MANMADE DISASTERS ON OUR HOME PLANET. A POTENTIAL RELATIONSHIP BETWEEN CLIMATE CHANGE AND SEISMIC ACTIVITY OF EARTH

Science has been given to mankind in order that it also understands the magnitude of disaster which mankind itself has caused to its home planet, too.

God has entrusted us with an almost perfect home planet to live on. Since then, man has chosen to continuously spoil and poison it through his foolish actions and overuse of resources. In our rush for money and profit we poisoned the oceans, polluted the atmosphere and exhausted at an incredible rate the resources of our home planet.

Until the present era, human civilizations have perished or immigrated in order to survive (for example the case of some islands' civilizations). Their disappearance has been determined either due to the full consumption of their available resources or due to climate change. Nowadays, both the crisis of the climate change and the consumption of resources were generated by man himself and it seems that, for the time being, we have nowhere else to go.

The wording "natural disaster" no longer reflects the reality nowadays and it is rather inappropriate and false. Since many present day natural disasters, especially weather related, are due to the actions of humans, nature is only fighting back against our actions. A much more appropriate term would be that of "manmade" disasters. Also, the term "acts of God" used in the same measure by both, believers and non-believers, it also not describes these present day disasters and the term which should be merely used would be of "acts of man", because these acts of man have caused these all subsequent disasters related to environment and climate change. Man, either prays to or blames God for these cataclysms when happen, but he almost always forgets that God has equipped him with the right and with the responsibility to choose his own actions. Man, however chose and still chooses wrongly when is to act responsibly with regard to the creation God has entrusted him for a good administration. Now, we desperately seek to find solutions to solve the problems caused by our own foolish actions.

There are numerous implications of the climate change and respectively of global warming caused by the economic activity of mankind. Some of these consequences as in [1], are already well known and they refer to extreme weather conditions, increase of the radiation on the Earth's surface where icecap has been melted thus causing increased further melting of ice, rising of the level of oceans, viruses and pathogens frozen in the icecap released and becoming active, etc.

This chapter is presenting another potential additional consequence of the climate change, by investigating the relationship between the seismic activity and the global warming causing melting of the polar icecaps.

According to a previous chapter of the author, many of these so called "natural" disaster are actually "manmade" disasters, as it is presented in [2]. The present chapter investigates the relationship between the climate change and the seismic activity of Earth, and also accounts a great portion of the seismic activity to those aforementioned "manmade" disasters.

I. SEISMIC DATA ANALYSIS

The first step is the analysis of seismic activity data of the last decades, in order to establish if there is an ascending trend in the frequency or magnitude of the earthquakes, or to see whether this data exhibits certain features which could indicate a certain change in the pattern of the seismic activity of Earth. If there is an ascending trend in the seismic activity, the correlation with the amount of the melted icecap (expressed in both: square kilometers and tons) is to be further analyzed. If however, there is no such ascending trend but still, the data shows certain features and changes in its pattern, these changes will be analyzed and explained using the models proposed and presented in this chapter. These models describe and explain how reduction of pressure exerted by the melted icecap leads to a redistribution of gravity pressing forces on the earth's crust and releases additional movement forces of the tectonic plates, thus causing an increased seismic activity.

Analysis of Seismic Activity Data

This section regards the quantitative analysis of the seismic activity data, namely frequency and magnitude of deadliest earthquakes by year in the last decades, according to [3], in order to establish if there is an ascending trend in the frequency or magnitude of the earthquakes, or to see whether this data exhibits certain features which could indicate a certain change in the pattern of the seismic activity of Earth. If there is an ascending trend in the seismic activity, the correlation with the amount of the melted icecap (expressed in both: square kilometers and tons) is to be further analyzed.

