EC VETERINARY SCIENCE
Research Article

ROR Modeling and Earthquake Forecast Until 2050

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Received: May 18, 2021; **Published:** September 30, 2021

Abstract

To model the data series of earthquakes at a global level and earthquakes of magnitude 5 or more that have occurred on the planet in the period from 1990 to 2010 and the number of earthquakes with magnitude 5 or more from 2000 to 2019, achieve a forecast until the year 2050. The Objective Regressive Methodology, ROR, is used. Correlation coefficients are obtained between the real value and the forecast of 100% for both types of earthquakes, both variables depend on the value of 17 years ago, the trend of the total of both earthquakes is to increase if the tendency to rise is maintained. It is necessary to emphasize that only the Civil Defense bodies are in charge of issuing alerts about the appearance of these phenomena and this work is part of the studies of alternative methodologies for the determinant prediction of the number of earthquakes. Our work shows the impact of the 22-year solar cycle on earthquakes, which coincides with similar works in our province on other natural phenomena. Perfect models are obtained both for total earthquakes and for those of magnitude 5 or more. The trends of earthquakes are increasing. The number of earthquakes that can occur on our planet can be predicted until the year 2050. The actual and predicted values are in good agreement. It is shown that it is possible to use the 22-year solar cycle to predict earthquakes.

Keywords: *ROR Mathematical Modeling; Forecast; Earthquakes; Trend; Solar Cycle*

Introduction

At the level of planet earth, there are a large number of earthquakes and the deaths associated with these phenomena are numerous as well as the economic and material damages associated with these phenomena, for this reason it is necessary to forecast these events with the necessary advance notice allow decisions to be made early enough to save lives and resources [1,2]. There are phenomena in nature that are influenced by the 11-year solar cycle, among them we have atmospheric pressure, the density of mosquitoes, the number of children with acute lymphoid leukemia [3,4], as well as a myriad of climatic variables and earthquakes are not phenomena alien to the climate system that is interconnected and interrelated with each other, If we stick to the philosophy that everything has to do with everything according to geographers, the information to be explained in a model depends on a certain number of variables and as these increase, then the way of explaining it truthfully increases. This is an conclusion of the authors expertise with the statistic.

Some authors have modeled and predicted global earthquakes [5]. The ROR methodology consists of several steps [6,7] and allows not only to mathematically model the larval densities of mosquitoes, as well as the population dynamics of mollusks, but goes further (possibility of modeling infectious entities of different etiologies, such as the HIV/AIDS, Cholera, Influences, Acute Respiratory Infections (ARI), Acute Bronchial Asthma Crises (CAAB), Fasciolosis, Angiostrongylosis and even, in the estimation of the length and area of the universe, monthly forecast of rainfall and extreme temperatures, prognosis of meteorological disturbances/hurricanes, prediction of the latitude and longitude of earthquakes, search of information in white noise, modeling of the equivalent effective temperature (TEE) and atmospheric pressure (PA) to the own electricity consumption of a municipality, province or nation [8-14]. In this methodology, the dichotomous variables DS, DI and NoC must first be created, where NoC is the number of cases in the base (its coefficient in the model represents the trend of the series). DS = 1, if NoC is odd; DI = 0, if NoC is even, and vice versa. DS represents a sawtooth function and DI this same function, but in an inverted way, in such a way that the variable to be modeled is trapped between these parameters and a large amount of variance can be explained. Subsequently, the module corresponding to the Regression analysis of the statistical package SPSS version 19.0 (IBM, 2010) is executed, specifically the ENTER method where the predicted variable and the ERROR are obtained. Then the autocorrelograms of the ERROR variable are obtained, paying attention to the maximums of the significant partial autocorrelations (PACF), and the new variables are then calculated, taking into account the significant Lag of the PACF. Finally, these variables are included in the new regression, returned in a process of successive approximations until a white noise is obtained in the errors of the regression. In the case of atmospheric pressure, the delays of one year in advance were used, as did other authors for the climatic indices [6,7].

