Impact of El Niño, IOD, and Monsoon Index in Determining the Possibility of Extreme Rainfall over Several Region at West Java

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Abstract **-** This study is mainly concerned an application of SST Niño 3.4, IOD and Monsoon index in determining the upcoming of the extreme rainfall over the *Indonesian Maritime Continent* (IMC). As one of the most important region located along the belt equator, the meteorological surface parameter over the IMC suspected is effecting mostly by the Monsoon system. This is a unique country, since located between two great continent (Asia and Australia) and two great ocean (Indian and Pacific). It indicates that the *Sea Surface Temperature* (SST) should become one of the most important parameter. Although, this region is affected by the Monsoon system, but another event called as the *Indian Ocean Dipole* (IOD) and *El Niño* suspected has a great effects also in determining the rainfall anomalies, especially for the extreme conditions. By this reason, we investigated the IOD and El-Niño index signal, especially the SST Niño 3.4 index. By assuming the drought and wet extreme condition is mostly affected by both parameter, we analysed the IOD and SST Niño 3.4 index for period of 1976 to 2000. For study cases, we concentrated to analyse the monthly rainfall data over Java Island, especially when the strongest *El Niño* and *Dipole Mode* event comes simultaneously. By applying the Multiple Linear Regression, we found the suitable formula of rainfall prediction over several region at West Java Province. Then, we applied the CPT (*Climate Predictability Tools*) technique, we found that drought extreme season is mostly affected by El-Niño event, while wet extreme season is mostly affected by the Dipole Mode event. Although, the recent value of SST Niño 3.4 gradually increase more than 2.4°C, however, if the IOD index still going on to the normal (neutral) condition, we suspect that until the end of this year, the drought extreme condition almost never attack to IMC, especially over Java Island. On the other hand, the *Dipole Mode* looks more responsible in determining the behaviour of rainfall anomalies over Java Island than *El Niño* event. In the end of ths study, we found that interaction between Monsoon, IOD and El-Niño will give more powerful to determine the rainfall anomalies for next year.

***Keywords*:** Monsoon, SST Niño 3.4, IOD, Reservoir, CPT technique

1. Introduction

As an unique country in the equatorial region that mostly covered by very deep active convection, Indonesia Maritime Continent (IMC) suspected covering by the Monsoon system. It means that we have only two different season, wet and dry season. Sometimes, we found the abnormal condition, such as long drought condition (more than six months) in mid of 1997/98, followed by the long wet season (also more than six months) in mid of 1998/99. We suspect that is not caused by the Monsoon, but another phenomena, namely El Niño and Dipole Mode that coming simultaneously. The severe problems related to long drought and wet condition teach us to investigate more the characteristics and mechanism of El Niño and Dipole Mode, especially when both phenomena coming to the Indonesia. The possible mechanism called as teleconnection between El Niño and Dipole Mode has already studied, such as Hendon (2003), Mc Bride et al (2003), Ashok et al. (2001, 2003) and Behera et al. (2006). By this one the main purpose of this study is to investigate the upcoming of long drought and wet condition over Java Island causing by the interaction of El Niño and Dipole Mode.

2. Methodology

The SST Niño 3.4 index data is taken from (http://www.cpc.noaa.gov/data/indices/nino34.mth.ascii.txt) for period of 1976 to 2000. While the IOD index is taken from (http://www.jamstec.go.jp/frcgc/research/d1/iod/DATA/dmi.weekly.txt). We applied the spectral technique (Fast Fourier Transform and Wavelet) and some statistical analysis (cross-correlation, multivariate, and Box-Jenkins approach). Special for Box-Jenkins approach, is divided into several stages, each model identification, parameter estimation models, testing or validation of the model, the determination of ARIMA models are relatively most suitable, and rainfall prediction up to end 2015. We present also some Climatic Research Unit (CRU) for spatial rainfall distribution over Java Island up to 2015.

