

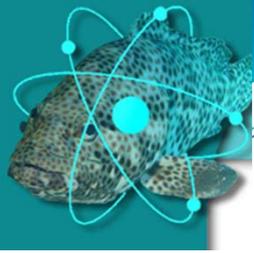


Analysis of ^7Be and ^{210}Pb concentration and $^7\text{Be}/^{210}\text{Pb}$ activity ratio in ground level air at Palermo (Italy)

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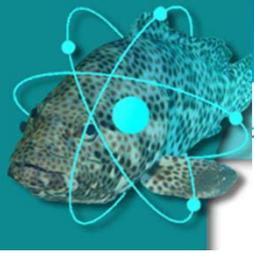
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OUTLINE

- INTRODUCTION
- THE SAMPLING STATION OF ENGINEERING DEPT.
- SAMPLING AND MEASUREMENTS
- RESULTS
- STATISTICAL ANALYSIS OF DATA
- CONCLUSIONS



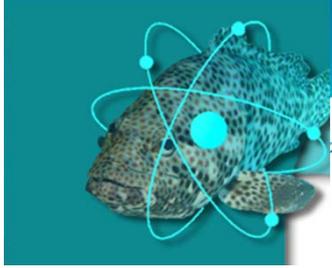
INTRODUCTION

Recently a renewed interest has been put on the use of radioactive tracers to study transport and mixing processes in the atmosphere. Among the most commonly used radioactive tracers in the atmosphere, ^7Be and ^{210}Pb have assumed an ever-increasing importance.

Beryllium-7 is the product of the interaction of cosmic rays with Nitrogen and Oxygen nuclei. Its cosmogenic origin makes the measured concentrations strongly dependent on the geographical position and seasonal cycles. It emits 478 keV gamma photons and has a half-life of about 53 days.

Lead-210 (half-life 22.3 years) is instead a decay product of the radioactive family of the ^{238}U . The specific activities of this radionuclide are therefore strongly dependent on the detection site. Its 46.5 keV gamma emission makes it necessary to use a detector suitable for low energies.

Both ^7Be and ^{210}Pb are commonly used radio tracers in transport and mixing in air processes studies.

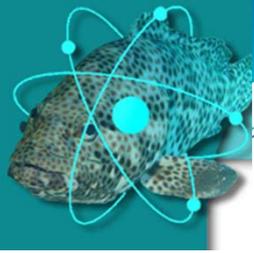


INTRODUCTION

With the availability of a planar HPGe detector, with a good efficiency for the direct measurement of the 46.5 keV gamma emission, ^{210}Pb activity measurements were again performed on the same samples collected in almost last 10 years of daily air monitoring.

In this way, to results of the measurements, carried out almost daily, of the concentrations in the air in Palermo of ^7Be (1982-2005), a set of ^{210}Pb air concentration (1995-2005) are analyzed and discussed.

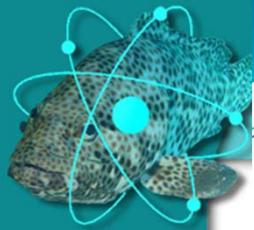
With regard to the period of joint availability of data (1995-2005) in order to highlight possible correlations between the two radionuclides and with local weather and climate data, the trend of the activity ratio of the two radionuclides whose origin is different was examined.



SAMPLING AND MEASUREMENTS



- Particulate collection was performed by aspiration of atmospheric air through 45x45 Sofiltra Poelman HYN-75 (Bleu type) cellulose filter paper using a high-volume air sampler located on the roof of our department 20 m above ground-level.
- The sampling time for all the particulate samples was 14 h from 6 p.m. to 8 a.m. the next day; the filtered air volume is typically about 10,000-12,000 m³.
- After particulate sampling, the filters were sprayed with a suitable fixer, cut into strips, folded and pressed into 6 cm side and 0.7 cm thickness packets by a 15-ton press. These samples are referred to as “packet-samples”.
- Actually the station is used occasionally and a renovation project has been drawn up with the use of automatic devices and a system for measurement of meteorological parameters.



SAMPLING AND MEASUREMENTS

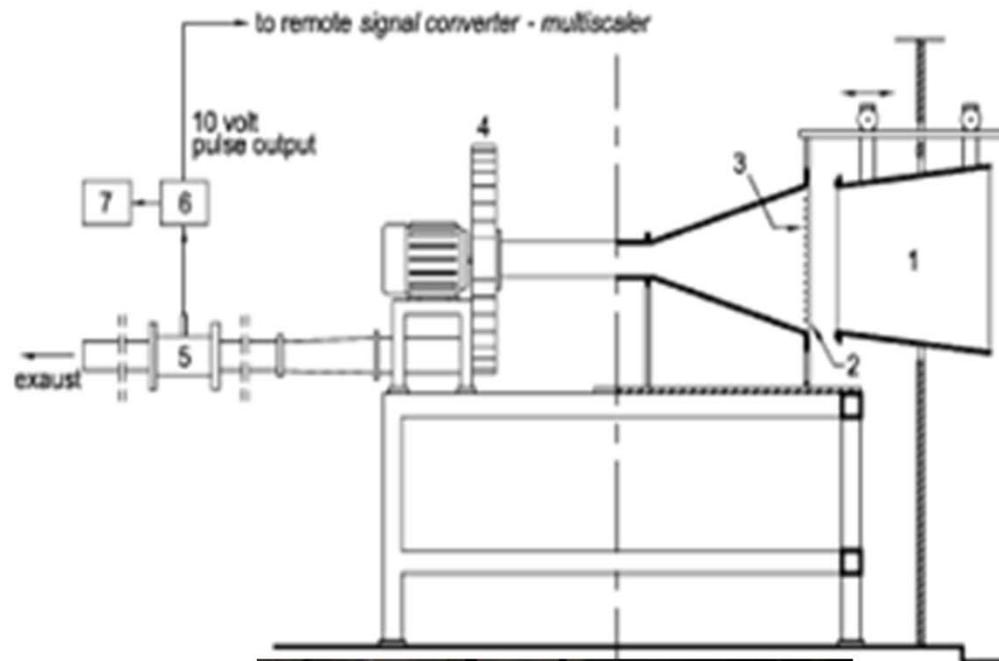
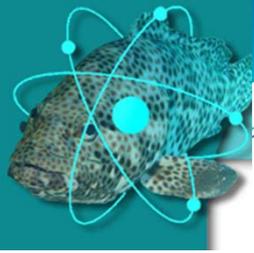


Fig. 1- Photograph and schematic of the sampling station with the indication of the main components. 1) Air inlet duct; 2) air entrance; 3) filter holder; 4) ventilating fan; 5) flow measurement turbine; 6,7) devices for generating flow signals.



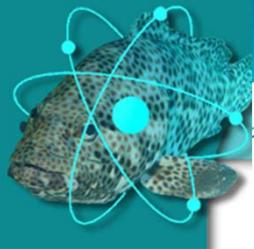
Fig. 2- Air particulate filter after the end of aspiration and reduced to "packet-sample" geometry .



SAMPLING AND MEASUREMENTS



- For ${}^7\text{Be}$ activity measurements a coaxial ORTEC GEM18180 detector with 18% relative efficiency, 2 keV FWHM at 1332 keV was principally used.
- For ${}^{210}\text{Pb}$, the same samples were measured by a GLP Series Planar Low-Energy Photon Spectrometer (LEPS), 1000 mm² active area and 7 mm depth, 0.254 mm thick beryllium window. The energy resolution (FWHM) is 440 eV at 5.9 keV and 620 eV at 122 keV.
- The electronic equipment associated with each detector consist generally of an ORTEC 672 amplifier and an ORTEC 919E EtherNIM multichannel Buffer connected into an Ethernet environment.
- The efficiencies of two systems for ${}^7\text{Be}$ and ${}^{210}\text{Pb}$ were previously determined as described (Cannizzaro et. al, 1999; Tomarchio, 2013, ...).
- In all the sample measurements, values of corresponding photopeak count rate for both ${}^7\text{Be}$ and ${}^{210}\text{Pb}$ turned out to be much larger than the detection limit of spectrometric analysis systems. This is due to high sampled air volume (about 12,000 m³ in 14 h) and to the use of a new HPGe planar detector, particularly suitable to detect 45.6 keV gamma-rays of ${}^{210}\text{Pb}$.



