#30

EQUATORIAL DST HOURLY VALUES

GG-41B

1 TAPE

Table of Contents

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1. INTRODUCTION:

The documentation for this data set was originally on paper, kept in NSSDC's Data Set Catalogs (DSCs). The paper documentation in the Data Set Catalogs have been made into digital images, and then collected into a single PDF file for each Data Set Catalog. The inventory information in these DSCs is current as of July 1, 2004. This inventory information is now no longer maintained in the DSCs, but is now managed in the inventory part of the NSSDC information system. The information existing in the DSCs is now not needed for locating the data files, but we did not remove that inventory information.

The offline tape datasets have now been migrated from the original magnetic tape to Archival Information Packages (AIP's).

A prior restoration may have been done on data sets, if a requestor of this data set has questions; they should send an inquiry to the request office to see if additional information exists.

2. ERRATA/CHANGE LOG:

NOTE: Changes are made in a text box, and will show up that way when displayed on screen with a PDF reader.

When printing, special settings may be required to make the text box appear on the printed output.

Version	Date	Person	Page	Description of Change
01				
02				

3 LINKS TO RELEVANT INFORMATION IN THE ONLINE NSSDC INFORMATION SYSTEM:

http://nssdc.gsfc.nasa.gov/nmc/

[NOTE: This link will take you to the main page of the NSSDC Master Catalog. There you will be able to perform searches to find additional information]

4. CATALOG MATERIALS:

a. Associated Documents — To find associated documents you will need to know the document ID number and then click here.
http://nssdcftp.gsfc.nasa.gov/miscellaneous/documents/

b. Core Catalog Materials

GG-41B

EQ. DST VALUES ON MAGNETIC TAPE

GG-41B

This data set has been restored. There was originally one 9-track, 6250 BPI tape written in EBCDIC. There is one restored tape written in ASCII. The DR tape is a 3480 cartridge and the DS tape is 9-track, 6250 BPI. The original tape was created on an IBM 3081 computer and the restored tape was created on an IBM 9021 computer. The DR and DS numbers along with the corresponding D number are as follows:

DR#	DS#	D#	FILES	TIME SPAN
DR004622	DS004622	D000275	1	01/01/57 - 12/31/83

REQ. AGENT	RAND. NO.	ACQ. SCIENTIST
DLB BER	RC 3518	KWC

GG - 41B
EQUATORIAL DST HOURLY VALUES

THIS DATA SET CONSISTS OF ONE MAGNETIC TAPE. IT IS 9 TRACK, 6250 BPI, WRITTEN IN EBCDIC ON AN IBM 3081 COMPUTER. THE TAPE NUMBERS AND TIME SPAN FOLLOW:

D#	C#	#of FILES	TIME SPAN
D-00275	C-00096	1	01/01/57 - 12/31/83

FORMAT OF EQUATORIAL DST HOURLY VALUES

POSITION	
1 - 3	LETTERS = DST
4 - 5	YEAR GMT
6 - 7	MONTH GMT
8	ASTERICK *
9 - 10	DAY GMT
11 - 20	BLANK
21 - 24	1st HOURLY VALUE
25 - 116	23 HOURLY VALUES AT 4 CHARACTERS PER VALUE
117 - 120	BLANK

The tape is 556, ~~BCD~~ ASCII, EVEN parity, 7 track and has 1 file. It was created on the IBM 7094 computer.

VOLUME XXXV
(PART I)

HOURLY VALUES OF EQUATORIAL *Dst* FOR THE IGY

MASAHISA SUGIURA

Goddard Space Flight Center, Greenbelt, Md.

HOURLY VALUES OF EQUATORIAL Dst FOR THE IGY

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Goddard Space Flight Center, Greenbelt, Md.

Using eight magnetic stations in low latitudes, hourly values of *Dst* are determined for the IGY. Three-hourly mean *Dst* values are compared with corresponding values based on Kertz's *Dst* indices. Three-hourly mean *Dst* is also compared with *ap* indices. It is found that *Dst* correlates well with *ap* in gross features and that during magnetic storms activity represented by *ap* recovers more rapidly than *Dst*.

1. Introduction

Among transient variations of the Earth's magnetic field the most outstanding in magnitude and duration are those of magnetic storms. Though their form and severity vary considerably from one event to another, the majority of magnetic storms have certain common characteristics. One of the characteristics is the decrease of the horizontal force, H, all over the world in the equatorial and moderate latitudes. This decrease is very nearly axially symmetric and does not depend on longitude or local time. Superimposed on the general decrease in H there are variations in all three components that depend on local time; these variations are of large amplitude in the polar regions.

It is thus convenient to analyze the storm variation D into two parts, *Dst* and *DS*. At an instant of time *Dst* is the average of D over all longitudes. *DS* is defined by $D - Dst$. The two variations *Dst* and *DS* may be obtained for a specified latitude, or for a zone of finite width centered at some latitude. These definitions apply to all three magnetic components.

For a well-defined storm *Dst* and *DS* can be determined as functions of storm time measured from the onset of the storm.

Statistical analyses of magnetic storm variations have been made essentially in the manner described above by MOOS[1], CHAPMAN[2-5], VESTINE *et al.*[6], YOKOUCHI[7,8], SUGIURA and CHAPMAN[9] and others.

However, the determination of *Dst* need not be limited to times of magnetic storms, but can be extended to periods of less magnetic activity or even to magnetically quiet times. In fact, *Dst* may be determined continuously as a function of universal time regardless of occurrence of magnetic storms. *Dst* so determined should provide a measure of magnetic activity.

VESTINE *et al.*[6] have published such continuous *Dst*; they gave hourly *Dst* curves for the Second Polar Year, September 1932 to August 1933 (Carnegie Institution of

Washington Publication 580, pp. 250 [illegible]). The hourly *Dst* values were obtained by averaging hourly departures from the annual mean for San Juan, Alibag and Honolulu, all in low geomagnetic latitude and spaced approximately evenly in longitude.

More recently AKASOFU and CHAPMAN determined *Dst* for several magnetic storms (cf. AKASOFU and CHAPMAN[10]), and their *Dst* curves have been extensively used by other workers. Such *Dst* data are now in great demand by those who concern themselves with solar cosmic rays, solar plasma, Earth's radiation belts and other related geophysical phenomena.

CHAPMAN, AKASOFU and the present author initiated determination of hourly *Dst* values for the IGY with a hope that such data would be published on a routine basis in the future. The work was carried out with assistance from J. C. CAIN of NASA and E. J. CHERNOSKY of Air Force Cambridge Research Laboratories.

KERTZ has derived three-hourly index for *Dst* for the IGY by a method different from the one adopted here. In Section 5, three-hourly *Dst* values obtained by our method are compared with the corresponding values based on KERTZ's indices.

