

Preserving NASA Historic and Current Mission Data and Adding Value to These for Future Researchers James Johnson^{1,3}, Ed Esfandiari^{1,3}, Emily Zamkoff^{2,3}, Irina Gerasimov^{1,3}, Atheer Al-Jazrawi^{2,3}, Gary Alcott³ (1) ADNET Systems Inc., (2) Telophase Corporation, (3) NASA Goddard Space Flight Center

Satellite



Introduction

The NASA Goddard Earth Sciences Data and Information Services Center (GES DISC) has been actively involved in many aspects of ensuring the long-term preservation of NASA earth science data and knowledge. This involves both the recovery and preservation of early NASA meteorological and other earth observation data, as well as preserving the more recent Earth Observation System (EOS) mission data sets which continue or have reached their end of lifetime.

Data Recovery Overview

1) NASA

Requests

At end of mission data originally went to NASA's National Space Science Data Center (NSSDC), and from there to the National Archives Federal Record Center (FRC).

Earth Science Data Recovery Task:

- Preserve NASA historic data written on 7-track and 9track tapes, 3480 cartridges,



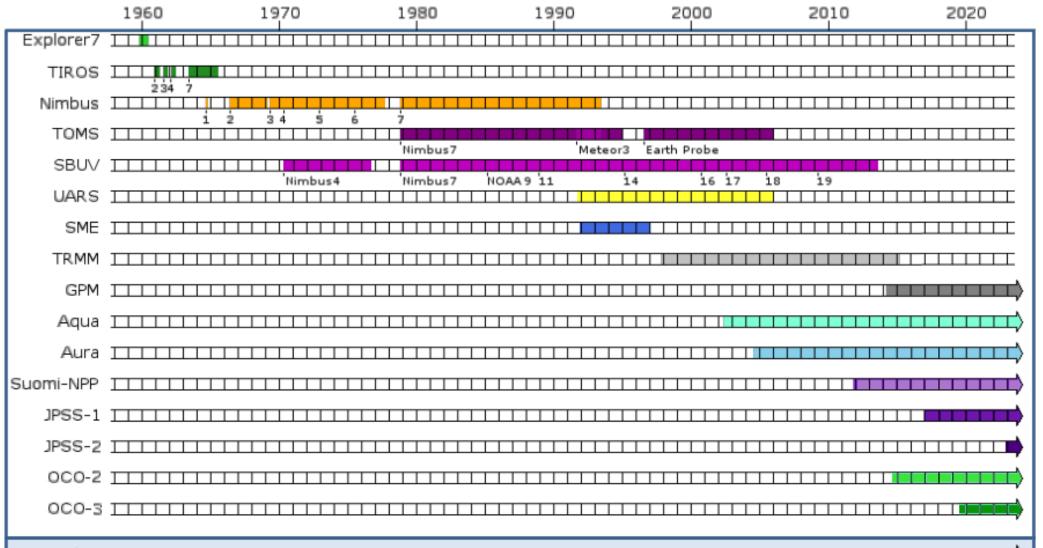
Recovers

Record End End of File Record Begin 128

Pitch, yaw, roll errors

-satellite lat and lon Anch

Almost 65 Years of Earth Data at GES DISC



- Save film imagery, and supporting documentation
- Data accessible online to the scientific community
- Add metadata to make data discoverable
- Free up space occupied by bulky media and need for climate controlled warehouse
- Funded by the NASA Earth Science Data and Information System (ESDIS) project
- Implemented and coordinated by the GES DISC.

