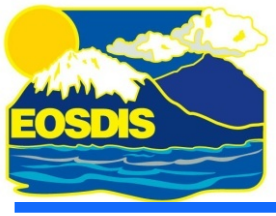
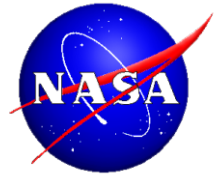




Nimbus II Permanent Records

EOSDIS Science Operations, ESDIS Project Code 423
Goddard Space Flight Center, Greenbelt, MD 20771

ESIP Federation Meeting, Santa Barbara, CA.
July 9, 2009

NIMBUS II Instruments Launched May 15, 1966

- 3 instruments collected Earth observations starting in May
  - Advanced Vidicon camera (AVCS) to provides television pictures of clouds in the earth's atmosphere
  - High resolution Infrared Radiometer (HRIR) to map the Earth's cloud cover at night and to measure the temperatures of cloud tops and terrain features
  - Medium resolution infrared radiometer (MRIR) to measure electromagnetic radiation emitted and reflected from the earth and its atmosphere in five wavelength bands

HRIR instrument

- Single scanning radiometer, using a 3.5 - 4.1 micron filter and Lead Selenide (PbSe) photoconductive detector cell radiatively cooled to -75 deg C.
  - Provides measurements of blackbody temperatures between 210K - 330K
    - Noise equivalent ~1 degree C for a 250K background
- Sun-synchronous, 108 minute nodal period
  - Scanning coincident with spacecraft velocity vector (no yaw error)
  - Scan mirror inclined 45 degrees to axis of rotation (scans perpendicular to flight path)
  - Scan rate operation of 44.7 revolutions per minute provides a scan line separation of 8.3 km
- Instantaneous field-of-view of 8.7 milliradians provides ground resolution of 8 km at an altitude of 1110 km
- Performance was excellent until orbit 2455 when the tape recorder failed
  - Time period of data coverage:
    - 16 May 1966 (Julian day 136) through 13 Nov 1966 (Julian day 319)
    - Most data collected during nighttime part of orbit
  - Faint 200-Hz interference – observed pre-launch – associated with AC noise on bus power
- Overall calibration in good agreement with pre-launch measurements
  - The HRIR detector, after stabilizing at -76°C post launch, exhibits a warming trend and became nominal at -65°C.
  - Overheating detector cell decreased the signal to noise ratio from 20 to 8

Nimbus II HRIR Inventory & Data

- The Nimbus II HRIR data was sent to the National Archives and Records Administration Washington National Records Center in the late 1960's
  - Nimbus II HRIR was stored on 7-track reel-to-reel computer tapes (primary and second copy) in boxes on shelves at a secure and environmentally controlled facility

- An inventory of the Nimbus II HRIR data collection was maintained at NASA Space Science Data Center
  - Electronic list of Nimbus II HRIR tapes and the associated Federal Record Center accession and box numbers
  - The list shows 7 tape numbers per box

Nimbus Recovery Project Goals

- Recover the Nimbus II HRIR data collection from the 7-track tapes stored at the Federal Records Center
- Archive Nimbus II HRIR at the Goddard Data Information Services Center (DISC) and make the data and documentation available to users via the internet

Recovery Methodology

- The recovery process uses specially developed tape drives, bit detection and processing techniques to read the 800 bpi, 7-track tapes
  - John Bordynuik Inc, Niagara Falls, Ontario, Canada
  - Estimating 1-2% will be unrecoverable, some tapes are missing, some have missing bytes
- Procedures involve sending the primary tape collection for recovery, checking the number of tapes and files processed against NSSDC inventory
- Identifying missing or unreadable tapes, repeating the process with the backup tape, destroying the tapes once off-site backups are secure.
- Developing code to unpack HRIR data, analyze and validate against the user guide and results found in research papers and journals
- Ingesting HRIR into DISC S4PA, ensuring the backup is secure, preparing EOSDIS-like metadata and documentation and making data available via GES DISC web site
- Validating the data with the current science community

Nimbus II HRIR Documentation

- Sources
  - Hard copy from NASA Space Science Data Center
  - Electronic copy from on-line access to NASA Technical Report Server
- Key Documentation and Companion Technical Reports
  - Nimbus Project 1966: *Nimbus II User's Guide*, GSFC, Greenbelt, MD., 229pp
  - Nimbus Project 1966: Nimbus II Data Catalog, GSFC, Greenbelt, MD., Vol. 2, 298pp
  - McNaney, J.J, Palmer, General Electric Co., and R. Shapiro, GSFC, 1969: *Nimbus II Flight Evaluation and Engineering Report (Launch through orbit 5275), NASA Technical Note D-4881,199p.*
  - Williamson, E. J., *1969: The accuracy of The High Resolution Infrared Radiometer on Nimbus II. GSFC, Greenbelt, MD, NASA TN-D-5551, 14p*

Nimbus II HRIR Data Recovery process

Data Restoration

NASA request
- Identify N2 tapes
- Request N2 boxes

FRC
- Retrieve N2 boxes
- Send N2 boxes to JBI

JBI restoration
- Restore N2 tapes
- Send N2 TAP files

NASA Validation & QA
- Assess completeness
- Evaluate data quality
- Extract / store each TAP file
- Rename TAP files
- Identify / Select duplicates
- Document process / status
- Collect Nimbus II doc

Data Ingest / archive / services

NASA Ingest & Archive
- Identify requirements
- Generate metadata
- Develop DIF
- Develop README
- Develop DISC web pages
- Ingest / archive into S4PA
- Publish to ECHO
- Test dev /TS1/ ops

