International Data Center Magnitudes and Their Relation to International Seismological Center Magnitudes Using Data for Ethiopia and Eritrea Regions

Khalda Yassin Ibrahim

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POSTER

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Khalda Yassin Ibrahim
National Data Center, Remote Sensing and Seismology Authority, National Center for Research
Email address: khalda7@hotmail.com

ABSTRACT

Abstract

Various type of magnitude scales are recognized for estimating the earthquakes size. Magnitude is one of the significant factors for a unified earthquakes catalog which is needed for seismic hazard assessment and disaster management. The variation in magnitude value from seismological agency to other stimulated the researchers to study the regression relationship between the magnitudes. The study area is located between latitudes 4^{0}- 16^{0} and Longitudes 36 ^{0}-42^{0} in the northeastern part of Africa region. A selected number of events which has magnitudes ranges from 3 to 5.6 for the period between 2000 and 2020 were used to create the regression relations. In this research the standard least-square regression (SR) and orthogonal regression (OR) were derived to assess the relation between the international data center (IDC) magnitudes in addition to the international seismological center (ISC) magnitudes based on body wave magnitude (mb), surface wave magnitude (MS) and local magnitudes (Ml), these regressions were adopted to choose the strong variables relations and the best regression model. Finally, the conversion equations between magnitudes were constructed and determined for wide range about twenty years.

Keywords:
Earthquake magnitude, standard least-square regression, orthogonal regression, International Data Center, International Seismological Center

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INTRODUCTION

1. Introduction

The magnitude regression has been widely studied (Castellaro and Bormann, 2007, Yadav et al., 2009, and Abdel Hafiez, 2015).The linear regression relationship is normally used to investigate the relationships between different magnitude data and to develop formulas for converting one magnitude to another. In general, linear regression analysis is a feasible method when comparing magnitudes based on the same waveforms, using identical measurement methods, and procedures in comparable period ranges. The simplest and most widely used technique for defining a linear functional relationship between two variables is linear least-square fitting. The majority of reported magnitude regression relations, such as Gutenberg and Richter (1956) classic relations between mb, Ms, and Ml, have been computed utilizing linear standard least-square regression (SR). The most popular method for determining the relationship between different types of magnitude is least-square linear regression and orthogonal regression (Kaverina et al.1996; Gasperini 2002; Gutdeutsch et al. 2002, 2005; Bindi et al. 2005 Braunmiller et al. 2005). The variations in magnitudes from agency to other are due to many reasons such as differences in seismograph response and the time window of maximum P- wave amplitudes. The main objective of the present study is to derive the regression relations between International data Center magnitudes and their relation to International seismological Center magnitudes to help when it becomes difficult to read any type of magnitude and solve any problem in the magnitudes type for the same events in case of missing data or unclear records that make it difficult to calculate the identified magnitude by the International Data Center and to evaluate their compatibility

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METHODS

3. Methods

The collected data of this study include three types of magnitudes body wave magnitude (mb), surface wave magnitude (Ms) and local magnitude (Ml) that is specified based on the maximum noticed amplitude on a Wood-Anderson seismometer. Body wave magnitude is more appropriate to assess the size of large earthquakes. It lets a rather fast and truthful assessment of the amount of high-frequency energy released by earthquakes and its possible cause of damage. The magnitudes range from 3 to 5.6 for the period between 2000 and 2020. These events were collected from the International Seismological Center (ISC) web site using two authors for magnitude the International Seismological Center (ISC) and the International Data Centre, CTBTO (IDC). The number of observations used for deriving the conversion equations and their magnitude ranges, as well as the maximum depth in each data set, are listed in Tables (1and 2).

The regression equations were derived for each dataset using standard least-square regression (SR) and orthogonal regression (OR) for the international data center. In the regression relations the values of mb show the dependent variable (Y), and the values of Ml or Ms display the independent variable (X) for mb-ML and mb-Ms scale while values of Ms represent the dependent variable and the values of Ml reveal the independent variable for MS-ML scale.

In addition, regression equations were derived for each dataset using SR and OR for the international seismological center and international data center. The values of mb (ISC) show the dependent variable (Y) and the values of mb (IDC), ML (IDC) and Ms (IDC) display the independent variable (X) for mb(ISC)-mb (IDC), mb(ISC) –ML(IDC), mb (ISC)-Ms (IDC) scale while values of Ms(ISC) represent the dependent variable and the values of Ms(IDC) reveal

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INTRODUCTION

This study is based on seismic event magnitudes between 3 and 5.6 for twenty years to find out, the earthquake magnitude regression relationships for magnitudes (Body wave Magnitude mb, Surface wave magnitude Ms and Local magnitude ML defined by the International Data Center and their relation to international seismological center magnitudes for the same events using data for Ethiopia and Eritrea regions based on the linear least-square (SR) and orthogonal (OR) regression.

