



README Document for

Nimbus 2 MRIR

Medium Resolution Infrared Radiometer

Level 1 Data Products:

MRIRN2L1

MRIRN2IM

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Version 1.2

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README document for Nimbus II MRIR

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1 Introduction

1.1 Brief Background

This document applies to the Nimbus II Medium Resolution Infrared Radiometer (MRIR) Level-1 data.

The Nimbus II Medium Resolution Infrared Radiometer (MRIR) was designed to measure electromagnetic radiation emitted and reflected from the earth and its atmosphere at 5 wavelengths.

The five wavelengths regions are as follows:

6.7 to 6.9 microns- This channel covers the 6.7 micron water vapor absorption band. Its purpose is to provide information on water vapor distribution in the upper troposphere and, in conjunction with the other channels to provide data concerning relative humidities at these altitudes

10 to 11 microns - microns- This channel measures surface or near surface temperatures over clear portions of the atmosphere. It also provides cloud cover and cloud height information (day and night).

14 to 16 microns – This channel, centered about the strong absorption band of CO₂ at 15 microns, measures radiation which emanates primarily from the stratosphere.

5 to 30 microns – This channel measures the emitted long wavelength infrared energy and, in conjunction with the reflected solar radiation channel furnishes data on the heat budget of the planet.

0.2 to 4.0 microns – This channel covers more than 99% of the solar spectrum and yields information on the intensity of the reflected solar energy from the earth and its atmosphere.

The Nimbus II was launched on May 15, 1966 on a Thrust Augmented Thor (TAT)/ Agena B vehicle. Three instruments were on board of the spacecraft.

- An Advanced Vidicon Camera System (AVCS) provided clouds in the earth atmosphere and, in clear areas, terrestrial features on the earth's surface (only during day-time).

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- A Medium Resolution Infrared Radiometer (MRIR) measured the electromagnetic radiation emitted and reflected from the earth and the atmosphere in five selected wavelengths (6.4-6.9, 10-11, 14-16, 5-30, 0.2-4.0 microns)
- A High Resolution Infrared Radiometer (HRIR) was available to provide earth cloud cover (nigh-time) and to measure the temperatures of cloud tops and terrain features.

The orbit of the satellite can be characterized by the following:

- near-circular orbit with apogee of 1179 km
- perigee height of 1095 km
- inclination of 100.311 degrees
- nodal period of 108.17 minutes
- near sun-synchronous

The Nimbus II MRIR data are available from 15 May 1966 (Day of year 135) through 28 July 1966 (Day of year 209).

1.2 Brief Background on Instruments

The radiant energy from the earth is collected by a mirror inclined to 45 degrees to the axis of rotation (scans perpendicular to flight path). The incident flux is focused onto a thermistor bolometer detector through appropriate filtering which limits the radiation to the desired wavelengths. A portion of a scan yields in-flight data calibration. The energy is modulated by a mechanical chopper to produce an AC signal from the detector. The signals are sampled 33.33 times per second.

1.3 Brief background on algorithms

The Nimbus II MRIR data was generated from the spacecraft telemetry, attitude data, orbital data. Digitized radiation data, and the Nimbus radiometer calibration package. The data are were created on IBM computers using a 36 bit architecture. Further information can be found on the Nimbus II Users' guide.

2 Data Organization

2.1 Background

2.2 Granularity

The Nimbus II MRIR were originally archived on 7-track tapes and then restored to 9-track tapes. The data in both 7-track and 9-track tapes were stored in 36-bit IBM binary format. A Canadian company (JBI) was contracted to restore to disks all 8 Nimbus II MRIR 9-track tapes. The content of each tape was written using a proprietary format (TAP) that allowed “bad” records to be flagged. Since tapes contain many files, the content of each file on a tape was retrieved and stored in a separate disk file using the same TAP format.

The Nimbus II MRIR 9-track tapes were archived at the National Space Science Data Center (NSSDC). The tape recovery process involved using specially developed tape drives, bit detection and processing techniques to read the 9-track tapes and store the recovered data in TAP(tape emulation format).