2. Magnetic Stations Used

The selection of magnetic stations was made with the following considerations: (1) Stations in low latitudes should be used to eliminate as much as possible disturbances originating in the auroral zones; (2) Stations near the magnetic equator should be avoided because the equatorial electrojet may introduce undesired variations; also magnetic storm variations are irregular and often augmented at the magnetic equator; (3) Stations should be distributed over longitude as uniformly as possible; (4) Reliable hourly *H* values are already available.

TABLE 1

Magnetic stations used—in the order of increasing geographic east longitude

Station	Geomagnetic		Geographic	
	Latitude	Longitude (E)	Latitude	Longitude (E)
Hermanus	S 33·3°	80·3°	S 34° 25'	19° 13'
Alibag	N 9·5°	143·7°	N 18° 38'	72° 55'
Kakioka	N 26·0°	206·0°	N 36° [illegible]	140° 11'
Apia	S 16·0°	260·2°	S 13° [illegible]	188° 14'
Honolulu	N 21·0°	266·4°	N 21° 18'	[illegible] 54'
San Juan	N 29·9°	3·2°	N 18° 23'	[illegible] 53'
Pilar	S 20·3°	4·6°	S 31° 40'	[illegible]
M'Bour	N 21·2°	55·1°	N 14 24'	343 03'

The magnetic stations used are listed in Table 1 in the order of geographic longitude. Of the eight stations, five are in the northern and three in the southern hemisphere. The geomagnetic latitudes of the stations range from 9·5 to 33·3°.

In Fig. 1 the stations used in the present investigation are marked with black circles with station names underlined, and the stations used by KERTZ are indicated by open circles; for the latter set the mean position of stations for each of the eight groups is shown by a circle with a cross, arrows indicating contributing member stations; stations used both in this paper and in Kertz's paper are each marked with a black circle together with an arrow toward the group mean.

2. Method of Derivation of *Dst*

For station i, the observed magnetic field $H^{(i)}$ at universal time t may be considered as the sum of the permanent field $H_0^{(i)}$ (including secular variation), solar daily variation $Sq^{(i)}$, lunar daily variation $L^{(i)}$ and disturbance $D^{(i)}$; i.e.

$$H^{(i)}(t) = H_0^{(i)}(t) + Sq^{(i)}(t) + L^{(i)}(t) + D^{(i)}(t). \tag{1}$$

Let the mean of $H^{(i)}(t)$ over the 18 months from July 1957 to December 1958 be denoted by $H_{00}^{(i)}$, and let this mean be a zero order approximation for $H_0^{(i)}(t)$. Let the deviation of $H_0^{(i)}(t)$ from $H_{00}^{(i)}$ be $\Delta H_0^{(i)}(t)$; i.e.

$$H_0^{(i)}(t) = H_{00}^{(i)} + \Delta H_0^{(i)}(t). \tag{2}$$

We denote the deviation of observed $H^{(i)}(t)$ from $H_{00}^{(i)}$ by $\Delta H^{(i)}(t)$; i.e.

$$\Delta H^{(i)}(t) = H^{(i)}(t) - H_{00}^{(i)}. \tag{3}$$

Substituting (1) and (2) in (3), we have

$$\Delta H^{(i)}(t) = \Delta H_0^{(i)}(t) + Sq^{(i)}(t) + L^{(i)}(t) + D^{(i)}(t). \tag{4}$$

For hour t we take the mean of $\Delta H^{(i)}(t)$ over the stations:

$$\overline{\Delta H(t)} = \overline{\Delta H_0(t)} + \overline{Sq(t)} + \overline{L(t)} + \overline{D(t)}, \tag{5}$$

where the upper bar in each term signifies the average over the stations.

Since the lunar variation L is small, we assume that the average of L is negligible and ignore L altogether. Then we have

$$\overline{\Delta H(t)} = \overline{\Delta H_0(t)} + \overline{Sq(t)} + \overline{D(t)}. \tag{6}$$

For station i for month M (where $M = 1, 2, \ldots, 18$ for the 18 months) we [illegible] mean daily variation of the five international quiet days from Greenwich midnight to Greenwich midnight, and subtract from each of the 25 hourly mean values the linear change obtained by linearly connecting the two midnight values. This linear change is assumed to represent the non-cyclic change that should be subtracted from Sq. It should be noted that Sq is measured from midnight level instead of its daily mean level.

The Sq variations so obtained were averaged over the stations. One would hope that this mean Sq would be nearly zero, or at least very small, but our results [illegible] Sq was not completely averaged out, and that the mean Sq had ranges of 8–[illegible] a not quite negligible amount. The form of the residual Sq varied systematically with season.

To represent Sq by a smoothly varying function throughout the whole period the mean Sq was expanded in a double Fourier series with month number M and Greenwich time T as two variables:

$$\sum_{n=1}^{6} \sum_{m=1}^{6} A_n^m \cos(mT + \alpha_m) \cos(nM + \beta_n).$$

Coefficients up to $n = m = 6$ were determined.

[illegible] day [illegible] was synthesized with this series. In the computation a [illegible] with the nominal [illegible] to each day. The synthesized mean Sq was [illegible] in (6) and was removed from $\overline{\Delta H(t)}$.

We are thus left with $\overline{\Delta H_0(t)} + \overline{D(t)}$. When this quantity was plotted for the entire IGY, points remained near a fixed level during quiet periods and did not show any systematic [illegible] all through the IGY. This was taken to mean that the secular variations were very nearly averaged out. Therefore, $\overline{\Delta H_0(t)}$ was assumed to be a constant. This constant determines the zero level for Dst.

In determining the value of this constant it is important to exclude, as much as possible, days that are in the recovery phase of magnetic storms; inclusion of such days will lower the zero level of Dst.

All the quiet periods in which two or more successive days had ap not exceeding 7 were selected, and the quantity $\overline{\Delta H(t)} - \overline{Sq(t)}$ ($= \overline{\Delta H_0} + \overline{D(t)}$) was averaged over all these selected quiet days. This average, which was 31 gamma, was taken to be the constant $\overline{\Delta H_0}$.

Removing this constant from all the hourly values, we obtain $\overline{D(t)}$. This average disturbance variation is the sum of $Dst(t)$ and the average $\overline{DS(t)}$. Since the selected eight stations are all in low latitudes and are distributed approximately uniformly over longitudes, $\overline{DS(t)}$ is assumed to be negligible, and we take $\overline{D(t)}$ to represent $Dst(t)$.

Summarizing, Dst is determined by

$$Dst(t) = \overline{H(t) - H_{00}} - \overline{Sq(t)} - \overline{\Delta H_0}. \tag{7}$$

[illegible] the first term is the average over the stations of the hourly H value measured from the mean H for the IGY, the second term represents the mean Sq, and the third [illegible] the mean Dst for the quiet periods.

