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How the strongest La-Nina affected the equatorial tropics? Global analysis in 2010 with TRMM satellite

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Abstract: This study analyzed the rainfall pattern changes in humid tropics at monthly scale during the strongest La-Nina event ever using Tropical Rainfall Measuring Mission (TRMM) satellite. At present the evidences had showed that the rainfall are changing and increasing in general in the tropics. However, specific characteristics of change including rate, quantity, and pattern was less elaborated. This parameters are critical to us in understand the changes, the cause, and most importantly figure out an appropriate method to adapt for the future scenarios. To anticipate the aforementioned issue, we had initiated the analysis to determine; 1) the trend of rainfall changes (events, quantity and spatial size) and 2) the rate of rainfall changes. The number of different rainfall events are determined to inform us the trend of impact of the La-Nina. On the other hand, the changes of rainfall quantity and spatial size primarily the increment cases would provide us with quantitative information how much the changes had occurred in specific areas and how large is the extent; whether it is a synoptic scale event or it was the aftermath effect at microscale. Finally, the rate of rainfall changes informed us how quick is the changes happen. The output from all the analyses will be used to classify types of impact that experienced by different parts of humid tropics; the most affected region by this La-Nina event.

Keywords: Climate Change, Big Geodata, Space Precipitation, GIS based analysis, Anomalies

1.0 INTRODUCTION

La Nina is a global phenomenon that caused extra rainfall occurrences; a result of the sea surface temperature decrement under the normal levels. This heavy rainfall is likely to cause catastrophes such as flood, sea level rises, and environmental safety due to heavy torrential rainfall. Adaptation to the hydro-meteorological changes is a major concern for many tropical region especially in the tropics (Wang et al. 2010; Wang et al. 2012; van der Voorn et al. 2012). However, specific characteristics of change including rate, quantity, and pattern was less elaborated. This parameters are critical to us in understand the changes, the cause, and most importantly figure out an appropriate method to adapt for the future scenarios (Beniston et al. 2012).

At present, the evidences had showed that the tropics has been claimed to be highly sensitive to environmental changes (Trenbeth, 2011). Rainfall are changing and increasing in general in the tropics (Chadwick et al. 2013). In the past decade, rainfall seasonality has been highly varied among different part of tropical region (Feng et al. 2013, Allan et al. 2010). The occurrences of extreme events such as La-Nina might exacerbates the significant changes of rainfall in this region due to high presence of vapor and cloud formation process. A thorough study on this is still inadequate and need quick attention. The availability of global satellite precipitation would be useful to address this concern.

Therefore this study investigates the impact of one of the strongest La-Nina in 2010 at global scale. Three objectives has been established, 1) measuring the rainfall changes, 2) analyzing the changes between different regions in the world, and 3) studying the trend of the rainfall changes. To materialize the objective we used the global dataset of widely used Tropical Rainfall Measuring Mission (TRMM). The output from all the analyses will be used to classify types of impact that experienced by different parts of world region particularly the humid tropics; the most likely affected region by the La-Nina event.

2.0 MATERIALS & METHOD

2.1 Global analysis on the impact of 2010 La-Nina

The impact of the 2010 La-Nina were measured by two means, first is the rainfall changes and secondly is the spatial occurrence of the events. Both analysis were relatively against the control environment of 2003. We select 2003 due to the absence of any major El-Nino or La-Nina during the year based on the global Oceanix Nino Index (ONI) Therefore, the data provides suitable control environment to measure the La-Nina effect. The rainfall changes were measured by summing up the total rainfall amount from June to December, the period in

2010 where La-Nina intensely occurred. Subsequently, the rainfall changes over specific region was identified. To evaluate the trend of the rainfall changes, the monthly rainfall average time series were developed.

2.2 Global precipitation data

Monthly rainfall data namely TRMM 3B43 from the Tropical Rainfall Measuring Mission (TRMM) were used as the primary data. The data was obtained from the Goddard Earth Sciences Data and Information Center through the official website of http://mirador. gsfc. nasa. gov. The TRMM data were chosen because of its high resolution (0.25 deg.), intensive global coverage and precise measurement. The data also has been widely used and recommended by many experts due to the mentioned factors.

