SECTION-V

GEOMAGNETISM AND RADIOPHYSICS

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A Comparative Study of Quiet Day Variation of the Geomagnetic Field at Dakshin Gangotri (India) and Novolazarevskaya (USSR) in Antarctica

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Abstract

The duration of the summer camp of the Fifth Indian Scientific Expedition to Antarctica coincided with an excellent spell of geomagnetic calm interspersed with severe disturbances. A comparative study of the quiet day features of the geomagnetic field at two nearby Antarctic stations was carried out. It was seen that the diurnal variation pattern at the USSR and the Indian magnetic stations were comparable but not on a one-to-one basis, with H component showing a greater difference. The day-to-day variability in the field at both stations was largest near 04 hrs UT, perhaps close to the 'Harang' discontinuity. The variability in the meridional component (D), being least, was in conformity.

Introduction

The Fifth Indian Scientific Expedition to Antarctica set up a temporary magnetic variation station at Dakshin Gangotri. The equipment used was a 3-component fluxgate magnetometer oriented to respond to magnetic field changes in H (Horizontal), Z (Vertical) and D (Declination) components.

The output was connected to a strip chart voltage recorder with the sensitivity of 100 nT/volt for all three components.

It is well known that USSR runs an uninterrupted magnetometer network in Antarctica one of which is located at Novolazarevskaya near the Indian station at Dakshin Gangotri. At Novolazarevskaya fully temperature compensated Bobrov quartz sensors with photographic registration have been utilised with sensitivity o£ H = 126 nT/cm, Z = 102 nT/cm and D = 146 nT/cm. In the southern hemisphere the magnetic field variations, strongly dependent on corrected geomagnetic latitude and magnetic local time, can show significant differences between two geographically nearby locations (Rangarajan *et al*, 1986). Therefore, it will be worthwhile to examine similarity of magnetic field changes during quiet condition at these two locations.

Useful geomagnetic data was collected at Dakshin Gangotri from January 11 to February 20, 1986. A remarkable feature of this duration was the continued quiescence of magnetic field conditions for several consecutive days, e.g. between 11 to 19 January and again from 1 to 5 February. The most violent magnetic disturbances occurred.,beginning on 6 February and ending by 9 February.

The magnetogram from Novolazarevskaya for January and February, 1986 was made available, on request, by World Data Centre B, Moscow, USSR. Their availability provided an opportunity to carry out a comparative study of the features of diurnal variation at Dakshin Gangotri and Novolazarevskaya.

In Table I are given the coordinates and other relevant parameters of the two magnetic stations.

Table I

	Dakshin Gangotri	**Novolazarevskaya**
Geographic Latitude	70°05'S	70°46'S
Geographic Longitude	12°00'E	11°49'E
Dipole Latitude	65.5° S	66.3° S
Corr. Geomagnetic Latitude	62.1° S	62.4° S
Corr. Geomagnetic Longitude	52.3°E	51.5° E
L Parameter	4.61	4.63
Magnetic Local Time (MLT)	(UT-1 hour)	(UT-1 hour)
Variometers used	Fluxgate	Bobrov Quartz

Data Analysis

Days with index Ap of magnetic activity 7 are considered an appropriate criterion for Quiet days. There were 16 days in the interval under consideration satisfying this condition. Of these, common data for all three elements for both stations were not available for 2 days. The records of Novolazarevskaya and Dakshin Gangotri were scaled to derive mean hourly values for these fourteen days. The hourly data were then corrected for non-cyclic variation and a reference level corresponding to the mean of three consecutive values centred on 00 UT was subtracted. This was essential to eliminate sudden jumps in D G records caused by main failure and/or instrumental adjustment.

The individual hourly values for 14 days for the two stations were then averaged to derive mean diurnal variation for the three elements H, 2 and D together with the variance for individual hours. The 24 hourly values for a day were also subjected to harmonic analysis to derive the phase and amplitude of the dominant harmonic components. Some of these features are discussed in the subsequent section.

Results and Discussion

(i) *Mean diurnal variation*

The mean diurnal variation patterns in the three magnetic elements at Dakshin Gangotri and Novolazarevskaya are shown in Fig. 1.

