THE CHARACTERISTICS OF INDIAN OCEAN DIPOLE MODE PRELIMINARY STUDY OF THE MONSOON VARIABILITY IN THE WESTERN PART OF INDONESIAN REGION

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ABSTRAK

Prediksi datangnya El-Nino and Southern Oscillation (ENSO) di Indonesia umumnya dikaitkan dengan perilaku anomali suhu permukaan laut (SPL) dan osilasi selatan (OS) antara kawasan Pasifik Barat hingga Pasifik Timur yang diwakili oleh Darwin (Australia) dan Tahiti (Kep. Hawai). Peristiwa ini erat kaitannya dengan pergeseran pusat-pusat konveksi yang ada di atas wilayah Indonesia, khususnya kawasan Indonesia bagian barat yang kaya akan awan-awan raksasa, seperti awan Cumulonimbus (Cb). Sehubungan dengan minimnya data meteorologi dan oseanografi di kawasan ini, kami mencoba mengkaji pada makalah ini beberapa hasil awal dari karakteristik Indian Ocean Dipole (IOD). Kami menggunakan data anomali Suhu Permukaan Laut (SPL), Tekanan Permukaan Laut (TPL) dan Radiasi Gelombang Panjang (RGP). Dengan menggunakan metode analisis spektrum, kami mendapatkan bahwa peak yang kuat muncul adalah osilasi tiga bulanan seperti yang terjadi pada data SPL dan TPL. Hal ini justru tidak terjadi pada data RGP, di mana peak dominan justru terjadi pada osilasi enam bulanan. Hal ini kemungkinan besar diakibatkan adanya musim transisi yang terjadi di kawasan ini dari musim kering ke musim penghujan dan juga sebaliknya. Sedangkan osilasi enam bulanan kemungkinan besar diakibatkan adanya pengaruh Monsun.

Kata kunci : variabilitas Monsun, indian ocean dipole dan enso

ABSTRACT

Prediction of El-Nino and Southern Oscillation (ENSO) phenomena in Indonesia, generally is corresponded to the Sea Surface Temperature anomaly (SSTa) and Southern Oscillation Index (SOI) along West to East Pacific Ocean between Darwin (Australia) and Tahiti (Hawai Islands). This phenomena is assumed having a good correlation with the moving average of convective activity, especially in the western part of Indonesia region which always covered by giant clouds like Cumulonimbus (Cb). Since only a few atmospheric and oceanography data in this region, we tried to investigate in this paper the preliminary results of the characteristics of Indian Ocean Dipole (IOD). We used the Sea Surface Temperature (SST), Sea Level Pressure (SLP) and Outgoing Longwave Radiation (OLR) of Dipole Mode Index (DMI) anomaly. By applying the spectrum method, we found that the most predominant peak of these parameters are three months oscillation such as on SST and SLP data analysis. While, for OLR data, the most predominant peak is six months oscillation. We suspect these phenomena are correspond the transition season from dry to rainy season for SST and SLP, and Monson season for OLR.

Keywords : Monsson variability, indian ocean dipole and enso

1 INTRODUCTION

It is now widely accepted that tropics play an important role in the global hydrological cycle, and tropical rainfall is the critical component of this role. Three-fourth of the atmosphere's heat energy derives from the release of latent heat of condensation in the process of precipitation. Two-thirds of the global precipitation occurs in the tropics. The variability of tropical rainfall affects the lives and economics of more than half of the world's population. The large spatial and temporal variability of rainfall systems poses a major challenge to estimating global rainfall.

Globally there are three equatorial heat sources that are interpreted as the driving force for the general circulation. One is Indonesia region which is called the "maritime continent" (Ramage, 1968), and other two are located over Africa and South America. Indonesia region is located between two great continents, Asia and Australia, and between two oceans, Pacific and Indian. Consequently, the surface meteorological elements in this region is characterized by "monsoon climate".

