INTEGRATING OPEN AND OBSERVATIONAL DATA FOR MODELING THE CLIMATE CHARACTERISTICS OF QUANG NAM PROVINCE, VIETNAM

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ABSTRACT

Up to now, the network of observational stations for local hydro-meteorological forecasting is still sparse. Therefore, generation of climatic maps at regional scale still faces many difficulties that leads to the low accuracy obtained. The main objective of this research is modeling the parameters of Quang Nam climatic maps based on open data combining the actual observational data at hydro-meteorological stations and neighborhood areas in the province. As a result, some components of climatic maps for Quang Nam province including the temperature, rainfall, humidity and wind speed were generated. Based on the research outputs, we evaluated the climate change in Quang Nam between different periods.

1. INTRODUCTION

Quang Nam is one of the largest province in Vietnam with the complicated topography. The high elevation and high relief mountainous area in western and the lowland as well as narrow plain in eastern coastal areas enriches the topographic characteristics of this province. Following the topographic context, the local climate of this area is also differentiating from the western to eastern, northern to southern. As the results, the hydrology system of this area is also polarized significantly between the watersheds and the seasons. However, the climate information of Quang Nam has not been updated timely and systematically.

Currently, the monitoring network for hydro-meteorological forecasting in Quang Nam province is sparse and not fully automated. The current forecasting models have not been able to update information for areas smaller than 10 square kilometers due to the limitations in technology and calculation capacity. Using open hydro-meteorological data has advantages in freely access, large number of observation stations and automatically updating. Morover, the modelling method in GIS is an effective tool to understanding the spatial distribution of the climate characteristics that may help to evaluate the climate of study area.

This study proposes a method for combining open and observational data for modelling the climate characteristics of Quang Nam province including temperature, rainfall, moisture, wind speed. Results is this study will be important source for monitoring the climate of this area.

2. METHODOLOGY

2.1. Study Area and Climate Characteristics

The study area is Quang Nam, a coastal province in Middle Central of Vietnam. The climate is characterized by tropical monsoon type which has two seasons with different

characteristics. The winter season from October to April with the Northeast monsoon that causes relatively cold air. The summer season from April to October is the operating time of the Southwest and Southeast monsoon which bring the rainfall and humidity.

In general, Quang Nam temperater is almost high through the year. The air temperature increases from north to south, from west to east and from high to low attitude. Annual average temperature in mountainous areas is 24.5 - 25.5^{0}C and in coastal plain is 25.5 - 26.0^{0}C.

The average annual rainfall in Quang Nam is large compared to other areas and the whole country. Total annual rainfall in the coastal plain and Hien, Nam Giang, Dai Loc districts is from 2200 to 2500mm, in the midland and mountainous areas from 3000 - 4000mm, the mountainous southwestern has average rainfall in a year on 4000mm.

Air humidity is closely related to air temperature and precipitation. In the rainy season, the humidity of coastal air can reach 85% - 88%, the mountain area can reach 90% - 95%. Humidity in the dry season of the coastal plain is only 80%, the mountain area is 80% - 85%.

There are two main types of wind that affect Quang Nam province: North East monsoon and southwest monsoon. Average annual wind speed in the mountains is 0.7 - 1.3 m/s, while the coastal plain reaches 1.3 - 1.6 m/s. The wind speed in the coastal plain is higher than the one in mountainous.

2.2. Data Used

In this paper, the open climate data was combined to observation data of meteorological stations in the area to model the climate characteristics of Quang Nam province such as temperature, , humidity, wind speed.

 - Open Data on Climate: There are many sources of data that can be exploited to study climate in the world. In this study we use climate data source from *globalweather.tamu.edu*. Selected climate stations are located in the province and neighboring areas. The time taken to model the climate characteristics is from 1983 to 2013. The data was downloaded from *globalweather.tamu.edu*, and was processed in GIS format.

 - Observational data on climate characteristics such as temperature, precipitation, humidity and wind speed are collected from meteorological stations in Quang Nam and surrounding areas.

