ENSO Impacts on Regional Rainfall and Vertical Humidity of Chiangmai, Thailand

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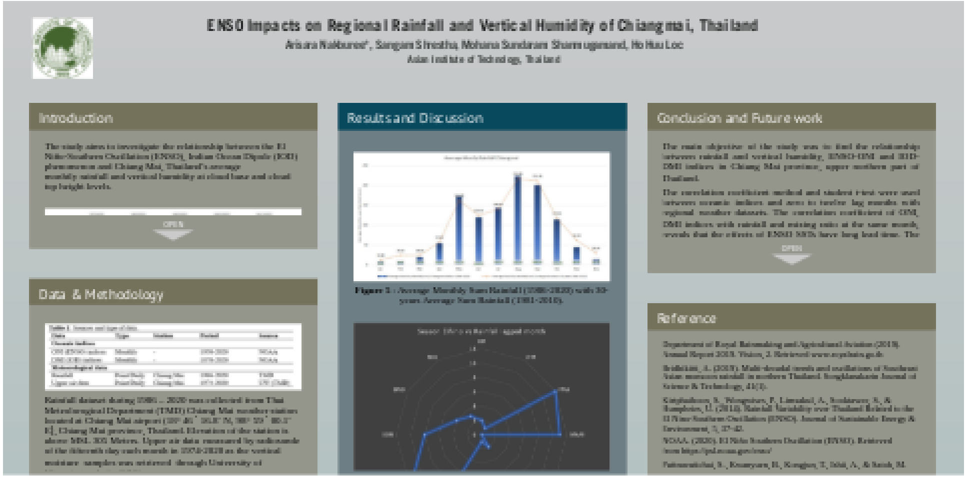
Abstract

The study aims to investigate the relationship between dominant climate variabilities namely El Niño-Southern Oscillation (ENSO), and Indian Ocean Dipole (IOD) versus rainfall, and vertical humidity in Chiangmai, Thailand. The Oceanic Niño Index (ONI) which represents ENSO status and Dipole Mode Index (DMI) which represent IOD indicator were collected for the period 1986-2020 (35 years). Subsequently, the 12-month lag correlations were analyzed between both indicators against rainfall and vertical moisture at cloud-base and cloud-top height levels for the same time periods. The results indicate that the impacts of both climate variabilities may not occur during the same period of the phenomenon. The effects of ENSO to weather pattern in Chiang Mai might be lagged by 0 to 12 months. Even though the correlation of the humidity versus ONI and DMI is fluctuated. The correlation results of ONI and cloud-base humidity level has moderate values and consistent with La Niña events. However, the DMI correlations against rainfall and mixing ratio are inconclusive due to insufficient data. The relationship between ONI index, rainfall, and mixing ratio can be used to predict the future rainfall and atmospheric moisture once they are validated. Keyword: ENSO, ONI, DMI, IOD, rainfall, mixing ratio, vertical humidity

ENSO Impacts on Regional Rainfall and Vertical Humidity of Chiangmai, Thailand



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INTRODUCTION

The study aims to investigate the relationship between the El Niño-Southern Oscillation (ENSO), Indian Ocean Dipole (IOD) phenomenon and Chiang Mai, Thailand's average monhtly rainfall and vertical humidity at cloud base and cloud top height levels.