3. Data and Method of Analysis

Data utama yang digunakan dalam penelitian ini meliputi data curah hujan stasiun penakar hujan Sukamandi, Subang (Jawa Barat) dan Pacitan (Jawa Timur) periode Januari 1996 – Desember 1999. Sementara data pendukung yang digunakan meliputi data indeks iklim global, khususnya data SST Niño3.4 dan data IOD periode 1958 – 2009. Sementara metode analisis yang digunakan meliputi analisis spektral untuk mengkaji periodisitas dari data indeks iklim global, dan analisis statistik meliputi regresi berganda (multiple regression) untuk mengkaji persentase pengaruh dari iklim global, dan korelasi silang untuk menentukan lag time antara data anomaly curah hujan dan indeks data iklim global.

4. Results and Discussions

We present here the time-series of IOD and SST Niño 3.4 index for period of 1976 to 2000 as showing in Fig.1. We can see those parameter looks have similar pattern, especially in 1982/83 and 1997/98 when their index lower or higher than 2 Celcius degree (Nicholson and Kim, 1997).

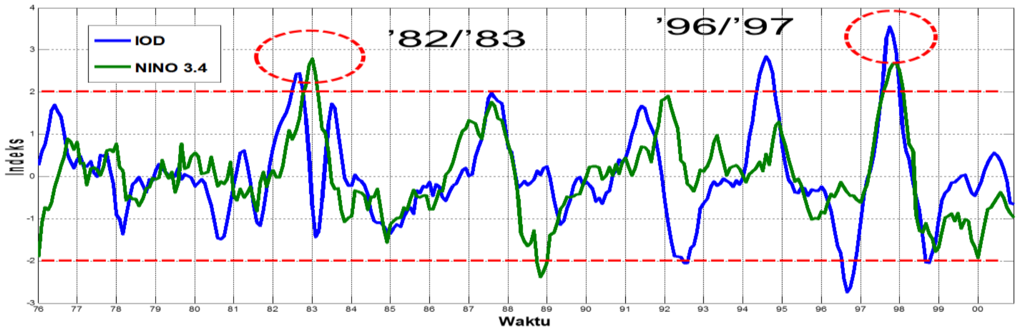

Figure 1. The time-series of IOD and SST Nino 3.4 index for period of 1976 to 2000

Please note here, although both parameter have same pattern, but they have a different oscillation. They have almost 5 and 3.5 years oscillation for SST Niño 3.4 and IOD index, respectively. However, we concentrate just when both phenomena coming simultaneously near same time, especially in 1982/83 and 1997/98 when both parameter increased until more than two Celcius degree. This is very important, since we assume the teleconnection between both phenomenon will give strong effect than if only one single phenomenon.

