



## RESEARCH ON EXTRACTION OF INFORMATION FROM REGIONAL CLIMATE MODEL HADGEM3-RA TO ESTABLISH THEMATIC MAP RELATED TO EXTREME TEMPERATURE

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### Abstract

*Vietnam is one of the countries strongly affected by climate change. The reports of the Vietnam Ministry of Natural Resources and Environment (2009, 2012) also confirmed that natural disasters have been more complex and extreme. The extreme events related to drought also have been increasing. Therefore, understanding the impacts of climate change at regional and national scales relating to extreme events is critical and urgent. This study used the regional climate model Hadgem3\_RA to extract factors related to extreme temperature to establish thematic maps over Vietnam. The aim of the article is to provide the potential to establish extreme temperature map to serve climate change adaptation and mitigation.*

**Keywords:** Climate change; Extreme temperature; Hadgem3-RA; Thematic map.

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### 1. Introduction

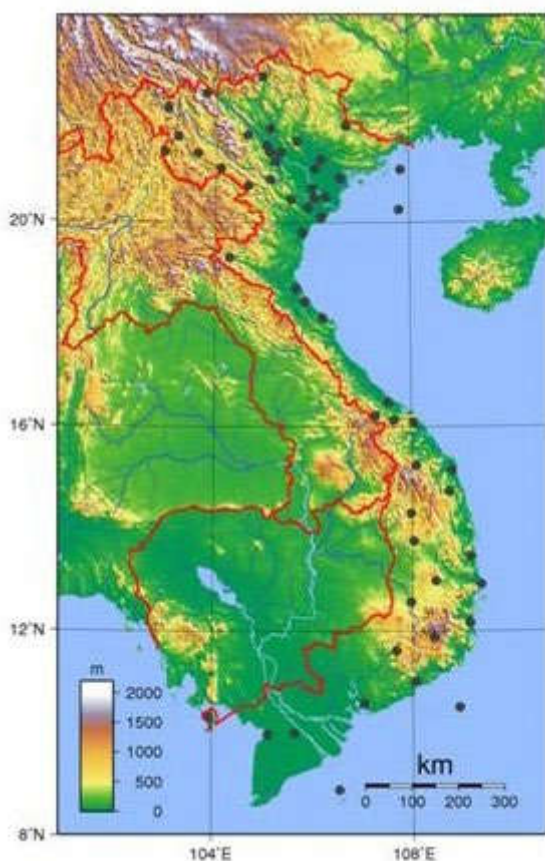
In Vietnam, temperature extremes are commonly defined according to temperature thresholds which affect human health. These comprise temperatures  $35^{\circ}\text{C}$  or  $<13 - 15^{\circ}\text{C}$ , as defined by the Vietnamese National Weather Service Center. Cold extremes usually occur in the northern part of Vietnam, where the temperature in the winter is  $4 - 5^{\circ}\text{C}$  lower than the zonal average [11], due to severe cold surges, whereas over the southern part of Vietnam, where average temperatures are very high in the summer, heat waves often occur. The latter will occur more often in the context of global warming (IPCC2007, Trenberth et al. 2007). IPCC (2007) stated

that the global average temperature has increased by  $0.74 \pm 0.18^{\circ}\text{C}$  in the period 1906 - 2005, and Asia became warmer by  $0.3 - 0.8^{\circ}\text{C}$  in the last 100 years. For Vietnam, warming of  $0.5 - 0.7^{\circ}\text{C}$  was observed in the last 50 years (1958 - 2007; Vietnam Ministry of Natural Resources and Environment 2009).