Materials and Methods

In this work, two databases were used, one, the number of total earthquakes on planet earth taken from ROR Mathematical Modeling applied to the forecast of total earthquakes at the global level http://www.veterinaria.org/revistas/redvet/n080814B/0814TM13.pdf REDVET Rev. Electron. vet. http://www.veterinaria.org/revistas/redvet 2014 Volume 15 No. 08B - http://www.veterinaria.org/revistas/redvet/n080814B.html. And the other is the number of earthquakes with magnitude 5 or more that can affect our planet from the year 2000 to 2019 https://es.statista.com/statistics/635155/numero-de-terremotos-registrados-a-leve- world/Earthquakes registered worldwide 2000 - 2019 Posted by Rosa Fernández, May 10, 2020. This statistic shows the annual evolution of the number of earthquakes registered worldwide from 2000 to 2019. In 2019, a total of 1,637 earthquakes were registered worldwide. Supplementary Notes, Data refer to earthquakes of magnitude 5 or greater. These data could not be obtained from an excel file because for Cuba this possibility was not available on the internet, so they had to be copied by hand and then added to the first database already mentioned.

It has been shown in other works 3,4 that the 11-year cycle influences many natural phenomena such as mosquitoes, children with acute lymphoid leukemia, as well as hurricanes, among others, hence the number of earthquakes was modeled first. Magnitude 5 or more using a parameter of 17 steps backwards, 11 of the solar cycle and more than 6 that influences the forecast of total earthquakes at a global level 5, then with this predicted value the earthquakes were modeled at a global level to have a forecast with 17 steps forward of the total earthquakes, until the year 2036, later the total number of earthquakes was modeled with 9 steps back depending on the number of earthquakes of magnitude 5 or more to have a predicted value until 2028 and to be able to run the ROR methodology with the highest possible length of concordance between both series, then this predicted value was assigned to the total variable of earthquakes so we have a base of the total of earthquakes up to the year 2028's using the ROR methodology using a 22-year cycle, that is, twice the solar cycle as other authors have already predicted [9] this new predicted value was used to predict the number of earthquakes with a magnitude greater than 5 and obtain data up to the year 2050 both in the total earthquakes as in those of magnitude 5 or more.

Results and Discussion

In table 1, the model for all earthquakes of magnitude 5 or more (Total5omas) explains 100% of the variance, since there is a division by zero, errors cannot be estimated.

Model	R	R squared[b]	R squared fitted	Standard error of the estimate	Durbin-Watson
1	1.000[a]	1.000	.	.	1.000

Table 1: *Summary of the model c, d.*

a: Predictors: lag17 earthquakes, DS, NoC.

b: For the regression through the origin (the model without interception), R squared measures the proportion of the variability in the dependent variable on the origin explained by the regression. This CANNOT be compared to R squared for models that include intercept.

c: Dependent variable: Total5omas.

d: Linear regression through the origin.

The ANOVA analysis of variance is highly significant and because the residual is zero, Fisher's F cannot be estimated (Table 2).

Model		Sum of squares	gl	Quadratic mean	F	Sig.
1	Regression	8400989.000	3	2800329.667	.	.[c]
	Residue	.000	0	.		
	Total	8400989.000[d]	3			

Table 2: *ANOVA a, b.*

a: Dependent variable: Total5omas.

b: Linear regression through the origin.

c: Predictors: lag17 earthquakes, SD, Trend.

d: This total sum of squares is not corrected for the constant because the constant is zero for the regression through the origin.

In table 3, the model obtained for Total5omas, this depends on the trend that is positive in 47.8 cases and the total of earthquakes 17 years ago (lag17 earthquakes), as can be seen, it is not possible to calculate the t statistics or their significance because we are in presence of a perfect model.

Model B		Non-standardized coefficients		Standardized coefficients t	Standardized coefficients t	Sig.
		Error Standard	Beta			
1	DS	215.830	.000	.074	.	.
	Trend	47.840	.000	.829	.	.
	lag17 earthquakes	.150	.000	.126	.	.

Table 3: *Coefficients a, b.*

a: Dependent variable: Total5omas.

b: Linear regression through the origin.

Figure 1 shows the prognosis of Total5omas and its increase according to the trend.

