



## European annual cosmic-ray dose map and estimation of population exposure

Georgia Cinelli (1), Valeria Gruber (2), Luca De Felice (3), Peter Bossew (4), Miguel Angel Hernández-Ceballos (3), Tore Tollefsen (3), Stefan Mundigl (5), and Marc De Cort (3)

(1) Independent researcher, (2) Austrian Agency for Health and Food Safety (AGES), Linz, Austria, (3) European Commission, DG Joint Research Centre, Directorate for Nuclear Safety & Security, Knowledge for Nuclear Safety, Security & Safeguards Unit, Ispra (VA), Italy, (4) German Federal Office for Radiation Protection (BfS), Berlin, Germany, (5) European Commission, DG ENER, Radiation Protection and Nuclear Safety Unit, Luxembourg

The Earth is continually bombarded by high energy cosmic-ray particles and the worldwide average exposure to cosmic rays represents about 13% of the total annual effective dose received by the population. Therefore assessment of cosmic-ray exposure at ground level is of great interest to better understand population exposure to ionizing radiation.

In the present work the annual effective dose resulting from cosmic radiation (photons, direct ionizing and neutron components) at ground level has been calculated following a simple methodology based only on elevation data. The European annual cosmic-ray dose map, at 1 km resolution, is presented and described. It reports the annual effective dose that a person may receive from cosmic rays at ground level, and it ranges from about 300 to 4000 microSv. The spatial distribution of the cosmic-ray dose rate over Europe obviously reflects the elevation map. The map shows that for half of the considered territory the annual cosmic-ray dose is below 360 microSv and for less than 1% above 1000 [U+F06D] microSv. The highest values are obtained at the highest places of Europe, such as the Alps, the Pyrenees and in eastern Turkey (with mountains above 3000 masl), in the latter reaching the maximum value of 4000 microSv. On the contrary, the minimum value of 300 microSv at sea level coincides mainly with coastal locations.

The map is part of the European Atlas of Natural Radiation, and it will be useful to estimate the annual dose that the public may receive from natural radioactivity.

Moreover, thanks to the availability of population data, the annual cosmic-ray collective dose has been evaluated and population-weighted average annual effective dose (per capita) due to cosmic ray has been estimated for each European country considered. The values range from about 300 microSv (Iceland) to 400 microSv (Turkey) per capita. The average value for all the countries considered is 330 microSv per capita.

This work represents a starting point in the estimation of effective cosmic-ray dose in Europe even if further work could be done to improve the dose assessment, such as considering the latitude, the temporal variability and fluctuations of cosmic ray particles, using different occupancy factor if living in countryside or city, in South or North Europe.