The variations are in close conformity with the anticipated diurnal patterns for locations near 60°S during local summer months close to solar minimum epoch. The range of variation at both stations in all the three components are

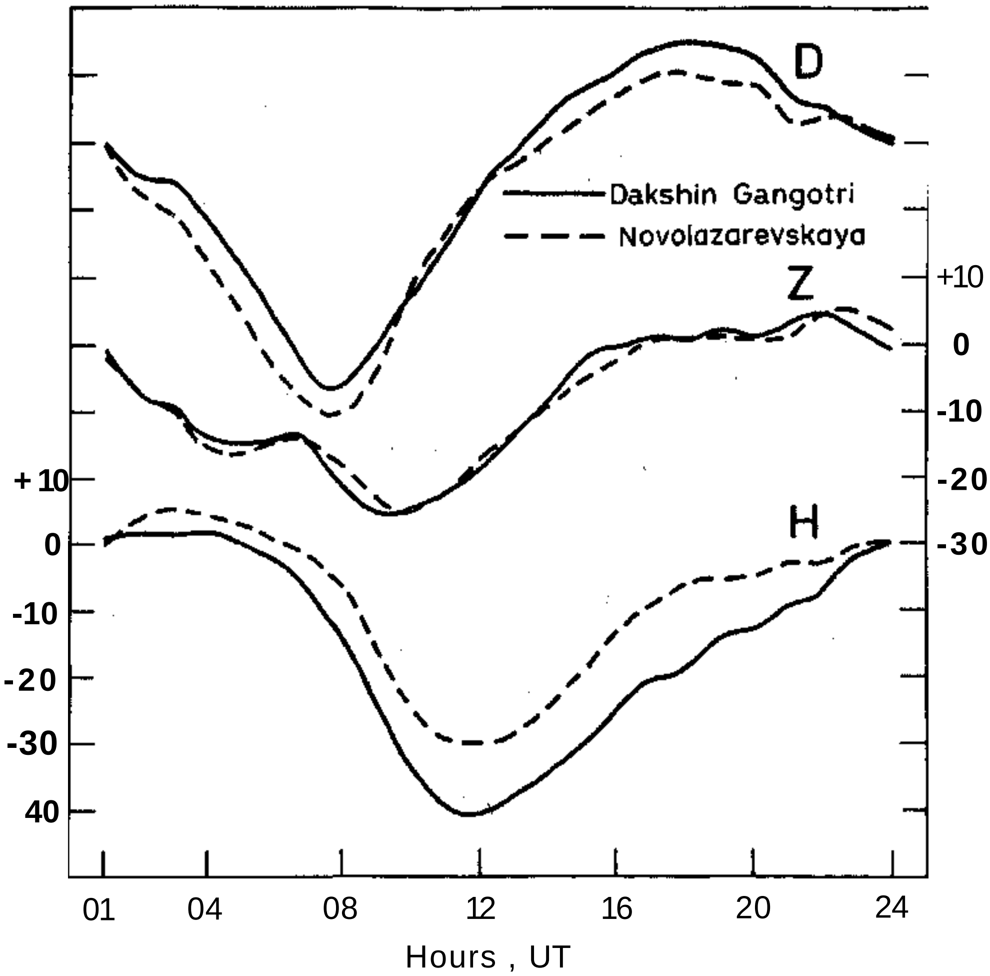

Fig. 1. *Mean diurnal variation in H, Z and D derived from records on quiet days at Dakshin Gangotri and Novolazarevskaya*

almost exactly the same. However, in H Component, the diurnal variation curve at "Novolazarevskaya does not coincide with that of Dakshin Gangotri. Both the maximum and minimum fields appear elevated. In D component the opposite seems to be true in the sense that the minimum and maximum at Dakshin Gangotri appears to be greater in magnitude relative to the reference level. These departures from total coincidence can be mainly attributed to the fact that the three dominant poles—Geographic, dip and corrected geomagnetic—are widely separated in Antarctic region (Ref Fig. 4; Rangarajan et *al,* 1986) so that even two stations in close proximity geographically may show significant differences in their geomagnetic variations.

The Z variations are in close agreement at the two stations. At both places the mean curve shows a secondary feature between 04 and 08 UT, not anticipated from the spherical harmonic expansion of the external field (Matsushita, 1967; Parkinson, 1983). In contrast to D and H, the average Z diurnal variation is not very smooth. At high latitudes, the auroral electrojet currents influence the short-term variations both by their intensity and mean location. In the vertical component, the effects can even reverse sign if two stations are located on either side of the centre of the electrojet. During quiet magnetospheric conditions, however, the average auroral oval will be located further towards the southern polar cap (Akasofu, 1977) in relation to the two stations so that intensity fluctuations will affect both in the same sense. Close similarity for the Z pattern also indicates that the sub surface electrical features at skin depths relevant to 24—hour periodicities beneath Novolazarevskaya and Dakshin Gangotri are quite comparable.

