JOURNAL OF THE PHYSICAL SOCIETY OF JAPAN Vol. 17, SUPPLEMENT A-I, 1962
INTERNATIONAL CONFERENCE ON COSMIC RAYS AND THE EARTH STORM Part I

I-2-P2. Blackouts and Sporadic E Layers*

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Discussion

Hultqvist, B. K. G.: You mentioned that you had found the same spiral form for the precipitation curves for the aurora as for the E_s. I would be very interested to know under which conditions those auroral spirals have been observed.

Piggott, W. R.: I have used the times of peak auroral occurrence as shown by auroral observations at the zenith and also published curves of auroral incidence from the U. S. S. R. Both are expressed in the form of LMT—latitude variations. The slopes and intercepts for different longitude zones are compared with those found for E_s and Blackout in the same zones. Reasonable straight lines are obtained though the scatter is somewhat greater than in the ionospheric case. The big changes in slope 1 hour in 1.45° to 1 hour in 4.7° show in both as do the shifts in intercepts (phase delay).

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INTERNATIONAL CONFERENCE ON COSMIC RAYS AND THE EARTH STORM Part I

I-2-P3. Drift of the E-Layer during Geomagnetic Storms

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Introduction

In the following the results of drift measurements of the ionosphere made in Norway will be given. The places of observations were Kjeller (near Oslo) at 60°N and Tromsö at 70°N. Both places are geomagnetically disturbed, Kjeller only during stronger storms, Tromsö,—lying close to the auroral zone,—by all geomagnetic storms.

Various methods and different frequency ranges have been in use and the main aim has been to trace the influence of geomagnetic storms on the *drift directions* of the ionosphere and to study the *anisometry* of the diffraction pattern.

In the following the results will be given of measurements carried out by the Norwegian ionospheric group on :

i) drift measurements of the *E*- and *Es*-layer using the Mitra method on 2 Mc/s.

ii) drift measurements of auroral echoes using a frequency on 40 Mc/s.

E-layer Drift Measurements

Series of measurements have been made at Kjeller and Tromso using the Mitra method.[1] The frequency used was 2—2.4 Mc/s and the distances between the receiving points were 130 m. A Phillips recorder was used and this equipment worked satisfactorily at Kjeller. On Fig. 1 the diurnal variation of the mean value of the wind vector observed at Kjeller during the *summer* season is given. Two series of observations have been made which gave similar results.

It is apparant that two different effects are present, the smooth semi-diurnal variation in the drift of the *normal* *E*-layer, at day time and the westernly drift of the *Es*—layer at night-time. Now the appearance of *Es* at Kjeller is usually connected with some geomagnetic disturbance and the westernly drift

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* Both manuscript and preprint have not been received.

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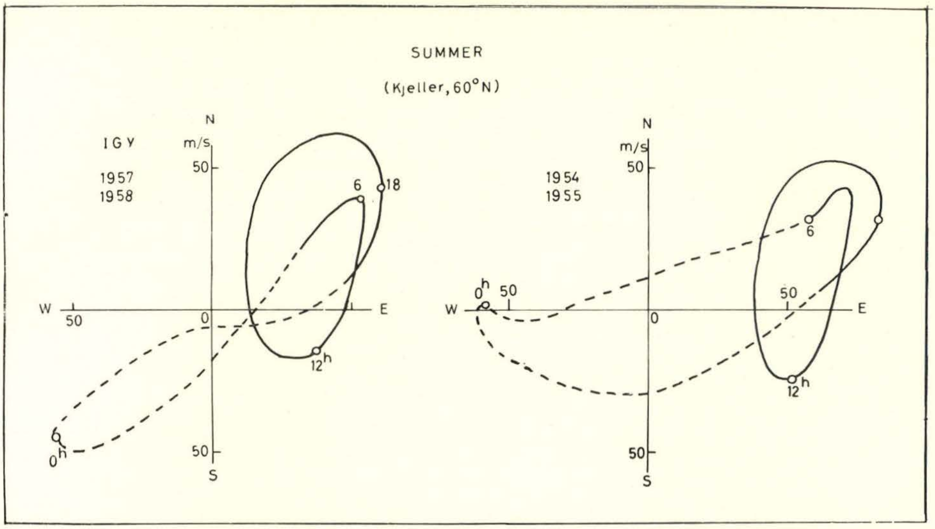

Fig. 1. Drift of the *E*-layer observed at Kjeller on 2 Mc/s. The wind-vector shows a semi-diurnal period clearly during *day-time* when the normal *E*-layer is present.

