International Journal of Physical Sciences Vol. 4 (1), pp. 044-046, January, 2009
Available online at http://www.academicjournals.org/IJPS
ISSN 1992 - 1950 © 2009 Academic Journals

Short Communication

The possible role of dynamic pressure from the interplanetary magnetic field on global warming

Michael A. Persinger

Biophysics Section, Biomolecular Sciences Program, Laurentian University, Sudbury, Ontario P3E 2C6. E-mail: mpersinger@laurentian.ca. Fax: 01-705-671-3844.

Accepted 24 December, 2008

Quantitative analyses suggest that the increase in global warming by about 1°C over the last century is related to the increase in geomagnetic activity. Maintained small increases in dynamic pressure in the order of a nanoPascal from the solar wind due to the expansion of the solar magnetic corona may be sufficient to produce the energy that has resulted in the increase of surface temperatures on the Earth and Mars. A 1 nPa increase in dynamic pressure is equivalent to the increase of about 16 nT in aa (average antipodal index) values observed over the last 100 years. The results support the hypothesis of El-Borie and Al-Thoyaib that geomagnetic activity can partially predict global mean temperatures.

Key words: Geomagnetic induction, solar corona expansion, global warming, solar wind, aa values.

INTRODUCTION

The contemporary concerns of a functional connection between global warming and enhanced anthropogenic production of green house gases are based upon correlations; however, correlations do not necessarily indicate causation. According to El-Borie and Al-Thoyaib (2006) the approximately 1.1°C increase in global mean temperature since 1877 is unlikely to be entirely a product of internal climate variability. They found that about 25% of the variance in global temperature could be accommodated by concurrent alterations in geomagnetic and solar activity. Over the past century terrestrial and oceanic temperatures have increased between 0.4 to 0.8°C while temperatures in the lower troposphere have increased between 0.8 and 2.2°C. The durations of the variations are strongly correlated with the solar cycle (Lassen and Friis-Christensen, 1995).

Generally there are two classes of physical mechanisms employed to describe the fluctuations in global temperature. The first involves the strong correlations between the inverse relationship between the strength of the interplanetary magnetic field (IMF) and galactic cosmic ray intensity. This factor is correlated with the formation of low cloud cover (Marsh and Svensmark, 2000). The second involves the strong correlation between total solar irradiance and low cloud cover (Kristjansson et al., 2002). The average increase in irradiance is about 3 Watts/m^2 from a base line of 1,365 Watts/m^2 from satellite heights during the peak of solar cycles compared to the troughs.

However there is a third process that might contribute to global warming. Dynamic pressure from increased velocity or density of the solar wind (IMF) can result in the production of energy within the earth's magnetic field that can affect the troposphere. It may not be coincidence that the rise in global warming has been concurrent with the doubling of the Sun's coronal magnetic field during the past 100 years (Lockwood et al., 1999). Stamper et al. (1999) found an unprecedented correlation of 0.97 between an optimal solar wind-magnetospheric energy coupling function. They argued the 39% increase of the aa (average antipodal index) over three solar cycles was related to rises in the interplanetary magnetic field strength, solar wind speed and density. In the present paper, quantitative values from a basic equation and comparisons to measurements over several decades suggest that a significant proportion of the rise in global temperature may be associated with the energy produced by this enhanced geomagnetic activity.

RESULTS AND DISCUSSION

Dynamic pressure from impinging matter is the product of its density (kg/m^3) and square of the velocity (m^2/s^2). According to dimensional analysis, the product of the dynamic pressure (kg/m s^2) and the volume to which it is applied is energy. If we assumed 10 protons/cc within the solar

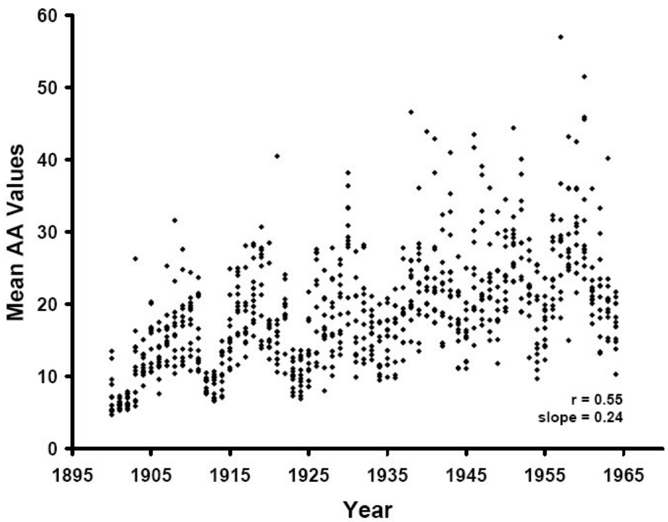

Figure 1. Scattergram of the monthly mean aa values (nanoTesla) and years between 1900 and 1965. The correlation coefficient was r = 0.55.