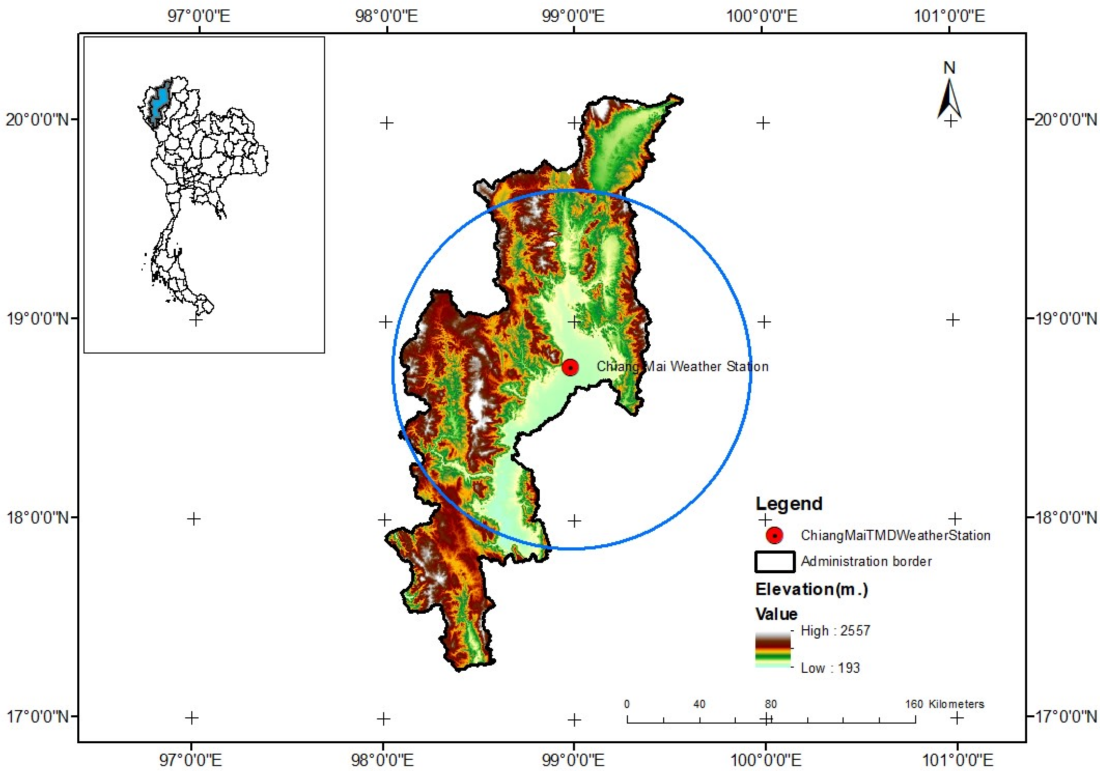

Figure 1 : Study Area Chiangmai, Thailand

DATA & METHODOLOGY

Table 1: Sources and type of data.

Data	Type	Station	Period	Source
Oceanic indices				
ONI (ENSO) indices	Monthly	-	1950-2020	NOAA
DMI (IOD) indices	Monthly	-	1870-2020	NOAA
Meteorological data				
Rainfall	Point/Daily	Chiang Mai	1986-2020	TMD
Upper air data	Point/Daily	Chiang Mai	1974-2020	UW (TMD)

Rainfall dataset during 1986 – 2020 was collected from Thai Meteolorogical Department (TMD) Chiang Mai weather station located at Chiang Mai airport (18° 46′ 16.8″ N, 98° 59′ 00.1″ E), Chiang Mai province, Thailand. Elevation of the station is above MSL 305 Meters. Upper air data measured by radiosonde of the fifteenth day each month in 1974-2020 as the vertical moisture samples was retrieved through University of Wyoming website (UW).

$$Mixing\ Ratio = \frac{mass\ of\ water\ vapor}{mass\ of\ dry\ air} \tag{1}$$

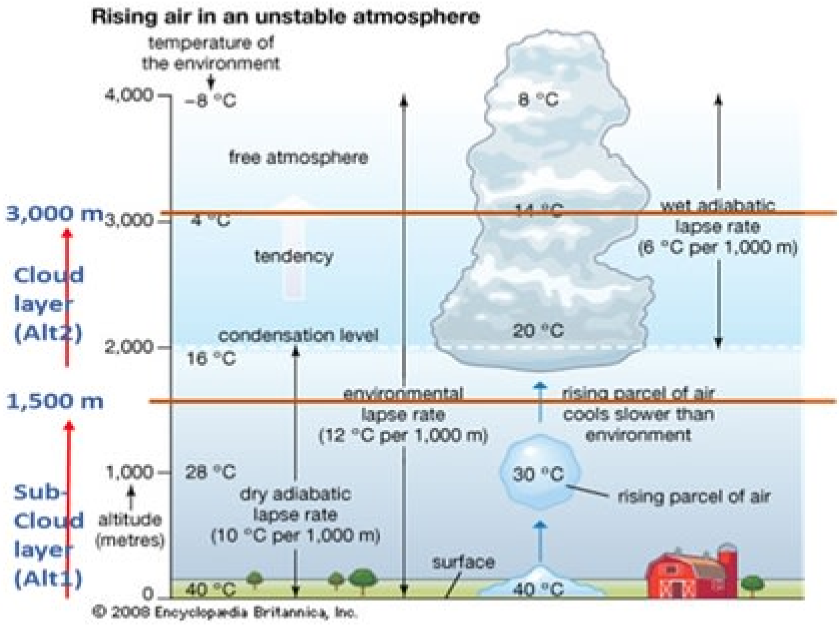

Figure 2 : Two Altitudes of Mixing Ratio Calculated as Vertical Humidity Representatives.

