# THE $^{40}K$ USED AS TRACER OF SAHARAN DUST CONTRIBUTIONS

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**INTRODUCTION**. The present study is carried out in Málaga, frequently affected by intrusions of air masses with high concentrations of atmospheric particulate matter. $^{40}K$ is a natural radionuclide and has been associated with the arrival of coarse re-suspended material from the Africa continent. A systematic 13-year analysis (January 2005-December 2017) of the concentration of radionuclides in bulk (wet + dry) deposition and PM10 air concentrations has been performed to test the possible utility of $^{40}K$ as tracer of African mineral dust inputs in Málaga (4° 28' 8" W ;36° 43' 40" N). Also the atmospheric aerosols are collected using a high volume sampler during 9-year (January 2009-December 2017). It is a prerequisite to know the environmental long-term behaviour of radionuclides an a relatively large number of values are required for statistically meaningful conclusions . The identification of African dust events was carried by 96-hour back-trajectory analysis arriving at thee different heights (500 m, 1500m, 3000m a.g.l.) calculate with the HYSPLIT model , and by the information obtained from the output of the dust regional Atmospheric model (DREAM 8b).

## MATERIAL AND METHODS

The sampling site is one of the environmental radioactivity monitoring network stations operate by the Spanish Nuclear Security Council (CSN). The sampling point is located above the ground, on the roof of the SCAI (24 m.a.s.l.), University of Málaga. Monthly precipitation and dry fallout samples were routinely collected on a monthly basis using a steel tray 1m$^2$ in area as a collecting system and polyethylene vessels of 25L capacity for rainwater samples reservoirs. Also, the atmospheric aerosols are collected using a high volume sampler with flow rate of about 8500 L min$^{-1}$. The sampling station used to collect aerosol samples was a PTI ASS-500. TSP (total suspended particulate) air pump G3 polypropylene filters (44x44 cm$^2$) were been used during sampling and were changed weekly. Measurements by gamma spectrometry were performed to determine the $^{40}K$ activities of the samples by intrinsic REGe detector.

## RESULTS AND DISCUSSION

The results from specific activities (Bq/L) of $^{40}K$ in bulk, $^{40}K$ (µBq/m$^3$) in air, PM10 and monthly number of days affected by intrusions were analyzed to derive the statistical estimates. Table 1 provides the summary of the descriptive statistics such as number of samples (N), arithmetic mean (AM), geometric mean (GM), standard deviation (SD), maximum (MAX) and minimum (MIN) values, the coefficient of variation (CV) and Skewness (GI).

***Table 1.-*** **Summary statistics of the activity concentrations of the 40K in bulk and air, PM10 and monthly days affected by African outbreaks.**

| | N (monthly) | AM | GM | SD | MAX | MIN | CV(%) | GI |
|---|---|---|---|---|---|---|---|---|
| K bulk (Bq/L) | 77 | 0.20 | 0.17 | 0.14 | 0.84 | 0.06 | 68 | 9.4 |
| K air (µBq/m$^3$) | 107 | 21.3 | 20.7 | 0.72 | 56.4 | 0.07 | 34 | 9.2 |
| PM10 (µg/m3) | 156 | 28.6 | 25.9 | 12.7 | 84 | 5.0 | 45 | 3.7 |
| Intrusions (number of days affected by African outbreaks | 156 | 10 | | 7.3 | 29 | 0 | 75 | -1.5 |

