SENRA Academic Publishers, Burnaby, British Columbia
Vol. 5, No. 2, pp. 1581-1584, June 2011
Online ISSN: 1920-3853; Print ISSN: 1715-9997

Canadian Journal of pure&applied sciences

SHORT COMMUNICATION

COMPARISON OF ATMOSPHERIC CO_2 LEVELS WITH A NATURAL PHENOMENON

Scott McNeil
SAIC-Frederick, 1050 Boyles Street, PO Box B, Frederick, MD 21702, USA

The rise in global temperature is due to the increase in greenhouse gases, primarily in the form of carbon dioxide (CO_2) - which has a rate of increase five times larger than before the pre-industrial era (Jansen *et al*., 2007). Historical atmospheric levels of CO_2 obtained from glacial ice cores (Etheridge *et al*., 1998) can be combined with atmospheric CO_2 levels collected on Mauna Loa in Hawaii (Keeling *et. al*., 2004; Pales and Keeling, 1965) to provide a record dating from the geologic past. Monthly readings at Mauna Loa since 1958, and now expanded to a network of worldwide sampling stations, provide essentially real-time monitoring of atmospheric CO_2 levels.

Concurrent with this rise in atmospheric CO_2 has been a decrease in the intensity of the Earth's protective shield: the geomagnetic field. Historical ship logs and magnetic observatories offer a record of geomagnetic intensity from the 1600's to the present (Jackson *et al*., 2000; Gubbins *et al*., 2006). These records show that the intensity of the geomagnetic field (**F**) was relatively stable prior to the late-1800s and then began a sharp decrease; in the last hundred years **F** decreased approximately 5% (USGS, 2011). A plot comparing the global average in magnetic field strength (i.e. the geomagnetic coefficient, "g10") with the increase in atmospheric CO_2 from the 17th century to the present reveals an inverse association (Fig. 1), with notable divergence starting in the mid-nineteenth century.

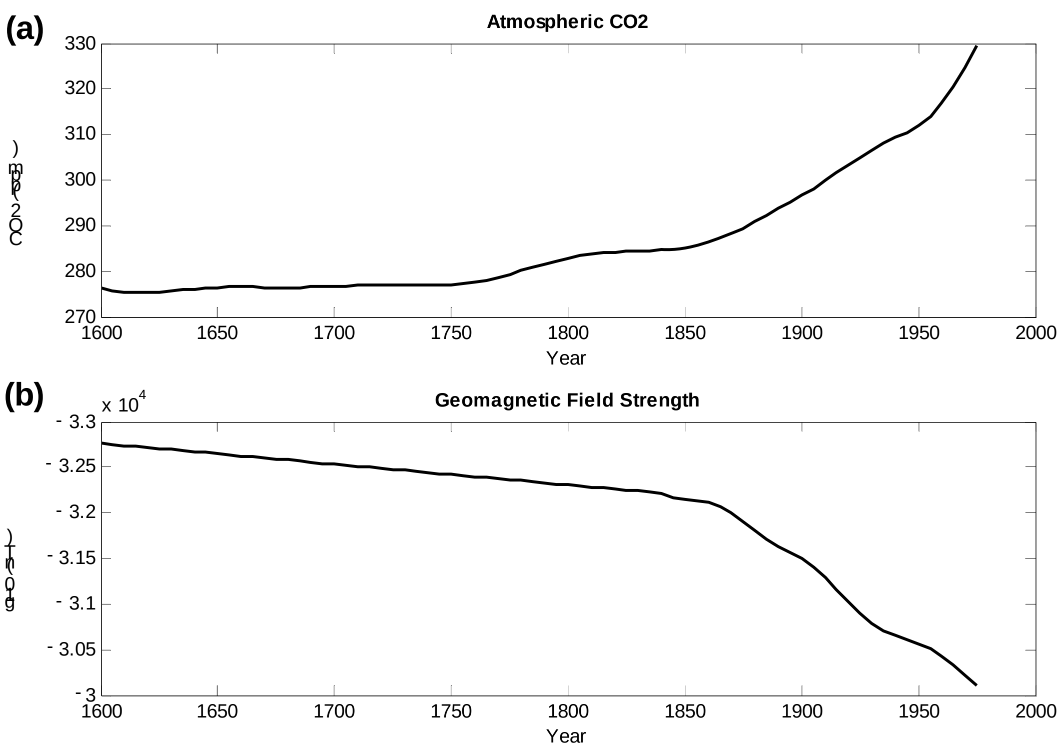

Fig. 1. Historical comparison of CO_2 levels with the geomagnetic field strength. Atmospheric CO_2 levels (**a**) mirror the global geomagnetic field strength (**b**) from the 16th century to present day [data source: (Gubbins *et al*., 2006; Etheridge *et. al*., 1998)].