During *night-time* when only reflections from an *Es*-layer are obtained, the wind-vector is directed towards W.

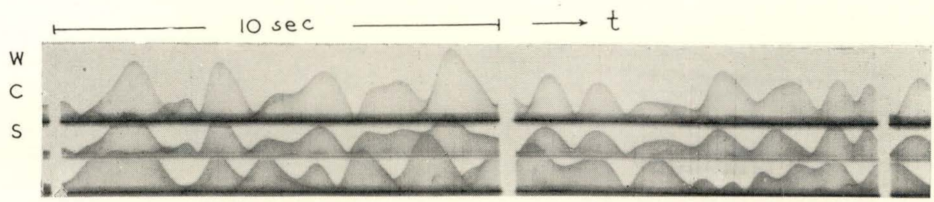

Fig. 2. Records of amplitudes of *Es*-echoes over the E-W and N-S bases at Tromsö. There is high correlation between the amplitude at the receiving points in E-W directions and a low correlation between the receiving points in N-S direction.

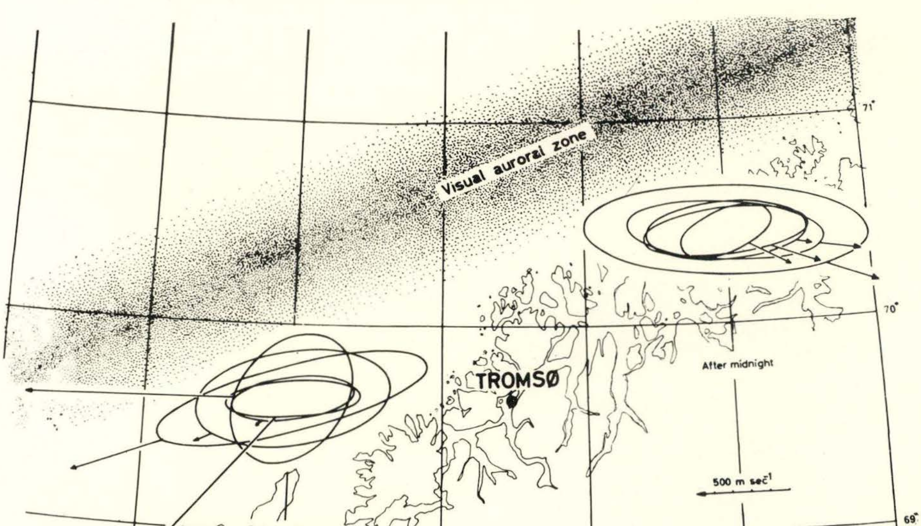

Fig. 3. Examples of correlation ellipses and drift velocities of the *Es*-amplitude pattern, observed at Tromsö (after Maehlum[2]).

of the *Es* must be considered as an effect of geomagnetic disturbance.

The figure indicates that one must be critical in applying harmonic analysis on results of drift measurements, it is apparant that two different drift effects here have been present. It is well known that the diurnal variation of *Es* varies with latitude, and at lower latitudes the appearance of *Es* seems not to be dependent on geomagnetic disturbance. It would be of interest to investigate if the equatorial *Es* exhibit a similar change in drift directions relative to the normal *E*-layer.

When the equipment for drift recordings was moved up to Tromsö close to the auroral zone, it turned out that it was difficult to apply the standard Mitra method for drift studies. The fading rate of the echoes even at quiet conditions was much higher than at Kjeller. A series of measurements were, however, carried out by recording the rapidly fading amplitudes of the *E*-echoes received on three aerials and displayed on a multibeam oscillograph. It turned out that there was a marked difference between the degree of correlation between the amplitude variations received over the two bases in E—W and N—S directions.