2.3 World region of vector GIS data

We create the vector data of the border of major regions in the world. There were ten respective region, 1) North America, 2) South America, 3) Europe, 4) Russia, 5) Africa, 6) North Africa-Southwest Asia, 7) East Asia, 8) South Asia, 9) Southeast Asia, and 10) Africa. This vector is purposely used to extract individual rainfall data for each region in the data processing.

3.0 RESULTS AND DISCUSSION

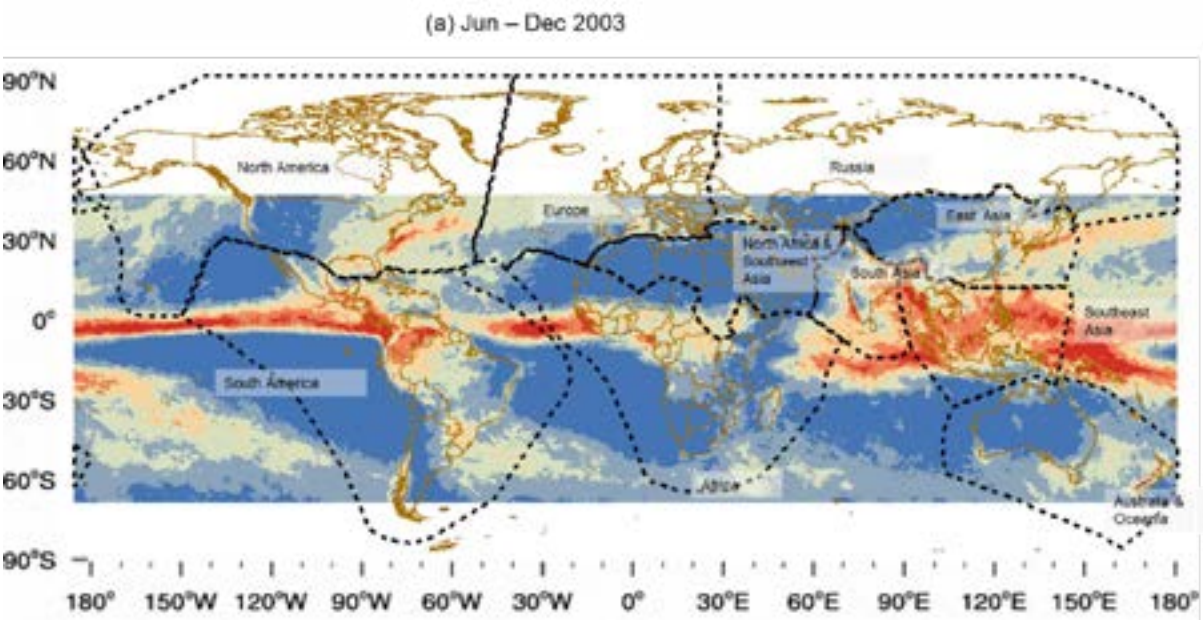
On average, rainfall increment was dominant in most region in the world except North America and Africa (Table 1). Major increment of rainfall was occurred in Southeast Asia (47%) and South Asia in (24%). Minor increment (<10%) were indicated in Europe, South America, Australia-Oceania and the rest part of Asia. Figure 1 had clearly showed that La-Nina exacerbates heavier rainfall throughout Southeast Asia region and South Asia.

Table 1. Summary of the rainfall increment during 2010 La-Nina

Region	Region no.	Rainfall (mm/month)		Percent of increment (%)
		2010	2003	
Southeast Asia	9	254	207	46.8
South Asia	8	170	145	24.8
Europe	3	89	79	10.8

East Asia	7	95	86	9.0
Australia and Oceania	10	64	55	9.0
South America	2	88	85	3.3
Russia	4	65	62	2.8
Africa	5	63	66	-2.7
North Africa & South-West Asia	6	15	19	-3.8
North America	1	81	86	-4.8

The differences between the 2010 and 2003 rainfall also confirmed that assumption (Figure 2). Based on that figure too, we could made conclusive remarks that Southeast Asia suffered the impact the most and significant increment was taken place in the equatorial region. The monthly time series indicated that the increment occurred gradually since June until December (Fig. 3). Nonetheless, the figure also revealed that the rainfall increment occurred substantially in major part of west Africa and North America but with minimal amount.



