Does Cosmic Weather Affect Infant Mortality Rate?

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Abstract

We propose to consider a link between infant mortality rate (IMR) and cosmic radiation density. The periodical increase in solar activity increases the effect of the magnetic field of the sun, and therefore weakens galactic cosmic rays hitting the earth's surface. As a result, embryos at their early stages of development may be less exposed to high-energy cosmic rays when the solar activity peaks. In this study cosmic ray density data were correlated with infant mortality rate in the following year. Statistical analysis shows that in the past 30 years, Pearson correlation between the change in cosmic radiation flux and the change in IMR in the following year was ~0.36 ($P<0.05$).

Introduction

Cosmic rays (CR) are highly energetic particles, originating from unknown sources outside our solar system and hitting the earth's surface at an extremely high speed. Although the atmosphere shields the earth's surface from cosmic rays, some of these highly penetrating particles can reach the ground, and their presence can still be detected even more than a mile below the earth's surface (Dorman, 2003). In fact, some extremely energetic particles can traverse the entire planet, exiting from its opposite side to continue their journey in outer space (Reya & Rodiger, 2005).

Energetic cosmic rays have a damaging effect on living organisms, which is substantially greater than X-rays or gamma-rays (Goldman, 1982; Shimada, Shima, Nojima, Seino & Setlow, 2005). Cosmic rays have been reported to affect gene mutation and genome instability (Arenz, Hellweg, Meier, & Baumstark-Khan, 2005; Yang, Mei, George, & Craise, 1996), break DNA strands (Lau, Hellweg, Kirchner & Baumstark-Khan, 2005; Baumstark-Kahn, Heilmann, & Rink, 2003), and degrade the immune system (Todd, Pecaut & Fleshner, 1999). The effect of cosmic rays have also been linked to sudden cardiac death (Soupel, 2006), and there is convincing evidence that irradiated cells can send out signals that can result in damage to nearby unirradiated cells (Brenner & Elliston, 2001). Other studies suggest that cosmic rays are among the causes of cancer in pilots and aircrew (Badrinath & Ramaiah, 1999; Pukkala et al., 2002), due to their exposure to cosmic rays in the higher atmosphere. This problem becomes more severe for manned space missions to relatively distant destinations such as Mars, where the magnetic field of the earth cannot shield the astronauts from cosmic rays (Curtis et al., 1998; Kim, George & Cucinotta, 2006; Petrov, 2005; Setlow, 2003). Due to the effect of cosmic rays on living organisms, cosmic rays are also considered as a possible cause of mass extinctions (Sigl, Schramm, Lee & Hill, 1997), and changes in cosmic ray activity have even been suggested to have a possible impact on the history of ancient civilizations (Gallet, Genevey, Le Goff, Fluteau & Eshraghi, 2006).

Considering the damaging effect of cosmic rays on living organisms, one can reasonably assume that cosmic rays can also damage embryos in their early stages of development. The number of cosmic rays hitting an embryo is dependent on its size, so that the number of cosmic rays hitting the fetus increases as the fetus enlarges. However, damage is expected to have a greater impact if the embryo is hit at an earlier stage of development. With ~2 primary cosmic ray hits per cm^2 per minute (Johnson, 1938), and assuming an average surface size of the embryo of 0.0075 mm^2 in the first week, the order of primary cosmic rays hitting an embryo before the end of the first week is ~1.5, and around 15 hits in the second week, assuming an average embryo surface size of 0.075 mm^2.

The frequency of cosmic rays hitting the earth is inversely correlated with solar activity (Wang, Sheeley & Rouillard, 2006). The sun flips its magnetic pole every ~11 years (Howard & Labonte 1980), a process that increases the number of sunspots that can be seen through telescopes. When cosmic rays approach the sun, they encounter the magnetic field of the heliosphere. This interaction results in the loss of some of the energy of the cosmic ray, making it less energetic and therefore less likely to ever reach the ground (Dorman, 2003). Solar activity during the magnetic polarity flip reduces the energy of galactic cosmic rays, so that the number of cosmic rays at sea level during the peak of the solar activity is smaller than the number of cosmic rays when the solar activity is at a minimum.