(ii) *Day-to-day variability*

Variances of the field fluctuations for each hour for the three elements are computed using the standard formula

$$V\ (X_i) = 1/N \qquad (X_{ii} \bar{X}_i)^2$$

$N = 14$ and $i = 1, 2,$ or 3

Where $X_1 = H$, $X_2 = Z$ and $X_3 = D$. Plots of the variances as a function of time in H, Z and D at Novolazarevskaya and Dakshin Gangotri are shown in Fig. 2.

Yacob and Arora (1974) showed that at low latitudes, the day-to-day variability of the field for each hour follows a diurnal pattern similar to the average solar quiet day variation, Sq, with maximum near local noon. They found that apart from very low variance for hours close to local midnight, the predawn field (03 or 04 local time) has the least variance indicative of their suitability as reference level.

The most striking feature of Fig. 2 is the fact that the diurnal pattern in variance has no sensible relationship with the average curve shown in Fig. 1. In other words, the day-to-day variability is not due to the amplitude fluctuation of the diurnal pattern. Phase changes from one day to another appears to be more- crucial parameter.

The variability in D is least at both locations compared to the other two elements. The variability in H and 2 at both stations exhibits a strong peak at 4 UT (corresponding to 3 MLT). This could be the time interval of 'Harang'

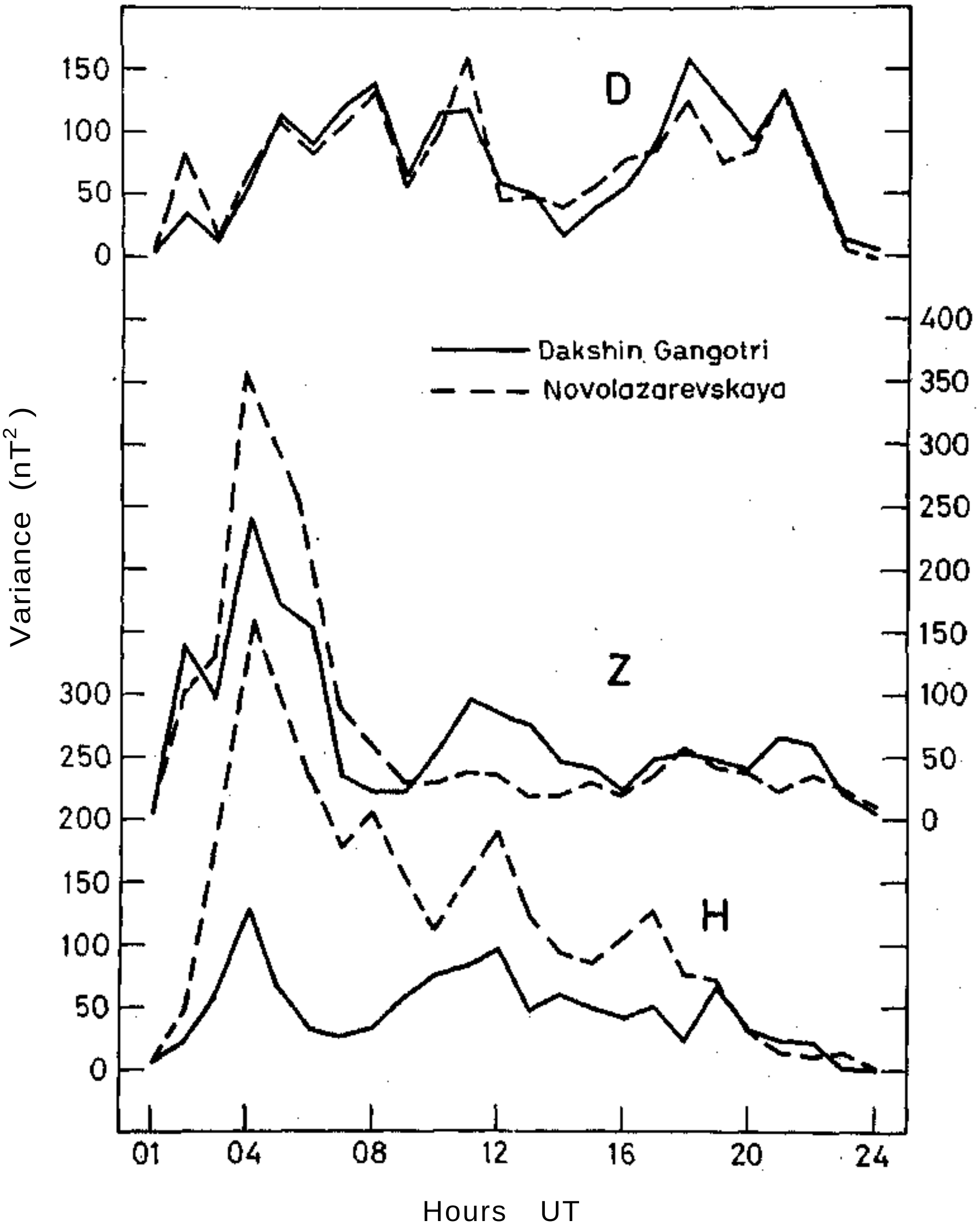

Fig. 2. *Day-to-day variability at each hour of the day in the three components of the magnetic field at Dakshin Gangotri and Novolazarevskaya for 14 chosen quiet days.*

discontinuity the border between eastward and westward electrojets. As the discontinuity moves in local-time from one day to another the influence of westward and eastward auroral electrojet could be alternated leading to such a large variance. As the Harang discontinuity coincides with the boundary between upward and downward field aligned currents (Akasofu, 1977) there would be no net meridional currents and therefore only small changes in Declination should be expected. Our results for the variability of Declination at both stations is in good conformity with this.