The tables below present this seismic activity data, per each decade between 1950 and 2020, since this is the available recorded earthquake data, as follows: Table I contains the number of earthquakes of magnitude greater than 7, Table II presents the number of major earthquakes per each decade, whereas a major earthquake is considered to have a magnitude between 7 and 8, Table III contains the number of earthquakes of magnitude greater than 8 and Table IV presents the cumulated or aggregated magnitude of earthquakes per each decade, whereas the cumulated magnitude is an expression of the cumulative seismic energy release, it is understood the value obtained by summing up the magnitudes of the deadliest earthquakes per year, of magnitude greater than 6. Although this new introduced indicator of cumulated magnitude may not exist in seismology, it is obvious that this indicator is directly proportional with the cumulative seismic energy release used by the seismologists.

TABLE I. NUMBER OF EARTHQUAKES OF MAGNITUDE GREATER THAN 7

Decade	Number of earthquakes of magnitude larger than 7
1951/1960	4
1961/1970	5
1971/1980	7
1981/1990	4
1990/2000	4
2001/2010	8
2011/2020	7

TABLE II. NUMBER OF MAJOR EARTHQUAKES PER DECADE

Decade	Number of major earthquakes per decade
1951/1960	10
1961/1970	10
1971/1980	10
1981/1990	10
1990/2000	10
2001/2010	10
2011/2020	10

TABLE III. NUMBER OF EARTHQUAKES OF MAGNITUDE GREATER THAN 8

Decade	Number of earthquakes of magnitude larger than 8
1951/1960	1
1961/1970	1
1971/1980	10
1981/1990	1
1990/2000	1*
2001/2010	3
2011/2020	1

TABLE IV. CUMULATED MAGNITUDE OF EARTHQUAKES PER DECADE

Decade	Cumulated magnitude of earthquakes per each decade (indicator previously defined in this chapter)
1951/1960	69.80
1961/1970	70.90
1971/1980	72.90
1981/1990	73.10
1990/2000	70.60
2001/2010	81.15
2011/2020	73.20

It is obvious that the data presented in the previous tables I to III does not show any clear ascending trend of the seismic activity of Earth, however still there are some important considerations to be made regarding this data presented.

Although the earthquake data does not show, at a first glance, an increase of the seismic activity in the last past 70 years, Table I Number of earthquakes of magnitude greater than 7, Table IV Cumulated or aggregated magnitude of earthquakes per each decade and Table III Number of earthquakes of magnitude greater than 8, exhibit the very same feature, namely they suggest, at a closer look, two important things: an increased seismic activity around 1980's followed by a decrease of this activity and an increased seismic activity in the last 20 years, at a higher level than the previous one.

One possible logical explanation, explanation which will be completed with the models in the next section, is that the balance of forces corresponding to the tectonic plates has been altered and afterwards, following to the movement of the tectonic plates on other positions has been restored for a further period of time.

One can observe that although there is no clear trend in the data presented, especially the data processed in the Table IV, show that there are actually some rather significant changes in the evolution of the seismic activity. According to this table, there is an increased incurred seismic activity in the 80's and 90's, caused by additional movement of the tectonic plates, followed by its decrease, potentially caused by the repositioning of the tectonic plates in other positions of equilibrium.

In the decade 2001/2010 there is recorded a maximal cumulated magnitude of 81.15, and moreover, two consecutive earthquakes of magnitude 8, have also been for the first time recorded. The very same repositioning of the tectonic plates and the subsequent de-tensioning of the tectonic forces has been taken place in the next decade at a higher level than the previous ones, namely at an aggregated level of 73.2 magnitude. As one can see in the Table IV, this cumulated magnitude of 73.2 is higher than any previous aggregated magnitude recorded in the period 1951/2000.

These changes and this periodic oscillation of the seismic activity are to be explained by the model of redistribution of gravity pressing forces on the earth's crust, as presented in the next section of this chapter.

