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Variation in airborne 137Cs peak levels with altitude from high-altitude locations across Europe after the arrival of Fukushima-labeled air masses

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During the Fukushima Daiichi nuclear power plant (FDNPP) accident, a dozen of high-altitude aerosol sampling stations, located between 850 and 3,454 m above sea level (a.s.l.), provided airborne activity levels across Europe (Fig. 1). This represents at most 5% of the total number of aerosol sampling locations that delivered airborne activity levels (at least one result) in Europe, in connection with this nuclear accident. High altitude stations are typically equipped with a high volume sampler that collects aerosols on filters. The Fukushima-labeled air mass arrival and the peak of airborne cesium-137 (137Cs) activity levels were registered in Europe at different dates depending on the location, with differences up to a factor of six on a regional scale. Besides this statement related to lowland areas, we have compared the maximum airborne levels registered at high-altitude European locations (850 m < altitudes < 3450 m) with what was observed at the closest lowland location. The vertical distribution of 137Cs peak level was not uniform even after a long travel time/distance from Japan. This being true at least in the atmospheric boundary layer and in the lower free troposphere. Moreover the relation '137Csmax vs. altitude' shows a decreasing trend (Fig. 2).

Results and discussion : Comparison of 137Cs and 7Be levels shows simultaneous increases at least when the 137Cs airborne level rose for the first time (Fig. 3). Zugspitze and Jungfraujoch stations attest of a time shift between 7Be and 137Cs peak that can be due to the particular dynamic of air movements at such high altitudes. After the 137Cs peak value, the plume concentration decreased whatever the 7Be level. Due to the cosmogenic origin of 7Be, its increase in the ground-level air is usually associated with downwind air movements, i.e. stratospheric air intrusions or at least air from high-tropospheric levels, into lower atmospheric layers. This means that Fukushima-labeled air masses registered at ground level were transported until Europe at rather high altitudes. This is consistent with 137Cs activity levels and 133Xe observations performed at the tropopause level thanks to aircraft samples over Germany and Switzerland (Estier and Steinmann). This also validates dispersion model computation according to which the Fukushima-labeled air masses were transported to Europe above 5500 m a.s.l.

Conclusions : High altitude locations are on 'sentry duty' for radioactive monitoring and cross-border spreading of a contaminated plume. In this sense they can provide useful information on the vertical spreading of radionuclides, reveal arrival times over a given region and make it possible to explain ground deposition levels as a result of interactions of cloud droplets or rain drops with aerosols at high altitude. Beside non-homogeneities encountered on the European scale at lowland locations, this study shows that 137Cs peak activity levels regularly decreased between about 3500 m and less than 1000 m a.s.l. In addition field measurements confirm that air masses travelled at high altitude and that the 137Cs peaks were due to air masses coming from high tropospheric levels. This study also highlights the need to reinforce high-altitude aerosol sampling during emergency situations. This will make it possible to specify the dispersion conditions for modeling purposes and help explaining simulation and observation discrepancies.