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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 offline tape datasets have now been migrated from the original magnetic tape to magnetic disk (starting in mid-2004). Accordingly, statements in the format descriptions that address such tape relevant factors as blocking and bit density are no longer applicable. The paper documentation in the DSCs have been scanned and made into digital images of the pages, 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. But this inventory information is now no longer maintained in the DSCs, but is now managed in the inventory part of the NSSDC information system, and the user should go to that interface (JIN) if further information is desired on possible later changes to the inventory information. The information existing in the DSCs is now not needed for locating data files, but we did not go to the trouble of removing that inventory information.

2. CHANGE LOG

Version	Date	Person	Page	Description of Change
01	10/19/2004	J. Manuel	1-6 and 8	Added to document

3. LINKS TO RELEVANT INFORMATION IN THE ONLINE NSSDC INFORMATION SYSTEM:
[NOTE: ANY OF THE INFORMATION FIELDS MIGHT BE BLANK.]
[THE "MATERIALS FOR DISTRIBUTION" FIELD IS HERE CALLED JUST "MATERIALS"]

"Remarks" for spacecraft SCNAME1":
http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=1977-102A--remark--

"Materials" for spacecraft SCNAME1":
http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=1977-102A--mat--

"Remarks" for SCNAME1 experiment EXNAME1:
http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=1977-102A&ex=09--remark--

"Materials" for SCNAME experiment EXNAME1:
http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=1977-102&ex=09--mat--

"Remarks" for EXNAME1 data set DSNAME1:
http://nssdc.gsfc.nasa.gov/database/MasterCatalog?ds=SPHE-00677--remark--

"Materials" for EXNAME1 data set DSNAME1:
http://nssdc.gsfc.nasa.gov/database/MasterCatalog?ds=SPHE-00677--mat--

"Remarks" for EXNAME1 data set DSNAME2:
http://nssdc.gsfc.nasa,gov/database/MasterCatalog?ds=SPHE-00677--remark--

"Materials" for EXNAME1 data set DSNAME2:
http://nssdc.gsfc.nasa.gov/database/MasterCatalog?ds=SPHE-00677--mat--

"Remarks" for EXNAME1 data set DSNAME3:

"Materials" for EXNAME1 data set DSNAME3:

"Remarks" for SCNAME1 experiment EXNAME2:

"Materials" for SCNAME1 experiment EXNAME2:

"Remarks" for EXNAME2 data set DSNAME1:
"Materials" for EXNAME2 data set DSNAME1:

"Remarks" for EXNAME2 data set DSNAME2:
"Materials" for EXNAME2 data set DSNAME2:

DATA SET CATALOG # 26

Vanguard III Proton Processional magnetometer

59-007A-01A 1 tape

VANGUARD 3

SCALAR MAGNETIC FIELD

59-007A-01A

THIS DATA SET HAS BEEN RESTORED. ORIGINALLY THERE WAS ONE 7-TRACK 556 BPI TAPE WRITTEN IN BCD. THERE IS ONE RESTORED TAPE WRITTEN IN EBCDIC, WHICH WAS PACKED DURING THE RESTORATION PROCESS. THE DR TAPE IS A 3480 CARTRIDGE AND THE DS TAPE IS 9-TRACK 6250 BPI. THE ORIGINAL TAPE WAS CREATED ON AN IBM 7094 COMPUTER. THE DR AND DS NUMBER ALONG WITH THE CORRESPONDING D NUMBER AND THE TIME SPAN IS AS FOLLOWS:

