TYPE OF REPORT: Semi-Annual

TIME PERIOD: January-June, 1993

NAME AND LOCATION: Alan Strahler, Boston University

CONTRACT NUMBER: NAS5-31369

OVERVIEW

During the reporting period, we continued our development and supporting research for the MODIS BRDF-Albedo and Land Cover/Land Cover Change products. This work included modeling, validation, and empirical studies involving data analysis.

TASK PROGRESS

BRDF-Albedo Product

Model Development

Modeling activity during this period proceded on several fronts. First, we continued the development of a new hybrid model that combines principles of radiative transfer and geometric optics to predict the BRDF of surfaces covered with non-homogeneous vegetation. The hybrid model is driven by conditional distributions of path lengths through and around individual plant canopies. It assumes scattering and negative exponential attenuation as calibrated by leaf reflectance, leaf area index, leaf angle distribution, and the index of branch and trunk material. This model is attractive as a candidate for the BRDF/Albedo product because it does not rely on the estimation or field measurement of component signatures. Rather, it is calibrated by physical parameters that may be estimated or measured directly. Inversion of this model thus yields physical parameters rather than scene-dependent signatures.

We also carried out the early development of a stochastic coupled model of surface BRDF and atmosphere. This models the autocorrelation structure in the top-of-atmosphere radiation field induced by having individual plants as discrete scattering media, as well as the modulation of this spatial structure by atmospheric multiple scattering. It is also easily adaptable to the case of discrete vegetation patches. This model will help us understand how spatial structure is influenced influenced by multiple scattering in the atmosphere at MODIS pixel sizes.

Since real scenes often contain topographic relief, we also began to develop a Monte Carlo technique to model the BRDF of a topographic surface. By comparing Lambertian and non-Lambertian surfaces, we can assess the effects of topographic relief on the BRDF of landscapes.

The development of yet another model was completed during the first part of the reporting period. This is an analytical model of a coupled BRDF and atmosphere system designed specifically for inversion and retrieval of empirical parameters that characterize the shape of the surface BRDF. A manuscript describing this model was completed and submitted for publication in Remote Sensing of Environment.

We also began work on a modification of the analytical model to provide a four-stream solution to the multiple scattering component. The first step is to develop and program the model for an atmosphere above a surface described with an empirical BRDF. The second step is to apply the four-stream solution to coupled atmosphere-canopy system.

Validation

In validation, we continued our efforts at validation of the mutual shadowing geometric-optical BRDF model using ground measurements and ASAS data from the FEDMAC experiment conducted by GSFC at Howland, Maine, in 1989 and 1990. This work focuses on forward modeling of the BRDF using measurements of component signatures acquired at the time of ASAS overpasses and comparing them with ASAS observations and with pyranometer measurements of hemispherical albedo collected simultaneously. The analysis showed good agreement between the model and the measurements, both in BRDF and albedo. Toward the close of the reporting period, a manuscript describing this work was submitted to Remote Sensing of Environment. (See publications section.) This work was carried out as a collaboration between Boston University and Philips Laboratory of the USAF.

We also began to construct a distributed-parameter BRDF database for the Stanislaus National Forest in California's Sierra Nevada for the purpose of albedo simulation. The database characterizes the geometric-optical characteristics of the vegetation cover of each 30-m pixel and models its BRDF using the terrain-dependent version of the mutual-shadowing BRDF model. The spectral albedo of the scene as a whole is calculated for a series of sun positions during the day and then extended to a broadband albedo for the solar spectrum. The model will show the variation in albedo with sun angle as simulated for a diverse region of vegetation covers and mountainous topography.

Algorithm Development

Late in the reporting period, we began blocking out the specific algorithm to be used for the BRDF/Albedo product. After some consideration, we decided that the problem will require multiple models that that are determined a priori from land cover data or previous fits. The models are as follows: (1) a slope-facet BRDF model for use where digital terrain data at 100-m resolution are available; (2) a slope-facet BRDF model where high resolution DTM data are not available but a statistical distribution of slope facets is known; (3) a BRDF model for plane-parallel vegetation canopies; (4) a geometric-optical model for canopies of discrete vegetation crowns; and (5) an empirical BRDF model for badly mixed pixels and heterogeneous regions.

