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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, as well as the preparation of revisions to draft Algorithm Technical Basis Documents (ATBDs) as required by the EOS Project.

TASK PROGRESS

BRDF/Albedo Product

Model Development

Although much of our effort during the 3-month reporting period was directed toward the continued development of the BRDF ATBD, we were still able to continue with model development. Here our efforts were focused on the semiempirical model approach to describing the BRDF. In this approach, the shape of the directional reflectance function for a surface is modeled as the weighted sum of two simple trigonometric functions of view and illumination positions and a constant. The constant and function weights are fitted to the directional observations by a least squares technique implemented by the Powell algorithm. The trig functions are attributed to (1) volume scattering and (2) surface scattering, and have a physical basis derived from simplification of physical theory. Actually, there are several candidate functions for each type (volume and surface scattering) , so a number of semiempirical models are possible. A more complete description appears in the BRDF/Albedo ATBD.

We also continued development of the Monte Carlo surface BRDF model and the stochastic BRDF model. The former models the BRDF of a heterogeneous mixed pixel ‘with topographic relief, and the latter models the influence of the atmosphere on the BRDF of a surface composed of three–dimensional envelopes of scattering media. Both of these efforts are directed toward the understanding of the spatial aggregation problem of land surface covers as it applies to BRDF. These models are being developed primarily by Shunlin Liang at GSFC; although no longer affiliated with BU, Dr. Liang continues to participate in MODIS research at a reduced level of activity.

Model Validation

Validation efforts focused on two modeling approaches: semiempirical models and our geometric-optical mutual shadowing model . For the semiempirical models, we examined the fit to directional reflectance measurements in red and NIR bands made on eleven surface types including soils, crops, forests and grasslands. For each surface type, three or four sets of measurements at different solar zenith angles were available. The models fit the measurements very will, with RMS errors often less than 5% of mean reflectance values.

In collaboration with USAF Phillips Laboratory, we continued the construction of a distributed-parameter BRDF database for the Stanislaus National Forest for the purpose of albedo simulation. The database characterizes the geometric-optical characteristics of the vegetation cover of each 30-m pixel and calculates the albedo of the scene as a whole, using the terrain-dependent version of the mutual shadowing BRDF model. The solar spectrum albedo for the entire diverse scene is quite conservative, varying only by +-10% or so with different sun angles. This suggests that albedo generalizes well over large regions, which is an important conclusion for climatic modelers as well as for the preparation of our BRDF/Albedo product. The major variable influencing albedo is the nature of the surface cover, not the sun angle. We continued work on the manuscript describing these results, but at the close of the reporting period the manuscript was still unfinished.

Algorithm Development

We also completed the development of the first version of the specific algorithm to be used to recover BRDF and albedo from MODIS and MISR data. The algorithm selects one of five candidate models to describe t-he BRDF: (1) a topographic model, driven by high-resolution digital terrain data; (2) a topographic model driven by a statistical characterization of slope facets; (3) a plane-parallel vegetation canopy model; (4) a geometric- optical model ; and (5) an empirical model with physically–derived kernels that describe the shape of the BRDF function without providing specific physical parameters. The BRDF algorithm uses the Powell algorithm to fit the specific model to the observations in a forward, iterative procedure. The software was delivered to the MODIS SDST in late January.

With the arrival of Dr. Wolfgang Wanner from the University of Kiel, we began the development of a new structure for the BRDF code that is much more flexible, allowing BRDF models to be freely added at will. With the new code, it w-ill be much easier to compare different models with data in both forward and inverse modes. This new version will provide the basis for our delivery of the next version of the code, due in October.

Algorithm Technical Basis Document

During the reporting period, we continued the development of the BRDF/Albedo product ATBD, which required a major expenditure of effort . Version 2.1 was completed and submitted to EOS Chief Scientist Mike King on March 1 as directed by the EOS Project.

Land Cover/Land-Cover Change Products

Land Cover

During the reporting period, we continued our studies of the effects of of resolution cell size on the distribution of land cover units. Previously, we had shown that estimates of the proportions of land cover types vary as a function of spatial resolution, with large changes occurring as aggregation becomes coarser and coarser. The changes are influenced by the initial coverage of each land cover class **as** related to that of other classes, and to the spatial pattern of occurrence (e.g. , patch size and shape) of the class. The target area for the study is the Plumas National Forest in the Sierra Nevada of California. Our current work uses linear regression and regression-tree models to predict cover class proportions using patch size, scale of aggregation, and the Shannon diversity index. We began a manuscript summarizing the results of our modeling work, which was still under development at the close of the period.

Our work on the use of neural net classifiers for the land cover product also continued. We began the application of a neural net classifier to TM data for the Plumas National Forest. These data were resampled to 250 m and 500 m spatial resolution, using the convolution algorithm provided by the MODIS SCST. The classifier performed quite well in separating the broad classes of land covers that are planned to be recognized in the final product. The classifier performed poorly, however, when exercised on composite NDVI data of the same area. The results seem to indicate that at the local scale of a small region, there is not much information in NDVI time trajectories; rather, that type of information is much more useful at the subcontinental or continental scale. However, the cover classes within a small region can be accurately distinguished using the spectral resolution that is lost in the conversion of measurements to composite NDVI. Further data analysis is planned before preparing a manuscript summarizing the results.

We also began an implementation of the Running and Nemani logic, which uses a hierarchical decision tree classifier on composite NDVI data, as applied to the Plumas National Forest. At the close of the period, studies were under way comparing the neural net and. decision-tree approaches to classification in the specific context of the Plumas.