DR#	DS#	D#	FILES	TIME SPAN
DR002836	DS002836	D000075	1	09/18/59 - 12/11/59

DATA SET CATALOG

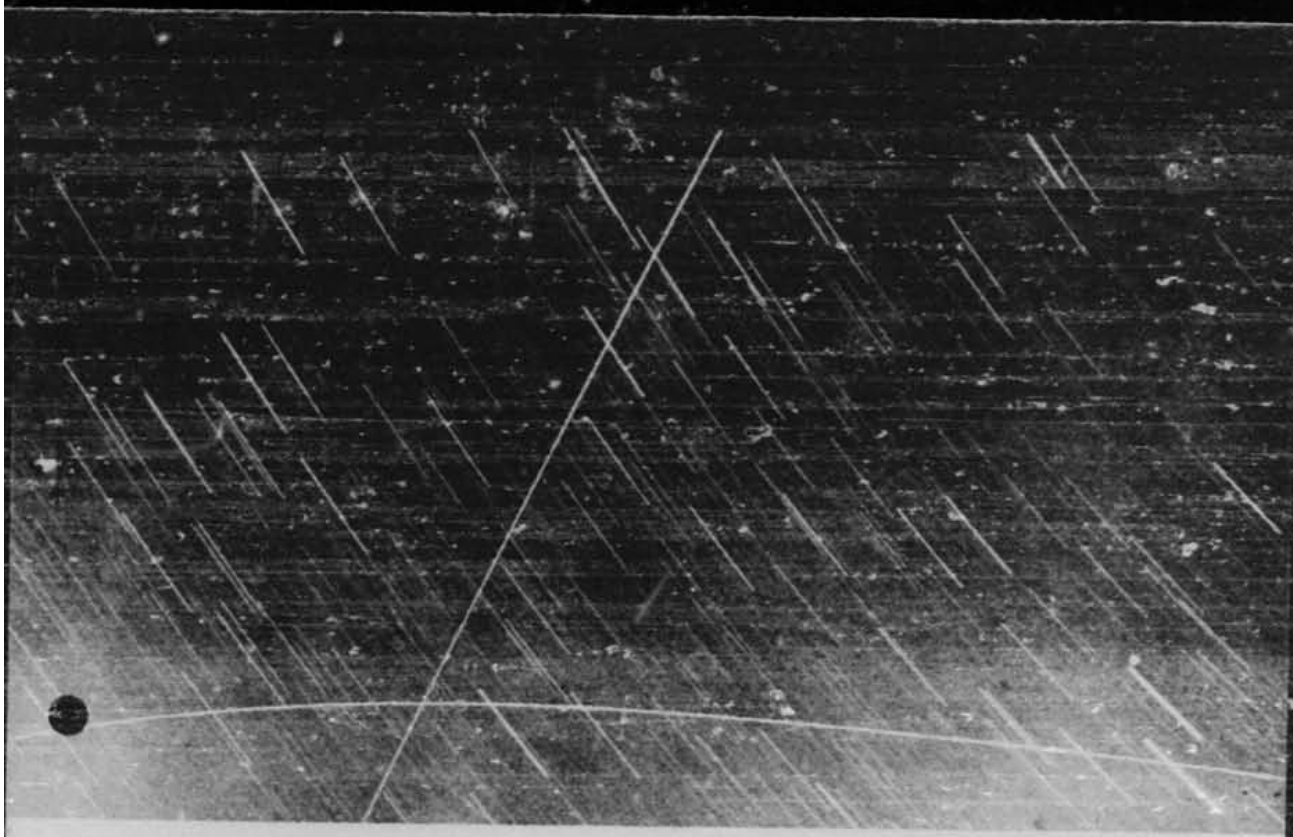
59-007A-01A

Vanguard 3
Proton Processional Magnetometer

This data set consists of a single magnetic tape (D-00075) in BCD. Most of the data contained on the tape are listed in "Vanguard III, project data summary" as Appendix D (p. 107 - 166). The magnetic tape does not contain the N and K(P) fields and has the station as a two digit code. The tape does, however, provide more significant digits than are generally listed. The tape also contains a set of values labeled "Field - Vanguard (or AFSWC coefficients)".

The data are documented in a Data Users' Note. No other documentation on the tape is available at the NSSDC. The tape consists of BCD card images recorded at 556 bpi on a 7 track tape. The data set consists of:

1) BCD list of part of the tapes
2) DUN describing the tape B0901
3) Appendix D of project data summary listing the partial tape contents.



DATA USERS' NOTE
NSSDC 67-28

VANGUARD 3 (1959 ETA 1)
PROTON PRECESSIONAL MAGNETOMETER

MAY 1967

NATIONAL SPACE SCIENCE DATA CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • GODDARD SPACE FLIGHT CENTER, GREENBELT, MD.

