Mean air temperature-precipitation models using genetic programming and its application under climate change scenarios.

G. Daniel Mejía S., Maritza L. Arganis J., Eliseo Carrizosa E., Jacquelinne Mariles G. José C. Ramírez G., Nikte Ocampo G., Margarita Preciado J., Jeanette Zambrano N..

Instituto de Ingeniería, Universidad Nacional Autónoma de México. Circuito Escolar S/N, Edificio 5, Ciudad Universitaria, Del. Coyoacán, México D.F., México. C.P. 04510 GMejiaS@iingen.unam.mx

XVI World Water Congress
International Water Resources Association (IWRA)
Cancun, Quintana Roo. Mexico, 29 May - 3 June, 2017

INTRODUCTION.

The study of the way in which climatological variables have been or will change over time in relation to greenhouse gas emissions and Climate Change has been the reason for numerous investigations since the end of the 19th century, which have increased since the eighties of the 20 century (Allerup et al. (2000), Piani et al. (2010), Chistensen et al. (2008), Berget et al. (2005)).

The Intergovernmental Panel on Climate Change (IPCC) defines climate change as "a statistically significant change, either in average climatic conditions or in its variability, which is maintained for an extended period (typically decades or longer)".

As a developing country, Mexico tends to be more vulnerable to many developed countries to climate change. The climate change scenarios are "coherent, internally consistent and plausible description of a possible future state of the world". They are not forecasts, as each stage is an alternative of how to involve the future climate. (Magaña,2006).

The emission of these gases into the atmosphere depends largely on the level of development of countries in the future, its population and the use of oil as a main source of energy supply.

In the IPCC Special Report on Emission Scenarios four storylines (A1, A2, B1 and B2), where the driving forces described in emissions of greenhouse gases and aerosols and their evolution during the twenty-first century were developed both globally and in different regions. Each line represents a level evolutionary divergent development in demographic, social, economic and technological issues.

In simple terms, the four storylines combine two sets of divergent trends: a series develops variations between economic and environmental values; the other series explores the variations between increased globalization and regionalization. These storylines can be summarized as follows.

- High emissions A1B
- Media Releases - High A2
- Average emissions - Low B2
- Low emissions B1

STUDY SITE.

The IMTA SEDEPECC (IMTA, 2016) platform uses different climate change scenarios, so their records were taken as the basis for this project; a drawback is that the platform does not provide a convenient way for each weather station of the database CNA accuracy, the platform only throws site data with an accuracy of 0.5 °, and established the coordinates is limited to one type of scenario A1B for a period from January 2010 to January 2060, with data for the Normal or averages for each year, data from temperature and intensity of rainfall is collected

In the Table 1 and Figure 1 the actual and approximate location regarding the platform SEDEPECC data, which information to work this step down is presented.

METHODOLOGY.

10 weather stations that have daily records of rainfall and air temperature were selected; monthly data were obtained from these records. In order to obtain this monthly data, the daily precipitation indexes were accumulated and simultaneously the maximum temperatures and minimum daily temperatures were averaged, according to their corresponding month.

Several correlation analyzes were performed between rainfall and maximum temperature historical data, as well as between rainfall and mean temperature, which resulted in a higher correlation in the latter combination.

Because of the arrangement and distribution of the data, the maximum value representative of each month of rainfall was considered, as well as the mean air temperature values corresponding to this year would complement the data of the month under analysis.

STATION	NAME	LATITUDE, °		LENGTH, °	
		Real	SEDEPECC	Real	SEDEPECC
25172	Sinaloa	25.6	25.5	-108.0	-108
22043	Queretaro	20.5	20.5	-100.2	-100
7343	Chiapas	16.7	17	-92.9	-93
26022	Sonora	30.8	31	-109.2	-109
31027	Yucatan	20.3	20	-89.6	-89.5
30041	Veracruz	20.9	21	-98.1	-98
16228	Michoacan	19.1	19	-102.3	-102
12142	Guerrero	16.8	17	-99.9	-100
3039	BCS	26.3	26	-111.9	-112
5147	Coahuila	27.2	27	-101.2	-101

Table 1. Location of sites near stations analyzed according to the SEDEPECC platform

