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Short communication

Arrival of radionuclides released by the Fukushima accident to Tenerife (Canary Islands)

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ABSTRACT

Two weeks after the accident at the Fukushima-Daichi nuclear power plant, 131I, 137Cs and 134Cs activities were measured in two different stations located in Tenerife (Canary Islands), situated at 300 (FIMERALL) and 2400 (IZAÑA) m.a.s.l, respectively. Peak measured activity concentrations were: 1.851 mBq/m3 (131I); 0.408 mBq/m3 (137Cs) and 0.382 mBq/m3 (134Cs). The activities measured at the FIMERALL station were always higher than at IZAÑA station, suggesting that the radioactive plume arrived to the island associated with low altitude air masses. Simulations of potential dispersion of the radioactive cloud (137Cs) after the nuclear accident in reactor Fukushima I show that radioactive pollution reached remote regions such as the Canary Islands in the Eastern subtropical North Atlantic. The corresponding effective dose to the local population was 1.17 nSv, a value less than one millionth of the annual limit for the general public. Therefore, there was no risk to public health.

1. Introduction

On March the 11th, 2011 a huge earthquake (9 in the Richter scale) took place on the Pacific Ocean, close to the east coast of Japan. The epicentre was located at 38.32°N, 142.37°E. The earthquake caused a powerful tsunami that devastated many of the coastal regions of Japan. The Fukushima-Daichi nuclear power station was critically damaged. Several explosions happened within the reactor plant of the Fukushima station due to both the earthquake and tsunami. Initially, controlled emissions of radioactive gases were released from the plant by the operators. Subsequently, the explosions released a large quantity of radioactive material to the atmosphere and to the sea. From 21 March to 30 April the power plant released 15,000 TBq of radioactive iodine and caesium to the sea water (IAEA, 2011a). According to data released by the Nuclear and Industrial Safety Agency of Japan, NISA (NISA, 2011), from 130 PBq to 150 PBq of ^{131}I and about 6.1–13 PBq of ^{137}Cs were released to the atmosphere due to the accident.

On March the 15th, the Japanese authorities alerted the population of the release of large amounts of radiation from the Fukushima-Daichi nuclear station. On March the 18th, the accident was qualified as a level 5 accident, according to the INES (International Nuclear and Radiological Event Scale) (IAEA, 2011b), by the local government. Subsequently, on April the 12, 2011, NISA attributed a 7-level to this accident (equal to that of Chernobyl although the radioactive material released from Fukushima-Daichi was much less). Radioactive iodine (^{131}I) and caesium 134 and 137 (^{134}Cs and ^{137}Cs) were detected in foodstuff (vegetables, cereals, eggs, meat, and seafood), drinking water and milk in several prefectures in Japan soon after the accident (Ministry of Health, 2011). ^{131}I values of up to 965 Bq/kg were recorded in tap water and up to 5300 Bq/kg in milk and dairy products (Murakami and Oki, 2012; Hamada and Ogino, 2012).

The radionuclides released due to the explosions attached themselves to atmospheric aerosols. This allowed a much larger dispersion of the radionuclides. This same effect was also observed after the Chernobyl accident (Devell et al., 1986; Saenko et al., 2011).

After the accident at Fukushima, radionuclides such as ^{131}I, ^{137}Cs and ^{134}Cs were measured at various monitoring stations in different parts of the Northern hemisphere. The first station to report these

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findings was located in the USA (Diaz Leon et al., 2011). Air mass forward-trajectory studies recently published (Lozano et al., 2011) have explained the motion of these radionuclides, first reaching the west coast of USA, travelling east over the USA, the Atlantic ocean and finally reaching Europe.

The first presence of radionuclides in continental Europe was reported days after the accident (Pittauerová et al., 2011; Manolopoulou et al., 2011). In the Iberian Peninsula, ^{131}I was first detected in filter samples collected from 15th to 22nd March at Cáceres monitoring station (CSN, 2011). The monitoring station at Seville also reported the presence of ^{137}Cs and ^{134}Cs soon after.

The Canary Islands are located approximately 1000 km south of the southern coast of the Spanish mainland and 150 km from the western coast of Morocco, opposite the Sahara Desert. ^{131}I, ^{137}Cs and ^{134}Cs were measured on aerosol filters exposed between March 21st–28th by the monitoring station of FIMERALL (Environmental Radioactivity and Medical Physics Laboratory of the University of La Laguna, Tenerife). This station is located at 300 m a.s.l. Measurements of ^{131}I, ^{137}Cs and ^{134}Cs were also conducted on aerosol filters at a second site, IZAÑA (Izaña Atmospheric Observatory) situated 40 km from the FIMERAL monitoring station at an altitude of 2400 m a.s.l. These additional aerosol filters were also analysed at the FIMERALL environmental radioactivity laboratory.