2.3. Climate Data Processing and Modeling

The modeling of the climatic characteristics of Quang Nam is carried out in the following process (Figure 3). After determining the objective of the project, we have explored the data on climate characteristics of Quang Nam province such as temperature, humidity, precipitation, wind speed from both open source and observational source. Subsequently, we have standardized weather data in accordance with the GIS format. Results from standardizing data were input to the GIS environment in order to select the appropriate interpolation method to model climate characteristics of Quang Nam. In this topic, Spline method was used to model the characteristics of temperature, rainfall, humidity and wind speed of the study area.
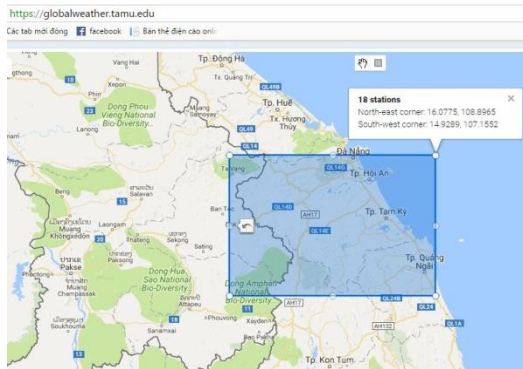
Figure 1: Selection of Study Area on *globalweather.tamu.edu*
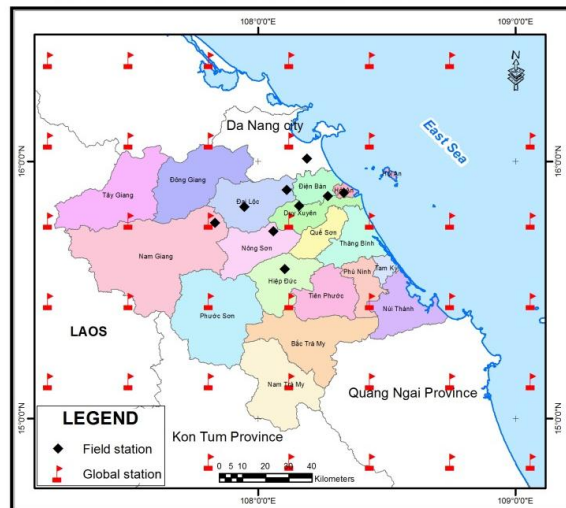

Figure 2: Map of global and local meteorological stations

Spline interpolation is an effective interpolation method that is smoother and has smaller error than some other interpolating polynomials. This method performs the computation to determine the number of nearest inputs passing through the given sample points. This method is optimal for less variable surfaces, such as elevation, water height, or concentration of pollution. It is not appropriate for areas have large variations on the surface within a short horizontal limit, because it may exceed the estimated values. Spline is a convenient way to interpolate climate elements over a period of months or years, but less suitable for daily and hourly periods.

The Spline method uses a mathematical function that minimizes the overall curvature of the surface. This method generates a smooth surface that precisely passes through the input points. The equation used in Spline interpolation method in this study is as follow [1]:

$$S(x, y) = T(x, y) + \sum_{j=1}^{N} \lambda_j R(r_j)$$

Where: j = 1, 2, ..., N. N is the number of observation points. λj are the coefficients found when solving linear systems. R(rj) is the distance from point (x, y) to point j. T(x, y) and R are defined differently, depending on the selected algorithm.
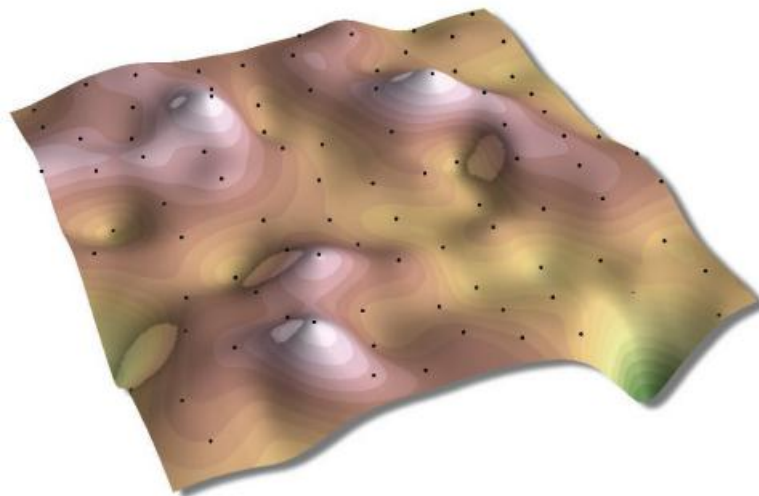