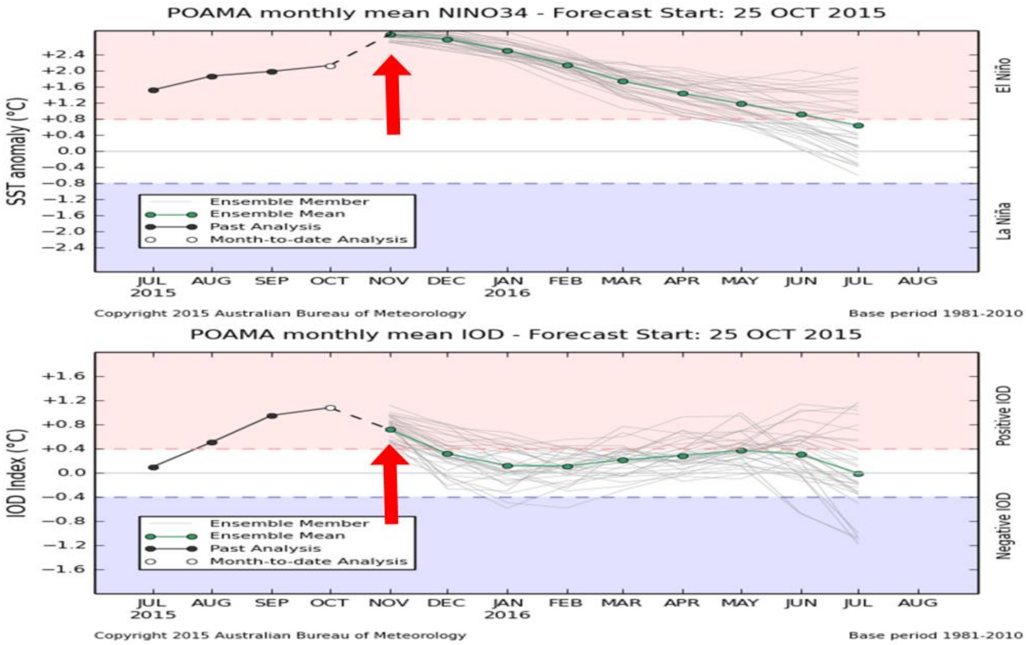

Figure 2. The time-series of the forecast value of SST Niño 3.4 and IOD by POAMA (Source: http:// http://www.bom.gov.au/climate/poama2.4/poama.shtml), downloaded at November 8, 2015, 06:07 AM)

But, what happened now?. Here, we present the current status of SST Niño 3.4 and IOD, respectively that already been done by the *Predictive Ocean Atmosphere Model for Australia* (POAMA) taken at August 4, 2015 as showing at Fig.2 above. A similar study using POAMA has already been done by Zhao and Hendon, 2009).

By assuming this model is working well, we can suspect that long drought like October 1997 never come back again to Indonesia at least until the end of this year. It caused since IOD plays a principal role in the formation of the repeated torrential rains over Indonesia, especially over the Western part. We suspect this because IOD location is closer to the Western part of Indonesia region. Basically, this is already been investigated by Hermawan *et al* (2011) when they studied the teleconnection between El Niño and *Dipole Mode*. This is already been confirmed by Saji and Yamagata (2003), Ashok *et al.*, (2004), dan Behera *et al.*, (2006).

We present here the location of this area study as showing at Fig. 3 below. From this figure, we can see several reservoirs (Dam). They are Cirata, Saguling, Darma. Jatiluhur, Cipanunjang, Satupatok, Cileunca, Pongkor, and Jatigede as the newest reservoir that located at Sumedang.

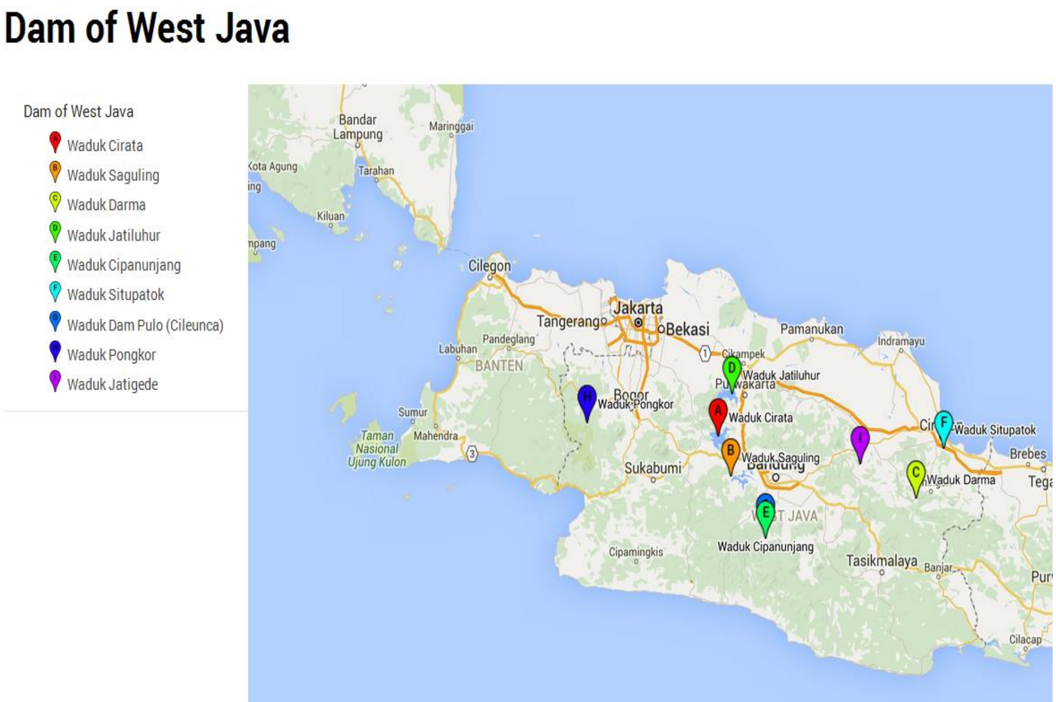

Figure 3. The distribution of reservoirs at West Java, Indonesia

Before we analyze more detail, we present here the rainfall composite analysis for each month taken from the CHIRPS data analysis for period of of 1981 to 2014 as showing at Figs. 4 and 5 below.