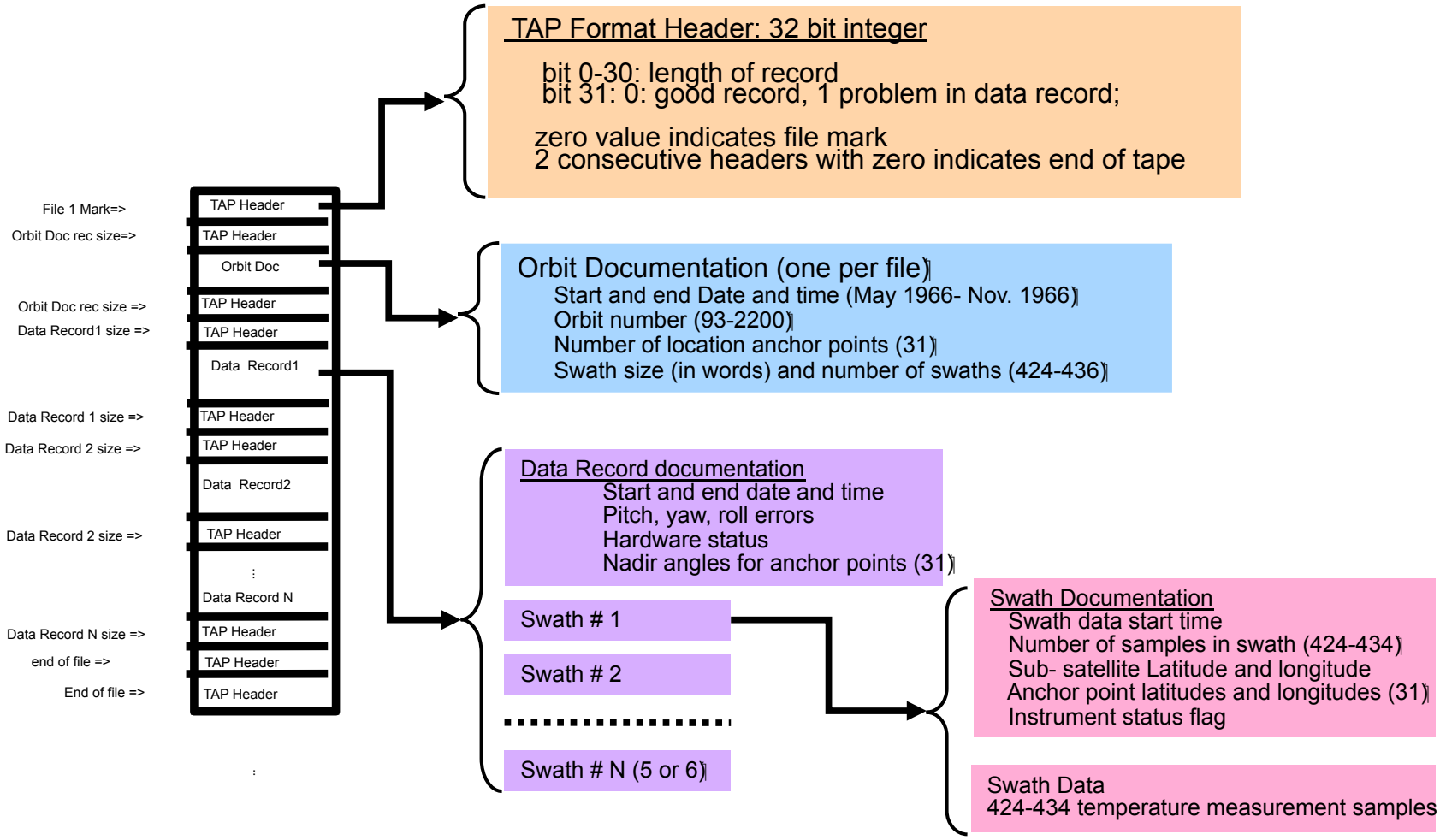
NASA backup & recovery
- Store data into RAID (level 5)
- Generate daily backup (new or updated products)
- Full backup of filled/closed volumes (100 GB)
- Move tapes to remote location (weekly)
- Read entire collection of remote tapes (6 months)
- Restore lost / damaged data from backup tapes

NASA request
- JBI destroys primary N2 tapes
- N2 backup tapes are destroyed

HRIR dataset Format

- The Nimbus HRIR data storage was based on a 36-bit architecture
  - 1 word = 36 bits; In most cases the last bit is not used.
- Data from tapes are stored in 8 bit format
  - The most significant bit (7) is
    - 1 when a byte could not be restored from tape
    - 0 when a byte was successfully restored from tape
  - Bit 6 is the parity bit read from tape
  - Bit 0-5 are data bits read from tape
- Header records listing the Data record lengths are interleaved with Data records.
- A word of 36 bits with a scaling factor of s is converted in real by using the relation:
- real = (integer value of 36 bits) / (2**(35-s))
- A word can be split into 2 half words (18 bits each). WordD (bits 1-18), wordA (bits 19-36)
- A wordD of 18bits with a scaling factor of s is converted in real by using the relation:
- real = (integer value of 18 bits) / (2**(17-s))
- A wordA of 18bits with a scaling factor of s is converted in real by using the relation:
- real = (integer value of 18 bits) / (2**(35-s))

