TYPE OF REPORT: Semiannual

TIME PERIOD: January to June, 1992

NAME AND LOCATION: Alan H. Strahler, Boston University

CONTRACT NUMBER: NAS5-31369

PREAMBLE

This report presents the status of tasks carried out under NASA contract NAS 5-31369 during the period January 1-June 30, 1992. This contract is for research and development of algorithms to be used in the preparation of specific data products from EOS instruments, primarily those of the Moderate Resolution Imaging Spectroradiometer (MODIS).

According to the terms of the contract, four different products or product types are under development. These are

> (1) land cover and land-cover change products, that will provide a categorization of the earth's land surface cover types at regular intervals using the MODIS instrument, as well as an identification of the processes that bring about land cover change;
>
> (2) a bidirectional reflectance distribution function (BRDF) product that describes the angular reflectance behavior of earth surface covers by empirical and/or deterministic physical models;
>
> (3) a hemispherical albedo product that provides the hemispherical albedo in selected spectral bands for the earth's land surface; and
>
> (4) a spatial-structure product that categorizes the spatial variance and covariance observed at 250 meter resolution in red and infrared bands, to be used as a tool for surface cover categorization and cloud detection in wavelength bands detected at coarser resolutions.

Structure of Report

In conforming with the reporting requirements for this contract, we have developed the concept of the research project summary document, which is a two-page overview of a specific investigation of a particular research problem or specific aspect of a broad research goal. These reports concisely address the task objectives, work accomplished, results of data analysis and interpretation, anticipated future actions, and possible problems and/or corrective actions needed for each specific project. These are updated on a monthly basis, but for semiannual and annual reports they are modified to reflect accomplishments during the longer time periods. These reports form the main body of this semiannual report. Here follows a discussion of the development of each of the four contracted products, their research projects, and their overall relation to the goal of product development.

LAND COVER

For land cover characterization, two distinct products are under development. The first of these is a land cover product that will map and inventory the land surface covers of the earth on a regular basis using MODIS and related EOS data sources. The second is the development of a product that will detect change in land cover, and identify and characterize the process that is producing such change. Both of these products are the joint responsibility of the principal investigators of the Land Subgroup of the MODIS science team. The role of the principal investigator under this contract is to lead and coordinate this joint effort.

The development of the land cover product includes two phases. One of these is the technical development of methodology for the land cover characterization. This involves the image processing strategies, classifiers, and other technical strategies necessary to provide the product. The other is the definition of the land cover units, which is a more difficult problem. The ultimate use of the land cover product will be by Interdisciplinary Science EOS investigators, who will infer from a particular land cover a suite of physical parameters that categorize the landscape at that point, and use these physical parameters in modeling and further calculations. For example, global climate modelers may wish to infer surface roughness, hemispherical albedo, and latent and sensible heat flux parameters from the land cover type. Still other parameters may need to be inferred from land cover type by IDS investigators in fields of ecology, hydrology, and biogeochemical cycling. Thus, the selection of land cover units is a difficult problem that must balance the needs of IDS investigators with the realities of the information content in MODIS and related EOS data.

Three specific research projects are being carried out under land cover. The LAND COVER UNITS project deals with the problem of unit definition along the lines discussed above. The LAND COVER TECH project researches technical issues that will be involved in the processing of MODIS data through the use of AVHRR HRPT data as a global analog for MODIS data. The LAND COVER TEST SITES project focuses on algorithm development and validation in a series of test sites that will be developed prior to launch and in the post-launch period as a mechanism for product development and validation.

The LAND COVER CHANGE product attempts to go beyond a simple multidate comparison of land cover categorizations to indicate a change process as well as the type of change that has occurred. The Land Cover Change research project summary provides the details of the current approach and work under way in the area.

BRDF

The BRDF projects have as their ultimate goal the development of a global BRDF product, originally to be derived from MODIS-T, MODIS, and MISR, all used in combination. With the demise of MODIS-T, the strategy will now rely primarily on MISR and MODIS. Three specific research projects are currently engaged in this area. The EOS BRDF PAPER project involves the preparation of three journal articles by the principal investigator and other collaborators on the MODIS Science Team. The first such article evaluates and compares the orbits and sensing characteristics of MISR, MODIS, and an array of other existing and planned EOS instruments. The manuscript was nearly completed in this reporting period.

The second specific project, EOS BRDF STRATEGY, involves the coordination of investigators on both the MODIS and MISR teams in developing a strategy for BRDF extraction from EOS instruments. As part of this effort, a BRDF Workshop was held in Columbia, Maryland, on June 26-27, which was attended by team members from both instrument teams and a few selected peers actively involved in BRDF research. The report of this meeting is currently in draft, and a final report is expected in the September, 1992, time frame.

The third specific research project, STAT BRDF, pursues methods to empirically fit the BRDF to a set of directional measurements, such as might be acquired from MODIS and MISR during one or more overpasses. Further details are provided in the text of the project report. The specific research project TOPO BRDF is just beginning. This project attempts to model the influence of digital terrain on directional radiance measurements made for large pixels.

