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Determining the Completeness of the Nimbus Meteorological Data Archive

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Introduction

NASA launched the Nimbus series of meteorological satellites in the 1960s and 70s. These satellites carried instruments for making observations of the Earth in the visible, infrared, ultraviolet, and microwave wavelengths. The original data archive consisted of a combination of digital data written to 7-track computer tapes and on various film media. Many of these data sets are now being migrated from the old media to the GES DISC modern online archive. The process involves recovering the digital data files from tape as well as scanning images of the data from film strips.

Some of the challenges of archiving the Nimbus data include the lack of any metadata from these old data sets. Metadata standards and self-describing data files did not exist at that time, and files were written on now obsolete hardware systems and outdated file formats. This requires creating metadata by reading the contents of the old data files. Some digital data files were corrupted over time, or were possibly improperly copied at the time of creation. Thus there are data gaps in the collections.

The film strips were stored in boxes and are now being scanned as JPEG-2000 images. The only information describing these images is what was written on them when they were originally created, and sometimes this information is incomplete or missing. We have the ability to cross-reference the scanned images against the digital data files to determine which of these best represents the data set from the various missions, or to see how complete the data sets are. In this presentation we compared data files and scanned images from the Nimbus-2 High-Resolution Infrared Radiometer (HRIR) for September 1966 to determine whether the data and images are properly archived with correct metadata.

Nimbus-2 HRIR

The Nimbus-2 HRIR instrument was launched on May 15, 1966, and was operational until November 11, 1966 when its tape recorder failed. The primary objectives of the mission were to: 1) map the Earth's cloud cover at night (complementing the AVCS or Advanced Vidicon Camera System's visual daytime measurements), and 2) make temperature measurements of cloud tops and view terrain features in the 3.5 – 4.1 micron region.

HRIR consisted of a radiometer with a scanning mirror rotating at 44.7 revolutions per minute allowing for contiguous scanning at the subsatellite point and for overlap between orbits. The radiometer instantaneous field of view was about 0.5°, which at an altitude of 1100 km corresponded to a ground resolution of approximately 8 km at nadir. The radiometer was capable of measuring radiance temperatures between 210° and 330° K. Selective daytime measurements were also made, typically only one or a few orbits per day, especially after the AVCS tape recorder failed on August 31. These daytime measurements include reflected solar radiation; although this did not saturate the instrument, usable data was still obtained.

Data Availability (1966)

Total 2470 data files*, and 2200 images
- Nighttime data only
- Nighttime and Daytime data

* includes swath fragments and duplicates

May

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

June

Sun	Mon	Tue	Wed	Thu	Fri	Sat
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

July

Sun	Mon	Tue	Wed	Thu	Fri	Sat
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

August

Sun	Mon	Tue	Wed	Thu	Fri	Sat
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

September

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

October

Sun	Mon	Tue	Wed	Thu	Fri	Sat
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

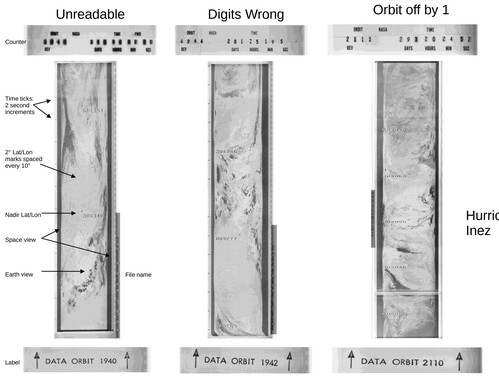
November

Sun	Mon	Tue	Wed	Thu	Fri	Sat
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

Image File Dataset Overview

- Product Identifier: HRIRN2IM.001
- Film strip images are scanned from negatives to files in the JPEG-2000 format (lossless)
- Set of images are tarred together according to roll of film
- Tar file metadata derived from image files start/end date, first/last orbit
- Individual images contain a counter with orbit readout, start day and time.
- Label affixed to image contains orbit number, used for image file name
- Time tick marks on side every 2 minutes along track
- Spatial info 2° lat/on marks every 10 degrees, and nadir lat/lon at 30 degree increments

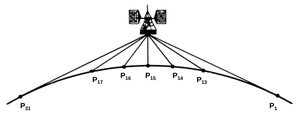
Examples of problems with images:



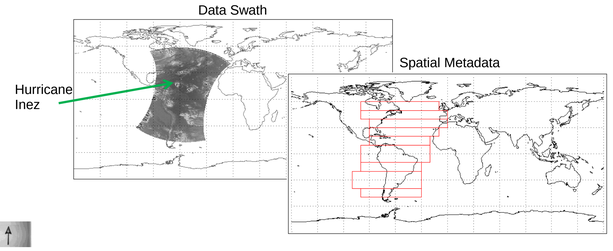
Data File Dataset Overview

- Product Identifier: HRIRN2L2.001
- Data recovered from original 7-track tapes
- Bad tapes result in problems with recovered data:
  - parity errors (unrecoverable)
  - missing headers (unrecoverable)
  - duplicate/triplicate data files (overwrite)
  - corrupted geolocation information (no spatial metadata)
- Data Files are stored in binary IBM 36-bit format
- Data Files contain 1 documentation header, and a set of data records each with a header and 6 swaths
- Measurements contain brightness temperatures
- Geolocation must computed from 31 tie-points that can be interpolated to each pixel (typically around 500) across track
- Metadata from documentation header (orbit number, start/ end date), spatial info

Figure at right shows some tie points used for geolocating swath data [from Ref. 4]



File: Nimbus2-HRIR_19660928_03-16-13_1811_001.TAP



Comparison of September Data and Images

The comparison of available Nimbus-2 HRIR data files and imagery required cross-checking inventories from both data sets. It was immediately clear that there was a problem between naming of the data and image files. Extensive detective work was needed to determine the problems. Fortunately the Nimbus program compiled an exhaustive catalog of all the HRIR measurements [see Ref. 2]. Problems found included:

- Data file orbit numbers from the documentation record were often incorrect, usually offset by 1
- Image file names based on orbit label (correct) and counter start time (usually incorrect or missing)
- A few images were missing orbit label (manual comparison with data files)
- Occasionally catalog missing in orbit info table but shown in catalog orbit chart

It was determined from the data catalog that the image orbit label was correct, and the data file orbits were (usually) incorrect. It was also determined that the data file start and end times are correct, the image file times are mostly unreliable (counter unreadable or wrong). The tables below summarizes the results of the comparison of available data files and images for September 1966.

September Summary

Total Nighttime Catalog Orbits	347
Total Nighttime Data Files*	411
Total Nighttime Image Files	339
Total Daytime Catalog Orbits	63
Total Daytime Data Files*	70
Total Daytime Orbit Files	59

* includes swath fragments and duplicates

Data File Missing where Image File Exists

Catalog Orbit #	Image Orbit #	Node
1481	1481	Day
1482	1481	Night
1508	1508	Night
1509	1508-1509	Day
1510	1509-1510	Day
1515	1515	Night
1527	1527	Night
1528	1528	Night
1531	1531	Night
1549	1549	Night
1555	1555	Night
1630	1630	Night
1631	1631	Night
1644	1644R	Night
1665	1665	Night
1693	1693	Night
1695	1694-1695D	Day
1719	1719	Night
1728	1728	Night
1740	1740	Night
1763	1763	Night
1781	1781	Night
1801	1801	Night
1802	1802D	Day

Image File Missing where Data File Exists

Catalog Orbit #	Data Orbit #	Date	Node
1575	1575	09/10 14:37:04	Day
1608	1612	09/13 02:54:17	Night
1628	1628	09/14 14:12:02	Day
1630	1630	09/14 17:40:02	Day
1669	1670	09/17 16:05:15	Day
1719	1719	09/21 10:36:52	Night
1758	1760	09/24 09:20:01	Night
1759	1760	09/24 10:43:18	Night
1767	1771 1771	09/25 01:27:06 09/25 01:37:28	Night Night
1768	1771	09/25 03:13:06	Night
1769	1771	09/25 04:48:18	Night
1770	1771	09/25 06:36:48	Night

Nimbus Datasets Available at the GES DISC

Tape Data:

HRIRN2L2.001 – Nimbus-2 / HRIR Level 2 Earth's Cloud Cover at Night, and Temperature of Cloud Tops and Terrain Features
MRIRN2L2.001 – Nimbus-2 / MRIR Level 2 Meteorological Radiation Data
HRIRN3L2.001 – Nimbus-3 / HRIR Level 2 Earth's Cloud Cover, and Temperature of Cloud Tops and Terrain Features
THIRN2L2CH115.001 – Nimbus-4 / THIR Level 2 Earth's Cloud Cover at Night, Temperature of Cloud Tops and Terrain Features at 11.5 microns
THIRN2L2CH67.001 – Nimbus-4 / THIR Level 2 Upper Troposphere and Stratosphere Water Vapor at 6.7 microns

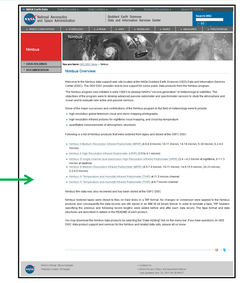
Film Images:

HRIRN1IM.001 – Nimbus-1 / HRIR Imagery of Cloud Cover at Night on 70 mm Film Strips in JPEG 2000 Format
HRIRN2IM.001 – Nimbus-2 / HRIR Imagery of Cloud Cover at Night on 70 mm Film Strips in JPEG 2000 Format
MRIRN2IM.001 – Nimbus-2 / MRIR Film Images in JPEG 2000 Format
HRIRN3IM.001 – Nimbus-3 / HRIR Imagery of Cloud Cover at Day and Night on 70 mm Film Strips in JPEG 2000 Format
MRIRN3IM.001 – Nimbus-3 / MRIR Film Images in JPEG 2000 Format
THIRN4IMCH67.001 – Nimbus-4 / THIR at 6.7 microns 70-mm Film Strips in JPEG 2000 Format
ESMRN5IM.001 – Nimbus-5 / ESMR Imagery of Brightness Temperature on 70 mm Film in JPEG 2000 Format
THIRN6IM.001 – Nimbus-6 / THIR at 6.7 and 11.5 micron Imagery of Brightness Temperature at Day & Night on 70 mm Film in JPEG 2000 Format
THIRN7IM.001 – Nimbus-7 / THIR at 6.7 and 11.5 micron Imagery of Brightness Temperature at Day & Night on 70 mm Film in JPEG 2000 Format

Documentation: READMEs, User's Guides, Data Catalogs, are available for each of the above datasets.

For more information on the Nimbus Meteorological Datasets please visit the web page:

http://disc.sci.gsfc.nasa.gov/nimbus



Conclusion

It would have been very difficult to say for sure which data set was most complete without access to the Nimbus-2 data catalog. After analyzing this catalog, and the available data files and images for September 1966, we conclude that both data sets are fairly complete, with the image data set slightly more complete. Whether or not this holds true for the other Nimbus data sets (MRIR, THIR, etc.) is hard to say. Fortunately, the Nimbus program made data catalogs available for Nimbus 1 through 6.

The image files are very difficult to work with (large size about 1500 x 15000 pixels). Information (spatial, time, orbit number) is imprinted on the images rather than available in a header that would be machine readable. Thus users need to examine each image manually. The images can really only be used quantitatively to obtain approximate temperature values and get an overall view of the data for the particular orbit.

The data files are written in an archaic 36-bit IBM format. A detailed file specification is included in the Nimbus-2 User's Guide [see Ref. 1], and so the data values can be computed. However some data records are corrupted (roughly a few percent), a result of deteriorating tapes, write problems to the original 7-track tapes, or bad downlinks from the Nimbus-2 spacecraft. Users must also calculate the geolocation of each pixel.

Finally, we would also like to state that not all of the primary original 7-track data tapes were fully recoverable, and thus some data files may have been lost. We are also looking into retrieving additional data from backup tapes to see if some of the missing data files are still available.

References

[1] Nimbus-II User's Guide, NASA Goddard Spaceflight Center, Greenbelt, Maryland, July 1966

[2] The Nimbus-II Data Catalog: Volumes 1-5, NASA Goddard Space Flight Center, Greenbelt, Maryland, July 1966

[3] Nimbus-I High Resolution Radiation Data Catalog and User's Manual: Vol. 1 Photofacsimile Film Strips, NASA Goddard Spaceflight Center, Greenbelt, Maryland, Jan. 1965

[4] Nimbus-I High Resolution Radiation Data Catalog and User's Manual: Vol. 2 Meteorological Radiation Tapes, NASA Goddard Spaceflight Center, Greenbelt, Maryland, July 1966