Impact of teleconnection between Indian Ocean Dipole (IOD) and El Niño at normal (neutral) phase condition on the Java Monsoon rainfall variability

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Abstract. The meteorological surface parameter over the Maritime Continent (MC), especially rainfall anomalies are very important to be investigated due to their impacts on the hydrometeorological hazards phenomena. Although, this region is affected by the Monsoon system, but another phenomena called as the Indian Ocean Dipole (IOD) and El Niño are suspected has a great effects in controlling the rainfall anomalies too. In this present study, we investigated the upcoming of IOD and El-Niño (represented as SST Nino 3.4) index, especially from October 2018 to February 2019. According to the prediction derived from POAMA (Predictive Ocean Atmosphere Model for Australia) model, Australia, that is issued by September 8, 2018, we found that those indexes (IOD and SST Nino 3.4) are located “near” the normal (neutral) phase condition. It means that Monsoon will become a pre-dominant peak oscillation during that period, although by assuming the Madden Julian Oscillation (MJO) also located at “near” normal condition. By using the IOD, SST Nino 3.4, and the CHIRPS (Climate Hazards Group InfraRed Precipitation with Station) monthly rainfall data for period of 37 years observation over Java Island, we found that rainy season is already started since December 2017. The transitional season (from rainy to dry season) is started from March to May 2018. The dry season itself is already started since June to August 2018. Basically, we found the second transitional season that is started from September to November 2018. Since, this study is mainly concerned to rainfall anomalies prediction when IOD and El-Nino is located “near” normal (neutral) phase position, we suspect that the early rainy season this year will be started at December 2018, and continue to rainy season at January and February 2019. Those all prediction will be working well by assuming that teleconnection between IOD and El Nino up to February 2019 still located “near” normal phase condition/position.

1. Introduction
As a large country in the equatorial region that mostly covered by deep actively convection, the Maritime Continent (MC) which includes the northern portion of Australia and consists of a complex organization of islands with varying size and orography is an interesting region for exploring multiscale interactions [1][2][3][4].

The climate of the MC is strongly influenced by the Indo-Pacific circulations because of its unique geographical location near the equator surrounded by shallow seas, including the warmest open ocean waters in the world [5][6]. A significant amount of uptake and release of latent heat is associated with
convection over this region, which influences the energy budget and the diabatic heating of the entire atmosphere [2][7].

This region not only shows a strong diurnal cycle in rainfall and convection [7][8][9][10], but substantial intraseasonal [11][12][13], seasonal, and interannual variations also occur [14][15][16][17]. Until now, Monsoon is still a predominant peak oscillation at this region. Therefore, we can see that MC basically has two big different seasons, namely dry and rainy season, respectively. This is for normal condition, but sometimes, we found an abnormal condition, such as long drought condition (more than six months) such as in 1997/98, followed by the long wet season (also more than six months) in 1998/99. We suspect that is not caused by the Monsoon, but another phenomena, namely El Niño and Indian Ocean Dipole (IOD) also has a strong effects, especially at abnormal position.

Both phenomena can significantly lead to decrease in rainfall, especially in the transitional season when entering the rainy season. The emergence of a strong El Niño phenomenon as such as seven times for the previous twenty years along with the occurrence of phenomenon of a Positive Dipole Mode that occurred almost at the same time resulting in considerably serious drought. For example, when both phenomena occurred in the year 1997/98 shifted the onset of the 1997/98 rainy season for 2-3 months (60-90 days) successively.

Recently, we have severe problems that we call as the hydrometeorological hazards. Droughts, floods, landslide, forest fire, haze, smoke and other hazards recently almost occurred during dry and/or rainy season, especially at the Western Part of MC region. This is the main reason why we need to investigate more characteristics and mechanism of El Niño and Indian Ocean Dipole, especially when both phenomena coming simultaneously near real time. The possible mechanism that usually as called as teleconnection or interaction between El Niño and Indian Ocean Dipole has already studied by previous researcher [18][19][20][21][22].

Please note here, the situation is a little bit different now. Both phenomena (El Niño and IODe) is suspected will be in neutral (normal) phase condition for several months later as already predicted by almost not only based on statistics, but also dynamics model, such as already done by POAMA (Predictive Ocean Atmosphere Model for Australia). It means that both phenomena will not have strong effects to control the rainfall variability over MC, especially for Java Island. On the other hand, we suspect that Monsoon system will become have more strong effects. By this reason, the main purpose of this study is to investigate effects of Monsoon system to the rainfall variability over MC, especially over Java, Indonesia when El Niño and IOD at normal (neutral) phase condition/position.