The monsoon variability should be considered as part of the oscillation in the coupled ocean/land/atmosphere system, which involves the largest continent and the largest ocean. This monsoon climate has typical rainy and dry season. The rainy season corresponds to the northeast monsoon period in the northern winter (winter monsoon), and the dry season does to the southwest monsoon period in the northern summer (summer monsoon) as explained by Yasunary (1981, 1990a and b) and Yasunary and Supiah (1988).

In Figures 1-1 and 1-2, a primary synoptic-scale circulation and associated precipitation features on the Asian winter and summer monsoon are studied by Johnson (1992). We can see the cold surges which move from the northern Pacific Ocean, together with cold surges from China to the southern hemisphere. This cold surges bring much of water vapor. The Coriolis force swiches the wind direction in the southern hemisphere. The wind blows through Sumatera and coverges to Java island.

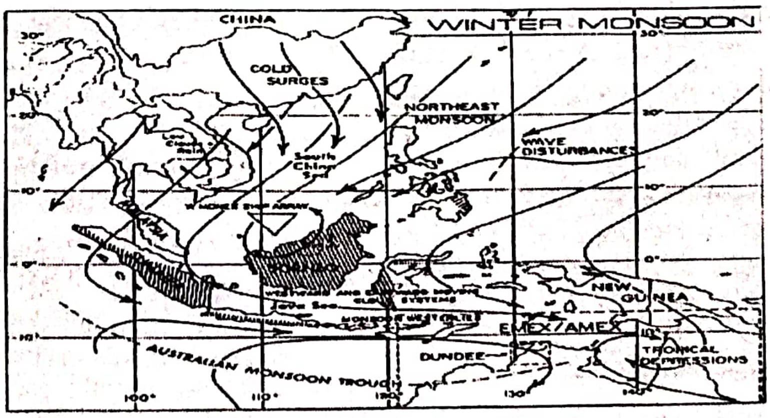

Figure 1-1: Primary circulations that affect precipitation in the region of monsoon for Wintern Monsoon (Johnson, 1992)

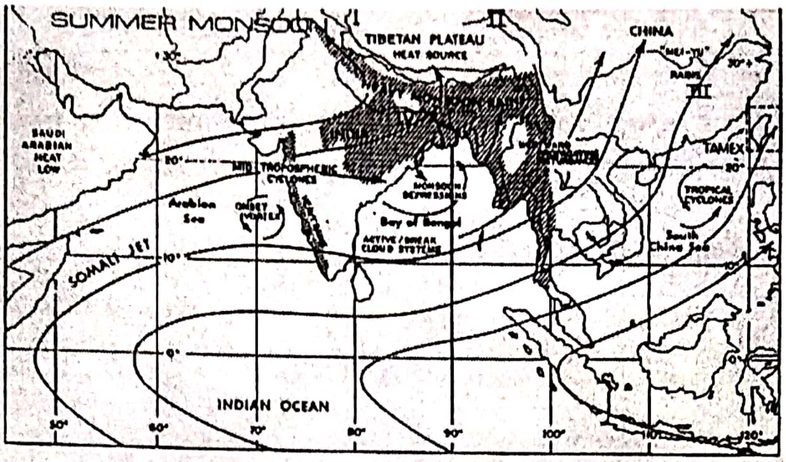

Figure 1-2 : As the same as Figure 1-1, but for Summer Monsoon (Johnson, 1992)

The summer monsoon appears when the depression over Asia, especially South China and Tibetan Plateau is developed. The wind blows from southern hemisphere to the northern hemisphere during summer monsoon and brings much water vapor to the southeast Asia. During this season, Indonesia region is influenced by the wind from Australian dry airmass. After passing the equator, the Coriolis force swiches the wind direction so that the winds becomes westerly in the northern hemisphere.