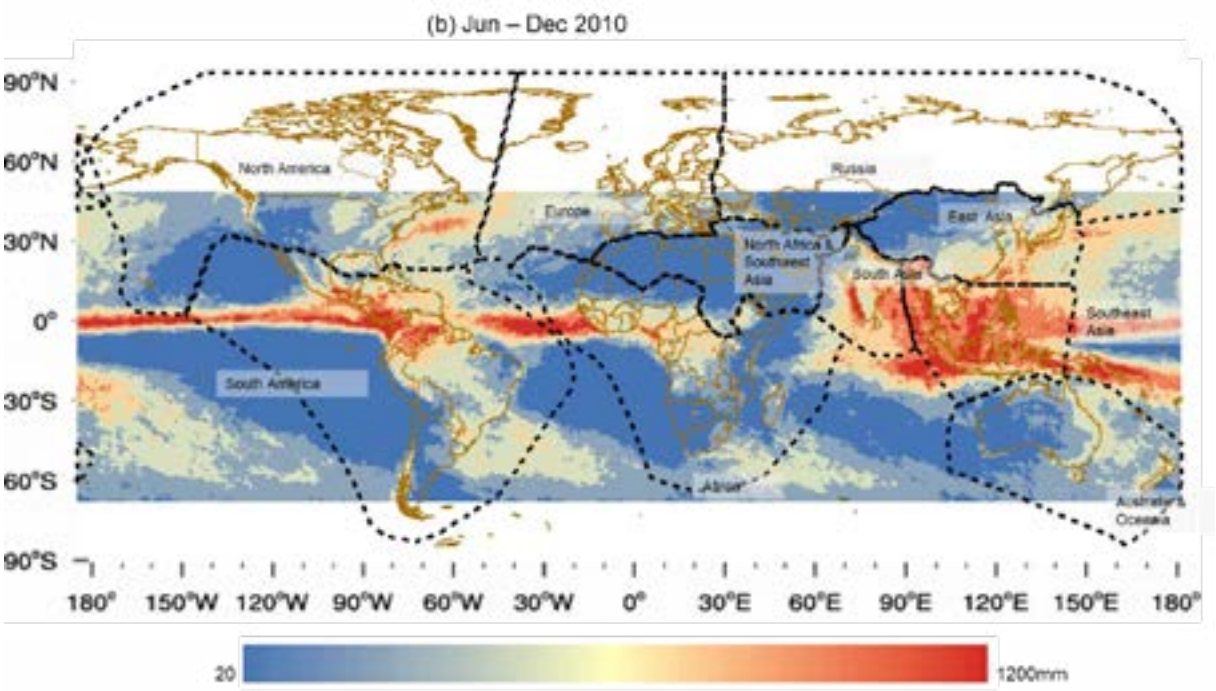


Figure 1. Six month accumulated rainfall (June-Dec) from TRMM satellite. (a) 2003, (b) 2010.