The changes in the energy and density of cosmic rays hitting the earth's surface when the sun flips its magnetic pole had been shown to have an effect on other global systems that do not have an immediate obvious link to CR. For instance, the lower activity of CR during the magnetic polarity flip was found correlated with precipitation (Kniveton & Todd, 2001) and climate changes (Svensmar, Pedersen, Marsh, Martin & Uggerhoj, 2006; Belov, Dorman, Gushchina, Obridko, Shelting & Yanke, 2005; Dorman & Dorman, 2005). Due to the effect of cosmic rays on the human body, it has been proposed that a manned Mars mission will be launched during the peak of the solar cycle, when the damaging effect of cosmic rays is expected to be substantially weaker due to the intensive solar activity.

Methods

The analysis is based on the correlation between the change in cosmic ray density measured on the surface of the Earth, and the change in infant mortality rate in the following year. Assuming that a cosmic ray hit can damage an embryo in its early stages of development, one can expect a sharper IMR decrease in the year following a sharp decrease in CR flux. For instance, a sharper decrease in infant mortality rate is expected in the year following the solar maximum, followed by an increase in the year after, when the effect of the solar activity gets smaller.

The two most recent flips of the solar magnetic pole took place in 1989 and 2000 (Koeckelenbergh, 1981), accompanied by a consequent decrease in the energy and density of cosmic rays hitting the earth's surface. The density of CR at terrestrial altitude, as measured in Oulu Cosmic Ray Station, is shown by Figure 1.

The data used for the analysis are the infant mortality rate in the United States, and the change (%) in infant mortality rate compared to the previous year. Assuming that cosmic radiation can damage an embryo, the IMR decrease in the first year after the solar maximum should be relatively high, while the following year should record a much smaller decrease, or even an increase in infant mortality rate.

Results

Figure 2 shows the infant mortality rate in the United States from 1977 to 2006. As can be learned from the figure, the year of 2001 had a very low infant mortality rate, followed by a surprising increase (of nearly 3 per 1000 births) in 2002. These data are in agreement with the intensive solar activity in 2000, which provided a better shield against cosmic rays during that time.

Examining the previous solar cycle, peaking in 1989, infant mortality rate in 1990 was 0.6 (per 1000 live births) lower than the one recorded in 1989. This sudden drop of more than 6% followed 5 consecutive years of decrease of less than 2% per year, and is the highest IMR decrease recorded in nearly 30 years.

Figure 3 shows the CR flux decrease and the IMR decrease in the following year. Since IMR is a function of very many parameters (Frey & Field, 2004; Kent 1991; World Health Organization, 2005), a perfect correlation between the two variables is not expected. However, a partial correlation is noticeable, and the Pearson correlation between the two variables is ~0.36 ($P<0.05$).

Discussion

The analysis of infant mortality rate in the US shows a correlation between the decrease in CR flux and the decrease in IMR in the following year. In particular, sharp IMR decreases were recorded in the years following the end of the solar cycle. The decrease is followed by an increase (or an unusually small decrease) in the following year, when the solar activity was getting less intensive.

The effect of cosmic rays may be even more significant on the number of miscarriages. However, unlike infant mortality rate, miscarriage statistics is not well recorded, and therefore no conclusion can be established based on these data.

Cosmic rays are significantly stronger and more frequent at higher altitudes. For instance, in altitude of 1 mile above sea level the cosmic ray density is 3.7 times greater than at sea level, and it is 12.8 times greater in altitude of 2 miles (Ziegler et al., 1996). These data are in agreement with the observation of higher infant mortality rate at altitudes of two miles above sea level, comparing to IMR recorded in the same country, but at lower altitudes (Keyes, Armaza, Neirmeyer, Vargas, Young & Moore, 2003).

The next flip of the solar magnetic pole is expected in 2011. If the proposed hypothesis is correct, a sharp decrease in infant mortality rate is expected around 2012, followed by a possible increase in 2013, which, in that case, will result from the increase in cosmic ray density.

Since cosmic rays are highly penetrating particles, no mechanism that can effectively protect embryos from cosmic rays is yet available. Since the magnetic field of the earth is consistently weakening (Sabaka, Olsen & Purucker, 2004), its effectiveness as a shield is degrading. This trend might also contribute to infant mortality rate in future years.