2. Data and method

The SST Niño 3.4 index data is taken from US National Weather Service Organization’s website [23] for the period of 1981 to 2017. While the IOD index is taken from the website of Japan Agency for Maritime-Earth Science and Technology [24]. The rainfall CHIRPS (Climate Hazards Group InfraRed Precipitation with Station) data is taken from IRI data library [25]. We also use the in-situ observation data taken from BMKG (Badan Meteorologi dan Geofisika), Indonesia [26].

We applied the spectral technique (Fast Fourier Transform and Wavelet) and some statistical analysis (cross-correlation, multivariate, and Box-Jenkins approach). For Box-Jenkins approach especially is divided into several stages. They are identification, parameter estimation models, testing or validation of the model, the determination of ARIMA models are relatively most suitable, and rainfall prediction up to the end of 2016.

We applied also the Climate Predictability Tool (CPT). That is a software package for constructing a seasonal climate forecast model, performing model validation, and producing forecasts given updated data. Its design has been tailored for producing seasonal climate forecasts using model output statistic (MOS) corrections to climate predictions from general circulation model (GCM), or for producing forecasts using fields of sea-surface temperatures or similar predictors.

Although the software is specifically tailored for these applications, it can be used in more general settings to perform canonical correlation analysis (CCA), principal components regression (PCR), or multiple linear regressions (MLR) on any data, and for any application.
3. Result and analysis
We present here the time-series of SST Niño 3.4 and IOD index for period of 1981 to 2017 as shown in figure 1. We can see those parameter looks have similar pattern, especially in 1982/83 and 1997/98 when those indexes are lower or higher than 2 Celcius degree.

![Figure 1](image1.png)

**Figure 1.** The time-series of the monthly of IOD and SST Nino 3.4 index for period of 1981 to 2017.

Although, both parameter (SST Nino 3.4 and IOD) looks to have same pattern, they have a different at peak oscillation. They are 5 and 3.5 year oscillation for SST Niño 3.4 and IOD index, respectively. In this present study, we focus on when both phenomena coming simultaneously near real time, like in 1982/83 and 1997/98. In 1997/98, especially both parameter increased until more than two degree. But, what happened now? As already predicted by the POAMA taken at March 3, 2017 as showing at figure 2. A similar study using POAMA has already been done by Zhao and Hendon [22][27].

![Figure 2](image2.png)

**Figure 2.** The long-range sea surface temperature outlooks [28]

By assuming this model is working well, we suspect that long drought season, such as in October 1997 looks never come back to MC at least until the end of this year. Please note here, since Indian Ocean Dipole (IOD) is located closer than El Nino, we suspect IOD plays a principal role in the formation of the repeated torrential rains over Indonesia, especially over the Western part. This is already been investigated by Hermawan et al. (2011) when they studied the teleconnection between El Niño and IOD [29]. This is already been confirmed also by Saji and Yamagata [30], Ashok et al.[31], and Behera et al. [21]. One the other hand, we can mention that from October 2018 to February 2019 the SST Nino 3.4 will increase slowly, while IOD will decrease also slowly. If SST Nino 3.4 will be far away from the normal condition, while IOD will be toward the normal phase position as shown at table 1 and table 2, respectively.
Table 1. SST Nino 3.4 anomaly probabilities until Feb 2019 [28].

| Month    | Oct 2018 | Nov 2018 | Dec 2018 | Jan 2019 | Feb 2019 |
|----------|----------|----------|----------|----------|----------|
| SST Nino 3.4 | 0.7°C | 0.9°C | 1.0°C | 1.1°C | 1.2°C |
| Below -0.8°C | 0% | 0% | 0% | 0% | 0% |
| Neutral | 50.5% | 32.3% | 25.3% | 24.2% | 18.2% |
| Above 0.8°C | 49.5% | 67.7% | 74.7% | 75.8% | 81.8% |

Table 2. IOD index probabilities until Feb 2019 [28].

| Month    | Oct 2018 | Nov 2018 | Dec 2018 | Jan 2019 | Feb 2017 |
|----------|----------|----------|----------|----------|----------|
| IOD      | 0.7°C | 0.5°C | 0.4°C | 0.2°C | 0.1°C |
| Below -0.4°C | 0% | 0% | 0% | 1% | 3% |
| Neutral | 8.1% | 31.3% | 41.4% | 75.8% | 80.8% |
| Above 0.4°C | 91.9% | 68.7% | 58.6% | 23.2% | 16.2% |

The most important point of table 1 and table 2 above is the probability of SST Nino 3.4 anomaly and IOD index decreases with time, especially for SST Nino 3.4 anomaly starting from 100% in March to 33.3% in July 2017. While, for IOD, this parameter looks stable at around 72.7% since May to July 2017. This is more clear when we compare with the IRI/CPC model. The results looks similar each other as shown in figure 3 below.