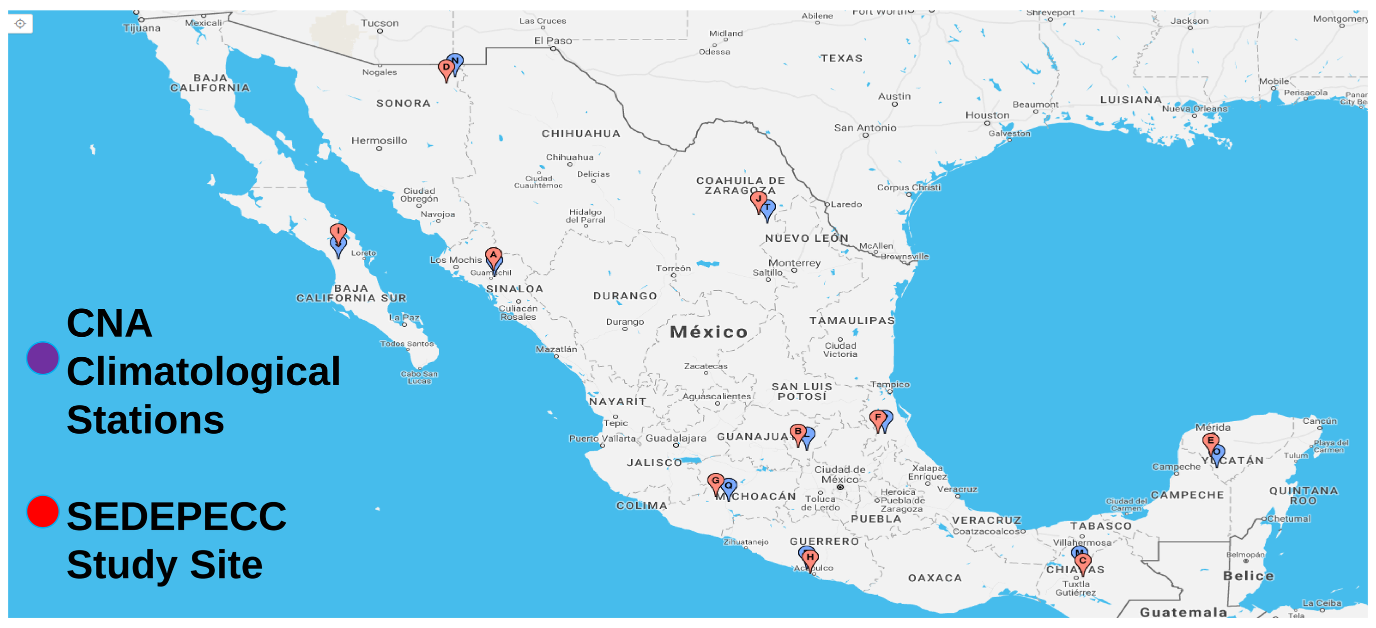

Figure 1 Study site

Once the information of the twelve months has been concentrated, the database is exported to a format that a genetic programming (GP) algorithm codified in MATLAB© recognizes and performs the appropriate calculations. Subsequently said program gave a solution file with an prefix notation which also comes with operators own the program, the task of converting it to infix notation was a purely careful work.

To evaluate the obtained results the relationship between the monthly rainfall (representative year) and the hp values calculated by the PG as a function of temperature against an identity function were drawn. For the next stage, monthly data of the representative year with similar characteristics (horizontal and vertical) were grouped to obtain new GP submodels. (Figures 2). The determination coefficient was considered to compare several GP models.