The models of icecap melting to explain the increased seismic activity

The earthquake data was analyzed based on the recordings of the deadliest earthquakes by year in [3] and following this analysis there is no clear ascending trend. Still, this data shows changes in its pattern as previously commented and presented in the tables above. These changes will be additionally analyzed and explained now, using the models proposed and presented in the next section.

The first general basic model describes and explains in a very simple manner, how reduction of pressure exerted by the melted icecap leads to a redistribution of gravity pressing forces on the earth's crust and releases additional movement forces of the tectonic plates, thus causing an increased seismic activity.

This first general basic model is only meant to generate an image of the consequences of the climate change. The second model, named general complex model, is more complex than the general basic model and takes into account variable and known values of density of ice in the polar icecap, as function of its height/depth, $\rho(h)$. Finally, the complex refined model of icecap melting, is based on more real assumptions and gives instructions how to calculate more exactly the influence of icecap melting on the earth's crust. The most complete set of assumptions, upon which the most complete model can be based upon, is also presented.

II. MODELS TO EXPLAIN THE EFFECT OF ICECAP MELTING

The general basic model of ice cap melting

1. Asssumptions used in the general basic model of icecap melting

The assumptions this general basic model is based upon in order to explain the increased seismic activity, are the following:

1. Uniform and symmetric distribution of the icecap around the Earth's poles
2. Approximate amounts of the yearly decrease of the icecap in tons
3. Approximate amounts of yearly decrease of the icecap in square kilometers
4. Actual position of the tectonic plates is not taken into consideration
5. The redistribution of weights due to the transformation of the ice from the icecap in ocean water is not to be considered
6. The centrifugal force of due to Earth rotation is not taken into consideration
7. Additional forces and other influences (such as activity of the magma or Earth core, etc.) are also not considered in this general model.
8. Constant value of the gravitational acceleration, g

This general simplified model is only meant to present the general idea, on which a completer and more complex model could be built.

2. The general basic model of icecap melting explained

Let us now consider two different moments in time, noted in this general model with (1) and (2). The weights, surfaces and thicknesses of the polar icecap, corresponding to those moments are G1, G2, S1, S2, respectively h1 and h2.

Taking into account the assumptions of the general basic model, presented above, the gravity pressing force exerted on the earth's crust at the moment (1) is p1=G1/S1, whereas at the moment (2) is p2=G2/S2. One can easily understand that the pressing forces at the moment (2) have seriously decreased.

On one hand, at the moment (2), on the surface previously occupied with ice which was freed by the ice melted, the pressure exerted on the earth's crust is now zero, whereas, on the surface which is still occupied with ice, the pressure exerted on the earth's crust has also diminished (p2 < p1), due to the decrease of the thickness of ice from h1 to h2 and hence due to the decrease of the weight exerted on square km, as well.

In order to understand the magnitude of this phenomenon, one can see the data presented by NASA in its websites: [6], [7], [8], [9] and [10]. It is also to be mentioned that, only in 2022 alone, the surface freed from ice melted was of about 400.000 square kilometers, surface which is almost double as compared to Romania's surface.

This basic simplified model presented before is only meant to generate a general idea about the serious implications of the global warming. Taking into account that both, frequency and intensity of earthquakes, have not significantly increased until now, this fact is only due to the periodical repositioning of the tectonic plates and the subsequent de-tensioning and readjustment of the tectonic forces, forces periodically increasing and decreasing by redistribution of the gravity pressing forces, as explained before, by this model.

B. The general complex model of icecap melting

1. Assumptions used in the complex model of icecap melting

This more complex model should take into consideration as much data as possible, data which can contribute to a much better accuracy of the model generated.