While at Novolazarevskaya the largest variances in H and Z are comparable, at Dakshin Gangotri H variability at its peak is considerably less in comparison to Z. At other hours, the variability factors introduce only a standard error of roughly 2 nT to the mean values" plotted in Fig. 1. In D, the variability exhibits a semidiurnal pattern with maxima around 7 and 19 UT (6 and 18 MLT).

The close similarity of the variability pattern in all these elements suggests that both stations are influenced by current fluctuations at locations sufficiently far away than their lateral separation.

(iii) *Features of the diurnal (24-hr) component*

The average variation over 24 hours of the 3 components of the field shown in Fig. 1, clearly indicates that the dominant periodicity is 24 hours, particularly for H and D.

To study the nature of the stability of the diurnal component, harmonic analysis was carried out for individual days to get the phase, amplitude and percentage of the total variance accounted for by the first harmonic.

In Fig. 3 are shown the percentage variance of the 24-hour component for each day for H, D and Z at both stations. The variance changes from one day to another in a similar fashion at both locations, particularly in Z and D. The variance for H is significantly larger (with an average >80% of the total variance) at Dakshin Gangotri in contrast to Novolazarevskaya with an average variance > 65%. Day 7 (corresponding to Jan. 31) is not dominantly diurnal with the percentage variance accounted for by the 24-hour component reaching a minimum of only 40-50% in H and Z. In D similar minima were also noticed for day nos 5 and 11.

Also shown in Fig. 3 are the epochs of maximum of the diurnal component derived from the corresponding phase angles for each day. Of the three components Declination seems to register a uniform maximum close to 18 UT with maximum departures of 17 to 19 UT between day Nos 5 and 7. In sharp contrast, the diurnal maximum in H shows pronounced variation between late evening hours and pre-dawn hours. The variability is largest between day Nos. 5 and 9 (corresponding to Jan. 18 and Feb. 2). Again there appears to be sensible disparity between Novolazarevskaya and Dakshin Gangotri with D.G. being associated with smaller fluctuations in epoch of maximum.