DATA USERS' NOTE
NSSDC 67-26

VANGUARD 3 (1959 ETA 1)

PROTON PRECESSIONAL MAGNETOMETER

EXPERIMENTER

J. P. Heppner

MAY 1967

FOREWORD

This Data Users' Note is specifically designed to help potential data users decide if they can make use of the data obtained in the Vanguard 3 (1959 Eta 1) proton precessional magnetometer experiment. Once a data user decides that he requires the data, it will serve as the unifying element - the key - in the actual use of the data available at the National Space Science Data Center (NSSDC). To achieve these goals, the Note briefly describes the experiment, including the instrumentation and measurements, the telemetry, and the operational experience. All available details are then provided on the actual reduction techniques and format of recorded data. For those desiring more details, the name and address of the experimenter are provided to facilitate direct contact. As a further aid, detailed references (and bibliography) are also included. When available, NASA accession numbers* are given. The primary purpose of these references is to identify the sources containing complete information concerning the subject under discussion. Most of these references are physically available at NSSDC - those that are not are readily obtainable.

Inquiries concerning the availability of data should be directed to:

National Space Science Data Center
Goddard Space Flight Center
Greenbelt, Maryland 20771
Area Code 301 982-6695

*For example, N64-2243 is an accession number for an article reported in the *Scientific and Technical Aerospace Reports* (STAR), and A63-5921 refers to an entry in the *International Aerospace Abstracts* (IAA).

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VANGUARD 3 (1959 ETA 1)
PROTON PRECESSIONAL MAGNETOMETER

BACKGROUND

The proton precessional magnetometer was one of three experiments aboard Vanguard 3. (See Figure 1.) The magnetometer was designed to make absolute measurements of the geomagnetic field above the ionosphere in order to deduce whether the electric currents giving rise to the main phase of magnetic storms were located in the ionosphere or at greater altitudes. Secondary objectives included the study of the equatorial electrojet and the mapping of the main field.

Vanguard 3 was launched on September 18, 1959, into an orbit with an inclination of 33.5 deg and an initial height range from 510 to 3753 km above the earth's surface. The initial period of Vanguard 3 was approximately 130 min.[1]

FIGURE 1
VANGUARD 3 EXPERIMENTS

No.	Experiment	Investigator(s)	Affiliation
01	Proton Precessional Magnetometer	J. P. Heppner	GSFC*
02	X-Ray Experiment	H. Friedman	NRL**
03	Micrometeorite	H. F. LaGow L. Secretan	GSFC* GSFC*

*Goddard Space Flight Center
**Naval Research Laboratory

EXPERIMENTER

J. P. Heppner - Goddard Space Flight Center

EXPERIMENT

Instrumentation and Measurements

The proton precessional magnetometer was designed to measure total scalar intensity of the magnetic field independent of satellite orientation by

measuring the proton precession frequency

$$f = 4257.6 \times F,$$

where F is the field intensity in gauss and the constant 4257.6 comes from the gyromagnetic ratio of the proton.

To obtain a precession signal of sufficient amplitude for measuring this frequency accurately, the proton sample is first polarized by passing a strong current through a coil surrounding the sample. When this current is cut off, a small but significant fraction of the protons are in phase in their precession and thus induce a detectable voltage at frequency f in the surrounding coil. Maximum amplitude of the precession signal is obtained by orienting the polarizing coil perpendicular to the magnetic field. However, the frequency of the induced signal is not a function of the orientation angle, and a non-perpendicular orientation will cause only a reduction in amplitude. If θ is the angle between the coil axis and the magnetic field vector, then the amplitude varies as $\sin^2 \theta$. The signal amplitude decays exponentially with a time constant that is a function of the proton sample.[2]

The instrument consisted of a sensing head, a high-gain, wide-bandpass amplifier, an 80-mw, 108.03 Mc/s telemetry transmitter, and a command receiver. The magnetometer sensing head was a 600-turn, 6-mh, 4-in. solenoid, wound on a 1-in. diameter cylinder filled with normal hexane. The polarization current was 6 amperes.[3,4] A typical amplifier response curve is shown in Figure 2.[5]