Access of Tapes	⇒ T	apes		Tapes to Digital Files	⇒	Copies of Tapes and Evaluates Data Quality
Data Processe 7) NASA Asks for Recovered Tapes to be Destroyed	ed (6) NASA Backup & Procedur	Re		Ļ	5) NASA Ingests & Archives Files; Makes Data Public

Retrieves

Tape Recovery Process

The magnetic tapes are restored with all bits saved in their original format to a digital tape file:

The GES DISC choose to make the individual data files from the digitzed tape available to users rather than the digital tape images. These are then extracted using custom software:

- Each experiment team designed their own unique file format, limits software reuse
- No concept of file-level metadata, needs to be extracted from each data file
- Data originally written on outdated IBM-360 or other machines, e.g.
- some use 36-bit rather than 32-bit words
- IBM integer, floats and characters, rather than IEEE values
- Text in EBCDIC or BCD not ASCII

For example, Nimbus HRIR, MRIR and THIR data are stored as 36-bit data values which are packed in either 6 x 6-bit (7-track) or $4\frac{1}{2}$ x 8 bit (9-track) words. Other data use other methods of packing or none.

After restoring the data it can viewed as in the image at right.

Metadata Extraction

Obtaining metadata requires reading the data file headers and data records using custom software, as the original tapes do not contain this level of information.

milat	MERRA-2 🔟							
ssil	GLDAS 🗖							
4	1	1960	1970	1980	1990	2000	2010	2020

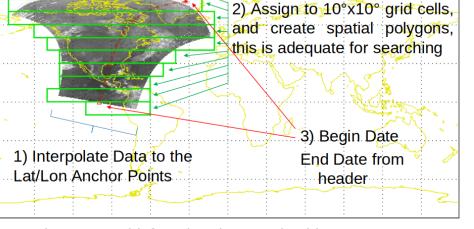
Data Recovered From Tapes and Film

(italics = not yet split into individual files, available upon request)

