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Beryllium-7 and solar activity

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Abstract

A very low concentration of ^{7}Be in air at Thessaloniki, Northern Greece (40°38′N, 22°58′E) was recorded on November 9, 2003 following a strong event of solar wind that occurred on October 29, 2003.

Keywords: Beryllium-7; Sunspots; Solar activity; Solar cycle

Beryllium-7 is a relatively short lived ($T_{1/2} = 53.3$ d) naturally occurring radionuclide of cosmogenic origin, which is formed by spallation processes of light atmospheric nuclei, such as nitrogen ($Z = 7$), oxygen ($Z = 8$) and even carbon ($Z = 6$) when they absorb protons and even neutrons of the primary component of cosmic rays (Lal et al., 1958; Lal and Suess, 1968). It serves as an excellent tracer for upper and lower tropopsheric sources and transport processes.

It is well known that the galactic cosmic-ray intensity at the earth's orbit is inversely related to solar activity (O'Brein, 1979). So, a decrease in the galactic cosmic-ray intensity has accompanied the recent increase in the solar activity, which will be followed by a decrease in the production rate of cosmic-ray products, such as Beryllium-7 that is therefore expected in a global scale.

This effect can be interpreted as follows: The solar wind is consistent with the relative low-energy particles eliminated the passage of the galactic cosmic radiation through the solar system to the earth and therefore it influences by reducing the production rate of cosmogenic origin radionuclides. A negative correlation is therefore expected between the atmospheric Beryllium-7 and sunspots (Hötzl et al., 1991; Ioannidou and Papastefanou, 1994).

For more than 15 years, since 1987 air samples by filtering have been collected continuously at the Atomic and Nuclear Physics Laboratory, in the Aristotle University of Thessaloniki (Greece) to study the temporal and spatial distribution on specific natural and anthropogenic radionuclides in the surface air. Fig. 1 shows the variation of the sunspot number as an index of solar activity as registered by the NOAA Space Environment Center in Boulder, Colorado and the ^{7}Be concentrations in air as were recorded in Thessaloniki, Greece during the 15-year period starting from 1987. The sampling period was 24 h each time. The sample quantity was about 2800 m^3 of air and the flow rate was $\sim 2\,m^3 \times min^{-1}$ (68 cfm). The filter was glass fiber type TFAG810 of STAPLEX with dimensions 20.32 cm × 25.40 cm (8″ × 10″) and collection efficiency 95% of particles 0.5 μm and over. The gamma radioactivity of the filters was measured by a gamma-spectrometry system consisted of a high resolution (1.9 keV at 1.33 MeV) and high efficiency (42%) high-purity Ge detector and the uncertainty of the measurements was better than 8.5%. The inverse relationship between the ^{7}Be concentration in air and the sunspot number is clearly evident. The period that covered the data is quite larger than the 11-year solar cycle.

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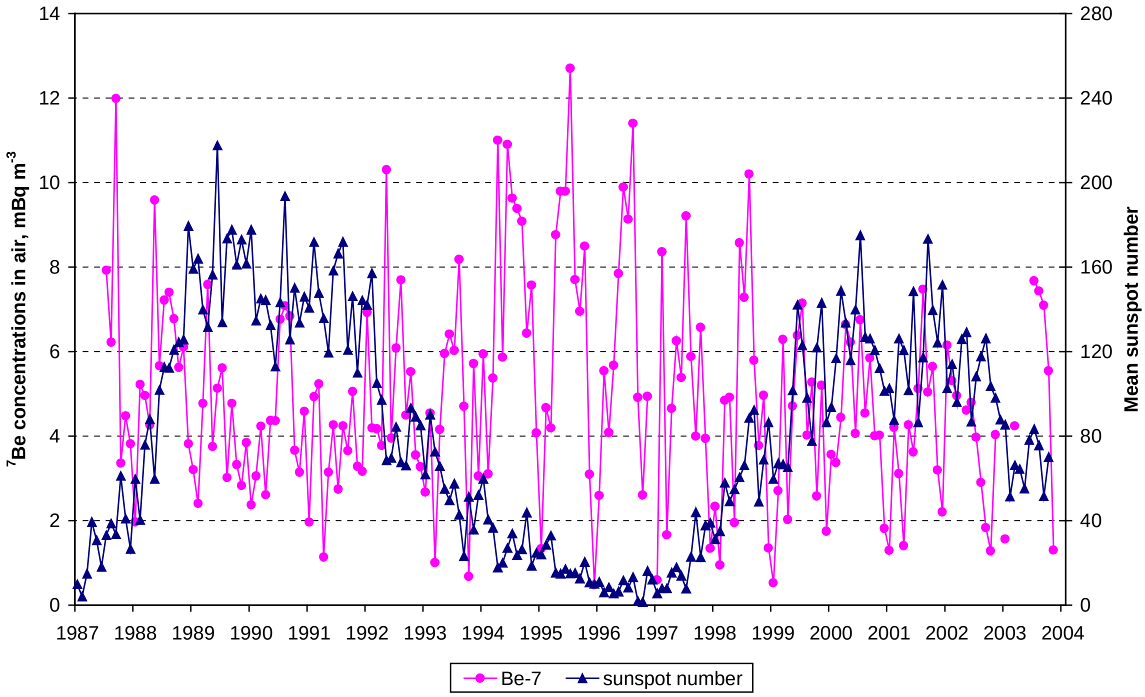

Fig. 1. Beryllium-7 and sunspot number at the period 1987–2003.

