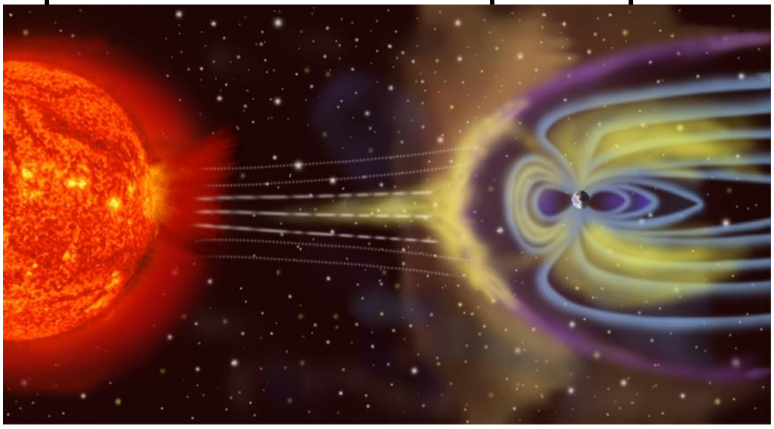
Exposure to cosmic radiation – public exposure



Exposure from cosmic radiation	**Average annual individual dose, mSv y^{-1}**	**Annual collective dose to UK population, man Sv y^{-1}**
At ground level	0.30	20,100
At high altitude	0.03	1,800
Total	**0.33**	**21,900**
Note that the exposure of aircrew from cosmic radiation during flights is discussed under Occupational Exposures.		

Cosmic radiation, which includes charged particles, x-rays and gamma rays, continually bombards the Earth and can be broadly divided into two distinct components, **solar radiation** and **galactic radiation**. The intensity of cosmic radiation is considerably reduced by the Earth's magnetic field (magnetosphere) deflecting away the lower energy charged particles. Magnetic shielding is less effective at the magnetic poles and consequently the dose rate varies with latitude. Absorption in the atmosphere also reduces the intensity of cosmic radiation. Broadly speaking, dose rates increase with both altitude and latitude. For simplicity, only the average dose rates due to cosmic radiation from exposure at ground level in the UK and while flying are considered here. The cosmic radiation dose rate is significantly higher at the altitudes at which commercial passenger aircraft fly when compared to the dose rate at ground level but given that many people do not fly or only spend a small fraction of their time flying then the average annual dose at higher altitudes is lower.

Solar radiation consists of lower energy cosmic radiation, originating from our Sun, composed mainly of protons, electrons, and x-rays. While solar radiation varies on an 11-year cycle, it is also highly variable on a day-to-day and even hourly basis, with holes in the Sun's corona causing variations in the stream of charged particles

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from the Sun that constantly irradiate the Earth's upper atmosphere. More particularly, solar flares have the potential to cause extreme bursts of radiation, with the solar X-rays and protons increasing by up to a factor of 10,000. Coronal mass ejections, the eruption of large amounts of plasma from the solar surface, can cause short-term changes in the radiation field at the Earth. These variations are termed "space weather", with the stream of particles released from the sun known as solar wind.

Galactic radiation, composed of high energy charged particles, x-rays and gamma rays originating from outside the solar system, comes from the remnants of supernovae and other catastrophic events. This arrives at the Earth at a fairly constant dose rate, though it is suppressed at times of intense solar wind.

Further reading about cosmic radiation, particularly solar radiation is available from a variety of sources. Some of these are summarised in the table below.

24-7 forecast of space weather	https://www.metoffice.gov.uk/weather/specialist-forecasts/space-weather
Information on space weather	https://spaceweather.com/.
Live information on solar X-rays	https://www.swpc.noaa.gov/products/goes-x-ray-flux
Live information on solar protons	https://www.swpc.noaa.gov/products/goes-proton-flux
Live information on cosmic ray neutrons	https://cosmicrays.oulu.fi/
Live information on atmospheric dose rates	https://spaceweather.surrey.ac.uk/maire-s_nowcast.php

There is a wide range of potential impacts from space weather that causes it to rank high on the UK National Risk Register (HM Government, 2025). The impacts, including radiation doses to people in commercial aviation, are summarized in a report by the Royal Academy of Engineering (Cannon et al, 2013) and the reasonable worst case scenario has been determined by the Space Environment Impacts Expert Group (https://www.bas.ac.uk/science/science-and-society/space-environment-impact-expert-group/) (Hapgood et al, 2021).

Estimating exposure at ground level

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The average annual dose at ground level is based on the estimated outdoor average annual dose rate from cosmic radiation at sea level of 0.37 mSv per year at latitudes corresponding to those of the UK (UNSCEAR, 2010). It was assumed that a typical building provides 20% shielding with an individual spending 90% of their time indoors, giving an overall dose rate of 0.3 mSv per year.

Estimating exposure at altitude

The European Commission (European Commission, 2004) reported a measured average dose rate, for all types of flights in the northern hemisphere, of 0.0038 mSv per hour. For this review an average dose rate of 0.004 mSv per hour was used to estimate the dose received during all flights to and from the UK. Civil Aviation Authority data (Civil Aviation Authority, 2024) on UK airlines indicates that UK residents took around 142.4 million flights in 2019, with an estimated total combined flight time of around 4.6 10^8 hours. This was combined with the estimated average dose rate to give an estimated annual collective dose to passengers of around 1,800 man Sv per year, with an average dose of about 0.01 mSv per passenger per flight. If it is assumed that the 142.4 million flights are shared equally between the entire UK population, this implies a bit more than 2 flights per person each year, giving an average dose to each person of 0.03 mSv y^{-1}. The actual dose to an individual will of course vary, depending on the number of flights that person takes, and the length and routes of those flights.

The dose rates from solar activity vary on an 11-year cycle, with solar radiation being stronger at the solar maximum. However, the higher energy galactic component is lowest at the solar maximum because of the more intense solar wind, so total dose rates are lowest at solar maximum.

References:

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European Commission (2004). *Cosmic radiation exposure of aircraft crew. Complilation of measured and calculated data. Final report of EURADOS WG5 to the Group of Experts established under Article 31 of the Euratom Treaty.* European Commission, Luxembourg, Radiation Protection 140.

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