		talics = not yet split into individual files, available upon requ	est)	
	Satellite	Instrument	Start Date	End Date
A	Explorer 7	Thermal Radiation Experiment	1959-10-19	1960-06-04
	TIROS 2	Medium Resolution Scanning Radiometer	1960-11-23	1961-04-13
	TIROS 3	Medium Resolution Scanning Radiometer	1961-07-12	1961-10-20
NL/		Low Resolution Omnidirectional Radiometer	1961-07-12	1961-09-30
A CONTRACTOR	TIROS 4	Medium Resolution Scanning Radiometer	1962-02-08	1962-06-28
		Low Resolution Omnidirectional Radiometer	1962-02-08	1962-06-30
at the second				
	TIROS 7	Medium Resolution Scanning Radiometer	1963-06-19	1965-06-19
		Low Resolution Omnidirectional Radiometer	1963-06-19	1963-08-29
	Nimbus 1	High Resolution Infrared Radiometer	1964-08-29	1964-09-22
	Nimbus 2	High Resolution Infrared Radiometer	1966-05-16	1966-11-15
		Medium Resolution Infrared Radiometer	1966-05-15	1966-07-28
	Nimbus 3	High Resolution Infrared Radiometer	1969-04-17	1970-03-21
		Medium Resolution Infrared Radiometer	1969-04-17	1970-03-21
		Satellite Infrared Spectrometer	1969-04-14	1970-06-19
	Nimbus 4	Temperature-Humidity Infrared Radiometer	1970-04-13	1971-04-01
		Infrared Interferometer Spectrometer	1970-04-09	1971-01-30
		Satellite Infrared Spectrometer	1970-04-08	1971-04-08
		Selective Chopper Radiometer	1970-07-27	1973-02-20
		Backscatter Ultraviolet Spectrometer	1970-04-10	1977-05-06
e li entit	Nimbus 5	Temperature-Humidity Infrared Radiometer	1972-12-19	1975-03-01
		Surface Composition Mapping Radiometer	1972-12-11	1972-12-30
		Electrically Scanning Microwave Radiometer	1972-12-11	1977-05-16
		Infrared Temperature Profile Radiometer	1975-02-14	1976-09-30
		Selective Chopper Radiometer	1974-12-12	1978-04-20
		Nimbus-E Microwave Spectrometer	1972-12-17	1973-10-31
	Nimbus 6	Temperature-Humidity Infrared Radiometer	1975-06-18	1977-08-11
		High Resolution Infrared Radiation Sounder	1975-06-13	1976-05-26
		Scanning Microwave Spectrometer	1975-06-15	1976-05-31
		Electrically Scanning Microwave Radiometer	1975-06-22	1977-08-11
		Limb Radiance Inversion Radiometer	1975-06-20	1976-01-06
		Pressure Modulator Radiometer	1975-06-16	1978-06-24
	Nimbuo 7			
	Nimbus 7	Temperature-Humidity Infrared Radiometer Limb Infrared Monitor of the Stratosphere	1978-10-30 1978-10-25	1985-05-13 1979-05-30
		•		
		Stratospheric and Mesospheric Sounder	1978-10-26	1983-06-10
		Solar Backscattered Ultraviolet	1978-10-31	1990-06-21
	470 0	Total Ozone Mapping Spectrometer	1978-11-01	1993-05-06
	ATS 6	Geosynchronous Very High Resolution Radiometer	1974-06-17	1974-08-30
	SMS 1	Visible Infrared Spin-Scan Radiometer	1974-07-01	1979-04-19
0 540	SMS 2 GOES 1	Visible Infrared Spin-Scan Radiometer	1975-02-17 1976-01-27	1980-08-22 1976-10-28
	GOES 2	Visible Infrared Spin-Scan Radiometer Visible Infrared Spin-Scan Radiometer	1976-01-27	1979-01-03
CAN AND	GOES 3	Visible Infrared Spin-Scan Radiometer	1977-00-29	1979-01-03
	STS-2 / OSTA 1	Ocean Color Experiment, Shuttle Multispectral Infrared Radiometer, Measurement of Air Pollution from Satellites	1981-11-12	1981-11-14
	STS-41G / OSTA 3	Shuttle Imaging Radar B, Large Format Camera, Measurement of Air Pollution from Satellites	1984-10-05	1984-10-13
	STS-51B / Spacelab 3	Atmospheric Trace Molecule Spectroscopy	1985-04-30	1985-05-01
	GEOS 2	Optical Beacon System	1968-03-18	1968-07-25
	GEOS 3	Satellite-to-Satellite Tracking	1975-04-09	1975-12-23
	EOLE 1 (CAS 1)	Upper Atmosphere Winds and Weather Data Relay System	1971-08-27	1972-07-04
	DMSP 5D-1 / F01	Multichannel Filter Radiometer (Special Sensor H)	1977-03-25	1977-07-23
	DMSP 5D-1 / F02	Multichannel Filter Radiometer (Special Sensor H)	1977-03-25	1977-07-23
	DMSP 5D-1 / F03	Multichannel Filter Radiometer (Special Sensor H)	1977-03-25	1977-07-23
	DMSP 5D-1 / F04	Multichannel Filter Radiometer (Special Sensor H)	1977-03-25	1977-07-23
	SME	Ultraviolet Ozone Experiment	1981-12-15	1986-12-18
		Visible Nitrogen Dioxide Experiment	1982-01-01	1986-12-18

Metadata attributes needed are

- spatial extent
- start/end time
- orbit number (when applicable)
- QA recovery stats
- original tape info (lineage)



4) Extract Orbit from header 5) Add Recovery QA

The metadata are then added to NASA's Common Metadata Repository (CMR) which allows users to search for the data through either the local GES DISC web search or the ESDIS search client.

More complicated is the extraction of metadata from scanned images. These often have no information, sometimes only the source of the image.

As a last step, data products are assigned a Digital Object Identifier (DOI) which allows one to cite the data, as well as provide a permanent means to locate and discover the data.