ALBEDO

The thrust of this effort is to develop a product that provides the albedo of the land surface cover, in one or more spectral bands, or possibly over a broad band, primarily for the use of global climate modelers. Inference of albedo from a single measurement is highly dependent on the angle of the measurement with respect to the angle and azimuth of illumination. We proposed an algorithm for this product using MODIS-T, but with the demise of MODIS-T, this function is probably best served by MISR, at least for the central portion of the MODIS swath that MISR will cover. Peter Muller, of both the MISR and MODIS teams, is working with other MISR team members on direct development of this algorithm.

However, with reasonable knowledge of the BRDF of surface covers, it may be possible to infer the albedo from a single MODIS measurement. In connection with this, I include three specific research reports for a collaborative effort between the principal investigator and personnel of the Geophysics Directorate of the Air Force Philips Laboratory. This work, which will also constitute the main body of a doctoral dissertation for a Philips Lab employee, involves an analysis of the sensitivity of narrow-band hemispherical albedo to illumination angle through a geometric-optical BRDF model developed by the principal investigator and his coworker, Dr. Xiaowen Li. Although MODIS funding supports only the principal investigator's collaborative effort, the full thrust of this research is reported here because of its relevance to the MODIS mission. Three specific research projects are reported. In BRDF ALBEDO, the Li-Strahler geometric-optical forest reflectance model is used to evaluate the sensitivity of narrow-band, hemispherical albedo to illumination angle. In BRDF ALBEDO VALIDATION, specific model runs are matched to a forested site and albedo measurements are made there. In BRDF ALBEDO SIMULATION, the albedo calculations are extended over a landscape of topographic relief as aggregated to the MODIS pixel sizes.

SPATIAL STRUCTURE

The Spatial Structure specific research project examines the application of statistical measures of spatial structure, including variance, covariance, the variogram and covariogram, for simulated images at multiple scales of resolution. These efforts are targeted toward an algorithm that can quantify subpixel spatial structure broadly and also target the presence of subpixel clouds in coarse resolution data.

PUBLICATIONS

During the reporting period, three publication appeared in print. These are all in the Proceedings of the International Geoscience and Remote Sensing Symposium, from May, 1992, and were also supported under the prior phase of this contract. Their bibliographic citations areshown below, and their texts are attached to this report.

Schaaf, C. B., Li, X., and Strahler, A. H., 1992, Effects of Solar Zenith Angle on Forest Canopy Albedos Calculated with a Geometric Optical Model, Proceedings IGARRS '92, May 26-29, 1992, Houston, Texas, pp. 347-349.

Li, X., and Strahler, A. H., 1992, Mutual Shadowing and Directional Reflectance of a Rough Surface: A Geometric-Optical Model, Proceedings IGARRS '92, May 26-29, 1992, Houston, Texas, pp. 766-768.

Liang, S., and Strahler, A. H., 1992, An Explicit Canopy BRDF Model and Inversion, Proceedings IGARRS '92, May 26-29, 1992, Houston, Texas, pp. 1487-1489.

RESEARCH PROJECT SUMMARY REPORTS:

BRDF ALBEDO

1. TITLE: Modeling the Direct-Beam Instantaneous Spectral Surface Albedo of a Forested Landscape using Geometric-Optics

2. PERSONNEL: Lead: Crystal Schaaf   Help: Xiaowen Li, Shunlin Liang

3. PROJECT AFFILIATION: MODIS

4. DATE PREPARED/UPDATED: 92-7-20

5. BRIEF DESCRIPTION: The Li-Strahler geometric-optical model incorporates mutual shadowing effects in its representation of the BRDF of an anisotropic canopied surface. This model can be extended by integration over the viewing hemisphere to provide a direct-beam, instantaneous surface albedo for that surface. Further integration over the sun's path in the sky can yield daily or longer interval albedos as well. These spectrally dependent hemispherical reflectance values can be computed for rugged terrain but do not directly include canopy multiple scattering, diffuse irradiance contributions, or specular leaf effects. Accommodations for these phenomena will be explored and where possible implemented.

6. BROAD CONTEXT:

A. Extend the Li-Strahler model to calculate instantaneous spectral albedos and ultimately to produce the daily albedos used by the climate modeling community.

B. Incorporate realistic corrections for rugged topography, diffuse irradiance contributions, and the specular effects of the canopy components.

C. Simulate the albedo computations that will be possible with EOS sensors such as MISR.

D. PhD for Crystal Schaaf.

7. REQUIREMENTS:

A. Albedo code from Li-Strahler geometric-optical model.

B. Code to compensate for the effect of topography.

C. Liang-Strahler coupled radiative transfer code to investigate the effects of diffuse irradiance and the specular leaf effects.

8. GENERAL PLAN

A. Implement albedo calculations in the geometric-optical model.

B. Test sensitivity of calculation to solar illumination angle using a set of hypothetical canopies.

C. Use Liang-Strahler coupled radiative transfer code and a variety of optical depths to assess the diffuse irradiance contribution to albedo.