SAMPLING AND MEASUREMENTS

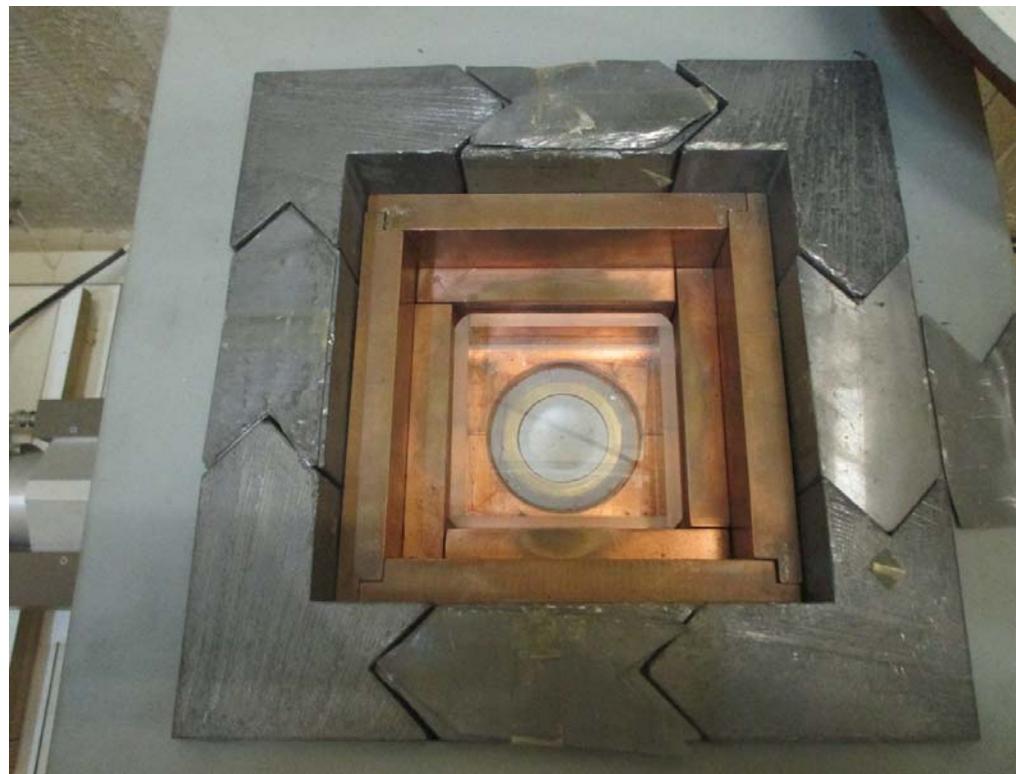
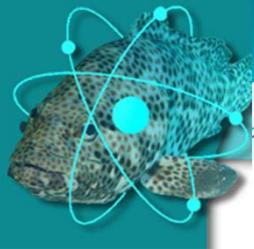


Figure 3 - Photographs of the spectrometric system and details of the measurement cavity filled with OFHC copper.



SAMPLING AND MEASUREMENTS

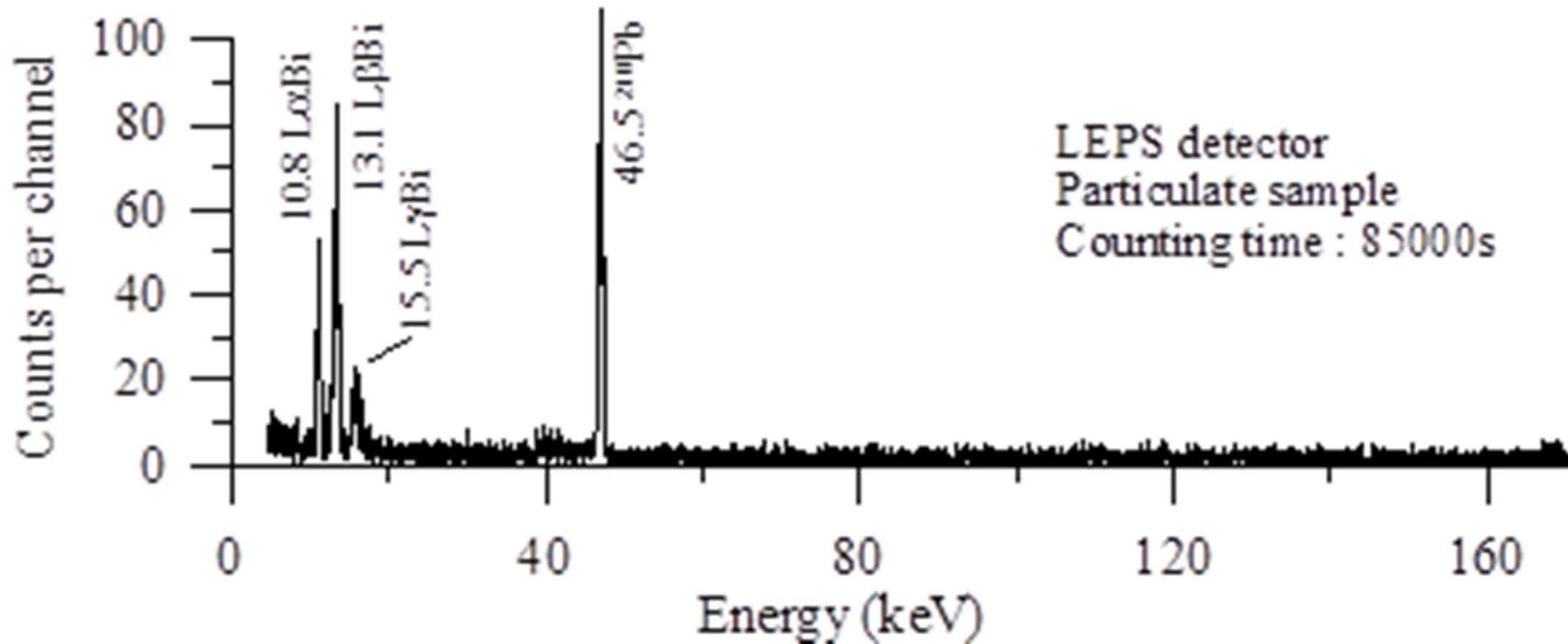
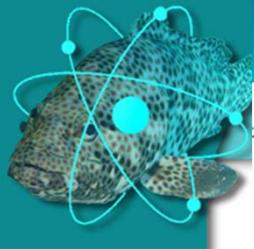


Figure 4 – Example of a gamma-ray spectrum detected on a filter sample with LEPS GLP Detector. The photoelectric peak at 46.5 keV of the ^{210}Pb and the peaks corresponding to Bi fluorescence energies are evident.



RESULTS AND DISCUSSION



Figure 5 - Daily air concentration of ^7Be for 1995–2004.

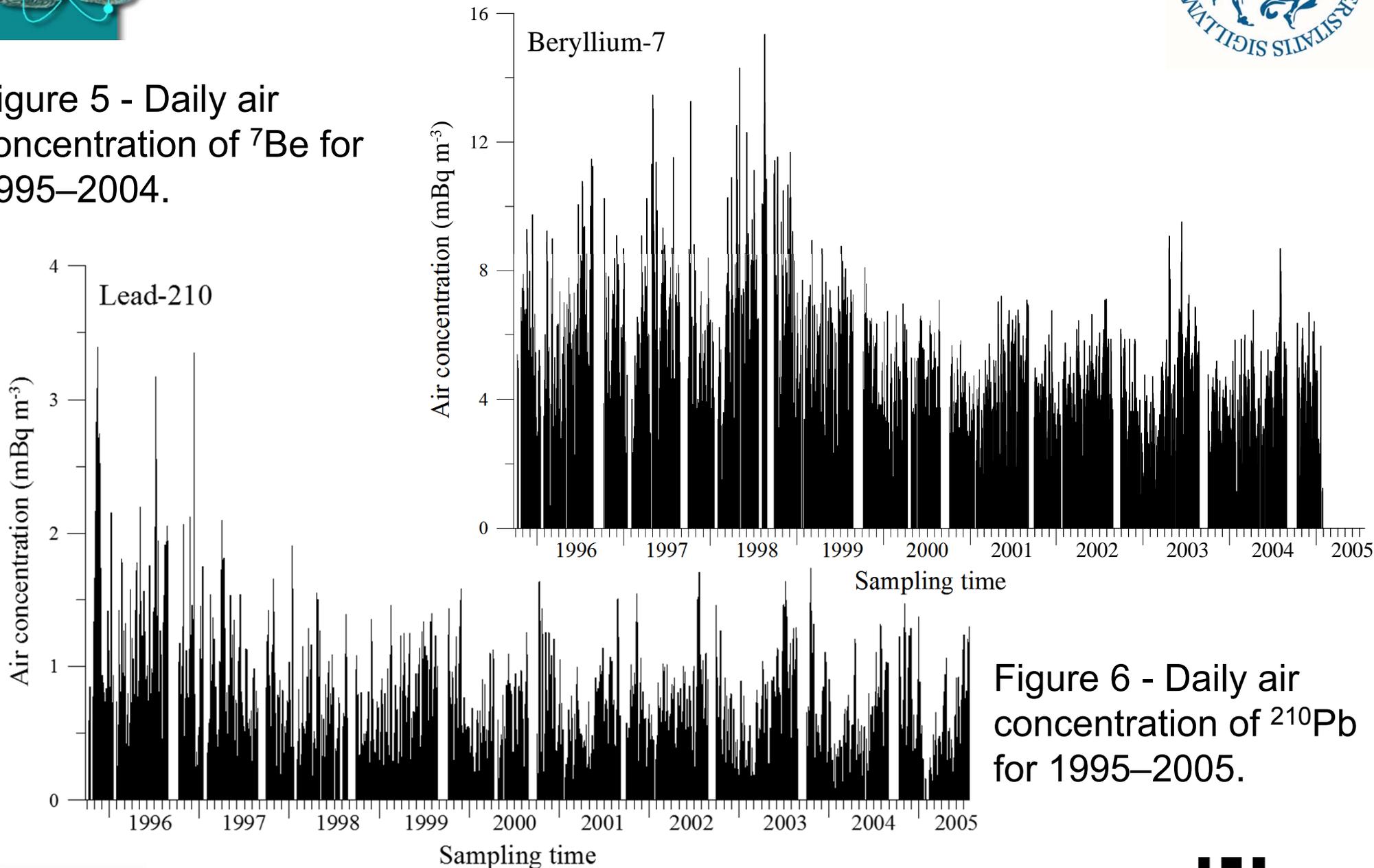
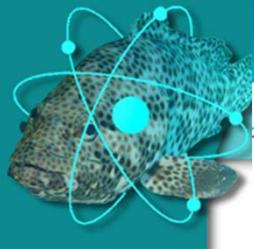