Preservation

GES DISC follows the guidelines developed for the preservation of data as specified in the NASA EOS Data and Information System (EOSDIS) Earth Science Data Preservation Content Specification (423-SPEC-001) document. Preservation documents are maintained on the GES DISC docserver for public access (except any ITAR or proprietary documents which are stored offline according to NASA and US federal regulations). Access is through the GES DISC Homepage.

To date, the GES DISC has consulted with the data science teams from the following completed missions: UARS, Earth Probe TOMS, Aura HIRDLS, and SORCE, in order to properly preserve their data and accompanying documentation.

The GES DISC is also currently working with the EOS science teams from TRMM, AIRS, MLS, OMI and additional missions prior to mission end to ensure that the relevant documents and data sets are properly archived for future researchers.

For the next step, the GES DISC is moving the data in its archive into the 'cloud'. Users can access the data directly using cloud services via AWS us-west-2 region.

Finding Data Preservation Items at the GES DISC

	SORCE Mission Pres	
Interview of the second of	Introduction 1 Measuring Instrument/Platform Description 2 Data Products & Metadata 3 Product Documentation 4 Instrument Calibration 5 Science Algorithm Software 6 Algorithm Inputs 7 Product Validation 8 Access & Analysis Tools 9 PCS Checklist	 4 Instrument Calibration 4.1 Calibration Status Reports SORCE Weekly Status Reports: Weekly Status Reports.zip SORCE Mission Ops Shift Reports: SORCE_Shift_Reports.zip Command Loads Latest version of Mission Ops Command Templates: sorce_command_templates.tar Map of template file name to activity type name: TemplateName_to_ActivityName_Mapping.csv SORCE command loads: sorce_command_loads.targ2 SORCE command loads description: Command Loads Description.txt RTS All science RTS's: RTS.zip M Procedures Word documents that drove cstol scripts used early in the mission: IM_procedures.zip SORCE command loads during Day Only Operations: sorce_command_loads_doop.tar.gz Documentation Mission Ops Final Report with Anomaly Report Log Appendix: not yet available SORCE_IM_TLM (Command and telemetry handbooks for the MU and each of the instruments) cmtlm.pdf soin_emdtlm.pdf soin_emdtlm.pdf soinsice_cmtlm.pdf
Science Focus Areas Tools News Resources Advocutus Amongenic Corporation Ginoria Ginoria Earlydia Forum Work # Earlydia Forum Work # Earlydia Forum Work # Earlydia Forum Work # Earlydia Forum Careg for Data Canade Variability Data Role for Hydradogy Service Rolease Data Role and Action Careg for Data Canade Variability Data Role for Hydradogy Service Rolease Padacators User Working Group CGC Web Mag Service Grad Core Grad Core Grad Core Grad Core Orbert/DuP and COS Missions & Projects FAQ Data Reservation Grad Point		 xps_cmdtlm.pdf 4.2 Calibration Data Description of the contents of SQL_database_code directory (word file): sql_database_code_description.docx Description of the contents of SQL_database_code directory (text file): sql_database_code_description.txt SQL Database Code



GES DISC Homepage https://disc.gsfc.nasa.gov

Ramapriyan, H.K., Moses, J.F., & Smith, D. (2022b). Preservation Content Implementation Guidance, Version 1.0. NASA Earth Science Data and Information System Standards Coordination Office, 25 January 2022. doi:10.5067/DOC/ESO/RFC-042

SQL code of SORCE and Planning and Scheduling databases: SQL_data

5 Science Algorithm Software Source Code TIM V19 source code: tim_processing-sorce_v19_archive@4cdb2531092.zip SIM V27 source code: sim_v27.zip SOLSTICE V18 source code: sorce_solstice_v18.zip SOLSTICE MgII source code: sorce_solstice_mgii_index.zip SOLSTICE lyman alpha source code: sorce_solstice_lyman_alpha_v18.zip XPS V12 source code: sorce_xps_v12.0.zip XPS V12.1 source code: xps _proc_v12.1.zip Documentation References describing Source Code: SORCE Source Code Refer