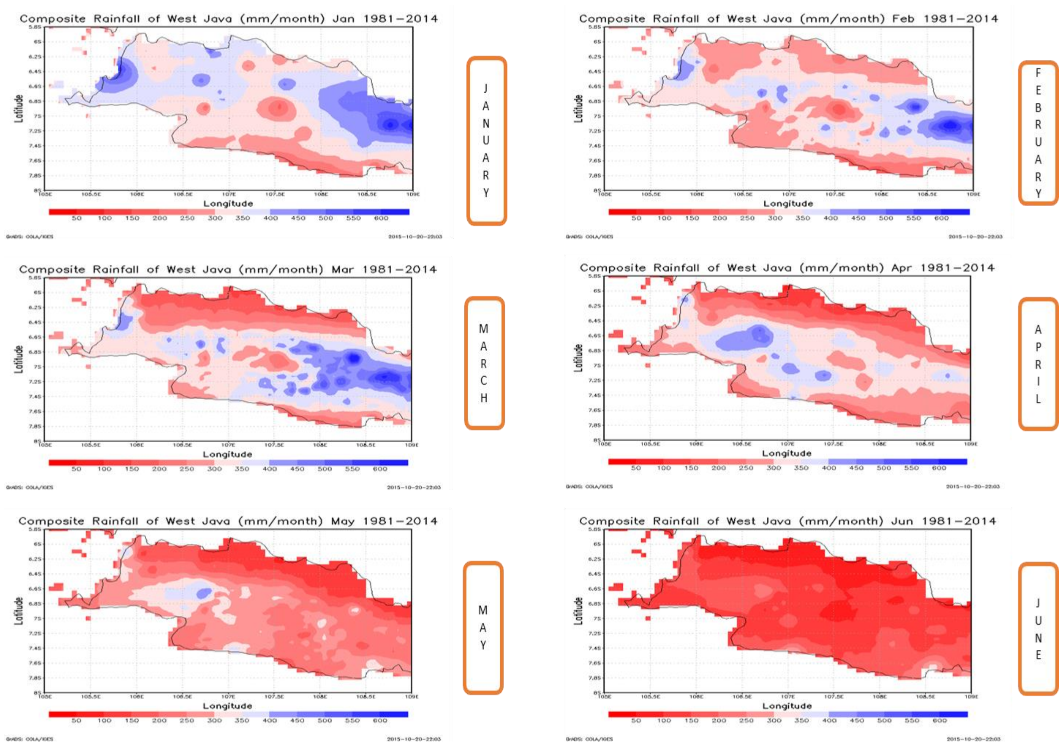

Figure 4. The composite rainfall analysis from January to June over West Java, Indonesia