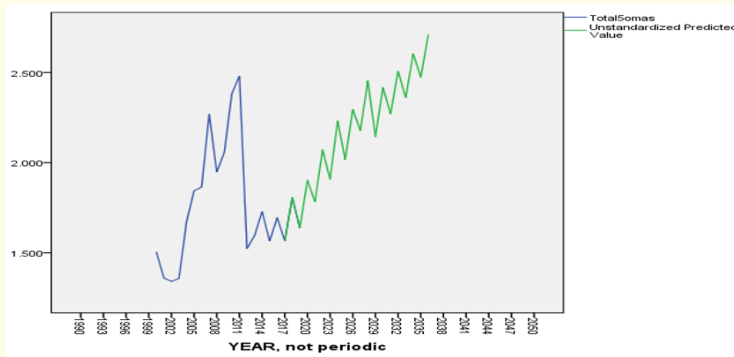

Figure 1: *Real and predicted value (Unstandardized Predicted Value) according to ROR.*

Subsequently, the total number of earthquakes was modeled as a function of delay 9 of earthquakes of magnitude 5 or more, obtaining a perfect model so that neither Fisher's F nor Student's T parameters can be appreciated.

The model obtained is shown in table 4.

Model B		Non-standardized coefficients		Standardized coefficients	t	Sig.
		Standard error	Beta			
1	DS	8139.472	.000	.311	.	.
	lag9sisms	9.850	.000	.764	.	.

Table 4: *Coefficients a, b.*

a: Dependent variable: totalsisms.

b: Linear regression through the origin.

Next, the total of earthquakes was modeled using the 22-year cycle, table 5 this model explains 99.4% of the variance, with a standard error of 2883.67 earthquakes, the Durbin Watson statistic is close to 1, which allows other variables this model, we will stay with this one because it allows us to predict in the long term.

Model	R	R squared[b]	R squared fitted	Standard error of the estimate	Durbin-Watson
1	.994[a]	.989	.984	2883.67079	1.012

Table 5: *Summary of the model c, d.*

a: Predictors: Step31, DI, DS, lag22 earthquakes, Trend.

b: For the regression through the origin (the model without interception), R squared measures the proportion of the variability in the dependent variable on the origin explained by the regression. This CANNOT be compared to R squared for models that include intercept.

c: Dependent variable: totalsisms.

d: Linear regression through the origin.

This result coincides with 9, in this work the existence of an 11-year cycle and its importance for modeling is demonstrated, coinciding with other works [8], which use the annual cycle of atmospheric pressure to see the impact on mosquitoes, this cycle annual, it extends for 11 years coincides with the solar cycle and it is very important to look for the behavior of the variable to be studied well in advance in the different natural processes being studied.

The analysis of variance (Table 6) is significant with a Fisher's F of 210,704 significant at 100%.

Model		Sum of squares	gl	Quadratic mean	F	Sig.
1	Regression	8760605481.910	5	175212109.382	210.704	.000[c]
	Residue	99786686.639	12	8315557.220		
	Total	8860392168.549[d]	17			

Table 6: *ANOVA a, b.*

a: Dependent variable: totalsisms.

b: Linear regression through the origin.

c: Predictors: Step31, DI, DS, lag22 earthquakes, Trend.

d: This total sum of squares is not corrected for the constant because the constant is zero for the regression through the origin.

This ROR model depends on DS and DI, two dichotomous variables that measure the ups and downs of the series, the trend is significant to increase in 40,546 earthquakes annually, Step 31 corresponds to the impact of the year 2020 in which it is estimated with zero error, which is not it is real but it is a measure that can bring good results since the total number of earthquakes in 2020 has not yet concluded (Table 7).

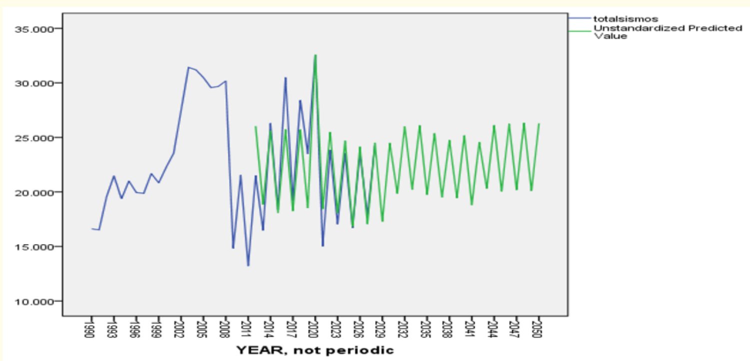

Figure 2: *Real and predicted value (Unstandardized Predicted Value) according to ROR for all earthquakes.*