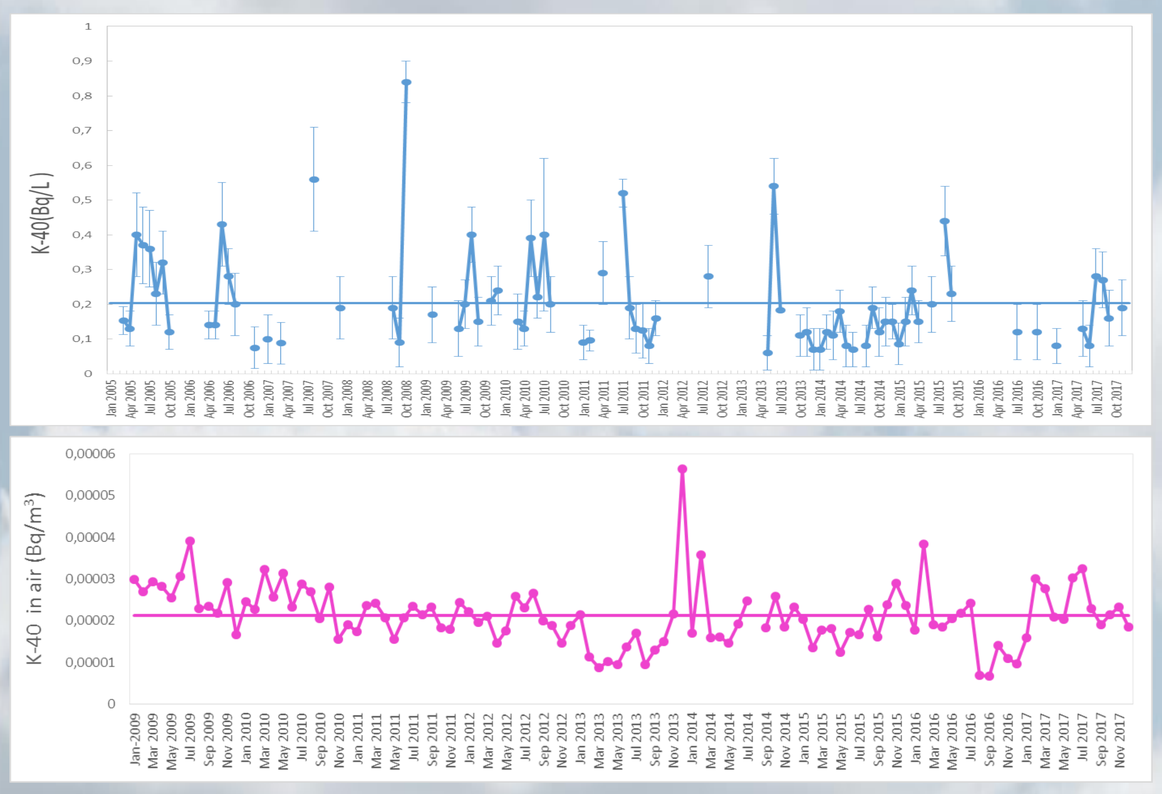


***Fig.1.-*** **Temporal evolution of $^{40}K$ in bulk and $^{40}K$ in air during the periods of January 2005-December 2017 and January 2009-December-2017, respectively**