Since [illegible] varies with latitude, it is desirable to normalize to the variation appropriate to [illegible]. Assuming that the Dst field is uniform and parallel to the geomagnetic [illegible] multiply the hourly Dst values obtained in the manner described above by $\sec \theta_m$ [illegible] θ_m is the mean geomagnetic latitude of the eight stations. In our case θ_m is [illegible] normalization factor is 1·08.

[illegible] call the values normalized to the magnetic equator the equatorial Dst values.

Tabulations and Graphs of Dst

[illegible] equatorial Dst values determined by the method described in the preceding section [illegible] tabulated in Table 2. In the tabulations, hourly values are given in units of gamma.

[illegible] equatorial hourly Dst values are graphically shown in Fig. 2. Like Dr. Bartels' [illegible] diagram each line represents one solar rotation of 27 days.

To compare our Dst with the three-hourly index ap, the hourly equatorial Dst values were averaged over each of the same three-hourly intervals as for ap, and the three-hourly Dst values so obtained are plotted together with ap in Fig. 3. Since Dst is negative during disturbed periods, the ap indices are plotted with negative sign.

Comparison of Dst with ap is made in Section 7.

5. Comparison with Kertz's *Dst* Indices

KERTZ has determined *Dst* indices by a different method (see part II, p. 49, of this volume).

To compare his results with ours, KERTZ's indices were converted to three-hourly values in gammas. This conversion was made by multiplying his indices by -3.

In Fig. 4, our three-hourly *Dst* (marked A) and KERTZ's *Dst* (marked B) are plotted parallel to each other.

Since KERTZ took weighted overlapping means of three-hourly intervals, the curves representing his *Dst* values are on the whole smoother than ours.

There appears to be a diurnal component not averaged out in KERTZ's *Dst*. Examples are: [illegible] to 20, 24 to 28 September 1957; 22 to 24 May 1958; 14 to 17, 19 to 21 October 1958, [illegible] to 22 November 1958. These diurnal components are probably due to *DS* not being averaged out.

The method we used does not involve any smoothing process. Hence our hourly *Dst* plots in Fig. 2 show variations in greater detail than the plots in Fig. 4 based on KERTZ's results. For instance in Fig. 2 an increase in H in the initial phase can be seen in many of the storms.

6. Discussions

It is generally thought that the magnetic field decrease in the main phase of a magnetic storm is due to a ring current. According to CHAPMAN[11] such a ring current was suggested by STÖRMER in 1911, though STÖRMER's current ring was not a complete ring, but a stream of electrons deflected round the Earth on the afternoon side. [illegible] further refers to SCHMIDT's study made in 1924 on an electrically neutral [illegible].

[illegible] and FERRARO[12,13] investigated a mechanism of formation of a ring current, [illegible] equilibrium, stability and decay.

[illegible][14] proposed for the main phase decrease of the magnetic field during a magnetic storm a mechanism in which charged particles trapped in the Earth's magnetic field drift longitudinally, thereby constituting net westward current.

With stimulus from the discovery of the trapped radiation belts the problem drew renewed interest in the recent years. Thus DESSLER and PARKER[15] gave a hydromagnetic [illegible] of the effect of a ring current consisting of trapped particles. The magnetic [illegible] a model ring current has been computed by AKASOFU and CHAPMAN[10] and [illegible], CAIN and CHAPMAN[16].

[illegible] no direct magnetic observation of a ring current by satellite or space probe there has been no definitive determination of the position of a ring current. However, Vanguard 3 magnetic measurements definitely indicate that the ring current must be above a few thousand kilometers from the Earth's surface (CAIN *et al.*[17]).

We believe that *Dst* is mainly due to the ring current, but that *Dst* also includes the magnetic field due to the currents on the interface between the magnetosphere and solar plasma and some residue of the polar disturbances. The second of these three parts is much less than the first, and may be negligible except in the initial phase of magnetic storms. The residue of the polar disturbances may be removed at least approximately by a more refined analysis, but such refinement is not attempted here.

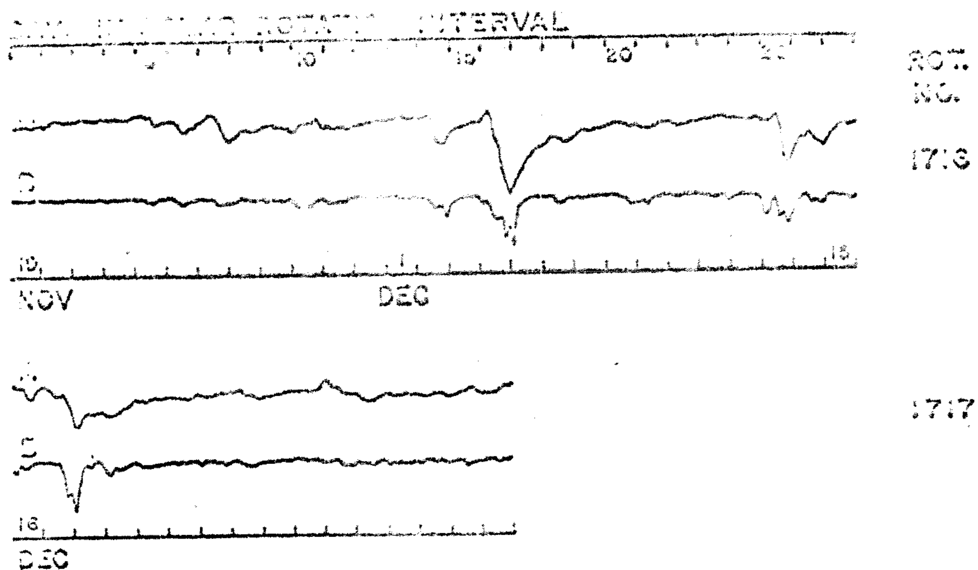

FIG. 3 (contd.). Comparison of *Dst* (A) with *ap* (B).

The hourly *Dst* plots as shown in Fig. 2 demonstrate the development and decay of a magnetic storm ring current very clearly. Even when there is no well-defined magnetic storm there often appears to be weak ring current activity lasting continuously for a considerable length of time. Some of these variations may be due to polar disturbances not completely eliminated.

The magnetic field observed on the Earth's surface is modulated by the strength of the solar wind, and such an effect may be included in the *Dst* variations.

7. Comparison of *Dst* with *ap* Indices

Figure 3 gives a graphical comparison of three-hourly mean *Dst* with three-hourly magnetic indices *ap*. The latter indices are averages of three-hourly *ranges* for twelve stations lying between 48 and 63° geomagnetic latitude. The three-hourly *Dst* values presented here are based on *hourly values* of *H* for eight stations between 9 and 34° geomagnetic latitude.

The *Dst* field is due to the electric currents flowing at great distances from the Earth, whereas the currents responsible for the magnetic disturbance represented by *ap* flow in the ionosphere.

