The Data Facility of the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS)

Pia J. Nielsen, Robert O. Green, Alex T. Murray, Bjorn T. Eng, H. Ian Novack, Manuel Solis, and Martin Olah

Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109

ABSTRACT

AVIRIS operations at the Jet Propulsion Laboratory include a significant data task. The AVIRIS data facility is responsible for data archiving, data calibration, quality monitoring and distribution. Since 1987, the data facility has archived over one terabyte of AVIRIS data and distributed these data to science investigators as requested. In this paper we describe recent improvements in the AVIRIS data facility.

1.0 INTRODUCTION

AVIRIS measures spatial images of the upwelling spectral radiance through 224 spectral channels at a rate of 17 megabits per second. On a single flight up to ten gigabytes (11,000 km^2) of data may be acquired. During a typical eight month period of flight operations AVIRIS will collect airborne science data on more than 30 flights. This translates to a collection on the order of 200 gigabytes of imaging spectrometer data each year. In the AVIRIS data facility, all of these data as well as ground calibration and engineering data are moved through the steps shown in Table 1. In Table 2, a summary of the AVIRIS data acquired and moved through the data facility since 1991 is given.

The AVIRIS sensor and data facility has been operational since 1989. In each year since, modifications have been pursued in most of the subsystems of the sensor and data facility. These modifications have been designed to improve the rate and the quality of calibrated imaging spectrometer data delivered to the science community. Changes to AVIRIS prior to 1992 have been described previously (Porter et al., 1990 and Hansen et al., 1992). In the following sections of this paper we describe more recent and planned improvements to the AVIRIS data facility.

2.0 AVIRIS DATA FACILITY IMPROVEMENTS

2.1 1992 Data Facility Modifications

In 1992, with the upgrade of the high density tape recorder in the AVIRIS sensor, a new high density tape recorder was installed in the AVIRIS data facility. Since installation, a sophisticated software interface has been developed between the HDTR and the AVIRIS archiving software. This allows rapid downloading as well as detailed monitoring of the AVIRIS data transferred from the high density data tape.

Prior to the 1992 flight season, a complete rewrite of the software to archive, calibrate and distribute AVIRIS data was undertaken. Typically 200 gigabytes of laboratory and flight AVIRIS data pass through this code each year. Most data distributed to investigators have the calibration algorithms (Green et al., 1992) applied in this code as well. A limited augmentation to the data facility computer hardware was undertaken in conjunction with the software upgrade. Sensor performance and data quality monitoring were designed into this new code as core capabilities. The upgrade was completed in 1992 and resulted in a quadrupling of the data archiving, calibration and distribution performance of the data facility.

As part of the AVIRIS software upgrade, a relational database was integrated into the AVIRIS data facility software to control and record AVIRIS data activities. This data base has significantly improved levels of data trend analysis as well as data acquisition, calibration and distribution tracking.

A policy was established in 1992, with the support of the AVIRIS NASA sponsors, to offer data acquired in previous years to investigators for the marginal cost of reproduction. This has resulted in the exploration of the uses of imaging spectrometry data by additional university, industry and government investigators.

2.2 1993 Data Facility Modifications

An extensive effort has been undertaken to eliminate potential single point failures in the AVIRIS data facility system in 1993. Removal of single point failure has been motivated by the desire to minimize interruptions in data delivery to the AVIRIS investigators. This effort has been largely successful with most of the AVIRIS software capable of operating on two or more computer hardware platforms. At present, the single HDTR at the data facility remains the dominant potential single point of failure.

In 1993, a software subsystem has been pursued to automate the generation of AVIRIS calibration files. This software allows rapid reduction of the gigabytes of radiometric calibration data acquired in the laboratory before and after each flight season. A number of analysis tools have been developed to monitor and validate this process of radiometric calibration file generation.

To allow use of AVIRIS data in calibrating and modeling current and future spaceborne sensors, software has been developed to offer AVIRIS data convolved to the spectral characteristics of a number of satellites. Currently weighted spectral convolution software has been completed for the Optical Sensor (OPS) on board the Japanese Earth Resources Satellite 1. For this spaceborne sensor, AVIRIS data are being used to establish the on orbit calibration of OPS (Green et al., 1993a). In the future, weighted spectral convolution AVIRIS imagery will be available in the AVIRIS spectral range for Landsat TM, Landsat MSS, AVHRR, EOS ASTER, EOS MODIS, EOS MISR, etc.

An improved capability for the monitoring of encoded sensor telemetry has been developed in 1993. The software allows the rapid extraction and trend analysis of telemetry stored in the AVIRIS data base. Monitoring and assessment of the sensor telemetry encoded on the high density data tape are required prior to authorizing subsequent airborne acquisitions of AVIRIS data.

