MODIS Semi-Annual Report
(covering the period January - June 1993)
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Task Objectives

The overall objectives of the MODIS/snow project are to: develop and test algorithms to map snow and sea ice extent and reflectance using MODIS data, and to employ the snow data to analyze spatial and temporal variability in bidirectional, reflected solar and emitted thermal radiances over snow and ice-covered areas. This will improve the current understanding of snow and ice cover which are key components of the global energy balance, and to provide snow-covered area measurements to other scientists for use in hydrologic and general circulation models. MODIS snow data will also be integrated with other remote sensing-derived data sets of snow such as from the EOS MIMR to enable the mapping of snow under conditions of cloudcover and darkness, and to enable snow depth to be estimated globally.

Work Accomplished

Work continued in several areas of research including the development of the snow-cover algorithm, snow mapping in Alaska using both passive microwave and AVHRR data and use of DEM data on a MODIS Airborne Simulator (MAS) Sierra Nevada scene; computer hardware was ordered and received, and MODIS Technical Team and the Team meetings were attended. Two papers were presented at the Eastern Snow Conference, Quebec City, Quebec, Canada. Also, the Science Computing Facility (SCF) Plan was written and turned in, and a draft of the Algorithm Theoretical Basis Document (ATBD) was written. The SCF plan is appended to the end of this report, as are copies of papers presented at the Eastern Snow Conference.

Snow-Mapping in Alaska, January-June 1989. SSMI passive microwave data from the period January - June 1989 have been mapped at a resolution of 1/4 latitude X 1/4 longitude resolution. Color-coded brightness temperature maps have been produced. The data show clearly the changes in microwave brightness temperature with changes in snow temperature. The data also show the dissipation of snow cover during the spring. In the future, passive microwave data will be increasingly

important for snow mapping, because of the ability to "see" through most clouds using sensors operating in the microwave part of the spectrum. Thus it is anticipated that the best snow maps will be produced using data from both the reflective and microwave parts of the electromagnetic spectrum. In the EOS era, MODIS and MIMR data will be used together to map snow-covered area and snow depth.

AVHRR data of Alaska covering the same period as covered by the SSMI data (January - June 1989) were received from Jim Tucker/923. AVHRR data were registed to SSMI data. The remote-sensing data were then registered to topographic data, and forest-cover data. A map of forest cover in Alaska was digitized by Penny Masuoka/SDST and registered to the other data to enable comparison of all data sets. Results show that forest cover and topographic influences affect the passive-microwave brightness temperature significantly, and that other influences are important, too. A persistent temperature inversion during the winter may be causing unusually low passive microwave brightness temperatures each year in the foothills of the Brooks Range, Alaska. A paper discussing these results was presented at the Eastern Snow Conference and is provided with this report.

Two additional data sets have been received from the EROS Data Center in Sioux Falls, SD. The first, called the "Greenness Index" provides AVHRR data of the State of Alaska in several bands during a 2-week time period in July of 1989. The second data set provides data of topographic contours of the entire United States. The greenness data, along with ancillary data from the National Atlas, permit the location of the boreal forests and tundra areas to be identified. The topographic data provide contours at 1000-m contour intervals for the State of Alaska.

Dr. Carl Benson, a glaciologist from the University of Alaska, who has been working on snow mapping Alaska, visited during the week of 12 April to discuss progress and to participate in writing the paper that Hall presented at the Eastern Snow Conference in June.

Snow-Mapping Algorithm Results as applied to TM Data. The Glacier National Park (GNP) TM scene from 14 March 1991 was imported into EASI/PACE and coded with the snow cover algorithm as a model in easi pace. The snow cover model was tested and analyzed on a subset (1024 X 1024 pixels) of the GNP image. It was also run on the entire image.

Visually, results look good, but there is not yet any way to verify the accuracy of the results of this scene.