It has been well documented that the interannual variability of monthly rainfall in Indonesia are strongly related to the ENSO (*e.g.* Berlage, 1957, 1966; Yasunary, 1981; Hackert and Hastenrath, 1986; Yasunary and Supiah, 1988; *see* Allan, 1991, for a review concerning mainly Australian region). Nicholls (1981, 1984) showed a mutual relationship between surface pressure at Darwin of northern Australia, SST around Indonesia and Indonesian rainfall from the view point of predictability of Indonesian weather condition.

In this matter, Indian Ocean Dipole (IOD) is defined as a coupled ocean-atmosphere phenomena in the Indian Ocean. It is normally characterized by anomalous cooling of Sea Surface Temperature (SST) in the south eastern equatorial Indian Ocean and anomalous warming of SST in the western equatorial Indian Ocean. Associated with these changes the normal convection situated over the eastern Indian Ocean warm pool shifts to the west and brings heavy rainfall over the east Africa and severe droughts/forest fires over the Indonesian region. A dipole structure in SST anomalies - cooler than normal SSTs appear off Sumatera in the southeast tropical Indian Ocean while the western tropical Indian Ocean is warmer than usual. Also strong easterly wind anomalies along the equator in the tropical eastern Indian Ocean.

The name IOD is presented by the zonal dipole structure of the various coupled ocean-atmosphere parameters such as SST, OLR (Outgoing Longwave Radiation) and Sea Surface Height anomalies. Generally, this configuration is also called positive IOD. Infact, a negative IOD also evolves preceding/following a positive IOD, with reverse in the configuration of the positive IOD as shown in Figures 1-3 and 1-4, respectively.

Positive Dipole Mode

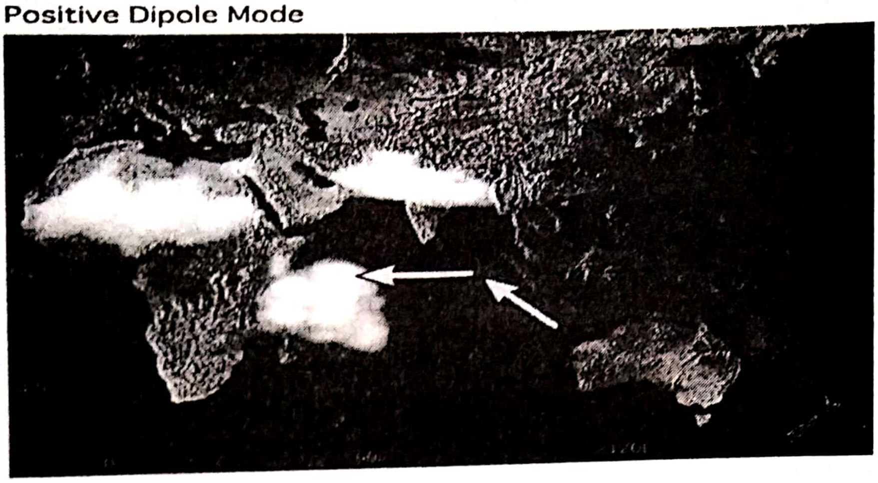

Figure 1-3: The Schematic diagram of SST anomalies (shading over Indonesia – Australia woling, shading over eastern coast of Africa and Japan warning) during a positive IOD event. White patches indicate increased convective activity. Arrows indicate wind direction (http://w3.jamstec.go.jp/frsgc/research/d1/saji/IOD1.html)