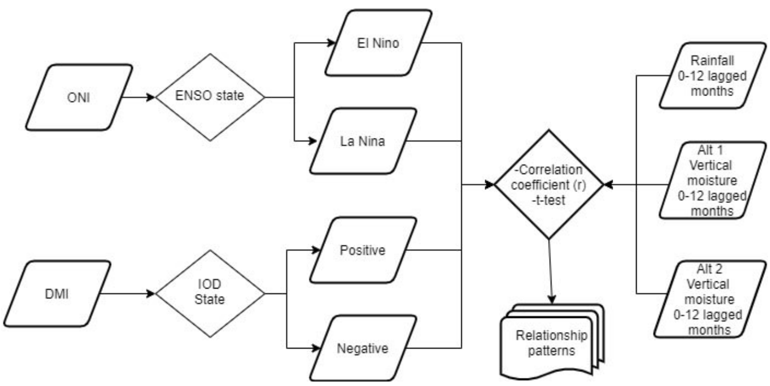

Figure 3 : Methodology Framework

The seasonal Oceanic Nino Index (ONI) represents ENSO state of El-ñino and Lañina states and Dipole Mode Index (DMI) which represents IOD positive and negative events were paired with average monthly sum rainfall, vertical mixing ratio at Altitude 1 (surface to 850hPa level) and Aititude 2 (850 - 700 hPa level) by 0-12 lagged month correlation and student t-test.

RESULTS AND DISCUSSION

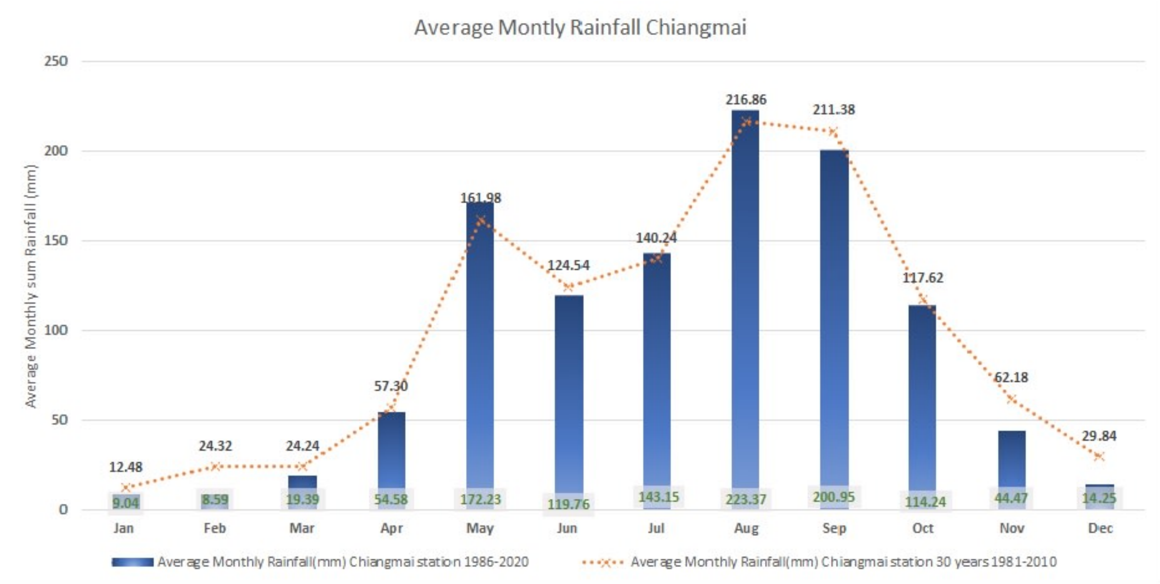

Figure 5 : Average Monthly Sum Rainfall (1986-2020) with 30-years Average Sum Rainfall (1981-2010).