Though the two indices differ widely in their derivations and represent magnetic fields produced by currents flowing in so different altitudes, the curves in Fig. 3 for these indices are remarkably parallel. Major changes of *Dst* are accompanied by large variations of *ap* variations of nearly equal magnitude. There is often a noticeable correlation between secondary peaks in *Dst* and those in *ap*.

It is uncertain how far the details of our *Dst* are due to *DS* that is not completely eliminated. However, it is very unlikely that all the minor changes and irregularities in our *Dst* are due to *DS* not being averaged out.

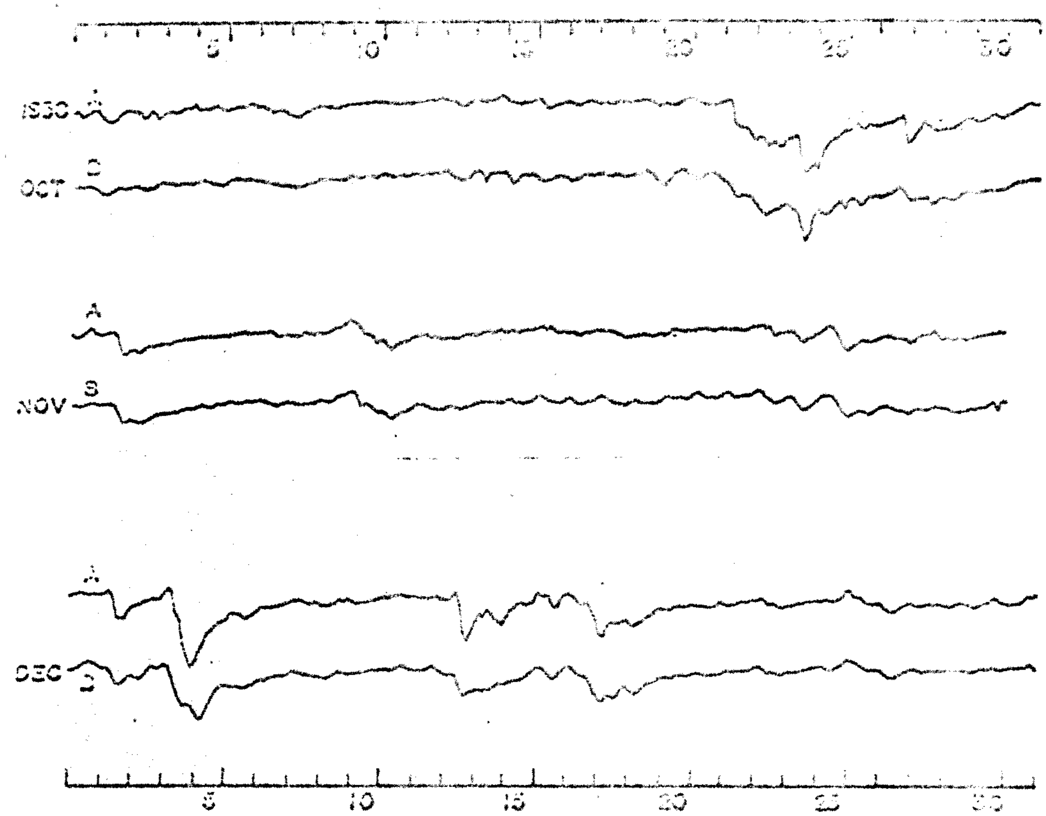

FIG. 4 (contd.). Comparison of *Dst* determined by author (A) with *Dst* based on KERTZ's indices (B).

There is a tendency for *ap* to recover more rapidly than *Dst* after a magnetic storm. This means that in a magnetic storm, polar disturbance dies away more quickly than does the ring current.

8. A Remark on the Induction in the Earth and in the Ionosphere

If a magnetic field varying with time is applied to the Earth, the magnetic induction within the conducting Earth will modify the applied field. The effect is to increase the variation in H, and the magnitude of the effect depends on the time scale of the applied field. Since *Dst* involves variations with periods of wide range, the effect of the magnetic induction in the Earth cannot be accurately estimated by a simple method.

The Earth, to some degree, is shielded by the ionosphere from varying magnetic fields produced by sources external to the ionosphere. This shielding effect depends on the rate of change of the applied magnetic field.

To deduce the magnetic field of a ring current from our *Dst* values appropriate corrections must be made for the induced magnetic fields.

Acknowledgements

[illegible]fessor S. Chapman initiated the publication of the hourly *Dst* data in the *Annals* [illegible]. I wish to express my thanks to him for his discussions and advice regarding [illegible] presentation; to Dr. J. C. Cain for his advice on machine computation and for discussions; to Dr. S.-I. Akasofu for his participation in the original planning and [illegible]cussions; and to Mr. [illegible] J. Chernosky and Miss M. P. Hagan for their contribution [illegible] the preparation of the observatory data in a form suitable for the machine processing.

I am greatly indebted to Mrs. Shirley Hendricks who performed the computation [illegible] an IBM 7090, and supervised plotting with an automatic plotter.

Our [illegible]cere thanks are extended to the directors of the magnetic observatories who made the necessary data available to us. Assistance received from the World Data Center [illegible] for Geomagnetism is gratefully acknowledged.

The present study was made while the author held an NASA—National Academy of [illegible]-National Research Council Senior Post-Doctoral Resident Research Associate-[illegible] on leave of absence from the Geophysical Institute of the University of Alaska.

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PROVISIONAL HOURLY VALUES OF EQUATORIAL Dst FOR 1961, 1962, AND 1963

by Masahisa Sugiura and Shirley Hendricks

Goddard Space Flight Center
Greenbelt, Md.

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INTRODUCTION

For the International Geophysical Year, July 1957 to December 1958, hourly values of equatorial Dst were computed using hourly values of the horizontal component, H, obtained at eight magnetic observatories.* These hourly Dst values have provided a measure of magnetic activity as a function of universal time, and have been useful for studies of cosmic rays, solar plasma, particles in the radiation belt, and other geophysical disturbance phenomena.

The present report gives Dst data for the years 1961 to 1963. The method of deduction is similar to that used for the IGY, but several improvements have been made as is explained below. For the method of analysis the reader is referred to the previous publication.* Only brief explanatory notes are given in the present report.

REMOVAL OF THE QUIET DAILY MAGNETIC VARIATION Sq

In the determination of Dst for the IGY, Sq was removed by the following method. For each observatory the mean daily variation for the five international quiet days was formed for each month. The non-cyclic change was removed from the mean Sq so determined by assuming that the former is linear in time. The residual Sq is the average over the observatories of the mean Sq corrected for the non-cyclic change, and hence it is a function of universal time (UT) and does not depend on local time. The residual Sq for the 18 months of the IGY was expressed in a double Fourier series with a month number M (= 1 to 18) and a UT hour number (= 1 to 24) as two variables. A synthetic residual Sq was then calculated with this Fourier series for each day, and was subtracted from the hourly values averaged over the observatories.