Negative Dipole Mode

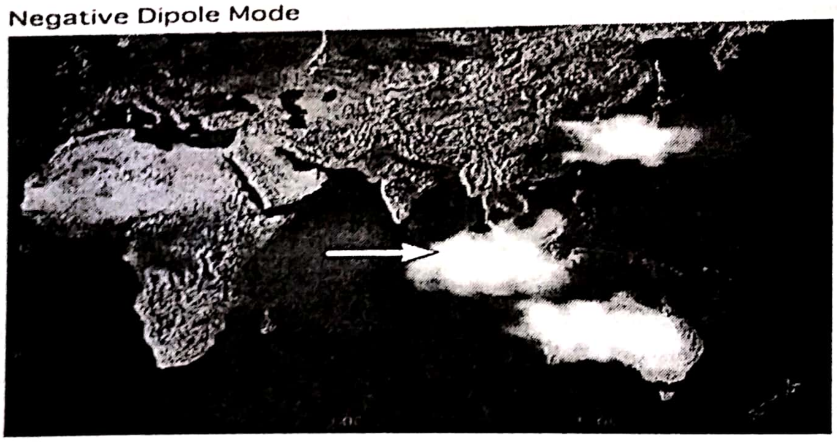

Figure 1-4: As the same as Figure 1-3, but for a negative IOD event. White patches indicate increased convective activity (shading over Indonesia – Australia woling, shading over eastern coast of Africa and Japan warning) (http://w3.jamstec.go.jp/frsgc/research/d1/saji/IOD1.html)

Because of the strong seasonal phase locking it is meaningful to use the compositing technique to portray the evolution of a DM event. Such a composite picture of SST and surface wind anomalies is shown in Figure 1-5. To make this picture we composited 6 significant events (1961, 1967, 1972, 1982, 1994 and 1997).

Note that :

- Cool SST anomalies first appear near the Lombok strait in May-June, accompanied by moderate southeasterly wind anomalies in the southeastern tropical Indian Ocean.
- In the following months, the cool anomalies intensify and migrates towards the equator along the Indonesian coastline. The western Indian Ocean is also warming up. The southeasterly anomalies are now stronger resulting in strong zonal anomalies along the equator and stronger alongshore winds along the coast of Indonesia. A rapid peaking of SST and wind anomalies occur in October, followed by rapid demise.

The aim of this paper is to investigate the characteristics of IOD as a preliminary results study the Monsoon variability in the Western part of Indonesian region. We hope all these informations could be applied to the role of the subsurface Indian Ocean phenomena later.

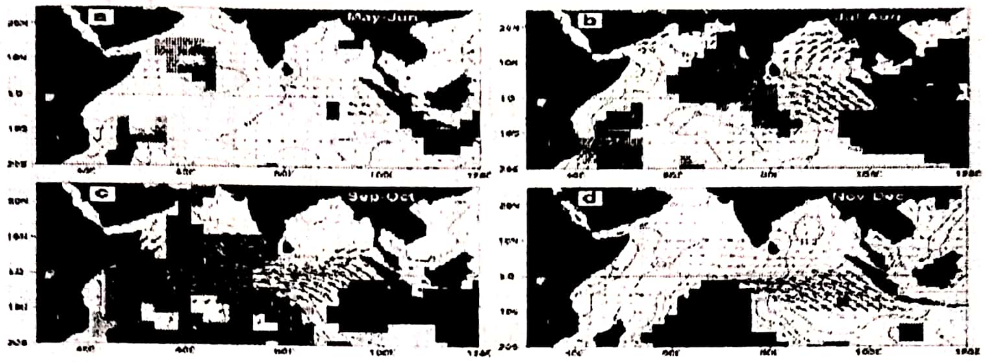

Figure 1-5 : Wind pattern over Indian Ocean from Mei to December

2 DATA AND METHOD OF ANALYSIS

In this study we used data obtained from three main parameter, namely SST (Sea Surface Temperature) monthly anomaly between the tropical western Indian Ocean (50E - 70E, 10S - 10N) period January 1871 to December 1997, OLR (Outgoing Longwave Radiation) monthly anomaly between Central Indian Ocean (70E-80E, 5S-5N) and Eastern Indian Ocean (90E-100E, 10S-Equator) period of January 1979 to July 2001 and SLP (Sea Level Pressure) monthly anomaly between Eastern Indian Ocean (86E-87E, 10S-9S) and Western Indian Ocean (44E-45E, 15S-14S) period of january 1958 to December 1999. Those data are taken from internet addressed on this web-side (http://w3.jamstec.go.jp/frsgc/research/d1/saji/dmi.html). Then, we plotted those data in Figures of 2-1, 2-2 and 2-3, respectively.

