SEMI-ANNUAL REPORT

NASA CONTRACT NAS 5-31368

For
MODIS Team Member: Steven W. Running
Assoc. Team Member: Ramakrishna R. Nemani
Software Engineer: Petr Votava
Subcontracted Programmer: Joe Glassy

15 July, 2002

OBJECTIVES:

We have defined the following near-term objectives for our MODIS contract:

- Test software for our MODIS products, #15 Leaf Area Index and Fraction Absorbed Photosynthetically Active Radiation, #16 Evapotranspiration from land surface, and #17 Daily Photosynthesis Annual Net Primary Production as MODAPS processing delivers global datasets.

- Deliver at launch software for the Aqua MODIS sensor, for MOD 15, MOD 17 and the new MOD 16, Surface Evaporation Index

- Develop MODIS applications products for national natural resource management.

- Organization of a validation effort using AMERIFLUX fluxnet sites to correlate and test the MODIS derived LAI and Net Primary Production.

The NTSG lab currently employs:

Dr. Steven Running, Director and Professor,
Dr. Ramakrishna Nemani, Research Assoc. Professor
Dr. John Kimball, Research Assistant Professor
Dr. Sinkyu Kang, Postdoctoral Research Associate
Dr. Maosheng Zhao, Postdoctoral Research Associate
Dr. Swarna Reddy, Research Associate
Mr. Petr Votava, Software Engineer
Mr. Chad Bowker, Programmer
Mr. Andrew Neuschwander, Programmer/Sys Admin
Mr. Saxon Holbrook, Computer Systems Engineer
Mr. Matt Reeves, PhD student
Mr. W. Matt Jolly, PhD student
Ms. Pat Andrews, PhD student

Ms. Rachel Loehman, PhD student
Ms. Cristina Milesi, PhD student
Ms. Ann Radil, PhD student
Ms. Divya Tipparaju, MS Student
Ms. Alana Oakins, Research Assistant
Ms. Youngee Cho, Office Manager

All of these members contribute to certain aspects of our MODIS work.

EOS-IWG

I participated in a number of projects to develop both MODLAND, and more generally EOS Land product validation. These projects are in many ways interrelated, and their efficiency is maximized by regular coordination. Following are brief summaries of current activity for:

BIGFOOT = a field ecological measurement program in the US
FLUXNET = a global array of CO_2 and H_2O flux towers
GTOS-NPP = a global program related to BIGFOOT for GTOS

BIGFOOT

The BigFoot project grew from a workshop held in 1996, which was attended by ecologists and scientists of related disciplines, primarily from the Long Term Ecological Research (LTER) Network. The purpose was to explore validation protocols and scaling issues that would lead to an improved understanding of several MODLand products. The BigFoot field sites are also EOS Land Validation Core Sites and are part of the FLUXNET program. The sites have active science programs concentrating on CO2, water vapor, and energy exchange using flux tower measurements. The "footprint" over which gas flux data are collected varies, but is roughly 1 km or less. For the BigFoot analysis, this footprint will be extended to 25 km2 to include multiple 1 km MODIS cells, hence the project name. BigFoot investigators will focus on validation of the MODLand land cover, LAI, FPAR, and NPP products. We will develop fine grain (25 m resolution) surfaces of land cover, LAI, FPAR, and NPP, aggregate these to 1 km resolution, then assess the similarities and differences between these surfaces and the MODLand products.

http://www.fsl.orst.edu/larse/bigfoot/overview.html

I attended the BIGFOOT annual project meeting at Sevilleta LTER in March 2002.

FLUXNET

The FLUXNET program is maturing rapidly as the cornerstone of EOS Land validation, website at:

http://daacl.ESD.ORNL.Gov/FLUXNET/.

There are now 120 sites globally, and substantial international coordination. We inaugurated the RealTime flux validation activity with the active participation of ORNL. The following text from the Ameriflux website explains the project, found at:

http://cdiac.esd.ornl.gov/programs/ameriflux/Model_Evaluation/index.html

Model Evaluation Using AmeriFlux Data

One of the ongoing justifications for the AmeriFlux network is the opportunity to use the measurements to test both satellite data and model simulations. Commencing October 2000 the Carbon Dioxide Information Analysis Center (CDIAC) began posting weekly micrometeorological data from participating AmeriFlux sites for an evaluation exercise initiated by Dr. Steve Running (Numerical Terradynamic Simulation Group (NTSG) at the University of Montana). During this exercise participating AmeriFlux sites will provide canopy-top, micrometeorological data every week for use by numerous models including NTSG's BIOME-BGC model. In return, site-specific daily evapotranspiration, GPP, NEE, and NPP model output and weekly MODIS-derived NPP values will be posted weekly for comparison by participating AmeriFlux scientists to their own productivity estimates. Other modeling teams are welcome to participate but must be willing to provide site-specific, daily ET, GPP, NEE, and NEP computations each week to CDIAC for use by participating AmeriFlux groups.

I attended the Asiaflux annual meeting in JeJu , South Korea in January 2002.

MODIS International Workshops

NTSG hosted two major international workshops in the last 6 months, summaries are included here.

The Maureen And Mike Mansfield Foundation | The Mansfield Center for Pacific Affairs | The Maureen & Mike Mansfield Center | The University of Montana

Mansfield Pacific Retreats

Retreats Overview | 2002 Retreat Program | Past Retreats | Sponsors and Supporters

Retreats Overview

Since 1996, the Mansfield Pacific Retreats have given leaders from the United States, China, Korea and Japan an unprecedented opportunity outside formal diplomatic channels to address some of the most complex and sensitive issues common to the Asia-Pacific region.

Each Retreat convenes an interdisciplinary group of 50-60 high-level officials from government, academia and industry for four days of presentations, keynote addresses, discussions and site visits. Retreats typically include congressional and ministerial participants.

2002 Retreat

The 2002 Retreat will take place June 26-29 in the Glacier National Park region of Montana. Entitled "Melting Mountains: Climate Change in the Asia Pacific Region," the focus of the program will be on the science and policy of climate change. Past Retreats have focused on such issues as food security and trade, energy and the environment, and urban air quality.

The Mansfield Pacific Retreats are organized by the Maureen and Mike Mansfield Center at the University of Montana and the Mansfield Center for Pacific Affairs, both of which are centers of the Maureen and Mike Mansfield Foundation. Funding and support are provided by foundations, individuals, corporations and the Maureen and Mike Mansfield Foundation.

RETREATS OVERVIEW | 2002 RETREAT PROGRAM | PAST RETREATS | SPONSORS AND SUPPORTERS

ABOUT THE CENTER | AMERICA'S WARS IN ASIA PROJECT | EDUCATION | MANSFIELD CONFERENCE | HOME

THE MAUREEN & MIKE MANSFIELD CENTER
Mansfield Library 4th Level
Missoula, Montana 59812-9946, USA
Phone: (406) 243-2988
Fax: (406) 243-2181
E-mail: mansctr@selway.umt.edu

The Fifth Mansfield Pacific Retreat: June 26-29, 2002

Melting Mountains:
Climate Change in the Asia Pacific Region

Wednesday, June 26 Airport arrivals to the Kalispell/Glacier (FCA) Airport, shuttles to Retreat hotels. Daytime recreation, shopping and relaxation in Bigfork village near Retreat center Lodging and registration at Marina Cay Resort and Mountain Lake Lodge

6:30 – 7:30 p.m. **Cocktail Hour** at Mountain Lake Lodge

7:30 **Opening Banquet** at Mountain Lake Lodge

Welcome Remarks:
Ms. Joanna R. Shelton: Director (Interim), Mansfield Center
Mr. L. Gordon Flake: Executive Director, Mansfield Center for Pacific Affairs

Distinguished Comments:

His Excellency Yang Jiechi: *Ambassador of the People's Republic of China to the United States of America,* Washington D.C.

Entertainment
Mr. Jack Gladstone (Member Blackfeet Indian tribe, Montana)

Thursday, June 27

7:15 – 8:30 a.m. Breakfast At Marina Cay Resort and Conference Center and Mountain Lake Lodge

8:45 – 9: 15 a.m. **Setting the Stage: Beyond Kyoto**

Mr. Elliot Diringer: Director, International Strategies, *Pew Center on Global Climate Change*; Former Deputy Assistant to the President and Deputy Press Secretary, *The White House*; Former Policy Advisor and Director of Communications, *Council on Environmental Quality*

9:30 -11:45 a.m. **Opening Session** at Marina Cay Resort and Conference Center

Session 1 at Marina Cay Resort and Conference Center

"Melting Mountains: Urban Zones, Protected Lands and the Climate Connection"

Moderator: Mr. L. Gordon Flake: Executive Director, Mansfield Center for Pacific Affairs
Dr. Nancy Kete, Director, Climate, Energy and Pollution Program, *World Resources Institute*: former Deputy Director, Office of Atmospheric Programs, U.S. E.P.A.
Dr. Lisa Graumlich: Director, *Mountain Research Center*, Montana State University, former Deputy Director, Biosphere II Center
Dr. Liu Shirong: Director, Forest Ecology and Research Bureau, *Chinese Academy of Forestry*

Mr. Aichi Kazuo: Director General, *Global Environmental* Action, Tokyo, Former *Minister of State*, *Environment Agency*, Japan
Mr. Thomas Jorling: Vice President of Environmental Health and Safety, *International Paper*

12:15 -1:00 p.m.	Lunch at Marina Cay Resort and Conference Center
1:00-2:00	**Presentation #1** ***"The Science of Climate"*** **Dr. Charles D. Keeling**: Professor of Oceanography, *Scripps Institution of Oceanography* **Dr. Tom Wigley:** Senior Scientist, *National Center for Atmospheric Research*
2:15 – 4:30	**Session 2** at Marina Cay Resort and Conference Center ***"Common Solutions: Industry, Technology and the Future of Climate Change"*** **Moderator: Dr. Philip West:** Mansfield Professor of Modern Asian Affairs **Mr. Elliot Roseman**: Principal, *ICF Consulting* **Mr. Takahashi Hideo**: Director, Environment, Science & Technology Bureau, *Keidanren – Japan Federation of Economic Organizations*, Tokyo **Ms. Judith Bayer**: Director, Environmental Government Affairs, *United Technologies* **Mr. Robert Prolman**: Director: International Environmental Affairs, *Weyerhaeuser*
P.M.	**Free time.** Participants may choose to dine at the location of their choice in Bigfork Montana. Village restaurants are within walking distance of the Retreat Center / Marina Cay Hotel. Shuttles will be provided for guests staying at the Mountain Lake Lodge.

Friday, June 28

7:00 – 8:00 a.m.	Breakfast At Marina Cay Resort and Conference Center and the Mountain Lake Lodge.
8:15 – 9:45	**Session 3** at Marina Cay Resort and Conference Center ***"The Road to India: Leading Multilateral Issues for COP8"*** **Moderator: Ambassador Mark Johnson** (ret.): Adjunct Mansfield Professor **Dr. Morishima Akio:** Chairman of the Board, *Institute for Global Environmental Strategies* **Dr. Lee, Sang Gon:** President, *Korea Energy Economics Institute* **Mr. Gao Feng**: Deputy Director General, Department of Treaties and Law, *Ministry of Foreign Affairs* **Mr. Daniel Reifsnyder**: Director: Office of Global Change, Bureau of Oceans and International Environmental and Scientific Affairs, *US State Department*
10:00	**Departure for Glacier National Park, West Glacier, and Logan Pass (via Going-To-The-Sun Highway)** Guided transportation by Sun Tours

11:00	**Presentation #2 at Glacier National Park Community Center, West Glacier** ***"Where Have All the Glaciers Gone?"*** **Dr. Dan Fagre**: Research Ecologist *U.S. Dept of the Interior / U.S. Geological Survey*
11:45-1:00 p.m.	**Lunch** and continued travel through Glacier Park to Logan Pass
1:00 - 4:00	**Hiking at Logan Pass (Hidden Lake) and additional sightseeing locations**
4:00-6:00	Return travel from Glacier National Park to Marina Cay Resort & Mountain Lake Lodge
7:00 – 9:30	**Western BBQ at the Marina Cay Resort** **Welcome Comments** **Mme. Li Xiaolin:** Vice President, *Chinese Peoples Association for Friendship with Foreign Countries* **Pete Hart:** Superintendent, *Glacier National Park* **The Hon. Bob Brown:** Secretary of State, *State of Montana* ***Multi-Media* Entertainment**: *Mr. Jack Gladstone* & *Mr. Rob Quist*

Saturday, June 29

7:30 – 8:30 a.m.	Breakfast at Marina Cay Resort and Conference Center and Mountain Lake Lodge
8:45 - 9:30	Presentation # 3 "***Global Climate Monitoring: NASA's Earth Observing System (EOS) Program and the Implications for Climate Research and Public Policy"*** **Dr. Steven W. Running**: Director, *Numerical Terradynamic Simulation Group*. The University of Montana. Former Chair, *Land Science Panel, NASA's EOS Project*
9:45 – 12:15	**Session 4** at Marina Cay Resort and Conference Center ***"The Kyoto Connection: Charting a Future Course"*** **Introductory comments and moderator**: **Joanna R. Shelton**: Director (Interim), The Maureen and Mike Mansfield Center **Mme**. **Jiang Zehui**, Leading Member of the *State Forestry Administration*, Beijing and President of the *Chinese Academy of Forestry*, China **Mr. John Beale**: Deputy Assistant Administrator, Office of Air and Radiation, *Environmental Protection Agency*, United States **Mr. Kim Chong Chun**: Former Director General for International Cooperation, *Ministry of Environment***,** Korea **Mr. Ishitobi Hiroyuki:** Senior Policy Coordinator, Climate Change Policy Division, *Ministry of Environment***,** Japan
12:30 -1:30 p.m.	Lunch at Marina Cay Resort and Conference Center
1:30-5:30	Free Time
5:30-6:30	Cocktails at Mountain Lake Lodge

6:30 – 8:30 **Final Banquet**: Mountain Lake Lodge

Closing Comments and Appreciations

Mr. L. Gordon Flake: Executive Director, Mansfield Center for Pacific Affairs
Ms. Joanna R. Shelton: Director (Interim), The Maureen and Mike Mansfield Center
Dr. Lois Muir: Provost and Vice President for Academic Affairs, The University of Montana

Distinguished Comments:

His Excellency Yang Sung Chul: *Ambassador of the Republic of Korea to the United States of America*, Washington D.C.

Welcome Invitation to the 6th Mansfield Pacific Retreat:

Mr. Ko Chang-Hyung*: Deputy Mayor, Seogwipo City, Jeju Island, Korea*

Sunday, June 30 Check-out and Departure

MODIS VEGETATION WORKSHOP

NTSG Workshops - Microsoft Internet Explorer

http://www.forestry.umt.edu/ntsg/MODISMTG/

NUMERICAL TERRADYNAMIC SIMULATION GROUP

MODIS Vegetation Workshop

- Schedule
- Registration:
  - -Online
  - -Download Form
- Getting to Missoula
- Hotels/Lodging
- About Missoula
- Other Attractions in Montana

University of Montana:

- Campus Recreation and Fitness Services
- Campus Map

Other MODIS Workshops:

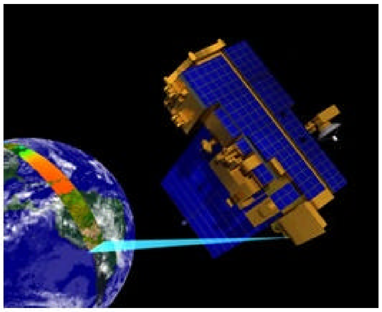
- GLCF
- NSIDC

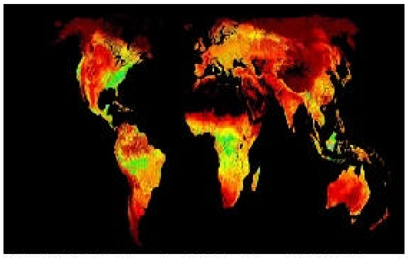
For Information on logistics, please contact:
Debbra Graham
Phone: (406) 243-4623
Fax: (406) 243-2047
Email Debbra

July 16 - 18, 2002

Workshop Objectives

This workshop is meant to give a comprehensive summary of the status of the MODIS Vegetation variables, now that a complete year, 2001, of data is available and has been analyzed. The MODIS Land Science team and relevant EOS DAACs will cover step-by-step details of the processing, distribution, analysis and interpretation of the MODIS Vegetation variables. The workshop will also include hands-on computer labs to take a user through details of data ordering, reprojection, reformatting and other technical tools. Finally, the Team members will give the results of analyzing the 2001 data year, including quality control flags, validation activities, and algorithm limitations.





Global PSN (May 1, 2001 - May 9, 2001)

Additionally, we will have an open Poster Session for any attendee who has used the MODIS Vegetation variables to report on their latest results. This workshop is being financially subsidized by NASA to allow maximum participation, particularly by graduate students interested in incorporating MODIS Vegetation data in their research.

