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Research paper

Effect of climate change on seasonal monsoon in Asia and its impact on the variability of monsoon rainfall in Southeast Asia

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ABSTRACT

Global warming and climate change is one of the most extensively researched and discussed topical issues affecting the environment. Although there are enough historical evidence to support the theory that climate change is a natural phenomenon, many research scientists are widely in agreement that the increase in temperature in the 20th century is anthropologically related. The associated effects are the variability of rainfall and cyclonic patterns that are being observed globally. In Southeast Asia the link between global warming and the seasonal atmospheric flow during the monsoon seasons shows varying degree of fuzziness. This study investigates the impact of climate change on the seasonality of monsoon Asia and its effect on the variability of monsoon rainfall in Southeast Asia. The comparison of decadal variation of precipitation and temperature anomalies before the 1970s found general increases which were mostly varying. But beyond the 1970s, global precipitation anomalous showed increases that almost corresponded with increases in global temperature anomalies for the same period. There are frequent changes and a shift westward of the Indian summer monsoon. Although precipitation is observed to be 70% below normal levels, in some areas the topography affects the intensity of rainfall. These shifting phenomenon of other monsoon season in the region are impacting on the variability of rainfall and the onset of monsoons in Southeast Asia and is predicted to delay for 15 days the onset of the monsoon in the future. The variability of monsoon rainfall in the SEA region is observed to be decadal and the frequency and intensity of intermittent flooding of some areas during the monsoon season have serious consequences on the human, financial, infrastructure and food security of the region.

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1. Introduction

The global circulation in terms of precipitation is an important element for the functionality of the Earth's system. It helps to regulate the temperature of the Earth by transporting heat from the tropics to the higher latitudes. However, this system is vulnerable to long-term temperature fluctuations, more commonly termed as climate change. Climate change is currently debated as an anthropologically enhanced phenomenon. Many scientists of today have been trying to quantify climate change and its relation with other

environmental systems. Arguably one of the most heavily dependent upon weather system is the monsoon season of Southeast Asia. While there are many literature available on the interactivity of the monsoon seasons, the impact of climate change in terms of rising temperatures on monsoon rainfall intensities in Southeast Asia has received little attention.

The objective of this study is to establish the link between global warming and precipitation increases and to understand the effects of these climate change trends on the dynamics of Asian monsoon seasons and how it impact rainfall variability in Southeast Asia. Climate change is discussed mainly in references to observed temperature anomalies (°C) from the late 20th century to the early 21st century, while rainfall variability of the East Asian summer monsoon is examined based on the observed seasonal rainfall anomaly. Secondary data on thermometric records over the last century have been analyzed to understand the effects of climate

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change from the overall variation and distribution of temperature and discussed in the context of meteorological records of global precipitation and importantly in the Southeast Asia region. The pattern of South Asian monsoons and other sub seasons are investigated to understand their effect and impact on rainfall distribution and vulnerability during the southeast monsoon season. In recent years, the erratic and unpredictable nature of the monsoons have caused extensive financial loss, damage to lives and property and also the destruction of the environment and farmlands. This consequently leads to food insecurity issues. It has thus, become a priority to predict and understand monsoon rainfall patterns in many Asian countries (Reuter et al., 2012).

2. Climate change and climate variability

Climate change is inevitable and unstoppable in its nature. However, the 20th century global warming has been linked directly with anthropological impacts, such as the burning of fossil fuel, excessive emission of greenhouse gases, and urbanization. Climate variability is concerned with the changeability in 'the mean state and other statistics (such as the standard deviation, extremes, or shape of frequency distribution) of climate elements on all spatial and temporal scales beyond those of individual weather events' (Serreze and Barry, 2010). Climate change on the other hand is variability that continues over a longer period and is statistically significant.

Global temperatures are recorded by combining temperature measurements from around the world. According to NOAA (2012a), due to the variability of methods of the data collection that include mercury thermometers invented in the early eighteen century, temperature records before 1850s are considered unreliable to be used for interpreting climate change. Therefore, temperature anomalies, the deviations from the referenced temperature (NOAA, 2012b), are used as a means to compare the change in temperatures. A positive value indicates a higher temperature and a negative value indicates a lower temperature from the referenced value. These differences are based on a normal, which can be explained as the 'arithmetic average of a climate element (e.g. temperature) over a 30-year period'.