D. Use Liang-Strahler coupled radiative transfer code to assess the impact of leaf specularity on albedo.

E. Assess impact of diffuse irradiance and leaf specularity on the Li-Strahler geometric-optical model.

F. Implement any corrections for diffuse irradiance and leaf specularity in the geometric-optical model.

G. Implement topographic corrections.

H. Implement code on parallel processor.

I. Investigate broadband computation.

J. Prepare dissertation/publication.

9. PROJECT STATUS: A and B complete, C, D and E in progress.

10. PRESENTATIONS/PUBLICATIONS:

A. C. Barker Schaaf, X. Li, and A. Strahler, Effects of Solar Zenith Angle on Forest Canopy Albedos Calculated with a Geometric-Optical Model, IGARSS Proceedings, 1992, pp. 347-349.

B. C. Barker Schaaf and A. Strahler, Solar Zenith Angle Effects on Forest Canopy Albedos Calculated with a Geometric-Optical Bidirectional Reflectance Model, in preparation for submission to IEEE Transactions in Geoscience and Remote Sensing: IGARSS'92 Special Issue, September, 1992.

C. PhD Dissertation or journal articles.

11. SPECIAL PROBLEMS/COMMENTS: No problems.

12. REPORTING PERIOD: January-June, 1992

13. ACCOMPLISHMENTS:

A. Completed General Plan items A and B.

B. Radiative transfer model runs for items C and D under way.

C. Results from items C and D results are being used in item E to assess impact of diffuse irradiance and leaf specularity on the geometric-optical model albedos.

BRDF ALBEDO SIMULATION

1. TITLE: Geometric-Optical Modeling of the Direct-Beam Instantaneous Spectral Surface Albedo of a Forested Landscape using a Simulation Scene and a Distributed Parameter Approach

2. PERSONNEL: Lead: Crystal Schaaf Help: Xiaowen Li, Scott Macomber

3. PROJECT AFFILIATION: MODIS

4. DATE PREPARED/UPDATED: 92-7-20

5. BRIEF DESCRIPTION: The Li-Strahler geometric-optical model represents the BRDF of an anisotropic canopied surface. This model can be extended by integrating over all view angles to provide a direct-beam, instantaneous spectral surface albedo for that surface. Further integration over the sun's path in the sky can yield daily or longer interval albedos as well. A simulated forested landscape with rugged terrain will be used to test the sensitivity of modeled albedos to illumination angle, topography, and sensor resolution.

6. BROAD CONTEXT:

A. Test the sensitivity of surface albedo to illumination angle, topography, and sensor resolution.

B. Come to an understanding of how albedos vary within and across the landscape.

C. PhD for Crystal Schaaf.

7. REQUIREMENTS:

A. Simulated forested landscape with canopy and background characteristics specified.

B. Appropriate DEM for the landscape.

C. Li-Strahler geometric-optical model extended for instantaneous albedo.

8. GENERAL PLAN

A. Obtain a Landsat image of Stanislaus National Forest that has been stratified according to canopy and background characteristics.

B. Obtain corresponding DEM.

C. Generate slopes and aspects.

D. Generate horizons for a realistic range of solar angles.

E. Obtain appropriate component signatures for the simulation stratifications.

F. Compute albedo for each stratification at each solar angle (assuming level terrain).

G. Use computations of each stratification type to generate images of albedo that can be looped through each solar angle (simulating the changes in albedo throughout a day).

H. Further stratify the simulation scene according to slope and aspect.

I. Recompute albedo for all new stratifications using appropriate terrain characteristics and regenerate albedo images.

J. Test sensitivity of albedo topographic variations.

K. Use a distributed parameter approach to generate albedos at various pixel resolutions and investigate sensitivity to scene variation.

L. Prepare dissertation/publication.

9. PROJECT STATUS: A, B, C, complete.

10. PRESENTATIONS/PUBLICATIONS:

A. PhD Dissertation or journal articles.

11. SPECIAL PROBLEMS/COMMENTS:

A. Horizon function in IPW not working.

B. Difficulties in determining appropriate component signatures.

12. REPORTING PERIOD: January-June, 1992

13. ACCOMPLISHMENTS:

A. Completed General Plan items A-C.

B. Newest version of Defense Mapping Agency 3 arc second digital terrain elevation data for Stanislaus obtained, and rectified. Item C reaccomplished. Initial comparisons with old slope and aspect values do not indicate any significant improvement.

BRDF ALBEDO VALIDATION

1. TITLE: Validation of a Geometric-Optical Model of Direct-Beam Instantaneous Spectral Surface Albedo for Forested Landscapes

2. PERSONNEL: Lead: Crystal Schaaf Help: Xiawen Li, Abuelgasim.

3. PROJECT AFFILIATION: MODIS

4. DATE PREPARED/UPDATED: 92-7-20

5. BRIEF DESCRIPTION: The Li-Strahler geometric-optical model incorporates the effects of shading and mutual shadowing by individual tree crowns to represent the BRDF of an anisotropic canopied surface. This model can be extended by integrating over all view angles to provide a direct-beam, instantaneous surface albedo for that surface. These spectrally dependent hemispherical reflectance values do not directly include multiple scattering, diffuse or specular effects, although some accommodations for these phenomena can be made. The FEDMAC tower site in Howland ME will be modeled using illumination angles appropriate for 8 September 1990 and the resultant albedos will be compared with tower pyranometer data collected on that date. Principal plane BRDFs will be compared with ASAS data also available from that date.