Telemetry

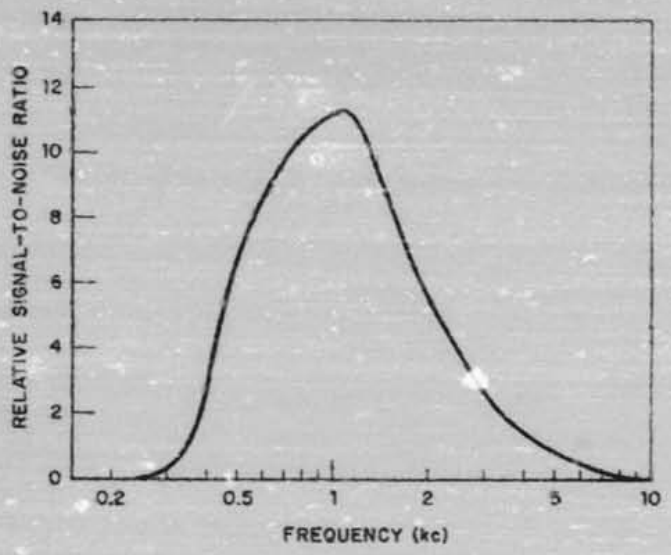
During operation, a command signal from the ground was received by a tuned receiver in the satellite. A relay closure at the output of the receiver then actuated a multivibrator programming circuit in the magnetometer. The programming circuit then performed the following functions:

1. Turned on the 108.03-Mc transmitter and the magnetometer amplifier

2. Connected the sensing-head coil to a 12-volt battery pack for about 2 sec, causing phase coherence of the protons in the sample by the resulting polarizing field

3. Switched the coil to the amplifier following polarization

FIGURE 2
TYPICAL RESPONSE CURVE FOR VANGUARD 3 AMPLIFIER



4. Switched off the 108.03-Mc transmitter and magnetometer amplifier after about 4 sec. The signal transmitted to the tracking stations was amplitude-modulated by the magnetometer signal.[3]

The Vanguard 3 tracking stations simultaneously recorded on magnetic tape the unfiltered modulation from the 108.03-Mc signal, a standard 100-kc signal, and the coded universal time. The precession signals of about 2-sec duration for each ground command ranged in frequency from about 300 to 2000 cps. The tape-recorded signals were subsequently digitized and recorded graphically and on magnetic tape.[5]

Operational Experience

The total number of observations considered suitable for analysis was 279[illegible]. The data were collected from September 18 to December 11, 1959, a period of 85 days. Perigee remained on the nightside throughout this interval although it oscillated twice past all latitudes up to the 33.5-deg limit.[3]

A qualitative survey of the magnetic activity during the period of satellite measurement, based on the observatory reports, is listed as follows:

September 18-27. Several moderate to severe disturbances spaced irregularly throughout the interval reported at less than five observatories at once. Most of the activity began about 1157 hr on September 20 when a sudden commencement (sc) was reported at five observatories with a storm ending at 2100 hr on September 22.

B. September 27-October 1. No reported disturbance.

C. October 1-8. A series of moderate to moderately severe disturbances, each of about a day's duration, only one weak sc being reported by one station.

D. October 8-17. No reported disturbance.

E. October 17-19. A moderate disturbance reported at six observatories, no clear sc.

F. October 19-29. Two short moderately severe disturbances reported at only two observatories.

G. October 29-November 7. A moderately severe disturbance beginning with a sc reported by 11 observatories at about 2348 hr on October 29. This disturbance continued at some stations through most of this interval or was followed by newly reported disturbances having no recognizable sc's.

H. November 7-21. Quiet except for a short disturbance November 14 reported at only three observatories.

I. November 21-27. One or more short disturbances reported by five observatories and ending by November 24.

J. November 27-29. A short moderately severe to severe storm with a sc reported at 17 observatories about 2351 hr on November 27 and ending by 0200 hr on November 29 at most stations.

K. November 29-December 5. Moderate to severe disturbances throughout most of the interval first reported on November 30 and ending at almost all stations by December 4.

L. December 5-11. A moderately severe to severe storm having a sc reported at 16 observatories at about 0659 hr on December 5 and ending at almost all stations on December 6. No disturbance was reported after December 7.

Analysis of the data clearly established that the principal source of D_{st} (ring current) variations was at altitudes greater than the Vanguard 3 apogee and not at ionospheric levels. However, the distribution of data with local time and altitude prevented conclusions from being drawn about the location of the sources of the DS or SD and S_q magnetic variations, including the equatorial electrojet.[3] One feature of the magnetometer data, not anticipated prior to the flight, was the detection of audio-frequency whistler signals.[6]

DATA

Reduction Techniques

A total of 2445 analog tapes was reduced to one BCD tape. The reduction techniques included a determination of frequency and time information. Due to the possibility of human error and error produced by electronic malfunction, the tapes were verified as much as practicable. The data given special attention were those which appeared more anomalous than others and those which deviated greatly from neighboring points.

