

Significance and Problems of Atmospheric Electric Measurements at the Ground in Polar and Oceanic Regions*)

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Abstract: The electrical phenomena in the atmosphere, caused by the global thunderstorm activity, are modulated by the local weather phenomena. The principal task of atmospheric research is the separation of these two domains of influence. The method normally used for this purpose, i. e. the comparison of the mean daily courses of the potential gradient with those found by the Carnegie-Institution some decades ago on the oceans, has found insufficient. Therefore, this method has to be replaced or, at least, completed by the method to compare the mean values of the potential gradient during undisturbed periods, e. g. days, measured simultaneously at different stations. — Applying this method to the results of a couple of stations in the non-polar continental areas these stations have found unfit for giving results of a global significance. Consequently, it is proposed for researches of the global atmospheric electric circuit to prefer in the future stations in the uninhabited polar and oceanic regions. A narrow connection with aerological measurements is desirable.

Zusammenfassung: Der durch die globale Gewittertätigkeit hervorgerufene luftelektrische Grundzustand wird durch das örtliche Wettergeschehen „moduliert“. Hauptaufgabe der luftelektrischen Forschung ist die Trennung dieser beiden Einflußbereiche. Bisher wird dies durch den Vergleich der mittleren Tagesgänge des luftelektrischen Potentialgefälles an den betreffenden Stationen mit den vor Jahrzehnten von der Carnegie-Institution auf den Ozeanen gefundenen mittleren Tagesgängen versucht. Dies Verfahren hat sich als unzureichend erwiesen und muß durch ein anderes ersetzt oder zumindest ergänzt werden, bei dem die während luftelektrisch ungestörter Zeiten gemessenen Werte (z. B. Tagesmittelwerte) miteinander verglichen werden, die gleichzeitig bestimmt worden sind. Eine Anwendung dieses Verfahrens auf eine Reihe von Stationen auf dem nicht-polaren Festland führt zu dem Ergebnis, daß an diesen Stationen der globale Anteil nicht erfaßt werden kann. Es wird deshalb vorgeschlagen, sich künftig für Untersuchungen mit globaler Zielsetzung auf Stationen in den unbewohnten Gebieten der Polarregionen und der Ozeane zu beschränken und außerdem eine enge Zusammenarbeit mit luftelektrisch-aerologischen Stationen anzustreben.

Introduction

Although atmospheric electrical researches in the polar regions are rather seldom, in general they have been particularly successful: They have led to two very important results concerning the explanation of the global relationships in atmospheric electricity:

First we remember the data of *H. Bennedorf* during a winter in Siberia (1899/1900) showing that the theory of *F. Exner* supposing a causal relationship between the

atmospheric electric field intensity and the water vapor content of the air does not exist.

Secondly we remember the discovery of the synchronous slope of the daily variation of the potential gradient over the whole world („Weltzeitperiode“), resulting first from the data of a couple of polar stations (*K. Hoffmann*, 1924). See also this journal 1954 (*H. Israël*, 1954).

Recently, the importance of measurements in these regions has been proved again by newer results I would like to present.

Problems

Discussing the significance of atmospheric electric measurements near the ground we think, first of all, of the problems connected with the global atmospheric electric circuit.

Since the atmospheric electric phenomena are generated by global influences, represented by the global thunderstorm activity, and modulated by the environmental weather situation, the explanation of results requires that methods must be found to separate the two domains of influence.

The usual method hitherto employed consists in comparing the mean daily course of the potential gradient for “fair-weather-days” with those found on the oceans by the Carnegie Institution some decades ago. This method is considered to be insufficient because (1) the result can be only a statistical one, (2) the data used for the comparisons belong to quite different periods, and because (3) there is no proof that a real separation is possible by these means. The first step to improve this situation must be an investigation on the significance of surface measurements with respect to the global picture in individual cases: Supposing that the global circuit emerges when the researches are restricted to “undisturbed fair-weather periods” we should

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expect that the data of different stations show a similar behavior.

For this purpose synoptical comparisons were carried out using synchronous daily means of the potential gradient and other elements measured during "undisturbed periods".

Results

The results are published in detail by *H. Israël* and *P. de Bruijn* (1968) and by *P. de Bruijn* (1968). So only some of them are presented here.

Plotting the data of two stations in a correlation graph we expect a distribution along a straight line without a scatter worth mentioning. But testing the results of different combinations of stations we find definitely other pictures:

Fig. 1 shows the correlation plot for the combination Potsdam and Wahnsdorf near Dresden — two stations at a small mutual distance (about 160 km). The straight line calculated is the regression line. In the upper righthand corner the correlation coefficient is given.

Although both stations are lying in the same weather and climate region, the scatter is surprisingly wide and the correlation coefficient is smaller than expected.

Comparisons of this kind were extended to several combinations of stations at different mutual distances.

