Nuclear Geophysiology

Tritium in Australian Precipitation: a 40 Year Record

Australian Government

ANSTO

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Introduction

Since 1960 monthly precipitation samples have been collected for tritium (^3H) analysis from various meteorological stations throughout Australia, for the Australian Nuclear Science and Technology Organisation (ANSTO), as part of the Global Network of Isotopes in Precipitation (GNIP) project. This global project is conducted by the International Atomic Energy Agency (IAEA) in cooperation with the World Meteorological Organisation (WMO). The locations of the meteorological stations throughout Australia are shown in Figure 1.

The period of sampling conducted at each station is listed in Table 1. Australia has an extensive data set extending from 1962 till present for three meteorological stations; these include Cape Grim, which is Australia's baseline station, Brisbane and Darwin.

Table 1. Data including latitude, longitude, altitude and the period of record for the 16 meteorological weather stations throughout Australia.

Meteorological Station	Latitude	Longitude	Altitude (m)	Period of record
Adelaide	34 57S	138 32E	7.6	1962 – 1991
Alice Springs	23 80S	133 88E	545.2	1964 – 1991
Bundaberg	24 52S	152 21E	13.7	1970 – 1980
Campbelltown	34 05S	150 49E	64.9	1970 – 1991
Charleville	26 25S	146 17E	303.8	1970 – 1980
Claredale	19 36S	147 25E	9.7	1970 – 1980
Brisbane	27 43S	153 08E	2.1	1962 - present
Darwin	12 26S	130 52E	28.6	1962 - present
Cape Grim	42 53S	147 20E	55.2	1962 - present
Longreach	23 26S	144 16E	190.5	1970 – 1991
Mackay	21 07S	149 10E	30.8	1970 – 1991
Melbourne	37 49S	144 58E	34.7	1960 – 1999
Narrabri	30 20S	149 45E	212.4	1971 – 1986
Perth	55 00S	115 58E	17.1	1963 – 1991
Ryde	33 56S	151 11E	3.0	1970 – 1980
Toowoomba	27 35S	151 56 E	586.6	1970 - 1980

Figure 1. Map of Australia depicting the median annual rainfall and locations of sixteen meteorological stations throughout Australia where monthly precipitation samples have been collected for tritium analysis (Courtesy of the Bureau of Meteorology).

Precipitation Analysis

Since 1970 monthly precipitation samples collected throughout Australia have been analysed for tritium at ANSTO, which has the only facility in Australia capable of low-level tritium analysis. The methodology used for the determination of low level tritium in environmental water samples is a process referred to as electrolytic enrichment followed by Liquid Scintillation Counting (Calf *et al.,* 1975). This is an established technique being employed by ANSTO and numerous laboratories worldwide.

Tritium Trends

The results of the yearly mean of the environmental isotope tritium in precipitation, weighted by the total amount of precipitation are displayed in Figure 2(a) - (c). The tritium concentration is reported in tritium units (TU), where one TU corresponds to one ^3H atom per 10^{18} atoms of hydrogen or 0.11919 ± 0.00021 Bq/kg.

Examination of the data highlights the changes in tritium levels that occurred in the Southern Hemisphere since 1962 due to atmospheric nuclear testing and the gradual decrease in the levels of tritium in precipitation following their ban. The data clearly records the increased levels of tritium injected into the atmosphere during 1961 –1962, one of the most intense periods of nuclear testing. Increased levels in the Southern Hemisphere were 10 to 100 times smaller compared to the Northern Hemisphere (Figure 2d).

The distribution of tritium levels in precipitation during the period from 1963 to 1968 for Australia indicate that the highest yearly mean levels of tritium in precipitation were found in Adelaide and reached 107 TU in 1964. From 1963 – 1980 there is a rapid decline of tritium levels, more than expected from natural decay, due to the incorporation of tritium via precipitation into the groundwater and oceans. From 1980 there is a steady decrease in tritium concentration and by 1990 the levels stabilised. Currently the levels have stabilised to 2-3 TU.

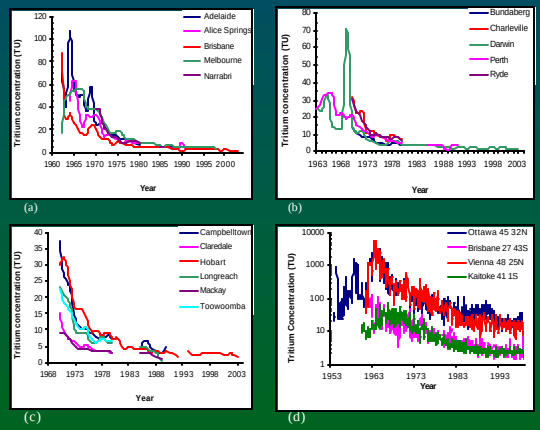

Figure 2(a) - (c). Yearly weighted mean of tritium in precipitation for the 16 meteorological stations throughout Australia. **(d)** Data since 1953 show the larger levels of tritium injected into the stratosphere in the Northern Hemisphere compared to the Southern Hemisphere. Data shown was obtained from the IAEA, GNIP database.

In summary levels of tritium in Australian precipitation are mainly due to natural origin and processes, although small releases of tritium from nuclear power plants and fuel reprocessing, almost exclusively in the Northern Hemisphere contribute to the levels (Happel *et al.*, 2004).

Tritium Traces Transpiration

Tritium, as tritiated water ($^3H^1HO$), is very mobile in the environment and delivers the benefit of tracing water through the soil-plant-atmosphere continuum. An ANSTO study was conducted on an approximately 8 m high tree (*Callistemon sp.*) where tritiated water was injected into the xylem tissue and root zone of the tree, the transpirate was collected over a 3 week period (Twining, 1994).

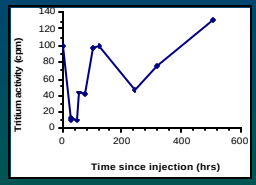

Figure 3. The average tritium activity of transpirate.

The average tritium activity in the transpirate is shown in Figure 3. Movement of tritiated water through the tree at a measurable rate and variations in the flux were observed. It was shown that tritium can be used as a measure of transpiration. This will be extended to use the stable isotopes of water containing deuterium (hydrogen-2) and oxygen-18 in IPILPS: Isotopes in Project for Intercomparison of Land-Surface Parameterization Schemes (McGuffie and Henderson-Sellers, 2004).

References

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