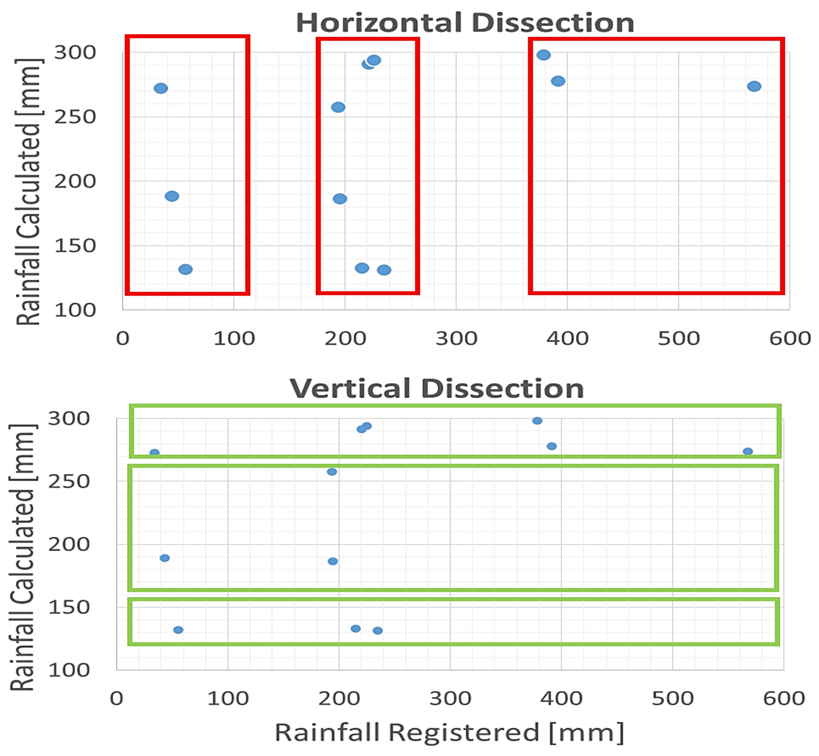

Figure 2 Measured and calculated data

$$R^2 = \frac{Variance\ y - Variance\ error\ y}{Variance\ y}$$

Data collected by the SEDEPECC platform were userd in all GP models to get a calculated rainfall and the annual pattern was compared against the representative year obtained with GP in the analyzed stations.

RESULTS AND CONCLUSIONS.

In this work new models obtained with GP were provided to approach meteorological phenomena based on monthly rainfall and air temperature in certain regions of Mexico, which can be useful to take appropriate measures to mitigate the damage or effects that could occur in nearly future.

According to the results, the station that best adapted to the modeling based on the behavior of rainfall intensity against the historical average temperature is Acahuato in Michoacan, Mexico with Key 16228 since obtained the highest R² result of establishing the best pattern through the following equations (Table 2).

STATION 16228

Month	DATA SET	EQUATION	R^2
ALL	ALL DATA	$hp=-0.0000017T^5+0.0134T^2+T-9.4449$	0.15
2,3,4,5, 12	H1	$hp=10.1959-0.3657T$	0.99
1,10,11	H2	$hp=-0.055T^2+1.4554T+1.0515$	
6,7,8,9	H3	$hp=104.246-3.7341T$	
1,2,9,10 ,11,1,2	V1	$hp=-0.00000005T^6+0.000001T^5+0.0212T^2-0.0196T$	0.58
3,7,8	V2	$hp=-0.4174T^3+9.2732T^2+8.86481T+1.8319$	
4,5,6	V3	$hp=154.517-5.9036T$	

Table 2 . Summary of equations used for station 16228.