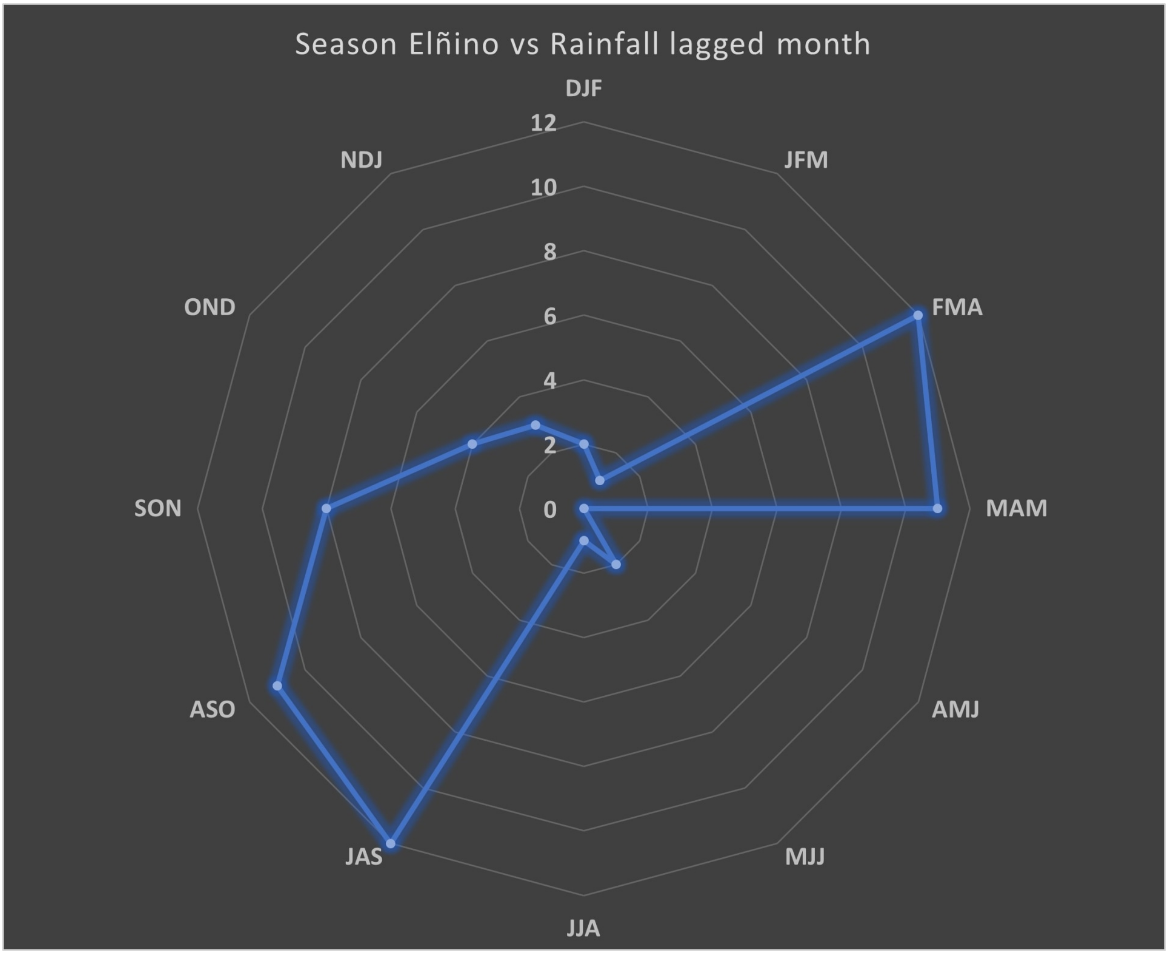

Figure 6 : Lagged month highest correlation and p-value < 0.05 between Seasonal El Niño and monthly rainfall.

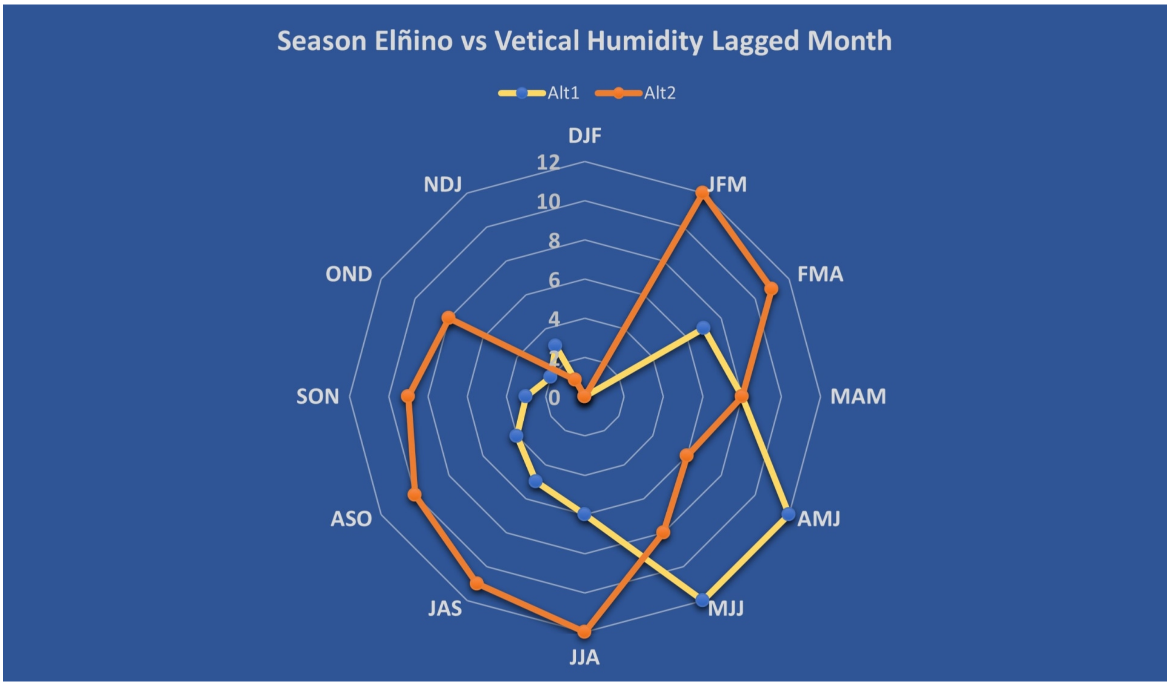

Figure 7 : Lagged month highest correlation and p-value < 0.05 between Seasonal El Niño and 2-level vertical moisture.