By applying the method of full correlation analysis developed by the Cambridge group it is possible to compute the true value of drift and the ellipse of correlation. Fig. 3 shows these quantities determined at Tromsö during geomagnetic storms for a number of cases according to Maehlum[2].

Two effects are present:

i) before midnight there is a movement towards W.

after midnight there is a movement towards E.

The drift speed may attain values of several hundred m/s, in median 150 m/s.

ii) the ellipse of correlation is stretched out in E–W direction.

There is further an indication of dependence of drift speed with the magnitude of the geomagnetic storm vector.

The orientation of the correlation ellipse at Tromsö with the major axis approximately parallel to the auroral zone and to the direction of the current system producing geomagnetic storms, is of special interest. An E–W orientation of the ellipse of correlation for the *Es*-diffraction pattern should be con-

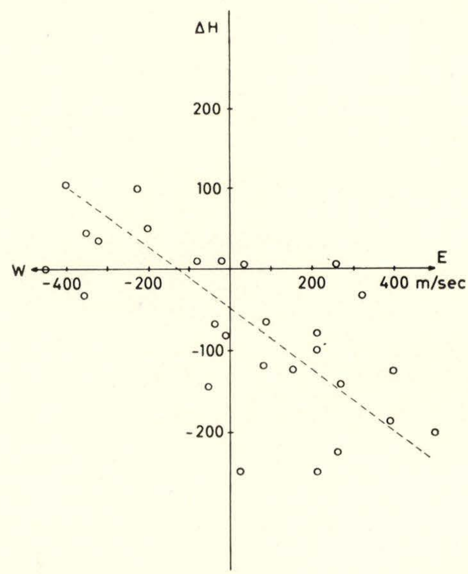

Fig. 4. Drift velocity of *Es* versus horizontal component of geomagnetic storm vector (after Maehlum[2]).

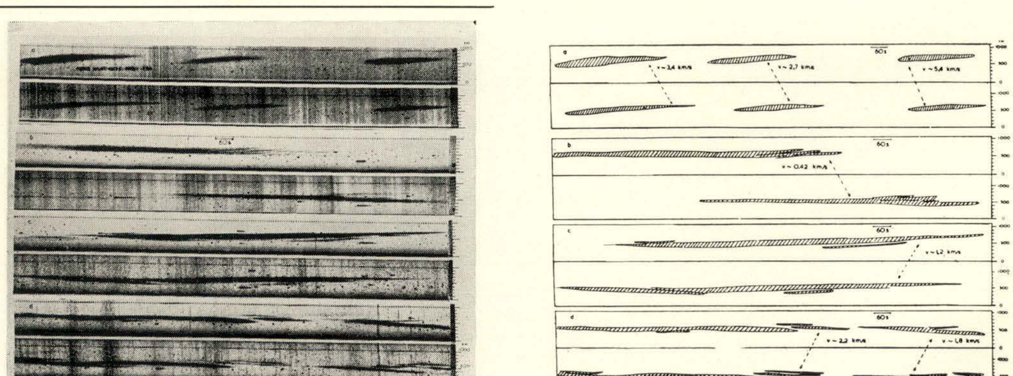

Fig. 5. Drift records of auroral echoes observed at Kjeller[3].

sidered as an argument for the presence of an electric field in E-W direction during geomagnetic storms.

Drift of Auroral Echoes

An E-W drift of auroral echoes was first observed at Jodrell Bank and has later been confirmed through observations at a number of places.

In Norway drift measurements have been carried out at Kjeller (near Oslo) and a Tromsö. The method used was to use a two channel arrangement and the pulses were transmitted and received on two directive aerials placed at an angle of divergence. It was thus possible to observe the appearance and disappearance of the echoes passing through from one aerial and to the other. The frequency used was 40 Mc/s. In Fig. 5 are shown records, and the diurnal variation of the drift directions are given in Fig. 6 based on a 8 month period of observations at Kjeller.