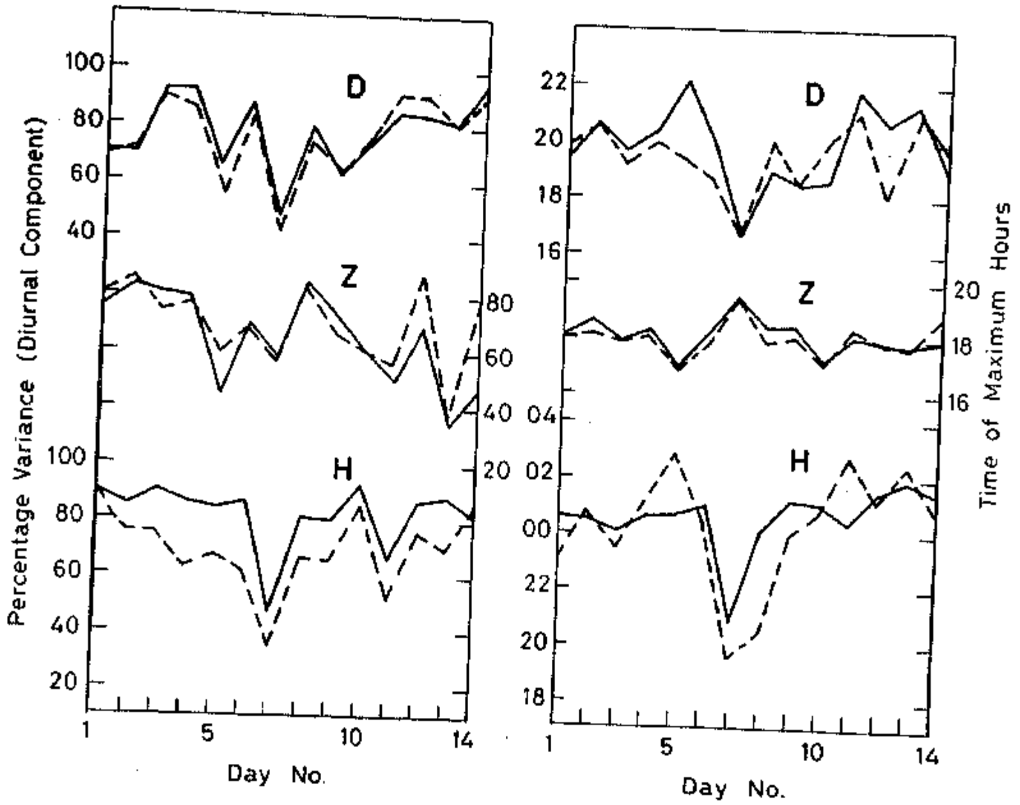

Fig. 3. Percentage variance accounted for by the dominant diurnal (24-hr) component of the daily variations and its epoch of maximum in H, Z and D at Dakshin Gangotri and Novolazarevskaya

The 24 hourly departures with reference to the night time reference levels of the three elements at Dakshin Gangotri and Novolazarevskaya for individual days are subjected to regression analysis to assess the variability from one day to another. The correlation coefficients for the fourteen days and the corresponding regression coefficients (slope of the linear relationship) are shown in Fig.4, For all the three elements the average correlation is greater than 0.9 with variability within the range of ± 0.1 in general; from one day to another. This indicates that the diurnal variability at both stations are not always in complete phase coincidence and cases with lower correlation indicate greater phase differences. The slope of the regression line, indicative of the relationship between changes in magnitudes at both stations exhibits far greater variability. As against an ideal slope of unity the average slope is less than one in all three elements. This indicates that the changes at Novolazarevskaya are, in general, less in magnitude compared to Dakshin Gangotri but not uniformly so from one day to another.

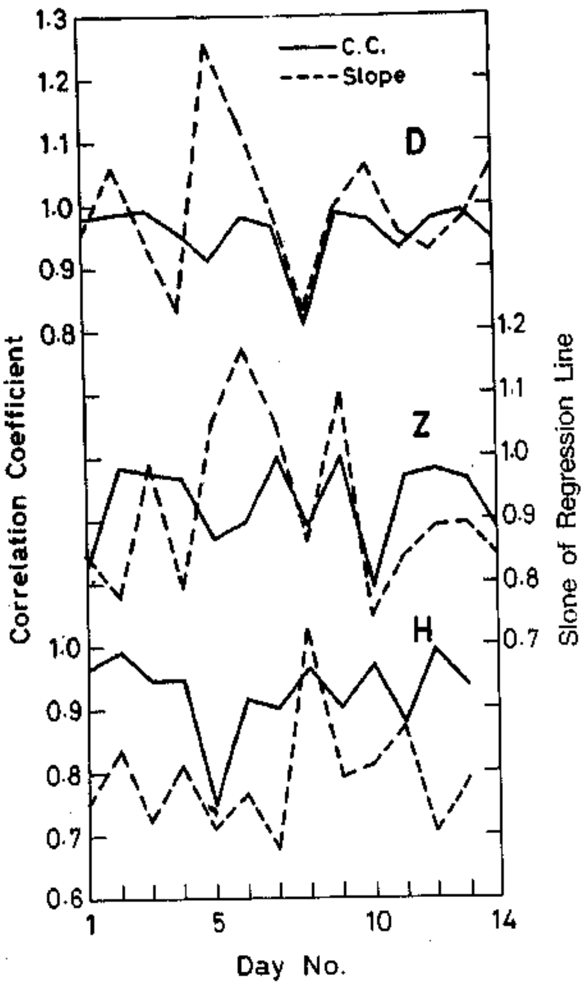

Fig. 4. Day-to-day changes in the correlation and linear regression between Dakshin Gangotri and Novolazarevskaya

Apart from the quiet day variations, certain short period variations can also be compared to highlight the dissimilarity between both the locations as a function of frequencies which can provide some information on the differences in the subsurface structures. They will be taken up in course of the time.

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