Corresponding author email: mcneils@saic.com

The use and worldwide distribution of magnetometers starting in the late-1800's has generated an continuous record of **F** for the last hundred years, with nanoTesla (nT) accuracy. The World Data Center (WDC) for Geomagnetism in Edinburgh houses this comprehensive set of precise geomagnetic data which is supplied from a worldwide network of magnetic observatories (World Data Center, 2011). Using data archived at WDC, globally distributed ground-based magnetometer stations were identified that had continuous recordings in **F** from the start of the twentieth century to the present, with non-linear trends in the mid-1900's similar to those obtained by other methods (Gubbins *et al*., 2006; Fig. 1b). Scatter plot analysis of **F** vs. CO_2 for this timeframe (Fig. 2) reveals a strong negative correlation (R^2 = - 0.94). This relationship is conserved well in the time derivative, which shows concurrent local maxima/minima and inflection points (Fig. 3).

The observations reported here demonstrate that the increase in atmospheric CO_2 exhibits strong temporal correlation with a natural phenomenon, namely the decrease in intensity of the geomagnetic field. This association is conserved in the time derivative, arguing against an incidental trend. A model that accounts for this inverse association is not straightforward. The global CO_2 cycle involves interaction between the atmosphere, biosphere and hydrosphere; a relationship between **F** and this cycle has not been established. Recently Pazur *et al*. (2008) presented evidence that microTesla (μT) changes in a magnetic field could influence the solubility constant of CO_2 in seawater (Pazur and Winklhofer, 2008). In their study, a controlled decrease in **F** resulted in an increase in released CO_2. This work was met with skepticism, however, due to potential flaws in the experimental design (Köhler *et al*., 2009). An alternative association between **F** and CO_2 may be found in the influence of **F** on photosynthesis itself. Several reports in the field of biomagnetics have now observed differences in plant growth and CO_2 uptake following exposure to μT strength magnetic fields (Yano *et al*. 2004; Huang and Wang, 2008). Although these studies were for relatively short time periods (~ 2 weeks), the trend in the CO_2 response tracked inversely with **F** -- consistent with the observations reported here. These analyses suggest a possible interaction between **F** and atmospheric CO_2. This putative relationship appears to be limited to the last few centuries, however, as paleomagnetic intensity reconstructions do not correlate with ice core CO_2 records over geologic timescales (Köhler *et al*., 2009).

