics and negative anomalies in the North Pacific mid-latitudes are found in the first EOF mode of the sea surface temperature with significant decadal and bi-decadal periods. On the other hand, in PB, the former tropical signals are not appeared and only the mid-latitude signals are identified. It is robustly demonstrated that oceanic signals of the South Pacific origin are keys in maintaining the ENSO-like variability. By separating oceanic signals in CTRL into decadal and bi-decadal components, it is also shown that relatively faster oceanic wave adjustments triggered by changes of wind-stress curl in the South Pacific extra-tropics for the decadal and slower mean isopycnal advection of subsurface temperature anomalies associated with modification of South Pacific eastern subtropical mode water for the bi-decadal are essential in the phase reversal of respective periods. Periodicity of the decadal (bi-decadal) variability is determined mainly by propagation time of the oceanic subsurface signals from the South Pacific extra-tropics (mid-latitudes) to the tropics.

Keywords: PDO, decadal ENSO

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS23-P07 Room:Convention Hall Time:May 22 17:15-18:30

Inpact of tropical instability waves on ENSO characteristics

IMADA, Yukiko[1*], Masahide Kimoto[2]

[1]Graduate School of Information Science and Engineering, Tokyo Institute of Technology, [2]Atmosphere and Ocean Research Institute, University of Tokyo

In this study, the impact of TIWs in the Pacific Ocean on El Nino/Southen Oscillation (ENSO) is investigated by introducing a new scheme of TIWs into our AOGCM MIROC with medium resolution.

Tropical instability waves (TIWs) are equatorial sub-synoptic-scale eddies observed both in the Pacific and Atlantic Oceans as cusp-shaped frontal waves propagating westward during the second half of the year, and are an important mechanism for distributing heat in the meridional direction. Recently, Yu and Liu (2003) showed that TIW intensity increases during La Nina years and is reduced during El Nino years with a linear relationship, which is related to the mechanism generating baroclinic instability. Furthermore, An (2008) suggested that TIWs could play an important role in producing the asymmetry between El Nino and La Nina. It is suggested that asymmetric heat transport associated with TIWs which are active (inactive) during La Nino (El Nino) gives an significant asymmetric negative feedback to ENSO, and explain the observed asymmetric feature of stronger-amplitude El Nino and weaker-amplitude La Nina asymmetry. However, there are several potential nonlinear processes causing the asymmetric behavior of ENSO in the tropical air-sea coupled system. The ENSO model presented by An (2008) is too simple to confirm the TIW contribution in the presence of other potential processes causing ENSO asymmetry. In this study, we investigated the impact of TIWs on ENSO characteristics in the mixture of nonlinear processes using an atmosphere and ocean general circulation model (AOGCM) MIROC. 100-year integrations were performed with and without the TIW parameterization which was the first attempt to represent the TIW-induced baroclinic eddy heat transport (Imada and Kimoto 2012).

A comparison between two experiments figured out important roles of baroclinic eddies in ENSO characteristic. One is the responsibility of TIWs for ENSO asymmetry. The GCM run with the TIW scheme showed larger skewness of sea surface temperature (SST) anomalies in the ENSO active region, which supports An (2008). Its effect was dominant compared with the other asymmetric sources such as nonlinear dynamical heating of ENSO (An and Jin 2004).The other role of baroclinic eddies is to change the mechanism of ENSO phase transition from a SST mode (Neelin et al,. 1998 ;Guilyardi, 2006) to a thermocline mode (Guilyardi, 2006) due to the stratification modified by the eddy heat transport around the off-equatorial thermocline. It also promotes the lower frequency of ENSO.

The resulting changes in ENSO characteristics are consistent with the observed ENSO modulation including increase of period, asymmetry, and shift from SST to thermocline mode, concurrent with the observed 1970's climate shift. The result of ocean assimilation conducted by high-resolution AOGCM also shows the increasing TIW activity through the increasing meridional density gradient in the eastern tropical Pacific associated with the climate shift. Therefore, this numerical approach provided a new suggestion that TIWs have an important role in the interaction between the Pacific decadal variability and ENSO, and have possibility to contribute to the understanding of them.