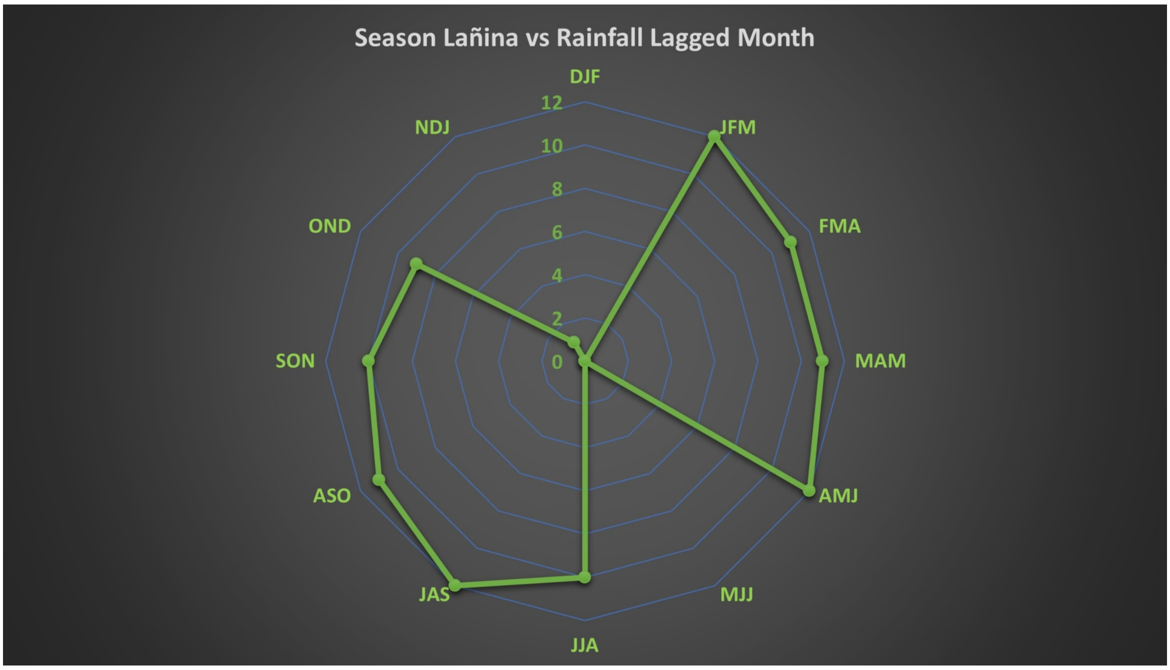

Figure 8 : Lagged month highest correlation and p-value < 0.05 between Seasonal La Niña and monthly rainfall.