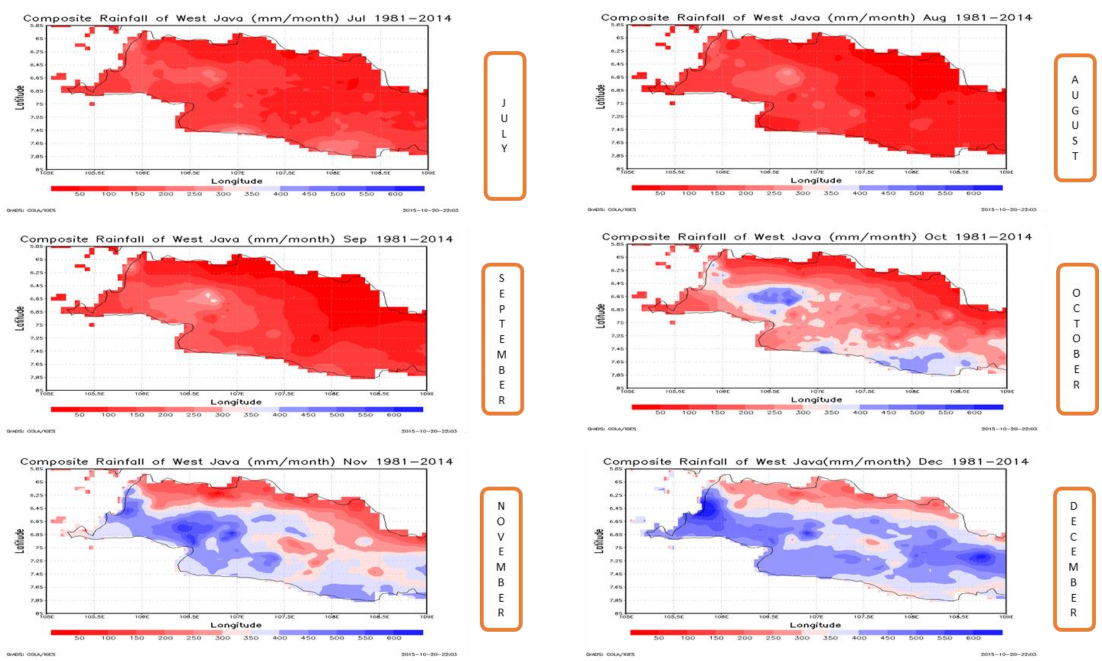

Figure 5. As the same as Fig. 4, but from July to December

If the blue color indicates the rainy season and the red color indicates the dry season, we can see from those figure the rainy season over West Java is starting from October and continue till April (7 months). While, the dry season will start from Mei to September (5 months). It indicates that most of West Java area is dominated by the rainy season. But, please note here, this condition is a little bit different, especially for the northern part of West Java. Most of them is still dry.

Since, we focussed on the seasonal forecasting, we present here the seasonal composite of rainfall pattern over West Java as showing at Figs. 6 and 7, respectively.

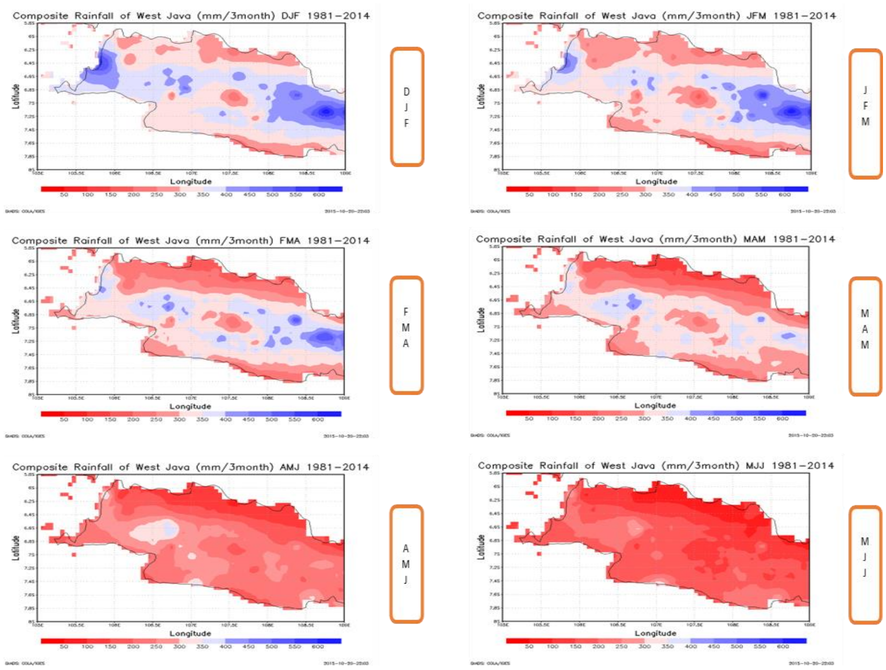

Figure 6. As the same as Fig. 4, but for seasonal composite from DJF (Dec-Jan-Feb) to MJJ (Mei-Jun-Jul)

