AVIRIS AND TIMS DATA PROCESSING AND DISTRIBUTION
AT THE
LAND PROCESSES DISTRIBUTED ACTIVE ARCHIVE CENTER

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1.   INTRODUCTION

The U. S. Government has initiated the Global Change Research Program, a systematic study of the Earth as a complete system. NASA's contribution to the Global Change Research Program is the Earth Observing System (EOS), a series of orbital sensor platforms and an associated data processing and distribution system. The EOS Data and Information System (EOSDIS) is the archiving, production, and distribution system for data collected by the EOS space segment and uses a multilayer architecture for processing, archiving, and distributing EOS data. The first layer consists of the spacecraft ground stations and processing facilities that receive the raw data from the orbiting platforms and then separate the data by individual sensors. The second layer consists of Distributed Active Archive Centers (DAAC) that process, distribute, and archive the sensor data. The third layer consists of a user science processing network. The EOSDIS is being developed in a phased implementation. The initial phase, Version 0, is a prototype of the operational system. Version 0 activities are based upon existing systems and are designed to provide an EOSDIS–like capability for information management and distribution. An important science support task is the creation of simulated data sets for EOS instruments from precursor aircraft or satellite data.

The Land Processes DAAC, at the EROS Data Center (EDC), is responsible for archiving and processing EOS precursor data from airborne instruments such as the Thermal Infrared Multispectral Scanner (TIMS), the Thematic Mapper Simulator (TMS), and the Airborne Visible and Infrared Imaging Spectrometer (AVIRIS). AVIRIS, TIMS, and TMS are flown by the NASA–Ames Research Center (ARC) on an ER–2. The ER–2 flies at 65000 feet and can carry up to three sensors simultaneously. Most jointly collected data sets are somewhat boresighted and roughly registered.

The instrument data are being used to construct data sets that simulate the spectral and spatial characteristics of the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instrument scheduled to be flown on the first EOS–AM spacecraft. The ASTER is designed to acquire 14 channels of land science data in the visible and near–IR (VNIR), shortwave–IR (SWIR), and thermal–IR (TIR) regions from .52 μm to 11.65 μm at high spatial resolutions of 15 m to 90 m. Stereo data will also be acquired in the VNIR region in a single band. The AVIRIS and TMS cover the ASTER VNIR and SWIR bands, and the TIMS covers the TIR bands. Simulated ASTER data sets have been generated over Death Valley, California, Cuprite, Nevada, and the Drum Mountains, Utah using a combination of AVIRIS, TIMS, and TMS data, and existing digital elevation models (DEM) for the topographic information.

2. TIMS ARCHIVE TRANSCRIPTION

The ARC and the DAAC have instituted a program to transcribe the existing ARC aircraft data holdings into an enhanced DAAC–compatible format with associated metadata and browse images. The new data format is shown in figure 1. It is similar to the old ARC format except that a new mission header that contains much of the flight summary report information has been added, as well as navigation data on a scanline–by–scanline basis as an additional band [channel] of data. Data from the aircraft's navigation system are matched to the appropriate scanline data, with interpolated data used between navigation data samples.
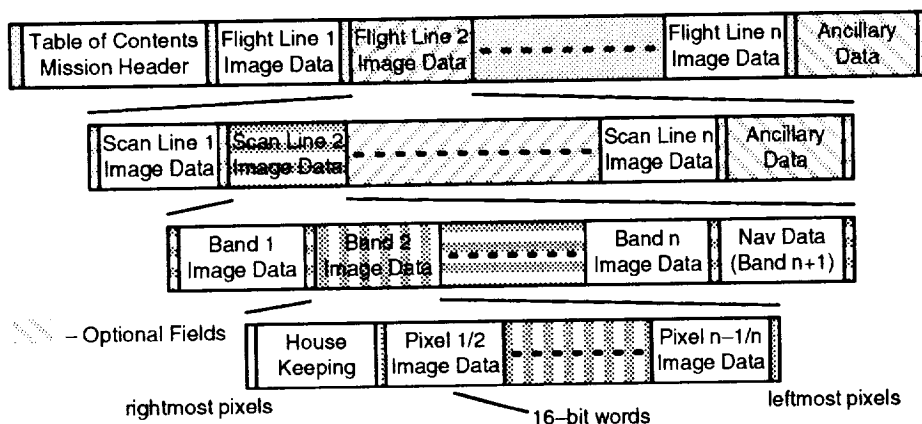
Figure 1. Aircraft Data Archive Format

The browse images for the TIMS are generated during the transcription process by subsampling and decorrelation–stretch (D–stretch) processing data from channels 5, 3, and 1 (red, green, and blue, respectively). The browse image is basically an online version of the Jet Propulsion Laboratory (JPL) hardcopy TIMS browse (quick–look) product. Browse images and metadata are used to populate the Version 0 Information Management System (IMS).