Figure 6 - Daily air concentration of ^{210}Pb for 1995–2005.



RESULTS AND DISCUSSION



Figure 7 - Average monthly air concentration of ^7Be , for the period 1995–2004.

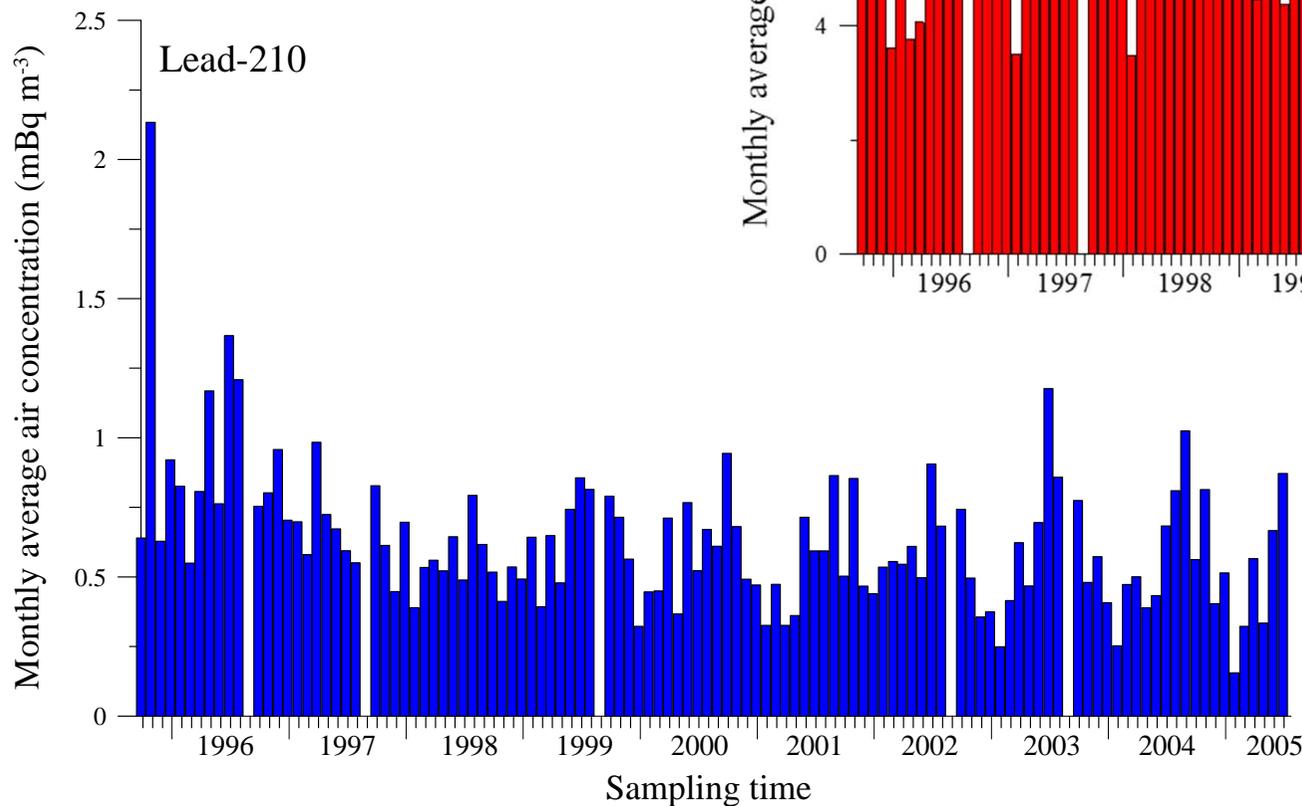
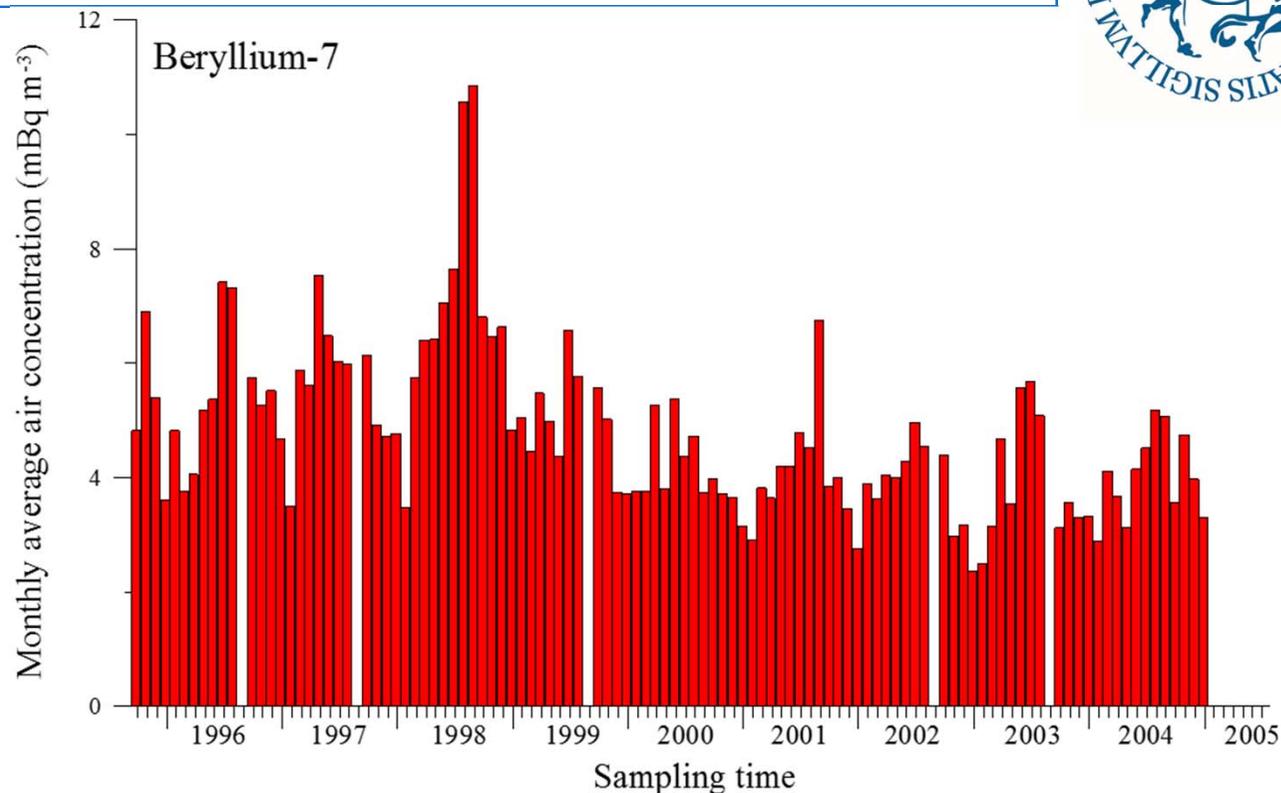
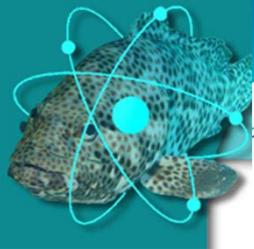


Figure 8 - Average monthly air concentration of ^{210}Pb , for the period 1995–2005.



