

**TYPE OF REPORT: Semiannual**  
**TIME PERIOD: Jan-Jun, 1999**  
**NAME AND LOCATION: Alan Strahler, Boston University**  
**CONTRACT NUMBER: NAS5-31369**  
**ABSTRACT -- KEY POINTS**

*BRDF/ALBEDO*

During the reporting period, we delivered a new version of the BRDF/Albedo code and tested it extensively on AVHRR data. We prepared a new global archetypical BRDF database and delivered that as well. We carried out extensive testing of QA tools and procedures in preparation for post-launch data flows. We added a new postdoctoral research, shared half-time with another project. Three papers were published, four papers were accepted, and two additional papers await publication. A further three papers have been submitted. A new version of the ATBD was delivered on April 30.

*LAND COVER/LAND-COVER CHANGE*

During the first half of 1999, we concentrated on algorithm testing using our North America site database. We continued our work with advanced technology (AT) neural nets and decision trees classifiers. A new map of North America was produced using neural network and decision tree classification algorithms based on multitemporal AVHRR data, and over 1100 training, testing and validation sites developed from Landsat TM data. A web database of IGBP global Confidence Sites was established (<http://geography.bu.edu/landcover/IGBP/index.html>), and Version 5.0 of the ATBD was delivered. In the coding effort, the Land Cover Monthly Code (MOD12M) that accumulates data for use by the quarterly classifier code was modified to include BRDF parameter information.

-----  
**TASK PROGRESS**

*BRDF/ALBEDO PRODUCT*

Personnel

Dr Xiaoyang Zhang from King's College, London has joined the group as a postdoctoral researcher.

*Algorithm Development*

Version 2.1 of the BRDF/Albedo Code (MOD43B) was delivered on 31 March 1999. In addition to various additional required metadata, this included constraints to limit the kernel weights and albedos to positive values and an

implementation of the coefficient of determination to aid in model selection and fit.

A global BRDF database of archetypal BRDF parameters was delivered on 19 May, 1999. This is used to aid in BRDF retrievals in cases of poor or limited sampling.

The LDOPE QA tools have been extensively tested at the BU SCF. Tiles of the input data (MODAGG) have been successfully ordered through MODAPS/MEBDOS and processed through the BRDF/Albedo code. In addition the tiles for standard QA processing post-launch have been identified and publicized on the LDOPE QA page.

#### *Scientific Advances*

Testing continues on the North American and New England AVHRR 1-km datasets from 1995. In particular the contribution of the BRDF archetypal database to magnitude inversions is being investigated. Comparisons between BRDF inversions from coincident data that have only been bulk atmospherically corrected and data that have been included aerosol corrections have indicated that the resulting albedos behave consistently with a stable offset in magnitude.

Work is underway on a new kernel -- the so-called LiTransit kernel, as it handles the transition from LiSparse to LiDense in forest canopies. The kernel is being used with field data and undergoing extensive sensitivity studies.

Collaboration continues with Dr. Wolfgang Lucht (now at the Potsdam Institut fur Klimafolgenforschung). Drs. Strahler and Schaaf visited the Institute for extensive discussions with the climate and biophysical modeling group on the use of MODIS data in the post-launch period.

Collaboration with the MODTRAN developers at the Air Force Research Laboratory resulted in inclusion of the MODIS BRDF algorithm being included as one of the BRDF characterizations available in MODTRAN4.

#### *Validation Activities*

Involved in planning for the mid-July KONVEX validation exercise in the Konza Prairie, Kansas. BU personnel will acquire spatial measurements of albedo during overflights by AVIRIS, AirMISR and MQUALS. KONVEX is led by Dr Dave Meyer from EDC and is MODLAND prelaunch validation effort.

#### *Publication/Talks Activities*

\* A paper on prototyping the MODIS BRDF/albedo algorithm with AVHRR and GOES data was published in JGR:

d'Entremont, R. E., C. L. Barker Schaaf, W. Lucht, and Alan H. Strahler. Retrieval of red spectral albedo and bidirectional reflectance using AVHRR HRPT and GOES satellite observations of the New England region, *J. Geophys. Res.*, D-104, 6229-6239, 1999.

