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ABSTRACT -- KEY POINTS

BRDF/ALBEDO

- 1) The global MOD43B BRDF/Albedo product was publically released.
- 2) Prototyping activities using MISR data were accomplished.
- 3) Extensive collaboration with our validation scientists (particularly Dr Liang and Dr Privette)
- 4) Personnel contributed to 8 papers which were published during the period, while 5 papers are still awaiting publication.

LAND COVER

- 1) Database development continued, with addition of new training sites and a vigorous quality-assurance effort.
- 2) The monthly land-cover product, MOD12M, was placed into production began to produce 32-day sets of inputs for the land cover classification algorithm.
- 3) We delivered a new version of the product code, MOD12Q, in November. By increasing processing at the PI SDF, the need to stage all 12 months of data at MODAPS was removed. In addition, the product will now deliver an expanded list of land cover classifications for the user community.
- 4) A first global land cover mapping using MODIS data was accomplished and presented at the fall AGU meeting.

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TASK PROGRESS

BRDF/ALBEDO PRODUCT

Personnel

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No staff changes during this period.

#### Algorithm development

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The BRDF/Albedo Product (MOD43B) (PGE23) was released to the public on 29 September, 2000. An extensive User's Guide was also provided (<http://geography.bu.edu/brdf/userguide/index.html>). "Beta" versions of MOD43B3 (Albedo) and MOD43B4 (Nadir BRDF-Adjusted Reflectance or NBAR) were included in this release which began with data from Day 193 (11 July 00) and used V2.2.1 of the code. The code has performed very well with the only limitations in quality due to the lack of aerosol correction in the input data and the overzealous detection of clouds by MOD35, the cloud mask. Aerosol corrections began with data from Day 273 (29 September 00) and products from MOD43B3 (Albedo) and MOD43B4 (NBAR) as well as the Model Parameters (MOD43B1) will be released "provisionally" with data from 31 October 00 onward. In addition, 5km browse images from Day 273 onward were added to the product, allowing easy evaluation of the global albedo and NBAR products.

#### Scientific advances

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Operationally, the algorithm is working very well. Although cloud cover often reduces the number of full BRDF inversions performed, the magnitude inversions (which convolve the limited observations obtained with a first guess of surface anisotropy from a database of archetypal BRDFs) have been available to fill in the gaps.

Work continues in-house on the enhancement of the LiTransit kernel and on specification of the appropriate use of a priori knowledge in the retrieval of BRDFs from sparse samples of remotely sensed data.

Prototyping activities to incorporate MISR data into the BRDF sample were also accomplished during this period by Ms Yufang Jin. Initial results comparing MODIS-only retrievals with MISR-only retrievals with combined retrievals were very encouraging.

Evaluation of the NBAR Product demonstrate that it captures the phenological signal well. NBAR serves as the primary input to the MOD12Q MODIS Land Cover Product.

#### Validation activities

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Close collaboration continued with Dr Shunlin Liang (UMD) over the BARC validation site. Comparisons with ETM derived albedos from 29 September

and 3 November 00 were very encouraging. NBAR comparisons were also favorable.

Data for the Mongu (SAFARI) site are also being accumulated for Dr Jeff Privette (GSFC) who maintains a tower at this location.

#### LAND COVER PRODUCT

##### Personnel

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A number of personnel actions took place within the land cover effort in the reporting period. Former Associate Team Member Douglas Muchoney was awarded his Boston University Ph.D. in June, 2000, and took a new position at Conservation International in Washington, D.C., in August, 2000. Researcher John Hodges began formal management of land cover team operations under the direction of Associate Team Member Prof. Mark Friedl. Student staffing changed, with Mutlu Ozdogan, Kristin Foord, and Daniel Blanco leaving land cover and Mandy Cooper and Alessandro Baccini joining the group.

##### Land Cover Database

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Training site acquisition continued during this period, focusing on South America during the summer and Asia during the fall. Our site quality assurance program continued, in which alternate analysts assign site labels and attributes independently and disagreements are resolved. John Hodges led a field trip of student analysts to the Harvard Forest to see vegetation variability first-hand. We also filled gaps and holes in parameterizations of individual sites using the STEP protocol. New Landsat-7 scenes were acquired primarily in the Australasian region.

We began a quantitative analysis of how well covered the Earth's land covers are in the STEP database, comparing the distribution of training sites with the EDC Olson classification, which recognizes nearly 100 specific classes. This study will guide further acquisition of Landsat-7 images.