wind and an average velocity of 468 km/s (this daily average for the years 2002 through 2008 was obtained from Jan Alvestad, http://www/dxlc. com/solar/ indices.html) then the dynamic pressure would be (10* 1.6 x 10^{-27} kg for proton mass/cc) * (10^6 cc/m^3) * (4.68 x 10^5 m/s)^2 which is equal to 3.5 x 10^{-9} kg/m s^2. This value is 3.5 nanoPascal (nPa).

If the average velocity of the solar wind had been 72 km/s slower (396 km/s) earlier in the twentieth century, with a correlative dynamic pressure of 2.5 nPa, the net increase would have been 1 nPa. A similar change in dynamic pressure would occur with doubling of the proton density. That an increase from 396 to 468 km/s over an approximately 100 year period would reflect expansion of the solar coronal source is supported by Lockwood et al. (1999). This 20% increase in solar wind velocity (without accommodating density) would be within the range (based on a least-squares method for the years 1964 - 1996) of the rise in the magnitude of the mean radial component of the coronal source (about 41%) when distance is accommodated (Lockwood et al., 1999).

The effective bioshell of the lower troposphere (assuming 10 km thickness) is 5.1 x 10^{18} m^3. When the presumed initial dynamic pressure of 2.5 nPa is multiplied by this volume the "potential" energy within that volume of the troposphere would be about 1.2 x 10^{10} J/s or 5.6 x 10^{17} J per year. This value would be equivalent to about 5,500 individual Hiroshima (20 kT) blasts per year (15 per day). However this energy would be distributed diffusely within the biosphere. An increase of 1 nPa and its associated energy would be equivalent to adding another 1,200 additional 20 kT blasts per year.

Within a volume (about 1.03 x 10^{22} m^3) equal to a shell that extends one earth radius (6,378 km) into space, the net increase of energy from this increase of dynamic pressure of only 1 nPa would be equivalent to 7.7 x 10^7, 20 kT blasts per year or once every 0.4 s. Even when one accommodates for attenuation by the elastic propagation of the dynamic pressure, the coupling coefficients from magnetohydrodynamic effects, and the divergent density from the degree of coupling between the geomagnetic field and the IMF, the energies would be substantial from a sustained 1 nPa increase in dynamic pressure. Clearly the cumulative energy would be greater for every successive increased increment of 1 nPa.

The energy (J) from PV (dynamic pressure x volume) potentially stored within the earth's magnetic field can be defined as:

$$PV = J = (B^2/2\ u) \times m^3$$

where B is the magnetic field strength in Tesla, u is magnetic permeability, and m^3 is the volume of the troposphere. From this equation we can solve for the required field strength B, the square root of [(2u J)/m^3].

The quantities for these values would be (2 x 4 pi x 10^{-7} N/A^2) x 1 nPa. The result is 16 nT. This is the value for the average increase in aa (average antipodal) activity since 1900 as reported by Lockwood et al. (1999) and can be seen in the attached scattergram (Figure 1) from Mayaud's monthly aa values for the years 1900 through 1968 (r = 0.55). This value is also consistent with the effects at ground level from sudden increases in dynamic pressure of the solar wind near the earth's orbit. Ground level magnetic field (nT) increase is proportional to the square root of the dynamic pressure. The coefficient ranges from 13 nT/$nPa^{0.5}$ (Siscoe et al., 1968) to 34 nT/$nPa^{0.5}$ (Su and Konradi, 1975). The empirical slope (Figure 1), Lockwood et al., 1999) is within this range. When one correlates Alvestad's yearly values for solar wind velocity and global aa values thus far for the present decade, the regression line (r = 0.92) displays a slope of 0.12 (standard error = 0.024), which is also congruent. The correlation (r = 0.52) between daily mean solar wind velocities (km/s) and daily aa values is shown in Figure 2.