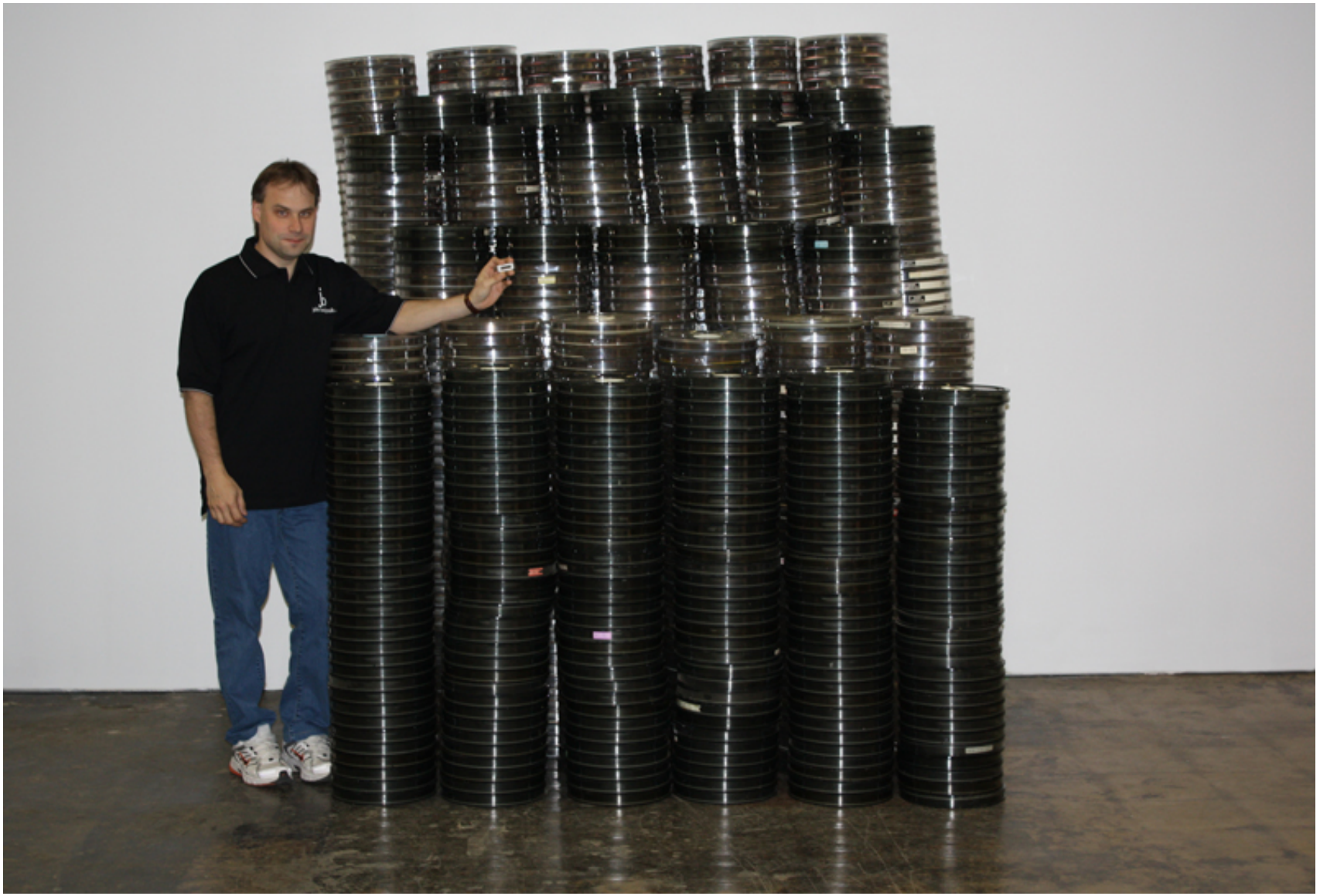
Nimbus II HRIR file data structure



Status of Nimbus II HRIR

- 249 boxes containing 1703 tapes were retrieved from FRC
  - 2 boxes (14 tapes) were left at FRC and will be retrieved and recovered by JBI in the next batch
  - 2 boxes are missing and currently unaccounted for – currently looking to identify boxes with backup tapes
- 1673 tapes were readable out of 1703 tapes:
  - 25 contained bad Orbit Documentation
  - 5 contained bad Records
- Out of 1673 readable tapes:
  - 222 files had bad records out of 2278 total
  - 126 files had records with bad parity bits
- A total of 6.7 GB were recovered