Two further methods were used to check the data. A reference field was generated directly from the measured total field data. By using this reference field it was possible to further investigate those few data with residual of 50γ. Another method of checking was to compute the gradients in Δ F with time for a given satellite pass. Cases involving larger changes of gradient were further checked.[3,5]

The accuracy of the data which appear on the tape is limited by the following minor effects:

1. Residual magnetism in the satellite package. On the basis of preflight tests, this is thought to have been no more than 1 gamma.

2. Shifts in frequency due to the angular motions of the satellite. Evidence indicates that the satellite was spin stabilized at 3 rps at injection. Within hours a precession began to develop as the angular momentum transferred to the larger moment of inertia about an axis perpendicular to the longitudinal axis. After 24 hr, the cone of precession was about 45 deg; by the second day a rotation with a 12-sec period was obtained. The effect of this type of rotation has been investigated by Bloom[7] and discussed by Heppner, Stolarik, and Meredith.[8]

3. Estimated presence of noise in the signal. The noise was estimated by the differences in readings of the magnetic field as determined

by two or more recordings at separate receivers of the same magnetometer transmission. The statistics of the differences between the pairs of observations give a roughly Gaussian distribution with a standard deviation of 3γ. Since these signals may have been averaged over slightly different intervals during which the geomagnetic field gradients might normally lead to these differences, similar statistics were derived from Δ F field differences. Here, however, the standard deviation came to 4γ. This was due to the inclusion of 11 values where the differences lay in the 14- to 18-gamma range because of suspected time errors.

4. Difficulty in assessing absolute time errors. The time averages were taken over different intervals depending on the counter "preset" and the trigger level. In general the precision of a time measurement is better than 0.03 sec. However, through either human error or faulty electronics, there are numerous instances where the coded time is incorrect by 1, 2, 10, or more sec. Since the accuracy of the time of an observation is as important as the magnetic field measurement in making a useful interpretation of that measurement, the reduction of the coded-time data was done with as much care as the frequency determination. When seeking physical interpretations for magnetic field measurements that seem anomalous, it is possible that the apparent anomaly is due to some undetected error in the recorded time of the observation.[5]

Timespan of Data

The BCD magnetic tape on hand at NSSDC covers the period of September 18 to December 11, 1959.

Format of Available Data

The data record description of the final BCD data tape is given in Figure 4. The tape has a density of 556 bpi and is written as follows:

Format (I2, I3, 4I2, F4.2, I1, I2, F2.1, F6.1, F6.3, F7.3, F6.2, 3F5.1, 22X)

A typical printout is shown in Figure 5.

The areas covered by Vanguard 3 data are mainly concentrated over approximately 3 percent of the earth's surface near the receiving stations. Very few successful signal transmissions were recorded at ranges in excess of 4000 km, and the majority of good data are within a 3000-km range. The distribution

FIGURE 3
FORMAT OF FINAL TAPE

Word No.	Quantity	Format Number	Units	Remarks
1	Station No.	I2		The Minitrack station code name
2	Analog Tape No.	I3		Tape number as designated by each station. Generally each satellite pass is recorded on a separate tape. In the few instances where more than one pass is on a given tape, it is given a consecutive number following a slash (/).
3	Month	I2		Time (UT) of the middle of the signal to the nearest 0.1 second
4	Day	I2		
5	Hour	I2		
6	Minute	I2		
7	Second	F4.2		
8	L	I1		A qualitative figure attached to each observation as follows: 0 - best data 5 - duplicate data recorded simultaneously at another receiving station. These data are considered less reliable than corresponding L-0 data. Duplicate data can be identified by listing time which is nearly always in agreement to a fraction of a second. 6 - duplicate frequency determinations of the same signal, with the more reliable signal having a smaller L number 7 - data that are considered sufficiently dubious to be rejected from analysis. The data could not be verified by a later frequency determination, the exact time was ambiguous, or there were other anomalous characteristics of the