In deriving Dst for 1961 to 1963 an improvement was made in the method of removal of Sq. Sq was first formed separately for each observatory and for each month from the five 'local' days that have a maximum overlap with the five 'international' quiet days. The non-cyclic change was

*Sugiura, M., "Hourly values of equatorial Dst for the International Geophysical Year," in *Annals of the International Geophysical Year*, Vol. 35, pp. 9-45, Oxford: Pergamon Press, 1964.

removed from Sq by assuming that it was linear from midnight to midnight on the 'local' quiet days selected. The series of observatory-Sq determined for each year by this method was expanded in a double Fourier series with the month number and local time as variables. Using this Fourier series, hourly values of a synthetic Sq variation were computed and were subtracted from the original hourly values. This procedure was followed for each observatory, and the resultant series of hourly values was averaged over the observatories.

For 1961 the observatories used are Hermanus, Alibag, Kakioka, Apia, Honolulu, San Juan, Pilar, and M'Bour. These eight observatories are the same as those used for the IGY. For 1962 and 1963, data were less complete than for the earlier years, and only three observatories, Hermanus, San Juan, and Honolulu were used; these three observatories being approximately equally spaced in longitude.

THE REFERENCE LEVEL

For the IGY the reference level, or the zero level, for Dst was defined by the average of hourly Dst values over the quiet periods in which two or more successive days had the *ap* index not exceeding 7. For 1961 a similar, but simplified method was used to determine the reference level. However a considerable improvement was made for 1962 and 1963 by taking into account for each observatory the secular variation that was completely ignored in the determination of Dst for the IGY and 1961.

CORRECTIONS FOR THE SECULAR VARIATIONS

In order to obtain a long series of Dst values covering many years with a meaningful common reference level it is necessary to correct for the secular variations. Such a correction was made in deriving Dst for 1962 and 1963.

For each observatory the annual mean value, y, of the horizontal component for the monthly selected ten quiet days was expressed in a power series

$$y = y_0 + a_1 x + a_2 x^2 ,$$

where y_0, a_1, and a_2 are constants and x is the time measured in years from 1960.5.

For Hermanus and San Juan, the constants y_0, a_1, and a_2 were determined by the method of least squares using the data for ten years from 1954 to 1963. For Honolulu the secular variation was determined for two periods; one from 1951 to 1960, and the other from 1960 to 1963. This division was made because the location of the Honolulu Magnetic Observatory was moved in 1960. The Observatory was at Barbers Point from 1947 to 1960, and was moved to a new site near Ewa Beach on Oahu Island, the distance between these two locations being approximately 10 km.

Values of the coefficients in the power series for the secular variation are given in Table 1 with the significance level expressed by 0, 1, 2, or 3. The latter is based on the confidence level in a t-test according to the following scheme:

Significance level	Confidence level
0	above or equal to 99%
1	above or equal to 95% and below 99%
2	above or equal to 50% and below 95%
3	below 50%

Table 1

Values of y_0, a_1, and a_2 for the Four Observatories.
(Significance levels are given in parentheses.)

Coefficient	Hermanus 1954—1963	San Juan 1954—1963	Honolulu	
			1951—1960	1960—1963
y_0	12900.800γ (0)	27657.540γ (0)	28377.036γ (0)	28107.399γ (0)
a_1	-74.830 (0)	5.478 (0)	-18.342 (0)	-3.600 (2)
a_2	0.091 (3)	-0.602 (1)	0.106 (2)	-3.000 (2)

The results in Table 1 show that the constant term y_0 and the coefficient a_1 of the linear term in the power series are highly significant except for the four-year period for Honolulu. This period is too short for the statistical test to be meaningful. However, even for this short period the fit is very good (Table 2c). Tables 2a, 2b, and 2c show comparisons of the given observed values and the computed values; the standard deviation is also provided in each table.

Table 2a

Observed and Computed H for Hermanus.
Standard deviation = 4.4γ.

Epoch	Observed* H	Computed H	Difference
1954.5	13348γ	13353γ	-5γ
1955.5	13281	13277	4
1956.5	13204	13202	2
1957.5	13128	13126	2
1958.5	13054	13051	3
1959.5	12974	12976	-2
1960.5	12893	12901	-8
1961.5	12825	12826	-1
1962.5	12755	12752	3
1963.5	12678	12677	1

*Mean of ten quiet days

Table 2b

Observed and Computed H for San Juan.
Standard deviation = 4.4γ.

Epoch	Observed* H	Computed H	Difference
1954.5	27604γ	27603γ	1γ
1955.5	27613	27615	-2
1956.5	27623	27626	-3
1957.5	27637	27636	1
1958.5	27652	27644	8
1959.5	27653	27651	2
1960.5	27651	27658	-7
1961.5	27660	27662	-2
1962.5	27666	27666	0
1963.5	27671	27669	2

*Mean of ten quiet days

NASA TECHNICAL NOTE

NASA TN D-5748

NASA TN D-5748

PROVISIONAL HOURLY VALUES OF EQUATORIAL Dst FOR 1964, 1965, 1966, AND 1967

by Masahisa Sugiura and Shirley Cain

Goddard Space Flight Center
Greenbelt, Md. 20771

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • WASHINGTON, D. C. • MAY 1970

/2

PROVISIONAL HOURLY VALUES OF EQUATORIAL Dst FOR 1964, 1965, 1966, AND 1967

by
Masahisa Sugiura and Shirley Cain
Goddard Space Flight Center

INTRODUCTION

Hourly values of equatorial Storm Time Variation (Dst) provide an index of magnetic activity as a function of universal time (UT). To a first approximation, Dst represents the diamagnetic effect of transient plasmas which are either injected into the magnetosphere or brought into existence by energization of the magnetospheric plasmas. The effect is such as to decrease Dst level. To a certain extent, Dst reflects responses of the magnetosphere to varying solar-wind pressure on its boundary; increases in the solar-wind pressure result in corresponding increases in Dst values.

The present report is a sequel to two previous publications which gave hourly Dst values for the International Geophysical Year, July 1957 to December 1958 (Sugiura, 1964), and for the years 1961, 1962, and 1963 (Sugiura and Hendricks, 1967). The method of derivation of Dst adopted here is described in these publications. The observatories used are the same as those for 1961-63, namely, Hermanus, San Juan, and Honolulu. The locations of these observatories are shown in Table 1.

Table 1 – Coordinates of the observatories used.