RESULTS AND DISCUSSION

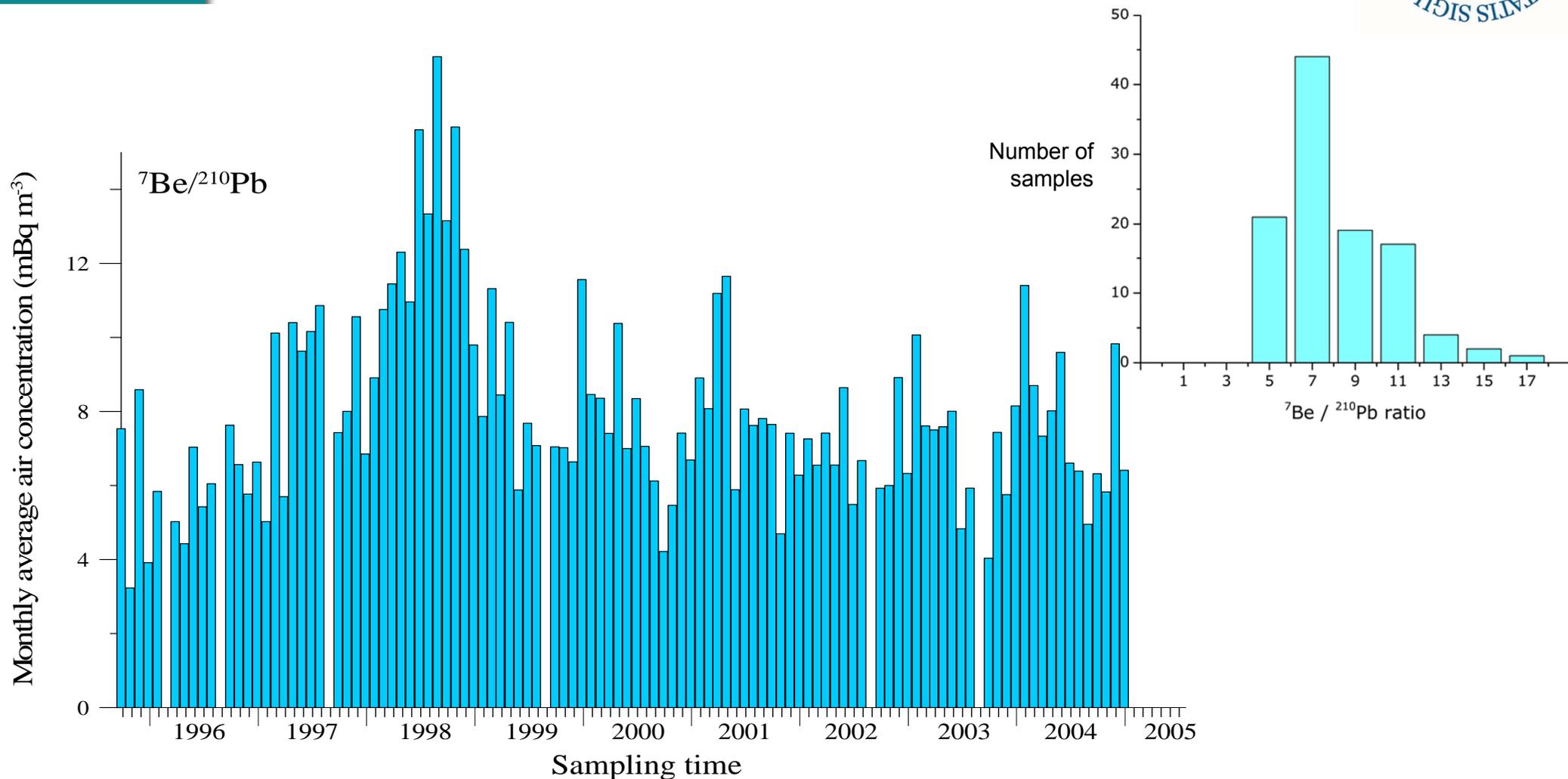
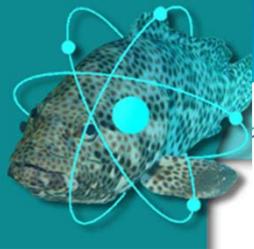
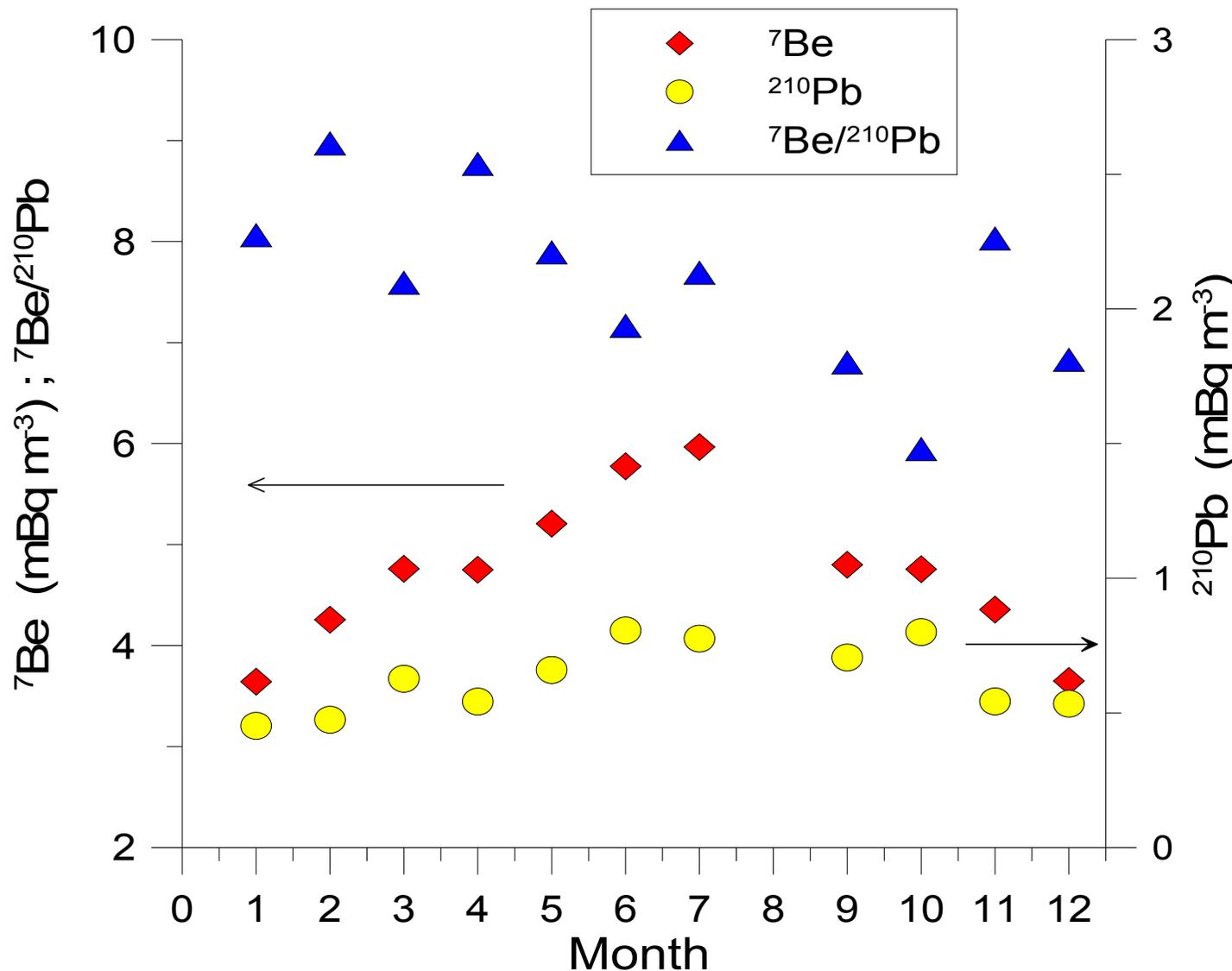


Figure 9 - Time series of monthly averaged ${}^7\text{Be}/{}^{210}\text{Pb}$ specific activity ratios. Frequency distribution function of monthly averaged ${}^7\text{Be}/{}^{210}\text{Pb}$ specific activity ratios.

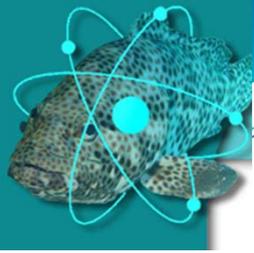


RESULTS AND DISCUSSION



Years : 1995-2005

Figure 10 – Behaviours of average of monthly average of ${}^7\text{Be}$ and ${}^{210}\text{Pb}$ air concentration, and ${}^7\text{Be}/{}^{210}\text{Pb}$ activity ratio.



