

Cosmic Radiation Exposure to the Australian Public

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Overview

An important component of background radiation is galactic cosmic radiation. This is a form of high-energy radiation that mainly originates outside the Solar System. Cosmic rays impact with the Earth's atmosphere, producing showers of secondary particles that are able to reach the Earth's surface.

The dose rate due to cosmic radiation varies with latitude, increasing toward the poles, and also rises with altitude. Australians are therefore exposed to a combination cosmic ray exposure consisting of both ground level exposure and exposure during air travel. In order to estimate an annual dose to the Australian public the model CARI-6 was used for both ground level and air travel. Both International and Domestic air travel are considered.

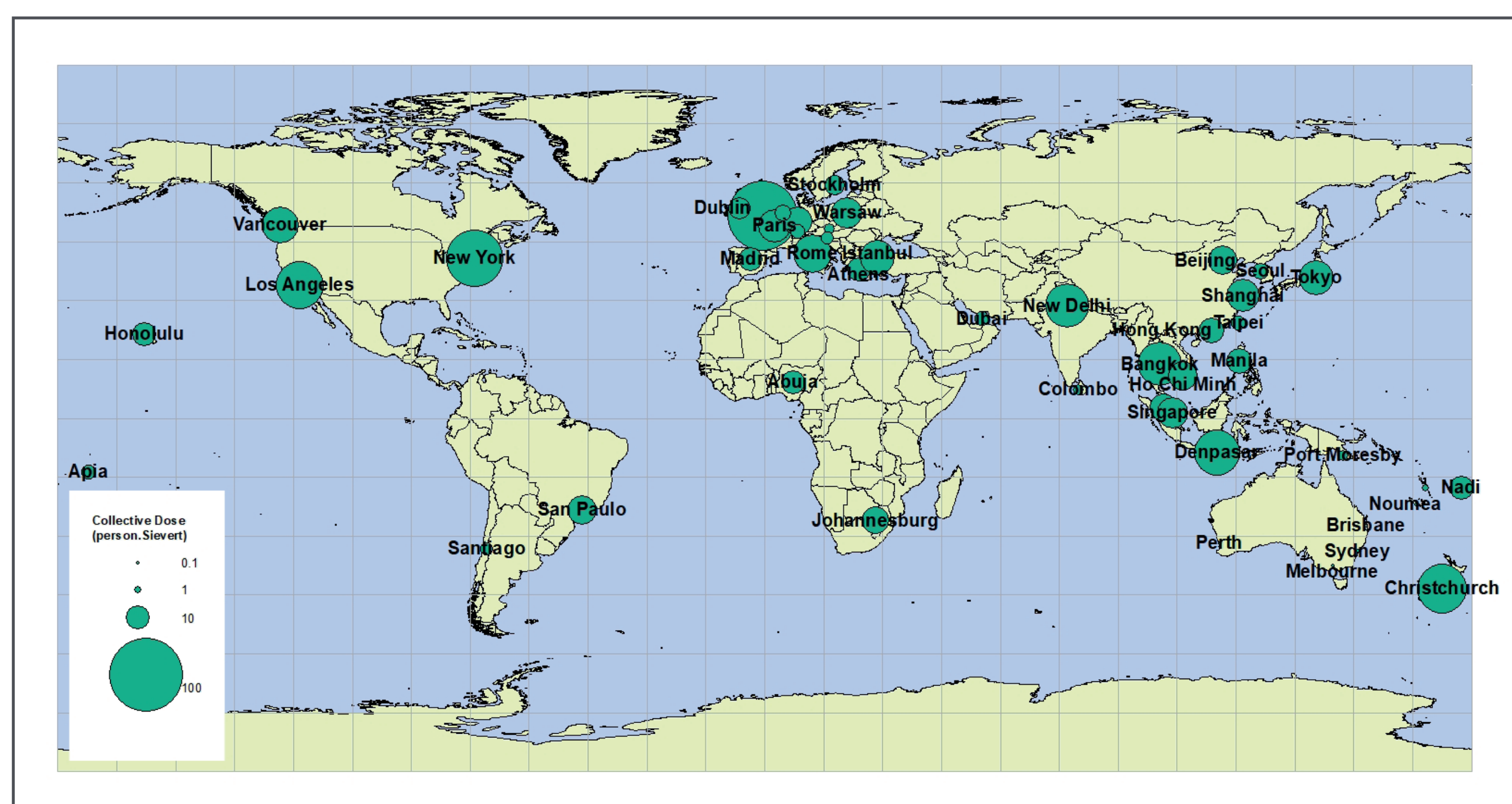


Figure 1: Proportional collective doses at major international cities

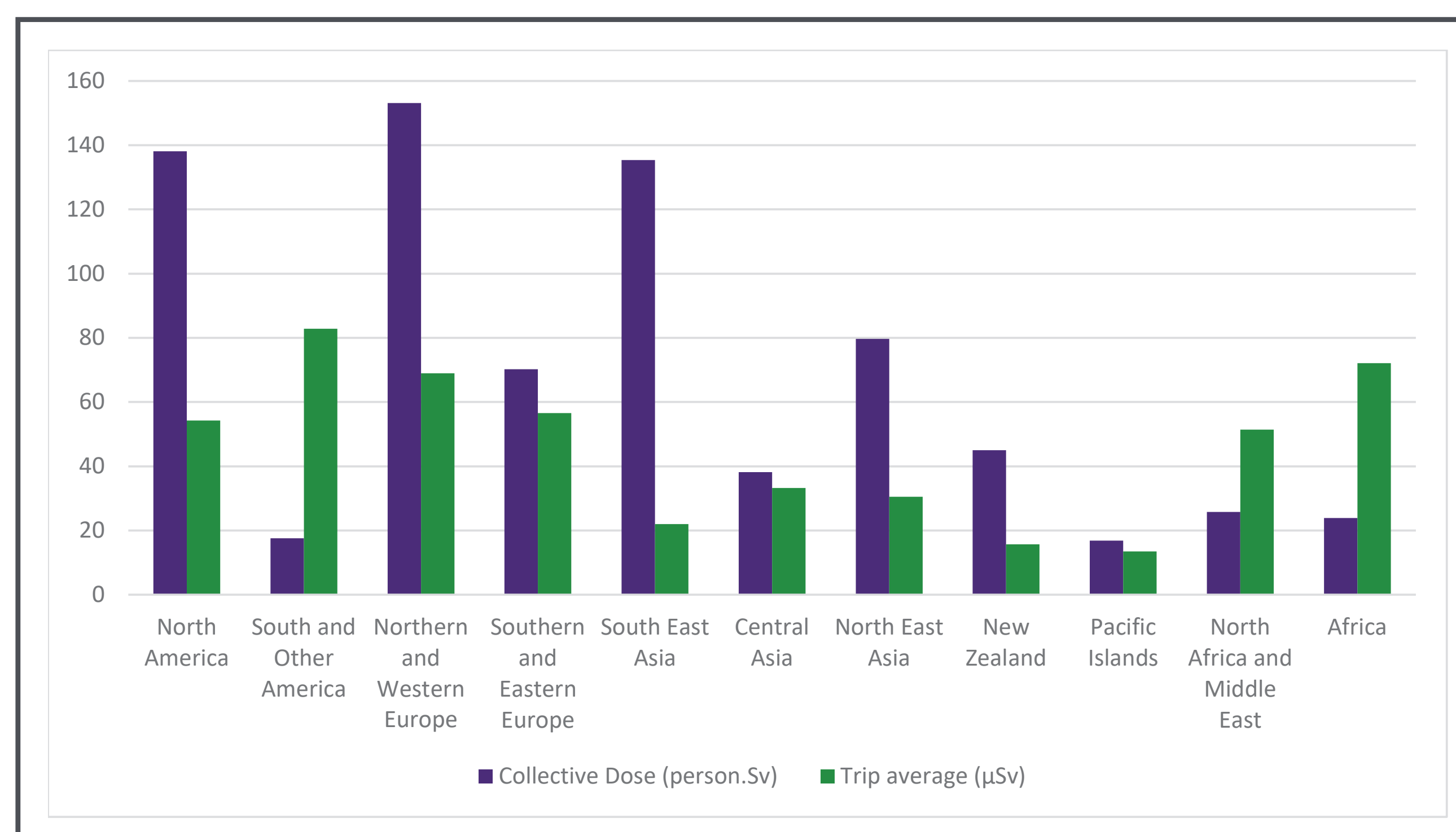


Figure 2: Collective dose and trip averages for international regions

Doses due to air travel

International:

An assessment of cosmic radiation dose to Australian residents was performed via modelling of doses received during both international and domestic flights. Data provided by the Australian Bureau of Statistics (ABS) was used to broadly assess the number of Australians undertaking air travel, Australian residents undertake approximately 20 000 000 international and 60 000 000 domestic flights annually. Collective doses for international destinations are shown in Figure 1. These doses are also shown grouped regionally in Figure 2, along with average trip doses to the same regions.

	Hong Kong	Kuala Lumpur	Singapore	Dubai	Los Angeles
Melbourne	28.3	27.4	25.8	43.6	49.4
Sydney	26.5	27.0	26.7	42.2	45.0
Brisbane	23.0	23.6	22.6	38.1	40.0
Perth	21.5	16.9	15.4	31.0	N/A

Table 1: Doses to major transit ports from Australian origins (μSv)

Domestic:

Doses along routes between 26 key Australian domestic locations were assessed. These routes account for more than 95% of all Australian domestic passengers. Doses for the top ten routes by passengers carried are shown in Table 2.

Route	Passengers	% of total passengers	Dose (µSv)	Collective dose (person.Sv)
Sydney-Melbourne	9 097 110	15	3.2	33.6
Sydney-Brisbane	4 746 256	8	3.9	21.5
Melbourne-Brisbane	3 541 071	6	7.0	28.8
Sydney-Gold Coast	2 740 745	4.6	3.7	11.8
Melbourne-Adelaide	2 456 426	4	2.8	7.8
Melbourne-Perth	2 033 242	3	15.5	36.4
Melbourne-Gold Coast	2 012 590	3.4	6.9	16.2
Sydney-Adelaide	1 898 268	3	6.5	14.2
Sydney-Perth	1 716 477	3	17.7	35.1
Melbourne-Hobart	1 630 259	2.7	3.8	7.2

Table 2: Top ten Australian domestic routes by number of passengers carried

Comparison:

	Total trips	Collective dose (person.Sv)	Population average (μSv/year)
Australian domestic	59 978 900	361.9	14.7
International	21 072 600	743.7	30.2

Table 3: Domestic and International travel doses for the 2017 calendar year, based on the total Australian population in that year of 24 601 860.

CARI-6

CARI-6 was first developed by the US Federal Aviation Administration's Civil Aerospace Medical Institute in 2004 to calculate the effective dose of cosmic radiation received by an individual (based on an anthropomorphic phantom) flying on an aircraft.

Flight analysis and ground level modelling:

Flight paths were modelled using CARI-6 with inputs of origin and destination location, flight duration, altitudes of two segments, and heliocentric potential. Flights were modelled using average parameters from the 2017 calendar year.

In order to confirm that CARI-6 could also be used to produce results at ground level, measurements of dose rate were taken at a single ground level location and compared to the effective dose rate calculated by CARI-6 for the same time and location.

The modelled dose rates compared favourably to the measurement, and CARI-6 was deemed appropriate to use. An Australian digital elevation model was also used.