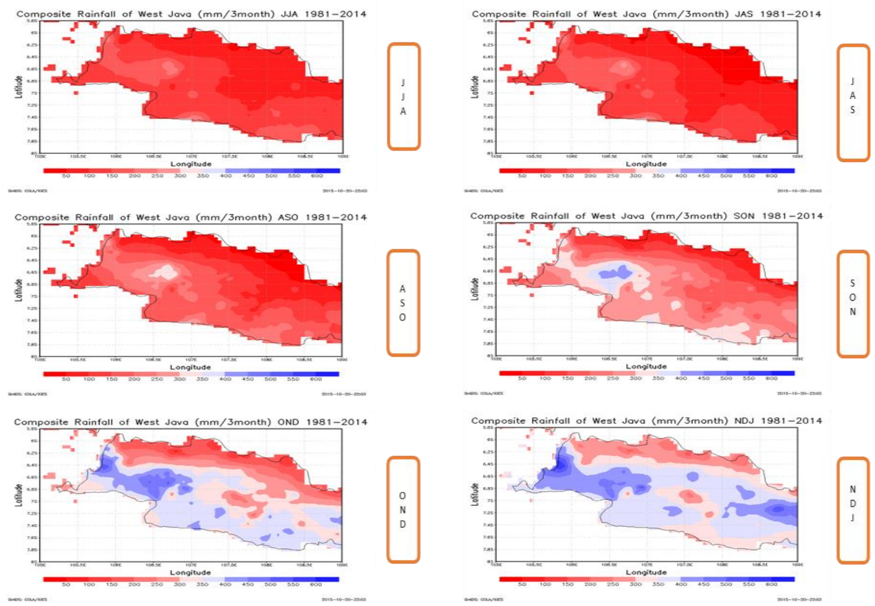

Figure 7. As the same as Fig. 6, but for seasonal composite from JJA (Jun-Jul-Aug) to NDJ (Nov-Dec-Jan)

At the end of this session we present here the comparison between tree months observation and climatology observation as showing at fig. 8 below.

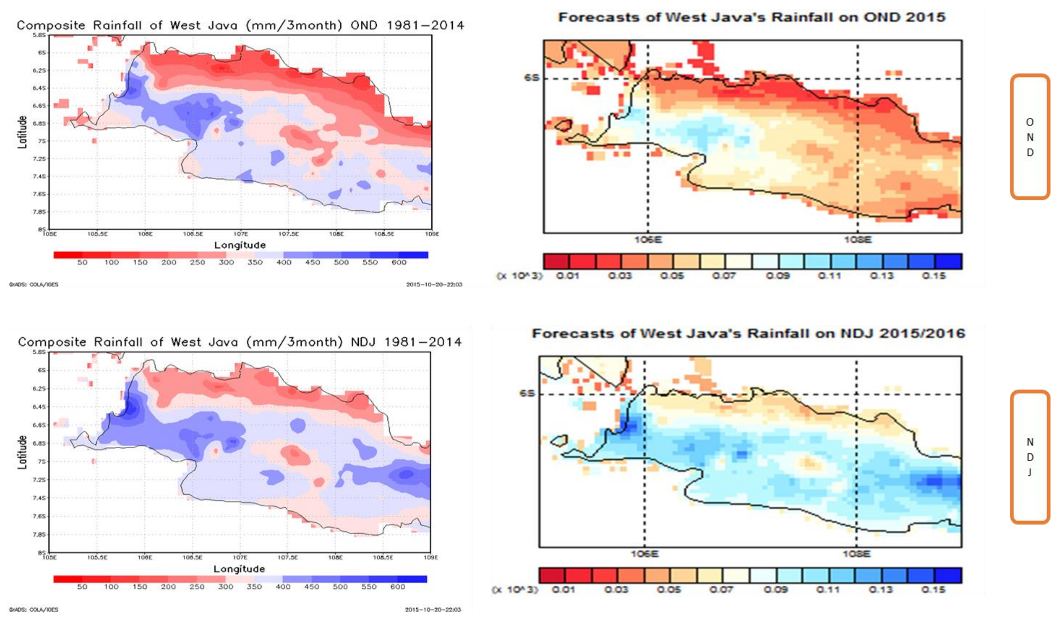

Figure 8. Comparison between composite and forecast analysis for seasonal prediction started from OND (Oct-Nov-Dec) NDJ (Nov-Dec-Jan).