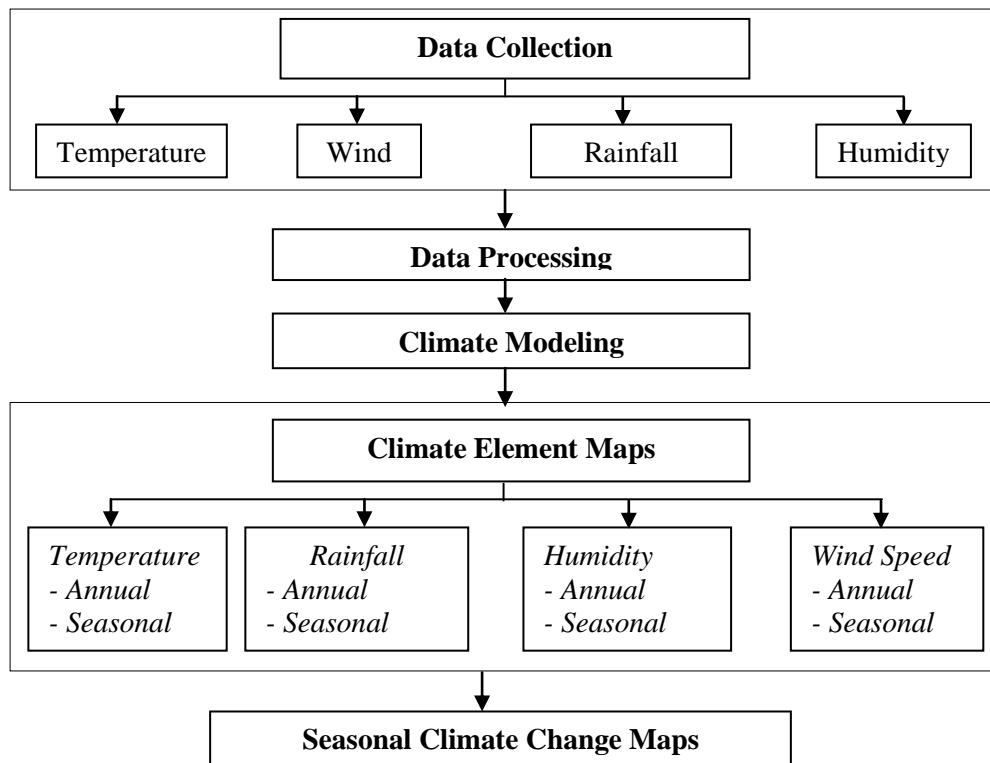**Figure 3: Spline interpolation surface [After ESRI 2004]**

Figure 4: Flowchart of Climate Modeling Mapping for Quang Nam

The climate data was downloaded from *globalweather.tamu.edu* website processed in GIS format.

The temperature data of stations include the maximum, minimum and average values. In this topic, we use average annual temperature, average temperature in dry season and rainy season in Quang Nam. Data was selected from 1983 to 2013. The average annual temperature was calculated by taking the mean of all the years from 1983 to 2013 of each station. The average seasonal temperature includes the average temperature of the dry season taken from April to October and the average temperature of the rainy season including the rest of the year.

Humidity and wind parameters were also processed similarly. We have taken the mean of humidity and wind speed of each station from 1983 to 2013. For humidity and wind, dry monsoon season is from January to June and the rainy season is from July to December.