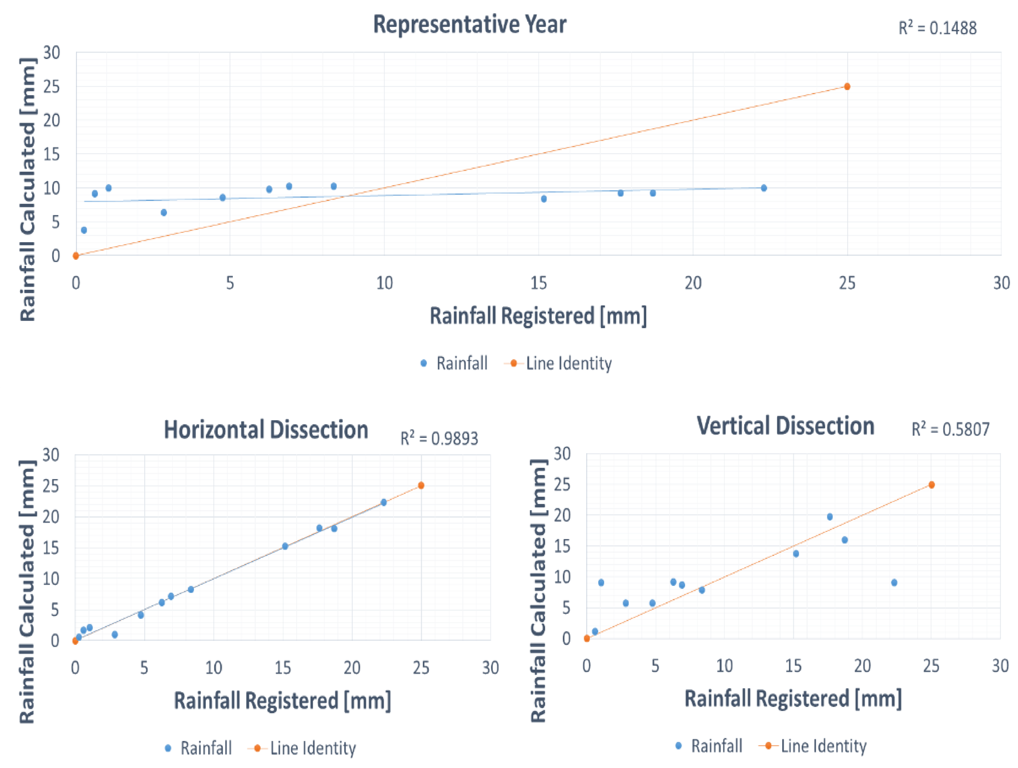

Figure 3. Comparison between the measured rain and the calculated rain.

Figure 3 shows the comparison between the data measured in a representative year and the data calculated by the PG models, likewise shows the data grouped horizontally and vertically, using an identity line to establish a better comparison parameter.

Figure 4 show graphically, the relationship between the record in the SEDEPEC the IMTA and calculated with the best model (horizontal dissection)

According to the above, you can model and get an overview of how rainfall and temperature will rise or will decrease as the case, creating long-term scenarios, which can establish a hydraulic work or prevention policies that mitigate the effects caused by these changes in these climatic characteristics.

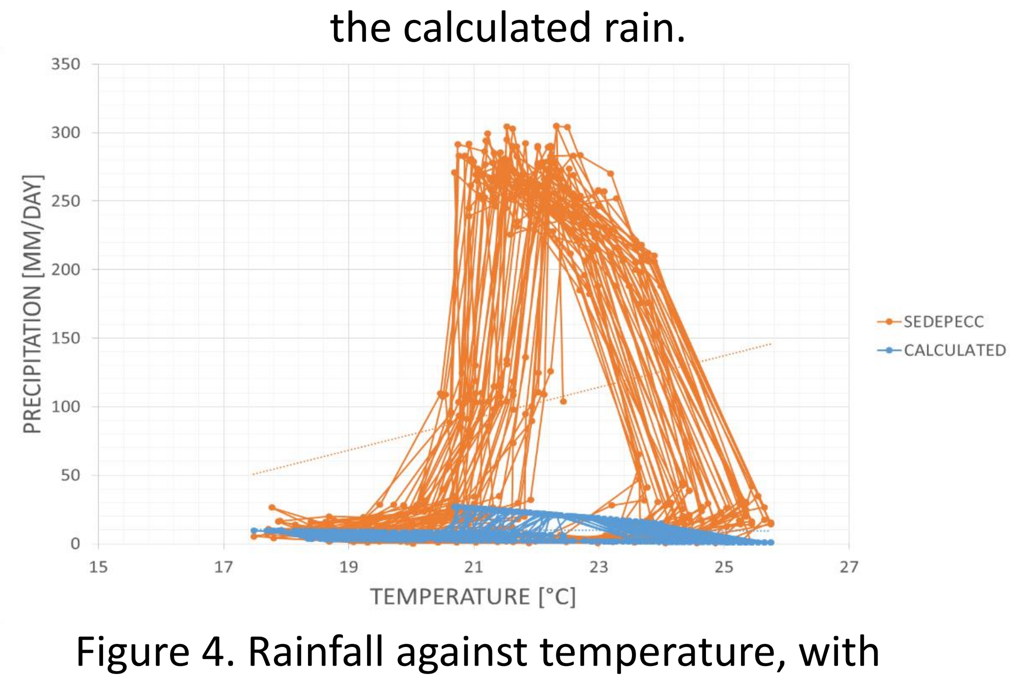

Figure 4. Rainfall against temperature, with adjustment formula overlaying the results recorded in the SEDEPEEC platform.

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