The status of the Nimbus II MRIR data restoration can be summarized as:

- Covered 3 months of observations
- all 8 tapes were successfully restored.
- 3 files had missing orbit documentation and were rejected
- 4 files were empty and were not included
- All other 1685 files could be read properly even though some may have “bad” records.
- Out of 1685 files 137 files were duplicates and 68 were kept
- 1616 files were ingested and archived at the GES DISC.

2.3 File Naming Convention

The Nimbus II MRIR level 1 data are named according to the following convention:

Nimbus2-MRIR-<YYYYMMDD>_<hh-mm-ss>_<orbit>_<version>.TAP where:

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YYYYMMDD is the starting date when the data was collected from the satellite and

YYYY: starting 4 digit calendar year (e.g. 1966)

MM: starting 2 digit month (e.g. 02 for February)

DD: starting 2 digit day of the year (e.g. 04 for day four)

hh-mm-ss is the starting time when the data was collected from the satellite and

hh : starting 2 digit hour (0-23) (e.g. 02 for hour 2)

mm: starting 2 digit minute (0-59) (e.g., 09 for 9 minutes)

ss: starting 2 digit seconds (0-59) , (e.g. 11 for 11 seconds)

orbit is the orbit number

version is a 3 digit number (e.g. 001)

2.4 File Format (TAP)

2.4.1 TAP Bytes

The first 8 bits retrieved from a 9-track restored tape was stored in a byte as described in the following Figure 1 . The tape parity bit (8th bit) was not kept during the restoration process. Bit 0-7 from tape were stored as bit 0-7 on disk.

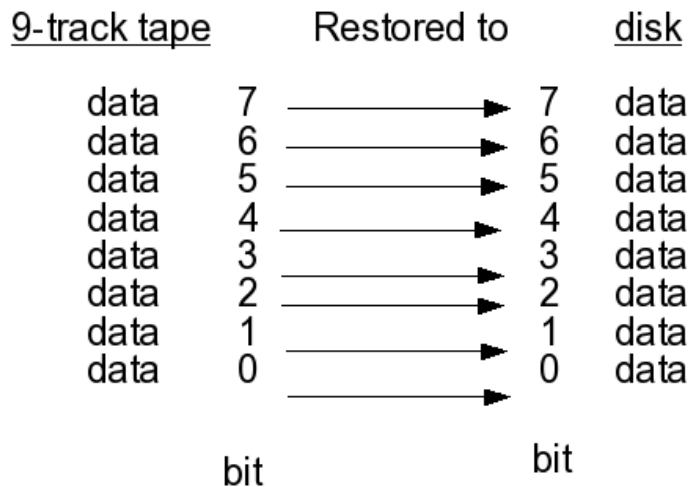


Figure 1: bit restoration from tape to disk

2.4.2 TAP headers

TAP headers are interleaved between the Nimbus II MRIR data records to indicate the length of the following and preceding data records. A TAP header is a 4 byte record which follows the following convention.

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- A number greater than zero indicates the length of a record
- A negative number indicates that a record has bytes that could not be restored from tapes and filled with zeros. The length of a record is obtained by taking the absolute value.
- a zero indicates the start of a file
- Two consecutive TAP headers with zero values are used to specify the end of a file.
- A data record is preceded by a header and followed by a header listing the length of the data record

An example of a C program to retrieve the length of a TAP header is illustrated in Appendix 7.1

2.4.3 MRIR Word

The basic unit of the Nimbus II data is a word which is a 36-bit IBM binary word. This means that in order to extract a 36-bit word from the restored files, 4.5 bytes (8-bits) must be read. With half 36 bit words, 2.25 bytes must be read. An example of how to extract a 36 bit word or ½ 36 bit word is illustrated in Appendix 7.2

To preserve space while maintaining a good resolution, data were originally stored using a scaling technique. The idea was to multiply a number by a factor before storing the value to tapes. Nimbus II data can be converted back to the initial value by dividing the stored value on tape (or TAP files) by $2^{(35-B)}$, where B is the scaling factor listed on the Nimbus II Data record format Table 1, Table 2, Table 3, and Table 4.