In recent years, extreme events that occurred in Vietnam increasingly more complicated. For example: The number of hot summer days' increases, the winter is shorter, in the North high land areas appeared frost and snow, the number of strong storms has increased every year. The influence of the earth's warming, climate change has a huge impact on

the lives and the economic development of Vietnam. Vietnamese economy is primarily agricultural development. Thus the problem of establish forecasting extreme maps in the future is essential to the timely adaptation measures. In Vietnam the evaluation and analysis of extreme events in the future through model with high resolution are continued during research and development. Currently, this research has taken the study of extreme climate events in two phases near future period and the last 30 years of the 21<sup>st</sup> century by model to establish thematic maps with high resolution to be able to continue to develop the previous studies

## 2. Data



**Figure1: Stations with daily time series of maximum temperature**

### a. Observation data

Daily minimum and maximum temperature for 56 stations were

kindly provided by the Vietnam Hydro Meteorological Data Center (HMDC). The data quality control was conducted based on 3 principles: (1) comparing each value with its climatological value for each station; (2) comparing the physical consistency between 2 or more variables; and (3) a spatial test for each value with that of adjacent stations. All suitable data were utilized in the calculation of percentiles and the detection of extreme climatic events.

### b. Model data

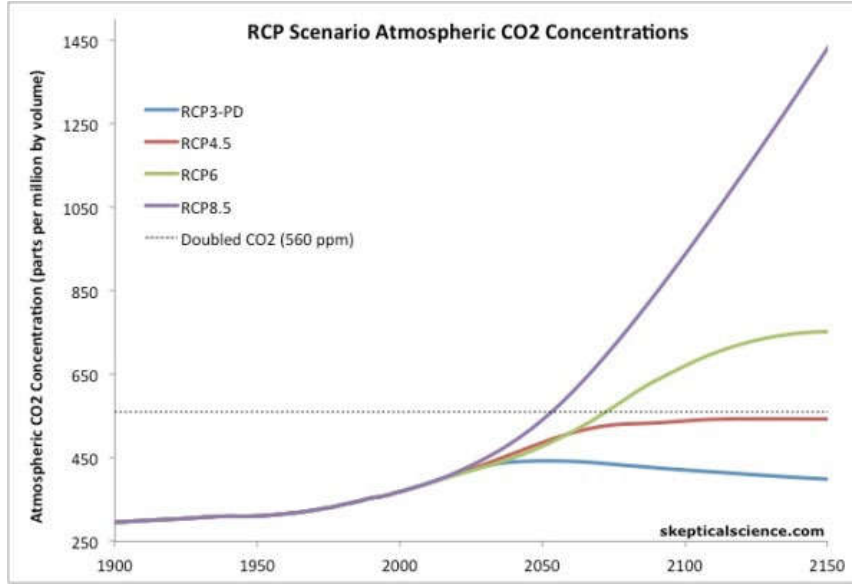
HadGEM3 - RA is based on the global atmospheric HadGEM3 of the Met Office Hadley Centre (MOHC). The configuration of HadGEM3 - RA is almost the same as the HadGEM3 - A. The number of grid points is 220 (west - east) by 183 (north - south), with a horizontal resolution 0.44 degree (approximately 50 km). For the future climate simulations, two different boundary conditions from the Representative Concentration Pathways (RCP) 4.5 and 8.5 scenarios of HadGEM2 - AO. The RCP 4.5 scenario is a stabilization scenario in which total radiated forcing is stabilized before 2100 through the employment of a range of technologies and strategies for reducing greenhouse gas emissions (Thomson et al., 2011). The RCP 8.5 scenario is characterized by increasing greenhouse gas emissions over time and is representative of scenarios in the literature which result in high greenhouse gas concentration levels (Riahi et al., 2011).

## 3. Methodology

Temperature is characteristic of atmospheric temperature regimes. Depending on climatic conditions where the background of each heat can be high or low, the range of temperature variation can be large or small. To characterize

the extreme temperatures, it is often considered the quantity of extreme temperature: maximum temperature (or the highest temperature - Tmax) and minimum temperatures (or low temperature - Tmin). In this study, from the core extreme indices, the factor Max

Tmax (Monthly maximum value of daily maximum temperature) was taken. All results for the index chosen have been calculated annually for two periods: the near future 2011 - 2030 and the last 30 years of the 21<sup>st</sup> century.