RESULTS AND DISCUSSION

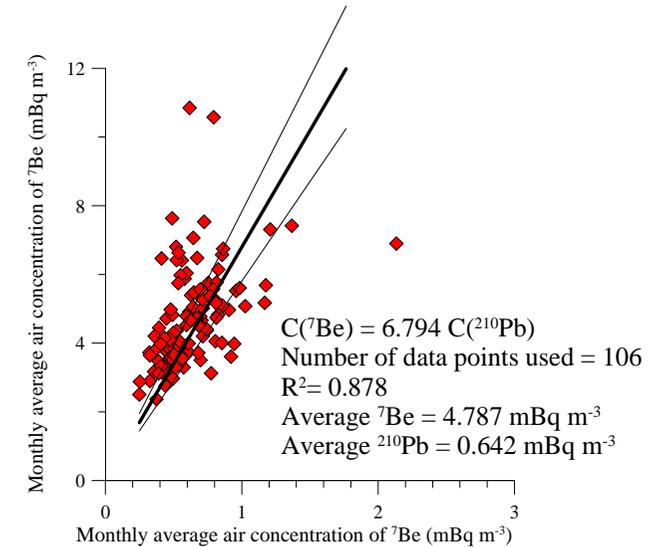
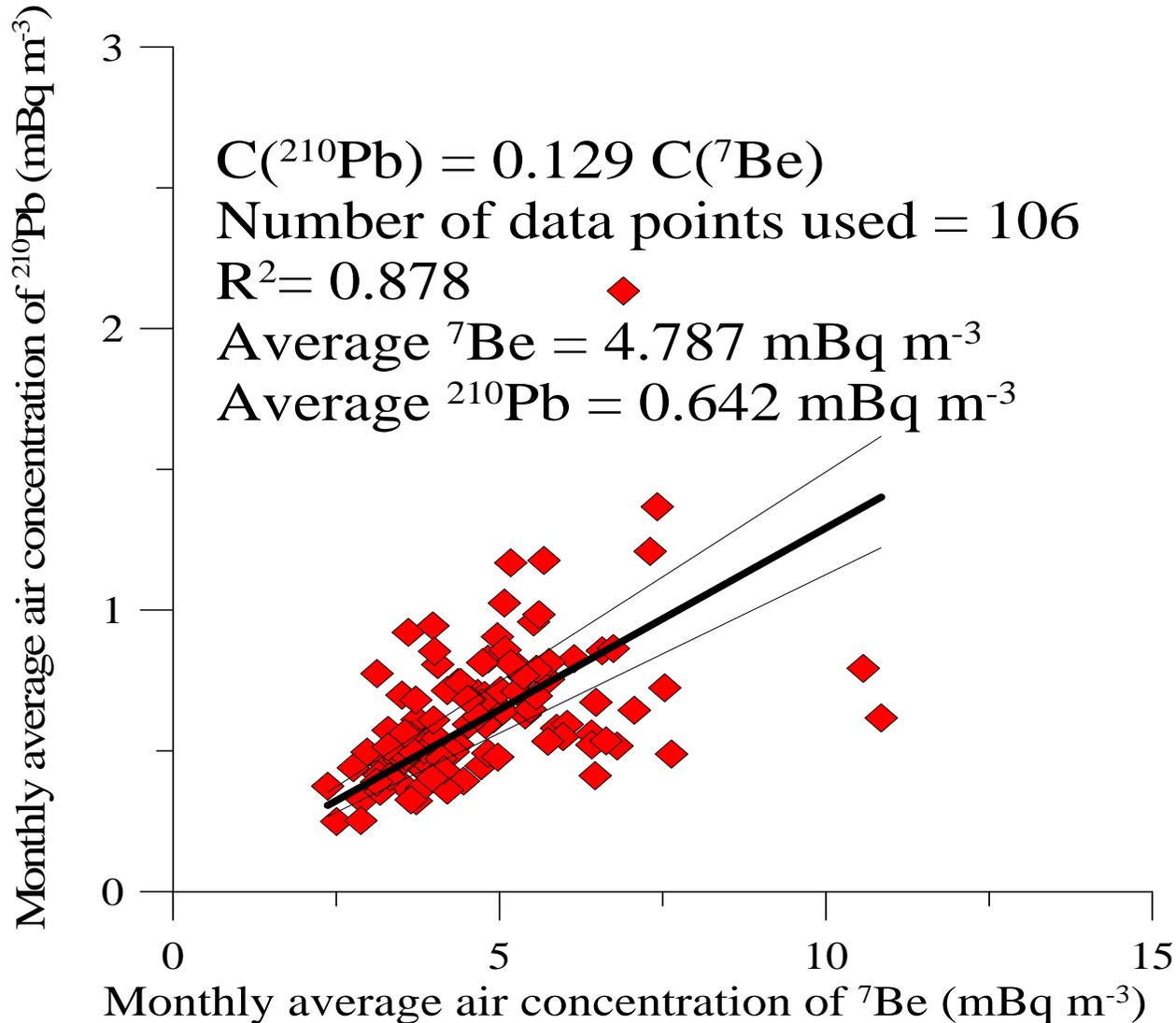
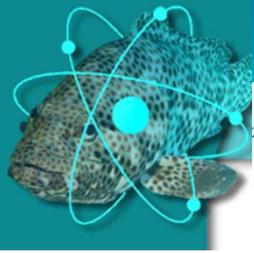


Figure 11 - ^7Be vs ^{210}Pb specific activity. A linear fitting through the origin is also shown. Despite their origin, a correlation seems to be exist.

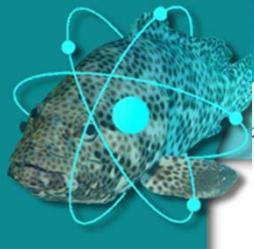




CORRELATION WITH METEOROLOGICAL PARAMETERS



Correlation with weather and climate parameters was also studied. Among the various parameters, there was a weak correlation with precipitation, but only with ^7Be , although this correlation can be assessed on a monthly basis, i.e. with the total amount of rainfall in the month. As already reported in [Cannizzaro *et al.*, 1999, 2004] there is a decrease in concentrations as the amount of precipitation increases, while the correlation with the average daily temperature appears even weaker. There is no evidence of correlation with relative humidity and the change in atmospheric pressure, while a dependence of the activity of ^{210}Pb on the wind direction, although referred to a period of time, has been demonstrated. In fact, ratio of $^7\text{Be}/^{210}\text{Pb}$ activities increases when NW wind direction (from the sea) is prevalent, because the maritime air masses have a lower Radon concentration.



CORRELATION WITH METEOROLOGICAL PARAMETERS



Figure 12. Correlation between the average monthly concentration of ${}^7\text{Be}$ and the amount of monthly rainfall.