Observatory	Geographic		Geomagnetic dipole latitude
	Latitude	Longitude	
Hermanus	−34.4°	19.2°E	−33.7°
Honolulu	21.3°	201.9°	21.1°
San Juan	18.4°	293.9°	29.9°

THE REFERENCE LEVEL

To insure a continuity of Dst over many years, its reference level has been assigned with special care. In deriving Dst for 1962 and 1963 (Sugiura and Hendricks, 1967) the reference level for each observatory was defined in a manner which took into account the secular variation. For each observatory, the reference level

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was expressed by a power series in time, and the coefficients for terms up to the quadratic were determined by the method of least squares using annual means of 10 quiet days.

In the present determination of Dst for 1964, 1965, 1966, and 1967, the 1962-63 coefficients were used, and the reference level for each observatory was simply extrapolated from the power series. A comparison of the calculated and observed reference levels of H up through 1963 was shown in the previous report (Sugiura and Hendricks, 1967; Tables 2a, 2b, 2c). Here, a similar comparison is made in Table 2, which shows that the differences between the observed annual averages and the computed values for the mid-year points are more irregular than those for 1961-63. This point will be examined in the future when the secular change coefficients are updated.

REMOVAL OF THE QUIET DAILY MAGNETIC VARIATION Sq

The method adopted here for the removal of Sq is the same as that used previously (Sugiura and Hendricks, 1967).

FIGURES AND TABLES OF Dst FOR 1964, 1965, 1966, AND 1967

Hourly values of equatorial Dst for the years 1964, 1965, 1966, and 1967 are given in Table 3 and are presented graphically in Figures 1a, 1b, 1c, and 1d. In each of these figures, the ordinates for the upper and lower horizontal lines for each month are indicated below the graph in γ.

Table 2 – Comparison of observed and computed reference levels for H.

Station	Epoch	Observed* H	Computed H	Difference
Hermanus	1964.5	12,603γ	12,616.γ	−13γ
	1965.5	12,529	12,529.	0
	1966.5	12,444	12,455	−11
Honolulu	1964.5	28,043	28,045	− 2
	1965.5	28,022	28,014	8
	1966.5	27,998	27,978	20
San Juan	1964.5	27,672	27,670	2
	1965.5	27,662**	27,670	− 8
	1966.5	27,668**	27,669	− 1

*Annual mean of 10 quiet days.

**In 1965 the San Juan Observatory was moved from the old site at 18°23′N, 293°53′E to a new location at 18°06.8′N, 293°51.2′E. The move resulted in a decrease in the horizontal component by 110γ. Since the formula expressing the secular variation refers to the old location, the hourly values obtained at the new site were adjusted to the old site by adding 110γ. Likewise, the annual means of 10 quiet days listed above for 1965 and 1966 are observed annual means plus 110γ.

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ACKNOWLEDGMENTS

We wish to thank the Hermanus Magnetic Observatory and the Environmental Science Service Administration for making the data available. We are greatly indebted to the staff of the World Data Center-A for Geomagnetism for their invaluable assistance.

Goddard Space Flight Center
National Aeronautics and Space Administration
Greenbelt, Maryland, December 18, 1969
188-36-01-01-51

REFERENCES

Sugiura, M., "Hourly Values of Equatorial Dst for the International Geophysical Year," *Annals of the International Geophysical Year,* 35: 9-45, Oxford: Pergamon Press, 1964.

Sugiura, M., and Hendricks, S., "Provisional Hourly Values of Equatorial Dst for 1961, 1962, and 1963," NASA Technical Note D-4047, August 1967.

X-612-70-3

PROVISIONAL HOURLY VALUES OF EQUATORIAL DST FOR 1968

M. SUGIURA
S. J. CAIN

JANUARY 1970

GSFC

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

PROVISIONAL HOURLY VALUES OF EQUATORIAL Dst FOR 1968

M. SUGIURA

S. J. CAIN

JANUARY 1970

Previous Reports on Dst

The present report is a sequel to the following three reports:

[1] Hourly Values of Equatorial Dst for the IGY, M. Sugiura, Annals of the International Geophysical Year, Vol. 35, p. 9, Pergamon Press, 1964.

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[3] Provisional Hourly Values of Equatorial Dst for 1964, 1965, 1966, and 1967, M. Sugiura and S. J. Cain, X-612-69-20, Goddard Space Flight Center, Greenbelt, Maryland, February 1969.

/4

Observatories

The observatories used are the same as in the previous publications 2 and 3 listed above, namely, Hermanus, San Juan, and Honolulu. The locations of these observatories are given in Table 1.

Table 1. Coordinates of the observatories used.

Observatory	Geographic Latitude	Geographic Longitude	Geomagnetic Dipole Latitude
Hermanus	- 34.4°	19.2°E	- 33.7°
Honolulu	21.3°	201.9°	21.1°
San Juan	18.4°	293.9°	29.9°

Reference Level

The reference level for each observatory was defined taking into account the secular variation. For each observatory the reference level was expressed by a power series in time, and the coefficients for terms up to the quadratic were determined by the method of least squares using the annual means of the "international quiet days". The power series is of the following form:

$$y = y_o + a_1 t + a_2 t^2$$

where, y_o, a_1, and a_2 are constants and t is time measured in years from 1960.5.

The constants y_o, a_1, and a_2 for the three observatories are listed in Table 2.

Table 2. Values of y_o, a_1, and a_2: unit γ

Coefficient	Honolulu	Hermanus	San Juan
y_o	28107.228	12833.100	27472.100
a_1	- 11.357	- 43.700	23.100
a_2	0.928	- 3.500	- 1.500

to examine the fit to the observed data the computed and observed values of H are given in Table 3.

Table 3. Comparison of the computed and observed values of H.

Honolulu:

Standard Deviation = 2.3γ

Epoch	Observed	Computed	Difference
1964.5	28046γ	28047γ	- 1γ
1965.5	28029	28027	2
1966.5	28006	28006	0
1967.5	27980	27982	- 2
1968.5	27958	27957	1

Hermanus:

Standard Deviation = 1.3γ

Epoch	Observed	Computed	Difference
1964.5	12602γ	12602γ	0γ
1965.5	12528	12527	1
1966.5	12444	12445	- 1
1967.5	12356	12356	0

San Juan:*

Standard Deviation = 0.4γ

Epoch	Observed	Computed	Difference
1965.5	27550γ	27550γ	0γ
1966.5	27557	27557	0
1967.5	27560	25560	0
1968.5	27561	27561	0

*The San Juan Observatory was moved in 1965 from the old site at $18^{\circ}23'$N, $293^{\circ}53'$E to a new location at $8^{\circ}06.8'$N, $293^{\circ}51.2'$E, and the move resulted in a decrease in the horizontal component by 110γ. The present determinations are based only on the observations made at the new site.

Figure and Tables of Dst for 1968

Hourly values of equatorial Dst for the year 1968 are shown graphically and are tabulated below.

Daily mean and monthly mean Dst values are given in a table following the hourly tabulations.

