Atmospheric electricity observations by Reinhold Reiter around Garmisch-Partenkirchen

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Abstract Atmospheric electricity measurements were made at several sites close to Garmisch-Partenkirchen during four decades from 1950 to 1990 by Dr Reinhold Reiter, together with other environmental measurements. The quantities determined include the atmospheric potential gradient, the vertical current and the ion concentrations, and observations made at the Mount Wank site (1780 m, 47° 30' N, 11° 09' E) from 1st August 1972 to 31st December 1983 are available in digital form.

Keywords: Potential Gradient, conduction current; global circuit;

1.   Introduction

Motivated by his interest in the influence of atmospheric electric processes on humans, Reinhold Reiter (1920-1998) started atmospheric electricity measurements in the early 1950s. Past measurements of atmospheric electricity are increasingly studied internationally (Aplin, 2020), because of widening interest in the global atmospheric electric circuit and its relevance to climate (e.g. Nicoll et al., 2019). Data obtained in clean air conditions are of particular importance, such as from mountain sites. The atmospheric electrical quantities obtained by Reiter within a sustained campaign of environmental measurements frequently fulfilled the clean air requirements.

32 Retier began with various measuring sites in Munich and southern Bavaria, probably to allow

33 intercomparisons. Later, he concentrated on measurements undertaken at Garmisch-

34 Partenkirchen, on the nearby Wank and Zugspitze mountains and onboard an instrumented

35 passenger cable car moving regularly between the Eibsee and the Zugspitze summit. (The

36 locations of these sites are shown in Fig. 1).

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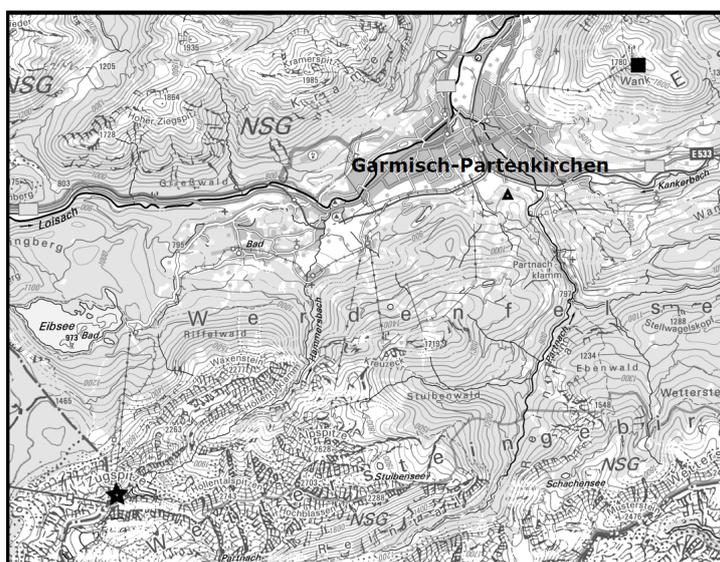
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39 Figure 1: Area around Garmisch-Partenkirchen (southern Bavaria, Germany) with the
40 observational sites marked: Wank (square, upper right), Central Institute (triangle) and
41 Zugspitze (star, lower left). The cable car runs almost directly north from the Zuspitze
42 summit to the right hand shore of lake Eibsee (map adapted from Digitale Topographische
43 Karte 1 : 100.000 (c) Bayerische Vermessungsverwaltung 2022, thanks to Martin Fasbender).

44

45 To undertake this, Reiter founded a privately-funded research institute, the *Physikalisch-*

46 *bioklimatische Forschungsstelle in Garmisch-Partenkirchen* which was incorporated as the

47 *Fraunhofer-Institut für Atmosphärische Umweltforschung* (IFU) in the Fraunhofer Society in

48 1962. He led this institute as its director until his retirement in 1985. In 2002 this institute

49 became part of the Institut für Meteorologie und Klimaforschung Atmosphärische

50 Umweltforschung (IMK-IFU), and Campus Alpin of the Karlsruher Institut für Technologie

51 (KIT).

52

53   Reinhold Reiter passed away on 24 September 1998 and a detailed memorial article was
54   published by Weihe (1999). It is understood that some possessions were bequeathed to Ettal
55   Abbey, a Benedictine monastery in Bavaria.

2.   Measurement locations

57   Reiter's principal scientific motivations were to investigate biometeorological responses to
58   atmospheric variables such as the concentrations of small ions, and to study short-term solar-
59   terrestrial influences on the global circuit. This may be reflected in the choice of mountain sites
60   for the measurements, which brought the possibility of low pollution conditions and least local
61   disturbances.