**Figure 2: The RCP Scenario Atmospheric CO<sub>2</sub> Concentrations**

Source: <http://skepticalscience.com/>

Fig. 2 illustrates the evolution of carbon dioxide (CO<sub>2</sub>) concentrations as observed in the 20<sup>th</sup> century and prescribed in the 21<sup>st</sup> century simulations in the RCP scenarios considered in this study. The radiated forcing trajectories in the RCPs can reflect various possible combinations of economic, technological, demographic, and policy developments [Moss et al., 2010]. Radiated forcing in RCP 4.5 peaks at about 4.5 W/m<sup>2</sup> (~540 ppm CO<sub>2</sub>) in the year 2100 (Thomson et al. [2011]). RCP 4.5 is comparable to the SRES scenario B1 with similar CO<sub>2</sub> concentrations and median temperature increases by 2100 according to Rogelj et al.[2012]. RCP8.5 assumes a high rate of radiated forcing increase, peaking at 8.5 W/m<sup>2</sup> (~940 ppm CO<sub>2</sub>) in the year 2100 (Riahi et al. [2011]). In this study, the climate simulations of the period 2011 to 2030 and 2071 to 2100

performed by CORDEX - HadGEM3 - RA have been analyzed with the RCP 4.5 and RCP 8.5 scenarios.

To calculate Max Tmax we define as below: Let  $Tx_{kj}$  be the daily maximum temperatures in month  $k$ , period  $j$ . The maximum daily maximum temperature each month is then:

$$TXx_{kj} = \max (Tx_{kj})$$

By the daily maximum temperature data of 52 meteorology station over the country, Max Tmax index has been calculated annually and the anomaly series were calculated for verification as follow:

$$X_{r,t} = \sum_{i=1}^{nt} (X_{i,t} - \bar{X}_i) / n_t$$

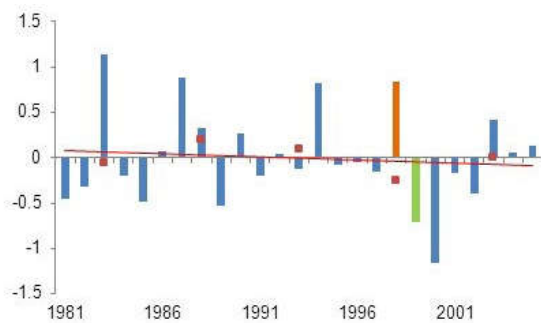
And the mean bias error:

$$MBE = [\sum (model - obs)] / n$$

All the results for the index Max Tmax at 53 meteorology station over the country were interpolated and then to establish thematic maps for extreme climate temperature over two periods in the future 2011 - 2030 and 2070 - 2100.

#### 4. Results and discussions

Using data extracted from the model CORDEX - HadGEM3 - RA in history over the period 1981 - 2005, the data were analyzed, statistical and the anomaly calculated as the following figure:

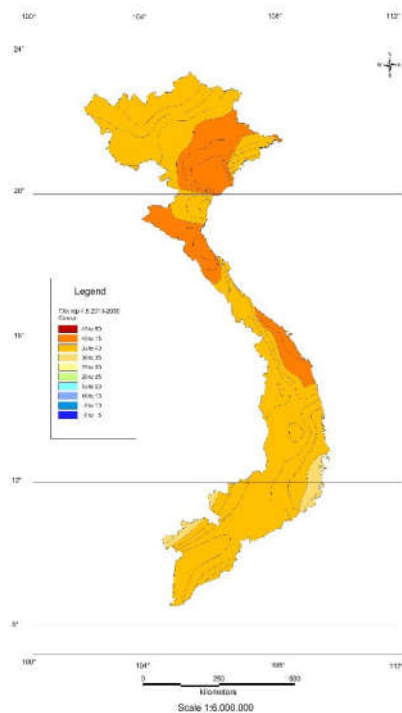


**Figure 3: Anomaly TXx- Monthly max daily T max**

Fig. 3 shows the anomaly of the monthly max daily temperature over the periods in history 1981 - 2005. From 1999 to 2005 the monthly maximum temperature had an increasing trend. Especially, in 1998, the orange bar shows a significant increase and opposite decrease in 1999. The evidence clearly shows El Nino phenomenon occurred in 1998 and La Nina in 1999 in Vietnam.