All AVIRIS data are archived, calibrated and distributed through the AVIRIS data facility. Based on the modifications described, the capability of the data facility to fulfill this role has kept pace with the growing demand for calibrated AVIRIS data. A summary of the recent and projected acquisition and distribution of AVIRIS data is given in Table 3. At present, an archive of approximately one terabyte of AVIRIS data acquired since test flights in 1987 is maintained under the cognizance of the data facility.

2.3 Data Facility Future Plans

In 1994 a new archive server computer is planned to be acquired in the AVIRIS data facility. This machine will replace hardware acquired in 1989 that is becoming unmaintainable. With this hardware upgrade, further improvements in data archiving rates and data quality monitoring will be possible. Compatibility with future system and network software releases will also be ensured. In conjunction with the archive server upgrade, the data facility plans to maintain AVIRIS quicklook images on-line for a one year period after acquisition. Maintaining these images on-line will allow investigators to retrieve and examine quicklook data as soon as they are available via modem or Internet. These improvements are consistent with the current goals of the AVIRIS data facility: 1) to deliver quicklook images to investigators within one week of acquisition, and 2) to calibrate and distribute data to investigators within two weeks of request. To exceed these performance goals in the future, on-line storage and direct network distribution of AVIRIS data are being investigated.

Finally, the data facility hopes to pursue the delivery of AVIRIS derived geophysical parameters in addition to the instrument measured signal and calibrated upwelling radiance currently offered. Geophysical parameters that are currently being considered are apparent surface reflectance (Green et al., 1993b), atmosphere water vapor, surface leaf water, cirrus cloud maps, surface oxygen pressure height, etc. Some of these parameters may be offered in the 1994 and 1995 time frame.

3.0 CONCLUSION

Since first becoming operational in 1989, the AVIRIS system has been undergoing incremental improvements. These improvements have occurred in both the sensor and

the data facility components of the AVIRIS project. These modifications and upgrades have been pursued to improve the quality of data provided to the science investigators.

In the data facility, efforts will continue towards improved data delivery rates. For example, network distribution of quicklook images and eventually AVIRIS data will be investigated. In addition, geophysical parameters, such as surface reflectance, may be offered directly from the AVIRIS data facility. By pursuing these improvements and upgrades, AVIRIS will continue to have an important role in providing calibrated imaging spectrometer data to researchers across the Earth science disciplines.

4.0 ACKNOWLEDGMENTS

This research was carried out at the Jet Propulsion Laboratory, California Institute of technology, under contract with the National Aeronautics and Space Administration.

5.0 REFERENCES

Green, Robert O., Steve Larson and Ian Novack, "Calibration of AVIRIS digitized data", Proc. Third Annual AVIRIS Workshop, JPL Publication 91-28, Jet Propulsion Laboratory, Pasadena, CA, pp. 109–118, 1991.

Green, Robert O., James E. Conel, Jeannette van den Bosch, Masanobu Shimada and Masao Nakai, "On-orbit Calibration of the Japanese Earth Resources Satellite-1 Optical Sensor Using the Airborne Visible-Infrared Imaging Spectrometer", IGARSS'93, Tokyo Japan, Optical Sensor and Calibration, in press, 1993a.

Green, Robert O., James E. Conel and Dar A. Roberts, "Estimation of Aerosol Optical Depth and Calculation of Apparent Surface Reflectance from Radiance Measured by the Airborne Visible-Infrared Imaging Spectrometer (AVIRIS) Using MODTRAN2", SPIE Conf. 1937, Imaging Spectrometry of the Terrestrial Environment, in press, 1993b.

Hansen, E. G., Steve Larson, H. Ian Novack, and Robert Bennett, "AVIRIS Ground Data Processing System", Proc. Third Annual Airborne Geoscience Workshop, JPL Publication 92-14, Jet Propulsion Laboratory, Pasadena, CA, pp. 80-82, 1992.

Porter, W. M., T. G. Chrien, E. G. Hansen, and C. M. Sarture, "Evolution of the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) Flight and Ground Data Processing System", Proceedings of SPIE, Vol. 1298, pp. 11–17, 1990.

6.0 TABLES

Table 1. AVIRIS Operational Characteristics

DATA FACILITY	
Performance monitoring	48 hours from acquisition
Archiving	One week from acquisition
Quicklook distribution	One week from acquisition
Calibration	Two weeks from request
Quality monitoring	Prior to distribution
Distribution	Two weeks from request
Engineering and data analysis	High priority as required

Table 2. Recent and planned AVIRIS data acquisition

	1991	1992	1993*
Months of operations	7	8	7
Aircraft bases	5	4	4
Principle investigators	52(Europe)	32	35
Investigator sites flown	137	172	200
Launches	36	34	35
Calibration experiments	3	3	3
Square kilometers flown	115,000	127,300	140,000
Flight scenes	1150	1273	1400
Gigabytes archived	161	178	196
Scenes calibrated/distributed	498	847	1000
Data turnaround (months)	5	2.5	1

*projected