The DAAC is making arrangements to transcribe the TIMS holdings at Stennis Space Center (SSC). The TIMS data at the SSC will be transcibed using a modified version of the system used to transcribe the data at the ARC. The transcription activity is scheduled to run through 1994 The primary 1993 activity is the cataloging of SSC holdings, with actual data transcription and ingest into the DAAC occurring in 1994.

3. AVIRIS ACTIVITIES

The DAAC and the JPL have agreed to have the DAAC process and distribute historical AVIRIS data. Plans call for a phased implementation of these capabilities. The first phase will be the implementation of distributed order processing for 1992 data. An online catalog of metadata and browse images will be available through the Version 0 IMS at the DAAC with order processing and product generation [retrievals] at the JPL. The second phase will be the transcription of historical AVIRIS data into a DAAC–compatible format and the generation of associated browse images and metadata for IMS population. The AVIRIS retrieval processing system is being modified to support both JPL and DAAC requirements and will be installed in both locations. When the data has been transcribed, the DAAC will assume responsibility for handling orders for historical data, and the JPL will only process current–season data. Once a flight season has ended, that season's data will be available from the DAAC as historical data.

110

The historical data sets available at the DAAC will be limited to the 1991 European campaign data, all standard product data sets, and full season data from 1992 onward. It was decided by both the DAAC science advisory panel and the AVIRIS project that, given the increased performance of the AVIRIS in 1992, the expected volume of pre–1992 data orders would not justify transcription of all pre–1992 data. All other pre–1992 data will still be available through special request from the AVIRIS Data Facility at the JPL.

4. DATA AVAILABILITY

Metadata and browse images for ARC and SSC aircraft data and AVIRIS data are entered into the Version 0 IMS. The IMS serves as an online catalog to access the DAAC holdings and to accept order requests. Orders for ARC or SSC data will be processed directly by the DAAC and orders for AVIRIS data will be passed to the JPL initially, and later processed at the DAAC.

Users will be able to form a database query using geographic location and other criteria. Geographic coordinates can be entered numerically or graphically using the mouse to select a region of interest. When a search is completed, the metadata for the flightlines or scenes meeting the search criteria can be displayed. Browse images can also be displayed interactively or transferred over Internet using anonymous FTP.

5. EOS SENSOR SIMULATIONS

An ASTER data set has been simulated by using TMS data for the VNIR and SWIR channels, TIMS data for the TIR channels, and a DEM for the stereo product. The ASTER stereo VNIR data will be used to generate a DEM, so it was felt that going directly to a DEM would be more appropriate than attempting to simulate the nadir– and backwards–looking images that would be acquired to create a DEM. The four VNIR bands were simulated exactly, but the TMS bandpasses only covered the first SWIR band exactly, straddled the next four SWIR bands, and provided no coverage of the last SWIR band. The TIMS provided coverage in all five of the TIR bands. The band matching between the ASTER, AVIRIS, TIMS, and TMS is shown in table 1.

The original data set was acquired by the ARC over Death Valley, CA on 22 November 1991. The TIMS and TMS were optically adjusted so they would be boresighted and have a ground resolution of 50 m. A 512 pixel by 512 scanline subset of the flightline was used for the simulation.

The first step in the simulation process was to correct for the aspect ratio distortion of the scanning process used to acquire the data. A version of the C130RECT program written by scientists at the JPL was used for correction. The corrected data were then registered to the DEM using an image–warping algorithm in the Land Analysis System (LAS) Tie–Points function. The DEM had a cell size of 90 m, so it was upsampled in resolution to 50 m cells for the registration process. Ten control points were selected in the TIMS image to register it to the DEM. Tie–Points was again used to register the TMS image to the TIMS image using 12 control points.

After the registration processes, the full–resolution image was rearranged to have the same band structure as the ASTER (see table 1). It was assumed that the aircraft image was acquired in the center of an ASTER swath as shown in figure 2. ASTER VNIR data will be acquired at 15 m resolution, so the TMS data were upsampled using the LAS cubic convolution function. The SWIR data are acquired at 30 m resolu-

tion and also required upsampling. The TIR data are acquired at 90 m resolution and were downsampled. The VNIR data registered to the DEM are shown in figure 3.