Validation of Snow-Mapping Algorithm. For his master's degree thesis at the University of California at Santa Barbara (UCSB), Walter Rosenthal mapped the snow cover on a TM scene of the Sierra Nevada Mountains, CA using a spectral mixture model, and compared his results with aerial photography. The accuracy of his technique was determined to be nearly 100 percent relative to the aerial photography. At our request, Rosenthal sent the TM scene and snow map to us. We have displayed the scene and have employed our snow-cover algorithm on this scene. Preliminary results show a weak correspondence between his map and our map. This has helped us to identify a flaw in our algorithm. Use of the solar zenith angle at each pixel instead of at the scene center may help to solve this problem. This is currently being implemented and our algorithm is undergoing modification. Following the algorithm modification, we will be able to calculate the accuracy of our snow-mapping algorithm, relative to Rosenthal's result, for that particular scene. This will be our first step toward quantifying the accuracy of our snow-mapping algorithm.

DEM data as applied to October 1991 MAS scene. Work has been progressing very slowly on registering the U.S.G.S. DEM data to the MAS scene of the Sierra Nevadas. This is because of the difficulty in locating landmarks common to the MAS and DEM data such that the data can be registered.

Ken Brown/925 has arranged an overflight of the ER-2 with the MAS over our study site in the Sierra Nevadas. There was a test flight in April. Those data, when obtained, will be analyzed in conjunction with the October 1991 MAS data, and the DEM data that we have of the same area.

Meetings. On 24 February, a meeting was held among D. Hall, J. Barker and V. Salomonson to discuss the progress of the snow-cover algorithm development efforts, and to identify the respective roles of MCST and the snow project for snow mapping using MODIS data. At that meeting it was decided that two algorithms would be developed both of which would be capable of mapping snow using MODIS data. However, at the last Team meeting, D. Hall and J. Barker discussed working together to develop and validate one algorithm that will be capable of global-snow mapping using MODIS data. Currently, two algorithms are being formulated.

On 24-26 March, the MODIS Team Meeting was held in Lanham, MD. D. Hall represented the snow project at the MODLAND and plenary meetings. Within MODLAND, several important issues were discussed. The use of the Long-Term Ecological Research sites as intensive-study sites for MODIS algorithm validation was discussed. Two sites in Alaska and one site in Montana appear to be useful for validation of the snow algorithm. In addition, the BOREAS sites will be useful for validation of the snow algorithms.

Future Work

In the next 6 months we expect to make progress in a number of areas. First, we expect to complete the algorithm theoretical basis document (ATBD) by mid-August. Currently we are devoting most of our efforts on this project to completing this document. The ATBD will cover the snow and sea-ice products. Validation of the results of our snow-cover algorithm over a TM scene in the Sierra Nevadas will continue, using Walter Rosenthal's classified scene as the 'ground truth.". Snow mapping in Alaska using a multisensor approach will continue in conjunction with colleagues in Alaska. This work is forming the basis for an enhanced snow product that will employ MODIS and MIMR data in the EOS era. Receipt of additional MODIS Airborne Simulator data over our test site in the Sierra Nevadas from the 1993 mission is expected. The LTER and MODIS Team meetings, as well as the MODIS Technical Team meetings will be attended.

Papers

MODLAND scientists have completed a paper entitled "Terrestrial remote sensing science and algorithms planned for EOS/MODIS" with S. Running as the first author, and all MODLAND members as co-authors. The paper was submitted to International Journal of Remote Sensing.

Two papers were presented at the 50th Annual Eastern Snow Conference held 7-10 June 1993 in Quebec City, Canada. The papers, will be published in a Proceedings volume following peer review. The titles and authors of the papers are: "Analysis of DMSP/SSMI and ERS-1 data of snow in central and northern Alaska," by D.K. Hall, C.S. Benson and J.Y.L. Chien, and "The developing moderate resolution imaging spectroradiometer (MODIS) snow-cover algorithm," by G.A. Riggs, D.K. Hall, V.V. Salomonson and J.L. Barker.