The Long-Term Variation of Galactic Cosmic Ray Flux and Its Possible Connection with the Current Trend of the Global Warming

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Abstract

Referring to the observational results on the cosmic ray fluxes obtained from several observing sites and the solar activity for more than a century since the year 1870, it is shown that the long-term variation of the cosmic ray intensity in the space of the inner solar system may have been strongly controlled by the magnetic fields transported from the sun. According to this variation, the cosmic rays in this space have a tendency to steadily decrease for the last hundred years. This tendency seems to have been deeply effective to the formation of cloud layers all over the earth's surface. It could thus be concluded that the gradual decrease of the cosmic ray intensity in the space of the inner solar system is responsible for the global warming for the last hundred years or more.

1. Introduction

It is now thought of that the current trend of the global warming is causally related to the accelerating consumption of fossil fuels in the industrial nations. However, it has been suggested that this warming might have been produced as the result of the gradual increase of the solar activity for more than a century since the year 1870. In fact, it has been well established that the brightness of the sun varies in proportion with the solar activity, though the variability of this brightness is very small.

The gradual increase of the solar activity for such a long period as more than a hundred years, therefore, seems to have been accompanied by the gradual decrease of the cosmic ray intensity in the interplanetary space [1]. Recently, Svmensmark and Friis-Christensen [2] have made clear that the solar activity, being numerically expressed by the relative sunspot numbers, is well inversely proportional to the formation of cloud layers in the lower atmosphere all over the world. According to them, the cosmic ray particles may be responsible for the production of ions in the atmosphere. These ions may become the nuclei for forming water droplets.

As described earlier, the intensity of the cosmic rays impinging upon the earth's atmosphere varies almost inversely proportional to the solar activity. Fur-

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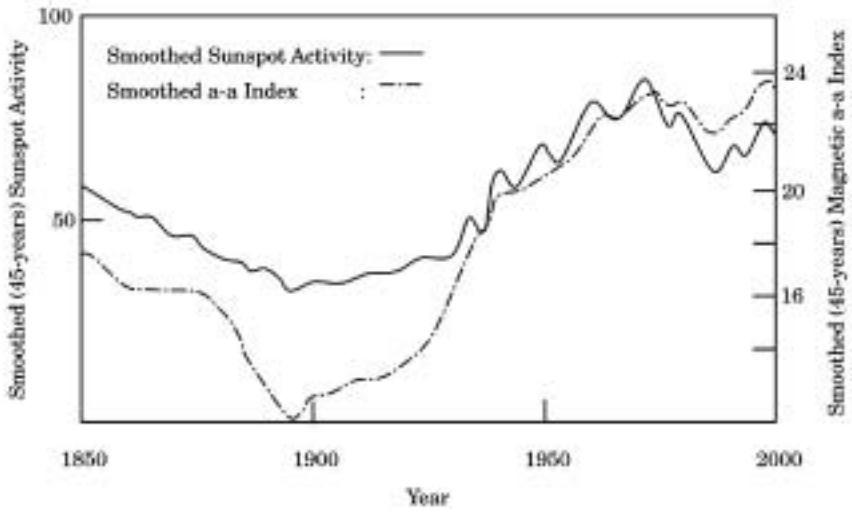

Fig. 1. The long-term variation of the solar activity as obtained from the 45-year running averages for the relative sunspot numbers. (See, [3])

thermore, this intensity has tendency to almost steadily decrease with time for the last hundred years while following the steady increase of the solar activity.

In this paper, it will be shown that this steady decrease of the cosmic ray intensity near the earth's orbit for the last hundred years or more must have been responsible for the global warming being currently experienced by us.

2. The Nature of the Long-Term Variation of the Solar Activity for the Last Hundred Years

It has been well established that, though sluggish it is, the solar activity has a tendency to increase almost steadily for more than hundred years since about the year 1870. This tendency is clearly seen when the long-term variation of the relative sunspot numbers is taken into account to find out how the solar activity had been varying with time for a century and more since the year 1870.

As have been analyzed by [1], the cosmic ray intensity as being observed at the earth has a tendency to steadily decrease for more than hundred years in the recent past with the enhancement of the interplanetary magnetic fields being originated in the solar photosphere. This enhancement of the magnetic fields in the interplanetary space is shown by the long-term variation of the a-a indices of the geomagnetic activity, which is causally connected with the behavior of these magnetic fields being transported from the sun by the solar wind.

According to [3], as shown in Fig. 1, the solar activity as deduced from

the 45-year running averages for the relative sunspot numbers has been increasing since the year 1900, though there exists a gap indicating that this activity slightly decreased in the last half of the 20th century. It is, however, clear from this figure that the a-a index, as a measure of the variability of the interplanetary magnetic fields, is varying almost in parallel with the sunspot activity. This means that the invasion of cosmic rays into the space of the inner solar system near the earth's orbit has become difficult as time went on since the year 1900.

3. The Behavior of the Interplanetary Magnetic Fields and Its Relation to the Cosmic Ray Background Intensity in the Sun's Neighborhood

The background intensity of cosmic rays in the space of the inner solar system is highly controlled by the magnetic fields there being transported from the solar photosphere. During the period while the solar activity is relatively higher, this intensity tends to become lower as being dependent on the degree of this activity. This thus means that the cosmic ray intensity near the earth's orbit is usually in the lowest state during the years corresponding to the phase of the maximum sunspot numbers in the eleven-year sunspot cycle and vice versa, though the time variation of this intensity is usually delayed by about two years for that of the relative sunspot numbers [3].

As is well known, the magnetic activity over the solar photosphere usually becomes quite active during the years while the sunspot activity is at maximum. The magnetic fields thus formed in the solar photosphere are extended into the outer coronal region and then transported by the solar wind from there into the interplanetary space far out of the sun.

Since cosmic rays are mainly prevented from invading into the space of the inner solar system due to the action of the magnetic fields in the interplanetary space, the cosmic ray intensity observed at the earth is so highly controlled that it tends to vary inversely proportional with the solar activity. As have been shown by in [4], the magnetic fields in the interplanetary space are strongly intensified in their strength due to the transport of the magnetic fields on the solar photosphere during the period while the sunspot activity is high. Cosmic ray intensity, therefore, tends to decrease highly during the maximum period of the solar activity cycle. So, this intensity in the space of the inner solar system tends to vary inversely proportional with the solar activity as being delayed by two years or so to the latter.

4. Discussion about the Possible Causal Relation Between the Solar Activity and the Global Warming

At present, it is known that the earth's environment has been becoming warmer with time since the year 1870, though this trend was reversed for twenty years since the year 1940. This long-term variation of the temperature at the earth's surface is well coincident with that of the sunspot activity, which is reflected upon the length of the each solar activity cycle as first found in [2].

If we refer to the results shown in Fig. 1 about the long-term variation of solar activity, it is clear that this activity was lowered for about twenty years after the year 1940. This lowering seemed necessarily effective to the decrease of the temperature at the earth's surface, since the brightness of the sun slightly decreased with the decrease of the sunspot activity.

These results may mean that the global warming being currently observed is necessarily accompanied by the long-term variation of solar activity as shown in Fig. 1, though we need consider the inevitable role of cosmic rays in the earth's environment.

5. References

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