Much of the data necessary to generate this complex model is either not published online or it has not been made available, since it is generated by sophisticated and costly instruments and equipment, as, for example, in the case of [4] and [5], and hence cannot be freely made available on internet. A great deal of this data which is actually not available on Internet, because of the higher costs related to this data, being either costs incurred due to the value of equipment involved in the gathering of this data, or costs with the scientists and researchers using this latest equipment and pieces of technology, could be used, if available, to generate this complex model presented**.** The assumptions this complex model is based upon, to explain the increased seismic activity, are the following:

1. The exact curvature (radius) of Earth is to be taken into consideration

2. The exact detailed distribution of the amounts of ice in the polar icecaps are to be considered in terms of both, surface and thickness

3. The exact amounts, in terms of quantity and position, of the yearly decrease of the icecaps in tons, are to be considered

4. The exact amounts, in terms of surface and position, of the yearly decrease of the polar icecaps in square kilometers, are to be considered

5. The precise positions of the tectonic plates and their inherent movement and movement forces are to be taken into consideration

6. The centrifugal force due to Earth's rotation is to be considered

7. The redistribution of weights and of their corresponding gravity pressing forces on earth's crust, due to the transformation of the ice from the icecap in ocean water, is to be considered

8. As much as possible all the other forces and influences, such as activity of the magma or Earth core, etc., are to be considered

9. Variable and known distribution of density of the ice in the polar ice cap, as a function of its height, $\rho(h)$

2. The general complex model of icecap melting explained

Let us now consider two different moments in time, noted in this general model with (I) and (II). The weights, surfaces and thicknesses of the polar icecap, corresponding to those moments are G1, G2, S1, S2, respectively h1 and h2, as it is presented in the figures 1 and 2 below.

Taking into account the assumptions of the general basic model, presented above, the gravity pressing force exerted on the earth's crust at the moment (I) is p1=G1/S1, whereas at the moment (II) is p2=G2/S2. One can easily understand that the pressing forces at the moment (II) have seriously decreased.

On one hand, at the moment (II), on the surface previously occupied with ice which was freed by the ice melted, the pressure exerted on the earth's crust is now zero, whereas, on the surface which is still occupied with ice, the pressure exerted on the earth's crust has also diminished (p2 < p1), due to the decrease of the thickness of ice from h1 to h2 and hence due to the decrease of the weight exerted on square km, as well.

In order to understand the magnitude of this phenomenon, one can see the data presented by NASA in its websites: [6], [7], [8], [9] and [10].

It is also to be mentioned that, only in 2022 alone, the surface freed from ice melted was of about 400.000 square kilometers, surface which is almost double as compared to Romania's surface.

This basic simplified model presented before is only meant to generate a general idea about the serious implications of the global warming. Taking into account that both, frequency and intensity of earthquakes, have not significantly increased until now, this fact is only due to the periodical repositioning of the tectonic plates and the subsequent de-tensioning and readjustment of the tectonic forces, forces periodically increasing and decreasing by redistribution of the gravity pressing forces, as explained before, by this model.

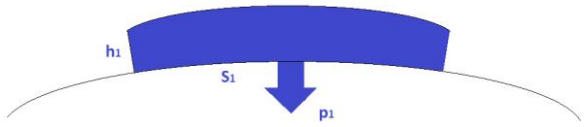

Fig.1

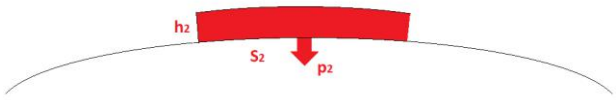

Fig.2

Since: $G = V\rho g \quad (1)$ and $V = Sh \quad (2)$ it follows:

$$p_1 = h_1\rho_1 g \quad (3)$$

and

$$p_2 = h_2 \rho_2 g \quad (4)$$

where, taking into account of the density distribution of ice depending on height, it follows:

$$\rho_1 = \frac{1}{h_1} \int_0^{h1} \rho(h) dh \quad (5)$$

and

$$\rho_2 = \frac{1}{h_2} \int_0^{h2} \rho(h) dh \quad (6)$$

C. The complex refined model of ice cap melting

1. Assumptions used in the complex refined model of icecap melting

This refined, more complex model takes into consideration much more data than the previous one, data which contributes to a much better accuracy of the model generated.