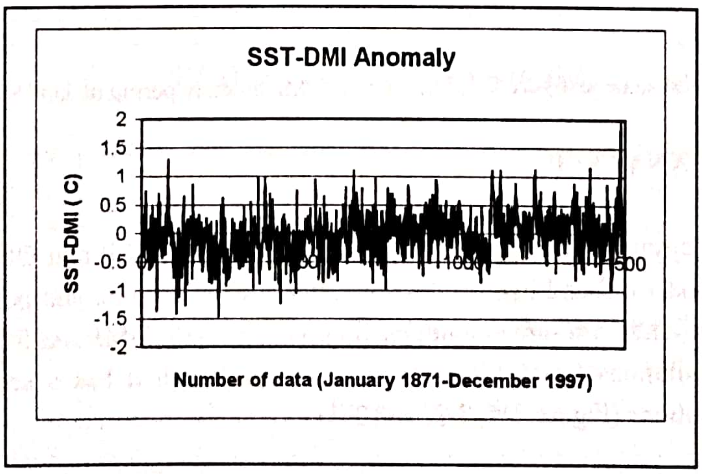

Figure 2-1: The SST-DMI anomaly from January 1871 to 1997

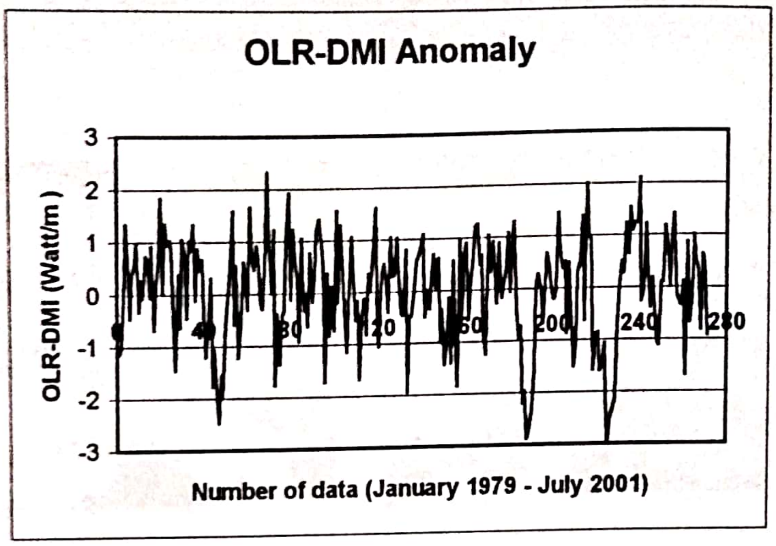

Figure 2-2: The same as figure 2-1, but for OLR-DMI anomaly period of Jan '79 to Jul '01

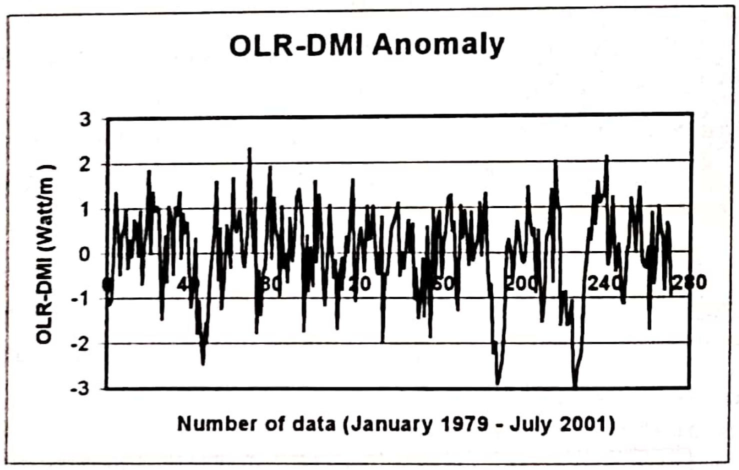

Figure 2-3: The same as figure 2-1, but for SLP-DMI anomaly period of Jan '58 to Dec '99

