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EMPIRICAL INVESTIGATION ON INFLUENCE OF MOON'S GRAVITATIONAL-FIELD TO EARTH'S GLOBAL TEMPERATURE

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Abstract. This research examined a possibility of the Moon's gravitational-wave that may influence Earth's global temperature, with a mathematical method of empirical analysis with the data of the global temperature, global carbon dioxide, and the distance between Moon and Earth. We made the regression analysis of the global temperature over the factors of Moon's gravitational field taken from the General Theory of Relativity and from the Newton's gravity theory, with the data of the carbon-dioxide. The result shows that Newton's gravitational field is related to Earth's global temperature, while the influence of Moon's gravitational wave is negligible. However, we also found a possibility that the gravitational wave could contribute to Moon's gravitational-field upon the analysis of multicollinearity of two factors taken from Newton's theory and the General Theory of Relativity.

Keywords: global temperature, Moon's gravitational field, gravitational wave, multicollinearity.

INTRODUCTION

Our previous research [1, 2] investigated the influence of Moon's gravitational-wave to the process of Earth's global warming with the methodology of empirical analysis with the database of Earth's global temperature and global carbon dioxide as well as the distance between Moon and Earth. Then, the result of the analysis suggested that there was a possibility, such that Moon's gravitational-wave influenced Earth's atmospheric temperature than global carbon dioxide could do. However, the presence of the gravitational-wave is not yet proven. In this research, we investigated the Moon's gravitational-field, in relation to the theory of 4-dimensional space that could include the gravitational-wave.

THEORY

The General Theory of Relativity [3] describes the actions of materials and energy flows in the gravitational field; while the gravitational wave is one of those flows of energy. At first, the actions of materials in the empty space, where only gravitational field exists, are described by the time-integral of the Lagrangian, $I_g = \int L\sqrt{-g}d^4x$, where $L\sqrt{-g}$ is the action density for the gravitational field. According to Einstein's law, $\delta I_g = -16\pi\int\left(R^{\mu\nu} - (1/2)g^{\mu\nu}R\right)\sqrt{-g}\,\delta g_{\mu\nu}d^4x = 0$, where $g_{\mu\nu}$ is a covariant fundamental tensor that describes the 4-dimensional curved space (of coordinates x_μ, where $\mu = 0, 1, 2, 3$), g is the determinant of $g_{\mu\nu}$, $R_{\mu\nu}$ is a Ricci Tensor that describes the curvature of the 4-dimensional curved space, $R_{\mu\nu} = R^{\rho}_{\mu\nu\rho}$, $R^{\beta}_{\nu\rho\delta} = \Gamma^{\beta}_{\nu\sigma,\rho} - \Gamma^{\beta}_{\nu\rho,\sigma} + \Gamma^{\alpha}_{\nu\sigma}\Gamma^{\beta}_{\alpha\rho} - \Gamma^{\alpha}_{\nu\rho}\Gamma^{\beta}_{\alpha\sigma}$, $\Gamma^{\mu}_{\nu\sigma} =$ $= g^{\mu\lambda}\Gamma_{\lambda\nu\sigma}$, $\Gamma_{\mu\nu\sigma} = \frac{1}{2}(g_{\mu\nu,\sigma} + g_{\mu\sigma,\nu} - g_{\nu\sigma,\mu})$, $g_{\mu\nu,\sigma} = \frac{\partial g_{\mu\nu}}{\partial x_{\sigma}}$ and $R = R^{\nu}_{\nu} =$ $= g^{\mu\nu}R_{\mu\nu}$. And, then, when an additional energy flow, such as gravitational wave is included one more extra Lagrangian, $I_c = c\int\sqrt{-g}d^4x$ is added to I_g. Here, $\delta I_c = c\int\frac{1}{2}g^{\mu\nu}\delta g_{\mu\nu}\sqrt{-g}d^4x$, and $\delta(I_g + I_c) = 0$. Hence, $16\pi\left(R^{\mu\nu} - \frac{1}{2}g^{\mu\nu}R\right) + \frac{1}{2}cg^{\mu\nu} = 0$, and then, $R = 4\lambda$. Hence, $R^{\mu\nu} - \frac{1}{2}g_{\mu\nu}R =$ $= -\lambda g_{\mu\nu}$. Here, λ is a constant, and it must have the dimensions of (distance)$^{-2}$, because $R_{\mu\nu}$ contains the second derivatives of $g_{\mu\nu}$ in the 4-dimensional curved space. However, in the General Theory of Relativity, energy of the gravitational field can be integrated only in a large 3-dimensional volume at a certain time, which tends to be infinity, so that the energy densities can be integrated in the 4-dimensinal curved coordinate system.