\* A paper on the coupling between surface BRDF and atmospheric correction was published in IEEE TGARS:

Hu, B., W. Lucht, and A. H. Strahler. The interrelationship of atmospheric correction of reflectances and surface BRDF retrieval: A sensitivity study, *IEEE Trans. Geosci. Remote Sens.*, 37, 724-738, 1999.

\* A paper describing the relationship between inherent and apparent spectral and broadband albedos was published in JAM:

S. Liang, A. H. Strahler, and C. W. Walthall, Retrieval of land surface albedo from satellite observations: A simulation study, *J. Appl. Meteorol.*, 38, 712-725, 1999.

\* A paper on the use of remotely sensed multiangle data has been submitted to and accepted by BAMS. The revisions have been completed:

Diner, D.J, G.P Asner, R. Davies, Y. Knyazikhin, J-P. Muller, A. Nolin, B. Pinty, C.B. Schaaf, and J. Stoeve, New directions in Earth observing: Scientific applications of multi-angle remote sensing. *Bull. Amer. Meteor. Soc.*, in press, 1999.

\* A paper on BRDF-corrected NDVI and albedo from AVHRR observations over South America has been accepted by RSE and revisions have been completed.

Hu, B., W. Lucht, A. Strahler, C. Schaaf, and M. Smith. Surface albedos and angle-corrected NDVI from AVHRR observations over South America

\* A paper on the noise sensitivity of MODIS BRDF/albedo retrievals has been accepted by IJRS and revisions have been completed:

Lucht, W., and P. Lewis. Theoretical noise sensitivity of BRDF and albedo retrieval from the EOS-MODIS and MISR sensors with respect to angular sampling, *Int. J. Remote Sensing*, in press., 1999

\* A definitive paper describing the scientific basis of the at-launch MODIS BRDF/Albedo algorithm has been accepted by IEEE TGARS and revisions have been completed:

Lucht, W., C.B. Schaaf, and A.H. Strahler. An Algorithm for the retrieval of albedo from space using semiempirical BRDF models, *IEEE Trans. Geosci., Remote Sens.*, in press., 1999.

\* A paper for the Proceedings of the Workshop on Optical Remote Sensing Terrestrial Surfaces (Finland, Sept 1997) has been accepted and will be published as part of a book.

Lucht, W., C. B. Schaaf, A. H. Strahler, and R. P. d'Entremont, Remote sensing of albedo using the BRDF in relation to land surface properties, in: Remote Sensing in the Context of Global Change Issues, Eds. M.M. Verstraete and M. Menenti, Kluwer, in press, 1999.

Lucht, W., C.B. Schaaf, A.H. Strahler, and R.P. d'Entremont. Remote sensing of albedo using the BRDF in relation to land surface properties.

\* A paper describing the PROVE albedo validation efforts at Jornada has been accepted by Remote Sensing Environment and revisions are underway:

Hyman, A. H., W. Lucht, A. H. Strahler, and M. J. Barnsley, A comparison of satellite-derived spectral albedos to ground-based broadband albedo measurements modelled to satellite spatial scale for a semi-desert landscape, Remote Sens. Environ, under revision, 1999.

\* A paper describing semi-empirical BRDF modeling was submitted to Remote Sensing Reviews for a special issue on the International Forum on BRDF (11-13 Dec, 1998).

Lucht, W., and J.-L. Roujean, Considerations in the Parametric Modeling of BRDF and Albedo from Multiangular Satellite Sensor Observations, submitted to Remote Sens. Rev., 1999.

\* A paper describing the ground measurements obtained during the Jornada PROVE'97 campaign has been submitted to for a special issue of RSE.

Hyman, A.H., W. Lucht, M.J. Barnsley, P. Hobson, J.-P. Muller, A.H. Strahler, and J. Privette, Pyranometer measurements of the spatial variability of albedo in the vicinity of a semi-desert instrumented tower site during Jornada PROVE'97. submitted to Remote Sensing of Environment, 1999.

\* A paper from a related project describing archetypal BRDFs and using AVHRR data was submitted to JCLim:

Strugnell, N., and W. Lucht, Continental-scale albedo inferred from AVHRR data, land cover class and field observations of typical BRDFs, submitted to J. Climate, 1999.

\* Three papers were submitted to the proceedings of the International Geosciences and Remote Sensing Symposium, IGARSS'99: The first was orally presented by Dr Schaaf at the conference in Hamburg, Germany.