Acknowledgements

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X-645-70-345
PREPRINT

PRELIMINARY HOURLY VALUES OF EQUATORIAL Dst FOR 1969

M. SUGIURA
D. J. POROS

SEPTEMBER 1970
REVISED
OCTOBER 1970

GSFC

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

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PRELIMINARY HOURLY VALUES OF EQUATORIAL Dst FOR 1969

M. Sugiura and D. J. Poros

October 1970

Preliminary hourly values of equatorial Dst for 1969 are presented.* These values are based on the data from Honolulu and San Juan only, and should be regarded as preliminary. Dst values based on data from three observatories will be published later to replace the tabulations given in this report.

*This revised report replaces the previously published report with the same X-series number dated September 1970.

X-612-70-3

PROVISIONAL HOURLY VALUES OF EQUATORIAL DST FOR 1968

M. SUGIURA
S. J. CAIN

JANUARY 1970

GSFC

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

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FAST ANALYSIS OF TAPE AND RECOVERY -- FATAR VER 4.3.5 -- INNOVATION DATA PROCESSING AUTHORIZED 12/13/93 PAGE 1

FATS070 CONTROL CARD TABLE SIZE IS 4096 BYTES

FATAR CONTROL CARDS

GG-41B
1/1/57 - 12/31/83

1-- ANALYZE BLP
2-- PRINT LF=1,B=1-10,CHAR
3-- PRINT LF=1,B=490-494,CHAR

FATS071 TAPE BUFFER SIZE IS 65535 BYTES

FATS040 TAPEIN IS NOT LABELED - LABELS=NO ASSUMED

CHARACTERISTICS OF THE TAPE TO BE ANALYZED

UNIT	SERIAL	DEN	TRTCH
5AC	NC2004	38000	

FATAR DETAIL REPORT

BLOCK NUMBER	LNGTH/ DISPL	MESSAGE/ BLOCK TYPE	1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80 (COLUMN GRID IS VALID ONLY FOR CHARACTER FORMATTED DATA)
* * * * * * *		START FILE 1	
		FATS038 DATA FILE IN ISCII/ASCII - TRANSLATED TO EBCDIC	
1	2400	PRINT REQUESTED	DST57 1 1 0 0 0 11 13 12 12 9 7 7 6 2 -1 -7 -7 -8 -1 9
2	2400	PRINT REQUESTED	DST57 1 21 0 0 0 34 34 29 26 19 13 16 9 -3 -3 -3 -4 9 18 6
3	2400	PRINT REQUESTED	DST57 2 10 0 0 0 -17 -17 -11 -5 -1 -2 2 8 10 8 0 -2 -2 -1 -3
4	2400	PRINT REQUESTED	DST57 3 2 0 0 0 -14 -27 -47 -66 -79-138-238-255-206-190-200-229-248-242-208
5	2400	PRINT REQUESTED	DST57 3 22 0 0 0 -54 -49 -43 -48 -49 -49 -43 -33 -38 -39 -35 -38 -35 -34 -31
6	2400	PRINT REQUESTED	DST57 4 11 0 0 0 -61 -62 -55 -51 -47 -39 -33 -29 -30 -32 -36 -49 -51 -43 -36
7	2400	PRINT REQUESTED	DST57 5 1 0 0 0 -18 -18 -15 -21 -21 -25 -33 -36 -39 -35 -28 -21 -24 -25 -26
8	2400	PRINT REQUESTED	DST57 5 21 0 0 0 -4 0 0 -2 2 -1 -6 -3 1 4 -8 -5 1 0 1
9	2400	PRINT REQUESTED	DST57 6 10 0 0 0 5 4 4 6 7 6 6 7 9 11 12 10 10 10 10
10	2400	PRINT REQUESTED	DST57 6 30 0 0 0 -6 -3 -6 -11 -15 6 14 16 10 -3 6 -28 -54 -49 -58
490	2400	PRINT REQUESTED	DST8310 12 0 0 0 3 7 9 8 10 10 8 7 6 8 10 8 7 7 6
491	2400	PRINT REQUESTED	DST8311 1 0 0 0 -9 -7 -14 -18 -18 -17 -16 -14 -15 -16 -20 -20 -21 -23 -19
492	2400	PRINT REQUESTED	DST8311 21 0 0 0 -20 -23 -20 -19 -19 -17 -15 -17 -18 -16 -10 -4 -5 -7 -9
493	2400	PRINT REQUESTED	DST8312 11 0 0 0 -29 -30 -29 -29 -26 -23 -15 -13 -3 0 4 6 -8 -6 -23
494	120	PRINT REQUESTED	DST8312 31 0 0 0 -29 -25 -25 -22 -17 -19 -26 -36 -38 -37 -34 -28 -18 -12 -11
* * * * * * *		END OF FILE 1 -- FILE CONTAINED 494 BLOCKS	

```
DST57 1* 2       11   3   6   9  10  12   7   5   8  32   7  -7  -7  -2  -1   1   2   5   5 -14  REC    1, LENGTH  120
 -41 -65 -65 -59
                                                                                                        CORRDST
DST57 1* 3      -50 -44 -42 -46 -43 -42 -41 -39 -40 -40 -36 -31 -33 -28 -27 -30 -32 -31 -29 -26  REC    2, LENGTH  120
 -28 -25 -24 -21                                                                                  D-00275     C-00096
DST57 1* 4      -22 -21 -21 -24 -23 -18 -18 -21 -24 -24 -23 -17 -14 -11  -9  -6  -4  -4  -4  -7  REC    3, LENGTH  120  GG-41B
 -10 -12 -13 -12
DST57 1* 5       -9  -4   1   2   3   3   3   2  -1  -3  -3   0   2   0   1   3   6   6   5   4  REC    4, LENGTH  120
   4   6   6   1
DST57 1* 6        2   4   3   3   9  21  24  22  12   9   9  15  14  12  11  12  14  16  21  28  REC    5, LENGTH  120
  35  38  38  28
DST57 1* 7       25  22  23  26  23  23  25  18  14   6  -0  -2   8  13  15  15  16  18  21  24  REC    6, LENGTH  120
  21  23  26  24
DST57 1* 8       18  12  10   6   7  14  23  23  21  14  18  -3  -6  -0   5   2   0 -11 -15 -15  REC    7, LENGTH  120
 -13 -16 -18 -19
DST57 1* 9      -13 -10 -10  -8  -7  -7  -6  -2  -3  -3  -7  -6  -3  -5 -13 -13 -19 -25 -25 -21  REC    8, LENGTH  120
 -16 -16 -20 -23
DST57 1*10      -27 -24 -30 -27 -18 -20 -27 -32 -31 -30 -31 -34 -40 -29 -23 -27 -26 -22 -26 -33  REC    9, LENGTH  120
 -31 -42 -40 -29
DST57 1*11      -30 -26 -24 -27 -28 -27 -27 -32 -36 -42 -44 -35 -37 -37 -32 -26 -24 -22 -23 -21  REC   10, LENGTH  120
 -18 -20 -19 -19
DST57 1*12      -12  -6  -8 -14 -12  -3  -1  -8 -16 -15 -11 -11  -9  -8  -5  -1   3   4   7   6  REC   11, LENGTH  120
   5   4   7   7
DST57 1*13       10  10   8   9  10  10   6   1  -0  -2  -2  -2   0   1   2   2   3   1   4   8  REC   12, LENGTH  120
   8  11  11   6
DST57 1*14        1  -1   1   1  -1   1   5  10  11  17  12  10   8   8   8  12  12  12  12  12  REC   13, LENGTH  120
  10  13  12  11
DST57 1*15       13   9   6   5   5   6   5   4   5   5   5   4   6   3   6  10   7   9   6   2  REC   14, LENGTH  120
   6  12  13  11
DST57 1*16        5   8   7   3   4   4   3   3  -7  -7  -1  -2  -5  -3  -3   0   3   4   4   2  REC   15, LENGTH  120
   3   4   2   1
DST57 1*17        1   2   2   1  -0  -0  -0  -2  -5  -4  -0   6   9   9   8  10  11  14  13  11  REC   16, LENGTH  120
   6  11  15  15
DST57 1*18       14  13  11   8  11  11   9   7   9  14  15  14  15  14  10  13  12  10   9   5  REC   17, LENGTH  120
   5   4   5   3
DST57 1*19        6   8   9  11  10  12  15  15  26  25  24  32  37  32  27  19  11   2  -3  -7  REC   18, LENGTH  120
 -11 -10  -5   1
DST57 1*20        3   0  -2   3   5   2   4   8  11  10   9  10  12  16  18  19  15  18  24  28  REC   19, LENGTH  120
  27  29  29  31
DST57 1*21       34  34  29  26  19  13  16   9  -3  -3  -3  -4   9  18   6 -16 -56 -76-106-131  REC   20, LENGTH  120
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DST57 1*22     -235-217-225-190-190-177-169-165-155-142-140-137-129-127-118-114-110-108-100 -92  REC   21, LENGTH  120
 -83 -79 -71 -66
DST57 1*23      -69 -71 -70 -70 -61 -57 -53 -51 -64 -81 -94 -96-114-111-105-106-103 -96 -96 -83  REC   22, LENGTH  120
```