Call For Posters

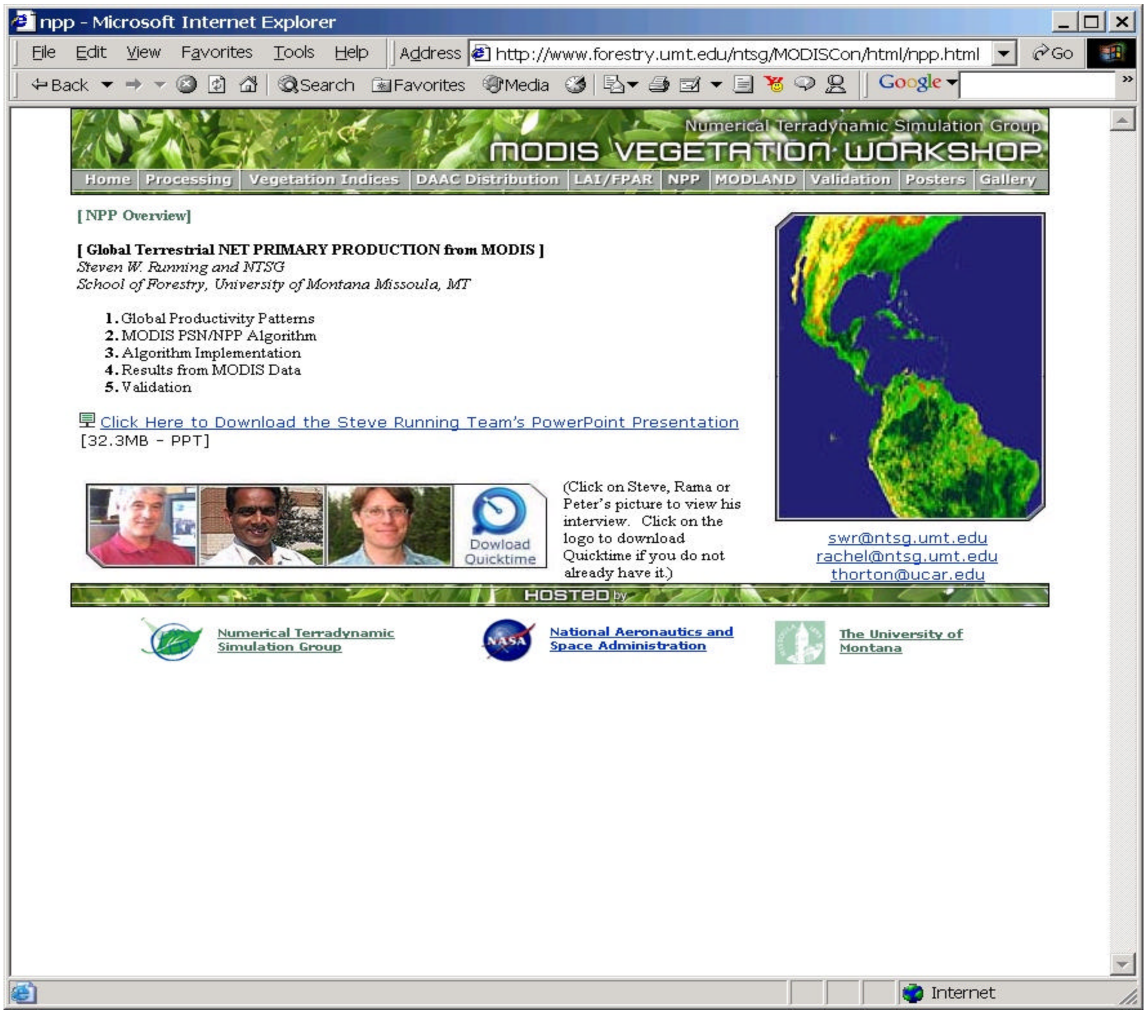
Each afternoon (see schedule) we will have an open Poster Session for attendees to report their results of working with the new MODIS datastream. Because the MODIS datastream is so new, we will accept new posters right up to July 15, and post all authors and titles electronically. Posters can include all aspects of acquiring and working with the MODIS Vegetation variables, including validation and new science projects.

If you want to submit a poster for the meeting, click here.

Hosted By:

N.T.S.G | University of Montana, Missoula | NASA


home - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address http://www.forestry.umt.edu/ntsg/MODISCon/
Go
Search Favorites Media
Google
Numerical Terradynamic Simulation Group
MODIS VEGETATION WORKSHOP
Home Processing Vegetation Indices DAAC Distribution LAI/FPAR NPP MODLAND Validation Posters Gallery
[MODIS Vegetation Workshop]
This workshop was meant to give a comprehensive summary of the status of the MODIS Vegetation variables, now that a complete year, 2001, of data is available and has been analyzed. The MODIS Land Science team and relevant EOS DAACs covered step-by-step details of the processing, distribution, analysis and interpretation of the MODIS Vegetation variables. The workshop also included hands-on computer labs to take a user through details of data ordering, reprojection, reformatting and other technical tools. Finally, the Team members gave the results of analyzing the 2001 data year, including quality control flags, validation activities, and algorithm limitations. Additionally, the workshop included open Poster Sessions for any attendee who had used the MODIS Vegetation variables to report on their latest results. This workshop was financially subsidized by NASA to allow maximum participation, particularly by graduate students interested in incorporating MODIS Vegetation data in their research.
[Dr. Steve Running's Introduction]
http://modis-land.gsfc.nasa.gov/
Download Quicktime
(Click on Steve's picture to view his intro to this site. Click on the logo to download Quicktime if you do not already have it.)
ycho@ntsg.umt.edu
Powered by Ninja Star Productions
HOSTED by
Numerical Terradynamic Simulation Group
National Aeronautics and Space Administration
The University of Montana
Done
Internet



<u>Meetings Attended by Steve Running, Jan –July 2002</u>

The Fifth Mansfield Pacific Retreat, Bigfork, MT, June 2002
U.S. Drought: Prediction, Impacts, Mitigation and Policy Washington DC, June 2002
AGU 2002 Spring Meeting, Washington DC, May 2002
ALOS Kyoto & Carbon Initiative 2nd Science Advisory Panel meeting, Santa Barbara, CA, May 2002
Aqua Science Working Group, Santa Barbara, CA, May 2002
HYDROS Site Review meeting, Santa Barbara, CA, May 2002
EMDI III, NCEAS meeting, Santa Barbara, CA, April 2002
4th US CCSSG Committee meeting, Washington DC, April 2002
CCSM-LandWG Working Group Meeting, Fr. Collins, CO, March 2002
MSU Extension Service Annual Conference 2002, Bozeman, MT, March 2002
Attended workshop on GLobal Change at the Land/Seal/Air Interface/ Bigfoot-LTER meeting, LaPaz Mexico, Albuquerque, NM, March 2002
Integrated Research Challenges Meeting, Ft. Collins, CO, Feb. 2002
2nd AsiaFlux Workshop, Seoul, Korea, Jan. 2002

ACTIVITIES OF R. Nemani (MODIS Associate Team Member)

MODIS Net primary production (MOD17)

One of the long-term goals of EOS is to produce consistent global NPP observations spanning the entire satellite record. This goal entails a careful cross-walk between AVHRR (1981-2000) and MODIS (2000 onwards) sensors. While the basic theory of vegetation monitoring did not change between the two sensors, MODIS represents a number of advances in spatial and temporal resolutions and state-of-the art algorithms applied to the raw radiance data. Using the MOD17 NPP algorithm and LAI/FPAR data sets derived from AVHRR and MODIS, we are testing the feasibility of producing consistent NPP data set from 1981.

Preliminary results show that MODIS NPP values are approximately 15-18% higher than AVHRR based NPP. Biome level differences are also evident between the two NPP estimates, resulting from differences in LAI/FPAR calculations. MODIS LAI/FPAR estimates tend to be higher owing to the atmospheric corrections applied to the reflectance data.

Since we used the same biome properties to translate absorbed PAR to NPP, the primary difference between the two sensors comes from derived absorbed radiation. Earlier studies showed that variation in APAR control NPP more than conversion efficiencies used in NPP models. NPP mapped at 0.5x0.5 degree resolution from AVHRR and MODIS based vegetation information are shown in figure 1. Currently, we are working on normalizing the two data sets (LAI/FPAR) through normalization performed biome by biome and by latitudinal bands.

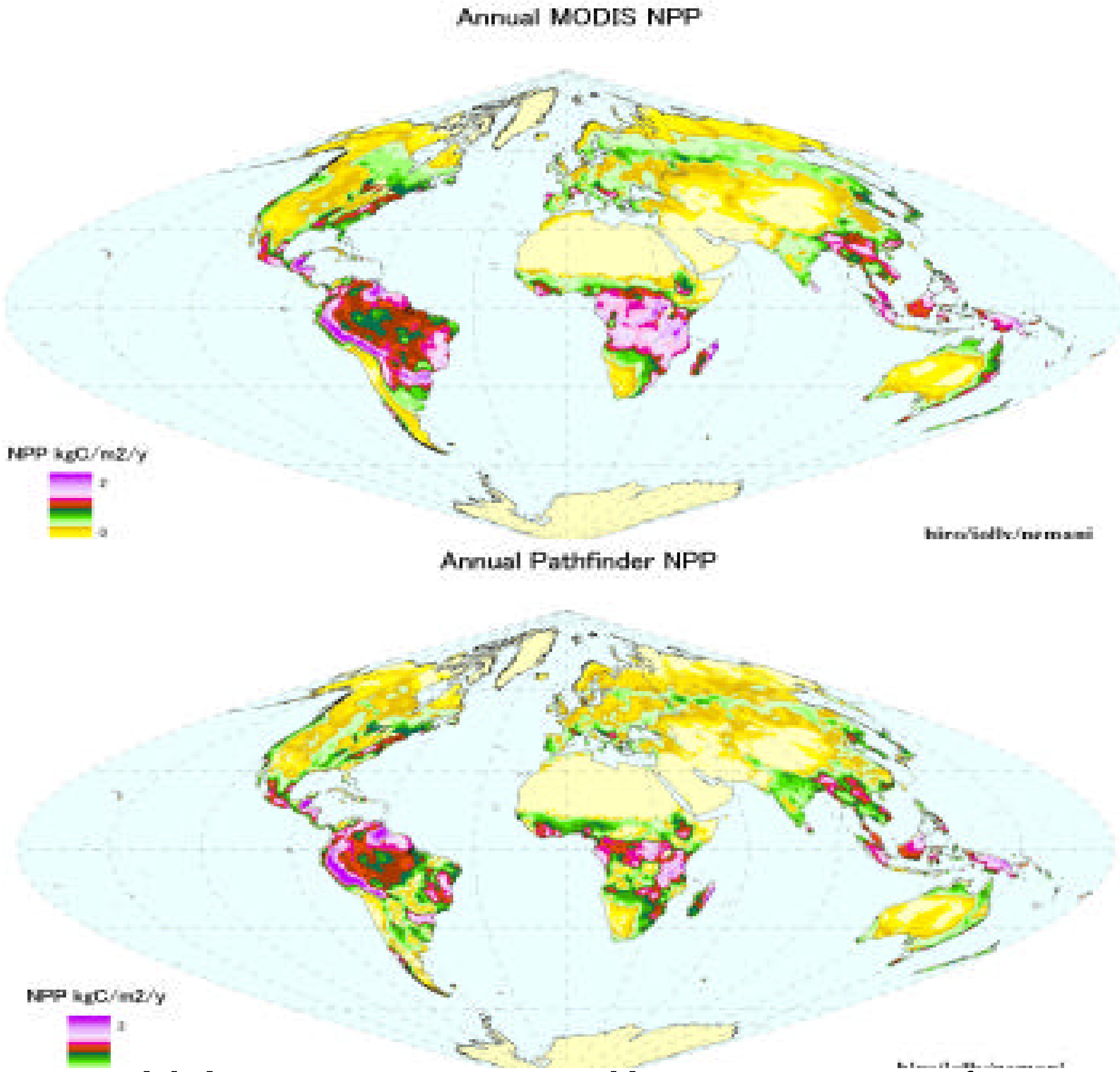


Figure 1: Global NPP estimates using monthly average LAI/FPAR from AVHRR (1982-1999) and MODIS (2000-2002).

MODIS Evaporation Index (MOD16)

Operational code for the MOD16 Evaporation Index product is ready to be used with AQUA/MODIS data. Currently, we are testing the algorithm using TERRA/MODIS data. Preliminary analysis showed promising results. Since MOD16 product is produced on a daily basis, compositing the daily values to an 8 day product is still being worked out. Since meteorological conditions can change significantly in an 8 day period, the highest EI value may not be a proper representation of surface conditions. This issue is being addressed using TERRA/MODIS data. An example of EI product over mid-western U.S derived from TERRA/MODIS is shown in figure 2.

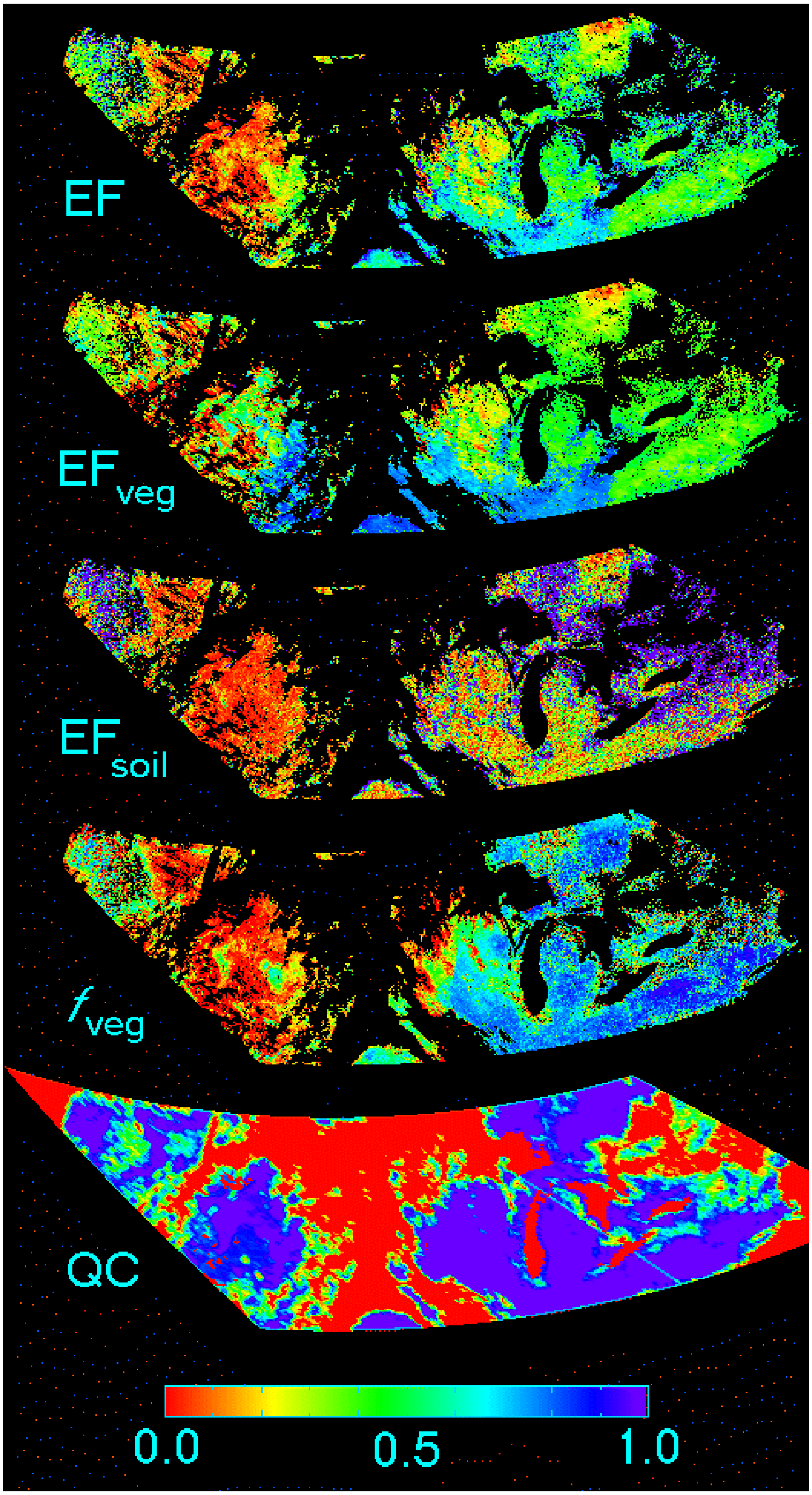


Figure 2 An example of MOD16 prototype produced from Terra/MODIS data. Northern continental United States. day 233 (August 20), year 2000.

PRESENTATIONS:

“Global net primary production: From AVHRR to MODIS”, presented at the MODIS Vegetation workshop, Missoula, MT, July 15,2002

“MODIS Evaporation Index”, presented at the MODIS Vegetation workshop, Missoula, MT, July 16, 2002

“Development of a Terrestrial observation and Prediction system”, presented at IEEE TGRS meeting , Toronto, Canada, May 2002

MEETINGS ATTENDED

MODIS Vegetation workshop, July 14-18, Missoula, MT
IEEE meeting, Toronto, Canada, May, 2002.

PUBLICATIONS:

Nemani et al., 2002. Recent trends in hydrologic balance have enhanced the terrestrial carbon sink in the U.S. Geophysical Research Letters (GL200214867, May 2002).

White, M.A., R. Nemani, P. Thornton and S. Running. 2002. Satellite evidence of phenological differences between urbanized and rural areas of the earthern United States deciduous broadleaf forest. Ecosystems, 5:260-267.

Milesi, C., C. Elvidge, R. Nemani and S. Running. 2002. Impact of land development on net primary production in the Southeastern United States. Remote Sensing of Environment (accepted).

White, M.A., and R. Nemani, 2002. A limited influence of growing season length on terrestrial carbon cycle? Global Change Biology (in press).

Nishida, K, R. Nemani, S. Running and J. Glassy. 2002. Implementation of MOD16 Evapotranspiration Algorithm for Prototype Terra/MODIS datasets. IEEE Transactions of Geoscience and Remote Sensing (revised).

Nishida, K., Nemani, R. R., Running, S. W., Glassy, J. M. (2002): Remote Sensing of Land Surface Evaporation (I) Theoretical Basis for an Operational Algorithm. *Journal of Geophysical Research D*, (revised)

<u>ACTIVITIES OF M. Zhao (Post-doc researcher) For 1/02-7/02</u>

Now we have an entire 2001 MODIS data and this allow us to validate MODIS products and study the sensitivity of MODIS algorithm to the variability of different inputs. The follows are the preliminary results from the works being done now.