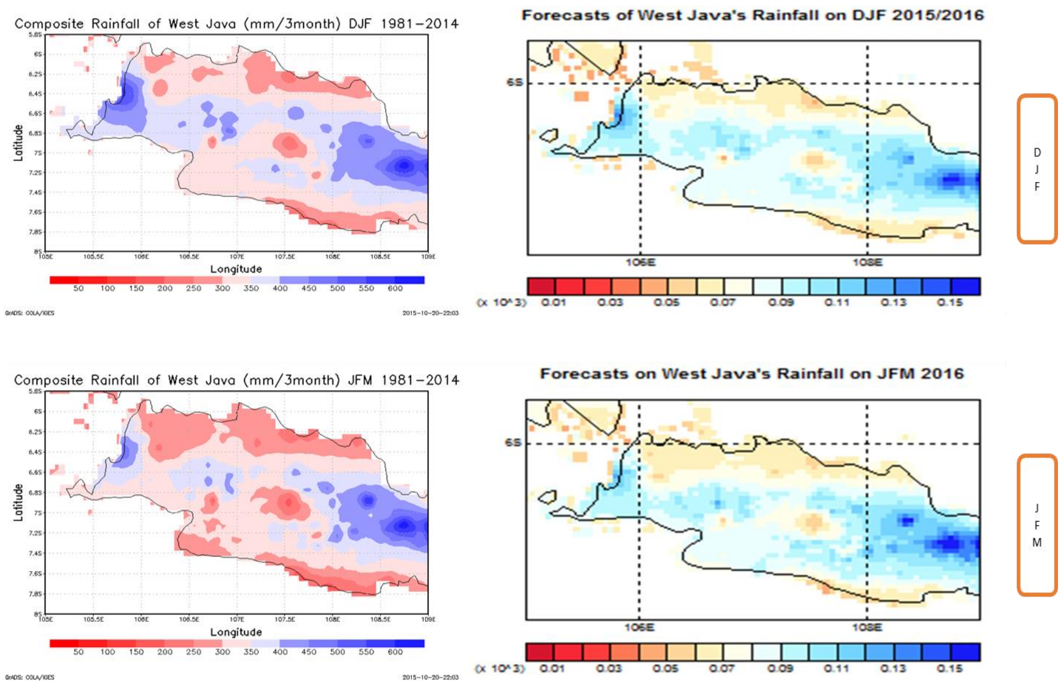

Figure 9. As the same as Fig. 8, but for period of DJF (Dec-Jan-Feb) to JFM (Jan-Feb-March), respectively

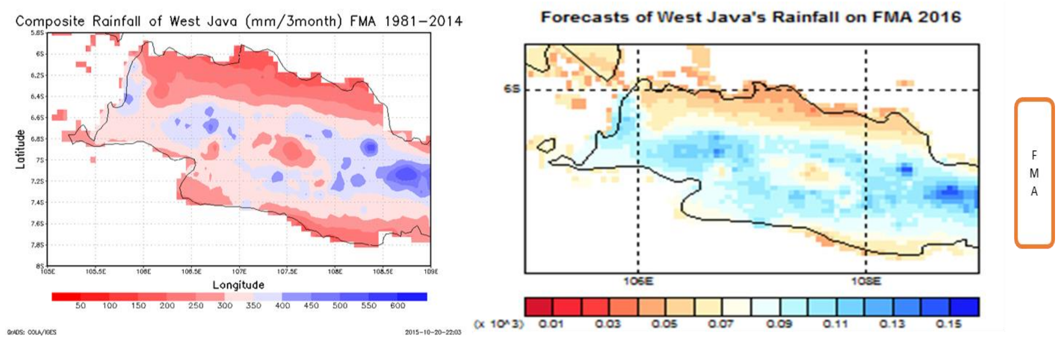

Figure 10. As the same as Fig. 8, but for period of FMA(Feb-March-April)

If we check carefully, we will see clearly the rainy season over West Java is starting from November. This is clearly indicated by the blue color. A few region at the Northern part of West Java that still clear condition.

To get more informations about this prediction, we are showing here the statistical analysis using the CCA (*Canonical Component Analysis*) technique, then we give them some scores such as seen in this table 1 below.