Ethiopia and Eritrea are located in the Northeastern part on the Horn of Africa (Fig 1).

Geologically, significant areas of northern and western Ethiopia, as well as smaller areas in the south and east, are underlain by Precambrian rocks. In large parts of western Ethiopia, massive piles of mostly Cenozoic volcanic rocks can be found. The eastern part of the country is covered by Mesozoic and Cenozoic sediments. The rift valley is covered by lacustrine sediments and volcanics. The geology of Eritrea consisted of Neoproterozoic terrenes and Tertiary to Recent volcanic rocks. Marine sediments of Mesozoic to Recent age are revealed in the coastal area. (Thomas, 2008).

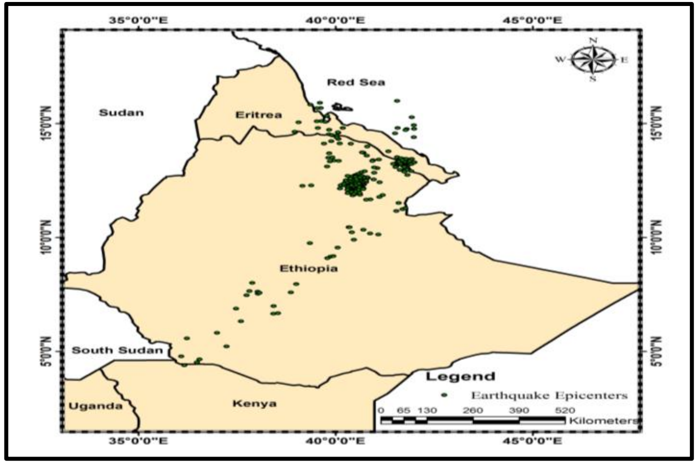

Fig 1 The study Area

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the independent variable for MS (ISC)-Ms (IDC) scale in The standard least-square regression (SR) and orthogonal regression (OR). The regression statistics are demonstrated in R squared, R adjusted and root means square error (RMSE). Where R squared states the percentage of data explained by the regression equation and RMSE serves to combine the difference between values predicted by the inferred equation and the observed values.

Table 1: Number of observations with their magnitude ranges and depth in each data set for the International data center (IDC)

Data-set	No of observations	Magnitude range	Maximum Depth (km)
mb-ML	338	3.4 ≤mb≤ 4.8 3 ≤ML≤ 5.2	27.4
mb-Ms	299	3.5 ≤mb≤ 5.3 3 ≤Ms≤ 5.4	27.4
Ms-ML	211	3 ≤Ms≤ 5.2 3 ≤ML≤ 5.2	27.4

Table 2: Number of observations with their magnitude ranges and depth in each data set for the International seismological center and International data center (IDC)

Data-set	No of observations	Magnitude range	Maximum Depth (km)
mb(ISC)-mb(IDC)	376	3.4 ≤mb (ISC)≤ 5.2 3.5 ≤mb (IDC)≤ 4.8	27.2
Ms(ISC)-Ms(IDC)	179	3.1 ≤Ms(ISC)≤ 5.4 3.1 ≤Ms(IDC)≤ 5.4	27.2
mb(ISC)-ML(IDC)	297	3.4 ≤mb(ISC)≤ 5.4 3 ≤ML(IDC)≤ 5.2	27.4
mb(ISC)-Ms(IDC)	254	3.5 ≤mb(ISC)≤ 5.6 3 ≤Ms(ID)≤ 5.4	27.2

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RESULTS

4. Results

To derive a relationship between different types of magnitudes, two regression methods were used: linear least square and orthogonal regression. These conversion relations were used in this analysis to measure the value of the dependent variable (Y) corresponding to a certain value of the independent variable(X). The final results for the international data center (IDC) regression relation illustrated in the table (3) and displayed in figures (2, 3 and 4).