1. DAO validation

DAO is one kind of assimilation data and original data are 1 degree with 3-hour interval. MODIS17 algorithm uses daily DAO data as input, and hence PSN and NPP values are largely dependent on the quality of DAO. We have found that over large part of Amazon region, NPP for 2001 is very low, and even some negative NPP appear in this region. But using NCEP data as input to run the algorithm for this region, NPP values are reasonable. Therefore, there is need to validate DAO. The problem for the validation is that common meteorological stations have no daily radiation observation; in addition, even most eddy flux towers have radiation observation, it is still hard to get them because 2001 is so latest.

Currently, we have just got 163 agricultural stations with observed radiation for 2001 over 4 states (Fig. 1). To some extend, these four states (California, Arizona, North Dakota and North Carolina) cover most of climatic zones of USA. For easier comparison, we just show seasonal mean value of each variable against the observed using one by one line. Further, in order to investigate how much error will be introduced to PSN and NPP by error from DAO, we run MODIS17 algorithm for each station's cutout by inputting DAO and observed, respectively. The results (fig. 2) suggest that, first, DAO can capture the seasonality of meteorological variables and its magnitude is fairly good. Secondly, DAO introduced more errors in summer than other seasons, and this leads to some errors of PSN in summer. For annual NPP, DAO running results are fairly agree with that run by observed.

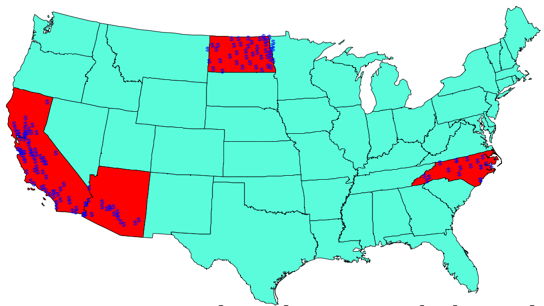
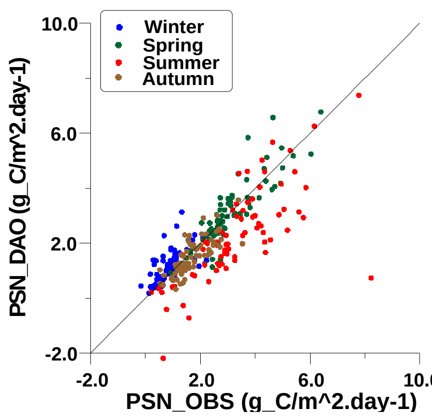


Fig.1 meteorological stations with observed radiation



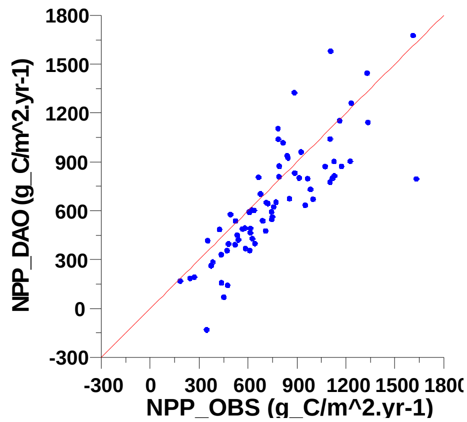


Fig.2 The DAO run MOD17 vs. observed meteorological run for stations cutout in California

Now we still try to contact some people who may have 2001 LBA data so that we can see DAO quality in Amazon region.

2, Validation of PSN and NPP

Validation of PSN and NPP is by using eddy flux towers observed GPP. Currently, for each tower, we got 5km by 5km cutout with ISIN projection using its latitude and longitude as the central pixel. For each cutout, we use land cover of central pixel as cutout vegetation type, and average the Fpar and Lai of pixels with the same land cover as central pixels. Using these mean Fpar and Lai run MOD17 algorithm to get cutout's PSN and NPP and then send the results to each towers' PI, this will enable us to find the way to improve our algorithm.

Now we have finished some programs that will automatically cut any pixel on land if accurate latitude and longitude provided. Also an IDL program has been finished to automatically plot all cutouts Fpar, Lai, EVI and PSN at once.

For validation of annual NPP, we have got multiyear (mean=12years) observed above ground biomass from 11 Long Term Ecological Research (LTER) stations. For comparison, we have converted MODIS NPP to biomass. The high R square value of regression equation indicates that MODIS NPP can capture NPP spatial pattern and magnitude (Fig. 3). However, above ground NPP commonly take up about 60% of NPP, so the parameter of 2.3897 seems a little high. Therefore, MODIS NPP may a little overestimate NPP.

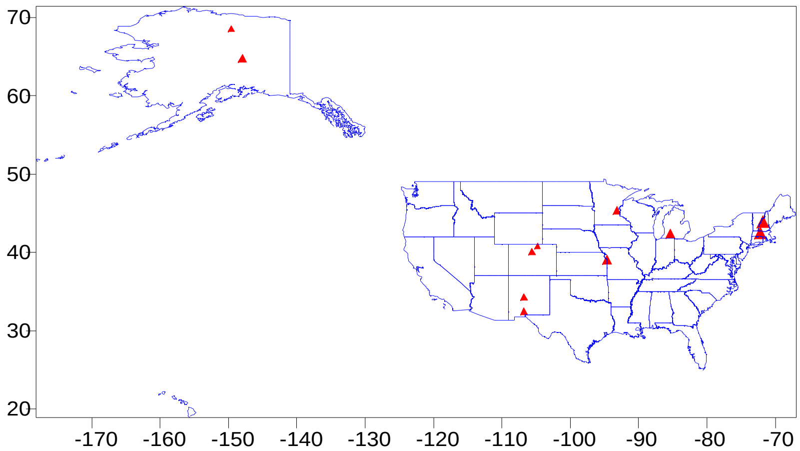


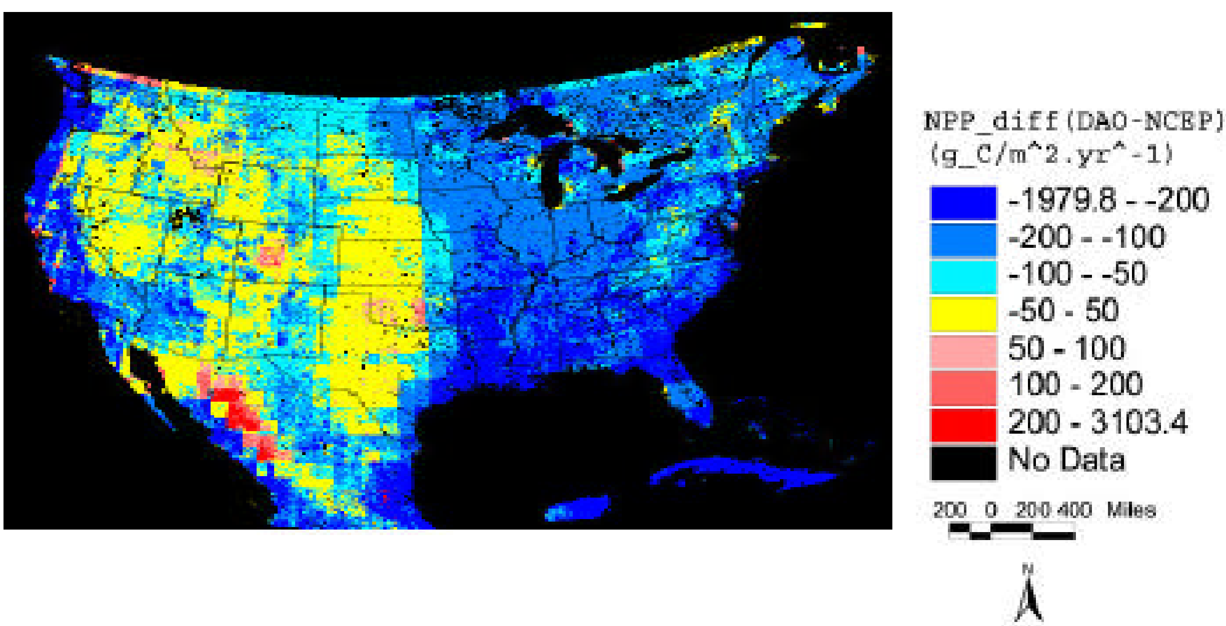
Fig.3 MODIS NPP vs. Observed LTER observed above ground NPP (left) and the LTER sites distribution (right).

3. Sensitivity of MODIS17 to the variability of inputs

1. Sensitivity to meteorological input

DAO is assimilation data, and NCEP is assimilated data, too, which is widely used. Now we have known there are big differences in tropical region between DAO and NCEP run MOD17. By validation of DAO, it reveals that DAO agrees well with the observed for USA. Because DAO spatial resolution is 1 degree, while NCEP is about 1.9 degree. Then we run MODIS algorithm forced by NCEP to see the sensitivity of MODIS17 to different meteorological inputs.

Results reveal that over large part of USA, the NCEP run overestimate PSN and NPP compared DAO run and observed run (Fig. 4). Therefore, the problem now is over USA, DAO quality is better than NCEP, while DAO has very big problem over much of tropic region, especially over Amazon region.



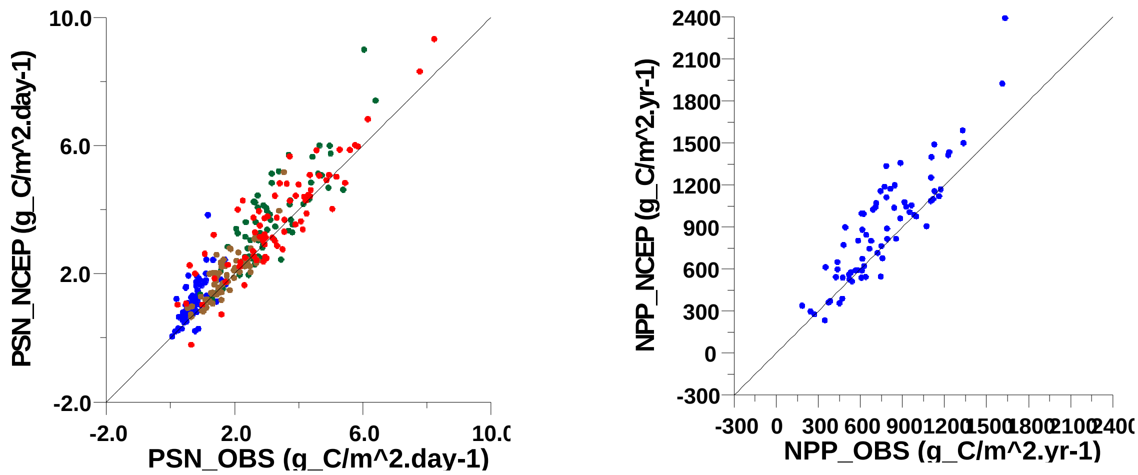


Fig.4 The difference of NPP between DAO and NCEP run The DAO run (left). NCEP run PSN and NPP vs. observed meteorological run for stations cutout in California (right).

2. *Sensitivity to MOD15A2 errors*

To study the sensitivity of MOD17 algorithm to the error from upstream input MOD15A2, we just set Fpar and Lai to change from –20% to 20% by 5% interval to run MODIS17 algorithm 81 time. Results (Fig. 5) demonstrate that, first, MOD17 is more sensitive to Fpar than Lai, and sensitive level is different for difference biomes, Secondly, if Fpar changes with a given proportional Lai as the graphics show below for difference biomes. NPP will be no change.

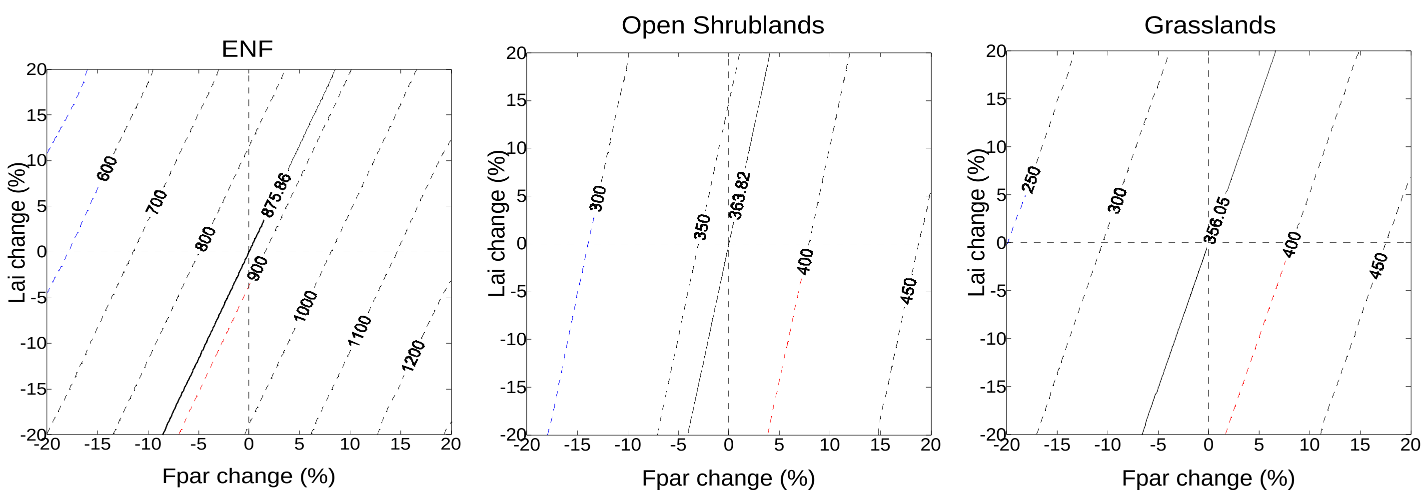


Fig.5 Some biomes' NPP contour lines to the change of Fpar and Lai

3. Sensitivity to MOD15 QC

MOD15 is 8-day composite data, and sometimes due to cloud contamination, LAI and Fpar are retrieved under different cloudy conditions, which is described by QC value. For annual NPP, we don't know how much error could be introduced to MOD17 NPP by MOD15 pixels with bad QC. To study this, we run the MOD17 in 5km by 5km moving window, we just average Fpar and Lai for these pixels with the same land cover as central pixel and best QC (Qc < = 4) to recalculate NPP. The results (fig. 6) suggest that, on the whole, the difference between quality-controlled MOD15 and no controlled is small. These pixels with large difference are scattered distributed. Also NPP histogram for difference biomes reveals that there is nearly no difference, too.

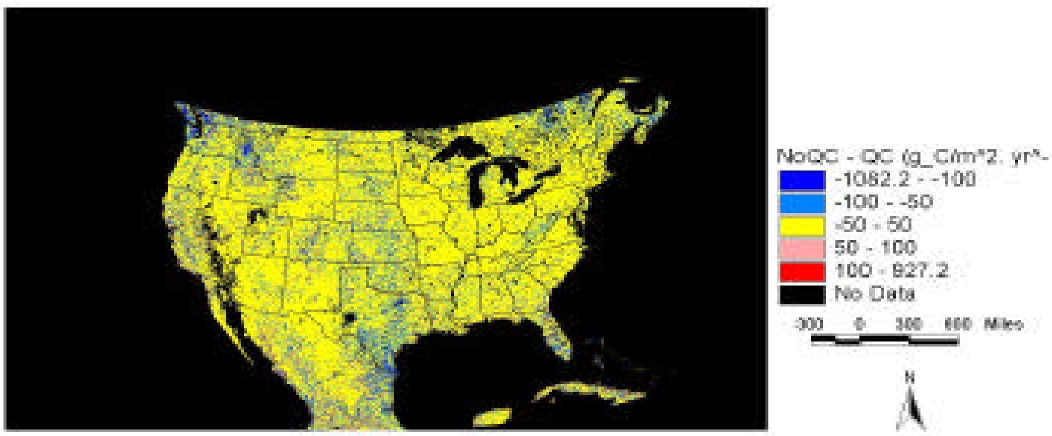


Fig.6 The difference of MOD17 NPP between no quality-controlled MOD15 forced NPP and quality-controlled run.

Presentation:

1. "DAO validation", Zhao M., presented at the MODIS Vegetation workshop, Missoula, MT, July 15,2002

2. "Sensitivity analysis of MOD17 to MOD15 input " , Zhao M., R. Nemani, S. W. Running, S. Kang , poster at the MODIS Vegetation workshop, Missoula, MT, July 15,2002

3. "Sensitivity of MODIS derived photosynthesis and net primary productivity to relative accuracy of meteorological inputs", Zhao M., W. M. Jolly, J. S. Kimball, R. Nemani, S. W. Running, S. Kang, presented at ESA meeting, Tucson, AZ, August 4, 2002

ACTIVITIES OF Sinkyu Kang (Post-doc researcher) For 1/02-7/02

I. Cloud Filling of MODIS 8-day photosynthetic product (MOD17A2 PSN)

II. A comparison study between MOD17A2 PSN and BIOME-BGC prediction

III. A Regional Phenology Model for Detecting Onset of Greenness in Temperate Mixed Forests, Korea: An Application of MODIS Leaf Area Index (LAI)

Presentations

1. Sinkyu Kang, Steve W. Running, Jong-Hwan Lim, Maosheng Zhao, Chandra Park. A Regional Phenology Model for Detecting Onset of Greenness in Temperate Mixed Forests, Korea: An Application of MODIS Leaf Area Index (LAI). A paper presented at MODIS Vegetation Workshop held in Missoula, MT, USA in July 16-18, 2002.
2. Sinkyu Kang, Steve W. Running, Rama Nemani, Maosheng Zhao. A Comparison Study between MOD17A2 PSN and Biome-BGC Prediction. A paper presented at MODIS Vegetation Workshop held in Missoula, MT, USA in July 16-18, 2002.
3. Sinkyu Kang, Maosheng Zhao, Steve W. Running. Cloud Filing of Mod17A2 Photosynthetic Product (PSN). A paper presented at VIII INTECOL Meeting held in Seoul, Korea in August 11-18, 2002.
4. Sinkyu Kang, Dowon Lee, Steve W. Running. Prospectiveness of modeling and MODIS data to predict effects of climatic variability on long-term carbon sequestration in a mixed hardwood forest. A paper presented at VIII INTECOL Meeting held in Seoul, Korea in August 11-18, 2002.