Table 1. The CCA score for each component factor (1= AUSMI, 2=ISMI, 3=WNPMI, 4=WYMI, 5=IOD, and 6=SST Niño 3.4)

Month	CCA MODE					
	1	2	3	4	5	6
OND 2015	0.72	0.47	0.48	0.40	0.19	0.03
NDJ 2015/2016	0.46	0.37	0.44	0.40	0.30	0.10
DJF 2015/2016	0.53	0.70	0.43	0.33	0.20	0.02
JFM 2016	0.63	0.56	0.32	0.25	0.25	0.02
FMA 2016	0.60	0.48	0.27	0.41	0.24	0.14

From Table 1 above again we can see the AUSMI (Australian Monsoon Index) looks more have powerful to control the rainfall behaviour over the West Java.

To complete our analysis, we present here comparison between observation and forecast to rainfall prediction that will be cming over Jatiluhur reservoir as the bigest reservoirs that located at West Java as showing at Fig. 11 below. From this figure, we can see clearly an a good agreement or pattern between observation and forecast for OND (October-November-Deceber) period.

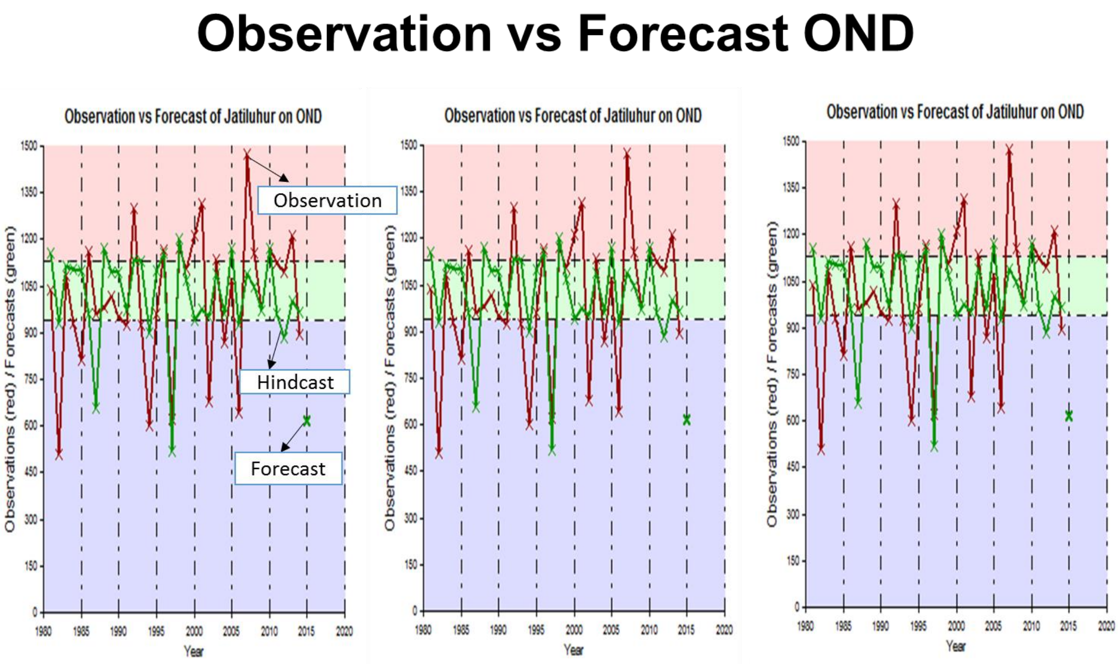

Figure 11. The comparison between observation and forecast for OND period over Jatiluhur

4. Conclusion

The rainfall distribution over West Java until the end of this year suspected is still in normal condition. Although, this region is mostly effected by the Monsoon system, but two other phenomena also has big effect in determining the behaviour of rainfall distribution. One of them is IOD that located in the Indian Ocean. This parameter looks more big effect than El- Niño that located in the Pacific Ocean. Although, in August the SST Niño 3.4 higher than 2 degree, but if the *IOD* index still in close to the normal condition, we suspect that long drought condition like in October 1997 never occurred again at least until the end of this year. We can use the CPT technique to predict the rainfall distribution for several seasonal month over West Java also. By using this technique, we can predict the rainfall behaviour until the next year, at less until February 2016.

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