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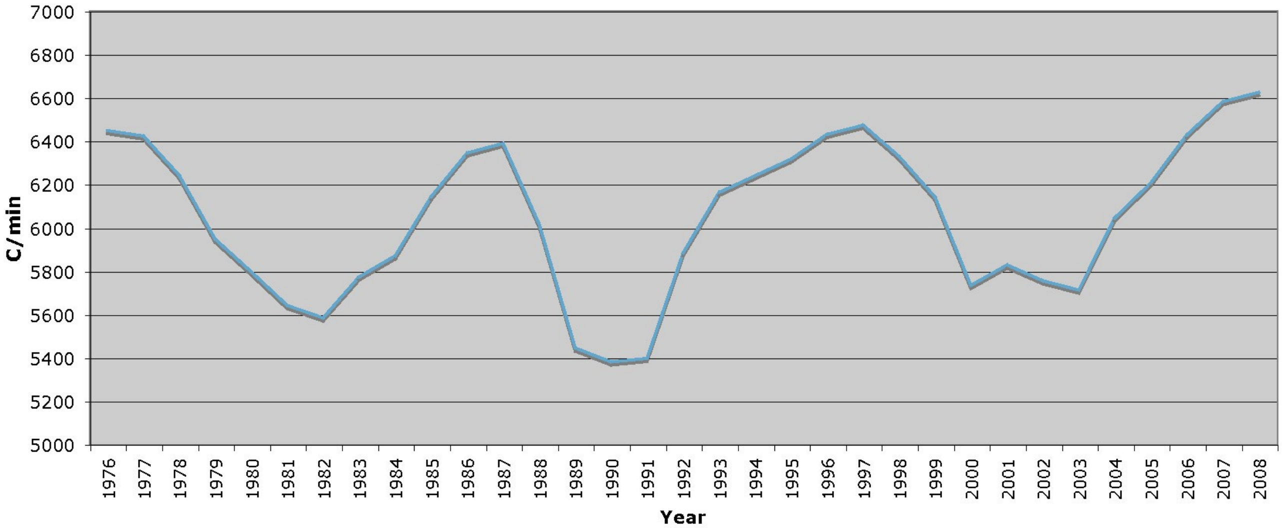

Figure 1. CR flux as recorded by Oulu Cosmic Ray Station. Years of higher flux are the years of more quiet sun, while the flux is significantly lower when the sun is active.