The simulated data set was presented at the joint ASTER science team meeting in February 1993 for review. At the meeting it was suggested that AVIRIS data could generate a high–fidelity simulation of the VNIR and SWIR bands using the ASTER filter functions, and that ground–truth data be provided to facilitate algorithm development.
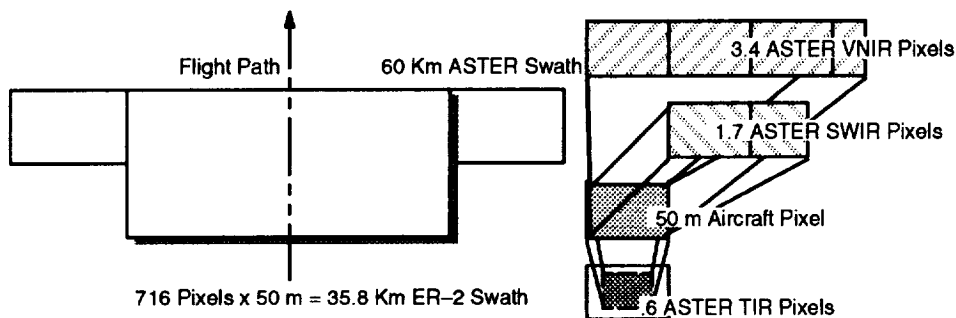

Figure 2. Spatial Mapping of Aircraft Data to ASTER

Table 1. ASTER Channel Mappings

| ASTER	Band	Range (um)	TIMS Ch	Range (um)	AVIRIS Ch	Range (um)	TMS Ch	Range (um)
VNIR	1	.52 - .6			13 - 21	.52 - .60	3	.52 - .60
	2	.63 - .69			25 - 30	.63 - .69	5	.63 - .69
	3N/3B	.76 - .86			41 - 51	.76 - .86	7	.76 - .90
SWIR	4	1.6 - 1.7			133 - 143	1.60 - 1.70	9	1.55 - 1.75
	5	2.14 - 2.18			191 - 194	2.14 - 2.18	10	2.08 - 2.35
	6	2.18 - 2.22			195 - 199	2.18 - 2.2	10	2.08 - 2.35
	7	2.23 - 2.28			200 - 205	2.2 - 2.29	10	2.08 - 2.35
	8	2.29 - 2.36			207 - 213	2.29 - 2.36	10	2.08 - 2.35
	9	2.36 - 2.43			214 - 220	2.36 - 2.43		
TIR	10	8.12 - 8.47	1	8.2 - 8.8				
	11	8.47 - 8.82	2	8.8 - 9.0				
	12	8.92 - 9.27	3	9.0 - 9.4				
	13	10.25 - 10.95	5	10.2 - 11.2				
	14	10.95 - 11.65	6	11.2 - 12.2				
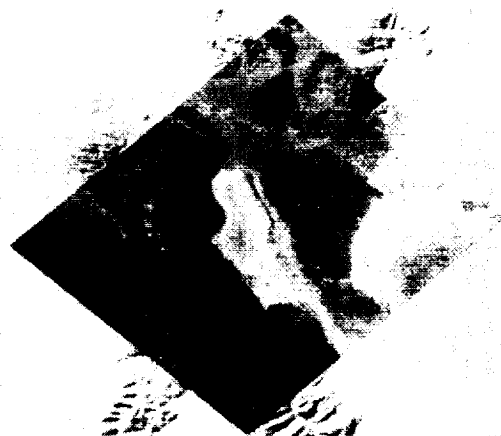
Figure 3. ASTER VNIR composite and DEM

ASTER simulations over test sites at Lake Tahoe, CA; Cuprite, NV; and the Drum Mountains, UT have also been generated. AVIRIS data are being used to simulate the VNIR and SWIR bands, while TIMS data are used for the TIR bands. The Cuprite data set will have a DEM derived from aerial photography, while the Drum Mountains data set uses a DEM derived from SPOT stereo data. Some atmospheric corrections may also be performed using prototype ASTER algorithms to obtain radiances at the ground. Further work may involve the use of other prototype algorithms to generate simulated higher level products.

6. CONCLUSIONS

Airborne scanner data are very useful in the simulation of EOS instruments and will be archived at the DAAC for use in both the EOS and general scientific research. As part of the archival process, the DAAC has populated the IMS with detailed metadata and browse images to aid user access to the data.