Nimbus 2 HRIR tapes



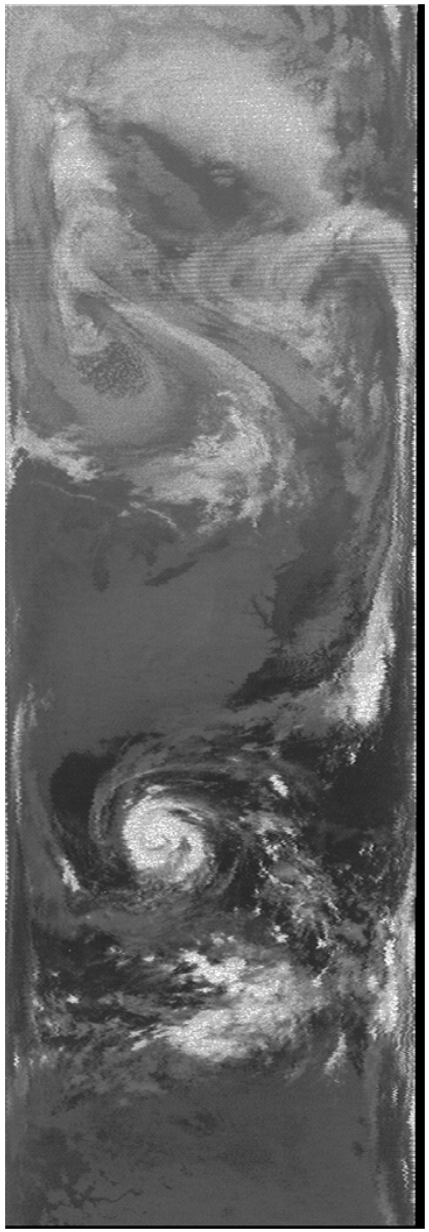
Ingest and Archive at GES DISC

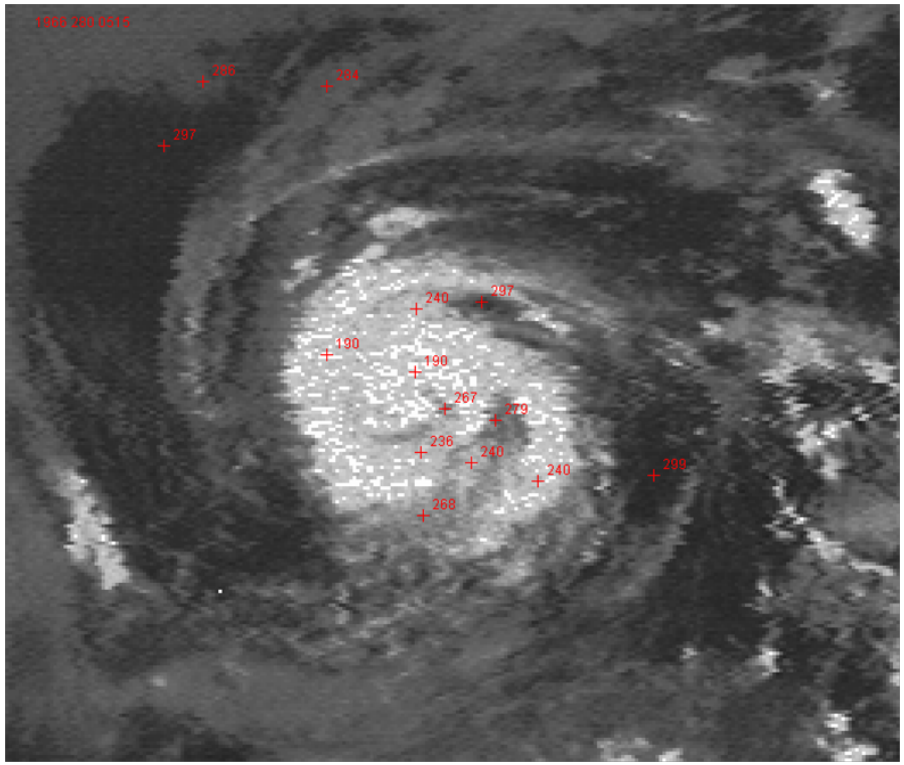
- Identified requirements for new missions/products
  - Storage (7GB), processing power, offsite backup
  - Level of Services (ftp), Search capabilities (ECHO-WIST)
- Identified file naming convention, developed utility to extract and create metadata files, and rename data files (File specs, temporal and spatial fields, orbit...)
- Prepared Directory Interchange Format (DIF) document used by Global Change Master Directory and README document describing data structure and format, Web page at GES DISC public Web site
- Ingested and tested new products and metadata, published metadata to ECHO enabling access by WIST

Nimbus II HRIR data is now available:

- http://daac.gsfc.nasa.gov/
- http://gcmd.nasa.gov/
- https://wist.echo.nasa.gov/~wist/api/imswelcome/

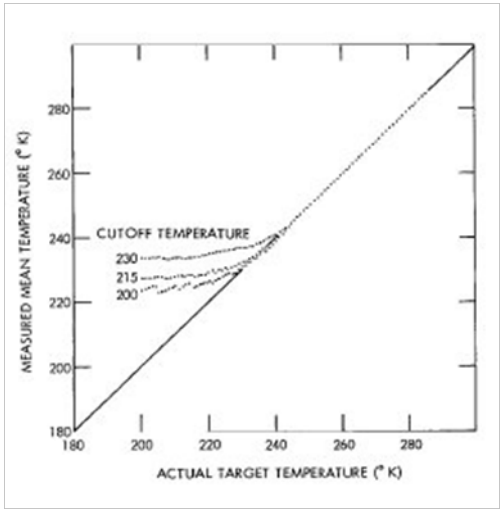
Equivalent Blackbody Temperature Calibration





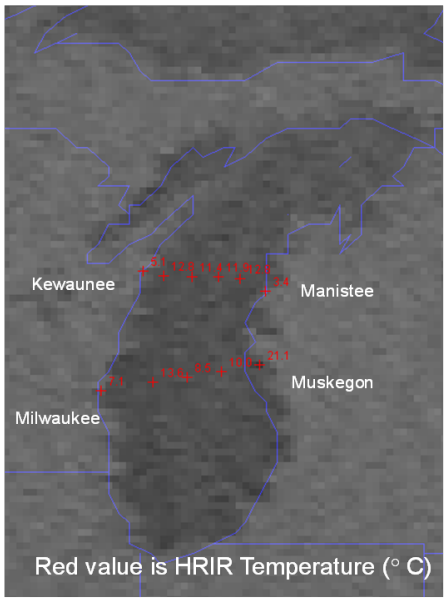
Hurricane INEZ

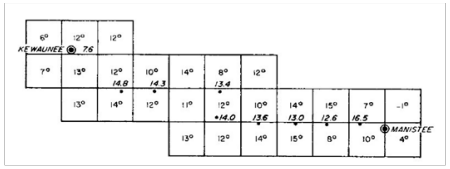
October 7, 1966 Orbit 1931



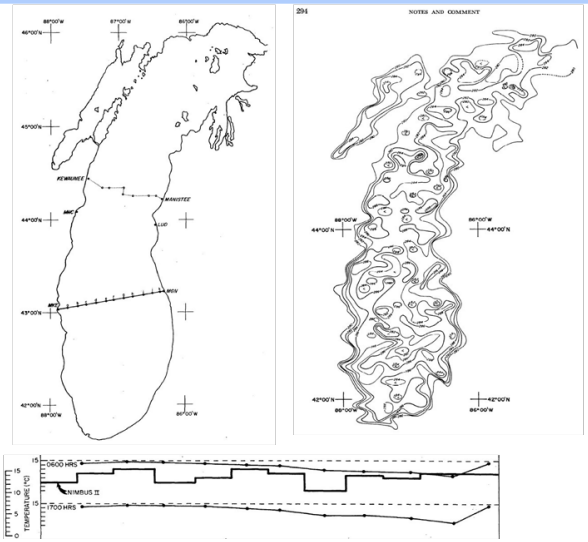
- Research and Applications using Nimbus II observations
  - Noise analysis suggests average error ~2.0°C
  - Williamson, E. J., 1969: The accuracy of The High Resolution Infrared Radiometer on Nimbus II.