3 RESULTS OF ANALYSIS

Power spectrum method is applied to monthly of SST, SLP and OLR-DMI anomaly. By using this method we found two oscillation patterns with predominant peaks that appear in each data elements. They are three month oscillations (for SST-DMI and SLP-DMI anomaly) and six month oscillations (for OLR-DMI anomaly), although it has a second predominant peak in three oscillations (Figure 3-1, 3-2, and 3-3).

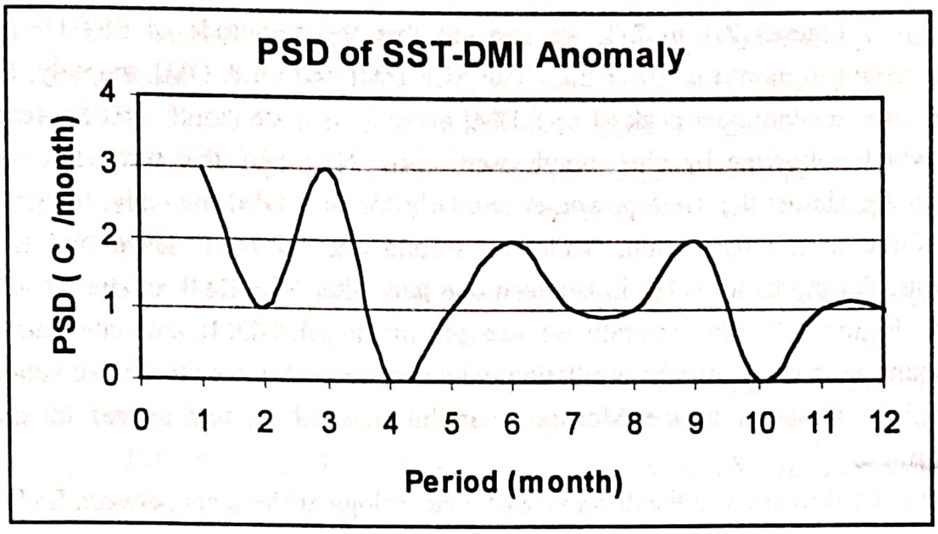

Figure 3-1: Power spectral density for sea surface temperature anomaly

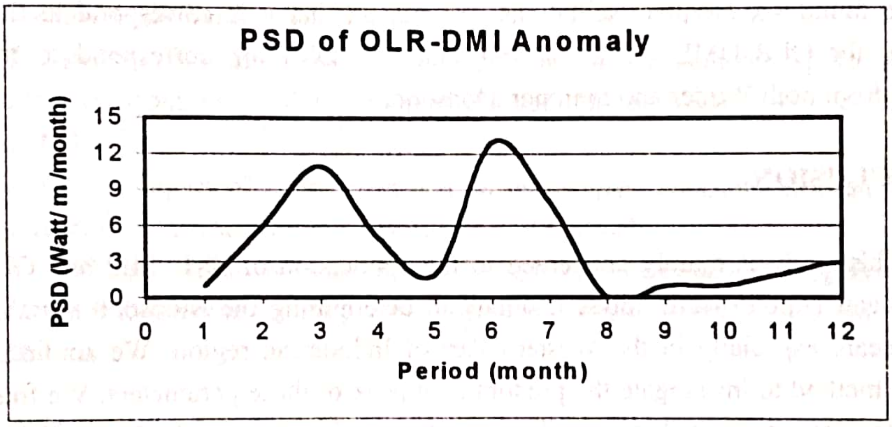

Figure 3-2 : The same as fig. 3-1, but for sea level pressure anomaly

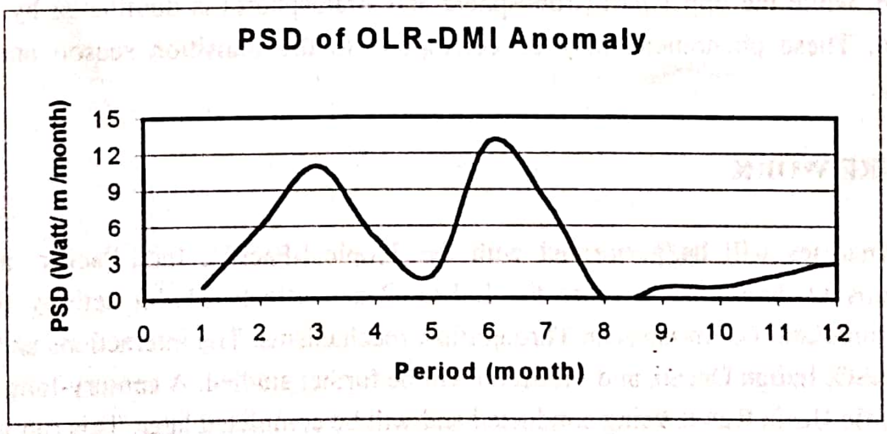

Figure 3-3 : The same as fig. 3-2, but for outgoing longwave radiation anomaly

4 DISCUSSIONS

From Figures 2-1 to 2-3, we can see that the amplitude of SST-DMI anomaly variation month to month is lower than both SLP-DMI and OLR-DMI anomaly. Figure 3-1 shows that the predominant peak of SST-DMI anomaly is three month, and the second is six months which following by nine month oscillations. Note here that three and nine month oscillation are almost the same power. A similarly for SLP-DMI anomaly, the predominant peak is three month oscillation, while the second and third are seven and ten months oscillations. On the hand, it lag in between one later after SST-DMI anomaly oscillation as shown in Figure 3-2. The contraly we can see in the OLR-DMI anomaly data the most predominant peak is six months oscillation, while the second is six month oscillation. It may be strongly correspond to the Monsoon variability which almost appear in six months oscillation.

