Data Article

Krypton-85 datasets of the northern and southern hemisphere collected over the past 60 years

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**A B S T R A C T**

With a half-life of 10.7 years, the noble gas radioisotope \textsuperscript{85}Kr is perfectly suited as a tracer to date ice and water that formed during the past half century. Furthermore, due to its inhomogeneous input into the atmosphere, it is a useful tool to investigate atmospheric circulation and backtrajectory analysis. The data presented here represent a comprehensive time series of atmospheric \textsuperscript{85}Kr activity concentrations in ground level air that can be used to model northern and southern hemispheric input functions, which is essential to apply \textsuperscript{85}Kr as a dating tracer. The collection comprises 11 datasets from 4 monitoring stations in the northern and 7 monitoring stations in the southern hemisphere, respectively. In total, it contains about 8000 measurements performed over the past 60 years, making it the largest published \textsuperscript{85}Kr record.

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### Specifications Table

| Subject       | Atmospheric Science |
|---------------|---------------------|
| Specific subject area | Monitoring of the atmospheric $^{85}$Kr concentrations in ground level air in the northern and southern hemisphere |
| Type of data  | Excel file in data repository, Table, Figure |
| How data were acquired | The $^{85}$Kr activity concentration data were acquired after gaschromatographic separation of krypton followed by $\beta$-decay counting of Kr-85 in gas proportional counters. |
| Data format   | Raw |
| Parameters for data collection | The krypton was sampled from ground level air and the monitoring stations were carefully chosen, to avoid contamination with locally produced $^{85}$Kr. |
| Description of data collection | Primary data of the data collection comprises the Adelaide dataset and all samples of the Schauinsland, Jungfraujoch and Freiburg datasets taken since (December 2018). All other data is secondary data taken from the cited papers. |
| Data source location | Primary data sources: Adelaide:  
Institution: CSIRO  
City/Town/Region: Adelaide  
Country: South Australia  
Lat/Lon of monitoring station: 34°58' S 138°38' E  
Antarctica:  
Institution: Institute of Environmental Physics, University Heidelberg, Germany  
City/Town/Region: Georg von Neumayer Station  
Country: Antarctica  
Lat/Lon of monitoring station: 70°40' S 08°16' W  
Cape Grim:  
Institution: CSIRO & Institute of Environmental Physics, University Heidelberg, Germany  
City/Town/Region: Tasmania  
Country: Australia  
Lat/Lon of monitoring station: 40°41' S 144°41' E  
Cape Point:  
Institution: Institute of Environmental Physics, University Heidelberg, Germany  
City/Town/Region: Cape of Good Hope  
Country: South Africa  
Lat/Lon of monitoring station: 34°32' S 18°29' E  
Darwin:  
Institution: Supervising Scientist Division, Environment Australia  
City/Town/Region: Darwin  
Country: Australia  
Lat/Lon of monitoring station: 12°28' S 130°50' E  
Early Measurements:  
Institutions:  
Physics Department, University Heidelberg, Germany  
Institute of Environmental Physics, University Heidelberg, Germany  
Planck Institute for Nuclear Physics, Heidelberg, Germany  
Max Planck Institute for Nuclear Physics, Freiburg-Schauinsland Branch, Germany  
Institute for Atmospheric Radioactivity (IAR), Federal Office of Civil Defence, Freiburg, Germany  
Commissariat a l'Energie Atomique, Department de la Protection Sanitaire, Fontenay-aux-Roses, France  
Air Resources Laboratories, National Oceanic and Atmospheric Administration, Silver Spring, MD 20910, U.S.A  
Freiburg:  
Institution: Bundesamt für Strahlenschutz  
City/Town/Region: Freiburg  
Country: Germany  
Lat/Lon of monitoring station: 48°00' N 07°51' E  
Jungfraujoch:  
Institution: Bundesamt für Strahlenschutz  
City/Town/Region: Berner Alps |

(continued on next page)
Value of the Data

- This comprehensive dataset is important for the application of $^{85}$Kr as a dating tracer in water and ice
- Researchers in the field of tracer hydrology can benefit from these data as it allows deriving a $^{85}$Kr input function for dating
- The $^{85}$Kr data is useful for investigating atmospheric circulation and it can support back trajectory models due to nuclear reprocessing plants as point like sources of $^{85}$Kr.
- The dataset will support the potential future application of $^{85}$Kr as a tool for the verification of nuclear arms control treaties.

1. Data Description

The data collection consists of 11 datasets of atmospheric $^{85}$Kr activity concentrations with 4 datasets from monitoring stations in the northern hemisphere ("Early Measurements NH", "Freiburg", "Schauinsland" and "Jungfrau") and 7 datasets from monitoring stations in the southern hemisphere ("Adelaide", "Antarctica", Cape Grim", "Cape Point", "Darwin", "Tahiti" and "Terre-Adélie") (Table 1).

All measurements were conducted via $\beta$-decay counting in gas proportional counters with a measurement uncertainty of about 3%. However, for the datasets "Tahiti" and "Terre-Adélie" no errors were given in the original publications and a conservative estimate of 10% measurement uncertainty was taken.

As seen in Fig. 1, the northern hemispheric data represents a coherent 60 years long series of measurements, while the southern hemispheric data set contains gaps of about 5 years between around 1980 and in the early 2010s. The $^{85}$Kr activity concentrations in the Freiburg, Schauinsland and Jungfrau dataset reach up to 6 Bq/m$^3$ air, while the southern hemispheric data do not exceed 1.5 Bq/m$^3$ air.
Fig. 1. The $^{85}$Kr activity concentration in ground level air is plotted against the sampling date for all 11 datasets.
2. Experimental Design, Materials and Methods

The collection of krypton samples for the analysis of $^{85}$Kr follows the same principle for all datasets. In a multistage process, 2 to 5 ml of pure krypton are separated from about 10 m$^3$ of air and the $^{85}$Kr activity concentration is determined via radioactive $\beta$-decay counting in gas proportional counters.

The first separation step is done by pumping air for one week with a constant flow of about 1 L/min through a liquid nitrogen cooled activated charcoal column. The pressure in the column is regulated to about 500 mbar to avoid condensation of oxygen and nitrogen, while most of the krypton is trapped [15]. After one week, the activated charcoal column is replaced with a clean column, to ensure continuous sampling. The charged column is heated to 300°C and the released gas is flushed into a 1 L aluminium container with helium as carrier gas. For the second purification step, the 1 L aluminium container is shipped to the laboratories of the “Bundesamt für Strahlenschutz” in Freiburg, Germany.

Via cryogenic purification, CO$_2$ is removed, and the residual gas mixture is flushed with helium through a smaller liquid nitrogen cooled activated charcoal trap to further remove the lighter air components, mainly O$_2$, N$_2$ and Ar.

In a third step, krypton is separated from xenon by gas chromatography with methane serving as a carrier and counting gas. The highly enriched krypton fraction is then flushed into a gas proportional counter to measure its $^{85}$Kr activity.

The overall measurement uncertainty for an atmospheric $^{85}$Kr measurement is about 3% with a $^{85}$Kr detection limit of typically around 4 mBq/m$^3$ air.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have or could be perceived to have influenced the work reported in this article.

CRediT authorship contribution statement

Arne Kersting: Data curation, Writing - original draft. Clemens Schlosser: Conceptualization, Investigation, Validation, Project administration. Sabine Schmid: Data curation, Validation. Martina Konrad: Data curation. Andreas Bollhöfer: Writing - review & editing, Supervision. Karen Barry: Data curation. Axel Suckow: Data curation, Writing - review & editing.
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