6. BROAD CONTEXT:

A. Validate the instantaneous spectral albedo extension to the Li-Strahler Model by using FEDMAC pyranometer data.

B. Further validate the original Li-Strahler model by using ASAS data.

C. Explore the limitations of the albedo model.

D. PhD for Crystal Schaaf.

7. REQUIREMENTS:

A. Albedo code from Li-Strahler geometric-optical model.

B. Maine FEDMAC pyranometer and meteorological data.

C. FEDMAC site forest characteristics.

D. Radiometric measurements of FEDMAC site to use as component signatures.

E. ASAS overflights from 8 Sept 90.

F. Liang-Strahler coupled radiative transfer code.

8. GENERAL PLAN

A. Obtain FEDMAC data set.

B. Make BRDF albedo computations using forest characteristics and radiometric measurements for solar angles appropriate on 8 Sept 90.

C. Obtain ASAS data for the principal plane across the tower site.

D. Compare modeled BRDFs to ASAS measurements.

E. Compare modeled albedos to pyranometer measurements.

F. Use Liang-Strahler coupled radiative transfer code to assess the contribution of diffuse irradiance throughout the day.

F. Prepare dissertation/publication.

9. PROJECT STATUS: A complete and C underway.

10. PRESENTATIONS/PUBLICATIONS:

A. PhD Dissertation or journal articles.

11. SPECIAL PROBLEMS/COMMENTS: No problems.

12. REPORTING PERIOD: January-June, 1992

13. ACCOMPLISHMENTS:

A. Data sets from General Plan items A and C have been obtained and processsing of ASAS principal plane values is underway.

EOS-BRDF PAPER

1. TITLE: Retrieval of BRDFs and Related Physical Parameters Using EOS Instruments I: Evaluation of Orbit-Sensor Scenarios

2. PERSONNEL: Lead: Alan. Help: Xiaowen, Mike Barnsley, David Jupp.

3. PRIMARY FUNDING SOURCE: MODIS

4. DATE PREPARED/UPDATED: 92-7-26

5. BRIEF DESCRIPTION: The abilities of Landsat, AVHRR, SPOT, MODIS-N, MODIS-T and MISR to make directional reflectance measurements are compared and evaluated in the context of deriving BRDFs and structural parameters remotely.

6. BROAD CONTEXT:

A. Better understand BRDF inference from EOS instruments

B. Build productive links with international collaborators

C. Provide context for MODIS BRDF algorithm development

7. REQUIREMENTS:

A. Orbit/angle codes: Xiaowen, Mike Barnsley

B. BRDF models: Xiaowen

8. GENERAL PLAN:

A. Run programs and prepare graphics for typical sensing scenarios and proper orbits.

B. Discuss and compare the abilities of the instruments to sample and retrieve the BRDF.

C. Interpret the implications for EOS, MODIS, and MISR.

D. Prepare manuscript and submit for publication.

9. PROJECT STATUS: A. and B., largely complete; C. in progress

10. PRESENTATIONS/PUBLICATIONS:

A. Journal article by Barnsley, Strahler, Muller, et al., to be completed early Fall, 1992

B. Prepare a brief oral report for the MODIS Team Meeting, April, 1992.

11. SPECIAL PROBLEMS/COMMENTS: None at this time.

12. REPORTING PERIOD: January-June, 1992

13. ACCOMPLISHMENTS:

A. A nearly-final draft has been prepared through email and fax. Several delays have been encountered due to the changing specifications for EOS instruments and orbits, and the need to redo specific calculations to accommodate them. The final submission is now expected in September, probably to either IEEE TGARS or Remote Sensing of Environment.

EOS-BRDF STRATEGY

1. TITLE: Develop BRDF Extraction Strategy for MODIS and MISR Instruments

2. PERSONNEL: Lead: Alan Strahler. Help: Xiaowen Li, Shunlin Liang, Mike Barnsley, David Jupp.

3. PRIMARY FUNDING SOURCE: MODIS

4. DATE PREPARED/UPDATED: 92-7-26

5. BRIEF DESCRIPTION: Work with MISR and MODIS Team Members to develop
the strategies needed for BRDF extraction and applications.

6. BROAD CONTEXT:

A. Better understand BRDF inference from EOS instruments.

B. Build productive links with MISR Team Members and BRDF peers.

C. Provide context for BRDF algorithm development.

7. REQUIREMENTS:

A. No special requirements.

8. GENERAL PLAN:

A. Plan, develop and conduct workshop of MODIS-MISR BRDF Team Members, June, 1992, following ISLSCP meeting in Columbia, Maryland.