Schaaf, C. B., W. Lucht, T. Tsang, F. Gao, N. Strugnell, L. Chen, Y. Liu, and A.H. Strahler, Prototyping the MODerate Resolution Imaging Spectroradiometer (MODIS) BRDF and Albedo Product, Proc. Int. Geosci. Remote Sens. Symp. (IGARSS'99), Hamburg, Germany, 28 June - 2 July, 1506-1508, 1999.

Li, X., J. Wang, and A.H. Strahler, Scale Effects and Scaling-up by Geometric-Optical Model, Proc. Int. Geosci. Remote Sens. Symp. (IGARSS'99), Hamburg, Germany, 28 June - 2 July, 1875-1877, 1999.

Meister, G., W. Lucht, A. Rothkirch, and H. Spitzer, Large scale multispectral BRDF of an urban area, Proc. Int. Geosci. Remote Sens. Symp. (IGARSS'99), Hamburg, Germany, 28 June - 2 July, 821-823, 1999.

\* One paper was included in the International Conference and Workshops on Ocean Colour, Land Surfaces, Radiation and Clouds, and Aerosols in Meribel, France.

Lucht, W., C. Schaaf, and A. H. Strahler, BRDF and albedo retrieval from space in relation to land surface modelling, Proc. Int. Conference/Workshops Ocean Colour, Land Surf., Rad. Clouds, Aerosols, Meribel, France, LS-P-04, 4 pp., 1999.

\* A seminar entitled "Daily Global Observations of the Earth's Biosphere with the Upcoming MODIS Sensor of NASA's Earth Observing System" was given at the Potsdam Institute for Klimafolgenforschung, June 24, 1999 by Dr Strahler.

## **LAND COVER/LAND COVER CHANGE**

### *Overview*

During this reporting period, the Landcover ATBD version 5.0 was delivered. Algorithm testing was performed using our North America site database. We continued our work with advanced technology (AT) neural nets and decision trees classifiers. A new map of North America was produced using neural network and decision tree classification algorithms based on multitemporal AVHRR data, and over 1100 training, testing and validation sites developed from Landsat TM data. A publication was prepared on the North America map, but had not yet been submitted by the close of the reporting period.

A web database of IGBP global Confidence Sites was established.

### *Algorithm Development and Testing*

We continued research on neural net classifiers focusing on operational processing scenarios. We continued processing of AVHRR, TM and ancillary data for a regional Central America test site, and development of a land surface parameter database.

We continued the development and testing of a land surface parameter database derived from Landsat TM and ancillary sources, concentrating on North America. We completed the development and documentation of our validation and test site database. Algorithm testing was expanded to North America based on over 1100 sites developed from Landsat TM data. Supervised classification was tested using neural network and decision tree classifiers.

### *Coding/Processing*

Land Cover Monthly Code (MOD12M) that accumulates data for use by the quarterly classifier code was modified to include BRDF parameter information. Various patches to handle upstream format changes and better evaluate QA were also implemented and the revised code was delivered in March.

Scripts to automatically process twelve months of monthly MOD12M output through the decision tree classifier were developed.

Golden Tiles for routine Landcover Quarterly Code (MOD12Q) Quality Assurance monitoring were selected. They represent a subset of the EOS Core Validation Sites.

### *Land Cover Change*

In Land-Cover Change, we developed case studies for 16 land-cover change sites in Africa. We continue work on the interannual variability of land-cover indicators at coarse spatial resolution for Africa using change vector analysis.

### *Publications/Professional Activity*

#### ***Published:***

Borak, J. S. and A. H. Strahler. 1999. Feature selection and land cover classification of a MODIS-like data set for a semiarid environment. *International Journal of Remote Sensing* 20:919-938.

#### ***In Press:***

Borak, J. S., E. F. Lambin and A. H. Strahler, 1999, The use of temporal metrics for land-cover change detection at coarse spatial scales. International Journal of Remote Sensing, in press.

Friedl, M., W. Woodcock, S. Gopal, D. Muchoney, A. Strahler and C. Barker-Schaaf. 1999. A Note on Procedures for Accuracy Assessment in Land Cover Maps Derived from AVHRR Data. In Press, Remote Sensing Letters, International Journal of Remote Sensing.

Gopal, S., Woodcock, C. and A. Strahler. 1999. Fuzzy ARTMAP classification of global land cover from the 1 degree AVHRR data set. Remote Sensing of Environment 67:23-243.