FIGURE 3 (Continued)
FORMAT OF FINAL TAPE

Word No.	Quantity	Format Number	Units	Remarks
8 (continued from previous page)	L			signal, as explained by the footnote, that cast doubt on the reliability of the measurement.
9	Footnote	I2		N - Notes as follows: 0 - no comment 1 - whistlers recorded during magnetometer readout, but not crossing magnetometer signal during measurement 2 - magnetometer signal quality poor 3 - irregular signal rise time 4 - possible errors due to erratic coded time. Time listed is based on reasonable assumptions and is very likely to be correct. 5 - magnetometer signal "pinched" 6 - 100-kc frequency standard poor. Data may have been determined by use of tracking filter. 7 - a combination of above comments or other peculiarities of such a nature that a detailed comment is available only in the original data logs 8 - whistler crossing of magnetometer signal during interval of measurement. If whistler strength was sufficient to affect apparent frequency, data were deleted.
10	Sigma	F2.1	gamma	Standard deviation of observations in gammas
11	Field	F6.1	gamma	Average scalar magnetic field in gammas (one gamma = 10^{-5} gauss = 10^{-9} webers/meter^2)

FIGURE 3 (Continued)
FORMAT OF FINAL TAPE

Word No.	Quantity	Format Number	Units	Remarks
12	Latitude	F6.3	deg	Position of the satellite in geodetic co-
13	Longitude	F7.3	deg	ordinates (east longitude and north lati-
14	Altitude	F6.2	km	tude in positive degrees, height above
15	Field-Finch	F5.1	gamma	the spheroid in kilometers)—based on the time given. Differences in absolute
16	Field-AFSWC	F5.1	gamma	scalar field between measured value and that computed using the Finch and Leaton
17	Field-Vanguard	F5.1	gamma	or AFSWC coefficients, respectively. A minus sign means that the computed field was greater than the measured field.
		22X		This is necessary to skip the 18 blank and the 4 zero characters that occur at the end of each logical record.

of data with altitude is given in Figure 6. As was expected from considerations of signal strength, there is a preponderance of data near perigee with a slow tailing off up to apogee.[5]

The distribution of data with respect to dip angle is given in Figure 7. This dip distribution was computed for each datum by using the Finch and Leaton coefficients.[9] Although the geographic latitude was small (±33.5 deg), the geomagnetic latitude limits reached 45 deg.[5]

FIGURE 4
SAMPLE OF DATA PRINTOUT

(See Figure 3 for Key to Column Headings)