A word of 36 bits with a scaling factor of B is converted by using the relation:
$$\text{value} = (\text{integer value of 36 bits}) / (2^{(35-B)})$$

When a word is divided in two ½ Word (WordD, and WordA), the actual values are converted by using the relation:

A wordD of 18bits with a scaling factor of B is converted in real by using the relation:
$$\text{value} = (\text{integer value of 18 bits}) / (2^{(17-B)})$$

A wordA of 18bits with a scaling factor of B is converted in real by using the relation:
$$\text{value} = (\text{integer value of 18 bits}) / (2^{(35-B)})$$

The scaling factor is mentioned and used in tables describing the Nimbus II MRIR records.

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2.5 Data Structure Inside a File

Two TAP 4 byte headers are stored before and after each Nimbus II MRIR records. The first Nimbus II MRIR record is an orbit data document record (68 bytes) followed by multiple data records. A Nimbus II data record is composed of a Data record documentation followed by several swath data records. The length of a data record (L) in words can be computed using the relation.

$$L = (\text{swaths per records}) * (\text{words per swath}) + (\text{number of nadir angles}) + 7$$

The overall structure of the Nimbus II files is depicted in Figure 2

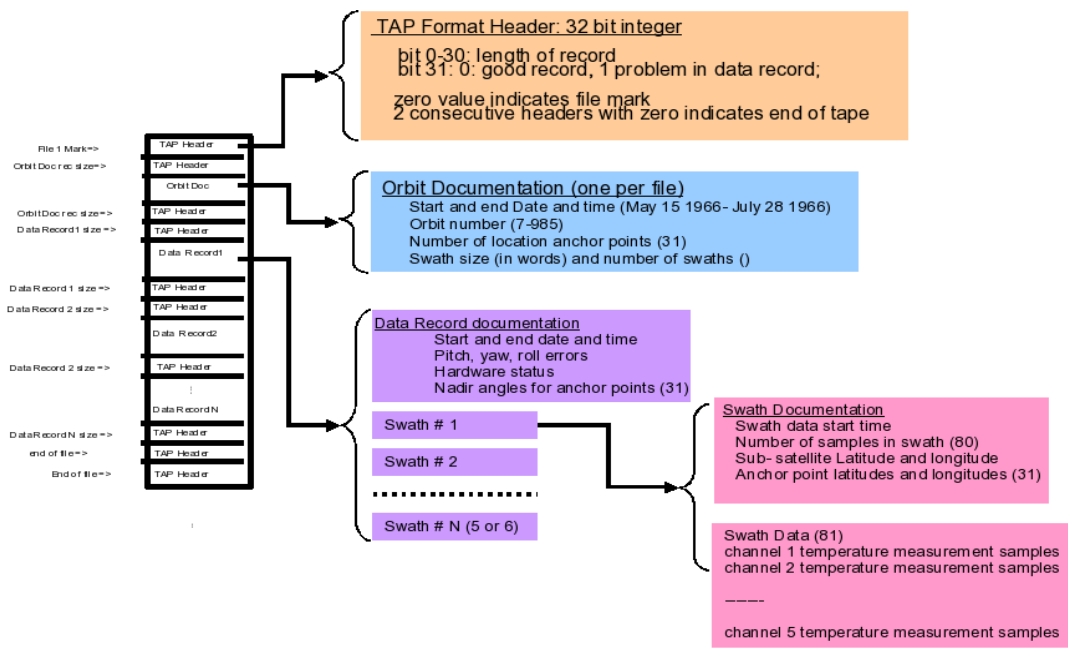


Figure 2: Nimbus II MRIR file structure

2.6 Key Metadata Fields

These are most likely to be used by users:

Temporal

- start Date / Time
- end Date/ Time

Geolocation

- latitude
- longitude

3 Data Contents

Described below are all the parameters associated with the Nimbus II MRIR files.

Table 2 describes in details all the parameters associated with an orbit. There is one orbit documentation record per file.