Much of the data necessary to generate this complex model is either not published online or it has not been made available, since it is generated by sophisticated and costly instruments and equipment, as, for example, in the case of [4] and [5], and hence cannot be freely made available on internet. A great deal of this data which is actually not available on Internet, because of the higher costs related to this data, being either costs incurred due to the value of equipment involved in the gathering of this data, or costs with the scientists and researchers using this latest equipment and pieces of technology, could be used, if available, to generate this complex model presented**.**

The assumptions this complex model is based upon, to explain the increased seismic activity, are the following:

1. The ice cap distribution around the North Pole is non uniform and non/symmetrical
2. The exact detailed distribution of the amounts of ice in the polar icecaps is to be considered in terms of both, surface, mass and thickness
3. The exact amounts, in terms of quantity and position, of the yearly decrease of the icecaps in tons, are to be considered
4. The exact amounts, in terms of surface and position, of the yearly decrease of the polar icecaps in square kilometers, are to be considered
5) The assumptions (4 to 7) from the previous general basic model are also to be considered.

2. The refined complex model of icecap melting explained

In order to feed with data this refined model of icecap melting, one can use the data regarding the icecap melting, recorded by NASA over the years, according to [6], [7], [8], [9] and [10].

In order to determine the reduction of pressure exerted on the earth's crust one can consider two different moments in time, (1) and (2), according to the figures 1 and 2, below:

Fig.1

Fig.2

One can easily assess the general effects taking place, according to the previous general model, namely that on the surface previously occupied with ice which was freed by the ice melted, the pressure exerted on the earth's crust is now zero, whereas, on the surface which is still occupied with ice, the pressure exerted on the earth's crust has diminished (p2 < p1).

Moreover, using this refined model, one can calculate the medium pressures exerted on a certain area, p1 and p2, corresponding to the two moments. Let us now consider a delimited square area of ice situated at the moment (1) above, between the coordinates (x1, x2) and (y1, y2) or more generally an arbitrary domain occupied with ice of virtually any shape (D) and its involution at the moment (2) above between the coordinates: (x1', x2') and (y1', y2'), or a domain (D').

Hence, knowing both, the icecap surface and the icecap mass distribution, one can determine the medium pressure exerted on the earth's crust, at each moment, using the following calculations according to (1), (2), (3) and (4), below:

$$p_{1med} = \frac{\iint_{x1,y1}^{x2,y2} g(x,y)m_1(x,y)dydx}{\iint_{x1,y1}^{x2,y2} dydx} \quad (1)$$

$$p_{1med} = \frac{\iint_{D} g(x,y)m_1(x,y)dydx}{\iint_{D} dydx} \quad (2)$$

$$p_{2med} = \frac{\iint_{x1',y1'}^{x2',y2'} g(x,y)m_2(x,y)dydx}{\iint_{x1',y1'}^{x2',y2'} dydx} \quad (3)$$

$$p_{2med} = \frac{\iint_{D'} g(x,y)m_2(x,y)dydx}{\iint_{D'} dydx} \quad (4)$$

where $m_1(x,y)$ and $m_2(x,y)$ represent the icecap mass distributions corresponding to the two moments in time and $g(x,y)$ is the gravitational acceleration corresponding to the position (x, y).

