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Final Report

Application of Atmospherically Corrected Reflectance Spectra from HIRIS to the Identification and Mapping of Aeolian Components in Soils

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Introduction

This final report encompasses all efforts funded under NASA including the HIRIS team leader activities. The results of the HIRIS team efforts as a group is summarized in the HIRIS Science Requirements Document. The rest of the research effort is codified in a number of published papers in peer-reviewed journals and proceedings of scientific meetings. This report is organized into a series of topic headings where a short summary is given and the appropriate references cited. Copies of all the relevant papers are collected in the appendix.

High Resolution Imaging Spectrometer (HIRIS)

The 14 member HIRIS Science Team represented all the major scientific disciplines that could make use of Earth observations from space with an imaging spectrometer. The instrument development was carried out at the Jet Propulsion Laboratory with science requirements support from the HIRIS Science Team. In 1992, NASA Headquarters informed theTeam that the HIRIS instrument had been removed from consideration for flight on the EOS platform. The Team was instructed to concentrate on applications of imaging spectrometry to vegetation analysis. Therefore, a number of the papers cited below are associated with applications of imaging spectrometry that were not foreseen in the original proposal.

The HIRIS instrument, as envisioned by the team, would cover the 0.4-2.5 μm wavelength with 210 spectral bands in an image swath 24 km wide (Goetz, 1989a; Goetz and Herring, 1989, Goetz and Davis, 1991). The terrestrial analog to HIRIS is AVIRIS (Vane and Goetz, 1993), the airborne visible/infrared imaging spectrometer, flown on the NASA ER-2. All the studies carried out under this contract made use of AVIRIS data as an analog to HIRIS. The full description of the HIRIS instrument and the official science requirements developed by the Science Team is embodied in the HIRIS Science Requirements Document (Goetz et al, 1991) attached in the appendix to this report.

Objectives and results

The major objective of HIRIS observations was to measure the composition of continental rock units and the dust coatings on them. In order to carry out this objective, it was necessary to develop a number of atmospheric correction techniques and this effort consumed much of the resources during the shortened contract, since a flight instrument was never developed.

Analysis software

At the beginning of this contract no commercial software existed to analyze imaging spectrometer data. A system called SIPS was developed (Kruse et al, 1993) that was subsequently licensed at no cost to over 200 research groups world-wide. SIPS was the foundation for the commercial software package called ENVI, distributed by RSI of Boulder, CO.

Atmospheric water vapor and clouds

Extensive work was carried out on developing a model to remove the effects of atmospheric absorption (Gao and Goetz, 1990a; Gao et al, 1991a,b; Gao et al, 1993; Gao et al, 1994). In particular the effects of atmospheric water vapor influences the at-sensor radiance in 60% of the spectral range. Precisions of 5-8% in total precipitable water vapor were achieved.

A new method for cloud cover determination was developed (Gao and Goetz, 1991). It was shown that, by the standard methods of threshholding (Kuo et al, 1990), significant underestimates are often made. Sub-visual clouds were mapped for the first time over land using the 1.37 μm water vapor absorption band (Gao et al, 1993; Goetz, 1994)

Instrument spectral calibration

In-flight calibration of imaging spectrometers is necessary because atmospheric models require spectral calibration accuracy of 0.1 nm or better. A method was developed for in-flight wavelength calibration using the 762 nm oxygen band (Goetz et al, 1995) that has the required accuracy.

Mineralogic Mapping

Imaging spectrometry makes it possible to map mineral composition directly. In the wavelength region in question both electronic transitions and vibrational modes in crystalline solids can be mapped. Methods to unmix spectra into their compositional components was begun under this contract (Goetz and Boardman, 1989; Boardman and Goetz, 1991). Other research included identifying buddingtonite and determining its relative abundance at Cuprite NV (Felzer et al, 1991; Felzer et al, 1994). General mineral mapping of OH-bearing and Fe-bearing minerals was reported (Goetz, 1989b; Taranik et al, 1990; Goetz et al, 1991a,b). In all cases imaging spectrometer data are far superior to multispectral data for the identification of surface mineralogy.

Vegetation mapping

At the direction of Dr. Diane Wickland of NASA Headquarters, HIRIS Team efforts were directed toward determining the feasibility of mapping chemical constituents in vegetation canopies. In particular the effects of liquid water in the leaves made it difficult to observe spectral features associated with canopy chemical constituents (Goetz et al, 1990; Gao and Goetz, 1992; Goetz et al, 1992; Gao and Goetz, 1994; Goetz and Boardman, 1995), although some success was achieved.

Eolian deposit mapping

Since HIRIS was not launched, it was not possible to carry out the mapping objective proposed. However, a beginning was attempted using Landsat data in an area in eastern Colorado (Forman et al, 1992). Further discussions were presented in general invited talks at symposia (Goetz, 1993)

Conclusions

The contract was completed without being able to launch HIRIS. However, a number of new and revolutionary techniques were developed that make possible the further development of imaging spectrometry into a major remote sensing tool.

Appendix

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