Table 3 describes in details all fields in a record documentation. There is one data record documentation per data record

Table 4 describes in details all fields in a swath data record. There are multiple swath data records in a single data record.

4 Data Services

The data product landing pages provide information about the data, as well as links to download the data files and relevant documentation:

https://disc.gsfc.nasa.gov/datacollection/MRIRN2L1_001.html

https://disc.gsfc.nasa.gov/datacollection/MRIRN2IM_001.html

5 Data interpretation and screening

5.1 Geolocation

The MRIR radiometer scans the earth in a clockwise direction from right to left. Each earth scan is defined by a family of mirror nadir angles. For each mirror angle, the latitude and longitude of the corresponding point on the earth's surface is recorded. The position of individual samples between two anchor points is determined by interpolation.

The latitude and longitude of the corresponding point on the earth's surface are used as references in computation of positions for each sample. There is still no information available describing how many anchor points were used for a swath. This issue is still being investigated.

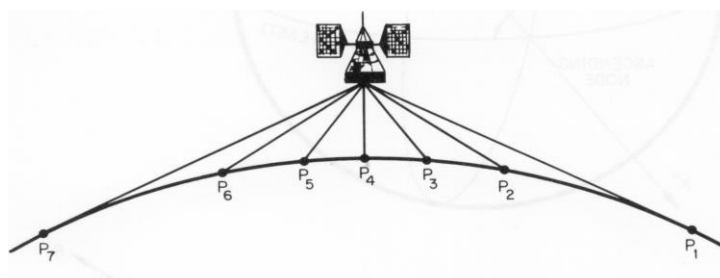


Figure 3: Nimbus II anchor points

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6 More Information

6.1 Point of Contact

URL: <https://disc.gsfc.nasa.gov/>

Name: GES DISC Help desk support group

email: gsfc-help-disc@lists.nasa.gov

phone: 301-614-5224

fax: 301-614-5268

Address: Goddard Earth Sciences Data and Information Services Center

Code 610.2

NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA

6.2 References

- Nimbus II users' guide, July 1966
- The Nimbus II advanced vidicon camera system data ; world montage catalog , 20 May through 31 August 1966
- The medium II medium resolution infrared pictorial data catalog volume 1 15 May through 21, June 1966
- The radiation balance of the earth-atmosphere system over both polar regions obtained from radiation measurements of th nimbus II meteorological satellite, September 1967
- Nimbus II flight evaluation and engineering report, Launch through orbit 5275 , February 1969

7 Appendices

7.1 Example on How to Extract the Record Length Listed in a TAP using C

```

int ReadHeader(ifd)      /* read header */
int ifd;

/* This function reads a TAP header (4 bytes) and return
   the size in bytes of the next record to read
   input
       ifd: file reference
   output
       reclen: size of the next record in bytes
*/

{
unsigned char    bytebuf[200];
int    j, size, value, reclen, signbit;

    size = read( ifd, bytebuf, 4) ;      /* read header */

    value = 0;
    for (j=0 ; j<=3 ; j++ )
        {
            value = value << 8;          /* shift left by 8 bits */
            value = value | bytebuf[j];
        }
    reclen = value;
    return reclen;
}

```

7.2 Example on How to Extract a Word (36 bits from) from a TAP File using C

Below is an example of a C routine to extract the 36 bit word (out of 6 unsigned bytes), remove the most significant bits of each byte and store the content into a long long interger.

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```
long long GetWord (initval,len)
unsigned char  initval[];      /* buffer containing the binary data */
int len;                      /* number of bytes */