Fig. 2 shows the results for three combinations of stations with global mutual distances. The correlation coefficients are so small,

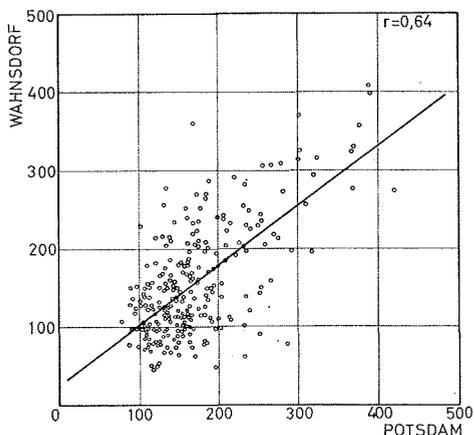


Fig. 1 Comparison of simultaneous daily means of the potential gradient during fair weather at the stations Potsdam and Wahnsdorf/Dresden (1934 bis 1939)

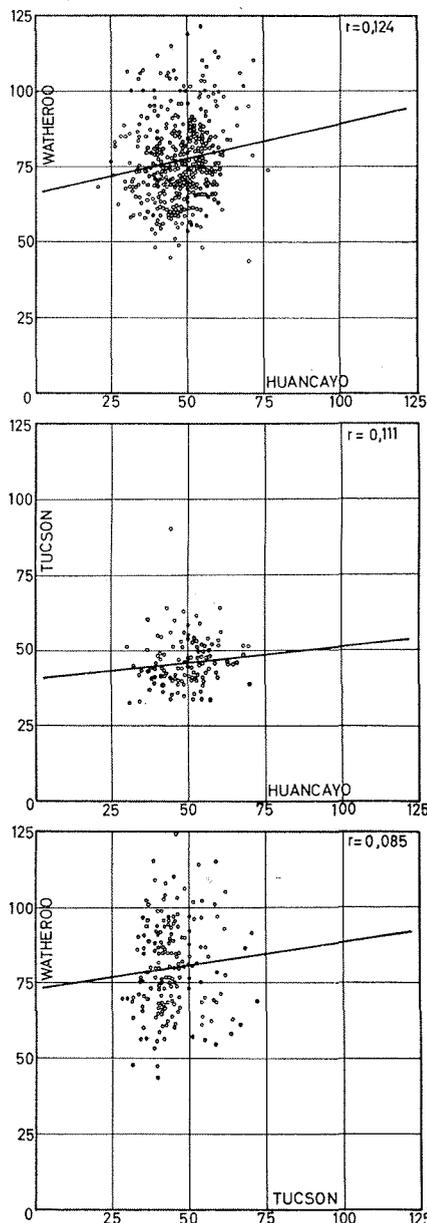


Fig. 2 Comparison of simultaneous daily means of the potential gradient during fair-weather-days for the combinations Huancayo, Peru — Watheroo, West Australia, Huancayo — Tucson, Arizona and Tucson — Watheroo (1922—1932).

and the scatters so wide, that obviously there exists no relationship in any case between the values correlated.

In general the results are worse when the mutual distances become larger.

Summarizing we find that, obviously, the global atmospheric electric behavior is

distorted by the local weather influences essentially more than expected and gathered from the former method to compare the mean daily courses.

The data material comprises only results of measurements at non-polar continental stations. A corresponding analysis with data from polar stations as well as from ocean stations could not be carried out hitherto, since there does not exist a sufficient data material. *)

On the other hand we are allowed, I believe, to anticipate a quite better result for these regions because otherwise it would not have been possible to detect the universal daily variation of the potential gradient and other subtle effects as the latitude effect. Looking for an explanation of these results we may conclude:

The behavior of the potential gradient at ground is influenced first of all by the aerosol content of the air and its variations. In the snow-covered an uninhabited polar regions the immission of aerosols, if existing at all, will be very small, whilst above the non-polar continental regions numerous natural and artificial injections of aerosols are present. On the wide oceans the only aerosol-source is the oceanic nuclei production. Therefore, the aerosol properties of air masses crossing the continental areas will be much more differentiated than those of air masses crossing the polar or the oceanic regions, respectively.

Conclusion

Looking onto the results discussed above we must consider some consequences with regard to the future atmospheric electric researches:

Since the separation of the global and the local influences, as required for the analysis of the atmospheric-electric behavior, seems to be totally impossible at continental stations — provided that the measurements were restricted to the atmospheric level near the ground — the most promising way for the future might be the establishment of a network of stations in undisturbed regions as they are to be seen in the polar and the oceanic regions.

*) A comparison of the data of two polar stations working simultaneously for the first time is in progress using the data of the American Southpole-Station and the Belgian Station "King Baudouin" in Antarctica (Personal information by Dr. H. W. Kasemir, Boulder, Colorado, and Dr. Buis, De Bilt, Nederland).

It might be very useful to complete these researches by aerological measurements. Since for researches of this kind a restriction to the uninhabited regions seems to be not necessary, they could be carried out at places distributed over the whole globe. Anyway, a close cooperation with the aerologic electric stations is to be aspired. The main task of such a cooperation would be to find out, day by day, representative values of the total potential difference between the earth's surface and the ionosphere.

Another question not yet cleared up concerns the significance of measurements on mountain tops. Although from the comparison of the results obtained at Jungfraujoch and Gornergrat in the Swiss Alps (see *H. Israël* and *P. de Bruijn* loc. cit.) these stations seem to be insufficient for the purpose aspired here, stations in higher altitudes as well as in other climatological regions may be suitable to be included into a world-wide network of representative atmospheric electrical stations.

To test whether or not a station is suitable for researches of the global circuit the method of comparing daily means described above should be applied.

These proposals will bring along a lot of problems and difficulties, e. g. concerning the claims of which care must be taken when constructing the new equipments suitable for measurements and registrations in the polar and the oceanic regions, concerning the organization of the network sketched above and — last but not least — questions of financing the future atmospheric electric researches. I think, we must overcome these difficulties if we want to find new research methods promising better results than the prevailing methods. Perhaps, we must "jettison" for this purpose some "beloved" customs and change several plans and ideas hitherto pursued.

References:

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Israël, H. und Bruijn, P. de, 1968: The present status of atmospheric electric research. *Archiv für Meteorol., Geophys. und Bioklimat.* (A) 16 (1958) 281—300.