1. ABOUT THE DATASET

Title: Eskdalemuir ion measurements 1909-1916

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Description: The electrical conductivity of atmospheric air depends on the positive and negative cluster ions (or "small ions") it contains. Here, intermittent daily ion measurements are presented from Eskdalemuir observatory in Scotland (55.314° N, 356.794° E), in initial work beginning soon after the observatory opened in 1908. These early ion measurements were made using an Ebert sampling apparatus. Air pollution reduces the air ion concentrations, hence ion information can provide an indirect measure of air pollution. As air ion measurements were made before routine air pollution monitoring began, ion measurements provide an indirect – and quantitative – source of early pollution information for comparisons. Eskdalemuir is now a background air pollution site. Some entries in the air ion record book containing the original data were initialled by the then Eskdalemuir superintendent, Lewis Fry Richardson.

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Related publications:

- Atmospheric electricity observations at Eskdalemuir Geophysical Observatory https://doi.org/10.5194/hgss-2023-15 (Harrison and Riddick, 2023) (Preprint)
- Atmospheric electricity observations at Eskdalemuir Geophysical Observatory https://doi.org/10.5194/hgss-15-5-2024 (Harrison and Riddick, 2024)
- Electrical properties of surface atmospheric air at Eskdalemuir, 1909-1911 (Harrison, 2007)
- Long-term measurements of the global atmospheric electric circuit at Eskdalemuir, Scotland, 1911-1981 (Harrison, 2004)

2. TERMS OF USE

3. PROJECT AND FUNDING INFORMATION

This dataset contains early air ion data measured at Eskdalemuir observatory, Scotland. These measurements were originally obtained by the Met Office.

The Eskdalemuir air ion data were recovered and keyed as part of ongoing atmospheric electricity research by Prof Giles Harrison in the Department of Meteorology, University of Reading, during the past twenty years. No external project funding has been received.

Eskdalemuir is in Dumfriesshire, Scotland, with the nearest towns Langholm and Lockerbie (Blackwell, 1958; Dawson, 2005). Fig 1 shows the location in the UK, with the positions marked of the other sites where related atmospheric electricity measurements were made (Harrison, 2003).

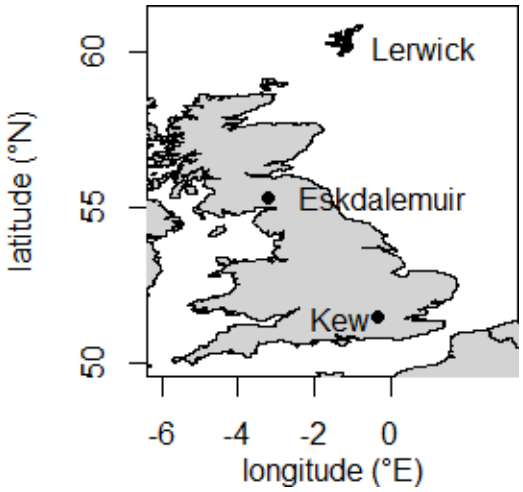

Figure 1. Map showing the position of Eskdalemuir. (The two further atmospheric electricity monitoring sites at Lerwick and Kew are also marked).

Air ions are formed in atmospheric air by the ionising action of natural radioactivity and cosmic rays. The core atomic ions form a "cluster ion", with organic species or water. (Cluster ions also called "small ions"). Each cluster ion carries a single positive or negative charge, and can be accelerated by electric forces present in the atmosphere. For example. the fair weather atmospheric electric field leads to slow vertical drift of the cluster ions, in a balance between electrical migration, weight and drag. Cluster ions are removed by attachment to aerosol or other droplets or particles present in the air, such as smoke, haze or fog. Variations in cluster ion concentrations are therefore indirectly related to the local air pollution, and hence can be used in reconstructing past air pollution (Harrison, 2006).

The typical properties conventionally determined are the ion number concentrations and mean mobility[1] (Hõrrak et al., 2000). Number concentrations are found from the current received by ions collected in an airstream moving at a known speed. The mobility is determined by deflecting ions from (or to) the collecting electrode, under known electric fields.