/*  this function removes the 2 most significant bits of each byte
and concatenates the "len" bytes (with the 2 bits removed)
into an integer
input
    initval array containing the bytes
    len      number of bytes to clean and concatenate
output
    value    integer containing the bytes cleaned and concatenated
*/
{
int j,pos;
unsigned char  byteclean;
long long value,signbit,res, signval;

value = 0;
pos=0;
signval = 1;
for (j=0 ; j<len ; j++ )
    {
    if ( j == 0 )
        {
        signbit = initval[pos] & 0x20;  /* get sign bit */
        if ( signbit == 32 )
            {
            value = value << 5;  /* shift left by 5 bits
to remove sign bit */
            signval = -1;
            byteclean = initval[pos] & 0x1f;
            value = value | byteclean;
            }
        else
            {
            value = value << 6;  /* shift left by 6 bits
to remove sign bit */
            byteclean = initval[pos] & 077; /* remove the 2
most significant bits */
            value = value | byteclean;
            }
        }
    else
        {
        value = value << 6;          /* shift left by 6 bits */
        byteclean = initval[pos] & 077; /* remove the 2 most
significant bits */
        value = value | byteclean;
        }
    pos++;
    }

value = value*signval;
return value;
}
```

7.3 Description of Metadata Fields

Following is a list of the XML metadata fields and a brief description for the MRIR data.

Table 1: XML Metadata Fields

field	Description	value
LongName	Long name of the product	MRIR/Nimbus-2 Level 1 Meteorological Radiation Data
ShortName	Short name of the product	MRIRN2L1
VersionID	Version ID of the ingested data product, not the processing version.	001
GranuleID	Granule ID (same as the name of the file).	Example: Nimbus2-MRIR-19660530_14-16-38_1043_v001.TAP
Format	File Format (see section on TAP for a full description).	TAP
ChecksumType	Type of checksum	CRC32
ChecksumValue	Value of the checksum using cksum command	Example: 3378917185
SizeBytes DataGranule	Total size of the data granule in bytes	Example: 4855962
InsertDateTime	Date and time when the granule was inserted into the archive. The date is YYYY-MM-DD and the time is in hh-mm-ss format	Example: 2009-05-30 17:20:44
RangeBeginning Date	Begin date when the data was collected. The date is in YYYY-MM-DD format	Example: 1966-05-30
RangeBeginning Time	Begin time of date when the data was collected. The time is in hh-mm-ss format	Example: 14:16:38
RangeEnding Date	End date when the data was collected. The date is in YYYY-MM-DD format	Example: 1966-05-30
RangeEnding Time	End time of date when the data was collected. The time is in hh-mm-ss format	Example: 15:11:08

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field	Description	value
Platform ShortName	Acronym or short name of the satellite or platform.	Nimbus2
Instrument ShortName	Acronym or short name of the instrument.	MRIR
SensorShortName	Name of the sensor	MRIR
Gpolygon PointLatitude	Latitudes of the polygons that represent the satellite coverage. Rectangles have been selected in this case. Each point of a rectangle is identified by its latitude and longitude	Example: -80.000000 -90.000000 -90.000000 -80.000000
Gpolygon PointLongitude	Longitudes of the polygons that represent the satellite coverage. Rectangles have been selected in this case. Each point of a rectangle is identified by its latitude and longitude	Example: 180.000000 180.000000 -180.000000 -180.000000
Orbit	Satellite orbit number. There is one orbit per file. A given orbit may have several files (partial orbits or data collected from different stations)	Example: 1043
Average_Elevation	Average elevation in km of the satellite during an orbit	Example: 1140.915
Station_Code	DAF Station identification code	Example: 2
Elapsed_Min_Time	Duration in minutes of data collected during an orbit	Example: 25

7.4 Description of Orbit Documentation Records

This record is unique for each file and provides information on the starting and end Date/time for a file, size and number of swaths, orbit number, and the number of anchor points used to identify the geo-location of the data.

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Table 2: Orbit Documentation record

Word No.	Quantity	Units	Scaling	Remarks
1	Nimbus Day	-----	B=35	Start day of the year (1966) for this file (orbit)
2	Hour	hh	B=35	Start hour for this file(orbit)
3	Minute	mm	B=35	Start minute for this file(orbit)
4	Second	ss	B=35	Start seconds for this file(orbit)
5	Nimbus Day	-----	B=35	End day of the year (1966) for this orbit
6	Hour	hh	B=35	End hour for this orbit
7	Minute	mm	B=35	End minute for this orbit
8	Second	ss	B=35	End seconds for this orbit
9	Mirror Rotation	Deg/Sec	B=26	Rotation rate of radiometer mirror
10	Sampling Frequency	Samples /Sec	B=35	Digital sampling frequency per second of vehicle time