We tried to analyze the difference of meteorological elements between SST-DMI and SLP-DMI anomaly oscillation. As is explained before, both parameter are located at sea surface. So, it should be same oscillation. But, OLR-DMI anomaly it should be different since is located in the top atmosphere and only detected from convective clouds activities. In this study, we found six months oscillations. We expect that it is correspond to the monsoon variability for OLR-DMI, while for SST and SLP-DMI are correspond to transition of Monsoon from both Winter and Summer Monsoon.

5 CONCLUSION

This study is mainly concerned to the application of SST, SLP and OLR-DMI of Indian Ocean Dipole Mode Index anomaly in determining the Monsoon variability in the Indian Ocean, especially in the Western Part of Indonesian region. We applied the Power Spectrum method to investigate the predominant peak of these parameters. We found that the most predominant peak is three months oscillation such as on data SST and SLP. While, the most predominant peak of OLR is dominated by six months oscillation. From these oscillations we can see that the surface of Indian Ocean is dominated by three months oscillation, while the upper part (troposphere and stratosphere) is dominated by six months oscillation. These phenomena may be correspond to the transition season and Monsoon variability.

6 FUTURE WORK

Analyses will be performed with the Tropical-Pacific, Indo-Pacific, and Indian-Ocean Runs to determine whether the Indian Ocean affects ENSO activity through the monsoon circulation or Indonesian Throughflow mechanisms. The interactions and feedbacks among ENSO, Indian Ocean, and Monsoon will be further studied. A century-long integration of the Pacific-Basin Run is being conducted and will be completed later. This run will be used to study the contribution of basin-wide interactions to decadal ENSO variability. We also interest to complete this study by applying the TRMM satellite data analysis for next works.

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