Ground level doses

Average Ground Level (Indoor) dose results are shown by state in Table 4. The variation over a solar cycle is also shown. The overall average per state is approximately 300 $\mu\text{Sv}/\text{year}$ with extremes of 226 $\mu\text{Sv}/\text{year}$ in Darwin and 369 $\mu\text{Sv}/\text{year}$ in Canberra. The total Australian population collective dose is 4157 person.Sv at ground level.

The collective dose (Figure 3) shows a considerable variation by state, from approximately 25–30% in Victoria and NSW, down to 1–2% in the Northern Territory, Tasmania and Australian Capital Territory. Figure 4 shows the relative contributions of both domestic (5%) and international (9%) air travel and ground level (86%) cosmic ray exposure to the population weighted dose to the Australian public. Given that the ground level population weighted average dose is 293 $\mu\text{Sv}/\text{year}$, the total average dose to the Australian public due to cosmic ray exposure is 341 $\mu\text{Sv}/\text{year}$.

State	Population	1990 average (μSv/year)	2009 average (μSv/year)	Overall average (μSv/year)	Collective dose	
					(person.Sv)	%
NSW	6 904 266	272	311	293	2023	3
VIC	5 345 695	277	321	301	1609	2
QLD	4 319 721	258	288	275	1188	1
SA	1 593 497	278	320	301	480	
WA	2 231 458	270	309	292	652	1
TAS	494 163	285	334	312	154	
NT	209 966	217	233	226	47	
ACT	356 587	339	393	369	132	

Table 4: Australian Annual Ground Level (Indoor) dose (μSv) from cosmic radiation - (1990 and 2009 represent solar minimum and solar maximum conditions respectively)