B. Prepare meeting report.

C. Develop research coordination plan for joint team efforts.

9. PROJECT STATUS: A. complete; B. in progress

10. PRESENTATIONS/PUBLICATIONS:

A. Workshop meeting report. Rough draft to participants, July, 1992. Final draft to participants, EOS authorities, September, 1992.

11. SPECIAL PROBLEMS/COMMENTS: None at this time.

12. REPORTING PERIOD: January-June, 1992

13. ACCOMPLISHMENTS:

A. Workshop was conducted, June 26-27.

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LAND COVER CHANGE

1. TITLE: Categorization and Identification of Land Cover Change Processes from MODIS data.

2. PERSONNEL: Lead: Eric Lambin Help: Alan Strahler, Aaron Moody

3. PRIMARY FUNDING SOURCE: MODIS

4. DATE PREPARED/UPDATED: 92-7-1

5. BRIEF DESCRIPTION: A change detection method will be developed for MODIS data in order to detect and categorize land cover change processes on a global scale and to quantify the rate of change. The method will be based on a comparison, on an annual basis, of the temporal development curve of a set of biophysical and spatial indicators derived from MODIS data. The seasonal dynamic of these indicators can be represented by a point in a multidimensional space, each dimension of this space corresponding to a time-composited observation. The vector representing the position of this point is a synthetic quantifier of both the accumulated value of the indicator through the season and the temporal pattern of the indicator. Change of seasonal dynamic of the indicator between successive years can be quantified by a distance measurement between successive points in the temporal multidimensional space. The distance between these points can be described by a change-vector, the magnitude of which describes the intensity of the change and the direction of which describes the nature of the change process. The method to calculate the change-vector can take into account the intrinsic variability of ecosystem conditions. The suitability of this approach to characterize the nature and intensity of various change processes will be explored.

6. BROAD CONTEXT:

A. Better understand land cover changes and processes and how these are reflected in remotely-sensed imagery.

B. Provide basic information for global change studies of human impact on earth ecosystems.

7. REQUIREMENTS:

A. Multitemporal composited AVHRR LAC/HRPT data over areas of active land cover change in different ecosystems. The areas should represent a wide array of land cover change processes.

B. Ground data, maps or high resolution remotely-sensed data (Landsat TM or SPOT) over the same areas.

8. GENERAL PLAN:

A. Identify the main processes of land cover change observed in the ecosystems under consideration.

B. Categorize of these land cover change processes in a classification system.

C. Develop criteria to recognize the different categories of land cover change processes from MODIS-N data.

D. Test these criteria on remotely sensed data (AVHRR LAC/HRPT data);

E. Test of methods to quantify the rate of the change process.

9. PROJECT STATUS: A, B, C, D in progress.

10. PRESENTATIONS/PUBLICATIONS:

A. Journal article on the results of the test on AVHRR LAC/HRPT data of the change detection approach over some test sites.

11. SPECIAL PROBLEMS/COMMENTS: None.

12. REPORTING PERIOD: January to June, 1992.

13. ACCOMPLISHMENTS:

A. Finalize preliminary literature review.

B. Continue development of methodology.

C. Travel to Ispra, Italy, May, 1992, to obtain the following data from the Joint Research Centre (Ispra), MTV Group (Malingreau):

- LAC/HRPT AVHRR data covering a region in West Africa across Mali, Senegal and Guinea (512 x 512 pixels), at 102 dates from 1987 to 1989 (2 hydrologic years). These data are geometrically corrected and accurately co-registered. They have been processed with the NEWTAN software (Vogt, 1990), which calculates several biophysical parameters, including NDVI and surface temperature.

- GAC AVHRR data covering West Africa (512 x 512 pixels), 261 10-days-composite images from 1981 to 1988. Only the NDVI is provided.

- Meteorological, hydrological, vegetation and land cover data on the corresponding years.

D. Temporal profiles for several pixels of known identity have been retrieved from the dataset and analyzed in terms of multitemporal change vectors.

LAND COVER TEST SITES

1. TITLE: Development of Land Cover/Land-Cover Change Characterization Techniques for MODIS-N Using Test Sites.

2. PERSONNEL: Lead: Aaron Moody Help: Alan Strahler

3. PRIMARY FUNDING SOURCE: MODIS

4. DATE PREPARED/UPDATED: 92-8-21

5. BRIEF DESCRIPTION: The utility of composited AVHRR data for Land Cover/Land-Cover Change categorization is examined in two ways. First, AVHRR characteristics and their relation to broad vegetation cover types are explored for selected regions of the U.S., including New England and Eastern New York, Maryland and the middle Atlantic region, and California. Second, land cover types and characteristics as inferred from AVHRR are examined for a set of 100 x 100 km U. S. test areas, including eastern Massachusetts; Konza Prairie; Glacier National Park; La Jornada, New Mexico; and Oak Ridge, Tennessee. Methods of AVHRR processing will include unsupervised and supervised classification; clustering based on temporal bands, principal components, and derived variables; labeling of AVHRR pixels based on NDVI time-trajectories; and comparison with MSS and other available data, such as TM and SPOT, for validation. Terrain effects will be assessed using digital terrain models.