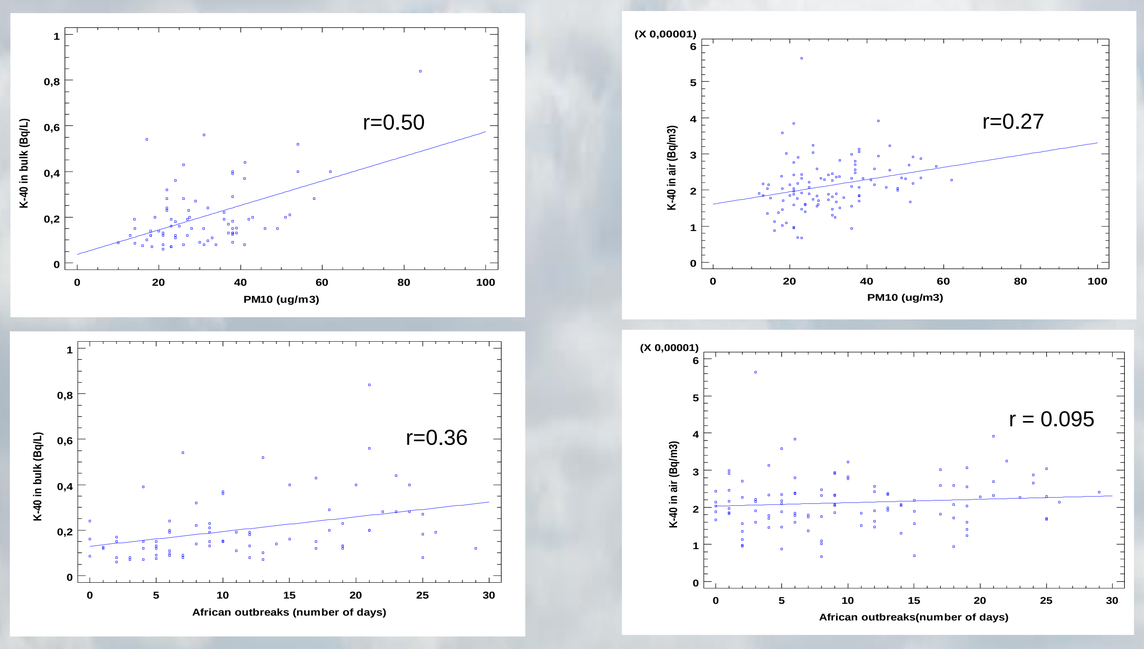


***Fig. 2.-*** **Scatter plots of $^{40}K$ in bulk and air versus PM10 and number of days affected by intrusions**

The $^{40}K$ in bulk deposition shows good correlations with PM10 and number of days affected by intrusions (0.50 and 0.36 respectively) while the $^{40}K$ in air presents lower correlations (0.27 and 0.095 respectively).

***Figure 3*** shows the seasonal variations of $^{40}K$ in bulk and air, PM10 and monthly days affected by intrusions. The highest values were observed in Spring and Summer and the lowest ones in Winter and Autumn, except $^{40}K$ in air, that is constant in all seasons approximately.

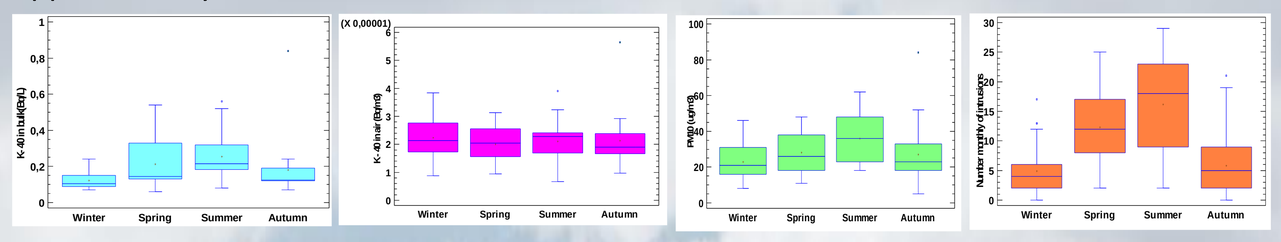


***Fig. 3.-*** **Seasonal variation of specific activities of $^{40}K$ bulk, $^{40}K$ air, PM10 and number of days affected by intrusions**

a)

| | PC1 | PC2 | PC3 |
|---|---|---|---|
| K-40 bulk | -0.060 | **0.732** | -0.077 |
| Air humidity | **0.797** | -0.065 | 0.014 |
| Number of intrusions | -0,.94 | **0.601** | -0.274 |
| Monthly distance travelled by wind | -0.096 | -0.031 | **0.956** |
| Air temperature | **-0.614** | **0.630** | -0.085 |
| PM10 | 0.118 | **0.800** | 0.191 |
| Rainfall amount | **0.878** | 0.031 | 0.027 |
| Rainfall duration | **0.929** | -0.101 | 0.024 |
| Wet days | **-0.930** | -0.143 | -0.110 |
| Dry days | **-0.921** | 0.157 | 0.096 |

b)

| | PC1 | PC2 | PC3 |
|---|---|---|---|
| K-40 air | 0.018 | 0.343 | **0.691** |
| Air humidity | **0.756** | -0.065 | -0.190 |
| Number of intrusions | -0.319 | **0.770** | -0.070 |
| Monthly distance travelled by wind | -0.109 | -0.156 | **0.740** |
| Air temperature | **-0.521** | **0.735** | -0.141 |
| PM10 | -0.040 | **0.822** | 0.285 |
| Rainfall amount | **0.906** | -0.092 | -0.070 |
| Rainfall duration | **0.920** | -0.163 | -0.002 |
| Wet days | **0.873** | -0.329 | 0.031 |
| Dry days | **-0.847** | 0.371 | -0.036 |