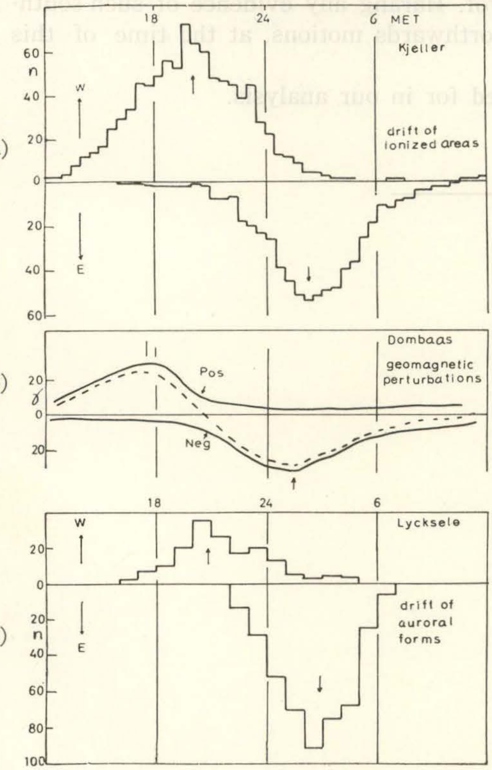

Fig. 6. (a) Diurnal variation of drift directions of *auroral echoes*, (b) diurnal variation of *geomagnetic perturbing vector* H, (c) diurnal variation of drift directions of *auraral forms* determined from all-sky photos (after Stoffregen).

We will point out that there is a difference in the character of drifts observed at Kjeller and Tromsö. At Kjeller we are observing the drifts which appear at the outer southern edge of the auroral zone, and simple and regular curves showing the drift effects are obtained. At Tromsö we are observing at the place of auroral maximum and even at the inner part of the auroral zone, and much more complicated and irregular drift effects are recorded.

It is of interest to compare the drift results obtained by the two methods: drift measurements of *Es* on 2 Mc/s and drift of auroral echoes on 40 Mc/s.

We see that there is a qualitative agreement in the diurnal change of drift directions during the day, and the drift directions are mainly confined to an E-W movement parallel to the auroral zone. There is however, a difference in the speeds, and we may sum up the values of speeds as follows:

drift speed of normal *E*-layer	50–100 m/s,
drift speed of normal *Es*-layer	100–600 m/s,
both measured on 2 Mc/s,	
drift speed of auroral echoes	1–3 km/s,
measured on 40 Mc/s.	

References

1) L. Harang and K. Pedersen: J. Geophys. Res. **62** (1957) 183.
2) L. Harang and J. Tröim: Planet. Space Sci. **5** (1961) 33.
3) B. Maehlum: Report No. 37, Norwegian Defence Research Establishment, Kjeller, Norway (1961).

Discussion

Veldkamp, J.: Did you find any dependence on the height of your drift-velocities and-directions in the *E*-region? It might be found by changing a little the frequency used (2 Mc/sec).

Harang, L.: I have not made this experiments, but it is known that experiments have been made by Jones.

Beynon, W. J. G.: Dr. Harang mentioned day to night changes in drift-velocity and suggested that the one referred to the normal E layer and the other to the sporadic E layer. In considering drift-velocities near the 100 km. level it is worth remembering that there are very marked height gradients of velocity at these levels and we have found a complete reversal of the direction of drift on a height range of a few kilometres.

Hines, C. O.: (1) Difference between E-region motions discussed by Prof. Harang, and the F-region motions mentioned by Mr. Ratcliffe, can reasonably be associated with the change from disturbed, higher-latitude, condition to undisturbed, lower latitude conditions. I believe that the motions of high-latitude radio-star scintillations centres (which are usually associated with the F-region) do exhibit the same transition as indicated by Prof. Harang. Such agreement is to be expected, at least if the E-sporadic ionization is being produced by precipitation from above.

(2) T. N. Davis' observations, and theory, would suggest that a southwards motion is to be expected at the time of transition from westwards to eastwards motions. It would likely be somewhat weaker. Has Prof. Harang any evidence of such southwards motions, at least preferentially over northwards motions, at the time of this transition?

Harang: Such motions have not been looked for in our analysis.