Land Cover/Land-Cover Change Product

Land Cover

In development of the land cover algorithm, we pursued an investigation of a very important problem for development and validation of the land cover product -- the effects of aggregation with increasing pixel size of the distribution of land cover types. This work uses data from the Plumas National Forest in California, a region of heterogeneous topography and heterogeneous natural vegetation covers. A thirty meter data base of land covers, provided by other investigators at Boston University, is being resampled at various pixel sizes to understand better how the proportions of land cover units change as a function of their overall abundance and pattern of fragmentation. Cover proportions are observed to change greatly in the aggregation process. The changes are influenced by the abundance of each cover type and its spatial pattern of occurrence.

Land-Cover Change

In development of the land cover change data product, we continued the exploration of the change vector technique as a tool for identifying and characterizing temporal change in registered data sets of AVHRR images in the Sahel region of West Africa. We extended the technique from brightness measurements to include measurements of surface temperature, as inferred from a split-window algorithm as applied to AVHRR channels 4 and 5, and to texture measurement of spatial structure that are produced by passing a moving window over each image. The information from each domain -- spectral, thermal, and spatial -- provides a different and useful input into the identification and characterization of change. This work was documented in a manuscript submitted to the International Journal of Remote Sensing. (See publications section.)

We also began negotions with J. Malingreau for the use of a 1-km AVHRR dataset from southeast Asia, similar in characteristics to that of the Sahel dataset. Although both datasets lack extensive ground validation, they have the appropriate temporal and spatial characteristics for development of the Land-Cover Change Parameter.

Algorithm Development

Our algorithm development for land cover continues to be slowed by lack of proper datasets. We need datasets that include the range of spatial, spectral and temporal information that MODIS will acquire. This requires rectified databases of Landsat TM and/or MSS data, convolved to 250- and 500-m resolution, and AVHRR (preferably uncomposited) data for at least a one-year period. Also essential is sufficient high-resolution ground truth to characterize the land cover well enough to allow quantitative assessment of different classification scenarios. The MODIS SDST has committed to helping us assemble these datasets, beginning with the Plumas National Forest, in California's Sierra Nevada. For this site, we have accurate vegetation cover information, derived from TM at 30-m, as well as rectified DTM data, due to an ongoing USFS timber mapping project here at BU. At present, the SDST is preparing the 250- and 500-m datasets and working on the registration of the EDC 1-km AVHRR composited dataset to the database.

ANTICIPATED ACTIVITIES DURING THE NEXT QUARTER

BRDF/Albedo Product

During the next quarter, we plan to complete the development of the first phase of the hybrid model and prepare a manuscript describing it to be submitted for publication. We will also continue further model development, including the stochastic and Monte Carlo models described above. We plan to complete the development of the four-stream model as well and submit it for publication. In validation efforts, we will continue the development of the distributed-parameter BRDF database for the Stanislaus National Forest.

Inasmuch as the BRDF/Albedo ATBD is due on July 30, we will continue development of our strategy for the production of this product and provide a draft of the ATBD to meet the deadline.

Land Cover/Land-Cover Change Product

We expect to continue our study of the effects of resolution cell size on the distribution of land cover units and submit a manscript summarizing our results for publication. We will also further study the change-vector technique for quantification of land-cover change. We will continue efforts to obtain suitable AVHRR datasets for this work.

Inasmuch as the Land Cover/Land-Cover Change ATBD is due on July 30, we will continue development of our strategy for the production of this product and provide a draft of the ATBD to meet the deadline.

PROBLEMS/CORRECTIVE ACTIONS

During this quarter, we did not encounter any significant problems requiring corrective actions beyond the every day problems that occur in research and algorithm development.

OTHER ACTIVITIES (APRIL-JUNE)

1. Crystal Schaaf, of Philips Laboratory, presented a paper at the International Symposium on Remote Sensing and Global Environmental Change, Graz, Austria, April 2-8, summarizing research in which the Principal Investigator's contribution was supported by this contract. The paper will be published in a proceedings volume. (See publications section below.)

2. The Principal Investigator received the Association of American Geographers/Remote Sensing Science Group Medal for Outstanding Contributions to Remote Sensing at the society's annual meeting in Atlanta, April 5-9.