Figure 3. The mid-Aug IRI/CPC model-based probabilistic ENSO forecast [32].

By assuming the rainfall variability is effected not only by IOD and El Niño, also by Monsoon. Looking at figure 3 carefully, we can see that both parameter (IOD and El Niño) is suspected to become in neutral phase condition for several months later. So, we are interest to investigate more effects of Monsoon system to rainfall variability over Java Island, such as already done by previous researcher [33][34][35]. What we can do now is we are trying firstly to show the rainfall pattern over Java Island using TRMM (Tropical Rainfall Measuring Mission) data that combined with the in-situ observation. Although, those data is not too long (2001-2009), but we can see clearly the difference pattern as shown in figure 4.
In figure 4, it is very clear the Monsoon pattern of rainfall over Java Island. The dry season normally is occurred about August. While, December and January is for rainy season. The length of dry season more longer at East Java than Mid of Java. Similarly, when we compare the rainfall pattern at Mid of Java comparing with the West Java. To make this analysis clearly, we are showing here the rainfall pattern over Yogyakarta as one representatif site for Mid of Java.

![Figure 4](image)

**Figure 4.** The rainfall pattern over Java Island starting from Banten (West Java), Jawa Barat (West Java), Jawa Tengah (Mid of Java), and Jawa Timur (East Java) taken from TRMM and In-situ Observation.

Figure 5. The rainfall pattern over Yogyakarta. (a) From January to June. Positive value indicates wet season (e.g. January to March), while negative value indicates dry season (e.g. June). Furthermore, April and May, since positive and negative not so clear, it indicates the transitional season from rainy to dry season. (b) From July to December. Please note, August is the most dry season over Yogyakarta. While, October and November is the transition season from wet to dry season.

![Figure 5](image)

To make clear this analysis, the following figures are showing the climatological rainfall pattern (spatially) over MC for each month starting from January to December. Two main data are used, they are rainfall and wind at 850 hPa (~ 1.45 km from MSL according to definition of Monsoon). We use the CRU (Climatic Research Unit) that taken from http://www.cru.uea.ac.uk/about-cru. The data is starting from 1948 to 2012 (almost 65 years, monthly). By assuming the SST Nino 3.4 anomaly and IOD index is nearby neutral condition, we suspect the Monsoon system will be more significant in determining the rainfall variability over MC.
Figure 6. The longitude-latitude section of rainfall and wind for period of 1948 to 2012; (a) for January, February, March, and April, respectively; (b) for May, June, July, and August, respectively; (c) for September, October, November, and December, respectively.

Looking at figure 6a, 6b and 6c, we can see clearly the wet season over Java Island at December, January, and February (DJF). While, June, July and August (JJA) is dry season. This is consistent with figure 4, 5a and 5b, respectively. We are showing this figures (figure 6a, 6b and 6c), since it is very important point to be understood. If we look up carefully, we can see that dry season will start from the Nusa Tenggara Timur (NTT). Then, move gradually to Nusa Tenggara Barat (NTB), again to Bali, East Java, Mid of Java, West Jaya, then will finish at South/Mid of Sumatera Island. This just for the normal condition, when El Nino and Dipole Mode at located near or close to the neutral phase. This results is similarly that already been done by Chang et al. [36] and Haylock et al. [37].

4. Conclusion
According to the prediction by POAMA and other agencies, along this year, at least untuk July 2017, the El Niño and IOD near the neutral (normal) condition/position. If this model working well and no strong effects to both parameter (El Niño and IOD), the Monsoon system will become a predominant peak oscillation over the MC, especially over Java Island. The rainy season basically has already started since December 2017 and now continue to January and February 2018. Usually, we mention as DJF period. While, dry season is already started from June, July, and August, 2018 respectively. Between both season, we found transitional season. They are from wet to dry season (usually in March, April and May), called as MAM period, respectively. While, from dry to wet season will happened at September, October and November, called as SON period. The dry season is suspected starting from NTT, NTB, continue to Bali, East Java, Mid of Java, until West Java, and etc. anThis will occurred, if SST Nino 3.4 and IOD still working at the normal (neutral) condition starting from October 2018 until February 2019.

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