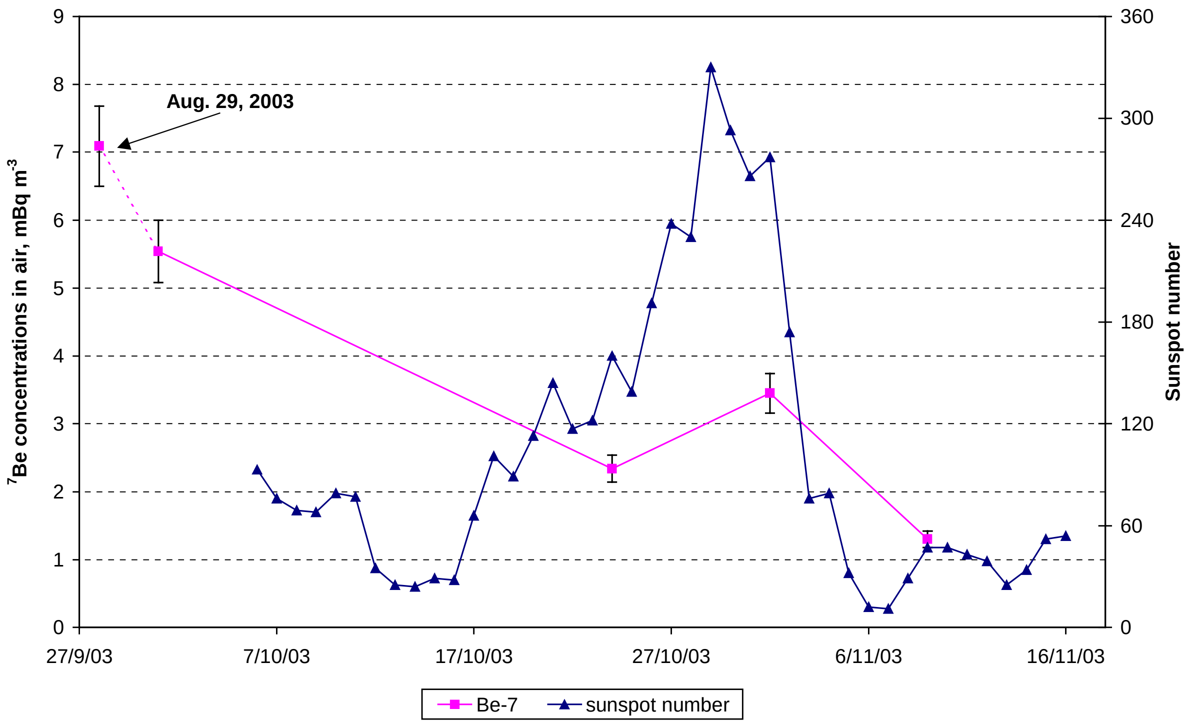

Fig. 2. Berylliym-7 and sunspot number at the period October–November 2003.

Recently on October 24, 2003, an event of strong solar wind accompanied by an increase of sunspot number has been occurred and followed by another event, the strongest one, on October 29, 2003 (sunspot number 330) seemed to affect the cosmic-ray intensity and resulted in a strong decrease of production rate of the cosmic-ray products leading to a very low-level concentration of ^{7}Be in air as low as $1.30 \pm 0.12\,\mathrm{mBq\,m^{-3}}$, regarding the corresponding values observed from July 10 through October 2, 2003 at Thessaloniki, Northern Greece (40°38′N, 22°58′E). Fig. 2 shows the ^{7}Be concentrations in air (four records) at Thessaloniki, Greece and the sunspot number as registered by NOAA for the months of October and November 2003. It is evident that the lowest value of ^{7}Be $1.30\,\mathrm{mBq\,m^{-3}}$ was recorded on November 9, 2003 and followed the highest value of sunspot number 330 which was registered on October 29, 2003. It must be noted that at the period of October–November 2003 in the 11-year solar cycle, as seeing at the curve of Fig. 1, we were at low sunspot number values and correspondingly at high ^{7}Be concentration values. These extraordinary events of solar wind were followed by a geomagnetic storm, which influenced the electromagnetic emissions in the earth.

This paper really confirms the occurrence of the solar wind event.

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