During the summer of 2000, we prepared a world database of agricultural regions used to reduce confusion between natural vegetation and agriculture in the final classification mapping process. In addition, we prepared a global database distinguishing between cereal and broadleaf crops for Ranga Myneni's LAI/FPAR algorithm and delivered it to Montana.

##### Algorithm Development and Coding

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We continued the development of the land cover monthly code (MOD12M) and it began to run successfully on MODIS data from Day 193 (11 July 00) onward. Our first DLT of MOD12M output, for the mid-July to mid-August time period, was received at our SCF in November.

In another milestone in algorithm development, we incorporated prior probabilities into the classification procedure, reading our global map of agricultural regions to reduce the confusion between natural vegetation and agriculture. We also began experimenting with more advanced uses of prior probabilities as a way of blending information from prior classifications with that of the present effort.

In operational codes, we modified MOD12Q to reduce processing and data loads on the MODAPS system. We now read and stage all data at the PI's SCF and carry out the classification locally. The MOD12Q code, which runs quarterly, now reads our classification as an input, attaches headers and metadata, and releases the product into the ECS data stream.

We also expanded our product to provide three additional classifications: U of Maryland, 14 classes; Myneni biomes, 6 classes; and Running biomes, 6 classes. These classification schemes, which supplement the IGBP 17-class scheme, will directly benefit the LAI/FPAR and NPP products.

We revised the specification for our Land Cover Change Product, which has now been retitled our Land Cover Dynamics Product. The change primarily includes moving phenological information from the land cover product to the Land Cover Dynamics Product. The change vector approach is still maintained, but awaits a first year of stable MODIS data as a basis for comparison with new observations. The specification will be submitted to ECS early in 2001 after finalization of some technical issues.

#### ANTICIPATED ACTIVITIES DURING THE NEXT QUARTER

##### BRDF/ALBEDO

The "provisional" MODIS BRDF/Albedo Products (MOD43B1-Model-Parameters, MOD43B3-Albedos and MOD43B4-NBAR) are all scheduled for public release on 2 Feb 01 (based on data from 31 October 2000 onward).

A code delivery is expected during the spring to incorporate changes required for the ingest of AQUA data. This will be the last code delivery before reprocessing begins in June 2001.

Presentations, posters and papers will be prepared for the EOS-IWG in Ft Lauderdale, FL, the Spring Meeting of the American Geophysical Union in Boston, MA and for IGARSS'01 in Sydney, Australia. Abstracts

will be submitted for the AMS Satellite Conference in Madison, Wisconsin as well.

We will continue to evaluate and refine the products (particularly focusing on updating the BRDF database) and will continue to aid Dr Liang, Dr Privette and our British and Chinese colleagues in field validation of the products.

#### LAND COVER

We look forward to releasing a beta-grade land cover map in the April time frame using as much MODIS data as are available by about mid-February, and to releasing a provisional product to be used in the first reprocessing by mid-May.

We will deliver the final Land Cover Dynamics product spec in the March-April time frame.

Presentations, posters and papers will be prepared for the EOS-IWG in Ft Lauderdale, FL, the Spring Meeting of the American Geophysical Union in Boston, MA and for IGARSS'01 in Sydney, Australia.

#### PUBLICATION/PRESENTATION ACTIVITY

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\* A paper describing semi-empirical BRDF modeling has been published in special issue of Remote Sensing Reviews 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, Remote Sens. Rev., 18, 343-380, 2000.

\* A paper describing Geometric-Optical BRDF modeling has been published in a special issue of Remote Sensing Reviews on the International Forum on BRDF (11-13 Dec, 1998).

Chen, J., X. Li, T. Nilson, and A. Strahler, Recent Advances in GO modeling and its applications, Remote Sens. Rev., 18, 227-262. 2000.

\* A paper discussing inversion methods has been published in a special issue of Remote Sensing Reviews on the International Forum on BRDF (11-13 Dec, 1998).

Kimes, D. S., Y. Knjazikhin, J.L. Privette, A.A. Abuelgasim, F. Gao, Inversion Methods for Physically-Based Models, in press, Remote Sens. Rev., 18. 381-440. 2000.

\* A paper discussing laboratory measured BRDFs has been published

in a special issue of Remote Sensing Reviews on the International Forum on BRDF (11-13 Dec, 1998).

Sandmeier, S. R., and A. H. Strahler, BRDF Laboratory Measurements, Remote Sens. Rev., 18, 481-502, 2000.

\* A paper providing an overview of the International Forum on BRDF (11-13 Dec, 1998) has been published in a special issue of Remote Sensing Reviews.