10001	918	7352055	2365486	30210	-119041	57045	-4426	726	187	0000
10001	918	7353450	2366742	29958	-118046	57332	-4402	720	167	0000
6007	91810074510		1168416	-11777	-77629125970	-1791	-931	147		0000
6007	9181008173150		2164324	-12717	-76189129948	-1805	-919	215		0000
7168	9181008	742	1164290	-12720	-76184129962	-1826	-940	195		0000
6007	9181008274		1163049	-13009	-75736131213	-1827	-934	216		0000
7168	91810083804		1161739	-13311	-75266132534	-1857	-955	210		0000
6007	9181008382356	8	1161725	-13317	-75257132558	-1842	-940	225		0000
8002	91814535334		1 92734	-33440	-76379313430	-910	-830	77		0000
8002	9181455	6	2 92297	-33360	-73784319411	-918	-804	122		0000
8002	918145542396	00	1 92597	-33276	-72159323062	-968	-838	100		0000
8002	91814554239		1 92622	-33276	-72159323062	-943	-814	124		0000
8002	9181496	110	1 91637	-33231	-71447324639	-1021	-885	57		0000
7170	9181456	135500	5 91962	-33230	-71437324660	-887	-751	191		0000
8002	9181457	852	1 89511	-33028	-68908330136	-917	-764	195		0000
8002	91814578032		1 88259	-32873	-67357333365	-749	-591	380		0000
8002	91814584083		1 86445	-32653	-65508337180	-935	-775	214		0000
6010	91819481042		1 77440	-11825	-79935355765	-1119	-731	-472		0000
6010	91819493691		1 78842	-9496	-77813350945	-1153	-719	-416		0000
6010	9181950	116500	1 79305	-9060	-77216349497	-1162	-717	-400		0000
5288	9181950	131	1 79295	-9057	-77213349488	-1175	-730	-413		0000
6010	91819502064		1 79704	-8708	-76737348305	-1166	-711	-383		0000
5288	918195020785	00	2 79658	-8706	-76733348296	-1215	-760	-432		0000
6010	91819504885		2 80278	-8196	-76042346552	-1210	-742	-399		0000
6010	9181951	781	1 80757	-7850	-75574345310	-1170	-693	-339		0000
5288	9181951	820500	2 80754	-7843	-75565345284	-1183	-705	-351		0000
5288	91819512662		1 81186	-7505	-75110344073	-1196	-710	-345		0000
6010	91819514625		1 83365	-5989	-73088338429	-1216	-695	-278		0000
5288	918195248295	00	1 83339	-5988	-73087338426	-1243	-721	-305		0000
5288	9181951	113	1 83679	-5747	-72767337498	-1282	-755	-330		0000
6010	9181953	125500	1 83713	-5745	-72764337489	-1252	-725	-300		0000
5288	91819542160		1 86264	-4221	-70756331432	-1283	-724	-242		0000
9002	9182000	841600	3101317	2660	-61769300619	-1583	-911	-98		0000
9002	9182000	900600	1101315	2672	-61753300560	-1597	-945	-131		0000
9002	9182000	904	101309	2673	-61752300556	-1605	-953	-140		0000
9002	918200032316	00	1102544	3151	-61122298232	-1645	-989	-148		0000
9002	91820003253		102591	3156	-61116298210	-1609	-954	-113		0000
9002	918200032676	00	1102574	3159	-61112298195	-1633	-978	-137		0000
4186	91821034569	10	3247765	-20865	133251165104	-2312	3257	-106		0000
4186	91821034588607		4247744	-20869	133259165129	-2319	3249	-113		0000
4186	91821035498610		3247139	-21077	133664166334	-2282	3247	-39		0000
4186	9182103550	6	3247139	-21079	133667166345	-2275	3253	-53		0000
4186	9182106	149600	2237757	-23781	139272183150	-2132	2832	68		0000
4186	9182106	176 10	1237717	-23786	139284183186	-2131	2813	50		0000
5289	91822191734		1152183	14318	-78280240022	-1513	-392	-76		0000
5289	918221950268		1155885	15032	-77163239917	-1585	-442	-103		0000
9003	91822264187		2206969	23746	-61160182502	-2002	-594	162		0000
9003	918222652288		1208263	23954	-60697181126	-2019	-615	168		0000
4187	9182328	312	1189363	-32704	137845272728	-1573	2313	32		0000
11001	919	414567	8 5267738	29255	-79223144258	-1468	618	143		0000
11001	919	415427	5269222	29373	-78747143148	-1498	365	111		0000
10002	919	2492173	18 7224488	26728	-119714164387	-1870	487	3		0000
10002	919	2502909	1238275	27923	-116329155584	-2017	507	93		0000
11002	919	301	7516001	0363326	33350	-76391	82344	-1190	1089	290	0000
11002	919	301	744	2363352	33349	-76381	82333	-1185	1103	304	0000
4189	919	4185579600	1116776	-19845	134892374507	-1475	1061	-541		0000
4189	919	4185580	10	1116795	-19845	134892374507	-1458	1078	-524	0000
4189	919	4192695610	3116079	-19382	135699374176	-1495	1011	-554		0000
4189	919	4192711	2116100	-19379	135703374176	-1471	1035	-530		0000
4189	919	4203504	10 1114657	-18352	137448373211	-1474	987	-521		0000
4189	919	4203512600	1114691	-18351	137450373210	-1439	1003	-486		0000

FIGURE 5
Distribution of Vanguard Data with Altitude

Altitude Range (km)		No. of Data
(Perigee)	510-799	565
	800-1099	273
	1100-1399	352
	1400-1699	239
	1700-1999	256
	2000-2299	234
	2300-2599	182
	2600-2899	198
	2900-3199	163
	3200-3499	137
(Apogee)	3500-3753	198

FIGURE 6
Distribution of Vanguard Data with Dip Angle

Angle Range (degrees)	No. of Data
0-9	153
10-19	204
20-29	254
30-39	324
40-49	225
50-59	874
60-67	763

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