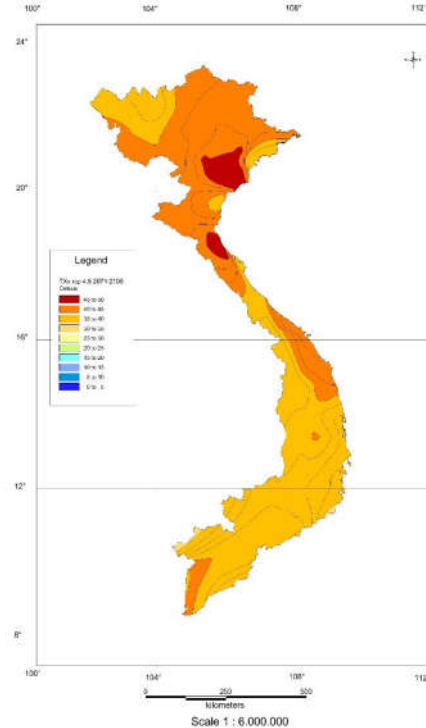
Vietnam had experienced during the 1997 - 1998 El Nino and 1998 - 1999 La Nina events show that there was an inadequate appreciation of linkages between global ENSO parameters and local weather variables. For instance, a prolonged drought during 1997 - 1998 caused a crop loss of as much as VND 5 trillion (US\$ 385 million). (DMU, 1998).

MONTHLY MAXIMUM VALUE OF DAILY MAXIMUM TEMPERATURE MAP  
SCENARIO RCP 4.5 PERIOD 2011-2030



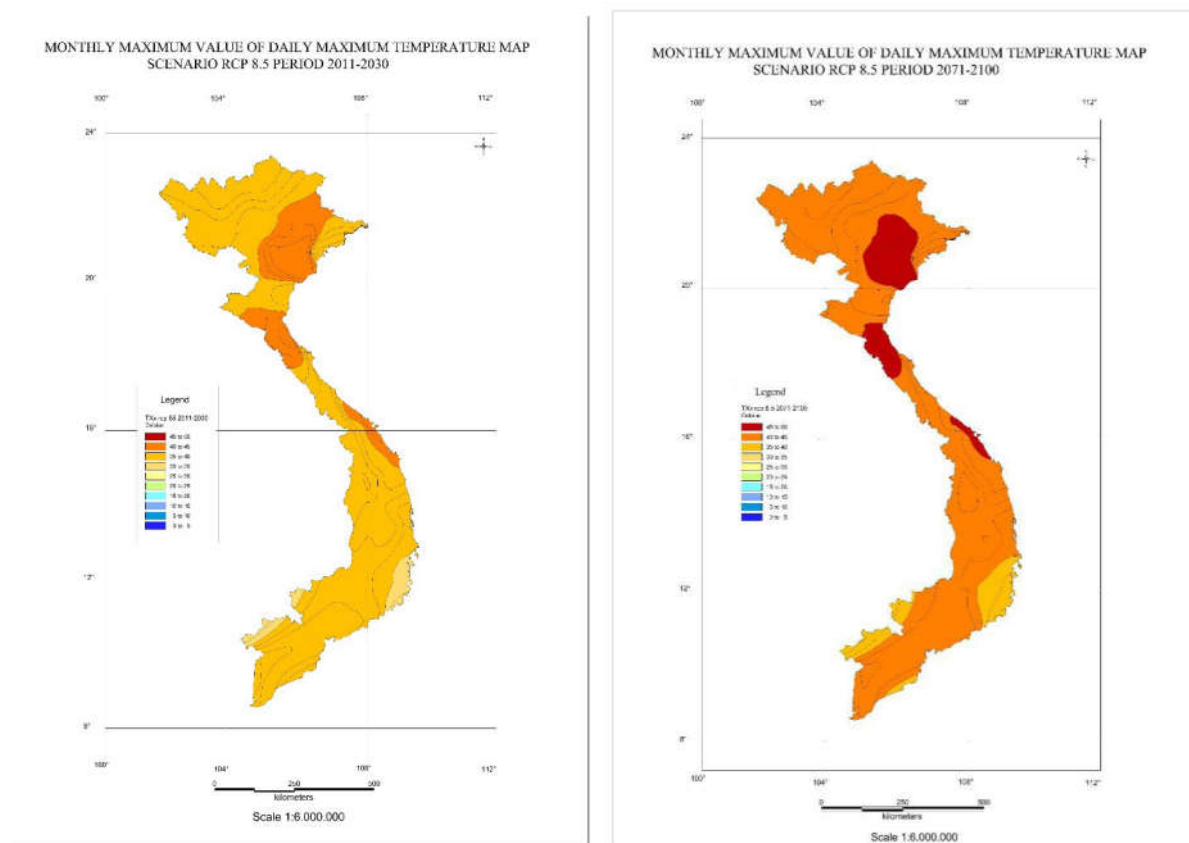
**a. Scenario RCP 4.5 period 2011 - 2030**