Publications

1. Sinkyu Kang, Steve W. Running, Jong-Hwan Lim, Maosheng Zhao, Chandra Park (2002) A Regional Phenology Model for Detecting Onset of Greenness in Temperate Mixed Forests, Korea: An Application of MODIS Leaf Area Index (LAI). Remote Sensing of Environment (in review).
2. Sinkyu Kang, Maosheng Zhao, Steve W. Running (2002). Cloud Filing of Mod17A2 Photosynthetic Product (PSN). Agricultural and Forest Meteorology (To be submitted**)**

Meetings Attended

MODIS Vegetation workshop, Missoula, MT, USA for July 14-18, 2002
VIII INTECOL meeting, Seoul, Korea for August 11-18, 2002

Cloud Filling of MODIS 8-day photosynthetic product (MOD17A2 PSN)

Introduction

In general, the MODLAND QC bits {0,1} valued at binary {00,01,10,11} from best to worst, should take precedence over almost all the others, as they typically integrate (or should integrate) the many subordinate measures (Joe Glassy, Director of MOD17 Software Development). In this study, we assume QC flags of “0” and “4” as best quality pixel and others are subjects contaminated by cloud, snow, etc. The contaminated pixel, frequently, shows unreasonable spatial and temporal patterns in fPAR, LAI, and PSN (Fig.1). Fig.1 shows well how QC flags correspond with unreasonable patterns of MOD17A2 PSN induced by clouds. If a pixel is detected cloudy in MOD35 cloud product, atmospheric correction is not implemented on the pixel. All the MODLAND products for the cloudy pixel remain contaminated by cloud. Cloud filling aims to fill the unreasonable patterns in spatial and temporal context. In this study, the effect of clouds on MODIS LAI, fPAR, and PSN products was inspected by emphasizing: (1) detection and processing of cloudy pixels in MODIS Land products and (2) handling of Quality Control (QC) flags. (3) Alternative cloud-filling algorithms were suggested and validated using data from flux-tower sites in USA. (4) Finally, examples of regional application to different climatic regimes were given in this study. The cloud-filling algorithms were based on spatial and temporal interpolation techniques combined with landcover classification and QC flags of MODIS land product.

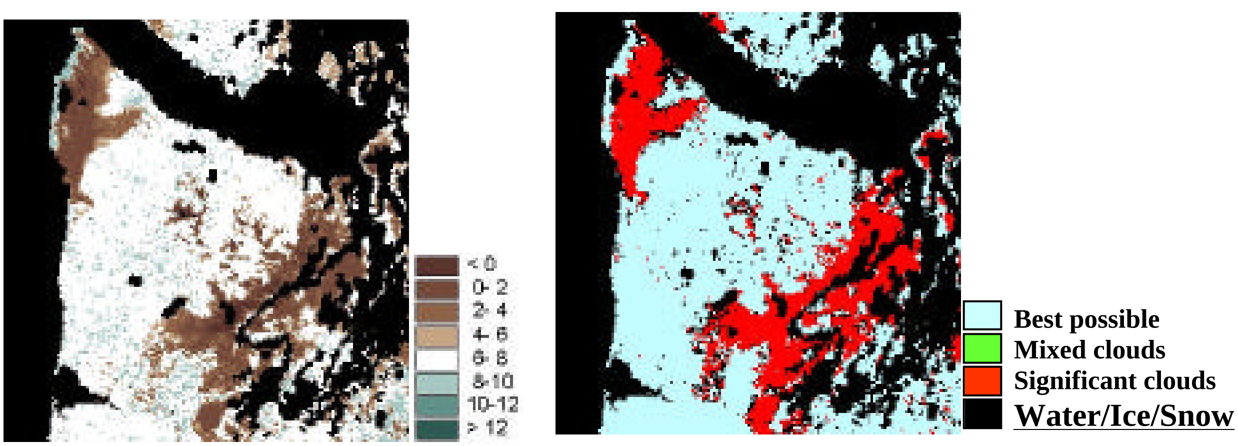


Fig.1 A sample image showing cloud contamination of MOD17A2 PSN (gC m^{-2} day^{-1}) and a corresponding Quality Control flags simplified into only 4 classes.

Cloud-filling algorithms

Under cloudy condition, MOD17A2 PSN has two sources of cloud contamination: MOD15A2 products and DAO meteorological data. DAO produces cloud contamination of PSN because DAO has too rough spatial resolution ($1^o \times 1^o$) compared to the resolution of MODIS Land Production (1km×1km) and hence, cannot capture effect of clouds on local meteorology. This problem can be solved with introducing finer scale meteorology in MOD17A2 algorithm, which is, however, beyond of this study. Instead, we emphasized and fixed the error from MOD15A2 products (FPAR and LAI) under cloudy condition in this study. Three different interpolation methods for filling cloud pixels were suggested (Fig.2): first is to fill PSN of a cloudy pixel with PSN values of surrounding cloud-free pixels; second is to fill FPAR of a cloudy pixel with FPAR values of surrounding cloud-free pixels and then adjust PSN of a cloudy pixel using the filled FPAR; third is to fill FPAR and LAI of a cloudy pixel with FPAR and LAI values of surrounding cloud-free pixels and then reruns MOD17A2 algorithm with the filled FPAR and LAI. The third method is in-processing algorithm because it need reprocessing of MOD17A2 algorithm, while the first and second ones are post-processing algorithm because they use existing products from MOD17 and MOD15 algorithms. Fig.2 summarizes three algorithms and shows input variables as well as processing methods. We abbreviate three methods with SI, fPAR, and fPAR-LAI, respectively. fPAR algorithm adjusts PSN of a cloud pixel with filled fPAR using Eq. 4. It assumes that GPP is considerably greater than MR, which fails sometimes.

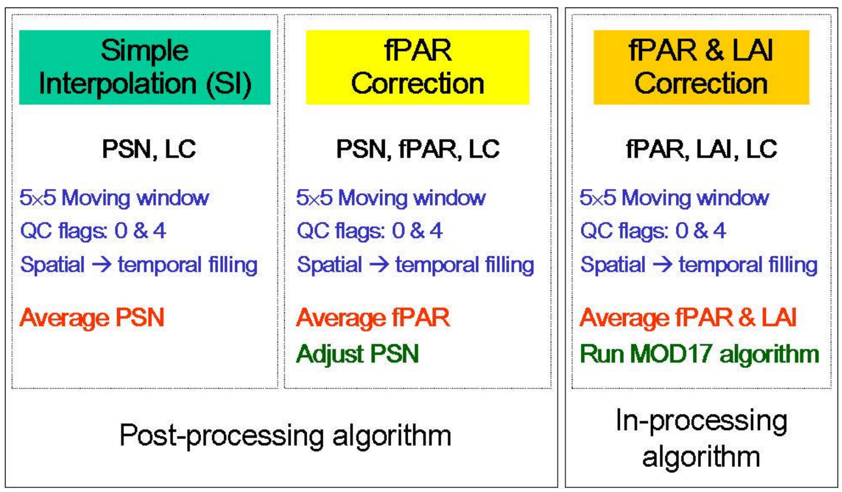


Fig.2 Proposed cloud-filling algorithms: SI, fPAR, and fPAR-LAI. Input variables and data processing and final correction methods for each algorithm are described subsequently. LC is MOD12Q1 landcover.

$$PSN = fPAR \cdot LUE - MR = fPAR \cdot LUE \cdot (1 - \frac{MR}{GPP}) \tag{1}$$

$$PSN_{adj} = fPAR_{adj} \cdot LUE \cdot (1 - \frac{MR}{GPP}) \tag{2}$$

$$CCC = \frac{fPAR_{adj}}{fPAR} \tag{3}$$

$$PSN_{adj} = CCC \cdot PSN \tag{4}$$

Each algorithm is based on spatial and temporal interpolation with moving window. Fig.3 illustrates how the interpolation is done with respect to PSN and fPAR and LAI incorporated with information from QC flags and landcover (MOD12Q1).

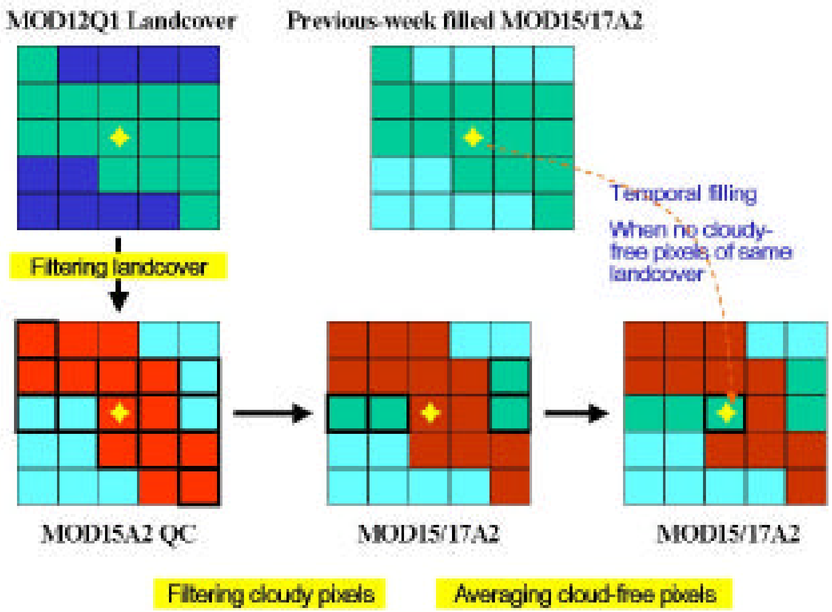


Fig.3 A schematic diagram illustrating process of spatial and temporal interpolation using information of landcover and QC flags.

For examples, we present comparison between MODIS FPAR, LAI, and PSN and filled values with the fPAR algorithm at a cooperative weather station at Macon county of North Carolina classified as deciduous broadleaf forest (Fig.4a). As well, we suggest a comparison between measured and filled FPAR at two Ameri-Flux tower stations, Willow Creek in WI and Niwot Ridge flux-tower in CO (Fig.4b).

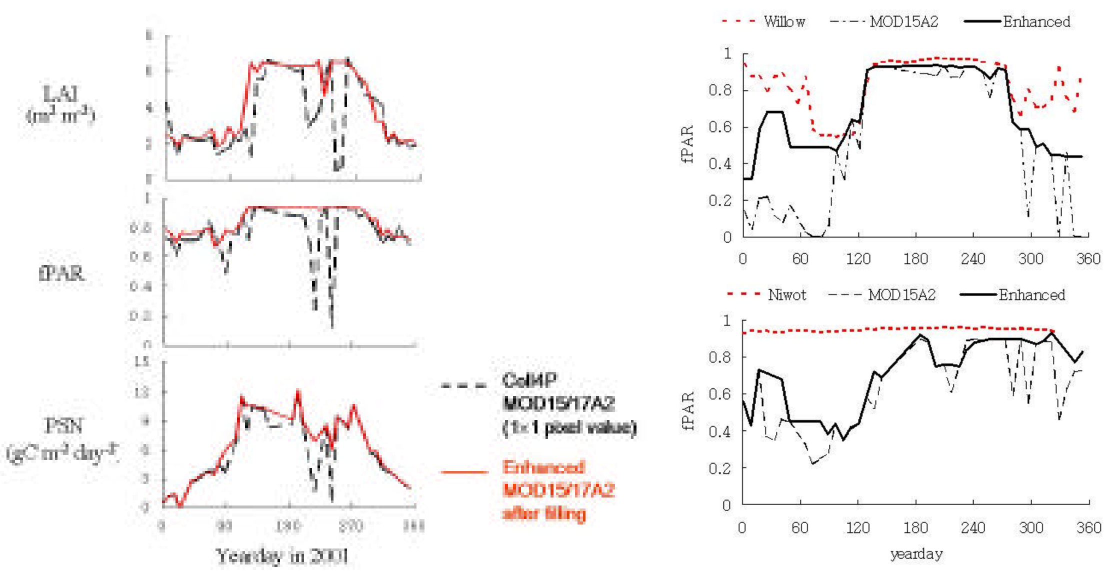


Fig.4 A sample result of cloud-filling at a weather station (left) and two flux-tower sites (right)

Regional comparison across climatic gradients

The proposed cloud-filling algorithms were applied and compared with each other in Pacific Northwest (PNW). Across PNW, we selected three distinct sub-regions for detailed comparison of the algorithms: Olympic National Park (ONP), North Cascades National Park (NCNP), and Glacier National Park (GNP) (Fig.5). Here, we suggest sample results from one-week (153~160 yearday in 2001) comparison (Fig.6a) and annual comparison using 43-week summation of PSN for ONP (Fig.6b).

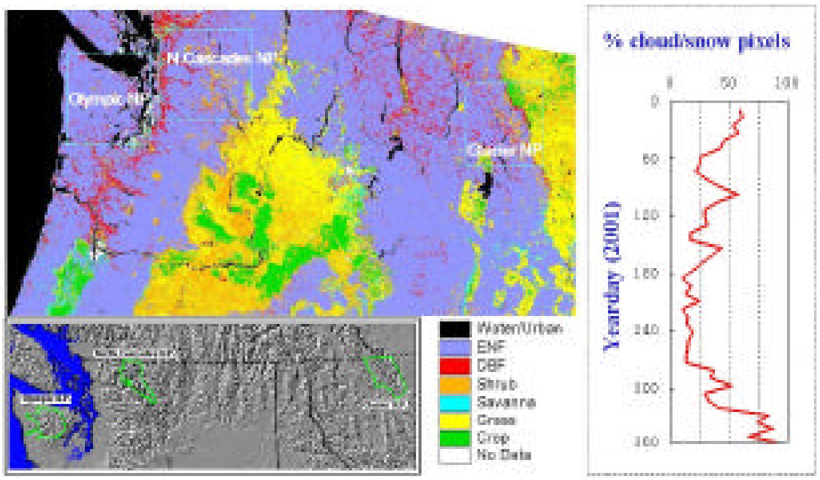


Fig.5 Landcover and topographic map of Pacific Northwest (PNW) and annual percent of cloud/snow cover in PNW in 2001.

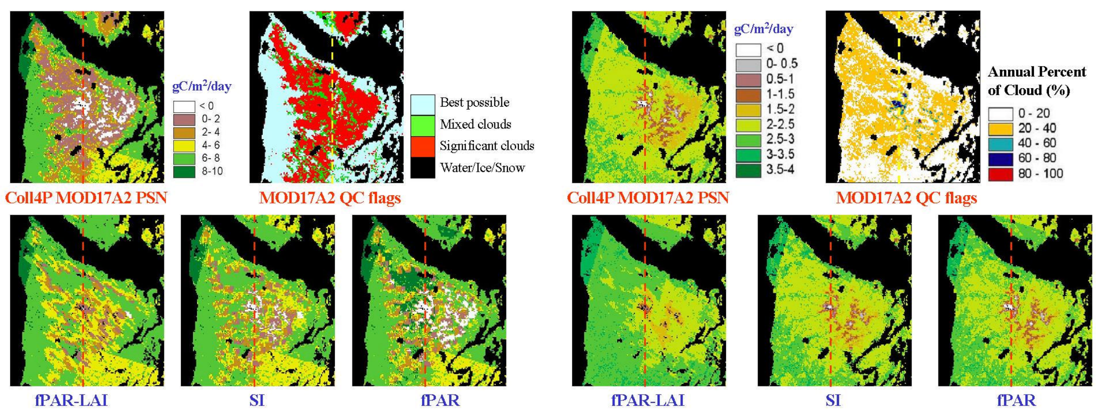


Fig.6 Comparison of MOD17A2 PSN (gC m^{-2} day^{-1}) with filled PSN produced three cloud-filling algorithms suggested in this study: (left) weekly comparison using 8-day PSN from 163 to 170 yearday and (right) annual comparison using 43-week averaged PSN in 2001.

Filled PSN values were generally higher (10~30% in weekly comparison and 10% in annual comparison) than MOD17A2 PSN but did not different significantly with each other (Fig.7a). Fig.7 also shows distinct gradient in mean daily PSN across the sub-regions, which follows gradients in annual precipitation. In PNW, evergreen needleleaf forest (ENF) showed highest sensitivity (~+10% in annual PSN) to cloud-filling (Fig.8), compared with other biome types. We suppose this is mainly because ENF is distributed in rugged montane area of PNW with frequent cloud cover.

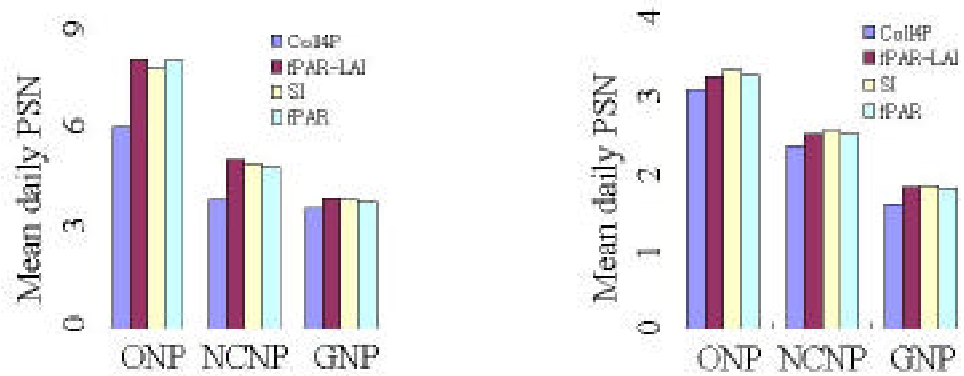


Fig.7 Comparison of MOD17A2 PSN with filled PSN (gC m^{-2} day^{-1}) in three sub-regions for a week (163~70 yearday) and 43 weeks in 2001.