According to the University of East Anglia's Climatic Research Unit in the UK, there is a distinctive increase in temperature after the last decline from 1945 to 1973 (Brohan et al., 2006). The somewhat exponential increase, shown in Fig. 1, is strongly believed to be anthropologically associated, caused by carbon

emission and urbanization. The impact of rapid urbanization on climate change is the temperature increase caused by buildings and urban activities. This increase in temperature has an immediate effect on the global rainfall distribution. The study NOAA-NCDC (2011) (Fig. 2) shows the total annual amount of global precipitation from 1910 to 2010. The changes in average precipitation over the period since 1910 to 2010 are seen on a baseline which does not change over time and which is also reflected in the global precipitation averages. A further look at the data shows more frequencies of negative precipitation anomalies from the 1950 to 1970. Beyond 1970, the frequent fluctuations between positive and negative precipitation anomalies follow the dramatic increase of global air temperature. Therefore, we can say that there is a relationship between global increase in temperature and precipitation changes beyond the 1970s.

3. Monsoon weather systems

Seasonality is caused by the tilting of the Earth, while the monsoon weather systems are a result of the land-sea temperature differences caused by solar radiation (Huffman et al., 1997). When the Earth rotates and revolves around the Sun, different seasons occur due to the different land masses of the northern and southern hemispheres. To understand this phenomenon, it is useful to note that the land surface area at the northern hemisphere is larger than the southern hemisphere. Therefore, the northern hemisphere is warmed greater. This causes opposing seasons between the northern and southern hemispheres. The two regimes of monsoon are the Southeast Asian summer monsoon (10° – 20° N) and the western North Pacific summer monsoon (10° – 20° N, 130° – 150° E), and are separated by a boundary over the South China Sea (Kripalani and Kulkarni, 1997). This seasonality is important in regulating rain regime. During winter, the tilting of the Earth allows less solar radiation at the northern hemisphere. This results in rapid cooling followed by pressure decrease in the atmosphere. Anti-cyclones develop over Siberia and the cold northeasterly air reaches the coastal waters of China before heading towards Southeast Asia (MMD, 2012). The East Asian winter monsoon (EAWM) is usually dry in Southeast Asia. During summer, the southwest monsoon rainfall is controlled by the warming of the northern hemisphere, where the heated air will rise, and be transported by the monsoon wind towards the southern hemisphere (Wolfson, 2012). East Asian summer monsoon (EASM) seasons are

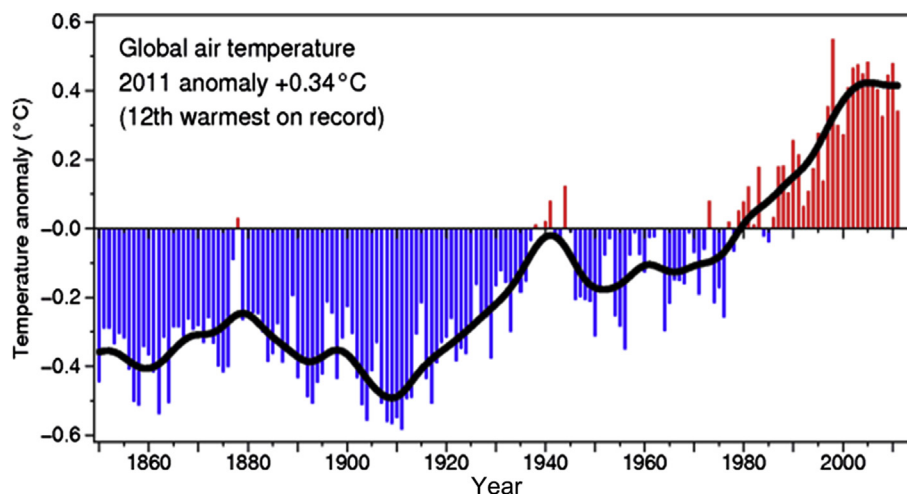


Figure 1. Global temperature anomaly from 1850 to 2010 (Brohan et al., 2006).

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