The total rainfall of the year is calculated by the total rainfall of the months from January to December of each year. Total dry season rainfall is calculated as total rainfall from January to June of each year. On the other hand, total rainfall in rainy season is calculated as total rainfall from July to December of each year. Similarly, we also processed monitoring data on temperature, precipitation, humidity and wind speed collected from meteorological observation stations in Quang Nam to increase the number of input data for modeling.

4.   RESULTS AND DISCUSSIONS

4.1.   Climate Element Maps of Quang Nam for the period from 1983 to 2013

Based on the mean temperature data of all the collected stations and the Spline interpolation method, the study has established the average annual and seasonal temperature maps of Quang Nam province from 1983 to 2013. The results are shown in Figure 5.
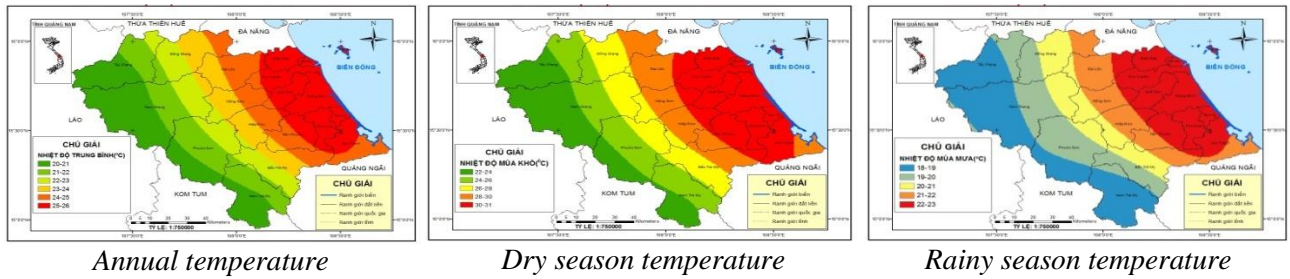
Annual temperature   *Dry season temperature*   *Rainy season temperature*

Figure 5: Maps of temperature in Quang Nam

Similarly, we have also established the mean and seasonal rainfall maps for the period 1983 - 2013 by the Spline interpolation method. The results are in Figure 6.

The average humidity of the measuring stations in Quang Nam is determined by the Spline interpolation method. As a result, we have established the yearly and seasonal average annual humidity maps of Quang Nam from 1983 to 2013. Similarly, we have also mapped the average and seasonal wind speed of Quang Nam from 1983 to 2013 by using Spline interpolation.
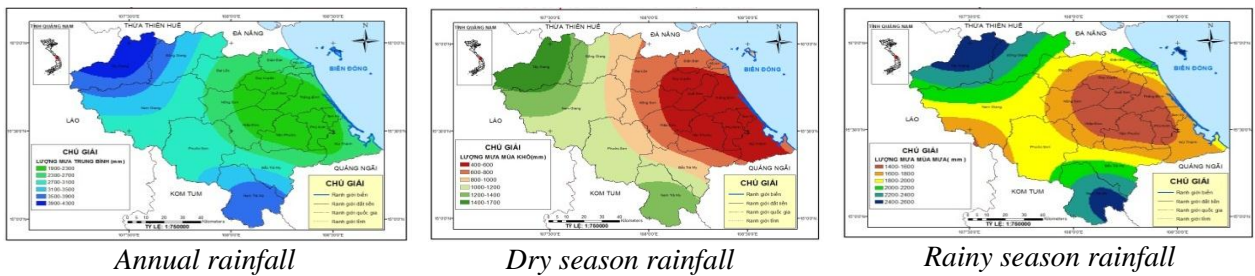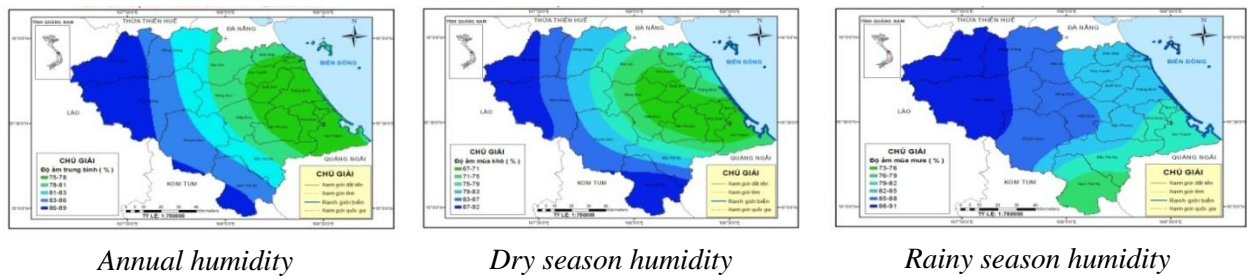