Model		Non-standardized coefficients		Standardized coefficients	t	Sig.
B		Standard error	Beta			
1	DS	27904.594	4826.393	.889	5.782	.000
	DI	20649.445	4838.626	.620	4.268	.001
	Trend	40.546	349.280	.056	.116	.910
	Lag22sismos	-.169	.355	-.174	-.475	.643
	Step31	7071.724	3107.956	.075	2.275	.042

Table 7: *Coefficients a, b.*

a: Dependent variable: totalsisms.

b: Linear regression through the origin.

Here is the ROR model for earthquakes of magnitude 5 or more. 99.9% of the variance is explained with an error of 70.27 earthquakes (Table 8).

Model	R	R squared[b]	R squared fitted	Standard error of the estimate	Durbin-Watson
1	.999[a]	.999	.998	70.27967	1.859

Table 8: *Summary of the model c, d.*

a: Predictors: Unstandardized Predicted Value, DI, NoC.

b: For the regression through the origin (the model without interception), R squared measures the proportion of the variability in the dependent variable on the origin explained by the regression. This CANNOT be compared to R squared for models that include intercept.

c: Dependent variable: Total5omas.

d: Linear regression through the origin.

The analysis of variance (Table 9) is significant with a Fisher's F of 1454.67 significant at 100%.

Model		Sum of squares	gl	Quadratic mean	F	Sig.
1	Regression	21554928.842	3	7184976.281	1454.675	.000[c]
	Residue	24696.158	5	4939.232		
	Total	21579625.000[d]	8			

Table 9: *ANOVA a, b.*

a: Dependent variable: Total5omas.

b: Linear regression through the origin.

c: Predictors: Unstandardized Predicted Value, DI, NoC.

d: This total sum of squares is not corrected for the constant because the constant is zero for the regression through the origin.

For the Total 5 omas model, the trend is significant at 90% and is to rise in 26 annual earthquakes, it is appreciated how significant is the value predicted by the previous model of total earthquakes (Unstandardized Predicted Value).

Model B		Non-standardized coefficients		Standardized coefficients	t	Sig.
		Standard error	Beta			
1	DI	167.877	99.487	.072	1.687	.152
	Tendencia	25.654	10.625	.415	2.414	.061
	Unstandardized Predicted Value	.040	.011	.541	3.672	.014

Table 10: *Coefficients a, b.*

a: Dependent variable: Total5omas.

b: Linear regression through the origin.

Figure 3 shows the long-term behavior up to the year 2050 of the total of 5 or more earthquakes.

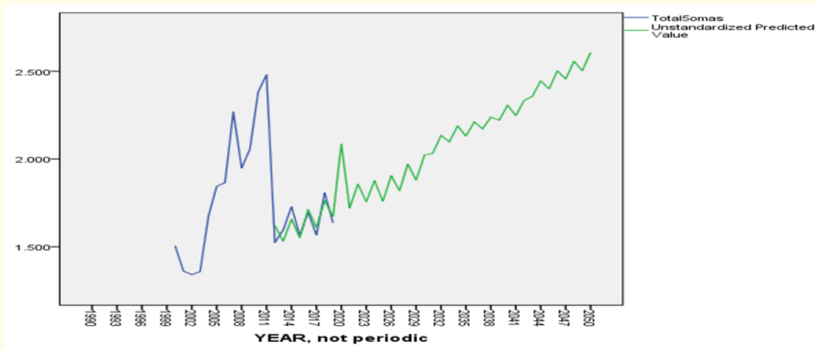

Figure 3: *Real and predicted value (Unstandardized Predicted Value) according to ROR for earthquakes of magnitude 5 or more.*

Conclusion

Perfect models are obtained both for total earthquakes and for those of magnitude 5 or more. The trends of earthquakes are to increase. The number of earthquakes that can occur can be predicted until the year 2050. The actual and predicted values are in good agreement and it is shown that it is possible to use the 22-year solar cycle to predict earthquakes.

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