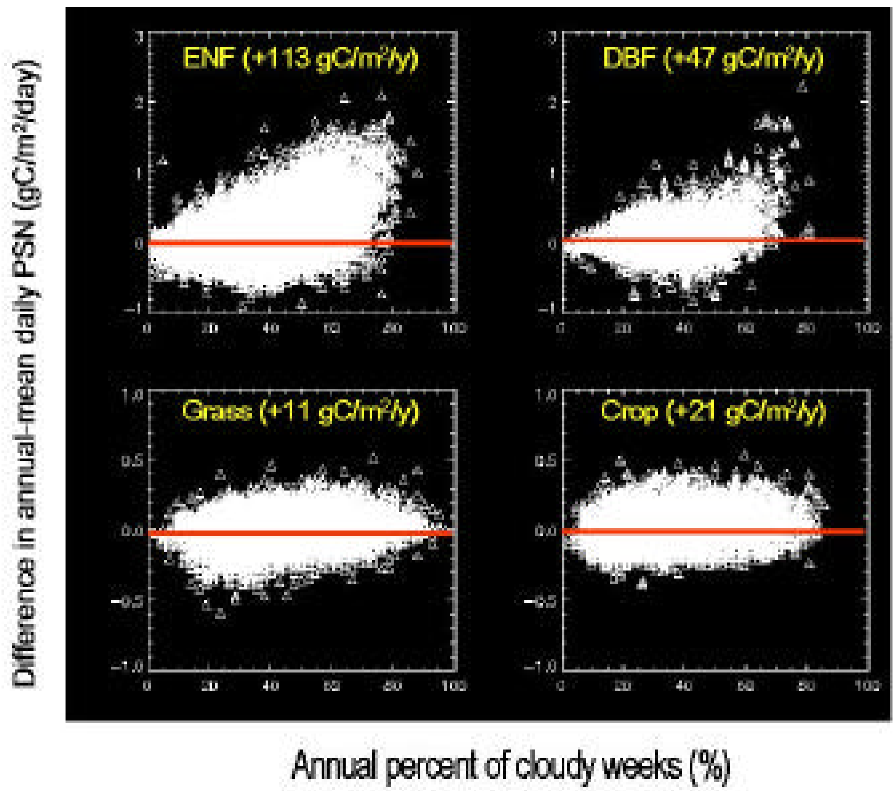


Fig.8 Difference in annual mean PSN (gC m^{-2} day^{-1}) between fPAR-LAI correction and MOD17A2 PSN and its relationship with annual percent of cloud cover. ENF and DBF are evergreen needleleaf forest and deciduous broadleaf forest, respectively. Values in parenthesis are annual accumulated difference (gC m^{-2} y^{-1}).

Summary and conclusions

We proposed one in-processing and two post-processing algorithms for filling FPAR, LAI, and PSN of cloudy pixels. We applied and compared the algorithms with MOD17A2 PSN across climatic gradients in PNW to identify where, when, and which biome is most sensitive to cloud-filling. Our tentative conclusions are described as bellows.

- In PNW, the cloud-filling produced higher PSN than Coll4P MOD17A2 (~10% in regional mean and up to +60% in point-wise comparison).
- The sensitivity to the cloud-filling increased in order of Grass (+11gC/m^2/y), Crop (+21), DBF (+47), and ENF(+113) in PNW.
- In weekly comparisons, two post-processing algorithms produced distinctly different patterns from the in-processing algorithm.
- In annual comparisons, three algorithm produced quite similar values and patterns.
- The cloud-filling is selectively recommended depending on local topography and meteorology.

A comparison study between MOD17A2 PSN and BIOME-BGC prediction

Sinkyu Kang, Maosheng Zhao, Rama Nemani, and Steve W. Running

Purpose

A biogeochemical ecosystem model, BIOME-BGC, has close relevance with MODIS photosynthetic products because parameters in biome property lookup table (BPLUT) were determined by rigorous BIOME-BGC simulations. As one of preliminary validation efforts for MODIS PSN, we conducted a comparison study between MODIS LAI/PSN and BIOME-BGC prediction. In this study, we compared biome-specific seasonal patterns of PSN from MODIS and BIOME-BGC simulations at over 3,000 NCDC Cooperative Weather Stations across conterminous USA (Fig.1).

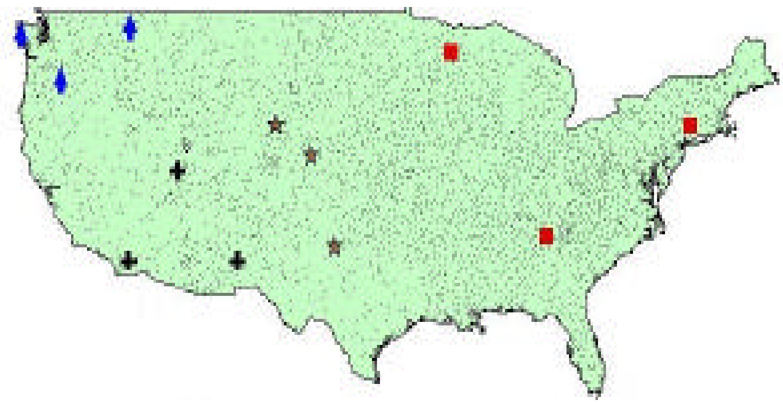


Fig.1 NCDC Cooperative Weather Stations across conterminous USA used in BIOME-BGC simulation and LAI comparison. Twelve marked points indicate selected weather stations for PSN comparison: , Evergreen Needleleaf Forest (ENF), , Deciduous Broadleaf Forest (DBF), , Shrub, , Grass.

Preparing MODIS products and implimenting BIOME-BGC

MODIS PSN and LAI were reprojected to Lambert Azimuthal Equal Area projection with 1km resolution, extract 5-by-5 cutouts where the coop. station is centered, and then averaged using pixel values with same landcover type and Quality Control flags of 0 and 4. For the purpose, MOD12Q1 Landcover was prepared with Lambert Azimuthal Equal Area projection with 1km resolution.

BIOME-BGC Simulation needs determination of initial values of numerous state variables, soil information, and eco-physiological parameters. We used eco-physiological parameters developed by White et al. (2000). The initial value of state variable was prepared by spin-up simulation for estimating state variables in steady-state of balanced carbon-budget condition. Eighteen-year Daymet data (1980-1997) were used for input meteorological data of spin-up simulation (Thornton et al., 1997). Input soil information, soil depth and texture, were derived from STATSGO database with 1km resolution. In soil depth calculation, rock fraction was considered to estimated effective soil depth. BIOME-BGC prediction for 2001 was implemented using 2001 meteorological data.from NCDC Cooperative Weather Stations across conterminous USA.

LAI Comparison

First, we compared modeled LAI with MOD15A2 LAI product. This comparison is essential for comparing PSN. Because MOD17 PSN uses LAI as one of input variables, it is meaningless to compare modeled PSN with MOD17PSN where modeled LAI and MOD15LAI are considerably different. We prepared a map of maximum, minimum, and growing-season mean LAI using 46-week MOD15 LAI across conterminous USA (Fig.2). The maps were used to extract 5-by-5 pixel mean LAI at each NCDC Cooperative Weather Stations, which was compared with modeled LAI depending on biome types (Fig.3). We constrained our PSN comparison sites where both modeled and MOD15 maximum LAI differed less than or equal to 10%.

Fig.2 A maximum LAI map derived from MOD15A2 LAI.

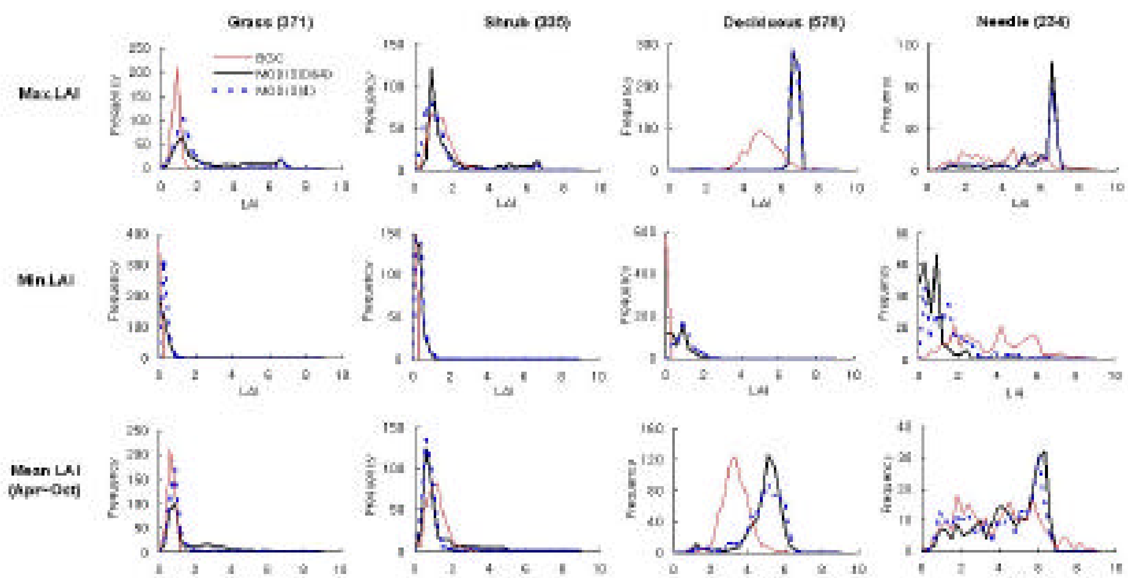


Fig.3 Histograms of maximum, minimum, and growing-season mean LAI derived from MOD15A2 LAI specific to biome types.

PSN Comparison

In this study, we mainly concentrated our PSN comparison to seasonal pattern but not absolute value because we aimed to test MOD17 PSN in aspects to its responsibility to external environmental change, such as seasonal climate variability. For the purpose, both modeled and MOD17 PSN were normalized using maximum PSN of both products, respectively. We also prepared time series of NCDC Cooperative Weather Stations and DAO, which were used as input meteorological data of BIOME-BGC and MOD17A2 PSN, respectively. Fig.4 shows normalized modeled and MOD17 seasonal variations and seasonal meteorological data specific to biome types at the selected weather stations in Fig.1.

Generally, seasonal pattern of MOD17 PSN was well fit with that of modeled PSN. Oregon ENF site and Texas Grass site, however, shows somewhat different seasonal patterns between normalized modeled and MOD17 PSN, which we suppose due to difference of input meteorology in both products. Compared to low DAO vapor pressure deficit (VPD), Oregon site shows high late summer VPD, which caused reduction in GPP and hence, negative PSN in late summer. Likewise, Texas site also showed high late summer VPD of DAO data, which resulted in big drop of MOD17 PSN in the late summer. In contrast, weather station VPD is generally high during the growing season and hence, forced that modeled PSN remains low during the seasons.

Comparison of absolute PSN values was suggested in Fig.5. In spite of similar LAI, MOD17 PSN generally showed higher values than the modeled PSN, except for DBF sites.

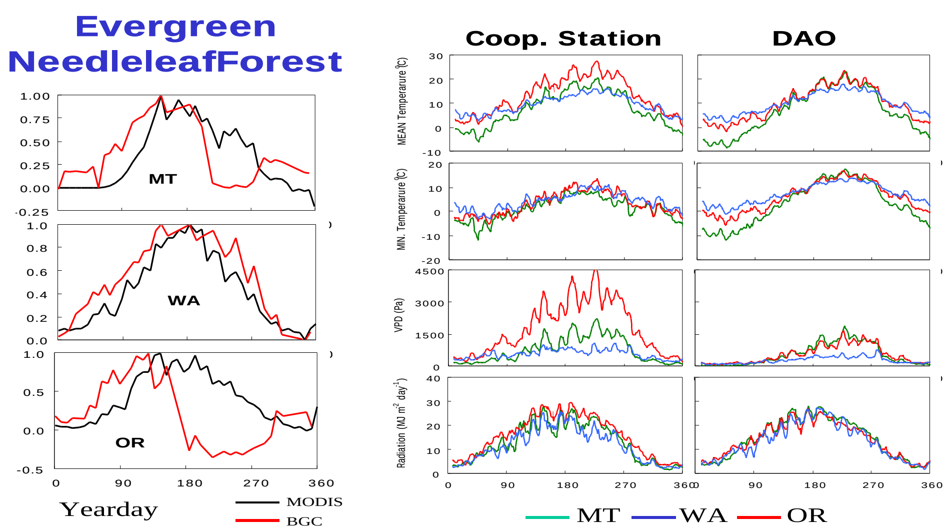


Fig.4 Biome-specific comparison of normalized PSN and meteorological data from NCDC weather stations and DAO at the selected sites in Fig.1.

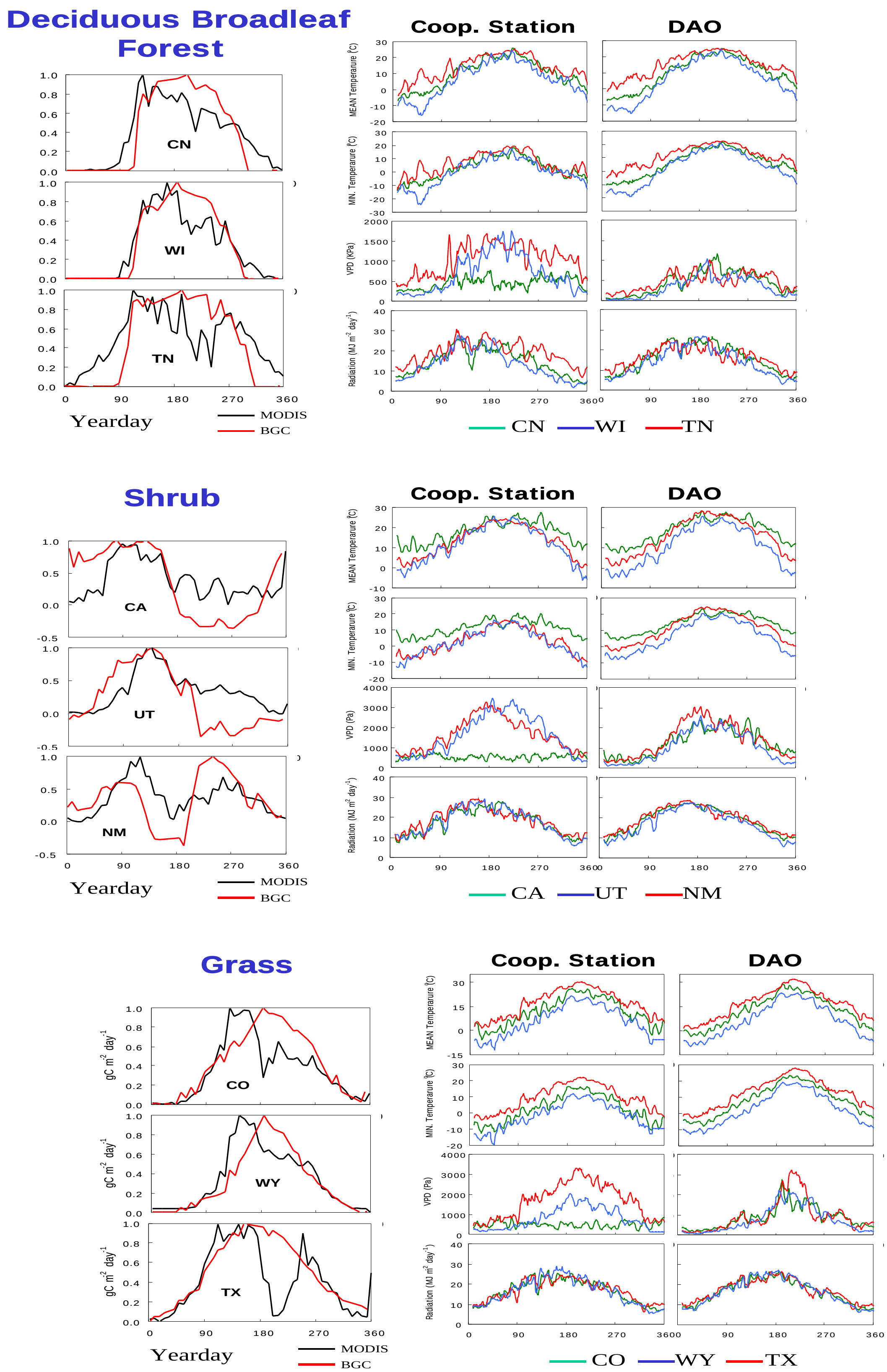
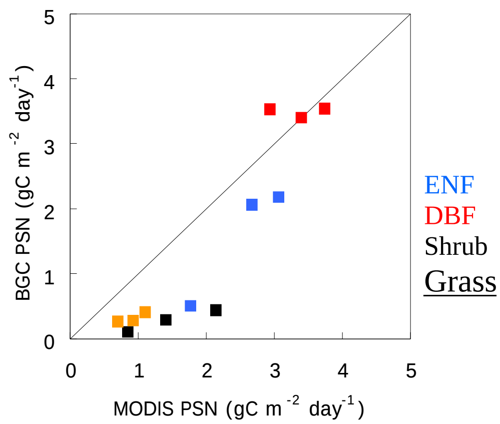


Fig.4 Continued



.

Fig.5 Biome-specific comparison of PSN at the selected sites in Fig.1.

Summary and conclusion

DBF sites showed the best fit between MOD17A2 PSN and the modeled PSN by BIOME-BGC in terms of both seasonal pattern and absolute value. At ENF sites, MOD17A2 PSN produced generally similar seasonal pattern but higher absolute value than the modeled PSN. At Shrub and Grass sites, the seasonal patterns were well fit with each other but MOD17A2 PSN were 3 to 6-times higher than the modeled PSN. ENF site in OR and Grass site in TX showed relatively big difference between both the PSN. It seems the difference in local and DAO meteorological data, especially VPD, explains the discrepancies. In summary, MOD17A2 PSN can capture, in spite of its simple algorithm, seasonal variability of PSN generated by complex biogeochemical processes of the more complex model, BIOME- BGC.