Nimbus II HRIR Confirms Airborne Lake Temperature Surveys



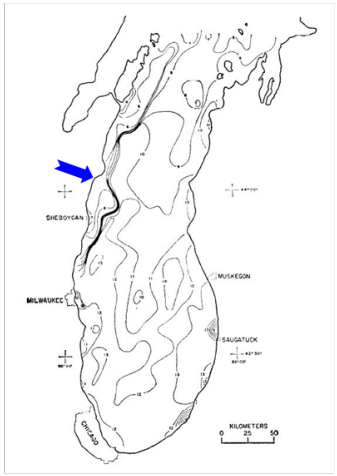


Nimbus II plots derived from 'gridprints', October 6, 1966
R/V INLAND SEAS cruise track between Manistee and Kewaunee (Noble and Wilkerson, 1970)



City of Madison ferry crossing temperatures between Milwaukee and Muskegon with Nimbus II plots derived from 'grid prints', October 6, 1966
(Noble and Wilkerson, 1970)

Coyote current boundary



Isotherms plotted from 1 minute average Airborne Radiances 18 October, 1966 (Noble and Wilkerson, 1970)

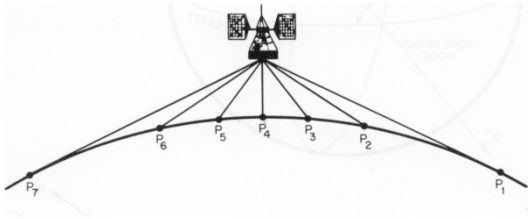
Coyote current was identified in 18 October observations

The HRIR radiance temperature pattern shows a tongue of warm water trending northeastward along the west side of the lake.

The appearance of a warm tongue was thought to be a precursor to formation of the seasonal 'Coyote Current'

Noble, V. E. and J. C. Wilkerson, 1970:
Airborne Temperature Surveys of Lake Michigan, October 1966 and 1967.
Limnology and Oceanography, 15, No. 2, 289-296.

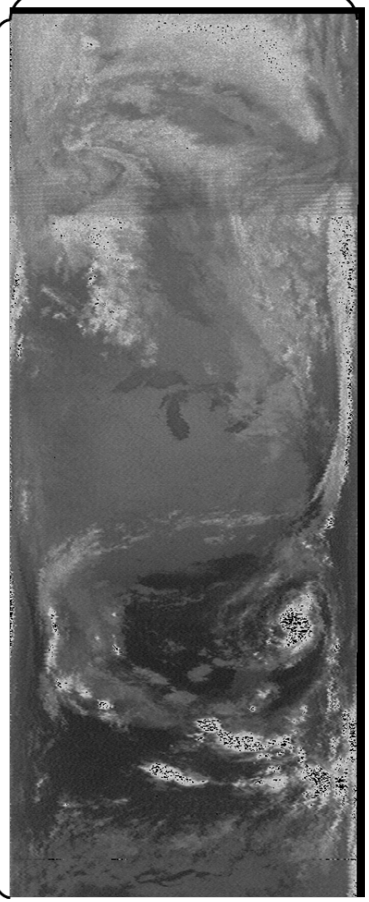
Geo-location Issue



430-432 Samples

Start Time: 5:50 GMT

184 records
1104 swaths

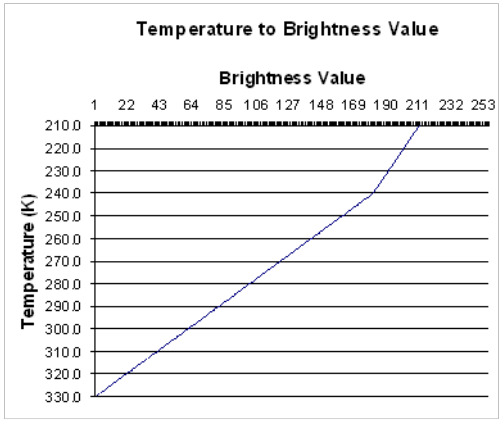


End Time 6:15 GMT

October 6, 1966
Orbit 1917

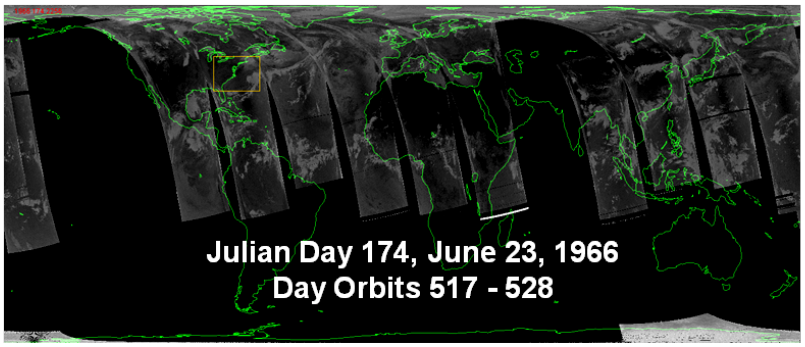
For Nimbus II era, geo-location was accomplished by creating lat-lon grids that would overlay the swath data

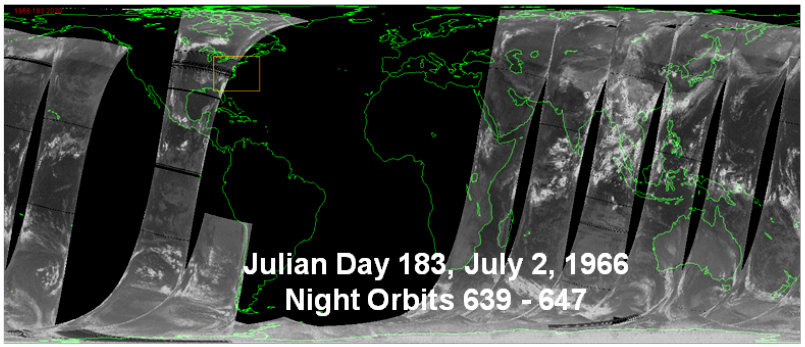
The user guide documentation does not give the algorithms to compute the latitudes and longitudes of temperature samples in the swath