Annual rainfall   *Dry season rainfall*   *Rainy season rainfall*

Figure 6: Maps of rainfall in Quang Nam

Annual humidity   *Dry season humidity*   *Rainy season humidity*

Figure 7: Maps of humidity in Quang Nam

Annual wind speed   *Dry season wind speed*   *Rainy season wind speed*
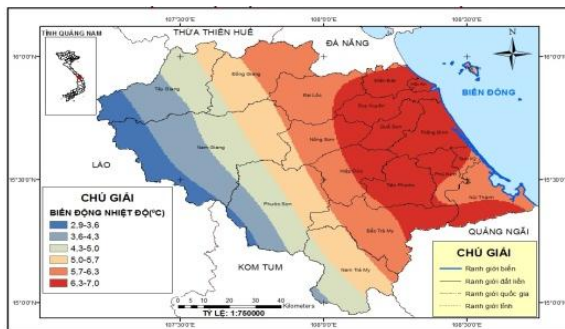
Figure 8: Maps of wind speed in Quang Nam

4.2. Evaluation of the Change in Climate Characteristics of Quang Nam in the period of 1983 -2013

We have overlaid maps on GIS to create the change maps in the temperature, rainfall,

humidity and seasonal speed of Quang Nam province from 1983 to 2013. The results are shown in Figure 9.

The temperature of Quang Nam province varies from east to west in relation to the topographic characteristics. The temperature between dry and wet season in Quang Nam varies from 2.9 to 7.0^{0}C. Temperature oscillations in lowland districts such as Thang Binh, Phu Ninh, Tien Phuoc, Que Son, Duy Xuyen, Dien Ban are much higher than in mountainous districts such as Tay Giang and Nam Giang. The reason is that Quang Nam's terrain is gradually lowered from West to East, so the temperature is also differentiated by terrain. The western part is mainly mountainous which is covered by the dense vegetations, so the temperature is cooler than the eastern part which is coastal terrain.
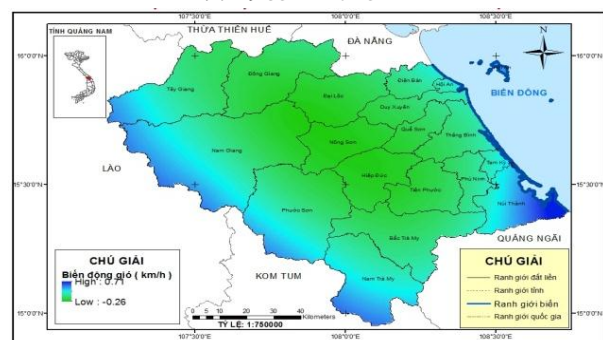

