7Be as tracer on the investigation of upper tropospheric dispersion of Saharan dust during the Mid-Winter 2000 Storm Events (Azores).

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Introduction and Experimental

7Be is a radionuclide produced from spallation processes of light atmospheric nuclei such as nitrogen 14, oxygen 16 and carbon 12, with protons and neutrons (Zanis et al. 2000). By measuring the activity of beryllium isotopes attached to submicrometre aerosol particles, information on the mechanism of exchange between the atmosphere and troposphere is obtained.

An atmospheric baseline station was established on the western coast of Terceira Island-Azores in order to improve our knowledge about the marine aerosol characteristics and formation (latitude: 38°41′26″N, longitude: 27°21′15″; altitude: 50 m, about 15 Km of Angra do Heroísmo, the main town of Terceira island, with 20000 inhabitants).

The aerosol collected at the Azores, during the 2000 Saharan mid-winter dust storm events, represent four day integral samples, and were collected, between February 26 and March 18. They were collected on quartz fibre filters, put on sealed bags containing a small amount of air and expressed mailed to the USGS for measure Beryllium-7 activities by the Eastern Surface Processes Team (USGS).

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Results and Discussion

The activities over the study period, fit a best-fit least-squares linear regression equation:

\[ 7Be \text{ activity} = 4.3 \times 10^{-3} \times (\max50m) + 4.2 \times 10^{-3} \times (\max1000m) - 9 \times 10^{-4} \times (\min5000m) \]

(Equation 1)

where max50m is the maximum altitude observed on the isentropic air mass trajectory of 50 m, max1000m the maximum altitude observed on the isentropic air mass trajectory of 1000 m and min5000m the minimum altitude observed on the isentropic air mass trajectory of 5000 m. The beryllium activity is expressed in mBq m⁻³ and the multilinear regression coefficient (r) was 0.95 at 95% of significance.

Along the mineral aerosol transport from North Africa, decreases in ozone’s total over Terceira Island, detected by TOMS (Earth Probe – Total Ozone Mapping Spectrometer), were negatively correlated with the activities. We verified that the changes in ozone are related to changes in the activities, through a linear regression at 95% of significance level. The best-fit least-squares linear regression, gives the equation:

\[ \Delta \text{Ozone} = -1.86 (7Be \text{ activity}) + 6.07 \]

(Equation 2)

where Aneso is the variation of the total ozone over Terceira Island in Dobson units (DU), 7Be activity activity the variation of beryllium-7 activity in mBq m⁻³. The linear regression coefficient was 0.98, suggesting a stronger dependence between the ozone losses and vertical transports from upper troposphere to lower tropospheric layers.

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The PM10 mass in this period was not directly correlated with 7Be activity, but with exception of one point, decreases in 7Be activity correspond to decreases in PM10 mass in agreement with a more severe dry deposition during longer trajectories. During the February-March 2000 Saharan events, the highest PM10 mass observed in Azores was 16 µg m⁻³ and the lowest, under typical meteorological conditions, 5 µg m⁻³. The transport of the mineral aerosol from North Africa which crossed Central Europe before arriving to the Azores Archipelago, had a PM10 mass of 125, 101 and 64 µg m⁻³.

If we assume the data published by Dibb et al. 2000 for the upper-troposphere on Central North Atlantic, the 7Be activity under typical meteorological condition exhibits a exponential behaviour with altitude. The 7Be activity which results from the empirical model that uses the data published by Dibb et al. 2000, for the 50m altitude, is in complete accordance with the minimum observed at 50m on Terceira Island during the study period. The minimum 7Be activity observed at Terceira is also in accordance with the soil level 7Be activity, estimated by Bhanderi et al. 1996 for the Globe surface. Based on the empirical model, the minimum altitude for the long-range transport of mineral aerosol from the 2000 sand storm was estimated. It was seen that the minimum altitude of the aerosol-collected in February-March travelled an altitude between 3.4 to 4.3 km in troposphere, before its arrival to Azores. The lowest altitude was associated to the strong transport of mineral aerosol directly from Maghreb to Azores.

The highest altitude was associated to long range transport from North Africa to Central Europe, then by the influence of the Azores High located during this period near British Islands, it moved towards Azores Archipelago.

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References