Extended future study

Errors, however, can come from both MOD17A2 PSN and BIOME-BGC simulation and hence, field-measured PSN (or GPP) needs to be incorporated with the comparison study for more rigorous validation. In this study, we ran BIOME-BGC using default eco-physiological parameters with STATSGO soil information rather than using station-specific calibrated parameters and soil information. For more rigorous comparison, BIOME-BGC needs to be parameterized specific to local site characteristics. We are now conducting this extended comparison and validation study in Ameri-Flux fluxtower sites in USA.

A Regional Phenology Model for Detecting Onset of Greenness in Temperate Mixed Forests, Korea: An Application of MODIS Leaf Area Index (LAI)

Sinkyu Kang, Steve W. Running, Jong-Hwan Lim, Maosheng Zhao, Chandra Park

Introduction

Leaf Area Index (LAI) (projected, $m^2\ m^{-2}$), a surrogate measure of the amount of canopy vegetation per unit area, is widely used as an important input/output variable of ecosystem models that relate solar radiation to terrestrial carbon and hydrologic cycles (Running and Coughlan, 1988; Band *et al*., 1993; Landsberg and Waring, 1997). LAI is an aggregate variable for canopy status in terms of radiation and thermal physics, which is applied with satellite data to estimate spatial and temporal patterns of LAI (Spanner *et al.*, 1990; Settle and Drake, 1993; Sellers *et al.*, 1994; Chen and Chilar, 1996; Myneni *et al.*, 1997a; White *et al.*, 1997; Turner *et al.*, 1999) and the timing of leaf onset or offset (Goward *et al.*, 1985; Bradley *et al.*, 1994; White *et al.*, 1997). Vegetation phenology, that is seasonality of LAI driven by environmental factors, controls seasonal variability in photosynthesis and evapotranspiration for a deciduous biome which is broadly distributed mid-latitude countries in the northern hemisphere. Together with maximum LAI, timings of leaf onset and offset are special concerns of vegetation phenology models, since those have considerable influences on spatial and interannual variability of terrestrial carbon cycles (Hanninen *et al.*, 1990; White *et al.*, 1997; Menzel and Fabian, 1999; White *et al.*, 1999).

In recent years, vegetation phenology has found new relevance within global climate change research, with increasing data obtained by satellites (White *et al.*, 1997) and by regional phenology networks (Kramer, 1994; Schwartz, 1998; Menzel and Fabian, 1999; Chuine *et al.*, 2000a). Together with meteorological data, surface-based phenology data have been used for developing several species-specific leaf onset and/or leaf offset models. The timing of leaf onset has been successfully modeled using cumulative thermal summation with or without consideration of chilling requirement (Cannell and Smith, 1983; Valentine, 1983; Marray *et al.*, 1989; Hanninen *et al.*, 1990; Hanninen, 1994; Kramer, 1994; Chuine and Cour, 1999; Chuine *et al.*, 1999; Chuine, 2000). Chuine *et al.* (2000) implemented a successful pilot study to scale phenology from the local to the regional level using species-specific phenological models. Regional or global carbon cycling models, however, consider mean phenological change within each pixel of a study area where diverse vegetations are aggregated. Large-scale carbon cycling models require regional or global-scale phenology models to capture aerial-mean phenological change related to average environmental conditions for each grid pixel. In this context, satellite data provides a means for monitoring regional or global-scale phenology (Running *et al.*, 1994; Moulin *et al.*, 1997; Myneni *et al.*, 1997a, 1997b). Notably, satellite spectroscopic reflectance from NOAA-AVHRR has been used to estimate the timing of leaf onset or offset because of its high temporal frequency, which can capture day-to-day variations in canopy status (Goward *et al.*, 1985; Bradley *et al.*, 1994; Liidele *et al.*, 1996; White *et al.*, 1997). White *et al.* (1997) used the normalized difference vegetation index (NDVI) from AVHRR to develop a continental phenology model for deciduous broadleaf and grass biomes in United States.

The current study aims to develop a regional phenology model for detecting leaf onset in temperate mixed forests using MODIS 8-day composite LAI product (MOD15A2). In contrast to its predecessors including AVHRR, MODIS incorporates enhanced atmospheric correction, improved geo-referencing, and the enhanced ability to monitor vegetation. In addition, MODIS provides further necessary information on landcover and cloud contamination for developing the phenology model. We also suggest an objective approach for model parameterization for general application to other regions, and validated the developed phenology model with field observed leaf onset in Korea.

SCIENCE TEAM ACTIVITIES:

John Kimball, Faith Ann Heinsch, Alana Oakins

Meetings attended:

July 2002:	MODIS Vegetation Workshop, Missoula MT.
July 2002:	IARC Research Development Workshop, Fairbanks AK.
August 2002:	Western Arctic Linkages Experiment Workshop, Polson MT.
August 2002:	ChEAS Workshop, Woodruff, WI.

Posters and Presentations:

Modeling the role of high latitude terrestrial ecosystems in the Arctic. Presentation for WALE Workshop, August 2002, Polson MT.

Using MODIS to estimate GPP/NPP on a global scale. Presentation for IARC Research Development Workshop, July 2002.

Biome-BGC and estimations of tower fluxes. Presentation for ChEAS 2002 Workshop, August 2002.

Science activities:

MODIS Science activities to date have been directed toward evaluating MODIS LAI, GPP and PSN products through intercomparisons with site network measurements and ecosystem process model simulations at tower eddy flux measurement sites from FLUXNET and other biophysical monitoring networks. Current activities include the assembly of tower site meteorology and water and CO2 flux data at half-hourly time steps. We have developed protocols for estimating and filling in missing tower data at half-hourly time steps in order to aggregate these data to complete daily time steps. Daily tower meteorological data are being used as inputs for stand level ecosystem process model (BIOME-BGC) and MODIS GPP and NPP algorithm (MOD-16/17) based simulations at each study site. Site-specific ecophysiological parameterization files have been developed for each study site, which are being used to generate BIOME-BGC daily model simulations for intercomparison with MODIS based products. Intercomparison studies involve direct comparisons of relative magnitudes and seasonal behavior between MODIS, Tower and BIOME-BGC results. Sensitivity analyses are also being conducted using alternate meteorological inputs derived from tower measurements and NCEP and DAO forecast model outputs. Protocols are also being developed to uncouple tower eddy flux net CO2 exchange measurements into GPP and respiration components to enable more direct comparison to MODIS and BIOME-BGC outputs.

To date, most of our analyses have occurred within the continental US. We have also conducted similar studies to evaluate MODIS LAI, GPP and NPP products for boreal and arctic sites in Alaska and Canada. Initial results indicate that the behavior of the MODIS algorithms at high latitudes is different than results show for other regions. MODIS LAI/FPAR data were found to exhibit a high degree of seasonality relative to ground based results even over predominantly evergreen coniferous forests. However, comparisons of annual maximum LAI between MODIS and site results showed a high level of agreement. Impacts of the strong seasonality of MODIS LAI/FPAR results on resulting GPP and NPP estimates was apparent but somewhat mitigated to a large degree because of other environmental controls on the seasonal behavior of these results such as light availability and temperature.

Integrating MODIS-derived Net Primary Production into scientific and management applications of Switzerland

Members of the EOS Training Center, working as part of an international research collaboration with the Swiss Federal Research Institute for Forest, Snow and Landscape Research, designed and implemented a research plan to facilitate the integration of MODIS-based Net Primary Production (NPP) data into scientific and management applications in Switzerland. The research plan was designed as a nested spatial and temporal scale application of several models and remote sensing-based tools in conjunction with field collected data to establish a long-term time-series of NPP for the country as well as to establish methods by which researchers could monitor changes in the domestic carbon budget.

The first phase of the research plan was to establish a long-term time series of NPP using the ecosystem process model BIOME-BGC. To accomplish this, researchers collected ancillary data on gas exchange and leaf characteristics of the dominant tree species throughout Switzerland. These data complement an already extensive set of data collected as part of Long Term Forest Ecological Research (LTFER) program. They will be used to parameterize BIOME-BGC for the sites within the LTFER network where we will generate estimates of NPP for at least 70 years. Within these sites, long-term validation data sets will be compiled from tree ring density chronologies to allow researchers to validate the NPP estimates.

After completion of the retrospective analysis, the second phase of the research plan is designed as a crossover from the BIOME-BGC NPP estimates to MODIS-derived estimates of NPP. To accomplish this, we will use a combination of the long-term dataset of LAI and FPAR derived from Pathfinder AVHRR data in conjunction with the at-launch MODIS NPP algorithm to generate an NPP time-series in the locale of the LTFER sites from 1982 to 2000 that will overlap the time-series of NPP generated from BIOME-BGC. This step is crucial to show that the dynamics of the of the more parsimonious remote sensing derived data tracks closely with the more rigorously estimated NPP values from BIOME-BGC. We will then use the MODIS NPP to continue the record from 2000 to present to establish the full time series as well as the means by which to monitor future changes.

In return for assistance with the technical and staffing aspects of such a project, the Swiss researchers are providing a data set for use in validation of MODIS NPP data products. Swiss researchers are developing methods to reconstruct NPP from stand measurements of leaf area index and biomass increments collected at all 17 sites within the LTFER network. This will provide Montana researchers with an excellent dataset to validate their NPP data products.

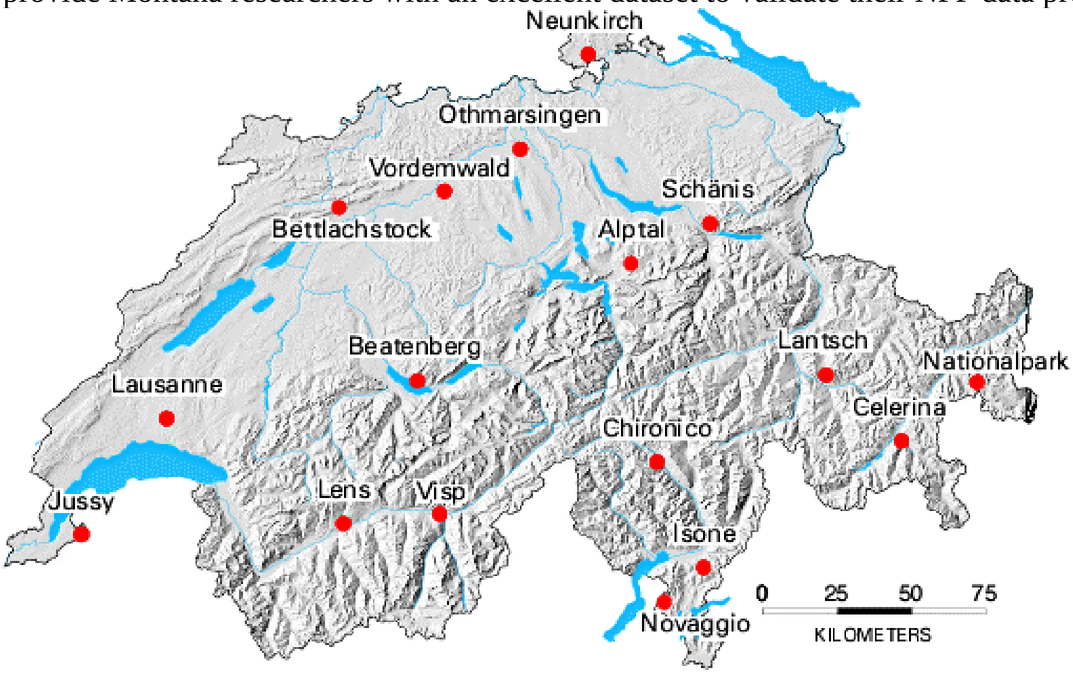


Figure 1 - Swiss carbon budget pilot study sites.

The effects of moisture status on the intra-annual dynamics of leaf area in the semi-arid regions of the Kalahari

We examined the effects of precipitation and soil moisture status on the dynamics of leaf area in semi-arid, drought-deciduous ecosystems in the Kalahari region of South Africa. We postulated that the onset of greenness in these vegetation types was controlled by a large significant precipitation event and the offset was a dynamic feedback between leaf area, soil water potential and net primary production. Leaf onset dates were estimated as the first day where a rainfall event exceeded that day's estimate of potential evapotranspiration after a defined dry season. Leaf senescence was determined by dynamically modeling the effects of downward trends in soil water potential on leaf area in relation to negative trends in net primary production (NPP) in the ecosystem process model BIOME-BGC. The results of predictions of leaf area index (LAI) were then compared to satellite-derived Normalized Difference Vegetation Indices (NDVI) to determine whether or not the modeled dynamics of the system supported our hypothesis. Mean absolute error (MAE) for the prediction of the onset date compared to onset dates derived from the NDVI times were 12.3 days for the Maun site and 27.5 days for the Tshane sites. Peak leaf timing and leaf fall dynamics were adequately predicted using the dynamic soil water controls on leaf area (Figure 2). In general, the results suggest that water moisture status cannot be ignored as a dynamic control on leaf area in these semi-arid, drought-deciduous ecosystems.

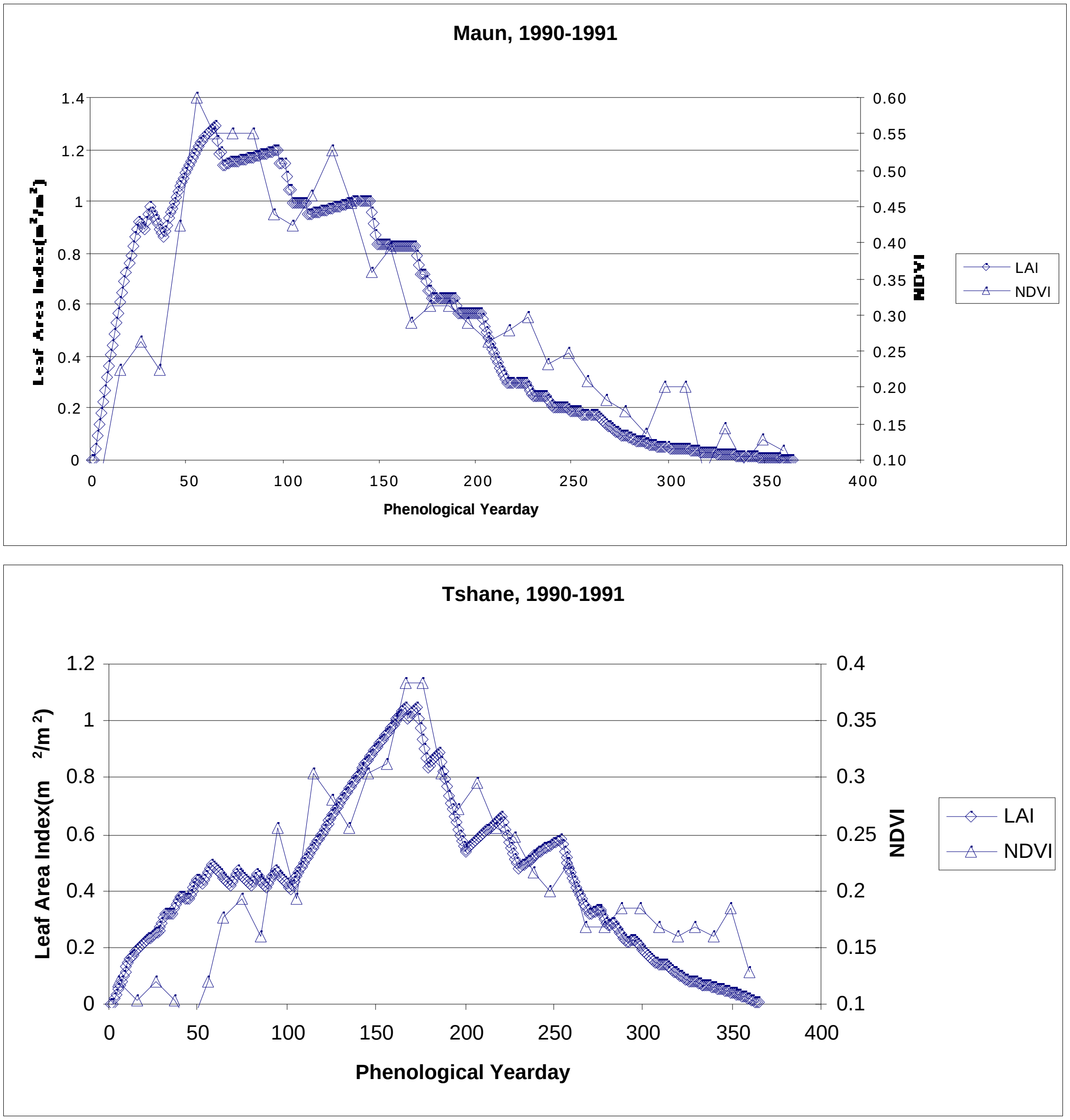


Figure 2 - Examples of model derived leaf area index compared to Pathfinder NDVI data for two sites within the Kalahari Transect.

Development of the Surface Observations Gridding System (SOGS)

The Surface Observations Gridding System (SOGS) is a near real-time system designed to interpolate surface meteorological data onto a user-defined grid. These data can then be used as inputs to ecological process models or hybrid models incorporating remote-sensed data with surface-based data. The system was developed to operate in near real-time by injesting surface observations from a multitude of internet-based data sources and incorporating those data into an SQL database which serves as the heart of the system. The point data can then be interpolated into surfaces of data using a user-selectable algorithm, Ordinary Kriging for temperature data and a truncated gaussian filter for precipitation by default. Upon completion, the system will be able to generate surfaces maximum and minimum temperature, precipitation, dewpoint temperature, vapor pressure deficit and solar radiation.