Liang, S., A. H. Strahler, M. J. Barnsley, C. C. Borel, D. J. Diner, S. A. W. Gerstl, A. J. Prata, and C. L. Walthall, 2000, Multiangle Remote Sensing: Past, Present and Future, Remote Sensing Reviews, 18, 83-102, 2000.

\* A paper discussing angular correction has been published in a special issue of Remote Sensing Reviews on the International Forum on BRDF (11-13 Dec, 1998).

Liang, S., J.C. Stroeve, I. F. Grant, A. H. Strahler, and J. P. Duvel, Angular Corrections to Satellite Data for Estimating Earth Radiation Budget, Remote Sens. Rev., 18, 103-136, 2000.

\* A paper describing the PROVE'97 albedo validation efforts at Jornada was published in Remote Sensing Environment.

Lucht, W., A.H. Hyman, A. H. Strahler, M. J. Barnsley, P. Hobson, and J.-P. Muller, 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., 74, 85-98, 2000.

\* A paper describing the ground measurements obtained during the Jornada PROVE'97 campaign was published by Remote Sensing Environments.

Barnsley, M. J., P. D. Hobson, A. H. Hyman, W. Lucht, J.-P. Muller, and A. H. Strahler, Characterizing the spatial variability of broadband albedo in a semi-desert environment for MODIS validation, Remote Sens. Environ., 74, 58-68, 2000.

\* A paper from a related project describing archetypal BRDFs and their use in conjunction with AVHRR data has been accepted by JCLim and is awaiting publication.

Strugnell, N., and W. Lucht, Continental-scale albedo inferred from AVHRR data, land cover class and field observations of typical BRDFs, in press, J. Climate, 2001.

\* A paper describing the LiTransit kernel has been accepted by

RSR for a special issue on the International Workshop on Multi-angular Measurements and Models (IWMMM-2), Ispra, Italy, 15-17 Sept, 1999 and is awaiting publication.

Gao, F., X. Li, A.H. Strahler and C. Schaaf, Evaluation of the LiTransit Kernel for BRDF Modeling, in press, Remote Sensing Reviews, 2001.

\* A paper exploring techniques to retrieve albedo from limited observations has been accepted by RSE and is awaiting publication.

Gao, F., C. Schaaf, A.H. Strahler and W. Lucht, Using a multi-kernel least variance approach to retrieve and evaluate albedo from limited BRDF observations, in press, Remote Sens. Environ., 2001.

\* A paper was published in a prestigious Chinese journal on scaling up with geometric optical BRDF models.

Li, X., J. Wang, and A. H. Strahler, Scale effects and scaling-up by geometric-optical model, Science in China (Series E), vol. 43 (Supplement), pp. 17-22, 2000.

\* A paper describing the use of magnitude inversions on a global basis was accepted by GRL and is awaiting publication.

Strugnell, N., W. Lucht and C. Schaaf, A global albedo data set derived from AVHRR data for use in climate simulations, in press, Geophys. Res. Lett., 2001.

\* A paper investigating the use of a priori knowledge was accepted by JGR and is awaiting publication.

Li, X., F. Gao, J. Wang, and A.H. Strahler, A Priori Knowledge Accumulation and its Application to Linear BRDF Model Inversions, in press, J. Geophys. Res., 2001.

\* Five papers were published in the proceedings of the International Geosciences and Remote Sensing Symposium, IGARSS'00 in Honolulu, Hawaii. The first was presented orally by Dr Li, while the second overview paper was presented orally on behalf of MODLAND by Dr Townshend. The rest were presented as posters.

Li, X., F. Gao, J. Wang, A. H. Strahler, W. Lucht, and C. Schaaf, Parameter Error Propagation in BRDF Derived by Fitting Multiple Angular Observations at a Single Sun Position, Proc. Int. Geosci. Remote Sens. Symp. (IGARSS'00), Honolulu, Hawaii, 24 - 28 July, 2000.

Justice, C., J. Townshend, E. Vermote, R. Sohlberg, J. Descloitres, D. Roy, D. Hall, V. Salomonson, G. Riggs, A. Huete, K. Didan, T. Miura, Z. Wan, A. Strahler, C. Schaaf, R. Myneni, S. Running, J. Glassy, R.

Nemani, N. El Saleous, R. Wolfe, Preliminary land surface products from the NASA Moderate Resolution Imaging Spectroradiometer (MODIS), Int. Geosci. Remote Sens. Symp. (IGARSS'00), Honolulu, Hawaii, 24 - 28 July, 2000.