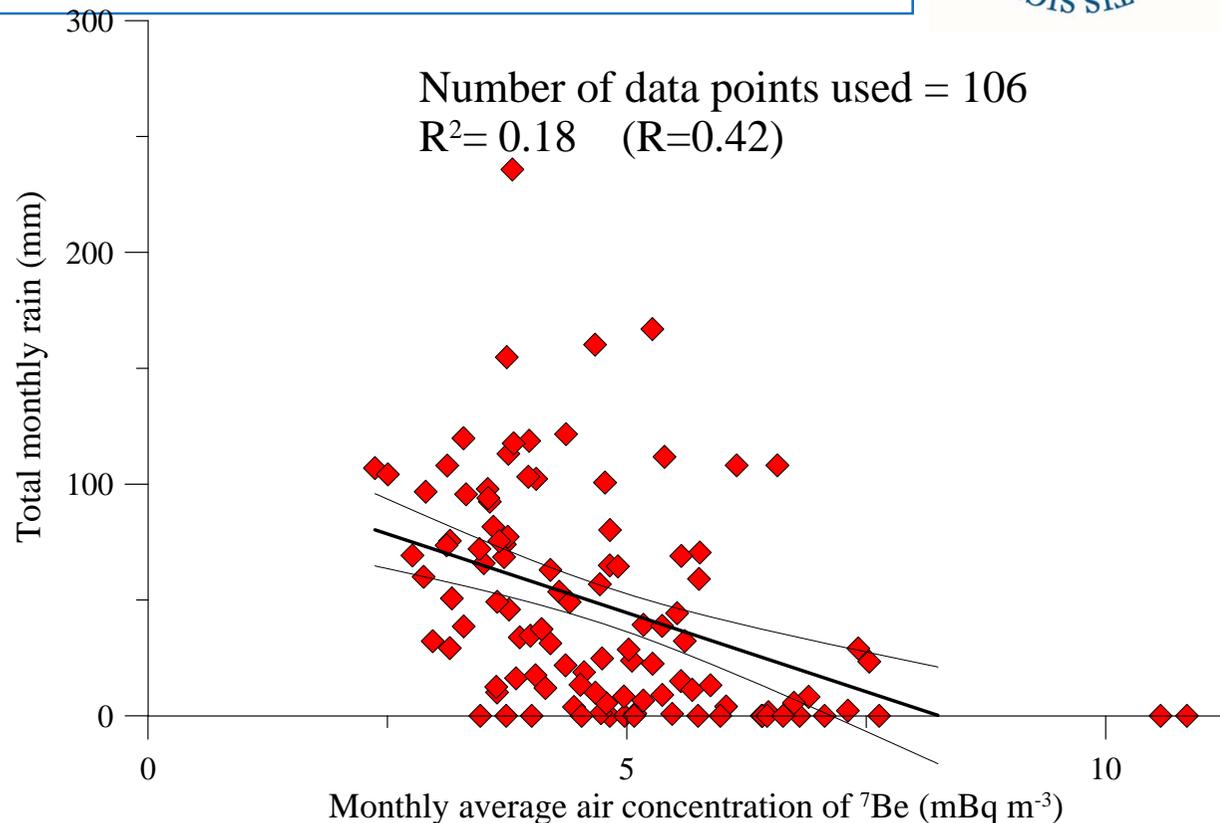
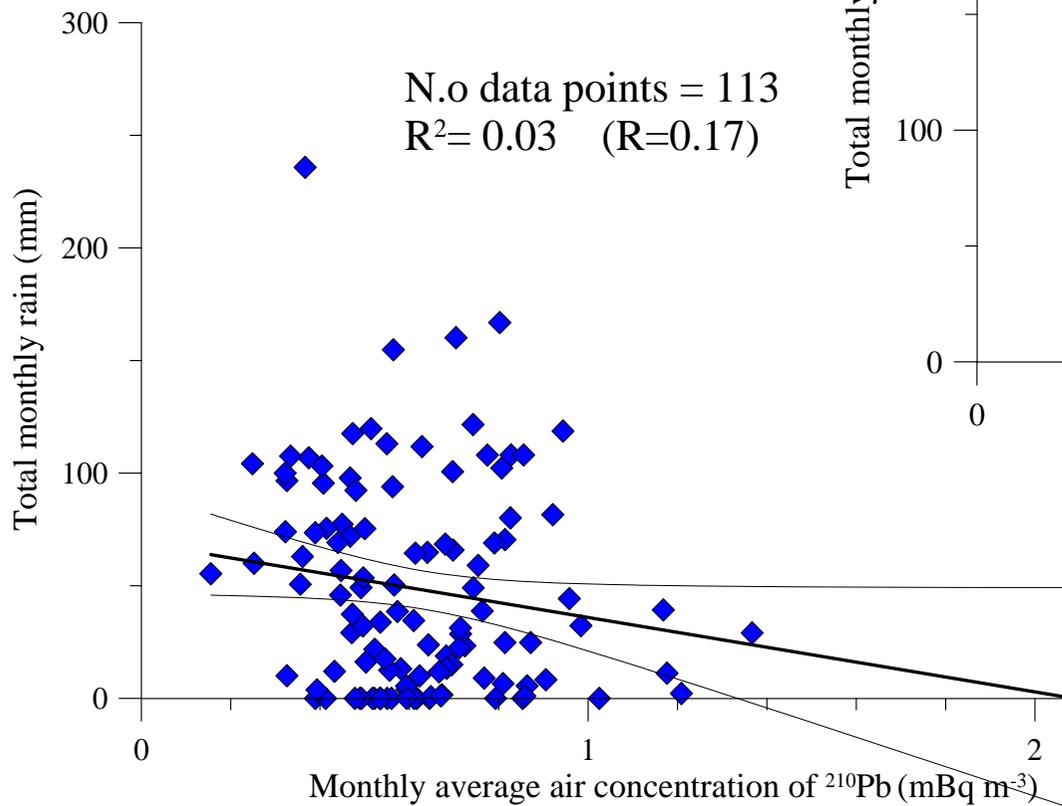
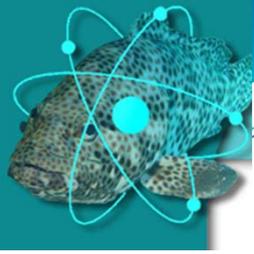


Figure 13-Correlation between the average monthly concentration of ${}^{210}\text{Pb}$ and the amount of monthly rainfall.



STATISTICAL ANALYSIS OF DATA



- The specific activities time series were reconstructed for the monthly and weekly average values in order to make homogeneous comparisons with available data from other geographical areas.
- Statistical analyses of specific activities values and their ratios have been carried out.
- Frequency distribution functions have been fitted using log-normal curves.
- A Fourier analysis has been performed, showing a common period of about 12 months. ^7Be also shows an additional time period corresponding to the 11 years sunspot number cycle, with which its concentration is anti-correlated.
- Correlations with precipitation and temperature have also been taken into account.

STATISTICAL ANALYSIS OF DATA

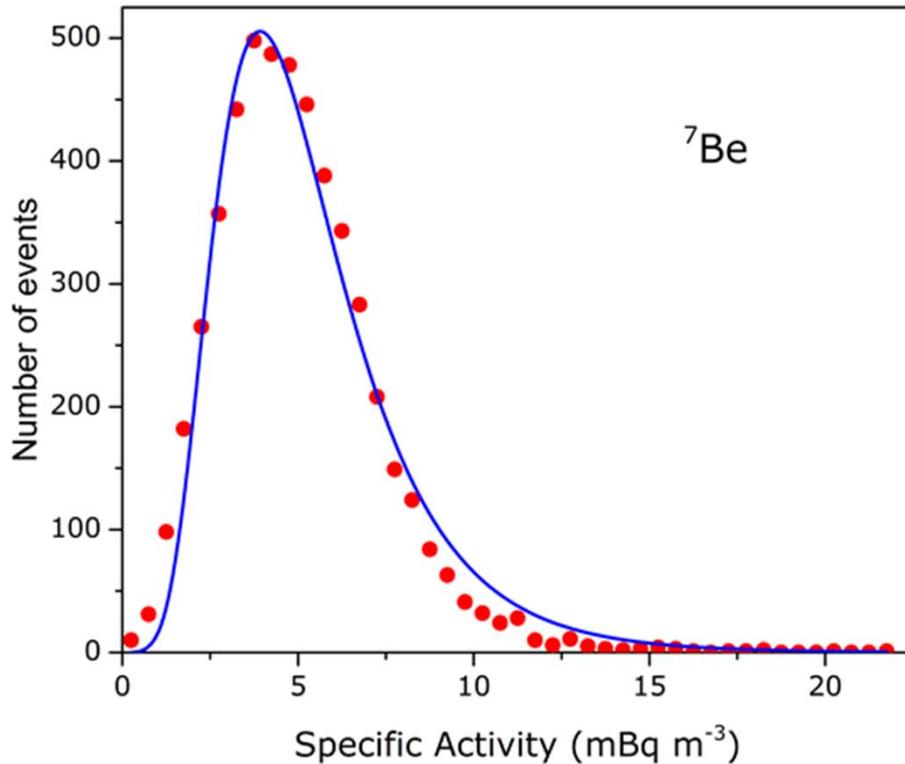
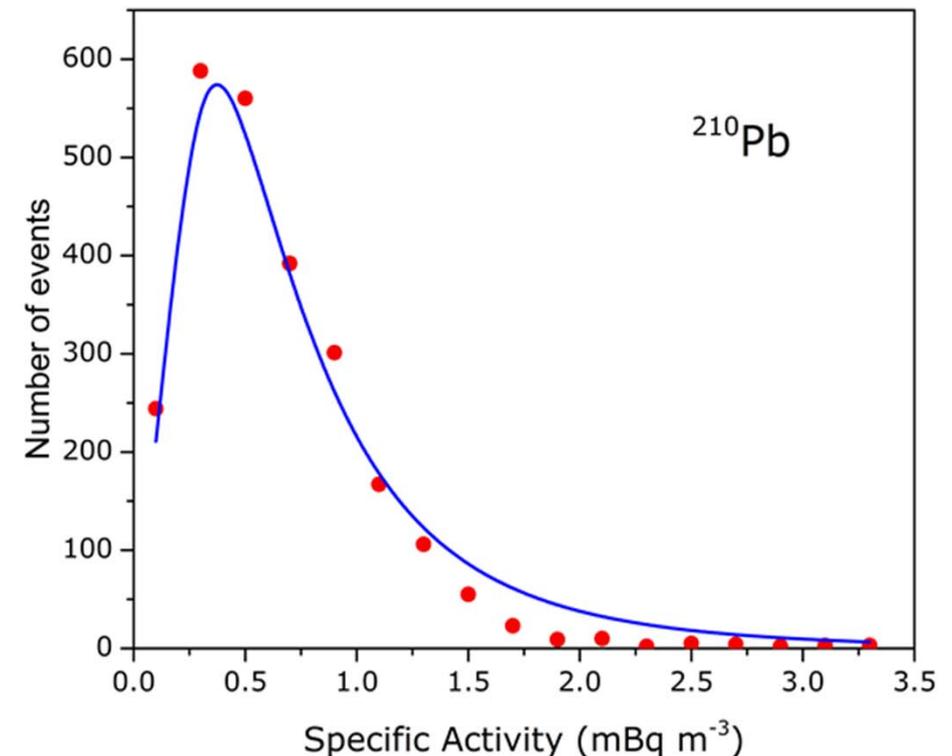
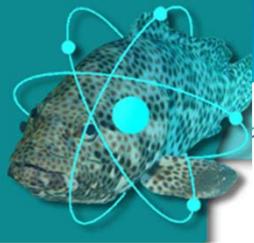


Figure 14 - Frequency density function for the measured values of ${}^7\text{Be}$ specific activity in mBq m^{-3} (points) along with a log-normal fitting (line). The R^2 value is 0.987.