These quantitative solutions strongly suggest that energy induced within the earth's magnetic field and generated into the lower troposphere could contribute to the small effects noted for global warming. The quantitative values support the correlations by El-Borie and Al-Thoyaib (2006) that specific increases in geomagnetic activity can partially pre-dict the variability in global mean temperatures. These values also suggest a mechanism by which increases in solar activity, the strength of the interplanetary magnetic field, and terrestrial global warming might occur. That increased release of green house gases, primarily carbon- dioxide and water vapour, from human activities is the singular source of the total variance in global warming is not likely. Correlations are not necessarily causation even with very strong

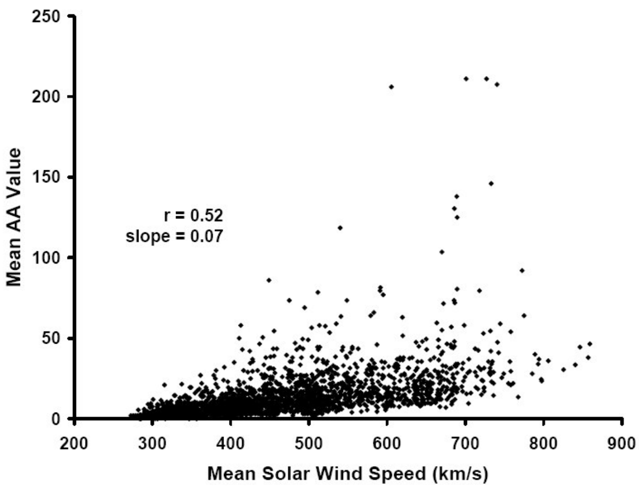

Figure 2. Scattergram of the daily solar wind speed (km/s) and the daily mean aa activity (nanoTesla) for the first decade (thus far) of the 21st century. The correlation coefficient was r = 0.52.

coefficients and appropriate lags. There is always the possibility of a third factor that causes both variables and hence is responsible for their strong but spurious association. It is very relevant that during the same period as the increase in global warming there has been a doubling of the sun's coronal magnetic field (Lockwood et al., 1999).

There have been reports of increased surface temperature of about 0.7°C over the last 20 years on Mars (Fenton et al., 2007). Although the mechanism was attributed to albedo-induced changes in wind directions, there are other explanations. If the solar corona is expanding and the interplanetary magnetic field is increasing in intensity and velocity, then the global warming is more likely to be non-specific from external variables. If this inference is correct then we should consider the possibility that the solar-based average increase in geomagnetic activity may be the causal variable for both the increased global terrestrial temperature and the factors that stimulate human activity to generate the gases that have been alleged to be responsible for this warming. A sudden and protracted decrease in solar-based dynamic pressure may have the opposite effect.

REFERENCES

El-Borie M A, Al-Thoyaib SS (2006). Can we use the aa geomagnetic activity index to predict partially the variability in global mean temperatures? Int. J. Phys. Sci. 1: 67-74.

Fenton LK, Geissler PE, Haberie RM (2007). Global warming and climate forcing by recent albedo changes on Mars. Nature 446: 646-649.

Kristjansson JE, Staple A, Kristiansen A (2002). A new look at possible connections between solar activity, clouds and climate. Geophys. Res. Lett. 29: 2107-2111.

Lassen K, Friis-Christensen E (1995). Variability of the solar cycle length during the past five centuries and the apparent association with terrestrial climate. J. Atmos. Solar-Terr. Phys. 57: 835-839.

Lockwood M, Stamper R, Wild MD (1999). A doubling of the sun's coronal magnetic field during the past 100 years. Nature 399: 437-439.

Marsh ND, Svensmark H (2000). Low cloud properties influenced by cosmic rays. Phys. Rev. Lett. 85: 5004-5008.

Siscoe GL, Formisano V, Lazarus V (1968). A calibration of the magnetopause. J. Geophys. Res. 73: 4869-4874.

Stamper R, Lockwood M, Wild MN, Clark TDG (1999). Solar causes of the long-term increase in geomagnetic activity. J. Geophys. Res. 104: 325-328.

Su SY, Konradi A (1975). Magnetic field depression at the earth's surface calculated from the relationship between size of the magnetosphere and the Dst values. J. Geophys. Res. 80: 195-199.