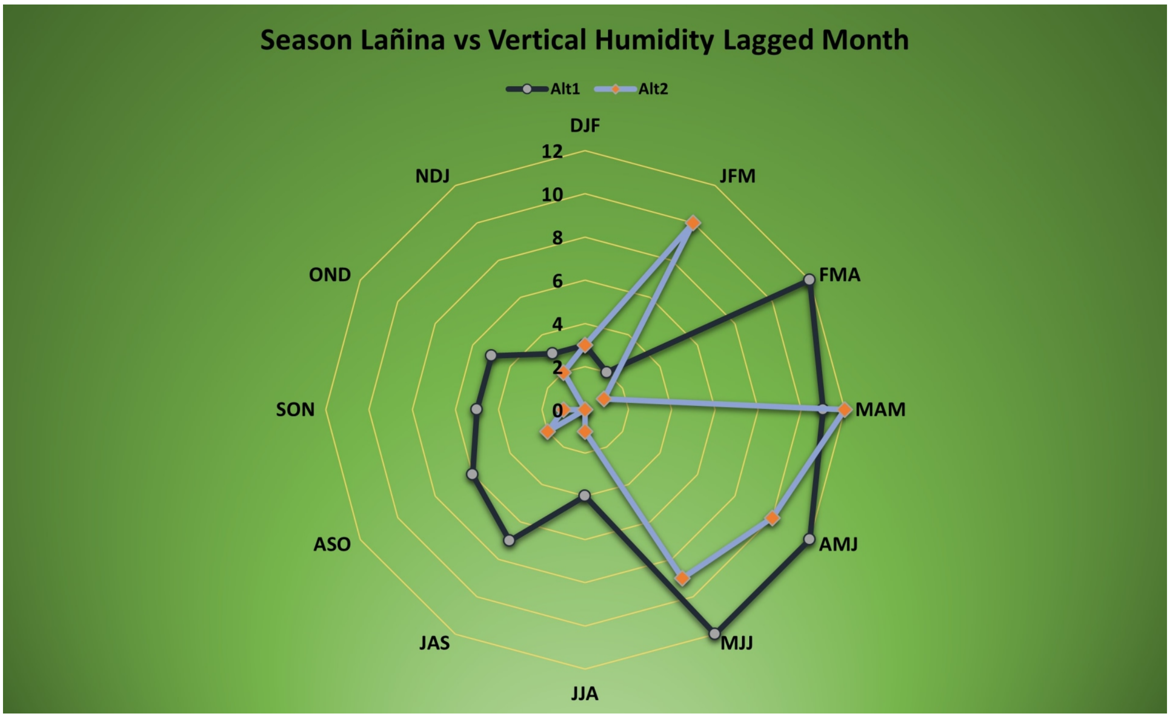

Figure 9 : Lagged month highest correlation and p-value < 0.05 between Seasonal La Niña and 2-level vertical moisture.

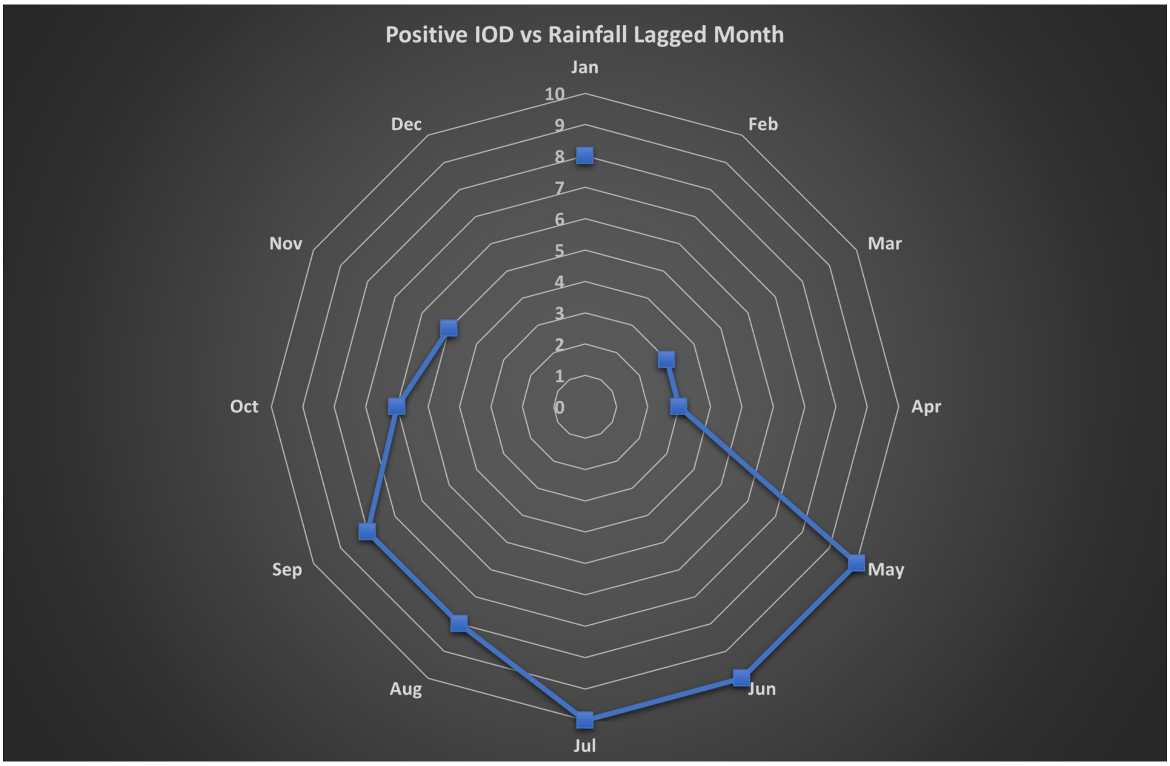

Figure 10 : Lagged month highest correlation and p-value < 0.05 between Positive IOD and rainfall.