Tables (3) Revealed the conversion equations for the international Data Center Magnitudes derived using SR and OR

Magnitude scale	Regression	Relationship	RMSE	R-Squared, R Sq (Adj) Correlation Coefficient and P- value
mb-ML	SR	mb = 4.1908 - 0.052522*ML	0.274	R- Sq= 0.62%, R Sq (Adj) =0.30%, Correlation Coefficient = -0.0785081 and P-value=0.1504
	OR	mb = 4.27796 - 0.0743738*ML	0.275	
mb-Ms	SR	mb = 2.19215 + 0.47231*MS	0.227	R- Sq= 48.48 %, R Sq (Adj) =48.30%, Correlation Coefficient = 0.696251 and P-value=0.00
	OR	mb = 1.91231 + 0.545475*MS	0.235	
Ms-Ml	SR	MS = 3.58189 + 0.0849251*ML	0.434	R- Sq= 0.69 % R Sq (Adj) =0.21 %, Correlation Coefficient = 0.0828896 and P-value= 0.2305
	OR	MS = 2.86685 + 0.26559*ML	0.441	

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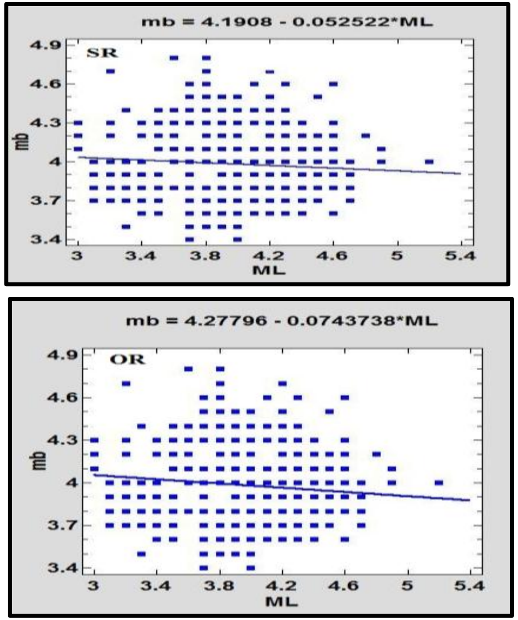

Fig 2. Linear (above) and orthogonal below) regression fitting between body wave magnitude (mb) and local magnitude (Ml)

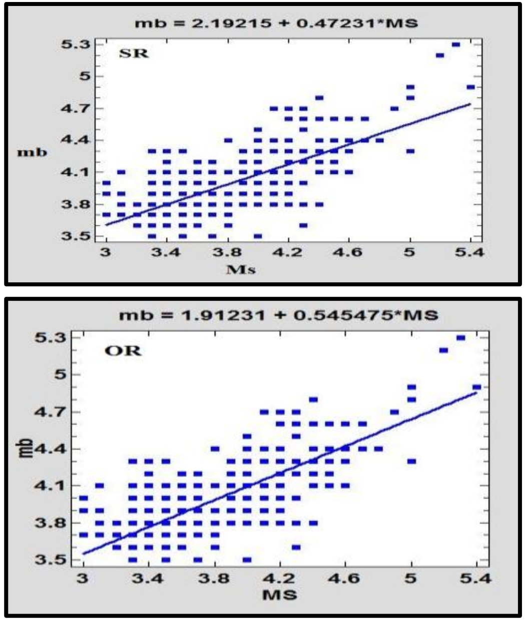

Fig 3. Linear (above) and orthogonal (below) regression fitting between body wave magnitude(mb) and Surface wave magnitude (Ms)

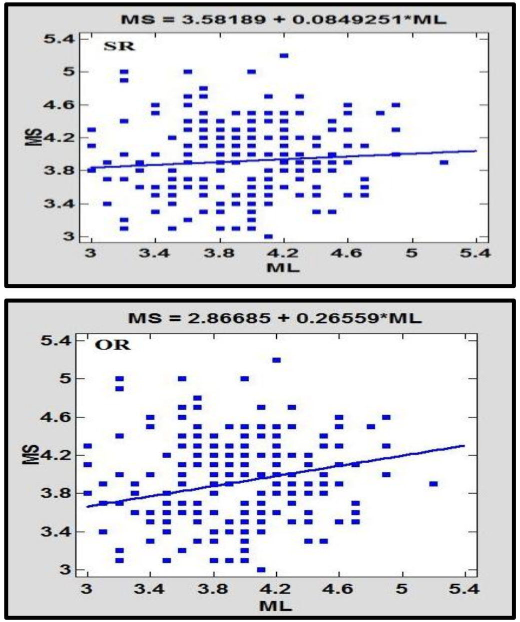

Fig 4. Linear (above) and orthogonal (below) regression fitting between Surface wave magnitude (Ms) and local magnitude (Ml)