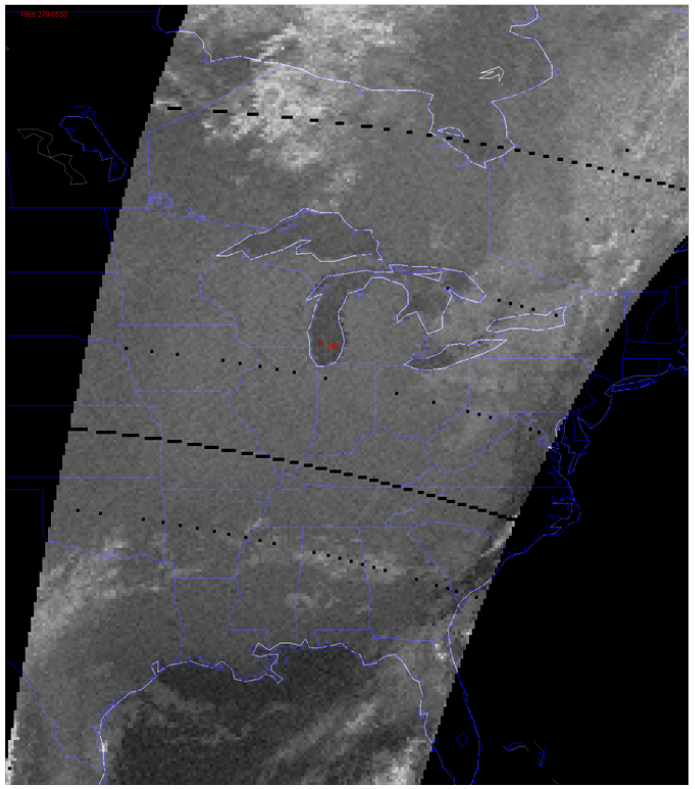


Mapping to Equal Area Grid

World Cylindrical Equal Area Grid



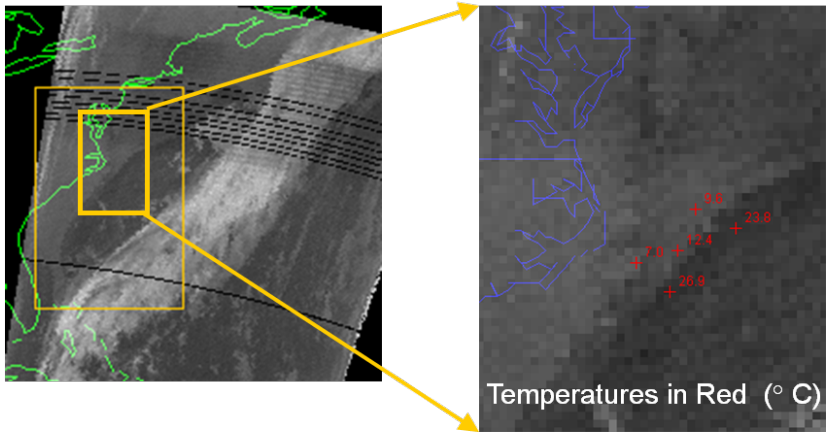




Nimbus II HRIR
October 6, 1966
Orbit 1917
Julian Day 279
Start Time 5:50
GMT
Mapped to
Cylindrical Equal
Area 12.5 km grid

Nimbus II HRIR Shows the Gulf Stream Location for Hurricane Alma Intensification

On June 11 Alma emerged into the Atlantic near Savannah, Georgia, and continued a northeast movement. While paralleling the Carolina coastline over the Gulf Stream, Alma briefly re-strengthened into a hurricane on the night of the 11th.
http://en.wikipedia.org/wiki/Hurricane_Alma_(1966)#Meteorological_history



Gulf Stream Location and Temperatures (°C)
Nimbus II HRIR Orbit 253
Julian Day 154, June 3rd 1966 4:21 GMT

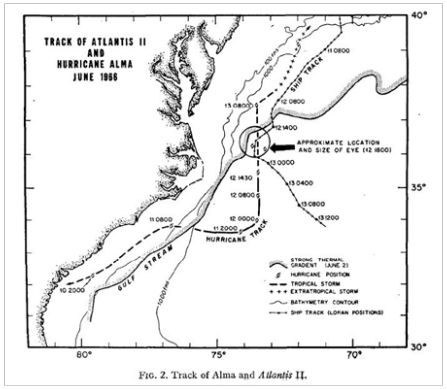
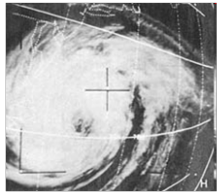
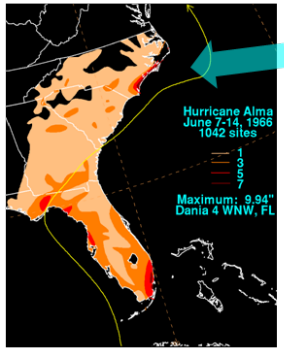


Fig. 2. Track of Alma and *Atlantis II*.

Location of the Gulf Stream depicted by Nimbus II HRIR measurements:
Beckerle, J. C., Woods Hole Oceanographic Institution, Woods Hole, MA.
Air and Sea Temperature During Traverse of Hurricane Alma 1966
Journal of Physical Oceanography, 4, July 1974, 487-492.

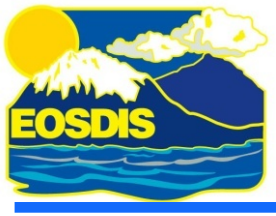


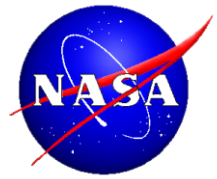
ESSA I satellite cloud photograph of Hurricane Alma at 1430 EDT 12 June 1966



Rain rate associated with Alma intensification along North Carolina Coast

Measurements of rainfall show location of Alma intensification along the coast of North Carolina:
David Roth, Hydrometeorological Prediction Center, Camp Springs, MD.
http://www.hpc.ncep.noaa.gov/tropical/rain/alma1966filledrainblk.gif





Backup

DIF

Summary
The Nimbus I High Resolution Infrared Radiometer (HRIR) was designed to perform two major functions: First, to map the Eath's cloud cover at night to complement the television coverage during the daytime portion of the orbit, and second, to measure the ... temperature of cloud tops and terrain features.

Measurements taken during the daytime do not reveal true surface temperatures since the radiometer operates in the 3.5 to 4.1 micron region and reflected solar radiation is added to emited surface radiation. However, reflected sunlight in this spectral region does not saturate the radiometer output and usable pictures can be made.

The data are stored in a binary TAP format (proprietary Tape emulated format).