62

63   The Garmisch-Partenkirchen measurements were obtained at permanent sites on the Zugspitze
64   (2964 m altitude) and Wank (1780 m) mountains, and at an additional site known as the Central
65   Research Institute, on the valley floor (740 m). A novel feature was the use of the cable car
66   connecting the Zugspitze and a ground station close to lake Eibsee, instrumented to carry
67   sensors in a regular path, sometimes passing repeatedly through fog and cloud layers. Vertical
68   profiles of ozone were obtained using this approach (Reiter, 1991).

3.   Apparatus

70   Customised instruments and systems were devised for the atmospheric electrical
71   measurements. A primary quantity studied was the vertical potential gradient (PG). On Wank,
72   as well as on the cable car, a radioactive collector probe was used, connected to a high
73   impedance electrometer amplifier. The PG sensing probe was heated, and its physical
74   construction refined during a long period of operation in mountain conditions, especially
75   precipitation. The atmospheric conductivity was measured with an aspirated Gerdien
76   condenser. A further measurement of the PG was made using an electrostatic field mill, and
77   the air-earth current with a wire antenna. A special device was developed for measuring the
78   space charge and, simultaneously, the natural radioactivity in the air. Beyond the usual fair
79   weather measurements, the precipitation current density was obtained with an electric rain
80   gauge. All these instruments and corresponding results are described in papers (Reiter, 1977a,
81   b), and Reiter's textbook (Reiter, 1992).

82   **4.   Data recovery**

83   Some of the measurements from the Bavarian Alps have previously been made available on a

84   CDROM, which was originally distributed through the collaborative network provided by the

85   SPECIAL scientific community (Rycroft and Füllekrug, 2004). These data values were

86   retrieved from magnetic tapes in summer 2000, with the help of one of Reiter's collaborators.

87   They provide hourly values from the Wank site (1780m, 47°30'N, 11°09'E), and span 1st

88   August 1972 to 31st December 1983. The wide range of quantities recorded is summarised in

89   Table 1, with the atmospheric electricity quantities identified.

90

91   **Table 1. Quantities recorded on Mount Wank (1972-1983)**

Description of measured quantity	*Symbol used in dataset*
Meteorological and Environmental	
air temperature	T
relative humidity	RF
water vapor partial pressure	E
specific humidity unit	SF
potential temperature	TH
equivalent potential temperature	THE
wind speed	WG
wind direction	WR
Sunshine duration	SD
Global solar irradiance	GS
Sky radiation	HS
UV intensity	UV
Atmospheric Electrical	
Electric field	F
Zero crossing of F	DU
Vertical current	I
Positive ion concentration	N+
Negative ion concentration	N-

Total ion concentration	SN
Positive ion conductivity	L+
Negative ion conductivity	L-
Total ion conductivity	SL
Number concentration of condensation nuclei	K1, K2, K3

92

5.   Discussion

94 The PG measurements obtained were over a sufficiently extended period to provide statistical

95 support for suspected solar effects on the lower atmosphere (Reiter, 1977b), which was a major

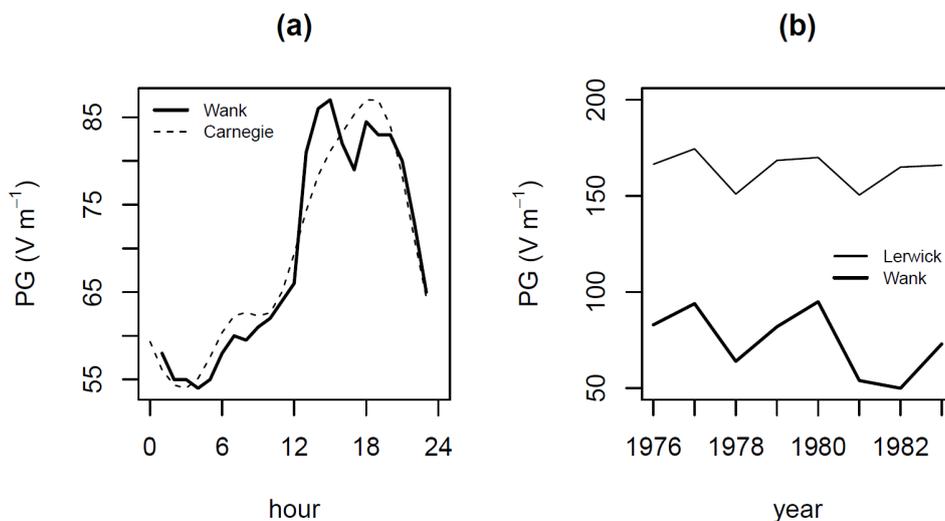
96 topic of research interest in the 1970s (e.g. Olson, 1971). Figure 2 shows examples from the

97 PG measurements, using data from the month of December only. In fig 2(a), the daily variation

98 is shown, which follows the global circuit's "Carnegie curve" variation. In fig 2(b), there is

99 some consistency evident with variations in annual PG measurements made in Shetland

100 (Harrison and Riddick, 2022), again suggestive of global circuit influences.