Taking into account two additional simplifying assumptions: constant radius of the Earth, R and constant gravitational acceleration and using the spherical polar coordinates in degrees, corresponding to Earth's longitude and latitude: $x = R\varphi^o$ and $y = R\rho^o$, and the domains (S) and (S') corresponding to domains (D) and (D'), in the new coordinates φ and ρ, it follows the medium pressure exerted on the Earth's crust according to (5), (6), (7) and (8), below:

$$p_{1med} = \frac{g\iint_{\varphi1,\rho1}^{\varphi2,\rho2} m_1(\varphi,\rho)d\varphi d\rho}{\iint_{\varphi1,\rho1}^{\varphi2,\rho2} d\varphi d\rho} \quad (5)$$

$$p_{1med} = \frac{g\iint_{S} m_1(\varphi,\rho)d\varphi d\rho}{\iint_{S} d\varphi d\rho} \quad (6)$$

$$p_{2med} = \frac{g\iint_{\varphi1',\rho1'}^{\varphi2',\rho2'} m_2(\varphi,\rho)d\varphi d\rho}{\iint_{\varphi1',\rho1'}^{\varphi2',\rho2'} d\varphi d\rho} \quad (7)$$

$$p_{2med} = \frac{g\iint_{S'} m_2(\varphi,\rho)d\varphi d\rho}{\iint_{S'} d\varphi d\rho} \quad (8)$$

If, however, these two previous simplifying assumptions are to be given up and one wants to calculate more exactly the medium pressure exerted on the Earth's crust using both, the dependence of Earth's radius and of the gravitational acceleration on their exact position, namely: $R = R(x,y)$, $g = g(x,y)$ and their translation in polar coordinates: $x = u(R,\varphi)$ and $y = v(R,\rho)$, then the above medium pressures can be now more exactly calculated, using the change of variables in the above integrals (1) and (2), which is rather convenient because the respective Jacobian regarding the above variables' changes reduces all previous fractions from (1) to (4).

Also in this case, NASA's measurements and determinations regarding the exact values of the gravitational acceleration and of the exact Earth's radius should be used for these calculations.

D. Assumptions to be used in the most complete model of polar icecap melting

1. The exact detailed distribution of the amounts of ice in the polar icecaps are to be considered in terms of both, surface and thickness
2. The exact amounts, in terms of quantity and position, of the yearly decrease of the icecaps in tons, are to be considered
3. The exact amounts, in terms of surface and position, of the yearly decrease of the polar icecaps in square kilometers, are to be considered
4. The exact curvature (radius) of Earth is to be taken into consideration
5. The exact value of the gravitational acceleration is to be considered
6. The precise positions of the tectonic plates and their inherent movement and movement forces are to be taken into consideration
7. The centrifugal force due to Earth's rotation is to be considered
8. The redistribution of weights and of their corresponding gravity pressing forces on earth's crust, due to the transformation of the ice from the icecap in ocean water, is to be considered
9. As much as possible all the other forces and influences, such as activity of the magma or Earth's core, etc., are to be considered

III. RESULTS AND DISCUSSION

Although there is no clear ascending trend in the seismic data recorded in the last decades, still this data indicates that there is highly likely that the actual pattern of the recorded seismic data may actually prove both, the model and the main hypothesis of this chapter, namely that there is a relationship between the climate change and the seismic activity of Earth.

Both, the analysis and the models presented, as well, have no claim to be completely exhaustive. A complete analysis of the seismic activity should also consider the number of earthquakes' replicas and their magnitude too, and the most complex model based on the ones presented in this chapter should also consider much more factors to be taken into consideration, according to the last most complete set of assumptions.

The movement of tectonic plates corresponding to the models presented in this chapter could also represent an explanation for the occurrence of earthquakes in areas where seismic activity has not been long time recorded before, such as the area of Oltenia in Romania, where recently significant seismic activity has been recorded.

However, since both of this data, corresponding to the seismic activity and the additional data for generating the complex model are not freely available on Internet, at this stage, one cannot go much deeper into the analysis presented in this chapter.

Furthermore, two different hypotheses related to the models presented in this chapter are possible. The first one is assuming that the seismic activity will continue as presented before and corresponding to data recorded so far, that is to say, there will be permanent periodical oscillations in the seismic activity caused by the redistribution of forces and the readjustment of the tectonic plates. Still, according to this first hypothesis, the average or aggregated magnitudes will permanently slightly increase in time, meaning that the balance point of the seismic activity will take place at increasingly higher magnitudes, that is to say at greater seismic activity levels.