PUBLICATIONS (APRIL-JUNE)

The status of pending publications supported all or in part by this contract and its predecessor is shown below for the period April-June, 1993. For the period January-March, 1993, see the prior quarterly report.

Submitted

The following manuscripts were submitted for publication during this reporting period:

Lambin, E. F. and A. H. Strahler, 1994, Indicators of Land-Cover Change for Change-Vector Analysis in Multitemporal Space at Course Spatial Scales, Int. J. Remote Sens., submitted.

Liang, S. and A. H. Strahler, 1994, Retrieval of surface BRDF from multiangle remotely sensed data, Remote Sens. Environ., submitted.

Liang, S., and A. H. Strahler, 1994, A four-stream solution for atmospheric radiance transfer over a non-Lambertian surface, Applied Optics, submitted.

Schaaf, C. L. B., and A. H. Strahler, 1993, Modeling the bidirectional reflectance and spectral albedo of a conifer forest, Proceedings, 25th International Symposium on Remote Sensing and Global Environmental Change, April 2-8, 1993, Graz, Austria.

Schaaf, C. L. B., and A. H. Strahler, 1994, Validation of bidirectional and hemispherical reflectance from a geometric-optical model using ASAS imagery and pyranometer measurements of a spruce forest, Remote Sens. Environ., submitted.

Previously Submitted

The following manuscripts were previously submitted and are in the review process:

Moody, A. and A. H. Strahler, 1993, Characteristics of composited AVHRR data and problems in their classification, submitted to International Journal of Remote Sensing.

Barnsley, M. J., A. H. Strahler, K. P. Morris, and J.-P. Muller, 1993, Sampling the surface bidirectional reflectance distribution function (BRDF): Evaluation of current and future satellite sensors, submitted to Remote Sensing Reviews.

Running, S., C. Justice, D. Hall, A. Huete, Y. Kaufmann, J-P. Muller, A. Strahler, V. Vanderbilt, Z-M. Wan, 1994, Terrestrial remote sensing science and algorithms planned for EOS/MODIS, Remote Sens. of Environ., submitted.

Lambin, E. F. and A. H. Strahler, 1994, Change-vector analysis: A tool to detect and categorize land-cover change processes using high temporal-resolution satellite data, submitted to Remote Sens. Environ.

Revised and Accepted

The following manuscripts were accepted for publication with revision, were revised, and resubmitted during this reporting period:

No publications were revised and accepted during this reporting period.

In Press

The following manuscripts were in press during this reporting period:

Schaaf, C. B. and A. H. Strahler, 1993, Solar zenith angle effects on forest canopy hemispherical reflectances calculated with a geometric-optical bidirectional reflectance model, IEEE Trans. Geosci. and Remote Sens., in press.

Liang, S. and A. H. Strahler, 1993, An analytic BRDF model of canopy radiative transfer and its inversion, IEEE Trans. Geosci. and Remote Sens., in press.

Abuelgasim, A. A. and A. H. Strahler, 1993, Modeling bidirectional radiance measurements collected by the Advanced Solid-State Array

Spectroradiometer (ASAS) over Oregon Transect conifer forests, Remote Sens. of Environ., in press.

Liang, S. and A. H. Strahler, Calculation of the angular radiance distribution for a coupled system of atmosphere and canopy media using an improved Gauss-Seidel algorithm, IEEE Trans. Geosci. and Remote Sens., in press.

Published

No new publications appeared during this reporting period.

ATTACHMENTS

Attached are copies of the following manuscripts or papers that were accepted for publication or appeared during the semiannual reporting period:

Abuelgasim, A. A. and A. H. Strahler, 1993, Modeling bidirectional radiance measurements collected by the Advanced Solid-State Array Spectroradiometer (ASAS) over Oregon Transect conifer forests, Remote Sens. of Environ., in press.

Liang, S. and A. H. Strahler, 1993, An analytic BRDF model of canopy radiative transfer and its inversion, IEEE Trans. Geosci. and Remote Sens., in press.

Schaaf, C. B. and A. H. Strahler, 1993, Solar zenith angle effects on forest canopy hemispherical reflectances calculated with a geometric-optical bidirectional reflectance model, IEEE Trans. Geosci. and Remote Sens., in press.