(a)   **(b)**

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102 Figure 2. Examples of Potential Gradient (PG) data from the Wank site. (a) Hourly median
103 PG using December-only values, 1976-1983 (solid line), overplotted on (relative) Carnegie
104 curve for November-December-January. (b) Annual December values for Lerwick (thin line)
105 and Wank (thick line), from Harrison (2004).

6. Conclusions

Atmospheric electricity and other environmental measurements were made in the Bavarian Alps over a long period, from which a series of hourly measurements for much of the 1970s is available digitally. In the PG data, the presence of global and solar-terrestrial signals is apparent, which indicates the likely wider applicability of the measurements. The endeavours at the Garmisch-Partenkirchen sites deserve to be more widely known.

Data availability

The 1972-1983 Wank dataset is openly accessible through the University of Reading's Research Data Archive, at https://doi.org/10.17864/1947.000445 .

Author Contributions

The authors jointly drafted the manuscript.

Competing interests

Kristian Schlegel is an editorial board member of HGSS. There are no other competing interests.

References

Aplin, K. L: Introduction to the special issue "Atmospheric electrical observatories", Hist. Geo Space. Sci., 11, 137–138, https://doi.org/10.5194/hgss-11-137-2020 , 2020.

Harrison, R. G.: Long-range correlations in measurements of the global atmospheric electric circuit, J. Atmos. Solar-Terrestrial Phys., 66, https://doi.org/10.1016/j.jastp.2004.05.001 , 2004.

Harrison, R. G., Riddick J. C.: Atmospheric electricity observations at Lerwick Geophysical Observatory, Hist. Geo Space. Sci., 13, 133–146, https://doi.org/10.5194/hgss-13-133-2022 , 2022.

Nicoll, K. A., Harrison, R. G., Barta, V., Bor, J., Brugge, R., Chillingarian, A., Chum, J., Georgoulias, A. K., Guha, A., Kourtidis, K., Kubicki, M., Mareev, E., Matthews, J., Mkrtchyan, H., Odzimek, A., Raulin, J.-P., Robert, D., Silva, H. G., Tacza, J., Yair, Y., and

138 Yaniv, R.: A global atmospheric electricity monitoring network for climate and geophysical
139 research, J. Atmos. Solar-Terrestrial Phys., 184, 18–29,
140 https://doi.org/10.1016/j.jastp.2019.01.003, 2019.

141 Olson, D. E.: The evidence for auroral effects on atmospheric electricity, Pure Appl.
142 Geophys. PAGEOPH, 84, 118–138, https://doi.org/10.1007/BF00875461, 1971.

143 Reiter, R.: Review of the History, Activities and Basic Facilities of the Institute for
144 Atmospheric Environmental Research, in: Electrical Processes in Atmospheres, 759–803,
145 1977a.

146 Reiter, R.: The electric potential of the ionosphere as controlled by the solar magnetic sector
147 structure. Result of a study over the period of a solar cycle, J. Atmos. Terr. Phys., 39,
148 https://doi.org/10.1016/0021-9169(77)90048-4, 1977b.

149 Reiter, R.: On the mean daily and seasonal variations of the vertical ozone profiles in the
150 lower troposphere. Atmos Environ, 25A, 9, pp1751-1757, 1991.

151 Reiter, R.: Phenomena in atmospheric and environmental electricity, Elsevier Science
152 Publishers, Amsterdam (572pp), 1992.

153 Rycroft, M. J. and Füllekrug, M.: The initiation and evolution of SPECIAL, J. Atmos. Solar-
154 Terrestrial Phys., 66, https://doi.org/10.1016/j.jastp.2004.05.013, 2004.

155 Weihe, W. H.: In memoriam Reinhold Reiter 17 November 1920-24 September 1998, Int. J.
156 Biometeorol., 43, https://doi.org/10.1007/s004840050122, 1999.