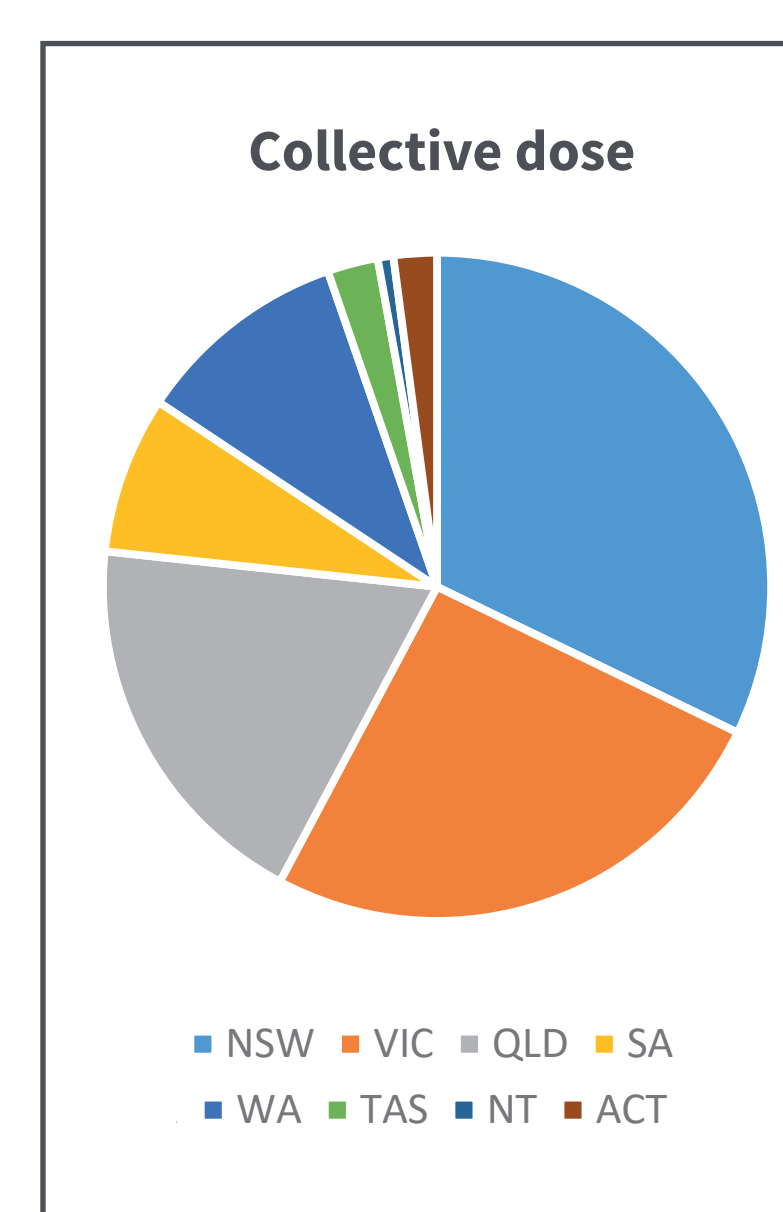


Figure 3:
Collective doses for each Australian state

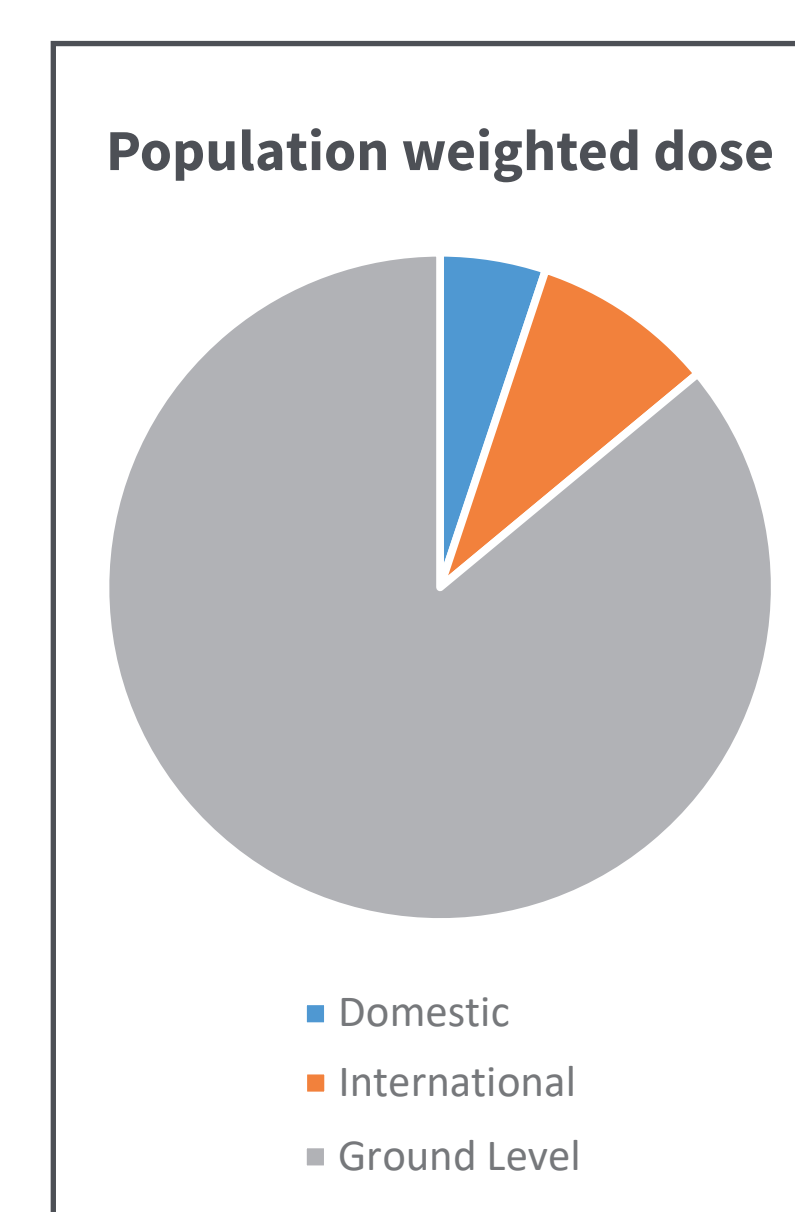


Figure 4:
Air travel compared to ground level
population weighted doses