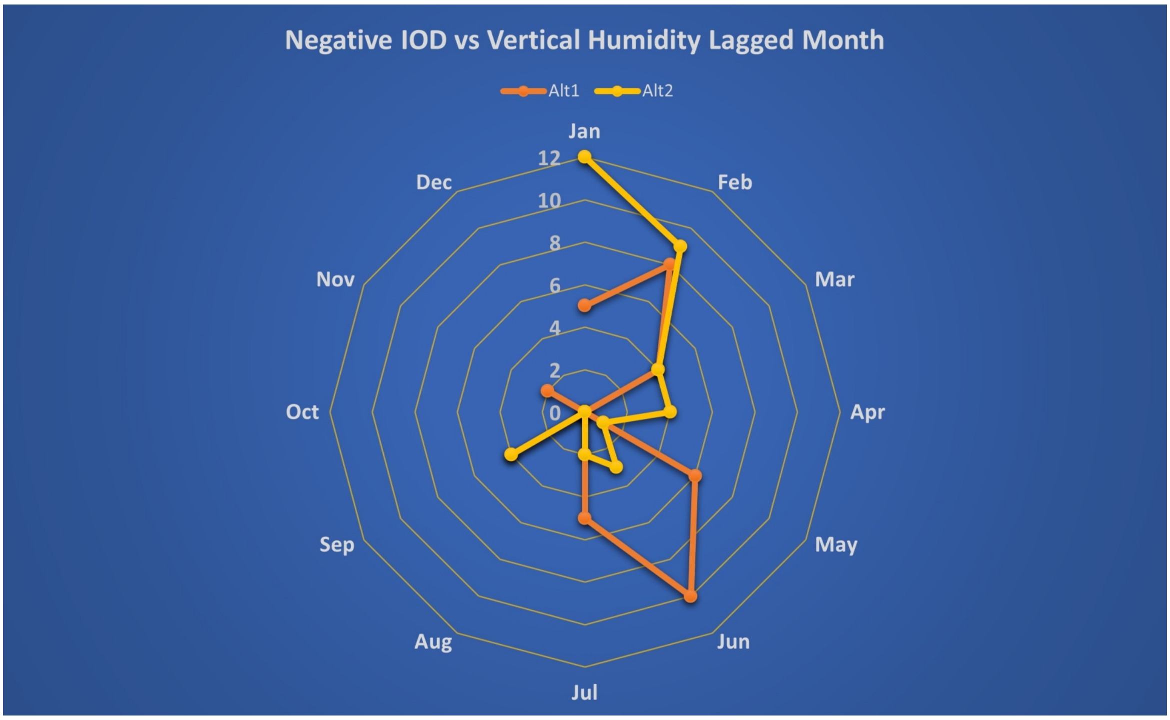

Figure 11 : Lagged month highest correlation and p-value < 0.05 between Positive IOD and 2-level vertical moisture.

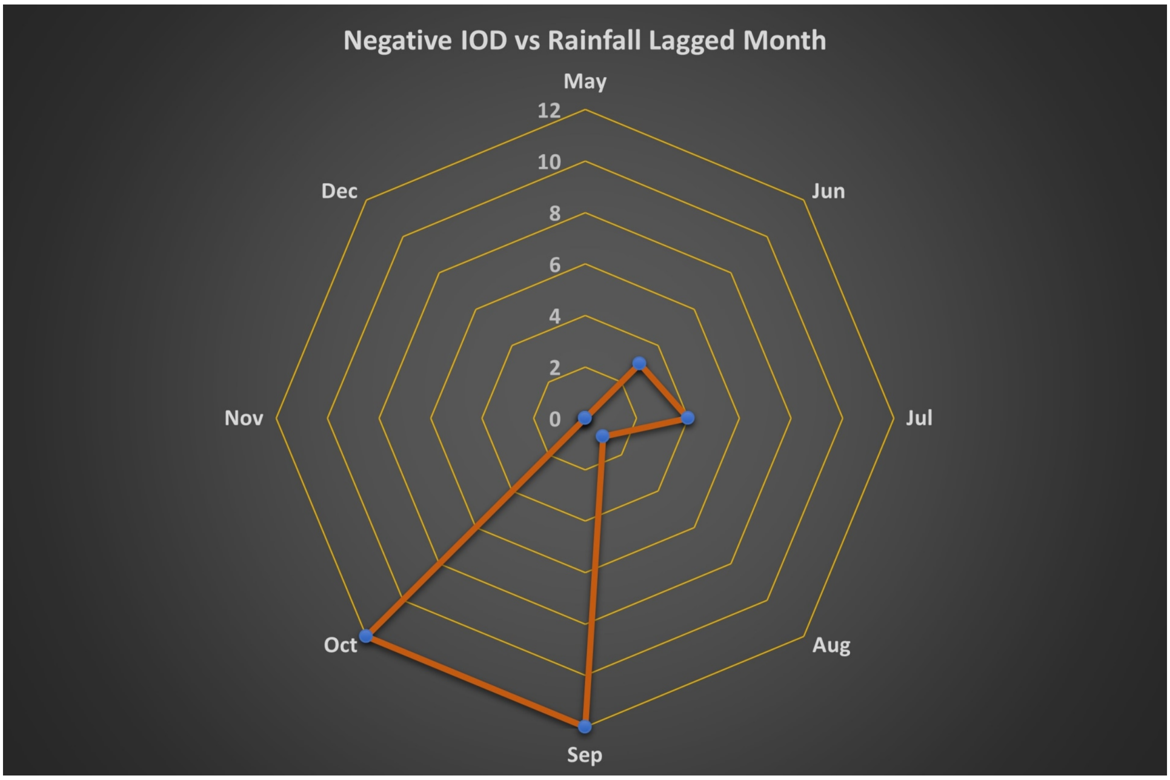

Figure 12 : Lagged month highest correlation and p-value < 0.05 between Negative IOD and rainfall.