On the other hand, Newton's theory of gravity assumes weak and static gravitational field, and therefore the space is nearly flat, not with curvature; therefore, the energy of the gravitational field has the dimensions of (distance)$^{-1}$. And, Newton's gravitational field is independent from other energy fields. For example, the gravitational wave cannot be integrated within Newton's gravitational field.

In this research, we tried to find how Moon's gravitational wave can be related to the gravitational field, by using the mathematical method for empirical analysis with the database. For this purpose, we analyzed the relation between (distance)$^{-2}$ and (distance)$^{-1}$, where (distance) is the distance between Moon and Earth, within the system of Earth's global temperature. The research question is, "Are (distance)$^{-2}$ and (distance)$^{-1}$ related?" If there is a relation, we have a possibility to assume the 4-dimensional curved space which allows the curvature and the second derivatives of the energy.

METHOD

In order to examine the above research question, we made the regression analysis of (distance)$^{-2}$ and (distance)$^{-1}$ over the global temperature of Earth. And, then, we analyzed the multicollinearity of (distance)$^{-2}$ and (distance)$^{-1}$. We followed the steps bellow:

1. We assumed the regression model: $t = c_1 + c_2 \cdot CO_2 + c_3\frac{1}{r} + c_4\frac{1}{r^2}$ in addition to the model which we used in our previous research [1, 2]: $t = c_1 + c_2 CO_2 + c_3\frac{1}{r^2}$, and then, we examined the coefficients and other characters of the models, which indicate the adequacy of the models. Here, t: Earth's global temperature, CO_2: Earth's carbon dioxide, r: distance between Moon and Earth, and c_1, c_2, c_3, and c_4: constant coefficients.

2. We investigated the multicollinearity of $1/(r^2)$ and $1/r$, by the following steps:

a) regress $1/(r^2)$ on $1/r$, and obtain the residuals, $1/(r^2)*$;

b) regress t (temperature) on $1/r$ and $1/(r^2)*$ to estimate the parameters of the global temperature function;

c) Denote the results of the second step by $t = c_1(1/r) + c_2 * 1/(r^2)*$;

d) Investigate the change of the value from c_2 to c_2*.

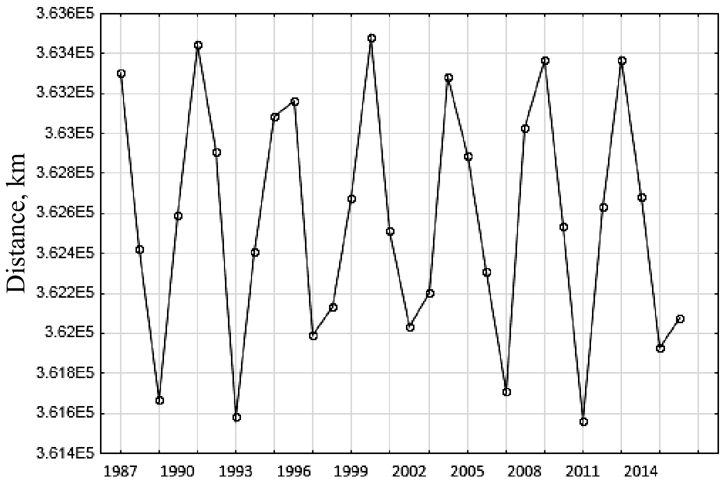
3. Database. The descriptive statistics of the data, from 1987 till 2009, of the global temperature (increased degree Celsius since 1978) [4], the global carbon dioxide (million tons) [5], the distance between Moon and Earth (r, km) [6], calculated $1/(r^2)$ ((km^{-2}), and calculated $1/r$ (km) are shown in Table 1, and the distance between Moon and Earth is shown in Figure.

Table 1. Descriptive statistics

Variable	**Global Tempera-ture (^oC)***	**CO_2 (million tons) ****	**Distance between Moon and Earth (*r*, km)**	$\frac{1}{r^2}$ **(km^{-2})**	$\frac{1}{r}$ **(km^{-1})**
Mean	0,29130	$1,25165 \cdot 10^3$	$3,62618 \cdot 10^5$	$7,60509 \cdot 10^{-12}$	$2,75773 \cdot 10^{-6}$
Standard deviation	0,12125	$2,14245 \cdot 10^2$	$5,98411 \cdot 10^2$	$2,51097 \cdot 10^{-14}$	$4,55200 \cdot 10^{-9}$
Minimum	0,10000	$8,92000 \cdot 10^2$	$3,61583 \cdot 10^5$	$7,56999 \cdot 10^{-12}$	$2,75116 \cdot 10^{-6}$
Maximum	0,43000	$1,62600 \cdot 10^3$	$3,63483 \cdot 10^5$	$7,64865 \cdot 10^{-12}$	$2,76562 \cdot 10^{-6}$
Skewness	–0,21063	0,14292	-0,15249	0,15787	0,15604
Kurtosis	1,29401	1,82491	1,67498	1,67879	1,67771
Valid number of observations	23	23	23	23	23

* Increased degree Celsius since 1978.