11	Orbit Number	-----	B=35	Orbit Number
12	Station Code	-----	B=35	Data Acquisition Facility (DAF) Station identification
13	Swath Block size	-----	B=35	Number of 36-bit words per swath
14	Swaths/records	-----	B=35	Number of swath per record
15	Number of locator points	-----	B=35	Number of anchor points per swath for which latitudes and longitudes are computed

7.5 Description of Data Record Documentation

The data documentation record provides information describing the subsequent swath data records.

Table 3: Data Documentation Record

Word No.	Quantity	Units	Scaling	Remarks
1D	Nimbus Day	-----	B=17	Start Day of the year for this data record
1A	Hour	hh	B=35	Start hour for this data record
2D	Minute	mm	B=17	Start minute for this data record
2A	Second	ss	B=35	Start seconds for this data record
3D	Roll Error	Degrees	B=14	Roll Error at start Date/time (word 1 and 2) for this record
3A	Pitch Error	Degrees	B=32	Pitch Error at start Date/time (word 1 and 2) for this record
4D	Yaw Error	Degrees	B=14	Yaw Error at start Date/time (word 1 and 2) for this record
4A	Height	Km	B=35	Height of the spacecraft at start Date/time (word 1 and 2) for this record
5D	Not used		B=17	Not used
5A	Housing one Temperature	Degrees K	B=32	Measured temperature of housing one at time specified in words one and two
6D	Housing two Temperature	Volts	B=14	Measured temperature of housing two at time specified in words one and two
6A	Electronics temperature	Degrees K	B=32	Measured temperature of electronics at start Date/time (word 1 and 2) for this record
7D	Chopper one Temperature	Degrees K	B=14	Measured temperature of chopper at start Date/time (word 1 and 2) for this record
7A	Chopper one Temperature	Degrees K	B=32	Measured temperature of chopper at start Date/time (word 1 and 2) for this record

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Word No.	Quantity	Units	Scaling	Remarks
8D	GHA of SUN	Degrees	B=14	GHA of Sun of at start Date/time (word 1 and 2) for this record
8A	Dec of SUN	Degrees	B=32	Declination of sun at start Date/time (word 1 and 2) for this record. Ninety degrees added to eliminate negative sign
9	Nadir Angle	Degrees	B=29	Nadir angle corresponding to the first anchor point and measured in the plane of the scanning radiometer

N	Nadir Angle	Degrees	B=29	Nadir angle corresponding to the last anchor point and measured in the plane of the scanning radiometer

7.6 Description of a Swath Data Record

Table 4: Swath Data Record

Word No.	Quantity	Units	Scaling	Remarks
(N+1)D	seconds	ss	B=8	Seconds elapsed since the start of the Date/time of this data record
(N+1)A	Data population	-----	B=35	Number of data points in this swath
(N+2)D	Latitude	Degrees	B=11	Latitude of the subsatellite point for this swath
(N+2)A	Longitude	Degrees	B=29	Longitude of the subsatellite point for this swath, positive westward 0 to 360
(N+3)D	Latitude	Degrees	B=11	Latitude of viewed point for the first anchor point

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Word No.	Quantity	Units	Scaling	Remarks
(N+3)A	Longitude	Degrees	B=29	Longitude of viewed point for the first anchor point.
...				
...				
(N+3+M)D	latitude	Degrees	B=11	Latitude of viewed point for the Mth anchor point
(N+3+M)A	Longitude	Degrees	B=29	Longitude of viewed point for the Mth anchor point
(N+3+M+1)D	MRIR Data	Degrees	B=14	First MRIR temperature measurement , channel 1
(N+3+M+1)A	MRIR Data	Degrees	B=32	First MRIR temperature measurement, channel 1
...				
...				
(N+3+M+K)D	MRIR Data	Degrees	B=14	Last MRIR temperature measurement , channel 1
(N+3+M+K)A	MRIR Data	Degrees	B=32	Last MRIR temperature measurement, channel 1
(N+3+M+K+1)D	MRIR Data	Degrees	B=14	First MRIR temperature measurement , channel 2
(N+3+M+K+1)A	MRIR Data	Degrees	B=32	First MRIR temperature measurement , channel 2
...				
...				
(N+3+M+2*K)D	MRIR Data	Degrees	B=14	Last MRIR temperature measurement , channel 2
(N+3+M+2*K)A	MRIR Data	Degrees	B=32	Last MRIR temperature measurement , channel 2
...				
...				
(N+3+M+4*K+1)D	MRIR Data	Degrees	B=14	First MRIR temperature measurement , channel 5
(N+3+M+4*K+1)A	MRIR Data	Degrees	B=32	First MRIR temperature measurement , channel 5
...				
...				

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Word No.	Quantity	Units	Scaling	Remarks
(N+3+M+5*K)D	MRIR Data	Degrees	B=14	Last MRIR temperature measurement , channel 5
(N+3+M+5*K)A	MRIR Data	Degrees	B=32	Last MRIR temperature measurement , channel 5

Note: All remaining or unused portions of a swath data block are set to zero, giving a swath block size as specified in the documentation record.

7.7 Quality Assurance Procedures

7.7.1 Data Producer QA

The Data Producer's QA information can be found in the XML metadata file under the section ProducersQA. The information begins with the following:

```
Record No, Bytes, Bad bytes
0, filemark
1, 84, 0
2, filemark
3, 102, 0
4, 11928, 0
:
<n-1>, 11928, 0
<n>, filemark
```

On each line there are 3 comma separated numbers: the first is the record number, the second is the record length in bytes, and the third is the number of bad bytes. The first Record #0 is a filemark which separates different files. Record # 1 has 84 bytes - this is the BCD header length. If the number of bad bytes is 0, this indicates the header is good. If the number is non-zero, there are bad bytes in the header. Record # 2 marks the end of the BCD header, and the start of the next file record. Record #3 has 102 bytes - this is the data header length. If the number of bad bytes is 0, this means all bytes are good, if the number is non-zero, there are bad bytes in the header. Record #4 is 11928 bytes. This is the nominal data record length. If the number of bad bytes is 0, that indicates this data record is good, if the number is non-zero, there are bad bytes in the data record. From this point, all subsequent records are data records and should have a length of 11928 with no bad bytes. A final filemark will indicate the end of the file. Sometimes the data are split into different orbits or orbit section files, and this will be noted with another filemark

7.7.2 Physical QA

Each restored file was read and its corresponding orbit documentation was extracted and used to derive the file name and to create a XML metadata file.

For each file the number of "bad" records was derived.

Plots of selected swaths were generated (with and without a world map) and some were compared with published papers.

7.7.3 Science QA

MRIR data were examined and validated using Nimbus2 MRIR documentation (e.g., The Nimbus II Medium resolution infrared pictorial data catalog, volume 1).

7.8 Image Files

The **MRIRN2IM** data product consists of 4 x 5 inch photographic film sheets from the Nimbus-2 Medium Resolution Infrared Radiometer. Each film sheet contains an entire orbit (daylight portion) of data measured at five wavelength bands: 6.4-6.9, 10-11, 14-16, 5-30, and 0.2-4.0 micrometers. There are also associated latitude grids, time, and gray scales representing different temperatures. The images are saved as JPEG 2000 digital files. About 3 weeks of images are archived into a TAR file. The processing techniques used to produce the data set and a full description of the data set are contained in section 4.3.4 of the "Nimbus II Users' Guide."

7.9 Acronyms

DAF: Data Acquisition Facility

EOS: Earth Observing System

GES DISC: Goddard Earth Sciences Data and Information Services Center

GSFC: Goddard Space Flight Center

MRIR: High Resolution Infrared Radiometer

L1: Level 1 Data

NASA: National Aeronautics and Space Administration

QA: Quality Assessment

UT: universal Time