Keywords: El Nino/Southern Oscillation, Tropical instability waves, Atmosphere and Ocean General Circulation Model, parameterization

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS23-P08 Room:Convention Hall Time:May 22 17:15-18:30

Pausing of the ENSO cycle: A case study for 1998 to 2002

NAGURA, Motoki[1*], Kentaro Ando[1], Keisuke Mizuno[1]

[1]Japan Agency for Marine-Earth Science and Technology

The heat balance of the surface mixed layer at the eastern equatorial Pacific Ocean (0, 140W) is examined to find mechanisms of the transition from 1998 La Nina to 2002 El Nino. The observations from the Tropical Atmosphere Ocean/Triangle Trans-Ocean Buoy Network (TAO/TRITON) are used. In the analysis period, La Nina lingers and El Nino does not immediately appear despite a deepened thermocline, which is described as ”pausing of ENSO cycle” by previous studies (e.g., Kessler 2002). The results from heat balance analysis show that the vertical heat advection anomaly and surface heat flux anomaly warm the mixed layer from 1999 to 2002, causing rise of the mixed layer temperature. A cooling anomaly due to horizontal heat advection counteracts the warming and slows down the transition from La Nina to El Nino. It is found that the eddy heat flux anomaly associated with weakened tropical instability waves significantly contributes to the cooling anomaly. During the normal period, meridional shear of the zonal currents between South Equatorial Current and North Equatorial Counter Current supplies energy via barotropic instability to tropical instability waves, giving rise to warming of equatorial cold tongue due to eddy heat flux. The Trade Winds are relaxed and South Equatorial Current is weakened during the transition from La Nina to El Nino, which results in weakening of the meridional shear of the zonal currents, decrease of tropical instability wave energy and thus reduction of warming due to eddy heat flux. The results presented here illustrate that the eddy activity has sizable influence on ENSO cycle in addition to the basin scale dynamics.

Keywords: El Nino, Tropical Instability Waves, Equatorial Pacific Ocean, Interannual Variability, Mixed Layer Heat Budget

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS23-P09 Room:Convention Hall Time:May 22 17:15-18:30

Breakdown of ENSO predictors in the 2000s: Changes in the thermocline variation and atmospheric intraseasonal forcing

HORII, Takanori[1*], Iwao Ueki[1], HANAWA, Kimio[2]

[1]RIGC, JAMSTEC, [2]Graduate School of Science, Tohoku University

Variations in the warm water volume (WWV) of the equatorial Pacific and atmospheric forcing from intraseasonal variation (ISV) in the western equatorial Pacific are regarded as two good predictors of the subsequent El Nino/Southern Oscillation (ENSO), with a lead time of two to three seasons. Here we report that the robust predictability of these predictors for ENSO has changed in the 2000s.

During 1981-2000, the recharge (discharge) of the WWV and strong (weak) ISV forcing preceded El Nino (La Nina) by two to three seasons. However, in the 2000s, the interrelationship between the WWV/ISV and following ENSO became weak, especially for the El Nino/La Nina events after 2005. Notably, the discharged phases of WWV that led to subsequent La Nina events were less observed since 2001. These changes may be caused by frequent occurrences of the ”warm-pool El Nino,” which is characterized by SST anomalies centered in the central equatorial Pacific.

Keywords: El Nino/Southern Oscillation (ENSO), Equatorial Pacific, Equatorial Warm Water Volume, Atmospheric Intraseasonal Variation

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS23-P10 Room:Convention Hall Time:May 22 17:15-18:30

The Cross-Equatorial Northerly Surge in the South China Sea and Precipitation Patterns over the Maritime Continent

HATTORI, Miki[1*], MORI, Shuichi[1], MATSUMOTO, Jun[2]

[1]Japan Agency for Marine-Earth Science and Technology, [2]Tokyo Metropolitan University

Cold surge in the northern South China Sea (hereafter CS) is pointed out to correlate to convective activity over the Maritime Continent, and it is reported as a case study that cold surge which across the equator affect the heavy rainfall in the Maritime Continent. In this study, in order to explain the occurrence of the surge in the equatorial region, we defined cross-equatorial northerly surge (CENS) and investigated background of occurrence and relationship with variation of precipitation.

The CENS in this study was defined as the area-averaged northerly wind exceeding 5 m s^{-1} over 105^{o}E-115^{o}E, 5^{o}S-EQ based on the QuikSCAT sea surface wind data. During the 10 winters from December 1999 to March 2009, 62 CENS events were extracted and classified into the following patterns: 11 events were associated with cold surges over the northern part of the South China Sea and termed the CS pattern; 20 events were associated with a convectively active phase of the tropical intra-seasonal variations and termed the MJO pattern; 16 events were associated with both cold surges and convectively active tropical intra-seasonal variations and termed the CS-MJO pattern; and other 15 events were not associated with these patterns. In the CS pattern, the increased precipitation to the north of the island of Java was significant. In the MJO pattern, a wide area of northerly winds in the vicinity of the depression around 10^{o}S continued for a longer period than in the CS pattern, and the increased precipitation west of Sumatra and south of Java was significant. The CS-MJO pattern showed features of both the CS and MJO patterns and was associated with the greatest increase in precipitation of the three patterns in particular, in northwestern Java and both north and south of Java. In the CENS events, increases in precipitation were observed in the Maritime Continent region, and notable difference in the precipitation distribution has been brought by difference in background fields.