6. BROAD CONTEXT:

A. Gain a basic physical understanding of the land surface, how it is changing, and how underlying controlling factors in the landscape influence the land cover.

B. Develop appropriate procedures for processing AVHRR and, ultimately MODIS data to produce global land cover/land-cover change inventories.

C. Moody, Ph.D.

7. REQUIREMENTS:

A. High temporal resolution AVHRR LAC data at continental and, eventually global scale.

B. MSS, TM, SPOT, and ground data from 20 to 30 100x100 km test sites representing a wide array of land cover types and mixtures.

C. Global digital terrain data.

8. GENERAL PLAN:

A. Use AVHRR data to run multiple land cover classifications using different techniques; eg. supervised and unsupervised classifications using temporal bands; principal component bands; and derived variables such as onset of greenness, max NDVI value, date of max value, length of growing season, etc.

B. Collect/compile high resolution satellite data and field data for a wide range of test sites representing many land cover types and combinations.

C. Test, validate and improve the classification procedures through comparison with the field data and high resolution satellite data.

D. Assess relative performance of various classification procedures and begin to formulate a plan for global land cover assessment.

9. PROJECT STATUS: A and B, in progress.

10. PRESENTATIONS/PUBLICATIONS:

B. Articles comparing performance of various classification techniques across a host of test sites; submit Spring 1993.

C. Part of Ph.D. Dissertation.

11. SPECIAL PROBLEMS/COMMENTS: No problems/comments

12. REPORTING PERIOD: January-June, 1992.

13. ACCOMPLISHMENTS:

A. Preliminary classifications performed for New England region using AVHRR data. Classification procedures included unsupervised clustering of biweekly composites, clustering of bands representing variables derived from the temporal curve (onset of greenness, length of growing season, maximum greenness value, date of maximum value), and clustering of principle component bands.

B. Desired locations for initial test sites have been identified by the land cover/land-cover change group. Two MSS scenes for each location have been selected and requested from EOS data center. This data should be forthcoming. Acquisition of this data will allow the continuation of item C and D in the General Plan section.

LAND COVER TECH

1. TITLE: Technical Issues in Processing Low Spatial, High Temporal Resolution Data Sets For Producing Global Land Cover/land-cover Change From MODIS

2. PERSONNEL: Lead: Aaron Moody Help: Alan Strahler, Eric Lambin

3. PRIMARY FUNDING SOURCE: MODIS

4. DATE PREPARED/UPDATED: 92-8-21

5. BRIEF DESCRIPTION: Technical problems associated with processing AVHRR data as a surrogate for MODIS will be explored and assessed with regard to their implications for producing land cover/land-cover change data sets. Such issues include cloud screening; image compositing

methods and frequency; off-nadir viewing distortion effects; scene rectification and registration; and vegetation indices.

6. BROAD CONTEXT:

A. Examine and understand the influence of temporal and spatial sampling considerations, clouds, compositing procedures, vegetation indices, and viewing geometry on AVHRR image data sets and how these will affect land cover characterization from MODIS-N.

B. Provide recommendations and explore new approaches to dealing with the issues outlined above.

C. Moody, Ph.D.

7. REQUIREMENTS:

A. High temporal resolution AVHRR LAC data at continental and, eventually global scale. It will be important to have daily data for at least a few small sub-areas.

8. GENERAL PLAN:

A. Review the literature for current procedures and problems associated with processing AVHRR data for land cover studies. Focus on strengths and weaknesses of compositing procedures, limitations of rectification and registration associated with viewing geometry and topography, and the relative merits of different vegetation indices. Include discussion of limitations encountered in attempting to process AVHRR data and how these may or may not prove problematic in the processing of MODIS data for land cover/land-cover change.

B. Recommend solutions to the limitations identified and defined in A above. Such recommendations may include hybrid cloud screening and compositing techniques, use of soil adjusted or atmospherically resistant vegetation indices, limitation of data to that within a certain view angle range, use of texture or spatial variance to assess data quality, and development of flexible compositing periods.

9. PROJECT STATUS: A. in progress.

10. PRESENTATIONS/PUBLICATIONS:

A. Article on clouds and viewing angle problems in composited AVHRR data; submit Fall, 1992.

B. Article recommending resolutions to problems discussed in paper A; submit Winter, 1992.

C. Part of Ph.D. Dissertation.

11. SPECIAL PROBLEMS/COMMENTS: No problems/comments

12. REPORTING PERIOD: January-June, 1992

13. ACCOMPLISHMENTS:

A. Third draft of paper (A) completed. Next draft in progress. Focus on: influence of viewing angle on data quality; success of the compositing procedure in eliminating cloud contaminated and off-nadir pixels; influence of the location of data receiving stations on the view angle of the imagery; influence of clouds which are included in the composited data upon unsupervised classification results.