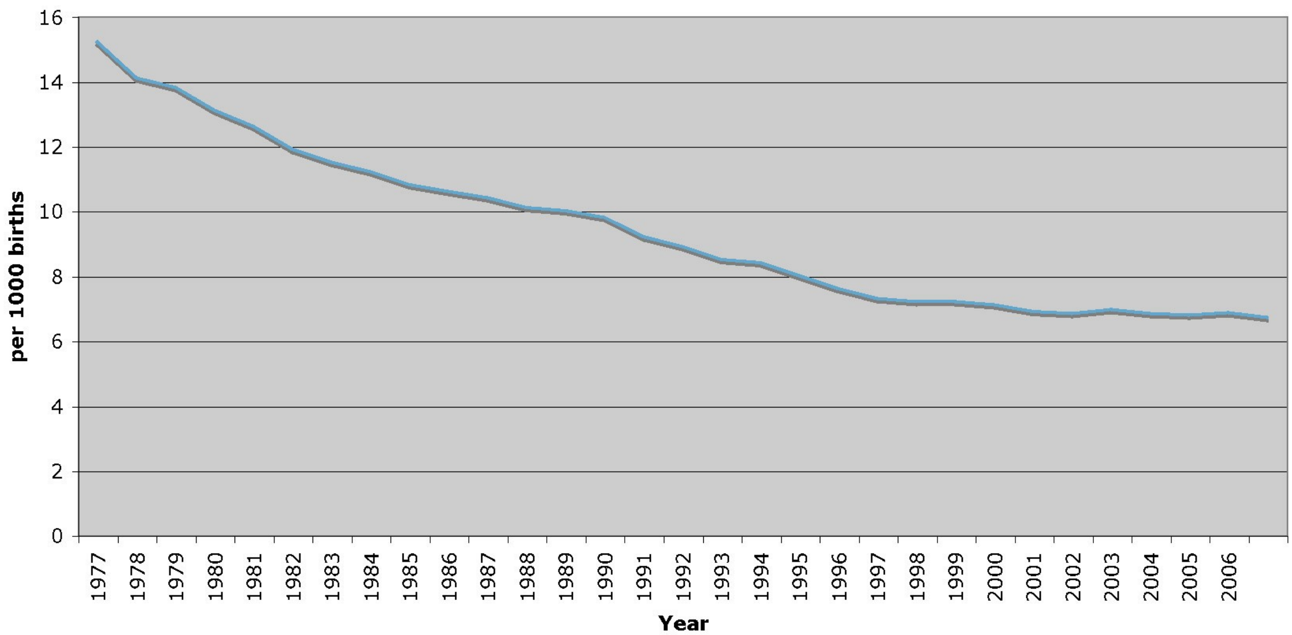

Figure 2. Infant mortality rate in the United States.

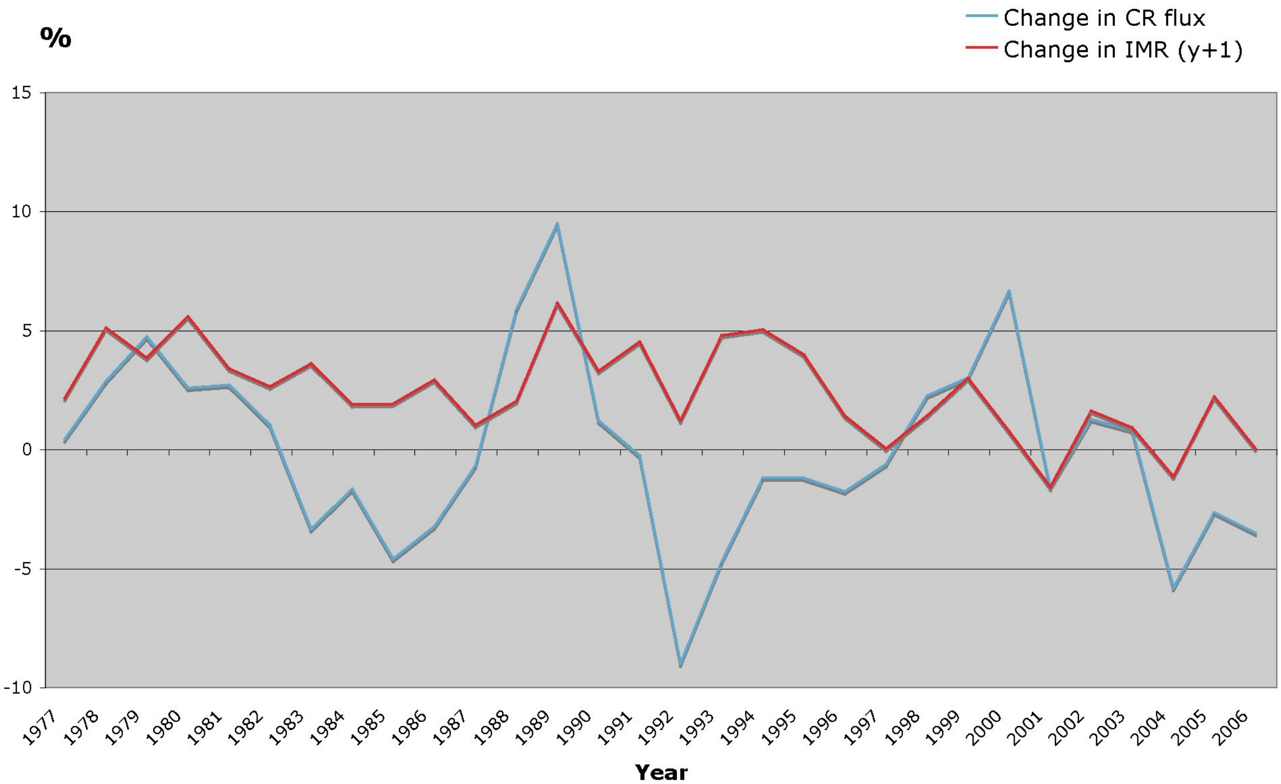

Figure 3. The change in CR flux and the change in IMR in the following year. The CR flux and IMR are visualized by Figures 1 and 2, respectively. This figure shows the change (%) in these values between every two consecutive years.