The second hypothesis regards a much gloomier and more pessimistic scenario and is assuming that there will be a tipping point in future, due to the redistribution of gravity pressing forces on the earth's crust because of the great amount of ice melted, and assumes that after this tipping point, the seismic activity will exponentially increase, thus causing disastrous cataclysmic seismic events.

Since the indicator introduced in this chapter, cumulated (cumulative) magnitude, is an expression of the cumulative seismic energy release, the quantity of the melted polar icecap can be linked with the reduced pressure exerted by ice, thus causing increased seismic activity.

IV. CONCLUSIONS

According to the research and findings in this chapter, it is very likely that there is a potential relationship between climate change and an increased seismic activity of Earth.

Hence, the hypothesis and the conclusion are that the models used in this chapter to describe and explain how the reduction of pressure due to the melting of polar icecap causes additional forces due to the redistribution of pressing gravity forces, thus moving the tectonic plates and causing increased seismic activity may be a valid one.

However, at this moment, the models presented in this chapter can neither be definitely approved nor categorically disproved by the seismic data recorded so far. Unfortunately, enough, this model may only be proven using the remaining data until 2040. In 2040, when according to actual predictions it is supposed that almost all polar icecap will melt, if the theory in this chapter will be confirmed, perhaps it may be too late for actions with regard to both, the consequences of the climate change and the outcomes predicted by this chapter, corresponding to either of the two main effect hypotheses of this model.

As many times in science, many theories and logical assumptions are proven with time, by further experiments and calculations, sometimes much later than the moment at which these theories and assumptions have been generated.

The model presented in this chapter may be also in accordance and consistent with the predictions and signs in the Bible, regarding huge earthquakes taking place in the last days. Thus, the tribulations of the end times may be hence, not caused by God and His wrath, but by mankind itself and by its own foolish actions.

REFERENCES

[1] WWF's website, Six ways loss of arctic ice impacts everyone: https://www.worldwildlife.org/pages/six-ways-loss-of-arctic-ice-impacts-everyone

[2] C. S. Nutu: "Governing Dynamics in Complex Systems using Big Data Information", Journal of DialogoConf, DOI: 10.51917/dialogo.2021.8.1.3**,** pp 43/54, 2021

[3]Wikipedia website, List of deadliest earthquakes: https://en.wikipedia.org/wiki/Lists_of_earthquakes

[4] C. S. Nutu, T. Axinte: "Microelectronics and nanotechnology and the fractal like structure of information, Knowledge and Science", SPIE Conference ATOM N International Conference, Constanta, DOI: 10.1117/12.2240114 (2016), Vol. 1, pp.394/402, 2016

[5] O. Cristea, F. Deliu, N. Badara, O. Tarabuta: "Experimental model for data transmission in the underwater environment", International Conference, Knowledge based Organization, 2018

[6] NASA's Global Climate Change website, Artic Sea ice at minimum extent: https://climate.nasa.gov/vital-signs/arctic-sea-ice/#:~:text=Summer%20Arctic%20sea%20ice%20extent,covered%20in%20ice)%20each%20September.

[7] NASA's Global Climate Change website, Antarctica mass variation: https://climate.nasa.gov/vital-signs/ice-sheets/#:~:text=Key%20Takeaway%3A,adding%20to%20sea%20level%20rise .

[8] NASA's earth observatory website, Antarctic and arctic sea ice: https://earthobservatory.nasa.gov/world-of-change/sea-ice-antarctic

[9] NASA's Global Climate Change website: https://climate.nasa.gov/ask-nasa-climate/2861/arctic-and-antarctic-sea-ice-how-are-they-different/

[10] NASA's website: https://www.nasa.gov/feature/esnt/2022/nasa-finds-2022-arctic-winter-sea-ice-10th-lowest-on-record