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RESULTS

The obtained conversions equations between the international seismological center (ISC) and the international data center (IDC) using SR and OR for each magnitude type presented in table (4) and exhibited in figures (5, 6, 7 and 8)

Table (4): Illustrated the completed conversions equations using SR and OR for international data center and international seismological center magnitudes

Magnitude scale	Regression	Relationship	RMSE	R-Squared& R Sq (Adj) Correlation Coefficient and P- value
mb (ISC)-mb(IDC)	SR	mb (ISC) = -1.04527 + 1.30483*mb (IDC)	0.155	R- Sq= 80.98 %, R Sq (Adj) =80.93%, Correlation Coefficient = 0.89988, P-value=0.00
	OR	mb (ISC) = -1.7243 + 1.47667*mb (IDC)	0.161	
mb (ISC)-ML (IDC)	SR	mb (ISC) = 4.65332 - 0.106651*ML (IDC)	0.393	R- Sq= 1.24%, R Sq (Adj) =0.91 % , Correlation Coefficient = -0.111585, P-value= 0.0547
	OR	mb (ISC) = 5.25777 - 0.258083*ML (IDC)	0.398	
mb (ISC)- Ms (IDC)	SR	mb (ISC) = 1.60908 + 0.683246*MS (IDC)	0.284	R- Sq= 53.38% R Sq (Adj) = = 53.20%, Correlation Coefficient = 0.730624, P-value= 0.00
	OR	mb (ISC) = 0.972305 + 0.848827*MS (IDC)	0.294	
Ms (ISC) - Ms (IDC)	SR	MS (ISC) = 0.117559 + 0.981183*MS (IDC)	0.129	R- Sq= 91.09% R Sq (Adj) =91.04 %., Correlation Coefficient = 0.954425, P-value= 0.00
	OR	MS (ISC) = -0.0338864 + 1.01941*MS (IDC)	0.146	

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RESULTS

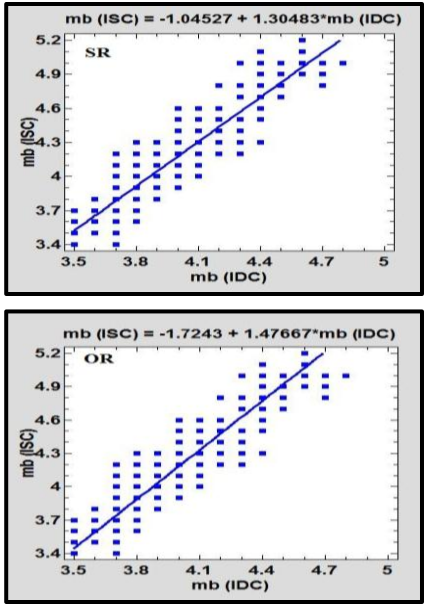

Fig 5. Linear (above) and orthogonal (below) regression fitting between mb for ISC and the IDC

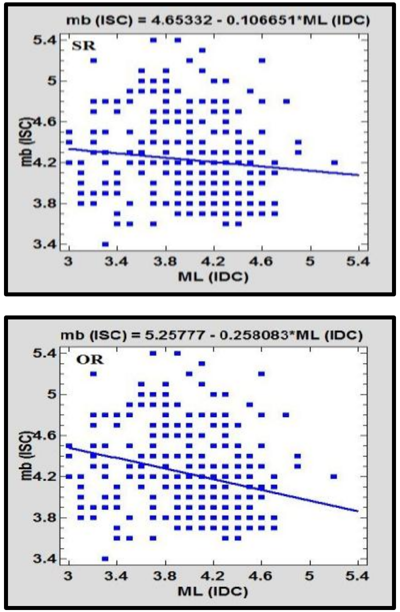

Fig 6. Linear (above) and orthogonal (below) regression fitting between mb for ISC and Ml for IDC

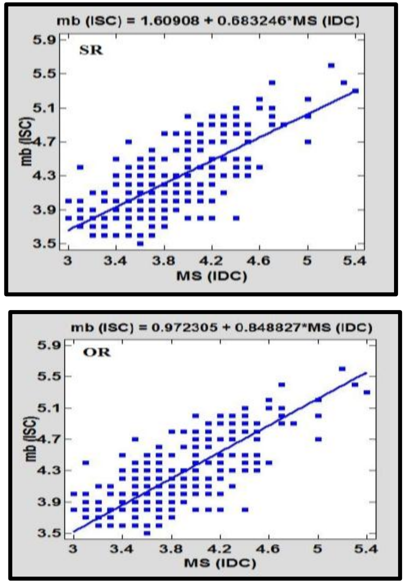

Fig 7. Linear (above) and orthogonal (below) regression fitting between mb for ISC and Ms for IDC