The HRIR instrument was launched on the Nimbus-2 satellite and was operational from May 16, 1966 through November 13, 1966

Data Resolution
Horizontal Resolution Range: 10 km - < 50 km or approximately .09 degree - < .5 degree

DIF

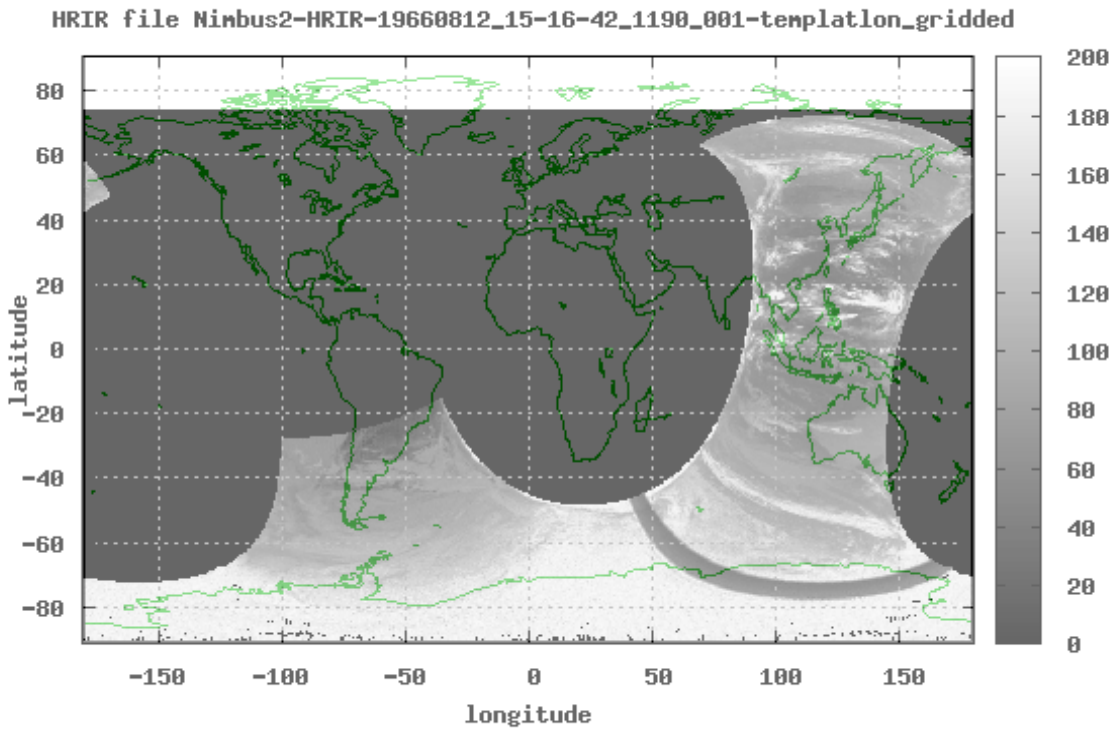
Data Set Citation
Dataset Creator: Goddard Space Flight Center (GSFC)
Dataset Title: Nimbus-2 Level 2 Earth's cloudcover at night, and Temperature of cloud tops and
Dataset Release Date: April 10, 2009
Dataset Release Place: Greenbelt, MD, USA
Dataset Publisher: Goddard Earth Science Data and Information Services(GES DISC)
Version: 001
Data Presentation Form: Digital Science Data
Online Resource: http://mirador.gsfc.nasa.gov/

Distribution
Distribution Media: Online (HTTP)
Distribution Format: 36 bit IBM binary format
Fees: No Fee