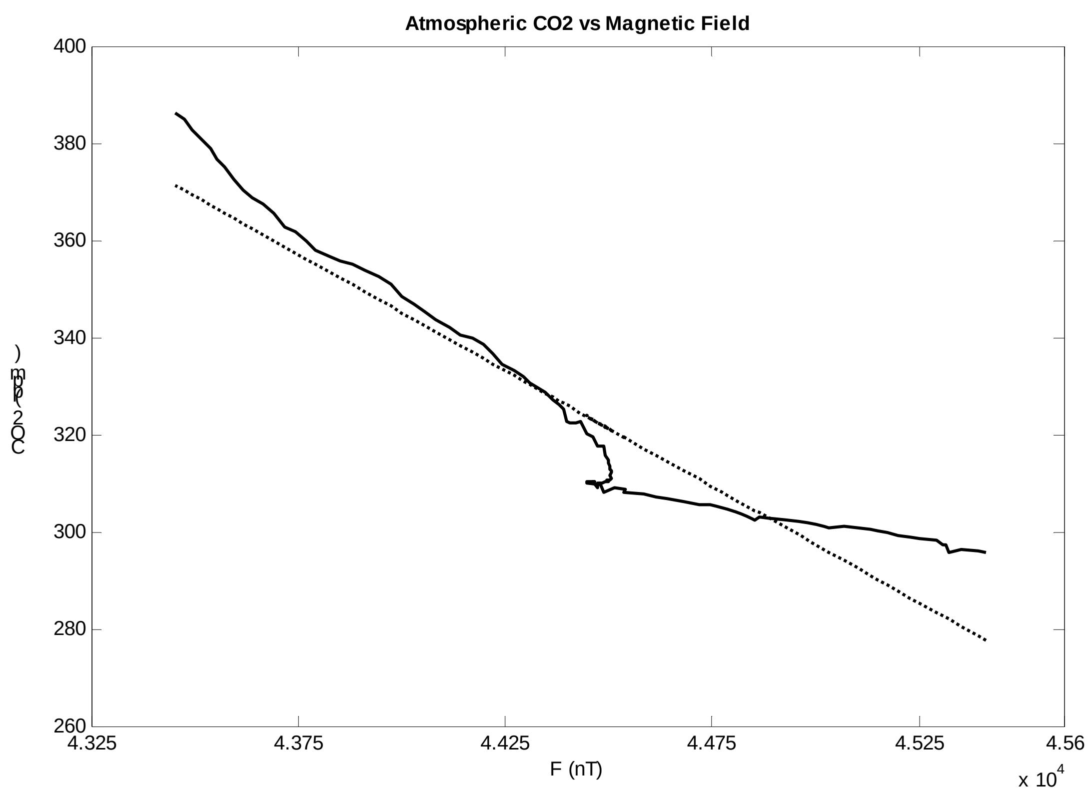

Fig. 2. Correlation of Atmospheric Carbon Dioxide with Global Magnetic Field. Scatterplot analysis of yearly global CO_2 concentration versus the relative global magnetic field intensity (**F**) for years 1900 to 2007. Dotted line is best fit using linear regression; correlation coefficient is shown, ρ < .001 using a matched pair t-test (MATLAB, R2008b).