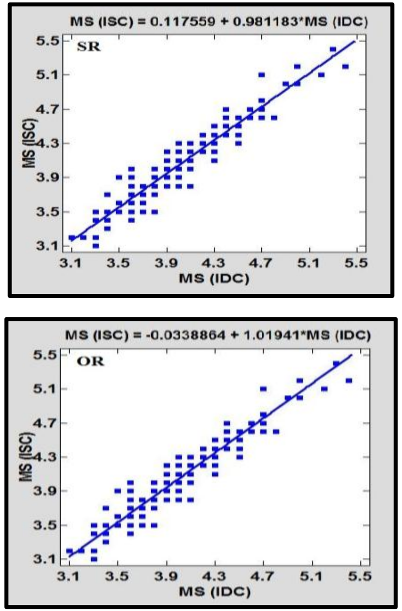

Fig 8. Linear (above) and orthogonal (below) regression fitting between Ms for ISC and IDC

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CONCLUSIONS

Conclusions

In this research the standard least-square regression (SR) and orthogonal (OR) have been used to develop the relation between international data center magnitudes in addition to their relation to international seismological center magnitudes.

The statistical parameters such as the resultant of p-value for the relation between magnitudes regression at the 95.0% confidence level and the correlation coefficient were used to reveal the statistical relationship between variables. Based on the final results that displayed in table (3) for the international data center the regression model between mb and Ms has the statistical significant variables relation and for international seismological center& international data center the results illustrated that the best statistical variables relations that is derived between Ms (ISC) –Ms (IDC), mb (ISC) - mb (IDC) and mb (ISC) – Ms (IDC) respectively (table 4). The slight difference in the RMSE for the regression equations demonstrated that SR is well represent the magnitude relations followed by OR. More detailed studies and statistical techniques should be applied to reveal the relation between these two agencies and rank the regression relations to obtain more accurate results

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References

References

•Abdel Hafiez H E (2015) Regression of regional magnitude relations used by Oman seismological network, Arab J Geosci (2015) 8:8633–8641, DOI0.1007/s12517-015-1802-y

•Bindi D, Spallarossa D, Eva C, Cattaneo M (2005) Local and duration magnitudes in northwestern Italy, seismic moment versus magnitude relationships. Bull Seismol Soc Am 95(2):592–604

•Braunmiller, J., Deichmann, N., Giardini, D.,Wiemer, S. & the SED Magnitude Working Group, 2005.Homogeneous moment-magnitude calibrationin Switzerland, *Bull. Seism. Soc. Am.*, **95**(1), 58–74.

•Castellaro, S., and P. Bormann (2007). Performance of different regression procedures on the magnitude conversion problem, Bull. Seismol. Soc. Am. 97, 1167–1175.

•Gasperini, P. & Ferrari, G., 2000. Deriving numerical estimates from descriptive information: the computation of earthquakes parameters, Annali di Geofisica, **43,** 729–746.

•Gutdeutsch, R., Kaiser, D. & Jentzsch, G., 2002. Estimation of earthquake magnitudes from epicentral intensities and other focal parameters in Central and Southern Europe, Geophys. J. Int., **151**(3), 824–834.

•Gutdeutsch, R., Kaiser, D., Bormann, P., Riufeng, L. & Ren, X., 2005. Regression analyse zur Umrechnung zwischen Magnituden des chinesischen Erdbebendienstes und des NEIC, Mitteilung der Deutschen Geophysikalischen Gesellschaft, **3,** 14–22.

•Gutenberg, B., and C. F. Richter (1956). Earthquake magnitude, intensity, energy and acceleration, Bull. Seism. Soc. Am. 46, 105–145

•Kaverina, A.N., Lander, A.V. & Prozorov, A.G., 1996. Global creepex distribution and its relation to earthquake-source geometry and tectonic origin, Geophys. J. Int., **125,** 249–265.

• Schlüter, Thomas (April 19, 2008).Geological Atlas of Africa: With Notes on Stratigraphy, Tectonics, Economic Geology, Geohazards, Geosites and Geoscientific Education of Each Country. Springer Science& Business Media. Retrieved October 18, 2016.

•Yadav, R. B. S., P. Bormann, B. K. Rastogi, M. C. Das, and S. Chopra (2009). A homogeneous and complete earthquake catalog for north east India and the adjoining region, Seismol. Res. Lett. 80, no. 4,609–627.