** To convert these estimates to units of carbon dioxide (CO_2), simply multiply these estimates by 3,667 [3].



Distance between Moon and Earth [1].

RESULTS

Regression Analysis (by Least Squares Estimations of Linear Classical Regression Model)

The global temperature $Y = \{y_1, \ldots, y_n\}$, the constant value 1, x_1, the measured global carbon-dioxide, x_2, the inverse of the distance between Moon and Earth, x_3, and the inverse of the squared distance between Moon and Earth, x_4, are transformed into the forms of $n \times 1$ vectors, y, x_1, x_2, x_3, x_4, where n is the number of observation, 23. Then, $n \times k$ matrix $X = \{x_1, x_2, x_3, x_4\}$ is defined, where $k = \mathrm{rank}(X)$. Then, we calculated the following matrices to get the coefficients b and their standard error (the diagonal elements of $\sqrt{V(b)}$).

$Q = X'X$, where X' is a transposed matrix of the matrix X;

$b = Q^{-1}X'Y$, where Q^{-1} is an inversed matrix of the matrix Q;

$\hat{Y} = Xb$: expected global temperature Y;

$$e = Y - \hat{Y}; \quad V(b) = \frac{e'e}{n-k} Q^{-1}.$$

And, the values of the square-root of the diagonal elements of $V(b)$ are the standard errors of elements of the estimated coefficient-vector b. The results of the regression analysis are shown in Table 2.

Table 2. Result of Regression Analysis and Model Characterization (adequacy)

Parameter		$Y = c_1 + c_2 CO_2 + c_3 1/(r^2)$	$Y = c_1 + c_2 CO_2 + c_3(1/r) + c_4 1/(r^2)$
c_1		–1,17863	$-3{,}52065 \cdot 10^{3}$
c_2	Coefficient of CO_2	$5{,}33150 \cdot 10^{-4}$	$5{,}31189 \cdot 10^{-4}$
	Standard error of CO_2	$4{,}27704 \cdot 10^{-5}$	$4{,}29964 \cdot 10^{-5}$
c_3	Coefficient of $1/r$	---	$2{,}55211 \cdot 10^{9}$
	Standard error of $1/r$	---	$2{,}78543 \cdot 10^{9}$
c_4	Coefficient of $1/(r^2)$	$1{,}05537 \cdot 10^{11}$	$-4{,}62552 \cdot 10^{14}$
	Standard error of $1/(r^2)$	$3{,}64932 \cdot 10^{11}$	$5{,}04955 \cdot 10^{14}$
R^2 (coefficient of determination)		0,88602	0,89084
Durbin-Watson Statistic		0,22092	0,40021
Sum of Squared Residuals		$3{,}68696 \cdot 10^{-2}$	$3{,}53096 \cdot 10^{-2}$

Multicollinearity

At first, we made the regression of $\frac{1}{r^2}$ on $\frac{1}{r}$, and obtain the residuals $\frac{1}{r^2}*$, by calculating the following matrices:

$$X = \left\{\frac{1}{r}, \frac{1}{r^2}\right\}\text{, a matrix made of two vectors } \frac{1}{r} \text{ and } \frac{1}{r_2}\text{;}$$

$$Q = X'X\text{, where, } X' \text{ is a transposed matrix of } X\text{;}$$

$$A = Q^{-1}\frac{1}{r}'\text{, where } Q^{-1} \text{ is an inversed matrix of } Q\text{;}$$

$$N = XA\text{;}$$

$M = I - N$, where, I is $k \times k$ matrix, in which all diagonal element is 1, and non-diagonal elements are ;

$$\frac{1}{r^2}* = M\frac{1}{r^2}.$$

And, then, we made a regression analysis with the following steps:

$$X* = \left\{\frac{1}{r}, \frac{1}{r^2}*\right\};$$

$$Q* = X*'\,X* = \begin{bmatrix} 1.74017 \cdot 10^{-10} & 5.18316 \cdot 10^{-32} \\ 5.18316 \cdot 10^{-32} & 3.46866 \cdot 10^{-27} \end{bmatrix};$$