Keywords: cold surge, Maritime Continent, monsoon, precipitation distribution

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS23-P11 Room:Convention Hall Time:May 22 17:15-18:30

Covariability between the Baiu Precipitation and Tropical Cyclone Activity through Large-Scale Atmospheric Circulations

YAMAURA, Tsuyoshi[1*], Tomohiko Tomita[2]

[1]Kumamoto University, [2]Kumamoto University, JAMSTEC/RIGC

Interannual variations of the Baiu precipitation and tropical cyclone (TC) activity in the western North Pacific (WNP) are linked to large-scale atmospheric circulations associated with the El Nino/Southern Oscillation (ENSO) and the Tropospheric Biennial Oscillation (TBO) of the Asian monsoon. This work examines covariability between the Baiu precipitation and the TC activity through the large-scale atmospheric circulations of the ENSO and the TBO.

In years when sea surface temperature (SST) anomalies are low in the eastern tropical Pacific with respect to the ENSO, the number of TCs increases around the Philippines in the Baiu season, June and July. On the other hand, in years of low SST anomalies in the eastern tropical Pacific related to the TBO, the strength of TCs is significantly enhanced to the southeast of Japan. Each of the two TC activities enhances a specific large-scale cyclonic circulation, which shifts the axis of monsoon westerlies and causes the anomalous Baiu precipitation. These modifications are dependent on the phase of the ENSO and the TBO. In years of high SST anomalies in the eastern tropical Pacific, the anomalous TC activity is small and sometimes has opposite impacts on the large-scale atmospheric circulations. Thus, the Baiu precipitation covaries with the TC activity through specific large-scale circulations, and the covariation is dependent on the phase of the ENSO and the TBO.

Keywords: Baiu, Tropical cyclone activity, the East Asian summer monsoon, ENSO, TBO

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS23-P12 Room:Convention Hall Time:May 22 17:15-18:30

Regional Climate Modeling Study of Wind Variations over Western Pacific Warm Pool before El Nino Onsets

MIYAMA, Toru[1*], HASEGAWA, Takuya[1]

[1]Japan Agency for Marine-Earth Science and Technology, Research Institute for Global Change

Prior to the onset of the 2002/03 El Nino event, strong northwesterly surface winds occurred along the northern coast of New Guinea. The winds caused upwelling occurred along the coast, and this relatively cool water spread out over a wider area to the northeast toward the equator. Hasegawa et al. [2009] hypothesized the low SST in this region generated a positive zonal SST gradient together with high SST in the east, and it contributed to enhancement of the westerly surface wind in this region, leading to the onset of the 2002/03 El Nino event. To confirm their hypothesis, we have started a regional climate modeling study in the western Pacific Warm Water Pool region. The goal is to understand this region in an ocean-atmosphere coupled system. As a first step, we performed experiments with a regional atmospheric model forced with sea surface temperature (SST) as a lower boundary condition. The model used in this study was the International Pacific Research Center (IPRC) Regional Atmospheric Model (iRAM). The model covered the western Pacific Ocean with a horizontal resolution of 0.25 degree. We in particular focused on December 2001, as Hasegawa et al [2009] did in their diagnostic study. This model reproduced the strong northwesterly surface winds along the northern coast of New Guinea in the control run. To measure impacts of cold SST along the New Guinea coast, we did additional experiments to cool SST further in this region. Decreasing SST enhanced divergence of wind in the overlying atmosphere. This was favorable to the enhancement of the westerly surface wind along the equator at the eastern edge of the Warm Water Pool, supporting Hasegawa et al. [2009]'s idea. We also pay attention to the role of the high mountains of New Guinea in shaping climate around this region. The central mountains of New Guinea have a peak elevation over 4000m high. This mountain helped to enhance upward air motion and convergence near the surface in the control run. In an experiment where the orography of New Guinea was flattened, these circulations were eliminated and the northwesterly along the northern coast was weakened. This suggests the orography of New Guinea provides a good environment for the feedback between the westerly and the coastal upwelling mentioned above. The difference with and without the orography also revealed that the high mountain enhances precipitation over the northern side of the mountain ridge in this season.

Keywords: El Nino, Warm Water Pool, gegional model, air-sea coupling, orography effect, New Guinea

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS23-P13 Room:Convention Hall Time:May 22 17:15-18:30

General Discussion: Multi-scale phenomena in the tropical Pacific

HASEGAWA, Takuya[1*]

[1]JAMSTEC-RIGC

Japanese only.

Keywords: General Discussion, tropical Pacific, temporal-spatial multi-scale, air-sea interaction