LAND COVER UNITS

1. TITLE: Investigation of Land Cover Units and their Appropriateness for Land Cover/Land-Cover Change Characterization using MODIS

2. PERSONNEL: Lead: Aaron Moody Help: Alan Strahler, Eric Lambin

3. PRIMARY FUNDING SOURCE: MODIS

4. DATE PREPARED/UPDATED: 92-8-21

5. BRIEF DESCRIPTION: The literature on land cover characterization strategies will be reviewed. The units of different classification schemes will be assessed with regard to their ability to support models of global climate, biogeochemical cycles and ecosystem dynamics. Focus will be on floristic, structural and functional classification schemes.

Existing global land cover data sets will be reviewed under the same criteria with a focus on the relationship between cover types and the physical parameters which need to be inferred from them for use in modeling activities.

6. BROAD CONTEXT:

A. Develop a background for the types of classification schemes that could be used for the purposes of global land-cover characterization.

B. Establish the strengths and weaknesses of existing classification schemes and global land-cover data sets vis a vis the current and future needs of global and regional scale models, and how these relate to land cover/land-cover change using MODIS.

C. Develop rationale for a scheme based on physical functionality of land cover units; eg. rates of gas, water, and energy exchange.

D. Part of Ph.D. for Moody

7. REQUIREMENTS:

A. Literature relating to land cover classification schemes, global land cover data sets, global process models, and the needs of the global science community for characterization of land-cover units.

B. Possibly digital and/or hard copies of existing global land cover data sets.

8. GENERAL PLAN:

A. Review the literature for approaches to classifying land-cover at regional to global scales. Focus especially on recently developed land-cover schemes which were designed for use with regional or global scale models.

B. Review existing regional and global land cover data sets with an eye towards their utility for serving EOS goals for global science. Discuss the potential for developing similar or improved products using remotely sensed data from MODIS. Explore issue of using remote sensing to produce functional rather than descriptive land cover data sets.

C. Review literature on global scale models, how they are supported by existing global land-cover data sets, and how land-cover units are translated into the types of quantities necessary to drive these models. Include investigation of modeling needs in terms of data resolution, spatial resolution of land-cover data sets and representatin of sub grid-scale variability.

D. Tie the above reviews together with the goals and objectives for land cover/land-cover change as stated by EOS and the U. S. Global Change Research Program and build a rationale for a type of land-cover characterization which is suited to meet these primary objectives.

E. Explore issues further with MODIS Land Team members at Land Cover meeting in September, 1992, at Flathead Lake, Montana.

9. PROJECT STATUS: A, B, C in progress.

10. PRESENTATIONS/PUBLICATIONS:

A. Article for publication

B. Part of Ph.D. Dissertation.

11. SPECIAL PROBLEMS/COMMENTS: No problems/comments

12. REPORTING PERIOD: January-June, 1992.

13. ACCOMPLISHMENTS:

A. Much literature gathered and some synthesis of materials.

B. Currently preparing material for upcoming Land Cover meeting. Focusing on land cover data needs of the EOS community, and how these needs may be met using MODIS data.

C. Have begun to compile literature on global land cover and land surface characteristics data sets.

D. Currently researching meso-scale and global scale climate, circulation and hydrologic models. Focus has been on land surface parameterization--especially characteristics associated with vegetation cover--and parameterization of subgrid-scale heterogeneities.

MODIS-SPATIAL STRUCTURE

1. TITLE: Development of Measures of Spatial Structure in MODIS-N 250m Imagery and Their Application for Local Surface Characterization and Subpixel Cloud Detection.

2. PERSONNEL: Lead: Pamela Cashman. Help: Shunlin Liang

3. PROJECT AFFILIATION: MODIS

4. DATE PREPARED/UPDATED: 92-8-24

5. BRIEF DESCRIPTION: Measures of spatial structure and their information content are explored for 250-m and 1-km MODIS imagery which
has been simulated by collapsing Landsat TM bands 3 and 4 to a lower resolution using an IFOV-simulating Fourier convolution filter. Measures tested include window variance and cross-band correlation; adjacent pixel variance and cross-correlation; and one-dimensional variance and covariance. The measures are examined for their ability to (1) characterize the spatial pattern of land surface covers, and (2) detect the presence of cloud cover for flagging of 1-km MODIS pixels.

6. BROAD CONTEXT:

A. Understand better the spatial characteristics of land covers at multiple resolutions.

B. Identify candidate algorithms for use in MODIS-N processing.

C. Enhance our ability to process images for spatial information by developing appropriate software.

D. Provide an MA degree for Pamela Cashman.

7. REQUIREMENTS:

A. Simulated two-band MODIS-N data at 250m and 1km resolutions.

B. Programs to calculate spatial structure measures in non-moving image windows.

8. GENERAL PLAN:

A. Search literature for relevant papers.

B. Acquire simulated MODIS-N data for clear and partly cloudy scenes from John Barker, GSFC.

C. Calculate statistical measures such as mean, standard deviation, kurtosis for both the red and infrared, and correlation between the red and infrared bands for 4 x 4 pixel windows using the 250 m data.

D. Calculate and plot spatial descriptors such as variograms, cross-variograms and correlograms for the same 16 pixel groups (corresponding to 1-km pixels).

E. Compare all statistical and spatial measures to spectral reflectance distributions (in 4x4 windows), searching for patterns and irregularities.