The aim of this study was to study the temporal variations in concentrations of fission related radionuclides in aerosol filters collected at the two stations of Tenerife (low and high altitude) after the accident at Fukushima and subsequently verify whether the ^{131}I, ^{137}Cs and ^{134}Cs concentrations measured at FIMERALL station were significantly different to the average values recorded at this station during the previous 5 years.

To complement this study, we have used simulations of ^{137}Cs dry deposition of the radioactive cloud performed by the Rhenish Institute for Environmental Research (RIU, 2011) as a first assessment of its potential impact over the Canary Islands. In addition, the effective dose to the population of Tenerife due to the presence of radionuclides in the air released by the accident at the Fukushima power station in Japan was calculated.

2. Methodology

2.1. Area of study

The island of Tenerife is located between 28°18′, 28°35′N and 16°07′, 16°49′W (see Fig. 1). The lower troposphere over this area is highly stratified. There is an inversion layer below 1800 m a. s. l. practically throughout all the year (Cuevas, 1995; Torres et al., 2001; Alonso-Pérez et al., 2007). This inversion layer is formed by the subsidence of air masses in the layer closest to the sea in combination with the influence of the North Atlantic anticyclone (Rodríguez et al., 2004). Both the higher and lower limit of the inversion layer show variation in altitude depending on the period of the year, with maximum values in winter and the beginning of spring and minimum in summer. The marine boundary layer, MBL, (<1000 m.a.s.l.) is limited by the thermal inversion layer. FIMERALL station is located in the MBL and IZAÑA station is located in the free troposphere.

The air masses that reach Tenerife come mostly from two well defined regions: 1) The North Atlantic, with an average frequency of 62% of the year and 2) Northern Africa, with an average frequency of 25% (Viana et al., 2002). The air masses from Northern Africa often carry large concentrations of dust aerosols mainly from the Sahara region (Rodríguez et al., 2011; Alonso-Pérez et al., 2012). Previous studies carried out by the FIMERALL laboratory and the Izaña Atmospheric Research Center have shown elevated concentrations of PM_{10} (diameter particles of aerosols $\leq$10 μm) and ^{137}Cs when Northern Africa air masses reach the Canary Islands (Karlsson et al., 2008; Hernandez et al., 2005b; Viana et al., 2002; Alonso-Pérez et al., 2007).

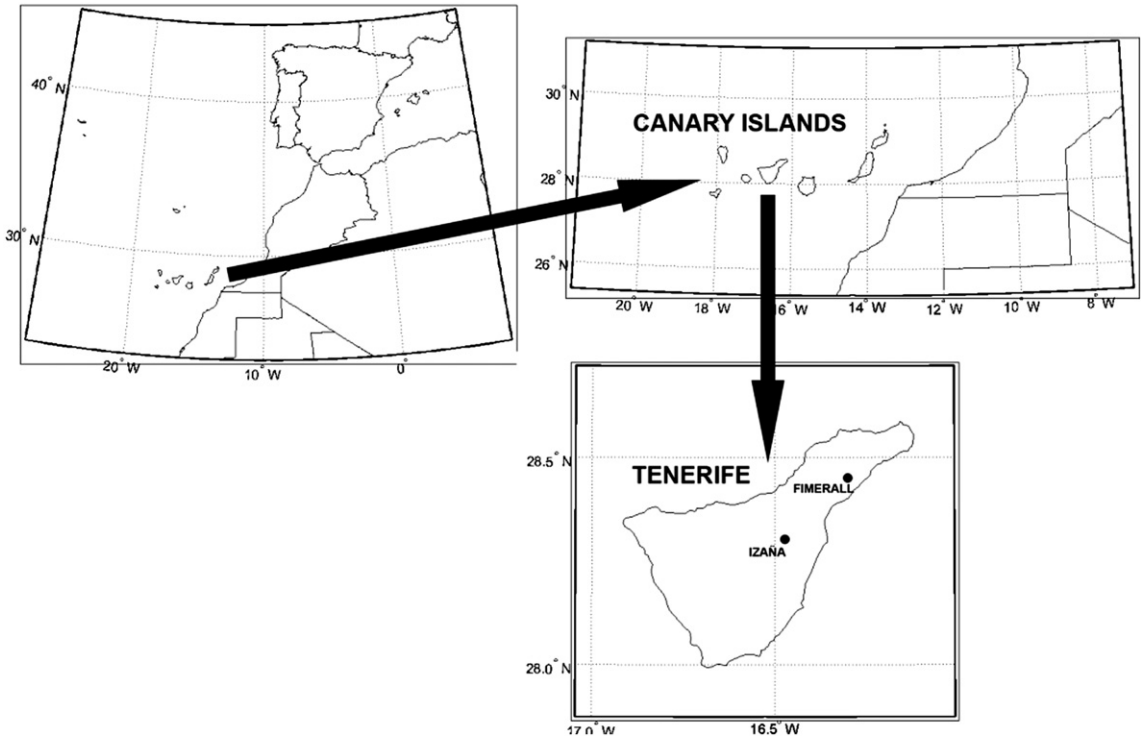

Fig. 1. Location of sampling stations.