At Eskdalemuir, atmospheric electricity measurements were made between 1911 and 1981 (Harrison and Riddick, 2023). In the early part of the data record, ion properties (concentration and mobility) were also obtained, using an Ebert Apparatus (Ebert, 1901). The Ebert apparatus was based on a vertical sampling tube containing charged electrodes, through which air was drawn by a fan. The rate of charge transfer to a central electrode was measured using a mechanical electrometer. By introducing a charged rod, some of the ions could be deflected, allowing the mean mobility to be found.

The Ebert ion counter was used at Eskdalemuir occasionally, on suitable fine afternoons[2]. The measurements were recorded in a leather-bound book, marked with "Atmospheric Electricity" and "Eskdalemuir" on the spine. The recovery of this volume and a summary of the measurements it contains are described in Harrison (2007). Further occasional values have since been found in the British Meteorological and Magnetic Yearbook (BMMY), which was issued annually[3], and these two

[1] For an ion moving in an electric field, the mobility is the mean speed per unit electric field.
[2] An image of the Ebert device in use at Eskdalemuir is available in the Royal Society picture library https://pictures.royalsociety.org/image-rs-11499 . The book in the picture appears similar to the one from which the data was transcribed.
[3] Scanned images of the BMMY have been made available by the British Geological Survey (BGS) at http://www.geomag.bgs.ac.uk/data_service/data/yearbooks/esk.html .

sources have been combined to provide a series of air ion data obtained at Eskdalemuir from 1909 to 1916.

A similar Ebert device was in use at the same time at Kew observatory. The Kew device operated less satisfactorily than the one at Eskdalemuir (Dobson, 1914), which seems likely to have been caused by substantial smoke pollution. A better approach was available – the Wilson apparatus (Scrase, 1934) – which probably led to decline in use of the Ebert device. There is a gap in the Eskdalemuir Ebert measurements during 1913. No mobility determinations were made from 1914, and the Ebert measurements ultimately ceased entirely at the end of 1916. Variability and inconsistency in the Ebert instrument's operation were remarked on in the BMMY (Shaw, 1916).

4. CONTENTS

This data submission contains intermittent daily determinations of ion properties, on settled afternoons around 15 UTC, at Eskdalemuir observatory. The values are contained in a single data file.

Filename	Contents
EbertValues_Eskdalemuir.csv	Positive and negative ion concentration and mobility data, for days on which measurements were made

The file is a plain ascii text file, with each line providing a set of data values in columns running from left to right, comma separated. The first two lines are header lines.

The file is organised as described in Table 1. Missing values are marked NA (Not Available). (Some ion concentrations and mobility values were recorded as "0" – this has been preserved in the data transcription, but as they make no physical sense, they should also be regarded as NA).

Table 1. Ion data file format

Column number	Quantity	Description	unit
1	Year	Time variable (value runs from 1909 to 1916)	GMT
2	Month	Month number	GMT
3	Day of month	Month day	GMT
4	Positive ion concentration	Number of positive charges per unit volume	elementary charges per cm^{-3}, × 1e20
5	Positive ion mobility	"specific velocity" of ion, in an electric field of 1 V cm^{-1}.	cm s^{-1}
6	Negative ion concentration	Number of negative charges per unit volume	elementary charges per cm^{-3}, × 1e20
7	Negative ion mobility	"specific velocity" of ion, in an electric field of 1 V cm^{-1}.	cm s^{-1}

Note that, during the period of these measurements, the value of the elementary charge itself was still being refined, which changed in 1917 to essentially the modern value (Millikan, 1930). **The values presented are directly from the original sources, which used an earlier (pre-1917) value of the elementary charge**. Corrections are discussed in Harrison (2007). See also Shaw, (1916).

5. DATA SOURCES

Values were keyed from the Eskdalemuir volume for 1909-1911, and from the BMMY thereafter. The 1916 values of charge per unit volume were multiplied by 1000, for consistency with the values of 1909-1915, following a change in tabulation practice.

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