Gao, F., X. Li, A. H. Strahler, C. Schaaf, Acquiring a Priori Knowledge from Ground and Spaceborne BRDF Measurements, Int. Geosci. Remote Sens. Symp. (IGARSS'00), Honolulu, Hawaii, 24 - 28 July, 2000.

Schaaf, C. B., F. Gao, A. H. Strahler, T. Tsang, W. Lucht, N. Strugnell, X. Li, J-P. Muller, P. Lewis, M. Barnsley, P. Hobson, M. Disney, M. Dunderdale, and G. Roberts, The MODerate resolution Imaging Spectroradiometer (MODIS) BRDF and Albedo Product: Preliminary Results, Int. Geosci. Remote Sens. Symp. (IGARSS'00), Honolulu, Hawaii, 24 - 28 July, 2000.

Zhang, X., C. B. Schaaf, F. Gao, M. A. Friedl, A. H. Strahler, and J. C. F. Hodges, Mapping Land Cover and Green Vegetation Abundance Using MODIS-Like Data: A Case Study of New England, Int. Geosci. Remote Sens. Symp. (IGARSS'00), Honolulu, Hawaii, 24 - 28 July, 2000.

\* A talk and a poster were presented at the American Geophysical Union Fall Meeting, San Francisco, CA , 15-19 Dec, 2000.

Li, X., F. Gao, A. Strahler, and C. Schaaf. Bidirectional NDVI and Atmosphere-coupled BRDF Inversion (abstract).

Schaaf, C. B., A. H. Strahler, F. Gao, W. Lucht, X. Li, J-P. Muller, P. Lewis, M. Barnsley, P. Hobson, M. Disney, M. Dunderdale, G. Roberts and C. Doll. The MODerate Resolution Imaging Spectroradiometer (MODIS) BRDF and Albedo Product (abstract).

\* A poster was presented at the International Conference on Progress in Phenology in Freising, Germany, 4-6 October, 2000.

Strahler, A., C. Schaaf, M. Friedl, W. Lucht, F. Gao, X. Zhang, D. McIver, J.C.F. Hodges. The use of MODIS Nadir BRDF-adjusted reflectances to monitor phenological activity (abstract).

\* A papers on the MODIS BRDF/Albedo Product was accepted for the proceedings of the 8th International Symposium on Physical Measurements and Signatures in Remote Sensing in Aussois, France in early 2001.

Schaaf, C. B., F. Gao, A. Strahler, W. Lucht, T. Tsang, N. Strugnell, X. Li, X. Zhang, J-P. Muller, P. Lewis, M. Barnsley, P. Hobson, M. Disney, M. Dunderdale, G. Roberts, C. Doll and S. Liang. Temporal Characteristics of the MODIS BRDF/Albedo Product.

\* Three papers on land cover algorithms and early results were published in the Proceedings of IGARSS 2000.

Zhang, X., C. B. Schaaf, F. Gao, M. A. Friedl, A. Strahler, and J. C. F. Hodges, Mapping land cover and green vegetation abundance using MODIS-like data: A case study of New England, Proceedings IEEE 2000 International Geoscience and Remote Sensing Symposium, Honolulu, Hawaii, 24-28 July 2000, pp. 2005-2007, 2000.

McIver, D. K and M. A. Friedl 2000: Local estimation of land cover classification quality using machine learning methods, Proceedings IEEE 2000 International Geoscience and Remote Sensing Symposium, Honolulu, Hawaii, 24-28 July 2000, pp. 3063-3065.

Friedl, M.A., S. Gopal, D. Muchoney, and A. H. Strahler 2000: Global land cover mapping from MODIS: Algorithm design and preliminary results, Proceedings IEEE 2000 International Geoscience and Remote Sensing Symposium, Honolulu, Hawaii, 24-28 July 2000, pp. 527-529.

\* A poster summarizing our land cover work was presented at a conference on phenology in Freising, Germany.

Strahler, Alan. H., Crystal B. Schaaf, Mark Friedl, Wolfgang Lucht, Feng Gao, Xiaoyang Zhang, Doug McIver, and John F. C. Hodges, The Use of MODIS Nadir BRDF-Adjusted Reflectances to Monitor Phenological Activity, Poster presentation , *International Conference on Progress in Phenology: Monitoring, Data Analysis, and Global Change Impacts*, October 4-6, 2000, Freising, Germany, 2000

\* Our first global classification from MODIS data was presented at the San Francisco AGU meeting in December 2000.

Friedl, M.A. and A.H. Strahler, Land Cover Mapping from MODIS: Initial results, EOS, Transactions of the American Geophysical Union (supplement to Vol 18, no. 48) San Francisco, Dec 19, 2000. pp. F273, 2000.