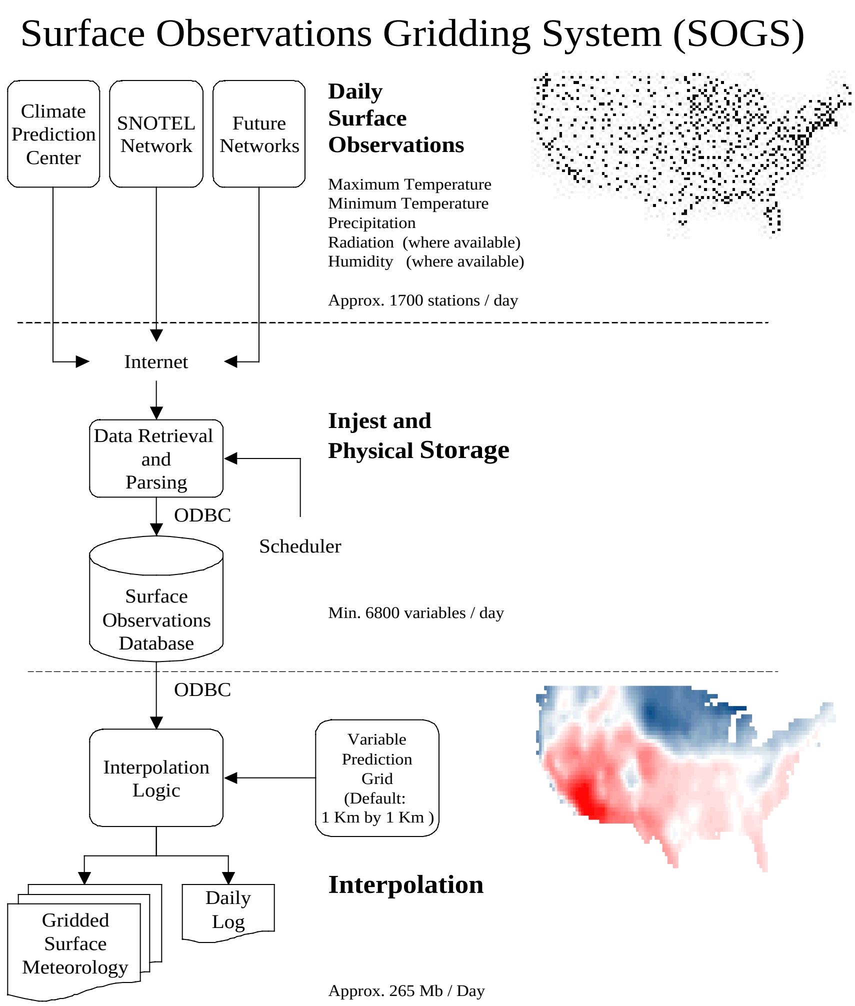


Figure 3 - System flow diagram of the Surface Observations Gridding System (SOGS).

APPLICATION OF MODERATE RESOLUTION IMAGING SPECTRORADIOMETER (MODIS) TO FORECAST RISK OF HANTAVIRUS PULMONARY SYNDROME IN THE CONTINENTAL UNITED STATES

Rachel Loehman

The importance of climate in determining the severity, timing, and distribution of infectious diseases has received considerable attention in recent years. The World Health Organization (WHO), Intergovernmental Panel on Climate Change (IPCC), Worldwatch Institute, and US Institute of Medicine's Committee on Emerging Microbial Threats have concluded that the effects of climate change on human health will be wide-ranging and profound (Last, 1993; Jackson, 1995; Kovats *et al*., 1998). A partial list of diseases likely to undergo changes in distribution or incidence includes malaria, dengue and yellow fevers, filariasis, encephalitis, schistosomiasis, and hantavirus pulmonary syndrome (Brown, 1996). Vector-borne diseases are especially sensitive to long-term changes in climate and short-term fluctuations in weather because such variations perturb the complex ecological systems that support vector populations (Myers *et al*., 2000). Global Circulation Models (GCM) predict increases in temperature and precipitation that may result in expansion of favorable habitats for vector-borne diseases, changes in rates of disease transmission, and movement of vectors into previously disease-free areas (Jackson, 1995). Additional effects of climate change on disease vectors include increased breeding cycles and rates of survival, resulting in large vector populations. Population growth and dispersal of disease vectors severely increases the risk of infection in human populations by bringing humans into close contact with transmissible pathogens. Existing epidemiological methods are incapable of forecasting the severity, timing, and distribution of emerging infectious diseases in the context of global change (Myers *et al*., 2000). Many researchers have recognized the need for models capable of predicting temporal and spatial risks of epidemics (Epstein, 1999; Patz and Lindsey, 1999; Myers *et al*., 2000; Rogers, 2000). The goal of such models is an understanding of the synergistic processes that determine the distribution of disease vectors.

Hantavirus pulmonary syndrome was first identified North America in the spring and summer of 1993. Initial cases were clustered in the Four Corners region of the southwestern US, where origins of the disease were traced to an unrecognized, directly transmissible virus later named Sin Nombre virus (SNV) (genus *Hantavirus*, family Bunyaviridae) (Schmaljohn and Hjelle, 1997). SNV is transmitted to humans through inhalation of secretions and excretions from infected *Peromyscus* rodents, in particular the deer mouse (*Peromyscus maniculatus*) (Mills *et al*., 1997; Glass *et al*., 2000).

Through identification of the processes that determine patterns of distribution of a disease vector, and an understanding of the effects of changes in climate and land cover on these patterns, models can forecast risk of disease emergence across large spatial scales, and into the future. The current research implements an integrated systems model of the dynamic interactions between *Peromyscus* rodents, vegetation dynamics, and climate. The biological basis for the model is the sensitivity of rodent populations to changes in precipitation, temperature and resource abundance described by the trophic cascade hypothesis. Infection rates within rodent populations are also sensitive, both to extrinsic (temperature, precipitation) and intrinsic (age composition, density) factors. Parmenter *et al*. (1999) note a three to six month lag interval in rodent population growth following increased resource abundance. This lag period suggests that the minimum predictive capability of a risk model driven by observed changes in biotic yield is three months, and may extend as far into the future as six months. Such seasonal forecasts provide sufficient notification period to allow health officials to prepare for potential outbreaks and educate at-risk populations about methods for disease prevention. Longer-term risk area predictions are also possible using GCM predictions, although these may have diminished precision compared to seasonal forecasts.

The use of NPP to monitor variations in resource abundance may significantly improve disease forecasting models. Glass *et al*. (2000) conclude as part of the only current HPS modeling effort that "the association between HPS risk and vegetation growth, as measured by the normalized difference vegetation index [NDVI], was inconsistent." The study attributes this inconsistency to a failure to account for the biological complexity of vector dynamics, and the inaccuracy of NDVI characterization of semi-arid and mixed vegetation environments. The proposed work will account for these shortcomings through the use of a complex and integrated model and advanced global monitoring methods. Net primary productivity (NPP) is a measure of terrestrial biological productivity. Increases in atmospheric CO_2 and global climate change may alter NPP over large areas (Running *et al*., 2000). Weekly NPP estimates are available from the Moderate Resolution Imaging Spectroradiometer (MODIS), a NASA sensor launched in 1998 as part of the Earth Observing System (EOS) program. Weekly MODIS NPP is produced using MODIS land cover to define a biome type and a biome and seasonally-specific conversion from photosynthetically-active radiation (PAR) to NPP (Running *et al*., 2000).

Activities of C. Milesi (Ph.D. Student)

We have completed an assessment of the impact of urban sprawl on regional net primary productivity (NPP) in the southeastern United States. While urban areas are generally thought to reduce the photosynthetic capacity of the land, little research has been devoted to quantifying the net effect of urbanization on NPP. The southeastern United States has undergone one of the highest rates of landscape change and urban sprawl in the country, representing the ideal study area in which to develop a remote sensing based methodology for a regional assessment of the impact or urbanization on ecosystem productivity.

We used a combination of MODIS and Defense Meteorological Satellite Program / Operational Linescan System (DMSP/OLS) to assess the extent of land cover changes due to recent urban development and the impact of these changes on NPP.

Change detection analysis was applied to the nighttime data from the DMSP/OLS for the year 1992/93 and 2000 to identify, in a spatially explicit way, land development occurred in the recent decade.

MODIS data for the year 2001 were used to estimate NPP for the southeastern region. Since urban areas are masked in the MOD15 and MOD17 products, we had to generate LAI/FPAR and NPP from the MOD13 data, using the MOD15 backup algorithm and the MODIS NPP logic. A 1 km land cover derived from the 1992 National Land Cover Data set (NLCD) was used to guide the algorithms. The urban class was assigned to the savanna land cover, defined as a two-layer canopy with an overstory of trees and an understory of grasses.

We estimated a retrospective NPP for the year 1992 by multiplying the number of pixels in each land cover by its mean NPP. An estimate of the NPP of the recently urbanized areas was obtained by multiplying the mean NPP for the urban category of each state by the number of newly developed pixels in the state.

The analysis indicated that urban land development irreversibly transformed about 1.9% of the southeastern United States between 1992/93 and 2000 (Figure 1). The largest increases in urbanization were recorded for the states of Georgia, Florida North Carolina and South Carolina.

Figure 2. Average nighttime lights with digital numbers greater or equal to 50 for (a) 1992/93, (b) 2000 and (c) difference between 2000 and 1992/93.

The 1992 total NPP for the southeastern United States was estimated to be 872.57 Tg (Teragrams) of carbon per year. Urban land development during the years 1992/93 and 2000 was estimated to reduce total NPP by 3.04 Tg of carbon per year, an average of 183 g of carbon per square meter of land developed (Table 1).

State	***Unit loss in NPP (g m^{-2} y^{-1})***	***Total loss in NPP (Tg y^{-1})***
Alabama	221	0.38
Florida	153	0.55
Georgia	204	0.63
Mississippi	196	0.26
N. Carolina	178	0.54
S. Carolina	194	0.37
Tennessee	163	0.30
SE-US	183	3.04

Table 1 Estimates of NPP lost due to estimated development between 1992/93 and 2000.

The results confirm that urbanization determines a loss of NPP in regions where plant growth is not resource limited, such as the southeastern United States. However, urban forestry programs, widely supported in some of the southeastern states, can contribute to contain this loss in NPP and maintain quite high levels of photosynthesis in urban areas.

Publications:

C. Milesi, C.D. Elvidge, R. R. Nemani and S.W. Running (2002), Assessing the impact of urban land development on net primary productivity in the southeastern United States. Remote Sensing of Environment *(accepted)*.

C. Milesi, C.D. Elvidge, R. R. Nemani and S.W. Running (2002), Assessing the environmental impacts of human settlements using satellite data. Environmental Management and Health *(in press)*.

ACTIVITIES OF P. Votava, Lead MODIS Software Engineer

OBJECTIVES

The objectives during the time period January 2002 to July 2001 are summarized here, with details on each of the indicated activity areas following.

- Patch our existing production code for Collection 3 reprocessing
- Prepare all our production code for Collection 4 reprocessing
- Oversee and troubleshoot MODAPS production of our biophysical land product suite.
- Perform ad-hoc Quality Assurance/Quality Control activities on our set of MODIS data products.
- Refine our SCF procedures and architecture using early MODIS product experience.
- Augment the MODAPS production team efforts by implementing selected SCF production scenarios required to supply NASA collaborators with early PR materials
- Continue to develop our MODIS/Aqua production code

WORK ACCOMPLISHED

From January 2002 to July 2002 we have focused our efforts mainly at troubleshooting of our at launch algorithms, and at monitoring of the production of our products in the MODIS Adaptive Processing System (MODAPS). As a part of the troubleshooting, we have implemented number of Quality Control and Quality Assurance procedures.

Key accomplishments for this period is further automation of procedures for PR image production, including reprojection, tiling, and sub-sampling. Additionally, we have improved our in-house software for our internal QA procedures with capabilities missing in all externally available tools. Most of this process is now database driven and the overall design uses a set of plug-in filters. Finally, we have produced global, local, and regional images of our MODIS PSN data for all the periods of 2001 and available periods of 2002 – this was done at 3 different resolutions. We have significantly upgraded our MODIS image Web site where all of these images are posted, and added database back end to this web site.

ALGORITHM DEVELOPMENT

FPAR, LAI Daily and 8-day Composite (PGE33, PGE34)

The main science logic in the daily and 8-day FPAR, LAI has been stable for quite some time, with the changes effected during this period mostly applying to minor engineering issues pertaining to QA handling and ECS metadata interpretation. Additionally, new version of PGE34 (v3.0.1) has been delivered. Last, two more patch deliveries has been made – both of them deal with metadata issues.

We are currently implementing major changes that are required for Collection 4 reprocessing – this includes changing the SCF QA in our of our algorithms, changing the Landcover used in daily FPAR/LAI (PGE33) and changing the strategy for compositing of our 8-day FPAR/LAI (PGE34).

The daily FPAR, LAI algorithm (PGE33) is currently at version v3.0.4, and is built using the SDPTK v5.2, HDFEOS 3.2, HDF 4.1r2, and MUM v.2.5.5 libraries. This algorithm is now at 18,723 LOC (77,095 LOC total includes the MUM API).

The 8-day FPAR, LAI algorithm (PGE34) is currently at version v3.0.6, and is built using the SDPTK v5.2, HDFEOS 3.2, HDF 4.1r2, and MUM v.2.5.5 libraries. This algorithm is now at 10,198 LOC (70,043 LOC total includes the MUM API).

PSN, NPP (PGE36, PGE37, PGE38) Algorithm

The PSN, NPP biophysical algorithm (ESDT: MOD17A1, A2, A3) is unique among the other MODIS Land algorithms in the degree to which it is a model oriented rather than instrument radiometry oriented process. It requires daily availability of the new DAO DAS subset of global surface climatology variables, as well as the FPAR, LAI 8-day composite tiles from the most recent period relative to the day, the MOD12Q1 landcover definition, and its static ancillary data. The single most critical factor that sets the PSN, NPP algorithm apart from the others its temporal sensitivity, driven by the way that cumulative (additive) state variables for GPP, GPP minus maintenance respiration, maximum leaf mass and annual sum of maintenance respiration are carried forward throughout the year. From a production standpoint, delivering a temporally reliable stream of FPAR, LAI data to the daily PSN, NPP algorithm has become one of the most challenging, quality limiting aspects of the MODAPS. In the larger MODIS Land processing stream, persistent production gap problems arising in the EDOS portion of the ground system have propagated tile and time drop-outs of the MODAGAGG to the daily FPAR, LAI processing. These in turn are reflected in drop-outs of 8-day MOD15A2 to the daily PSN algorithm. While corrections to EDOS problems are reportedly on their way, to run our PSN, NPP algorithm reliably, our SCF has had to locally stage up the required inputs, to implement limited processing here. Recently we were able to generate several 8-day period sequences of PSN, NPP daily runs, culminating in the generation of (2) 8-day period PSN data product sets, each approximately 288 tiles globally. We have spent much time troubleshooting issues with our PSN algorithm, including analysis of the results from the 2001 runs and the analysis of the DAO data. We are currently working on changes to get the production code ready for Collection 4 reprocessing.

The PSN, NPP algorithm (PGE36, 37, 38) are currently at version v3.0.8, built using the SDPTK v5.2, HDFEOS 3.2, HDF 4.1r2, and MUM v.2.5.8 libraries. The PSN, NPP algorithm is now at 18037 LOC (78,093 LOC total includes the MUM API).

QA AND OPERATIONAL ACTIVITIES

Quality Assurance activities for this period focused mainly on retrieving and visually inspecting frequent samples of golden tile products of FPAR, LAI 8-day composite product, and the outputs of our 8-day PSN. We did update our QA tool environment during this time, as summarized here:

- Our IDL visualization software was upgraded to 5.5. We are still awaiting solid support for the HDFEOS 3.x and HDF data models from the major COTS vendors (RSI, ESRI, etc).
- Our HDFLook visualization and QA software was upgraded to v.8.2
- A number of small, console tools were refined, including the ***eosmt*** tool for quick analysis of FPAR and LAI products.
- W have refined a tile-wise reprojection utility (reprojtool, v1.16 for reprojecting MODIS ISINUS tiles into the Lambert Azimuthal Equal Area, Robinson's, Goodes interrupted homolosine, and Plate Carre rectangular map projections. This utility has been integrated with our distributed application framework.
- Further development of in-house QA tools that provide additional capabilities beyond what is currently available from external sources
- Improved our system for image production which includes reprojection, mosaicing, subsampling and creating a JPEG or GIF image. This is done done with JAVA JNI, CORBA and C. All the components have been integrated and the system is now fully automated, including database back-end and web front-end.

SCF DEVELOPMENT

Incremental additions to the Montana SCF were made during this period to increase our ability to perform high volume QA, test, and limited production in support of our global validation program.
We have added two 16-node Linux clusters and additional 2TB of RAID disk

Linux Cluster Development and Implementation

In last several months we have geared up to do several processing campaigns that involved our Linux clusters. The development of the cluster and automation software has spanned several versions. We have now completed the move from collection of Perl and shell scripts towards an integrated Java environment that gives us more control in the distributed environment. We have refined our Java client/server model to implement the distribution of tasks among the hosts in the cluster. One of the advantages of this approach is that we have removed the limitation of running the distributed environment only on Linux hosts – the Java portability should allow us to operate in truly heterogeneous environment.

UM SCF Cluster and Processing Development

We have currently implemented distributed cluster servers to run both the FPAR, LAI 8-day (PGE34) and PSN daily (PGE36). On the client side we have a new version of PGE34 client and scheduler that implements a simple load balancing scheme. Additionally, we have added our global PR (reprojection, mosaicing, subsampleing, and imaging) system to run on our distributed environment as well. This system has been used in runs that produced our latest PSN composites. A similar system was used to produce our global 8-day PSN composite, which is quite bit more complicated. In the latter case, we needed to perform around 5,000 tile executions using the PGE. On current Linux cluster this required ca 4 hours to complete. In the next version , we plan on implementing a better graphical user interface for our system and to unify the Java/RMI environment. The initial step of each processing campaign starts with a PCF (runtime input command set) generation step is now part of the distributed environment and is done in Java. Finally, we have integrated our production algorithms with the Java distributed system, which helps us to maintain unified API across many different algorithms, and thus enables us to do much faster integration and more efficient scheduling.