Figure 15 - Frequency density function for the measured values of ${}^{210}\text{Pb}$ specific activity in mBq m^{-3} (points) along with a log-normal fitting (line). The R^2 value is 0.989.





STATISTICAL ANALYSIS OF DATA

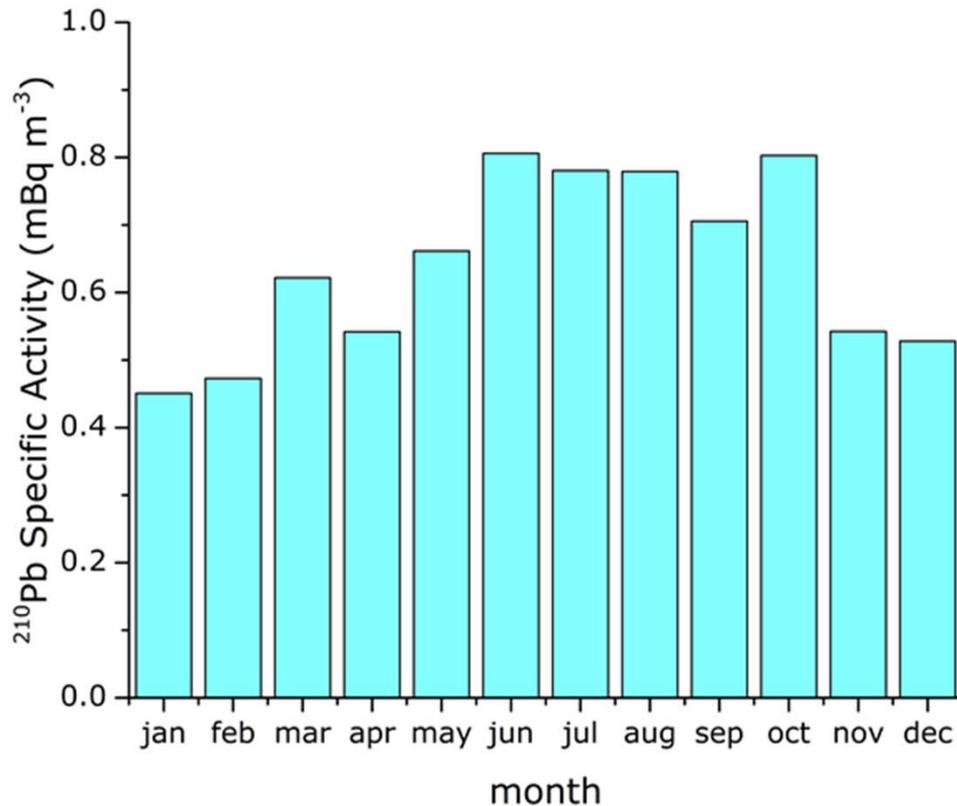
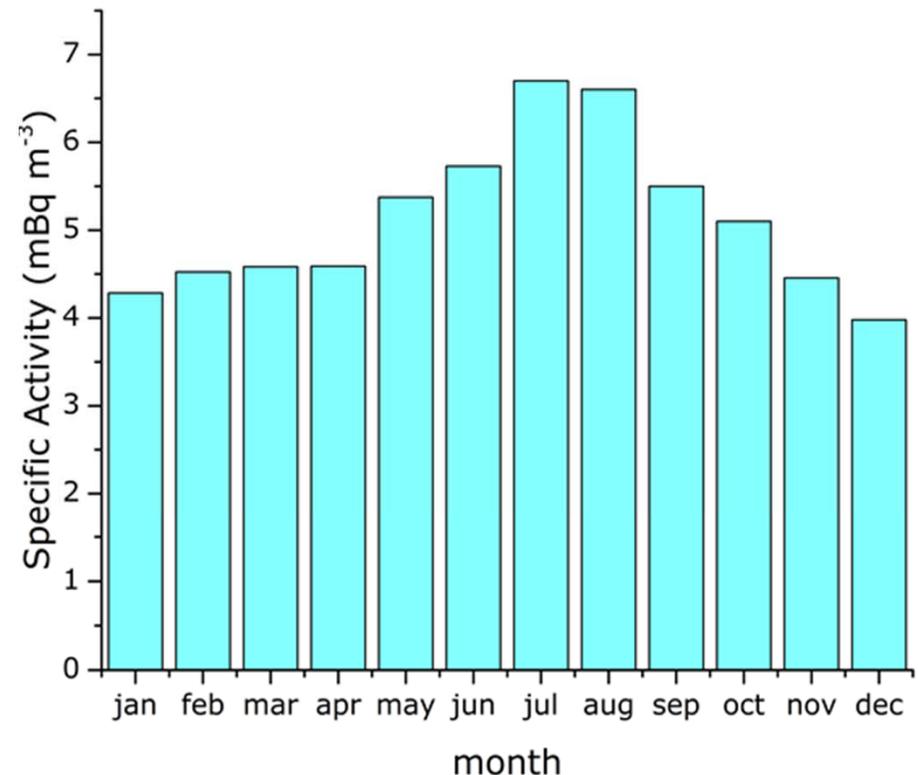
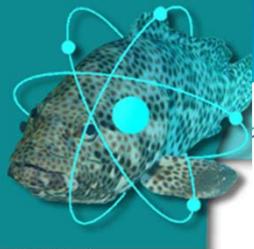


Figure 17 - Monthly averaged ⁷Be specific activity in mBq m⁻³. It is highlighted an increase during warmer months.

Figure 16 - Monthly averaged ²¹⁰Pb specific activity in mBq m⁻³. A small increase of averaged specific activity occurs in the Summer-Autumn months.