Land–Cover Change

During this period, we continued development of the change-vector technique for identifying and quantifying land-cover change processes. This work was carried out primarily by Eric Lambin at the Joint Research Center in Ispra, Italy. Most of the period was spent in assembling a database of 10 years of registered AVHRR GAC NDVI and surface temperature data for Africa. The data were composite at monthly intervals. At the close of the reporting period, the database was still being assembled.

Algorithm Development

A considerable effort during this period was devoted to the redrafting of the Land Cover/Land-Cover Change Product ATBD. version 2.0 of the ATBD was prepared and submitted on March 1, as requested by the EOS Project.

As a prototype algorithm, we delivered a trained neural net with input images and output classification to the MODIS SDST.

ANTICIPATED ACTIVITIES DURING THE NEXT QUARTER

BRDF/Albedo Product

Our primary activities during the next quarter for the BRDF/Albedo product will be (1) to continue to develop, refine and test the BRDF/Albedo algorithm and (2) prepare for the presentation of the algorithm at the ATBD Review Panel meeting scheduled for early May.

Land Cover/Land-Cover Change Product

We will continue the studies of land cover proportion estimation at coarse spatial resolutions, and finalize our results with a second manuscript to be ready at the end of the quarter. We will conduct trials comparing the neural net classifier to the Running–Loveland thresholding method. For the Land-Cover Change Parameter, we will concentrate on further development and processing of the African GAC dataset being provided by Malingreau at the JRC in Ispra.

As in the case of the BRDF/Albedo product, we will also continue our preparation for the peer review of the Land Cover ATBD.

PROBLEMS/CORRECTIVE ACTIONS

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

OTHER ACTIVITIES

1. Dr. Wolfgang Wanner, of the University of Kiel, joined the BRDF research team. Dr. Wanner's prior research was in space physics and concerned interplanetary fields of matter and energy in the solar system.

2. Dr. Eric Lambin, formerly Assistant Professor of Geography at Boston University, continued research at the EU Joint Research Center in Ispra, Italy, focused on land cover change. Although no longer supported by our MODIS budget, this work continues to be of direct relevance. Dr. Lambin was proposed as an Associate Team Member, and his appointment was approved by Team Leader Vince Salomonson.

3. Two new first-year graduate students, Jordan Borak and Paul Fisher, began work on the land cover product, providing support for Aaron Moody.

4. The Principal Investigator attended the Sixth International Symposium on Physical Measures and Signatures in Remote Sensing and presented a paper summarizing recent work in BRDF modeling. The symposium was held in Val d'Isere, France, January 17-21, 1994.

5. The Principal Investigator attended an informal meeting at GSFC on February 1 which focused on BRDF and VI issues and presented plans for BRDF retrieval from MODIS and MISR as included in the ATBD .

6. On Tuesday, March 15, Tom Pagano and Carl Schueler of Santa Barbara Research visited BU and were briefed on the status of the BRDF/Albedo and Land Cover products by the BU research staff.

7. The Principal Investigator attended the Annual Meeting of the Association of American Geographers during the period March 29-April 2, presenting a paper on the MODIS instrument and the land products to be derived from it. The meeting was Field in San Francisco.

PUBLICATIONS

The status of pending publications supported all or in part by this contract and its predecessor is shown below.

Submitted

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

Strahler, A. H., 1995, Vegetation canopy reflectance modeling -- Recent developments and remote sensing perspectives, submitted for journal publication through the Proceedings of the Sixth International Symposium on Physical Measurements and Signatures in Remote Sensing.

Previously Submitted

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

Li, X., A. H. Strahler, and C. E. Woodcock, 1994, A hybrid geometric optical-radiative transfer approach for modeling albedo and discretional reflectance of discontinuous canopies, IEEE Trans. Geosci . and Remote Sens. , submitted.

Liang, S. and A. H. Strahler, 1994, An analytic radiative transfer mode1 for a coupled atmosphere and leaf canopy, J. Geophys. Res. , submitted.

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

Revised and Accepted

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

Barker Schaaf, C., X. Li and A. H. Strahler, 1994, Topographic effects of bidirectional and hemispherical reflectances calculated with a geometric–optical canopy model, IEEE Trans. Geosci. and Remote Sens. , in press.

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

In Press

The following manuscripts were in press during this reporting period:

Moody, .A. , and C. E. Woodcock, 1994, Scale-dependent errors in the estimation of land–cover proportions–-Implications for global land-cover datasets, Photogrammetric Engineering and Remote Sensing, in press.

Barnsley, M. J., A. H. Strahler, K. P. Morris, and J.-P. Muller, 1994, Sampling the surface bidirectional reflectance distribution function (BRDF) : Evaluation of current and future satellite sensors, Remote Sensing Reviews, in press.

Moody, A. and A. H. Strahler, 1994, Characteristics of composite AVHRR data and problems in their classification, Int. J. Remote Sens. , in press.

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. Environ. , in press.

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, Remote Sens. Environ. , in press.

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. , in press.

Published (Copies to be provided with semiannual report)

Abuelgasim, A. A. and A. H. Strahler, 1994, Modeling bidirectional radiance measurements collected by the Advanced Solid-State Array Spectroradiometer (ASAS) over Oregon Transect conifer forests, Remote Sens. of Environ. , vol. 47, pp. 261-275.