COLLABORATIONS: SCIENCE AND DATA SYSTEMS

During this period the following collaborations were pursued for MODIS related activities:

- Continued to closely collaborate with the Boston University staff (Yura K, Yu Zhang, Yujie Wang, Ranga Myneni in the refinements to QA procedures and interpretation of MOD15A1 and MOD15A2.
- We initiated an interim scheme to locally archive our daily intermediate data products (MOD15A1 and MOD17A1), in support of our on-going Quality Assurance program, via periodic downloads from the MODAPS production environment.

CONFERENCES/MEETINGS

- MODIS Science Team Meeting, December 2001
- IGARSS 2002, June 2002

TALKS

- *Java Distributed Application Framework (JDAF)* at MST, 2001
- *Distributed Application Framework for Earth-Science Data Processing* at IGARSS'02

POSTERS

- Biospheric Forecasting (co-author) at IGARSS'02

PAPERS

P. Votava et al, 2002. *Distributed Application Framework for Earth-Science Data Processing*. In proceedings of IGARSS 2002, June 2002, Toronto, Canada.

<u>MODIS Related Activities:</u>

Prepared by: Saxon Holbrook, Compute Service Team Manager (CST) & Network Administrator

CST Members: Chad Bowker (Data Manager), Andrew Neuschwander (Linux System Admin), Andy Michaelis (Student Programmer), Doug Wissenbach (Student Programmer), Josh Schwartzman (Student Web Programmer)

Meetings/Training attended:

January 2002:	ESTO Technology Planning Workshop, Greenbelt, MD (S. Holbrook)
January 2002:	ESIP Federation Meeting, Anchorage AK. (S. Holbrook)
February 2002:	HDF Workshop, Greenbelt, MD. (C. Bowker, A. Neuschwander)
May 2002:	Aqua Launch, Buellton, CA. (S. Holbrook, A. Neuschwander)
May 2002:	ESIP Federation Meeting, College Park, MD. (S. Holbrook)
June 2002:	SEEDS Workshop, San Diego, CA. (C. Bowker)
July 2002:	MODIS Vegetation Workshop, Missoula, MT. (CST)
July 2002:	ArcGIS ESRI Training, Bozeman, MT. (S. Holbrook)

Activities

- Participate in ESIP Federation Activities

S. Holbrook attended both ESIP Federation Meetings in 2002 and participated in multiple breakout sessions and hands on training sessions. He is an active member of the Proposal Review Working Group formed in January 2002 and regularly participates in the MODIS Cluster and ESTO Cluster. NTSG continues to server the DAYMET.org website. Metrics are being collected and reported through the Federation's Metric Portal.

- Develop DAO in-line quality scanning tools

D. Wissenbach is developing this software, which will provide the SCF with information about the quality and state of the DAO data before local processing begins. The software will perform spot checks on the feed and report the statistical variability as compared to recent and historical trends.

- Re-Design of the data and image tracking database schema into ADICS

ADICS is the Automated Data Ingestion and Cataloging System. The goal of ADICS is to provide a general and extensible system for 1) reliably and efficiently getting data into NTSG's network, 2) cataloging the type, format, and location of data we ingest, 3) providing a searchable interface so that users can see what we have and where we have it, and finally 4) providing a relationship between images generated from data and the data files. These Four goals are to be implemented in four specific subsystems. 1) A set of extensible Perl scripts will be used to retrieve data from remote sources, or to ingest and catalog data that are pushed to us. These scripts will do all data transfers in a reliable journaled manner. 2) A PostgreSQL database will be used to store the location, type, and formats of data in our holdings. Also, this database will detail the relationships between datasets and between data files and generated images. 3) A web interface will allow users to search through the SQL database for data files based on dataset, algorithm, spatial, and temporal constraints. 4) The NTSG Images website will be able to lookup which data files generated the images that it serves.

- Populate and Organize Data Warehouse holdings
  C. Bowker has established multiple data-push subscription services and is negotiating others with EDC and the GSFC. He has tracked down and remove redundant copies of datasets spread across the network and is in the process of reorganizing the data into a database and human friendly form such that it can be easily populated into ADICS and still used directly by users.

- Continued Development of NTSG Images/Data Gateway
  J. Schwartzman designed a new Images/Data Gateway, which interfaces with the new ADICS database schema. The CST is currently experimenting with multiple internet technologies including Web Mapping servers and GIS data servers.

- SCF Development (Modified from Petr's)
  Incremental additions to the Montana SCF were made during this period to increase our ability to perform high volume QA, test, and limited production in support of our global validation program. We have added two 16-node Linux clusters and additional 2TB of RAID disk, 1TB of RAID storage for our Data Warehouse, Catalyst 4006 Network Switch to facility GB-Ethernet. We have upgraded all Research, Post Doc, Graduate Student and Support Staff Workstations.

- Linux Cluster Development and Implementation (From Petr's)
  In last several months we have geared up to do several processing campaigns that involved our Linux clusters. The development of the cluster and automation software has spanned several versions. We have now completed the move from collection of Perl and shell scripts towards an integrated Java environment that gives us more control in the distributed environment. We have refined our Java client/server model to implement the distribution of tasks among the hosts in the cluster. One of the advantages of this approach is that we have removed the limitation of running the distributed environment only on Linux hosts – the Java portability should allow us to operate in truly heterogeneous environment.

- UM SCF Cluster and Processing Development (From Petr's)
  We have currently implemented distributed cluster servers to run both the FPAR, LAI 8-day (PGE34) and PSN daily (PGE36). On the client side we have a new version of PGE34 client and scheduler that implements a simple load balancing scheme. Additionally, we have added our global PR (reprojection, mosaicing, subsampleing, and imaging) system

to run on our distributed environment as well. This system has been used in runs that produced our latest PSN composites. A similar system was used to produce our global 8-day PSN composite, which is quite bit more complicated. In the latter case, we needed to perform around 5,000 tile executions using the PGE. On current Linux cluster this required ca 4 hours to complete. In the next version , we plan on implementing a better graphical user interface for our system and to unify the Java/RMI environment. The initial step of each processing campaign starts with a PCF (runtime input command set) generation step is now part of the distributed environment and is done in Java. Finally, we have integrated our production algorithms with the Java distributed system, which helps us to maintain unified API across many different algorithms, and thus enables us to do much faster integration and more efficient scheduling.

Activities of Lupine Logic, Inc (LLI) J.M.Glassy, Casey Gerstle

on contract to Univ. Montana NTSG NASA MODIS Land SCF

January 2002 to July 2002

OBJECTIVES

Key LLI objectives during this period have been to:

- contribute software design and implementation effort to the Aqua Evapotranspiration (EI) MYD16 algorithm
- participate in troubleshooting and support of the heritage Terra NTSG biophysical land algorithms (daily FPAR, LAI, 8-day FPAR, LAI, daily, 8-day PSN, and annual NPP).
- Obtain, organize and characterize key test input data sets for the EI algorithm in development, including MODAGAGG, MOD12Q1, MOD15A1, and MOD11A1.
- Coordinate in a variety of quality assurance activities for the FPAR, LAI, PSN, and NPP algorithms.

WORK ACCOMPLISHED

Our LLI group has been involved during this period in two primary activity areas. The first involves primary software development for the ECS implementation of the Aqua Evapotranspiration (EI) algorithm, and the second activity involves a variety of tasks in support of the Terra heritage land algorithms (daily FPAR, 8-day FPAR,LAI, daily PSN, 8-day PSN, and annual NPP). This second activity area includes helping to track the status of the DAO customized “Montana subset” product used to provide climatology parameters for the PSN, NPP algorithms.

In addition to primary software development work, a good deal of our time has been spent in obtaining and characterizing test inputs for the EI algorithm. A number of key chances in the land cover classification layer have been made during this period, which affect the EI and all other NTSG algorithms, so we have closely tracked this evolution.

We have also participated with Dr. Kenlo Nishida in developing content for the MYD16 web site, located at URL: www.ntsg.umt.edu/MOD16

At NTSG's request, LLI representatives have also participated in meetings with visitors to the NTSG lab to discuss MODIS algorithms, provide operational overviews of the production system, and discuss future extensions and applications for the MODIS land data products.

Aqua EI ALGORITHM DEVELOPMENT

At LLI, we have partitioned the software design of the EI algorithm (daily intermediate PGE77, 8-day composite PGE78) into several segments:

- Inner science codes contributed by Kenlo Nishida
- MUM API codes common to all NTSG MODIS land algorithms
- Ancillary inputs (coefficients, tables, etc)
- "Seed" source code supplying overall template logic (PGE33, PGE34, latest versions)
- Test data sets of surface temperature, land cover, daily intermediate surface reflectances (MODAGAGG), and daily intermediate FPAR, LAI.

The current status of our EI ECS code development reflects concurrent progress on each of the code partitions cited above. Recent changes in the QA structure inherited from the MOD15A1 and MODAGAGG product have necessitated development iterations that were not originally anticipated, which has resulted in delays relative to our original plan.

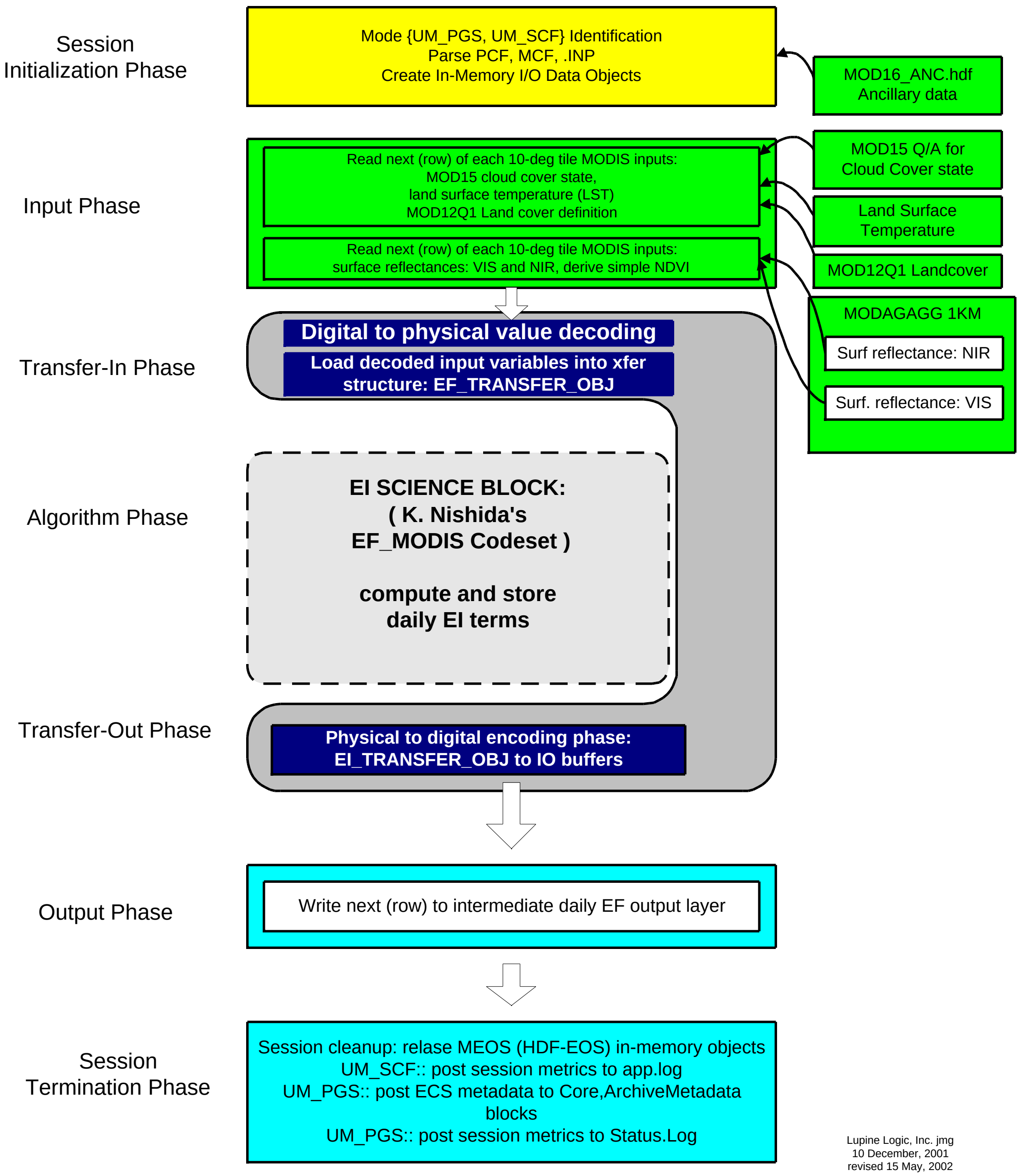
Estimates of the task area completed are shown below:

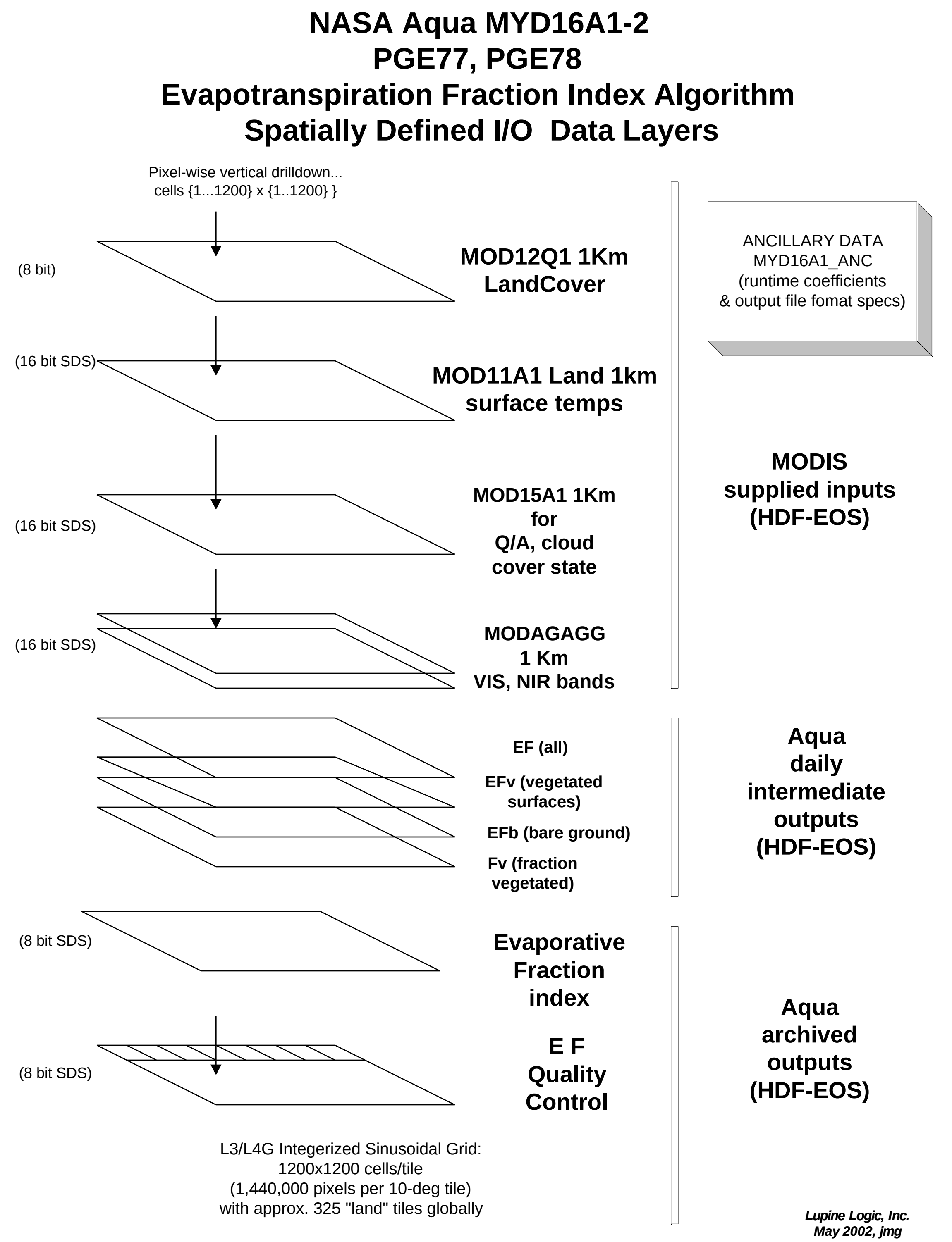
- Ancillary inputs, culminating in the generation of a new MYD16_ANC.hdf file : 85%.
- MUM API library: the current version (v2.5.9) is ready for integration; we are considering a revision to v.3.0 to fold in changes and minor improvements scheduled to implemented since March 2001, but the v.3.0 generation will likely be implemented several months after the Collection 4 ECS codes are delivered.
- EI/ET codeset: integration of Dr. Nishida's standalone codes into ECS compliant sources have been considerably slowed by changes in the governing underlying QA structure and minor changes to each of the key inputs (surface temperature, daily FPAR,LAI,Land Cover (MOD12Q1) and MODAGAGG). Integration status is now estimated at 40% complete.

Refinements in the overall logic flow and input/output scheme are reflected in the following diagrams:

MODIS MOD16 Algorithm Component:
Evaporative Fraction Index (EI)

Software Organization





COLLABORATIONS

Dr. Petr Votava – participatee in on-going collaboration in the refinement of MODIS SCF algorithms for local and MODAPS ECS processing throughout the period.

Dr. David Danks, Institute for Human and Machine Coginition; joint NASA AMES project planning meeting, August 12 2002

MEETINGS ATTENDED

Rhessys Modeling Workshop, July 10-11 2002
MODIS Vegetation Workshop, July 16-18, 2002
MODIS Coordination Monthly meetings between LLI and NTSG, usually held at NTSG office.

PUBLICATIONS

Assisted with technical contributions and co-authored Dr. Kenlo Nishida's paper, "An Operational Remote Sensing Algorithm of Land Surface Evaporation" (Nishida, Nemani, Running, and Glassy) submitted to the Journal of Geophysical Research, publication pending.