

## Analyses of long-term measurements (2005-2012) of $^7\text{Be}$ concentrations in surface air aerosols.

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Cosmogenic particles hitting the atmosphere lead to the production of  $^7\text{Be}$  ( $T_{1/2}=53.3$  days) in the lower stratosphere and upper troposphere. Once  $^7\text{Be}$  is formed is rapidly associated with submicron aerosol particles and participates in the formation and growth of the accumulation mode (from 0.07 to 2  $\mu\text{m}$ ) aerosols, which is a major reservoir of pollutants in the atmosphere (Ioannidou *et al.*, 2011). This naturally occurring radionuclide is a most important isotope in studying atmospheric processes because of its convenient half-life and sufficiently detectable  $\gamma$ -radiation ( $E\gamma = 0.477$  MeV), which has served for studying precipitation scavenging, vertical and horizontal removal of air masses, aerosol transit and residence times in the troposphere.  $^7\text{Be}$  surface air activity shows a strong dependence on altitude, latitude, local climate and seasonal variations.

The aim of the present study is to explain the behaviour of aerosols, associated with  $^7\text{Be}$ , in the surface atmosphere using exploratory data analysis in order to obtain information on their possible mechanisms of transport and deposition. Long-term variations of the radionuclide concentrations are discussed in relation with precipitation, temperature, temperature interval, relative humidity, solar radiation, pressure, wind and Saharan dust events. Least significant difference test (LSD) and principal component analysis (PCA) with varimax rotation have been applied to study the datasets.

Airborne particulate samples were collected weekly during an 8 years period (January 2005 till December 2012) at Malaga, on the Southeastern coast of Spain, (36° 43' 40" N; 4° 28' 8" W; 54 m a.s.l.). The sampling point is located approximately 5 km away from the coastline and the local sources of anthropogenic aerosols are limited to emissions from cars. Due to its geographical vicinity with the African continent, our study area is frequently affected by intrusions of Saharan air. The Sahara desert is one of the principal sources of natural dust in the northern hemisphere.

Aerosol particles were continuously collected in cellulose filter with 0.8- $\mu\text{m}$  pore size. Gamma measurements were performed with a coaxial-type germanium detector. A total of 96 samples of aerosols were analyzed and  $^7\text{Be}$  specific activity was determined. The meteorological parameters studied during the sampling period were provided by the Spanish National Institute of Meteorology (AEMET). Data for the number of days with high probability of episodes of Saharan intrusions have been obtained from the CALIMA project which is the result of Commendation of Management Agreement between the Ministry of Environment and Rural and Marine Affairs (MARM) and the State Agency National Research Council.

The mean specific activity of  $^7\text{Be}$  in near-surface air measured over the 8-year studied period was  $4.28 \pm 1.88$   $\text{mBq m}^{-3}$ , with a minimum of  $0.34$   $\text{mBq m}^{-3}$  and a maximum of  $14.9$   $\text{mBq m}^{-3}$ . Concentrations show seasonal variations with values above the annual mean occurring mainly in the spring and summer months of each year. LSD test was applied to find which months differed significantly in order to put the samples into homogeneous groups.

The activity concentrations of  $^7\text{Be}$  have a significant positive relationship with Saharan dust events ( $r=0.519$ ), temperature ( $r=0.44$ ) and solar radiation ( $r=0.399$ ). On the contrary, a negative correlation was observed with the amount of precipitation ( $r=-0.33$ ) and relative humidity ( $r=-0.31$ ). In the period January–June transport of Saharan dust toward Spain is mainly due to the cyclonic activities over the West or South of Portugal, while in the summer this transport is governed by the anti-cyclonic activities over the East or Southeast of Iberian Peninsula (Rodríguez *et al.*, 2001).

The results of the PCA analysis showed that the monthly behaviour of  $^7\text{Be}$  aerosols in our sampling coastal site was represented by three groups which explain 71.55% of total variance. The first principal component explained 42.45% of the total variance of the dataset and it was positively correlated with  $^7\text{Be}$ , Sahara dust events, temperature and radiation and negatively with relative humidity and precipitation.

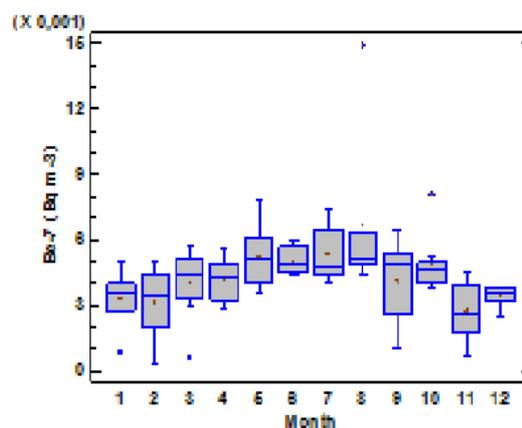


Figure 1. Boxplot of the  $^7\text{Be}$  concentrations on a monthly basis.

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