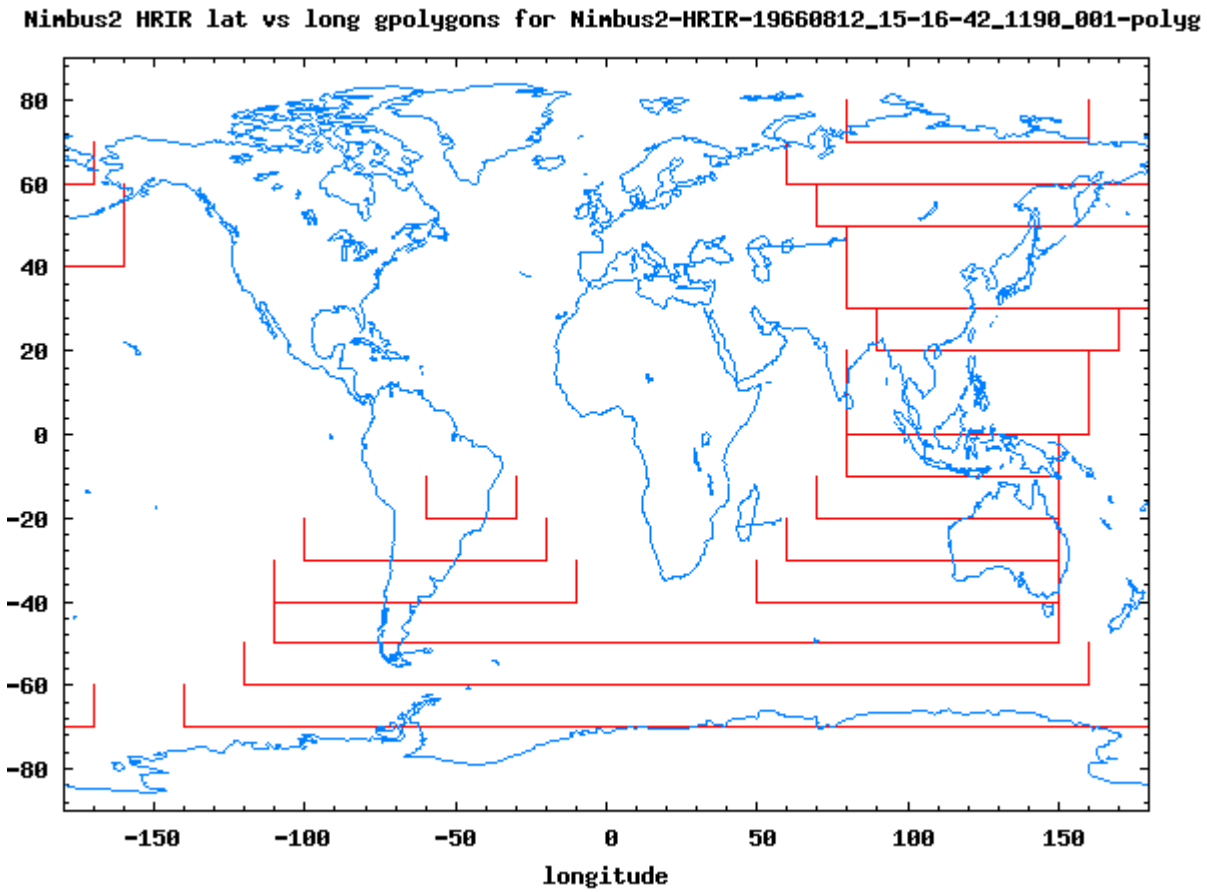
XML metadata

- Collection (shortname, longname, version)
- Granule (granuleId, format, total size, insertion time, time of coverage)
- Files (name, checksum, size)
- Platform
- Spatial attributes(list of latitudes and longitudes of gpolygons)
- Product specifics (orbit, average elevation, station code, orbit time coverage)

Nimbus II HRIR orbit 1190



Gpolygons for orbit 1190 at 10*10 resolution



Nimbus 2 HRIR file naming convention

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

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)

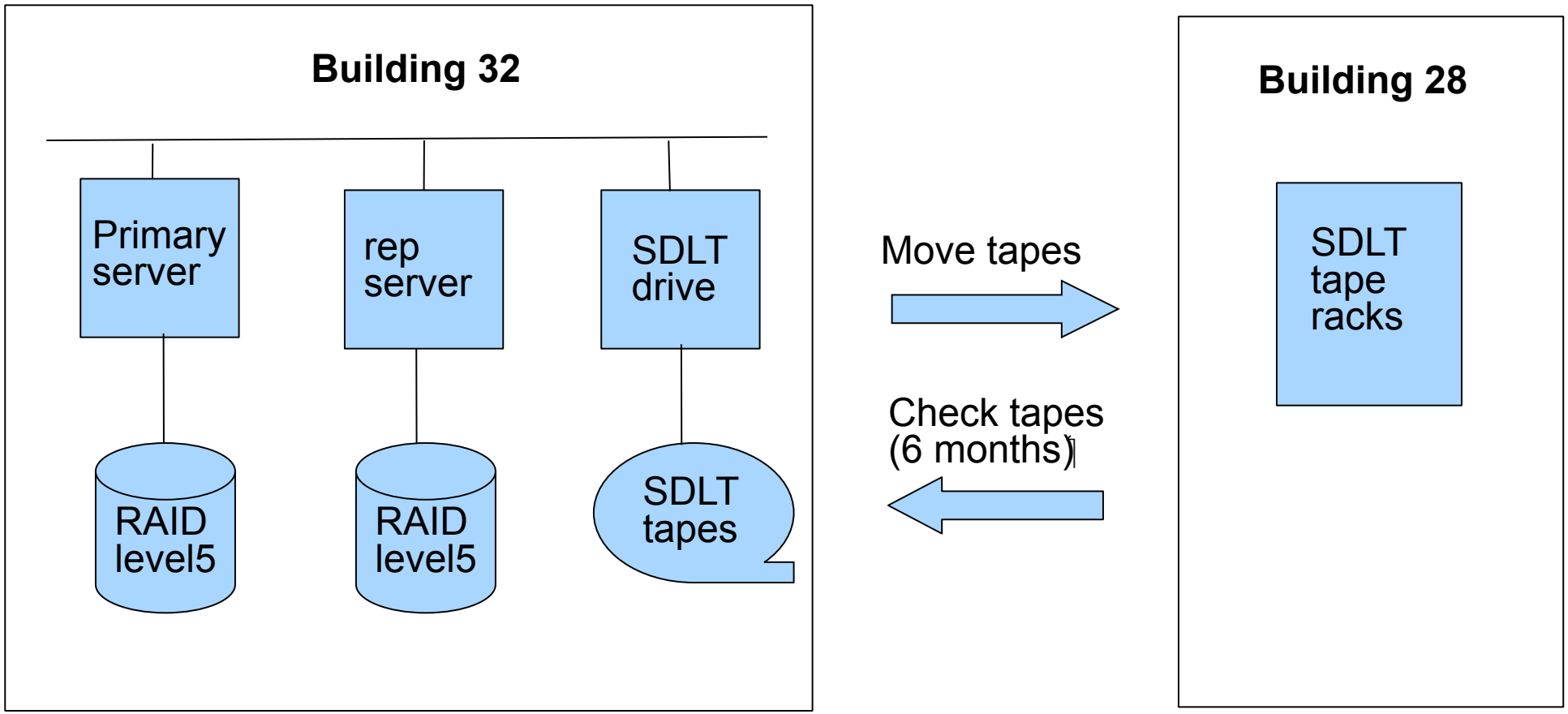
hh-mm-ss is the starting time when the data was collected from the satellite and
- hh : starting 2 digit hour (0-23) (e.g. 02 for hour 2)
- mm: starting 2 digit minute (0-59) (e.g., 09 for 9 minutes)
- ss: starting 2 digit seconds (0-59) , (e.g. 11 for 11 seconds)

orbit is the orbit number

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

Example: Nimbus2-HRIR-19660805_12-05-31_1245.TAP

Backup process diagram



Data Backup & Recovery process

- Nimbus II HRIR data is stored on primary server into RAID (level 5) and on secondary server into RAID (level 5)
- A daily local backup of new or updated products is made on SDLT tape (stored in B32)
- Full remote backup of a Volume on SDLT tape (stored in building 28) when a Volume is filled (100 GB) or a Volume is closed (i.e. in the case of Nimbus II HRIR that holds only 6.7 GB)
- All remote backup tapes are tested every 6 months
- Data lost or damaged is recovered from the local backup or remote backup tapes.
- The backup of Nimbus II HRIR data is part of the standard GES DISC operating procedures

Documents Backup & Recovery

- Nimbus II HRIR documents are stored into RAID (level 5)
- Daily backup on DLT tape and disk of new documents (tapes stored in B32)
- Weekly backup on DLT tape of documents (tapes stored in B28)