STATISTICAL ANALYSIS OF DATA

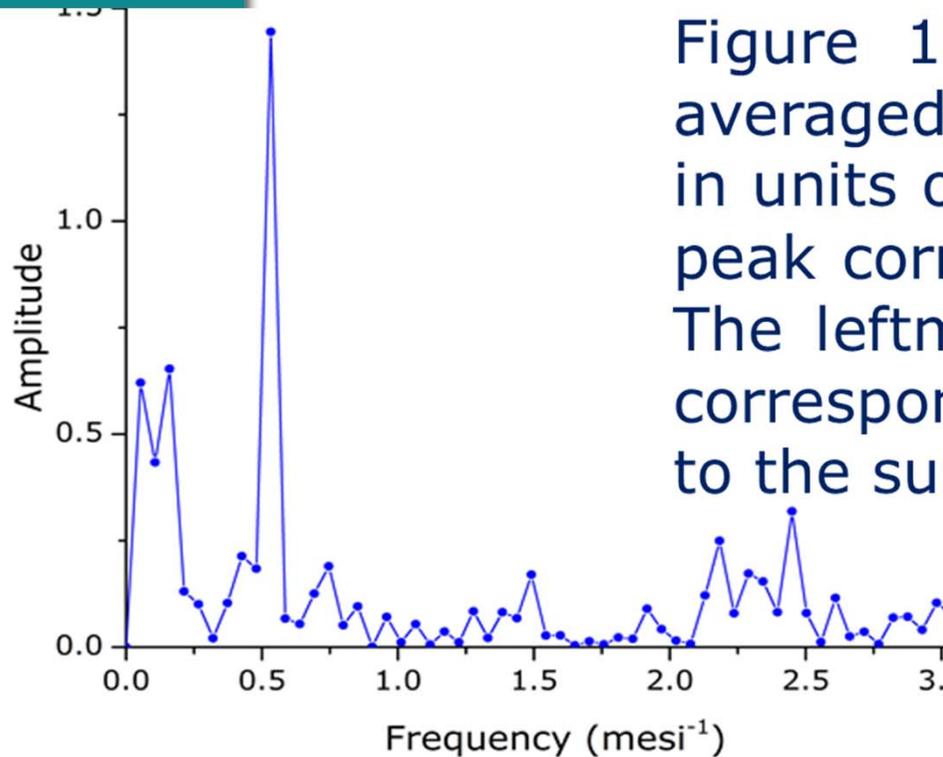
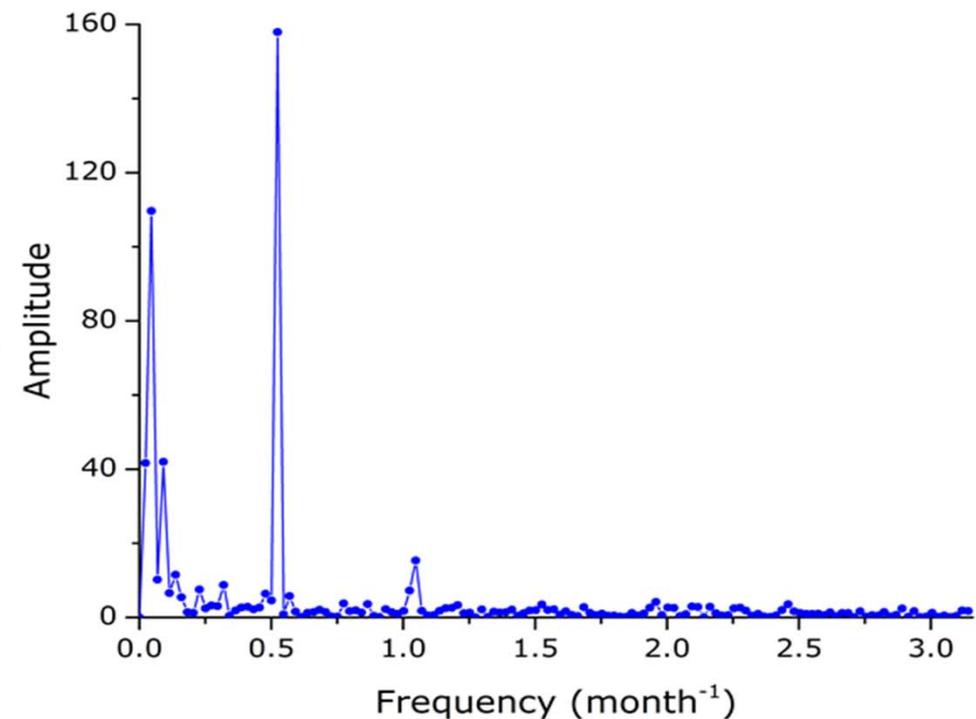
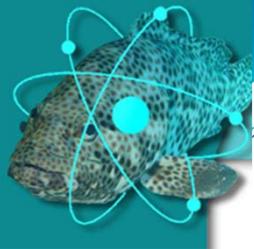


Figure 18 - Spectral analysis of monthly averaged ${}^7\text{Be}$ specific activity. Frequency is in units of $2\pi/T$, with T in months. The main peak corresponds to a period of 12 months. The leftmost peak at a frequency of 0.046 corresponds to a period of 11.5 years, close to the sun spot period.

Figure 19 - Spectral analysis of monthly averaged ${}^{210}\text{Pb}$ specific activity. Frequency is in units of $2\pi/T$, with T in months. The main peak corresponds to a period of 12 months.





STATISTICAL ANALYSIS OF DATA

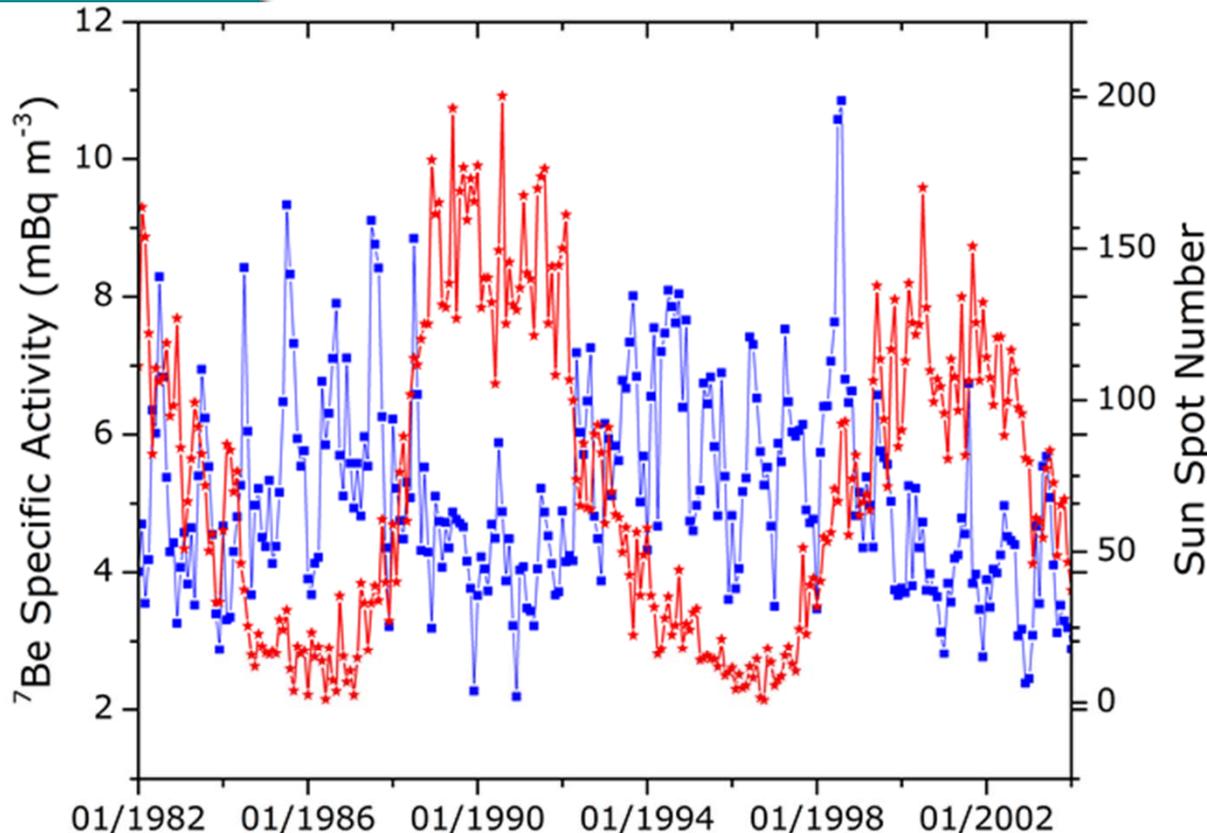
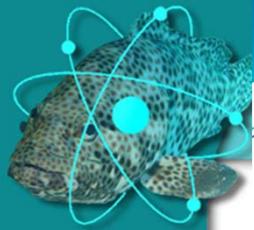


Figure 20 - Time series of monthly averaged ^7Be specific activity (blue), along with Sun Spot Number. An anti-correlation is clearly visible.

The graph shows a phase opposition between the two series. The correlation coefficient r between the two series is approximately -0.349 . The significance of the correlation coefficient was verified by submitting the variable to a t-test

$$t = |r| \sqrt{n-2} / \sqrt{1-r^2} \approx 6.17$$

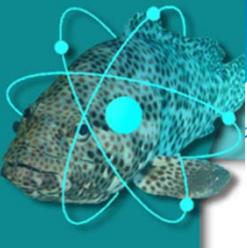
where n indicates the size of the data series (276 in our case). For an α -level of 0.05 we obtain a p-value of about $2.45 \cdot 10^{-9}$ and a t of about 1.97 [Miller and Miller, 2011].



CONCLUSIONS



- The results of the study about the behavior of ^7Be and ^{210}Pb air activity concentration and of $^7\text{Be}/^{210}\text{Pb}$ activity ratio confirm the suitability of the above-mentioned analyses as sensitive tools for studying air transport processes.
- The observed correlation between ^7Be and ^{210}Pb concentrations demonstrates that the air movement is more important than their origin to understand their behavior in the atmosphere.
- Beryllium-7 concentration increase during warmer months is explained with vertical air mixing and a transport of cosmogenic radionuclides towards low atmospheric level.
- The similar increase on ^{210}Pb concentration in Summer/Autumn months can be related, probably, to a recirculation of ^{210}Pb deposited in ground surface and not already migrated into the soil.
- Seasonal variation seems related to temperature change and rain quantity more than pressure change or relative humidity.
- The correlation that was observed between ^{210}Pb and ^7Be concentrations hints that these two radionuclides could be used as tracers of environmental processes.



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activity ratio in ground level air at Palermo (Italy)**

**THANKS FOR YOUR ATTENTION !!!
QUESTIONS ?**

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