Hodges, John C. F., Crystal L. B. Schaaf, Douglas M. Muchoney, Doug McIver, Mark Friedl, Huaying Chi, and Alan H. Strahler, Data simulation impacts on modis land cover classification development, Proceedings of the IEEE Geosciences and Remote Sensing Symposium, 1999.

Muchoney, D.M., J. Borak, H. Chi, M. Friedl, J. Hodges, N. Morrow and A. Strahler. 1999. Application of the MODIS Global Supervised Classification Model to Vegetation and Land Cover Mapping of Central America. In Press, International Journal of Remote Sensing.

Muchoney, D.M., A. Strahler, J. Hodges and J. LoCastro. 1999. The IGBP DISCover Confidence Sites and the System for Terrestrial Ecosystem Parameterization: Tools for Validating Global Land Cover Data. In Press, Photogrammetric Engineering and Remote Sensing.

***Submitted:***

Shaohua Fan, Alan Strahler, Xiaowen Li and John Hodges. EIFOV as a Function of View Geometry for MODIS. Photogrammetric Engineering and Remote Sensing (Submitted).

***Papers Presented:***

Hodges, John C. F., Crystal L. B. Schaaf, Douglas M. Muchoney, Doug McIver, Mark Friedl, Huaying Chi, and Alan H. Strahler. 1999. Data simulation impacts on modis land cover classification development, Proc. IEEE Geosciences and Remote Sensing Symposium, IGARSS'99, Hamburg Germany, 28 June - 2 July, 1999.

Muchoney, D.M. and A.H. Strahler, Description and parameterization of the IGBP global Confidence sites. AAG 95th Annual Meeting, 23-27 March 1999. Honolulu, HI

---

*PARTICIPATION IN MODIS ACTIVITIES*

- \* SDST Meeting: March 30-31 1999; GSFC
- \* MODIS Science Team Meeting: May 4-5 1999; Greenbelt, MD
- \* MODIS Land and Atmosphere Discipline Group Meeting: May 6, 1999; Greenbelt, MD

---

*ANTICIPATED ACTIVITIES DURING THE NEXT HALF YEAR*

*BRDF/ALBEDO*

- \* Participate in the KONVEX field experiment at the Konza Prairie LTER in Kansas in July.
- \* Meet with members of Robert Dickinson's climate modeling IDS group in July.
- \* Prepare papers and posters for the Second International Workshop on Multiangular Measurements and Models (IWMMM-2) in Ispra, Italy in September and deliver presentations. (Four papers have been submitted)
- \* Participate in the MODAPS/ MOSS-2 testing at GSFC.
- \* Prepare journal articles describing prototyping efforts with AVHRR prior to launch.
- \* Continue testing of at-launch algorithm. Prepare for delivery of early science products
- \* Prepare and execute QA strategy for products, now expected late in the calendar year.

*LAND COVER/LAND COVER CHANGE*

In anticipation of a late 1999 launch, our focus is test site development, operational testing of algorithm and code globally, and preparation for generation of early science products.

- \* Expand algorithm testing to South America and to the globe. We will expand test activities to developing a global test site database based on the 400 IGBP Core sites, the 30 MODLAND Core test sites and the MODIS geolocation sites.
- \* Test processing chain by using AVHRR data that has been converted to nadir reflectances through the BRDF/Albedo Product code, has been formatted with the Monthly Landcover code, a subset of which interacts with the classification train and test scripts to produce a fully trained tree that is applied to the entire data set with the Quarterly Landcover Product code.
- \* Test processing chain with MODIS simulated data on MEBDOS.
- \* Participate in the KONVEX field experiment 10-18 July 1999.
- \* Classification algorithm development and testing will focus on the operational aspects (process, flow) of neural net and decision trees classifiers.
- \* Improve automated classifier scripts to handle MODIS monthly file formats (HDF-EOS, QA, data formats).
- \* In land cover change activities, continue testing of change vector and neural network change detection techniques at specific sites to complement the multitemporal nature of the land cover activities. We will complete the land-cover change case studies and the interannual variability work, and write up the results of both activities.

#### *PROBLEMS/CORRECTIVE ACTIONS*

During this reporting period, we did not encounter any significant problems requiring corrective actions.