$$A* = Q*^{-1}\,X*';$$

$$b* = A*Y;$$

$$N* = X*A*;$$

$$M* = I - N*;$$

$$e* = M*Y;$$

$$V(b*) = \frac{e*'\,e*}{n-k}Q*^{-1}.$$

And, the values of the square-root of the diagonal elements of $V(b*)$ are the standard errors of elements of the estimated coefficient-vector $b*$. The calculated coefficients and their standard errors are shown in the second column of Table 3 $\left(Y = c_1\frac{1}{r} + c_2\frac{1}{r^2}*\right)$. The third column of Table 3 $\left(Y = c_1\frac{1}{r}* + c_2\frac{1}{r^2}\right)$ was calculated after the regression of $\frac{1}{r}$ on $\frac{1}{r^2}$, to obtain the residuals $\frac{1}{r}*$; and, the first column of Table 3 $\left(Y = c_1\frac{1}{r} + c_2\frac{1}{r^2}\right)$ was calculated by making the regression of Y on $\frac{1}{r}$ and $\frac{1}{r^2}$.

Table 3. Comparison of Calculated Coefficients and Standard Errors

Parameter		$Y = c_1 \frac{1}{r} + c_2 \frac{1}{r^2}$	$Y = c_1 \frac{1}{r} + c_2 \frac{1}{r^2}*$	$Y = c_1 \frac{1}{r}* + c_2 \frac{1}{r^2}$
c_1	Coefficient	$7{,}68915 \cdot 10^5$	$1{,}05630 \cdot 10^5$	$7{,}68916 \cdot 10^5$
	Standard error	$5{,}81004 \cdot 10^6$	$9{,}38188 \cdot 10^3$	$5{,}81005 \cdot 10^6$
c_2	Coefficient	$-2{,}40517 \cdot 10^{11}$	$-2{,}40519 \cdot 10^{11}$	$3{,}83024 \cdot 10^{10}$
	Standard error	$2{,}10681 \cdot 10^{12}$	$2{,}10681 \cdot 10^{12}$	$3{,}40201 \cdot 10^9$

ANALYSIS OF THE RESULTS

1. We added $\frac{1}{r}$ to the Classical Regression Model of our previous analysis [1]. The result shows more adequacy of the model in comparison with the previous model [1] in the coefficient of determination, Durbin-Watson Statistic and Sum of Squared Residuals; however, the sign of the coefficient of $\frac{1}{r^2}$ changed from positive sign (plus) to negative sign (minus), in Table 2. It means that $\frac{1}{r}$ is an influential variable to Earth's global temperature; while, $\frac{1}{r^2}$ is not influential in this system of Moon's gravitational field and Earth's global temperature.

2. We tested the multicollinearity of $\frac{1}{r}$ and $\frac{1}{r^2}$, by changing $\frac{1}{r^2}$ to $\frac{1}{r^2}*$ by auxiliary residual regression, and then made the regression of Earth's temperature (Y) over $\frac{1}{r}$ and $\frac{1}{r^2}*$. As the result, multicollinearity was found. In Table 3, the coefficient of $\frac{1}{r}$ changed from $7{,}68915 \cdot 10^5$ to $1{,}05630 \cdot 10^5$. It means that $\frac{1}{r^2}$ lowered the influence of $\frac{1}{r}$. On the other hand, we also changed $\frac{1}{r}$ to $\frac{1}{r}*$ by auxiliary residual regression, and then made the regression of Earth's temperature (Y) over $\frac{1}{r}*$ and $\frac{1}{r^2}$. The result shows that the coefficient of $\frac{1}{r^2}$ changed from $-2{,}40517 \cdot 10^{11}$ to $3{,}83024 \cdot 10^{10}$. This result means that $\frac{1}{r}$ increased the influence of $\frac{1}{r^2}$ in the system.

After these calculations, we conclude that $\frac{1}{r}$ and $\frac{1}{r^2}$ are related in the system of Moon's gravitational-field and Earth's temperature. This finding also implies that Moon's gravitational-field may be mainly described in the flat space, although non-linear space (4-dimentional curved space in theory) could also influence the gravitational field of this system where the gravitational wave could interact.

CONCLUSION AND RECOMMENDATION

In the system of Earth's global temperature with Moon's gravitational field, the effect of $\frac{1}{r^2}$ is negligible in the presence of $\frac{1}{r}$. However, there is the multicollinearity between $\frac{1}{r}$ and $\frac{1}{r^2}$, which suggests the existence of the gravitational wave's interaction to the gravitational field; therefore there is a possibility for assuming the 4-dimensional curved space, instead of flat space. Further simulation is needed to model the system of flat space and curved space, which may explain how the gravitational wave and the gravitational field are interrelated.

So far, our calculation has shown that the influence of Moon's gravitational field to Earth's global temperature is significant than the influences of CO_2.

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