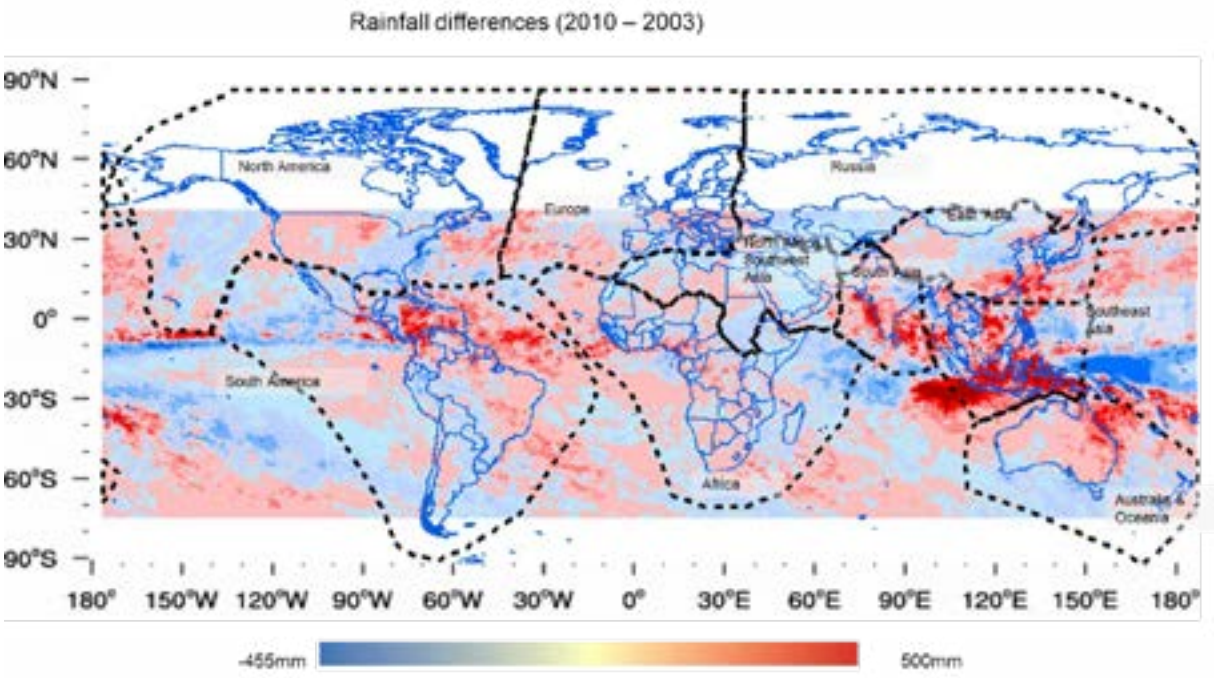


Figure 2. Rainfall differences (2010-2003)

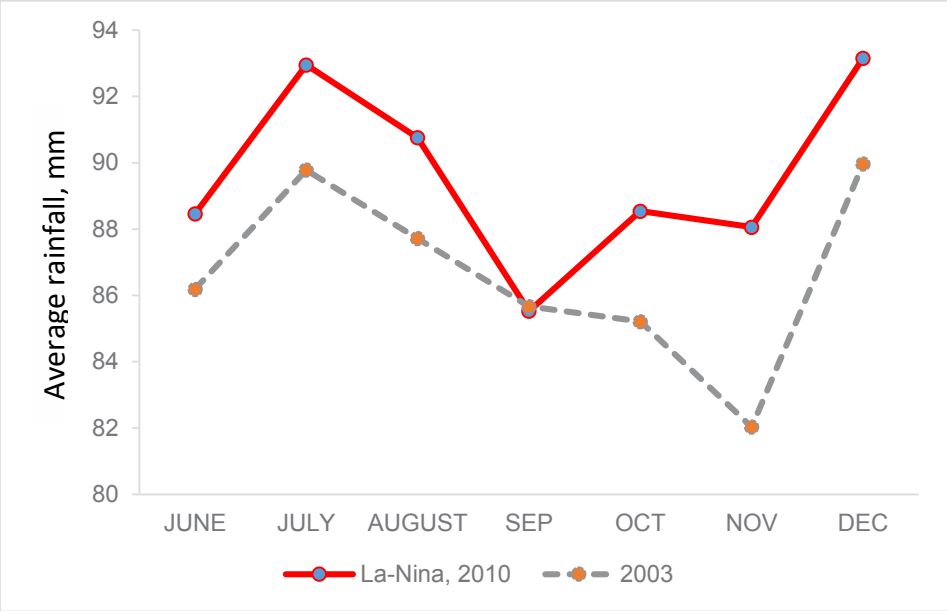


Figure 3. Monthly rainfall increment during La-Nina

4.0 CONCLUSION

This study has found out that the La Nina event in 2010 had impacted the Southeast Asia region the most compared to other region. In general, the dominant effect for most equatorial humid tropics was experiencing rainfall increment with varied intensity. The rainfall had increased significantly and it had been occurred gradually since June until December. The output of this study is useful to initiate appropriate adaptation, mitigation and prevention framework at local scale.

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