F. Calculate and examine indicator maps for both 250-m bands.

G. Examine spatial heterogeneity as a function of the landscape, and examine how spatial measures are influenced by partial cloud cover. Record observations.

H. Quantify cloud cover for each 1-km pixel based on 250-m data.

I. Develop a procedure (complete with appropriate algorithm(s)) and indexing system to quantify spatial structure and variation.

J. Test the procedure on both atmospherically corrected and uncorrected data to determine the importance of when to apply the algorithm(s).

K. Prepare Thesis/publication manuscript.

9. PROJECT STATUS: A. largely complete; B complete for cloud-free images; C complete; D complete; E complete; F complete; G in progress.

10. PRESENTATION/PUBLICATIONS:

A. Article in appropriate journal.

B. Pamela Cashman MA thesis.

11. SPECIAL PROBLEMS/COMMENTS:

A. Examination of the original TM data has revealed few cloudy pixels.

B. Literature is difficult to find as little has been written under the topics of spatial variation and spatial structure.

12. REPORTING PERIOD: January-June, 1992.

13. ACCOMPLISHMENTS:

A. Continued searching for relevant literature.

B. Completed General Plan items B-F.

C. Began recording observations as in item G, for preparation of thesis manuscript, as in item K.

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STAT-BRDF

1. TITLE: A Statistical BRDF Model

2. PERSONNEL: Lead: Shunlin. Help: Elgasim.

3. PRIMARY FUNDING SOURCE: MODIS

4. DATE PREPARED/UPDATED: 92-7-26

5. BRIEF DESCRIPTION: We develop a simple but effective method for characterizing and retrieving the BRDF from directional measurements at the top of the atmosphere. The BRDF is modeled as a composite of two functions--a limacon function that produces the familiar bowl-shape of BRDF's, and a hotspot function, using an expotential function.
Using six parameters, the LARS soybean BRDF data of Ranson et al. is fitted within 3%. Inversion is tested with ASAS data from the FEDMAC experiment for the infrared band to retrieve BRDF shape.
Further, the model can be easily incorporated into atmospheric models as a nonlambertian boundary condition.

6. BROAD CONTEXT:

A. Enhance our understanding of the characteristics of BRDFs.

B. Explore BRDF retrieval in the context of MODIS/MISR EOS instruments.

C. Ph.D for Shunlin.

7. REQUIREMENTS:

A. Ranson soybean reflectance data.

B. ASAS data for FEDmac site (Irons) and PARABOLA BRDF measurements (Deering).

C. Running C programs for BRDF retrieval.

8. GENERAL PLAN:

A. Develop the statistical BRDF model.

B. Develop parametric atmosphere RT model over nonlambertian surface model.

C. Validate with Ranson soybean canopy reflectance measurements.

D. Process ASAS data.

E. Retrieve BRDF from ASAS.

F. Retrieve BRDF from Deering measurements.

G. Prepare dissertation/publication manuscript.

9. PROJECT STATUS: A.-F. complete; G. in progress.

10. PRESENTATIONS/PUBLICATIONS:

A. Retrieval of BRDF from multiangle remotely sensed data, expected September, 1992

B. Ph.D dissertation, November, 1992

11. SPECIAL PROBLEMS/COMMENTS: No special problems.

12. REPORTING PERIOD: January-June, 1992

13. ACCOMPLISHMENTS:

A. All tasks completed, with manuscript still in final editing at close of reporting period.

TOPO-BRDF

1. TITLE: Evaluation of topographic effect on BRDF

2. PERSONNEL: Lead: Shunlin Liang.

3. PROJECT AFFILIATION: MODIS

4. DATE PREPARED/UPDATED: 92-7-7

5. BRIEF DESCRIPTION: For 1KM spatial resolution of the MODIS, most of pixels will be mixtures of many features. In rugged regions, topography has a significant effect on upwelling radiance. In this study, the radiation field will be quantitatively calculated for different random distributions of the slope and height at different spatial scales using physical optics theory.

6. BROAD CONTEXT:

A. Enhance our understanding of the characteristics of BRDFs.

B. Explore BRDF dependence on topography in the context of MODIS/MISR EOS instruments.

7. REQUIREMENTS:

A. DEM data for a mountain region.

B. Lab measurements of upwelling radiance or PARABOLA data from different random roughness surfaces.

C. Running C programs for simulation and scaling.

8. GENERAL PLAN:

A. Develop masking/shadowing functions for random rough surfaces.

B. Evaluate the multiple scattering field.

C. Develop Monte-Carlo or progressive radiosity simulation programs.

D. Measure upwelling radiance on lab conditions.

E. Analyze the random distributions of the slope and height using DEM.

F. Validate with measurement data and simulations.

G. Prepare publication manuscripts.

9. PROJECT STATUS: A. in progress.

10. PRESENTATIONS/PUBLICATIONS:

A. Manuscripts for publication.

11. SPECIAL PROBLEMS/COMMENTS: No special problems.

12. REPORTING PERIOD: January to June, 1992

13. ACCOMPLISHMENTS: None during period (Started in early June).

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