-80 -77 -75 -64

DST57 1*24 -63 -63 -71 -71 -69 -64 -60 -59 -63 -59 -52 -50 -51 -48 -46 -45 -43 -39 -34 -27 REC 23, LENGTH 120
-26 -24 -22 -44

```
DST7412*12       3   4   3  -1  -5  -5  -7 -12 -13  -4  -2 -11 -16 -14 -12 -13 -10  -8  -7  -6  REC   1, LENGTH  120
  -4  -7  -9  -6
DST7412*13      -2   1  -2   3   4   5   4   5   3  -2  -1  -2   1   1  -2  -3  -7 -13  -8  -7  REC   2, LENGTH  120
  -6  -7 -11 -16
DST7412*14     -13  -5  -5  -8 -10 -13 -15 -11  -8  -7  -7  -7  -9  -7  -5  -3  -5  -9  -8  -6  REC   3, LENGTH  120
  -7  -6  -5  -3
DST7412*15      -2  -1   0  -0  -3  -6  -6  -9  -9 -12 -11  -8 -10 -12 -10  -5  -5 -10 -10 -10  REC   4, LENGTH  120
  -9  -9  -8  -7
DST7412*16      -1   2   4   4   3   1  -1  -2  -5  -9  -9  -5  -2   0   1  -2  -1   1   2   8  REC   5, LENGTH  120
  14  20  31  36
DST7412*17      15  14  16  22  25  19  21  17  14  12   9   1  -0   8  10   9   4  -4  -6   2  REC   6, LENGTH  120
  -0   1 -19 -21
DST7412*18     -18 -11  -5  -5  -7 -14 -13 -16 -13  -9 -10 -11 -14 -21 -18 -11  -7  -4  -3  -6  REC   7, LENGTH  120
  -2  -7 -11  -8
DST7412*19      -3   4   0  -3  -2  -1  -3  -5  -6  -7  -4  -9  -5  -5  -6  -3  -1  -3  -8 -10  REC   8, LENGTH  120
 -10 -15 -26 -31
DST7412*20     -23 -22 -20 -19 -16 -15 -16 -13 -14 -11 -10 -11 -10  -7  -6  -7 -12  -8  -5  -8  REC   9, LENGTH  120
  -5  -8  -7  -5
DST7412*21      -1  -1  -5  -2   2   3   3  -0  -4  -2  -0  -1  -8 -13  -8  -7  -8  -9  -8 -12  REC  10, LENGTH  120
 -11  -8 -10 -15
DST7412*22     -11  -8 -10 -14 -13  -8  -3  -0  -2  -4  -5  -4  -5   1   2  -0   2   5   6   7  REC  11, LENGTH  120
   4   4   4   6
DST7412*23       6  15  17  14  13  10   7   7  10  11  15  12  10  14   3 -10  -8 -11 -14 -10  REC  12, LENGTH  120
 -10 -10 -13  -8
DST7412*24       1   3   4   4   2   1   1  -0   0   2   3  -1  -1  -1  -4  -8  -9  -4  -5  -4  REC  13, LENGTH  120
  -6  -8  -8  -8
DST7412*25      -1   4   3   2   5   7   8   8   6   4   4   4   3   7   9   3  -6 -20 -24 -22  REC  14, LENGTH  120
 -13 -13 -18 -15
DST7412*26      -9  -1  -2  -4  -2   6  11   8   1  -3 -11  -9  -3  -1   1   1  -1  -1  -3  -5  REC  15, LENGTH  120
  -5  -7  -7  -8
DST7412*27      -9  -9  -6   1   5   1  -5  -8 -14  -7  -2   3   5  -5 -16 -14 -14 -14  -9 -11  REC  16, LENGTH  120
 -12 -15 -13 -10
DST7412*28      -3   5   9   6   7  10  11   2   2  -1   3   4   2  -4  -4  -3  -2  -2  -4  -6  REC  17, LENGTH  120
  -5  -6  -9  -7
DST7412*29      -6  -1   7  11   9  11  11  12  16  10   9   7   9   9   5   0  -0   2   4   4  REC  18, LENGTH  120
   0   1   2   5
DST7412*30       5   5   6   7   6   7   7   8  11  12  14  14  14  14  15  14  11   9  11  15  REC  19, LENGTH  120
  18  15  11  13
DST7412*31      15  10  -2   1   4  -1  -3  -3  -3  -4  -4  -0   3  11  13   9   2   5  11  15  REC  20, LENGTH  120
  13  11  10   9
```