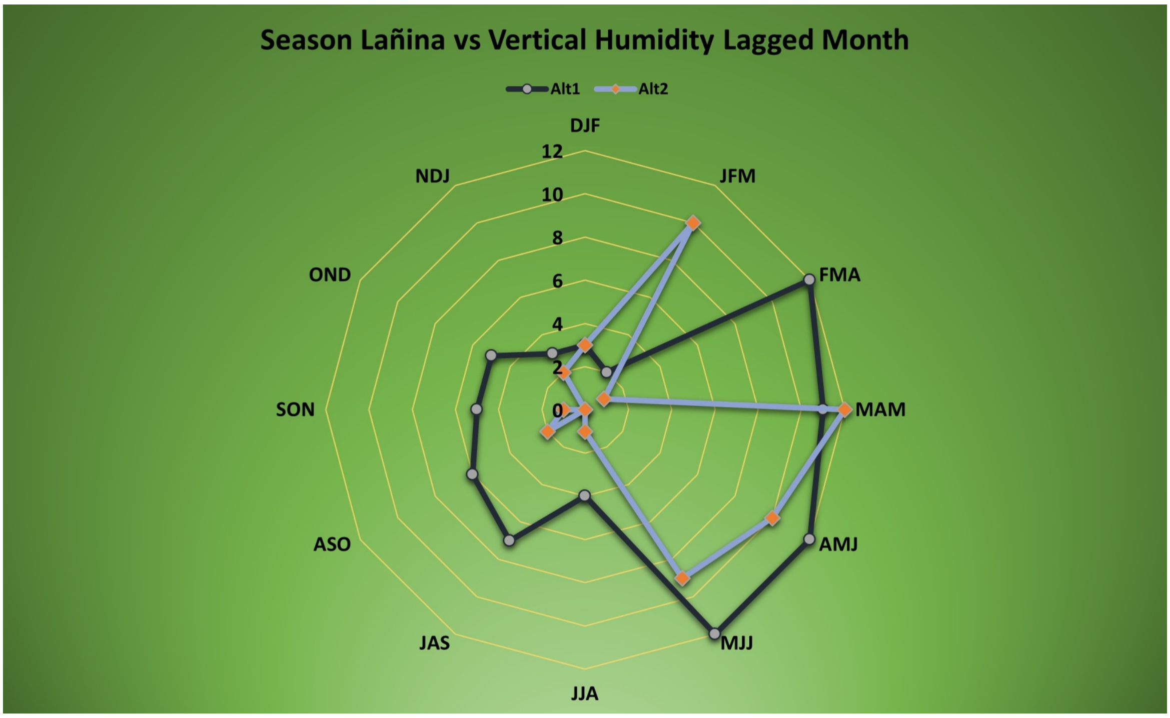

Figure 13 : Lagged month highest correlation and p-value < 0.05 between Negative IOD and 2-level vertical moisture.

The results indicate that the impacts on regional rainfall may not occur during the same period of the phenomenons. The effects of ENSO to weather pattern in Chiang Mai might be lagged from 0 to 12 months. Even though the correlation of the humidity versus ONI and DMI is fluctuated. The correlation results of ONI and surface to cloud-base humidity level has moderate values and consistent with La Niña events. However, the DMI correlation with rainfall and mixing ratio are inconclusive due to insufficient data.

CONCLUSION AND FUTURE WORK

The main objective of the study was to find the relationship between rainfall and vertical humidity, ENSO-ONI and IOD-DMI indices in Chiang Mai province, upper northern part of Thailand.

The correlation coefficient method and student t-test were used between oceanic indices and zero to twelve lag months with regional weather datasets. The correlation coefficient of ONI, DMI indices with rainfall and mixing ratio at the same month, reveals that the effects of ENSO SSTs have long lead time. The results of correlation coefficients between ONI, DMI indices and 1-year lagged rainfall and mixing ratio datasets show that the implication of ENSO phenomenon can be delayed until 12 months. While DMI indices with rainfall and mixing ratio is inconclusive due to lack of datasets.

Additional data of weather stations in North and Northeast parts of Thailand will be collected and analyzed with ENSO, IOD and MJO indices in attempt to find the relationship which can lead to future impacts forecast of abovementioned events on regional weather.

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Keyword: ENSO, ONI, DMI, IOD, rainfall, mixing ratio, vertical humidity