***Table 2.-*** **Results from factor analysis applied on $^{40}K$ bulk, $^{40}K$ air and some parameters.**

The total variance explained is about 75% in both cases. PC1 illustrates correlations among some meteorological parameters. The main difference between $^{40}K$ in bulk and $^{40}K$ in air is that the first one is related with PM10, intrusions and air temperature (see PC2 Table 2a) whereas $^{40}K$ in air is only related with the wind (see PC3, Table 2b).

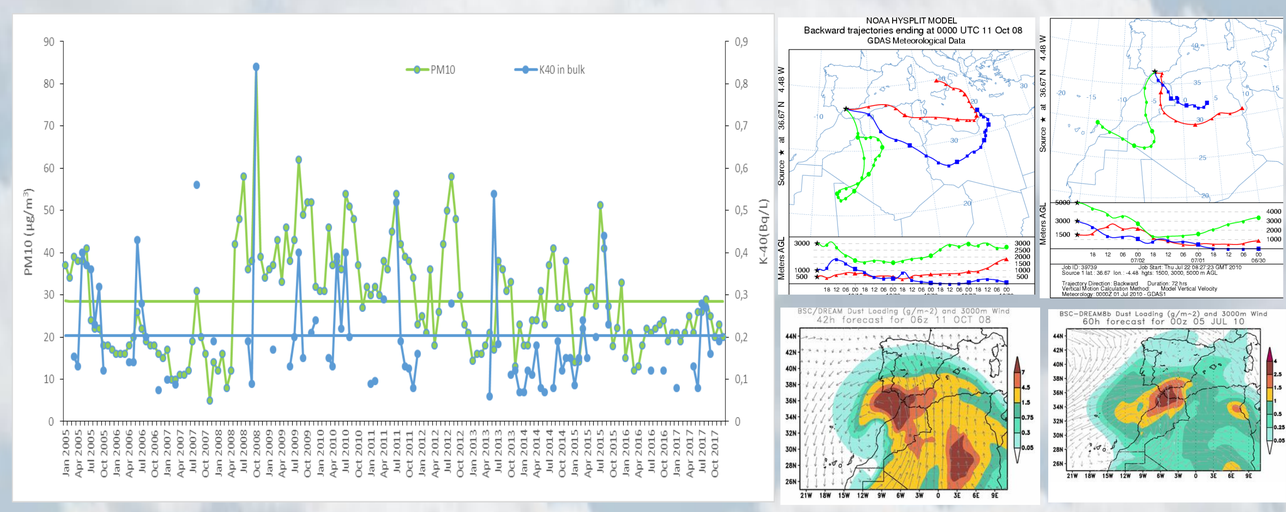


***Fig.4.-*** **Temporal evolution of $^{40}K$ in bulk and $^{40}K$ in air during the period of January 2005-December 2017. Some examples of backward trajectories and dust images.**

The identification of African events was confirmed by means of back-trajectory analysis (at 500m, 1500m, 3000m a.g.l.) and BSC-Dream8b dust images. Figure 4 shows two plots examples where $^{40}K$ and PM10 are máximum, being the origin of these events mainly from the North and West Sahara.

## CONCLUSION

- These results show that the monitoring of $^{40}K$ in bulk deposition at this coastal site gives information on the influence of African dust intrusions by the identified factors in the VARIMAX rotation, so it can be used as radiotracer of Saharan dust contributions.
- The $^{40}K$ in air only show correlation with monthly distance travelled by wind, identified in the VARIMAX rotation, probably due to its crustal origin as it is found in most kinds of soil, and can be easily lifted and transported by wind erosion and is associated with the arrival of coarse re-suspended material.

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