MONTHLY MAXIMUM VALUE OF DAILY MAXIMUM TEMPERATURE MAP  
SCENARIO RCP 4.5 PERIOD 2071-2100



**b. Scenario RCP 4.5 period 2071 - 2100**





*c. Scenario RCP 8.5 period 2011 - 2030*

*d. Scenario RCP 8.5 period 2071 - 2100*

**Figure 4: Monthly maximum value of daily maximum temperature (TXx) maps**

The CORDEX - HadGEM3 - RA as the other climate models always have bias. As the results, the CORDEX - HadGEM3 - RA has a cold bias with temperature as well. We calculated the mean bias of the Maximum temperature is -2.977 Celsius degrees. On the other hand, by the absolute threshold, the mean bias of monthly max daily Tmax is only -0.05 Celsius degrees. Therefore, we used this method to calculate the model data for the future which is more accurate.

For the results, the data was extracted from the model CORDEX - HadGEM3 - RA gave relatively accurate results in history and we have the base to analyze it for the future.

As the results, in RCP4.5 period 2011 - 2030 the monthly temperature could be average around 37°C over the country.

The regions predicted to 40 - 45°C are the North Delta (Hanoi, Hai Duong, Hoa Binh, Bac Giang, Nam Dinh, Thai Binh), North Center (Nghe An, Ha Tinh), and apart of center (Hue, Da Nang). In the last 30 years of the 21<sup>st</sup> century, the regions have 40 - 45°C will expand to over the North of Vietnam. And two places predicted that have temperature increase to 45 - 50°C are Hanoi capital and Vinh city.

In RCP 8.5 of the period 2071 to 2100 this averaged temperature (Max Tmax) predicted increase to 42.7°C over the country.

## 5. Conclusion

This study analyzed changes extreme temperature index in Vietnam based on maximum temperature data of

the 56 stations over Vietnam. Besides, CORDEX - HadGEM3 - RA daily data were used to compare and predict the extreme in temperature in the future. The data were calculated monthly maximum temperature.

In the period 1981 - 2005, the daily temperature was collected in 56 meteorological stations, the results of the analyst shows the temperature had a trend to increase over the country. The calculations also presented clearly the unusual phenomenon of weather as El Nino 1998 and La Nina 1999. The monthly maximum temperature was also calculated for future periods: the near future 2011 to 2030 and the last 30 years of the 21<sup>st</sup> century using two scenarios RCP 4.5 and RCP 8.5 (APCC, 2012). The results show the increased trend in monthly maximum temperature over the country for the future as a consequence of global warming.

The research also opens new direction related to establishing a map of extreme weather and climate change in order to provide information to adapt and cope with climate change. Therefore, there should be further studies with multiple indices of climate, and bias correction of the model to improve the accuracy of results.

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