*Change of temperature in Quang Nam
in 1983 – 2013*
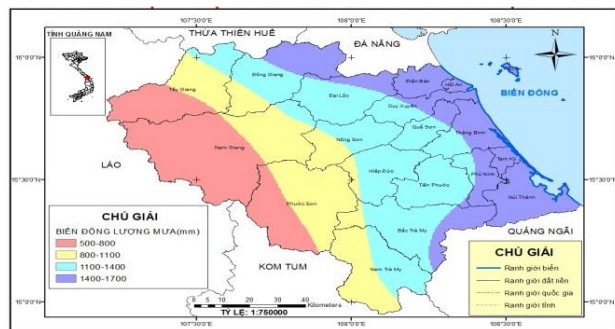
*Change of rainfall in Quang Nam
in 1983 – 2013*
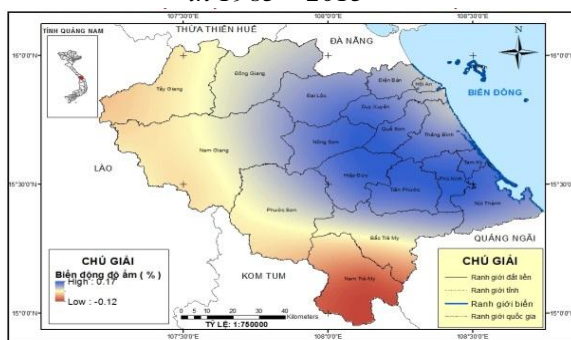
*Change of humidity in Quang Nam
in 1983 – 2013*

*Change of wind speed in Quang Nam
in 1983 – 2013*

Figure 9: Maps of Change in Climate Characteristics of Quang Nam

Rainfall in Quang Nam province varies widely among coastal and mountainous districts. Rainfall in coastal area is from 1400mm to 1700mm while mountainous area is from 500mm to 800mm. The rainfall oscillation in the coastal districts such as Hoi An, Dien Ban and Tam Ky are higher than in mountainous districts such as Tay Giang, Nam Giang and Phuoc Son. This is because the seasonal rainfall in the mountainous areas of the province is more distributed than in the coastal areas. The east of the Truong Son Range receives moisture wind from the sea, causing heavy rainfall in mountainous areas. In the early months of the summer, when the southwest monsoon prevails, the mountainous areas of the province are still raining, while the coastal plains are dry. At the end of the summer, when the southwest monsoon signs, the coastal plain of Quang Nam starts the rainy season

Considering the humidity, it is observed that the strong oscillation is in coastal areas such as Hoi An, Nui Thanh, Tam Ky. The weak oscillation values are in mountainous areas such as Tay Giang, Nam Giang and Bac Tra My. Due to the variation of topography, the humidity decreases from the Northwest to the Southeast. The Truong Son mountain Range plays as a barrier which causes heavy rain in the east side, so the seasonal air humidity is

high. Coastal sand dunes in the dry season are influenced by winds of the Northern Hemisphere, so the humidity is low.

The value of wind speed oscillation is high in the coastal areas of Nui Thanh district and Truong Son mountain range, and weak in the central area. Due to the uncovered terrain, the east (coastal) wind speed is high. Winds in the mountain do not show the conditions of the circulation as in the plain, coastal and especially in the island. The wind speed decreases from the delta to the mountains. Strong wind in the mountains mainly due to thunderstorms, hurricanes cause; Meanwhile in the island and the coastal plain, the strong winds are mainly due to the contribution of the typhoon and northeast monsoon.

5.   CONCLUSIONS

Quang Nam is a province with very complicated terrain and geography, with tropical monsoon climate and special characteristics due to the impact of terrain.

Integrating the open and observational data on climate combined with Spline interpolation method, this study has established the maps on the characteristics of climate such as annual average temperature, temperature in the rainy season, dry season; annual rainfall, rainfall in rainy season, dry season; Annual humidity, humidity in rainy season, dry season; average annual wind speed, rainy monsoon and dry season wind speed.

Subsequently, we have analyzed and assessed the characteristics of Quang Nam climate spatially and temporally. The results show that the climate characteristics of Quang Nam are distributed according to the natural rules.

Based the maps of climate elements, the study has also generated the change maps in climate characteristics of Quang Nam. The results show that the temperature, rainfall, humidity and wind speed of Quang Nam have a clear seasonal variation.

6.   REFERENCES

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