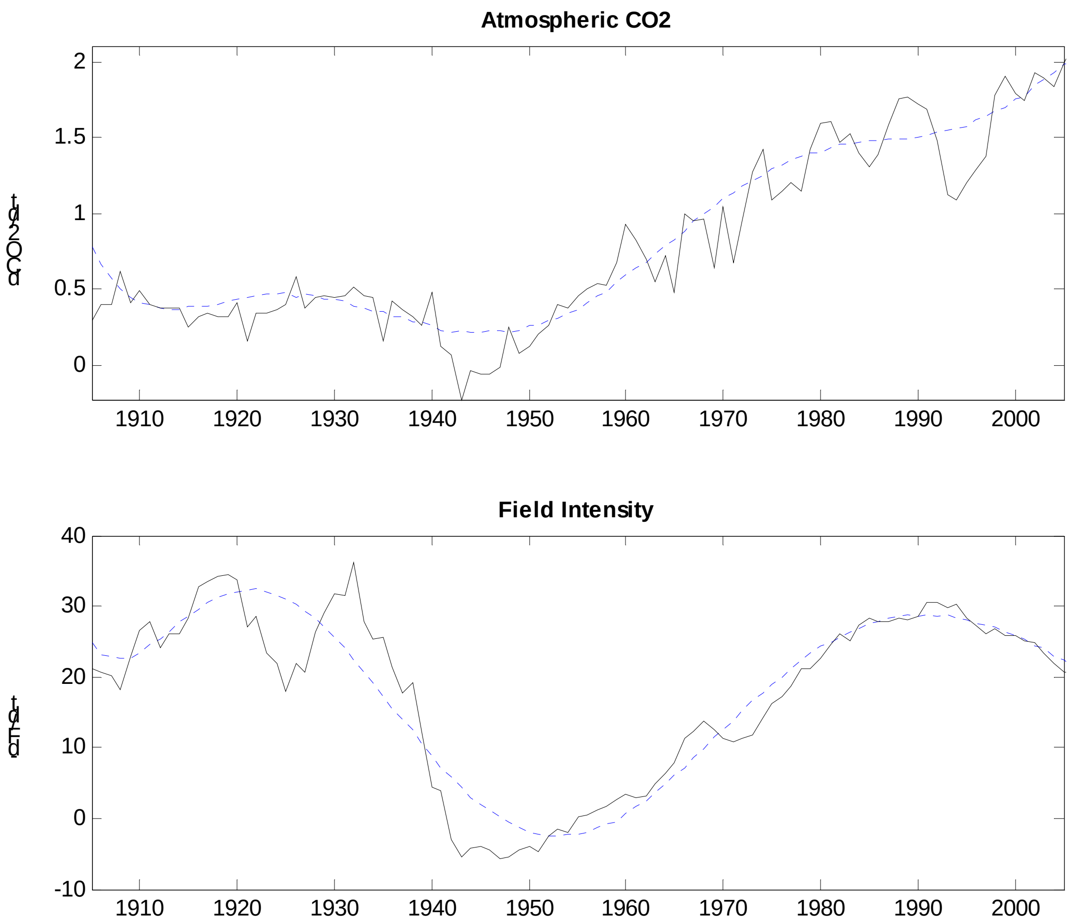

Fig. 3. Time derivative for CO_2 and geomagnetic field. (a) dCO_2/dt and (**b**) dF/dt; **F** is presented as negative (-) values to show the inverse relationship. Solid line in graphs is empirical data smoothed using a 5-year moving average; dotted line is curve of best fit.

ACKNOWLEDGEMENTS

The results presented in this paper rely on data collected at magnetic observatories. The author thanks the national institutes that support them and INTERMAGNET for promoting high standards of magnetic observatory practice. The author also thanks David Gubbins for providing the geomagnetic data used in figure 1.

COMPETING FINANCIAL INTERESTS

The author declares no competing financial interests.

REFERENCES

Etheridge, DM., Steele, LP., Langenfelds, RL., Francey, RJ., Barnola, JM. and Morgan, VI. 1998. Historical CO_2 records from the Law Dome DE08, DE08-2, and DSS ice cores. In Trends: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, US. Department of Energy, Oak Ridge, Tenn., USA., http://cdiac.esd.ornl.gov/

Gubbins, D., Jones, AL. and Finlay, CC. 2006. Fall in Earth's magnetic field is erratic. Science. 312:900-902.

Huang, HH. and Wang, SR. 2008. The effects of inverter magnetic fields on early seed germination of mung beans. Bioelectromagnetics. 29:649-657.

Jackson, A., Jonkers, ART. and Walker, MR. 2000. Four centuries of geomagnetic secular variation from historical records. Philosophical Transactions: Mathematical, Physical and Engineering Sciences. Geomagnetic Polarity Reversals and Long-Term Secular Variation. 358(1768):957-990.

Jansen, E., Overpeck, J., Briffa, KR., Duplessy, J.-C., Joos, F., Masson-Delmotte, V., D. Olago, D., Otto-Bliesner, B., Peltier, WR., Rahmstorf, S., Ramesh, R., Raynaud, D., Rind, D., Solomina, O., Villalba, R. and Zhang, D. 2007. Paleoclimate. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Eds. Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, KB., Tignor, M. and Miller, HL. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Keeling, CD. and Whorf, TP. 2004. Atmospheric CO_2 concentrations derived from flask air samples at sites in the SIO network. In Trends: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, US Department of Energy, Oak Ridge, Tennessee, USA, http://cdiac.esd.ornl.gov/.

Köhler, P., Muscheler, R., Richter, KU., Snowball, I. and Wolf-Gladrow, DA. 2009. Comment on "Magnetic effect on CO_2 solubility in seawater: A possible link between geomagnetic field variations and climate" by Alexander Pazur and Michael Winklhofer. Geophys. Res. Lett. 36:L03705.

MATLAB version R2008[b]. The Mathworks, Inc. 2008. Natick, Massachusetts, US.

Pales, J. C. and Keeling, CD. 1965. The concentration of atmospheric carbon dioxide in Hawaii. J. Geophys. Res. 70:6053-6076.

Pazur, A. and Winklhofer, M. 2008. Magnetic effect on CO_2 solubility in seawater: A possible link between geomagnetic field variations and climate. Geophys. Res. Lett. 35:L16710.

United States Geological Survey (USGS), National Geomagnetism Program. 2011. http://geomag.usgs.gov/

World Data Centre for Geomagnetism (Edinburgh). 2011. http://www.wdc.bgs.ac.uk/. Magnetic observatories used for this analysis were ABG, API, COI, OTT, SIT and VSS.

Yano, A., Ohashi, Y., Hirasaki, T. and Fujiwara, K. 2004. Effects of a 60 Hz magnetic field on photosynthetic CO_2 uptake and early growth of radish seedlings. Bioelectromagnetics. 25:572-581.

Received: Jan 19, 2011; Revised: Feb 28, 2011;
Accepted: March 4, 2011